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Engineers and Planners • San Francisco

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

LAS VEGAS, NEVADA

FINAL

YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE

CONCEPTUAL DESIGN REPORT

De Leuw, Cather & Company
Subcontract Agreement No. 14-900078-12

120 Howard Street
San Francisco, CA 94105

1 June 1992

EXECUTIVE SUMMARY

PROJECT DESCRIPTION AND PURPOSE

Context of the Study

In accordance with the Nuclear Waste Policy Amendments Act of 1987, Yucca Mountain was designated as the site to be investigated as a potential repository for the disposal of high-level radioactive waste. The Yucca Mountain site is an undeveloped area located on the southwestern edge of the Nevada Test Site (NTS), about 100 miles northwest of Las Vegas. The site currently lacks rail service or an existing right-of-way. If the Yucca Mountain site is found suitable for the repository, rail service is desirable to the Office of Civilian Waste Management (OCRWM) Program because of the potential of rail transportation to reduce costs and to reduce the number of shipments relative to highway transportation.

A Preliminary Rail Access Study[1] evaluated 13 potential rail spur options. Alternative routes within the major options were also developed. Each of these options was then evaluated for potential land use conflicts and access to regional rail carriers. Three potential routes having few land use conflicts and having access to regional carriers were recommended for further investigation. Figure 1 shows these three routes. The Jean route is estimated to be about 120 miles long, the Carlin route to be about 365 miles long, and Caliente route to be about 365 miles long.

The remaining ten routes continue to be monitored and should any of the present conflicts change, a re-evaluation of that route will be made. The DOE has not identified any preferred route and recognizes that the transportation issues need a full and open treatment under the National Environmental Policy Act. The issue of transportation will be included in public hearings to support development of the Environmental Impact Statement (EIS) proceedings for either the Monitored Retrievable Storage Faci or the Yucca Mountain Project or both.

Purpose of This Study

In December 1989, a contract was placed with De Leuw, Co. of San Francisco to develop the conceptual desi three rail spur routes identified for further stud addition, the contract also included the developr conceptual design of a roadway from the existin

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[1]DOE/YMP-89-16, "Preliminary Rail Acces

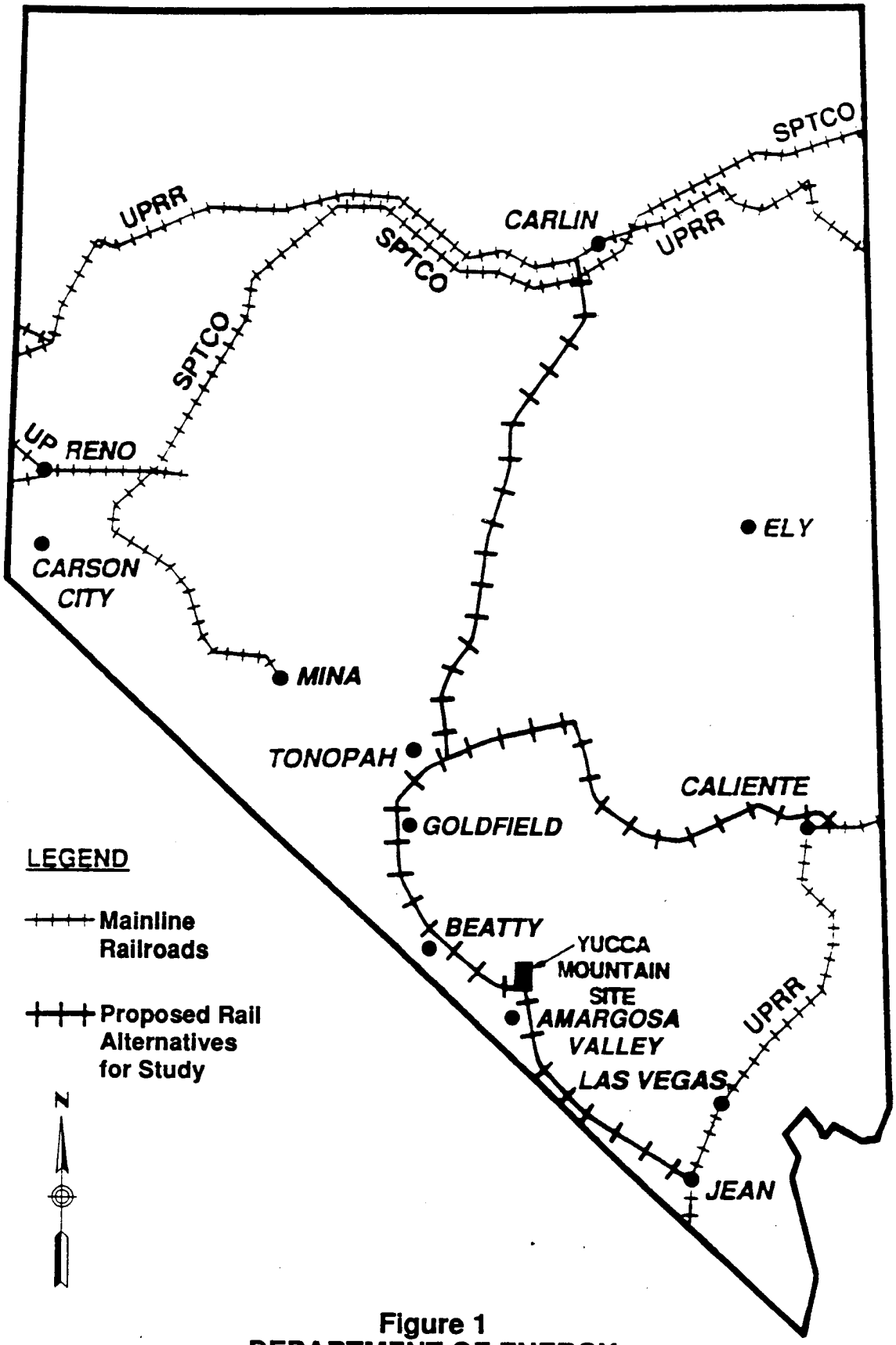

Figure 1
DEPARTMENT OF ENERGY
PROPOSED RAIL ATERNATIVES
FOR FURTHER STUDY

(U.S. Route 95) into the potential repository site. It was decided by the DOE to initiate the rail spur study of the Caliente route first based upon the desire of the community leaders in the City of Caliente and Lincoln County. This study addresses the conceptual design of the first of the rail spur routes, the Caliente route.

Community Involvement

The rail spur study project has included the extensive involvement of Nevadans in the feasibility evaluations of the potential rail spur routes. Meetings were conducted with local officials along the potential route to get their initial comments on the route evaluation process. By soliciting routing comments throughout the process, the DOE hopes that potential routes can be identified which best meet the needs of DOE and Nevadans. Recommendations made by Lincoln County and the City of Caliente were made pursuant to Section 5032 of the Nuclear Waste Policy Amendments Act of 1987. Recommendations made by local communities were and will continue to be included in route evaluation activities.

SCOPE OF WORK

The principal scope of work for this study was to develop the conceptual design, provide a preliminary environmental analysis, and prepare a cost estimate for the Caliente route. This task included an environmental screening to aid in route siting. Aimed at minimizing potential environmental impacts, the environmental screening was limited to an assembly of information from secondary sources. Screening of other factors was limited to minimizing the impact of the route on private lands and developed areas, based on comments from the local communities.

The Caliente conceptual design also included a design of an access highway from U.S. 95 to the potential Yucca Mountain site, a distance of about 16 miles. This highway was designed for automobile and truck access.

In developing and screening potential routes from the Caliente area, route segments were identified within the study area based only on railroad engineering requirements of not exceeding a 2.5% grade and an 8.0 degree maximum curvature (minimum curve radius of approximately 720 feet). These requirements were selected to be compatible with current mainline railroad practices.

Two possible routes from the vicinity of Caliente to the potential site at Yucca Mountain were developed which constituted an envelope of possible routes between the Caliente area and the potential Yucca Mountain site. Developing conceptual designs for

the entire length of both routes was beyond the resources of this study. Consequently, the route and options studied in detail were identified based on preliminary technical results, and a series of meetings that were held with local community representatives (Figure 2). Approximately 725 miles of potential rail line were included in this detail study.

Summary of Engineering Studies

Plan and Profile Development. Information was developed on engineering factors including distance, grade, rise and fall, the amount of cut and fill required, curvature, drainage, and rail operations. Hydrologic studies were conducted to evaluate worst case run-off flows for a 100-year flood condition. Geotechnical studies were performed to determine soil and rock types for determining side slope angles and excavation costs. Conceptual designs were developed for the alignment, bridges, grade separations, drainage structures, and other engineering structures. These designs were described on 1"=500' scale plan and profile drawings.

Environmental Constraint Refinement. Environmental constraints were evaluated to compliment the engineering tradeoffs in route locations to assure that the base route and options do not traverse environmentally sensitive areas. Geological features such as mineral resources, potential land slide areas and fault lines, and subsurface water were also identified to determine if these features would constitute a possible constraint to the rail routes.

In addition, archaeological studies were conducted to assure that the potential route and options do not traverse restricted, historical, archaeological or cultural sites. Archaeological and historical sites were identified from listings on the National Register of Historic Places and from information obtained from the State Historic Preservation Office (SHPO).

Operations Plan. The type of operation selected will influence locations of various features of the railroad such as the siting of crew change points, service and maintenance facilities, sidings, switches, track junctions, and other operational features. These features were determined to a conceptual level based on the studies. The following five types of operation were considered:

1. DOE owned and operated.
2. DOE owned and short line operated.
3. DOE owned and contractor (repository) operated.
4. DOE owned and Class I railroad operated.
5. Privately owned and operated.

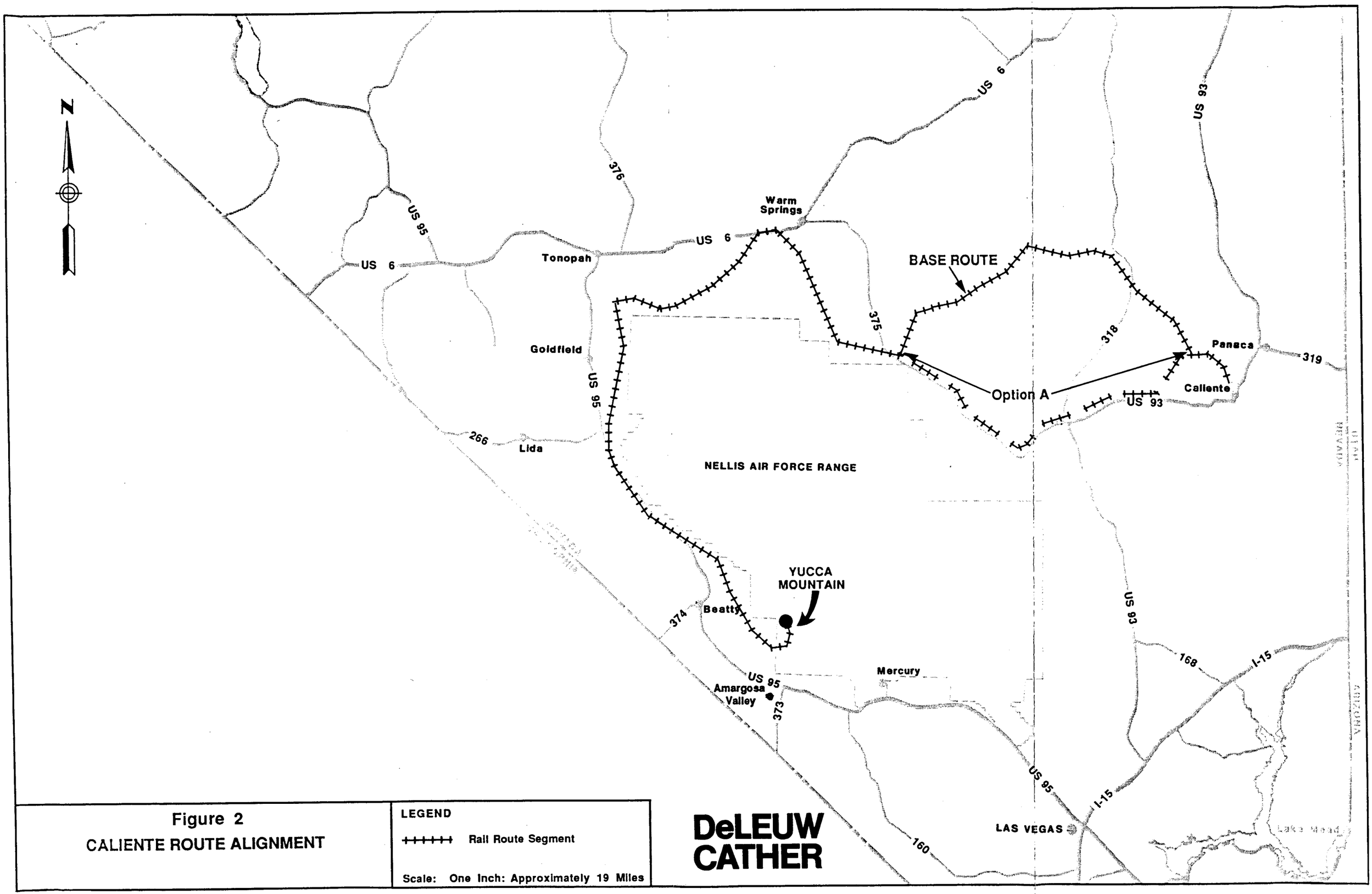

Figure 2
CALIENTE ROUTE ALIGNMENT

TABLE 1
COST ESTIMATE COMPARISON
RAILROAD ITEMS (INCLUDING ACCESS ROAD)

Cost Category	Millions of 1990 $
Base Route	$1,008
Rolling Stock, Equipment, and Building Facilities	$17
TOTAL BASE ROUTE	$1,025
Additional Cost for Optional Design Features:	
Concrete Ties	$37
Automatic Signal System	$13
Route A Option	$310

All types of operation appear feasible at this time. Pros and cons of the several types will need to be considered by the DOE prior to a definitive recommendation of the operating type.

Construction and Operating Costs. Construction costs included major items such as trackwork and associated materials, earthwork, bridge and grade separation structures, drainage structures, and operation and maintenance facilities. Table 1 summarizes the construction costs for the basic design with increments for optional design features. The base route has an estimated construction cost of just over one billion dollars.

CONCLUSIONS

The results of this rail spur study indicate that there is a potential feasible rail route, with several options, from the Caliente area to the potential repository site at Yucca Mountain that avoids severe or significant land access and environmental restrictions. Conceptual plan and profile evaluations indicate that this route can be constructed within the limitation of present railroad engineering practices and is within normal operating standards.

TABLE OF CONTENTS

Section — Page No.

EXECUTIVE SUMMARY.....i

1. INTRODUCTION.....1-1

1.1 Project Description and Purpose 1-1
1.2 Scope of Work 1-3
1.3 Study Area 1-4
1.4 Organization of the Study.....1-4
1.5 Organization of the Report 1-5

2. ALIGNMENT ALTERNATIVES.....2-1

2.1 Study Area Definition.....2-1
2.2 Route Segment Definition and Identification.....2-1
2.3 Route Segment Environmental Screening.....2-3
2.4 Alternative Routes.....2-23

3. ENGINEERING.....3-1

3.1 Introduction and Scope of Engineering Analysis...3-1
3.2 Methodology and Basis for Design.....3-1
3.3 Alternative Alignment Layouts 3-4
3.4 Track and Roadway.....3-8
3.5 Roads.....3-11
3.6 Access Road.....3-12
3.7 Facilities.....3-12
3.8 Geotechnical.....3-13
3.9 Drainage.....3-17
3.10 Structures.....3-19
3.11 Signals.....3-25
3.12 Communications.....3-31
3.13 Right-of-Way.....3-33

4. OPERATIONS.....4-1

4.1 Overview of Rail Operations.....4-1
4.2 Institutional Aspects.....4-3
4.3 Transportation Aspects.....4-16
4.4 Operational Aspects.....4-25
4.5 Maintenance 4-34
4.6 Emergency Response.....4-35
4.7 Facility Requirements.....4-37
4.8 Equipment Requirements 4-37
4.9 The Railroad Operational Evaluation.....4-39

TABLE OF CONTENTS (Continued)

Section — Page No.

5. CAPITAL COSTS.....5-1

5.1 Scope.....5-1
5.2 Methodology and Basis of Cost Estimates.....5-1
5.3 Capital Cost Summaries.....5-5

6. OPERATIONS AND MAINTENANCE COSTS.....6-1

6.1 Scope 6-1
6.2 Methodology 6-1
6.3 Institutional Implications.....6-3
6.4 Operating Cost Summaries.....6-6
6.5 Cost Summary for the Caliente Route.....6-9

7. ENVIRONMENTAL AND ARCHAEOLOGICAL ASPECTS.....7-1

7.1 Refinement of Land Use and Environmental Restrictions.....7-1
7.2 Archaeological Screening.....7-5

APPENDICES OR SEPARATE VOLUMES

A. Engineering Drawings

B. Operating Cost Estimate Details
C. DOE Orders
D. Design Criteria
E. Access Road Report

F. Environmental Report

G. Geotechnical Report

H. Hydrology Report

LIST OF FIGURES

Figure No.	Title	Page No.
1-1	Potential Rail Alternative and Nevada State Rail Network	1-2
2-1	Caliente Alternative: Study Area	2-2
2-2	Study Area and Initial Route Segments-Quad I	2-5
2-3	Study Area and Initial Route Segments-Quad II	2-6
2-4	Study Area and Initial Route Segments-Quad III	2-7
2-5	Study Area and Initial Route Segments-Quad IV	2-8
2-6	Study Area and Initial Route Segments-Quad V	2-9
2-7	Study Area and Initial Route Segments-Quad VI	2-10
2-8	Environmental Constraints-Quad I	2-11
2-9	Environmental Constraints-Quad II	2-12
2-10	Environmental Constraints-Quad III	2-13
2-11	Environmental Constraints-Quad IV	2-14
2-12	Environmental Constraints-Quad V	2-15
2-13	Environmental Constraints-Quad VI	2-16
2-14	Selected Route Option for Conceptional Design-Quad II	2-17
2-15	Selected Route Option for Conceptional Design-Quad III	2-18
2-16	Selected Route Option for Conceptional Design-Quad IV	2-19
2-17	Selected Route Option for Conceptional Design-Quad V	2-20
2-18	Selected Route Option for Conceptional Design-Quad VI	2-21
4-1	Train Configuration	4-18

LIST OF FIGURES (Continued)

Figure No.	Title	Page No.
4-2	Travel Time Assumption Scenario #1	4-20
4-3	Travel Time Assumption Scenario #2	4-23

LIST OF TABLES

Table No.	Title	Page No.
2-1	Land Use Environmental, Biological, and Geotechnical Restriction	2-4
2-2	Comparison of Route F and Route G Alternatives	2-29
3-1	Yucca Mountain Rail Access Development Railroad Facilities	3-37
3-1	Grade Separations	3-22
3-2	Stream Crossings	3-23
5-1	Cost Estimate Railroad Items: Route A Option	5-9
5-2	Cost Estimate Railroad Items: Base Route	5-10
5-3	Grade Separations	5-11
5-4	Stream Crossings	5-12
5-5	Dark Territory With Local Hazard Detection Route A Option	5-14
5-6	Dark Territory With Local Hazard Detection Base Route	5-15
5-7	Automatic Block Signal System Route A Option	5-16
5-8	Automatic Block Signal System Base Route	5-17
5-9	Advanced Train Control System Route A Option	5-18
5-10	Advanced Train Control System Base Route	5-19
5-11	Dark Territory with Local Hazard Detection Route A Option	5-20

LIST OF TABLES (continued)

Table No.	Title	Page No.
5-12	Dark Territory With Local Hazard Detection Base Route	5-21
5-13	Automatic Block Signal System Route A Option	5-22
5-14	Automatic Block Signal System Base Route	5-23
5-15	Advanced Train Control System Route A Option	5-24
5-16	Advanced Train Control System Base Route	5-25
5-17	Cost Estimate Access Road	5-26
5-18	Cost Estimate Summary Railroad and Access Road Route A Option	5-27
5-19	Cost Estimate Summary Railroad and Access Road Base Route	5-28
5-20	Cost Estimate Comparison	5-29
5-21	Locomotives and Cars	5-30
5-22	Maintenance Equipment	5-31
5-23	Facilities	5-32
5-24	Emergency Equipment	5-33
5-25	Summary of Capital Cost	5-34
5-26	Composite Summary of Capital Costs	5-35
6-1	Personnel Annual Cost	6-7
6-2	Summary of Annual O&M costs	6-10
6-3	Cash Flow for Variable Capital O&M Cost	6-11
6-4	Caliente Base Route Net Present Value and Annualized Cost	6-14
7-1	Summary of Cultural Sites within the Caliente Alternative	7-7
7-2	NRHP Status of Previously Recorded Sites on the Caliente Alternative	7-8

1. INTRODUCTION

1.1 PROJECT DESCRIPTION AND PURPOSE

1.1.1 Context of the Study

In accordance with the Nuclear Waste Policy Amendments Act of 1987, Yucca Mountain was designated as the site to be investigated as a potential repository for the disposal of high-level radioactive waste. The Yucca Mountain site is an undeveloped area located on the southwestern edge of the Nevada Test Site (NTS), about 100 miles northwest of Las Vegas. The site currently lacks rail service or an existing right-of-way. If the Yucca Mountain site is found suitable for the repository, rail service is desirable to the Office of Civilian Waste Management (OCRWM) Program because of the potential of rail transportation to reduce costs and to reduce the number of shipments relative to highway transportation.

A Preliminary Rail Access Study[1] evaluated 13 potential rail spur options. Alternative routes within the major options were also developed. Each of these options was then evaluated for potential land use conflicts and access to regional rail carriers. Three potential routes having few land use conflicts and having access to regional carriers were recommended for further investigation. Figure 1-1 shows these three routes. The Jean route is estimated to be about 120 miles long, the Carlin route to be about 365 miles long, and Caliente route to be about 365 miles long.

The remaining ten routes continue to be monitored and should any of the present conflicts change, a re-evaluation of that route will be made. Complete details of the evaluation of the 13 routes can be found in the previous study[1]. The DOE has not identified any preferred route and recognizes that the transportation issues need a full and open treatment under the National Environmental Policy Act. The issue of transportation will be included in public hearings to support development of the Environmental Impact Statement (EIS) proceedings for either the Monitored Retrievable Storage Facility or the Yucca Mountain Project or both.

1.1.2 Purpose of This Study

In December 1989, a contract was placed with De Leuw, Cather & Co. of San Francisco, to develop the conceptual designs of the three rail spur routes identified for further study. In

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[1]DOE/YMP-89-16, "Preliminary Rail Access Study", January 1990.

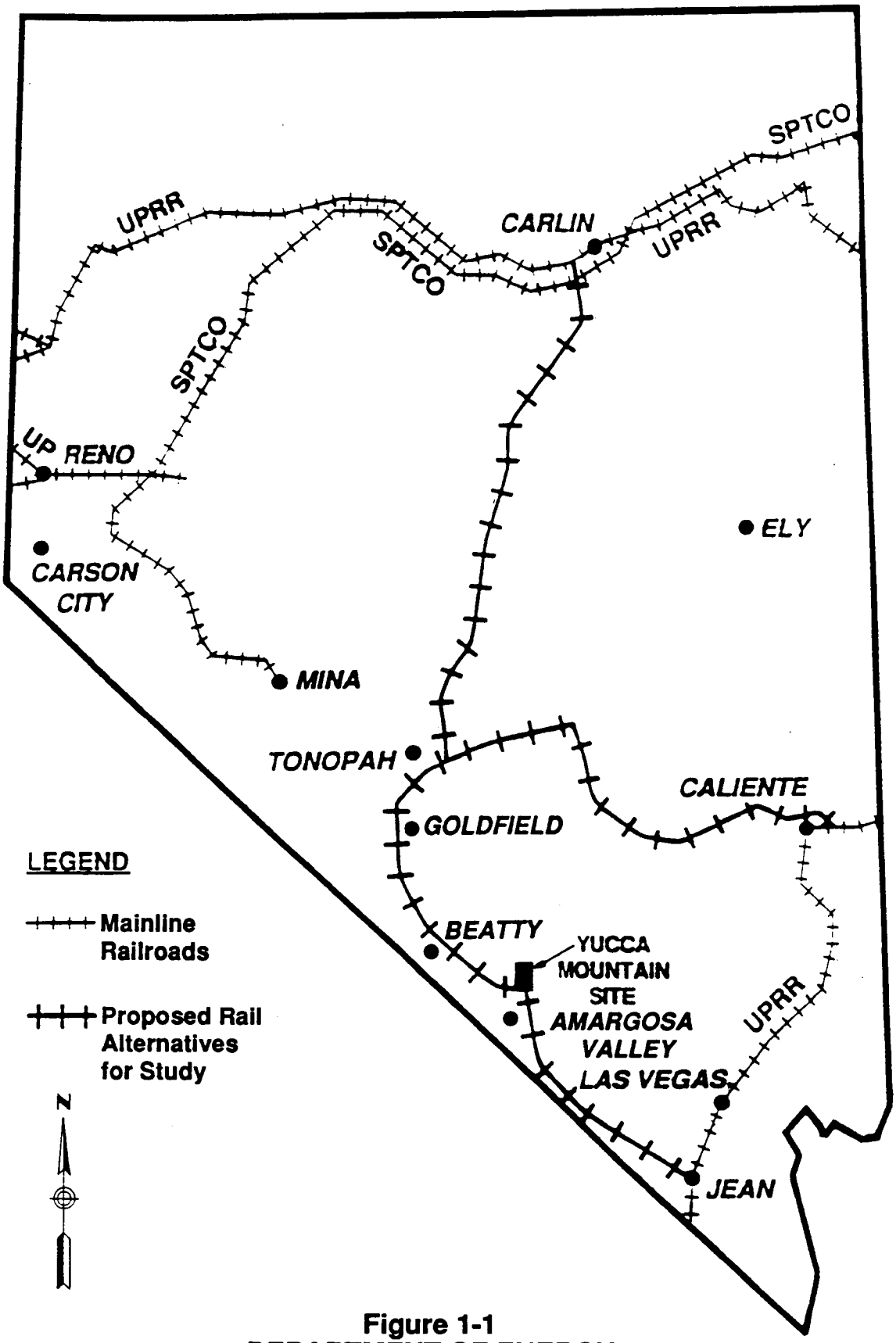

Figure 1-1
DEPARTMENT OF ENERGY
PROPOSED RAIL ATERNATIVES
FOR FURTHER STUDY

addition, the contract also included the development of the conceptual design of a roadway from the existing main road (U.S. Route 95) into the potential repository site.

The first task of the DOE rail spur study was to determine which of the three potential rail routes would be studied first. It was decided by the DOE to initiate the rail spur study of the Caliente route first based upon the desire of the community leaders in the City of Caliente and Lincoln County. This study addresses the conceptual design of the first of the rail spur routes, the Caliente route.

1.1.3 Community Involvement

The rail spur study project has included the extensive involvement of Nevadans in the feasibility evaluations of the potential rail spur routes. Prior to initiating evaluation of the Caliente route, meetings were conducted with local officials along the potential route to get their initial input to the route selection process. By soliciting routing comments through a variety of interactions, the DOE hopes that potential routes can be identified which best meet the needs of DOE and Nevadans. Recommendations made by Lincoln County and the City of Caliente were made pursuant to Section 5032 of the Nuclear Waste Policy Amendments Act of 1987. Recommendations made by local communities were and will continue to be included in route selection activities.

1.2 SCOPE OF WORK

The principal scope of work for this study is to develop the conceptual design, provide a preliminary environmental analysis, and prepare a cost estimate for the Caliente route. The work was conducted in two tasks. Task 1 was the development of general design criteria and a detailed work plan[2].

Task 2 is the primary subject of this conceptual design report. It includes the development of conceptual design, environmental information, and a cost estimate for the Caliente route to Yucca Mountain. This task included an environmental screening to aid in route siting. Aimed at minimizing potential environmental impacts, the environmental screening was limited to an assembly of information from secondary sources. Screening of other

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[2]Project Management Plan and Design Criteria Report (the latter included as Appendix D), prepared for SAIC by De Leuw, Cather & Co., May 19, 1990.

factors was limited to minimizing the impact of the route on private lands and developed areas, based on comments from the local communities.

Task 2 also addressed the conceptual design of an access highway from U.S. 95 to the potential Yucca Mountain site, a distance of about 16 miles. This highway was designed for automobile and truck access.

1.3 STUDY AREA

As part of the earlier Preliminary Rail Access Study, a route was selected from the Caliente area to avoid land use impacts encountered in the more populated areas of Nevada. The route began in the vicinity of Caliente on the Union Pacific mainline and generally followed U.S. 93, Nevada Route 375, and U.S. 6 westerly across central Nevada to the north of the Nevada Test Site and the Nellis Air Force Range (Figure 1-1). In the vicinity of Tonopah, the route turned southerly past Goldfield and Beatty to skirt the western edge of the Air Force Range, roughly paralleling U.S. 95 to the potential site at Yucca Mountain. Although remote, some of the terrain traversed by this potential route is very rugged.

In the previous study, the feasibility of this route was investigated with large scale U.S. Geological Survey (USGS) mapping (1:250,000 scale). As discussed in more detail in Chapter 2, the general area of this route was expanded for the current study to allow a more comprehensive and exhaustive analysis of the possible rail spur routes from the Union Pacific Railroad in eastern Nevada.

1.4 ORGANIZATION OF STUDY

To provide these services in a timely, cost-effective manner, the various tasks were divided among a set of subconsultants. The firms that assisted De Leuw on this project and their responsibilities are described below.

- Kennedy/Jenks/Chilton. K/J/C's areas of responsibility were surface hydrology, survey and mapping, property investigation, utility and roadway crossings, and miscellaneous civil work including the conceptual design of the access roadway.

- Dames & Moore. Dames & Moore was responsible for the project ecology, geology, subsurface hydrology, waste management, and energy.

- Archaeological Research Services, Inc. Project cultural and archaeological studies were conducted by ARS.

- Nick Pritza, Consultant. Mr. Pritza served as the leading rail operations consultant.

- Transportation Logistics Co. . The activities of Transportation Logistics Co. consisted of railroad operations cost identification and analysis.

1.5 ORGANIZATION OF THIS REPORT

The next chapter of this report discusses the expanded study area, alignment alternatives that were identified and screened, and the screening process. Chapter 2 concludes with a discussion of how specific alignments were selected, refined, revised or deleted. Chapter 3 presents the bulk of the study, the engineering conceptual design. This includes the basis for design, discussion of alternative alignments studied, and summaries of the various engineering studies conducted, including geotechnical, drainage, structural, and signals and communications.

Chapter 4 describes rail operations, beginning with a background on rail operations. It considers the operational requirements of the Caliente route, investigates possible ownership and operating scenarios, and discusses advantages and disadvantages of operation types.

Chapters 5 and 6 discuss the estimated capital and operating costs respectively. The main text of the report concludes with a brief discussion in Chapter 7 of the investigation of the environmental constraints of the selected alignments.

The appendices include supporting material and background reports. Appendix A consists of the reduced engineering drawings (1 inch = 500 feet) of the route, including plan and profile sheets, detail drawings, and structural drawings. Appendix B includes operating cost estimate details. A summary of applicable DOE orders and the design criteria comprise Appendices C and D, respectively. The access road report is included as Appendix E. The remaining appendices (F, G, and H) include the environmental reports, the geotechnical report, and the hydrology report. The appendices are bound as separate volumes.

2. ALIGNMENT ALTERNATIVE

2.1 STUDY AREA DEFINITION

To minimize the potential of overlooking feasible routes in the Caliente corridor, the planning team established a broad study area to evaluate for all potential routes. The study area was selected to include all available areas that might be useful for developing alignments. It was bounded by areas of land use conflicts and engineering constraints caused by the mountainous terrain.

In the vicinity of Caliente the study area was bounded by the Utah state line and the Union Pacific railroad on the east, Las Vegas on the south, and the Desert National Wildlife Range and the Nellis Air Force Range on the west. The Nellis Air Force Range was a major land use conflict for possible routes in southwestern Nevada because of its large area, proximity to Yucca Mountain, and incompatible activities (Figure 2-1). The range is used for Air Force training operations which include bombing practice and low overflights.

To the north of the Nellis Air Force Range, the study area boundary was the Air Force Range to the south and the several mountain ranges to the north. For the entire study area, the northern boundary was drawn at the point where the passes in the mountain ranges cannot be traversed east to west because of grade limitations of 2.5%.

To the west of the Air Force Range, the study area boundaries were the range to the east and the California border and several mountain ranges to the west. In addition, some of the mountain ranges within these boundaries were not considered in the study areas because of their rugged terrain. The study area is shown schematically by the dashed boundary line in Figure 2-1. Figure 2-1 also shows the key to the expanded scale graphics discussed in the next section.

2.2 ROUTE SEGMENT DEFINITION AND IDENTIFICATION

As the next step in developing and screening potential routes in the corridor, a total of 89 potential route segments were identified within the study area based on railroad engineering requirements of not exceeding a 2.5% grade and an 8.0 degree maximum curvature (minimum curve radius of approximately 720 feet). These segments utilized all reasonable route possibilities that could be identified on the 1:250,000-scale USGS maps. The general procedure was to:

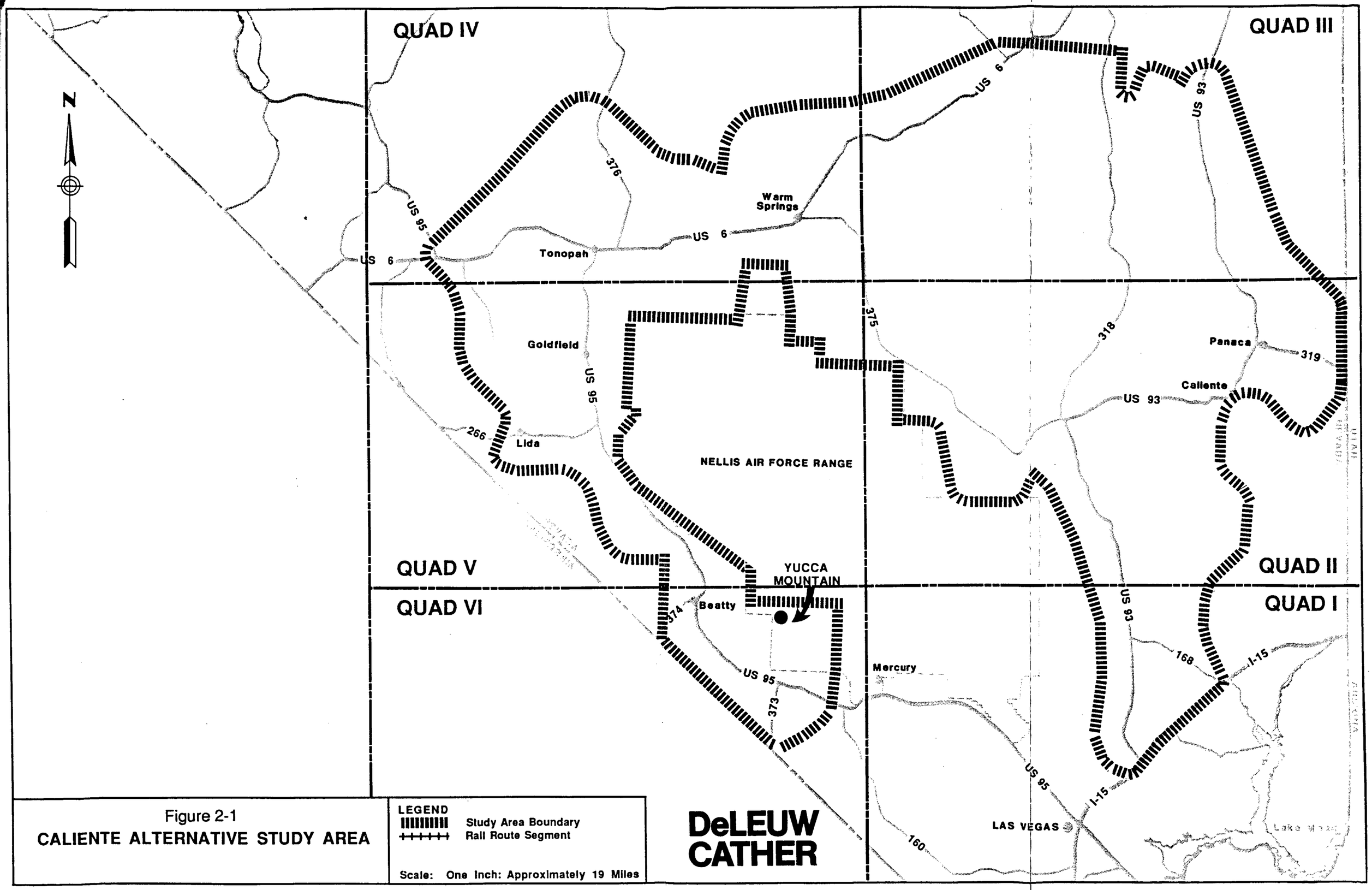


Figure 2-1
CALIENTE ALTERNATIVE STUDY AREA

LEGEND
Study Area Boundary
Rail Route Segment

Scale: One Inch: Approximately 19 Miles

DeLEUW CATHER

- First, identify potentially usable segments traversing the study area that did not encounter significant engineering barriers such as mountain ranges.

- Second, identify the mountain passes that might allow the development of additional segments. Starting at the top of the pass, if a segment could be drawn off in both directions with a 2.5% or lower grade, the segment was considered usable and was linked in with the other route segments.

- National forest lands were avoided during this process because national forests typically occupied areas too steep for railroad construction, the information was available on the USGS maps, and railroad right of way would likely be a controversial use of the national forest lands. This conflict was classified as a "significant restriction" in the analysis of land use constraints (Table 2-1). No other environmental constraints were considered in this step to permit as full an engineering investigation as possible.

The result was a matrix of potential rail route segments that was called the "spider web". These segments are illustrated by Figures 2-2 through 2-7. As compared with Figure 2-1, these figures give an expanded view of the study area based on 1:250,000-scale USGS maps. The locations of the six USGS quadrangles are identified on Figure 2-1. The quadrangles are numbered I through VI counterclockwise through the study area.

Engineering statistics for each of the 89 segments were then complied, consisting of length, rise/fall, and bridges required (stream crossings). Segments were then linked together into possible routes. Over a dozen potential routes were identified utilizing various combinations of these route segments. Because of the complexity of the route possibilities and the preliminary nature of the engineering data available on them, the route segments were screened for potential land use and environmental constraints to guide further route development.

2.3 ROUTE SEGMENT ENVIRONMENTAL SCREENING

In a step parallel to the development of engineering data for the 89 route segments, environmental and land use restrictions for each segment were identified and compiled (Figures 2-8 through 2-18). The prime concerns in this portion of the study were the constraints imposed by large designated resource management areas. These areas include Wilderness Study Areas (WSA's), Areas of Critical Environmental Concern (ACEC's), Visual Resource Management (VRM) areas, park lands, national forests, wildlife refuges, Indian reservations, military facilities, and other protective withdrawals. Sensitive biological habitats were also

TABLE 2-1

LAND USE, ENVIRONMENTAL, BIOLOGICAL, AND GEOTECHNICAL RESTRICTIONS

LEVEL 1: NO RESTRICTIONS
(Not depicted on Figures 2-8 through 2-13)

- Unspecified Bureau of Land Management Lands
- Class IV Visual Resources Management (VRM) Areas
- Wildlife and vegetation species with no specific restrictions
- Geotechnical features

LEVEL 2: MILD RESTRICTIONS
(Areas shown in blue on Figures 2-8 through 2-13)

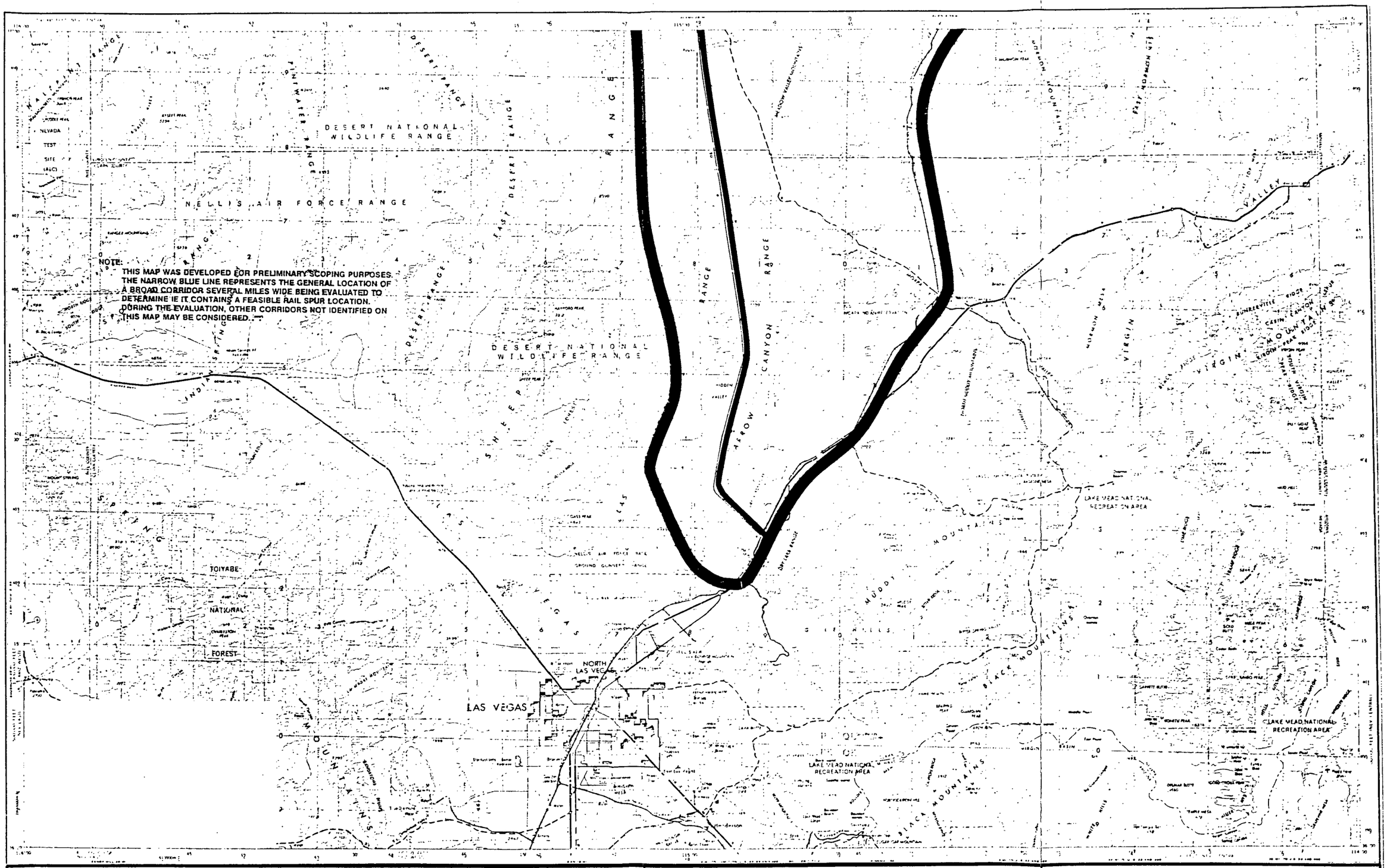
- Class III Visual Resource Management (VRM) Areas
- Patented (privately owned) lands
- Wild horse and burro ranges
- Bighorn Sheep, Mule Deer, and Elk Management Areas
- State protected and candidate species for Federal protection, including Bighorn Sheep, Canadian Elk, and Gila Monster

LEVEL 3: SIGNIFICANT RESTRICTIONS
(Areas shown in yellow on Figures 2-8 through 2-13)

- Class II Visual Resource Management (VRM) Areas
- National Forests
- Indian Reservations
- Reservoirs and water reserves
- State and county lands
- Species protected under the Endangered Species Act of 1973 can only be disturbed under Section 7 of the Act). Includes Pahranagat Valley Vole, Amargosa Toad.

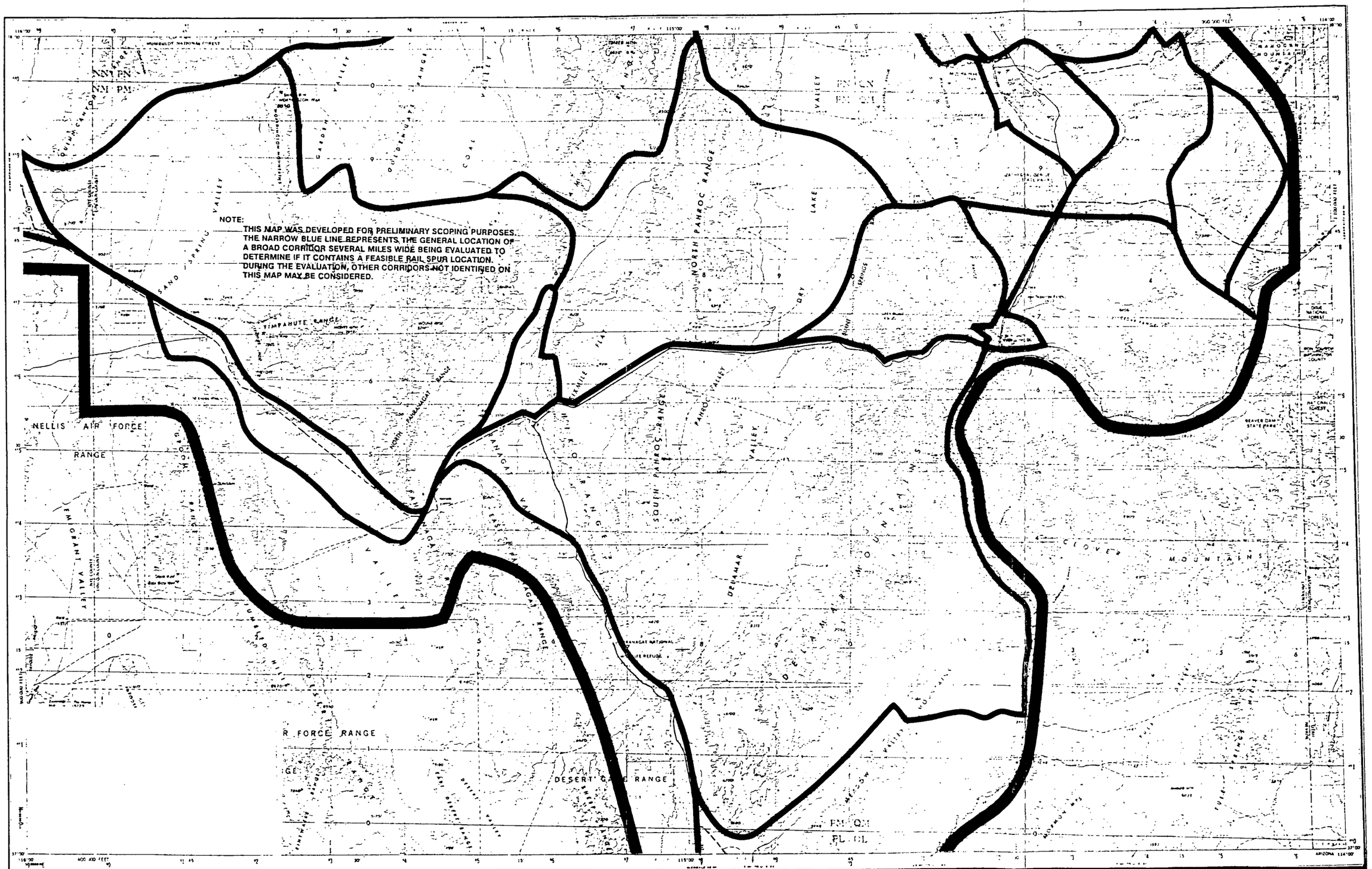
LEVEL 4: SEVERE RESTRICTIONS/INCOMPATIBLE USE
(Areas shown in red on Figures 2-8 through 2-13)

- Wilderness Study Areas
- Class I Visual Resource Management (VRM) Areas
- Areas of Critical Environmental Concern (ACEC's)
- Parkland/Wildlife Refuges/Monuments
- Bureau of Land Management Protective Withdrawal Lands
- Species publicly recognized as endangered, including Desert Tortoise, Bald Eagle, and Peregrine Falcon.
- Military facilities and reservations



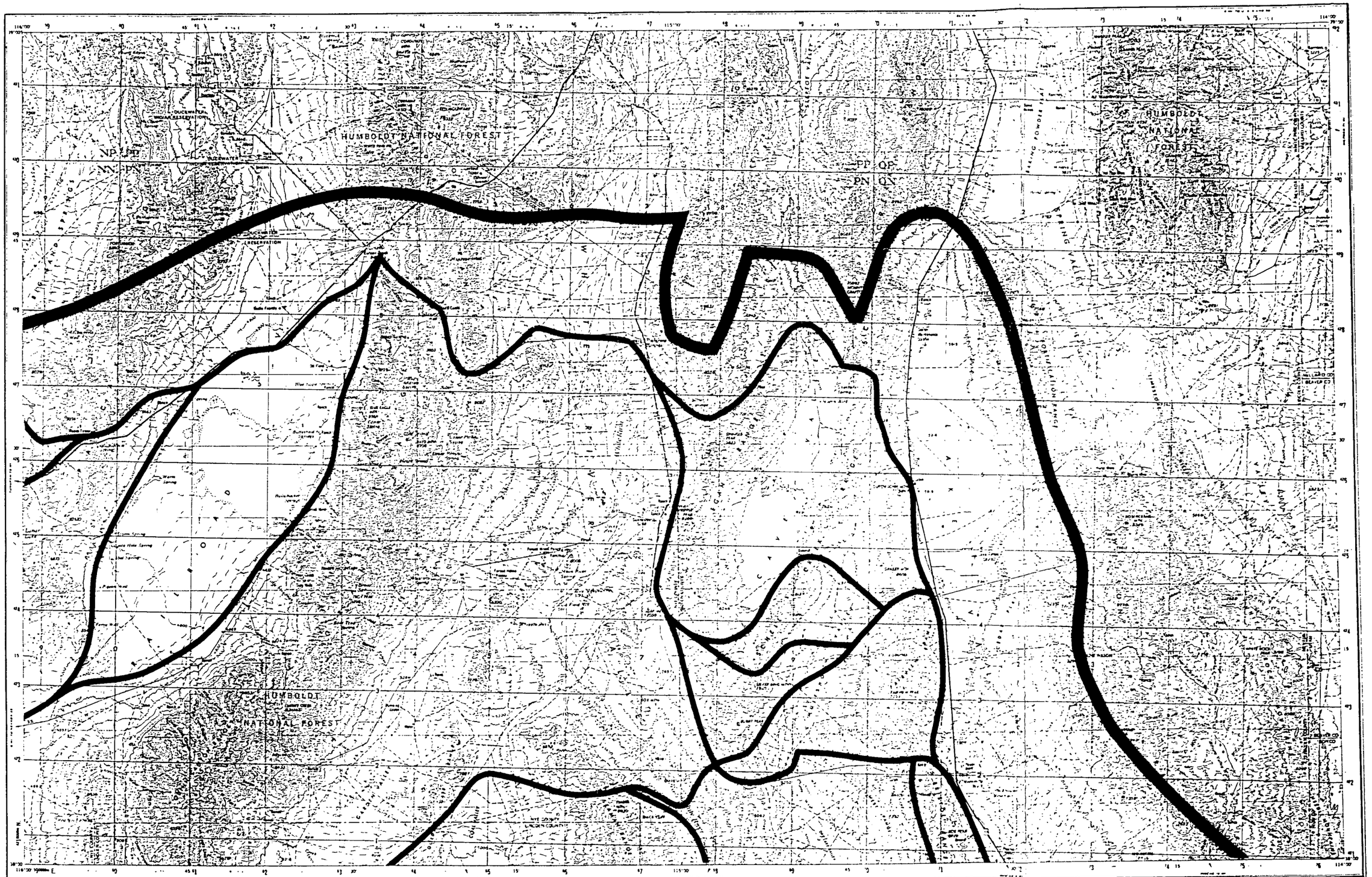
STUDY AREA
AND INITIAL ROUTE SEGMENTS

Figure 2-2
Rail Access Development
YUCCA MOUNTAIN PROJECT
QUAD I



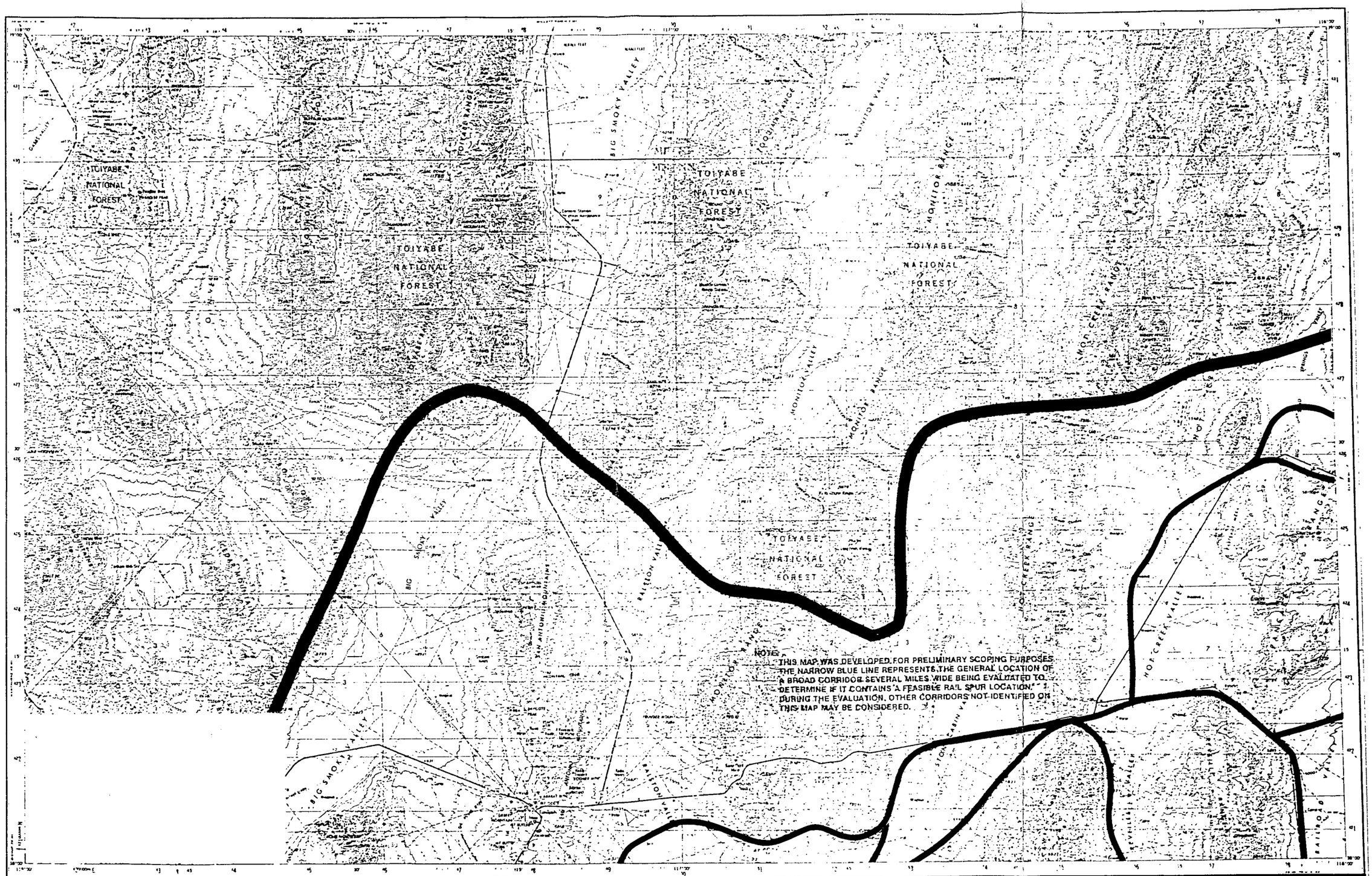
STUDY AREA
AND INITIAL ROUTE SEGMENTS

Figure 2-3
Rail Access Development
YUCCA MOUNTAIN PROJECT
QUAD II



STUDY AREA
AND INITIAL ROUTE SEGMENTS

Figure 2-4
Rail Access Development
YUCCA MOUNTAIN PROJECT
QUAD III



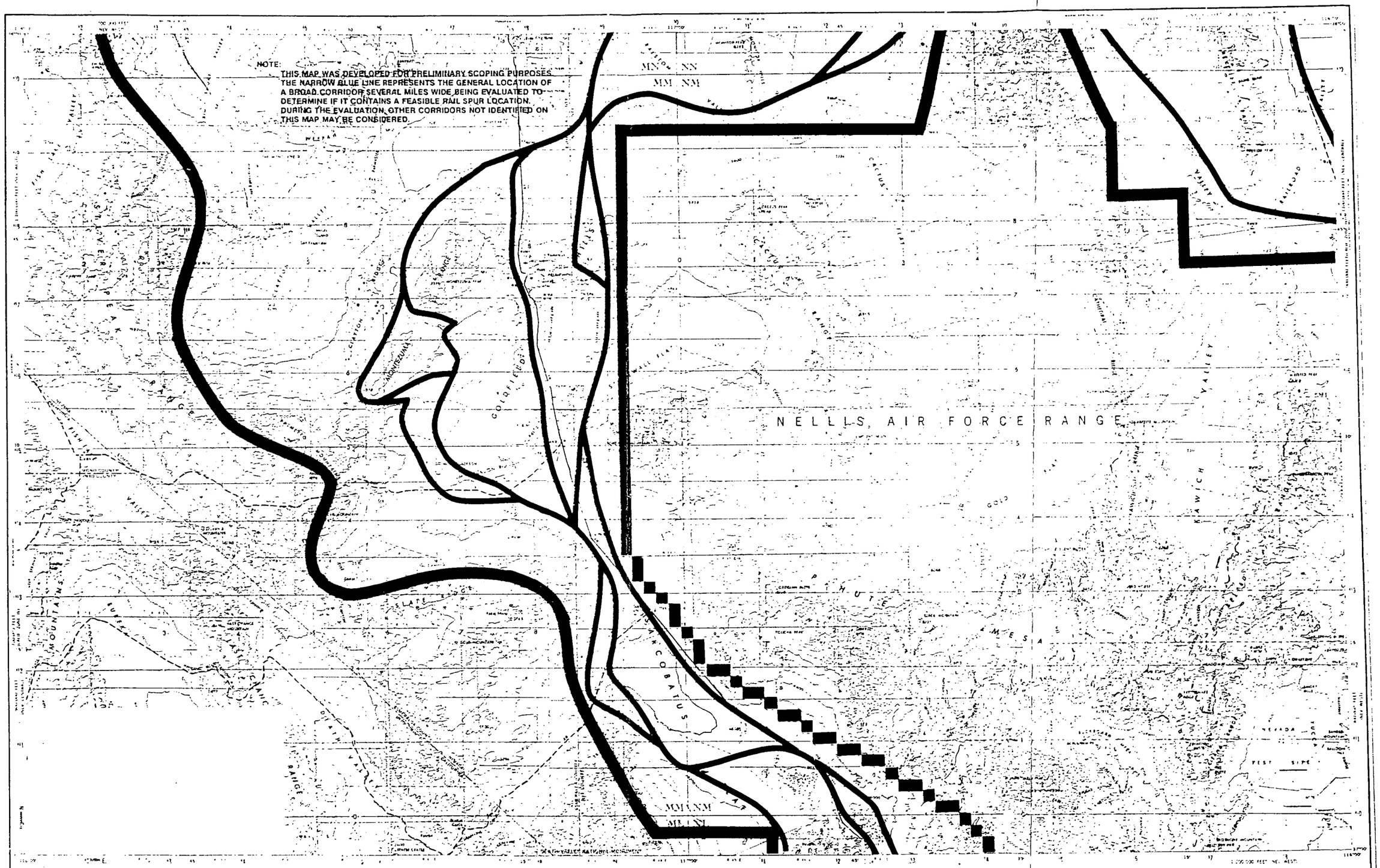
STUDY AREA AND INITIAL ROUTE SEGMENTS

Figure 2-5

Rail Access Development

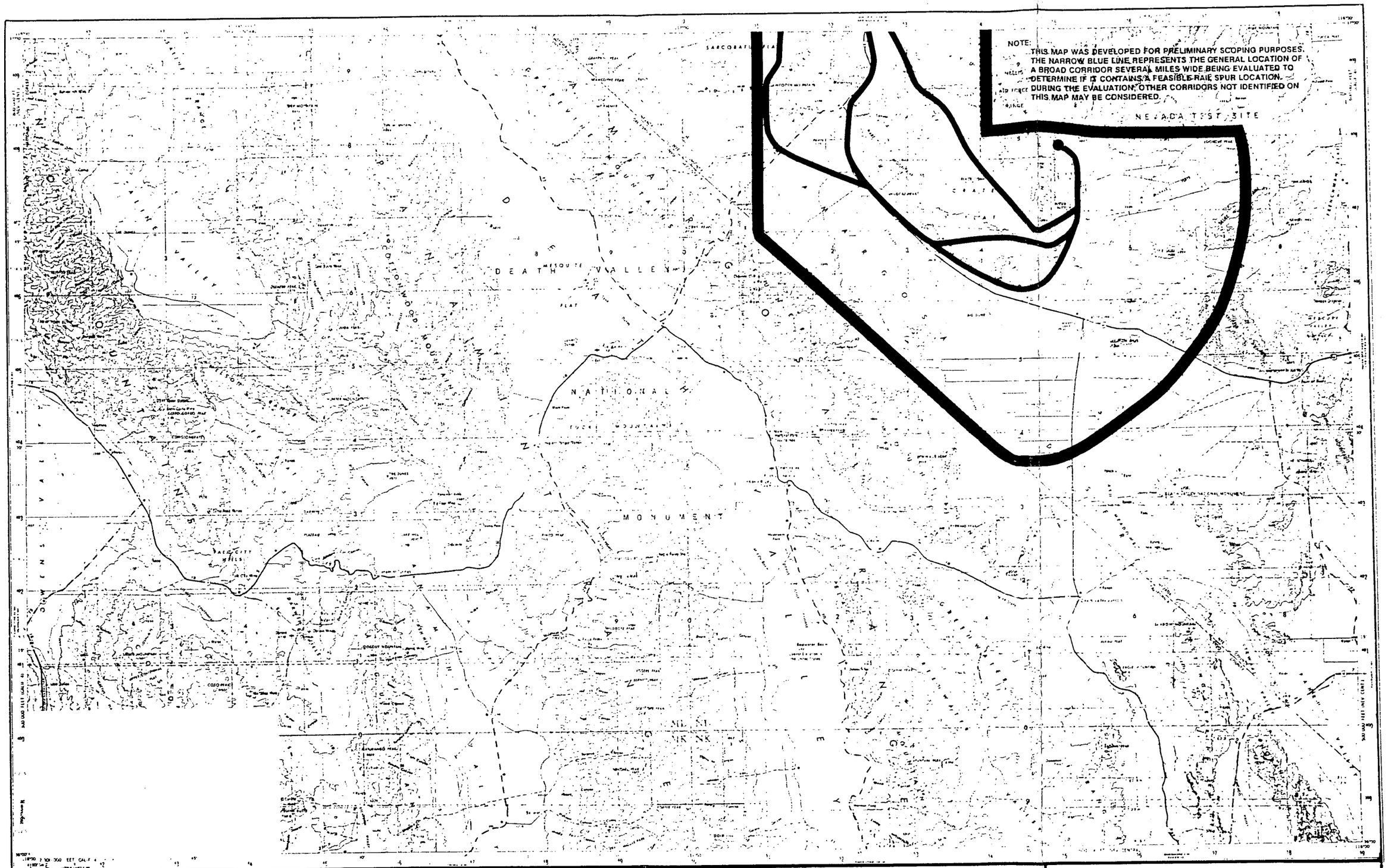
YUCCA MOUNTAIN PROJECT

QUAD IV



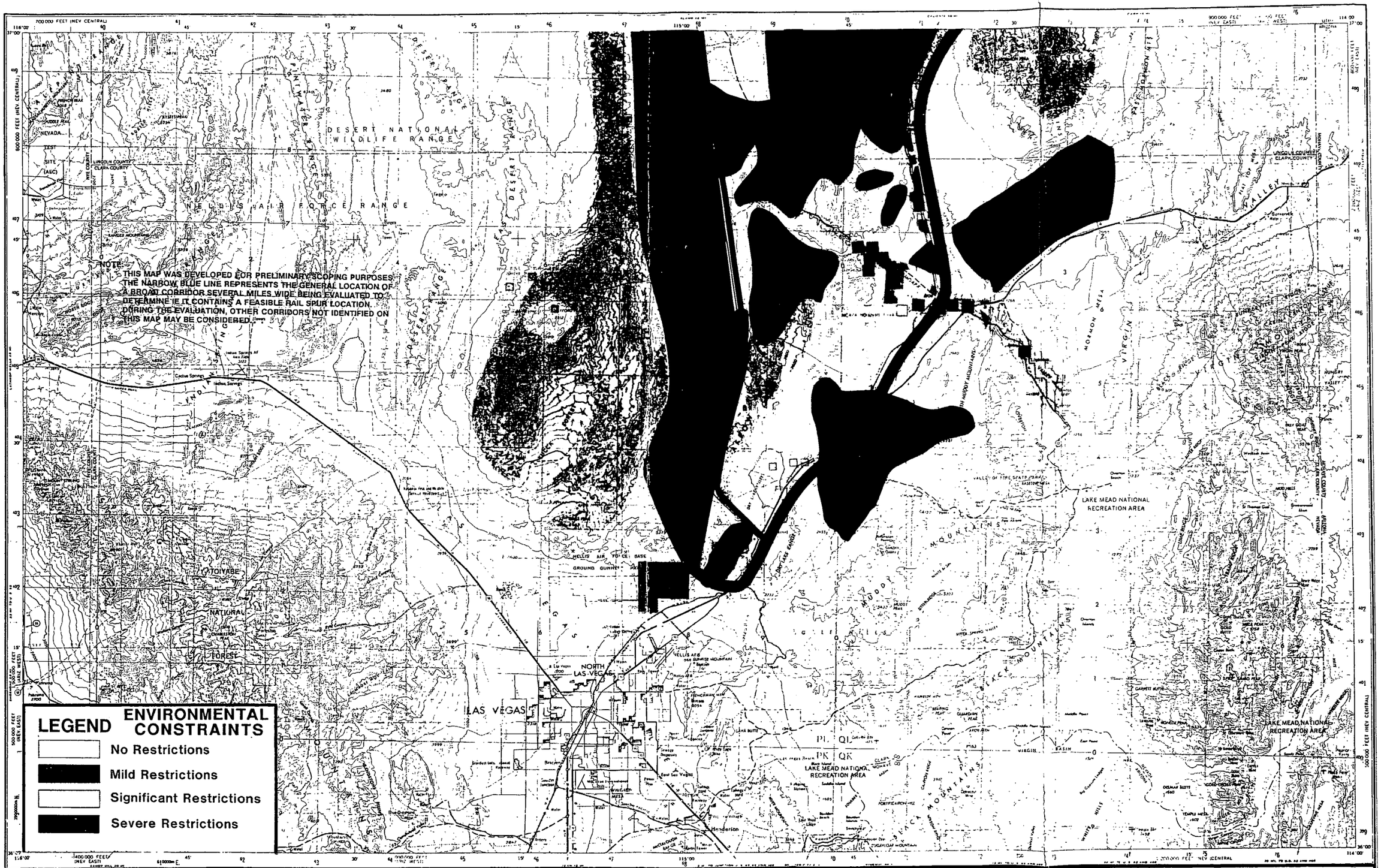
STUDY AREA
AND INITIAL ROUTE SEGMENTS

Figure 2-6
Rail Access Development
YUCCA MOUNTAIN PROJECT
QUAD V



STUDY AREA
AND INITIAL ROUTE SEGMENTS

Figure 2-7
Rail Access Development
YUCCA MOUNTAIN PROJECT
QUAD VI

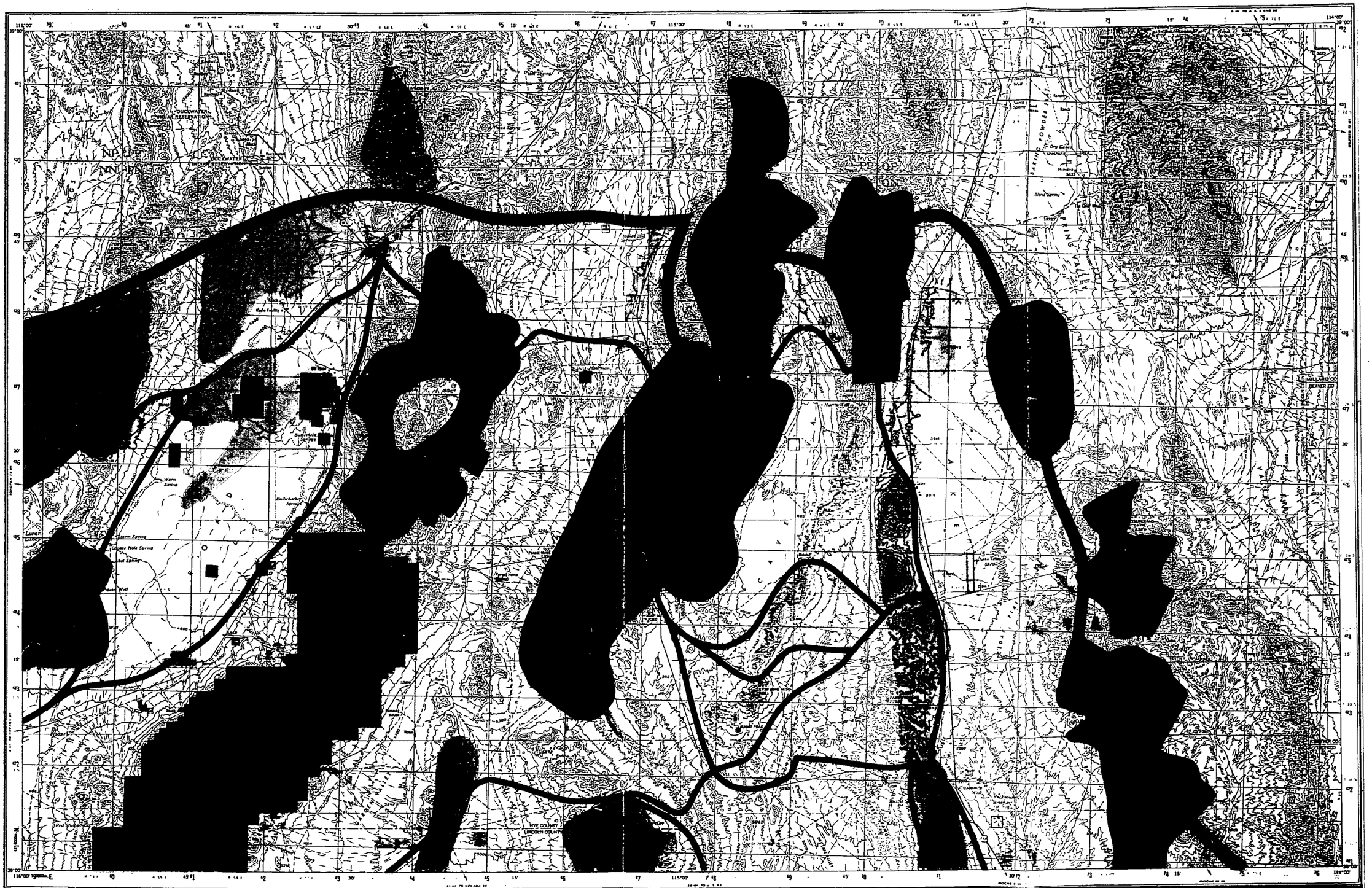


ENVIRONMENTAL CONSTRAINTS

Figure 2-8
Rail Access Development
YUCCA MOUNTAIN PROJECT
QUAD I

ENVIRONMENTAL CONSTRAINTS

Figure 2-9
Rail Access Development
YUCCA MOUNTAIN PROJECT
QUAD II

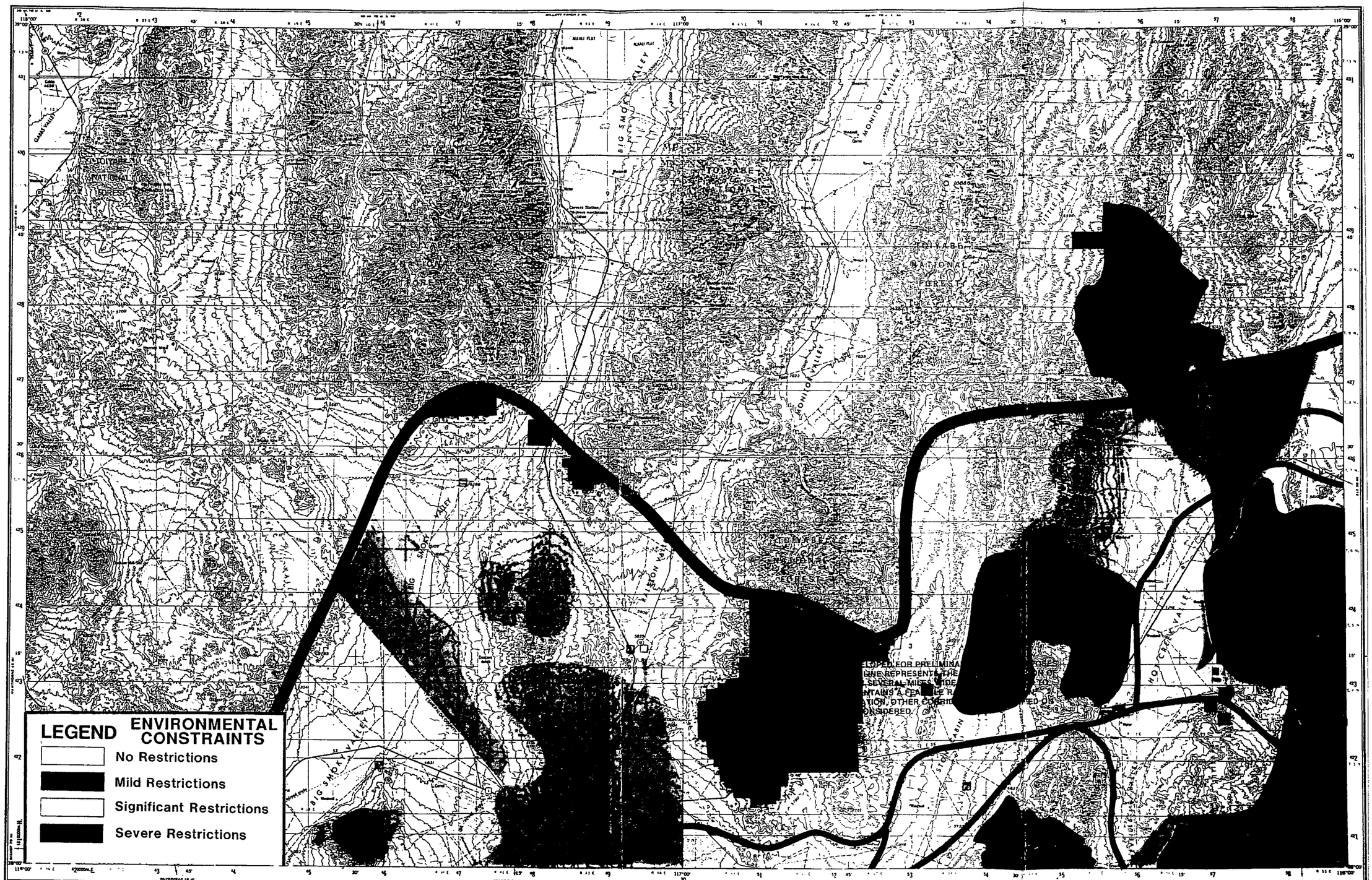


LEGEND **ENVIRONMENTAL CONSTRAINTS**

- No Restrictions
- Mild Restrictions
- Significant Restrictions
- Severe Restrictions

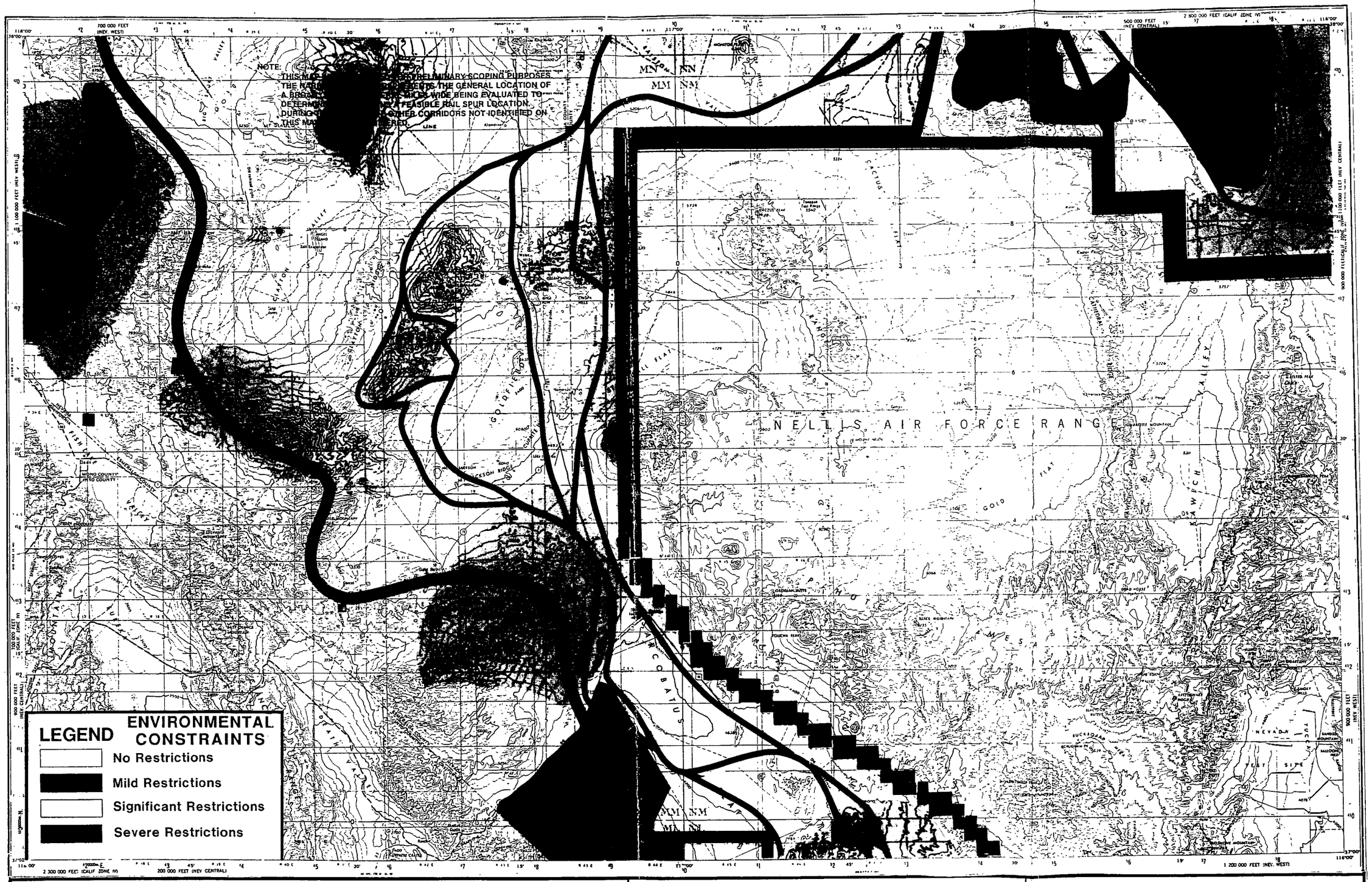
ENVIRONMENTAL CONSTRAINTS

Figure 2-10
Rail Access Development
YUCCA MOUNTAIN PROJECT
QUAD III



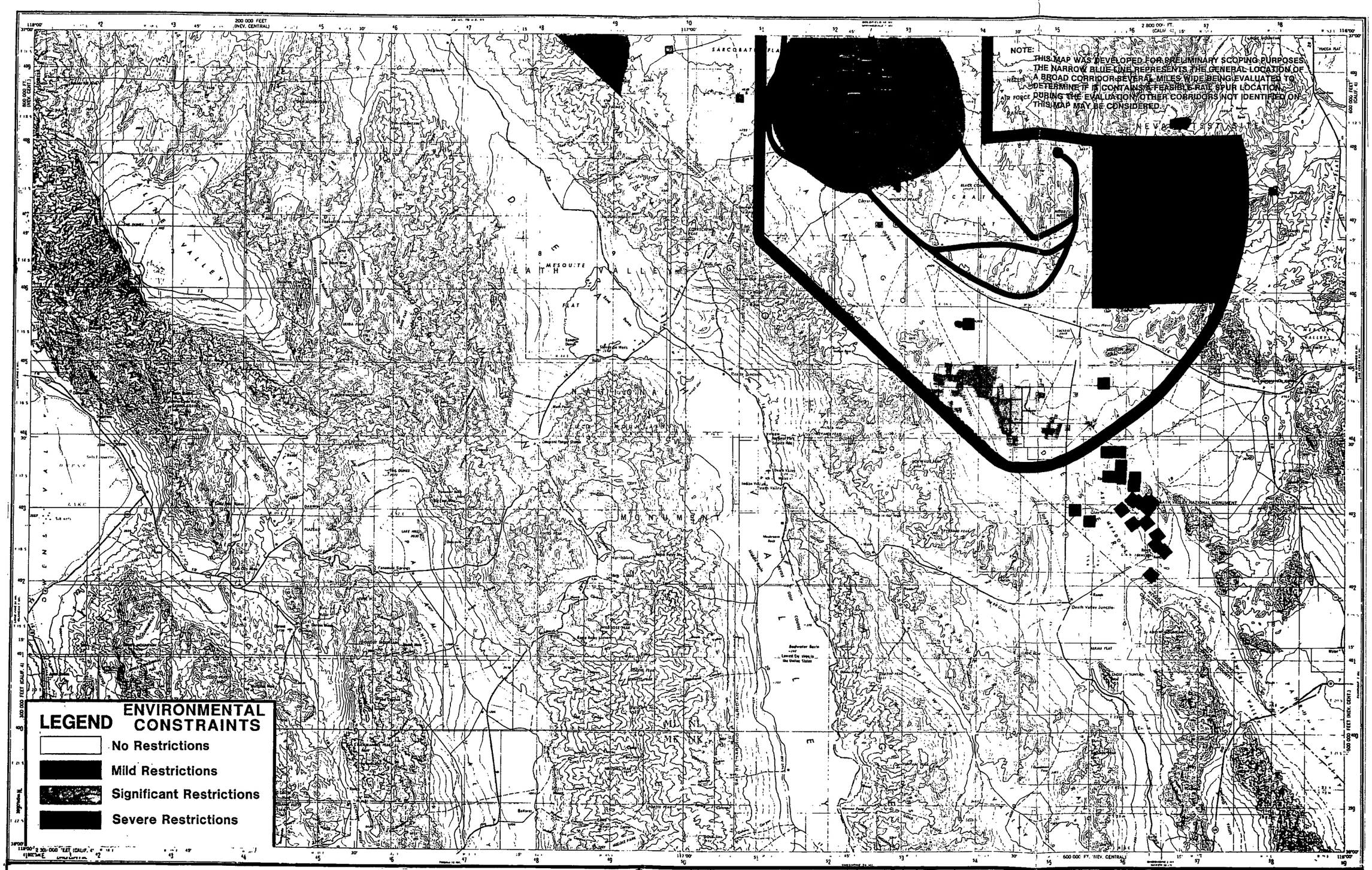
ENVIRONMENTAL CONSTRAINTS

Figure 2-11
Rail Access Development
YUCCA MOUNTAIN PROJECT
QUAD IV



ENVIRONMENTAL CONSTRAINTS

Figure 2-12
Rail Access Development
YUCCA MOUNTAIN PROJECT
QUAD V



ENVIRONMENTAL CONSTRAINTS

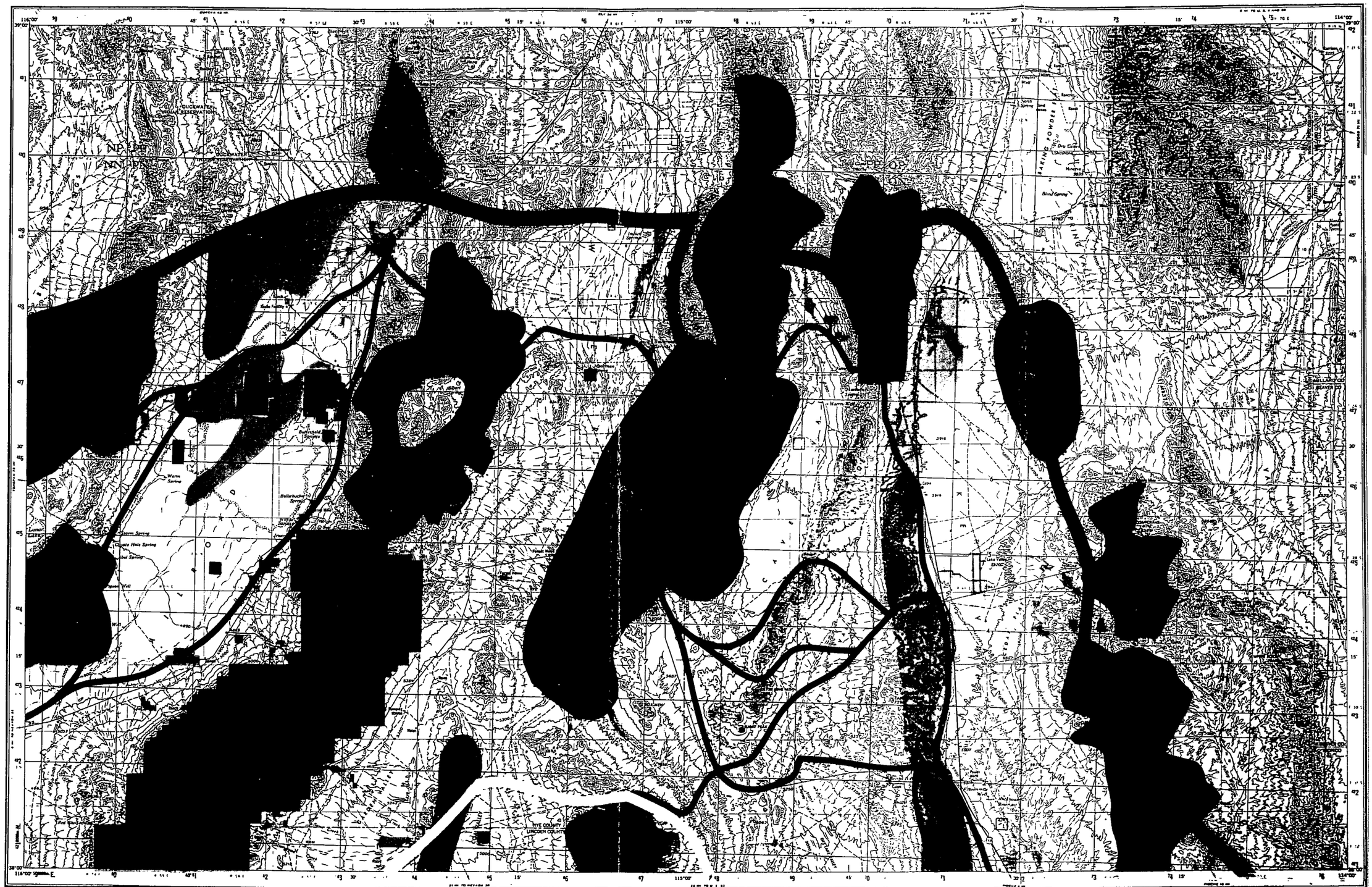
Figure 2-13
Rail Access Development
YUCCA MOUNTAIN PROJECT
QUAD VI

ROUTE OPTIONS

- Option A
- Option B
- Option B - Not Studied

SELECTED ROUTE OPTIONS FOR CONCEPTUAL DESIGN

Figure 2-14
Rail Access Development
YUCCA MOUNTAIN PROJECT
QUAD II



LEGEND

ENVIRONMENTAL CONSTRAINTS

- No Restrictions
- Mild Restrictions
- Significant Restrictions
- Severe Restrictions

ROUTE OPTIONS

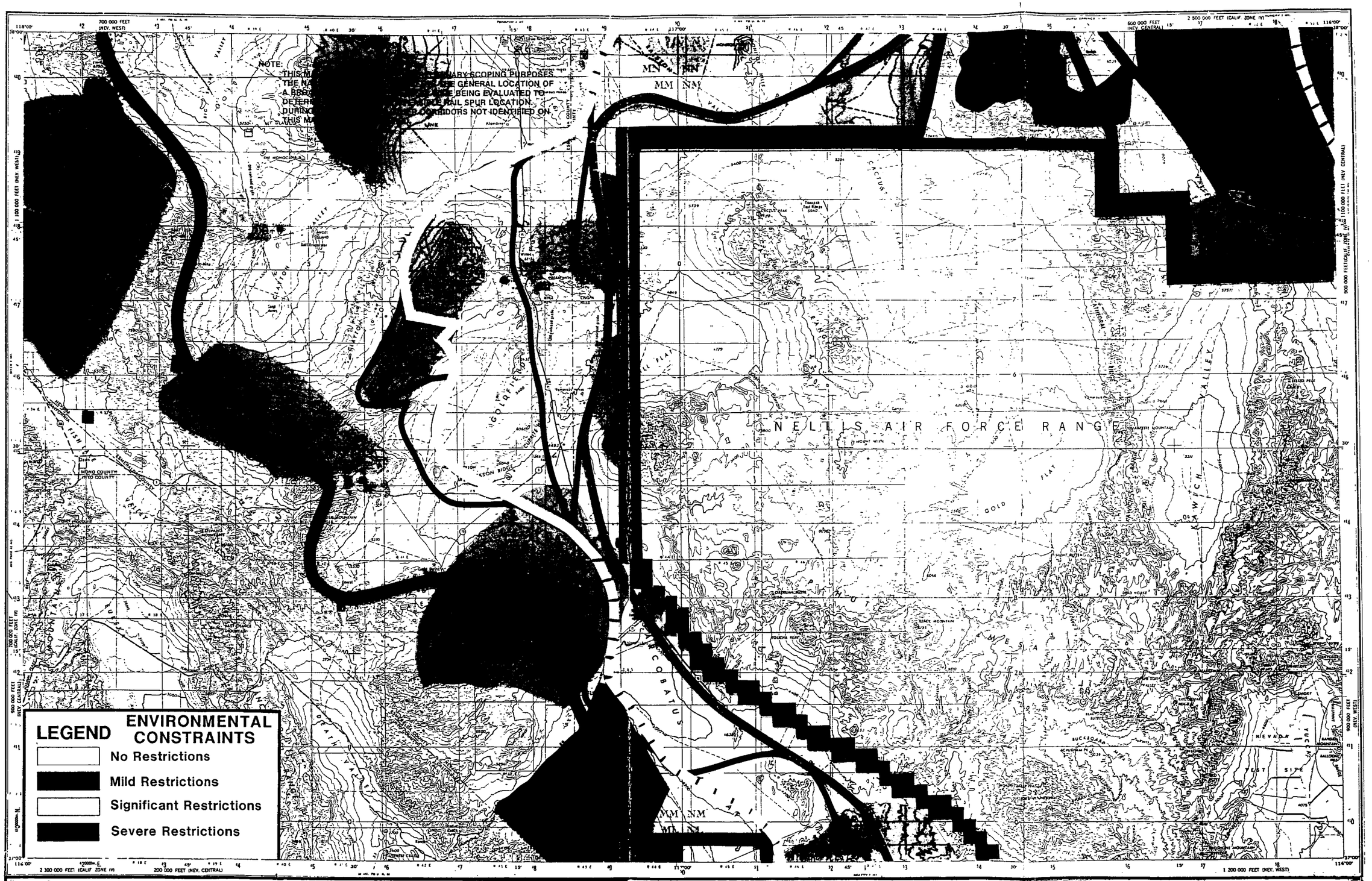
- Option A
- Option B
- Option B - Not Studied

SELECTED ROUTE OPTIONS FOR CONCEPTUAL DESIGN

Figure 2-15
Rail Access Development
YUCCA MOUNTAIN PROJECT
QUAD III

SELECTED ROUTE OPTIONS FOR CONCEPTUAL DESIGN

Figure 2-16
Rail Access Development
YUCCA MOUNTAIN PROJECT
QUAD IV

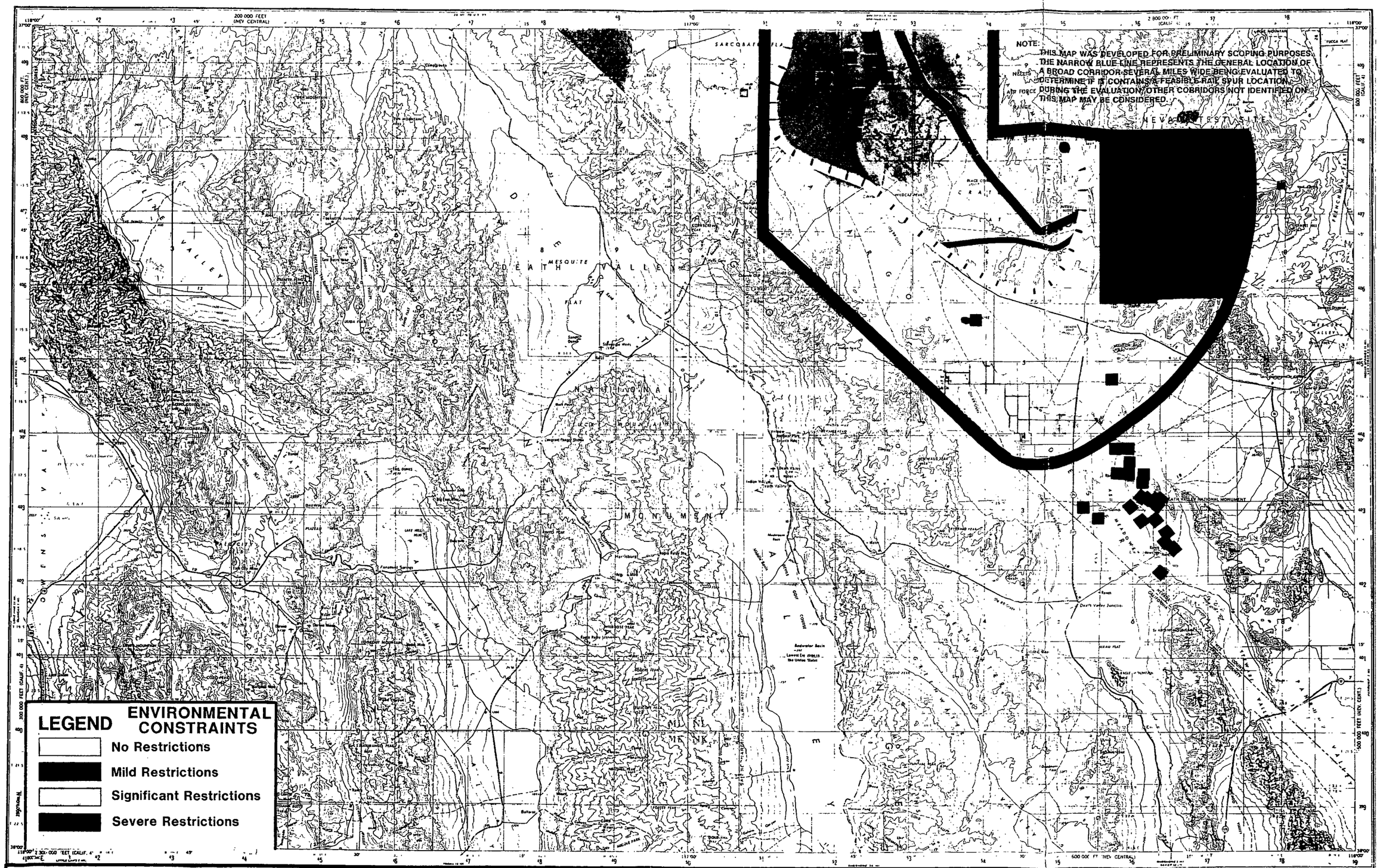


ROUTE OPTIONS

- Option A
- Option B
- Option B - Not Studied

SELECTED ROUTE OPTIONS FOR CONCEPTUAL DESIGN

Figure 2-17
Rail Access Development
YUCCA MOUNTAIN PROJECT
QUAD V



ROUTE OPTIONS

- Option A
- Option B
- Option B - Not Studied

SELECTED ROUTE OPTIONS FOR CONCEPTUAL DESIGN

Figure 2-18

Rail Access Development

YUCCA MOUNTAIN PROJECT

QUAD VI

identified, particularly Desert Tortoise habitat, and were of major concern.

These features were categorized into four levels of restriction (Table 2-1): Level 1: No restrictions, Level 2: Mild restrictions, Level 3: Significant restrictions, and Level 4: Severe restrictions. These restrictions were chosen to reflect the requirements set by various regulatory agencies, including the Bureau of Land Management (BLM), the National Forest Service, and the National Park Service. The primary consideration was the difficulty of securing right-of-way access, as follows:

- Level 1 consisted of areas with no known restrictions.
- Level 2 restrictions reflected conditions for which extra cost or mitigation might be necessary, as in the acquisition of private land or the crossing of a wild horse and burro management area, but railroad construction was likely to be feasible.
- Level 3 restrictions reflected a much higher level of restriction, such as railroad construction being allowed only if there were no other feasible alternative.
- Level 4 restrictions were used for land use, habitat, or cultural designations that either prohibit railroad construction or would potentially be controversial enough to result in such a restriction.

Habitat involvements were determined on the basis of federally and state-listed species of endangered, threatened, and species of special concern, or protected species with no specific restrictions. Archaeological and historical sites at this screening level were identified from listings on the National Register of Historic Places. No historic or archaeological sites are included on the project maps because of the lack of involvement of the segments with any known sites and to protect these resources from intruders.

These restrictions are graphically overlayed over the route segments on Figures 2-8 through 2-13, where red corresponds to the most severe restriction, yellow corresponds to significant restrictions, and blue corresponds to mild restrictions. No restriction is indicated by the absence of a color overlay.

Discussing these restrictions in reverse order, segments with involvements with Level 4 restrictions were considered to be impractical and were dropped from any further consideration at this time. Because some of these Level 4 restrictions are based on land use environmental classifications, such as Wilderness Study Areas, that may change in the future, some of the

impractical segments could be reconsidered if such a change occurs.

Level 3 involvements may have proved to be permissible provided that no other route was feasible and sufficient mitigation were provided. However, feasible segments were identified that had no contact with Level 3 restrictions and any involvement with this level were also dropped from consideration in favor of the avoidance alternatives. The only acceptable segment alternatives were determined to occur under Levels 1 and 2, although Level 2 restrictions were avoided where possible.

Evaluating the effect of these restrictions on the route segments, two possible routes from the vicinity of Caliente to the potential site at Yucca Mountain were developed which constituted an envelope of possible routes between the Caliente area and the potential Yucca Mountain site. Figures 2-14 through 2-18 display these routes. Quadrant I (northeast of Las Vegas) is not included in this set of figures because no feasible route was found in that quadrant.

Developing conceptual designs for the entire length of both routes was beyond the resources of this study. Consequently, the route and options studied in detail were identified based on preliminary technical results, and a series of meetings that were held with local community representatives. Lincoln County and Caliente officials identified additional options considered in the study. Esmeralda County officials suggested the evaluation of the route going west of Goldfield in the area of the Montezuma Range. In Nye County, a route close to the Nellis Air Force Range was selected for detailed study. Other identified options could be studied in future conceptual designs of other routes if suggested by the local community representatives.

Approximately 500 miles of potential rail line were studied in detail. An additional 225 miles of potential rail line were evaluated in less detail. Plan and profile drawings are included in Appendix A of this report for approximately 443 miles of potential rail line.

2.4 ALTERNATIVE ROUTES

The alignment selection process involved the evaluation and elimination of various alternative alignments between Caliente and Yucca Mountain. This section documents the alignment alternatives considered and rejected. The approximate corridors of these alignment alternatives are shown in the figures referenced in the discussion below. See Section 3.3 for a description of the recommended alignment.

2.4.1 Crestline to Panaca

This alternative route originated on the Union Pacific at Crestline and proceeded northwest through Sheep Spring Draw and west of Dow Mountain past White Wash. The alignment crossed Nevada State Highway 319, proceeded west and crossed the highway a total of three times with grade separations and passed through the north edge of the town of Panaca. The alignment then proceeded in a southwest direction on the old Union Pacific alignment and then northwest to a junction point with the Caliente Route (Figure 2-14).

When compared to the chosen route going north from Caliente, this route was over 15 miles longer, had steep grades, sharp curvature and involved extensive earthwork due to the topography. Because of these factors, this segment would cost roughly over five times more than the comparable one from Caliente or about $88 million more. In addition, the longer length and steeper gradient on the route would increase the operating and maintenance cost of the shipments. The route was eliminated for these reasons.

2.4.2 Crestline to Weepah Springs via Pioche

This route also originated on the Union Pacific at Crestline and followed the Crestline to Panaca alignment for approximately 12.5 miles where it diverged from the previous alignment and proceeded in a northerly direction, crossing Highway 319 and Kill Wash. The alignment proceeded on the former Union Pacific north of Condor Canyon. The route then crossed Nevada State Highway 322 and proceeded in a westerly direction north of Pioche and the Pioche Mills. The alignment crossed U. S. Highway 93, and paralleled the highway past the Jackrabbit Mines where it continued in a westerly direction along the Bristol and West Range, and past Bristol Wells. The route then proceeded westerly past Fairview Wash and across Dry Lake Valley. The alignment then crossed the White River with a bridge and over Highway 318 with a grade separation. The route then proceeded southwest to a junction point with the Caliente Route B, the northern most of the two selected routes (Figures 2-14 and 2-15).

When compared to the chosen route, this route was very lengthy and would require extensive grading because of the topography and the length. The route was eliminated for these reasons.

2.4.3 Panaca to Pioche

This route originated in Caliente on the Union Pacific and was a continuation along the former Union Pacific alignment north of Panaca. The alignment proceeded through Condor Canyon to a point north of the Canyon where it joined the Crestline to Weepah

Springs alignment. The line required various changes in the former Union Pacific alignment because of excess curvature on the former line through Condor Canyon (Figure 2-14).

When compared to the chosen route, this route was very lengthy and would require extensive grading and other civil work. The route was eliminated for these reasons.

2.4.4 Bennett Pass Cutoff

This route originated at a junction point with the Caliente Route in the vicinity of Bennett Pass and then proceeded northeast of the Highland Range and the Bristol Range to a junction with the Crestline to Weepah Springs alignment (Figures 14 and 15).

The route was a cutoff that utilized the westerly portion of the Weepah Springs alignment. Compared with the chosen route, this route was lengthy and would involve extensive grading. The route was eliminated for these reasons.

2.4.5 Reveille Mountain to Mud Lake

This segment of the railroad corridor extends from a point southeast of Reveille Mountain Range, just west of the confluence of Routes A (red, southern most) and B (yellow, northern most), to Mud Lake (Figures 14, 16, and 17). The corridor is characterized by two different types of terrain bisected by a north-to-south mountain range. Rolling terrain and mountainous grades exist east of the Kawich Mountain Range, and relatively flat ground is found to the west of the Kawich Mountains. The most accessible crossing of the mountain range is a pass located north of Kawich Range near State Route 6 and the Warm Springs Summit. All alignment alternatives considered included this pass.

Several different alignment alternatives were available in the southeastern portion of this segment. Paths were restricted, however, by the Nellis Air Force Range to the west and an environmentally sensitive area east of the unmarked road between Reveille Mill and Cedar Pipeline Ranch. The preferred route parallels the road several hundred feet to the west. Disadvantages include heavy cuts and fill in the area around Sta.11600+00. An alternative route followed a more westerly path closer to the boundary of Nellis Air Force Base. Earthwork would not be reduced by this alternative, while increased vertical grades and overall length of track would result in a more costly design. This alternative was therefore rejected.

The alignment approaching the mountain pass from the east requires long, steep grades to reach the higher elevations in

this region. In order to minimize grades, the alignment follows the contours and involves steep side slopes. Horizontal curves are sharp in a few areas. Cut and fill quantities would be significant since extended portions of track will either be carved into the side of mountains or have to be supported by other means. Due to a higher profile along the alignment, the crossing of Cow Canyon would require a bridge of considerable length and height.

An alternative design in this region consisted of a more easterly alignment that would follow lower elevations until Cow Canyon could be passed without need of a bridge. The disadvantage of this alternative would be the subsequent loss of elevation in the approach to the mountain pass at Warm Springs Summit. Beyond Cow Canyon, an extended climb at maximum grade would be necessary to reach the highest elevation of the mountain pass. Considering the operational characteristics of this alternate design, the higher path to the mountain pass is preferred.

The alignment west of the Kawich Mountain Range was less restricted than that to the east. In most areas the terrain is flat and few obstacles exist. Horizontal alignment in this region follows existing roads where possible, until it reaches the area north of Mud Lake.

2.4.6 Mud Lake to Stonewall Pass: Nye County

This part of the railroad corridor extends from a point north of Mud Lake to an area south of Ralston near Stonewall Pass. The corridor is characterized by rolling and mountainous terrain over most of the route. Constraints in the area are the developed areas of Goldfield to the west and the restricted Nellis Air Range boundary to the east. Goldfield Hills Mountain Range divides the route so that the northern half of the alignment is ascending toward a summit and the southern half is descending (Figure 2-17).

The preferred alignment consists of steep grades and tight curves over the middle portion of the route. A mountain pass is located east of Goldfield and west of Goldfield Hills.

An alternative alignment consisted of passing through Goldfield Hills close to the Air Force Range, rather than the area near Goldfield. Because of the proximity of the range boundary east of the hills, crossing the mountain range to the east would involve extensive earthwork, including a tunnel at the summit near Willow Springs. It is doubtful that project design standards of curvature and grade could be maintained throughout this alternative alignment.

2.4.7 Mud Lake to Stonewall Pass: Esmeralda County Alternative

In response to interest indicated by Esmeralda County in having the rail access pass through that county, an alternative alignment passing to the west of Goldfield was developed. This alignment was identified as Route G and is shown in yellow on Figure 2-17. Five subalternatives of Route G were considered within the overall corridor. The preferred alignment to the east of Goldfield and within Nye County (discussed in Section 2.4.6) is identified as Route F and is shown in red on Figure 2-17.

Route G begins at the same point as Route F, northwest of Mud Lake, two miles east of the Esmeralda County Line. Route G proceeds on a westerly bearing, crosses over U.S. 95, and continues west to Alkali Lake, which lies just east of Paymaster Ridge. The route turns south to avoid both features, and crosses Silver Peak Road at grade. Route G proceeds south, virtually perpendicular to the contours, ascending at maximum grade (2.5%) for a distance of 9 miles along the valley between the Montezuma Range and Clayton Ridge. High embankments and deep cuts are required in this area.

Route G then turns east to cross the Montezuma Range in the valley of Jackson Wash. This alignment involves 3 miles ascending at maximum grade, followed by 8 miles descending at maximum grade, extensive cut through the Jackson Wash Canyon, and potential inundation when Jackson Wash is in flood. East of Montezuma, the route turns south, continuing along the course of Jackson Wash in the valley between Montezuma and the Goldfield Hills, southwest of the town of Goldfield.

Route G continues on a southeast bearing as it approaches Mount Jackson Ridge. Traversing this ridge involves a 2.5% descending grade about 5 miles long. South of the ridge, the route crosses over State Route 266 then continues across Lida Valley and Jackson Wash, along the base of Slate Ridge, towards Stonewall Pass. To avoid the large elevation drop through Stonewall Pass, the route turns north, crosses over U.S. 95 and follows the base of the small, unnamed ridge close to Alkali Flat. It rejoins Route F about 2 miles south of the end of Alkali Flat and 1 mile west of the Air Force Range boundary.

The total length of Route G is 58 miles, as compared with its alternative, Route F, which is 32 miles. In addition to the basic alignment of Route G as described above, several alternative subalignments were explored, as follows:

2.4.7.1 Route G-1. Route G-1 continues south where Route G turns east to cross the Montezuma Range. The route bears southwest to follow the base of the mountain range, skirts around its southwest end near Railroad Spring, and heads northeast along the valley between Montezuma Range and the Palmetto Mountains.

The alignment turns and continues approximately due east, across Jackson Wash, until it meets and rejoins Route G. This route involves an 11 mile segment of 2.5% grade, (2.5 miles up, 8.5 miles down) starting where G-1 curves east around the southwest end of the Montezuma Range. Route G-1 also involves an additional 6 miles of overall track length, but avoids the heavy cut and potential inundation from Jackson Wash associated with the canyon route (Route G.)

2.4.7.2 Route G-2. Route G-2 replaces a segment of G just south of Alkali Lake, where G turns south on 2.5% ascending grade. Route G-2 employs a series of 4 reversing curves to flatten the grade in the area to 1.6%. Use of Route G-2 improves a 9 mile 2.5% grade on Route G to a 16 mile 1.6% grade followed by a 4 mile 2.5% grade. G-2 involves an additional 6 miles of track length, compared with Route G.

2.4.7.3 Route G-3. Route G-3 follows Route G until it emerges on the east side of the Montezuma Range. At that point Route G turns south, following Jackson Wash. Route G-3 continues east across the valley, and turns south along the west edge of the Goldfield Hills. Route G-3 rejoins Route G two miles south of the end of the Goldfield Hills Range. Route G-3 enjoys a more favorable profile than G, eliminating an 8 mile segment of maximum grade, and avoids some of the risk of inundation from Jackson Wash. It has 2.5 miles additional length compared to Route G.

2.4.7.4 Route G-4. Route G-4 follows Route G-1 around the south end of the Montezuma Range, then follows the south side of the range, bearing northwest until it crosses the G route. It then turns and bears southwest until it joins the G-3 alignment. G-4 eliminates the long (8.5 mile) 2.5% grade of route G-1, replacing it with a 9 mile grade of 2.0% and 5 miles additional length overall compared to G-1, and 11 miles additional length compared to Route G.

2.4.7.5 Route G versus Route F. Route F is preferred to any of the Route G alignments because it has a much shorter length, with consequent lower construction and operating costs. At roughly half the length of the shortest Route G Alternative, it represents a saving of nearly 30 track miles and about $50 million in construction cost. Even though the Route G alignments are longer, they pass through terrain much more mountainous than on Route F. Grade and curvature conditions are therefore not alleviated by the longer lengths, but are exacerbated. Table 2-2 presents relative cost and other parameters of the alternative routes.

To satisfy Esmeralda County's interest in rail access, a spur from Route "F" into Esmeralda County could be added. Such a spur would probably be about 6 miles long, terminate near Goldfield, and cost about $13 million.

TABLE 2-2. COMPARISON OF ROUTE F AND ROUTE G ALTERNATIVES

Alternative	F	G	G/G-1/G	G/G-2/G	G/G-3/G	G/G-1/G-4/G
Length (mi)	31.8	57.7	63.4	63.2	60.3	68.3
Cost (million $)	61.2	109.4	117.0	121.5	109.1	129.4
Ave Grade (%)*	1.3%	1.3	1.3	1.2	1.3	1.2
Grades> 5 mi & 1.8%	6 mi @ 1.9% 7.5 @ 2.2	9 mi @ 2.5% 8 2.5% 5 2.5%	9 mi @ 2.5% 8.5 @ 2.5% 5 @ 2.5%	8 mi 5 @ 2.5%	9 mi @ 2.5% 5 @ 2.5%	9 mi @ 2.5% 9 @ 2.0% 5 @ 2.5%
Curves by Degree:						
0° - 2° 45'	14	16	16	17	16	17
3° - 3° 45'	3	1	1	3	1	1
4° - 8° 00'	0	0	0	2	0	3

* Total Rise & Fall divided by route length

2.4.8 Sarcobatus Flat to Coba Mountain

One alternative alignment in this area continues along the east side of the highway, but closer to it than on the preferred route because of the proximity of the Nellis boundary. It traverses an alluvial fan and crosses Tolicha Wash at its narrowest point outside of its canyon. It continues along the base of the mountain and develops elevation to cross the highway and rejoin the chosen alignment north of Coba Mountain. This route is shorter and requires less embankment, but the profile has a substantial "hump", which is undesirable for operational reasons (Figures 2-17 and 2-18).

A second alternative is identical to that described above, but employs a 2000 foot segment of deep cut to avoid crossing the highway. It rejoins the main route south of Coba Mountain, where it resumes an alignment parallel to and east of U.S. 95. By staying on the east side of U.S. 95, this alternative saves two grade separations, but involves heavy cut and an unfavorable profile. The chosen route, though longer than the above two alternatives and requires two grade separation structures, was chosen for its more favorable profile.

2.4.9 Oasis Valley Area

An alternative alignment was considered in this area (Figures 2-17 and 2-18) to avoid crossing private property. The alignment follows the west side of the valley for a distance of 1.5 miles, then turns southwest, crosses the valley, and rejoins the main route on the east side of Oasis Valley. This alignment has an inferior profile (more rise and fall) compared to the preferred alignment, and crosses the valley at an angle, requiring a longer bridge to span the projected 100 year storm flow in the valley.

A second alternative alignment continued due west until it approached Colson Pond before turning south down the west side of the valley. This alignment followed contours more closely, but was rejected because of the additional track length it required. In addition, it posed a greater impact on the existing development at Colson Pond.

2.4.10 South end of Oasis Valley to North end of Crater Flat

A tunnel alternative was considered to eliminate the diversion to the east by going under Yucca Mountain (Figure 2-18). The tunnel portion of this alternative would be 8000 feet long and save 6.5 miles of track. The tunnel route would also offer a much straighter and flatter alignment and avoid the heavy earthwork involved in crossing Yucca Mountain. The tunnel alternative was rejected, however, because of the cost of tunneling.

2.4.11 Crater Flat

An alternative alignment across Crater Flat would proceed south tending west, parallel to contours, on the west side of Crater flat (Figure 2-18). South of Red Cone, it would turn east, toward southern Yucca Mountain. This alignment would be longer and offer no advantage over the chosen route, and was therefore not considered in detail.

An alternative sub-alignment between Black Cone and Yucca Mountain was also considered, involving reverse curves near the mountain to flatten the profile. It was determined, however, that the straighter, shorter alignment has a satisfactory profile and thus was chosen over this alternative route.

2.4.12 Crater Flat to Busted Butte

An alternative alignment to avoid crossing the southern portion of Yucca Mountain was developed (Figure 2-18). This route continues south from the point the preferred route turns east to cross the ridge northwest of Yucca Mountain. The route follows the west side of Yucca Mountain south to within 2000 feet of U.S. 95, skirts around the south end of the mountain, heads east parallel to the highway, then turns north, up Jackson Flat, parallel to Fortymile Wash. It rejoins the preferred route at Busted Butte. This alignment enjoys a smooth profile over flat ground, requiring minimal earthwork. It was rejected, however, for the additional 10 miles of trackwork it would require.

A short tunnel section was considered briefly for the crossing of the ridge on the west side of Yucca Mountain. Because of the steep rise in elevation to the plateau, however, a substantial improvement in profile could not be obtained and this alternative was rejected.

3. ENGINEERING

3.1 INTRODUCTION AND SCOPE OF ENGINEERING ANALYSIS

This chapter describes the engineering studies that were performed for the alternative and selected alignments. Engineering and related technical studies were performed for this conceptual study for the purposes of identifying concepts and estimating costs of railroad alignments within the Caliente route corridor. The identification of concepts includes the establishment of railroad layouts (plan and profile) and the assessment of related engineering items, such as geotechnical constraints, drainage and structural requirements, signals and communications facilities, and other fixed facilities required for the construction and operation of a railroad.

The level of detail undertaken for the technical studies was sufficient to establish possible routes and to identify significant impacts. Optimization of layouts and related engineering items at continuing stages of study will undoubtedly result in refinements of the concepts presented in this report.

3.2 METHODOLOGY AND BASIS FOR DESIGN

3.2.1 Mapping and Field Reconnaissance

The study of railroad or any similar facility which must be built requires information on the ground topography. Historically, this information was obtained from field reconnaissance. The original railroads' alignments were established largely from individual knowledge of the terrain obtained by visual inspection. Topographic mapping, when it was obtained, was established for narrow corridors and prepared on site by survey crews. The development of aerial stereo photography greatly increased the range and ease of preparing topographic mapping. Since the 1940's the United States Geological Survey (USGS) has prepared mapping covering virtually the entire contiguous 48 states. These maps are available at different scales and levels of detail, depending on the areas.

The maps used for this study are at a scale of 1:24,000 (1" = 2,000'). Each individual map covers an area equivalent to 7 1/2 minutes of longitude and latitude. These maps are consequently known as 7 1/2 minute quadrangle, or "quad" sheets. The coverage of each map in the study area equates to approximately 31,000 feet east-west and 46,000 feet in a north-south direction, or about 33,000 acres. Approximately 88 quad sheets were required for the study of all the alignment alternatives in this study; the selected alignments pass through about 67 sheets.

The USGS has a continuing program to update the original maps; the accuracy of any particular map depends on when it was last revised, and what has changed within its limits since its last revision. The mapping updates are generally done from aerial photographs and other records, and are not as accurate as the original maps. The latest revision dates of maps within the study area range from 1967 to 1987.

Topography, or the configuration of the ground surface, is represented on the maps by contour lines, which trace points at equal elevations. The contour interval, or vertical distance, between contour lines on any particular map depends on the nature of the terrain and the scale of the map. Contour intervals on quad sheets used for this study vary from 5 feet in flat areas to 40 feet in mountainous terrain. National mapping standards to which the USGS maps conform require that 90% of the elevations determined from the contour lines to be accurate to within half the contour interval, and the remaining 10% to be within one contour interval of true elevations. Thus, elevations shown on some of maps can be off by as much as forty feet.

Initial identification and study of routes was made on the basis of reproducible mapping which was prepared from the published quad sheets. All work was done manually at the initial study stage. Once the first round of elimination (see Chapter 2) had taken place, the mapping covering the remaining corridors was converted to digitized format for further development using CADD technology. This process required some revision as engineering studies, which were continuing concurrent with the preparation of the digitized mapping, resulted in modifications to the route layouts. Once the individual quad sheets were digitized, development of layouts and related engineering continued on CADD files. Work on CADD consisted primarily of earthwork volume calculation and the preparation of plan and profile drawings. Some minor adjustments to profiles were made, but the basic horizontal alignments that had been developed in the early phases of the study were retained. The basic CADD views will be translated in DXF format for use in an ARC/INFO environment.

Once the initial alignments had been identified, field reconnaissance trips were undertaken to inspect the alignments. Field trips were taken by civil engineers in charge of the route layouts, geotechnical and drainage engineers. Geotechnical reconnaissance also included a helicopter tour over the study area. (Additional field inspection was performed by planners evaluating impacts of the routes on cultural and natural resources.)

3.2.2 Design Criteria

The engineering elements of a railroad are integrally related to the railroad's operation. The design criteria established for this study were done so in conjunction with the functional and operational requirements for the transport of the cargo. Criteria were initially established at the beginning of the study, and modified as the study progressed. Some criteria may continue to be modified as study and design proceed. The complete Design Criteria for this study are presented in Appendix D. The following discussion illuminates some of the major considerations.

Although each railroad in the United States has its own engineering standards and criteria, industry standards have been established by the American Railway Engineering Association (AREA) in its "Manual for Railway Engineering (Fixed Properties)"and "Portfolio for Trackdown Plans". This document is the basis for the core of the design criteria established for this study. DOE Order 6430.1A, Section 0245 "Railroad Design" establishes some specific design criteria, but generally refers to the AREA standards. Other DOE Orders establish criteria for facilities related to the railroad design and operation. In addition, the Federal Railroad Administration (FRA) has established minimum standards for track maintenance and signals which affect maximum speeds. Furthermore, the Nevada Public Service Commission has jurisdiction on railroad related design elements such as clearances and grade crossings. The Design Criteria established for this study were developed in conformance with all applicable requirements. Applicable DOE orders are listed in Appendix C.

There are three principal elements of the criteria: functional requirements, geometric criteria, and related items. Functional requirements (Appendix D, Chapter 1) reflect the operational parameters; the criteria in this Chapter were developed largely from DOE requirements, either as explicit criteria or as interpreted by the Operations Engineer. The train consist and operations scenario for the delivery of HLW were established by SAIC. Geometric criteria (Appendix D, Chapters 2 through 4) were established by the Consultant on the basis of AREA standards and generally accepted industry practice.

The criterion which most significantly affects the engineering and operation of a railroad is the maximum grade. DOE Order 6430.1A.0245-16 (Grades) limits design grades to below 3% without approval by the cognizant DOE authority. This value is quite steep for a railroad, though grades of up to 4% are sometimes used in mountainous terrain. (The steepest main line railroad grade in the United States is 4.8% -- 250 feet per mile.) A maximum grade of 2.5% was established for this study.

Criteria for related items (Appendix D, Chapters 5 through 12) generally concern engineering that comes after the routes have been selected, though some of these items, such as soils or drainage can influence route alignment. The criteria for railroad signals have been established to develop order of magnitude costs for different levels of train signal systems. The provision of signals on this railroad is a policy decision based on the nature of the cargo and its associated hazards. See Section 3.11 for a discussion of signals.

3.3 ALTERNATIVE ALIGNMENT LAYOUTS

The alignment, or path the railroad will follow between Caliente and the Yucca Mountain site, was laid out to minimize construction cost while avoiding operational problems. Construction costs increase with the length of track and the amounts of excavation and embankment required, while operational considerations require that grades, vertical and horizontal curvature are kept to a minimum. The alignment also must avoid interference with environmentally sensitive areas, Archaeological Sites, private property and The Nellis Air Force Range. Various different routes were considered and evaluated according to these criteria. This section describes the alignments that emerged as the most feasible, which are depicted in plan and profile at a scale of 1"=500'.

The two main alignments between Caliente and Yucca Mountain that were chosen are referred to as the Base Route or the Route B Option and the Route A Option. They are different only in Lincoln County. The Route A Option utilizes the southerly route along U.S. Highway 93 and through Hiko Canyon and Hancock Summit. Its general corridor was shown in red on Figure 2-14. The Base Route is 35 to 40 miles north of the Route A Option, passing through the Golden Gate Mountains. Its general corridor was shown in yellow on Figure 2-14.

3.3.1 Caliente Route - Route A Option (Sta. 1,500 to Sta. 11,000)

The Base Route and the Route A Option originate in the town of Caliente, at the east edge of the town where a two-track interchange with the Union Pacific Railroad will be constructed. The combined alignment proceeds north along the former Union Pacific line to Panaca, parallel to U.S. Highway 93 and Meadow Valley Wash. South of Panaca the combined route swings to the west and crosses over Highway 93 and proceeds through Bennett Springs. The alignment continues west to the east junction point of the Route A Option and the Base Route on the east side of Dry Lake Valley. This common portion of the line is approximately 29 miles long.

The Route A Option proceeds south parallel to an electrical transmission line and maintenance road. The alignment then proceeds west, parallel to and north of Highway 93. At Pahroc Summit the line continues north along an unimproved road through Hiko Canyon, across the Pahranagat Valley with a bridge, and over Nevada State Highway 318 with a grade separation.

The alignment through the Pahranagat Valley proceeds south along the west edge of the valley and then west and north of Highway 375. The line continues through Hancock Summit with a 2.4 mile long tunnel. The route then proceeds northwest parallel and north of Highway 375. The alignment proceeds through Tikaboo Valley, Coyote Summit and the town of Rachel. The route then swings north in the vicinity of the Nye/Lincoln County line and north of the Nellis Air Force Range. The line then meets the west junction point with the Base Route, on the east side of Reveille Range and continues west on a common alignment. This is the only portion of the alignments that is not identical for the Base Route and the Route A Option.

3.3.2 Caliente Route - Base Route (Sta. 1,500 to Sta. 11,000)

The Base Route branches off to the northwest at Dry Lake Valley, and proceeds northwest while Route A continues south towards Pahroc Valley. The Base Route proceeds west through Dog Hollow and crosses Dry Lake Valley, then continues north and east of the White River Valley. The line crosses the White River Valley with a bridge, and over Highway 318 with a grade separation. The alignment continues north along the western edge of the White River Valley and proceeds west and north of the Weepah Springs Wilderness Area. The route goes through Timber Mountain Pass, crossing Coal Valley through a pass of the Golden Gate Range. The route is approximately three miles north and parallel to the Nye/Lincoln County Line.

The alignment then proceeds southwest crossing Garden Valley north of the Worthington Mountains. It continues west across the Sand Spring Valley northern boundary, then proceeds southwest, crossing the Nye/Lincoln County Line and proceeding south of the Quinn Canyon Range to the junction point with the Route A Option. The route then continues on a common alignment with the Route A Option in a southwesterly direction.

3.3.3 Eastern Nye County (Sta. 11,000 to Sta. 15,830)

This segment begins in the Railroad Valley, east of State Route 375, and west of the confluence of the Base Route and the Route A Option. The railroad crosses over the highway, then proceeds west into Reveille Valley, and turns northwest. Restricted environmental and wilderness areas exist to the east of the track

and extend up to the Reveille Mountain Range. Nellis Air Force Range is located to the south and west of the railroad alignment throughout most of the valley. Several bridges are required in the southern end of Reveille Valley. With the exception of two isolated areas of deep cut, earthwork quantities are not significant.

The alignment quickly changes to a northerly heading near Cottonwood Canyon as the railroad begins a gradual ascent from the Reveille Valley to a mountain pass located at Warm Springs Summit. The abrupt change in direction is required to avoid archaeological ruins at Reveille Mill. Horizontal curves in the area are established to follow existing ground contours more closely as cross-slopes associated with the Kawich Mountain Range become steep. Earthwork is heavier here than in the valley and consists of considerable lengths of track in moderate cut and fill. Grades are not particularly steep but change directions frequently.

The approach to the mountain pass at Warm Springs Summit from the east involves the steepest grades. Cut and fill quantities increase and grades approach the design maximum. A 1000 ft. bridge is required near the toe of the slope at Cow Canyon. Once the Warm Springs Summit is traversed, the alignment turns southwest and descends into Stone Cabin Valley and Ralston Valley.

3.3.4 Mud Lake to Stonewall Mountain (Sta. 15,830 to Sta.17,477)

This segment begins at a point northwest of Mud Lake in Ralston Valley. The alignment turns south before reaching Esmeralda County to follow a corridor between the county line and the limits of Nellis Air Force Range. The horizontal and vertical alignment north of Goldfield Hills consists of gentle curves, long tangents, and moderate grades.

As the alignment enters the Goldfield Hills from the north, grades increase sharply and extend over long stretches of track to get over the summit, due east of Goldfield. Horizontal curvature also is increased as the railroad curves to avoid deep cuts, mine shafts, existing roads and environmentally sensitive areas. Grades are steep as the track descends to the southern slopes of Goldfield Hills. Earthwork quantities will be the greatest in this region.

South of the mountainous terrain of Goldfield Hills, horizontal alignment and vertical grades become less severe and earthwork diminishes. The railroad parallels existing roads until the

alignment reaches Stonewall Flat, south of Ralston and east of U.S. Route 95.

3.3.5 Stonewall Mountain to Sarcobatus Flat, (Sta. 19,603 to Sta. 20,700)

The alignment proceeds south following contours at the base of Stonewall Mountain, roughly parallel to US 95 and an old railroad grade. A more westerly route, closer to Alkali Flat, is avoided due to possible inundation of the area during storm events.

South of the mountain, the alignment continues parallel to the old railroad grade across Alkali Flat, and down Lida Valley between two unnamed ridges. To the west, US 95 crosses a plateau before traversing Stonewall Pass, which involves an elevation drop of 100 feet in 1500 feet, or a gradient of 6.7 percent. This route was consequently not considered for the railroad. A second valley east of the chosen alignment is in the Nellis Air Force Range, and is off-limits to the railroad. Beyond the Stonewall Pass area, the alignment approaches US 95, then turns southeast and proceeds across Sarcobatus Flat, nearly parallel to and 2000 feet east of the highway

3.3.6 Sarcobatus Flat to Oasis Valley (Sta. 20,700 to Sta. 22,200)

The alignment continues southeast on the east side of US 95, to the area near the south end of Pahute Mesa. Following the contours, it crosses US 95 and skirts an alluvial fan in a long curve past Tolicha Wash and back towards US 95 at Coba Mountain. With Coba Mountain in the way, the railroad crosses US 95 again and resumes an alignment on the east side, parallel to the freeway. The alignment continues parallel to US 95, then turns west into the valley on the north side of Oasis Mountain and proceeds toward Oasis Valley, which offers a wide, flat north-south corridor. US 95, meanwhile, follows a pass through Oasis Mountain/Bullfrog Hills and joins an a arm of Oasis Valley near the town of Springfield. The US 95 corridor at this point is unsuitable for the railroad alignment due to grades, proximity to the town of Springfield, and the Amargosa River, which may be subject to floods. Approaching Oasis Valley, the alignment bends south, crosses the valley on a bridge, then turns due south, parallel to the contours.

3.3.7 South end of Oasis Valley to South end of Crater Flat (Sta. 22,200 to Sta. 23,670)

Blocked by Yucca Mountain from continuing south, the alignment curves east, follows contours and enters the valley containing

Beatty Wash. It parallels Beatty Wash for a distance of 2 miles on an approximately due east bearing, crosses the wash, then develops elevation on the gently sloping area on the south side of the Wash before winding its way along a pass through Yucca Mountain, re-emerging at the north end of Crater Flat.

Continuing south, the alignment makes several reverse curves to develop elevation, then assumes an alignment tending east and following contours on the east side of Crater Flat. It passes north of Black Cone and continues south and east before turning east to enter a pass through a southern section of Yucca Mountain.

3.3.8 Yucca Mountain to Repository Site (Sta. 23,670 to Sta. 24,425)

The route traverses a pass through a southern Yucca Mountain ridge, which will require deep cut and maximum grade over a distance of about 2000 feet. Beyond the ridge, the alignment continues east across a plateau, approaches a second, much flatter pass, and emerges on the east side of Yucca Mountain, just south of Busted Butte and west of the 40 mile Wash. From Busted Butte, the alignment proceeds virtually due north, following contours to within about one mile of the site. Reverse curves are employed to develop elevation to attain the repository site.

3.4 TRACK AND ROADWAY

Drawing D02-001 (Sheet No. 9 in Appendix A) shows the typical sections developed for this study. The track and roadway configuration of a railroad is the most important element affecting cost, as each item in the section extends over the length of the railroad. The term "track" refers to the rails and associated hardware, such as tie plates and spikes, the ties and the ballast. Sub-ballast is sometimes included as a track item. The term "roadway" refers to the graded elements of the section, such as the sub-grade, ditches, and side slopes. Sub-ballast is frequently constructed by a general or civil contractor, so it can also be included as a roadbed element. The individual items comprising the track and roadbed section are discussed below.

3.4.1 Rail

The size and shape of rail sections are designated by a number representing the nominal weight in pounds per yard of a single rail. Historically there have been over a hundred different rail sections used by U.S. railroads. AREA currently designates eight different rail sections ranging from 90 to 140 lb, but only two

are generally used for new railroad construction: 115 and 132 lb. The heavier rail section is used on high density main lines. The 115 lb. section has been selected for this study, due to the low density of traffic.

Individual sections of rail were previously joined together with joint bars. Continuous welded rail (CWR) has all but replaced bolted rail. CWR is today cheaper to install than bolted rail, and results in reduced track maintenance due to the elimination of the joints. Some joints may still be required to isolate track circuits and at special trackwork, but technology is developing to eliminate even these joints. CWR must be laid at controlled temperatures to avoid buckling or "sun kinks" in hot weather.

3.4.2 Ties

Timber ties are shown on the typical section. The size shown is the AREA standard for main line railroad construction. The entire U.S. railroad network was constructed with timber ties. Concrete ties are common in other countries, where wood is expensive. Some U.S. railroads are using concrete ties in special situations, such as sharp curves and in areas of heavy tonnage. Concrete ties are more expensive to install than timber ties. In certain situations such as heavy traffic and/or in wet climate they can be as economical as timber ties, due to longer life and reduced maintenance costs. Timber ties are considered adequate and proper for the Yucca Mountain Railroad. Cost estimates for construction with timber ties and with concrete ties have been included in this report.

3.4.3 Ballast

Ballast is the material which holds the ties in place and which distributes the wheel loads to the subgrade. Ballast usually consists of crushed rock gravel, though railroads have historically used slag, cinders, and other material. AREA has standards for ballast material qualities and gradation. The depth of 8" shown on the typical section conforms to AREA and general industry standards for the traffic projected on this railroad.

3.4.4 Sub-ballast

Sub-ballast consists of granular, well graded material similar to a highway base or subbase course. Sub-ballast, when used, is a method of achieving some economy in the cost of ballast construction. The selection of ballast and sub-ballast material depends largely on local availability of suitable materials.

More detailed engineering at later stages of design should include the definition of ballast and sub-ballast depths and materials.

3.4.5 Roadbed

The roadbed or platform width for a single track is a matter of railroad policy. The roadbed provides a maintenance walkway. Railroad standards for new main line construction vary from 24 feet to 30 feet. Branch and spur lines might have 20-foot widths. A ditch is constructed in cut sections to channel runoff away from the tracks. The ditch also provides space for placing snow cleared from the track during winters. The actual dimensions of the ditch would be developed during detail design based on site specific hydrologic and hydraulic analyses. The section shown is typical for a railroad. The two-foot wide bench beyond the ditch is a nominal area for catching soil which will slide down the cut slopes. The actual width of this bench would vary, depending on the nature of the material and the depth of cut. The bench also increases the space available for storing snow.

3.4.6 Track Spacing

On a single-track railroad, the only places where track spacing is an issue is at passing sidings and in yards. Minimum distances for track spacing are matters of railroad policy and State regulatory requirements. The 15 foot value selected for this study conforms to current main line standards for U.S. railroads, and meets the Nevada PSC requirement for a track parallel to a main line track. Some railroads are increasing their standards for track spacing on new construction to allow for longer and wider loads.

3.4.7 Side Slopes

The cut and fill slopes shown on the typical section conform to the recommendations of the geotechnical report. Site-specific values were incorporated into the calculation of earthwork volumes.

3.4.8 Maintenance Roads

The maintenance roads shown on the typical section are actually provisions for trackside access where deemed necessary due to special situations. Maintenance of railroad tracks and roadbed, usually called maintenance of way, can be done with either rail-mounted equipment or a combination of rail-mounted and rubber-

tired equipment. "Hi-rail" equipment has rubber tires with flanged wheels attached to the undercarriage to allow the vehicle to travel on tracks as well as roads.

Maintenance of way was originally done entirely from the tracks, as there were no roads. Today, railroads tend to use off-track equipment for maintenance of routes with frequent trains, so the maintenance equipment can get out of the way and back on the track quickly to minimize delays to the train traffic and the maintenance crews. A widened roadbed width is usually provided to permit track access for the maintenance equipment. For low-density railroad tracks, interference between traffic and maintenance crews is not a significant problem. Maintenance of way can be performed with rail-mounted equipment, so the additional cost of a wider platform is not required for maintenance.

No specific locations for maintenance roads have been identified at the present stage of the design.

3.5 ROADS

Crossings of the Yucca Mountain rail access at existing highways and roads were divided into three classifications as follows:

Type of Road	Type of Crossing
State Highways	Grade Separation
Secondary and all paved roads	Crossing signals with gates high volume crossing surface
Unpaved Roads and Private Drives	Crossbuck Timber crossing surface

Five crossings of state highways were identified for grade separations, including US93 south of Panaca, SR318 in White River Valley (Base Route) or near Hiko Canyon (Route A Option), SR375 in Railroad Valley, and two crossings of US95 south of Scottys Junction. One paved road crossing is required at Caliente and one at the crossing of the railroad and the access road to be built between US 95 and the repository site (See section 3.6). The numerous unpaved roads crossings on the alignment were identified on the basis of the topographic mapping and field reconnaissance. These roads were not identified as to ownership or destination, and consist mostly of unimproved jeep trails in the desert. Some 132 such crossings were identified and

indicated on the 1"=500' scale plans. Minor grading will be required at some of the crossings.

A road/rail grade separation could have the railroad over the existing highway (overpass or overhead) or the highway over the railroad (underpass). Each structure would be configured on the basis of site topography. All the grade separations identified in this corridor are overpasses.

Drawing S02-002 of the Plans presents a generic plan, profile and cross section of the type of structure envisioned. For commentary on the design, refer to section 3.10.

3.6 ACCESS ROAD

A fifteen mile paved access road from US95 to the repository site would provide vehicular access to the site for repository staff and deliveries by truck. The road would follow an approximately north-south alignment, along the east side of Forty Mile Wash. The northern half would be roughly parallel to and east of the railroad access except at the final approach to the site. In that vicinity the road and railroad will cross, with warning signals and automatic gates.

The road will be open to the public between US95 and the Nevada Test Site, a distance of about two miles. At the boundary, a gate and gatehouse will be installed, beyond which only authorized repository traffic will be permitted.

For more information and drawings showing the plan, profile and details of the road, see the report, Yucca Mountain Project Access Road Conceptual Design, dated January 1991, attached as Appendix E to this report.

3.7 FACILITIES

Various facilities to accommodate the operation of the railroad were conceptionally designed. The engineering of the facilities is described in this section. Functional requirements are addressed in Chapter 3. The remoteness of the area required various items to be included which would normally be readily available in more populated areas. Stand alone water and sanitary facilities were included at most locations. The following is a description of the various facilities that are required and are included in the cost estimates contained in Chapter 5 for most of the operating scenarios. Specific locations of these facilities have not been established at this stage of the project.

- Operations Center - Central point for management and control of the railroad as well as the focal point for communications. This would normally be at the headquarters of the railroad operating the route, but in the case of a short-line or other local operator, it would be combined with the maintenance headquarters.

- Locomotive shop - One Track, Two Locomotives, Inspection Pit, Overhead Crane, complete with Storage Shop, Office and Welfare Facilities (Locker Room, Dining Area, Etc.) containing 6,280 square feet.

- Maintenance Headquarters - Outpost - Headquarters point for maintenance employees including Garage, Office and Welfare Facilities containing 2,630 square feet.

- Maintenance Headquarters - Central - Headquarters point for maintenance employees including Headquarters, Car Department, Crew Station, Office and Welfare Facilities containing 5,130 square feet.

- Automotive Vehicle Maintenance - Headquarters, Storage Area, Office and Welfare Facilities containing 2,630 square feet.

- Emergency Station - Fire Truck Pumper/Tanker, Ambulance, First Aid, Communications, Office and Welfare Facilities containing 3,880 Square Feet. This facility would not be required if emergency response services are locally contracted.

- Dormitory - Bedrooms, Dining Area, Kitchen, Recreation Area and Welfare Facilities containing 2,630 square feet.

- Fueling Station - Two Fueling Stanchions, 20,000 Gallon Fuel Tank, Sand Tower, Collector Pans, Waste Oil Tank and Oil separator.

- Railroad car Repair Station - Concrete Jacking Pads, Jib Cranes, Car Puller and Foreman's Office.

All building facilities are of modular design, concrete block with stucco finish, metal roof, clerestory ventilating windows, air condition and sectional overhead insulated metal doors as required.

Facilities design is in compliance with DOE orders 5480.4 (E S & H Protection Standards), 5480.7 (Fire Protection), 5480.11 (Radiation Protection) and DOE Order 6430.1A.02 (Site and Civil Engineering). Continued compliance with the appliance DOE Orders will be required in final design.

3.8 GEOTECHNICAL

3.8.1 Purpose

The purpose of the geotechnical investigation is to provide data for the design, construction, performance, and cost of the railroad. Geotechnical design provides standards for selection of earthwork slopes in embankments and excavations and gives the foundation designer data needed to select suitable foundations for structures. Methods of construction become crucial when special geotechnical conditions such as rock slide or near-surface ground water areas are reported. Performance relates to the maintenance life of the railroad in terms of anticipated subsidence of structures, soil erosion, and the corrosive effect of soils on construction materials. The summation of these considerations is reflected in the total cost of constructing and maintaining the railroad over its design life span.

For this conceptual study, a geotechnical investigation was undertaken for the following reasons:

- Identify significant geological features such as earthquake faults which could affect the route alignments.
- Provide data for cut and fill slopes to estimate earthwork quantities.
- Provide other geotechnical information of importance to the designer, such as seismology, groundwater presence, and mining activity.

3.8.2 Methodology

gThe investigation began with concurrent information gathering of regional geology, faulting, seismicity, mining claims, ground water, and soil types. Pertinent reference materials were identified and when available, obtained from relevant agencies. University and local libraries provided site-specific information and were visited by research team members. Two days of air reconnaissance by helicopter was carried out using video cameras with voice narration. Numerous photographs were taken during ground reconnaissance.

Analysis of regional geology was made from maps and reports provided by the U.S. Geological Survey (USGS) and the Nevada Bureau of Mines & Geology (NBMG). The documents studied describe areas usually contained within limits of a given county, but some cover larger areas having common geological factors. Maps ranging in scale from 1:1,000,000 (small) to 1:24,000 (large) were employed.

Faulting was analyzed from USGS maps. Seismicity findings were derived from materials which included the Earthquake Epicenter Map of Nevada, published by the Seismological Laboratory of the University of Nevada at Reno. The NBMG and the U.S. Department

of the Interior Bureau of Land Management (BLM) were sources for location of mining areas and mining claims.

Ground water studies were made from well boring logs and from ground water maps published by the USGS.

Surface soils, defined as having a nominal depth of five feet, were differentiated by physical properties using the Unified Soil Classification System (USCS) of the U.S. Department of Agriculture Soil Conservation Service (SCS). The soil classification system of the American Association of State Highway & Transportation Officials (AASHTO) was also used to identify soil types.

Landform characteristics were identified from field investigations, soil and geology reports, topographic, geologic, and satellite imagery maps. Where data was unavailable, characteristics were ascertained by extrapolation of similar landforms with related soil and rock groups. Formations were mapped along the route on USGS 7-1/2 minute series topographical quad sheets, focusing on a 1 to 1-1/2 mile wide corridor. Embankment slopes in cut and fill were then determined by soil and rock classification. Slopes conform to criteria recommended in the American Railway Engineering Association's "AREA Manual"(1988) for slopes to depths of 50 feet or greater.

Recommendations for structural foundations were based on existing structures constructed in similar geotechnical environments.

3.8.3 Summary of Results

The Geotechnical Report provides information for conceptual design of the Caliente Route. It describes regional topography and geology and gives a general picture of faulting, seismicity, mining, and ground water through presentation of the map figures and explanatory text.

3.8.3.1 Topography. Alluvial deposits cover 70% of the project corridor. Lake beds of reworked silt and clay were found in Lida, Ralston, Reveille, Railroad, Dry Lake, and Sand Spring Valleys. Sand dunes cover vast tracts of the southern ends of Ralston Valley and the Quinn Canyon Range. Dunes also occur in Railroad Valley. Gravels dip 5 degrees outward from mountain fronts and are overlain with colluvium and talus.

3.8.3.2 Faulting. Five types of faulting occur along the route: thrust, strike-slip, volcano-related high angle, and gravity sliding. Thrust faulting includes faults with low angles, folding, and related tear faulting. Volcano-related high angle faulting includes doming and cauldron subsidence.

Faults range in length from a few hundred feet to 46 miles (west-most fault of the Pahroc Range). Thrust and normal high angle faults predominate and strike-slip faults are mapped only on the

northern ends of the Hiko and South Pahroc Ranges. The area between Goldfield and Warm Springs appears to be free of significant faulting. No historic faults, those which have occurred in recent centuries, were found along the corridor. Systems in the Highland and Pahranagat Ranges were developed during the Mesozoic Era, at or prior to the formation of the Rocky Mountains. Remaining fault systems are of the later Cenozoic Era, having been formed during the last 60 million years.

3.8.3.3 Seismicity. Between 1930 and 1960, there have been two earthquakes exceeding Richter magnitude 6 (Hiko Range), four of magnitudes 5.0 to 5.9 (Warm Springs and Sarcobatus Flats), and numerous quakes of 4.0 or less. Anticipated frequencies of occurrence for magnitude 6 are once in ten years, and for magnitude 7, once in 27 years. None of the largest quakes to date have occurred within the corridor proper.

3.8.3.4 Mining. There are several mines near the route. Adjustments in route alignment may eliminate conflicts with the mines.

3.8.3.5 Groundwater. Four areas have ground water at depths of 30 feet or less:

- North of Caliente, depths are typically 30 feet, but may be as shallow as five feet.
- In Sand Spring Valley, most well logs show depths greater than 100 feet, but depths less than 30 feet also occur.
- Southeast of Scotty's Junction, in Sarcobatus Flat, depths as shallow as 15 feet have been found.
- Northeast of Beatty, contour patterns indicate depths ranging from 10 to 30 feet, however no well logs have been found for this region.

These areas are all located in flat valleys where cut excavations are not expected, but structural foundations may have to take ground water into consideration.

3.8.3.6 Conceptual Design. Conceptual design of cut and fill slopes was established through analysis of soils encountered along the route. In order to do this, soil classifications were first listed. Properties of each classification were then determined, thus establishing cut and fill slope criteria. Classifications were then mapped so that earthwork cost estimates could be prepared.

The primary source of surface soil information was SCS soil maps. Geological information also was obtained from the USGS, NBMG, the

University of Nevada library at Reno, and state archives in Carson City. The route was traveled by ground and by air to confirm the data obtained. Soil classifications were then listed and evaluated for swelling and shrinking, corrosiveness, frost action, and cut slope requirements in accordance with SCS descriptive characteristics for each classification. Cut slopes were given numerical values. All other evaluations were quantitative.

Classifications were placed on topographic maps of the route alignment and further evaluated for depth to bedrock and for suitability as sources of sand and gravel. Upon completion of the soil mapping, a table of soil parameters and characteristics was prepared, listing map quadrangle sheet names alphabetically, with tabulations of soil symbols, corresponding classifications, cut slopes and other data, for each sheet. This table was used to find the limits of various cut slopes for calculating earthwork cost estimates.

To estimate earthwork quantities, engineers developed cross-section templates for each cut slope. A 2:1 horizontal to vertical fill slope template was assumed for all fill, since it is not known what soil types will be used for that purpose.

3.9 DRAINAGE

3.9.1 Hydrology

As a first step to determine drainage structure requirements for the Yucca Mountain Rail Access, a hydrology study of the area was conducted. The scope of this study included evaluating all catchment areas that would drain across the rail alignment, in order to determine the approximate locations of the necessary culverts and bridges, and estimate the peak flows at these locations. These flows were to be based on a 100 year storm event, which is defined as a storm which has a 1% change of occurring in any given year. The full text of the study report comprises Appendix H to this report.

The Nevada State Engineer's map of Designated Groundwater Basins identifies the major drainage basins in the study area. These basins were divided into watersheds where they drain across the alignment. The areas of these watersheds and their ground slopes were measured from U.S. Geological Survey (USGS) contour maps. Field surveys were taken to identify soil types, relative moisture contents, vegetation types and cover density, and Soil Conservation Service (SCS) curves were used to predict the effect of these parameters on runoff rates. The National Oceanic and Atmospheric Administration (NOAA) Atlas 2 was the source of rainfall intensity and duration data.

Watersheds more than five square miles were studied using the Corps of Engineer's HEC-1 hydrology program, while watersheds between one and five square miles were evaluated using regional regression equations. Watersheds less than one square mile were not assessed.

3.9.1.1 HEC-1 Program. The HEC-1 program is a highly versatile hydrology model. For a specific watershed, it utilizes the data listed above and generates the peak runoff expected at the concentration point for that area. In this study, the concentration point is the location where the runoff crosses the railroad alignment. The level of detail of the program, and the conceptual nature of this rail access study, made the HEC-1 program appropriate for use only on watersheds larger than five square miles in the study area.

3.9.1.2 Regional Regression Equations. By contrast to the HEC-1 program, which models a watershed and predicts a runoff volume based on the specific features and expected rainfall of an individual watershed, regional regression analysis is a statistical method that utilizes a population of watershed characteristics and corresponding peak discharge data to generate an equation relating discharge values to watershed characteristics. The equation can then be used to predict a discharge value from watershed characteristics, provided the watershed in question is comparable to those in the population. Compared to the HEC-1 program, the regression equation method takes into account substantially fewer parameters, and the peak discharge values it generates are less reliable.

In this study, watershed and discharge data generated by the HEC-1 program for the larger watersheds, supplemented with data from other hydrology studies in Southern Nevada, comprised the data population. The regression analysis was performed on this data using the Multiple Linear Regression Program (MLRP) developed by the Corps of Engineers. Two equations were generated, one for each of two types of watersheds, and these were used to predict approximate 100-year discharge values for watersheds between one and five square miles.

3.9.2 Drainage Structures

The purpose of the hydrology analysis is to calculate design flows and establish a basis for the estimate of drainage structure costs. Drainage structures on a railroad typically vary in size and configuration depending on the specific sites, and vary from a minimum 18 inch diameter pipe culverts to bridges. For this conceptual study, it was not feasible to design and cost every individual drainage structure. In order to obtain a reasonable cost estimate, drainage structures were divided into two classes: minor structures, including pipe and

box culverts, and major structures, which were defined as bridges. The threshold differentiating the two was established by the structural engineer based on the economics of bridge construction. Any structure that would be larger than five large culverts was considered to be a bridge.

The design discharge corresponding to this threshold structure was estimated using US Bureau of Public Roads (US BPR) hydraulic design charts. A value of 4500 CFS was calculated. Once this figure was established, each structure with higher flows was analyzed individually as a bridge. Individual bridges and flows are shown in the tables in Section 3.10.

Bridges to span the larger flows were sized and costed, and are indicated on the plans. For the smaller flows, culvert requirements for a representative segment of the alignment were sized and costed, and converted to a per-mile cost which was applied to the entire length of the railroad. This cost is identified as "Minor Drainage Structures" in the cost estimate.

A total of 421 watersheds was identified in this study, of which 10% or less will require a bridge. The largest flows are on the order of 15,000 to 35,000 cubic feet per second (cfs), with one at 43,000 cfs. A 30,000 cfs run-off volume translates roughly to a 2500 foot-wide flood plane flowing 3 feet deep at a speed of 4 feet per second. Such a flow could be constricted to go under a 1200 foot-long bridge.

Not all locations within the study area are suitable for a simple bridge or series of culverts to transport flood waters under the railroad. In some locations, the alignment crosses active alluvial fans, on which flow patterns are random and change with each major storm event. Put another way, locations of major flows crossing the alignment in active alluvial fans are unpredictable. To solve this problem, dikes, channelization or many extra culverts may be needed. A study of the effects of alluvial fans was not within the slope of this study. Research in the area is currently being performed by Dr. R.H. French of the Desert Research Institute. Future design activities will be coordinated with this DRI research.

3.10 STRUCTURES

3.10.1 Scope of Work

The conceptual design of major structures includes grade separation bridges (rail over road), and bridges for stream crossings of major watersheds. The structures have been located from the topography on the plans, and sized to provide adequate road clearances or waterway openings. The bridge sizes are shown on the plans and profiles for each route being considered. A

complete table of structures showing locations and sizes is included at the end of this section.

3.10.2.1 Grade Separations. Based on the profiles developed for the railroad, all bridge sites investigated require rail over road structures line. The bridges should be three span structures. The center span lengths have been calculated to provide an opening for two 12-foot traffic lanes, two 10-foot shoulders and 3 feet of clearance to the pier faces. This provides a normal opening of 50 feet clear between pier faces. The actual span length has been calculated for each bridge to allow for the measured skew angle.

The side span lengths are calculated to provide for a 2:1 embankment slope, starting 2 feet below the bridge deck soffit, with a toe at the back of the pier, and allowing for the skew angle. Vertical clearances have been checked to provide a minimum of 16'-6". To provide this minimum clearance, the railroad profile has been raised rather than lowering existing roads. However, where the calculated clearance exceeded the minimum value, the profile has not been lowered.

3.10.2.2 Stream Crossings. Catchment areas producing a 100 year design discharge of greater than 4,500 cubic feet per second have been investigated for bridges. The normal flood level has been calculated using Manning's formula to determine the depth of flow and velocity in the approximate cross section of the stream bed as determined from the 1=500' scale mapping. Bridge openings have been sized to limit possible scour damage and provide adequate freeboard. River bridge spans have been chosen in multiples of 75 or 100 feet, where the total opening is sufficient to limit the velocity under the bridge to 7 feet per second, or to provide a constriction ratio of between 0.5 and 0.7. Also the profile has been raised where needed to provide 3 feet of freeboard. At this stage, bridge backwater calculations have not been carried out, since the assumed cross sections are only approximate.

3.10.3 Basis of Design

3.10.3.1 Grade Separations. Structures supporting railroad loads are designed according to the latest revisions of Volumes I and II of the "Manual of Railroad Engineering", published by AREA. The design load is Cooper E80 plus impact load. The superstructure width is 19 feet, which provides for 9'-0" clearance from the centerline of track to the face of the tubular handrailing on both sides.

For simplicity of design, fabrication, erection and maintenance, superstructures consist of four standard precast prestressed concrete box girder units, placed side by side. These box beams

are 3'-6" wide, and vary in depth from 4'-0" for a 52 foot span to 6'-0" for an 80 foot span.

Vertical clearances were checked at each site, to provide for a minimum of 16'-6". These calculations were based on 7" of rail, 7" of tie and 8" of ballast, with an allowance of 2" for tolerances, giving a total of 2 feet in addition to the box beam depth. Existing road grades were interpolated between contours, or spot elevations shown on the 1=500' plans.

The piers are all single rectangular columns, with hammerhead caps and spread footings. The abutments are cantilever walls, with earwing returns parallel to the track centerline and founded on spread footings. In the use of embankment heights greater than 30 feet, it could be more economical to use a strip footing, supported on driven piles. Refer to Table 3-1 at the end of Section 3.10 for data on individual grade separations.

3.10.3.2 Stream Crossings. The use of Manning's formula for calculating the depth and velocity of flow in normal stream sections, has been simplified by making the following assumptions:

1. The roughness coefficient was taken as 0.07 representing ground conditions of sand and gravel, with cobbles and a few boulders, plus light brush.

2. The stream bed slopes are constant between adjacent contours on either side of the bridge site.

3. The wetted perimeter of each section is the same as the surface width, hence ignoring the small difference between the water surface and the stream bed surface, measured across the stream.

The bridge openings were chosen in multiples of 100 or 75 feet. The overall opening was controlled by the following limits, in order to avoid excessive scour or possible flooding of the track by backwater.

1. Average velocity through the bridge opening is not more than 7 feet per second.

2. Bridge opening ratio is not less than 70% for stream bed slopes of 2% or greater.

3. Bridge ratio is not less than 50% for stream bed slopes less than 1%.

4. Minimum freebound under bridge beams is 3 feet.

5. Concrete abutments have splayed wingwalls up to 30 feet high.

6. Spill-through abutments have rock armoring at the embankment toes for fill heights greater than 30 feet.

For simplicity of construction, and possible economy in repetition, use of the same standard box beams as for grade separation bridges has been assumed. During final design the alternative of a cast-in-place reinforced concrete box girder bridge should also be detailed, so that contractors can bid on both types.

The piers are all circular to provide less turbulence than rectangular piers, with hammerhead caps and spread footings. The cantilever wall abutments and splayed wing walls are on spread footings. The spill-through abutments for fill heights greater than 30 feet are on pile foundations.

For the stream crossings between Caliente and Panaca, where the alignment follows an abandoned railroad, there were no hydrology calculations. Bridges were sized by taking 50% greater opening width than on the existing railroad which assumes that the original design was not based on a 100 year flood. A minimum opening of 75 feet was used and box culverts were assumed for smaller streams. Refer to Table 3-2 for data on individual structures.

TABLE 3-1 GRADE SEPARATIONS

Station	Skew(°)	Spans (feet)
2076+00	30	35/60/35
4352+00(Base Route)	44	60/73/60
6097+00(Route A Opt.)	52	93/93/93
11001+50	25	37/58/37
20751+50	56	85/93/85
21083+50	48	60/78/60

TABLE 3-2 STREAM CROSSINGS

Station	Flow (CFS)	Length (feet)
1529+00	*	150
1543+00	*	170
1571+00	*	200
1671+00	*	150
1676+00	*	150
1691+00	*	150
1867+00	*	75
1934+00	*	150
2055+00	14,000	600
2945+00	4,700	200

(*No hydrology available)

(Base Route Only)

3355+00	8,850	500
3379+00	16,650	500
3469+00	6,750	300
4370+00	9,500	400
5565+00	6,000	300
5934+00	16,500	500
6127+00	6,700	200
6195+00	6,400	200
6275+00	5,750	400
6431+50	6,450	300
6506+50	5,000	300
7053+00	5,200	300
7254+00	10,850	500

TABLE 3-2 STREAM CROSSINGS (Continued)

Station	Flow (CFS)	Length (feet)
(Route A Option Only)		
4084+00	14,100	500
5730+00	9,250	400
6051+00	10,000	700
6242+00	5,000	300
6671+00	5,800	200
6324+00	8,150	400
7448+00	10,300	400
8488+00	13,900	700
8309+00	6,500	400
Common Section		
11576+00	5,500	400
13054+00	3,950	500
13836+00	6,450	400
14095+00	9,900	600
14950+00	42,700	1000
14985+00	9,850	400
15451+00	28,800	700
17157+00	7,700	200
19900+00	29,800	1200
20320+00	34,600	1300
20830+00	14,800	500
21865+00	29,200	1200
22325+00	15,800	300

3.11 SIGNALS

3.11.1. Functions of Railroad Signals.

The principal purpose of a railroad signal system is to ensure safe movement of trains under all anticipated situations. The stopping distance of a freight train usually exceeds required sighting distance, and a method is required to provide sufficient warning to a train should a hazardous condition exist in advance of its current location. Furthermore, the track alignment, geographical features and weather conditions can all decrease sight distance. The signal system or the personnel in charge of operating the railroad must verify that it is safe to proceed into any given section of the railroad before allowing a train to continue.

A railroad can be operated without a signal system if sufficient operating personnel, rules and procedures are employed, and the operating speed and other considerations permit. The manual block system uses an operator or dispatcher to control the access into each segment of the railroad based on knowledge of the actual conditions in that area. Modern communications allow the dispatcher to be placed at a central point, and use the schedule and train orders to control the movement of trains via voice communications. The dispatcher is charged with monitoring and directing all train operations on the railroad. Departures from terminal locations, coordination of trains that must meet and pass at sidings along the railroad, schedule deviations, track outages and emergencies are all under the supervision and control of the dispatcher. Where there is no signal system, the dispatcher alone can give the train permission to proceed. Train orders, which are issued by the dispatcher and confirmed by the train operator, contain the basic level of permission to proceed over a section of the railroad.

Where a signal system is in effect, the authority to proceed is presented by the wayside or in-cab display of an aspect that, by rule, requires the train to operate in accordance with the indication. The dispatcher is still in charge of all operations on the line, but the automatic system, by monitoring the location of trains and status of hazard detection systems,provides the immediate vital information to allow train movement into a section of the railroad.

There are three distinct functions of signals used on a railroad. Train movement signals keep trains apart from each other. Local hazard signals detect potentially dangerous conditions on the track or on the trains. Highway and road grade crossing signals keep trains and road traffic from crashing into each other.

3.11.2 Rationale For System Design

Train movement signals are usually provided on railroads when traffic density requires keeping trains a safe distance away from each other. A normal freight railroad with only three round trips per month, or only one train normally scheduled on the track at any time, would not be signaled. A Yucca Mountain railroad will carry a unique cargo, so the basis for signalizing a normal freight railroad may not be relevant. In addition, most of the other railroad tracks over which the nuclear waste train will travel are signalized, so one could argue that a Yucca Mountain railroad should be no less controlled than the rest of the routes in the country. The provision of signals on this railroad is therefore a policy decision based on the nature of the cargo and the potential hazards associated with it. The engineering study has identified three options for train signals for the purposes of identifying the capabilities of train signals and estimating costs.

3.11.3 Applicable Regulations and Standards

Part 236.0 (c) of the Rules and Regulations Governing Railroad Signal and Train Control Systems issued by the Federal Railroad Administration, FRA, of the Department of Transportation states in part, "where...a freight train is operated at a speed of 50 or more miles per hour, a block signal system shall be placed permanently in effect....." A block signal system is a method of governing the movement of trains into or within one or more blocks by signals placed at the entrance to these blocks. These signals display indications, called aspects, for the various conditions of the blocks ahead. Aspects used on most U.S. railroads consist of colored lights. If the block ahead is occupied by another train, the signal would indicate STOP. And, if the block was not occupied, the signal would indicate CLEAR or some intermediate aspect depending on the location of the train or hazardous condition ahead. The train operator must, by operating rules, take the appropriate action at each wayside signal.

The design and installation of the signal system must comply with the aforementioned FRA rules and regulations, the principles and practices of the Association of American Railroads and state and local laws.

3.11.4 Signal Systems and Functions

3.11.4.1 Train Movement Signals. There are two basic categories of signal systems. First, the time interval system, where trains are separated in time by a schedule. And, second, the space interval

system, where the railroad is divided into segments called blocks, and trains are separated by maintaining a number of unoccupied blocks between them.

- Time Interval System: The timetable and train orders provide the basis for train movement and separation. Trains operating in opposing directions will meet at passing sidings, and trains must be dispatched from terminal locations. These provisions are included in the schedule. The superiority of trains would be noted in the schedules and train orders, which would determine which train must yield the main track and take the siding when two trains meet on the railroad. The schedule would be designed to have the inferior train arrive at the siding well in advance of the superior train for safe operations on the railroad. Superior trains would typically be those headed for Yucca Mountain, and inferior trains would be empty trains headed away from the potential repository. The train dispatcher would have to monitor train movements using the time table and verbal communications with the train operator. The schedule would be designed to dispatch trains at intervals significantly longer than safe train stopping distance. As long as both train remains on schedule, safe train operation would be maintained.

- Space Interval System: This system is composed of two basic elements, train detection and information display. In a conventional block signal system, train detection is performed by track circuits, which are electrical circuits that use the running rails as part of the circuit. The circuits are designed with a source of energy, steady state direct current (DC), alternating current or coded DC, at one end and a detection device at the other end of the length of track or block. The continuous flow of energy in the circuit represents an unoccupied length of track or block. The presence of the train's axle/wheel combination forms a short circuit between the two running rails, interrupting the energy to the detection device at one end of the circuit. This is known as a "closed loop" design, and any failure or broken wire results in a circuit condition identical to the presence of a train. In this way, safety of train detection is ensured.

  The second element of the system, information display, is typically in the form of a wayside signal in railroad applications. This signal is composed of a series of colored lights stacked one upon another. The color of the lights is used to convey information to the train operator about the track blocks ahead. If the track circuit detection device was not energized, or if there were a failure condition or a train in its circuit, it would control the signal to illuminate a colored light, usually red, indicating stop. The signal in approach to the "red" signal would be illuminated a different color to allow a train to proceed, but also informing it that the next signal is red.

3.11.4.2 Track Circuits. The typical track circuits that can be used with a non-electrified railroad are direct current circuits with a battery source and relay as a detection device. Shorter track circuits can use alternating current as a source and an AC relay as a detection device. Each track circuit is separated from the adjacent circuit by insulated rail joints, which prevent the electrical signals from passing.

A more modern development is the coded track circuit, which exhibits superior characteristics such as longer transmission distance and better train detection with rusty rails. These systems are all electronic, and have a DC source which is interrupted at a rate based on the condition of the tracks in advance. This pulsating current is detected and decoded at the other end of the circuit and the signal lights are illuminated accordingly. The pulsating direct current signals are of a greater magnitude than in conventional direct current circuits. This allows the rust on the rails to be more easily ionized for improved train detection.

The coded track circuits, like most all track circuits, require insulated rail joints to electrically define the limits of each track circuit. Coded DC track circuit signals may have to bypass the insulated joint and be transmitted to the next adjacent block signal. This task is performed by regenerative repeaters that detect the pulsating current, amplify it, verify the integrity of the signal and retransmit it around the insulated joint to the next receiver. This allows the signals to be transmitted over great distances.

3.11.4.3 Types of Signal Systems. The types of signal systems are described below:

- (DARK) No Signal System, Train Radio Verbal Coordination with Train Orders. This concept has no block signal system. Train operators report to the central control facility upon reaching predesignated locations along the line. The time table would be used by train dispatchers to manually measure train progress, using a train sheet, against the schedule and monitor relative position of all traffic on the railroad for meet and pass planning and coordination. The safe separation of trains would be controlled by adherence to the schedule and train orders.

- Manual Block System. The most basic type block signal system is the manual block system. This system requires an operator at each signal location to manually control the signal aspect. The block operator uses the timetable, train orders and the train sheet to monitor traffic on the railroad. Radio or telephone communications between adjacent locations and train radios would be required. Each block operator communicates train movements to the adjacent block operator. In this way,

train movements are coordinated to ensure safe train movement. A Manual Block system would meet the requirements of the FRA for operation at speeds of 50 mph or greater. However, this type of system would require an extensive operating staff and facilities for them at each signal location along the entire railroad.

- Automatic Block Signal System. The second type of block signal system is the automatic block signal (ABS) system. The automatic block signal system uses track circuits to detect the location of trains and automatically illuminates signal lights based on this location information. Trains are safely separated by adhering to the signal indications.

- Advanced Train Control System, ATCS. The newest concept in train detection and tracking is the Advanced Train Control System (ATCS). This radio-based system employs markers consisting of inert (non-powered) transponders installed at regular intervals along the entire length of the railroad. These markers identify their exact location. As the train passes them, this location data is received and processed by equipment on board the locomotive. The on board equipment is implemented with vital microprocessor technology and includes an odometer that is used to measure train location between markers. The location data is compared at marker locations to ensure that safe and reliable train location data is transmitted to the central control facility. The central control facility receives and processes the location data of all trains on the railroad as well as detected hazards. This processing is also performed by a vital microprocessor.

  If a cab signaling concept were to be employed, the proper aspect would be transmitted to the train for the current zone and the next zone in advance of the train and would be displayed in the train's cab. Changes in system conditions are transmitted to the central facility and appropriate aspect messages are composed and transmitted back to the trains. The train location information is transmitted to the central control facility and displayed on a CRT-based display. The dispatchers can monitor train location in real time and coordinate all train movements. The schedule and train orders supplement the real time train location information and would be used by operating personnel to coordinate train movements via voice radio contact with train crews.

3.11.4.4 Local Hazard Detection Signals. There are two basic categories of local hazards.

- Wayside hazards that occur along the railroad right-of-way. These type hazards include rock slides, high water, broken rails and open track switch points. Where an automatic block signal system is employed, the hazard detection system

controls the signal aspects, which tell the train to stop prior to the hazardous location. Where a block signal system is not in use, local warning signals are place at least safe braking distance away from the detected hazard.

- Train (on-board) related hazards include overheated wheel bearings, cracked wheels and dragging equipment. Local detectors along the track detect hazards on the train and control signal aspects where a block signal system exists, or provide a local warning signal indication of the hazard if there is no block signal system.

3.11.4.5 Grade Crossing Signals. Grade crossing signals prevent trains and road traffic from crashing into each other. Specific grade crossing devices are usually governed by state regulatory agencies, and include bells, flashing lights and gates. The signal is activated by the train detection system when an approaching train is within defined limits of the crossing. The train detector consists of a constant warning device which actuates the crossing warning signals a fixed time interval ahead of the train, regardless of the train's speed.

3.11.4.6 Signal-related Communications. Effective operation of the railroad will require both voice and data communications. Voice communications are required between the central control facility and all trains on the system and with operating and maintenance staff anywhere within the system. Where an automatic block signal system is not employed, voice contact with trains on the system is a primary tool to verify train location and maintain adequate train separation. A space radio system is the preferred method of systemwide voice communications.

Data communications is required to alert operating personnel of the hazards that exist along the railroad, and to communicate train location within the railroad. Data communications can be via radio that uses a combination of base stations, repeaters and microwave links or geosynchronous satellites. Data communications can also be performed via land lines using local telephone company facilities supplemented by data transmission systems. The coded DC track circuit is a form of data transmission system because it allows information about the hazards and train location to be transmitted along the railroad via the running rails.

3.11.5 Recommendations

The nature of the cargo and the length of the rail line, 350 to 400 miles, to the potential Yucca Mountain repository make train location and tracking primary factors to consider when designing signal and communications systems. However, as stated earlier, the very low traffic density would not normally justify a

signalized railroad. The basic signal system recommended for a Yucca Mountain railroad is a "dark" railroad with detection and annunciation of local hazards, and grade crossing signals at paved roads. Maximum authorized speed would thus be 49 mph in accordance with FRA regulations. The hazards present along the railroad right-of-way and those detectable on board the train would be annunciated locally and at a central location for action by the train dispatcher. In this way, a train on the railroad can be notified of the hazardous condition thereby preventing a potentially unsafe situation.

3.12 COMMUNICATIONS

3.12.1 Voice Communications

A two-way radio system is needed to support voice communications among train operators, maintenance personnel and the central control facility at Yucca Mountain to coordinate schedule changes and maintenance activities, report on operating conditions, and facilitate response to hazardous or emergency conditions. With the use of appropriate interface equipment, a radio system can also be used to transmit data such as alarms from detectors.

Specific groups of frequencies have been set aside by the Federal Communications Commission for use by railroads and rail transit systems to support their mobile communications requirements. These include channels in the 150 Megahertz (MHz) very high frequency (VHF) band and in the 450 MHZ and 900 MHz ultra high frequency (UHF) spectrum bands. Radio links in these frequency bands are generally referred to as line-of-sight communications because signal strength drops off quickly beyond the visual horizon. VHF frequencies provide a wider coverage area than UHF frequencies for a given tower height and transmission power, and are therefore preferred for most railroad operations.

A group of 97 channels in the 160 to 162 MHz VHF band has been allocated for railroad use. Assignment of these frequencies is handled by the Association of American Railroads. While these frequencies are heavily utilized in major metropolitan areas, no problem is anticipated in finding one or two frequencies in this band available for use by a Yucca Mountain railroad, considering the rural area in which it will be operating.

3.12.2 ATCS Communications

ATCS systems use radio-based data transmissions to provide cab signals in the locomotive for train control. However, most of these systems use different frequencies than those typically used for voice communications. The ATCS specification calls for the use of channels in the 900 Mhz band, although a modification of

this approach using satellite transmissions is also being investigated. Because of the error checking and redundancy built into data transmissions, reliable data communications can be achieved with received signal level much lower than that needed for clear voice communications. Therefore, if an ATCS system is selected it is likely that separate train radios and base stations will be needed for the voice radio and ATCS data radio, although they would share use of the tower and equipment shelter.

3.12.3 Radio Base Stations

The coverage that can be achieved from a radio base station depends on transmission power, tower height, height of the transmitter site above the surrounding terrain, type of antenna, and the type of geographic area in which coverage is to be provided. Mountainous areas are probably the most difficult terrain in which to predict coverage. As a rule of thumb, large railroads assume that a base station will be needed every 30 miles when planning for coverage of new routes. The same assumption was used in estimating costs for this railroad, which resulted 12 base stations for the 340 to 350 mile line. However, a thorough site study ad engineering analysis is needed before this design can be advance beyond the conceptual stage. An additional base station was added to Route A to transmit signals through a leaky feeder coaxial cable in the tunnel section, so that trains would continue to receive radio transmissions while in the tunnel.

3.12.4 Microwave Transmission

Since the radio base stations have a limited range of coverage, it will be necessary to have some type of a backbone transmission system to carry signals between the base station locations and the central control site. One method frequently employed for long distance communications is microwave transmission. Microwave systems operate at the high end of the UHF band, typically in the 6, 11, 18 and 23 gigahertz (GHz) frequency band. As with the two-way radio frequency bands mentioned above, the lower frequency 6 GHz band is preferred since signals travel farther before fading than they do in the higher frequency bands.

Unlike mobile radio systems in which the antenna transmits signals over a broad area to support point-to-multipoint communications, microwave systems are used mainly for point-to point communications. Microwave systems use dish shaped antennas to focus the energy into a narrow beam, allowing the signal to be transmitted farther.

In situations where a fairly small number of mobile radio base stations need to communicate with each other, it is sometimes

possible to use a second frequency in the two-way radio band to act as a repeater for the signals. It may be possible to combine this technique with the use of leased lines form the local telephone company at Caliente Interchange and the mid-route location to provide a much lower cost method of transmitting signals between the Yucca Mountain site and the base stations. However, since it is impossible to determine the feasibility of this approach without a much more detailed engineering analysis, the cost estimate reflects the more traditional and more expensive microwave system.

A transmitter site will be needed for each of the radio base station and microwave locations. As a general rule, it is desirable to locate these sites on the highest mountain peaks available that are close to the rail line. The site must have road access since it will be necessary to perform periodic inspection and maintenance of the equipment. It may be possible to find one or two locations where a tower already exists, such as a common carrier microwave site, on which space can be leased to mount an antenna. Costs for purchase or lease of land for tower sites has not been included in the communications cost estimate.

3.13 RIGHT-OF-WAY

Most of the alignment passes through land owned by the Bureau of Land Management (BLM), and it is assumed that right-of-way and borrow pits will be made available in these areas at no cost to DOE. The last twelve miles of the railroad, at the approach to the repository site, lie within the Nevada Test Site, which is already property of the DOE.

In a few isolated areas along the alignment, portions of privately-owned land may need to be acquired by DOE for the railroad right-of-way. The affected areas are south of Panaca, in the Pahranagat Valley (Route B), a few locations between Mud Lake and Lida Valley, in Sarcobatus Flat near Scottys Junction, and in Oasis Valley, northeast of Springdale.

4. OPERATIONS

4.1 OVERVIEW OF RAIL OPERATIONS

4.1.1 Terminology and Definitions

The terminology "operations" has several interpretations in the railroad industry and especially with customers and individuals that transact business with the railroads. The usage of this term could make reference to a department in the railroad organization, a management center, functions associated with train movements, or the application of the term as defined in the dictionary. The usage of the term in this report is qualified below to avoid confusion.

4.1.1.1 The Operating Department. The Operating Department in a typical railroad organization is usually the largest department in the company when compared to the other vital segments. It is usually managed by the Vice President of Operations who has the responsibility for all system functions associated with train movements, track and equipment maintenance, engineering, equipment distribution, training, safety, and procedures.

4.1.1.2 The System Operations Center. The System Operations Center on a railroad is a 24-hour office usually situated at the headquarters of the carrier that is responsible for the management of trains, cars, locomotives, and train and engine crews. The center also serves as a focal point for accumulation and dissemination of vital information associated with emergencies such as derailments, fires, floods, hazardous materials incidents, and injuries and fatalities. The initial reporting and notification of such events to regulatory bodies and top company management is the responsibility of the center that is commonly referred to as Operations.

4.1.1.3 Operations. Operations is also a term that is used to associate events, procedures, or personnel that are directly related to train movements but are disassociated from that portion of the Operating Department that is involved in track or equipment maintenance.

4.1.2 Railroad Methodology and Technology

The railroads can be viewed as possibly the greatest advancement in transportation through the development and application of machine generated energy to transport goods and people over a low friction roadway. By overcoming the limitation of using a single vehicle to move shipments and reliance on animal power, the railroads emerged as a viable and efficient mode of

transportation. The willingness of the industry to accept and implement the latest technology into their system enabled the railroads to operate bigger and heavier trains efficiently and safely at higher speeds. The most significant example would be the application of air brakes and automatic couplers to the rolling stock, and the usage of telegraph and telephones to issue movement instructions to trains.

The introduction of signal systems to control movements, and provide protection for trains, was a notable step toward establishing a safer operating environment. This is especially true when the visibility is limited in a region that has a heavy density of traffic and obscure curves. Some of this early technology has been modernized, but generally it has been replaced with state of the art equipment. Presently, the trend is toward the usage of modern computers in conjunction with microwave and fiber optics communication systems to transmit data and control train movements.

4.1.3 Scope of Rail Operations Analysis

The conceptual operation plan for the Caliente route of the potential Yucca Mountain Rail Access Project is a preliminary effort based on the conceptual alignments and profiles presented in this report. It is also based on general operational railroad knowledge that was gained through the consultant's 43 years of experience with a major railroad, including establishing schedules, operational parameters, and overseeing actual movement of the Department of Defense, and Department of Energy shipments, many of which required special surveillance and security due to the sensitive and controversial nature of the load.

Based on Department of Energy projections, this plan anticipates seven to eight shipments per month without a MRS and four to five shipments per month with a MRS. Shared use is also expected, though the likely volume of shared-use trains is not known at this time.

This plan presents a reasonable assessment as to how train operations would be conducted without a costly model analysis. This plan includes locomotive and train crew requirements, transit time for the shipments, and possible location for the crew change point and other facilities. An operation scenario was developed describing two of the possible options in train operations, based on the assumption that it is desirable for the shipment to be moved directly to the potential repository without any delays between the mainline railroad and the potential site.

Five methods of managing and operating the railroad are also addressed. Although there are similarities in the overall operation of the railroad, each of the modes is different in scope, dependability, safety, experience, equipment inventory,

and personnel requirement. A summary of the advantages and disadvantages of each is given at the end of this chapter. Track and equipment maintenance are addressed by identifying the equipment, facilities and personnel requirements under each scenario. A cost analysis, described in Chapter 6, is made for each mode for comparison purposes.

The necessity for a Railroad Emergency Response Team is evaluated to determine what role it plays during an emergency, inasmuch as the Department of Energy (DOE) has the Radiological Assistance Program (RAP) team in place. Additional National Railroad infrastructure are addressed briefly to show how it may impact the train operations on the potential railroad. Lastly, the operations plan concludes with recommendations for the contractual mode of operation.

4.2 INSTITUTIONAL ASPECTS

4.2.1 Institutional Overview

Historically, especially in the western part of the United States, the railroads were constructed to encourage the settlement of virgin territory by providing the means of transportation for goods and people. The support of the Federal Government, through generous land grants and financial assistance, helped bring about these objectives, and eventually tied the nation together with a network of railroads. However, in the present era, railroads are usually built only when there is assurance that the endeavor will provide a reasonable return on investments and be a profitable venture for the carrier on a long term basis.

Since this possible Department of Energy (DOE) railroad does not fall into either category, the construction of the rail line becomes a rather unique undertaking. In this particular instance the federal government participation in the building of a railroad into a remote region, that does not have rail access, is for a very exceptional and special purpose. The possible line would serve as the final leg, or link, for rail transportation of high level radioactive waste from a junction point on a major trunk line to the potential repository. The sole purpose and justification for the building of a rail line would be to provide a safe and efficient method for the transportation of a waste product that is placed solely in the custody of the Department of Energy for movement and disposal. Since the railroads have the capability of handling larger and heavier shipments than motor carriers, it becomes highly desirable to use the rail mode of transportation in order to reduce the number of individual shipments over the life of the program.

Although this chapter describes a conceptual overview, further advisory assistance in managerial and operational skills from the various sources that are presently associated, or available, within the railroad industry will be important. Such support is suggested not only in the future stages of development but also during the entire operational phase to support the implementation and maintenance of a safe and efficient operation.

4.2.2 Ownership and Operating Scenarios

The participation of the Department of Energy in the design, construction, and procurement process for the new railroad would be a one time effort during the life of the program. However, the role of the DOE would change drastically if the decision is made to venture into the operation and maintenance of the new railroad. It automatically would change from a one time effort in construction and procurement to a 24-hour daily task in train operations, inspection and repair of track and equipment, training and supervising personnel, and working under strict operating rules and federal regulations.

The undertaking would be a major task, unlike the operation of a small branch line or industrial spur that government agencies have been known to manage and operate very successfully. The length of the rail line alone places it in the size category of a regional railroad. The mountainous terrain the rail line would traverse, and the steep grades associated with the route, would be comparable to those of some major western railroads. Although the gross tonnage and volume of traffic would be substantially less than what regional and major carriers handle, the operational and regulatory procedures would be the same, if not stricter, due to the commodity that is being transported.

Due to the operating conditions and regulatory requirements, it would be important that the DOE hire knowledgeable and experienced railroad personnel to operate the trains and maintain the track and equipment. Incentive pay may be important over a long term due to the remote location of the rail line and the necessity for personnel to work and reside in a sparsely populated desert environment.

4.2.2.1 DOE Owned and DOE Operated. This option allows the DOE to have full control over the construction, management and operation of the railroad except in those areas where other federal and state regulatory requirements must be complied with. The undertaking can be categorically summarized as follows:

- Design and build the rail line from a junction point on the connecting railroad to the potential repository site and construct all the necessary facilities associated with the

railroad, including those necessary for shared use with of the rail line with other public or private entities.

- Purchase or lease all the locomotives, cars, emergency equipment, and track maintenance machinery to support the new railroad operation.

- Hire personnel, test facilities, establish training programs, develop the operational policy, formulate the operating rules and procedures, and institute a maintenance and inspection program.

- Maintain a daily 24-hour railroad operation with a fully qualified staff of managerial personnel, track and equipment maintenance employees, train operation crews, train movement control personnel, and a security force for the life of the project. Coordinate with shared use as is feasible.

- Maintain records and perform inspections and maintenance on rail equipment and trackage as may be required by the Code of Federal Regulations (CFR-49) and the State of Nevada Public Service Commission regulations.

- Utilize train operations, train control, and signal maintenance employees in a manner prescribed under the Code of Federal Regulations (CFR 49 Part 228.) which limits the length of time certain employees may remain on duty.

- The DOE would be liable for all the activities associated with the railroad with the exception of those from shared use.

4.2.2.2 <u>DOE Owned and Shortline Operated</u>. This option allows the DOE to delegate the operation of the railroad to an existing small carrier through a selection process. The bid would be awarded to the lowest cost and most qualified and cost-effective operator under a long term contractual agreement.

- The DOE would control the design and building of the rail line from a junction point on the connecting railroad to the potential repository site, and construct all the necessary facilities associated with the railroad.

- The railroad and facilities would be assigned to the shortline carrier with a contractual agreement that the trackage will be maintained to a Class 4 track standard (49 CFR).

- The DOE would purchase or lease all the locomotives, cars, emergency equipment, and track maintenance machinery to support the new railroad operation. Such equipment would be assigned to the shortline carrier for use on the DOE railroad. The shortline operator would be contractually responsible for the inspection and maintenance of the equipment (49 CFR). Additionally the contract would not permit the shortline carrier to transfer or sublease any of the DOE owned equipment

to other railroad companies that may be under the same management.

- The DOE would take the necessary action to make the railroad operational, which would include the final testing of the trackage, signals, facilities, and equipment before contracting the operation to the shortline carrier.

- The DOE would establish priorities and develop a contractual policy as to the handling of DOE shipments on the new railroad. The shortline carrier would adhere to these terms to insure that DOE objectives were met satisfactorily.

- It is recommended that the shortline carrier maintain a daily 24 hour railroad operation with a qualified managerial staff, train operation crews, train movement control personnel, and security forces per a contractual agreement to insure that DOE shipments are moved promptly and directly to the repository without any delays. The shortline railroads usually design their train operations to limited and non expeditious service in order to get better utilization of equipment and personnel. The employees are trained to perform many tasks, rather than being specialists in a given field. The strategy is very effective in controlling expenses but places limitations on service.

- The shortline carrier would maintain records and perform inspections and maintenance on rail equipment and trackage as may be required by the Code of Federal Regulations (CFR-49) and the State of Nevada Public Service Commission regulations.

- The shortline carrier would comply with the Code of Federal Regulations (CFR 49 Part 228.) which limits the length of time certain employees may remain on duty.

- The shortline carrier would be liable for all the activities associated with the railroad and should have sufficient insurance.

- The shortline carrier may under certain circumstances choose to rely on specialized service firms to handle major track and equipment maintenance to avoid increasing the size of the permanent work force. The practice is quite common where there is no conflict with labor agreements.

- The shortline operator will very likely try to develop additional revenue by providing rail transportation for other commodities. This will be important to the profitability of the venture because it is unlikely that the DOE traffic alone will be sufficient to support the operation without subsidies. The DOE should be aware and recognize the fact that shortline Railroads do not have the financial reserves to sustain any

lengthy loss of revenue. This would be the most important concern to the DOE in entering a long term contractual agreement with a shortline operator.

4.2.2.3 DOE Owned and Contractor Operated. Under this option the DOE would retain the ownership of the railroad, and facilities, but would rely on a contractor to perform all functions associated with maintenance and train operations.

- The DOE would control design and building of the rail line from a junction point on the connecting railroad to the potential repository site, and construct all the necessary facilities associated with the railroad.

- The DOE would purchase or lease all the locomotives, cars, emergency equipment, and track maintenance machinery to support the new railroad operation.

- The DOE would take the necessary action to make the railroad operational which would include the final testing of the trackage, signals, facilities, and equipment.

- The DOE would assume the financial responsibility for the operation and maintenance of the railroad by entering into a contractual agreement with a knowledgeable and reliable contractor that would be obligated to protect the DOE railroad operation interests. This could very well be the same party that is responsible for the operation of the repository. The contractor would very likely be reimbursed on a cost plus basis for services rendered.

- The contractor would be maintain records and perform inspections and maintenance on rail equipment and trackage as may be required by the Code of Federal Regulations (CFR-49) and the State of Nevada Public Service Commission regulations.

- The contractor would comply with the requirements of Code of Federal Regulations (CFR 49 Part 228.) which limits the length of time certain employees may remain on duty.

- The contractor carrier would be liable for all the activities associated with the railroad and should maintain sufficient insurance.

- The contractor may, under certain circumstances, choose to rely on specialized service firms to handle major track and equipment maintenance.

4.2.2.4 DOE Owned and Class I Railroad Operated. This option provides the DOE with a completely different scenario for operation of the railroad. The new rail line would become an extension of the connecting railroad rather than being an

independent carrier. Additionally it reduces the DOE capital investment in equipment and facilities and virtually removes the DOE out of the railroad business for the life of the program.

- The DOE would control the design and building of the rail line from a junction point on the connecting railroad to the potential repository site, and construct all the support facilities to satisfy the new mode of operation. Certain facilities such as a locomotive shop, interchange point, railroad headquarters, dispatchers office, and various other structures would not be necessary. The railroad and important facilities would be turned over to the connecting carrier to operate and maintain as an extension to their railroad.

- The DOE would purchase only the escort, cask, and buffer cars and possibly the switcher for the repository under this mode of operation. The balance of the equipment would be furnished by the connecting carrier. Under a contractual agreement the carrier would be responsible for the inspection and maintenance of the DOE equipment.

- The DOE would take the necessary action to make the railroad operational, which would include the final testing of the trackage, signals, and facilities, before entrusting the operation to the connecting operator. The contractual agreement would have a provision that the railroad would be maintained to a Class 4 track standard (CFR-49).

- The DOE would establish priorities and develop a contractual policy for the handling of the DOE shipment on the new railroad. The carrier, under a contractual agreement, would provide service that meets the DOE objectives.

- The connecting carrier would have the ability to quickly respond to DOE service requirements through the utilization of their managerial personnel, train operation crews, security forces, and emergency response teams that are readily available on short notice. The train movements would be controlled from a fully staffed 24-hour control office on a real time basis.

- The DOE shipments would move to the repository without the need to change crews or locomotives at the new railroad junction point.

- All the road locomotives, emergency and track maintenance equipment would be furnished and maintained by the carrier. Such equipment would be operated by experienced and fully qualified employees presently employed by the railroad.

- The carrier would comply with all the regulatory requirements under the Code of Federal Regulations (CFR-49) and State of Nevada Public Service Commission Regulations.

- The crew change station on the new railroad should be constructed at the location and to the specifications of the connecting carrier. This would include certain requirements associated with living quarters and other facilities that are covered by the Code of Federal Regulations (CFR-49) and labor agreements.

- The DOE would construct the rail car shop near the repository to the specifications of the carrier or contractor that will ultimately be conducting the inspection and maintenance on the escort, cask, and buffer cars in the facility.

- The connecting carrier would be liable for all the activities associated with the railroad.

4.2.2.5 Privately Owned and Privately Operated. Under this the DOE would sell the rail line, facilities, and equipment to a private concern, or consortium, with a contractual agreement for the usage and maintenance of the railroad during the life of the DOE program.

- The DOE would control the design and building of the rail line from a junction point on the connecting railroad to the potential repository site, and construct all the necessary facilities associated with the railroad. The railroad and the facilities would be sold to the private concern with a contractual agreement that the track will be maintained to a Class 4 track standard (CFR-49).

- The DOE would purchase or lease all locomotives, cars, emergency equipment, and track maintenance machinery to support the new railroad operation. Such equipment would be sold or leased to the new owner for use on the new railroad.

- The DOE would take the necessary action to make the railroad operational, which would include the final testing of the trackage, signals, facilities, and equipment before the sale is finalized.

- The DOE would establish priorities and develop a contractual policy for the handling of the DOE shipment on the new railroad. The new owner should have a contractual agreement to adhere to provisions that insure the objectives of the DOE are fulfilled satisfactorily.

- The private concern would have a contractual commitment to maintain a 24-hour railroad operation with qualified managerial personnel, train operation crews, train movement

control personnel, and security forces when moving a DOE shipment. Such a contract with the operator is recommended to insure that DOE shipments are moved promptly and directly to the repository without any delays.

- The operator would comply with all the regulatory requirements under the Code of Federal Regulations (CFR-49) and State of Nevada Public Service Commission Regulations.

- The owner, in purchasing the railroad, will likely develop other business on the rail line to generate additional revenue. There will have to be a contractual agreement that such business will not be detrimental to the DOE effort.

- The DOE would require assurance, perhaps by bonding, that the private concern will remain a viable rail transportation company for the life of the program.

4.2.3 Regulatory Requirements

The operator of the railroad will have to respond to the requirements of certain federal and state regulations and city ordinances in order to remain operational. Additionally, there are rules, standards, and procedures that the railroad industry has developed through the Association of American Railroads that will need to be implemented and maintained in order to interchange equipment with other carriers.

4.2.3.1 Code of Federal Regulations. The Federal Railroad Administration (FRA) of the Department of Transportation (DOT) is responsible for the enforcement of statutes and regulations related to railroad safety. The majority of regulations that fall under the FRA enforcement are found in Chapter II of the Code of Federal Regulations referred to as 49 CFR parts 200 through 268. However, certain regulations pertaining to the transportation of hazardous materials under Chapter I part 149 are also enforced by the FRA. Because the Code of Federal Regulations (CFR) is constantly updated by the individual issues of the Federal Register, the two publications must be used together to determine the latest version of any rule.

The application and interpretation of the CFR for the purpose of this report will be used in a board brush approach as how the regulations impact the design, maintenance, and operation of the railroad.

- The CFR would establish the maximum allowable train speed on the new rail line based on the design and construction standard and the quality of track maintenance. Based on the present design specification, the railroad would be maintained to a FRA Class 4 track standard which would allow freight

trains to operate at a maximum speed of 60 MPH if the track is signaled and 49 MPH if it is not signaled.

- The track inspection and maintenance would have to be conducted as prescribed in the CFR. If a segment of the track does not meet all the requirements for the intended class of track, the train speed would be reduced to the class for which the track is in compliance.

- The locomotives would have to meet certain CFR standards and be subject to prescribed inspection at required intervals.

- Rail cars and other rail mobile equipment are required to meet certain CFR standards and periodic inspections to remain in compliance. There are minimum standards that equipment, regardless of ownership, must meet before being allowed to move in the train.

- The CFR has a provision that is commonly referred to as the "Hours of Service Law" which governs the maximum length of time certain railroad employees can remain on duty without a rest period. A general interpretation of the regulation limits an employee to 12 hours on duty if engaged in the movement of trains, 8 hours if the duties are connected with the issuance of train movement instructions, and 12 hours for employees involved in signal system maintenance. The regulation also specifies rest requirements before returning to work. There is also a provision which addresses the distance requirements in a railroad environment for the construction of employee sleeping quarters.

- The CFR has numerous provisions for record keeping and reporting of inspections, train movements, accidents, and various other events related to the railroad.

- The FRA inspectors generally make inspections to enforce compliance and assess penalties for any violations.

4.2.3.2 State of Nevada Regulations. The Public Service Commission of Nevada (PSC) is responsible for the enforcement of statutes and regulations related to certain railroad standards. safety, and operation of trains in the state of Nevada. The PSC railroad inspector is responsible for the enforcement of the regulations.

4.2.3.3 Association of American Railroad Rules. The rules formulated by the Association of American Railroads (AAR) in two manuals, designated as the "Field Manual" and the "Office Manual" address the proper and fair handling of all matters related to interchange of freight traffic between carriers. The AAR Interchange Rules are based on agreed to terms for safety

requirements, standards, and settlement of damages and repairs to equipment. Any traffic interchanged with a carrier would be subject to these rules unless covered by an independent agreement between the two parties.

4.2.4 National Railroad Infrastructure

The railroads over the past two decades have undergone some significant changes through mergers, rehabilitation programs, and federal deregulation of freight rates to survive as a viable mode of transportation. Furthermore, the industry has taken advantage of the latest technology to implement more efficient and economic methods to manage, maintain and operate the railroads. Presently, many of the railroads are undergoing major changes in their organizational structure by eliminating layers of management in order to more quickly respond to customers needs and operational problems. The improvement and efficiency process would no doubt be an ongoing effort but certain existing problems discussed below will be much harder and more expensive to resolve.

In addressing the conceptual design of the DOE railroad and the development of an operational plan, it is prudent to recognize the unresolved problems and understand how they will impact the new railroad operation. These issues are national in scope and, as such, are beyond the scope of this contract. However, these issue are summarized here because they could have some effect on the operation of any new rail access route. Some have been addressed in the design. Others are more appropriately considered at a later time and/or from a national perspective.

4.2.4.1 Clearance and Weight Limitations. The railroad industry inherited the height, width, and weight limitation problem progressively over time due to the inability to recognize the potential problem during the construction stage of the rail lines. The demand for larger railroad equipment to some extent forced the carriers to take corrective action in resolving some of the problems on the main trunk lines and over some of the routes. This was accomplished by strengthening the track structure and increasing the height and side clearances as much as possible. In order to establish some control over the problem the rail industry established weight and dimensional standards on all rail cars and especially open top loads so that unrestricted movement could be accomplished between railroads.

Shipments in excess of the standard could not be moved without prearranged permission from the carriers involved in the routing. Because the process requires special loading, measuring, and handling procedures, such movements are usually slow and very cumbersome. The railroad industry would prefer a more efficient method to move oversize shipments, but it is unattainable unless

costly measures are taken to increase clearances in tunnels and the distance between tracks and other structures. Most of the railroads are establishing new clearance standards for new track construction or new alignments. Consequently, the possibility of a new 20-foot track center standard should be evaluated prior to final design of a new rail line in order to avoid the problems that presently exist in rail industry.

4.2.4.2 Train Size and Configuration Constraints. The DOE shipments would very likely be subject to the operational constraints of several carriers while enroute to or from the repository. Such constraints may vary on each of the railroads that is involved in the routing. The handling and movement procedures would be influenced by the ruling grades, weight limitation on bridges, physical layout of interchange trackage, and operational procedures on each railroad. It may become necessary under certain circumstances to gear the entire movement to the most restrictive operation or rail link in order to minimize switching cars in and out of the train. It is also prudent that consideration be given to designing flexibility into Repository and Monitored Retrievable Storage facilities to accommodate any train configuration that may be received from the carriers. Some of the anticipated constraints can best be summarized in the following manner.

- Spacer Cars. Due to weight limitations over certain bridges or trestles, some railroads may place spacer cars between the cask bearing cars to distribute the concentrated train weight when moving over such structures. Under certain other conditions, especially on steep descending grades, it may be necessary to insert additional cars in the train to achieve more effective braking on the train. Both scenarios would require proper placement of the additional cars to the train consist either at the originating point or at a designated location while enroute. In the event DOE chose to furnish the spacer cars from the origin, to avoid switching delays enroute, the train size would nearly double. The only other option is to rely on the carrier to preselect appropriate cars to insert in the trains as needed. Under either option, the constraints increase the costs of transportation. The sidings for the Caliente route would be able to accommodate a train with the additional cars.

- Railroad Interchange. The need for an interchange facility between carriers is a requirement to effectively exchange traffic. Usually the carriers have agreed to terms as how the interchange of cars will be accomplished. Generally each party to the agreement will assemble a train or a block of cars in their own switching yard which is ultimately delivered to the interchange track. The receiving carrier will perform an inspection on cars before taking responsibility for further

movement. This is usually a very routine and uncomplicated task that railroads conduct among themselves.

However, under certain conditions the physical location and track layout of the yard facilities between carriers will automatically reverse the direction of the rail cars being interchanged. Generally, this does not present any problems because rail cars need not be directionally oriented to move in a train. However, directionally reversing the equipment in a DOE HLW train will present operational problems to DOE and the carrier. Under such a scenario the train would encounter delay having the escort car placed on the opposite end of the train. In the event the cask cars are needed to be directionally oriented for unloading at the repository or the MRS facility, it would entail turning the entire train at some location before making delivery into the facility. This turning could be accomplished at the "Y" track at Caliente.

- Railroad Craft Unions. The railroad industry has some of the strongest craft unions in the nation. This is especially true with those representing the employees that are directly associated with the operation of trains or switching of cars in rail yard facilities. The unions conduct their negotiations with the carriers on a national level which involves the majority of rail carriers. Although the unions have become more lenient in their demands, the terms of the existing national agreement remain firmly in place. Some of the provisions that deal with wages date back to the turn of the century whereby employees are paid on a mileage basis rather than on an hourly scale. Under the terms, 108 miles of travel constitutes one day's pay. When such a pay formula is applied to train crew members on a present day freight train, it equates to nearly three days pay for 8 hours of work.

  The agreement contains numerous fringe benefits and penalty provisions that are very costly to the carriers. Some of the stipulations require additional pay for road crews that perform car switching, pick up or set out cars, turn cars or locomotives, and numerous other minor tasks associated with train operations. Additional pay penalties are assessed if the train does not leave the initial station at a prescribed leaving time. The same type of penalty is assessed if the train is not allowed to move promptly into the yard facility at the final station. The instrument is very cumbersome to apply to daily train operations due to the antiquated and restrictive terms that place limitations on management as how the crews can be utilized. Such constraints on the DOE railroad could add to the cost of the rail car movements to the potential repository.

- Speed Restrictions. During the early 1970's, the Board of Directors of the Association of American Railroads approved

the recommendation of the General Committee that established operating procedures for movement of spent nuclear fuel via rail. Under the recommended practice, a maximum speed of 35 MPH was imposed on all rail cars bearing casks loaded with spent nuclear fuel. During the same time frame the Department of Defense (DOD) also placed a 35 MPH speed restriction on their rail casks whether loaded or empty. The railroads continue to abide by the recommended practice and the DOD restriction. The speed restriction, if adopted by the operator of the new DOE railroad, could affect the operational plan. The slower speed could impact the utilization of train crews and possibly motivate relocating the crew change point.

- Fenced Sidings. The railroad industry has in place the ability to provide surveillance and protection for rail shipments. It has demonstrated the capability of moving thousands of security sensitive shipments such as ammunition, bombs, explosives, rocket motors and military equipment successfully by utilizing railroad police to provide security and protection. Most of these shipments move in common rail cars that do not carry a signature that identifies the commodity. However, there have been occasions when railroad police were ineffective providing protection for controversial sensitive shipments that carried a clear identity. A case in point is the DOE war head train, the so called White Train, that protest groups harassed and attempted to stop at various locations along the rail route. When the groups did stop the train, the railroad police, with full support from the local law enforcement officers, could not disperse the crowd or make effective arrests.

  There was a consensus among many in the rail industry that a "Safe Haven" facility would have been helpful in providing protection for the train during such protests. Since the HLW train could possibly attract the same type of attention, fenced sidings are included in the conceptual design at about 100-mile intervals on the new rail line (Appendix B). This design is a trade off between the limited availability of law enforcement personnel to provide security and protection for the train and the personnel in the railroad's remote regions and the cost of providing fenced sidings more frequently. Regular sidings are provided about every 20 miles, which is acceptable for the level of traffic expected (Appendix B).

4.2.5 Shared Use of the Railroad

The potential for the shared use of the DOE railroad is difficult to forecast, but the opportunity for the Department of Defense, business firms, and entrepreneurs to have ready access to rail service should generate some business. The rail carriers capabilities to handle large bulk shipments, oversize loads, and piggy back traffic at competitive deregulated rates should be of benefit for businesses that require transportation services or for the Department of Defense. Additionally, the availability of a railroad may be viewed by some as an opportunity to enter into

ventures that were previously perceived as unworkable. Generally, firms that ship, receive, or export raw products such as cement, coal, ore, rock, sand, and gravel require rail service to remain market competitive. Furthermore, the facilities that handle such products in large volumes are designed to accommodate unit train shipments to obtain maximum efficiency in loading and unloading.

The railroad would also greatly benefit anyone that would desire to develop an industrial park or distribution center in central Nevada. The ability of the carrier to provide TOFC (Trailer on Flat Car) and COFC (Container on Flat Car) service to the facility would immensely enhance the competitive position of the center. There are no doubt numerous other possibilities for shared use of the railroad that should be evaluated. A more in depth study is suggested to fully address the future transportation demands involving various industries, businesses, customers, government agencies and other rail carriers.

4.3 TRANSPORTATION ASPECTS

4.3.1 Train Consist

Within the railroad industry most of the train makeup practices are established on operational decisions. Such decisions include safety of the operation, locomotive power assignments or requirements, length of train, ruling grade, weather conditions, type of traffic, and train schedules. The type of traffic has a great impact on the train consist due to the variables that enter into the train makeup procedures.

- Code of Federal Regulations, Bureau of Explosives Tariff, and railroad rules specify how rail cars that are placarded Explosives, Poison Gas, Radioactive, Corrosive, Chlorine, Oxidizer, Poison, Flammable and etc., must be positioned in the train.

- Generally railroad rules determine where empty cars will be placed in relation to loaded or heavy cars in the same train to avoid undesirable track train dynamics over certain types of terrain.

- Car length should be considered in the makeup of the train to insure the train length will not exceed the siding capacity. This point should also be considered in the interface with the repository support facilities.

- Certain shipments and rail equipment should be positioned and moved in specific locations of the train consist in order to control and minimize damage associated with train motion.

- Care should be taken to select appropriate trains to move shipments or equipment that requires movement at slower speeds. Such selection is important to avoid delay to expedited traffic.

- The type of traffic and equipment determines the train size and tonnage which in turn defines the locomotive power requirements for the ruling grade of the railroad.

- Some railroads adjust the train length to the ambient temperature in order to minimize air brake problems during the cold weather season. When the temperature reaches the freezing range the train lengths are reduced.

4.3.1.1 Cask Train Make Up. Criteria used in designing the cask train consist and developing the locomotive horsepower requirement was based on information furnished by Science Applications International Corporation (SAIC) representatives in various meetings. To establish upper limits for this analysis and design, several assumptions were made. It is assumed that the large 150 ton MRS-to-repository cask would be used with an eight axle, depressed center flat car of 360,000 pound capacity. The shipments are assumed to be made with escorts under a unit train concept.

Since suitable rail cars to accommodate the escorts are not readily available in the railroad inventory, it is assumed that a compatible car for use on the cask train will be designed and constructed. The basic unit train would consist of ten loaded cask cars each weighing approximately 440,000 pounds, two solid bottom gondola type buffer cars ballasted with non-shiftable material to approximately 180,000 pounds, and one all steel construction escort car weighing about 200,000 pounds.

The 13-car train weighing about 2480 tons would require a minimum of two 3000 horsepower diesel electric road locomotives to move the train over the 2.5% ruling grade. However, due to the remoteness of the rail line and the inability to have ready access to additional locomotives in the event of a malfunction, operation of the train with one additional locomotive is recommended for a total 9000 horsepower. This train consist is illustrated in Figure 4-1.

Assembling the train will require strict compliance with the regulations pertaining to rail movement of cars placarded radioactive. The procedure in making up the unit train will entail separating locomotives from the HLW with one buffer car and inserting one buffer car between HLW and the escort car. It should be noted that the 2500 foot sidings and interchange tracks that are recommended for the rail line will easily accommodate the unit train that is about 1300 feet in length. However, the balance of the track capacity is recommended in the event spacer

H.L.W. CASK TRAIN

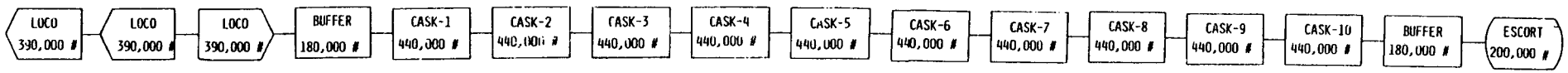


Figure 4-1
TRAIN CONFIGURATION

cars have to be inserted in the train as addressed under item 4.2.4.2 of this report.

4.3.2 Shipment Scenario

For the purpose of this conceptual design report, two train operational scenarios were developed describing crew requirements, basic procedures, and train movement of the shipment. The first scenario concentrated on one of the possible operational plans that may be applicable to an independently managed railroad. The second scenario focused on a plan whereby the Union Pacific operates the train over the new railroad as if it were an extension to their present operation. The description of each scenario can be better visualized by referring to the diagrams below. The operational procedures are covered in very general terms.

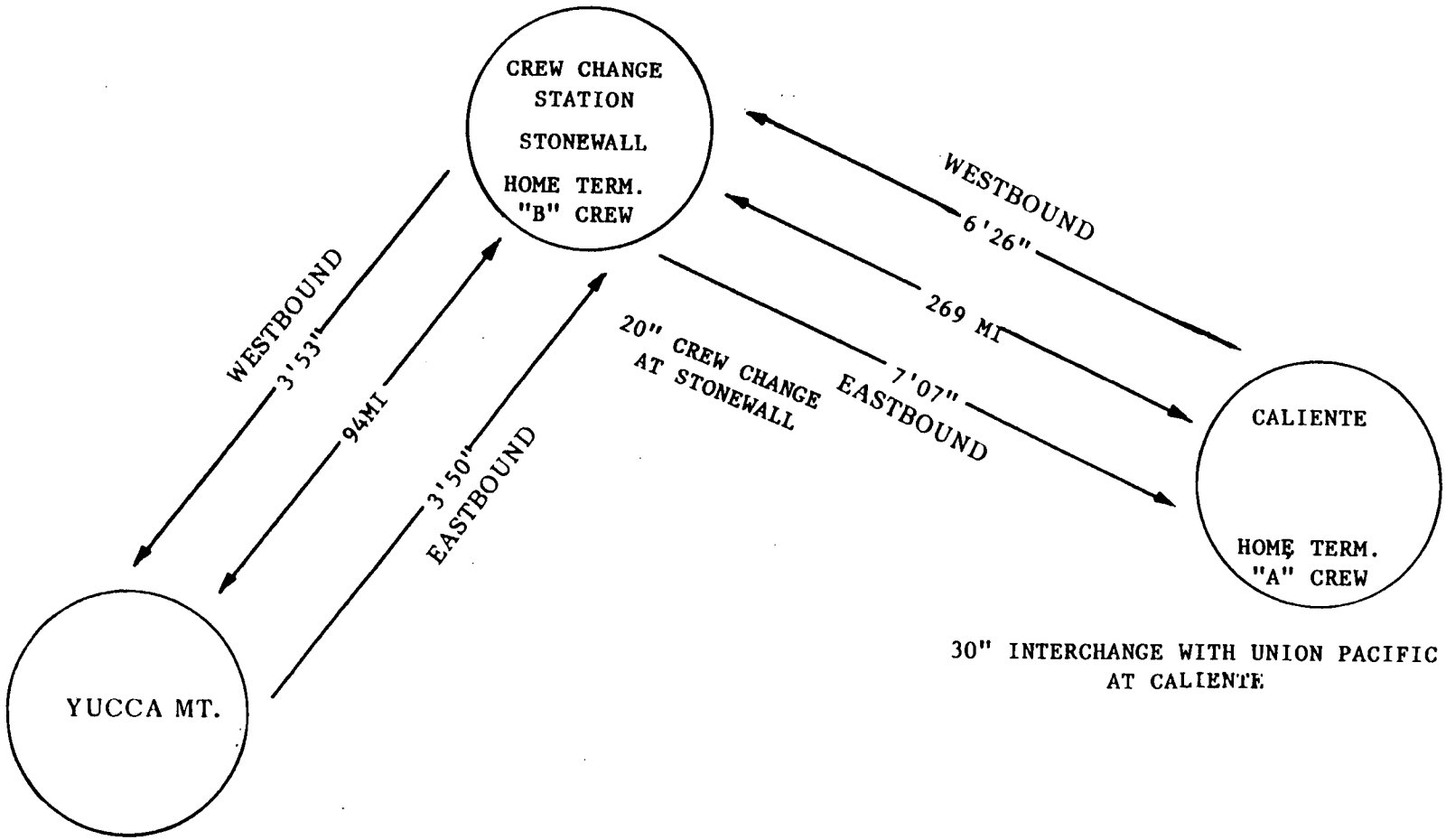
4.3.2.1 Scenario # 1: Independent Railroad. The new railroad between Caliente, NV, and Yucca Mountain will be operated as an independent carrier that has a traffic interchange with the Union Pacific Railroad at Caliente. Due to the length of the rail line and the overall travel time for the train, two home terminals for the train and engine crews are recommended. The home terminal for the "A" crew will be at Caliente and the home terminal for the "B" crew will be at a station referred to as Stonewall which is approximately 94 rail miles from Yucca Mountain. For the purpose of this scenario, it will be assumed the entire 363 miles of railroad via north route "B"is signaled so that trains may operate at maximum allowable track speed. Figure 4-2 illustrates this scenario schematically.

The train size will be limited to ten cask cars, two buffer cars, and one occupied escort car for a total of thirteen cars approximately 2480 tons. Three 3000 horsepower locomotives will be stationed at Caliente to handle the train. This scenario is constructed so that crews and locomotives are readily available at key locations to promptly move the shipment and minimize the need for coordination. The primary objective in the effort is to keep the train moving and avoid any delays. All the intricate procedures in operations and detailed executions of duties by personnel will not be addressed in this broad brush approach. The following sequence of events will occur in the movement of the shipment.

- The shipment is received from the Union Pacific on the designated interchange track at Caliente, and an interchange inspection (See 4.2.3.3) is performed by the receiving carrier's car inspectors. All work and inspection is accomplished under blue flag protection (49 CFR 218.23).

SCENARIO #1
OPERATIONAL PLAN
VIA NORTH ROUTE "B"

"A" CREW REST & LAYOVER AT STONEWALL
9'43"



30" INTERCHANGE WITH UNION PACIFIC
AT CALIENTE

SET OUT & PICK UP TRAIN YUCCA MT.
2'00"

UP MILEAGE TO MILFORD UT - 114 MI.
UP MILEAGE TO LAS VEGAS NV - 125 MI.
UP CREW LAYOVER AT CALIENTE- 23'56"

Figure 4-2
TRAVEL TIME ASSUMPTIONS
Scenario #1

- The "A" crew that is stationed at Caliente, places the three power unit locomotive consist on the train. A train air brake test is then conducted (49 CFR Part 232).

- Upon completion of the train air brake test and with train movement authorization from the train dispatcher, the shipment is moved by the "A" Crew from Caliente to Stonewall, a distance of 269 miles in approximately six and one half hours. The time factor is an estimate that should be viewed as the best case scenario in train transit time. See Section 4.4.3 for a brief discussion of the estimate.

- On arrival at Stonewall, the "A" crew performs procedural requirements to log information on prescribed forms and then proceeds to point of lodging. The "B" crew, which is stationed at Stonewall, takes charge of the train and receives train movement authorization from the dispatcher to move the train from Stonewall to Yucca Mountain. Upon completion of an air brake test and a walking inspection of the train, the "B" Crew moves the shipment to Yucca Mountain, a distance of 94 miles in approximately four hours. The shipment is delivered into the repository facility and the locomotives are removed from the train. The "B" crew performs procedural requirements to log information on prescribed forms and make preparation for the return trip.

- During approximately a two hour layover at Yucca Mountain, the locomotives will be fully serviced. There may be an occasion when the locomotive consist will have to be turned on the turning track (assumed to be part of the repository), or units in the consist will have to be replaced with units from the repair shop. Such tasks will vary with each trip, but once the work is completed, the "B" crew will place the locomotives on a preassembled train of empty casks for the return trip to Stonewall.

- Once the "B" crew has placed the three power unit locomotive consist on the train and a train air brake test is completed as prescribed under 49 CFR Part 232, the train will be ready for the return trip to Stonewall. The dispatcher's new train movement authorization will allow the "B" crew to move the shipment to Stonewall. The 94 mile road trip is accomplished in approximately four hours. Upon arrival at Stonewall the "B" crew performs procedural requirements to log information on prescribed forms and is released from duty.

- The "A" crew, which has received the required rest at Stonewall as prescribed under 49 CFR Part 228, will take charge of the train upon arrival. Upon completion of an air brake test and a walking inspection of the train, the "A" Crew, with train movement authorization from the dispatcher,

will move the shipment to Caliente. The 269 mile movement is accomplished in approximately seven hours. At Caliente the shipment is delivered to a designated interchange track of the connecting carrier and the locomotives are removed from the train and taken to the service facilities. The "A" crew performs procedural requirements to log information on prescribed forms and is released from duty.

- The Union Pacific performs an interchange inspection and places the two power unit locomotive consist on the train. The crew has received the required rest at Caliente as prescribed under 49 CFR Part 228 and is placed on duty to take charge of the train. After completing the train air brake test and receiving train movement authorization from the connecting dispatcher, the train is then moved out of Caliente onto the Union Pacific main track.

- All the train movement data, the time crews went on and off duty, weather conditions, unusual events affecting movement of trains, train movement instructions, and many other items and transactions are issued and recorded in prescribed form by the train dispatcher as required under 49 CFR Part 228, the same section of the CFR that governs the number of hours a dispatcher is allowed to work.

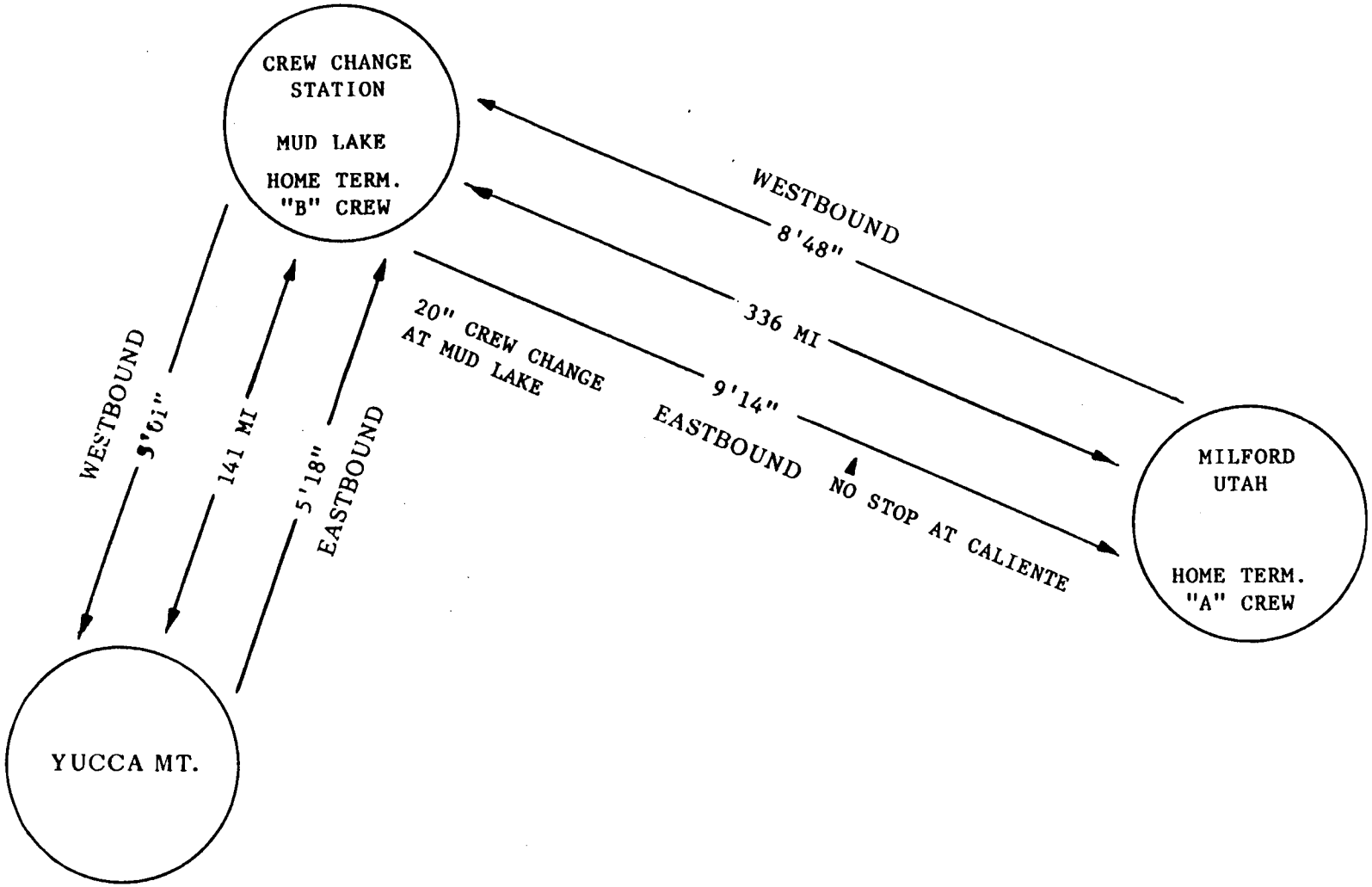
4.3.2.2 Scenario # 2: Union Pacific Operation. The new railroad between Caliente, NV, and Yucca Mountain would be operated as an extension of the Union Pacific rather than as an independent carrier. Under this scenario there would be no need for an interchange at Caliente or associated facilities. Additionally, it reduces the DOE capital investment in equipment and facilities as covered under item 4.2.2.4.

Due to the length of the rail line and the overall travel time for the train, it is recommended to establish one home terminal for the train and engine crews on the new railroad. The home terminal for the "B" crew will be at a station referred to as Mud Lake which is approximately 141 miles north of Yucca Mountain. For the purpose of this scenario it will be assumed the entire 363 miles of railroad via north route "B"is signaled so that trains may operate at maximum allowable track speed. Figure 4-3 illustrates this scenario schematically.

The train size will be limited to ten cask cars, two buffer cars, and one occupied escort car for a total of thirteen cars approximately 2480 tons. Three Union Pacific 3000 horsepower locomotives will be used to handle the train. This scenario is constructed so that crews and locomotives are readily available at key locations to promptly move the shipment. The primary

SCENARIO #2
OPERATIONAL PLAN
VIA NORTH ROUTE "B"

"A" CREW REST & LAYOVER AT MUD LAKE
18'19"



"B" CREW REST & LAYOVER AT YUCCA MT.
8'00"

MILEAGE MILFORD UTAH TO YUCCA MT.
477 MILES

Figure 4-3
TRAVEL TIME ASSUMPTIONS
Scenario #2

objective in the effort is to keep the train moving and avoid any delays. All the intricate procedures in operations and detailed executions of duties by personnel will not be addressed in this general approach. The following sequence of events will occur in the movement of the shipment.

- The Union Pacific (UP) would dispatch the train from Milford, Utah with UP locomotives and crew ("A" crew) to operate through to Mud Lake, NV, a distance of 336 miles. The train would not stop at Caliente as the power switch to the DOE railroad would be controlled remotely by the UP dispatcher. The train movement authorization from Milford to Mud Lake would be authorized by the same UP dispatcher. The 336 mile road trip would be accomplished in about nine hours under best case scenario. The crew change point could be moved east of Mud Lake to reduce this travel time and balance the two legs of the trip. Section 4.4.3 discusses the estimate.

- On arrival at Mud Lake, the UP "A" crew performs procedural requirements to log information on prescribed forms and then proceeds to point of lodging. The UP "B" crew, which is stationed at Mud Lake, takes charge of the train and receives train movement authorization from the UP dispatcher to move the train from Mud Lake to Yucca Mountain. Upon completion of an air brake test and a walking inspection of the train, the "B" crew moves the shipment to Yucca Mountain a distance of 141 miles in approximately five hours. The shipment is delivered into the repository facility and the locomotives are removed from the train and placed on the service track. The "B" crew performs procedural requirements to log information on prescribed forms and then proceeds to point of lodging for rest.

- After the "B" crew has received eight hours of rest as prescribed by 49 CFR Part 228, the crew is placed back on duty to handle the empty cask train back to Mud Lake.

- During the eight hour layover at Yucca Mountain, the locomotives are fully serviced. There may be an occasion when the locomotive consist will have to be turned on the turning track.

- The "B" crew will place the three power unit locomotive consist on the preassembled empty cask train and a train air brake test will be conducted as prescribed under 49 CFR Part 232. After receiving authorization from the UP dispatcher, the "B" crew will move the train from Yucca Mountain to Mud Lake, a distance of 141 miles in approximately five and one half hours. Upon arrival at Mud Lake, the "B" crew performs procedural requirements to log information on prescribed forms and is released from duty.

- The "A" crew, which has received the required rest at Mud Lake as prescribed under 49 CFR Part 228 will take charge of the train on arrival. Upon completion of an air brake test and a walking inspection of the train, the "A" crew with train movement authorization from the UP dispatcher will move the shipment through to Milford, Utah without stopping at Caliente. The 336 mile movement is accomplished in approximately nine hours and 30 minutes.

4.4 OPERATIONAL ASPECTS

4.4.1 Locomotive Specifications

The following subsections include some suggestions to be considered for the selection of locomotives during the detail design phase.

4.4.1.1 General Considerations. Generally speaking locomotives are available from only two manufacturers in the United States. Each company has several models that vary in size and design and come with many options in order to meet individual railroad requirements. The switcher type locomotives are used to perform yard and industrial switching of rail cars. Whereas, the road locomotives are used to move freight trains at various speeds over many types of terrain. The four wheel truck locomotives are usually used on the lighter weight expedited trains that do not require additional tractive effort on steep grades. The six wheel truck locomotives with equal amount of horsepower, but more tractive effort, are used to move heavy trains at slower speeds on all types of grade. Each type of locomotive has advantages and disadvantages that should be fully addressed in the detail design stage before a selection is made for procurement.

There are advantages if the road locomotive fleet is made up of identical models from the same manufacturer. This approach will reduce the inventory of spare parts, insure that locomotive component parts are interchangeable and minimize the need to train and qualify personnel to perform maintenance and repair on more than one type of locomotive. The locomotives should be new with state of the art equipment that have a proven track record for endurance and satisfactory performance under adverse weather conditions. Additionally, the locomotives should be compatible with the locomotives in the ownership of the connecting railroad to insure that units can be intermixed in the locomotive consist during an emergency.

A switcher type locomotive, if purchased, is best acquired new with state of the art equipment from the same manufacturer as the road locomotives. The switcher should be compatible with the road locomotives and have the capabilities to perform road locomotive work in an intermixed unit consist, or as a single

locomotive. A majority of the component parts should be interchangeable with the road locomotives in order to reduce the inventory of spare parts.

4.4.1.2 Locomotive Fleet Size. The key ingredient to a successful and efficient railroad operation is the availability of locomotive power to promptly address emergencies and move traffic on a timely basis. Nearly every rail movement function relies on the tractive effort of the locomotive in achieving mobility. Whenever rail carriers experience a shortage of locomotives to move their trains, a gradual breakdown in service and maintenance becomes apparent.

A bare minimum of locomotives for the Caliente route would be four units. This number assumes that there would be only one train moved at a time, using three locomotives, leaving the fourth for a spare or other duties. The bunched arrival of trains or other circumstances requiring more locomotives than this bare minimum would result in delays in the handling of shipments. Appendix B describes in detail some of the possible situations in which this minimum number of locomotives could cause delayed operations or maintenance in comparison to the schedule that would be possible with a larger locomotive fleet.

For these reasons, a trade off study comparing the cost of capital for the additional power units with the likely costs of delay is recommended for the design phase. In order to have the flexibility to meet the majority of possible locomotive requirements, consideration should be given to acquiring eight road power units.

4.4.2 Operational Constraints and Impacts

The key to avoiding operational constraints is to avoid the constraints that presently exist in the railroad industry, some of which are addressed under item 4.2.4.2. The regulatory constraints will have to be accepted, regardless of how restrictive, and implemented into the daily operational plan. Any other limitation or restriction that become apparent during the design stage should be evaluated as to the impact they will have on the overall railroad operation. In the event problems become apparent, appropriate action should be taken immediately to implement measures and procedures to address the difficulty. There are presently some obvious and identifiable constraints that may impact the railroad operation.

4.4.2.1 Personnel and Work Environment. It is suggested that the DOE or Operator hire knowledgeable and experienced railroad personnel to operate the trains and perform maintenance on the track and equipment. Maximum use will be made of local labor in accomplishing this. The history of rail operations in the

Caliente area suggests that there are people who like to work and reside in the remote desert environment who would return if employment were available. If there are not enough personnel who would be willing to make a long-term commitment to the program, which could result in a perpetual hiring and training program, a higher wage scale or incentives may be of value.

4.4.2.2. Steep and Long Descending Grades. The operation of heavy trains on steep, long descending grades will present problems unless proper procedures in train handling are implemented and strictly adhered to by train crews. In order to insure that crews observe the procedures and rules, it is suggested that the supervisory personnel constantly test and check the crews for compliance. This will be especially true on the descending grades with sharp curvature which requires reduction in train speed at precise locations.

4.4.2.3. Train Handling and Braking. The handling and braking of the train on steep descending grades may prove to be a cumbersome and a time consuming task unless special attention is given to the design of the equipment and special features on road locomotives. In the railroad industry each carrier has identified the train braking and handling problems on specific grades. To cope with the problem, special procedures have been developed whereby crews should take certain action before attempting to move the train on the steep descending grade. The train size and whether the locomotives are equipped with special braking features are the key in initialing such actions.

If the criteria do not meet the prescribed standard, the train should be stopped at a point on the cresting grade and the crew should set up air brake retainers on specific number of cars in the train. Without going into great detail, retainers on a rail cars are a devices that help retain some brake cylinder pressure in order to maintain some retarding force on a descending grade. After required procedural functions are accomplished the train may proceed on the descending grade. The crew may be required to stop the train a certain location and remain standing for a specific amount of time to cool the wheels. Once the train is off the grade the train should be stopped again to manually normalize the retainer device on each car. These types of operational problems on a Cask train can be minimized to a great extent if the equipment is designed properly and the locomotives are equipped with extended range dynamic brakes.

The diameter of the wheels on the rail cars is one of the key ingredients in car design to help alleviate braking problems. As a rule of the thumb, wheels 36 inches in diameter are more suitable under most scenarios. However, equipping the locomotives with extended range dynamic brakes contributes more toward efficient and effective braking than any other feature. Dynamic brakes retard the train speed on descending grades

through electrical conversion of the locomotives traction motors into generators whereby the momentum of the train rotates the generators which in turn retards the speed of the train. Proper car design and dynamic braking can minimize many of the operational constraints on a mountainous railroad.

4.4.2.3. Signal System. A non-signaled railroad will have very little impact on the overall train operations under normal conditions. The reduction in speed from 55 MPH to 49 MPH due to the provision under 49 CFR Part 236 for a non signaled railroad have very little influence, by best estimate, on the running time of a cask train over the railroad.

However, equipping the railroad with an Automatic Block Signal System (ABS) would contribute an additional margin of safety to train operations by providing advance indications of certain hazardous track conditions. The advance warning of a broken rail, defective or misaligned switch, and awareness of any free rolling equipment that may accidentally be on the main track is a safety factor that should not be ignored. This is especially important during night time operations, and periods of inclement weather when the visibility is poor. Additionally,a signal system could be an effective and efficient method of integrating safety devices, such as the hot box, dragging equipment, cracked wheel, rock slide, and high water detectors into the overall system operation.

4.4.3 Travel Time Requirements and Assumptions

Travel time was computed by analyzing the grades and curves for each section of track. Based on power, braking, and safety considerations, an appropriate speed was selected for each section. The resulting speed profile was then used to compute travel time as displayed in Figures 4-2 and 4-3. Appendix B includes a more detailed time table for operation over the base alignment, the "B" northern alignment through Lincoln County.

4.5 MAINTENANCE

4.5.1 Railroad Maintenance

The track, signal, and equipment maintenance on the railroad is very unique compared to the balance of the transportation industry. Unlike other modes of transportation where public funds subsidize the maintenance support for highways and airports, the rail industry relies on their own funding to maintain their trackage. Furthermore, all the maintenance on track, signals, and equipment must be conducted to a certain standard as prescribed by federal and state regulations. The industry is under constant scrutiny of the federal and state

inspectors that assess fines if the carrier is not in compliance with the regulations that cover nearly every aspect of the railroad operation. Such strict constraints make it very difficult to perform the required maintenance with any flexibility.

4.5.2 Locomotive and Rail Car Maintenance

In order to accomplish the necessary maintenance and inspection on the locomotives and rail cars, it will be important that the carrier has the facilities that are fully equipped to perform the work efficiently. Such facilities are recommended to be staffed with highly qualified personnel to insure the quality of work meets the high standards that the sensitive shipments will require. The rail cars will need special attention due to their weight and exposure to long hauls over other railroads. It is very likely that other agencies may insist on being present when some of the inspections are performed to insure proper procedures are followed.

4.5.3 Track Maintenance

Due to the low volume of traffic there will be minimal wear on the trackage during the life of the program. However, routine maintenance and inspection will be important to insure the railroad is held to the designed Class 4 track standard. In order to achieve the objective, it is recommended to retain qualified employees to perform the inspection and maintenance with dedication. It would be advisable to keep the work force to a minimum to control costs by utilizing mechanized track repair equipment to the fullest extent possible. A periodic inspection by an ultrasonic rail testing vehicle will be required to check for latent rail defects. Appendix B includes a descriptive list of equipment that is suggested be made available for the maintenance crews.

4.6 EMERGENCY RESPONSE

4.6.1 Emergency Action Plan

The railroad industry as a whole has recognized that it is essential to develop and implement emergency procedures and train personnel to respond quickly and effectively to any emergency condition on the railroad. Generally, such emergencies are associated with derailments, fires, explosions, grade crossing accidents, personal injuries, and environmental incidents. Procedures are designed to assist personnel in handling each situation efficiently through prompt response, saving of lives, protection of property, assessment of the accident, ordering of

emergency equipment, accurate reporting, restoration of service, furnishing current factual and concise information to the media, conducting a thorough investigation as to the cause of the accident, and filing close out reports to all parties concerned. It is recommended for the railroad to develop similar procedures to effectively deal with emergencies and to satisfy the requirements under 49 CFR Part 225 and various other local and state regulatory codes.

4.6.1.1 First Response Team. Usually when a railroad has a derailment or a similar type of an accident there are certain key personnel that are immediately dispatched to the scene to make an evaluation and implement plans to restore service. However, their role is altogether different from that of the First Response Team (FRT) which is primarily concerned with hazardous material problems associated with the accident. The members are trained to properly handle the situation and implement appropriate activities to reduce the impact of the incident on the railroad and the public. The FRT is significantly different from the DOE Radiological Assistance Team (RAT) because they should be able to respond to any of the 1500 hazardous materials that are transported by rail rather than to just one involving radioactive material. The FRT members are trained to undertake the following responsibilities.

- Identify the specific hazard associated with the material.
- Implement safety measures into the incident activities.
- Promptly notify proper authorities.
- Establish a command post.
- Establish coordination and cooperation with local emergency response teams.
- Initial action for containment and clean up of the spill.
- Formulate and submit incident report.

4.6.2 Railroad Emergency Equipment

Appendix B contains a annotated list of recommended railroad emergency equipment. To lower initial capital cost, most of the equipment would be leased as needed. Exceptions to this include the recommended purchase of a snow plow and an emergency response Hi Rail vehicle.

4.7 FACILITIES REQUIREMENTS

The selection of the mode of operation greatly impacts the requirements for certain facilities associated with the railroad. There will be fewer requirements if the railroad is operated as a rail extension of the trunk line carrier rather than as a independent railroad under various types of management. However, for the purpose of this conceptual design report, the facilities required are identified in general terms as appropriate to a non-DOE rail carrier.

The requirements are identified under two categories. One addresses those connected with the interchange point, the crew change station, and rail terminal facilities at the repository. The following Table 4-1 lists these facilities. Appendix B provides an annotated list of these facilities. The other category identifies all other components associated with the trackage between the three railroad stations. Appendix B discusses these components.

4.8 EQUIPMENT REQUIREMENTS

There are certain equipment requirements that the DOE will have to address under all five of the operational scenarios. The Trunk Line or the shortline option may present an opportunity to utilize some of the common equipment in their ownership such as box cars, ballast cars, gondola, and flat cars to meet the DOE requirements. Under the other options DOE will be compelled to purchase or lease that type of equipment for the life of the program. However, the personnel cars for the maintenance crews and the escort cars may need an outright purchase to satisfy the special requirements. The detail design should address the specification for each type of equipment to insure it is compatible with the overall operation.

TABLE 4-1

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
RAILROAD FACILITIES

Interchange Point	Railroad Headquarters & Crew Change Terminal	Railroad Facility Outside Repository
Interchange Tracks	---	---
Turning Track	Turning Track	Turning Track
Emergency Material Storage track	Emergency Material Storage track	Emergency Material Storage track
Emergency Equipment Track		Emergency Equipment Track
Fenced Siding	Fenced Siding	—
—	Siding	Siding
HiRail & Heliport Pad	HiRail & Heliport Pad	HiRail & Heliport Pad
Emergency Station		Emergency Station
Garage & Storage Building		Garage & Storage Building
Crew Station & Office	Crew Station & Office	Crew Station and Train Dispatcher Office
—		Headquarters for Opr.Personnel
Locomotive Service Facility	Locomotive Service Facility	Locomotive Service Facility
Derail Protection	—	---
—	—	Locomotive Repair & Inspection Facility
—	—	Rail Car Repair & Inspection Facility

4.9 THE RAILROAD OPERATIONAL EVALUATION

The following summary of operational advantages and disadvantages is based on the present day preliminary evaluation of the Caliente route for rail access into the Yucca Mountain region. A re-evaluation is suggested for the detail design stage to determine if other options may be available or if major changes are detected in the present opportunities.

4.9.1 Government Owned and Trunk Line Operated

The option of the government owned railroad being operated as a line extension of the trunk line connecting carrier has the greatest potential of providing the DOE with efficient and safe service. This is because of the depth and breadth of experience of management and employees and the availability of equipment. Other advantages of this mode of operation include:

- Such an operation would eliminate the necessity for interchange of cars and the associated A.A.R. inspection requirements at the junction point.
- DOE delegates the responsibility for the shipment to major carriers from the origin point to the destination without any DOE involvement in railroad
- The operation would also reduce the requirements for many of the facilities and equipment that would be required under other operational scenarios.
- Liability would be shared with the operator.

Disadvantages of this mode of operation include:

- The DOE would inherit the work rules of the trunk line railroad, possibly resulting in higher costs.
- The DOE would have less direct control than in a DOE operated railroad.

4.9.2 Government Owned and Short Line Operated

The primary advantage of having the operation of a government owned railroad contracted to a shortline operator is the potential cost saving compared with other options. The shortlines usually operate a railroad with a minimal non-union staff, whereby one individual may perform numerous tasks such as make operational decisions, operate trains, perform maintenance and inspection of track, locomotives, and cars.

Potential disadvantages of this operational option include:

- There would be more uncertainty about the financial status, qualifications, and long-term commitment of the shortline operator. A thorough investigation would be recommended to determine if the shortline operator is qualified and capable of participating in such an operation, particularly to determine the operator's past record in transporting radioactive or other hazardous materials.

- The shortline operator's emergency response capability would also be of concern. Major railroads and various contractors are usually relied upon to assist during emergencies such as derailments, washouts, and snow tie ups.

- Shortline operators can have a tendency to sacrifice expertise for efficiency. This type of service and cost effective operation may be satisfactory in some cases, but it becomes a distinct disadvantage and undesirable method when sensitive material is involved. The shortlines entrepreneur spirit and willingness to explore innovative ways of doing business may overcome this problem.

- The only solution for a shortfall in service would be the willingness of the DOE to subsidize the operation in order to insure a desirable level of service, which would reduce some of the cost savings of the shortline operator.

4.9.3 Government Owned and Government Operated

There is more uncertainty in this option because of the lack of a comparable model. Significant advantages of this mode are the greater control that DOE would have over the operation and not having to deal with the work rules of existing railroad unions.

Disadvantages of this mode of operation are:

- DOE assumption of all operating liability.

- Potential difficulty of attracting and retaining experienced personnel. There would also be a potential lack of supervisory experience to know whether things were being done right.

- DOE has to acquire more equipment and develop a larger staff and more facilities than in other modes.

4.9.4 Government Owned and Repository Contractor Operated

This scenario is closer to the government owned and government operated railroad than the others with the exception that the contractor would assume some of the liability.

Other advantages of this mode would be:

- No direct responsibility for personnel.
- Potentially simpler work rules giving lower operating cost than Class I operated.

Disadvantages of this mode include:

- Probably higher cost than government owned and operated because of the contractor's need to make a profit.
- Potential problems with quality and depth of experience among the operating staff.
- More limited peer review of operations in comparison with Class I operated and shortline operated.

4.9.5 Privately Owned and Privately Operated

The advantages of this mode of operation include:

- Less direct liability to the government.
- No direct responsibility for personnel.
- Possibly better suited to respond to the economic development concerns of the area.

The disadvantages of this mode of operations include:

- Potential problems with quality and depth of experience among the operating staff.
- More limited peer review of operations in comparison with Class I operated and shortline operated.
- Potentially less responsive to the needs of the government than the Class I or the contractor operator.
- Potentially more operator financial problems than with the Class I or contractor operator.

5. CAPITAL COSTS

5.1 SCOPE

Capital costs represent the initial expenditures that are required to design and construct the railroad, construct necessary building structures, and procure rolling stock and other durable equipment, so as to set up a system to accommodate the desired rail operation. These items are fixed investments that are expected to last for the entire duration of the program, i.e. 25 years.

Railroad design and construction cost estimates cover two routes, the Base Route and the Route A Option, and variations under different engineering assumptions, from types of ties to types of signals. The discussion was based primarily on the magnitude of design and construction engineering effort involved.

Other capital costs, including rolling stock, maintenance equipment, building facilities, and emergency equipment, could vary with the ownership and operating scenarios. Thus this part of the capital costs are evaluated separately.

A composite summary of the total capital cost is presented under institutional categories in order to achieve consistency with operating cost estimates in the following Chapter 6. The cost of railroad design and construction was selected from the results of the previous chapters.

5.2 METHODOLOGY AND BASIS OF COST ESTIMATES

5.2.1 Cost Elements

5.2.1.1 Direct Railroad Way Construction Costs. Direct costs represent those already quantified railroad way facility components. At this conceptual level of study, only major items can be identified, including track, earthwork, bridges, signal and communications equipment, ancillary buildings and facilities attached to the railroad way. Other items, such as fence for the mainline railroad way, which can be estimated as a function of route length, are also included.

5.2.1.2 Right of Way Costs. Right of way costs were studied for privately owned property that might be acquired. Based on the average appraised value of land in the affected areas and the small amount of property involved, it was determined that the maximum probable cost of right-of-way acquisition would be minimal compared with other direct costs of building the railroad

way. No costs have been estimated for intergovernmental transfers.

Similarly, the costs of acquiring right-of-way across patented mining claims was determined to be minimal based on the small number of patented claims crossed. Unpatented claims were not estimated at this time because the railroad right of way does not block access to subsurface mineral rights

5.2.1.3 Contingencies. Contingencies represent items related to construction and equipment that cannot be directly estimated. Contingencies are calculated as percentages of construction and equipment costs and added to the respective costs. The specific percentages depend on the level of detail of the direct cost estimate. At this conceptual level of study, contingencies are included to account for the following factors:

- Items that cannot be identified or quantified due to the preliminary level of design. Any item that would be a cost item in a construction contract but is not included in the present study would be in this category. These items include mobilization, developing the water supply, etc.

- Variations in estimated quantities, due principally to the conceptual nature of the design and the lack of precision of the base mapping. A major element in this category is earthwork.

- Variations in unit prices, due to uncertainties in the construction and equipment markets. The size of this contingency factor depends on how far in the future the construction is expected to occur. Inflation is not included in this factor. Inflation is an economic cost which does not affect one particular industry, though the effects of inflation can vary among different areas of the economy.

- Changed site and contract conditions. These items are normal construction contingencies for civil and structural work. "Changed site conditions" in this context does not include the effects of uncovering any environmentally or culturally sensitive ground conditions. It is an allowance for unsuitable soils or unanticipated foundation conditions, in addition to field changes and quantity variations that normally occur on an engineering project.

- Possible changes to design criteria and construction standards that would increase costs. These changes might include items such as heavier rail, wider subgrade width or non-standard subgrade compaction requirements, etc.

The following contingency factors were applied to direct costs in this study:

• Railroad Way Construction (Track, Civil and Structural Engineering, Signals and Communications)	35.%
• Access Road	20.%
• Rolling Stock	20.%
• Building Facilities	20.%
• Equipment	20.%

5.2.1.4 Planning, engineering, construction management and administrative costs. These items represent the technical and managerial work that is required before and during construction. At this stage in the project, work remaining prior to construction includes the EIS, preliminary engineering, detail design and possibly procurement of certain equipment and materials. Construction management includes contract management and field inspection. Administrative costs represent costs to the owner (in this case the DOE) for program implementation and control.

These costs are calculated as a percentage of total way construction costs (i.e. direct costs plus corresponding contingencies). The following factors account for this allowance:

• Planning (EIS/EIR)	4.%
• Engineering (Preliminary & Detail Design)	10.%
• Construction Management	6.%
• DOE Administration	4.%
• Total	24.%

The building facility construction and equipment procurement also require technical design/supervision and general overseeing management. However, the costs for such effort are not uniform under different ownership/operating scenario, and are nevertheless minimal in comparison to the one in railroad way construction (much less than one percent). Therefore, this part of engineering and management costs are not separately calculated.

5.2.1.5 Rolling Stock. This item refers to the trains that travel on the railroad. Since Escort Cars, Cask Cars, Buffer and Spacer Cars, and other type of cars in a regular train are provided by national program, only locomotives need to be purchased for the Yucca Mountain Railroad. Other needed railroad vehicles, may or may not be used on a regular basis, such as Ballast Cars and Boxcars, are also included on the list.

5.2.1.6 Maintenance Equipment Costs. Maintenance equipment in the context of this estimate is specialized machinery required for the maintenance of the railroad. Mixed equipment for maintaining locomotives and other rolling stock is only a minor part of this estimation.

5.2.1.7 Building Facilities. Under this category, spaces for offices, shops, garages and warehouses, and ancillary trackage are evaluated with respect to their building costs.

5.2.1.8 Emergency Equipment. Costs for rescuing vehicles of different type to handle difficult situations are listed. Most of them are considered to be provided by local government or obtained on a rental basis, and thus not treated as capital costs.

5.2.2 Methodology

5.2.2.1 Unit Costs. Unit costs of track construction were developed from DeLeuw, Cather's accumulated data, updated by verbal vendor quotations. Costs of civil construction, such as earthwork and highway items, were developed using Nevada DOT published construction contract information. Unit costs for communications and signal equipment were obtained from equipment vendors. The unit costs used for ancillary facilities were developed from the size and function of the various facilities. Facilities were conceptually designed and are not site specific. The unit costs of locomotives and maintenance equipment were based on verbal quotations and communications with vendors and railroad engineering staff member.

5.2.2.2 Quantities. Earthwork volumes were calculated from the digital terrain data in the three-dimensional CADD files created for this study. Volumes were not adjusted for shrinkage or swell. Length of track was developed from the engineering layouts. Quantities of communications and signal equipment were estimated on the basis of track length or numbers of specific hazard detectors as applicable. Ancillary facility building areas were obtained from conceptual layouts prepared for the facilities. The number of locomotives was calculated on the basis of train consist, tractive effort and grade as described in Chapter 4. Maintenance equipment requirements were developed by the experienced operations engineering consultants. Detailed list of needed procurement and the sizes of facilities are attached in Appendix B.

5.2.2.3 Other Elements. Minor structures (anything not identified as a bridge) were sized for a representative segment of the route. The costs of these structures were then estimated using unit cost data obtained from the Nevada DOT. A unit cost per track-mile was calculated, and this cost was applied to the

entire route. Each major structure (bridge over a watercourse or road/rail grade separation) was sized and its building cost was estimated individually (See Table 5-3, Grade Separations, and Table 5-4, Stream Crossings, for data on individual major structures).

5.2.3 Basis of Costs

5.2.3.1 Items included. Costs are in 1990 dollars. Construction costs include all direct and indirect costs related to the individual work items, viz:

- Direct labor and equipment costs involved with furnishing and installing or placing the materials. Direct labor in this context includes salaries and payroll burden costs. Equipment costs include rental or purchase and depreciation, and fuel.
- All material and transportation costs, including taxes.
- Contractor field indirect costs, including indirect labor (field office personnel), security, storage and warehousing where applicable, bonding and insurance, and interest.
- Overhead and profit.

5.2.3.2 Items excluded. Costs which are not included as unit prices are accounted for in the contingencies. Project costs do not include interest or other financing charges, if any, that might be directly attributable to the funding of the project. Inflation is not included. Costs for possible mitigation of environmental or cultural impacts that might be identified during later project stages or are not included. Railroad facilities within the boundaries of the Yucca Mountain Repository were not included within the scope of work for this study; associated costs are therefore not included.

5.3 CAPITAL COST SUMMARIES

5.3.1 Cost Summaries for Railroad Way Construction

5.3.1.1 Direct Railroad Way Construction

Costs elements associated with the railroad way construction are track, civil construction and structures, signals and communications, and right of way. Civil construction includes earthwork, drainage, road and related items such as fence. Tables 5-1 through 5-17 present direct construction costs, as defined in paragraph 5.2.1.1. (For ease of reference, all tables in this chapter are placed at the end of the chapter.)

Track, civil and structural costs of the alignments from Caliente to the potential Yucca Mountain repository site are shown in Tables 5-1 and 5-2. Each table represents a complete alignment via the Base Route or the Route A Option. The unit costs for excavation in these tables include excavation, hauling and placement in embankment, either within the right of way or as waste. The quantities for borrow therefore represent the additional material required when there is insufficient excavation for embankment volumes. Earth movement or "mass haul" was not analyzed for this study; the volumes of excavation, embankment and borrow represent the aggregate quantities for the entire routes. The basic estimates are shown for track with timber ties. For comparison, the incremental and total costs for construction with concrete ties are shown. The costs for grade separations and stream crossings are listed in Tables 5-3 and 5-4, which are deliberations of corresponding items in Tables 5-1 and 5-2.

Signals costs are shown in Tables 5-5 through 5-10. There are three options for signals for each of the two routes: Unsignalized (Dark) Railroad; Automatic Block Signal System (ABS); and Advanced Train Control System (ATCS).

- Option 1: No signal system (Dark), hazard detection for local hazards and transmission of hazard indications to a Central Control Facility. A computer-based basic system is employed to log and display all hazards and their locations. This is the recommended configuration.

- Option 2: Wayside automatic block system (ABS) with wayside signals and coded track circuits for train detection. Hazard indications are transmitted to the Central Control Facility. A basic, computer-based system is employed to log and display all hazards and their locations, and to track movement of trains on the railroad.

- Option 3: Advanced train control system (ATCS) for train location and detection. Hazard indications are transmitted to the Central Control Facility. A small scale computer-based central traffic control system is employed at Yucca Mountain to display and track trains operating on the railroad and log and display all hazards and their locations. The overall systems cost is dependent on the number of locomotives and the spacing of the transponders along the railroad.

The estimated cost of the advanced train control system, Option 3, is lower than the wayside ABS system, Option 2, because its installation is not as labor intensive. In addition, it uses the radio system for its communications link rather than wayside track circuit equipment that requires local solar power. However, the

ATCS equipment is in its infancy, and the cost data is very tentative at this point in time.

The costs for all three options include local solar power, but exclude data transmission to the central control facility. These costs are included in the communications systems cost estimates, which are presented in Tables 5-11 through 5-16. Table 5-17 is dedicated to the cost estimate for building access road.

5.3.1.2 Total Cost for Railroad Way Construction. Total project costs including contingencies and costs for planning, engineering, construction management and administration are shown in Table 5-18 for the Route A Option and Table 5-19 for the Base Route. The basic costs are shown for track with timber ties and a "dark" or unsignaled railroad. In this context, local hazard detection for rock slides and high water, in addition to grade crossing signals, are included in the unsignaled railroad.

Tables 5-18 and 5-19 also show the incremental and total project costs for the routes with each of two alternative types of construction: concrete ties instead of timber ties, and either ABS or ATCS instead of unsignaled. Each comparison is made with respect to the cost of the basic construction. Because contingencies and some other costs are calculated as percentages of direct way construction costs, the appropriate items are added to the incremental costs to obtain consistent project cost comparisons. Tables 5-18 and 5-19 also show the costs of originating both options from Crestline instead of Caliente.

Table 5-20 is a summary of the costs of the twelve combinations of route, tie material and signal system. The costs shown in this table include all direct and indirect costs.

5.3.2 Cost Summaries for Rolling Stock, Equipment, and Facilities

The similarity in the costs for Rolling Stock, Equipment and Facilities is that all these costs vary in size in reflecting different institutional considerations.

Table 5-21 shows the costs for Locomotives and Cars procurement. Table 5-22 shows the costs for maintenance equipment procurement. In these two parts of the capital costs, the Class I Railroad Operated alternative does not need any procurement, and the Privately Owned and Privately Operated alternative requires only limited purchase.

Building Facilities and Emergency Equipment Costs are presented in Tables 5-23 and 5-24, respectively. The Class I Railroad Operated alternative has a limited savings, while most of its building facilities, except headquarter and dispatch offices, have to be in locations as other alternatives. Building Facilities costs for

other alternatives are identical. Emergency equipment in most cases is considered either to be provided by the local government (Ambulance) or to be arranged on a rental basis from a Class I railroad company or from other companies in Las Vegas.

The total cost for these items are recapped in Table 5-25 with additional contingency costs. A significant difference is shown between the Class I Railroad Operated alternative and the other Government Owned alternatives, namely Government Operated, Shortline Operated and Contractor Operated. Savings on the Class I Railroad Operated alternative is due to utilizing the Railroad owned rolling stock and maintenance equipments, which would be charged in a lump sum fashion reflected in operating and maintenance costs in Chapter 6.

5.3.3 Composite Summary for Capital Costs

Table 5-26 presents a composite summary of total capital costs for the Caliente Route. The base set of numbers is for the recommended railroad way construction alternative, namely the unsignaled Base Route with timber ties. By using the attached tabulation of additional costs for optional design features, the composite summary of capital costs can be easily modified to account for other design features.

TABLE 5-1
COST ESTIMATE
RAILROAD ITEMS
TRACK, CIVIL & STRUCTURES
ROUTE A OPTION

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST ($1,000)
Clearing & Grubbing	3,800	Acre	$500	$1,900
Earth Excavation	22,000,000	CY	$6	$132,000
Rock Excavation (Ripped)	2,400,000	CY	$10	$24,000
Rock Excavation (Blasted)	1,520,000	CY	$20	$30,400
Borrow	27,600,000	CY	$7	$193,200
Tunnel	12,500	TF	$4,800	$60,000
Subballast	1,128,000	CY	$18	$20,304
Railroad Track (with Timber Ties)	1,880,000	TF	$115	$216,200
No. 8 Turnout	2	EA	$30,000	$60
No. 10 Turnout	37	EA	$35,000	$1,295
Grade Crossings - High Volume	2	EA	$10,000	$20
Grade Crossings - Timber	132	EA	$3,000	$396
Standard Crossbucks	264	EA	$100	$26
Fencing - Standard ROW	3,640,000	LF	$5	$18,200
Fencing - Security (Chain Link)	16,400	LF	$15	$246
Grade Separation Structures		LS		$2,280
Major Drainage Structures		LS		$45,300
Minor Drainage Structures	351.4	MI	$58,000	$20,381
TOTAL COST (Timber Ties)				$766,209
Additional cost for concrete ties	1,880,000	TF	$12	$22,560
TOTAL COST (Concrete Ties)				$788,769

TABLE 5-2
COST ESTIMATE
RAILROAD ITEMS
TRACK, CIVIL & STRUCTURES
BASE ROUTE

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST ($1,000)
Clearing & Grubbing	3,700	Acre	$500	$1,850
Earth Excavation	33,200,000	CY	$6	$199,200
Rock Excavation (Ripped)	900,000	CY	$10	$9,000
Rock Excavation (Blasted)		CY	$20	$0
Borrow	7,290,000	CY	$7	$51,030
Subballast	1,098,000	CY	$18	$19,764
Railroad Track (with Timber Ties)	1,830,000	TF	$115	$210,450
No. 8 Turnout	2	EA	$30,000	$60
No. 10 Turnout	35	EA	$35,000	$1,225
Grade Crossings - High Volume	2	EA	$10,000	$20
Grade Crossings - Timber	126	EA	$3,000	$378
Standard Crossbucks	252	EA	$100	$25
Fencing - Standard ROW	3,570,000	LF	$5	$17,850
Fencing - Security (Chain Link)	16,400	LF	$15	$246
Grade Separation Structures		LS		$2,110
Major Drainage Structures		LS		$47,400
Minor Drainage Structures	341.6	MI	$58,000	$19,813
TOTAL COST (Timber Ties)				$580,421
Additional cost for concrete ties	1,830,000	TF	$12	$21,960
TOTAL COST (Concrete Ties)				$602,381

TABLE 5.3 GRADE SEPARATIONS

Station	Skew(°)	Spans (feet)	Cost[1]
2076+00	30	35/60/35	$260,000
4352+00(Base Route)	44	60/73/60	386,000
6097+00(Route A Opt)	52	93/93/93	558,000
11001+50	25	37/58/37	264,000
20751+50	56	85/93/85	526,000
21083+50	48	60/78/60	396,000

Total Cost Base Route = $1,832,000
Total Cost Route A Option = $2,004,000

[1] Cost Estimate for Grade Separations is based on $2,000 per track foot, or approximately $100 per square foot of superstructure.

TABLE 5.4 STREAM CROSSINGS

Station	Flow (CFS)	Length (feet)	Cost[2]
1529+00	*	150	450,000
1543+00	*	170	510,000
1571+00	*	200	600,000
1671+00	*	150	450,000
1676+00	*	150	450,000
1691+00	*	150	450,000
1867+00	*	75	225,000
1934+00	*	150	450,000
2055+00	14,000	600	1,800,000
2945+00	4,700	200	600,000

(*No hydrology available)

Subtotal(Common Section): $5,985,000

Station (Base Route)	Flow (CFS)	Length Feet	Cost
3355+00	8,850	500	1,500,000
3379+00	16,650	500	1,500,000
3469+00	6,750	300	900,000
4370+00	9,500	400	1,200,000
5565+00	6,000	300	900,000
5934+00	16,500	500	1,500,000
6127+00	6,700	200	600,000
6195+00	6,400	200	600,000
6275+00	5,750	400	1,200,000
6431+50	6,450	300	900,000
6506+50	5,000	300	900,000
7053+00	5,200	300	900,000
7254+00	10,850	500	1,500,000
Subtotal (Base Route):			$14,100,000

[2] The cost estimate for stream crossings is based on $3,000 per track foot, or approximately $150 per square foot of superstructure. The rate is higher for stream crossings than for grade separations to allow for construction of spur dikes, splayed wingwalls, and possible higher piers and abutments.

TABLE 5.4 STREAM CROSSINGS (Cont.)

Station (Route A Option)	Flow (CFS)	Length (feet)	Cost[3]
4084+00	14,100	500	1,500,000
5730+00	9,250	400	1,200,000
6051+00	10,000	700	2,100,000
6242+00	5,000	300	900,000
6671+00	5,800	200	600,000
6324+00	8,150	400	1,200,000
7448+00	10,300	400	1,200,000
8488+00	13,900	700	2,100,000
8309+00	6,500	400	1,200,000
	Subtotal (Route A Option):		$12,000,000
Common Section			
11576+00	5,500	400	1,200,000
13054+00	3,950	500	1,500,000
13836+00	6,450	400	1,200,000
14095+00	9,900	600	1,800,000
14950+00	42,700	1000	3,000,000
14985+00	9,850	400	1,200,000
15451+00	28,800	700	2,100,000
17157+00	7,700	200	600,000
19900+00	29,800	1200	3,600,000
20320+00	34,600	1300	3,900,000
20830+00	14,800	500	1,500,000
21865+00	29,200	1200	3,600,000
22325+00	15,800	300	900,000
Subtotal (Common Section):			$26,100,000

Total Cost Base Route = $46,185,000
Total Cost Route A Option = $44,085,000

[3] The cost estimate for stream crossings is based on $3,000 per track foot, or approximately $150 per square foot of superstructure. The rate is higher for stream crossings than for grade separations to allow for construction of spur dikes, splayed wingwalls, and possible higher piers and abutments.

TABLE 5-5

DARK TERRITORY WITH LOCAL HAZARD DETECTION
Option 1, Route A Option

Signal Costs

SYSTEM ELEMENT	QTY.	UNIT	UNIT COST	TOTAL COST ($1,000)
Rock Slide Detector Fence	85,000	LF	$50	$4,250
High Water Detector	27	Each	$7,300	$197
Hot Box & Wheel Detector	21	Each	$75,000	$1,575
Dragging Equipment Detector	21	Each	$22,500	$472
Track Switch-Hand Throw Type	48	Each	$4,500	$216
Local Warning Signal	82	Each	$14,400	$1,181
Solar Power:				
- 20 ERI System (ST20)	45	Each	$2,400	$108
- 100 ERI System (MR100)	21	Each	$3,400	$71
- 600 ERI System (KW600)	21	Each	$15,000	$315
- 400 ERI System (MR400)	1	Each	$9,400	$9
DC to AC Converter	21	Each	$5,000	$105
Central Control Equipment	1	Each	$163,000	$163
Grade Crossing Warning	2	Each	$65,000	$130

TOTAL COST - OPTION 1 Route A Option $8,793

TABLE 5-6
DARK TERRITORY WITH LOCAL HAZARD DETECTION
Option 1, Base Route

Signal Costs

SYSTEM ELEMENT	QTY.	UNIT	UNIT COST	TOTAL COST ($1,000)
Rock Slide Detector Fence	99,000	LF	$50	$4,950
High Water Detector	31	Each	$7,300	$226
Hot Box & Wheel Detector	20	Each	$75,000	$1,500
Dragging Equipment Detector	20	Each	$22,500	$450
Track Switch-Hand Throw Type	46	Each	$4,500	$207
Local Warning Signal	100	Each	$14,400	$1,440
Solar Power:				
- 20 ERI System (ST20)	53	Each	$2,400	$127
- 100 ERI System (MR100)	20	Each	$3,400	$68
- 600 ERI System (KW600)	20	Each	$15,000	$300
- 400 ERI System (MR400)	1	Each	$ 9,400	$9
DC to AC Converter	20	Each	$5,000	$100
Central Control Equipment	1	Each	$163,000	$163
Grade Crossing Warning	2	Each	$65,000	$130
TOTAL COST - OPTION 1 Base Route				$9,671

TABLE 5-7
AUTOMATIC BLOCK SIGNAL SYSTEM
Option 2, Route A Option

Signal Costs

SYSTEM ELEMENT	QTY.	UNIT	UNIT COST	TOTAL COST ($1,000)
Rock Slide Detector Fence	85,000	LF	$50	$4,250
High Water Detector	27	Each	$7,300	$197
Hot Box & Wheel Detector	21	Each	$75,000	$1,575
Dragging Equipment Detector	21	Each	$22,500	$472
Track Switch-Hand Throw Type	48	Each	$4,500	$216
Coded Track Circuits	350	Mile	$10,000	$3,500
Intermediate Signal	124	Each	$27,500	$3,410
Solar Power:				$0
- 20 ERI System (ST20)	45	Each	$2,400	$108
- 100 ERI System (MR100)	21	Each	$3,400	$71
- 200 ERI System (MR200)	30	Each	$5,400	$162
- 600 ERI System (KW600)	145	Each	$15,000	$2,175
- 400 ERI System (MR400)	1	Each	$9,400	$9
DC to AC Converter	21	Each	$5,000	$105
Central Control Equipment	1	Each	$163,000	$163
Grade Crossing Warning	2	Each	$65,000	$130
TOTAL COST - OPTION 2 Route A Option				$16,544

TABLE 5-8
AUTOMATIC BLOCK SIGNAL SYSTEM
Option 2, Base Route

Signal Costs

SYSTEM ELEMENT	QTY.	UNIT	UNIT COST	TOTAL COST ($1,000)
Rock Slide Detector Fence	99,000	LF	$50	$4,950
High Water Detector	31	Each	$7,300	$226
Hot Box & Wheel Detector	20	Each	$75,000	$1,500
Dragging Equipment Detector	20	Each	$22,500	$450
Track Switch-Hand Throw Type	46	Each	$4,500	$207
Coded Track Circuits	340	Mile	$10,000	$3,400
Intermediate Signal	140	Each	$27,500	$3,850
Solar Power:				$0
- 20 ERI System (ST20)	53	Each	$2,400	$127
- 100 ERI System (MR100)	20	Each	$3,400	$68
- 200 ERI System (MR200)	10	Each	$5,400	$54
- 600 ERI System (KW600)	160	Each	$15,000	$2,400
- 400 ERI System (MR400)	1	Each	$9,400	$9
DC to AC Converter	20	Each	$5,000	$100
Central Control Equipment	1	Each	$163,000	$163
Grade Crossing Warning	2	Each	$65,000	$130
TOTAL COST - OPTION 2 Base Route				$17,635

TABLE 5-9
ADVANCED TRAIN CONTROL SYSTEM
Option 3, Route A Option

Signal Costs

SYSTEM ELEMENT	QTY.	UNIT	UNIT COST	TOTAL COST ($1,000)
Rock Slide Detector Fence	85,000	LF	$50	$4,250
High Water Detector	27	Each	$7,300	$197
Hot Box & Wheel Detector	21	Each	$75,000	$1,575
Dragging Equipment Detector	21	Each	$22,500	$472
Track Switch-Hand Throw Type	48	Each	$4,500	$216
Local Warning Signal	82	Each	$14,400	$1,181
Solar Power:				$0
- 20 ERI System (ST20)	45	Each	$2,400	$108
- 100 ERI System (MR100)	21	Each	$3,400	$71
- 600 ERI System (KW600)	21	Each	$15,000	$315
- 400 ERI System (MR400)	1	Each	$9,400	$9
DC to AC Converter	21	Each	$5,000	$105
Advanced Train Control:				$0
- Wayside Transponder(1)	125	Each	$3,000	$375
- Locomotive Equipment	4	Each	$77,500	$310
- Central Control Equipment	1	Each	$539,500	$539
Grade Crossing Warning	2	Each	$65,000	$130
TOTAL COST - OPTION 3 Route A Option				$9,855

Note (1) 1 transponder per 5 miles + 1 per mainline turnout

Table 5-10
ADVANCED TRAIN CONTROL SYSTEM
Option 3 Base Route

Signal Costs

SYSTEM ELEMENT	QTY.	UNIT	UNIT COST	TOTAL COST ($1,000)
Rock Slide Detector Fence	99,000	LF	$50	$4,950
High Water Detector	31	Each	$7,300	$226
Hot Box & Wheel Detector	20	Each	$75,000	$1,500
Dragging Equipment Detector	20	Each	$22,500	$450
Track Switch-Hand Throw Type	46	Each	$4,500	$207
Local Warning Signal	100	Each	$14,400	$1,440
Solar Power:				
- 20 ERI System (ST20)	53	Each	$2,400	$127
- 100 ERI System (MR100)	20	Each	$3,400	$68
- 600 ERI System (KW600)	20	Each	$15,000	$300
- 400 ERI System (MR400)	1	Each	$9,400	$9
DC to AC Converter	20	Each	$5,000	$100
Advanced Train Control:				$0
- Wayside Transponder(1)	120	Each	$3,000	$360
- Locomotive Equipment	4	Each	$77,500	$310
- Central Control Equipment	1	Each	$539,500	$539
Grade Crossing Warning	2	Each	$65,000	$130
TOTAL COST - OPTION 3 Base Route				$10,717

Note (1) 1 transponder per 5 miles + 1 per mainline turnout

TABLE 5-11
TERRITORY WITH LOCAL HAZARD DETECTION
Option 1 Route A Option

Communications Costs

SYSTEM ELEMENT	QTY.	UNIT	UNIT COST	TOTAL COST
RADIO EQUIPMENT FOR LOCAL COVERAGE				
Radio Base Station (incl. antenna, transmission line & installation)	13	Each	$12,000	$156,000
Equipment Shelter	13	Each	13,000	$169,000
Tower (70 - 80 ft.)	13	Each	10,000	$130,000
Radiax Cable	2.5	Mile	80,000	$200,000
Locomotive Radio	4	Each	2,200	$8,800
Mobile Radio		Each	1,500	$0
Portable Radio		Each	800	$0
Wayside Radio - Rock Slide	14	Each	2,000	$28,000
Wayside Radio - High Water	27	Each	2,000	$54,000
Wayside Radio -Hot Box/Drag	21	Each	2,000	$42,000
Wayside Radio - Siding	19	Each	2,000	$38,000
Wayside Telephone - Siding	19	Each	50	$950
Control Console	1	Each	1,300	$1,300
Subtotal				828,050
MICROWAVE SYSTEM FOR BACKBONE TRANSMISSION				
Microwave Equipment (incl. transmtr, rcvr, antenna, waveguide & installation)	12	Each	35,000	420,000
Add'l Cost for Tower	12	Each	10,000	120,000
Subtotal				540,000

TOTAL COST - OPTION 1, Route A Option $1,368,050

TABLE 5-12
DARK TERRITORY WITH LOCAL HAZARD DETECTION
Option 1 Base Route

Communications Costs

SYSTEM ELEMENT	QTY.	UNIT	UNIT COST	TOTAL COST
RADIO EQUIPMENT FOR LOCAL COVERAGE				
Radio Base Station (incl. antenna, transmission line & installation)	12	Each	$12,000	$144,000
Equipment Shelter	12	Each	13,000	156,000
Tower (70 - 80 ft.)	12	Each	10,000	120,000
Locomotive Radio	4	Each	2,200	8,800
Mobile Radio		Each	1,500	0
Portable Radio		Each	800	0
Wayside Radio - Rock Slide	19	Each	2,000	38,000
Wayside Radio - High Water	31	Each	2,000	62,000
Wayside Radio -Hot Box/Drag	20	Each	2,000	40,000
Wayside Radio - Siding	18	Each	2,000	36,000
Wayside Telephone - Siding	18	Each	50	900
Control Console	1	Each	1,300	1,300
Subtotal				607,000
MICROWAVE SYSTEM FOR BACKBONE TRANSMISSION				
Microwave Equipment (incl. transmtr, rcvr, antenna, waveguide & installation)	12	Each	35,000	420,000
Add'l Cost for Tower	12	Each	10,000	120,000
Subtotal				540,000

TOTAL COST - OPTION 1, Base Route $1,147,000

TABLE 5-13
AUTOMATIC BLOCK SIGNAL SYSTEM
Option 2 Route A Option

Communications Costs

SYSTEM ELEMENT	QTY.	UNIT	UNIT COST	TOTAL COST
RADIO EQUIPMENT FOR LOCAL COVERAGE				
Radio Base Station (incl. antenna, transmission line & installation)	13	Each	$12,000	$156,000
Equipment Shelter	13	Each	13,000	169,000
Tower (70 - 80 ft.)	13	Each	10,000	130,000
Radiax Cable	2.5	Mile	80,000	200,000
Locomotive Radio	4	Each	2,200	8,800
Mobile Radio		Each	1,500	0
Portable Radio		Each	800	0
Wayside Radio - Rock Slide	0	Each	2,000	0
Wayside Radio - High Water	0	Each	2,000	0
Wayside Radio -Hot Box/Drag	21	Each	2,000	42,000
Wayside Radio - Siding	19	Each	2,000	38,000
Wayside Telephone - Siding	19	Each	50	950
Control Console	1	Each	1,300	1,300
Subtotal				746,050
MICROWAVE SYSTEM FOR BACKBONE TRANSMISSION				
Microwave Equipment (incl. transmtr, rcvr, antenna, waveguide & installation)	12	Each	35,000	420,000
Add'l Cost for Tower	12	Each	10,000	120,000
Subtotal				540,000

TOTAL COST - OPTION 2, Route A Option $1,286,050

TABLE 5-14
AUTOMATIC BLOCK SIGNAL SYSTEM
Option 2 Base Route

Communications Costs

SYSTEM ELEMENT	QTY.	UNIT	UNIT COST	TOTAL COST
RADIO EQUIPMENT FOR LOCAL COVERAGE				
Radio Base Station (incl. antenna, transmission line & installation)	12	Each	$12,000	$144,000
Equipment Shelter	12	Each	13,000	156,000
Tower (70 - 80 ft.)	12	Each	10,000	120,000
Locomotive Radio	4	Each	2,200	8,800
Mobile Radio		Each	1,500	0
Portable Radio		Each	800	0
Wayside Radio - Rock Slide	0	Each	2,000	0
Wayside Radio - High Water	0	Each	2,000	0
Wayside Radio -Hot Box/Drag	20	Each	2,000	40,000
Wayside Radio - Siding	18	Each	2,000	36,000
Wayside Telephone - Siding	18	Each	50	900
Control Console	1	Each	1,300	1,300
Subtotal				507,000
MICROWAVE SYSTEM FOR BACKBONE TRANSMISSION				
Microwave Equipment (incl. transmtr, rcvr, antenna, waveguide & installation)	12	Each	35,000	420,000
Add'l Cost for Tower	12	Each	10,000	120,000
Subtotal				540,000

TOTAL COST - OPTION 2 Base Route $1,047,000

TABLE 5-15
ADVANCED TRAIN CONTROL SYSTEM
Option 3 Route A Option

Communications Costs

SYSTEM ELEMENT	QTY.	UNIT	UNIT COST	TOTAL COST
RADIO EQUIPMENT FOR LOCAL COVERAGE				
Radio Base Station - Voice (incl. antenna, transmission line & installation)	13	Each	$12,000	$156,000
Radio Base Station - ATCS	13	Each	17,000	$221,000
Equipment Shelter	13	Each	13,000	169,000
Tower (70 - 80 ft.)	13	Each	10,000	130,000
Radiax Cable	2.5	Mile	80,000	200,000
Locomotive Radio - Voice	4	Each	2,200	8,800
Locomotive Radio - ATCS	4	Each	4,000	16,000
Mobile Radio		Each	1,500	0
Portable Radio		Each	800	0
Waysd ATCS Radio-Rock Slide	14	Each	4,000	56,000
Waysd ATCS Radio-High Water	27	Each	4,000	108,000
Waysd ATCSRadio-Hot Bx/Drag	21	Each	4,000	84,000
Wayside Radio - Siding	19	Each	2,000	38,000
Wayside Telephone - Siding	19	Each	50	950
Control Console	1	Each	1,300	1,300
Subtotal				1,189,050
MICROWAVE SYSTEM FOR BACKBONE TRANSMISSION				
Microwave Equipment (incl. transmtr, rcvr, antenna, waveguide & installation)	12	Each	35,000	420,000
Add'l Cost for Tower	12	Each	10,000	120,000
Subtotal				540,000

TOTAL COST - OPTION 3 Route A Option $1,729,050

TABLE 5-16
ADVANCED TRAIN CONTROL SYSTEM
Option 3 Base Route

Communications Costs

SYSTEM ELEMENT	QTY.	UNIT	UNIT COST	TOTAL COST
RADIO EQUIPMENT FOR LOCAL COVERAGE				
Radio Base Station - Voice (incl. antenna, transmission line & installation)	12	Each	$12,000	$144,000
Radio Base Station - ATCS	12	Each	17,000	$204,000
Equipment Shelter	12	Each	13,000	156,000
Tower (70 - 80 ft.)	12	Each	10,000	120,000
Locomotive Radio - Voice	4	Each	2,200	8,800
Locomotive Radio - ATCS	4	Each	4,000	16,000
Mobile Radio		Each	1,500	0
Portable Radio		Each	800	0
Waysd ATCS Radio-Rock Slide	19	Each	4,000	76,000
Waysd ATCS Radio-High Water	31	Each	4,000	124,000
Waysd ATCSRadio-Hot Bx/Drag	20	Each	4,000	80,000
Wayside Radio - Siding	18	Each	2,000	36,000
Wayside Telephone - Siding	18	Each	50	900
Control Console	1	Each	1,300	1,300
Subtotal				967,000
MICROWAVE SYSTEM FOR BACKBONE TRANSMISSION				
Microwave Equipment (incl. transmtr, rcvr, antenna, waveguide & installation)	12	Each	35,000	420,000
Add'l Cost for Tower	12	Each	10,000	120,000
Subtotal				540,000

TOTAL COST - OPTION 3 Base Route $1,507,000

TABLE 5-17
COST ESTIMATE
ACCESS ROAD

DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL COST ($1,000)
Clearing and Grubbing	185	Acre	$500	$93
Excavation	130,000	CY	$6	$780
CMP Drainage Culverts	1,200	LF	$25	$30
Flared End Sections	40	EA	$200	$8
Concrete Box Culverts	1,200	CY	$400	$480
V-Ditch Drainage	720	STA	$25	$18
Medium Riprap	1,200	CY	$25	$30
Heavy Riprap	400	CY	$30	$12
Subbase	124,000	CY	$18	$2,232
Aggregate base	146,000	CY	$20	$2,920
AC Pavement	367,000	SY	$15	$5,505
Guardrail	3,000	LF	$45	$135
Guide Posts	645	EA	$25	$16
Signs	180	SF	$30	$5
Sign Posts	30	EA	$500	$15
Pavement Markings		LS		$39
Guard Station		LS		$67
TOTAL DIRECT COST				$12,385
CONTINGENCIES	20%			$2,477
TOTAL CONSTRUCTION COST				$14,862
PLANNING, ENGINEERING, CM & ADMIN	24%			$3,567
TOTAL PROJECT COST				$18,429

TABLE 5-18
COST ESTIMATE SUMMARY
RAILROAD AND ACCESS ROAD ROUTE A OPTION

ELEMENT		COST ($MILLION)	COMMENTS
TRACK, CIVIL & STRUCTURES		$766.2	TIMBER TIES
SIGNALS		$8.8	UNSIGNALED
COMMUNICATIONS		$1.4	
TOTAL DIRECT CONSTRUCTION COSTS		$776.4	
CONTINGENCIES	35%	$271.7	
TOTAL CONSTRUCTION COSTS		$1,048.1	
PLANNING, ENGINEERING, CM & ADMIN	24%	$251.5	
TOTAL FACILITIES COSTS		$1,299.6	
ACCESS ROAD		$18.4	
TOTAL PROJECT COSTS[4]		$1,318.1	
ADDITIONAL COST FOR CONCRETE TIES:			
DIRECT COST		$22.6	INCREMENTAL
CONTINGENCIES		$7.9	COST OVER
SUBTOTAL		$30.5	TIMBER TIES
PLANNING, ENGINEERING, CM & ADMIN		$7.3	
TOTAL ADDITIONAL COST		$37.8	
TOTAL PROJECT COST		$1,355.8	
ADDITIONAL COST FOR AUTOMATIC BLOCK SIGNAL SYSTEM:			
SIGNALS		$7.8	INCREMENTAL
COMMUNICATIONS		($0.1)	COST OVER
TOTAL		$7.7	UNSIGNALED
CONTINGENCIES		$2.7	RAILROAD
SUBTOTAL		$10.4	
PLANNING, ENGINEERING, CM & ADMIN		$2.5	
TOTAL INCREMENTAL COST		$12.8	
TOTAL PROJECT COST		$1,330.9	
ADDITIONAL COST FOR ADVANCED TRAIN CONTROL SYSTEM:			
SIGNALS		$1.1	INCREMENTAL
COMMUNICATIONS		$0.4	COST OVER
TOTAL		$1.4	UNSIGNALED
CONTINGENCIES		$0.5	RAILROAD
SUBTOTAL		$1.9	
PLANNING, ENGINEERING, CM & ADMIN		$0.5	
TOTAL INCREMENTAL COST		$2.4	
TOTAL PROJECT COST		$1,320.5	

[4]The additional cost of beginning the Route A Option at Crestline instead of Caliente would be about $88 million for a total project cost of $1,405.8 million. Additional costs for other items that vary with distance such as concrete ties should be increased by 4.2% to reflect the longer length of this option.

TABLE 5-19
COST ESTIMATE SUMMARY
RAILROAD AND ACCESS ROAD: BASE ROUTE

ELEMENT		COST ($MILLION)	COMMENTS
TRACK, CIVIL & STRUCTURES		$580.4	TIMBER TIES
SIGNALS		$9.7	UNSIGNALED
COMMUNICATIONS		$1.1	
TOTAL DIREST CONSTRUCTION COSTS		$591.2	
CONTINGENCIES	35%	$206.9	
TOTAL CONSTRUCTION COSTS		$798.2	
PLANNING, ENGINEERING, CM & ADMIN	24%	$191.6	
TOTAL FACILITIES COSTS		$989.7	
ACCESS ROAD		$18.4	
TOTAL PROJECT COSTS[5]		$1,008.2	
ADDITIONAL COST FOR CONCRETE TIES:			
DIRECT COST		$22.0	INCREMENTAL
CONTINGENCIES		$7.7	COST OVER
SUBTOTAL		$29.6	TIMBER TIES
PLANNING, ENGINEERING, CM & ADMIN		$7.1	
TOTAL ADDITIONAL COST		$36.8	
TOTAL PROJECT COST		$1,044.9	
ADDITIONAL COST FOR AUTOMATIC BLOCK SIGNAL SYSTEM:			
SIGNALS		$8.0	INCREMENTAL
COMMUNICATIONS		($0.1)	COST OVER
TOTAL		$7.9	UNSIGNALED
CONTINGENCIES		$2.8	RAILROAD
SUBTOTAL		$10.6	
PLANNING, ENGINEERING, CM & ADMIN		$2.5	
TOTAL ADDITIONAL COST		$13.2	
TOTAL PROJECT COST		$1,021.3	
ADDITIONAL COST FOR ADVANCED TRAIN CONTROL SYSTEM:			
SIGNALS		$1.0	INCREMENTAL
COMMUNICATIONS		$0.4	COST OVER
TOTAL		$1.4	UNSIGNALED
CONTINGENCIES		$0.5	RAILROAD
SUBTOTAL		$1.9	
PLANNING, ENGINEERING, CM & ADMIN		$0.5	
TOTAL ADDITIONAL COST		$2.4	
TOTAL PROJECT COST		$1,010.5	

[5]The additional cost of beginning the Base Route at Crestline instead of Caliente would be about $88 million for a total project cost of $1,095.9 million. Additional costs for other items that vary with distance such as concrete ties should be increased by 4.3% to reflect the longer length of this option.

TABLE 5-20
COST ESTIMATE COMPARISON
(1990 MILLION $)

RAILROAD ITEMS (INCLUDING ACCESS ROAD)

	ROUTE A OPTION		BASE ROUTE	
TYPE OF SIGNALS	TIMBER TIES	CONCRETE TIES	TIMBER TIES	CONCRETE TIES
UNSIGNALED	$1,318.1	$1,355.8	$1,008.2	$1,044.9
ABS	$1,330.9	$1,368.7	$1,021.3	$1,058.1
ATCS	$1,320.5	$1,358.2	$1,010.5	$1,047.3

TABLE 5-21
LOCOMOTIVES AND CARS (IN 1990 DOLLAR)

Item	Unit Cost	Government Owned								Privately Owned	
		Gov't Op'd		Short Line Op'd		Contractor Op'd		Railroad Op'd		Privately Op'd	
		Units	Cost	Units	Cost	Units	Cost	Units	Cost	Units	Cost
1. Locomotive	1250000	4	5,000,000	4	5,000,000	4	5,000,000	0	0	4	5,000,000
2. Ballast Cars	30000	10	300,000	10	300,000	10	300,000	0	0	0	0
3. Air Dump Cars	38000	2	76,000	2	76,000	2	76,000	0	0	0	0
4. Boxcar	32000	3	96,000	3	96,000	3	96,000	0	0	0	0
5. Flat Car	30000	4	120,000	4	120,000	4	120,000	0	0	0	0
6. Personnel Cars	200000	3	600,000	3	600,000	3	600,000	0	0	0	0
7. Gondolas	30000	3	90,000	3	90,000	3	90,000	0	0	0	0
8. Switch engine	750000										
9. Escort Cars											
10. Cask Cars				Provided by National Program							
11. HD Flats											
12. Buffer Cars											
13. Spacers Cars											
Total			6,282,000		6,282,000		6,282,000		0		5,000,000

TABLE 5-22
MAINTENANCE EQUIPMENT (IN 1990 DOLLAR)

Item	Unit Cost	Government Owned								Privately Owned	
		Gov't Op'd		Short Line Op'd		Contractor Op'd		Railroad Op'd		Privately Op'd	
		Units	Cost	Units	Cost	Units	Cost	Units	Cost	Units	Cost
1. Automated Tampers	150000	2	300,000	2	300,000	2	300,000	0	0	0	0
2. Ballast Compactor	250000	1	250,000	1	250,000	1	250,000	0	0	0	0
3. Ballast Regulator	150000	1	150,000	1	150,000	1	150,000	0	0	0	0
4. Tie Removers	95000	1	95,000	1	95,000	1	95,000	0	0	0	0
5. Track Aligners and Gauger	100000	1	100,000	1	100,000	1	100,000	0	0	0	0
6. Spreader and Ditcher	100000	1	100,000	1	100,000	1	100,000	0	0	0	0
7. Track Crane	300000	1	300,000	1	300,000	1	300,000	0	0	0	0
8. Sand Remover /Snow Blower	250000	1	250,000	1	250,000	1	250,000	0	0	0	0
9. HiRail Inspection Car	32000	2	64,000	2	64,000	2	64,000	0	0	2	64,000
10. HiRail Truck	44000	2	88,000	2	88,000	2	88,000	0	0	0	0
11. HiRail Lube & Fuel	46000	2	92,000	2	92,000	2	92,000	0	0	0	0
12. Grader, Caterpillar	85000	2	170,000	2	170,000	2	170,000	0	0	0	0
13. Front Loader	65000	2	130,000	2	130,000	2	130,000	0	0	0	0
14. Automobile, Pool Cars	9600	3	28,800	3	28,800	3	28,800	0	0	3	28,800
15. 4*4 All Terrain Vehicles	14500	2	29,000	2	29,000	2	29,000	0	0	2	29,000
16. Utility Pick-up Truck	7800	2	15,600	2	15,600	2	15,600	0	0	2	15,600
17. Utility Passenger Vans	14500	2	29,000	2	29,000	2	29,000	0	0	2	29,000
18. Forklift, General Purpose	30000	2	60,000	2	60,000	2	60,000	0	0	1	30,000
19. Utility Trailer	2800	2	5,600	2	5,600	2	5,600	0	0	0	0
20. Track Carts MoW	2500	2	5,000	2	5,000	2	5,000	0	0	0	0
21. Portable Equipment	150000	1	150,000	1	150,000	1	150,000	0	0	.25	37,500
22. Shop Tools (Lathes..)	1000000	1	1,000,000	1	1,000,000	1	1,000,000	0	0	1	1,000,000
Total			3,412,000		3,412,000		3,412,000		0		1,233,900

TABLE 5-23
FACILITIES (IN 1990 DOLLARS)

Item	Unit Cost	Government Owned								Privately Owned	
		Gov't Op'd		Short Line Op'd		Contractor Op'd		Railroad Op'd		Privately Op'd	
		Units	Cost	Units	Cost	Units	Cost	Units	Cost	Units	Cost
1. Turning Tracks and Wyes	562500	1	562,500	1	562,500	1	562,500	1	562,500	1	562,500
2. Emergency Equipment Track	125000	2	250,000	2	250,000	2	250,000	2	250,000	2	250,000
3. Fencing for Sidings	3000	4	12,000	4	12,000	4	12,000	4	12,000	4	12,000
4. HiRail Heliport Pads	125000	3	375,000	3	375,000	3	375,000	2	250,000	3	375,000
5. Garages & Warehouses	108000	3	324,000	3	324,000	3	324,000	2	216,000	3	324,000
6. Crew Station & Offices	72000	2	144,000	2	144,000	2	144,000	2	144,000	2	144,000
7. Locomotive Service Facil.	360000	3	1,080,000	3	1,080,000	3	1,080,000	2	720,000	3	1,080,000
8. Headquarters (bldg. only)	720000	1	720,000	1	720,000	1	720,000	0	0	1	720,000
9. Dispatch Offices	72000	1	72,000	1	72,000	1	72,000	0	0	1	72,000
10. Locomotive & Car Shop	720000	1	720,000	1	720,000	1	720,000	1	720,000	1	720,000
11. Emergency Station	120000	Provided by Local Government or National Program									
12. Interchange Track @ Caliente		Included in Construction Cost									
13. Sidings		Included in Construction Cost									
Total			4,259,500		4,259,500		4,259,500		2,874,500		4,259,500

TABLE 5-24
EMERGENCY EQUIPMENT (IN 1990 DOLLAR)

Item	Unit Cost	Government Owned								Privately Owned	
		Gov't Op'd		Short Line Op'd		Contractor Op'd		Railroad Op'd		Privately Op'd	
		Units	Cost	Units	Cost	Units	Cost	Units	Cost	Units	Cost
1. 1st Response Vehicle	55000	1	55,000	1	55,000	1	55,000	1	55,000	1	55,000
2. Snowplow, Locomotive	30000	2	60,000	2	60,000	2	60,000	0	0	2	60,000
3. Ambulance	80000	Provided by Local Government									
4. Wreckmaster	110000	Rent when needed									
5. Fire Truck	125000	Rent when needed									
6. Mobile Derrick	2000000	Rent when needed									
7. 250T HiRail Crane	550000	Rent when needed									
Total			115,000		115,000		115,000		55,000		115,000

TABLE 5-25
SUMMARY OF CAPITAL COST (IN 1990 DOLLAR)

Category of Personnel	Government Owned				Privately Owned
	Gov't Op'd	Short Line Op'd	Contractor Op'd	Railroad Op'd	Privately Op'd
Locomotives and Cars	6,282,000	6,282,000	6,282,000	Contract	5,000,000
Maintenance Equipment	3,412,000	3,412,000	3,412,000	Contract	1,233,900
Facilities	4,259,500	4,259,500	4,259,500	2,874,500	4,259,500
Emergency Equipment	115,000	115,000	115,000	55,000	115,000
Contingency Cost	2,813,700	2,813,700	2,813,700	585,900	2,121,680
Total	16,882,200	16,882,200	16,882,200	3,515,400	12,730,080

TABLE 5-26
COMPOSITE SUMMARY OF CAPITAL COSTS (In Million 1990 Dollars)

Category of Personnel	Government Owned				Privately Owned
	Gov't Op'd	Short Line Op'd	Contractor Op'd	Railroad Op'd	Privately Op'd
Railroad Way Construction (Base Route, Timber Ties, Unsignaled)	1,008.2	1,008.2	1,008.2	1,008.2	1,008.2
Rolling Stock, Equipment, and Building Facilities	16.9	16.9	16.9	3.5	12.7
Total Capital Costs	1,025.1	1,025.1	1,025.1	1,011.7	1,020.9

ADDITIONAL COST FOR OPTIONAL DESIGN FEATURES
(In Million 1990 Dollars)

Route A Option, Timber Ties, Unsignaled	309.9
Concrete Ties, Unsignaled	347.6
Automatic Block Signals	12.9
Advanced Train Control System	2.4
Base Route	
Concrete Ties, Unsignaled	36.7
Automatic Block Signals	13.1
Advanced Train Control System	2.4

6. OPERATION AND MAINTENANCE COSTS

6.1 SCOPE

Operations and maintenance costs (O&M Costs) are those costs required to operate and upkeep the railroad after initial construction is completed and equipment purchased. Items covered by O&M Costs include personnel, maintenance of way, maintenance of rolling stock from routine inspections to overhauls, both in house or contracted. Different from long-term capital costs, operations and maintenance costs are day-to-day or short-term based and therefore calculated annually. Anticipated variations of O&M Costs over the entire duration of the program, in the form of cash flow, are also a concern of both the owner and the operator.

6.2 METHODOLOGY

6.2.1 Cost Elements

6.2.1.1 Personnel Costs. Personnel costs include base salaries, supplemental fringe benefits and additional incentive package for a personnel payroll that is functionally necessary. Cost of staff training and placement will also be included in this category.

The estimated personnel payroll used as a basis was designed to meet the minimum requirements of normal railroad operation. Six major employment segments were considered indispensable in accomplishing the desired railroad operations and maintenance. These personnel categories are:

- Administrative officers for general management and contract coordination;
- Mechanical personnel in dealing with routine rolling stock inspections, regular checking and minor repairs;
- Operations, Planning and Control in charge of train operational dispatching and coordination;
- Maintenance of way staff handling tasks related to upkeep of the railroad tracks, signals and communications systems;
- Security and first response team with regard to protection of the properties and physical facilities as well as responding to the immediate actions should emergency situations occur;

- Operating crews, including engineers, train operators with various on-board duties, in directly delivering the train service.

6.2.1.2 Operating Costs. Operating costs here are defined narrowly as non-labor expenditures in train operation, including costs for fuel, lube and sand, routine check-up and inspection, and other procedures directly attached to train operation.

6.2.1.3 Mechanical Costs. This item covers minor shop work performed in house and related spare parts and materials for repairs on locomotives, escort cars, cask cars, buffer and spacer cars, and other vehicles and equipment.

6.2.1.4 Contracted Maintenance. Major overhauls on locomotives and major repairs on other vehicle and equipment fall into this category. Because such overhauls and major repairs occur infrequently in time and generally the operation load is light, contracting out these activities is considered more cost efficient than investing in equipment and facilities for such purposes. Cycles for overhauls and major repairs are expected to be every ten years.

6.2.1.5 Maintenance of Way. Maintenance of way cost elements include materials, warehousing, and replacement of segments of railroad track, ballast, rip rap, switches, joints, ties, spikes, etc. Also included are continuous and/or periodic inspections and engineering adjustments of the roadbed, bridges, access roads, weed-snow-sand-water clearance of the right of way, and all other requirements to assure operation in accordance with American Railway Engineering Association (AREA) specifications for normalized maintenance. Equipment related to the maintenance of way include vehicles to carry personnel and machinery to the way maintenance site, and machinery for maintaining the railroad, cuts, sidings, and turning tracks, and so on.

6.2.1.6 Contingencies. Contingencies, set at 25% of the total operating cost, represent items related to operation and maintenance that cannot be precisely determined at this stage. Unexpected costs that might occur also belong to this category.

6.2.2 Methodology

6.2.2.1 Personnel Pay Scale and Disposition. The personnel costs are estimated based on standard 1990 rate scales in the rail industry, as published by AAR for the December 1990 fourth quarter. Such a standard rate includes wages and supplemental fringe benefits. In addition, a cost of living allowance adjustment is believed necessary to accommodate for the remote and harsh desert working environment and provide an incentive to enjoin the project over a long term.

Variations on the personnel pay rate scale between the institutional alternatives are as below:

- Government Owned / Government Operated 100%
- Government Owned / Shortline Operated 80%
- Government Owned / Contractor Operated 110%
- Government Owned / Railroad Operated 100%
- Privately Owned / Privately Operated 80%

Number of people engaged in different responsibilities is estimated for each institutional alternative based on its particular operational philosophy, assuming the overall service is similar with all the alternatives.

6.2.2.2 Industry Formulae for Operating Costs Operating cost estimating formulae and parameters derived from common practice can be found in railroad operations manuals. Extensive consultation to the industry sources have been made, as reflected in the list of references and sources of cost data in Appendix B. The formulae and parameters referred in this study include:

- Fuel, Lube, Sand: $65 per operating locomotive per trip
- Routine Maintenance: $15,000 per locomotive per year
- Mechanical Cost: $0.80 per locomotive per mile per trip
- Material in Maintenance of Way: 30% of labor costs for maintenance of way
- Maintenance of Facilities: 5% of the facility worth
- Contingencies: 25% of the total operating costs

6.3 INSTITUTIONAL IMPLICATIONS

Section 3.2 includes a detailed summary of the five operating scenarios, the major responsibilities of the parties involved, and some of the institutional implications of each arrangement. This section outlines the effect of these factors on operating cost. Relatively efficient staffing levels are assumed for all of the scenarios as part of an effort to keep operating costs to a realistic minimum.

6.3.1 Government Owned and Government Operated

The costs presented in Section 6.4 assume an efficiently organized and run government organization as the operator of the rail line. The advantages and disadvantages of this type of operation with respect to cost are as follows:

- The government organization can make use of non-union wage rates and work rules which increase cost efficiency with respect to the Class I railroad environment. However, the

need to employ incentive pay to attract and keep personnel in the desert environment is assumed to make the actual wage scales about even.

- There is no need to make a profit. In principle, total costs can be lower than those of the private sector. However, because the environment is not competitive, there is also less incentive to hold down costs.

- The staffing level of the railroad, the key factor in the operating and maintenance costs, is assumed to be at realistic minimum level to respond to the concern that the government owner or user is expected to have about the level of ongoing operational costs. Although staff levels are adjusted among the scenarios to reflect differences in organizational style and utilization of personnel, there is some risk in this scenario with respect to this assumption because the non-competitive environment may lead to a more inflated staff. The staffing level is also sized for the routine operation. There is no margin for the unexpected. Although a 25% contingency is added to these costs as partial compensation for the risk, it applies evenly to the other scenarios as well.

- Equipment and rolling stock costs are substantially higher than for the Class I operated and/or maintained because all equipment must be purchased initially. The only exception to this is the assumption that most emergency equipment such as cranes can be leased on an "as needed" basis. However, only four locomotives are purchased, a minimum number. As with the staff, the capital equipment is selected for the average situation with no margin for the unexpected.

- A primary advantage of the government owned and operated scenario is relatively greater control over both the operation and the costs of it than in comparison with the other scenarios.

6.3.2 Government Owned and Short Line Operated

In comparison to the government owned and government operated case, the government owned and short line operated scenario has the following advantages and disadvantages:

- Because of job sharing and pressures from private sector competition, the short line operator can achieve the lowest operating cost of any of the scenarios.

- The disadvantage is that there is marginally less control over the operation because the short line operator is trying to

stretch his resources as far as they will go. This inhibits speed and creates a risk of non-performance.

- The capital facility costs are the same as for the previous scenario. Similarly, most maintenance of way is performed by short line employees.

6.3.3 Government Owned and Contractor Operated

This contractor differs from the short line operator in that he is not a specialized railroad contractor but rather a more general industrial contractor who might also be the operating contractor at the potential site. This is the mode of operation of Hawthorne Army Ammunition Plant at Hawthorne, NV, in which the contractor Day & Zimmermann/Basil Corporation operates both the plant and the access railroad. Cost factors include:

- The contractor generally costs more than a short line operator because the contract arrangement is usually on a cost-plus-fixed-fee basis, creating an incentive to use as much labor as the operation will support.

- Though not as competitive as the short line operator, use of the contractor might improve overall long run efficiency and cost effectiveness at the site.

- The capital facility costs are the same as for the previous two scenarios. Similarly, most maintenance of way is performed by contractor employees.

6.3.4 Government Owned and Class I Railroad Operated

For the Caliente route, the relevant Class I railroad is the Union Pacific. Cost factors include:

- Less facility investment is required than for the previous three scenarios because the UP would use its own major maintenance facilities, operations center, maintenance equipment, and so on.

- Higher operating cost may be incurred because of less efficient work rules, the need to cover fixed organization costs, profit, and semi-monopoly pricing. Because the contract cost would be established by negotiation, the assumed costs are based on judgement.

- No cost incentive pay is assumed for Class I railroad employees because Nevada already is their operating territory. However, the cost saving that this might give in comparison to

the other scenarios is lost to the above factors that tend to cause higher costs.

- A depth of resources and experience unmatched by any of the other potential operators suggests that the Class I contractor would be the most responsive. The Class I contractor would also perform all of the maintenance of way.

6.3.5 Privately Owned and Operated

From one perspective, this scenario is similar to the previous three and involves just another contractor operating the railroad. However, the ownership would now be in private hands, such as a joint powers authority. In this sense, this arrangement is similar to a city transit line or railroad. Thus the main consideration in this arrangement would not be cost but realization of limited political control of the railroad at a relatively local level. Costs factors include:

- If the private owner is a joint powers authority or some other political body, the cost environment would be similar to the government owned and operated. However, because the rural counties, if they constituted the joint powers authority, might be likely to contract out the operation, the wage rates are assumed to match the short line scenario.

- Because less industrial expertise might exist at the local rural level, maintenance of way is assumed contracted to a Class I rail operator.

- The capital facility costs are the same as for the first three scenarios.

6.4 OPERATING COST SUMMARIES

6.4.1. Operating Annual Costs

Table 6-1 presents the personnel costs under different alternatives, including job titles, number of people at different positions and their compensation rates. Because of its existing organizational and operational setup and different way of charging to the program, Class I Railroad has few people on the direct payroll except one administrator and several security guards. The Privately Owned and Operated alternative ends up with a short payroll after skipping the Maintenance of Way, which is the largest number of employee segment under other alternatives. The Government Operated alternative has the biggest payroll among all the alternatives, particularly in a much bigger administration.

TABLE 6-1

PERSONNEL (IN 1990 DOLLAR)

Category of Personnel	Government Owned								Privately Owned	
	Gov't Op'd		Short Line Op'd		Contractor Op'd		Railroad Op'd		Privately Op'd	
	Persons	Av. Pay	Persons	Av. Pay	Persons	Av. Pay	Persons	Av. Pay	Persons	Av. Pay
Administrative										
General Manager	1	112,000	1	89,600	0	0	0	0	1	89,600
Adm. & Contracts Officer	1	105,000	0	0	1	115,500	0	0	0	0
Superintendent	1	100,800	0	0	1	123,200	1	100,800	1	80,640
Secretarial & Clerks	3	50,652	0	0	0	0	0	0	1	40,520
Subtotal	6	469,756	1	89,600	2	238,700	1	100,800	3	210,760
Mechanical										
Locomotive & Car Foreman	1	70,000	1	56,000	1	77,000	0	0	1	56,000
Car Inspector	1	62,400	1	49,920	0	0	0	0	1	49,920
Mechanics	3	54,000	4	43,200	3	59,400	0	0	4	43,200
Subtotal	5	294,400	6	278,720	4	255,200	0	0	6	278,720
Operations, Planning & Control										
Chief Dispatcher	1	84,000	1	67,200	1	92,400	0	0	1	67,200
Dispatchers	3	75,600	3	60,480	3	83,160	0	0	3	60,480
Road Foreman of Engines	1	82,000	0	0	0	0	0	0	0	0
Subtotal	5	392,800	4	248,640	4	341,880	0	0	4	248,640
Maintenance of Way									(Assumed all track	
Roadmaster	1	81,600	1	65,280	1	89,760	0	0	Maintenance will	
Maintenance Foremen	2	63,050	2	50,440	2	69,350	0	0	be contracted to	
Maintenance Personnel	12	50,652	6	40,520	12	55,725	0	0	an industrial rail	
Equip. & Veh. Operators	2	56,700	2	45,360	2	62,375	0	0	contractor)	
Subtotal	17	928,924	11	500,000	17	1,021,910	0	0		
Security & 1st Response Team										
Chief Special Agent	1	84,000	1	67,200	1	92,400	0	0	1	67,200
Sp. Agent & 1st Response	2	62,400	2	49,920	2	68,640	2	84,000	2	49,920
Subtotal	3	208,800	3	167,040	3	229,680	2	168,000	3	167,040

TABLE 6-1 (CONT.)

PERSONNEL ANNUAL COST (IN 1990 DOLLARS)

Category of Personnel	Government Owned								Privately Owned	
	Gov't Op'd		Short Line Op'd		Contractor Op'd		Railroad Op'd		Privately Op'd	
	Persons	Av. Pay	Persons	Av. Pay	Persons	Av. Pay	Persons	Av. Pay	Persons	Av. Pay
Operating Personnel										
Supervisor of Crews	0	0	0	0	1	90,200	0	0	1	67,200
Engineers	3	72,800	3	58,240	3	80,100	0	0	3	58,240
Conductors	3	69,600	3	55,680	3	76,560	0	0	3	55,680
Brakemen	3	66,000	3	52,800	3	72,600	0	0	3	52,800
Subtotal	9	625,200	9	500,160	10	777,980	0	0	10	567,360
Total	45	2,919,880	34	1,784,160	40	2,865,350	3	268,800	26	1,472,520

Table 6-2 summarizes the total operating annual cost by recapping the personnel costs divided into responsibility groups and by applying industry cost estimating formulae and parameters on other categories of operating costs.

6.4.2 Cash Flow Table for the Program Duration

A cash flow chart is shown in Table 6-3. It reflects the anticipated operating cost in 1990 dollars on an annual basis over the 25 years, the expected duration of the program. While most of the items stay constant, the contracted maintenance (overhauls) and maintenance of way compose the irregular expenditures over time.

6.5 COST SUMMARY FOR THE CALIENTE ROUTE

Table 6-4 summarizes the program costs using net present value and annualized costs to compare operating scenarios. Because costs include initial capital costs and variable annual costs, these statistics are useful for comparing the scenario costs. Net present value capitalizes all costs over the 25 year operation period. Annualized costs amortize all costs, including the initial capital costs, over the 25-year period. The discount rate used is 4% per year, the appropriate opportunity cost for a low risk public sector investment analyzed in constant dollars.

The upper section of Table 6-4 summarizes the variable capital plus O&M costs from Table 6-3. The result is a range of annualized costs from $4.4 million for the shortline operator to $7.2 million for the Class I operator. The other three scenarios cluster in between these two extremes.

The lower section of Table 6-4 summarizes the total capital costs of the program from Chapter 5 plus the variable O&M costs. On an annualized basis, there is less than a $3 million per year difference between the least expensive short line operator ($68.7 million) and the most expensive Class I operator ($71.6 million). The other scenarios are about $70 million per year.

The net present value summary varies between $1.07 billion and $1.11 billion for the same operator categories. The initial capital construction costs dominate the cost summary.

TABLE 6-2
SUMMARY OF ANNUAL O&M COSTS (IN 1990 DOLLARS)

Category of Personnel	Government Owned								Privately Owned	
	Gov't Op'd		Short Line Op'd		Contractor Op'd		Railroad Op'd		Privately Op'd	
	Units	Av. Cost	Units	Av. Cost	Units	Av. Cost	Units	Av. Cost	Units	Av. Cost
Personnel										
Administrative	6	469,756	1	89,600	2	238,700	1	100,800	3	210,760
Mechanical	5	294,400	6	278,720	4	255,200	0	0	6	278,720
Operations, Plg & Control	5	392,800	4	248,640	4	341,880	0	0	4	248,640
Maintenance of Way	17	928,924	11	500,000	17	1,021,910	0	0	0	0
Security & 1st Response Tea	3	208,800	3	167,040	3	229,680	2	168,000	3	167,040
Operating Team	9	625,200	9	500,160	10	777,980	0	0	10	567,360
Subtotal	45	2,919,880	34	1,784,160	40	2,865,350	3	268,800	26	1,472,520
Operating cost										
Fuel, Lube, Sand		262,080		262,080		262,080		Contracted		Contracted
Routine Maintenance		60,000		60,000		60,000		Contracted		Contracted
Subtotal/Contract		322,080		322,080		322,080		3,712,296		354,288
Contracted Maintenance										
Major Overhaul		50,000		50,000		50,000		Contracted		50,000
Other Equipment		10,000		10,000		10,000		Contracted		0
Subtotal		60,000		60,000		60,000		Contracted		50,000
Mechanical Cost (Locomotives)		97,574		97,574		97,574		Contracted		Contracted
Maintenance of Way										
Materials/Contract		278,677		150,000		306,573		1,426,590		1,426,590
Facilities		212,975		212,975		212,975		143,725		212,975
Subtotal		491,652		362,975		519,548		1,570,315		1,639,565
Contingency @ 25%		972,797		656,697		966,138		1,387,853		879,093
Total		4,863,983		3,283,487		4,830,691		6,939,264		4,395,466

TABLE 6-3
CASH FLOW FOR VARIABLE CAPITAL AND O&M COSTS

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Government Owned											
Government Operated											
Routine Cost		4,525,306	4,525,306	4,525,306	4,525,306	4,525,306	4,525,306	4,525,306	4,525,306	4,525,306	4,525,306
Irregular Cost	14,068,500	278,677	278,677	55,735	55,735	55,735	55,735	55,735	55,735	55,735	655,735
Total	14,068,500	4,803,983	4,803,983	4,581,041	4,581,041	4,581,041	4,581,041	4,581,041	4,581,041	4,581,041	5,181,041
Shortline Operated											
Routine Cost		3,073,487	3,073,487	3,073,487	3,073,487	3,073,487	3,073,487	3,073,487	3,073,487	3,073,487	3,073,487
Irregular Cost	14,068,500	150,000	150,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	630,000
Total	14,068,500	3,223,487	3,223,487	3,103,487	3,103,487	3,103,487	3,103,487	3,103,487	3,103,487	3,103,487	3,703,487
Contractor Operated											
Routine Cost		4,464,118	4,464,118	4,464,118	4,464,118	4,464,118	4,464,118	4,464,118	4,464,118	4,464,118	4,464,118
Irregular Cost	14,068,500	306,573	306,573	61,315	61,315	61,315	61,315	61,315	61,315	61,315	661,315
Total	14,068,500	4,770,691	4,770,691	4,525,433	4,525,433	4,525,433	4,525,433	4,525,433	4,525,433	4,525,433	5,125,433
Railroad Operated											
Routine Cost		5,512,674	5,512,674	5,512,674	5,512,674	5,512,674	5,512,674	5,512,674	5,512,674	5,512,674	5,512,674
Irregular Cost	2,929,500	1,426,590	1,426,590	1,069,943	1,069,943	1,069,943	1,069,943	1,069,943	1,069,943	1,069,943	1,069,943
Total	2,929,500	6,939,264	6,939,264	6,582,617	6,582,617	6,582,617	6,582,617	6,582,617	6,582,617	6,582,617	6,582,617
Privately Owned											
Privately Operated											
Routine Cost		2,906,376	2,906,376	2,906,376	2,906,376	2,906,376	2,906,376	2,906,376	2,906,376	2,906,376	2,906,376
Irregular Cost	10,608,400	1,426,590	1,426,590	1,069,943	1,069,943	1,069,943	1,069,943	1,069,943	1,069,943	1,069,943	1,569,943
Total	10,608,400	4,332,966	4,332,966	3,976,319	3,976,319	3,976,319	3,976,319	3,976,319	3,976,319	3,976,319	4,476,319

TABLE 6-3
CASH FLOW FOR VARIABLE CAPITAL AND O&M COSTS (CONT.)

PAGE 2

	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21
Government Owned											
Government Operated											
Routine Cost	4,525,306	4,525,306	4,525,306	4,525,306	4,525,306	4,525,306	4,525,306	4,525,306	4,525,306	4,525,306	4,525,306
Irregular Cost	278,677	278,677	278,677	278,677	278,677	278,677	278,677	278,677	278,677	278,677	278,677
Total	4,803,983	4,803,983	4,803,983	4,803,983	4,803,983	4,803,983	5,403,983	4,803,983	4,803,983	4,803,983	4,803,983
ShortLine Operated											
Routine Cost	3,073,487	3,073,487	3,073,487	3,073,487	3,073,487	3,073,487	3,073,487	3,073,487	3,073,487	3,073,487	3,073,487
Irregular Cost	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	750,000	150,000
Total	3,223,487	3,223,487	3,223,487	3,223,487	3,223,487	3,223,487	3,223,487	3,223,487	3,223,487	3,823,487	3,223,487
Contractor Operated											
Routine Cost	4,464,118	4,464,118	4,464,118	4,464,118	4,464,118	4,464,118	4,464,118	4,464,118	4,464,118	4,464,118	4,464,118
Irregular Cost	306,573	306,573	306,573	306,573	306,573	306,573	906,573	306,573	306,573	306,573	306,573
Total	4,770,691	4,770,691	4,770,691	4,770,691	4,770,691	4,770,691	5,370,691	4,770,691	4,770,691	4,770,691	4,770,691
Railroad Operated											
Routine Cost	5,512,674	5,512,674	5,512,674	5,512,674	5,512,674	5,512,674	5,512,674	5,512,674	5,512,674	5,512,674	5,512,674
Irregular Cost	1,426,590	1,426,590	1,426,590	1,426,590	1,426,590	1,426,590	1,426,590	1,426,590	1,426,590	1,426,590	1,426,590
Total	6,939,264	6,939,264	6,939,264	6,939,264	6,939,264	6,939,264	6,939,264	6,939,264	6,939,264	6,939,264	6,939,264
Privately Owned											
Privately Operated											
Routine Cost	2,906,376	2,906,376	2,906,376	2,906,376	2,906,376	2,906,376	2,906,376	2,906,376	2,906,376	2,906,376	2,906,376
Irregular Cost	1,426,590	1,426,590	1,426,590	1,426,590	1,426,590	1,426,590	1,926,590	1,426,590	1,426,590	1,426,590	1,426,590
Total	4,332,966	4,332,966	4,332,966	4,332,966	4,332,966	4,332,966	4,832,966	4,332,966	4,332,966	4,332,966	4,332,966

TABLE 6-3
CASH FLOW FOR VARIABLE CAPITAL AND O&M COSTS (CONT.)

PAGE 3

	Year 22	Year 23	Year 24	Year 25
Government Owned				
Government Operated				
Routine Cost	4,525,306	4,525,306	4,525,306	4,525,306
Irregular Cost	278,677	278,677	278,677	278,677
Total	4,803,983	4,803,983	4,803,983	4,803,983
Shortline Operated				
Routine Cost	3,073,487	3,073,487	3,073,487	3,073,487
Irregular Cost	150,000	150,000	150,000	150,000
Total	3,223,487	3,223,487	3,223,487	3,223,487
Contractor Operated				
Routine Cost	4,464,118	4,464,118	4,464,118	4,464,118
Irregular Cost	306,573	306,573	306,573	306,573
Total	4,770,691	4,770,691	4,770,691	4,770,691
Railroad Operated				
Routine Cost	5,512,674	5,512,674	5,512,674	5,512,674
Irregular Cost	1,426,590	1,426,590	1,426,590	1,426,590
Total	6,582,617	6,582,617	6,582,617	6,582,617
Privately Owned				
Privately Operated				
Routine Cost	2,906,376	2,906,376	2,906,376	2,906,376
Irregular Cost	1,426,590	1,426,590	1,426,590	1,426,590
Total	4,332,966	4,332,966	4,332,966	4,332,966

TABLE 6-4

CALIENTE BASE ROUTE
NET PRESENT VALUE AND ANNUALIZED COST
(1990 Million $)

Ownership:	Government Owned				Private
Operator:	Gov't	Shortline	Contractor	Class I	Private
Variable Capital Plus O&M Costs					
Net Present Value	87.71	64.59	87.02	105.48	75.74
Annualized	5.94	4.36	5.91	7.23	5.20
Total Capital Plus O&M Costs*					
Net Present Value	1,093.41	1,070.29	1,092.72	1,111.18	1,081.44
Annualized	70.32	68.74	70.29	71.60	69.58

* With Base Route, Timber Ties, Unsignaled Railroad Construction Alternative.

7. ENVIRONMENTAL AND ARCHAEOLOGICAL ASPECTS

This chapter describes the development of environmental data at 1:24,000 scale. This process was a refinement of the identification of environmental restrictions at 1:250,000 scale described in Chapter 2. It was interactive with the development and modification of the route segments at 1:24,000 scale. The background report for the ecology portion of this chapter are included in Appendix F.

7.1 REFINEMENT OF LAND USE AND ENVIRONMENTAL RESTRICTIONS

7.1.1 Land Use Restrictions

Land use restrictions were reviewed at 1:24,000 scale as a result of three activities:

7.1.1.1 Refinement of Resource Management Area Boundaries. The boundaries of some resource management areas required replotting on 1:24,000-scale maps to clarify the restrictions to developing specific alignments along the Base Route, the northern route through Lincoln County. None posed a limitation not outlined in the larger scale analysis.

7.1.1.2 Research of Land Ownership Records. Private ownership of land along the potential alignments was researched through public records. The general extent of private land ownership is summarized in Section 3.13. Efforts were made to avoid private land when engineering considerations would permit. Generally, there would be little contact with private land by the alignments investigated. This information is included as a layer in the design files.

7.1.1.2 Research of Mining Claims. Similar to the investigation of private ownership of land along the potential alignments, mining claims were researched from public records. Because the conceptual design describes a general corridor, final design would avoid significant conflicts with most claims. The current alignments were selected to avoid any large established mine sites. This information is included as a layer in the design files.

7.1.2 Biological Resources

To determine the location of known sensitive biological resources and their relationship to the potential Caliente route, data was compiled from published materials as well as other secondary sources. For much of the area, no sensitive biological features were identified from available information sources. Relatively

few biological surveys have been conducted in this part of Nevada. It is anticipated that additional surveys would discover more resources.

Habitats identified in the alignment are those of the Desert Tortoise, Bighorn Sheep, various raptors, and the Pahranagat Valley Vole. Descriptions of potential species involvements are included below with a summary of findings.

7.1.2.1 Desert Tortoise. The Desert Tortoise is listed as a Threatened species and is afforded protection under the Endangered Species Act. The terminus of the potential route is situated within tortoise habitat. Tortoises or tortoise habitat may not be disturbed without an Incidental Take Permit from the U.S. Fish and Wildlife Service (USFWS). To issue the permit, the USFWS will require information as to the distribution and relative tortoise densities in the project area, including the specific number of tortoises and acres of habitat being taken. The USFWS usually issues these permits as part of a Biological Opinion.

The information required by USFWS is typically provided by a Biological Assessment. An acceptable Assessment contains a project description, literature search results, field survey results, an appraisal of expected impacts (direct, indirect, and cumulative), and a plan for measures designed to mitigate and compensate for those impacts.

Current USFWS recommendations for performing field surveys for this type of linear facility include having biologists, experienced in desert tortoise survey techniques, walk a total of 14 parallel transects centered on the alignment.

Recent tortoise mitigation measures stipulated in other Biological Opinions include:

- Pre-construction survey. Tortoises from the construction zone are relocated into adjacent undisturbed habitat.

- Education. A worker education program designed to alert the construction related personnel of the importance and necessity of minimizing take of desert tortoise and tortoise habitat.

- Monitoring. Biologists monitor actual construction to prevent or reduce inadvertent tortoise mortality.

- A post-construction report which documents the efficacy of the mitigation measures.

In addition to these mitigation measures, compensation for the loss of animals and habitat is also required. Compensation funds

are used to purchase habitat for the species, and perhaps for research on a problem or threat to the species. In Nevada, compensation is assessed at $324.00 per acre of disturbance for permanently lost habitat, and at 40% ($127.00/acre) for temporarily disturbed habitat.

7.1.2.2 Bighorn Sheep. The Nevada Department of Wildlife (NDOW) has the primary responsibility for the protection and management of this game species throughout the state. The Bureau of Land Management (BLM) is also responsible for minimizing impacts to Bighorn sheep on public lands under their administration. The NDOW Technical Supervisor-Habitat has stated that traversing areas with Bighorn sheep is a relatively simple process. Linear facilities such as a railroad do not seriously disturb this species. In addition, Bighorn sheep primarily occupy the higher elevations and slopes while the alignment lies in the lower elevations, and the alignment does not intersect known critical migration corridors.

Should alignment be determined to fragment habitat or to otherwise impede the continued free travel between two or more populations, then under or overpasses could be constructed to prevent this type of genetic isolation. Desert tortoises could also utilize a scaled down version of similar such tunnels if deemed necessary.

7.1.2.3 Raptors. All of these predatory birds are protected by the Migratory Species Act and some (Bald eagles and Peregrine falcons) have a higher degree of protection as they are listed as endangered and are fully protected by the Endangered Species Act. In addition, eagles are afforded a third level of protection under the federal Eagle Act.

The alignment traverses known portions of the Peregrine and Bald eagle winter range on the Hiko SE and Mount Irish SE 7.5 minute USGS quadrangle maps. Like the Bighorn sheep, these birds primarily occur in the rocky escarpments. The birds are likely to forage over the alignment, however, this is considered to be an insignificant impact. The critical issue in this case is to avoid nesting and roosting sites. This can be done by re-routes or scheduling construction after fledglings have left the nest. No known nesting sites of these species was identified during the scoping process.

7.1.2.4 Pahranagat Valley Vole. The range of this small mammal is limited to the Pahranagat Valley. A candidate for federal listing as threatened or endangered, the USFWS will need to determine whether this project will jeopardize the continued existence of the species. It is likely that a trapping study would be required to census this species. This type of census usually involves setting a pre-determined number of traps in a

pre-determined pattern on or near the alignment and trapping for a pre-determined number of nights.

An example of how the permitting and study process may occur is outlined as follows:

- Obtain Memoranda of Understanding (MOU) and scientific collecting permit from NDOW.

- Consult with NDOW and USFWS to determine appropriate trapping stratagems. One possible result would be the requirement to set four 100-trap grids and run these for three nights, and to repeat this effort three weeks later.

- Determine whether the project would have an adverse impact on this species. If impacts are expected, determine a minor route adjustment to minimize or eliminate those impacts.

7.1.2.5 Sensitive Areas. The Pahranagat Valley was determined to be the most sensitive area in the alignment. The single greatest concentration of sensitive biological resources occurs along the alignment in this area. Bighorn sheep, raptors, and voles, as discussed above, all occur in this area.

The only other known sensitive area along the alignment is close to Yucca Mountain. Desert tortoise are concentrated near the project terminus. It is anticipated that any involvements with sensitive species that may occur would take place in these locations. Hence, surveys and trapping studies undertaken in the future should pay particular attention to these locations.

7.1.2.6 Conclusion. This route has been adjusted and relocated several times in the course of this project in order to avoid contacts with sensitive species, in addition to other resources and features, and has managed to minimize contact with most sensitive biological resources. Where conflicts remain, there are mechanisms in place that would allow permitting of construction through these areas.

7.2 ARCHAEOLOGICAL SCREENING

This section presents the results of a Cultural Resources Class I Summary Inventory for the routes developed in the study.

7.2.1 Introduction and Purpose of the Class I Inventory

The Class I inventory for the Caliente alternative presents information concerning prehistory, ethnohistory, Native American concerns, and history, as well as discussions of the natural environment, past and present. Data were gathered from the existing literature and from major regional archival repositories. The study was augmented with site visits to a selected sample of prehistoric, historic and ethnohistoric sites.

The methods and purpose of a Class I inventory were taken from existing U. S. Department of the Interior, Nevada Bureau of Land Management guidelines for cultural resources investigations in the State (USDI 1989:5).

This Class I study provides background data which can be used to evaluate both the need for additional study as well as the significance of prehistoric and historic cultural resources expected to occur. Given the limited amount of previous systematic research within the Caliente Alternate study area, an intensive cultural resources inventory will be needed along virtually all of the route, if selected, to locate and evaluate sites eligible for the NRHP. Only limited recommendations presently can be made regarding specific sites to be avoided since, in the absence of complete inventory data, elimination of one perceived problem by avoidance (through re-routing) may only push the project into another problem area. An intensive inventory effort should also involve more detailed examination of regional historic archives. In instances where avoidance is not possible and scientific research potential is established, mitigative efforts (through excavation, historical research, and analysis) would be necessary.

7.2.2 Methodology

The study area is represented by a one-mile wide corridor for most of its length among all segments. However, expanded study areas were defined by DCCO in some places where engineering constraints or other environmental factors precluded definition of the narrower corridor.

The cultural resources study zone comprises an area larger than would likely be affected during construction. Specifically, the study area minimally includes a one-half mile width swath on each side of the mapped centerline. However, wider study areas,

referred to as "expanded study areas," were also defined reflecting either the proximity of minor alternative alignments, current uncertainties about the engineering feasibility of specific centerlines, or the prospect of other constraints to design. Pending selection of the Caliente route as the preferred railway access route (as well as development of final construction plans), the study area comprises a potential impact zone wherein the relative values of known cultural resources can be used to rank alternatives, if any, and where the potential for cultural resources can be similarly applied to identify sensitive areas.

Information from prior cultural resource investigations was obtained from file searches at DAS/ERC, including previous projects and site locations. The status of each site with regard to eligibility for the National Register of Historic Places (NRHP) was obtained from site forms and from the Nevada State Historic Preservation Office/Division of Historic Preservation and Archaeology. The file search produced usable information concerning 125 cultural resource locations. The literature and archival searches were supplemented by a field "windshield" survey of selected cultural sites within the Caliente alternative. No contacts were made with Native American sources or area residents for the purpose of obtaining information at this stage of the project.

7.2.3 Summary of Cultural Resources

Approximately 109 sites of prehistoric, historic, or ethnohistoric importance are determined to be situated within the project area. The distribution of sites are defined on Table 7-1. Only one of these sites, the Caliente Train Station, has been formally listed on the NRHP. The status of the remaining sites are shown on Table 7-2.

The types of cultural sites that may be encountered by the potential project consist basically of Native American settlement, hunting camp, and rock art sites. The area also contains several sites of historic significance regarding the westward expansion of the United States, including ranch and railroad-related sites, mining camps, mineral processing sites, towns and urban centers, military facilities, and sites related to the exploration of the territory.

Area of potentially sensitive sites, that is areas where the likelihood of encountering previously unrecorded cultural sites is significant, were estimated based upon the occurrence of

TABLE 7-1

SUMMARY OF CULTURAL SITES WITHIN THE CALIENTE ALTERNATIVE

Route	Pre.	Hist.	Pre. & Hist.	Pre. & Ethno.	Pre., Ethno., & Hist.	Unk.	Total	%
A	27	2	2	1	1	0	33	30.28
Base	8	2	3	0	0	0	13	11.93
Mud Lake	14	0	0	0	0	0	14	12.84
Goldfld	2	0	0	0	0	0	2	1.83
Beatty	38	3	5	0	0	1	47	43.12
Total	89	7	10	2	1	1	109	100.00
%	81.65	6.42	9.17	0.92	0.92		0.92	100.00

Pre.: Prehistoric Hist.,: Historic Ethno.: Ethnohistoric Unk.: Unknown

Note: Small sites and isolates not included

TABLE 7-2

NRHP STATUS OF PREVIOUSLY RECORDED SITES ON THE CALIENTE ALTERNATIVE

	Route					
NRHP Status	A	Base	ML	Gfld	Beatty	Total
NRHP listed	0	1	0	0	0	1
Recommended NRHP Eligible	3	2	1	0	13	19
Evaluation Recommended	6	2	2	0	3	13
Unevaluated	13	2	5	0	8	28
Unknown Status	1	3	6	2	15	27
Recommended Not Eligible	8	3	0	0	8	19
Not Eligible	2	0	0	0	0	2
Total	33	13	14	2	47	109

previously recorded resources. The locations of potential sites are estimated as follows:

- Several areas along the Route A Option are determined to contain abundant sites, or sites which cannot apparently be avoided within the study corridor, including the Pahroc Summit Pass area. Multiple sites are found in the Crystal Springs area, while fewer are found further north near Hiko. The Pahranagat Valley is likely to contain numerous resources, whichever alternative segment is chosen.

- On the Base Route, the abandoned segment of the Union Pacific Railroad is considered sensitive.

- The route past Mud Lake is likely to contain numerous sites on the north edge of Mud lake as well as in the Reeds Ranch area. A sensitive site was visited at Reveille Mill along this route.

- Another railroad berm is situated close to the centerline of the route past Goldfield on the USGS East of Goldfield quadrangle, near the potential route.

- The terminus of the route past Beatty within the Nevada Test Site contains Multiple sites on the USGS Busted Butte quadrangle. Other areas of high site density are found near the Springdale and Scottys Junction areas.

7.2.4 Possible Native American Concerns

The Nevada Test Site and Yucca Mountain are located on land claimed to be Western Shoshone aboriginal territory. At this stage of the project, no contacts have been made with Native American groups. Consequently, their specific concerns cannot be identified at this time. It is known however, that Native Americans have cultural and religious interests regarding the project area. It is recommended that direct contacts be made to the individual tribal groups in the project area, should the Caliente Alternative be selected for detailed study under an EIS. These tribal groups could then be consulted as to the cultural, historical and religious significance of places, crossed by the potential railroad right-of-way.

QA: N/A

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YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE

CONCEPTUAL DESIGN REPORT

APPENDICES B, C, D, & E

De Leuw, Cather & Company
Subcontract Agreement No. 14-900078-12

120 Howard Street
San Francisco, CA 94105

1 June 1992

FILE 1/DRAWER 5

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YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE

CONCEPTUAL DESIGN REPORT

APPENDIX B
OPERATING PLAN AND COST DETAILS

De Leuw, Cather & Company
Subcontract Agreement No. 14-900078-12

120 Howard Street
San Francisco, CA 94105

1 June 1992

RAILROAD EQUIPMENT

This appendix discusses detail on railroad equipment including its operation and maintenance equipment as well as cost. These lists of equipment are suggestions for consideration during more detailed design and planning for the rail access options. Equipment may be purchased, leased, or furnished by a contract operator.

LOCOMOTIVE REQUIREMENTS

Costs estimates for the Caliente route included four locomotives, probably a minimum number for adequate operation of the railroad. The following paragraphs discuss considerations for increasing the number of locomotives that should be reviewed in more detailed planning.

The key ingredient to a successful and efficient railroad operation is the availability of locomotive power to promptly address emergencies and move traffic on a timely basis. Nearly every rail movement function must rely on the tractive effort of the locomotive in achieving mobility. Whenever rail carriers experience a shortage of locomotives to move their trains, a gradual breakdown in service and maintenance becomes apparent. The service deterioration is brought about due to the inability of the carrier to perform all the tasks efficiently and provide satisfactory service to the customer. In order to recover from such predicaments, the railroads will resort to deferred preventive maintenance on locomotives in order to keep every power unit working to minimize traffic delay. A prolonged period of neglect to the power units will often result in costly repairs and congestion in the repair shops.

An obvious solution to such a problem would be to initiate action to lease locomotives during such a crisis. However, the effort to lease usually proves to be ineffective because all the national carriers usually meet their seasonal business peaks at the same time which can result in a nationwide locomotive shortage. The locomotives that are available for lease are usually of very poor quality and very unreliable. In order to avoid such problems on the DOE railroad, the locomotive specifications and requirements should be fully addressed to efficiently meet the operational objectives.

There are many factors that must be considered in determining locomotive requirements for the DOE railroad. It is very easy to determine how much horsepower or how many locomotives are required to move a uniform size train of 13 cars with 2480 tons over a ruling grade of two and one half percent. This is especially true if the train was to operate on a strict and

precise schedule and no other traffic would enter into the transportation plan. However this is not the real railroad world where unpredictable and unforeseen events occur every hour of the day. Such events have a great impact on the utilization of locomotive power and the movement of trains. This is especially true on the smaller railroads, with limited resources, where the consequences of an event could have a drastic influence on the overall operation. Analyzing some of the following possible problems and how they affect a small carrier may be helpful in establishing a realist number for locomotive requirements:

- Usually a minor derailment involving locomotives due to a misaligned switch will remove the locomotives from service for several days if the running gear or traction motors are damaged. Should the fuel tanks get ruptured in the process it may present further problems. It should be pointed out that misaligned and defective switches are one of the major causes for derailment.

- Minor side contacts with other equipment in switching moves, resulting in damage to safety appliances, are also a common event that requires immediate repairs in order to be in compliance with 49 CFR Part 230.

- Flat spots on locomotive wheels due to improper application of brakes and various other reasons require locomotives to be removed from service to have the defects corrected. This is a common event with inexperienced personnel.

- An additional locomotive may be required on the HLW train in the event some national railroad requires spacer cars between the cask cars for operational purpose. This could very well increase the train size by 1,000 tons.

- An additional set of locomotives may occasionally be required to move a HLW shipment as a result of two trains arriving at the interchange point in the same time frame due to operational problems on other carriers. Trains do not move in perfect cycles when long distant movements are involved and operational problems are encountered.

- Snow problems, especially in deep cuts, may require two or more locomotives with pilot plows to keep the railroad open and avoid the buildup of snow that may require a costly rotary snow plow operation.

- In the event sand buildup on the track becomes a problem, locomotives will be required to handle the spreader (called the spreader-ditcher-plow in the equipment description).

- Track maintenance crews, under certain circumstances, require locomotives to move equipment and material at work locations.

- Two locomotives are usually required on emergency equipment trains that are dispatched to the scene of a derailment. The unit consist is assembled so that there is a cab headed in each direction to insure ease of maneuverability at the site.

- During flooding conditions when emergency ballast and rock is required immediately to save the track from extensive damage locomotives must be readily available to move such material. It should be pointed out that such heavy material will require more than one locomotive to successfully move more than nine cars over two and one half percent grade.

- A spare unit will be required to replace locomotives that are due for inspection and maintenance.

- Locomotives will be required to move any common traffic that is shipped by rail to the repository or other DOE facilities. This will be especially true for the repair parts associated with the cask cars.

RECOMMENDED MAINTENANCE EQUIPMENT

This listing identifies equipment that is likely to be needed to maintain a railroad of this length. The equipment can either be owned by the operator, leased from another adjoining railroad, or obtained as needed from an equipment company.

Ballast Compactor. The Ballast Compactor is a rail mobile machine that is used for compacting ballast in the cribs, between the ties, and on the shoulders of the road bed. The machine increases the lateral and longitudinal track stability after a rail, tie, or ballast renewal program, and newly constructed trackage.

Tamper. The rail mobile mechanized Tampers are used to compact the ballast under the ties. The machines are available in various sizes, and have capabilities of performing many track maintenance tasks in conjunction with the uniform compaction of ballast under the ties. The state of the art equipment does away with the labor intensive track maintenance by consolidating the effort of raising, leveling, lining, and tamping the track structure. Smaller units are used solely for spot tamping and smoothing of the riding quality of the track.

Tie Remover and Inserter. The Tie Remover and Inserter is a high speed rail mobile machine the extracts worn, broken or accident damaged ties from the track, and inserts new ties as replacements. It is unlikely that a tie renewal program will ever be required, during the life of the new railroad, but the Tie Remover and Inserter is a vital piece of equipment in prompt

restoration of rail service in the event tie damage is experienced due to a derailed car or dragging equipment.

Ballast Regulator. The Ballast Regulator is a versatile rail mobile machine that is used in various capacities related to ballast maintenance operations. The machine can perform tasks such as ballast shaping, shoulder profiling, transferring and distributing ballast, and plowing ballast from one side of the track to the opposite side in a single motion.

Track Crane. A Track Crane is a self propelled rail or road mobile machine that is utilized for material handling such as rail, ties, rail, plates, spikes, and various other maintenance items. Usually the Track Crane is readily converted to a magnet, crane, dragline or clamshell operation, and has the capability to pull or shove rail cars with work materials.

Sand Removal Machine. The Sand Removal Machine is usually used in the desert areas to control the buildup of blowing and drifting sand on the track which could develop into a very serious and unsafe condition if not addressed effectively. Sand buildup could cause cars to derail, but a more serious condition could develop if the sand gradually builds up between the base of the rail and the tie plates, whereby the track spikes are partially pulled out of the ties creating an unstable track condition. The Sand Removal Machine is equipped with a "V" shaped plow and side wings to plow the stand off the track. A rear mounted broom and conveyer compliment the plow effort by removing the balance of the sand so that the ties and rail fasteners are exposed for inspection. Modified Jet Snow Blower machines are also capable of controlling sand buildup under certain conditions such as switching yards or siding switches.

Hi Rail Personnel and Inspection Car. A Hi Rail Personnel and Inspection Car is a typical rubber tire vehicle that is equipped with special flange type steel guide wheels that can be lowered into position on the rails so that vehicle becomes rail mobile. The Hi Rail Car is used to transport personnel to locations on the railroad that are not accessible by road or to conduct track and right of way inspections. The vehicle is also used as a pilot or escort car to proceed ahead of a train, during adverse conditions, to ensure that the trackage is safe for movement of the train. Hi rail cars are usually restricted to maximum speed of 35 MPH while operating in rail mode.

Hi Rail Truck. A Hi Rail truck, like the Hi Rail car, is a rubber tire vehicle that is equipped with special flange type steel guide wheels so that it can move on railroad trackage. Primary use is to transport personnel, tools, and material by rail into areas that are not accessible by road or to perform track maintenance inspections

Custom Designed Fuel and Lubrication Hi Rail Truck. A Custom Designed Fuel and Lubrication Hi Rail Truck would have the capabilities of moving via road or rail, but the primary purpose for such a vehicle would be to provide fuel and lubrication for the maintenance machinery in remote areas that are not road accessible. The vehicle would serve as a mobile service and light repair facility that would be assigned to each maintenance crew to perform preventive maintenance on the machinery and eliminate the need to move the equipment to a central facility for such tasks.

Spreader-Ditcher-Plow. The Spreader-Ditcher-Plow type heavy duty machine is used for multi purposes in the railroad industry such as ballasting, ditching, contouring, spreading and plowing tasks associated with track maintenance. The machine is also used extensively to plow snow and ice, especially in deep cuts where the snow has to be moved away from the track section with the side wings.

Various Types of Mobile Maintenance Equipment. There is a need for various types of mobile maintenance and transportation equipment to fulfill the requirements and provide efficient usage of personnel and equipment. Most of the mobile equipment is readily available from various dealers and vendors.

- Automobile
- Utility truck
- Four wheel drive terrain vehicle
- Front end loader
- Road Grader
- Fork lift
- Snow Blower
- Track cart
- Trailer

Portable Power Tools. Portable hand held track and equipment power tools are vital in performing specific tasks and minor and routine maintenance work on the railroad. Such tools maybe hydraulic, air, electric or gas powered, but in every instance the most efficient and safe tools that are available to fit the task should be utilized. The following hand held power tools should prove to be very useful.

- Portable unit

- Spike puller
- Spike driver
- Tie tamper
- Rail drill
- Rail saw
- Rail grinder
- Impact wrench
- Jack
- Chain saw
- Welding equipment

Track Hand Tools. The traditional track Hand Tools are still required in the railroad industry to perform specific tasks under certain conditions. Some of the most common hand tools are:

- Track gauge
- Track level
- Claw bar
- Spike puller
- Lining bar
- Track jack
- Track wrench
- Adze
- Track pick
- Track shove
- Scoop shovel
- Switch broom
- Tie tong
- Drift punch

- Track punch
- Spike maul
- Sledge Hammer
- Track Chisel
- Tamping bar

RAILROAD EMERGENCY EQUIPMENT

Wrecker Derrick. The Wrecker Derrick is a rail mobile, self propelled crane that is capable of lifting heavy rail cars and other equipment. Usually the Wrecker Derrick is used in conjunction with other emergency equipment to assist in clearing up train derailments. In the event of a derailment involving the proposed 440,000 pound car and cask this is probably the only piece of mobile equipment that has the lifting capacity to upright and re-rail the car and cask. Usually there are other rail cars loaded with special equipment such as heavy duty cables/slings, rail panels, tools flood lights, track material, rail car trucks, and personnel cars that accompany the Wrecker Derrick as a total support unit. Due to the additional support equipment the derrick and cars are moved by a two locomotives to the desired site. The self propelled mode of the Wrecker Derrick is only used when re-railing cars or making a short distance movement.

Hi Rail Wrecker Crane. The Hi Rail Wrecker Crane is a self propelled rail or road mobile heavy duty crane that is used to upright and re-rail cars involved in a derailment, or to perform heavy lifting tasks in the railroad environment. Due to the Hi Rail Wrecker Crane ease of mobility and capability of handling most tasks with the least amount of assistance from other sources, it has become the most relied upon piece of emergency equipment for response to derailments. Usually, special permits are required to move the crane over the highway systems.

Wreckmaster. The Wreckmaster is a steel tread, crawler type machine specially equipped with a front end earth moving blade, a side boom, and a winch for use at derailment sites. The machine is used to move derailed cars and cargo away from the track roadbed so the tracks can be rebuilt. It is also used to move earth and ballast in building up the roadbed for placement of the track panels. The machine is transported to the site on a rail flat car.

Snow Plow. Snow Plows are available in various sizes and types to meet the requirements of specific railroads and regions. A Single Track Wedge Snow Plow, in conjunction with the front end snow plows on the locomotives, should be adequate to cope with the anticipated snow problems in the deep cuts if the conditions are addressed properly. The Wedge Single Track Snow Plow is designed to throw snow to both sides of the track as it is shoved by a locomotive consist. The plow is capable of handling deeper snow than the plows on the locomotive. However, timely removal of the snow before it is allowed to pack or turn into ice is the key to a successful operation. The Wedge Plow does not have a cab nor is it occupied by personnel.

The self propelled Wedge Plows usually do not have the tractive effort nor the capacity to effectively handle long deep drifts. However, there are many areas in the railroad environment where such equipment is very effective such as yards, industrial trackage, and some sections of the main track that is usually not susceptible to drifting conditions or deep snow.

Ambulance and Fire Truck. The railroads usually rely on the local communities with trained personnel to a provide such emergency services. However if such service is inadequate or unavailable due to the remoteness of the region railroads will acquire the necessary equipment and train personnel to perform such duties. It should be pointed out that the railroad industry is presently taking action to train public emergency teams how to effectively perform their duties in the unfamiliar railroad environment. The focus is placed on safety, procedures in obtaining information, key contacts, and handling of hazardous material incidents. The DOE may wish to take the same approach along the new rail route.

Emergency Response Vehicle. In order to respond more quickly and effectively to a hazardous material spillage or release with trained personnel some carriers have acquired special vehicles for the purpose. Such vehicles are usually road and rail mobile with a enclosed truck type body. The vehicle is equipped with a two way radio phone and special equipment to implement proper activities at the scene of the incident. The truck has special compartments that accommodate various types of emergency equipment such as first aid kits, stretchers, blankets, oxygen, hand tools, protective clothing, hazardous material manuals, various types of fire extinguisher, ladders, and lights. The vehicles are situated at strategic locations along the railroad for use during emergencies by the local first response team.

Miscellaneous Emergency Equipment. All of the maintenance of track equipment under emergency conditions is made available to work in conjunction with the emergency equipment,in restoring the track for service and normalizing the operations.

RAILROAD FACILITIES

Trunk Line Interchange Facilities

It is recommended that the facility be engineered so all the trackage is on level ground, or in a saucer bowl design, to insure that cars will not roll out. The entire complex must meet the requirements and standards of EPA, OSHA, State and local agencies.

Interchange Tracks. A minimum of two Interchange Tracks should be provided at the facility to receive or deliver trains or cars

interchanged between the two railroads. Each of the tracks should be approximately 2500 feet in length and have the capacity to handle an entire train for the repository or the connecting trunk line without being switched to another track. The tracks should have switches at both ends to reduce switching moves when cars or trains are interchanged.

Turning Track. A Turning Track should be available at the Interchange Point to insure that locomotives, cars, and equipment can be turned when conditions require that such a move be accomplished. The Turning Track can be designed as a loop track or as a Wye (Y).

Emergency Material Storage Track. The Emergency Material Storage Track should be designed to accommodate approximately 20 cars (about 1200 feet in length) loaded with Emergency Ballast, Rock, Ties, and Panel Rail.

Emergency Equipment Track. The Emergency Equipment Track should be designed to hold approximately twenty pieces of emergency and repair equipment (about 1000 feet in length). The emergency equipment should include a Derrick and Idler car for the derrick boom, Mobile Crane on rail wheels, Tool car, Personnel car, Wedge Snow Plow, Snow Blower, and flat cars loaded with a Grader, Wreckmaster (Bull Dozer with a Side Boom), and Unloading Ramp.

Maintenance equipment should include mechanized Tampers, Liners, Ballast Regulators, Tie Removers and Inserters, Track Cranes and other mobile maintenance equipment that may be required.

Fenced Siding. The Interchange Facility should have fenced siding of approximately 2500 feet in length equipped with flood lights and locking devices on the to provide security for trains, cars, locomotives, escort cars, and other equipment when conditions require such protection.

Hi-Rail Pad and Heliport. The Hi-Rail Pad should be located near a road or where a road crosses the track, within the facility, so that Hi-Rail vehicles can be driven onto the track and made rail mobile. The same facility can also be used to remove Hi-Rail vehicles off the track. The paved area could be expanded to serve as a heliport.

Emergency Station. The Emergency Station should be designed to accommodate a fire engine, ambulance, and a first response vehicle. The station should also serve as a First Aid center.

Garage and Storage Building. The Garage and Storage Building should be designed to accommodate a Hi-Rail Vehicle and a small truck. The storage area should have the capacity to store fuel and oil filters, lubricants for locomotive and cars, spare brake shoes, knuckles, air hoses, flares and torpedoes, and other

necessary items related to railroad operations such as track maintenance tools. The building should be located near the track where the locomotives will be parked for servicing.

Crew Station and Office. The Crew Station and Office, for the local operational officer, would serve as a focal point for all DOE railroad activities at the Interchange Point. The building should have office space, rest rooms, waiting room, washroom & shower, and be equipped with telephones, television, facsimile and copy machines, desks and files. The facility would serve as the ready room for the train and engine crews, where preparatory functions will be conducted and operating instructions from the Train Dispatcher will be received before boarding the out bound train. The building should be heated and air-conditioned.

Locomotive Service Facility. The Locomotive Service Facility should be designed so that once a locomotive is spotted to be serviced, all six tasks which include, fueling, sanding, watering, routine inspection, minor repairs, and the cleaning and servicing of the cab can be accomplished without moving the locomotive. The fuel storage tanks at the facility should be capable of receiving fuel via truck or rail car. The locomotive sanding facility must be capable of providing dry sand for the locomotives. In the event dry sand is unavailable a sand drying facility with storage capacity is recommended. The facility should have the capability to provide potable water for locomotive cabs and the escort cars.

Derail Protection. Derail Protection must be designed into the Interchange Facility to insure that locomotives, cars or other rail equipment will not roll out onto the main track or into the connecting carriers trackage.

Crew Change Station

The entire facility should be engineered so that all trackage is on level ground or in a saucer bowl design to insure that cars, locomotives, and other equipment will not roll out. The entire complex must meet the requirements and standards of EPA, OSHA, State and local agencies.

Turning Track. A Turning Track at the Crew Change Station should be provided to insure that locomotives, cars, and equipment can be turned when conditions require that such moves be accomplished. Turning of equipment, especially locomotives, is a common operational event that transpires in daily operations due to unforeseen events or emergency conditions. The Turning Track can be designed as a loop track or as a Wye (Y).

Emergency Material Storage Track. The Emergency Material Storage Track should be designed to hold approximately 20 cars (about

1200 feet in length) to accommodate cars loaded with emergency ballast, rock, ties, and panel rail.

Fenced Siding. The crew change station should have fenced siding of approximately 2500 feet in length equipped with flood lights and locking devices on the gates to provide security to trains, cars, locomotives, escort cars, and equipment during an emergency situation. The fenced siding should be located away from the other facilities.

Siding. A siding of approximately 2500 feet in length, at the Crew Change Station, should be viewed as the pivotal siding in the train operations, and very vital to the Train Dispatcher, because most of the meets and passes of trains will be accomplished on this siding.

Hi-Rail and Heliport. The Hi-Rail Pad should be located near a road or where a road crosses a track so that Hi-Rail vehicles can be driven onto the track and made rail mobile. The same facility can also be used to remove Hi-Rail vehicles off the track. The same paved area could be expanded to serve as a Heliport.

Crew Station and Office. The Crew Station and Office, for the local operational officer, would serve as a focal point for all DOE railroad activities at the Interchange Point. The building should have office space, rest rooms, waiting room, washroom & shower, and be equipped with telephones, television, facsimile and copy machines, desks and files. The facility would serve as the ready room for the train and engine crews, where preparatory functions will be conducted and operating instructions from the Train Dispatcher will be received before boarding the out bound train. The building should be heated and air-conditioned.

Locomotive Service Facility. The Locomotive Service Facility should be designed so that once a locomotive is spotted to be serviced, all six tasks which include, fueling, sanding, watering, routine inspection, minor repairs, and the cleaning and servicing of the cab can be accomplished without moving the locomotive. The fuel storage tanks at the facility should be capable of receiving fuel via truck or rail car. The locomotive sanding facility must be capable of providing dry sand for the locomotives. In the event dry sand is unavailable a sand drying facility with storage capacity will be required. The facility should have the capability to provide potable water for locomotive cabs and the escort cars.

Repository Exterior Railroad Facilities

The entire facility should be engineered so all the trackage is on level ground, or in a saucer bowl design, to insure cars will

not roll out. The entire complex must meet the requirements and standards of EPA, OSHA, State and local agencies.

Turning Track. A Turning Track should be available at the railroad facility outside the Repository to insure that locomotives, cars, and equipment can be turned when conditions require that such a move be accomplished. The Turning Track can be designed as a loop track or as a Wye (Y), and situated so it will facilitate the Locomotive and Car Repair Facilities and other railroad facilities outside of the repository.

Emergency Material Storage Track. The Emergency Material Storage Track should be designed to hold approximately 20 cars (about 1200 feet in length) to accommodate cars loaded with emergency ballast, rock, ties, and panel rail.

Emergency Equipment Track. The Emergency Equipment Track should be designed to hold approximately twenty pieces of emergency and repair equipment (about 1000 feet in length). The emergency equipment would include a Derrick and Idler car for the derrick boom, Mobile Crane on rail wheels, Tool car, Personnel car, Wedge Snow Plow, Snow Blower, and flat cars loaded with a Grader, Wreckmaster (Bull Dozer with a Side Boom), and Unloading Ramp.

Maintenance equipment would include mechanized Tampers, Liners, Ballast Regulators, Tie Removers and Inserters, Track Cranes and other mobile maintenance equipment that may be required.

Siding. The Repositary area should have a siding of approximately 2500 feet in length outside of the area to make meets with other trains or equipment. The track could also be utilized as run around track when it is necessary to run the locomotive around the train,in the event the shipment has to be shoved into the Repository area.

Hi-Rail Pad and Heliport. The Hi-Rail Pad should be located near a road or where a road crosses the track within the facility, so that Hi-Rail vehicles can be driven onto the track and made rail mobile. The same facility can also be used to remove the Hi-Rail vehicle off the track. The paved area could be expanded to serve as a heliport.

Emergency Station. The Emergency Station should be designed to accommodate a fire engine, ambulance, and a first response vehicle. The station should also serve as a First Aid center. The station should be located to jointly serve the Locomotive and Car Repair Facility and other rail facilities outside the repository.

Garage and Storage Building. The Garage and Storage Building should be designed to accommodate a Hi-Rail Vehicle and a small truck. The storage area should have the capacity to store bags

of locomotive sand, fuel and oil filters, lubricants for locomotive and cars, spare brake shoes, knuckles, air hoses, flares and torpedoes, and other necessary items related to railroad operations such as track maintenance tools. The building should be located near the track where the locomotives will be parked for servicing.

Train Dispatchers Office and Crew Station. The Train Dispatchers office should b e designed as a 24 hour office from where all train and rail mobile equipment movements will be controlled. The office should be equipped with desks, files, telephone, railroad radios, Railroad Standard Clock, and intercom connection with all the other facilities within Crew Change Station. The facility should also have a train and engine crew ready room where the crews will perform the required preparatory functions, and receive their operating instructions from the train dispatcher before boarding the train.

Headquarters for Operating Personnel. The Headquarters for Operating Personnel should include offices for the following officers and supervisors.

- Railroad Manager
- Asst. Railroad Manager
- Administrative Officer
- Trainmaster-Rules Examiner
- Road Foreman of Engines
- Chief Mechanical Officer
- Chief Track Engineer
- System Engineer
- Roadmaster
- Chief Special Agent
- Special Agent
- Communication and Signal Officer
- Environmental Officer
- Safety-Public Information Officer

The facility should also have a conference room, receptionist and secretarial staff area. If functions, other than those related

to operations, are to be conducted from the Headquarters Building additional space will be required.

Locomotive Service Facility. The Locomotive Service Facility should be designed so that once a locomotive is spotted to be serviced, all six tasks which include, fueling, sanding, watering, routine inspection, minor repairs, and the cleaning and servicing of the cab can be accomplished without moving the locomotive. The fuel storage tanks at the facility should be capable of receiving fuel via truck or rail car. The locomotive sanding facility must be capable of providing dry sand for the locomotives. In the event dry sand is unavailable a sand drying facility with storage capacity will be required. The facility should have the capability to provide potable water for locomotive cabs and the escort cars.

Locomotive and Car Repair Facilities. The Locomotive and Car Repair Facilities should be located outside the Repository area but conveniently situated in relation to the Repository and Locomotive Service Facility so that equipment, due for inspection or requiring repairs, may be moved in and out of the facilities with ease. The Locomotive and Car Repair Facilities should be located adjacent to each other so that the personnel adjustment can be readily accomplished to meet the work load of either shop. The entire complex must meet the requirements and standards of EPA, OSHA, State and local agencies.

- The Locomotive Inspection and Repair Facilities should be designed to accommodate simultaneously at least two of the most modern six wheel truck locomotives presently available. The trackage, within the shop, should also have the capacity to provide storage for a spare locomotive or one that may not be in active service, such as track maintenance. The shop should be designed with an inspection lubrication and repair pit and have the capabilities to perform all federally imposed inspections. The repair facility should have all the machine tools, cranes, and instruments to conduct inspections and have the capability to perform all maintenance and repair work on the locomotive fleet. Storage for various locomotive spare parts, lubricants, solvents will have to be incorporated into the shop design. A conveniently located tool room, rest and wash, personnel break area, and office space with desks, files, telephones, railroad radios and other essential items should be included in the layout.

- Rail Car Inspection and Repair Facility should be capable of performing all inspections and repairs on the fleet of cask, buffer, spacer, escort cars, and other rail mobile equipment. The shop should be equipped with machine tools, cranes, and instruments to perform inspections and do all maintenance, and painting on the car fleet. The facility

should be equipped with storage space for spare parts, paints, lubricants, solvents and other vital materials associated with car repair. The shop should also have a tool room, rest and wash room, a personnel break area, office space with desks, files, telephones and railroad radios, and other essential items. All car movements, within the facility, should be accomplished with a car puller rather than a locomotive. There should be adequate car storage trackage near the shop to accommodate cars awaiting repairs and inspection.

Main Track

The Main track should be designed to the minimum acceptable profile grade possible, but not to exceed the recommended maximum of 2.5 percent compensated. The track should be designed for a maximum speed of 60 MPH depending on curves and construction restrictions, and a minimum speed of 30 MPH. The minimum speed requirement is essential in order to operate the trains as far as possible under the constraints of the Hours of Service Laws and keep the number of crew change points to a minimum. A slower minimum speed may prove to be more expensive. The track should be constructed to a very high standard, utilizing new materials that meet the specifications of the connecting main line carrier. This would insure availability of interchangeable material during an emergency, and reduce the inventory of spare parts. Compatibility with the main line railroad is essential for prompt restoration of rail service, in the event of an unforeseen occurrence that requires immediate action.

The close clearance problems, that presently exist in the railroad industry, should be eliminated on the potential line. The height and width clearance should be addressed in the design process, so that all cars and loads received in interchange may move freely over the railroad without concern about clearance problems. The railroad design should not inherit any traditional restrictive standards from the present day railroad industry. The track centers should be increased to at least 20 feet which is a new regulatory standard in the State of California for new track construction. Some of the major railroads have accepted this as their new standard.

Signal System. It is highly desirable to equip the railroad with an Automatic Block Signal System that will help insure the safe operations of trains by providing protection against other train movements, and provide advance indication of certain hazardous track conditions. Emergency events and conditions such as broken rails, defective or misaligned switches, and awareness of any free rolling equipment that may accidentally be on the main track can only be detected by an efficient and safe signal system. In the present era of advanced technology in electronic, that is applicable to signal systems, there should be no compromise for

the extra margin of safety in the railroad environment. Additionally, the Automatic Block Signal System would allow the trains to operate at maximum allowable speed for Class 4 track, rather than being restricted to a maximum speed of 49 MPH on non-signaled trackage as prescribed under 49 CFR Part 233.

Sidings. Sidings of approximately 2500 feet in length will be required to meet and pass trains. The sidings should be constructed as much as possible on level terrain, and conditions permitting be spaced at intervals of 10 to 20 miles. The spacing of sidings should not be in excess of 20 miles to insure efficient movement of trains and the avoidance of prolonged delays when accomplishing meets and passes. The distance between sidings is also a vital operational factor in the event cars or locomotives develop wheel or journal defects. In such a situation, especially with heavy equipment, the defective car or locomotive must be removed from the train to avoid track damage or a possible derailment. The distance between sidings, under such conditions, becomes very important due to the necessity of moving the defective piece of equipment, at slow speed, to the next siding for removal from the train. Sidings are also very essential to track maintenance crews for storage of track machinery and material near the work site, when track maintenance work is being conducted.

Fenced Siding. Fenced sidings, of approximately 2500 feet in length and about one quarter of a mile from the adjacent track, will be required at intervals of approximately every 100 miles along the main track. The facility should be equipped with flood lights and locking devices on the gates to provide security for the train, cars, or equipment when necessary. An electrical receptacle should be located near the siding so that the locomotive or escort car can provide electrical power for the flood lights when required. The need for this unique facility, that does not presently exist on other railroads, can be justified due to the limited availability of law enforcement personnel in the remote area to provide security and protection for the train and personnel during an emergency. The facility should also have a building, within the fenced area, to provide shelter for the maintenance personnel in the event of adverse weather or other unforeseen problems.

Hot Box Detectors. Hot Journal Detectors should be located along the main track at appropriate intervals of approximately 15 to 20 miles midway between sidings. In the event of a high reading on the detector, which indicates an overheated bearing, it would allow the train to be stopped short of the next siding for inspection. This spacing would set the shortest distance from the point where the defective car can be switched out of the train.

High Water Detectors. High Water Detectors should be located at appropriate locations such as bridges and culverts that are susceptible to flooding conditions and heavy runoffs.

Rock Slide Fences and Detectors. Rock Slide Fences should be located adjacent to the track in deep cuts, canyons, along steep hills, and mountainous terrain that is susceptible to mud and rock slides.

Dragging Equipment Detectors. Dragging Equipment Detectors should be located at intervals of approximately 15 to 20 miles along the main track. It is also important that the detectors are placed at appropriate locations two or three miles prior to where a train enters a tunnel or crosses a trestle.

Cracked Wheel Detectors. Cracked Wheel Detectors are ultrasound devices that are capable of detecting cracks in wheels while the train is in motion. The detector is just becoming available in the railroad industry and has been in limited use. Presently, the device is only effective when train speeds are reduced to 15 MPH passing the detector. With the present technology the detector could be effective at locations such as the interchange point, crew change station, or leaving the potential repository, where the train will be operating at a slow speed. The manufacturer of the device is hopeful of adapting it to perform at higher train speeds.

Railroad Grade Crossing Signs, Lights, and Gates. Railroad Grade Crossing Signs, Lights, and Gates should be placed at all grade crossings to provide warnings and protection to all pedestrians and vehicles crossing the railroad tracks.

Right of Way Fencing. Appropriate Fencing should be applied along the right of way property at all locations where such protection is required for humans, livestock, and wild game animals.

Markers and Signs. Appropriate Markers and Signs are required in the railroad environment to insure efficient and safe operation of trains and to provide personnel with advance warning of certain conditions that may affect their duties and safety. The Markers and Signs should be located at vital locations and be fully visible. The following markers and signs should be installed:

- Mile Markers
- Clearance Warning
- Hazardous Warning
- Stumbling Hazards

- Reduce and Resume Speed
- Slow Orders
- Whistle Posts
- Bridge Numbers
- Culvert Markers
- Derails
- Yard Limits
- Station and Siding Signs
- Private Property
- Private Roadways
- Grade Crossings
- Stop Signs
- Detector Signs

Ballast Loading Facility. A Ballast Loading Facility near a ballast pit will be required to load ballast into rail cars, either directly from the pit or out of trucks. The trackage in the facility should be able to accommodate about 25 cars (1200 feet in length) for loading.

SOURCES OF OPERATING COST DATA

Southern Pacific Transportation Co., San Francisco, Ca

Union Pacific Railway Cop., Omaha, Ne

Santa Fe Railway Co., Chicago, Il

Kyle Railroad Co., San Francisco, Ca

Day and Zimmermann/Basil Corp., Hawthorne, Nv

Army Ammunition Plant, Hawthorne, NV

Electromotive Division GM, La Grange, Il

Caterpillar Tractor Co., Chicago, Il

Shaw Construction and Crane Co., Carson City, Nv

Peterbilt Truck Co., San Jose, Ca

Gunderson Bros, Portland, Or

Sperry Rand Corp. Chicago, Il

Association of American Railroads, Washington DC

Industrial Railroads Inc., San Leandro, Ca

Kershaw Corp., Omaha, Ne

American La France Corp., Baltimore, Md

Pacific Bell System, San Ramon Ca

Motorola Corp, San Francisco, Ca

Port of Los Angeles, Los Angeles, Ca

Port of Long Beach, Long Beach, Ca

ICTF, Long Beach, Ca

COST FOR EQUIPMENT AND ROLLING STOCK

LOCOMOTIVES AND CARS
UNIT COSTS - NEW
(1990 $)

	Item	Unit Cost	Sources
1.	Locomotive, SD60 or equiv., 4000 HP	$ 1,250,000	1
2.	Switch engine, SW 2400 or equiv.	750,000	1
3.	Ballast Cars, GBS, HiSide, 100TCap	30,000	2
4.	Air Dump Cars, GBS, Hyd Side Discharge	38,000	3
5.	Boxcar,. XM, 87.5Cap	32,000	4
6.	Flatcar, FB, 70TCap	30,000	4
7.	Personnel Cars, PB or PSD	200,000	5
8.	Gondolas, GB, 95TCap	30,000	4
9.	Escort Cars	*	
10.	Cask Cars	*	
11.	HD Flats	*	
12	Buffer Cars	*	
13.	Spacers Cars	*	

1. Cost estimated by EMD of General Motors Corp.
2. Cost estimated by Gunderson Bros.
3. Cost estimated by MK Co.
4. Cost estimated by Brae Corp.
5. Cost estimated by SPTCo.

*National Program Government Provided Equipment

MAINTENANCE EQUIPMENT
ESTIMATED COST - NEW

	Item	Estimated Cost
1.	Tampers, automated	$ 150,000
2.	Ballast compactor	250,000
3.	Ballast regulator	150,000
4.	Tie removers	95,000
5.	Track Aligners and guager	100,000
6.	Spreader and ditcher	100,000
7.	Track Crane Heavy Duty	300,000
	Bridge	70,000
	Tie	55,000
8.	Sand remover or snow blower	250,000
9.	HiRail Inspection car-Chev S10 +Conv.	32,000
10.	HiRail Truck-Chev 4000+Conv.	44,000
11.	HiRail Lube & Fuel Chev 4000+Conv.	46,000
12.	Grader, Caterpillar	85,000
13.	Front Loader, Cat all terrain	65,000
14.	Automoblie, Pool cars	9,600
15.	4x4 11 Terrain Vehicles Chev K10	14,500
16.	Truck, Utility Pick Up Chev K1500	7,800
17.	Truck, Utility passenger Chev Astro	14,500
18.	Forklift, general purpose	30,000
19.	Trailer, Utility	2,800
20.	Track carts Mow	2,500
21.	Portable equip and hand tools	150,000
22.	Shop tools, (grinders lathes, wheel turning equip, pneumatic jacks etc.)	1,000,000

FACILITIES

	Item	Size	Cost per
1.	Interchange Tracks at Caliente	2500' TF	$ In const. cost
2.	Turning tracks and wyes	2500' TF lead	562,500 each
3.	Emergency Equipment Tracks	1000' TF	125,000 each
4.	Fenced sidings (fencing only)	6 Ft. chain link	$6/LF
5.	HiRail Heliport pads	2500 SF	125,000 each
6.	Emergency Stations	2000 SF	120,000 each
7.	Garages & Warehouses	1800 SF	108,000 each
8.	Crew Station & Offices	1200 SF	72,000 each
9.	Locomotive service facility incl. equipment	6000 SF	360,000 each
10.	Headquarters no incl. furnishings	12,000 SF	720,000 each
11.	Dispatch Offices	1200 SF	72,000 each
12.	Sidings	2500 TF	In Const. Cost
13.	Locomotive and car shop combination	14,000 SF	720,000 each

EMERGENCY EQUIPMENT

	Item	Unit Cost	Source
1.	Derrick, mobile	$ 2,000,000	5
2.	HiRail Crane 250T	550,000	5
3.	Wreckmaster w/side boom	110,000	3
4.	Snowplow, locomotive	30,000	2
5.	Fire Truck, all terrain	125,000	1
6.	1st response vehicle	55,000	4
7.	Ambulance, all terrain	80,000	1

Estimated cost provided by:

1. California Dept. of Forestry
2. Gunderson Bros.
3. Caterpiller Corp.
4. US Coast Guard
5. Kershaw Corp.

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

LAS VEGAS, NEVADA

YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE

CONCEPTUAL DESIGN REPORT

APPENDIX C
DOE ORDERS

De Leuw, Cather & Company
Subcontract Agreement No. 14-900078-12

120 Howard Street
San Francisco, CA 94105

1 June 1992

DOE ORDERS APPLICABLE TO THE YUCCA MOUNTAIN RAILROAD

Major DOE Orders that apply to the Yucca Mountain Railroad design, construction and operation are listed and summarized in this Appendix.

ORDER NUMBER	SECTION NUMBER	DESCRIPTION	REQUIREMENTS OR COMMENTS
6430.1A	Division 2	Site and Civil Engineering	Most of the requirements are too specific to be applicable at this conceptual study level.
6430.1A	0245-1	Railroad Design	Refers to AREA; requires compliance with State commissions and other regulatory bodies regarding railway crossings at public highways
	0245-4	Structures	Requires Cooper E-80 Minimum loading.
	0245-6	Ties	Allows use of nonwooden ties.
	0245-13	Ballast	Requires a minimum 8 inches depth under ties.
	0245-15	Superelevation	States that superelevation shall not be used on curves where speed is less than 20 miles per hour
	0245-16	Grades	Requires analysis to design grades below 3 percent; states that grades shall not exceed 3 percent without approval by the cognizant DOE authority.

ORDER NUMBER	SECTION NUMBER	DESCRIPTION	REQUIREMENTS OR COMMENTS
	0250-3	Roads	Requires design of roads and streets to comply with AASHTO GDHS-84.
	0250-5	Pavements	Requires designs to comply with local State highway department standards.
	0111	Structural Design Requirements	
	0111-2	Loads	
	0111-4	Structural Systems for Highway and Railway Structures	References AASHTO HB-13 for highway structures and AREA for railway structures.
	0301-2	Concrete	Same references as for section 0111-4.
	0512-7	Structural Steel	Same references as for section 0111-4.
	0514-1	Structural Aluminum	References AASHTO HB-13 and AASHTO LTS-1 for highway structures, and AREA for railway structures.
	0610-2	Wood Structures	Same references as for section 0111-4.
5480.4		ES&H Protection Standards	
5480.7		Fire protection	
5480.11		Radiation Protection	

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

LAS VEGAS, NEVADA

YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE

CONCEPTUAL DESIGN REPORT

APPENDIX D
DESIGN CRITERIA

De Leuw, Cather & Company
Subcontract Agreement No. 14-900078-12

120 Howard Street
San Francisco, CA 94105

1 June 1992

CONTENTS

CHAPTER	PAGE
1 - FUNCTIONAL REOUIREMENTS	1-1
1.1 RAILROAD OPERATIONS	1-1
1.2 SAFETY REQUIREMENTS	1-6
1.3 PROJECTED USAGE AND FACILITY LIFE REQUIREMENTS	1-8
1.4 ROADWAY REQUIREMENT	1-9
1.5 ENVIRONMENTAL REQUIREMENTS	1-9
1.6 SOCIAL REQUIREMENTS	1-9
1.7 ECONOMIC REQUIREMENTS	1-9
2 - TRACK ALIGNMENT	2-1
2.1 BASIS FOR CRITERIA	2-1
2.2 ALIGNMENT CONTROL	2-1
2.3 HORIZONTAL ALIGNMENT	2-1
2.4 TRACK SUPERELEVATION	2-3
2.5 HORIZONTAL CURVATURE	2-3
2.6 VERTICAL ALIGNMENT	2-4
2.7 VERTICAL CURVATURE	2-5
2.8 CLEARANCES	2-6
3 - TRACKWORK	3-1
3.1 INTRODUCTION	3-1
3.2 CLASSIFICATION OF TRACK	3-1
3.3 TRACK CONSTRUCTION TYPE	3-1
3.4 TRACK GAUGE	3-1
3.5 RAIL	3-2
3.6 SPECIAL TRACKWORK	3-2
3.7 DERAILS	3-3
3.8 END OF TRACK RESTRAINING DEVICE	3-3
3.9 SUBBALLAST AND BALLAST	3-3
3.10 TIES	3-4
3.11 RAIL FASTENERS	3-4
3.12 JOINING RAIL	3-5
3.13 GRADE CROSSINGS	3-5
4 - ROADWAY	4-1
4.1 GENERAL	4-1
4.2 SUBGRADE	4-1
4.3 SLOPES	4-2
4.4 DRAINAGE	4-2
4.5 UNDERTRACK STRUCTURES	4-2
4.6 WAYSIDE ACCESS	4-3
4.7 SPECIAL TRACKWAY CONDITIONS	4-3

CHAPTER	PAGE
5 - SIGNALS	5-1
5.1 SIGNALS AND TRAIN CONTROL	5-1
5.2 COMMUNICATIONS	5-3
6 - ROADS	6-1
6.1 GENERAL	6-1
6.2 ACCESS ROAD	6-1
6.3 MAINTENANCE ROADS	6-2
7 - TRAFFIC CONTROL	7-1
8 - UTILITIES	8-1
9 - DRAINAGE	9-1
9.1 GENERAL	9-1
9.2 HYDROLOGICAL CHARACTERISTICS	9-1
9.3 HYDRAULIC CHARACTERISTICS	9-1
10 - GEOTECHNICAL INFORMATION	10-1
11 - BRIDGE STRUCTURES	11-1
11.1 GENERAL	11-1
11.2 RAILROAD BRIDGES	11-1
11.3 HIGHWAY BRIDGES	11-1
11.4 STRUCTURE TYPE	11-1
12 - BUILDINGS	12-1
APPENDIX D-A	D-A-1
APPENDIX D-B	D-B-1

CHAPTER 1 - FUNCTIONAL REQUIREMENTS

1.1 RAILROAD OPERATIONS

1.1.1 Train Operations Scenario

A. Assumptions

1. Federal Waste Management System (FWMS) fully operational with an eastern MRS; two dedicated trains per month from Monitored Retrievable Storage Facility (MRS);

2. Fuel plus Defense High Level Waste (DHLW) from Savannah River Site (SRS), ID and Hanford destined to repository.

3. Western fuel will by-pass MRS; this means a few more From - Reactor rail casks plus truck casks occasionally.

4. From reactor casks and DHLW casks will occasionally arrive at access railroad interface point and will be handled in separate trains as required.

5. It will be desirable to avoid build-up of loaded casks at Caliente/Carlin.

6. CASK - CAR ASSUMPTIONS

CASK TYPE	CAR DESCRIPTION
From Reactor	Four-axle, 263,000lb GVW conventional flat car 50-60'long
From MRS	Eight-axle 440,000lb GVW depressed center car 80-100'long
DHLW	Four-axle 263,000lb GVW conventional flat car 50-60'long

B. Proposed Scenario

An MRS dedicated train carrying up to ten 150 ton casks routinely arrives at the intercharge yard every two weeks. These casks may contain intact fuel or consolidated fuel with related Non-Fuel Bearing Component (NFBC)/trash from consolidation. Occasionally, three to five 100 ton From-Reactor casks and two or three 100 ton DHLW casks

will arrive at but will be handled in a separate train to the repository as required.

Maximum train frequency to the Nuclear Waste Repository (NWR) will therefore consist of two round trip trains with up to ten-440,000lb. cask cars and one round-trip train with up to eight-263,000lb cask cars per month.

1.1.2 Train Consist

A train consist will be established for the purpose of developing an operations plan and associated costs for the Yucca Mountain Access Railroad. National railroad operations constraints which may affect train consist will not be considered for this conceptual study.

1.1.3 Train Operations Analysis

An analysis may be performed to determine the following characteristics:

1. Locomotive requirements
2. Travel Time
3. Operational constraints, such as the effects of braking on long segments of steep grade.

This analysis would be performed on the maximum length train using computer programs such as a train Performance Simulator as deemed appropriate, consistent with the nature of the study and budget. The objects of this analysis will be to determine the feasibility of the corridor in terms of trains operations, and to establish a basis for capital costs of locomotives and related equipment.

The maximum length train will consist of the following cars:

1. Locomotives as required, plus one spare. Locomotive requirements will be established on the basis of ruling grade and tonnage ratings of locomotives.
2. Ten 440,000 lb. cask cars with eight axles. Length shall be assumed at 91 ft.
3. 100-ton gondola cars loaded with sand or gravel for use as buffer cars and spacer cars. The number of spacer cars will be established on the basis of braking requirements. There will be two buffer cars. One buffer car will precede the first cask car, and one will trail behind the last cask car. Length of each car shall be 50 feet. Gross weight is 263,000 lbs.
4. One escort car at the rear of the train. The escort car will be a standard railroad passenger coach car, weighing 200,000 lbs. with a length of 85 feet.

1.1.4 Equipment Requirement

The following equipment shall be provided by the rail line operator or, in the case of heavy emergency equipment, by the closest mainline railroad.

1. Fuel facilities for locomotives, escort cars, and other motorized railroad equipment.
2. Sand facilities for locomotives.
3. Water facilities for locomotives and escort cars.
4. Emergency equipment:

    a. Derrick
    b. Mobile heavy duty crane.
    c. Bulldozer.
    d. Carloads of ballast.
    e. Carloads of track panels.
    f. Spare switches and frogs.
    g. Snowplow.
    h. Ambulance. (Contracted Service)
    i. Fully equipped "First Response Team" vehicle.
    j. Carloads of rip-rap.

5. Inspection Equipment:

    a. Hi-rail vehicle capable of transporting vital emergency tools and material.
    b. Rail flaw detector and track geometry car (scheduled contracted service).

6. Track Maintenance Equipment:

    a. Various hand tools associated with railroad track maintenance.
    b. Mechanical tie tamper.
    c. Mechanical lining machine.
    d. Mechanical surfacing machine.
    e. Welder.
    f. Spike driver.
    g. Track Crane.
    h. Spreader-Ditch plow. (Scheduled contracted service)

7. Storage for Equipment:

    a. Sheds for emergency equipment.
    b. Trackage for emergency equipment.
    c. Trackage for spare locomotives.
    d. Trackage for buffer and spacer cars.
    e. Trackage for escort cars (with standby power).

8. Locomotive and Car Requirements:

    a. An additional locomotive as a spare and to move emergency and maintenance equipment.

b. Gondola cars to handle ties, rail and track panels.
c. Hopper cars to handle track ballast.

1.1.5 Track Requirements

In addition to the main-line track, the following tracks shall be provided:

1. Wye track to turn equipment at each end of the railroad and if required at the midway point along the route.
2. Siding tracks spaced approximately every 20 miles. Sidings shall be 2,500 feet long.
3. Holding trackage for trains at fenced sidings spaced approximately every 100 miles. Sidings will be 2,500 feet long. Where a fenced siding occurs at or near a location for a passing siding, the passing siding will be deleted. The fenced siding at or near the route mid-point will be incorporated into the other tracks to be provided at the mid-point facility.
4. Interchange and storage tracks at the connecting railroad as listed in paragraph 1.1.8.

1.1.6 Communications and Signals

A. Communications

The following communication facilities shall be provided:

1. Telephone at Caliente Interchange, Yucca Mountain site, Train Dispatchers office, all sidings and the mid-route crew change facilities.
2. Radio on locomotives, escort cars, inspection vehicles, all other mobile equipment.
3. Radio communication from unsignalized detector locations, such as high water or rock slides, to the train dispatcher office.

B. Signals and Train Control

The provision of train signals, train control or train detection systems is a policy decision based on the nature of the cargo and the hazards associated with it. The low volume of train traffic itself would not normally warrant signals on a similar freight railroad.

Signals could provide some or all of the following functions:

1. Detection of trains and maintenance equipment (including hi-rail vehicles) on the tracks.
2. Detection of broken rails and open switches.
3. Authorization to proceed.
4. Speed control.
5. Communication of train location to Dispatcher.
6. Detection of highwater, rock slides, dragging equipment and hot journals.

Criteria for grade crossing protection signals are listed in Chapter 7, Traffic Control
Design criteria for specific signal systems are listed in Chapter 5, Signals.

1.1.7 Yucca Mountain Repository Facilities

The design and planning of facilities within the Yucca Mountain Repository site are not included in the scope of work for the access railroad.

1.1.8 Connection Line Interface

The design of facilities at the connection to the connecting railroad at Caliente shall be based on the delivery of the unit consist trains by the connecting railroad's locomotives.

At the interface with the connecting railroad line, the following facilities shall be provided:

1. Two interchange tracks and a runaround track. The interchange tracks shall be long enough to store a single train, including locomotives.
2. Tracks for inspection and bad order set-off.
3. Communication link with connecting line train dispatcher.
4. Facility to exchange shipping papers.
5. On-site contact person to resolve operational problems.

1.1.9 Labor Agreements

The following labor agreements affect the operation of trains:

1. National.
2. Regional.
3. System and local.
4. Federal and State laws covering employees rights.

1.1.10 Federal Regulations

The following Federal agencies have regulations affecting the movement of trains:

1. Federal Railroad Administration. (FRA)
2. Nuclear Regulatory Commission. (NRC)
3. Department of Energy. (DOE)
4. Environmental Protection Agency. (EPA)

1.1.11 State of Nevada Regulations

The following State of Nevada agencies have regulations affecting the movement of trains:

1. State Department of Transportation.
2. Public Service Commission

1.1.12 Railroad Associations

The following railroad associations have established guidelines and policies affecting the movement of trains:

1. Association of American Railroads. (AAR)
   a. Bureau of Explosives.
   b. Research and Test Department
   c. Transportation Test Center.
   d. Safety and Operating Rules.
2. The American Short Line Railroad Association.

1.2 SAFETY REQUIREMENTS

This section will be revised to be consistent with DOE Order 5500.1A and OCRWM Memorandum on Response to Transportation Emergencies (July 1988 Draft) when received.

1.2.1 Derailments

The risk of derailment can be reduced by:

1. Frequent inspections.
2. Speed restrictions as required.
3. Strict compliance with rules and regulations.
4. Proper maintenance of track and equipment.
5. Installation of equipment
   a. Hot journal detectors.
   b. Dragging equipment detectors.
   c. Rock and mud slide detectors.
   d. High water detectors.
   e. Grade crossing protection.
   f. Signal systems.

Following a derailment the following actions must take place:

1. Determine if anyone was injured and dispatch medical assistance if required.
2. Determine if there is a fire or hazardous material involved.
3. Hold all other rail traffic until determined how serious.
4. Dispatch emergency equipment, personnel, and First Response Team if hazardous materials are involved.
5. Notify proper Federal, State, and Local authorities.
6. Provide any other assistance as may be required.

8. Submit follow up reports.

1.2.2 Emergency Medication

Emergency medication shall be administered by:

1. Consulting the First Aid and Hazardous Material Manual guidelines.
2. Local Fire Department and doctors.
3. Rescue and ambulance teams.
4. Other assistance as available.

1.2.3. Security

Security would be provided by:

1. Escort on train.
2. Railroad Police.
3. Local law enforcement officers.
4. State Police.
5. Federal Marshal and FBI.
6. Security/surveillance facilities.

1.2.4. "First Response Team"

The "First Response Team" will consist of:

1. Railroad personnel.
2. State and local emergency response personnel (police, fire, and emergency medical).
3. D.O.E. if radioactive.
4. A.A.R. Bureau of Explosives.
5. F.R.A.
6. CHEMTREC

1.2.5 Cleanup Procedures and Assistance

The DOE and railroad carrier have the primary responsibility for the physical cleanup, which may require the services of an environmental cleanup contractor. The Federal, State and local agencies involvement is required to insure cleanup procedures, regulations, and standards are complied with, and the spill material is disposed of properly. The Shipper of the commodity involved in the incident is usually present during the cleanup.

1.3 PROJECTED USAGE AND FACILITY LIFE REQUIREMENTS

If the repository is ready to receive shipments by 2010, the 25-year active period for receiving HLW shipments would run from 2010 to 2034. This duration would be followed by a 27-year inactive period during which the rail access route would be maintained in case a technological innovation makes recovery of the HLW viable, in which case it would be removed from the repository by rail. Otherwise, only non-repository and maintenance use of the rail access route is expected. Finally the repository will be decommissioned or permanently closed over an 8-year period at the end of the inactive period. Unless non-repository use of the railroad can justify its continued operation, the railroad equipment and materials would be salvaged during this period and the route abandoned.

In sum, there is 52-year active/inactive period that the track must be maintained for rail service. If the rail line is built in advance of the opening of the repository, this period would be correspondingly longer.

1.4 ROADWAY REQUIREMENTS

The access road from U.S. 95 to the site should be capable of safely carrying up to 5,000 vehicles per day at normal highway speeds, including truck combinations of legal size and weight. The design vehicle will be "over the road" semi tractor and trailer with a H-20 design loading, which corresponds to a maximum 32,000 lb axle load. In addition, the AASHTO overload provisions for a single vehicle require a maximum live load in one lane only of 48,000 lb per axle (twice the H-15 load).

Maintenance roads parallel to the rail line for maintenance and emergency purposes will be provided only in specific locations where access from other road or terrain is difficult. Maintenance roads should be within the rail right of way.

1.5 ENVIRONMENTAL REQUIREMENTS

Environmental impacts of the rail line and access roads should be minimized or mitigated to the fullest extent required under NEPA.

1.6 SOCIAL REQUIREMENTS

Without adding significant cost or risk to HLW rail operations to Yucca Mountain, the alignment of the access spur should be developed to give reasonable access to communities desiring rail access while avoiding intrusion within communities not concerned with rail access.

1.7 ECONOMIC REQUIREMENTS

Without adding significant cost or risk to HLW rail operations to Yucca Mountain, the alignment of the access spur should be developed to give reasonable access to economic activities along the route such as mining or other industry.

CHAPTER 2 - TRACK ALIGNMENT

2.1 BASIS FOR CRITERIA

These criteria were developed with considerations for functional requirements, safety, and current accepted railroad engineering practice. Unless otherwise stated in these criteria, the track safety requirements for the system shall be not less than those prescribed by the Federal Railroad Administration's "Track Safety Standards on Track Geometry", for Class 4 tracks.

2.2 ALIGNMENT CONTROL

2.2.1 Horizontal

Coordinates for control points established for the system shall be located on the UTM Coordinate System, Zone 11, converted to feet.

2.2.2 Vertical

The vertical control shall be based on the NGS 1929 Mean Sea Level Datum, as defined by the NGS descriptions with the most recent adjustments.

2.3 HORIZONTAL ALIGNMENT

2.3.1 General

The parameters for the design of horizontal alignments have been established in accordance with the recommendations of the current issue of Manual for Railway Engineering published by the American Railway Engineering Association (AREA).

For this conceptual study the horizontal alignment of tracks shall consist of tangents joined to circular curves. Spirals shall not be identified.

2.3.2 Speed Requirements

Main-line. Curvature and superelevation shall be related to design speed and the acceleration and deceleration characteristics of the design train. Whenever practical, the geometrics shall accommodate a design speed of 60 miles per hour, depending on the location of curves and construction limitations, of the design train. Design speed will not necessarily be the same as maximum authorized speed, which will be established on the basis of train operations and signaling design. Wherever restrictions limit the speed to less than the design speed, every attempt shall be made to maintain alignment to accommodate the highest speed possible.

Yard and Secondary Track. The geometric design for yard and secondary track shall accommodate the operational requirements for each particular location.

The geometric design speed shall be equal to or greater than the speed provided by the special trackwork.

2.3.3 Control

The alignment control shall be the centerline of the main-line track. Because it forms the basic control for all other system facilities, the control centerline shall be stationed throughout its length.

The alignment of passing sidings and secondary tracks will not be defined by detailed geometry where their geometry can be defined from the control centerline. Through non-parallel horizontal areas and in other locations where this procedure is not feasible, these tracks shall have separately defined geometry beginning and ending with station equalities to the control centerline.

2.3.4 Minimum Tangent Length

Tangents on main line track shall be joined by circular curves. Tangent lengths shall be compensated to allow for spiral transition curves between the tangent and the circular curve in the final alignment design. The desired minimum uncompensated tangent length shall be 200 feet. One hundred feet shall be used as the absolute minimum for main-line track. Yard and siding track will not require any allowance for spiral curves. Yard track shall have a desirable minimum tangent length of 100 feet with an absolute minimum of 50 feet.

2.3.5 Track Spacing

Depending upon curvature and upon the operational function for the particular section of line, track spacing will vary. Normal track centers are 15 feet. Refer to section 2.8.2 for further guidelines pertaining to track spacing.

2.4 TRACK SUPERELEVATION

Superelevation is the vertical distance that the outer rail is raised above the inner rail on curves. Superelevation, speed and curvature care related by the formula shown in Appendix A. Maximum superelevation, Ea, shall be as shown in Table 1 of Appendix A. Unbalanced superelevation, Eu, shall be 2 inches. Superelevation shall not be used on curves where design speed is less than 20 mph.

The desired maximum actual superelevation (E_a) shall be 4 inches. However, where the design speed of a section of alignment can be increased by the addition of actual superelevation above 4 inches, an absolute maximum of 6 inches may be used.

For purposes of calculating speed limits on curves, superelevation shall be established in 1/4-inch increments. To allow for loss of superelevation during actual railroad operations, all curves should be constructed and maintained with a minimum of 1/2" actual superelevation. For speed limit

calculations, zero superelevation shall be assumed when the calculated value is less than 1/2 inch.

2.5 HORIZONTAL CURVATURE

2.5.1 Circular Curves

Circular curves shall be defined by the chord definition of curvature and specified by degree of curvature (D) in degrees.

The maximum degree of curvature shall be as follows:

Track Type	Desirable	Absolute
Main-Line	2° 00′	8° 00′
Yard & Secondary	8° 00′	12° 00′

The desired minimum length of circular curve (L_c) in feet along main-line tracks shall be three times the design speed (V) in miles per hour, or 100 feet, whichever is greater.

For yard and main-line multitrack layouts, where two or more tracks follow the same general alignment, the tracks shall be placed on concentric curves.

2.5.2 Transition Spiral Curves

General All horizontal circular curves in the main-line tracks require transition spirals where joining tangent track or where compounded to a curve of a different radius in the final design. For this conceptual study, the transition spiral is defined as a curve whose radius varies inversely as the distance along the curve from the point of spiral. Transition spiral curves will not be shown, but will be calculated to determine the increased tangent length between circular curves as discussed in Section 2.3.4.
The desirable and absolute minimum spiral lengths shall be determined using the formulas in Appendix B. Spiral lengths shall be rounded up to the nearest 10 feet. One-half the spiral curve length of each curve shall be added to the minimum allowable uncompensated target lengths to establish the minimum acceptable tangent between unspiralled curves.

Where physical restrictions or higher speed requirements make the use of the desirable spiral lengths prohibitive or impractical, the absolute minimum spiral length shall be used.

2.5.3 Reverse Curves

Double Reverse Curves. Double reverse curves shall not be used in the system unless the length of the second curve is at least 450 feet.

2.5.4 Compound Curves

Compound circular curves may be used to avoid broken back curves. Broken back curves are defined as two curves in the same direction with a less than minimum allowable intervening tangent.

2.6 VERTICAL ALIGNMENT

2.6.1 General

The profile grade is defined as the top of the low rail. Changes in profile gradients shall be joined by parabolic vertical curves at crests and sags. Compensation of grades is required for horizontal curvature.

2.6.2 Maximum and Minimum Gradient, Main-Line

The maximum profile gradient on main-line track shall be 2.5 percent compensated for horizontal curvature. Compensation for horizontal curvature shall be 0.04 percent for each one degree of curvature. To facilitate drainage, a minimum gradient of 0.3 percent shall is desirable in cuts. A gradient of zero percent for at-grade or embankment construction is acceptable if drainage can be accommodated.

2.6.3 Maximum and Minimum Gradient, Yard and Secondary Tracks

In yard and secondary tracks, the minimum gradient shall be 0.0 percent and maximum compensated gradient shall be 1.0 percent, except as follows:

- The uncompensated gradient for storage tracks may be 0.2 percent provided the grade is sloped away from the lead track and/or has a sag in the profile. Permanent stub-end storage tracks shall be sloped away from the turnout at 0.2 percent. Double-ended storage tracks shall be at 0% grade or (where feasible) have a sag in their profiles.

- Throat area tracks should preferably be on a slope. The desirable uncompensated gradient shall be 0.2 percent. Throat area tracks shall be sloped away from the main-line tracks; zero percent gradient may be considered with prior approval.

- Track located within buildings shall be level.

2.7 VERTICAL CURVATURE

2.7.1 General

Vertical tangents along main-line track shall be connected by parabolic vertical curves having a constant rate of change of grade.

2.7.2 Desirable Length of Vertical Curve

The desirable length of vertical curve (LVC) in main-line track shall be determined by the following formulas:

$$LVC = A/R$$

using:

R = 0.1 in sags

R = 0.2 in crests

where:

LVC = Length of vertical curve in 100 feet stations.

R = Rate of change percent per 100 feet station.

A = The algebraic difference in the grades (in percent) approaching and leaving the curve.

The desirable length of vertical curve in yard and secondary track shall be determined by substituting the following values for R:

R = 0.5 in sags

R = 1.0 in crests

2.7.3 Minimum Length of Vertical Curve

The absolute minimum length of vertical curve in main-line track shall be determined by substituting the following the following values for R:

R = 0.2 for sags

R = 0.4 for crests

The absolute minimum length of vertical curve in yard and secondary tracks shall be determined by substituting the following values for R:

R = 1.0 for sags

R = 2.0 for crests

2.7.4 Reverse Vertical Curves

Reverse vertical curves may not be used. Vertical curves in opposite directions shall have a desirable minimum tangent length of 200 feet, or an absolute minimum tangent length of 100 ft.

2.7.5 Compound Vertical Curves

Compound or asymmetrical vertical curves will not be used.

2.7.6 Combined Horizontal and Vertical Curves

Where possible, combined horizontal and vertical curves shall be avoided. Wherever practical, when a vertical curve occurs within the limits of a horizontal curve, the length of the vertical curve shall be increased to at least 1.5 times the minimum required length.

2.8 CLEARANCES

2.8.1 General

The following minimum horizontal clearances are applicable for tangent alignment. These clearances will be compensated for horizontal curvature and superelevation when required.

2.8.2 Horizontal Clearances - Tangent Alignment

- Between main-line track and siding track, 15'-0"
- Between parallel yard tracks, track center to center, as follows:

- Lead track to a ladder track	20'-0"
- Running track to a ladder track	20'-0"
- Ladder track to a ladder track	
With roadway	42'-0"
Without roadway	20'-0"
- Storage track to a storage track	
With roadway	36'-0"
Without roadway	14'-0"
- Building tracks	20'-0"
- Wayside storage tracks	15'-0"
- Storage track to main-line track	16'-0"

- Fixed structure, measured from centerline of track and nearest point of fixed structure as follows:

- General	9'-0"
- Thru Bridges	9'-0"
- Overhead Bridges	18'-0" on one side; 9'-0" on the other side
- In Tunnels	9'-0"

2.8.3 Compensation for Curvature and Superelevation

If necessary for specific locations or reasons during this conceptual study, horizontal clearance shall be increased for curvature and superelevation.

The additional clearance required for horizontal curvature shall be one and one half inch per degree of curvature.

The additional clearance required for superelevation shall be 3-1/2 inches per inch of differential superelevation.

2.8.4 Vertical Clearances

Vertical clearance, railroad structure over local public roads and streets, shall be as required by the Authority having jurisdiction over the roads. Minimum vertical clearance shall be 16'-6".

Vertical clearance, railroad structure under a fixed structure, shall be 23'-0" minimum measured from top of rail to the nearest point of obstruction.

CHAPTER 3 - TRACKWORK

3.1 INTRODUCTION

Track materials and special trackwork shall comply with the current edition of the American Railway Engineering Association (AREA) Manual for Railway Engineering and Portfolio of Trackwork Plans.

3.2 CLASSIFICATION OF TRACK

Track shall be divided into two classes:

- Main-line track. Main-line track shall consist of all track constructed for the purpose of carrying high level nuclear waste.

- Yard and secondary track. Yard track and secondary track shall consist of all other track constructed for the purpose of switching, storing, or maintaining railroad equipment or rolling stock. Interline connector and yard lead tracks shall be constructed to main-line track standards.

3.3 TRACK CONSTRUCTION TYPE

Trackwork shall be of tie and ballast construction conforming to the following:

- Main-line track. Track shall consist of concrete ties with resilient fasteners or timber ties with plates and cut spikes, ballast, and subballast upon a prepared subgrade.

- Yard track. Yard track shall consist of timber ties, tie plates, cut spikes, ballast, and subballast upon a prepared subgrade.

- Special trackwork Special trackwork shall consist of timber ties, tie plates, cut spikes, ballast, and subballast upon a prepared subgrade.

3.4 TRACK GAUGE

Standard track gauge throughout the system for tangent track and curved track shall be 4 feet 8-1/2 inches, as measured between inside faces of running rail at a point 5/8-inch below the plane defined by the top of the two running rails.

3.5 RAIL

3.5.1 Main-Line Tracks

Standard running rails shall be new 115RE section, continuously welded (CWR), control cooled or vacuum degassed carbon steel rail manufactured in accordance with current AREA "Specifications for Steel Rail" and "Specifications for Fabrication of Continuously Welded Rail".

3.5.2 Yard and Secondary Tracks

For purposes of this conceptual study, yard and secondary track shall be the same as Main Line tracks. During later stages of the design, secondhand rail for yard and secondary tracks may be considered.

3.6 SPECIAL TRACKWORK

This section defines special trackwork configurations, outlines location procedures, describes component features, and lists operating constraints.

3.6.1 Configurations

All turnouts shall be lateral units. No equilateral turnouts shall be assumed for this study.

The unit and their criteria to be used on the system include:

- Main-line track crossovers, turnouts to sidings, yards, and end-of-line storage tracks shall use No. 10 turnouts (19-foot 6-inch curved split switch).
- Yard tracks may use No. 8 turnouts (13-foot curved split switch).

3.6.2 Location Criteria

Crossovers and turnouts shall be located on tangent track and on constant profile grades.

The length of the turnout unit shall extend from ten feet before the point of switch to ten feet beyond the last long tie.

The separation distances required between the points of switches of various combinations and the directions of turnouts shall have a desirable minimum of 25 feet. The desirable horizontal and vertical tangent distance preceding a point of switch shall be 25 feet, and the absolute minimum shall be 10 feet.

3.6.3 Component Features

The basis of design for all special trackwork components is the AREA "Portfolio of Trackwork Plans". Geo-textile fabric shall be used under all ballasted special trackwork installations.

3.6.4 Operating Speeds

The maximum operating speeds through the various turnouts designated for use on the system are shown below. The speed restriction is for the curved lateral portion. For the tangent portion maximum authorized speed will govern.

OPERATING SPEEDS THROUGH TURNOUTS

TURNOUT NO.	MAXIMUM SPEED LIMIT (MPH)
8	15
10	20

3.7 DERAILS

Derails shall be installed on access tracks to railroad sidings and on any yard or secondary track normally used for the storage of unattended cars or locomotives if any of these tracks are directly connected to the main-line track and their prevailing grade descends to the main-line track. This condition should be avoided whenever possible.

3.8 END OF TRACK RESTRAINING DEVICE

A rail-mounted vehicle retarding device shall be used on stub-end tracks. This device will limit movement by absorbing vehicle energy. It shall include an anti-climbing feature. Should conditions warrant, an additional hydraulic car-retarder or sand box may be considered.

3.9 SUBBALLAST AND BALLAST

3.9.1 Ballast

Crushed stone conforming to Chapter 1 of the current issue of the AREA Manual for Railway Engineering for specifications of ballast shall be used for ballast.

3.9.2 Subballast

The subballast for all tracks shall consist of a uniform layer placed and compacted over the entire width of the roadbed. All subballast material shall conform to current State of Nevada Department of Highway, "Standard Specifications for Road and Bridge Construction, Section 302".

3.10 TIES

3.10.1 Concrete Ties

Concrete cross ties used in main-line ballasted track shall be spaced a maximum of 30 inches center-to-center. They shall include a cant (1:40) on the rail bearing area.

3.10.2 Timber Ties

All timber ties shall be mixed hardwoods and have anti-splitting devices installed in accordance with current AREA specifications. All timber ties shall be air seasoned and treated in accordance with the current AREA "Specifications for Preservatives." Timber ties shall be treated by the empty cell process in accordance with AREA "Specifications for Treatment."

Timber Cross Ties. Timber cross ties shall be used in yard ballasted track and grade crossings. All timber cross ties shall be new, 9 feet 0 inches in length and 7 inches by 9 inches in cross section. They shall conform to current AREA "Specifications For Timber Cross Ties."

Timber Switch Ties All timber switch ties shall be new, 7 inches by 9 inches in cross section, in lengths specified in the trackwork standard drawings. They shall conform to the current AREA "Specifications for Timber Switch Ties."

3.11 RAIL FASTENERS

Concrete ties shall use resilient clip track fasteners suitable for the loading and operating conditions of the system. The fastener assembly shall also have an insulating tie pad and clip insulators. Main-line timber cross ties shall use a cut spike fastener, complete with double-shoulder canted (1:40) tie plate. Special plates shall be used to support switch and frog components. Yard track and yard special trackwork shall utilize cut spikes and AREA plates.

3.12 JOINING RAIL

3.12.1 Main Line Track

Main line track shall consist of Continuously Welded Rail (CWR), except for special situations such as insulated joints or other locations.

3.12.2 Secondary Track

Secondary track shall consist of either CWR or jointed rail.

3.13 GRADE CROSSINGS

3.13.1 Highway

Main-line track grade crossings shall be high volume types such as prefabricated rubber, rubber and steel composite or concrete, or low volume timber panels, dependent upon vehicular traffic volume. Yard grade crossings shall utilize timber panels or asphalt concrete. Track underdrains shall be used at all grade crossing sites in conjunction with suitable geotextile filter fabrics. Grade crossings shall be located on tangent tracks wherever possible. Grade crossings located in curved track and special trackwork shall be avoided wherever possible. Timber cross ties shall be used for all grade crossings.

3.13.2 Railroad

Railroad grade crossings (tracks crossing tracks) should be avoided.

CHAPTER 4 - ROADWAY

4.1 GENERAL

Roadway is defined as that portion of the rail line that has been prepared to support the track and its associated structures. Roadway generally includes the subgrade, slopes of cuts and fills, and drainage systems for diverting or carrying water away from the track area.

4.2 SUBGRADE

The subgrade is the finished surface of the trackbed below the subballast. The subgrade supports the loads transmitted through the ballast and subballast. The support of the track depends ultimately on the stability of the subgrade. Uniformity is the goal of subgrade design because it is differential rather than total vertical movement that leads to unsatisfactory track geometry.

4.2.1 Stabilization of Subgrade

Stabilization of the subgrade may be specified where indicated by geotechnical investigations. The material and method selected will be evaluated and recommended by the designer.

4.2.2 Configuration

The subgrade shall be crowned and sloped away from the apex of the crown on a slope of 24 horizontal to 1 vertical. The location of the apex of the crown shall be, for single track, at the centerline of the track; for double track, at a line midway between the two tracks.

4.2.3 Elevation

The elevation of the top of subgrade is determined from the profile grade line (PGL) of the tracks. The depth of the track structure must be used to determine the subgrade elevation.

4.2.4 Dimensions

The width of the subgrade is determined by the track centers and track geometry, The subgrade must be of sufficient width to support the subballast. For purposes of this conceptual study, no adjustments will be made to subgrade widths based on curvature and superelevation.
The width of the top surface of subballast shall be 24 feet.

4.3 SLOPES

Side slopes for cut and full shall be in accordance with the geotechnical recommendations.

4.4 DRAINAGE

Track stability requires that water seeping or flowing toward the track shall be intercepted and diverted before it reaches the track, and that water falling upon the track area shall be quickly drained.

4.4.1 Side Ditches

Side ditches shall be provided parallel to the railroad tracks through sections in cut. Intercepting ditches at the tops of slopes and along benches shall be provided where required. The design of ditches shall conform to criteria given in the drainage chapter of these criteria. Side ditches shall be used at the bottoms of fills as necessary to provide continuity of drainage.

4.4.2 Underdrains in Retained Sections

Longitudinal perforated drains shall be provided immediately adjacent to retaining walls and at grade crossings. The underdrain pipe shall be encased in an envelope of suitable filter fabric and crushed stone. The fabric shall extend up to and under the ballast. A similar drainage arrangement shall be provided where lateral clearance does not permit a drainage ditch, such as yard areas.

4.5 UNDERTRACK STRUCTURES

Direct burial cable, gas lines, utilities, or other structures may cross or run parallel to the track. All undertrack utility crossing carrier lines shall be encased. Casing pipes shall extend throughout the right-of-way have at least three feet of cover between the track subgrade and the top of the casing.

4.6 WAYSIDE ACCESS

Access to the track or roadbed will be provided as required for maintenance and emergency work. Hi-rail vehicle access will be available at all grade crossings. Provisions for hi-rail access shall also be made at grade separations. All sidings which have maintenance road access shall have hi-rail access.

Parallel maintenance roads shall be provided as necessary for emergency access.

4.7 SPECIAL CONDITIONS

The configuration of the subgrade underlying yards requires special consideration. The subgrade shall have lateral slopes of 24:1 for drainage. The yard ballast shall be even with the top of the tie between tracks, and additional ballast shall be placed along the outside edge of perimeter tracks to provide for an adequate walkway space.

CHAPTER 5 - SIGNALS AND COMMUNICATIONS

5.1 SIGNALS AND TRAIN CONTROL

5.1.1 General

This chapter describes design criteria and guidelines for various train signaling and control systems that could be adopted. Specific functions are described in Chapter 1.

Train signals could be designed to serve two separate though inter-related functions:

1. Control of train movement,
2. Detection of local hazards,

Signals for control of train movement could use either an Automatic Block Signal (ABS) system or an Advance Train Control System (ATCS). Detection of local hazards shall be via local signal systems, unless the hazard detection is included in the train control signal system. Specific hazards that shall be detected are:

- Rock Slides
- High water
- Hot Journal and Cracked wheels
- Dragging equipment

Grade crossing signal warning device are described in Chapter 7. Specific Criteria for train signals are described below.

5.1.2. Train Movement Signals (optional)

A. Automatic Block Signal System

For average siding spacing of 20 miles, each segment of track between sidings shall be divided into two blocks. The segment of main line track adjacent to the siding shall also constitute a signal block, and each siding will constitute a block. Blocks between sidings shall not be shorter than 5 miles in length, nor longer than 15 miles.

Each end of block shall be protected by two-way signal masts. A three-aspect system shall be employed.

B. Advanced Train Control System

An ATCS shall include cab signaling, but not speed control. Track mounted transponders shall be located at five mile intervals. Radio stations shall be located at the Yucca Mountain Depository, the mid-point operations facility, the beginning of line station, and at all sidings.

5.1.3 Hazard Detection Signals

A. Rock Slide Detectors

Rock Slide detector fences and related signal equipment shall be installed at locations in cuts which are subject to rock slides. The Geotechnical Report shall be used to establish potential rock slide areas in the absence of site specific data. Areas where cut slopes steeper than 1:1 are recommended may be assumed to be potential rock slide areas. However, site-specific data or knowledge shall govern. Rock slide fences shall be placed on one or both sides of the track, as applicable. Minimum length of rock slide fence is 40 feet. Additional lengths of 40 feet may be added to obtain required coverage for individual zones up to 1,600 feet long. Fences on both sides of the track can be combined into a single zone with a maximum total length of 1,600 feet.

B. Hot High Water Detectors

High water detectors and related signal equipment shall be located at all hydraulic structures identified as bridges, and at any specific minor drainage structures where high water is a potential problem. The Hydrology Report shall be used to the extent possible to identify such locations.

C. Hot Journal and Cracked wheel detectors

Combined overheated Journal bearing and cracked wheel detectors shall be located approximately midway between sidings.

D. Dragging Equipment Detectors

Dragging equipment detectors shall be located approximately midway between sidings and at approaches to special operations areas, such as:

1. Yucca Mountain Depository
2. Mid Point Operations Center
3. Railway Interchange Yard
4. Tunnels

E. Open Switch Detection

If an ABS System is employed for the basic signal system, open switch detection will be provided as normal functions of the track circuits and wayside signals. No switch point detection signals will be provided for an unsignalized railroad.

5.1.4 Miscellaneous Items

Solar power equipment shall be included at all signal equipment locations.

All local hazard detectors shall have radio communication relays to the central dispatch facility. Detectors of on-board conditions such as hot journal, cracked wheel and dragging equipment shall also have radio relays to

the locomotive cabs. Detectors for track and wayside conditions such as rock slides and high water, shall similarly have radio relays to the locomotive cabs unless a block signal system is employed. With an ABS system, these local hazard detectors shall be integrated with the signals controlling the bocks on both sides of the hazards.

5.2 COMMUNICATIONS

5.2.1. Telephone

Telephones at the Caliente Interchange area, the maintenance facilities, the Yucca Mountain Repository and the mid-point crew interchange area shall be connected to the local telephone company network. Existing telephone lines are assumed to exist at these locations. Radio telephones shall be utilized for telephones at sidings.

CHAPTER 6 - ROADS

6.1 GENERAL

This chapter presents criteria for the access roadway from US-95 at Lathrop Wells to the unloading facility at Yucca Mountain, and for maintenance roads where required.

6.2 ACCESS ROAD

The access roadway will be designed in accordance with Nevada Department of Transportation (NDOT) standards. Department of Energy and Nye County criteria will be reviewed for compliance. The intersection with US-95 will be designed in accordance with NDOT standards.

The access road will be a public roadway for approximately 2 miles from the intersection of US-95 to the boundary of the test site. From the boundary to the Yucca Mountain site, approximately 18 miles, the road will be a private road operated by the Department of Energy.

6.2.1 Speed

The design speed will be 70 miles per hour. The posted speed will be 55 miles per hour.

6.2.2 Design Vehicle

The design vehicle will be "over the road" semi tractor and trailer with a H-20 design loading, which corresponds to a maximum 32,000 lbs axle load. The AASHTO overload provisions also require a maximum live load in one lane only of 48,000 lbs per axle (twice the H-15 load).

6.2.3 Average Daily Traffic

Volumes will be very low consisting of project related traffic. The design traffic volume shall be 5000 average daily trips (ADT).
Public traffic will be halted at the boundary of the test site.

6.2.4 Alignment

The roadway alignment will be determined by the allowable grades, allowable curve radii and aesthetic considerations.

6.2.4.1 Grades

The roadway will be designed with a maximum desired grade of 6% and a maximum allowable grade of 8%.

6.2.4.2 Curves

The roadway will be designed with horizontal curves, super elevation rates and sight distances consistent with the 70 MPH design speed.

6.2.4.3 Aesthetics

The alignment for the roadway will be reviewed for visual impact and efforts made to lessen unsightly cuts and fills.

6.2.5 Typical Section

The roadway will be a paved 2 lane roadway with 14-foot lane widths and graveled 8-foot shoulders. The typical crown slope will be 2%. The backslopes on cuts and fills will be dependent upon the geotechnical information developed during the design phase of the project. Fill slopes steeper than 3:1 will be protected with metal guard rails. Cut slopes will be set back from the roadway to allow construction of a drainage swale.

6.2.6 Drainage

Storm water will be channeled under the roadway with drainage structures to allow the roadway to function safely during periods of rainfall. See Chapter 9 - Drainage of these criteria.

6.3 MAINTENANCE ROADS

A maintenance road will be provided at selected locations where access is not otherwise possible. The road shall be located within the right of way at the top of cut or toe of slope. A maintenance road will not be provided if there is a public road adjacent to the rail line.

6.3.1 Speed

The design speed shall be 30 miles per hour.

6.3.2 Design Vehicle

The design vehicle shall be AASHTO SU (Single Unit Truck)

6.3.3 Average Daily Traffic

Traffic volume shall be less than 100 ADT. The maintenance roads shall not be expected to be open to the public.

6.3.4 Alignment

The road alignment will be determined by the allowable grades and turning radii of the design vehicle.

The road will be designed with a maximum desired grade of 10 percent and a maximum allowable grade of 20 percent.

6.3.5 Typical Section

The road will be a unpaved graveled one lane roadway with a 10 foot lane width. The road will be cross sloped at 4 percent.

6.3.6 Design Effort

For this conceptual design, the locations of maintenance roads will be indicated on the railroad alignment drawings. No alignments or profiles will be developed for the roads, and earthwork quantities associated with the roads will not be calculated. Costs of the road surfaces will be estimated on the basis of lineal feet of road.

CHAPTER 7 - TRAFFIC CONTROL

This chapter establishes criteria for vehicular grade separations and crossings.

Type of Road and Traffic	Type of Traffic Control
State Highways	Grade Separation
Secondary and all paved roads	Crossing signals with gates
	High volume crossing surface
Unpaved Roads	Crossbuck
	Timber crossing Surface
Private drives	Crossbuck
	Timber crossing surface

In areas where the distance between minor roads is significantly greater than 20 miles, consideration should be given to provision of grade crossings more frequently at potential road locations to prevent the railroad from acting as a barrier.

CHAPTER 8 - UTILITIES

Utilities for building will be included in the square foot unit costs.

Electrical power shall be furnished for the operation of automatic gates at grade crossings, either hard wired from nearby electric lines or solar-powered.

Utility relocations will not be designed but a cost allowance shall be included in the estimate.

Where the alignment of the railroad or roadways crosses over any existing utility, a casing shall be built around the carrier line. These crossings shall be designed in accordance with Part 5 of Chapter 1 of the Manual for Railway Engineering published by AREA.

Where railroad alignments follow existing utilities, either overhead or below ground, the alignment should be set so that the right of way does not encroach on the utility line. In exceptional cases where terrain or environmental considerations restrict the alignment, the utility may be permitted to share the railroad right of way. However, a minimum distance of fifty feet shall be maintained between the railroad track and the parallel utility line.

CHAPTER 9 - DRAINAGE

9.1 GENERAL

The hydrological and hydraulic characteristics of watersheds larger than one square mile will be analyzed to determine the size of bridges, culverts and ditches.

9.2 HYDROLOGICAL CHARACTERISTICS

The peak discharge rates for watersheds with areas between one and five square miles shall be estimated using the regional multiple regression equations. Watersheds larger than five square miles shall be analyzed using the Army Corps of Engineers Hydrology Program, HEC-1. FEMA data shall be used for peak discharge rates where available.

The design frequency shall be the 100-year flood. For closed watersheds (no outlet) the design water level shall be that resulting from a 100-year design frequency combined with a reasonable carryover volume from the previous year.

9.3 HYDRAULIC CHARACTERISTICS

For small culverts, corrugated steel pipe shall be used with the addition of asphalt or synthetic lining where considered necessary for local conditions. Concrete box culverts or bridges shall be used for large design flows.

The headwater at culverts shall not exceed an elevation four feet below the profile grade line.

The minimum gradient for open ditches shall be 0.3 percent. The maximum velocity shall not exceed 3 feet per second for sandy conditions and 6 feet per second for rock conditions.

10. GEOTECHNICAL INFORMATION

Geotechnical information for the project design is essential for developing the route and structure requirements.

Geotechnical design shall be in accordance with Chapter 1 of the AREA Manual for Railroad Engineering and the recommendations of the geotechnical report which will be prepared for this project.

CHAPTER 11 - BRIDGE STRUCTURES

11.1 GENERAL

This chapter describes the structural criteria for railroad and highway structures which carry the new rail line and access road over streams and other roads.

The information developed from the hydrology report shall be used to size structures over streams. Structures over roadways shall be sized to provide the horizontal and vertical clearances required. See Section 2.8 - Clearances of these criteria.

11.2 RAILROAD BRIDGES

Structures supporting railroad loads shall be designed according to the latest revisions of Volumes I and II of the Manual for Railroad Engineering published by AREA.

The design load shall be Cooper E 80 plus impact load.

11.3 HIGHWAY BRIDGES

Structures supporting highway loads shall be designed according to the Standard Specifications for Highway Bridges published by AASHTO.

The design load shall be H-20.

11.4 STRUCTURE TYPE

For erection and maintenance simplicity, bridge structures shall be composed of precast prestressed concrete box girder units utilizing simple spans. Railroad bridges shall be ballasted deck with 8 inches of ballast under the bottom of tie.

Alternative bridge designs shall be investigated if a crossing of Forty-Mile Wash is required.

For highway bridge structures spanning the railroad, type of structure shall be based on the lengths of the spans required and may be either conventional reinforced concrete or prestressed concrete.

CHAPTER 12 - BUILDINGS

The required buildings are a function of the specific operating plans for the railroad and cannot be specified at this time. Following generation of the operating plans for the difference scenarios, requirements for buildings to satisfy the relevant functional requirements will be developed.

Schematic layouts of railroad storage, maintenance and operating areas will be developed. These layouts will not be site specific, but will be prepared to establish general configurations and land requirements.

APPENDIX D-1

Track superelevation is based on the following formula:

$$E_t = Ea + Eu = (3.96V^2) / R_c = 0.0007\ D\ V^2$$

where:

E_t = Total superelevation = Ea + Eu
Ea = Actual track superelevation in inches
Eu = Unbalanced superelevation in inches
V = Design speed in miles per hour
R_c = Radius of curvature in feet
D = Radius of curvature in degrees

Table 1

Maximum Superelevation Rates

Degree of Curve			Maximum Ea
0°	to	4° -00′	6"
4° -01′	to	6° -00′	5"
6° -01′	to	8° -00′	4"
8° -01′	and greater		3"

TABLE 2
MAXIMUM SPEEDS ON CURVES
Eu = 2 IN

SUPERELEVATION IN

DEGREE OF CURVE DEG	MIN	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.25	5.50	5.75	6.00
0	15	107	113	120	125	131	136	141	146	151	156	160	165	169	173	177	181	185	189	193	196	200	204	207	210	214
0	30	76	80	85	89	93	96	100	104	107	110	113	116	120	122	125	128	131	134	136	139	141	144	146	149	151
0	45	62	65	69	72	76	79	82	85	87	90	93	95	98	100	102	105	107	109	111	113	115	118	120	121	123
1	0	53	57	60	63	65	68	71	73	76	78	80	82	85	87	89	91	93	94	96	98	100	102	104	105	107
1	15	48	51	53	56	59	61	63	65	68	70	72	74	76	77	79	81	83	85	86	88	89	91	93	94	96
1	30	44	46	49	51	53	56	58	60	62	64	65	67	69	71	72	74	76	77	79	80	82	83	85	86	87
1	45	40	43	45	47	49	52	53	55	57	59	61	62	64	65	67	69	70	71	73	74	76	77	78	80	81
2	0	38	40	42	44	46	48	50	52	53	55	57	58	60	61	63	64	65	67	68	69	71	72	73	74	76
2	15	36	38	40	42	44	45	47	49	50	52	53	55	56	58	59	60	62	63	64	65	67	68	69	70	71
2	30	34	36	38	40	41	43	45	46	48	49	51	52	53	55	56	57	59	60	61	62	63	64	65	67	68
2	45	32	34	36	38	39	41	43	44	46	47	48	50	51	52	53	55	56	57	58	59	60	61	62	63	64
3	0	31	33	35	36	38	39	41	42	44	45	46	48	49	50	51	52	53	55	56	57	58	59	60	61	62
3	15	30	31	33	35	36	38	39	41	42	43	44	46	47	48	49	50	51	52	53	54	55	56	57	58	59
3	30	29	30	32	34	35	36	38	39	40	42	43	44	45	46	47	48	49	51	52	52	53	54	55	56	57
3	45	28	29	31	32	34	35	37	38	39	40	41	43	44	45	46	47	48	49	50	51	52	53	53	54	55
4	0	27	28	30	31	33	34	35	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	53
4	15	26	28	29	30	32	33	34	36	37	38	39	40	41	42	43	44	45	46	47	48	49	49	50	51	52
4	30	25	27	28	30	31	32	33	35	36	37	38	39	40	41	42	43	44	45	45	46	47	48	49	50	50
4	45	25	26	27	29	30	31	32	34	35	36	37	38	39	40	41	42	42	43	44	45	46	47	47	48	49
5	0	24	25	27	28	29	30	32	33	34	35	36	37	38	39	40	41	41	42	43	44	45	46	46	47	48
5	15	23	25	26	27	29	30	31	32	33	34	35	36	37	38	39	40	40	41	42	43	44	44	45	46	47
5	30	23	24	25	27	28	29	30	31	32	33	34	35	36	37	38	39	39	40	41	42	43	43	44	45	46
5	45	22	24	25	26	27	28	29	31	32	32	33	34	35	36	37	38	39	39	40	41	42	42	43	44	45
6	0	22	23	24	26	27	28	29	30	31	32	33	34	35	35	36	37	38	39	39	40	41	42	42	43	44
6	15	21	23	24	25	26	27	28	29	30	31	32	33	34	35	35	36	37	38	39	39	40	41	41	42	43
6	30	21	22	23	25	26	27	28	29	30	31	31	32	33	34	35	36	36	37	38	39	39	40	41	41	42
6	45	21	22	23	24	25	26	27	28	29	30	31	32	33	33	34	35	36	36	37	38	38	39	40	40	41
7	0	20	21	23	24	25	26	27	28	29	29	30	31	32	33	34	34	35	36	36	37	38	38	39	40	40
7	15	20	21	22	23	24	25	26	27	28	29	30	31	31	32	33	34	34	35	36	36	37	38	38	39	40
7	30	20	21	22	23	24	25	26	27	28	28	29	30	31	32	32	33	34	35	35	36	37	37	38	39	39
7	45	19	20	21	23	24	24	25	26	27	28	29	30	30	31	32	33	33	34	35	35	36	37	37	38	38
8	0	19	20	21	22	23	24	25	26	27	28	28	29	30	31	31	32	33	33	34	35	35	36	37	37	38

NOTES: 1 VALUES ABOVE THE DASHED LINE ARE NOT APPLICABLE TO THIS STUDY
2 VALUES BELOW THE SOLID LINE MAY NOT BE USED

APPENDIX D-2

The desirable spiral length is the greater obtained from the following formulas:

$L_s = 1.4\ V\ Ea$

$L_s = 60\ Ea$

Where:

L_s = Length of transition spiral curve in feet

V = Design speed in miles per hour

Ea = Actual track superelevation in inches

The absolute minimum spiral length shall be the greatest length obtained from the following formulas:

$L_s = 1.17\ V\ Ea$

$L_s = 1.0\ V\ Eu$

$L_s = 50\ Ea$

$L_s = 75$ feet minimum

Where:

Eu = Unbalanced superelevation in inches

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

LAS VEGAS, NEVADA

YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE

CONCEPTUAL DESIGN REPORT

APPENDIX E
ACCESS ROAD REPORT

De Leuw, Cather & Company
Subcontract Agreement No. 14-900078-12

120 Howard Street
San Francisco, CA 94105

1 June 1992

YUCCA MOUNTAIN PROJECT
ACCESS ROAD -- CONCEPTUAL DESIGN

I. INTRODUCTION

Yucca Mountain, located on the southwestern side of the Nevada Test Site is being investigated as a potential repository for high level nuclear wastes by the Department of Energy. At present, the Yucca Mountain site lacks rail access and has only indirect road access. The purpose of this report is to develop a conceptual : 1) design for highway access to the site. This report lists our preliminary recommendations for a highway route, its characteristics, and cost. An eight-sheet plan set is included in this report. It contains map references, typical cross-sections, and the highway plan and profile sheets.

II. SCOPE

This study is conceptual in nature. Physical access to the route was limited during the period of this investigation and no substantive field work has been done to date. This study was limited to information that is available offsite. The map work at this stage is limited to USGS 7.5 minute quadrangles. Other facets of a final design, including geotechnical, environmental, and archaeological studies are not addressed at this time.

III. LOCATION AND LAND STATUS

The map on Sheet 1 of 8 illustrates the location of the project area. The proposed site for the Yucca Mountain Facility is in unsurveyed Section 35 of Township 12 South, Range 49 East, MDM, in Nye County Nevada. The access road corridor is located on the Busted Butte and Amargosa Valley USGS Quadrangles, and on the USGS 30'x60' Beatty Quadrangle.

The access road starts at US 95, 23 miles southeast of Beatty and 100 miles northwest of Las Vegas. The road is 15.2 miles long.

The first 2.3 miles of the route lies on unrestricted BLM Public Lands. Within this area the route crosses the rights-of-way of a power transmission line and telecommunications line. The Plan & Profile, Sheet 3 of 8, illustrates the location of these features. The remaining roadway is across lands of the Nevada Test Site (NTS) which were withdrawn from public access in 1959. At this time, the highway corridor is void of any known activities, civilian or military. Archaeological and environmental concerns are outside the scope of this work.

IV. ROUTE SELECTION

Several different options are available for access to the Yucca Mountain Repository. These alternatives are identified on Figure 1 (located in the back pocket of this report). A preferred route would be constructed up the center of the valley on the west side of Forty Mile Wash. This route appears to offer: 1) the most direct access, 2) the most protection from flood events, 3) the least environmental and visual impact, 4) the least interaction with other NTS activities, and 5) the least cost.

The alignment is detailed on the Plan and Profile Sheets, numbered 3 through 8 of 8. The plan and profile elevations were derived from USGS 7.5 minute quadrangles. This work is approximate and not based on field surveys. For the last six miles of the route, the railroad and highway will converge to occupy the same corridor. An at-grade crossing of the railroad is needed at approximately one mile from the facility site.

V. HIGHWAY DESIGN STANDARDS

The basis of design standards for this project are the minimum requirements of the Nevada Department of Transportation (NDOT). The NDOT standards are themselves derived from those of AASHTO, ASTM, FHWA and other established sources. The minimum standards proposed for this project are typical of a Nevada rural highway.

VI. HYDROLOGY

Summer flash floods are the hydrologic event which governs the design of this project. The design standard chosen for this project are flood events of the 100-year, 6-hour storm.

Peak Runoff

A USGS hydrologic study at nearby Jackass Flats was completed in 1980. The report developed regional regression equations for estimating peak 100-year runoffs. As part of its railroad hydrology study, Kennedy/Jenks/Chilton developed its own regression models, and also ran larger basins on the HEC-1 computerized hydrologic program. The reader is referred to Appendix F for a detailed explanation of the Kennedy/Jenks/Chilton model.

Only one major watershed is crossed by the proposed highway route. Its basin lies west of, and contributes to, the drainage crossing at station 532+00. Below, the runoff results of both the USGS and K/J/C models are compared for the basin. The basin is identified as Hydrographic Basin #227A-3 in the Hydrologic Report on the Caliente Railroad Route.

---------- 100-YEAR, PEAK RUNOFF ESTIMATE ----------

Basin	USGS Model	K/J/C Model
# 227A-3	2673 cfs	3182 cfs

Where crossed by the highway, this watershed appears to be a small meandering channel incised into a broad wash. A box culvert structure is planned for conveyance of this drainage under the highway and is based on the higher runoff estimate. Field studies are needed to evaluate the horizontal and vertical stability of the channel.

At this stage of work, the other drainage crossings do not appear to be significant.

Protection

Where necessary, riprap will be placed to prevent erosion and help energy dissipation. It is NDOT general policy that hydrologic improvements be limited to the areas within the immediate corridor. Open channel guidelines established by NDOT are: 1) minimum gradient for open ditches is 0.3%, and 2) maximum water velocity for soil ditches is 3 ft/sec.

Where the rail and highway occupy the same corridor, the rail will be uphill of the highway with a drainage swale between them. Storm drains, consisting of closed pipe culverts, will be used to convey water under the highway.

VII. CONSTRUCTION DETAILS

Design Characteristics

The proposed route requires a minimum number of major cuts-and-fills and curves. It crosses flat to slightly rolling topography with drainage crossings being the main impediments. Our recommendations for design characteristics of the highway are the following:

Design Speed	70 MPH
Posted Speed	55 MPH maximum
Design Vehicle	32,000 lb axle load; 80,000 lbs gross, (HS20-44 standard)
Design Traffic (ADT)	5000 (per SAIC)
Design Grades	4% (maximum)
Note:	At 4%, length of up hill grade should not be more than 1,000 feet without addition of an uphill passing lane.
Vertical Curves	Min 600' length for grade changes greater than 0.2%, up to 1.5%.
Horizontal Curve Radius	2000' (minimum)
Note:	3,000' or more desired
Minimum Sight Distance	850'
Cross Slope, normal	2% bidirectional from centerline
Superelevation	0.07 ft/ft (maximum)

Roadway Widths

The access road will be two lanes for most of its length. A passing lane will be added for the last 5600 feet of uphill grades close to the Facility.

Travel Lanes	12'	lane in each direction
Passing Lane	12'	(where needed)
Paved Shoulder	8'	wide on each side.
Widening	5'	(for embankments 3:1 and steeper)

Roadway Section

On flat terrain, the roadway surface will lie approximately two feet above the existing grade. Refer to the typical cross-sections illustrated on Sheet 2 of 8.

Open graded surfacing .....3/4", minus 3/8" material
Asphalt cement concrete .....6" (two 3" lifts)
Aggregate base material .....12", compacted to ASTM 95%
Subbase material .....10", compacted to ASTM 90%
Existing soils .....cleared and grubbed, scarified 6-inches and compacted to 90% as needed.

Embankment Fill

Embankment slopes will be constructed in accordance with the following table. Guard rails are required for slopes of 3:1 and steeper.

Fill Slopes	Slope Ratio
0' - 5'	10:1
5' - 10'	6:1
10' - 15'	4:1
15' - 20'	3:1
20'+	2:1

Excavation Slopes

Excavation slopes will be constructed in accordance with the following table.

Depth of Cut	Back Slope Ratio
0' - 4'	6:1
4' - 15'	4:1
15'+	2:1

Side Ditches

Where the highway is constructed in a cut, side ditches will be sized and provided to intercept runoff. Side ditch slopes from the shoulder to the ditch's flow line will slope at maximum ratio of 6:1.

Pipe Culverts

At least five small drainages requiring culverts are known to exist from the existing data, and approximately 15 more are expected once high resolution topography becomes available. A number of drainages will need to be channeled under the highway. For estimation of construction costs, we have assumed the route will require 20-36" culverts. Ultimate sizing will undoubtedly vary and some reductions may be possible once the final hydrology and design data is in hand.

Box Culverts

A cast-in-place reinforced concrete box culvert is anticipated for the wash crossing at station 532+00. The final design will probably accommodate embankments for both the highway and the railroad crossing. The wash will require an four-barrel 10' x 10' RCB with each barrel being 10 feet wide and 10 feet high. The RCB will also require upstream and downstream channel protection.

Riprap

Some protective channelization will be required upstream of the culvert structures, and also downstream as energy dissipators. The estimated quantities are based on a minimum of 40' of channel lining upstream and 10' downstream of most structures.

Guardrail

Guardrails will be necessary where fill slopes are 3:1 and steeper with fill heights greater than five feet. Quantities are based upon 100' feet of guardrail (on both sides) at each culvert crossing, and 1000' on each side of the major wash crossing. The guard rails include safety reflectors.

Permanent Signs

Permanent traffic signs will be required at a number of locations. These include markers at the US 95 intersection, boundary control at the NTS border, speed limit, curve, and railroad crossing signs. Approximately 30 signs will be necessary.

Pavement Markings

Pavement markings will include centerline and shoulder striping along the highway plus new markings for the intersection at US 95. Raised pavement markers will be used as rumble strips at the railroad grade crossing.

Safety Markings

Reflector guide posts will outline the highway shoulder at intervals of 250'.

Railroad Crossing

A railroad-highway crossing will be needed on approach to the facility. Train traffic to the site is estimated to be one trains per week. Considering this low frequency, an at-grade crossing is recommended A grade separation crossing has been considered and identified in initial work, however only the at-grade crossing option is presented in the Plan and Profile, Sheet 8 of 8.

Accordingly, the quantity and cost estimates for the access road are also based solely on the at-grade crossing concept.

The preferred location for this crossing is on the final slope up to the site. The crossing would be protected by automatic gates and warning lights. There will be good visibility in both directions.

A number of railroad crossings are enumerated in the Caliente rail alignment project. Cost for this crossing is included under the railroad study.

Entrance Facility

Public access to the highway will be controlled by a guard station at the NTS border. This is about 2.3 miles from the US 95 intersection. Though the requirements for this guard station have not been identified, we anticipate the following items will be required: warning signs, movable gates, traffic control islands, a guard station, guard quarters, overhead lighting, fencing, extra traffic lanes and parking. The preliminary cost for these facilities is based on lump sum estimates for these items.

Highway Corridor

The nominal corridor width for the highway is 100'. Approximately 6 miles from the facility, the railroad will converge with the access road and both will occupy the same corridor. This will provide some economy at the wash crossing at 535+00 and help to minimize impacts at the final approach to the Facility.

Intersections

One highway intersection will be developed as part of this project. Where the route intersects US highway 95, special provisions will be needed such as acceleration and deceleration lanes, signs, and markers. Sheet 2 of 8 illustrates a layout of the intersection.

IV. CONCLUSIONS

The purpose of this study was to identify the most desirable highway route to the Yucca Mountain Facility, and its probable cost which is preestimated in Table 5.17. This project is conceptual in nature and is based upon broad preliminary generalizations.

Our study has identified the center route, as identified in Figure 1, as the most practical and economic.

V. FUTURE STUDIES

To continue the design of this project, the following studies are needed:

1) Access to the study site by project personnel. The groundwork required includes surveying, hydrologic, and geotechnical studies. Quality aerial photos are also required.

2) Detailed topographic control: An airphoto flight of the corridor is needed if mappable photos are not already available. A contour control of 2' is desirable for design purposes. A ground survey to establish alignment is required in advance of the mapping.

3) Once the route has been staked, ground surveys for archaeological and environmental clearance should be done.

4) Geotechnical testing of foundations soils and the identification of materials sites.

5) Hydrologic reviews and channel cross-sections for the drainage crossings.

APPENDIX A

YUCCA MOUNTAIN PROJECT
ACCESS ROAD

ESTIMATED MATERIAL QUANTITIES

Item	Location	Units	Quantity
Clearing and Grubbing:			
100' Corridor	0+00 to 801+00	ac	185
Excavation:			
	500+00 to 560+00	cuyd	100,000
	Remainder of route	cuyd	30,000
			130,000
CMP Drainage Culverts:			
20 - 36" x 60'		ft	1,200
flared end sections		ea	40
Poured Concrete Box Culverts:			
8 - 10' x 8' x 200' x12" walls	535+00	cuyd	2,000
V-Ditch Drainage:			
Special Development at Excavation Cuts		sta	720
Riprap:			
at culverts (medium)		cuyd	1,200
at box culvert bridge (heavy)		cuyd	400
Subbase Material, 10":			
Section, 2 lane	0+00 to 801+00	cuyd	138,000
Passing lane, 12'	745+00 to 801+00	cuyd	2,500
Intersection, 2 lanes @ 1200'		cuyd	1,000
			141,000
Aggregate Base Material, 12" thickness:			
Section, 2 lane	0+00 to 801+00	cuyd	142,500
Passing lane, 12'	745+00 to 801+00	cyyd	2,500
Intersection, 2 lanes @ 1200'		cuyd	1,000
			146,000
Asphalt Concrete Pavement, 6" thickness:			
2-12' travel lanes	0+00 to 801+00	sqyd	356,000
12' passing lane	765+00 to 790+00	sqyd	7,500
Intersection		sqyd	3,500
			367,000

Item	Location	Units	Quantity
Guardrail:			
culvert crossings: 5 @ 200'		ft	1,000
box culvert bridge: 2 sides @ 1000'		ft	2,000
Guide Posts:			
spaced at 250' intervals			645
Railroad Grade Crossing:			
Covered under railroad project			
Permanent Signs:			
30 Signs,		sqft	180
steel support poles			30
Pavement Markings:			
Yellow, dashed and solid		mi	15.2
White solid		mi	30.6
Intersection, yellow		mi	0.7
Intersection, white		mi	0.6
Guard Station Facilities:			
Lighting			8
Signs			10
Guard shack			1
Other Facilities			

APPENDIX B

YUCCA MOUNTAIN PROJECT
ACCESS ROAD

ESTIMATED PROJECT COST

Item	Unit Cost	Quantity	Cost
Contractor Mobilization:		L.S.	$ 1,250,000
Clearing and Grubbing:			
100' Corridor	$15,000/ac	185 ac	2,775,000
Excavation:	$5/cuyd	130,000 cuyd	650,000
CMP Drainage Culverts:			
20 - 36" x 60	$25/ft	1,200 ft	30,000
flared end sections	$200/ea	40 ea	8,000
Poured Concrete Box Culverts:	$400/cuyd	2,000 cuyd	800,000
V-Ditch Drainage:	$25/sta.	720 sta.	18,000
Riprap:			
Medium	$25/cuyd	1200 cuyd	30,000
Heavy	$30/cuyd	400 cuyd	12,000
Subbase Material:	$8/cuyd	140,000 cuyd	1,120,000
Aggregate Base:	$10/cuyd	146,000 cuyd	1,460,000
Asphalt Cement Pavement:	$15/sqyd	367,000 sqyd	5,505,000
Guardrail:	$20/ft	3,000 ft	60,000
Guide Posts:	$25/ea	645	16,125
Railroad Grade Crossing:			
Covered under railroad project			
Permanent Signs:			
30 Signs	$30/sqft	180 sqft	5,400
steel support poles	$500 ea	30	15,000

Item	Unit Cost	Quantity	Cost
Pavement Markings:			
Yellow	$500/mi	15.3 mi	7,650
White solid	$1000/mi	30.6 mi	30,600
Intersection, yellow	$500/mi	0.7 mi	350
Intersection, white	$1000/mi	0.6 mi	600
Guard Station Facilities:			
Lighting			5,000
Signs			7,000
Guard shack			30,000
Other Facilities			25,000
Construction Water		1 ls	250,000
	Estimated Total		$ 14,110,725
	25% Contingency		3,529,275
	Subtotal		$17,640,000
	Engineering & Inspection (15%)		2,660,000
	TOTAL PROJECT ESTIMATE		$ 20,300,000

APPENDIX C

YUCCA MOUNTAIN PROJECT
ACCESS ROAD

ROADWAY STRUCTURAL SECTION

The following assumptions were made in determining the pavement structural section for the roadway.

1.	Design Life	20 Years
2.	Average Daily Traffic	2,500 Vehicles per lane
3.	Percentage of 5 axle trucks	25 %
4.	"R" Value of subgrade	25
5.	"R" Value of aggregate subbase	50
6.	"R" Value of aggregate base	78

Using the California Department of Transportation Design Method, the following analysis was made.

1. Determine the Traffic Index (T.I.)

   A) Equivalent Axle Load for Design Life
   EAL = ADT/lane * %age Trucks * EAL Constant
   EAL = 2500 * 25% * 13,780
   EAL = 8,612,500

   B) $T.I. = 9.0 * (EAL/1,000,000)^{0.119}$
   T.I. = 11.6 (approximately 11.5)

2. Determine the Asphalt Concrete Pavement Thickness

   A) G.E. = 0.0032 * T.I. * (100 - R)
   G.E. = 0.0032 * 11.5 * (100 - 78)
   G.E. = 0.8096
   In California a "Safety Factor" of 0.20' is a added to G.E.

   B) Using Caltrans Gravel Equivalent Table for T.I. = 11.5 and G.E. = 0.81, the required thickness of Asphalt Cement Pavement is equal to 0.50 feet or 6-inches.

3. Determine Aggregate Base Thickness

   A) G.E. = (0.0032) * T.I. * (100 - R) - (G.E. AC Pavement)
   G.E. = (0.0032) * (11.5) * (100 - 50) - 0.81
   G.E. = 1.84 - 0.81
   G.E. = 1.03

   B) Using the CalTrans G.E. Table for aggregate base for a T.I. = 11.5 and G.E. = 1.03, the required thickness of Aggregate Base is 0.95 feet or 12-inches.

4. Determine Aggregate Subbase thickness

A) G.E. = (0.0032) * T.I. * (100 - R) - (G.E. of overlaying material)
G.E. = (0.0032) * 11.5 * (100 - 25) - 1.84
G.E. = 2.76 - 1.84
G.E. = 0.92 less 0.02 "Safety Factor"
G.E. = 0.72

B) Using CalTrans G.E. Table for aggregate subbase material for a T.I. = 11.5 and G.E. = 0.72, the required thickness of Aggregate Subbase Material is 0.72 feet.

From this analysis, the following is the recommended structural section for the access road:

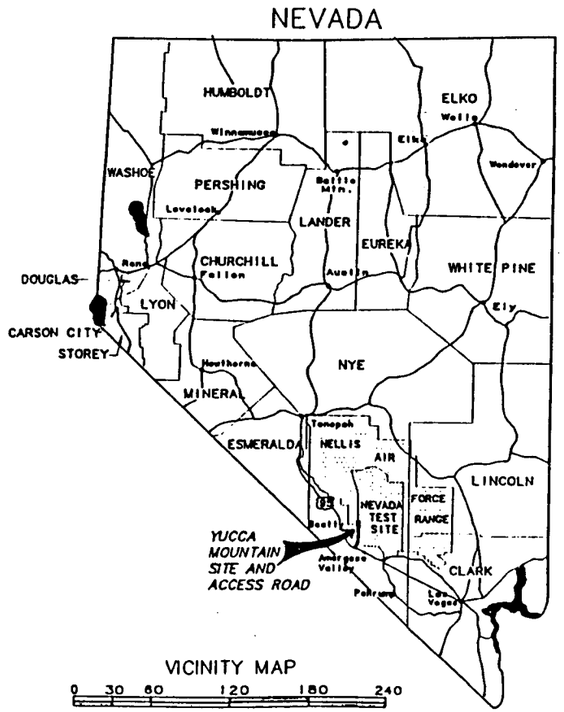
Asphalt Cement Pavement 7-inches

Aggregate Base 12-inches

Aggregate Subbase Material 9-inches

YUCCA MOUNTAIN
RAIL ACCESS DEVELOPMENT PROJECT
-ACCESS ROAD-

CONCEPTUAL DESIGN
PLANS, PROFILES & DETAILS



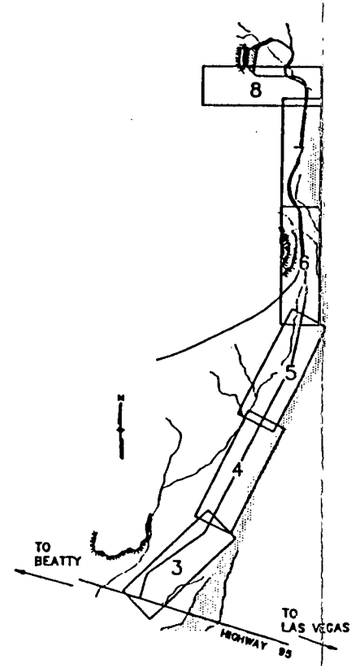
VICINITY MAP

0 30 60 120 180 240

SCALE: 1" = APPROX. 60 MILES

LIST OF DRAWINGS

SHEET NO.	DRAWING TITLE
1	TITLE SHEET
2	DETAIL SHEET
3	ACCESS ROAD PLAN & PROFILE STA 0+00–140+00
4	" " STA 140+00–280+00
5	" " STA 280+00–420+00
6	" " STA 420+00–560+00
7	" " STA 560+00–700+00
8	" " STA 700+00–FACILITY



KEY MAP

NOT TO SCALE

REDUCED 50%

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE

TITLE SHEET

prepared for: Science Applications International Corporation, Las Vegas, Nevada

SCALE: AS NOTED

DeLEUW CATHER & COMPANY
Engineers & Planners San Francisco, CA

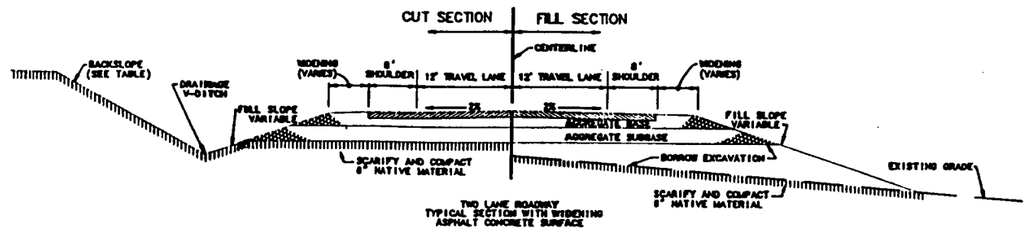
DATE

Kennedy/Jenks/Chilton
Consulting Engineers Reno, NV

SHEET NO. 1 of 8

DESIGNED ____ CHECKED ____
DRAWN RAH APPROVED ____

REV	DESCRIPTION	DATE	BY



CUTBANK SLOPES

DEPTH OF CUT	BACKSLOPE RATIO
0–4'	6:1
4'–15'	4:1
15'+	2:1

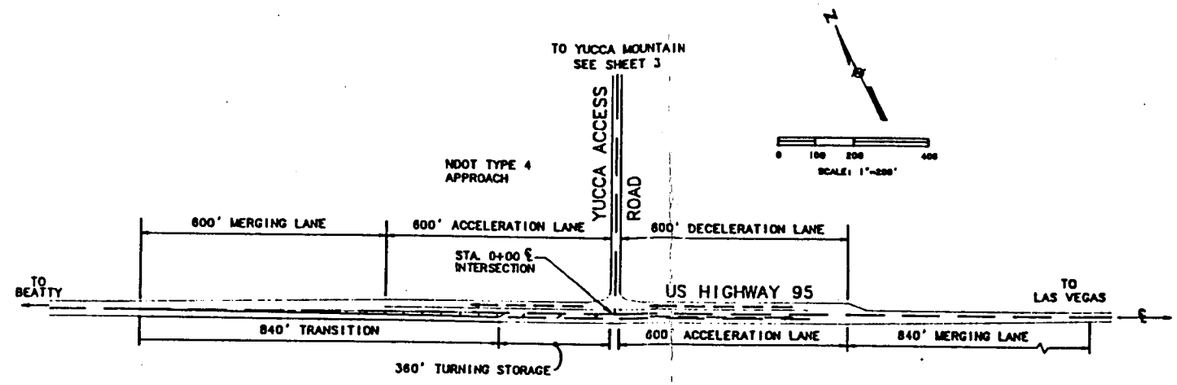
FILL SLOPES

HEIGHT	FILL SLOPE RATIO	WIDENING
0'–5'	10:1	0
5'–10'	6:1	0
10'–15'	4:1	0
15'–20'	3:1	5'
20'+	2:1	5'

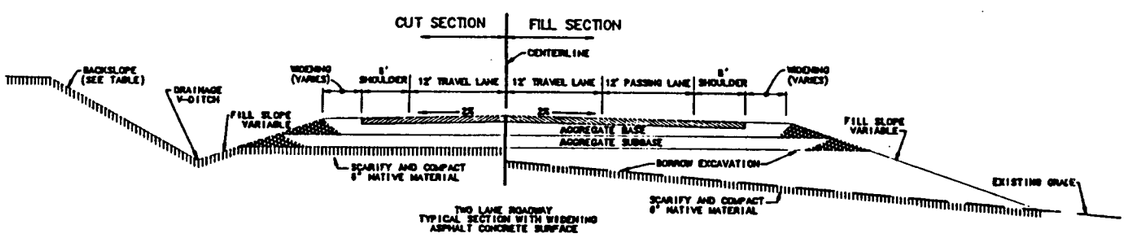
TYPICAL ROADWAY SECTION

NOT TO SCALE

STA. 0+00 TO 745+00



INTERSECTION DETAIL



CUTBANK SLOPES

DEPTH OF CUT	BACKSLOPE RATIO
0–4'	6:1
4'–15'	4:1
15'+	2:1

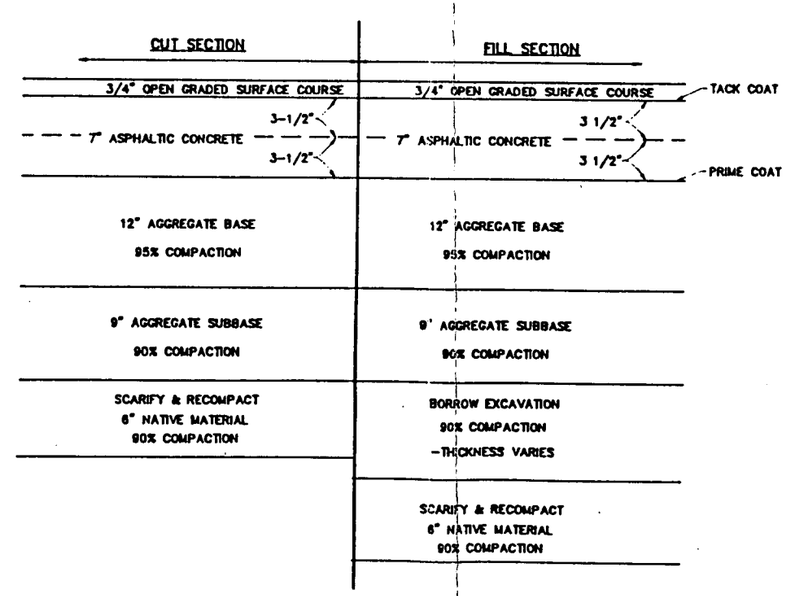
FILL SLOPES

HEIGHT	FILL SLOPE RATIO	WIDENING
0'–5'	10:1	0
5'–10'	6:1	0
10'–15'	4:1	0
15'–20'	3:1	5'
20'+	2:1	5'

TYPICAL ROADWAY SECTION W/PASSING LANE

NOT TO SCALE

STA. 745+00 TO 799+73±



TYPICAL PAVEMENT SECTIONS

NOT TO SCALE

LIST OF ABBREVIATIONS

EL	ELEVATION
GB	GRADE BREAK
NDOT	NEVADA DEPARTMENT OF TRANSPORTATION
PC	POINT OF CURVATURE
PT	POINT OF TANGENCY
PVI	POINT OF VERTICAL INTERSECTION
RCB	REINFORCED CONCRETE BOX
STA	STATION
W/	WITH

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YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE

DETAIL SHEET

prepared for: Science Applications International Corporation, Las Vegas, Nevada

SCALE: AS NOTED

DATE

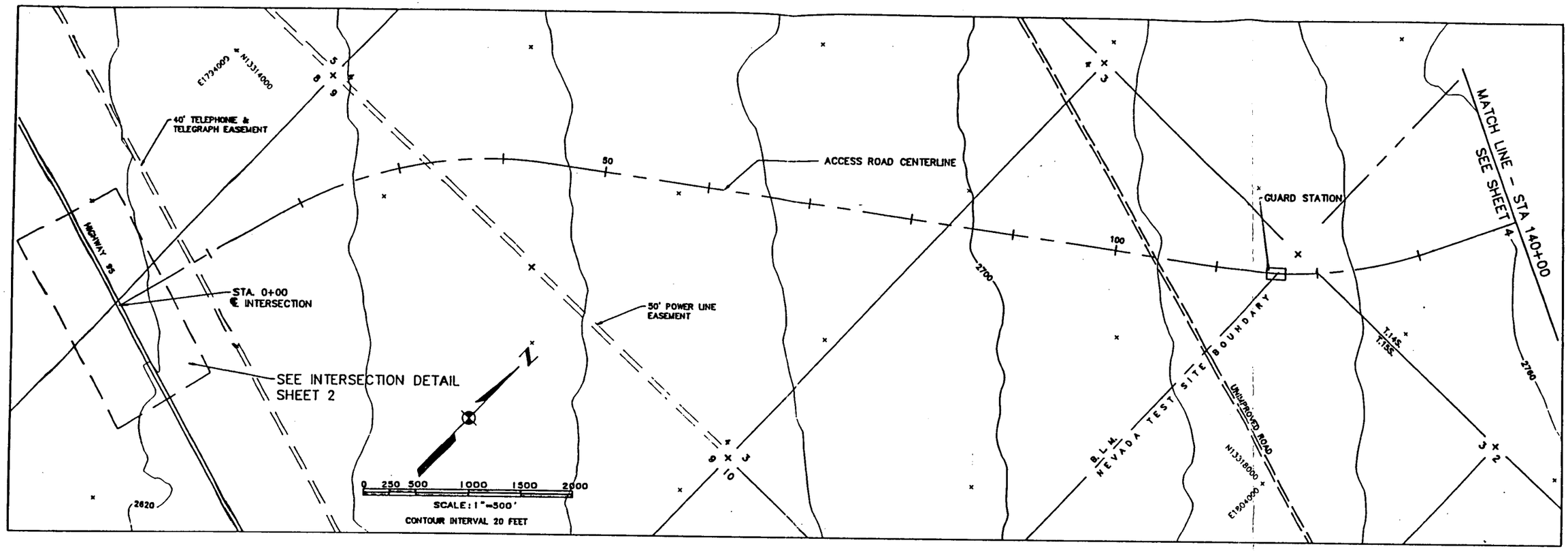
DeLEUW CATHER & COMPANY
Engineers & Planners San Francisco, CA

Kennedy/Jenks/Chilton
Consulting Engineers Reno, NV

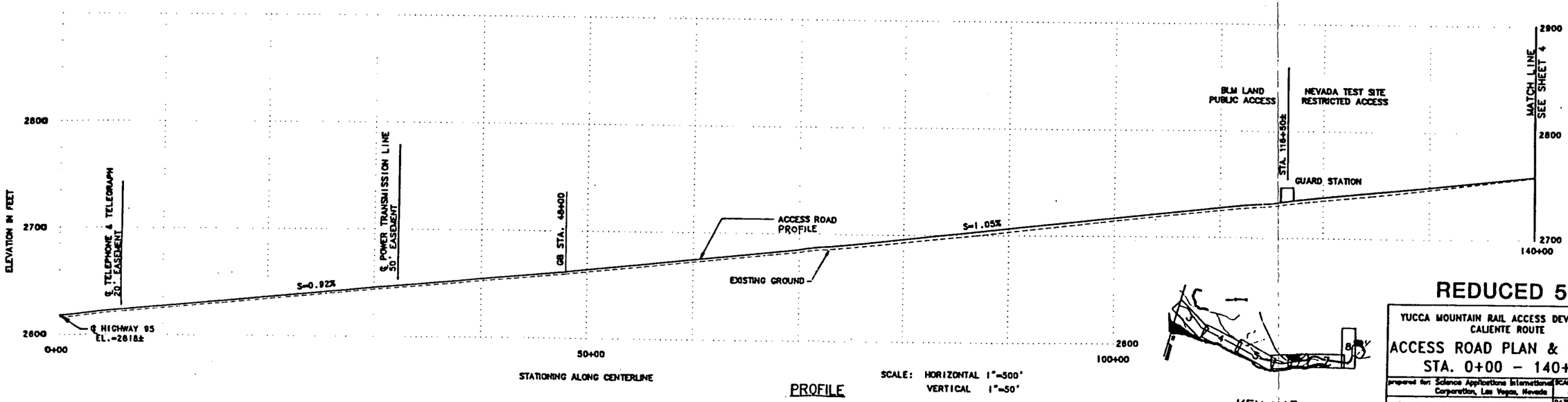
SHEET NO. 2 OF 8

DESIGNED ____ CHECKED ____
DRAWN RAH APPROVED ____

REV	DESCRIPTION	DATE	BY



PLAN



PROFILE

SCALE: HORIZONTAL 1"=500'
VERTICAL 1"=50'

KEY MAP

REDUCED 50%

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE

ACCESS ROAD PLAN & PROFILE
STA. 0+00 - 140+00

prepared for: Science Applications International Corporation, Las Vegas, Nevada

SCALE: AS NOTED

DeLEUW CATHER & COMPANY
Engineers & Planners San Francisco, CA

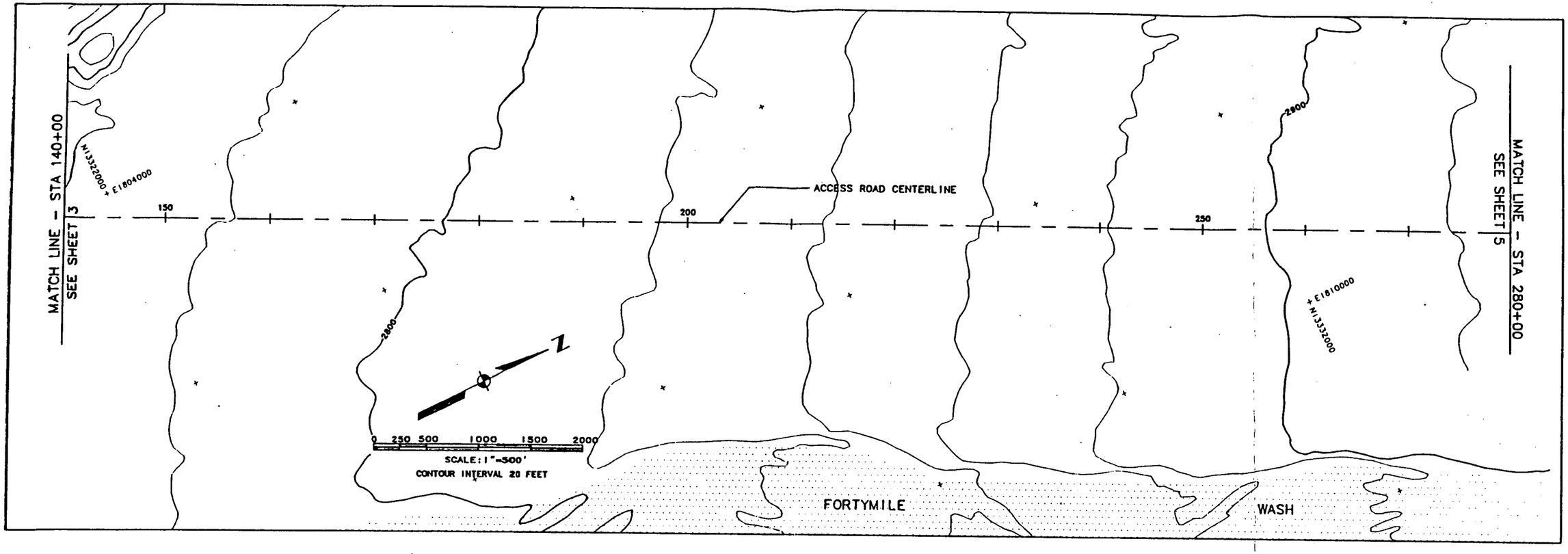
DATE

Kennedy/Jenks/Chilton
Consulting Engineers Reno, NV

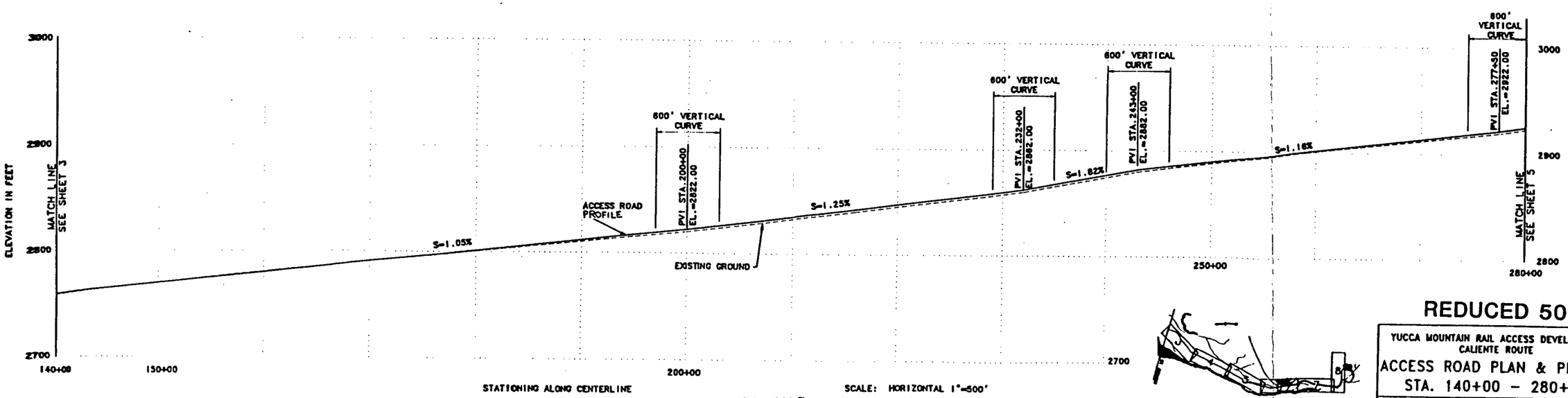
SHEET NO. 3 OF 8

DESIGNED ____ CHECKED ____
DRAWN RAH APPROVED ____

REV	DESCRIPTION	DATE	BY



PLAN



PROFILE

SCALE: HORIZONTAL 1"=500'
VERTICAL 1"=50'

KEY MAP

REDUCED 50%

REV	DESCRIPTION	DATE	BY

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE

ACCESS ROAD PLAN & PROFILE
STA. 140+00 - 280+00

prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW CATHER & COMPANY
Engineers & Planners San Francisco, CA

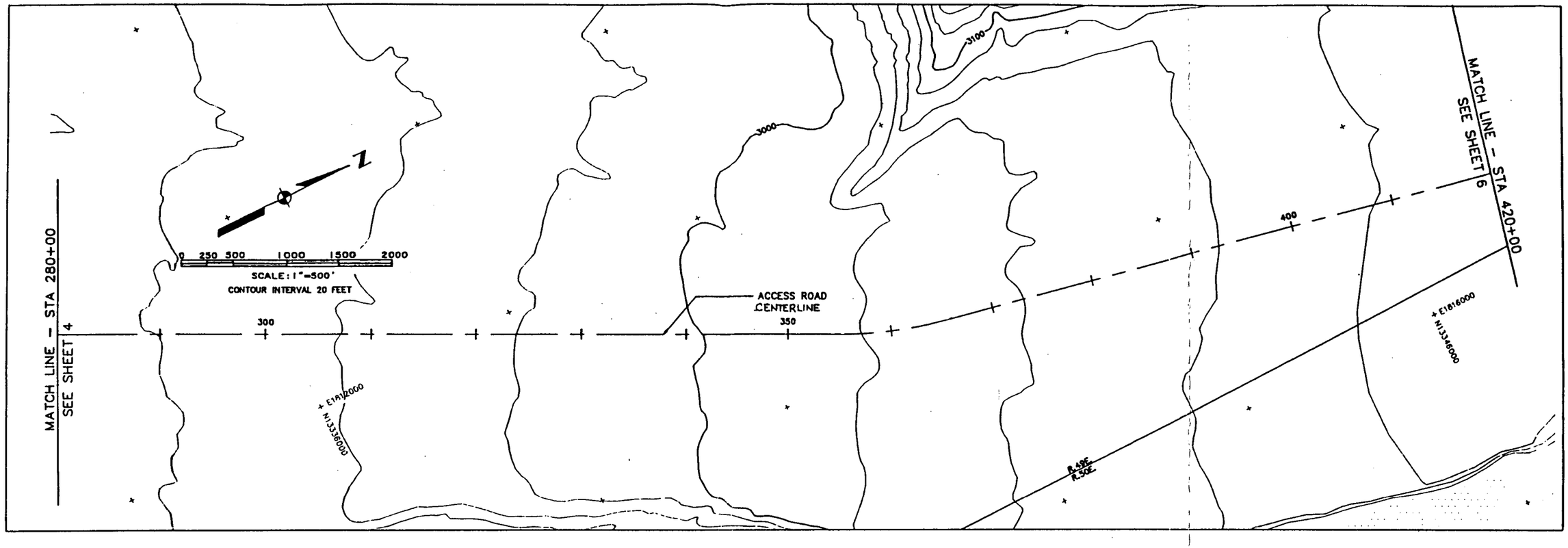
Kennedy/Jenks/Chilton
Consulting Engineers Reno, NV

SCALE: AS NOTED

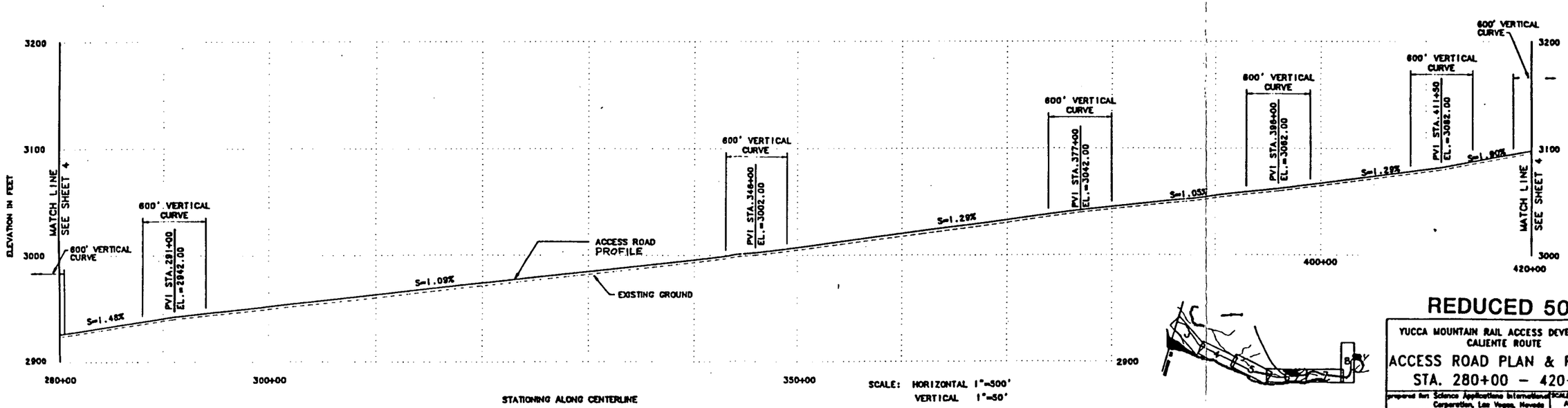
DATE

SHEET NO. 4 of 8

DESIGNED ____ CHECKED ____
DRAWN RAH APPROVED ____



PLAN



PROFILE

KEY MAP

REDUCED 50%

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE

ACCESS ROAD PLAN & PROFILE
STA. 280+00 – 420+00

prepared for: Science Applications International Corporation, Las Vegas, Nevada

SCALE: AS NOTED

DeLEUW CATHER & COMPANY
Engineers & Planners San Francisco, CA

DATE

Kennedy/Jenks/Chilton
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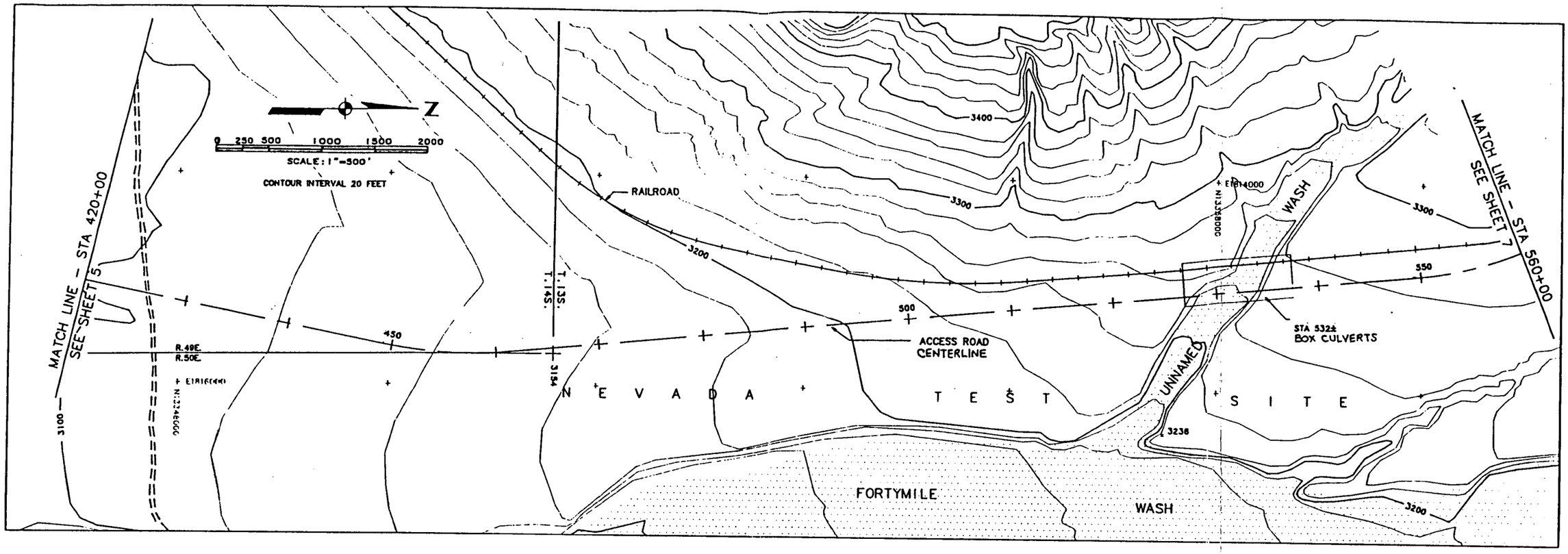
SHEET NO. 5 OF 8

DESIGNED ____ CHECKED ____
DRAWN RAH APPROVED ____

REV	DESCRIPTION	DATE	BY

K/J/C JOB# 897045.01

Project No. P04353



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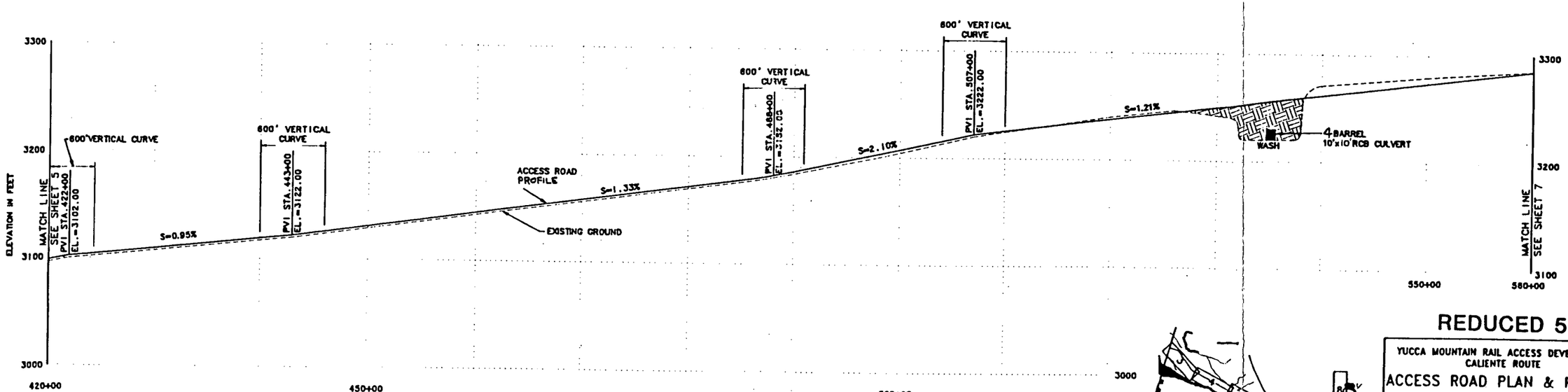
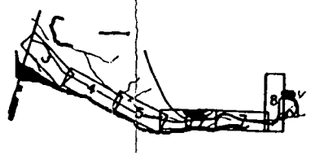


PROFILE

SCALE: HORIZONTAL 1"=500'
VERTICAL 1"=50'



KEY MAP

REDUCED 50%

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE

ACCESS ROAD PLAN & PROFILE
STA. 420+00 – 560+00

prepared for: Science Applications International Corporation, Las Vegas, Nevada

SCALE: AS NOTED

DeLEUW CATHER & COMPANY
Engineers & Planners San Francisco, CA

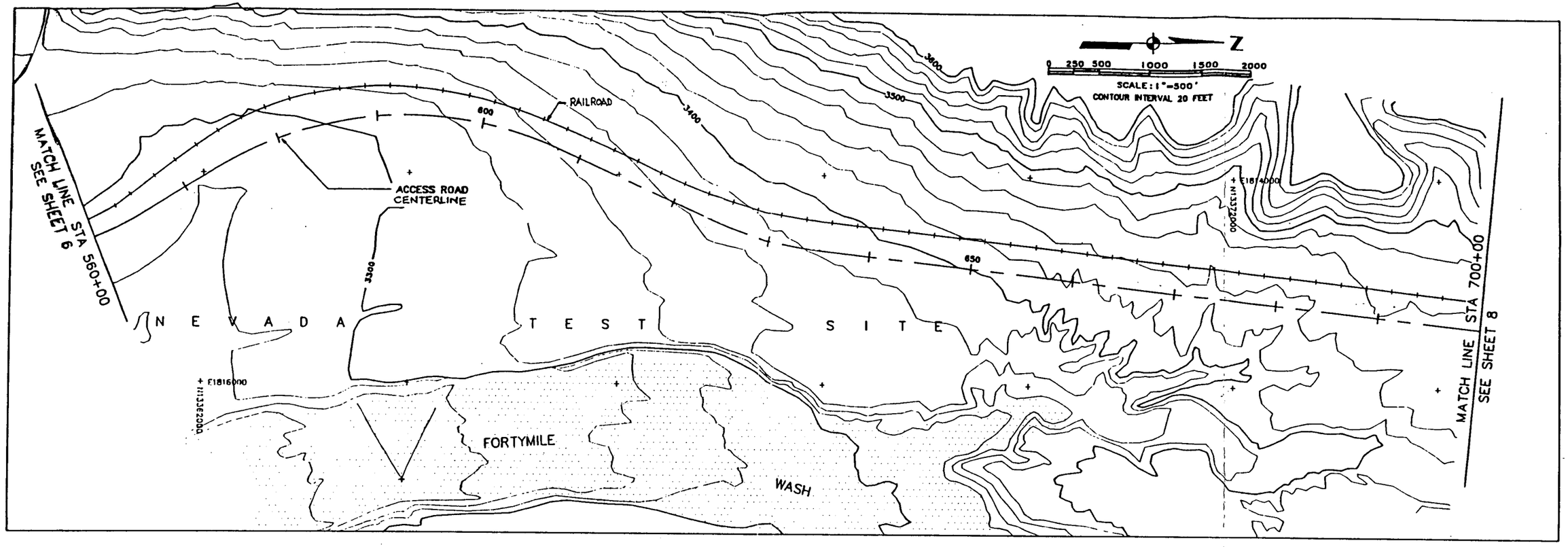
DATE

Kennedy/Jenks/Chilton
Consulting Engineers Reno, NV

SHEET NO. 6 OF 8

DESIGNED ____ CHECKED ____
DRAWN RAH APPROVED ____

REV	DESCRIPTION	DATE	BY



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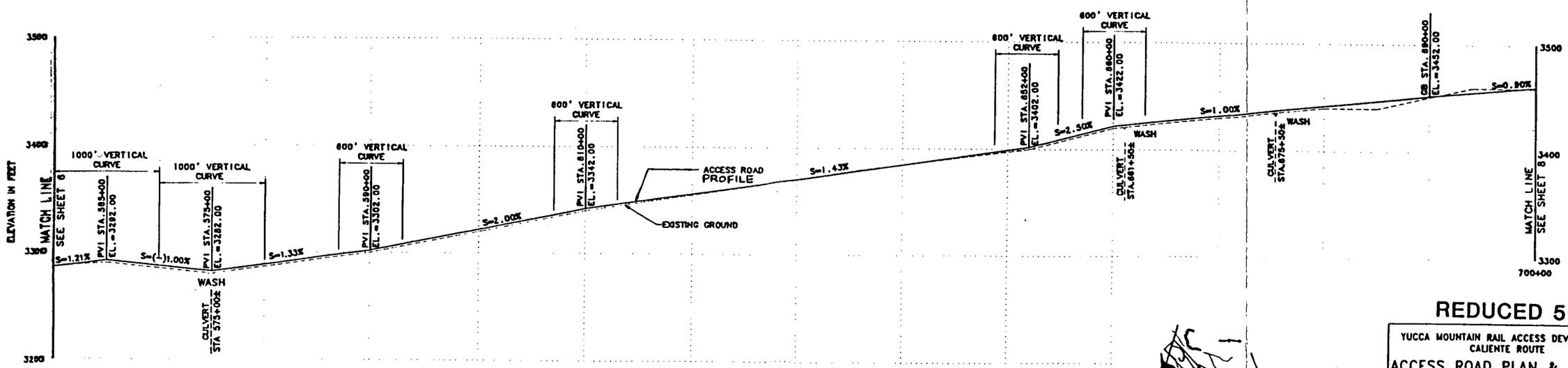
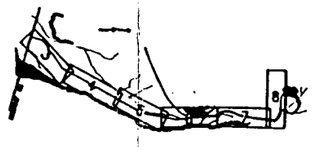


PROFILE

STATIONING ALONG CENTERLINE

SCALE: HORIZONTAL 1"=500'
VERTICAL 1"=50'



KEY MAP

REDUCED 50%

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE

ACCESS ROAD PLAN & PROFILE
STA. 560+00 – 700+00

prepared for: Science Applications International Corporation, Las Vegas, Nevada

SCALE: AS NOTED

DATE

DeLEUW CATHER & COMPANY
Engineers & Planners San Francisco, CA

Kennedy/Jenks/Chilton
Consulting Engineers Reno, NV

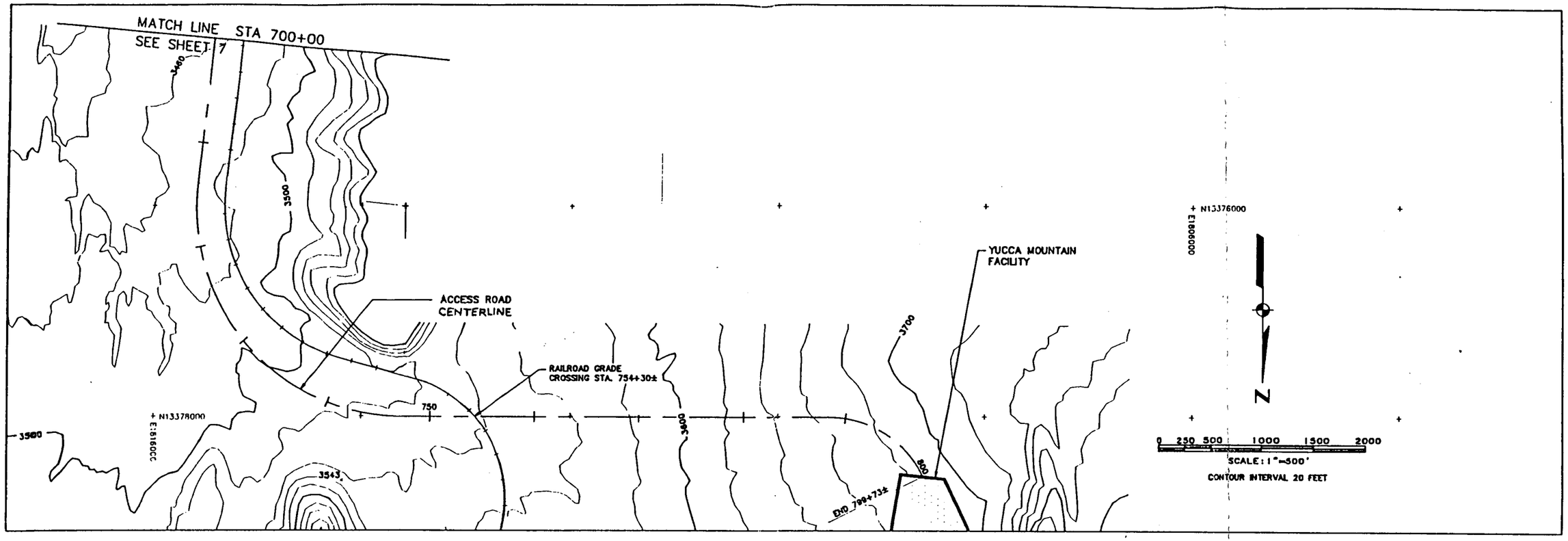
SHEET NO. 7 OF 8

DESIGNED ____ CHECKED ____
DRAWN RAH APPROVED ____

REV	DESCRIPTION	DATE	BY

W/J/C JOB # 897045.01

Project No. P04193



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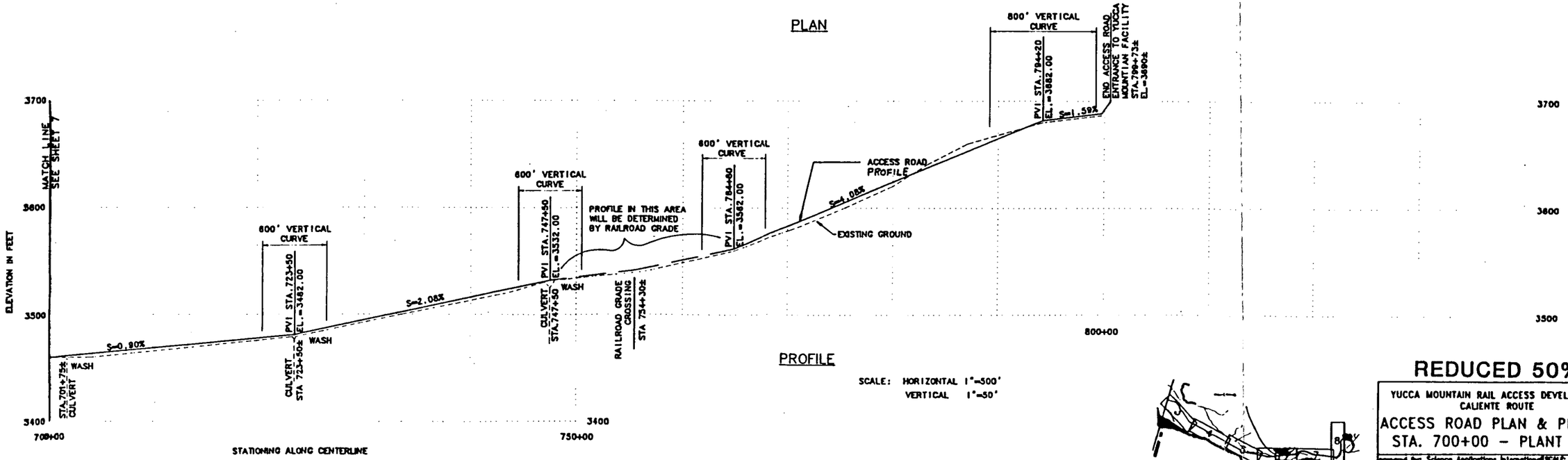

PROFILE

SCALE: HORIZONTAL 1"=500'
VERTICAL 1"=50'

KEY MAP

REDUCED 50%

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE

ACCESS ROAD PLAN & PROFILE
STA. 700+00 – PLANT SITE

prepared for: Science Applications International Corporation, Las Vegas, Nevada

SCALE: AS NOTED

DeLEUW CATHER & COMPANY
Engineers & Planners San Francisco, CA

DATE

Kennedy/Jenks/Chilton
Consulting Engineers Reno, NV

SHEET NO. 8 OF 8

DESIGNED ____ CHECKED ____
DRAWN ____ RAH ____ APPROVED ____

REV	DESCRIPTION	DATE	BY

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

LAS VEGAS, NEVADA

YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE

CONCEPTUAL DESIGN REPORT

APPENDICES F & G

De Leuw, Cather & Company
Subcontract Agreement No. 14-900078-12

120 Howard Street
San Francisco, CA 94105

1 June 1991

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

LAS VEGAS, NEVADA

YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE

CONCEPTUAL DESIGN REPORT

APPENDIX F
ENVIRONMENTAL REPORTS, VOLUME 3
ECOLOGY

De Leuw, Cather & Company
Subcontract Agreement No. 14-900078-12

120 Howard Street
San Francisco, CA 94105

1 March 1991

FACSIMILE TRANSMITTAL FORM

Archaeological Research Services, Inc.
P.O. Box 701
287 S. "D" St.
Virginia City, Nevada 89440

Telephone: 702/847-0615
FAX: 702/847-0616

DATE: 29MAY91
TIME: 9:15 AM

The following pages are being sent to the attention of: PAUL STANDISH
Company/Agency: WESTINGHOUSE ELECTRIC CORP/NUCLEAR WASTE DEPARTMENT
FAX Number: 1/794-7008 OR -7009
Total number of pages transmitted (including this cover): 10

Paul: In response to your call yesterday concerning what portions of the cultural resources report on the Caliente Alternate/Yucca Mountain Rail Access Project should not be released to the public, I am sending the attached pages of report text (pages 26, 27, 39-42 inclusive, 58, 61 and the single page of Table 6). I have used a heavy marker to line out those portions of discussion I wish withheld and will be forwarding a set to you in hard copy (Westinghouse Electric Corporation, Nuclear Waste Department, Valley Bank Center, 101 Convention Center Drive, Las Vegas, NV 89109). In addition, but not included here by way of copies, please do not distribute: a) the page of Appendix B which gives township, range and section of previously recorded archaeological sites, b) IMACS site forms (however, you shouldn't have received copies of these anyway, although summary site descriptions are included in the report), c) Figures 207-210 in the report text, which concern ethnographic site areas.

If you have any questions, please give me a call. Also, if the hard copy should go to some other address, please let me know. Thanks.

Sent by: Tom Burke Tom Burke

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
RECORD PROBLEM REPORT

QA: N/A

RPR #: _____

1. Problem Description

Pages obliterated due to binding. No better copy available.

Document contains ~~Obter~~ obliterations 7/9/01 MAM

2. Initiated By

Name	Org.	Telephone	Date
Melissa A. McGuire	Env. Compliance	295-0319	07/09/01

3. Concur

BSC Manager, RM & DC, or Designee _____ Date _____

4. Initiate AP-16.Q? ☐ Yes ☐ No Initials of Records Manager: _____

5. Actions Taken to Review and Resolve Problem:

6. Actions Completed:

BSC Manager, RM & DC, or Designee: _____ Sign _____ Print _____ Date

For consideration of potential impacts, the one site listed on the NRHP (26Ln1508, the Caliente Train Station), as well as those recommended eligible, those for which evaluation is recommended, and those of unknown or unevaluated status should be considered sensitive pending accumulation of more information. Other than the Caliente Train Station, which is on Route B, the greatest proportion of sensitive sites is on Route I, followed by Route A. Routes B and D have moderate proportions of sensitive sites, while only two are found on Route F.

Four sites included in Table 5 have been the object of archaeological data recovery studies at Yucca Mountain (Reno et al. 1989). These include 26Ny2970, -2993, -3039 and -3116. The data recovery efforts were designed to mitigate adverse effects resulting from direct impacts (Reno et al. 1989:209). Accordingly, it is assumed that the archaeological information potential of these sites has been mitigated adequately such that no further work would be necessary should they be affected as a result of selection of the Caliente Alternate for the rail transportation system. Further, it is possible that the research value of the sites has been destroyed since the data recovery program was completed. However, if these sites were to be affected by selection of the Caliente Alternate, it is recommended that the DoE and the Nevada State Historic Preservation Officer consult to determine whether any of these four sites retain sufficient integrity and additional research potential to merit more investigation.

Another five sites in the Yucca Mountain area have been tested (Pippin 1984), including 26Ny2960, -3037, -3050, -3051 and -3127. Each is recommended as having further research potential which should be mitigated if impacts are anticipated.

Potentially Sensitive Areas Along the Caliente Alternate Based on Previously Recorded Cultural Resources

For this analysis, locations of previously recorded cultural resources have been examined with regard primarily to density. That is, in the following discussion, "sensitive" relates to the likelihood that known cultural resources would be affected given their abundance within the corridor. This analysis is largely subjective and does not include consideration of NRHP status. To some degree, these results may also be taken as a measure of where new cultural resources are most likely to be encountered along the various routes, based on a non-systematic sample deriving from various development-driven inventories as well as random recordation.

Several areas along Route A contain abundant sites, or sites which cannot apparently be avoided within the study corridor, including 26Ln259 [redacted] Multiple sites are found in the [redacted] area, while fewer are found further north near [redacted]. The Pahranagat Valley is likely to contain numerous resources whichever alternative is chosen.

On Route B, the abandoned segment of the Union Pacific Railroad (26Ln3670) is considered sensitive.

Route D contains numerous sites on the [redacted] as well as in the [redacted] area. As discussed elsewhere in this report, a sensitive site was visited at [redacted] along this route.

Another railroad berm (26Ny1581) is situated close to the centerline of Route F on the USGS Stonewall Pass quadrangle and is considered sensitive. In addition, a new archaeological site with prehistoric and historic components was observed [redacted] which is within the study area. The location has been reported to DCCO to avoid impacts if possible.

The terminus of Route I within the Nevada Test Site contains multiple sites on the USGS Busted Butte quadrangle. Other areas of high site density are found on the [redacted] quadrangles.

PREVIOUS CULTURAL RESOURCES REPORTS OF INVESTIGATIONS IN THE CALIENTE ALTERNATE STUDY AREA

Very little of the Caliente Alternate study corridors has been covered by previous cultural resources inventories. That is, despite more than 100 reports of prior investigations, an estimated maximum of 1% of the study area has actually been examined systematically. The only extensive block area survey encompassing a portion of the alignment (specifically Route I) is at the line's terminus within the Nevada Test Site.

Otherwise, surveyed areas comprise linear segments and small, scattered blocks. The former include a number of intensive inventories by the Nevada Department of Transportation (NDOT) which are of value for the information they provide about potentially sensitive areas which often are in close proximity to the Caliente Alternate centerline. This is especially true where the railroad alternate closely parallels existing highways [redacted]

These results have one major implication for the Caliente Alternate, should it be selected. Namely, very little, if any, of the potential alignment could be excluded from intensive examination prior to development. However, there are extensive segments (particularly along Route A) where, if arrangements for right-of-way use could be established with NDOT, the railroad could be constructed within a previously inventoried area. Pending agreement between the DoE and the Nevada SHPO, these areas might not require re-examination. Further, the use of previously inventoried corridors would at the outset be expected to establish some measure of impact to sites recommended NRHP eligible or having an uncertain status, compared with results of an entirely new inventory elsewhere which would be expected to also result in identification of potentially sensitive sites but at a later stage in project planning.

in the area, on the assumption that a permanent water source would have been a critical limiting factor to human habitation and given the ethnographers' descriptions that camps were situated in proximity to these sources.

- Site 601-1 is [redacted] near Route F. A previously unrecorded, moderately large archaeological site (estimated at 200 x 200 m) with prehistoric and historic components, as well as modern ranching features, was observed. Prehistoric artifact categories included obsidian and chert bifaces (but no temporal diagnostics), flake tools, and ground stone (including one example of a possible hopper mortar). In addition, apparent near-surface hearths or midden were observed eroding in various places on the site, particularly on the bluff overlooking the spring proper Historic artifacts and features include a corral, a modified spring [i.e., water source], barrel hoops, cast iron stove parts, hole-in-cap cans with crimped side seams, modern sanitary cans, earthenware ceramics and otherwise non-diagnostic glass bottle sherds in a variety of colors (purple, aqua, brown, white). In addition, the area includes an occasional rock cairn or rock alignment of unknown affiliation. Integrity appears good, having been affected by cattle grazing and erosion. However, the potential for subsurface deposits to a depth of 25+ cm below surface appears demonstrated based on examination of erosional profiles. The site definitely merits further examination and archaeological testing; for the present the site should be considered very sensitive and likely NRHP eligible. An ethnohistoric association may be demonstrated by the historic artifacts present.

- Site 601-5 is [redacted], situated on Route D; the site has not been recorded formally but is relatively well known from historical records (Paher 1970). A number of historic features, including remains of the mill, a pond, an apparently recent tarpaper and wood line shack, a concrete pad, remains of a possible post/rail/mud house (cf. Graham and Owen 1988, photograph in lower right hand corner, p. 21), a rock-lined dugout, wire fence corral, and a large (approximately 80 x 100 ft x 5-7 ft high) and very well made rock corral. In addition, historic and modern artifacts were abundant, especially near the mill remains and the mud house. However, no evidence of prehistoric activity was observed. Thus, it is unlikely that prehistoric to historic occupational continuity by Native Americans is represented by the archaeological remains at this site. However, Native Americans may have occupied or worked at the site during the historic period, although their ethnic presence was not established during the inspection. It was considered likely that any evidence of prehistoric occupation would have been further west near an apparent spring visible from the mill site. Integrity appears good to excellent overall, and the site is likely eligible for the NRHP. Mr. Richard Sykes, DGCO, has indicated that steps will be taken to avoid the [redacted] during planning stages for the Caliente Alternate.

- Site 601-6, a previously recorded site (26Ln201), is [redacted] on Route A. A prehistoric component was observed north of the spring proper and [redacted] including quartzite, obsidian and chert debitage (sparse), and a shaped sandstone mano. These were found in an area that appears disturbed by modern heavy equipment blading. A heavily overgrown area immediately around the spring was also inspected but with negative results. Additional inspection in areas where the site has been described previously was

precluded by the presence of posted signs restricting access; efforts to locate individuals on site who would permit access were unsuccessful, so no further attempts were made to examine the site, in accordance with policies established for field visits associated with the Caliente Alternate study. In summary, integrity cannot be evaluated except for the small area north of the spring. However, and for a variety of reasons including Native American concerns (discussed elsewhere in this report) and the potential for both significant historic and prehistoric archaeological remains, the site area should be treated as sensitive and likely eligible for the NRHP.

- Site 601-9 is [redacted] situated on the now-abandoned Route C of the Caliente Alternate. A moderate sized pond was seen, as were nearby corrals. A marker on the site records several historical events associated with the spring, [redacted] Very little was found in the way of archaeological remains, and nothing was noted which can be taken to confirm any sort of ethnographic Native American presence. A very limited amount of historic period artifacts (e.g., purple glass, earthenware ceramics) was seen. Prehistoric artifacts were not much more abundant, comprising a single Fremont, plain greyware sherd, a basalt core and three pieces of debitage, including chert and obsidian. It is considered highly likely that recent alluvial deposition has covered artifacts in the area. While integrity cannot be assessed, the area should be considered sensitive should development be proposed there. Additional investigations should incorporate subsurface testing to determine the nature, extent and significance of the site.

- Site 601-17 [redacted] is an extremely large, previously unrecorded prehistoric site situated near abundant springs in [redacted] Valley (Route I). Lithic debitage comprised mostly chert (approximately 95%) with some obsidian and was very dense in plates, up to an estimated 100+ pieces per square meter. Much of the artifactual remains was observed in low, sandy dune areas which have been deflated. Biface fragments and ground stone tools were also seen. [redacted], a large area of private land was examined. There is definitely the potential that historic Native Americans lived in the area given the presence of the prehistoric remains. While integrity has been diminished in some places by deflation, the scientific information potential appears high, and the area should be considered NRHP-eligible pending further examination. While the examined parcel is just on the western edge of the Route I corridor, it is environmentally very similar to other nearby parts of [redacted] Valley which are included in the Caliente Alternate. Thus, similar kinds of sites with similar potential for significance may be anticipated in this area of the Caliente Alternate.

PREVIOUSLY RECORDED ARCHAEOLOGICAL SITES

- Site 601-2 (26Ny1625) is located [redacted] near Route D. A very sparse flaked stone scatter was observed including a core, two biface fragments and debitage of chert and chalcedony. Also noted were a wire-pail paint can as well as a plywood construct which may have been part of an airplane structure, the latter perhaps associated with the activity of the Tonopah airfield during

World War II. Site boundaries were not determined, but extend for an estimated minimum of 200-400 ft. Integrity appears to be very good, although the sandy substrate in the area makes this somewhat speculative. Status with regard to the NRHP remains "unknown."

- Site 601-3 (26Ny251) is a complex of rockshelters near Route D, one of which has been partially excavated with important regional results (Self 1980). In addition, the alluvial apron east of the shelter, [redacted] contains an extensive prehistoric artifact scatter (ground stone, abundant debitage, Numic pottery) as well as an historic component (hole-in-cap cans, modified tin can, purple and other bottle glass sherds) estimated to date to the late nineteenth and early twentieth centuries. The remnant of the excavation trench from the 1970s was still visible at the rockshelter, although it was apparent that the area of those excavations has also been subjected to subsequent illicit excavation by artifact seekers. An estimated 75% of fill situated within 10 ft of the back wall of Lowe Shelter proper has been disturbed, although the adjoining apron area to the east appeared undisturbed. At least two shelter areas further south had artifacts observable at the surface (e.g., whole metates, debitage) but had no apparent evidence of disturbance other than cattle tracks and manure. The site complex should be considered NRHP eligible and sensitive for both its scientific information potential as well as Native American concerns.

- Site 601-4 (26Ny816) is a sparse but extensive flaked stone scatter [redacted] near Route D. Flakes of chert, chalcedony and obsidian were observed in the area of coppice dunes and a pebble pavement. However, all inspected specimens were extremely worn from either wind-blown sand or water. Thus, it appears the area retains little integrity due to erosion. Further, artifactual analysis might be meaningless or nearly so given weathering on the specimens. Based on these observations, the site is not likely to be NRHP eligible unless much better preserved portions of the site are identified.

- Site 601-7 includes two previously recorded sites--26Ln202 and 26Ln1567. These sites are found in the area [redacted] near Route A. Artifacts vary in density from extremely sparse to dense and comprise primarily debitage (quartzite, chert, obsidian, rhyolite or similar igneous), some bifaces, a probable Elko projectile point fragment, and limited ground stone. In addition, remnants of a railroad berm were observed on the north end of the site area. Examination was limited to areas between existing highways and barbed wire fences. Thus, site boundaries were not determined, but may extend to the White River. The variable surface artifact density may reflect erosion, deposition, or prehistoric activity areas. In general, artifact density increased with proximity to the river and [redacted]. That area may be most sensitive and is most likely to be NRHP eligible.

- Site 601-8 (26Ln3670) is the now-abandoned bed of the Union Pacific Railroad [redacted] on Route B. The feature was observed only from the nearby highway. However, such features retain the potential for associated work camps. This potential, in addition to possible important associations with themes of transportation, settlement and urbanization in the area, make the site sensitive. Integrity appeared excellent except for the

removal of the railroad iron. The site should be considered NRHP eligible, as recorded on the site record form.

- Site 601-10 is a previously unrecorded rockshelter with Fremont ceramics, ground stone and debitage (obsidian, chert). The site was observed and inspected in an unsuccessful attempt to find the previously recorded site 26Ln1531. About 20 sherds were exposed at surface as a result of amateur excavation in the rockshelter; however, an estimated 50-75% of the rockshelter interior remains undisturbed as does the adjoining apron and area of the surface scatter. The ceramics were grey in color, although two with a brown exterior were noted; all were undecorated. One rim sherd was identified. Charcoal was observed within the exposed fill, suggesting the possibility that chronometric or subsistence data may be preserved. The site is outside the Caliente Alternate study area [redacted]. However, it may be significant and NRHP eligible.

- Site 601-11 (26Ln259) is situated [redacted] within the Route A corridor. Both sides of US 93 were examined. Artifacts were observed on each side but comprised debitage only, in obsidian and chert raw materials. Artifacts were extremely sparse virtually everywhere, although density increased in areas closer to the summit. In addition, debitage density increased slightly in the vicinity of four large boulders on the north side of the highway, suggesting possible use of these as rockshelters for temporary occupation. An historic-age hole-in-cap can was also seen. The paucity of artifacts at surface may indicate little research potential. Integrity appears very good; the site should be considered unevaluated for the NRHP.

- Site 601-12 (26Ln3036) is an isolated rock art feature consisting of a curvilinear petroglyph on a single boulder. No artifacts were observed in association. The site is considered sensitive because of Native American concerns. Previous description may have reasonably exhausted its scientific research potential, so it may not be NRHP eligible under criterion d. The site is near Route A.

- Site 601-13 (26Ln660) is one of three sites on Route A [redacted], two of which are situated in proximity to SR 375. The site was much larger than suggested by the site form map, measuring at least 600 ft on both the east-west and north-west axes; however, boundaries were undetermined. Artifact density was low. Integrity appears good, although deflation was apparent in dune areas. The site would require further evaluation to make a determination of NRHP eligibility.

- Site 601-14 (26Ln711b), located [redacted] on Route A, was represented by fairly dense debitage in places, although density was highly variable in this area of sand and dunes. Only obsidian raw material was observed. Examination was limited by the onset of rainy weather. Boundaries are undetermined. Integrity appears good, having been affected by limited road traffic and probably erosion. The site has previously been recommended NRHP eligible, an opinion which should stand pending further investigation.

- Site 601-15 (26Ln658), also [redacted] on Route A, comprised a moderately dense scatter of primarily obsidian debitage, although

largely in the winter, in the case of the Western Shoshone, and more-or-less year round, in the case of those Southern Paiute camps with gardens. In addition general locations are known for certain key economic activities, such as large and small game hunting or gathering of key plant foods. Some locations of important mythic places are known for both ethnic groups, but only two such are known for the territories of the subgroups who lived in the area crossed by rail alternatives. Six ethnographically documented sites are actually located within study areas for the rail alternatives (Table 6).

Two Southern Paiute sites are located on rail alternatives. These are a Panaca camp and garden site at [redacted] and a large Paranagat camp and garden site at [redacted]. This is also an important location in the local version of the Southern Paiute origin myth (cf., Miller 1983a; Laird 1976). [redacted] is where Coyote opened his basket, allowing people to emerge to settle the Southern Paiute homeland. A hill nearby is reported by one of Isabel Kelly's Paranagat consultants to be Coyote's Jug (the water jug or basket he dropped at that time).

Four Western Shoshone sites are located on rail alternatives. These are two Kawich camp sites, one a winter camp [redacted] (Steward 1938:Figure 8, No. 44). The other is a camp [redacted] on the east side of the Kawich Range (Steward 1938:Figure 8, No. 47). The latter may have been occupied during the operation of that mill, but this is not specified by Steward. The other two Western Shoshone sites on rail alternatives are a camp located [redacted] (Steward 1938:Figure 7, No. 34) in the territory of the Lida subgroup, and a winter camp [redacted] (Steward 1938:Figure 7, No. 49). During the post-contact period a large garden was maintained at this site providing a share of the annual subsistence and requiring more-or-less year round occupation of the site (Rusco 1986-1988; Hamby 1986-1988).

The Class I Cultural Resource Inventory

The Class I cultural resource inventory prepared by ARS on the basis of existing information in the literature and archaeological site record repositories includes a total of 109 cultural resource properties in the project area. Of these archaeological sites, 102 (94 percent) have prehistoric and/or post-contact Native American components, representing occupation and/or other activities of the ancestors and/or predecessors of the Western Shoshone and Southern Paiute subgroups listed above. The rest of the inventory consists of historical properties apparently representing only non-Indian occupation or use.

Past experience with Native American consultation on archaeological projects has shown that many Western Shoshone and Southern Paiute people, particularly those who are most interested in their cultural and religious traditions, are interested in all prehistoric sites (Rusco 1986-1988). Some,

Table 6. Ethnographically Reported Sites Located on or Within Three Kilometers of Proposed Rail Alternative.

Subgroup Site No.	Site Description	General Location (township, range)	AMS Map (1:250,000)	Nearby Archaeo-logical site	Reference
Panaca 22	Camps, with gardens	Caliente [redacted]	Caliente		Kelly, 1932-1933
Paranagat	Camps, with gardens; mythic significance: where Coyote released first people from his water basket	Caliente [redacted]	Caliente		Kelly, 1932-1933
Kawich 3	Winter camps	Warm Springs T R	Tonopah		Steward 1938: Fig. 8, #44
Kawich 6	Camp at Reveille Mill	Reveille Mill [redacted]	Tonopah		Steward 1938: Fig. 8, #47
Lida/Goldfield	Camp	ca. 11 km east of Goldfield, [redacted]	Goldfield		Steward 1938: Fig. 7, #34
Beatty 1	Camp (gardens in post-contact period)	NE of Beatty T R	Goldfield		Steward 1938: Fig. 7, #49

The quality of information available on the site records for properties on the project area cultural resource inventory virtually precludes the reliable identification of all sites in the sensitive categories. Of the 102 prehistoric or post-contact Indian sites, a total of 18 (18 percent) can be so classified.

Of these, 11 (61 percent) are within Southern Paiute Territory. Six are reasonably attributable to direct ancestors of the Panaca and Paranagat people. These include five open sites and two rockshelters in Southern Paiute territory. Three open sites (26Ln214, -233 and -234) and one rockshelter (26Ln1531) are within a short distance of the important [redacted] gardening and mythic site complex in Paranagat territory. The rockshelter (26Ln1531) has rock art, and in addition to this another rock art site (26Ln217) is near [redacted]. Two other rock art sites (26Ln1514 and -3036) are also in Paranagat territory. One of the open sites with prehistoric components is described as being on a historic cemetery and a marginal note on the record notes the presence of Indian graves (Table 7).

Seven sites (39 percent) are in Western Shoshone territory (Table 8). Only two (26Ny251 and -408) are directly ancestral on the basis of archaeological information. The first is a rockshelter [redacted], within the territory of the Lida subgroup, and the second is an open site [redacted] a subgroup territory identified by Steward (1938:Figure 8), but not discussed. The valley is west of the Hot Springs Range and the northern tip of the Kawich Range. The other sites are three rockshelters (26Ny2113, -3109 and -3127) in Ralston and in the Beatty and Belted Range territories, and two rock art sites (26Ny215 and -806) in Beatty/Belted Range and Kawich territories, respectively.

In addition to the known ethnographic and archaeological sites on the proposed rail alignments, there are numerous topographic features that may be sensitive, notably springs or other water sources, caves or rock overhangs, and major passes through which prehistoric or remembered trails may have gone.

Discussion

A total of 24 sensitive sites (6 ethnographic and 18 archaeological) are known to be on or very near one or more of the alternate rail alignments. It is reasonable to expect, on the basis of the project staff's past experience in Native American consultation that most, if not all of these will be of interest to tribal consultants. A revitalization of interest in tribal history is as responsible for this as are the religious concerns discussed briefly above.

As noted earlier, the lack of adequate archaeological or ethnographic information about the proposed alignment alternatives precludes any but the most general recommendations. An exception is the information about the [redacted] location. Five of the archaeological sites are near the ethnographically known [redacted] occupation and garden site, a location which also has mythic significance. It is almost certain that this site would be regarded as sacred and culturally important to the Southern Paiute people. Avoidance of this area, if at all feasible, would preserve an important site complex.

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

LAS VEGAS, NEVADA

YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE

CONCEPTUAL DESIGN REPORT

APPENDICES F & G

De Leuw, Cather & Company
Subcontract Agreement No. 14-900078-12

120 Howard Street
San Francisco, CA 94105

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ECOLOGY

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TECHNICAL MEMORANDUM - MILESTONE 1
YUCCA MOUNTAIN RAIL ACCESS PROJECT
PRELIMINARY REVIEW OF SIGNIFICANT BIOLOGICAL AND GEOLOGICAL CONSTRAINTS WITHIN A BROAD CORRIDOR

July 10, 1990

DAMES & MOORE

TABLE OF CONTENTS

PAGE

1.0 INTRODUCTION 1

2.0 DATA SOURCES 1
2.1 Biological 1
2.2 Geological 2

3.0 POTENTIAL RESOURCE ISSUES 4
3.1 Biological 4
3.1.1 Botanical Resource Species 5
3.1.2 Wildlife Resource Species 6
3.2 Geological 7
3.2.1 Potentially Active Quaternary Faults 8
3.2.2 Quaternary Landslides 9
3.2.3 Mineral Deposits and Oil and Gas Fields 9
3.2.4 Shallow Ground Water 9

4.0 CONCLUSIONS 10
4.1 Biological 10
4.2 Geological 11

LIST OF PLATES

Plate Number

BIOLOGICAL SENSITIVITY LEVEL MAPS

1	Sheet 1
2	Sheet 2
3	Sheet 6
4	Sheet 7
5	Sheet 10
6	Sheet 10A

MINERALS OIL AND GAS WITHIN THE CALIENTE STUDY ROUTE

7	Las Vegas 1° x 2°	Map 1
8	Death Valley	Map 2
9	Goldfield	Map 6
10	Tonopah	Map 7
11	Caliente	Map 10

SHALLOW GROUND WATER AND QUATERNARY FAULTS WITHIN THE CALIENTE STUDY ROUTE

12	Las Vegas 1° x 2°	Map 1
13	Death Valley	Map 2
14	Goldfield	Map 6
15	Tonopah	Map 7
16	Caliente	Map 10
17	Lund	Map 10A

MINERALS, OIL GAS, AND LANDSLIDE DEPOSITS

18	Caliente 1° x 2°	Map 10

1.0 INTRODUCTION

This technical memorandum contains the results of Dames & Moore's preliminary review of potentially significant biologic and geologic issues that may affect the siting of a proposed rail line that would extend across Nevada from Caliente to Yucca Mountain. The rail line will be used to transport high-level radioactive waste to a proposed permanent repository at Yucca Mountain. This review was conducted for De Leuw Cather and Company (DC&C) under the scope of work that is referred to as Step 1 of Task 2 in the Scope of Services agreement between Dames & Moore and DC&C.

At this initial stage in the siting process there is not yet a specific, designated route that is being evaluated. Rather, the preliminary review has covered a broad, irregular region within the southern half of Nevada where the rail line is expected to be located. The area under consideration is referred to as the Rail Access Study Zone (RASZ). Included in the RASZ are most of Lincoln County, central and southwestern Nye County, the eastern half of Esmeralda County, and a wedge-shaped area in the north-central part of Clark County. It is expected that the information presented in this technical memorandum will be used to assist in the definition of potential rail corridors within the RASZ that will be the focus of more detailed evaluations. Selection and examination of possible routes will be the next phase in the overall siting process, which is designed to be a methodical progression from regional-scale studies to more focused and site specific studies leading to the ultimate designation of a rail corridor.

To evaluate the land within the RASZ, we reviewed readily available region-wide data to identify significant biological and geologic resources and conditions that potentially could preclude the siting of a rail corridor or that would require substantial mitigative measures to be taken in conjunction with the corridor. The data were compiled onto 1:250,000 scale maps using base maps that were provided by DC&C. The base maps for the RASZ have been designated as Sheets 1, 2, 6, 7, 10, and 10A, and correspond to the U.S. Geological Survey's 1 x 2 degree sheets named Las Vegas, Death Valley, Goldfield, Tonopah, Caliente, and Lund, respectively.

2.0 DATA SOURCES

2.1 Biological

Most of the information on biological resources was obtained from Dames & Moore's Geographic Information Management System (GIMS) database. Using these data, overlay maps were compiled which show the habitat areas for the various sensitive species within the RASZ (refer to the attached Sensitivity Level Maps). The existing GIMS database contains both Botanical and Wildlife data. The following four steps describe the map production process for the GIMS data:

1. The original GIMS data, in Lambert Projection, was converted to Universal Transverse Mercator (UTM), to enable registration and division of the data into the six 1:250,000 scale base map sheets that comprise the study area.

2. The GIMS Database was screened for Botanical and Wildlife data within each of the six maps.

3. The 76 Botanical categories and 100 Wildlife categories were collapsed into a rating system consisting of five categories. A rating of 1 represents the highest constraint level and a rating of 5 represents the lowest constraint level.

4. The five categories of both the Botanical and Wildlife data were plotted together on each of the six base map sheets.

The timeliness of the most recent updates to the database are unknown, which may render some data subject to question; nevertheless, the maps are believed to be substantively correct and are in general agreement with the known status of the species. However, when describing natural systems, emigration, immigration, migration, and seasonal population movements will affect the accuracy of the data.

2.2 Geological

Our data review of geological resources relied mainly upon published regional-scale reports and maps that were obtained from the Nevada Bureau of Mines and Geology (NBMG) and the U.S. Geological Survey (USGS). Other regional-scale studies and more detailed investigations may be available, but generally were not researched due to the limited scope and time constraints for this preliminary review.

The publications that provided data used to evaluate potential geologic constraints within the RASZ include the following:

- Stewart, J.H. and Carlson, J.E., 1978, Geologic map of Nevada: USGS in cooperation with the NBMG, 1:500,000.

- Longwell, C.R., et al., 1965, Geology and mineral deposits of Clark County, Nevada: NBMG, Bull. 62.

- Nakata, J.K., et al., 1982, Quaternary fault map of the Basin and Range and Rio Grande Rift provinces, western United States: USGS, Open-file Rpt. 82-579.

- Cornwall, H.R., 1972, Geology and mineral deposits of southern Nye County, Nevada: NBMG, Bull. 77.

- Kleinhampl, F.J. and Ziony, J.I., 1985, Geology of northern Nye County, Nevada: NBMG, Bull. 99A.

- _____, 1984, Mineral resources of northern Nye County, Nevada: NBMG, Bull. 99B.

- Thenhaus, P.C. and Wentworth, C.M. 1982, Map showing zones of similar ages of surface faulting and estimated maximum earthquake size in the Basin and Range province and selected adjacent areas: USGS, Open-File Rpt. 82-742.

- Tschanz, C.M. and Pampeyan, E.H., 1970, Geology and mineral deposits of Lincoln County, Nevada: NBMG, Bull. 73.

- Albers, J.P. and Stewart J.H., 1972, Geology and mineral deposits of Esmeralda County, Nevada: NBMG, Bull. 78.

- Garside, L.J.,et al., 1988, Oil and gas developments in Nevada: NBMG, Bull. 104.

- Hess, R., et al., 1990, Oil and gas wells drilled in Nevada since 1986: NBMG, List L-8, an update of information in NBMG Bull. 104.

- Bonham, H.F.,Jr., 1989, Bulk-minable precious-metal deposits and prospects in Nevada: NBMG, Map 91.

- Feuerbach, D.L., et al., 1990, Structural control of Pleistocene volcanism in Crater Flat, Nevada: Geological Society of America, Abs. with Prog., v.22, No. 3, p. 23.

- Fleming, K.L. and Jones, R.B., 1989, Active metal and industrial mineral mines in Nevada-1988: NBMG, DBM-2.

- Papke, K.G., 1973, Industrial mineral deposits of Nevada: NBMG, Map 46.

- Schilling, J.H. 1976, Metal mining districts of Nevada: NBMG, Map 37.

- Rogers, A.M.,et al., 1987, Evaluation of the seismicity of the southern Great Basin and its relationship to the tectonic framework of the region: USGS, Open-File Rpt. 87-408.

- Rush, F.E., 1974, Static ground water levels of Nevada: Nevada Division of Water Resources, Map, 1:750,000.

- Bedinger, M.S.,et al., 1984, Maps showing ground-water levels, springs, and depth to ground water, Basin and Range province, Nevada: USGS, Water-Resources Investigations Rpt. 83-4119-B.

- Bohannon, R.G., 1978, Preliminary geologic map of the Las Vegas 1° x 2° quadrangle, Nevada, Arizona, and California: USGS Open-File Rpt. 78-670.

- Wallace, R.E., 1984, Patterns and timing of late Quaternary faulting in the Great Basin Province and relation to some regional tectonic features: Journal Geophys. Res., v. 89, no. B7, p. 5763-5769.

- Weide, D.L., 1982, Surficial geologic map of the Las Vegas 1° x 2° quadrangle, Nevada, Arizona, California, and Utah: USGS Open-File Rpt. 82-706.

- Wells, S.G., et al., 1990, Geomorphic assessment of late Quaternary volcanism in the Yucca Mountain area, southern Nevada: Implications for the proposed high-level radioactive waste repository: Geology, v. 18, no. 6, p. 549-553.

- USGS, 1:100,000 scale topographic maps, including the following quadrangles: Beatty (1986), Cactus Flat (1988), Caliente (1978), Clover Mts. (1978), Death Valley Junction (1986), Duckwater (1980), Garrison (1979), Goldfield (1985), Last Chance Range (1985), Las Vegas (1986), Mount Jefferson (1978), Pahranagat Range (1985), Pahute Mesa (1979), Quinn Canyon Range (1988), Timpahute Range (1988), Tonopah (1987), Warm Springs (1987), and Wilson Creek Range (1982).

- USGS, 1:62,500 scale topographic maps, including the following quadrangles: Dry Lake (1952), Arrow Canyon (1958), and Moapa (1958).

3.0 POTENTIAL RESOURCE ISSUES

3.1 Biological

For the purposes of this preliminary review each identified sensitive species was assigned a relative rating that corresponds with the current level of legal protection, the amount of difficulty in obtaining permits, and the expense required to develop its habitat.

The following numbers were assigned to the described categories of sensitive species in our rating system:

1. These are federally protected and politically and/or biologically sensitive species. Organisms in this group have the highest degree of federal protection and/or are very popular with environmental groups and the general public; thus, obtaining permits to develop in this habitat category would be the most difficult, time-consuming, and expensive.

2. Species in this rating class are protected, as are the species in the previous class, by the Endangered Species Act of 1973 (ESA). Designated species cannot be disturbed

in any manner, except under the provisions of Section 7 of ESA. Through a consultation process, the U.S. Fish and Wildlife Service (USFWS) may issue a permit to develop in this habitat. The process of obtaining a Section 7 permit may take one year or more.

3. Species in this class are candidates for federal protection and may in the future be moved to a "2" rating. This upgrade is unlikely, however, until the USFWS has collected more information.

4. State-protected species such as those in this category have the potential to be as much of a biological constraint as those in Class 1. However in practice, species in this class usually have a lower degree of protection than those with federal recognition and status.

5. Plants in this class are recommended for protection by the Northern Nevada Plant Society; currently however, they have no specific legal status.

In the following listings, those species with one (1) rating are indicated in bold type, as these represent the greatest constraints (refer to Biological Sensitivity Level Maps Plates 1-6 for locations where the listed species have been identified).

3.1.1 Botanical Resource Species

Map Location/ Species Code	Species	Rating
9B	Arctomecon californica	2
11B	Astragalus geyeri var. triguetrus	3
18B	Ferrocactus acanthodes var. lecontei	4
19B	Frasera gypsicola	4
20B	**Opuntia whipplei var. multigeniculata**	**1**
31B	Astragalus mohavensis var. hemigyrus	5
39B	Gallium hilendiae spp. kingstonense	5
42B	Penstomen fructicformis ssp. amargosae	5
48B	Federal Candidate C2 Species (38)	3

Species 20B, Opuntia whipplei, represents the greatest botanical constraint. The preferred habitat for this cactus, however, are rocky limestone clifftops, areas not likely to be disturbed by the project. Therefore, botanical constraints within the RASZ may not be significant. However, sensitive and rare plant surveys will be required in the appropriate season, but it is unlikely that re-routes would result. In addition, all cactus and yucca species are protected under state law, and permits would be required prior to their disturbance or removal.

3.1.2 Wildlife Resource Species

Map Location/ Species Code	Species	Rating
1W	**Federally-listed Fish Species (18)**	1
4W	Gila Monster	4
5W	**Desert Tortoise**	1
6W	**Bald Eagle**	1
7W	**Peregrine Falcon**	1
8W	**Federal Candidate Invertebrates (18)**	1
9W	**Federal Candidate Fish (24)**	1
10W	Amargosa Toad	2
18W	Yellow-Billed Cuckoo	4
24W	Pahranagat Valley Vole	2
29W	Sage Grouse	2
31W	Canadian Elk	4
33W	Bighorn Sheep	4
37W	**Combination of 1W and 8W**	1
38W	**Combination of 1W and 9W**	1
49W	Combination of 6W and 7W	2
56W	**Combination of 6W, 7W, and 24W**	1

59W	Combination of 6W, 7W, and 33W	1
77W	Combination of 7W and 33W	1
78W	Combination of 9W and 10W	1
95W	Combination of 31W and 33W	1
96W	Combination of 5W, 6W, and 7W	1

Other sensitive avian species are known to occur in the project area, however, their activity is presumed to be limited to occasional foraging events; therefore, no significant constraints are expected.

All areas inhabitated with a sensitive species are indicated on the Sensitivity Level Maps. Map areas with one or more "1" rated species are emphasized, as are other areas with high potential for biological constraints. These latter areas should not be categorically excluded from consideration, however, as many of the resident species have very specific habitat requirements. The proposed route might easily avoid some of these habitats without having any substantial impacts. The perigrine falcon, for example, uses high cliff faces and rocky escarpments as nesting sites. It is unlikely that the railway will traverse such areas.

Given the arid nature of Nevada and the limited supply and availability of water, it is not surprising that several of the critical constraint species are aquatic. These aquatic areas and the associated watersheds should be avoided wherever possible.

The Wild Horses and Burro Act affords federal protection for these species. Although not specifically mapped, these animals may occur in portions of the project area. However, linear facilities such as the proposed railway typically have little effect on these species.

3.2 Geological

There are only a few types of geologic hazards that would probably be considered absolute fatal flaws for the siting of a rail corridor. Examples of such hazards might be an active volcano, rift zone, fault, or surging glacier. With the possible exception of potentially active faults, none of the latter geologic hazards have been identified within the RASZ. The youngest volcanic deposits identified within the RASZ are basalts erupted by the Lathrop Wells cone, located just north of U.S. Highway 95 about six miles west of Lathrop Wells in Nye County (within Map Sheet 2 Plate 8). Based on geomorphic and pedogenic analys Wells, et al (1990) suggest that this cinder cone was most recently active approxima 20,000 years ago. Also in that general area, six to ten miles north-northwest of the L Wells volcanic center, other basalts were erupted during the period 0.78-1.0 milli ago from a string of cinder cones within Crater Flat (Feuerbach, et al., 1990).

Other, less formidable geologic hazards like those associated with areas susceptible to liquefaction, slope instability, seismic shaking, soil subsidence, etc. may be significant, but can usually be mitigated using engineering solutions or otherwise avoided. These hazards were therefore not considered to be potential fatal flaws and researching the presence of these conditions within the RASZ was not explicitly done at this preliminary stage of the project. Moreover, these types of hazards are rarely depicted on regional-scale geologic maps, but are generally only identified in more detailed and site-specific types of studies.

The lithologies exposed within the RASZ can be broadly classified as one of two types: either consolidated bedrock or Quaternary alluvial deposits. Bedrock units are generally composed of either Paleozoic sedimentary rocks, much of which are limestone or dolomite, or various types of Tertiary volcanic rocks. Alluvial sediments include such facies as fan deposits, stream and wash deposits, playa deposits, colluvium, etc. The character of the lithologies found in the RASZ was not considered to pose a significant constraint to the siting of a rail access corridor, and was therefore not a point of focus during this review.

The data obtained for this study allowed definition of several characteristics within the RASZ that are germane to siting of a rail corridor. These characteristics include potentially active Quaternary faults, mines and mineral prospects, probable areas of shallow ground water, and, in several locations, Quaternary landslides (refer to map sheets).

3.2.1 Potentially Active Quaternary Faults

The information on possible Quaternary faults was obtained from maps compiled by Nakata, et al. (1982), from the Geologic Map of Nevada, and from the NBMG bulletins on the geology of individual counties. Faults known or strongly suspected to have been active during Quaternary time are depicted on the published geologic maps as solid lines within Quaternary deposits or as solid or dashed lines forming the contact between Quaternary deposits and older bedrock units. Faults whose locations are not well established or which are inferred to have been active in the Quaternary are generally those depicted as dotted lines on the geologic maps. These faults are typically concealed beneath alluvial deposits that flank the mountain ranges and their presence is commonly inferred based on geomorphic evidence that can be seen in the field or on aerial photographs. Of the faults identified for this review, most occur along either the eastern or western flank of a mountain range. However, there are numerous mountain ranges within the RASZ where faults have not been mapped. This can not necessarily be taken as evidence that range-front faults are not present along those ranges. It may simply mean that evidence of these faults has not been recognized. Only a few of the probable Quaternary faults identified on the accompanying maps occur in the interiors of mountain ranges or valleys.

3.2.2 Quaternary Landslides

Several Quaternary landslide deposits were identified from the published geologic maps. One of these landslides is located within Meadow Valley Wash Canyon, south of Caliente in Lincoln County (Map 10 Plate 18). The other landslide deposits are located several miles south of Goldfield, in Esmeralda County (Map 6 Plate 14). It is likely that

there are additional landslides and landslide prone areas within the RASZ, but their identification would require more detailed and site-specific research. In general, narrow canyons and steep mountain slopes should be regarded as possible areas where slope instability may occur. Canyons, alluvial fans, and washes are also commonly susceptible to flood and debris flow hazards.

3.2.3 Mineral Deposits and Oil and Gas Fields

Information on the locations of mines, mineral deposits, prospects, and oil and gas fields was obtained from the NBMG bulletins on the geology and mineral resources of individual counties, from map compilations published by NBMG, and from the USGS topographic maps. No attempt was made to distinguish between active and inactive mines, or between major and minor mineral deposits and mines, or to delineate the size of the area involved in a mineral deposit or mine. Most of the mines and mineral deposits occur within mountainous areas.

Notable concentrations of mines and mineral deposits are found in the northern Bristol Range, Highland Range, and Pioche Hills in Lincoln County (Maps 10A and 10 Plates 16 & 18), around the Beatty area in Nye County (Map 2 Plate 8), and in the Weepah Hills, Palmetto Mountains, and Goldfield area in Esmeralda County (Map 6 Plate 9). Few mines or mineral deposits have been identified in valley areas. Exceptions to this generalization are evaporite deposits which have been mined from Clayton Valley in Esmeralda County (Map 6 Plate 9), and three oil field areas located within Railroad Valley in Nye County (Map 10A Plate 17). In addition, an approximately 38 square-mile area located in the southernmost portion of the RASZ in Clark County has been established as a heavy-industry development zone by Clark County (Map 1 Plate 7).

3.2.4 Shallow Ground Water

Data on the occurrence of shallow ground water were obtained from two regional-scale map compilations, by Rush (Nevada Division of Water Resources, 1974) and by Bedinger, et al. (USGS, 1984). Areas where ground water may occur at depths of 10 feet or less were delineated based on these two references. Such areas could be susceptible to liquefaction during earthquakes or may require other engineering considerations. Shallow ground water is also relatively easily contaminated by surface sources.

The identified areas of shallow ground water generally occur in valleys that also contain playa deposits. However, the area of shallow ground water does not necessarily coincide with the limits of the playa deposits, nor do all valleys with playas have ground water as shallow as 10 feet. Occurrences of shallow ground water are at Clayton Valley and Sarcobatus Flat in Esmeralda County (Map 6 Plate 9 Plates 16 & 17), at Hot Creek and Railroad Valleys in Nye County (Maps 7 and 10A Plates 15 & 17), and at Dry Lake and Lake Valleys in Lincoln County (Maps 10 and 10A). Several identified areas of shallow ground water appear to be associated with clusters of springs and/or faults, such as along the eastern side of Railroad Valley and northwest of Moapa (Map 1 Plate 7) in Clark County. Narrow, elongate areas of shallow ground water were identified at Pahranagat

TECHNICAL MEMORANDUM-MILESTONE 2
YUCCA MOUNTAIN RAIL ACCESS PROJECT
CALIENTE ROUTE
PRELIMINARY REVIEW OF SIGNIFICANT BIOLOGICAL AND GEOLOGICAL CONSTRAINTS WITHIN A ONE (1) TO TEN (10) MILE WIDE CORRIDOR

September 1990
10805-449-001

LIST OF PLATES

Plate Number

BIOLOGICAL SENSITIVITY MAPS/1:100,000

1.	Cactus Flat	1:100,000	(Biological)
2.	Cactus Flat	1:100,000	(Botanical)
3.	Gold Field	1:100,000	(Botanical)
4.	Gold Field	1:100,000	(Biological)
5.	Timpahute Range	1:100,000	(Botanical)
6.	Timpahute Range	1:100,000	(Biological)
7.	Last Chance Range	1:100,000	(Botanical)
8.	Last Chance Range	1:100,000	(Biological)
9.	Beatty	1:100,000	(Biological)
10.	Beatty	1:100,000	(Botanical)
11.	Pahute	1:100,000	(Botanical)
12.	Pahute	1:100,000	(Biological)
13.	Wilson Creek	1:100,000	(Botanical)
14.	Wilson Creek	1:100,000	(Biological)
15.	Caliente	1:100,000	(Botanical)
16.	Caliente	1:100,000	(Biological)
17.	Quinn Canyon Range	1:100,000	(Botanical)
18.	Quinn Canyon	1:100,000	(Biological)
19.	Warm Springs	1:100,000	(Biological)
20.	Warm Springs	1:100,000	(Botanical)

21.	Paharanagat	1:100,000	(Botanical)
22.	Paharanagat	1:100,000	(Biological)

BIOLOGICAL SENSITIVITY MAPS/1:24,000

1.	Worthington Peak	1:24,000
2.	McCutchen Pass	1:24,000
3.	Pahroc Spring SE	1:24,000
4.	McMahon Ridge	1:24,000
5.	Ralston	1:24,000
6.	Goldfield	1:24,000
7.	Mud Lake NW	1:24,000
8.	Stone Cabin Ranch SE	1:24,000
9.	Condor Canyon	1:24,000
10.	Panaca	1:24,000
11.	The Bluffs	1:24,000
12.	Crescent Reservoir	1:24,000
13.	Hancock Summit	1:24,000
14.	Mount Irish SE	1:24,000
15.	Hiko	1:24,000
16.	Hiko SE	1:24,000
17.	Paymaster Ridge	1:24,000
18.	Reveille Peak SE	1:24,000
19.	Revielle Peak	1:24,000
20.	Reveille Peak NW	1:24,000
21.	Mud Lake North	1:24,000

22.	Scotty's Junction NE	1:24,000
23.	Scotty's Junction	1:24,000
24.	Indian Cove	1:24,000
25.	Water Gap East	1:24,000
26.	Water Gap West	1:24,000
27.	Thirsty Canyon SW	1:24,000
28.	SpringDale	1:24,000
29.	SpringDale NE	1:24,000
30.	Big Dune	1:24,000
31.	Kawich Peak NE	1:24,000
32.	Crater Flat	1:24,000
33.	DeadMan Spring NE	1:24,000
34.	Quinn Canyon Springs	1:24,000
35.	Pahroc Spring NE	1:24,000
36.	DeadMan Spring SE	1:24,000
37.	SpringDale NW	1:24,000
38.	Beatty MTN	1:24,000
39.	StoneWall Pass	1:24,000

GEOLOGIC HAZARDS & SHALLOW GROUNDWATER/1:100,000

1.	Cactus Flat	1:100,000
2.	Last Chance Range	1:100,000
3.	Warm Springs	1:100,000
4.	GoldField	1:100,000
5.	Pahute Mesa	1:100,000
6.	Caliente	1:100,000
7.	Beatty	1:100,000
8.	Pahranagat	1:100,000
9.	Wilson Creek	1:100,000
10.	Quinn Canyon	1:100,000
11.	Timpahute Range	1:100,000

TECHNICAL MEMORANDUM-MILESTONE 2
YUCCA MOUNTAIN RAIL ACCESS PROJECT
CALIENTE ROUTE
PRELIMINARY REVIEW OF SIGNIFICANT
BIOLOGICAL AND GEOLOGICAL
CONSTRAINTS WITHIN A ONE (1) TO TEN (10) MILE WIDE CORRIDOR

TABLE OF CONTENTS

Section		Page
1.0	INTRODUCTION	1
2.0	SUMMARY OF DATA REVIEWED	3
2.1	BIOLOGICAL DATA SOURCES	3
2.2	GEOLOGICAL DATA SOURCES	4
3.0	POTENTIAL RESOURCE ISSUES	5
3.1	BIOLOGICAL SENSITIVITY ANALYSIS	5
3.2	GEOLOGIC HAZARDS	9
4.0	CONCLUSIONS AND RECOMMENDATIONS	12
4.1	BIOLOGICAL	12
4.2	GEOLOGICAL	14
	REFERENCES	16

LIST OF TABLES

TABLE 1 - SENSITIVE BIOLOGICAL RESOURCES OF THE PROPOSED CORRIDOR
TABLE 2 - BIOLOGICAL RESOURCES RELATIVE SENSITIVITY LEVELS
TABLE 3 - QUATERNARY FAULTS

TECHNICAL MEMORANDUM-MILESTONE 2
YUCCA MOUNTAIN RAIL ACCESS PROJECT
CALIENTE ROUTE
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1.0 INTRODUCTION

This technical memorandum contains the results of a refinement of Dames & Moore's preliminary Step 1 review of potentially significant biologic and geologic issues that may affect the siting of a proposed rail line that would extend across Nevada from Caliente to Yucca Mountain. The rail line will be used to transport high-level radioactive waste to a proposed permanent repository at Yucca Mountain. This review was conducted for De Leuw, Cather & Company (DCC) under the scope of work that is referred to as Step 2 of Task 2 in the Scope of Services agreement between Dames & Moore and DCC. Maps, provided by DCC, of the proposed route and possible alternative routes, dated August 16 - 30, 1990, were used to define the study area.

At this stage in the siting process, a one (1) to ten (10) mile wide corridor along the designated route is being evaluated. To evaluate the land within the corridor along the Caliente Route, we reviewed readily available region-wide data to identify significant biological and geologic resources and conditions that potentially could preclude the siting of a rail corridor or that would require substantial mitigative measures to be taken in conjunction with the corridor. The data for a ten (10) mile wide corridor was complied onto 1:100,000 scale maps using base maps that were provided by DCC. The findings of the Step 1 indicated that sensitive biological resources were present in the proposed Rail Access Study Zone (RASZ). In biologically sensitive areas along the route, data for a one (1) mile wide corridor were compiled onto 1:24,000 scale base maps provided by DCC.

An inventory of sensitive biological resources was conducted as described in Section 2.1. The objectives of this inventory were three fold:

- Identify sensitive species and habitats.
- Collect available location information.
- Map locations of sensitive resources.

Sensitive species consist of federally or state-listed threatened or endangered species that are protected by law due to their extreme rarity or vulnerability. Sensitive species also include a wide variety of other plants and animals that have limited distribution, unusual scientific or educational value, or Although the latter species do not have the same scarcity or vulnerability as legally protected species, they are afforded some protection and may be candidates for listing in the future.

Following the mapping of the locations of sensitive species and habitats, a sensitivity analysis was conducted, as described in Section 3.1. The objective of the analysis was to rate the mapped resources in order of their sensitivity to impacts caused by the development of the proposed project.

The inventory mapping and sensitivity analysis were conducted in preparation for a selection process for an environmentally preferred corridor. The location and degree of sensitivity levels of the mapped biological resources will provide criteria, along with other environmental, land use, and engineering constraints, to select the corridor.

Ultimately, the proposed rail spur will not affect a wide area and will likely have a minimal effect on geologic resources. The types and locations of these resources are shown on overlays in the Step 1 report. Additionally, there may be potential for the rail spur to cause beneficial economic impacts if the tracks can be used to haul ore and mining-related materials. This report presents a summary of the data reviewed for geologic hazards in Section 2.2 and the potential for significant geologic hazards along the route in Section 3.2.

2.0 SUMMARY OF DATA REVIEWED

2.1 BIOLOGICAL DATA SOURCES

Secondary biological data was collected for the study area from applicable scientific literature, agency file data, and data base services. Phone and personal interviews of agency personnel were conducted to provide the best available information on sensitive species and areas of concern. In addition, areas over portions of the proposed route were flown to provide further clarification. A list of sensitive resources expected to occur in the proposed corridor is compiled in Table 1.

The information described above was combined with locational data obtained from a Dames & Moore Geographic Information System (GIS) database. Locational information on sensitive wildlife and wildlife habitat consisted of polygonal and point location data, while sensitive fish and plant location consisted primarily of point data.

The accuracy of the mapping was influenced by several factors: 1) mapping scale (source data was often 1:500,000), 2) the size of the study area, 3) lack of precise locational data in some instances, especially for the more mobile animal species, and 4) the age and reliability of some locational data. Many locations of sensitive species are historic observations over 50 years old and may be vague or erroneous. A final point; the absence of a sensitivity level only indicates that no reports of sensitive species were found, field surveys would be required to assess the actual presence or absence of a sensitive resource.

The major data sources are listed below:

Bureau of Land Management (BLM)
Dames & Moore GIS database
Nevada Department of Wildlife (NDOW)
Northern Nevada Native Plant Society (NNNPS)
Nevada Department of Forestry (NDF)
Nevada Natural Heritage Program (NNHP)
The Nature Conservancy (TNC)
U.S. Fish and Wildlife Service (USFWS)

2.2 GEOLOGICAL DATA SOURCES

The assessment of potential geologic hazards along the proposed rail access routes was accomplished by conducting a review of published reports and then compiling pertinent data obtained from those reports onto 1:100,000 scale map overlays. The proposed rail access route locations were provided to Dames & Moore by De Leuw Cather Company (DCC). These routes were shown on August 15, 1990 blueline reproductions of U.S. Geological Survey 30 x 60 minute topographic map sheets and also on 7½ minute topographic quadrangle maps. Using these maps as a guide, we performed a literature search to identify published geologic information that included a swath of land (usually one-mile wide, but wider in certain specified sections of the route) centered on the proposed routes. The following bibliographies were researched to help identify potential sources of information:

- The publications list of the Nevada Bureau of Mines and Geology, 1990.
- The geologic map index of Nevada, 1976, Reprinted 1983: U.S. Geological Survey.
- The bibliography of Nevada geology and mineral resources through 1980: Nevada Bureau of Mines and Geology, Special Pub. 7.
- The bibliography and index of geology, 1979 - April, 1990: The American Geological Institute.

A list of potential references for each of the 30 x 60 minute (1:100,000 scale) map sheets that covered the routes was compiled from the above bibliographies. The references were then obtained from Dames & Moore's in-house library or from the University of Nevada. After reviewing these references, usable information on potential geologic hazards was plotted on map overlays for distribution to DCC.

3.0 POTENTIAL RESOURCE ISSUES

3.1 BIOLOGICAL SENSITIVITY ANALYSIS

The relative sensitivity of the biological resources was rated and placed into four rating categories as shown on maps 1-39 in order to aid the corridor selection process. The assignment of a resource to a particular category was based on the apparent sensitivity of the resource to the impacts of the construction and operation of a rail line.

In evaluating the relative sensitivity of the various species to the proposed project, the following factors were considered:

(1) Degree of legal protection. A Federally listed species, for example, has greater legal protection and regulation than candidate or unlisted species.

(2) Nature of occurrence. Widely ranging, highly mobile species are less likely to be affected than highly restricted immobile species. Conversely, highly localized resources, such as a small pond with an endemic fish species, can be relatively easy to avoid in the routing of a linear facility.

(3) Ability to respond to disturbance impacts. Most plants, for example, react poorly to surface disturbance activities, while certain wildlife species either temporarily avoid impact activities or acclimatize to them.

(4) Degree of concern assigned to resource by agency personnel. Certain species have been given elevated status with regard to regulation and\or management due to the high biological or economic value ascribed to the resource by the agency, without regard to the official legal protection status. Hence, game species may be treated with a level of concern often equal to legally-protected species.

A rating system was developed and the various biological resources were assigned to sensitivity levels as shown on Table 2. The rating system ranges from Level 4, with the highest degree of sensitivity, through Level 1 which is habitat with no record of the occurrence of a sensitive resource. A list of the resources in each level with the rationale for the inclusion in a given level is as follows:

Level 4. Severe Restrictions/Incompatible Use

Federal or state listed wildlife species with a very restricted known range or distribution.

Federal and state listed plant species.

Known nesting sites of state or federally protected avian species.

Permanent wetland/aquatic habitat.

Federal or state listed species with very limited known range are protected from adverse impacts by strict laws and regulations. However, not all listed species are included in this category. The species in this level have the highest probability of adverse affects caused by the proposed project due the inherent vulnerability of the species and\or the limited size and nature of its habitat. Wildlife species in this element include the known nesting sites of any listed avian species.

This level includes all state and federally listed plants. Limited habitat and the relatively restricted ranges of these populations makes it more feasible and prudent to avoid these areas than to disturb these species and attempt mitigation.

Ephemeral washes and simple streambed crossings where design measures and mitigation mechanisms are well developed are not considered in this category as impacts under these conditions are temporary and mitigable.

Permanent aquatic/wetland habitats are included in this category for several reasons. The land traversed by the proposed route in southern Nevada is among the most arid in the United States, consequently permanent wetland and riparian resources are quite scarce. The limited nature of these resources makes them very valuable in themselves, however, the value of these water sources to other wildlife species cannot be overemphasized. Migratory birds, particularly waterfowl, have a very high degree of both protection and sensitivity, therefore avoiding these areas will prevent adverse effects to these species. In addition, Nevada has 18 federally protected fish species, 5 state listed fish species, and 24 federal candidate fish species. Avoidance of these wetland and riparian elements will prevent impacts to these scarce and sensitive species.

Level 3. Significant Restrictions

Federal and state listed species.

Category I or II Bighorn sheep habitat and travel corridors between I and II habitat.

Crucial Mule Deer, Elk, or Pronghorn Antelope habitat.

This category contains federally and state protected species that are less likely to be impacted by the proposed project, but which should, however, be avoided where possible. Due to the size of their range relative to the proposed amount of disturbance and/or the behavioral characteristics, these species are less susceptible to impacts than those in Level 4.

Bighorn sheep habitat has been divided into three Categories by the BLM in coordination with NDOW. The stated goals of the BLM are to:

- Maintain or enhance the habitat currently supporting viable populations of desert bighorn sheep (Category I).
- Enhance habitat on areas with remnant herds that are capable of supporting viable herds (Category II).
- Maintain and enhance historic habitat to allow reintroduction of viable populations (Category III). This category is considered a Level 2 restriction.

To achieve these goals, the BLM has developed a 15 point plan of management and standards. In the context of this project, the most important point is:

Crucial areas, such as lambing grounds, migration routes, mineral licks, and areas within one mile of permanent water sources, will receive maximum habitat protection.

Level 2. Mild Restrictions

Wild/feral horses and burros.

NNNPS and/or NNHP recommended plants and animals.

Federal C-2 (candidate for listing) species.

Category III bighorn sheep habitat.

State or BLM sensitive species.

Raptor foraging areas.

Plants protected under the Nevada Cactus and Yucca statutes.

This category represents biological resources that are much the same as in Level 3, Significant Restrictions, but with a lower protection or sensitivity status. For example, this level contains species that are candidates for federal protection, or are recommended for protection by either the Northern Nevada Native Plant Society (NNNPS) or the Nevada Natural Heritage Program (NNHP).

Raptors, such as bald eagles, peregrine falcons, or prairie falcons, may forage over huge areas traversed by the corridor. A linear facility of this nature should have little or no impacts on the nature of the land use by these species.

The Wild Horse and Burro Act of 1973 states that these animals will be allowed "free and unrestricted access" to the lands they occupied in 1973. A rail line, as proposed for this project, does not create a barrier for these agile animals, and where necessary can be designed to accommodate their movement. The ranges of these animals are, according to BLM and NDOW, so widespread that mapping at this level would not be meaningful.

Distribution maps for cactus and yucca species are not available due to the widespread and ubiquitous nature of these plants. However, obtaining permits from the Nevada Department of Forestry in order to legally disturb or remove these species is a relatively simple process.

As impacts at this level are expected to be non-significant or minimal, it is assumed that any required mitigation measures for the resources in this category would be feasible and readily accomplished without major regulatory obstacles and costs.

Level 1. No Restrictions

Wildlife and vegetation with no specific status or level of protection.

The ungulate (mule deer, antelope, and elk), and chukar (an introduced game bird) forging ranges are so widespread that the impacts of a project of this nature are expected to be negligible.

Mule deer, for example, are virtually ubiquitous over much of the area traversed by the proposed corridor, therefore any of the highly localized impacts due to this project are expected to be non-significant. Likewise, chukars inhabit relatively large territories and, being very shy and elusive, are expected to avoid all but the most transient and negligible effects.

Critically or crucially important areas and movement corridors for these species are considered Level 3.

3.2 GEOLOGICAL HAZARDS

The data that were reviewed provided for explicit identification of only two geological hazards along the rail access routes: probable Quaternary age faults/ground shaking and areas of shallow groundwater (liquefaction, etc.). These hazards are discussed in more detail below. Other potential geologic hazards are either not present along the route, are unlikely to affect the proposed rail line, or are being evaluated by others. These other geologic hazards are summarized as follows:

- Flooding/Debris Flows. The potential for flooding and debris flows to affect the line is being evaluated by Kennedy/Jenks/Chilton;

- Subsidence. Regional subsidence of ground surface may occur in some areas as a result of significant groundwater withdrawals. Subsidence would only occur in basin areas

underlain by considerable thicknesses of alluvium where very large quantities of groundwater were withdrawn. Rail lines are not particularly susceptible to subsidence because they are flexible over long distances and would likely accommodate some settlement. Furthermore, at this time significant groundwater withdrawal is unlikely in most of the alluvial basins crossed by the rail line. Therefore, subsidence is not expected to be a significant hazard to the project; and

- Landslides. Information necessary to evaluate slope stability along the route was not contained within the data reviewed. However, it is our understanding that general landslide hazards are being evaluated by DCC based on their overflight of the route.

Before discussing possible Quaternary faults and areas of shallow ground water, it should be noted that no potential geologic hazards were identified (or plotted on map overlays) in the vicinity of the proposed rail access routes within the following three 1:100,000 map sheets: Wilson Creek Range, Pahranagat Range, and Quinn Canyon Range.

Possible Quaternary Faults

In the tectonically active Basin and Range province it will be difficult to site the rail access route and avoid crossing a Quaternary fault. Quaternary faults pose a potential threat to engineered structures due to surface rupture (displacement across the fault) and due to the effects of seismic shaking. Nakata, et al. (1982) have produced a compilation which shows there are hundreds of Quaternary faults within the Basin and Range. Most of these faults are located along the western and eastern boundaries of the Basin and Range; fewer of these faults are located in that part of Nevada which is crossed by the proposed access route. Research indicates that recurrence intervals for significant displacement events on most of these faults is on the order of thousands to tens of thousands of years (Wallace, 1984; Ryall, 1977).

The data reviewed for this study indicate that the following Quaternary faults shown on Table 3 are crossed by the proposed rail access routes. In addition to these faults, several others were plotted on the map overlays which were within the near vicinity of the proposed route, but which did not actually

cross the route. The available references provided no other specific data on the above faults, such as slip rate, rupture recurrence interval, maximum probable earthquake, etc.

Strong ground motion resulting from earthquakes may be expected to affect all portions of the proposed rail line. The amount of shaking will generally be highest near the area of fault rupture. However, site specific geologic conditions may modify this general relationship. Information is generally not available regarding the probability of fault activity in the region. For the purposes of this evaluation, all portions of the proposed rail line are considered to be approximately equally subject to strong ground shaking from earthquakes.

Shallow Groundwater

Several possible areas of shallow groundwater (within about 10 feet of the surface) were identified along the proposed rail access routes. These areas may require special engineering design considerations, such as to address the potential for liquefaction during an earthquake; shallow ground water may also be subject to relatively easy contamination from surface sources. The areas where shallow ground water may exist include: in a portion of Sarcobatus Flat, on the Last Change Range Sheet (Malmberg and Eakin, 1962; Bedinger, et al., 1984); within Oasis Valley, on the Pahute Mesa Sheet (Malmberg and Eakin, 1962); within Meadow Valley, on the Caliente Sheet (Phoenix, 1948); and within Sand Springs and Pahranagat Valleys, on the Timpahute Range Sheet (Bedinger, et al., 1984). In addition, the proposed rail corridor includes portions of the playa of Mud Lake and an unnamed playa on the northwest side of Stonewall Mountain, both on the Goldfield Sheet. However, ground water was not reported to be shallow at those two playas by any of the references.

Although shallow groundwater is not reported to be present in the vicinity of the anticipated fueling centers, these locations may be susceptible to groundwater contamination. Appropriate precautions to prevent releases of fuel will be required in these areas. High-level radioactive waste will be transported in canisters designed to remain intact upon impact such as a train accident. In addition, risk of upset associated with transporting the canisters within the ten (10) mile wide proposed corridor would be no greater than anywhere else in the country and probably would involve much less risk.

4.0 CONCLUSIONS

4.1 BIOLOGICAL

According to The Nature Conservancy's central data base, in August of 1989, Nevada was the state with the sixth highest number of endangered or threatened vertebrate wildlife species (36). Coincidentally, Nevada also has the sixth highest number of threatened or endangered plant species (136). When considering also the state protected and candidate species, the list of sensitive species in Nevada exceeds four hundred.

Jurisdiction over formally listed threatened and endangered species is held by the U.S. Fish and Wildlife Service. An "incidental take permit", allowing the removal or disturbance of these species while in the pursuit of an otherwise lawful activity may be granted under the provisions of Section 7 or Section 10A of the Endangered Species Act.

"Take" is defined to mean "harming, harassing, pursuing, hunting, wounding, killing, capturing, collecting, or attempting to engage in such conduct". This term also includes modification of habitat that would result in harm to the species.

The proposed project, regarded as a whole, should have minimal impacts on these sensitive resources. Highly mobile species with extensive ranges, such as mule deer, will in all likelihood utilize other portions of their range during construction and/or become rapidly accustomed to the operation of the rail line. Sensitive species with a limited home range, such as a protected fish in an isolated pond, are relatively easy to avoid by slightly adjusting the route to avoid these resources. In addition, a large part of the proposed corridor parallels existing roads and utilities.

Given the high number of sensitive resources and the length of the corridor, it was expected that some conflicts would be unavoidable. U.S. Geologic Survey 7.5 minute series maps that indicate that the corridor either closely impinges or traverses sensitive habitat include: Hiko SE, Hiko, and Mount Irish SE. In addition, the route traverses known tortoise habitat on the Crater Flat, Big Dune, and Scotty's Junction quadrangles.

The desert tortoise (Gopherus[=Xerobates, =Scaptochelys] agassizii) is relatively common throughout the Mojave and Sonoran deserts and occurs as far south as Sinaloa, Mexico. It has declined substantially in numbers during recent years through most of its range. The decline is probably due to a number of reasons, including a disease condition exacerbated by the stress of several drought seasons, loss of habitat, predation by common ravens (Corvus corax), and direct disturbance by humans. In response to these decreases, the United States Fish and Wildlife Service (USFWS) listed the tortoise as a federally endangered species on an emergency basis. In April of 1990, the desert tortoise was granted more permanent federal listing status as threatened (50 FR 12178, April 2, 1990).

In order to issue an incidental take permit for construction of a project that may affect the desert tortoise, the USFWS will issue a Biological Opinion, in accordance with the formal consultation requirements of the Endangered Species Act, as amended. A Biological Assessment that addresses the potential impacts to the desert tortoise resulting from the construction and operation of the proposed project, and measures to mitigate and compensate for those impacts provides USFWS the information needed to form the Opinion. The preparation of a Biological Assessment usually involves a combination of literature search, agency contact, and field surveys.

On the Hiko SE quadrangle, the corridor comes within one mile of Category II bighorn sheep habitat. The rail line, however, is located in the valley floor, while the bighorn occupy the mountainous slopes. Given the distance and the respective nature of the sheep and project terrain requirements, impacts are expected to be temporary and minor in nature.

On two quadrangle maps, Hiko and Mount Irish SE, different sensitive species have overlapping ranges along the corridor. Peregrine falcons and bald eagles forage over Pahranagat Valley Vole habitat in the former, and over Category II bighorn sheep habitat in the latter. In these cases, both the vole and bighorn were considered to have a higher degree of sensitivity than the foraging range, therefore the more restrictive rating was assigned.

The Hiko canyon portion of the route is expected to be the most environmentally sensitive. The corridor is shown to parallel State Highway 375. The Frenchy Lake Wilderness Study Area lies to the north of the highway. Crystal Springs, which is inhabited with a federally listed fish species, and the Crystal Wash riparian area lie to the south. In addition, as described above, bighorn sheep, a candidate species mammal, and two species of endangered raptor also utilize this area. If re-routed either south or

north, development of this project could minimize or avoid significant impacts to these sensitive resources.

4.2 GEOLOGICAL

Only a very small portion of the proposed rail access corridor is exposed to the potential geologic hazards identified on the map overlays. It is not possible to quantify with certainty the degree of risk associated with surface fault rupture at the Quaternary fault crossings. The risk of surface rupture is probably quite low during the projected design life of the rail line given the relatively small number of fault crossings and the long recurrence intervals for displacement events on most Basin and Range faults. If this low level of risk is unacceptable, then the proposed corridor may need to avoid fault crossings, since it is unlikely that methods exist to mitigate the potential damage from a surface displacement that could range from 3-30 feet if a fault were to rupture.

The areas of shallow ground water along the corridor are not considered to be a serious constraint. These areas should be evaluated for potential liquefaction susceptibility and for other possible engineering considerations so that mitigative design measures can be incorporated into the construction of the rail line if necessary. Consideration should also be given to activities and operations associated with construction and operation of the rail line that could result in contamination of the shallow ground water. If potential impacts to ground-water quality are identified, then it is recommended that mitigation measures be taken to reduce or eliminate such adverse conditions.

A potential hazard that could not be shown on the map overlays or considered in detail at this stage of the environmental effects analysis is that of seismic shaking. The Basin and Range is a seismically active region (Smith, 1978), and all parts of the access corridor in Nevada are exposed to this potential hazard. Major earthquakes have affected the region during historical times, including for example, such notable events as the Magnitude 8 Owens Valley, California earthquake in 1872 and the Magnitude 7.1 Fairview Peak, Nevada earthquake in 1954 (Ryall, 1977). Recorded seismicity for the southern Nevada region is generally characterized by numerous small magnitude earthquakes ($M \leq 4$) distributed irregularly within a broad east-west zone between latitudes 36°N and 38°N (Rogers, et al., 1987; Smith, 1978). The earthquake epicenter locations generally do not coincide with known faults.

Thenhaus and Wentworth (1982) believe that a broad part of southern Nevada, including much of the rail access corridor between longitudes 115°W and 116.5°W, is susceptible to maximum earthquakes of Magnitude 7.5. Rogers, et al. (1977) have estimated a Magnitude 7.0 earthquake as the maximum event that could impact the Nevada Test Site region (NTS). They indicate that such an earthquake would result in peak accelerations in the range of 0.2 - 0.7g at various locations within the NTS. Again, it should be noted that recurrence intervals for such maximum magnitude events are considered to be greater than one thousand years (Rogers, et al., 1977; Ryall, 1977).

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TABLE 1

SENSITIVE BIOLOGICAL RESOURCES OF THE PROPOSED CORRIDOR

SPECIES[1]	RELATIVE[2] SENSITIVITY LEVEL	COMMON[3] NAME	SCIENTIFIC[4] NAME	STATUS[5] FEDERAL/STATE
WILDLIFE RESOURCES				
1W	4	Federally-listed Fish Species(18)		T & E/E & R
5W	3	Desert Tortoise	Gopherus agassizii	T/R
6W	2	Bald Eagle	Haliaeetus leucocephalus	E/E
7W	2	Peregrine Falcon	Falco peregrinus anatum	E/E
8W	2	Federal Candidate Invertebrates (15)		C[2]/-
9W	4	Federal Candidate Fish (24)		C[2]/-
10W	2	Amargosa Toad	Bufo nelsoni	C[2]/-
24W	2	Pahranagat Valley Vole	Microtus montanus fucosus	C[2]/-
32W	2	Pronghorn Andelope	Antilocapra americana	-/G
33W	3 or 2	Bighorn Sheep	Ovis canadensis	-/G
38W	4	1,9		
49W	2	6,7		
56W	2	6,7,24		
59W	3 or 2	6,7,33		
78W	4	9,10		
101W	3 or 2	Mule Deer	Odocoileus hemionus	-/G
102W	4	Prairie Falcon	Falco mexicanus	-/P

TABLE 1 (Continued)

SPECIES[1]	RELATIVE[2] SENSITIVITY LEVEL	COMMON[3] NAME	SCIENTIFIC[4] NAME	STATUS[5] FEDERAL/STATE
BOTANICAL RESOURCES				
2B	4	Spring-loving centaury	Centaurium namophilum var. namophilum	T/CE
48B	2	Federal Candidate C2 Species (38)		C[2]
77B	2	Joshua Tree	Yucca brevifolia	-/P

1 Species numbers (and combinations) assigned for mapping purposes.

2 4 = Severe Restrictions/Incompatible Use
3 = Significant Restrictions
2 = Mild Restrictions
1 = No Restrictions

3 Common names follows: Mozingo and Williams (1980), Smith and York (1984), for plants; Collins et al. (1982) for reptiles, American Ornithologists' Union (AOU) (1983) for birds and Jones et al. (1982) for mammals.

4 Scientific nomenclature follows: Mozingo and Williams (1980), Smith and York (1984), for plants; Collins et al. (1982) for reptiles; American Ornithologists' Union (AOU) (1983) for birds and Jones et al. (1982) for mammals.

5 Federal status (USFWS, 1985b and 1987): E = listed endangered; T = threatened; C2 = Category 2 candidate for listing (threatened and/or distribution data are insufficient to support federal listing). State status: E - listed endangered; R = listed rare; P = protected; G = game: (Nevada Board of Fish and Game Commissioners, 1978).

TABLE 2

BIOLOGICAL RESOURCES RELATIVE SENSITIVITY LEVELS

Level 4. SEVERE RESTRICTIONS/INCOMPATIBLE USE

Federal or state listed wildlife species with a very restricted known range or distribution.

Federal and state listed plant species.

Known nesting sites of state or federally protected avian species.

Permanent wetland/aquatic habitat.

Level 3. SIGNIFICANT RESTRICTIONS

Federal and state listed species.

Category I or II Bighorn sheep habitat and travel corridors between I and II habitat.

Crucial Mule Deer, Elk, or Pronghorn Antelope habitat.

Sage grouse leks and nesting habitat.

Level 2. MILD RESTRICTIONS

Wild/feral horses and burros.

NNNPS and/or NNHP recommended plants and animals.

Federal C-2 (candidate for listing) species.

State or BLM sensitive species.

Category III bighorn sheep habitat.

Raptor foraging areas.

Plants protected under the Nevada Cactus and Yucca statutes.

Level 1. NO RESTRICTIONS

Wildlife and vegetation with no specific status or level of protection.

TABLE 3

QUATERNARY FAULTS

Fault Name	Location	Reference	Comments
Dry Lake	Caliente Sheet, east side of Dry Lake Valley.	Tschanz and Pampeyan, 1970. Stewart and Carlson, 1978.	
Pah Roc	Caliente Sheet, east side of south Pah Roc Range.	Ibid.	
White River	Caliente Sheet, west side of north Pah Roc Range.	Ibid.	
Unnamed	Timpahute Range Sheet, at Coyote Pass along Hwy 375.	Stewart and Carlson, 1978.	Uncertain whether this short fault is Quaternary.
Unnamed	Timpahute Range Sheet, southeast side of Sand Spring Valley.	Stewart and Carlson, 1978. Tschanz and Pampeyan, 1970.	
Unnamed	Warm Springs Sheet, east side of Kawich Range.	Stewart and Carlson, 1978. Kleinhampl and Ziony, 1985. Cornwall, 1972.	Nakata et al. (1982) indicates last movement occurred during last 500,000 years.

TABLE 3 (Continued)

Fault Name	Location	Reference	Comments
Unnamed	Warm Springs Sheet, west side of Kawich Range.	Stewart and Carlson, 1978. Kleinhampl and Ziony, 1985.	
Unnamed	Cactus Flat Sheet, west side of the Reveille Range.	Stewart and Carlson, 1978. Cornwall, 1972. Ekren, et al., 1971.	Only Ekren, et al., shows this fault extending south far enough to cross Alternative D.
Unnamed	Goldfield Sheet, east edge of Alkali-Lake Valley	Albers and Stewart, 1972.	May not be a Quaternary fault; possible drafting error in Albers and Stewart's geologic map.
Unnamed	Goldfield Sheet, near Railroad Pass on Hwy 265.	Ibid	Same as above.
Unnamed	Beatty Sheet, within Crater Flat.	Feuerbach, et al., 1990. Cornwall and Kleinhampl, 1961.	Presence of this concealed fault is suggested by the alinement of Quaternary cinder cones.

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L90-LSV-KWM-049

October 5, 1990

De Leuw-Cather & Company
120 Howard Street
San Francisco, CA 94119

Attention: Mr. Richard Sikes

RE: **ADDENDUM to Technical Memorandum-Milestone 2 Yucca Mountain Rail Access Project Caliente Route**

Dear Rick,

At your request, this addendum has been prepared to address specific questions and issues raised at your September 28, 1990, monthly staff meeting in San Francisco.

This addendum describes, in general terms, the current permitting and survey requirements that are likely to be required in order to allow construction in certain sensitive biological habitats.

As we discussed on the phone, based on the literature searches and agency contacts, there do not appear to be any insurmountable obstacles, of a biological nature, to this particular route.

If you have any questions or comments, or if I may be of further assistance, please feel free to contact me.

Sincerely,

DAMES & MOORE

Ken MacDonald

Kenneth W. MacDonald
Staff Environmental Scientist

KWM/trc

cc: Elizabeth Hughes (D&M, SAC)

TABLE OF CONTENTS

		PAGE
1.0	INTRODUCTION	1
2.0	SENSITIVE HABITAT	1
2.1	Desert Tortoise	1
2.2	Bighorn Sheep	2
2.3	Raptors	3
2.4	Pahranagat Valley Vole	3
2.5	Pahranagat Valley	4
3.0	CONCLUSION	4

1.0 INTRODUCTION

In September, 1990, Dames & Moore completed a technical report for De Leuw, Cather & Company on the sensitive biological resources expected to be affected by the construction and operation a rail line. This addendum to that report has been prepared to discuss potential issues and the anticipated permitting processes.

For the original report, biological data were compiled to determine the location of known sensitive resources in the project area. For much of the area no sensitive biological features were identified from available information sources. This is not surprising in that relatively few surveys have been conducted in this portion of Nevada. A complete evaluation of project impacts would require additional surveys. It is anticipated that additional surveys would discover additional resources.

Deleuw Cather has demonstrated diligence in the route design and selection process while attempting to reconcile all the engineering, biological, geotechnical, land use, and other constraints. Given the great distance included in the project area some conflicts were expected, however, the current route has been adjusted to minimize these conflicts.

2.0 SENSITIVE HABITAT

Habitat of the desert tortoise, bighorn sheep, raptors, and the Pahranagat Valley Vole are traversed by the alignment. In addition, the proposed route crosses the Hiko Canyon area where the ranges of several sensitive resources overlap.

2.1 Desert Tortoise

The terminus of the site lies well within desert tortoise habitat, therefore, it is reasonable to assume that any alternative routing would traverse this habitat.

The desert tortoise is listed as a threatened species and is afforded federal protection under the Endangered Species Act. As discussed in the original report, neither tortoises nor tortoise habitat may be disturbed without receiving an "incidental take" permit from the United States Fish and Wildlife Service (USFWS). In order to determine the specific number of tortoises and acres of tortoise habitat allowed to be taken, USFWS requires information on the distribution and relative tortoise densities in the project area. USFWS usually issues this permit as part of a Biological Opinion.

A Biological Assessment typically provides the information required by USFWS. An acceptable Assessment contains a project description, literature search results, field survey results, an appraisal of expected impacts (direct, indirect, and cumulative), and a plan for measures designed to mitigate and compensate for those impacts.

Current USFWS recommendations for performing field surveys for this type of linear facility include having biologists, experienced in desert tortoise survey techniques, walk a total of 14 parallel transects centered on the alignment.

Recent tortoise mitigation measures stipulated in other Biological Opinions include:

1. Pre-construction survey. Tortoises from the construction zone are relocated into adjacent undisturbed habitat.

2. Education. A worker education program designed to alert the construction related personnel of the importance and necessity of minimizing take of desert tortoise and tortoise habitat.

3. Monitoring. Biologists monitor actual construction to prevent or reduce inadvertent tortoise mortality.

4. A post-construction report which documents the efficacy of the mitigation measures.

In addition to these mitigation measures, compensation for the loss of animals and habitat is also required. Compensation funds are used to purchase habitat for the species, and perhaps for research on a problem or threat to the species. In Nevada, compensation is assessed at $324.00 per acre of disturbance for permanently lost habitat, and at 40% ($127.00/acre) for temporarily disturbed habitat.

2.2 Bighorn Sheep

The Nevada Department of Wildlife (NDOW) has the primary responsibility for the protection and management of this game species throughout the state. The Bureau of Land Management (BLM) is also responsible for minimizing impacts to bighorn sheep on public lands under their administration (which includes nearly all of the project area). The NDOW Technical Supervisor-Habitat stated traversing areas with bighorn sheep is a relatively simple process. Linear facilities of this nature do not seriously disturb this species. In addition, bighorn sheep primarily occupy the slopes while the alignment lies in the lower elevations, and the alignment does not intersect known critical migration corridors.

If the alignment is determined to fragment habitat or to otherwise impede the continued free travel between two or more populations, then under- or overpasses could be constructed to prevent this type of genetic isolation. Incidentally, tortoises could also utilize a scaled down version of the same type of tunnels if deemed necessary.

2.3 Raptors

All of these predatory birds are protected by the Migratory Species Act and some (bald eagles and peregrine falcons) have a higher degree of protection as they are listed as endangered and are fully protected by the Endangered Species Act. In addition, eagles are afforded a third level of protection under the federal Eagle Act.

The alignment traverses known portions of the peregrine and bald eagle winter range on the Hiko SE and Mount Irish SE 7.5 minute USGS quadrangle maps. Like the bighorn sheep, these birds primarily occur in the rocky escarpments. The birds are likely to forage over the alignment, however, this is considered to be an insignificant impact. The critical issue in this case is to avoid nesting and roosting sites. This can be done by re-routes or scheduling construction after fledglings have left the nest. No known nesting sites of these species was identified during the scoping process.

2.4 Pahranagat Valley Vole

The range of this small mammal is limited to the Pahranagat Valley. A candidate for federal listing as threatened or endangered, the USFWS will need to determine whether this project will jeopardize the continued existence of the species. It is likely that a trapping study would be required to census this species. This type of census usually involves setting a pre-determined number of traps in a pre-determined pattern on or near the alignment and trapping for a pre-determined number of nights.

An example of how the permitting and study process may occur would be as follows:

1. Obtain Memoranda of Understanding (MOU) and scientific collecting permit from NDOW.

2. Consult with NDOW and USFWS to determine appropriate trapping stratagems. One possible result would be the requirement to set four 100-trap grids and run these for three nights, and to repeat this effort three weeks later.

3. Determine whether the project would have an adverse impact on this species. If impacts are expected, determine a minor route adjustment to minimize or eliminate these those impacts.

2.5 Pahranagat Valley

The single greatest concentration of sensitive biological resources occurs along the alignment in this area. Bighorn sheep, raptors, and voles, as discussed above, all occur in this area. In addition, the original route would have disturbed Crystal Springs and a federally protected fish species. It is highly unlikely that the USFWS would have approved that route. The alignment has subsequently been re-routed south of Crystal Springs in to what is probably the optimal crossing through this area.

3.0 CONCLUSION

This route has been adjusted and relocated several times in the course of this project and the most current version (received by Dames & Moore on September 23, 1990) has managed to minimize contact with most sensitive biological resources. Where conflicts remain, there are mechanisms in place that would allow permitting of construction through these areas.

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November 9, 1990

RECEIVED
NOV 14 1990
DeLeuw, Cather & Co., S.F.

Mr. Richard Sikes
De Leuw-Cather & Company
120 Howard Street
San Francisco, CA 94119

Dear Rick,

At your request for additional information, this letter has been prepared to compare the relative biological sensitivity of a Hiko Canyon re-route with the existing proposed rail route south of Crystal Springs, Nevada.

This analysis was based, as discussed in the Technical Memorandum-Milestone 2, on historical data and agency contact. As you know, the actual field surveys may result in the discovery of additional sensitive biological resources.

There are four resources in question with the first three common to both alternatives:

1. Bald Eagle and Peregrine Falcon wintering habitat.

   Both alternatives would traverse approximately the same amount of valley floor in this habitat. This is not expected to be a significant impact given the nature of the raptors land use patterns. Therefore, equal and minimal impacts to these species would be expected.

2. Bald Eagle, Peregrine Falcon and Bighorn sheep habitat.

   The Hiko Canyon alternative would result in about 40% less disturbance since is crosses proportionally less of this habitat. Again with minimal and, in all likelihood, acceptable impacts.

3. Bald Eagle, Peregrine Falcon and Pahranagat Valley Vole habitat.

   Each alternative will result in approximately equal disturbance. The permit to construct in Vole habitat, we believe, in either case, would be contingent on a census and trapping effort.

4. Riparian habitat.

   It appears that the Crystal Springs alternative will impinge on a riparian zone. Given the scarcity of wetlands in Nevada, and the known occurrence of a federally protected fish species in this area, the sensitivity and relative value of Crystal Springs is the highest on either alternative.

In conclusion, the Hiko Canyon alternative would be preferred because it disturbs less known sensitive resources and habitat and does not appear to impact riparian habitat.

It has been a pleasure completing this analysis for De Leuw-Cather. As always, if you have any questions or comments regarding the report, please feel free to contact me.

Regards,

Ken MacDonald

Ken MacDonald
Staff Environmental Scientist

cc: G. Shearin (Deleuw-Cather)
E. Hughes (D&M, SAC)
L. Bowen (D&M, LVO)

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

LAS VEGAS, NEVADA

YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE

CONCEPTUAL DESIGN REPORT

APPENDIX G
GEOTECHNICAL REPORT

De Leuw, Cather & Company
Subcontract Agreement No. 14-900078-12

120 Howard Street
San Francisco, CA 94105

1 June 1992

TABLE OF CONTENTS

	Page
Introduction	1
Project History/Description	2
Investigation	3
Regional Topography	4
Regional Geology	5
Faulting	13
Seismicity	17
Mining	18
Groundwater	19
Soil and Rock Parameters and Characteristics	21
Structure Foundations	23
Geological Characteristics of Cut Slopes	24
Bibliography	

LIST OF FIGURES

Figure 1	Location Map
Figure 2	Project Location Plan
Figure 3	Late Quarternary and Historic Faults
Figure 4	Earthquakes in the Nevada Region Recorded from 1852 to 1988
Figure 5	Earthquake Epicenter Map of Southern Nevada
Figure 6	Mining Activities
Figure 7	Depth to Groundwater
Figure 8	Quadrangle Key Map

LIST OF TABLES

Table 1	Soil Parameters and Characteristics
Table 2	General Soil Characteristics
Table 3	Fill Slopes
Table 4	Structures
Table 5	Recommended Cut Slopes in Rock

Introduction

This report presents the results of a Geotechnical Feasibility Study of the Caliente Route for the Yucca Mountain Railroad Access Alignment, located in central and south-central Nevada. This report provides a basis for estimating geotechnically related construction costs and quantities for the soil and rock encountered within the proposed Caliente alignment corridors. Alternative routes were added after completion of the Preliminary Geotechnical Report, but were not included in the final report because of the stringent design schedule.

The scope of work included, but was not limited to, an investigation and gathering of pertinent geotechnical data, such as geologic and soil maps, aerial photographs and subsurface logs. Soil maps from the U. S. Department of Agriculture Soil Conservation Service (SCS) served as the primary source of surficial information.

Geologic information was obtained from the U. S. Geological Survey and State-level geologic agencies. Pertinent information was also collected from libraries and other agencies. An aerial survey was flown by helicopter and the majority of the alignment with its various alternative routes was video taped.

In addition to providing information for estimating geotechnically related construction costs, estimated maximum safe slopes are recommended with probable remedial measures, when required. Evaluations and recommendations are also given regarding embankments, foundations and other construction features specific to selected portions of the alignment. Considerations regarding seismicity, material sources, faulting, ground water and active mines are also included.

Project History/Description

The Nuclear Waste Policy Act (NWPA) of 1982 established the national policy for storage, transportation and disposal of high-level nuclear waste (HLW). Following evaluation by the Department of Energy (DOE) of a number of candidate repository sites and public input, the NWPA Administration selected the Yucca Mountain site in 1987 for site characterization.

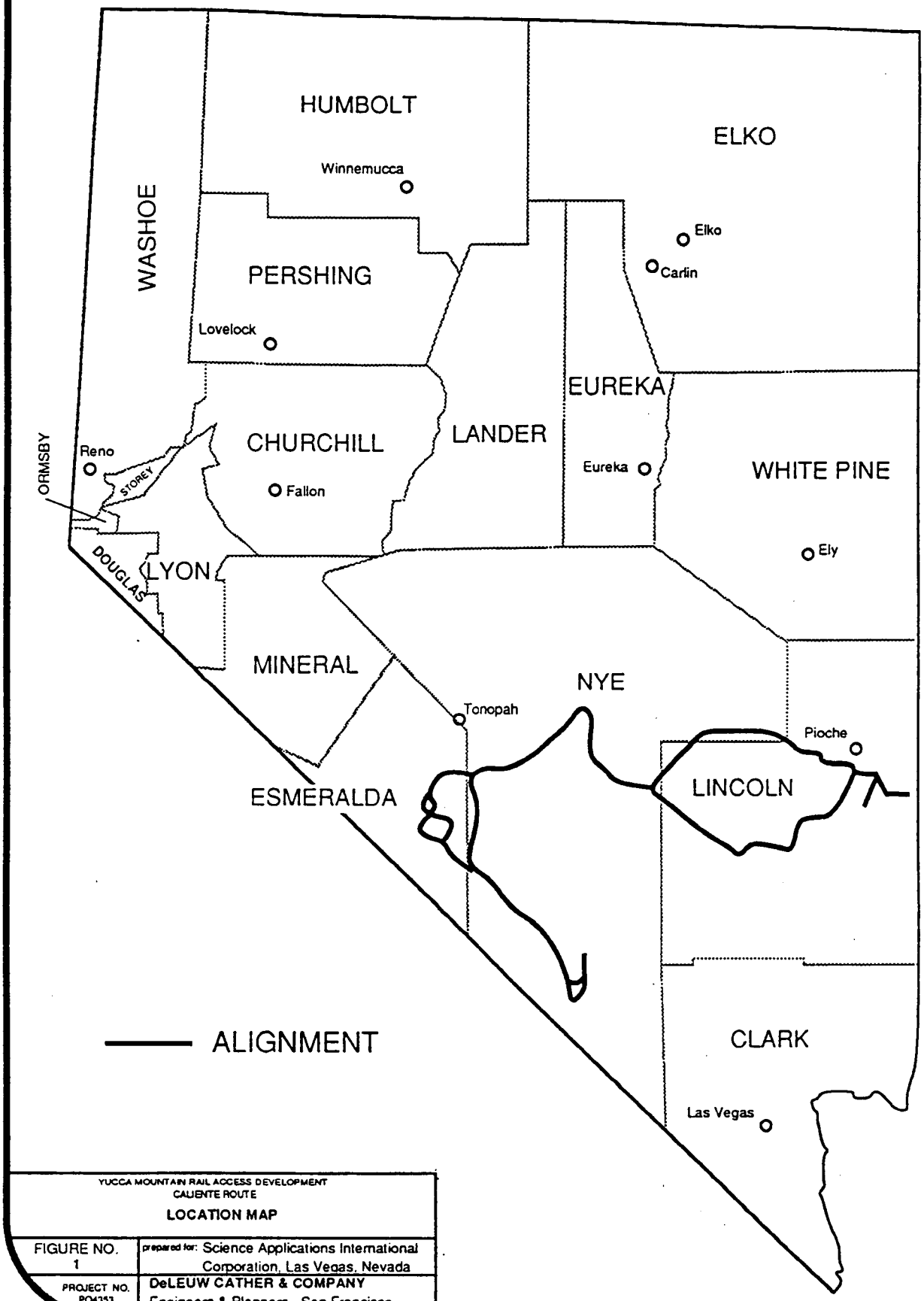
Department of Energy HLW shipments will be governed by the 1987 amendment to the NWPA. Shipments will consist of: commercial spent nuclear fuel discharged from more than 120 civilian nuclear reactor facilities at over 70 locations; solidified high-level defense waste from the Idaho National Engineering Laboratory, Hanford Reservations, and the Savannah River Site; and high-level waste from the West Valley Commercial Demonstration Plant in New York.

DOE is evaluating potential rail access routes from existing mainlines to the proposed Yucca Mountain site. The nearest railroad to Yucca Mountain is the Union Pacific mainline through Las Vegas, approximately 100 miles southeast of the site. Both the Union Pacific and the Southern Pacific have mainline potential rail routes to connect with the Yucca Mountain site. The routes were investigated in a previous study (Draft Report, Transportation Access Study - Yucca Mountain Site. Prepared for SAIC by De Leuw, Cather & Co. (DCCO), 10 October 1988).

Of these potential connection routes, three have been selected[1]: Caliente, Carlin and Jean. This report addresses the Caliente Route (Figure 1) which begins on

1 Use DOE/YMP-89-16, "Preliminary Rail Access Study", January 1990.

STATE OF NEVADA



YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE

LOCATION MAP

FIGURE NO. 1	prepared for: Science Applications International Corporation, Las Vegas, Nevada
PROJECT NO. P04353	DeLEUW CATHER & COMPANY Engineers & Planners - San Francisco

the Union Pacific Railroad at Caliente, Nevada and proceeds counterclockwise around the Nevada Test Site, approximately coinciding with SR375, US6 and US95 to the Yucca Mountain Repository Site. The total route length, with its several sub-alternative segments, is over 600 miles.

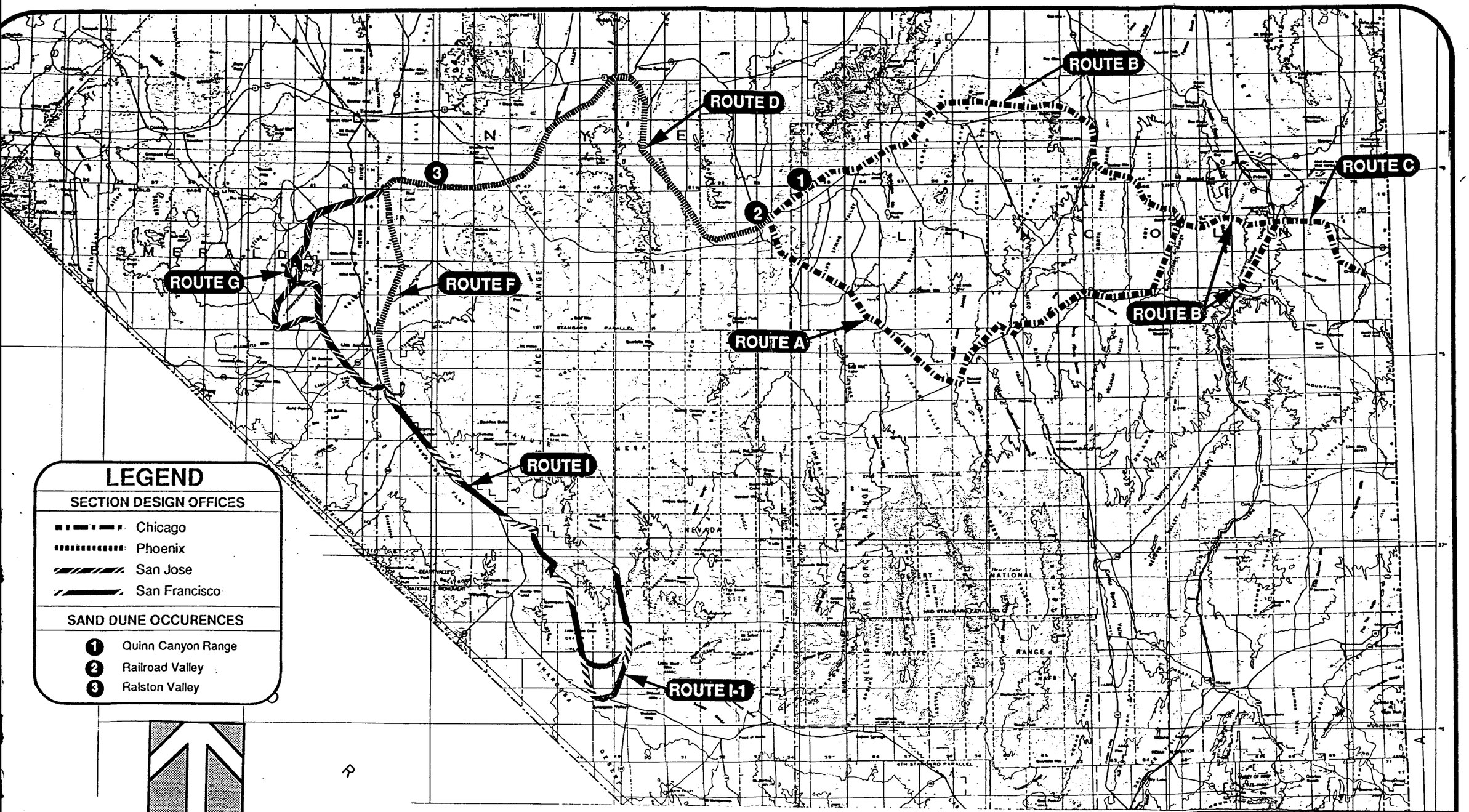
The conceptual route design is divided into four sections, each section being designed by a separate DCCO office. This report provides information and recommendations for the entire Caliente route, but the information can be easily discerned by the individual design section. The four design sections are identified on the Project Location Plan (Figure 2).

Investigation

The investigation consisted of a desk-top study with the main source of information being soil and geologic maps. Supporting data was also collected regarding groundwater, seismicity, mining and faulting.

Data collection was done in two concurrent efforts. The major effort involved identifying pertinent soils and geologic references and obtaining them from the particular agencies. The other effort required a literature search at local libraries and universities. Reports, documents, subsurface logs, maps and pertinent references were identified and obtained, where possible. These references provided information on seismicity, groundwater, faulting, mining, etc.

The study focused on mapping soil and rock formations within an alignment corridor approximately one to one and one-half miles wide. Since there are many



YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE

PROJECT LOCATION PLAN

prepared for: Science Applications International Corporation, Las Vegas, Nevada	FIGURE NO. 2
DeLEUW CATHER & COMPANY Engineers & Planners - San Francisco	PROJECT NO. PO4353

different soil and rock classifications throughout the alignment corridor, they are listed in tabular form elsewhere in this report. The listing includes pertinent soil and rock evaluations and interpretations to aid the designer when estimating various geotechnically related construction costs.

This report presents data currently available from the SCS. Where data was unavailable, evaluations and recommendations were based on extrapolation from similar landforms, adjacent soil and rock, and their physical properties relative to individual soil groups. For landform characteristics, topographical, geological and satellite image maps were used.

In addition to the collection of published information, two field trips were made. The first trip was a "windshield" survey, which consisted of driving along or near as much of the alignment as could be accessed by vehicle. The second field trip consisted of a two-day aerial survey by helicopter over the majority of the alignment. A narrated video film was made to aid various design offices in assessing their sections.

Regional Topography

The proposed railroad alignment lies entirely within the Great Basin region of the Basin and Range physiographic province, a region characterized by a series of generally north-trending mountain ranges separated by intermontane alluviated valleys. The mountain ranges are generally five to fifteen miles wide and rise 1,000 to 5,000 feet above adjoining valleys which are typically as wide as the mountain ranges. The northeast half of the alignment (Lincoln and Nye counties) have ranges that are typically elongated and extend more than 50 miles in a north

or northeasterly direction. In the southwest half of the alignment, the topography is irregular. The ranges either vary in shape or are almost equidimensional and bow-shaped having southward convexity. These ranges are separated by less clearly defined bow-shaped valleys. The zone of irregular topography (Walker Belt) extends in a northwesterly direction along the western Nevada border within Esmeralda and southwestern Nye Counties.

Meadow Valley Wash, a tributary of the Colorado River which drains the eastern part of the area, is the only integrated permanent outside drainage system. The remaining area drains into a number of local interior drainage basins, most of them containing playas (dry lakes). The main drainage flow in many of the intermontane valleys parallels the northeast striking valleys and is commonly ephemeral and partly submerged. The runoff apparently flows through the alluvium and along solution cavities and fractures in the Paleozoic carbonate rocks that underlie the basins and intervening highlands. Wind action has affected the intermontane valleys to different degrees. Deflated basins (blowouts), accumulation of sand in solitary dunes, dune fields and desert pavement are locally well developed. Vast tracts of sand dunes occur in southern Ralston Valley and part of Railroad Valley. The extreme southern end of Quinn Canyon Range is partly covered by sand (Figure 2).

Regional Geology

The rocks occurring along the alignment range in age from Precambrian to Quaternary.

The oldest exposed Precambrian Age rocks consist of, in ascending chronological order, the Wyman Formation, Reed Dolomite, Deep Spring Formation and Stirling Quartzite. Scattered outcrops occur in Esmeralda and southwestern Nye Counties.

The Wyman formation is composed of phyllitic siltstone and silty claystone and minor amounts of limestone, limy siltstone and very fine-grained sandstone. These strata are somewhat metamorphosed and well-bedded.

Reed Dolomite outcrops in Slate Ridge and on the northwestern slopes of Montezuma Peak. This formation of medium to coarsely crystalline dolomite appears structureless but this may be due to movement that has obliterated the original bedding. On the best exposure of the Reed Dolomite on Mount Dunfee, beds from one to four feet thick are common in much of the formation and the total thickness of the Reed Dolomite is over 1,500 feet.

The Deep Spring Formation is a heterogeneous unit about 1,800 feet thick containing siltstone, sandstone, quartzite and dolomite. It outcrops on Mount Dunfee on the west side of the Montezuma Range and six miles to the east-southeast of Mount Dunfee.

Exposures of Stirling Quartzite are scattered on Bare Mountain. This formation consists of quartzite with minor conglomerate, siltstone, phyllite and fine-grained sandstone and shale beds.

Cambrian Age strata are exposed at scattered localities throughout the project. The following formations have been described in literature: Wood Canyon,

Zabriskie Quartzite, Carrara, Poleta, Harkless, Mule Spring Limestone, Emigrant, Limestone and Dolomite, Highland Peak, Chisholm Shale and Pioche Shale. This listing does not present formations in chronological order, but as they occur along the project from its end in southwest Nye County.

The Wood Canyon Formation outcrops on Bare Mountain and overlies the Precambrian Stirling Quartzite. It consists of siltstone, quartzite, shale and dolomite beds.

The Zabriskie Quartzite conformably overlies the Wood Canyon Formation. This Early Cambrian Age rock is homogeneous fine- to coarse-grained quartzite with siltstone and micaceous quartzite transitioning into the underlying older strata. This rock is exposed on Bare Mountain and Bullfrog Hills and is overlain by the Carrara Formation.

The Carrara Formation consists of interstratified shale and limestone with minor amounts of sandstone and siltstone. This formation reaches a thickness of 1,500 to 1,785 feet.

The Poleta Formation is one of the most distinctive units in the Precambrian and Lower Cambrian sequence due to a variety of lithologic types and abundance of fossils. It outcrops fairly extensively on Clayton Ridge, Clayton Valley and Mount Jackson. The formation is composed of oolitic limestone, siltstone, phyllitic siltstone, sandstone and quartzite. The lower and upper members are dominantly limestone, whereas the middle member contains siltstone and minor quartzite and limestone.

The Harkless Formation of the Lower Cambrian sequence is 3,500 feet thick in most occurrences in Esmeralda County. It is divisible into two members - a quartzitic siltstone in the lower one-third of the formation and siltstone in the upper two-thirds of the formation. These strata outcrop on Slate Ridge, Mount Jack Ridge, Goldfield Hills and Montezuma Range and are overlain by two younger formations of early Cambrian Age; Mule Spring Limestone and the Emigrant Formation.

The maximum thickness of the Mule Spring Limestone is estimated to be 500 feet. Some locations are about 250 feet thick and these locations consist of thin beds of limy siltstone, silty limestone and limestone.

The Emigrant Formation consists of limestone, siltstone, shale, limestone and chert members. The total thickness of this formation as well as the thickness of the individual strata varies but can be up to 1,800 feet (Goldfield Hills).

Devonian Savy Dolomite and Simonson Dolomite are exposed in the Hiko, Pahranagat and Timpahute Ranges. The Savy Dolomite is up to 1,600 feet thick in the Pahranagat Range and cross-bedded with sandstone or quartzite seams. The coarse-grained Simonson Dolomite is 1,200 feet thick and widely exposed in Hiko Range. Smaller outcrops are found in the Pahranagat and Timpahute Ranges. Within the Devonian rocks of the Guilamette Formation, three distinct metamorphic facies are recognized; sandy limestone, limestone and dolomite. These facies interbed so that in most places there are rocks from two or all three of the facies. The sandy limestone facies consists of about 1,600 feet of limestone and dolomite that contain up to sixteen sandstone or quartzite beds.

The Cambrian rocks along the project in Lincoln County are represented by Limestone, Dolomite, Dunderberg shale and the Highland Peak Formation. The Highland Peak Formation outcrops over large areas in the Highland, Burnt Springs and Chief Ranges and in Black Canyon. It is composed of several types of limestone and dolomite and is fine- to coarse-grained and thin-bedded. The thickness of this formation is estimated to exceed 3,000 feet. The limestone, dolomite and Dunderberg Shale formation outcrops in Black Canyon, Burnt Springs Range and Highland Range.

Ordovician rocks in Nye County are exposed on Bare Mountain, the southern-most slopes of Hot Creek Range and the northern-most slopes of Kawich Range. In Lincoln County, there are several small outcrops in the Timpahute and Burnt Springs Ranges and in Black Canyon. The Pogonip Group, which is the single representative of the Ordovician Age along the alignment in Lincoln County, is up to 300 feet thick and composed of thin-bedded silty limestone.

Mississipian Age rocks in Nye County have been mapped on the northern part of Bare Mountain and are represented by the Eleana Formation consisting of shale, argillite, siliceous siltstone, quartzite conglomerate and minor limestone. The estimated thickness of this formation is 7,700 feet. Carboniferous strata of the Mississipian and Pennsylvanian Age are exposed at scattered locations in Pahranagat and Timpahute Ranges. They consist of limestone and clastic rocks up to 2,000 feet thick.

Mezozic Era rocks are represented by outcrops of coarse-grained plutonic bodies of menzonite and granodiorite and medium-grained rocks of dioritic and andesitic

composition. These outcrops occur northwest of Montezuma Range.

Tertiary volcanic and associated tuffaceous clastic rocks cover mountain ranges along the alignment in southwestern Nye County. Massive formations of ash-fall tuffs lie on Yucca Mountain and the northern fringes of the Sarcobatus Flat. Welded tuff consisting of rhyolitic ash flow is mapped on the northeastern slopes of Bullfrog Hills and east of Springdale where it covers the western slopes of the Timber Mountain Caldera. Massive outcrops of rhyolite occur north of Bullfrog Hills. Tertiary basalt flow outcrops in the central part of Sarcobatus Flat.

Vast areas of surficial strata in Goldfield Hills are formed by the Siebert Tuff Formation consisting of tuff, tuffaceous shale and diatomite. The other common formation in the Goldfield Hills is the Thirsty Canyon Tuff. At scattered locations, the rhyolitic welded ash flows, Milltow Andesite and the rhyolites of the Sandstone Formation are mapped. Thirsty Canyon Tuff and Siebert Tuff have been deposited on the northwestern slopes of Mount Jackson Ridge. The central part of Montezuma Range consists of welded and non-welded ash flows with sizable outcrops of dark rhyolite. The ash flows also cover the northwestern slopes of Montezuma Peak and northwestern Goldfield Hills. The Tertiary rocks in Ralston Valley, Cactus Flat and Stone Cabin Valley outcrop at a few locations and consist of rhyolite flows. The outcrops of welded tuff, ash-fall tuff and tuffaceous sedimentary rocks have been mapped around the southern and eastern slopes of Monitor Hills. The northern part of Kawich Range is built of a massive body of tuffaceous rocks and ash flow tuffs. Locally, smaller bodies of silicic lavas consisting of rhyodacitic and andesitic rocks are encountered.

A variety of Tertiary rocks outcrop along Hot Creek between Reveille Range and Pancake Range. They are: rhyolitic ash flow tuff, tuff of Bald Mountain, silicic tuffs, intrusive bodies and sedimentary strata.

The two major groups of Tertiary rocks exposed throughout the project in Lincoln County are the younger volcanic rocks and the later Tertiary lake bed deposits and unconsolidated rocks. The first group consists of volcanic rocks and intravolcanic sediments composed largely of volcanic fragments. The second group consists of Pliocene Age lake beds and tilted postvolcanic gravels of unknown age. The vast body of younger volcanic rocks are deposited on the southern slope of Quinn Canyon Range. They also cover large areas of the basin between Irish Mountain, Pahranagat Range and East Pahranagat Range and are widely exposed in North Pahroc Range and on the northern slopes of South Pahroc Range. These rocks are not sub-divided further because of complex stratigraphic relations within the group as a result of several periods of local structural movement and past erosion.

The older volcanic rocks related to the Oligocene and Eocene Ages fill the area between Groom and Timpahute Ranges. These rocks are also exposed on the slopes of Burnt Springs Range, The Bluffs, Chief Range and the Black Canyon, and cover vast areas on both sides of State Highway 319 east of Panaca, Nevada. Tuffs and tuffaceous sediments are exposed in Quinn Canyon, Timpahute, and South Pahroc Range and along State Highway 319.

A distinctive ignimbrite layer is widely exposed in Pahranagat Range and outcrops in Hiko Range. Older lake beds of the Panaca and Muddy Creek Formations cover a

large area of the Meadow Valley and outcrop on the southeastern and western slopes of Pahranagat Valley. The older Pliocene gravels cover the southwestern slopes of the Timpahute Range and the western slopes of Hiko Range.

Alluvial deposits of Tertiary and Quarternary Age cover 70 percent of the project area. They consist of fluviatile gravels flanking mountains and grading into fluviatile and lacustrine sand and silt in the valleys.

Basin floor deposits consist of sandy silts and silty sand and become coarser-grained toward the active drainages. The material is typically low to medium plasiticity, however, generally higher plasiticity may be related to the soil containing a higher percentage of the volcanic rock detritus. Volcanic detritus is commonly much finer-grained than that derived from the Paleozoic sedimentary rocks. Debris from quartzite areas is particularly coarse.

Gravels dip approximately five degrees outward from the mountain fronts and are overlain by colluvium and talus at the range base. Older alluvium and gravels are as much as 1,000 to 2,000 feet thick in the deeper basins.

The intermediate and younger lake beds of Late Pleistocene Age are found in Sand Spring, Dry Lake, Railroad, Reveille, Ralston, and Lida Valleys. Sediments deposited in these lakes were largely reworked silt and clay that were first deposited in the older and larger lakes of Pliocene Age, which occupied many of these same basins. The thickness of the intermediate and younger lake beds is probably much less than the thickness of the Pliocene Lake beds, but in many basins the beds make a continuous section that cannot be distinguished.

Recent sediments are divided into three units on the geologic map: recent playa deposits, dune sand and younger alluvium. The recent playa sediments are relatively thin deposits of largely reworked silt and clay derived from older lacustrine sediments presently exposed in the drainage basins of the playas. The amount of sediment derived directly from the surrounding mountain blocks is considered to be negligible under present climatic conditions.

Dune sand is mapped along the project in Sand Springs, Ralston and Railroad Valleys. Each area is east of a playa from which the sand was derived. The sand is estimated to be less than 100 feet thick.

Younger alluvium is associated with recent drainage channels which includes reworked older alluvium. Thin veneers of younger alluvium on lake beds, playas, older alluvium and gravel are generally included with the older deposits.

Faulting

The earliest tectonic imprints in Nevada are related to a complex series of events consisting largely of compressional folding and thrusting in the Mesozic Era and the breakup of the supercontinent, Pangaea.

Two thrust faults of that age occur in the project area: Highland and Pahranagat Range Thrust.

The most important tectonism of Cenozoic Age consisted of crustal extension that produced the present day block-faulted basins and ranges. The structural deformation within the project area can be divided into the following types:

(1) folding and thrusting and related tear faulting; (2) strike-slip (wrench) faulting; (3) cauldron subsidence, doming and high-angle faulting related to volcanic activity; (4) Basin-Range high-angle normal faulting: (5) gravity sliding.

The most prominent structural features are shown on Figure 3. A brief description of these features follows:

Bare Mountain - The intense deformation by folding, intense thrust and right-lateral faulting caused the rocks to dip northward in successive blocks separated by tear faults and low-angle undulating thrust faults. The tear faults have right-lateral displacements, strike approximately north-south, and dip 50 to 80 degrees east. Bare Mountain is bounded on the east and west flanks by Basin-Range normal faults with downward movement in the valleys.

Bullfrog Hills - A series of normal faults dropping the volcanic rocks downward successively to the northwest is related to subsidence from the caldera rim. Similar movement of the downward drop of north and northwest striking faults may explain the postvolcanic tectonics at the southwest rim of Timber Mountain caldera.

Goldfield Hills and Mount Jackson Ridge - A number of northeastward-trending high-angle faults cut upper and lower plate rocks in the central part of Goldfield Hills. There is one distinctive, low-angle east striking thrust fault that is transverse to the range. In the central Mount Jackson Ridge, numerous high-angle faults strike northeast cutting the Cambrian Age strata.

Montezuma Range - A system of high-angle faults strike northeast on the western side of Montezuma Peak and the northeast end of Montezuma Range. Just off the northwest end of the Montezuma Range is a northwest-trending ridge about three miles long composed of gently folded Harkless Formation intruded by westward-dipping rhyolite and diorite dikes. The presence of several small plutons and numerous dikes suggests that the entire north end of the Montezuma Range is underlain by plutonic rock at shallow depth.

In the northern part of Kawich Range, the ash flow tuffs have been intruded by a large irregular body of porphyritic rhyodacite. Thrust faults generally follow the contours of intrusion. Two normal faults converge as they trend to the Hot Creek Valley. A system of normal faults trending northwest flanks the Kawich and Revielle Ranges on both the east and west sides. The number of short normal faults striking northwest increases on both sides of the northeast rim of the Caldera in the central part of Kawich Range. This faulting is related to the volcano-tectonic activity in the late Tertiary Age.

The southern part of Quinn Canyon Range shows very limited tectonic discontinuities. One exception is a basaltic outcrop at Sand Spring Valley which shows north, west, and northeast striking high-angle faults developed as the basaltic body intruded older tuffaceous deposits.

Two major normal faults of post-Laramide Age traverse the western slopes of Timpahute Range. Namely, the Penoyer and Tempiute Faults. At least two major prevolcanic thrust plates are located in this range within the Carboniferous and

Devonian rocks. In the Worthington Mountains, the principal structure is the Freiberg thrust with Cambrian and Ordovician rocks at the base.

In Pahranagat and East Pahranagat Ranges, three structural blocks of pre-Tertiary formations are recognized. From the west to the east they are: the east dipping homoclinal sequence of Paleozoic rocks that makes up the high crest of Pahranagat Range, the thrust plate on the east side of the Pahranagat Range, and the overturned fold belt in the East Pahranagat Range.

The most western thrust is cut by many normal faults that strike east to northeast.

In the central part of the Hiko Range, several major high-angle faults striking east and northeast are mapped in the body of Paleozoic and Tertiary sedimentary rocks. A system of post-Laramide normal faults trending north and dipping steeply east breaks up the Tertiary Age rocks of the Pahroc Range. The stratigraphic separation of the volcanic rocks on these faults is less than a few hundred feet, however, the displacement of the Paleozoic strata may be much greater. The western-most of these faults, the Pahroc fault, extends in a north-south direction for over 46 miles. The White River fault which separates Pennsylvanian and Permian Age rocks from a volcanic body, can be traced continuously nearly 11 miles.

The Burnt Spring Range is the southwestern extension of the structure in Ely Springs and Black Canyon. The upper Cambrian Age rocks are highly faulted

against the Highland Peak Formation. The faults strike varies from northwest to northeast surrounding the body of younger volcanic rocks.

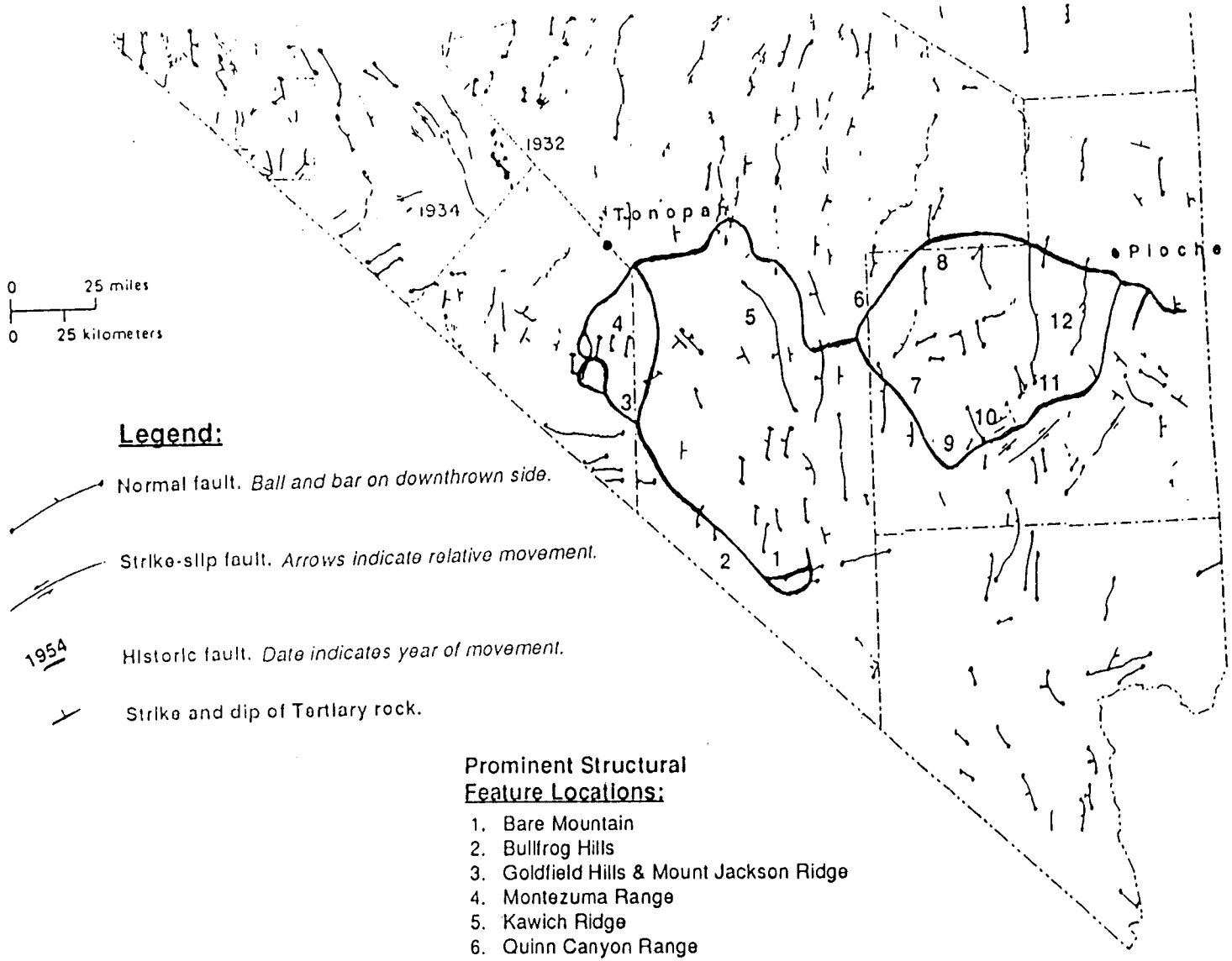
The major Laramide structure in the Highland Range is the Highland Thrust. The Highland Range consists of two structural elements. The first is the east-tilted fault block which makes up the main part of the range; the second is the Highland thrust plate. Several normal faults striking northeast are mapped around the thrust.

It is difficult to generalize about the structure of an area as large and as complex as more than 600 miles of railroad which crosses ranges and valleys of different geological eras and orogenic histories. The complexity of the structure shown on Figure 3 depicts only major tectonic features. Each thrust and fault is surrounded or flanked by a large number of high-angle faults up to several hundred feet long cutting beds into blocks.

Seismicity

The State of Nevada lies within the Basin and Range province, one of the most seismically active regions in the United States. Nevada ranks in the top three states subject to the largest earthquakes over the last 150 years. The historical earthquake record is shown on Figure 4.

A number of earthquakes between Richter magnitude 4 and 6 occurred within the proposed alignment area between 1930 and 1960. These events (shown on Figure 5) were derived from the Earthquake Epicenter Map of Nevada and are described below:



Legend:

Normal fault. *Ball and bar on downthrown side.*

Strike-slip fault. *Arrows indicate relative movement.*

1954 Historic fault. *Date indicates year of movement.*

Strike and dip of Tertiary rock.

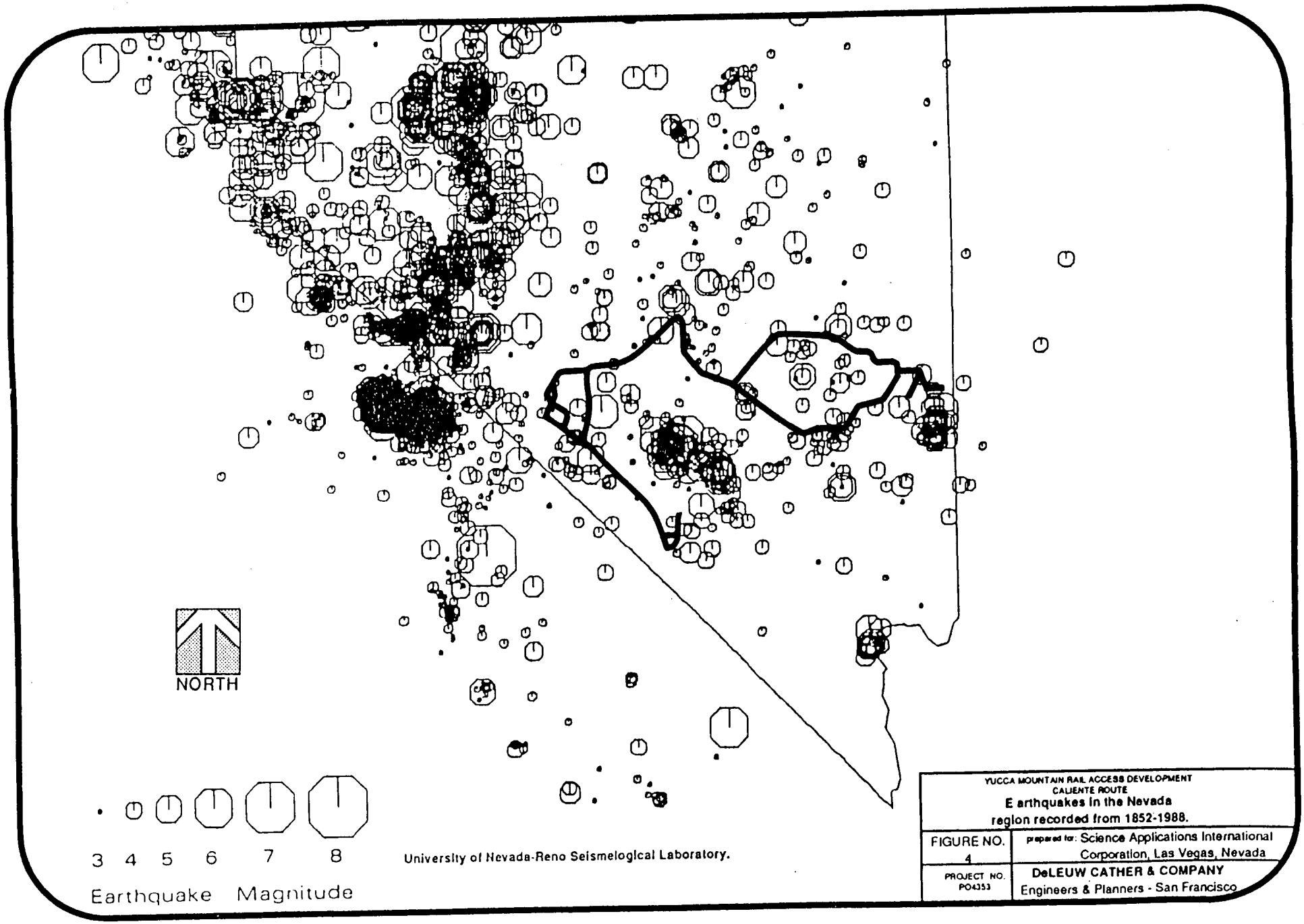
Prominent Structural Feature Locations:

1. Bare Mountain
2. Bullfrog Hills
3. Goldfield Hills & Mount Jackson Ridge
4. Montezuma Range
5. Kawich Ridge
6. Quinn Canyon Range
7. Timpahute Range
8. Worthington Mountain
9. Pahrangat Range
10. Hiko Range
11. Pahroc Range
12. Highland Range

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE

LATE QUATERNARY AND HISTORIC FAULTS

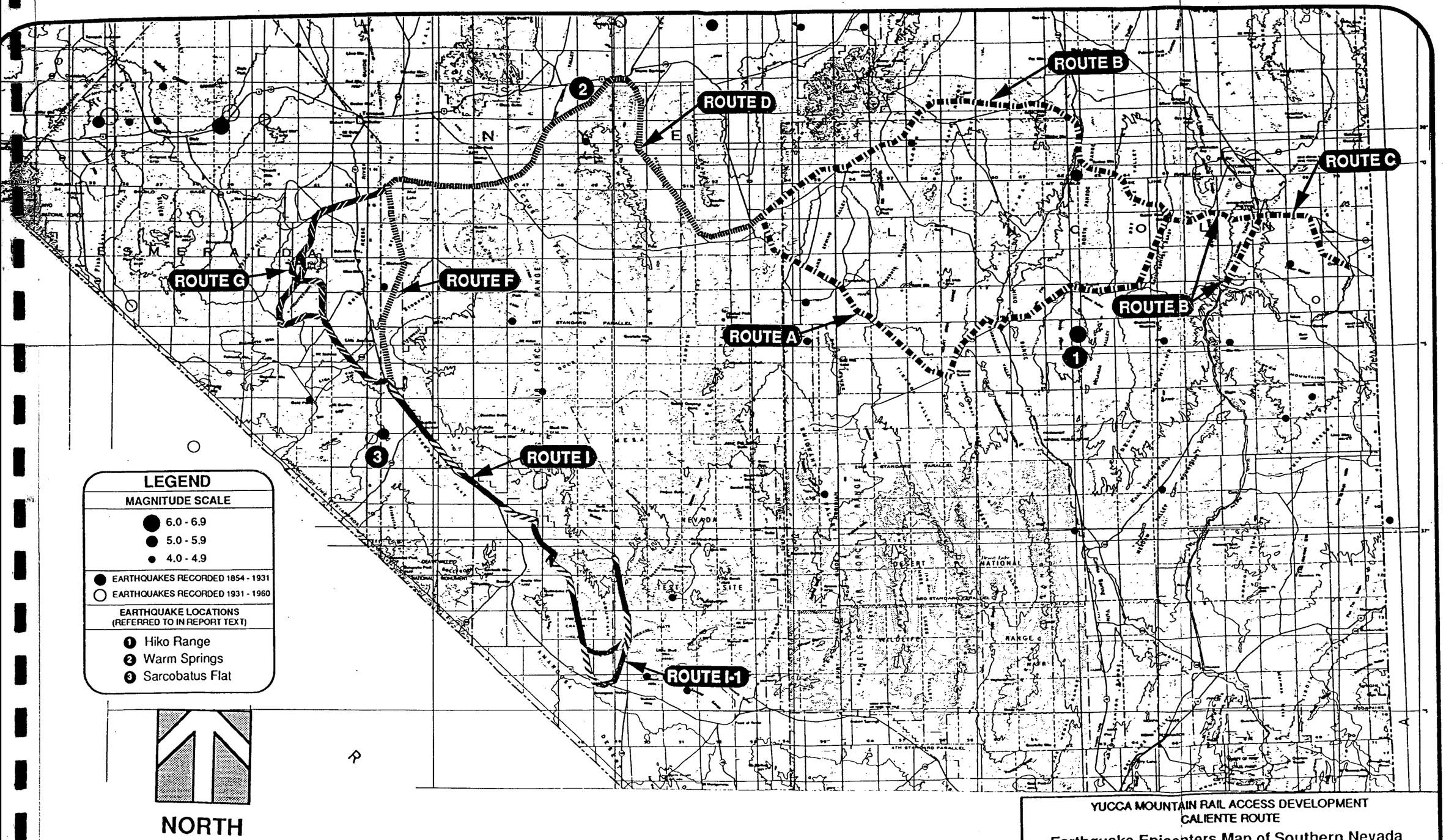
FIGURE NO. 3	prepared by: Science Applications International Corporation, Las Vegas, Nevada
INDUCT NO. 104352	DeLEUW CATHER & COMPANY Engineers & Planners · San Francisco



YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE

Earthquakes in the Nevada region recorded from 1852-1988.

FIGURE NO. 4	prepared for: Science Applications International Corporation, Las Vegas, Nevada
PROJECT NO. PO4353	DeLEUW CATHER & COMPANY Engineers & Planners - San Francisco



SOURCE: D.B. Slemmons and J.I. Gemlett, 1964.

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE

Earthquake Epicenters Map of Southern Nevada

prepared for: Science Applications International Corporation, Las Vegas, Nevada	FIGURE NO. 5
DeLEUW CATHER & COMPANY Engineers & Planners - San Francisco	PROJECT NO. P04353

Two events exceeding magnitude 6 occurred in the Hiko Range south of Highway 93. Four consecutive earthquakes of magnitude 5 to 5.9 occurred at Warm Springs and Sarcobatus Flat. Smaller events were also recorded along the alignment.

Richter magnitudes above 5 or 5.5 are potentially destructive at the epicenter. Although earthquakes do not occur at regular intervals, the average frequency of earthquakes of magnitude 6 and greater in Nevada has been about one every ten years, while earthquakes of magnitude 7 and greater average one every 27 years. Although the largest historical earthquakes occurred some distance from the alignment, they could induce land or rock slides and cause damage to the railroad system. Geologically young faults, which are the source of the earthquakes, can be found throughout the alignment.

Though there has been no recent tectonic activity within the project area the stability of cut slopes and base foundation support must consider potential seismicity as well as strata bedding, joint orientations and structural discontinuities.

Mining

Nevada is ranked among the top gold and silver producers in the United States. These and other precious metals and industrial mineral deposits, result in Nevada leading the nation in the number of mining claims filed with the U.S. Bureau of Land Management.

One of the considerations when establishing the proposed alignment is whether it conflicts with mining activities.

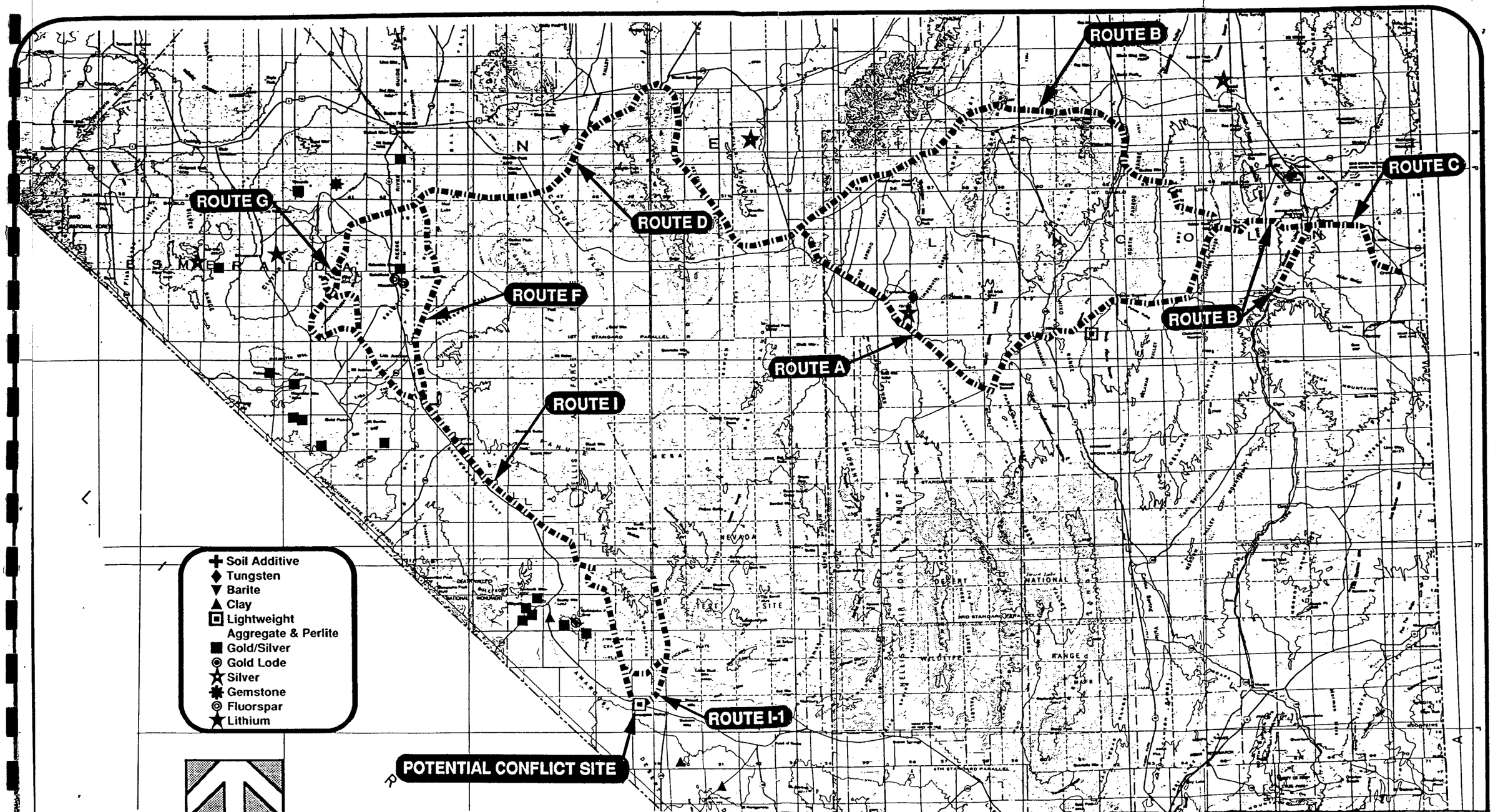
While some mining operations can go on for years, many are short-term, lasting two or three years. Because of this, a long-term project such as the proposed Caliente alignment may conflict with mining claims not yet established. A research of current literature (1989) indicates that there are several mines near the proposed route; therefore, slight alignment adjustments could result in conflict.

There is a potential conflict on Route I-1 along US95, north-northeast of Lathrop Wells, as shown on Figure 6. Potential conflict, as well as any recent claims, started subsequent to the study should be investigated before establishing a final alignment.

Groundwater

Groundwater must always be considered and designed for when it is encountered in civil engineering projects. Since the Caliente Route traverses such a large area, the level of groundwater will vary significantly. Figure 7 shows the Caliente Route relative to groundwater levels from a 1984 study. Most of the proposed alignment is in areas where the groundwater is greater than 100 feet below the ground surface.

There are, however, four potential areas along the route from the 1984 study where groundwater is recorded at 30 feet or less below ground surface. This information is based on well logs from the 1960's. Although the data from the well logs and the 1984 study are over 20 years apart, the recorded ground water levels from both studies are approximately the same.



SOURCE: Nevada Bureau of Mines and Geology, 1984.

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE

MINING ACTIVITIES

prepared for: Science Applications International Corporation, Las Vegas, Nevada

FIGURE NO. 6

DeLEUW CATHER & COMPANY
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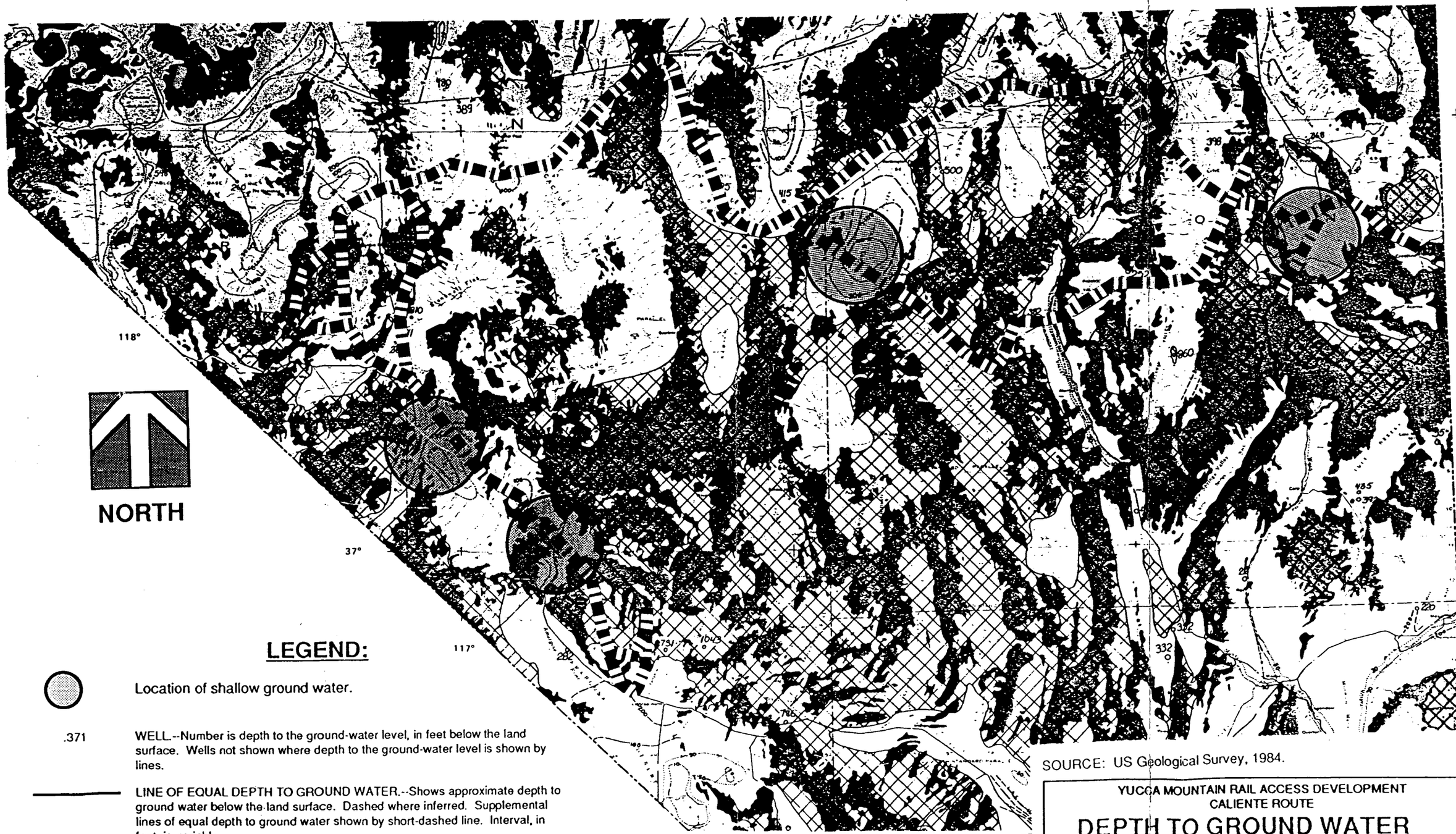
PROJECT NO. PO4353



LEGEND:

Location of shallow ground water.

.371 WELL.--Number is depth to the ground-water level, in feet below the land surface. Wells not shown where depth to the ground-water level is shown by lines.

LINE OF EQUAL DEPTH TO GROUND WATER.--Shows approximate depth to ground water below the land surface. Dashed where inferred. Supplemental lines of equal depth to ground water shown by short-dashed line. Interval, in feet, is variable.

AREA WITHIN WHICH DEPTH TO GROUND WATER MAY BE EQUAL TO OR GREATER THAN 500 FEET BELOW THE LAND SURFACE.--May include local areas of shallow, perched water. Locally, wells showing depth to ground water greater than 500 feet may occur outside ruled areas.

SOURCE: US Geological Survey, 1984.

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE

DEPTH TO GROUND WATER

prepared for: Science Applications International Corporation, Las Vegas, Nevada	FIGURE NO. 7
DeLEUW CATHER & COMPANY Engineers & Planners - San Francisco	PROJECT NO. PO4353

One area is at the eastern end of the route, north of Caliente. Well logs indicate water levels typically at 30 feet and as shallow as five feet. This segment of the route uses existing track, but any new construction may have to consider the shallow water level.

The second area is located in Sand Spring Valley; however, most of the well logs in this area indicate the groundwater level to be greater than 100 feet below ground surface.

The third area is located in Sarcobatus Flat, southeast of Scotty's Junction. Data from well logs indicate a ground water level as shallow as 15 feet.

A fourth area was identified where the alignment is northeast of Beatty; however, well logs were not found for this location. The pattern of the contours indicate the groundwater levels to be in the range of 10 to 30 feet below the ground surface.

Unless there is substantial cut, most of the alignment will not be directly affected by groundwater. The areas of measured shallow groundwater levels are in the flat valleys and will not typically require deep excavations except where drilled shafts are required to support structures. Depending on the subsurface material, caving or sloughing during shaft excavation is possible which would require the use of slurry, grouting or full or partial depth casing.

A more detailed study of the groundwater conditions and drainage features will be done by others and should be referred to when specific hydrologic information is

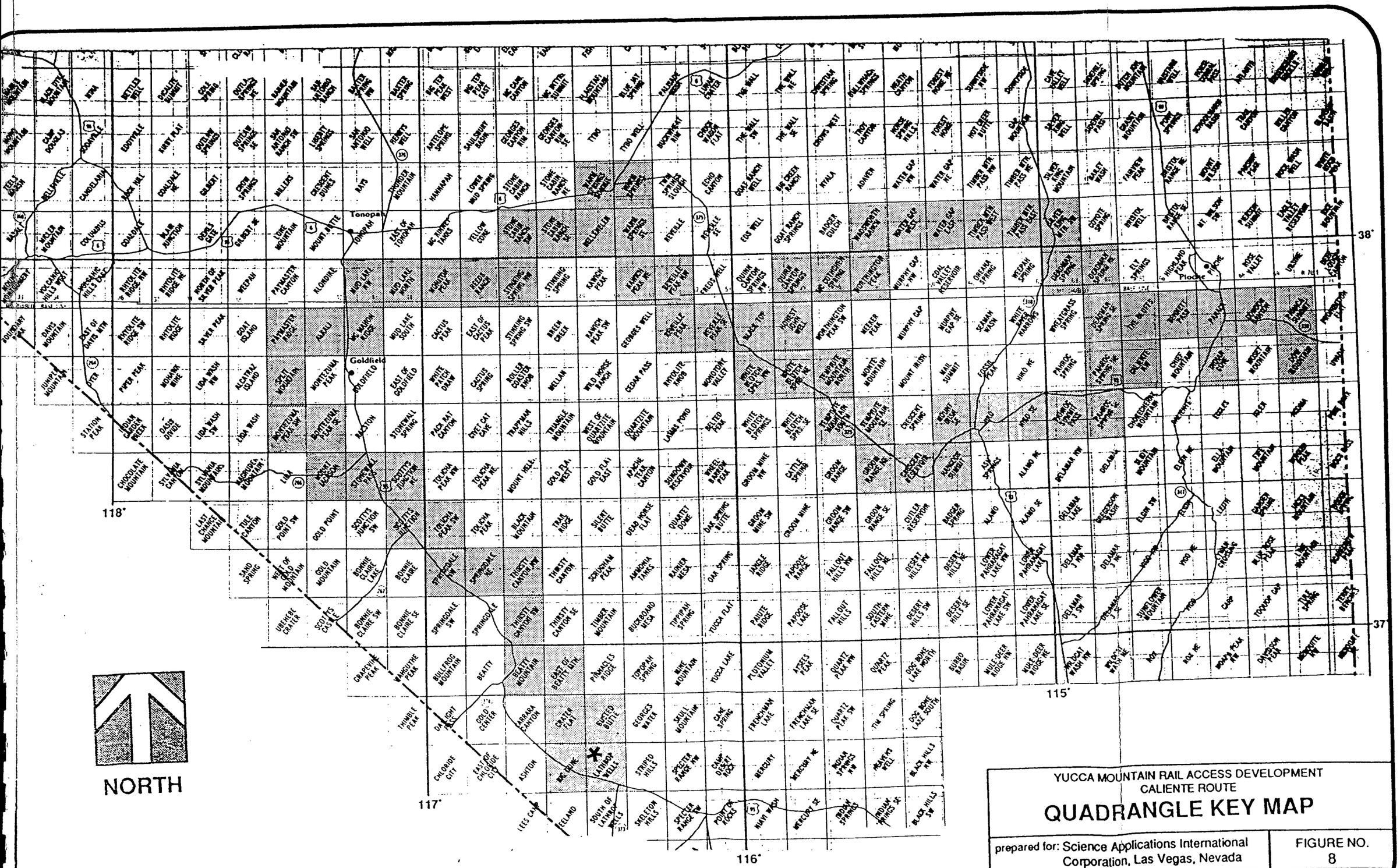
required. Soundings in active wells along the alignment should be done to confirm current water levels.

Soil and Rock Parameters and Characteristics

Soil and rock have been identified along the Caliente alignment and mapped on U.S. Department of the Interior 7-1/2 minute series topographical quadrangle sheets. A key map (Figure 8) highlights those quadrangle sheets which contain a segment of the proposed Caliente alignment. The quadrangle sheets are arranged alphabetically and are included with this report.

There are three categories of soil symbols shown on the quadrangle sheets:

1. SCS soil symbols with SCS assigned soil properties.
2. SCS soil symbols which have not as yet been assigned properties by the SCS. These symbols are enclosed in parentheses and are intended for future reference in case SCS properties become available later.
3. Generalized symbols to be used in place of the symbols enclosed in parentheses. These symbols include:



*THIS QUADRANGLE IS NOW NAMED AMARGOSA VALLEY

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE

QUADRANGLE KEY MAP

prepared for: Science Applications International Corporation, Las Vegas, Nevada	FIGURE NO. 8
DeLEUW CATHER & COMPANY Engineers & Planners - San Francisco	PROJECT NO. PO4353

Mz - mesozoic and older rock outcrops

Qaf - alluvial flat and lake deposits

Qed - eolian deposits

Qfn - alluvial fan deposits

Qsd - alluvial stream deposits

Qt - talus slopes

Tbg - basaltic or granite outcrops

Tt - tertiary rock outcrops

Table 1 is a summary of the properties of the soils mapped on the 7-1/2 minute quadrangle sheets. This table is also arranged alphabetically by quadrangle sheet name. Soil symbols in Table 1 correspond to the SCS soil symbols for which properties are available and for generalized soil symbols for which properties have been assigned.

The information contained in Table 1 refers to the soils found within the upper five feet of existing ground. It is assumed that the upper one- to two-foot layer of soil will be removed as a result of normal clearing and grubbing operations; therefore, that data is not included in Table 1.

There is, in some instances, information on the tables or maps which could not be interpreted directly from the SCS data or which did not have a Soil Conservation study available. Where possible, information was inferred from other available information and noted on the tables and maps.

Table 1 - Soil Parameters and Characteristics

Quadrangle Name	Soil Symbol	Soil Classification USCS	Soil Classification AASHTO	Source of Gravel	Source of Sand	Shrink/ Swell	Corrosivity Steel	Corrosivity Concrete	Depth to Bedrock	Frost Action	*Cut Slope H:V	Excavatability
ALKALI	101	SC,SM-SC,SP-SM,GP,GP-GM	A-1,2,6	Pr	Pr	L-M	H	L		L	3:1	
	108	SC,SP,SM-SC,SP-SM,GP,GP-GM	A-1,2,6	Pr	Pr	L-M	H	L		L	3:1	
	111	SM,SM-SC,GC,GM,GM-GC	A-1,2,4,6,7	IP	IP	L-M	H	L	<5'	L	3:1	
	122	SM,SP,SP-SM,GM,GP,GP-GM	A-1,2	Pr	Pr	L	H	L		L	2:1	
	327	SM,SP-SM,GC,GM,GP,GP-GM	A-1,2	F	F	L	H	L-H		L	2:1	
	400	SM,GM,GC,GP,GP-GM,GM-GC	A-1,2	Pr	Pr	L	H	L		L	2:1	
	Qaf										3:1	
	Qap										3:1	
AMARGOSA VALLEY	Qfn										3:1	
	Qt										3:1	
	Tt										1:1	
BEATTY MOUNTAIN	Qfn										3:1	
	Qsd										3:1	
	Tt										1:1	
BELLEHELEN	3130	SM,SP,GM,GP,GP-GM*	A-1,2*	Pr*	F*	M	H	L		L	2:1	Slightly hard, friable
	3134	SM,SP,GM,GP,GP-GM*	A-1,2*	Pr*	F*	L-M	H	L		L	2:1	Slightly hard, friable
	3226	CL,ML*	A-4,7*	U*	U*	L-M	M	L	<5'	M	3:1	Soft, v. friable
BENNETT PASS	BA	TOO VARIABLE FOR ESTIMATES									3:1	
	DMD	Hardpan, GM	A-1	U	U	L	H	H		L	2:1	
	Mz										1:1	Rippable Hardpan
	Qfn										3:1	
	Qt										3:1	
	US	GM	A-1,2	U	U	L	H	H		M	2:1	
BIG DUNE	Qfn										3:1	
	Tbg										1:1	
	Tt										1:1	
BLACK TOP	Amb	HARDPAN,SM,GM	A-1-b	U	F-G	L	H				2:1	Dense Hardpan
	FgA	SM	A-2,4	U	P	L	H				3:1	Easy
	LsC	GM	A-1-a	F-G	F	L	H				2:1	Easy, Sand & Gravel Increase w/ Depth
	NeD	GM,SM	A-4	P	U	L	H		<5'		3:1	Bedrock Less Than 20"
	RI	PROPERTIES NOT ESTIMATED									3:1	
BUSTED BUTTE	Qfn										3:1	
	Qsd										3:1	
	Qt										3:1	
	Tt										1:1	
CALIENTE NW	Qfn										3:1	
	Qsd										3:1	
	Qt										3:1	
CONDOR CANYON	ACC	SM, SP-SM	A-1,2	U	F	L	H	H		L	2:1	
	AE	SM, SP-SM	A-1,2	U	F	L	H	H		L	2:1	
	BA	TOO VARIABLE FOR ESTIMATES									3:1	
	CG	SM	A-1	P	P	L	H	H		M	2:1	
	HDC	SM	A-1,2	U	P	L	H	H		M	2:1	
	IO	GC	A-2,6,7	U	U	M	H	H	<5'	M	3:1	
	KO	SC, SC-SM	A-4	U	U	L	H	H	<5'	L	3:1	
	VGC	GC, GP-GM	A-1,2,4	F	F	L-M	H	H		L-H	3:1	Rippable Hardpan
	ZOF	GC	A-6	U	U	M	H	H	<5'	M	3:1	
CRATER FLAT	Qfn										3:1	

Table 1 - Soil Parameters and Characteristics

Quadrangle Name	Soil Symbol	Soil Classification USCS	Soil Classification AASHTO	Source of Gravel	Source of Sand	Shrink/ Swell	Corrosivity Steel	Corrosivity Concrete	Depth to Bedrock	Frost Action	*Cut Slope H:V	Excavatability
CRESCENT RESERVOIR	Mz										1:1	
	Qfn										3:1	
	Qt										3:1	
DEADMAN SPRING	Qfn										3:1	
	Qt										3:1	
DEADMAN SPRING NE	Qaf										3:1	
	Qfn										3:1	
	Qsd										3:1	
	Qt										3:1	
DEADMAN SPRING SE	Qaf										3:1	
	Qfn										3:1	
DOW MOUNTAIN	CE	SC	A-2,6,7	U	U	M	M	M	<5'	H	3:1	
	DA	ML	A-4	U	U	L	H	H	<5'	H	3:1	
	FAC	SC,CL,SM-SC	A-2,6	U	U	M	H	H		H	3:1	
	IO	GC	A-2,6,7	U	U	M	H	H	<5'	M	3:1	
	IR	GC	A-2,6,7	U	U	M	H	H	<5'	M	3:1	
EAST OF BEATTY MTN	Qfn										3:1	
	Tt										1:1	
EAST OF GOLDFIELD	Qfn										3:1	
	Qt										3:1	
	Tt										1:1	
GOLDFIELD	369	SC,SM,SM-SC,GC,GM	A-1,2,6	IP	IP	L-M	H	L	<5'	L	3:1	
	Qfn										3:1	
	Qt										3:1	
GROOM RANGE NE	Qfn										3:1	
HANCOCK SUMMIT	Qfn										1:1	
HIKO	Mz										3:1	
	Qal										3:1	
	Qfn										3:1	
	Qt										3:1	
HIKO SE	Qfn										3:1	
	Qt										2:1	Dense, Hardpan
HONEST JOHN WELL	Amb	HARDPAN,SM,GM	A-1-b	U	F-G	L	H				3:1	
	RI	PROPERTIES NOT ESTIMATED									3:1	Hardpan, Dense, Basalt at 30°
	SID	CL,HARDPAN	A-6,7	U	U	M	H		<5'		2:1	Rippable Hardpan
	TIC	GM	A-1-a	U	U-P	L	H			L	3:1	
INDIAN COVE	Gh	ML	A-4,5	U	U	L	H	H		H	3:1	
	Pa	CL	A-6,7	U	U	M	H	H		H	3:1	Slightly hard, v. friable
KAWICH PEAK NE	3610	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	M	H	L	<5'	L	3:1	Hard, friable
	3640	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L-M	H	L		M	3:1	Hard firm
	3740	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L-M	H	L		L	3:1	Hard firm
	3741	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L	H	L		L	2:1	V. hard, firm to soft, friable
	3810	SM,SP,GM,GP,GP-GM*	A-1,2*	Pr*	F*	L-M	H	L		L	2:1	V. hard, firm to soft, friable
	3811	SM,SP,GM,GP,GP-GM*	A-1,2*	Pr*	F*	L-M	H	L		L	3:1	
MC CUTCHEN SPRING	Qfn										3:1	
	Qt										3:1	
MC MAHON RIDGE	101	SC,SM-SC,SP-SM,GP,GP-GM	A-1,2,6	Pr	Pr	L-M	H	L		L	2:1	
	122	SM,SP,SP-SM,GM,GP,GP-GM	A-1,2	Pr	Pr	L	H	L		L	3:1	
	144	SM,SC,GM,GP,GP-GM,GM-GC	A-1,2,6	IP	IP	L-M	H	L		L	2:1	
	222	SM,SC,GM,GC	A-1,2	IP	IP	M	H	L	<5'	L	3:1	
	280	GM,GC,GP-GM	A-1,2,7	IP	IP	L-M	H	L	<5'	L	3:1	
	281	SM,SM-SC,GM,GC	A-1,2,6	IP	IP	L	H	L	<5'	L	3:1	
	362	SM,SM-SC,GC,GM	A-1,2,6	IP	IP	L	H	L	<5'	L	3:1	
	364	SM,SC,SM-SC,GC,GM,GP-GM	A-1,2,6	IP	IP	L-M	H	L	<5'	L	3:1	
	Qfn										3:1	

Table 1 - Soil Parameters and Characteristics

Quadrangle Name	Soil Symbol	Soil Classification USCS	Soil Classification AASHTO	Source of Gravel	Source of Sand	Shrink/ Swell	Corrosivity Steel	Corrosivity Concrete	Depth to Bedrock	Frost Action	*Cut Slope H:V	Excavatability
MONITOR PEAK	Qaf										3:1	
	Qap										3:1	
	Qfn										3:1	
	Qt										3:1	
MONTEZUMA PEAK	200	CL,SC,SM,GC,GM,GP-GM,GM-GC	A-1,2,6	F	F	L-M	M-H	L	<5'	M	3:1	
	201	CL,SM,SC,GC,GM,GP-GM,GM-GC	A-1,2,6	Pr	Pr	L-M	H	L		L-M	3:1	
	230	SM,SM-SC,GC,GM-GC	A-1,2,6	IP	IP	L	H	L	<5'	L	3:1	
	237	GC,GM,GM-GC	A-1,2	IP	IP	L	M	L	<5'	M	2:1	
	273	CL,SC,SP,SM,SP-SM,GC,GM,GP-GM,GP	A-1,2	F	F	M	H	L-H		L	2:1	
	362	SM,SM-SC,GC,GM	A-1,2,6	IP	IP	L	H	L	<5'	L	3:1	
	446	SM,SP,GM,GP,GP-GM	A-1,2	Pr	F	L	H	L		L	2:1	
	Qfn										3:1	
	Tt										1:1	
MONTEZUMA PEAK SE	180	CL,ML,CL-ML	A-4,6	IP	IP	L-M	M-H	L	<5'	M	3:1	
	230	SM,SM-SC,GC,GM-GC	A-1,2,6	IP	IP	L	H	L	<5'	L	3:1	
	237	GC,GM,GM-GC	A-1,2	IP	IP	L	M	L	<5'	M	2:1	
	355	CL-ML,ML,SM,SM-SC,GM	A-1,2,4	IP	IP	L	H	H	<5'	L	3:1	
	362	SM,SM-SC,GC,GM	A-1,2,6	IP	IP	L	H	L	<5'	L	3:1	
	400	SM,GM,GC,GP,GP-GM,GM-GC	A-1,2	Pr	Pr	L	H	L		L	2:1	
	422	SM	A-1,2	IP	IP	M	H	L		L	2:1	
	446	SM,SP,GM,GP,GP-GM	A-1,2	Pr	F	L	H	L		L	2:1	
	Qfn										3:1	
	Qt										3:1	
	Tt										1:1	
MONTEZUMA PEAK SW	111	SM,SM-SC,GC,GM,GM-GC	A-1,2,4,6,7	IP	IP	L-M	H	L	<5'	L	3:1	
	112	GM	A-1	IP	IP	L	H	L	<5'	L	2:1	
	122	SM,SP,SP-SM,GM,GP,GP-GM	A-1,2	Pr	Pr	L	H	L		L	2:1	
	225	SC,SM,GC,GM,GP	A-1,2	IP	IP	L-M	H	L	<5'	L	2:1	
	237	GC,GM,GM-GC	A-1,2	IP	IP	L	M	L	<5'	M	2:1	
	280	GM,GC,GP-GM	A-1,2,7	IP	IP	L-M	H	L	<5'	L	3:1	
	362	SM,SM-SC,GC,GM	A-1,2,6	IP	IP	L	H	L	<5'	L	3:1	
	460	GP, GP-GM	A-1	Pr	IP	L	H	L		L	2:1	
	462	GP, GP-GM	A-1	Pr	IP	L	H	L		L	2:1	
	Mz										1:1	
	Qfn										3:1	
	Qt										3:1	
MOUNT IRISH SE	Qfn										3:1	
	Qt										3:1	
	Tt										1:1	
MOUNT JACKSON	Qfn										3:1	
	Qt										3:1	
MUD LAKE NORTH	Qaf										3:1	
	Qfn										3:1	
MUD LAKE NW	109	SC,SM-GC,GC,GP,GM,GP-GM	A-1,2,6	IP	IP	L-M	H	L	<5'	L	3:1	
	111	SM,SM-SC,GC,GM,GM-GC	A-1,2,4,6,7	IP	IP	L-M	H	L	<5'	L	3:1	
	112	GM	A-1	IP	IP	L	H	L	<5'	L	2:1	
	122	SM,SP,SP-SM,GM,GP,GP-GM	A-1,2	Pr	Pr	L	H	L		L	2:1	
	222	SM,SC,GM,GC	A-1,2	IP	IP	M	H	L	<5'	L	2:1	
	281	SM,SM-SC,GM,GC	A-1,2,6	IP	IP	L	H	L	<5'	L	3:1	
	Qfn										3:1	

Table 1 - Soil Parameters and Characteristics

Quadrangle Name	Soil Symbol	Soil Classification USCS	Soil Classification AASHTO	Source of Gravel	Source of Sand	Shrink/ Swell	Corrosivity Steel	Corrosivity Concrete	Depth to Bedrock	Frost Action	*Cut Slope H:V	Excavatability
MUD LAKE SOUTH	Qap										3:1	
	Qfn										3:1	
	Qt										3:1	
	Tt										1:1	
PAHROC SPRING NE	Qfn										3:1	
PAHROC SPRING SE	Qfn										3:1	
PAHROC SUMMIT PASS	Qfn										3:1	
	Qt										3:1	
PANACA	BA	TOO VARIABLE FOR ESTIMATES									3:1	
	Gf	ML	A-4,5	U	U	L	H	H		H	3:1	
	Gg	ML	A-4,5	U	U	L	H	H		H	3:1	
	Gh	ML	A-4,5	U	U	L	H	H		H	3:1	
	GM	ML	A-4,5	U	U	L	H	H		H	3:1	
	HDC	SM	A-1,2	U	P	L	H	H		M	2:1	
	KO	SC, SC-SM	A-4	U	U	L	H	H	<5'	L	3:1	
	LC	SM	A-2	U	P	L	H	H		M	2:1	
	MU	ML, SM, SP-SM, GM	A-1	U	U	L	H	H		L	2:1	Rippable Hardpan
	Pa	CL	A-6,7	U	U	M	H	H		H	3:1	
	Pe	CL	A-6,7	U	U	M	H	H		H	3:1	
	Pg	CL	A-6,7	U	U	M	H	H		H	3:1	
	US	GM	A-1,2	U	U	L	H	H		M	2:1	Rippable Hardpan
PANACA SUMMIT	IO	GC	A-2,6,7	U	U	M	H	H	<5'	M	3:1	
	IR	GC	A-2,6,7	U	U	M	H	H	<5'	M	3:1	
	VGC	GC, GP-GM	A-1,2,4	F	F	L-M	H	H		L-H	3:1	Rippable Hardpan
PAYMASTER RIDGE	Qfn										3:1	
	Qt										3:1	
QUINN CANYON SPRINGS	Qfn										3:1	
	Qt										3:1	
RALSTON	108	SC,SP,SM-SC,SP-SM,GP,GP-GM	A-1,2,6	Pr	Pr	L-M	H	L		L	3:1	
	414	SM,SM-SC,GC,GM	A-1,2,6	IP	IP	L	H	L	<5'	L	3:1	
	442	SP,SM,SP-SM,GP,GM,GP-GM	A-1	Pr	Pr	L	H	L		L	2:1	
	Qal										3:1	
	Qap										3:1	
	Qfn										3:1	
REEDS RANCH	Qal										3:1	
	Qsd										3:1	
	Qt										3:1	
REVIELLE PEAK	3600	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L	H	L		L	3:1	v. hard, v. firm
	3610	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	M	H	L	<5'	L	3:1	Slightly hard, v. friable
	3620	CL,SC,SM,SM-SC*	A-3,4,6,7*	IP*	IP*	M	H	L	<5'	M	3:1	Soft, v. friable
	3640	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L-M	H	L		M	3:1	Hard, friable
	3811	SM,SP,GM,GP,GP-GM*	A-1,2*	Pr*	F*	L-M	H	L		L	2:1	V. hard, firm to soft, friable
	3830	CL,SC,SM,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L	H	L	<5'	L	3:1	4-14" bedrock
	3842	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L	H	L		M	3:1	Soft, v. friable
	Tbg										1:1	
	Tt										1:1	
REVIELLE PEAK NW	3600	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L	H	L		L	3:1	v. hard, v. firm
	3610	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	M	H	L	<5'	L	3:1	Slightly hard, v. friable
	3640	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L-M	H	L		M	3:1	Hard, friable
	3741	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L	H	L		L	3:1	Hard firm

Table 1 - Soil Parameters and Characteristics

Quadrangle Name	Soil Symbol	Soil Classification USCS	Soil Classification AASHTO	Source of Gravel	Source of Sand	Shrink/ Swell	Corrosivity Steel	Corrosivity Concrete	Depth to Bedrock	Frost Action	*Cut Slope H:V	Excavatability
REVIELLE PEAK SE	3137	SM,SP,GM,GP,GP-GM*	A-1,2*	Pr*	F*	L-M	H	L		L	2:1	Slightly hard, friable
	3600	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L	H	L		L	3:1	v. hard, v. firm
	3700	SM,SP,GM,GP,GP-GM*	A-1,2*	Pr*	F*	L-M	H	L		L	2:1	Soft, v. friable
	3740	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L-M	H	L		L	3:1	Hard firm
	3748	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L	H	L		L	3:1	Hard firm to soft friable
	3750	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L	H	L		L	3:1	Soft, v. friable
	3842	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L	H	L		M	3:1	Soft, v. friable
SCOTTYS JUNCTION	Qal										3:1	
	Qfn										3:1	
	Qt										3:1	
SCOTTYS JUNCTION NE	Qfn										3:1	
	Qt										3:1	
	Tt										1:1	
SILVER KING MTN SW	Qfn										3:1	
	Qsd										3:1	
SPLIT MOUNTAIN	111	SM,SM-SC,GC,GM,GM-GC	A-1,2,4,6,7	IP	IP	L-M	H	L	<5'	L	3:1	
	112	GM	A-1	IP	IP	L	H	L	<5'	L	2:1	
	200	CL,SC,SM,GC,GM,GP-GM,GM-GC	A-1,2,6	F	F	L-M	M-H	L	<5'	M	3:1	
	201	CL,SM,SC,GC,GM,GP-GM,GM-GC	A-1,2,6	Pr	Pr	L-M	H	L		L-M	3:1	
	225	SC,SM,GC,GM,GP	A-1,2	IP	IP	L-M	H	L	<5'	L	2:1	
	233	GC,GM,GM-GC	A-1,2	IP	IP	L	H	L	<5'	L	2:1	
	235	SM,GC,GM,GM-GC	A-2,4	IP	IP	L-M	H	L	<5'	L	3:1	
	237	GC,GM,GM-GC	A-1,2	IP	IP	L	M	L	<5'	M	2:1	
	400	SM,GM,GC,GP,GP-GM,GM-GC	A-1,2	Pr	Pr	L	H	L		L	2:1	
	Mz										1:1	
	Qfn										3:1	
	Qt										3:1	
SPRINGDALE	Qfn										3:1	
	Qt										3:1	
SPRINGDALE NE	Qap										3:1	
	Qfn										3:1	
	Qt										3:1	
SPRINGDALE NW	Qfn										3:1	
	Qsd										3:1	
	Qt										1:1	
	Tt										3:1	
STINKING SPRING NW	Qal										3:1	
	Qfn										3:1	
	Qsd										3:1	
	Qt										3:1	
STONE CABIN RANCH SE	Qal										3:1	
	Qfn										3:1	
	Qsd										3:1	
STONE CABIN RANCH SW	Qal										3:1	
	Qfn										3:1	
STONEWALL PASS	108	SC,SP,SM-SC,SP-SM,GP,GP-GM	A-1,2,6	Pr	Pr	L-M	H	L		L	3:1	
	360	SM,SM-SC,GC,GM	A-1,2,6	IP	IP	L	H	L	<5'	L	3:1	
	400	SM,GM,GC,GP,GP-GM,GM-GC	A-1,2	Pr	Pr	L	H	L		L	2:1	
	421	CL,CH,SC,SM,SM-SC,GC,GP,GP-GM	A-1,2,4,6,7	IP	IP	M-H	H	L		L	3:1	
	Qap										3:1	
	Qfn										3:1	
	Qt										3:1	

Table 1 - Soil Parameters and Characteristics

Quadrangle Name	Soil Symbol	Soil Classification USCS	Soil Classification AASHTO	Source of Gravel	Source of Sand	Shrink/ Swell	Corrosivity Steel	Corrosivity Concrete	Depth to Bedrock	Frost Action	*Cut Slope H:V	Excavatability
TEMPIUTE MOUNTAIN NORTH	Qfn										3:1	
	Qsd										3:1	
TEMPIUTE MOUNTAIN SE	Qfn										3:1	
	Qt										3:1	
TEMPIUTE MOUNTAIN SOUTH	Qfn										1:1	
	Qt										3:1	
	Mz										3:1	
THE BLUFFS	Qfn										3:1	
	Qt										3:1	
THIRSTY CANYON SW	Qfn										3:1	
	Qsd										2:1	
	Qt										1:1	
TIMBER MTN PASS EAST	3580	GP, GP-GM	A-1	P	IP	L	H	M		L	3:1	
	Mz										3:1	
	Qfn										3:1	
	Qsd										3:1	
	Qt										3:1	
TIMBER MTN PASS WEST	Qal										3:1	
	Qfn										3:1	
	Qt										3:1	
TOLICHA PEAK SW	Qfn										3:1	
	Qt										3:1	
WADSWORTH RANCH	Qal										2:1	
	Qfn										2:1	
WARM SPRINGS	3131	SC-GP	A-1,2	Pr	Pr						2:1	
	3137	SM,SP,GM,GP,GP-GM*	A-1,2*	Pr*	F*	L-M	H	L		L	2:1	Slightly hard, friable
	3138	SM,SP,GM,GP,GP-GM*	A-1,2*	Pr*	F*	L-M	H	L		L	2:1	Slightly hard, friable
	3226	CL,ML*	A-4,7*	U*	U*	L-M	M	L	<5'	M	3:1	Soft, v. friable
	3415	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L	H	L		L-M	3:1	Soft to slightly hard, friable
	3467	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	M	H	L		M	3:1	Cemented hardpan, hard v. friable
	3630	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L	H	L		L	3:1	Soft, friable
	3702	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L	H	L		L	3:1	Soft, v. friable
	3730	CL,SC,SM*	A-3,4,6,*	IP*	IP*	L	H	L	<5'	M	3:1	5-14" bedrock
	3803	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L-M	H	L		L-M	3:1	Cemented hardpan
	3804	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L-M	H	L		L	3:1	Cemented hardpan
	Qfn										3:1	
WARM SPRINGS NW (SUMMIT)	3223	CL,ML*	A-4,7*	U*	U*	L	M	L	<5'	M	3:1	Soft, v. friable
	3463	GC-GP	A-1	Pr	Pr						2:1	
	3730	CL,SC,SM*	A-3,4,6,*	IP*	IP*	L	H	L	<5'	M	3:1	5-14" bedrock
	3804	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L-M	H	L		L	3:1	Cemented hardpan
	3830	CL,SC,SM,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L	H	L	<5'	L	3:1	4-14" bedrock
	Qfn										3:1	
	Qt										3:1	
WARM SPRINGS SE	3137	SM,SP,GM,GP,GP-GM*	A-1,2*	Pr*	F*	L-M	H	L		L	2:1	Slightly hard, friable
	3226	CL,ML*	A-4,7*	U*	U*	L-M	M	L	<5'	M	3:1	Soft, v. friable
	3410	SM-SP	A-1	Pr	Pr						2:1	
	3460	GP-GM	A-1	Pr	Pr						2:1	
	3610	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	M	H	L	<5'	L	3:1	Slightly hard, v. friable
	3630	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L	H	L		L	3:1	Soft, friable
	3740	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L-M	H	L		L	3:1	Hard firm
	3800	CL,,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	M	H	L		L	3:1	Cemented hardpan
	3803	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L-M	H	L		L-M	3:1	Cemented hardpan
	3810	SM,SP,GM,GP,GP-GM*	A-1,2*	Pr*	F*	L-M	H	L		L	2:1	V. hard, firm to soft, friable
	3842	CL,SC,SM,SM-SC,GC,GP,GP-GM*	A-1,2,4,6,*	IP*	IP*	L	H	L		M	3:1	Soft, v. friable

Table 1 - Soil Parameters and Characteristics

Quadrangle Name	Soil Symbol	Soil Classification		Source of		Shrink/	Corrosivity		Depth to	Frost	*Cut Slope	Excavatability
		USCS	AASHTO	Gravel	Sand	Swell	Steel	Concrete	Bedrock	Action	H:V	
WATER GAP EAST	Qal										3:1	
	Qap										3:1	
	Qfn										3:1	
WATER GAP WEST	Qal										3:1	
	Qfn										3:1	
	Qt										3:1	
WHITE BLOTCH SPRGS. NW	KsB	SM	A-2,4	U	U	L	H				3:1	Easy, Sand & Gravel Increase w/ Depth
	LsC	GM	A-1-a	F-G	F	L	H				2:1	Easy, Sand & Gravel Increase w/ Depth
	RI	PROPERTIES NOT ESTIMATED									3:1	
	SID	CL,HARDPAN	A-6,7	U	U	M	H		<5'		3:1	Hardpan, Dense, Basalt at 30°
	TkB	GP,GW	A-1-a	U	U	L	H				2:1	Hardpan, Gravel Increase w/ Depth
WHITE BLOTCH SPRGS. NE	Bs	CL,ML,SC,SM,GP,GW	A-2,4,6	U	U	L-M	H				3:1	Hard, Cemented
	BuC	GP,GW	A-1-a	G	F	L	M				2:1	Gravel & Cobbles
	CKB	SM,GM	A-1,2-ab	F	F	L	H				2:1	Easy
	Ja	CL,ML	A-4,7	U	U	M-H	H				3:1	Hardpan to 2'
	Kp	CL,CH,SP	A-3,6,7	U	F	L	H				3:1	Easy
	KsB	SM	A-2,4	U	U	L	H				3:1	Easy, Sand & Gravel Increase w/ Depth
	PmA	SM,GP	A-4,1-a	U	P	LM	H				3:1	Gravel Increase w/ Depth
	PnA	GP	A-1-a	U-F	P-F	L	H				2:1	Gravel Increase w/ Depth
	SID	CL,HARDPAN	A-6,7	U	U	M	H		<5'		3:1	Hardpan, Dense, Basalt at 30°
	TkB	GP,GW	A-1-a	U	U	L	H				2:1	Hardpan, Gravel Increase w/ Depth
	Tp	HARDPAN,SM,GM	A-1,a,b	U	U	L	H				2:1	Hardpan w/ Loose Gravel Below
WORTHINGTON PEAK	Qal										3:1	

LEGEND

F - Fair
G - Good
H - High
IP - Improbable
L - Low
M - Moderate
P - Poor
Pr - Probable
U - Unsuited
* -Inferred from Data

One of the categories identified during this study is the classification of soils by the Unified Soil Classification System (USCS) and AASHTO systems. Using the classifications in the Soil and Rock Parameter tables, the soil can be generally evaluated for roadway support as shown on Table 2.

Cut slopes in soil and rock will typically follow the guidelines outlined in the AREA manual (1988) unless information obtained during this study requires these recommendations to be modified. For further discussion, see the section on cut slopes in this report.

Limitations on slope and height of fill are based on soil type. Table 3 lists the maximum fill heights and slopes for the various soils classified by the USCS. Since it is not known what soil types will be used for fill locations, it is suggested a 2H:1V maximum slope to be used for estimating earthwork.

Structure Foundations

Recommendations are provided for all structures identified at this time. For some locations, a bridge structure may be a feasible alternative to embankment. There are generally two types of structure anticipated; major roadway crossings and major drainage crossings.

The selection of a particular foundation system will depend on local subsurface conditions but the following factors will generally determine the foundation type.

Table 2 - GENERAL SOIL CHARACTERISTICS

	(1) Symbol	(2) Erosion On Exposed Slope	(3) Value As Subgrade	(4) Pumping Action	(5) Stability In Compacted Fills	(6) Compaction Characteristics	(7) Typical Duty Type Geotextile Fabric Use
GRAVELS	GW	NONE *	EXCELLENT	NONE	VERY GOOD	Excellent; crawler-type tractor, rubber-tired roller, steel-wheeled roller.	NONE REQUIRED
	GP	NONE *	EXCELLENT	NONE	REASONABLY GOOD	Good; crawler type tractor, rubber-tired roller, steel-wheeled roller.	NONE REQUIRED
	GM	NONE TO SLIGHT	GOOD	NONE	REASONABLY GOOD	Good with close moisture control; rubber-tired roller, sheepfoot roller.	NONE REQUIRED
	GC	NONE TO SLIGHT	GOOD	SLIGHT	FAIR	Excellent; rubber tired roller, sheepfoot roller.	NONE REQUIRED
SANDS	SW	SLIGHT TO HIGH WITH DECREASING GRAVEL CONTENT	EXCELLENT	NONE	VERY GOOD	Excellent; crawler type tractor, rubber tired roller,	NONE REQUIRED
	SP	HIGH	GOOD	NONE	REASONABLY GOOD WITH FLAT SLOPES	Good; crawler-type tractor, rubber-tired roller.	NONE REQUIRED
	SM	HIGH	POOR	NONE TO SLIGHT	FAIR	Good with close moisture control; rubber-tired roller, sheepfoot roller.	SLIGHT REGULAR
	SC	SLIGHT	POOR	SLIGHT	FAIR	Excellent; rubber-tired roller, sheepfoot roller.	SLIGHT REGULAR
SILTS AND CLAYS OF LOW PLASTICITY	ML	VERY HIGH	POOR	SLIGHT TO POOR	POOR	Poor To Good with close moisture control; rubber-tired roller, sheepfoot roller.	YES REGULAR
	CL	NONE TO SLIGHT	VERY POOR	POOR	REASONABLE	Fair To Good; rubber-tired roller, sheepfoot roller.	YES HEAVY
SILTS AND CLAYS OF HIGH PLASTICITY	MH	NONE TO SLIGHT	VERY POOR	VERY POOR	POOR	Poor To Very Poor; sheepfoot roller.	YES HEAVY
	CH	NONE	VERY POOR	VERY POOR	FAIR WITH FLAT SLOPES	Fair To Good; sheepfoot roller.	YES EXTRA HEAVY
ORGANIC	OH	VARIABLE	VERY POOR	VERY POOR	NOT TO BE USED	Poor To Very Poor.	YES EXTRA HEAVY
	PT	NOT APPLICABLE	REMOVE COMPLETELY	VERY POOR	NOT TO BE USED	Compaction Not Possible.	YES EXTRA HEAVY

NOTES
(With respect to columns)

2 Ability of natural soil to resist erosion on an exposed slope. Soils marked * may be used to protect eroding slopes of other materials.

3 Value as stable subgrade for roadbed when protected by suitable ballast and subballast material. Good soils may be used to protect poorer soils in subgrade.

4 Tendency of soil to pump up and foul balast under traffic.

5 Stability of soil against bulging and subsidence when used in a rolled fill. Cross check with Column (2) to forecast tendency to erode.

6 Equipment listed will usually produce the required moisture content and thickness of lift are properly controlled.

7 Typical type Geotextile Fabric. Use is dependent upon existing or proposed subgrade design. Fabric will not improve soil classification. If additional strength is required, use enough stabilized material, granular base material, subballast and ballast to properly span the weak subgrade soil.

SOURCE: 1988 AREA Manual for Railway Engineering

TABLE 3 - FILL SLOPES

Approximate Equivalent, Unified System	Condition of Exposure			
	Condition 1 (Not Subject to Inundation)		Condition 2 (Subject to Inundation)	
	Height of Fill, feet	Side Slope	Height of Fill, feet	Side Slope
GW, GP and SW	Not Critical	1 1/2 to 1	Not Critical	2 to 1
SP	Not Critical	1 1/2 to 1	Not Critical	2 to 1
GM and SM	Less than 50	2 to 1	Less than 50	3 to 1
GC or SC	Less than 50	2 to 1	Less than 50	3 to 1
ML,MH	Less than 50	2 to 1	Less than 50	3 to 1
CL,CH	Less than 50	2 to 1	Less than 50	3 to 1

Notes:

(1) Under Condition 2, higher fills on the order of 35 to 50 feet should be compacted to at least 100% for portions subject to inundation. Major fills composed of unusual materials analyzed by soil mechanics which have low shearing resistance should be methods.

(2) For soils of the CL or CH groups, the lower compaction requirements shown are only for low fills . (10 to 15 feet or less) not subject to inundation.

(3) Highly organic soils are not generally suitable for fill construction.

SOURCE: "Foundation Engineering Handbook", Winterkorn and Fang, 1975.

- Depth to competent soil.
- Depth to competent bedrock.
- Potential scour depth.

The structures are identified according to the quadrangle sheet name. Table 4 lists the quadrangle, approximate station, condition requiring the structure and proposed foundation system. Foundations at drainage features also account for scour, which has been estimated at 20 feet. This estimate is comparable to the total scour derived for similar conditions in Maricopa County, Arizona. Typically the spread footings proposed at the grade separations are assumed to rely on support from granular soils or weathered rock.

Geological Characteristics of Cut Slopes

Table 1 presents guidelines for cut slopes in the soils and rock encountered along the alignment. These recommendations apply to shallow cuts, less than 50 feet deep. Several areas of excavation in excess of 50 feet have been identified and proposed slopes are presented in Table 5.

Geological characteristics in these deep cut areas are described below, based on available geological data:

Within the cut area at station 1200+00 of Route G, Mount Jackson Quadrangle, about 50 percent of the excavation will be within the Cambrian limestone, claystone and chert of the Emigrant Formation. The total thickness of this formation can be over 500 feet. The upper exposed layers are heavily weathered

Table 5 - RECOMENDED CUT SLOPES IN ROCK

(For excavations than 50 feet.)

Quadrangle Name	Route Designation	Approximate Station	Approximate Cut Depth	Rock Data	Slope Profile
Mount Jackson	G	1200+00	200'	Cambrian claystone, limestone and chert. Miocene welded ash flow. Dip may coincide locally with the slope.	Variable slope with permanent benches. General slope 50° (0.84:1).
	G	1800+00	100'	Pliocene rhyolite plugs, domes and flows. Miocene welded ash flows.	Uniform slope 70° (0.36:1).
Split Mountain	G	1900+30	100'	Tertiary airfall tuff and nonwelded ash flows.	Uniform slope 0.36:1.
	G	2000+20	200'	Tertiary airfall tuff and nonwelded ash flows.	Uniform slope 0.36:1.
	G-3	2000+35	170'	Tertiary airfall tuff and nonwelded ash flows.	Uniform slope 0.36:1.
Montezuma Peak SW	G-1	1900+70	200'	Thrust area. Jurassic to Tertiary Age rhyolite, porphyry dike rocks. Cambrian claystone and limestone of Emigrant formation.	Variable slope with benches. General slope 0.84:1.
	G-4	2200+50	100'	Thrust area. Jurassic to Tertiary Age rhyolite, porphyry dike rocks. Cambrian claystone and limestone of Emigrant formation.	Variable slope with benches. General slope 0.84:1.
Montezuma Peak	G	1800+00	100'	Tertiary rhyolite and rhyodacite.	Uniform slope 0.36:1.
	G		150'	Tertiary airfall tuff and nonwelded ash flows.	Uniform slope 0.36:1.
Crescent Reservoir	A	15000+30 to 15100+80	460'	Younger volcanic rocks undivided including intravolcanic sedimentary rocks and perlite.	Uniform slope 0.36:1 with benches for excavation and hauling.
	A	15400+00	100'	Younger volcanic rocks undivided including intravolcanic sedimentary rocks and perlite.	Uniform slope 0.36:1.
Tempiute Mountain South	A	16200+00	50'	Ordovician thick-bedded, cliff forming limestone, silty and shaly limestone of Pogonip Group. Mississippian clastic rocks, volcanic undifferentiated (~70% area).	Uniform slope 0.84:1.

Table 4 - STRUCTURES

QUADRANGLE	CONDITION REQUIRING STRUCTURE	APPROXIMATE STATION	PROPOSED FOUNDATION SYSTEM	REMARKS
BLACK TOP	GRADE SEPARATION AT SR 375	177+00	SPREAD FOOTING	
BUSTED BUTTE	BRIDGE WASH CROSSING	370+00	DRILLED PILES 40-60 FEET (INCLUDING SCOUR) ALTERNATIVE: BOX CULVERTS	ESTIMATED 20' SCOUR
HIKO	GRADE SEPARATIONS AT US 93	142+40 143+80	SPREAD FOOTING SPREAD FOOTING	
McMAHON RIDGE	GRADE SEPARATIONS AT US 95		SPREAD FOOTING	
MOUNT IRISH	GRADE SEPARATION AT SR 375	145+80	SPREAD FOOTING	
MOUNT JACKSON	GRADE SEPARATIONS AT US 266	6+50	SPREAD FOOTING	
PANACA	GRADE SEPARATIONS AT US 93	210+30 343+50	SPREAD FOOTING SPREAD FOOTING ALTERNATIVE: DRIVEN PILES 30-40 FEET	COMPETENT SOIL APPROX. 15-20 DEEP.
SPRINGDALE NW	GRADE SEPARATIONS AT US 95 BRIDGE	3797+70 3721+00 3940+00	SPREAD FOOTING SPREAD FOOTING DRILLED PILES 40-60 FEET (INCLUDING SCOUR)	ESTIMATED 20' SCOUR
STONEWALL PASS	GRADE SEPARATIONS AT US 95 WASH CROSSINGS	5031+10 5008+00	SPREAD FOOTING SPREAD FOOTING BOX CULVERTS	
TOLICHA PEAK	WASH CROSSINGS		BOX CULVERTS	
WARM SPRINGS	COW CANYON	30+70	SPREAD FOOTING AT ABUTMENTS SOUTH ABUTMENTS ANCHORED ALTERNATIVE AT SOUTH ABUTMENT: DRILLED PILES SOCKETED INTO ROCK DRILLED PILES AT PIERS: ASSUME SOCKETED INTO ROCK (DEPTH TO ROCK UNKNOWN)	WELDED ASH FLOW TUFFS; BEDDING IN DIRECTION OF SLOPE AT SOUTH SIDE.

and decomposed. The limestone occurs in beds 1/2 to 3 inches thick interstratified with chert. The rocks are tightly folded and moderately jointed.

Tertiary welded ash flow is exposed on the north and central part of the cut. The ash flow contains quartz clasts and breccia.

The rhyolite plugs, domes and flows that outcrop at station 1800+00 of Route G, Mount Jackson Quadrangle, show a variety of structures and textures. Some facies exhibit well-defined flowage banding, others have strongly developed platy structure, and some are massive. Those rocks are stable in cuts although they are weathered and jointed at the surface.

Route G and G-3, shown on the Split Mountain Quadrangle, intersect the body of Tertiary unwelded ash flows of the Montezuma Range. The tuff unit is locally a thousand feet thick with distinct bedding and low-angle dips over a large area.

Routes G-1 and G-4, on the Montezuma Peak SW Quadrangle, cut through Cambrian rocks of the Emigrant Formation, Jurasic to Tertiary Age rhyolite and porphyry dike rocks.

The cut may expose low-angle thrust faults and a number of striking northeast faults. Rocks may show largely varying dips between subsequent faults. The older Cambrian claystone and limestone are heavily decomposed at the surface.

Tertiary rhyolite and rhyodacite showing platy or massive structure are exposed at station 1800± of Route G on the Montezuma Peak Quadrangle in Montezuma Range. Most of the rhyolite is probably extrusive but some can be intrusive into the bedded tuff.

The cut is up to 450 feet and is likely within the body of the volcanic rocks in the Mount Irish Range, shown on the Crescent Reservoir Quadrangle. Those rocks, however competent, need to be cut with benches to facilitate excavation work and provide safety from rockfalls.

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SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

LAS VEGAS, NEVADA

YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE

CONCEPTUAL DESIGN REPORT

APPENDIX H
HYDROLOGY REPORT

De Leuw, Cather & Company
Subcontract Agreement No. 14-900078-12

120 Howard Street
San Francisco, CA 94105

1 June 1992

HYDROLOGY REPORT

YUCCA MOUNTAIN RAIL ACCESS STUDY - CALIENTE ROUTE

VOLUME I - REPORT

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PREPARED FOR:

DELEUW CATHER & COMPANY
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OCTOBER 1990
REVISED DECEMBER 1990

Volume I
TABLE OF CONTENTS

Chapter	Title	Page
1	**INTRODUCTION**	1.1
	Scope of Study	1.1
	Previous Studies	1.4
	FEMA Flood Insurance Studies	1.4
	Corps of Engineers	1.5
	Other Studies	1.6
	Report Revision	1.6
2	**DESCRIPTION OF STUDY AREA**	2.1
	General Description	2.1
	Physical Description	2.1
	Climate	2.1
	Vegetation	2.4
	Existing Development	2.4
	Special Drainage Design Considerations	2.4
	Alluvial Fans	2.5
	Closed Basin Lakes	2.6
	Sedimentation	2.6
	Basin 141	2.6
	Basin 142	2.12
	Basin 143	2.14
	Basin 144	2.16
	Basin 145	2.21
	Basin 146	2.23
	Basin 149	2.27
	Basin 156	2.32

Volume I
TABLE OF CONTENTS (cont.)

Chapter	Title	Page
2	**DESCRIPTION OF STUDY AREA (cont.)**	
	Basin 169A	2.34
	Basin 170	2.36
	Basin 171	2.38
	Basin 172	2.40
	Basin 173A	2.42
	Basin 181	2.46
	Basin 182	2.48
	Basin 197	2.50
	Basin 203	2.52
	Basin 208	2.56
	Basin 209	2.58
	Basin 227A	2.62
	Basin 228	2.64
	Basin 229	2.68
3	**HYDROLOGIC ANALYSIS**	
	Introduction	3.1
	Recurrence Interval	3.1
	Choice of Hydrologic Model	3.2
	Method of Computing Flood Hydrograph	3.4
	Watershed Area	3.4
	Curve Number	3.5
	Watershed Lag Time	3.6
	Rainfall Depth	3.6

Volume I
TABLE OF CONTENTS (cont.)

Chapter	Title	Page
3	**HYDROLOGIC ANALYSIS (Cont.)**	
	Time Distribution of Rainfall	3.7
	Spatial Distribution of Rainfall	3.7
	Methods for Routing Hydrographs Through Channel Reaches	3.8
	Reservoir Routing	3.9
	Regional Regression Analysis	3.10
	Hydrologic Analysis of Small Basins	3.10
	Closed Basin Lake Analysis	3.11
	Estimate of Runoff Volume to Mud Lake	3.11
	Computation of Lake Level in Mud Lake	3.12
4	**RESULTS OF HYDROLOGIC ANALYSIS**	
	Introduction	4.1
	Results of HEC-1 Analysis of Larger Watersheds	4.1
	Sensitivity Analysis	4.1
	Results of Sensitivity Analysis	4.27
	Comparison of Results With Other Studies	4.29
	Regional Regression Analysis	4.29
	Alluvial Watersheds	4.30
	Normal Watersheds	4.30
	Hydrologic Analysis of Small Basins	4.31
	Closed Basin Lake Analysis	4.31
	Peak Discharges Reported By FEMA	4.32
	Peak Discharges for More Frequent Events	4.33

TABLE OF CONTENTS (cont.)

APPENDICES

A **BIBLIOGRAPHY**

B **SMALL WATERSHED DATA**

LIST OF TABLES

Table No.	Title	Page
1-1	Status of FEMA Flood Insurance Studies For Communities Within The Study Area	1.5
4-1	Summary of Discharges	4.2
4-2	Accuracy of Curve Number Variables	4.23
4-3	Accuracy of Lag Time Variables	4.24
4-4	Results of Sensitivity Analysis	4.27
4-5	Results of Multiple Regression Analysis	4.30
4-6	Results of Runoff Volume Analysis For Mud Lake	4.32
4-7	Comparison of 100-year & N-year Discharges	4.33

TABLE OF CONTENTS (cont.)

LIST OF FIGURES

Figure No.	Title	Page
1-1	Culvert Spacing Example	1.2
2-1	Location Map	2.2
2-2	Index Map	2.3
2-3	Basin 141	2.7
2-4	FEMA Flood Insurance Rate Map	2.9
2-5	FEMA Flood Insurance Rate Map	2.10
2-6	FEMA Flood Insurance Rate Map	2.11
2-7	Basin 142	2.13
2-8	Basin 143	2.15
2-9	Basin 144	2.17
2-10	FEMA Flood Insurance Rate Map	2.18
2-11	FEMA Flood Insurance Rate Map	2.19
2-12	FEMA Flood Insurance Rate Map	2.20
2-13	Basin 145	2.22
2-14	Basin 146	2.24
2-15	FEMA Flood Insurance Rate Map	2.25
2-16	FEMA Flood Insurance Rate Map	2.26
2-17	Basin 149	2.28
2-18	FEMA Flood Insurance Rate Map	2.29
2-19	FEMA Flood Insurance Rate Map	2.30
2-20	FEMA Flood Insurance Rate Map	2.31
2-21	Basin 156	2.33

TABLE OF CONTENTS (cont.)

LIST OF FIGURES - Continued

Figure No.	Title	Page
2-22	Basin 169A	2.35
2-23	Basin 170	2.37
2-24	Basin 171	2.39
2-25	Basin 172	2.41
2-26	Basin 173A	2.43
2-27	FEMA Flood Insurance Rate Map	2.44
2-28	FEMA Flood Insurance Rate Map	2.45
2-29	Basin 181	2.47
2-30	Basin 182	2.49
2-31	Basin 197	2.51
2-32	Basin 203	2.53
2-33	FEMA Flood Insurance Rate Map	2.54
2-34	FEMA Flood Insurance Rate Map	2.55
2-35	Basin 208	2.57
2-36	Basin 209	2.59
2-37	FEMA Flood Insurance Rate Map	2.60
2-38	FEMA Flood Insurance Rate Map	2.61
2-39	Basin 227A	2.63
2-40	Basin 228	2.65
2-41	FEMA Flood Insurance Rate Map	2.66
2-42	FEMA Flood Insurance Rate Map	2.67

TABLE OF CONTENTS (cont.)

LIST OF FIGURES - Continued

Figure No.	Title	Page
2-43	Basin 229	2.69
2-44	FEMA Flood Insurance Rate Map	2.70
4-1	Normal Watershed Example	4.25
4-2	Alluvial Watershed Example	4.26
4-3	Comparison of Slope and Velocity For Study Watersheds	4.28
4-4	100-year, 6-hour Precipitation Depth	4.34
4-5	C.O.E 100 Yr. Peak Discharge Curve	4.35

CHAPTER 1

INTRODUCTION

SCOPE OF STUDY

Kennedy/Jenks/Chilton contracted with DeLeuw Cather and Company to prepare a hydrology report that would provide hydrologic data to be used in the conceptual design of the Yucca Mountain access railway. The railway alignments under consideration as a part of this study, provide access to the proposed Yucca Mountain repository site from the Union Pacific Railroad near Caliente.

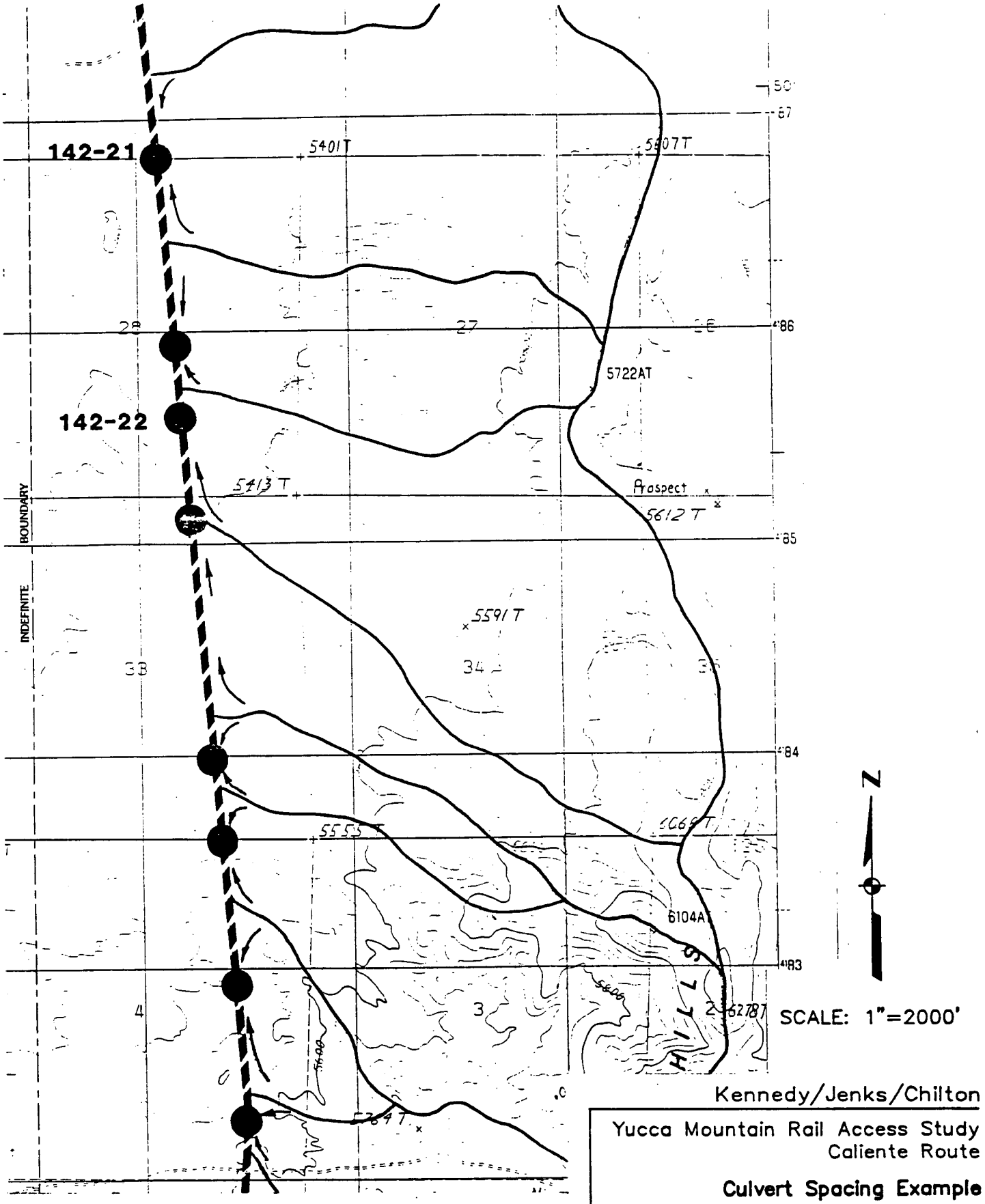
This report describes the scope of the study, methods of analysis used, limitations to the use of the data and study results. This is a conceptual level study intended to provide approximate design discharges for use by DeLeuw Cather and Company for estimating the cost of drainage structures associated with the alignments under consideration. This study also provides information regarding the portions of the route which will warrant special drainage design considerations.

The scope of work for this study included the following:

- Identify the locations of the primary drainage structures, along the routes to be studied, using reasonable assumptions regarding diversions and adequate culvert spacing. Culvert spacing was determined based upon conditions at each location along the proposed alignment. Use of training dikes and diversions of reasonable length can be used at most locations without significantly concentrating flows or substantially increasing the size of the drainage structure. Upon completion of the watershed delineation, the average culvert spacing used to identify watershed boundaries was found to be approximately 2300 feet. Figure 1.1 shows a typical segment of the proposed route with culvert locations and diversions shown.

- For 620 miles of railway, the culvert spacing described above would result in approximately 1400 drainage structures. The scope of this study only included the analysis of drainage areas greater than one square mile in size. Of the 1400 drainage structures to be encountered, 440 watersheds were found to be greater than one square mile in size. This report presents the results for these 440 watersheds which are greater than one square mile. Therefore, there are approximately 960 additional drainage structures required, for the proposed railway alignments identified, for watersheds that would have less than one square mile of contributing drainage area.

- Using the State Engineer's map of Designated Groundwater Basins, the study area was subdivided into major drainage



LEGEND

PROPOSED RAILROAD ALIGNMENT

DRAINAGE BASIN BOUNDARIES

CULVERT LOCATION

Kennedy/Jenks/Chilton

Yucca Mountain Rail Access Study
Caliente Route

Culvert Spacing Example

K/J/C 897045.01

December 1990

Figure 1.1

provinces. The drainage areas contributing to each drainage structure were delineated on the 7.5 minute USGS quadrangle maps. Drainage areas greater than one square mile in size were identified for hydrologic analysis. The drainage areas identified to be greater than one square mile were numbered based upon the State Engineer's Basin identification numbers.

- The drainage areas, that exceeded five square miles in size, were separated from the list of watersheds, for analysis using HEC-1. The watersheds greater than one square mile but less than five square miles were identified for analysis using regional analysis. The methods of regional analysis are described in further detail in Chapter 3.

- Watershed and design precipitation data were collected for each of the watersheds that were greater than five square miles in size. Watershed areas, watercourse lengths and other watershed data were measured from the 7.5 minute USGS quadrangle maps. Design rainfall depths were calculated using the procedures and maps contained in NOAA Atlas 2 (Ref. 35). This data was used in conjunction with the Corps of Engineers' computer program HEC-1 to compute peak discharges for each of these watersheds.

- The results of the HEC-1 analysis were used, in conjunction with the results from other studies in the Las Vegas and Caliente areas (Ref. 4 & 16), to develop regional regression equations for use on the watersheds greater than one square mile and less than five square miles in size. Two sets of equations were developed for this purpose. The first set was based upon the results from watersheds that exhibit a typical dendritic stream pattern with well defined channels along the primary flow path. The second set of equations was based upon the results from watersheds that are typical of alluvial fans that have several parallel poorly defined primary channels dominated by wide shallow flow. Examples of each of these types of watersheds and further explanation are provided in Chapter 3.

- Watershed and design precipitation data were collected for each of the watersheds that were greater than one square mile but less than five square miles in size. Watershed areas and watercourse lengths and slopes were measured from the 7.5 minute USGS quadrangle maps. Design rainfall depths were estimated using the maps contained in NOAA Atlas 2 (Ref. 35). This data was used in conjunction with the regional regression equations developed as a part of this study, to approximate the 100-year peak discharges for these drainage areas.

- Locations with significant and unusual flooding hazards were also identified. These locations include sections of proposed alignment impacted by alluvial fans, closed basin lakes, extremely high peak discharges, wide shallow flow and locations were the Federal Emergency Management Agency has identified "Floodways" and flood plains.

Each of these items are discussed in detail in this report. The estimated peak discharges are also summarized in Table 4.1.

PREVIOUS STUDIES

During the initial phase of this project a literature search was performed to identify existing information sources. The following sections describe previous engineering and hydrologic studies which are relevant to this project.

FEMA Flood Insurance Studies

In 1968 the National Flood Insurance Act was enacted which created the National Flood Insurance Program (NFIP). In 1973 the Flood Disaster Project Act was also enacted. This Act required the purchase of flood insurance "as a condition of receiving any form of federal or federally-related financial assistance for acquisition or construction purposes with respect to insurable buildings and mobile homes within an identified special flood, mudslide, or flood-related erosion hazard area that is located within any community participating in the Program."

In order for a property owner to purchase flood insurance from the Federal Insurance Administration (FIA), the community in which the property lies must be participating in the NFIP. Upon initial entry into the NFIP a community typically entered the "Emergency Program".

Upon the community's entry into the Emergency Program, a set of Flood Hazard Boundary Maps (FHBM) are published which identify approximate "special flood hazard areas." The FHBM's serve as a temporary flood plain management tool until a more detailed study can be conducted.

The Federal Emergency Management Agency (FEMA) then initiates a Flood Insurance Study (FIS). The FIS will include a detailed hydrologic and hydraulic analysis for the primary drainages within the community and approximate studies for important smaller drainages and for areas with low development potential. After completion of the FIS and adoption of a Flood Plain Management Ordinance by the community, the Flood Insurance Study and a set of Flood Insurance Rate Maps (FIRM) are published by FEMA and the community enters the regular program of the NFIP.

A detailed hydraulic analysis for a watercourse typically includes the computation of the "floodway." The floodway is defined by FEMA as "... the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 100-year flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced." The area of the floodplain between the floodway and the outer limit of the 100-year flood limit, is defined as the floodway fringe. The floodway is identified to assist the community in management of the floodplains identified in the Flood Insurance

Study. The community can allow appropriately protected encroachments within the floodway fringe. A community that is participating in the NFIP will have been required to adopt a floodplain management ordinance that would prohibit encroachment into the floodway.

Table 1.1 identifies the status of the Flood Insurance Studies and flood hazard maps prepared by FEMA for the communities within the study area.

TABLE 1-1
Status of FEMA Flood Insurance Studies
For Communities Within the Study Area

Community	Entry Date Regular Program	Current Map Date	Date of Published Flood Insurance Study
Nye County	4/12/83	4/12/83	no study published
Esmeralda County [1]			
Lincoln County	3/01/84	2/17/88	2/17/88
City of Caliente	10/15/85	10/15/85	10/15/85

[1] Esmeralda County is not participating in the National Flood Insurance Program. Therefore, there are no flood hazard maps published by FEMA for Esmeralda County.

Nye County has a set of FIRMs which only contain approximate flood hazard boundaries. Since no detailed studies were performed, peak discharges were not computed as a part of the Flood Insurance Study. Water surface profiles and floodways were also not computed and a Flood Insurance Study was not published.

Corps of Engineers

Four reports prepared by the U.S. Army Corps of Engineers, where reviewed for applicable regional characteristics data or statistical peak discharge values to be used in the regional analysis (Refs. 32-35). These studies are detailed hydrology studies for drainage basins in both northern and southern Nevada.

The Los Angeles District office of the U.S. Army Corps of Engineers has prepared two hydrologic studies related to a flood control investigation for the Las Vegas Wash and other portions of the Las Vegas area. These reports present very useful site specific hydrologic data as well as a regional analysis using stream gage data from gages throughout the southwest.

The Sacramento District office of the U.S. Army Corps of Engineers has prepared several hydrologic studies for the Truckee Meadows during the last 15 to 20 years. The most detailed of these studies was a hydrology

report for the Truckee River Basin completed in 1980. This report summarizes the results and input data from a hydrologic modeling study for the Truckee River Basin and summarizes the results of a statistical analysis for several of the watersheds within the Truckee River Basin.

The Sacramento District office of the U.S. Army Corps of Engineers prepared a hydrologic study for the Humboldt River in northern Nevada. This report summarizes the results and input data from a hydrologic modeling study for the Humboldt River Basin and summarizes the results of a statistical analysis for several of the watersheds within the Humboldt River Basin. This study was useful for comparison of calibrated initial and constant loss rates.

Other Studies

Kennedy/Jenks/Chilton prepared a detailed hydrologic analysis for the conceptual design studies for the Southern Segment of the Las Vegas Beltway (Ref. 16). This study includes a detailed hydrologic analysis of 71 watersheds in southern Las Vegas Valley using HEC-1. The results of the Beltway study were used in the regional analysis developed as a part of this study.

Other studies prepared by consulting engineers (Ref. 4) and the USGS were also reviewed for applicable data to be used in the regional analysis (Ref. 40 & 41).

REPORT REVISION

This report was originally submitted on October 25, 1990 in two volumes. Volume I is the report. Volume II is the Technical Appendix and was submitted as Book 1 of 2 and Book 2 of 2. During a meeting held on November 7, 1990 between staff of Kennedy/Jenks/Chilton and DeLeuw Cather and Company, certain revisions to the report were requested. This Volume I update includes the revisions and clarifications requested in that meeting and in subsequent correspondence.

This report revision adds additional detail and data to Volume I of the report. Minor editorial changes were made to chapters 1, 2 and 3. Chapter 4 was revised to add the results of the sensitivity analysis performed as a part of the study, include the 100-year, 6 hour rainfall map for the study area, add information on the ratio of 100-year to more frequent event peak discharges and add additional clarification and editorial revisions. An appendix was also added to Volume I to present the data for the smaller drainage areas included in this study. No changes were made to Volume II, peak discharge data or the recommendations made in the original report.

CHAPTER 2

DESCRIPTION OF STUDY AREA

GENERAL DESCRIPTION

The study area (Figure 2.1) is located in southern Nevada approximately 60 miles north of Las Vegas, Nevada and extends from the Nevada/Utah border to the California/Nevada border. This study area encompasses portions of Nye, Esmeralda and Lincoln Counties.

The railway alignment under consideration with this study is shown on Figure 2.2 beginning near the Nevada/Utah border at the Union Pacific Railroad and extending west to a point just south of the town of Tonopah where the alignment proceeds south through Scotty's Junction and ultimately arrives at the proposed Yucca Mountain repository site. Several alternative alignments are also shown. The total length of the railway under consideration, including the alternatives, is approximately 620 miles.

Figure 2.2 also shows the location of each major drainage province within the study area. The major drainage provinces are based upon the Nevada State Engineer's designated groundwater basins. The boundaries of these basins are groundwater divides and not necessarily surface water divides, such as the northern boundary of Basin 208 and 203. With the exception of White River (Basin 208 and 209) and Meadow Valley Wash (Basin 203), the areas contributing surface water flow to the proposed railway are within the drainage provinces shown. The study area within these drainage provinces encompasses approximately 12,315 square miles.

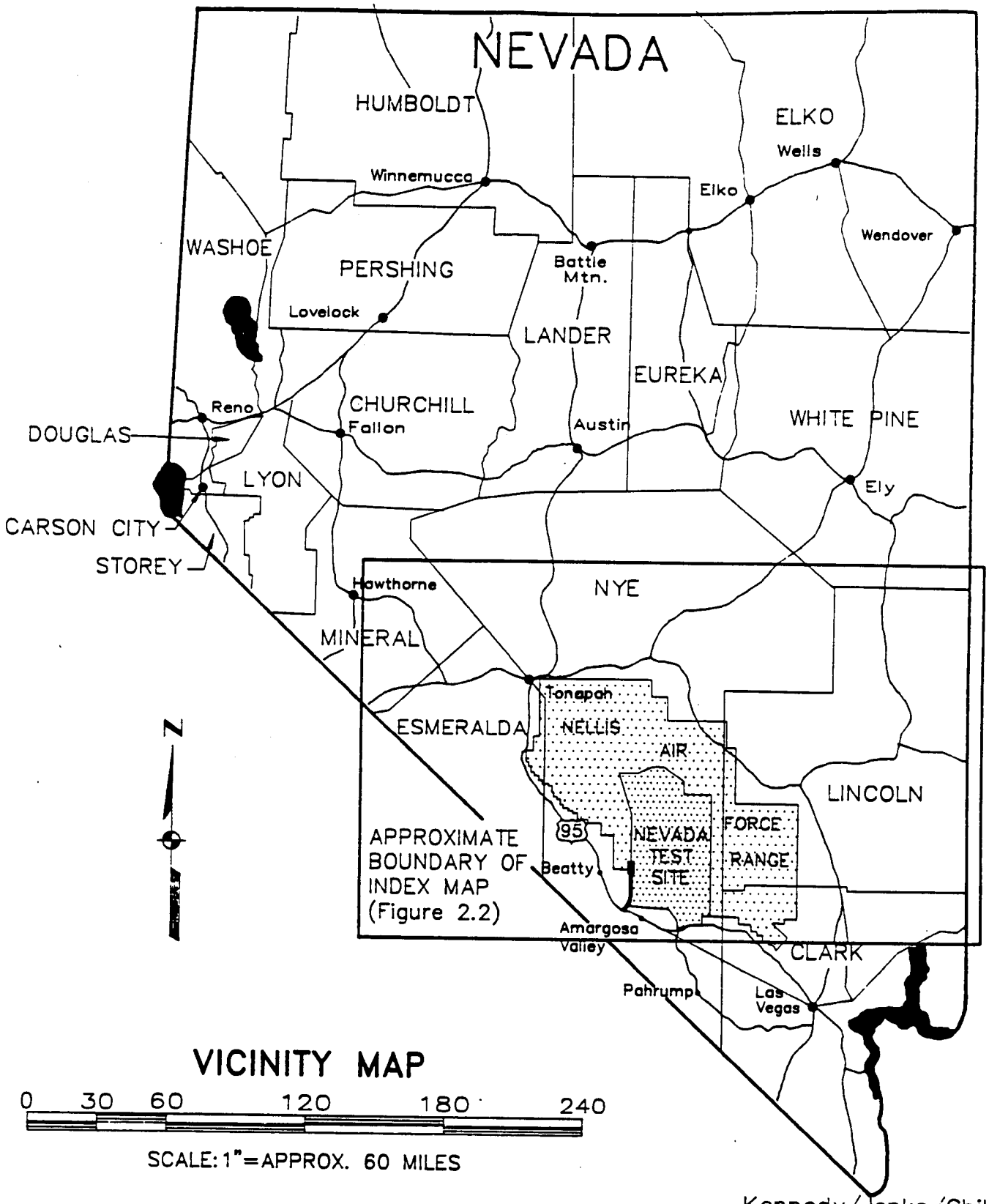
PHYSICAL DESCRIPTION

The study area is located in the Basin and Range Province. The Basin and Range Province extends from southern Oregon and Idaho to Northern Mexico, and from central Utah to Eastern California. The study area is typical of the Basin and Range Province which is comprised of north to northeast trending mountains and valleys formed by faulting referred to as "horst and graben" structures.

Rock types in the study area are comprised chiefly of tertiary volcanics in the mountains and quaternary alluvial sediments in the valleys, with smaller amounts of paleozoic sedimentary and volcanics of varying ages occurring throughout the mountains. Locations within the study area range in elevation from 2500 to over 10,000 feet above sea level.

CLIMATE

Climate within the study area varies considerably due to topographic and meteorological characteristics of the area. The western portion of the study area lies in a region that is located just east of the Sierra Nevada Range. It experiences a rain shadowing effect for winter storm patterns that cross the Sierras from the west. The eastern portion of



VICINITY MAP

0 30 60 120 180 240

SCALE: 1"=APPROX. 60 MILES

Kennedy/Jenks/Chilton

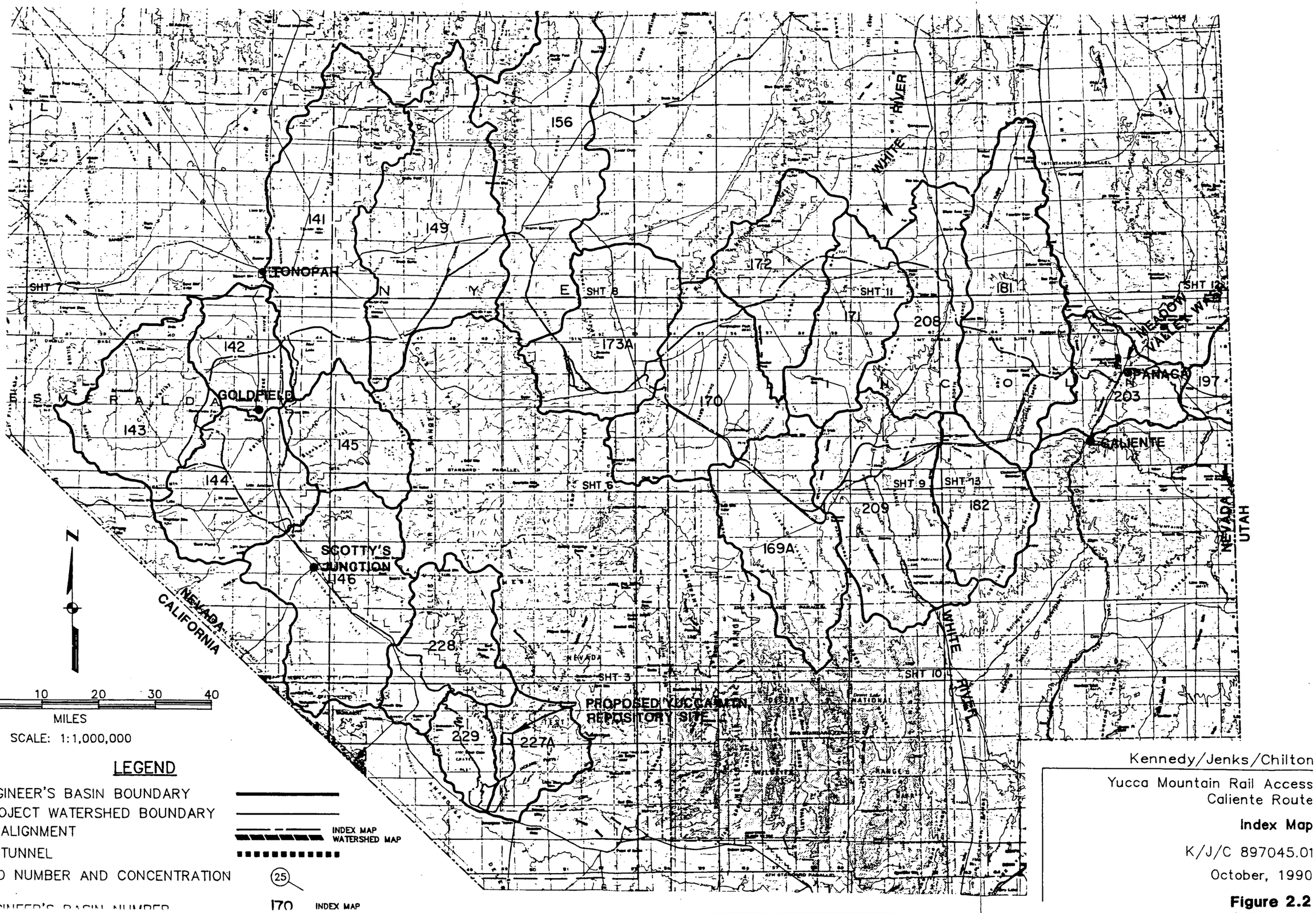
Yucca Mountain Rail Access Study
Caliente Route

Vicinity Map

K/J/C 897045.01

October, 1990

Figure 2.1



Kennedy/Jenks/Chilton

Yucca Mountain Rail Access
Caliente Route

Index Map

K/J/C 897045.01

October, 1990

Figure 2.2

the study area lies in a region that is impacted by moist summer air flows from the Gulf of Mexico. French (1983 - Ref. 14) describes the western portion of the study area as a deficit zone due to the relatively low average annual precipitation values in this zone. He describes the eastern region of the study area as an excess zone since the moist summer air flow pattern and distance from the Sierra Nevada Range results in higher average annual precipitation values compared to the western zone. These regional climatic characteristics also impact the statistical rainfall depths for the durations of interest in this study (Forest, 1989 - Ref. 12).

Average annual precipitation depths in the study area range from 5 to 20 inches. The lowest values are encountered near the proposed Yucca Mountain site. The greatest values are encountered near the peaks that are at the upper end of basins 141 and 149.

Average annual temperatures range from 40 degrees fahrenheit in the higher elevations to 55 degrees near the southwest portion of the study area. Winter time low temperatures of -30 degrees are not uncommon in the Meadow Valley area near Caliente.

VEGETATION

Study area vegetation includes various types of desert grasses and shrubs in the valley areas and pine, juniper and mountain brushes in the mountain areas. The desert brushes in the western portion of the study area include primarily greasewood, shadscale, bud sagebrush and rabbitbrush. The desert brushes in the eastern portion of the study area include black sagebrush, big sagebrush, rabbitbrush and squirreltail.

At elevations that are greater than 5500 to 6000 feet above sea level, juniper, pinion pine, horsebrush and mountain mahogany are encountered.

EXISTING DEVELOPMENT

The majority of the study area is undeveloped. Improvements in the study area consist of isolated ranches, mining operations and a few small towns such as Goldfield, Caliente and Panaca.

SPECIAL DRAINAGE DESIGN CONSIDERATIONS

Drainage design in the arid west must consider some of the unique flooding related design difficulties that the arid west experiences such as; the random flow patterns associated with active alluvial fans, the long duration flooding adjacent to closed basin lakes, and the high sediment content in flood flows originating from natural sand bed streams.

In addition, the impact of the drainage design on properties upstream and downstream of the proposed facility must be considered. In areas where the route crosses regulatory floodways identified by FEMA, it must

also be demonstrated that the proposed facility will not increase the water surface profile in the vicinity of the facility by an amount greater than one foot, significantly increase average channel velocities or alter the floodway delineation upstream and downstream of the structure. In some cases, the increase in water surface resulting from the delineated floodway may be much less than one foot at a particular location. An encroachment at that location which causes a one foot increase in water surface elevation may result in adverse impacts on the floodway upstream or downstream of that location.

Alluvial Fans

An alluvial fan is typically a cone shaped surface formed where flows from the mountain front exit onto the milder sloping valley floor. The abrupt change in slope and channel geometry results in the deposition of much of the streams sediment and debris load near the upper portion of the fan surface. Active alluvial fans are undergoing a constant building process and are being reshaped by the deposition of sediments and the redistribution of sediments with each significant event. Analysis of flow processes on active alluvial fans is difficult because of the random nature of the flow patterns on alluvial fan surfaces.

FEMA has developed a method of identifying flooding and flow velocity related hazards on active alluvial fans (FEMA 1985; Dawdy 1979; Dawdy 1986). This method is a stochastic model that relates the potential for a given depth and velocity of flow in each region of the fan surface with the discharge at the alluvial fan apex. During a 100-year event, only a portion of the alluvial fan surface would be flooded. The entire fan surface is mapped as 100-year flood zone since the direction of the flow path on the fan is random and will likely change with each significant event.

The 100-year flood zones for alluvial fans are identified by FEMA as Zone AO with a depth (typically ranging from one to five feet) and velocity (typically ranging from one to ten ft/sec) reported (For example: Zone AO depth 3, velocity 5). The depth and velocity is a probable depth (in feet) and velocity (in feet/second) that would be experienced in a hypothetical rectangular channel which could be formed in that region of the fan as a result of a 100-year discharge occurring at the fan apex.

An active alluvial fan will have several identifiable characteristics. For example, an active alluvial fan will typically have a convex shape to the fan surface as a result of the depositional and reshaping process. The surface soils will be very erodible and there will be many distinguishable shallow channels radiating from the apex. For continuation of the depositional process, the upstream channel must carry significant amounts of sediment and debris during significant flow events.

Where alluvial fan flooding hazards exist, special care should be taken in the selection of drainage structure sizes for the railway to cross the alluvial fan surface since the bulk of the discharge could arrive at various locations with each significant event.

Closed Basin Lakes

In the Great Basin Province closed basin lakes are a common phenomenon. Since many of the valleys in the Great Basin do not have an outlet to the ocean, the surface water drains to a "terminal" or "closed basin lake". The levels in these lakes will vary considerably from year to year in response to yearly changes in average precipitation and extreme events. The only outflows from these lakes are from evaporation and infiltration. The amount of infiltration can be minimal in many cases since the lake bottoms tend to become sealed by the accumulation of silt and cementation of the soil.

Areas flooded by high lake levels in closed basin lakes, can be inundated for extended periods of time (days, weeks or months). The water in these lakes can often have high levels of dissolved salt and other constituents. Flooding of structures and roadway embankments, as a result of high lake levels, can result in significant damage to these structures from saturation, settlement, uplifting and wave action.

Sedimentation

Many of the watercourses crossed by the proposed railway are relatively steep sand bed channels. During extreme events, the flow will often contain a significant sediment volume. Design of drainage structures in such an environment must consider sediment control measures. At locations where abrupt changes in flow velocity occur, sediment accumulation or scour can occur. Sediment accumulation at culvert inlets can substantially reduce culvert capacity.

The outlets of culverts will often require channel protection to prevent culvert induced scour at the outlet. Use of outlet aprons, rip-rapped protected splash pools and other outlet protection measures should be considered in the design concepts for drainage.

In some case, bridges may be the most cost effective type of drainage structure. The depth of the bridge piers must consider the potential for considerable local scour around the bridge piers. Inadequate pier depth can result in bridge failure by undermining of the bridge support structure.

The following sections will describe the conditions in each drainage province in greater detail and summarize many of the site specific special design considerations identified as a part of this study.

BASIN 141

Basin 141 is located near the western portion of the study area. This basin includes the town of Tonopah. The proposed railway crosses the southern portion of Basin 141. The drainage area that contributes to the proposed railway originates primarily from the portion of the basin

that is north of the alignment.

Description

Basin 141 (Figure 2.3) is approximately 62 miles long, 20 miles wide and is approximately 985 square miles in size. This basin is a closed basin which originates in the Monitor Range. Drainage from the mountain slopes enters Ralston Valley and flows south to Mud Lake at the extreme southern end of the basin. The adjacent Basin 149 also drains into Basin 141 and Mud Lake at the southeast corner of Basin 141.

The prominent vegetation types are desert shrub in the majority of the watershed and pinion pine and juniper above 5500 to 6000 feet. The desert shrubs include primarily greasewood, shadscale, bud sagebrush and rabbitbrush.

Average annual precipitation in the basin ranges from 8 inches on the valley floor to 18 inches on the Monitor Range at the northeast portion of the Basin.

Other Studies

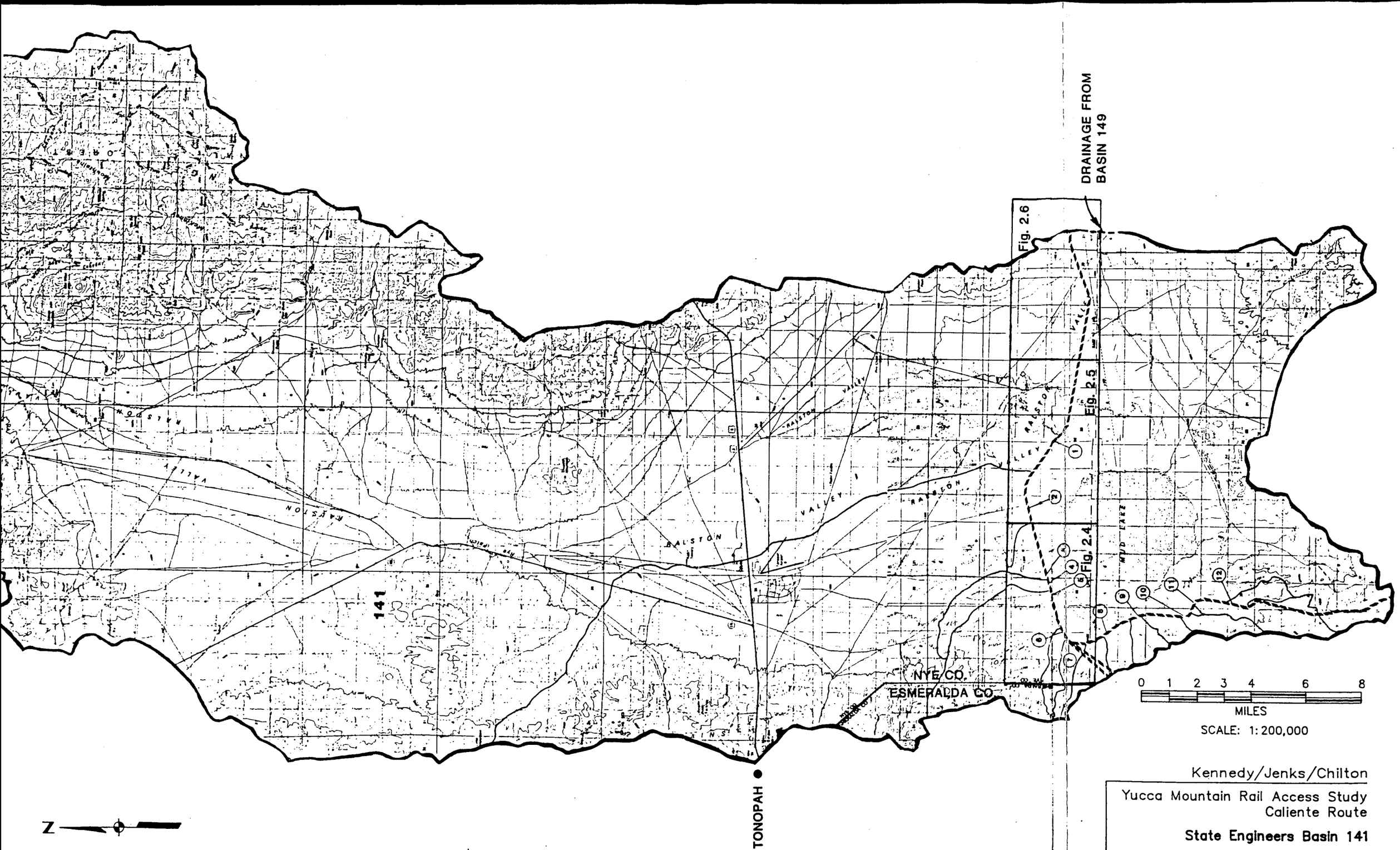
The Nye County Flood Insurance Rate Maps, published by FEMA, show approximate flood limits for the major drainages in this basin and an approximate extent of flooding associated with Mud Lake. These flood hazard boundaries are based only on approximate methods and were not the result of any detailed analyses.

Figure 2.4, 2.5 and 2.6 show the locations where the proposed railway alignment crosses flood hazard areas identified by FEMA. The approximate locations of Figures 2.4, 2.5 and 2.6 are shown on Figure 2.3 for reference. Additional flood hazard areas have been mapped within Nye County but are not shown on these figures.

Special Design Considerations

Flooding associated with closed basin lakes differs in many ways from the type of flooding associated with streams. Structures inundated by closed basin lakes could be inundated for days, weeks or months. The longer duration flooding can result in complete failure of the structure from saturation, settlement, uplifting or wave action. Mud Lake is a closed basin since there is no lake outlet and the only outflows from the lake are evaporation and infiltration. Fill associated with the railway embankment should avoid the areas identified for potentially high lake levels.

Based upon the hydrologic analysis conducted as a part of this study, the extent of flooding associated with Mud Lake as shown on the FIRM maps, may be inaccurate. The 100-year lake level estimated in this study produces a pool elevation and maximum aerial extent of inundation that is higher than what is suggested by the FIRM. Chapters 3 and 4 provide additional information on the extent of flooding associated with Mud Lake.



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Yucca Mountain Rail Access Study
Caliente Route

State Engineers Basin 141

K/J/C 897045.01

October, 1990

Figure 2.3

Source: Federal Emergency Management Agency
FIRM Panel 320018 0103 B Date: April 12, 1983

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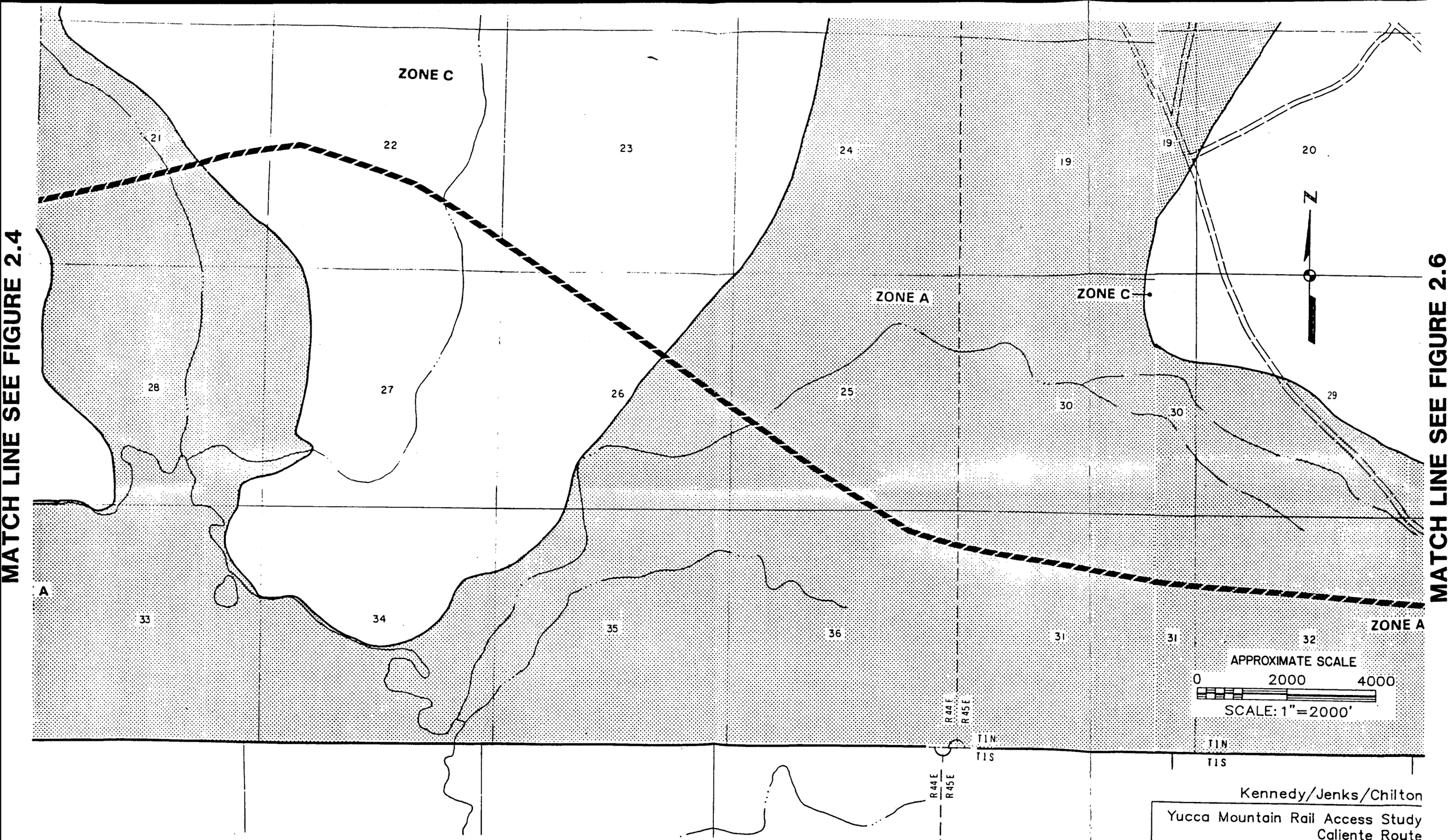
Yucca Mountain Rail Access Study
Caliente Route

FEMA Flood Insurance Rate Map

K/J/C 897045.01

October, 1990

FIGURE 2.4



Source: Federal Emergency Management Agency
FIRM Panel 320018 0103 B Date: April 12, 1983
FIRM Panel 320018 0104 B Date: April 12, 1983

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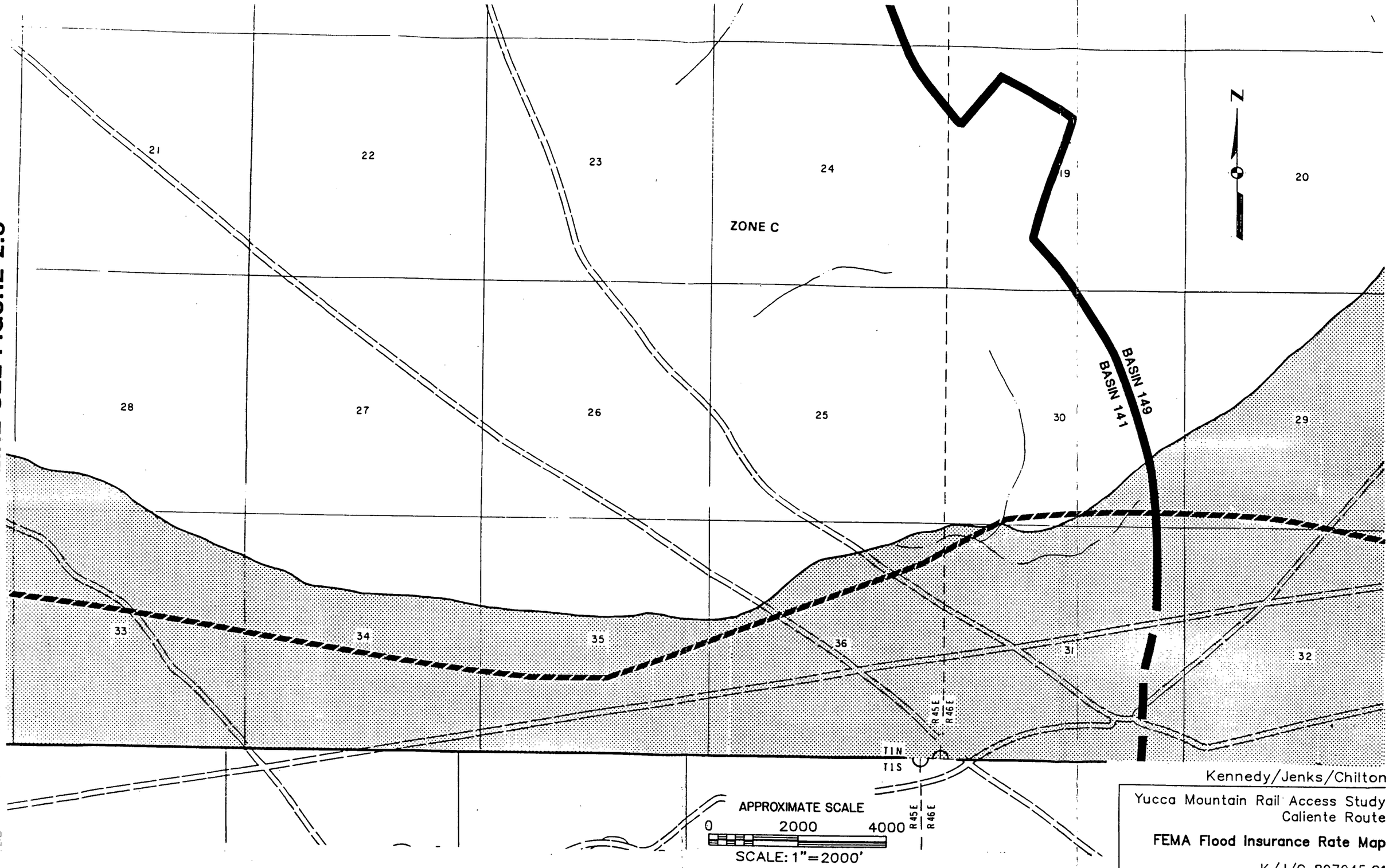
Yucca Mountain Rail Access Study
Caliente Route

FEMA Flood Insurance Rate Map

K/J/C 897045.01

October, 1990

FIGURE 2.5



Source: Federal Emergency Management Agency
FIRM Panel 320018 0104 B Date: April 12, 1983

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Caliente Route

FEMA Flood Insurance Rate Map

K/J/C 897045.01

October, 1990

FIGURE **2.6**

MACHINE SELECT FIGURE 2.5

In addition, the streams that enter Mud Lake from Ralston Valley are wide and shallow. Collection of the flow for conveyance under the railway will require a series of drainage and diversion structures.

BASIN 142

Basin 142 is located near the western portion of the study area. This basin includes the town of Goldfield. The proposed railway crosses the south central and eastern portions of Basin 142. The drainage area that contributes to the proposed railway originates primarily from the portion of the basin that is south and east of the alignment.

Description

Basin 142 (Figure 2.7) is approximately 25 miles long, 18 miles wide and is approximately 310 square miles in size. This basin is a closed basin which drains to a small playa near the west central part of the basin.

The prominent vegetation types are desert shrub consisting primarily of greasewood, shadscale, bud sagebrush and rabbitbrush.

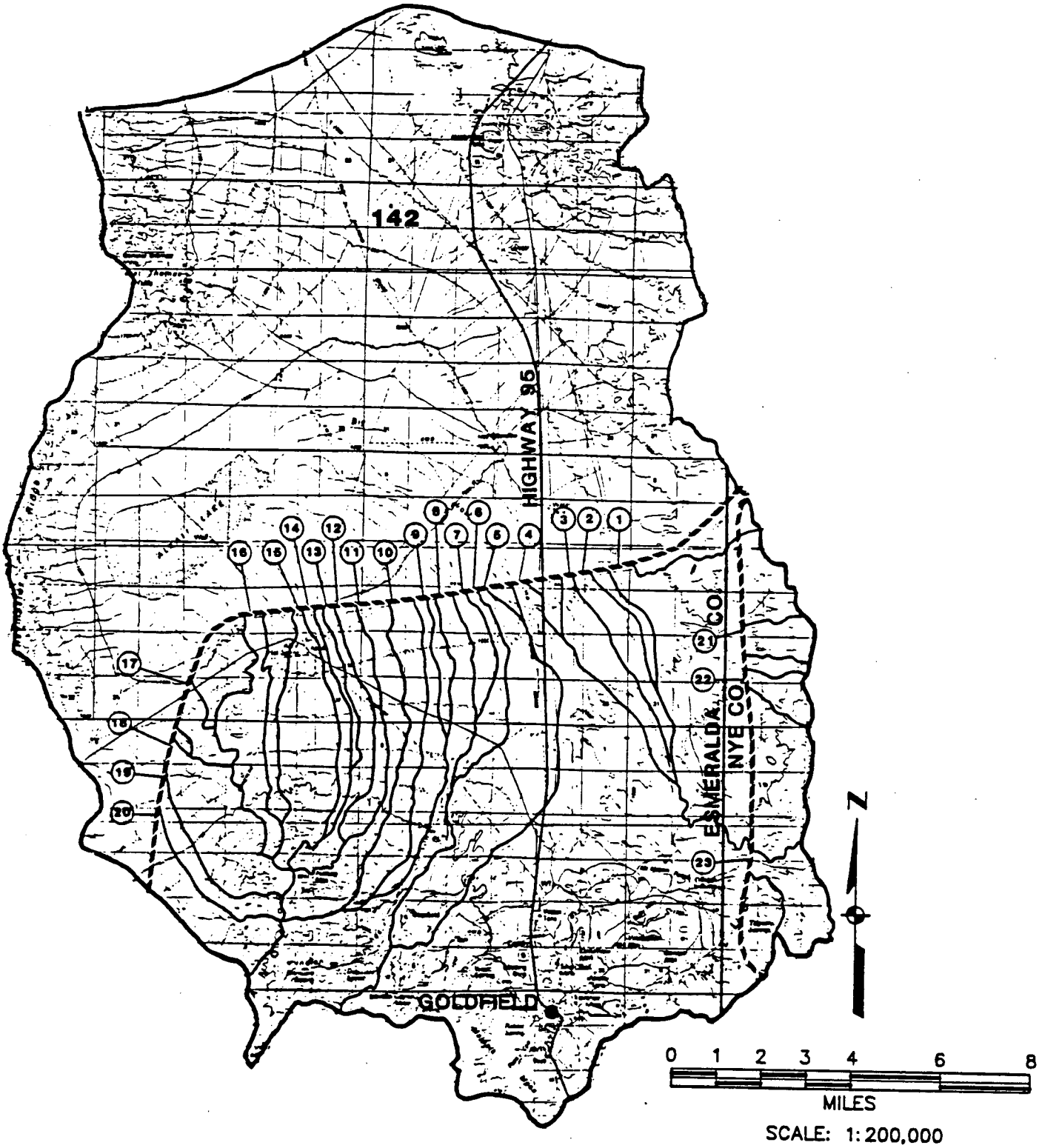
Average annual precipitation in the basin ranges from 7 inches on the valley floor to 12 inches on the highest portions of the surrounding mountain ranges.

Other Studies

This basin is located within Esmeralda County which does not have any flood hazards identified by FEMA.

Special Design Considerations

The drainages contributing to the proposed railway within this basin originate from relatively steep alluvial watersheds. Flows from extreme events will also be carrying a significant sediment load. Sudden changes to conveyance geometry can result in a change in flow velocity which in turn can result in deposition of sediment or additional scour. Drainage structures should be designed using sediment control considerations.



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Yucca Mountain Rail Access Study
Caliente Route

State Engineers Basin 142

K/J/C 897045.01

October, 1990

Figure 2.7

BASIN 143

Basin 143 is located at the extreme western portion of the study area. The proposed railway crosses through the eastern portion of Basin 143. The drainage area that contributes to the proposed railway originates primarily from the portion of the basin that is east and south of the alignment.

Description

Basin 143 (Figure 2.8) is approximately 37 miles long, 30 miles wide and is approximately 575 square miles in size. This basin is a closed basin which drains to a small playa near the central part of the basin in Clayton Valley. The basin is bounded on the north by the Weepah Hills, on the east by Clayton Ridge, on the west by the Silver Peak Range and on the south by the Palmetto Mountains.

The prominent vegetation type in this watershed is desert shrub consisting primarily of greasewood, shadscale, bud sagebrush and rabbitbrush.

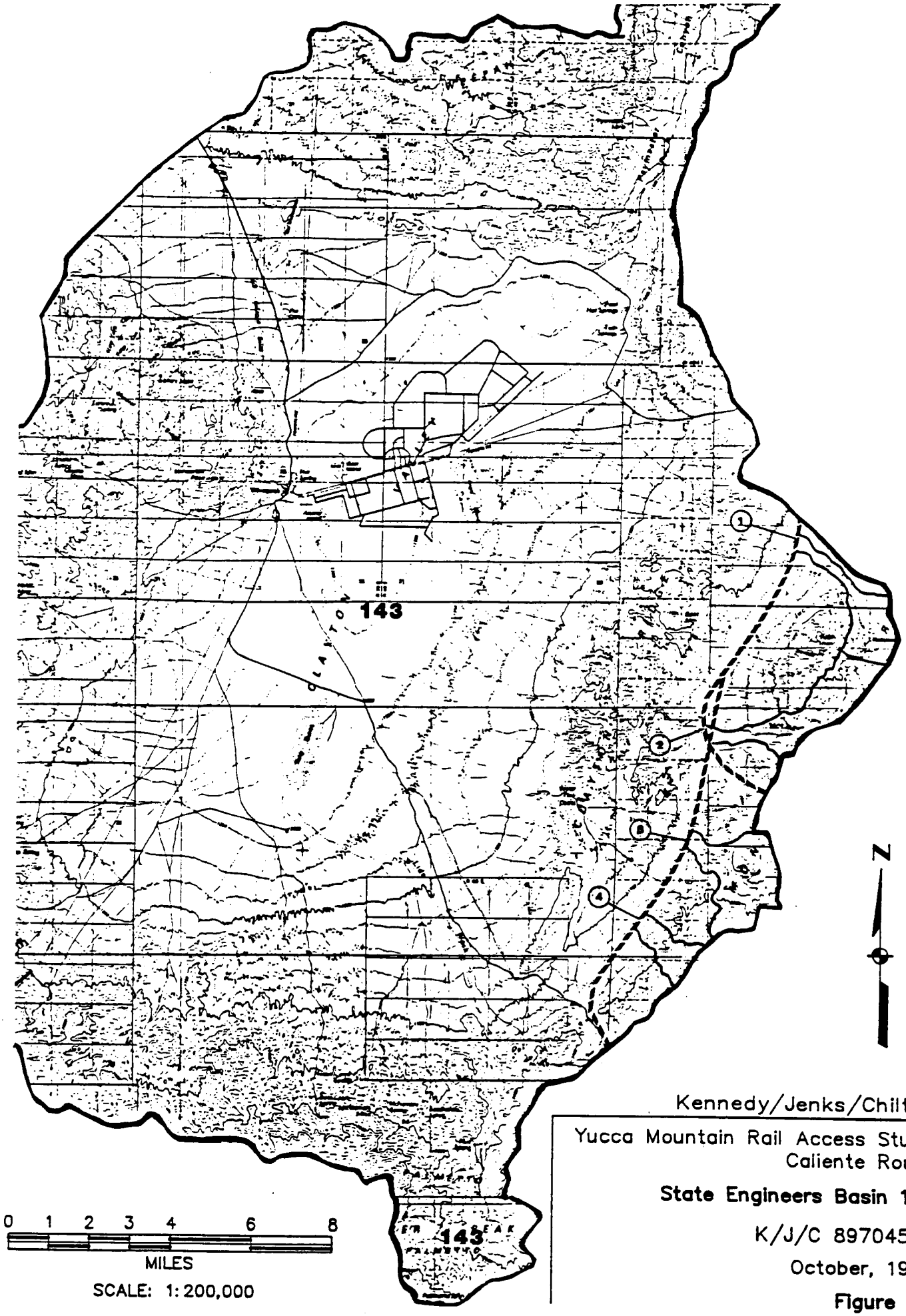
Average annual precipitation in the basin ranges from 7 inches on the valley floor to 14 inches on the highest portions of the surrounding mountain ranges.

Other Studies

This basin is located within Esmeralda County which does not have any flood hazards identified by FEMA.

Special Design Considerations

The drainages contributing to the proposed railway within this basin originate from relatively steep watersheds. Flows from extreme events will also be carrying a significant sediment load. Sudden changes to conveyance geometry can result in a change in flow velocity which in turn can result in deposition of sediment or additional scour. Drainage structures should be designed using sediment control considerations.



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Yucca Mountain Rail Access Study
Caliente Route

State Engineers Basin 143

K/J/C 897045.01

October, 1990

Figure 2.8

BASIN 144

Basin 144 is located near the western portion of the study area. This basin includes the small communities of Lida, Gold Point and Lida Junction. The proposed railway has two primary alignment alternatives that cross through the central and eastern portion of Basin 144. The drainage area that contributes to the proposed railway originates from all portions of the basin.

Description

Basin 144 (Figure 2.9) is approximately 27 miles long, 29 miles wide and is approximately 535 square miles in size. This basin drains into the northwest corner of Basin 146. The basin is bounded on the north by the Montezuma Range, on the east by the Stonewall Mountains, on the west by the Silver Peak Range and on the south by Slate Ridge.

The prominent vegetation type in this watershed is desert shrub consisting primarily of greasewood, shadscale, bud sagebrush and rabbitbrush.

Average annual precipitation in the basin ranges from 7 inches on the valley floor to 14 inches on the highest portions of the surrounding mountain ranges.

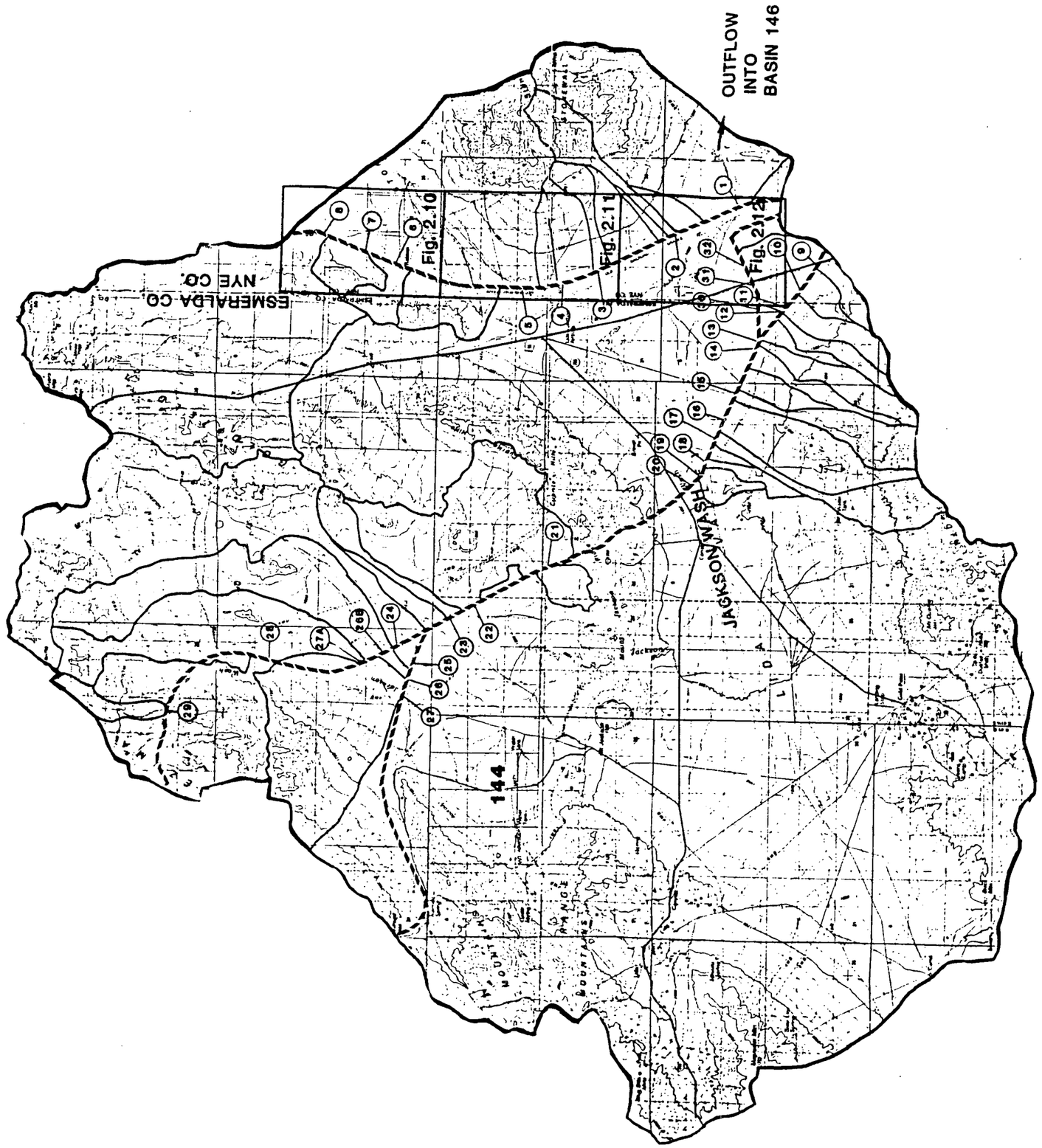
Other Studies

This basin is located within Esmeralda and Nye Counties. The portion of the basin within Esmeralda County does not have any flood hazards identified by FEMA. The portion of the basin within Nye County has approximate flood hazard areas identified for a portion of Jackson Wash and Stonewall Flat. These flood hazard areas are shown on Figures 2.10, 2.11 and 2.12 in the vicinity of the proposed railway alignment. Additional flood hazard areas have been identified by FEMA for other portions of Nye County but are not shown on these figures.

Special Design Considerations

Jackson Wash produces a relatively high peak discharge where it impacts the proposed railway at two locations (144-1 and 144-20). This flow also impacts the proposed railway as wide shallow flow.

Many of the drainages contributing to the proposed railway within this basin originate from relatively steep watersheds. Flows from extreme events will also be carrying a significant sediment load. Sudden changes to conveyance geometry can result in a change in flow velocity which in turn can result in deposition of sediment or additional scour. Drainage structures should be designed using sediment control considerations.



Z

0 1 2 3 4 6 8

MILES

SCALE: 1:200,000

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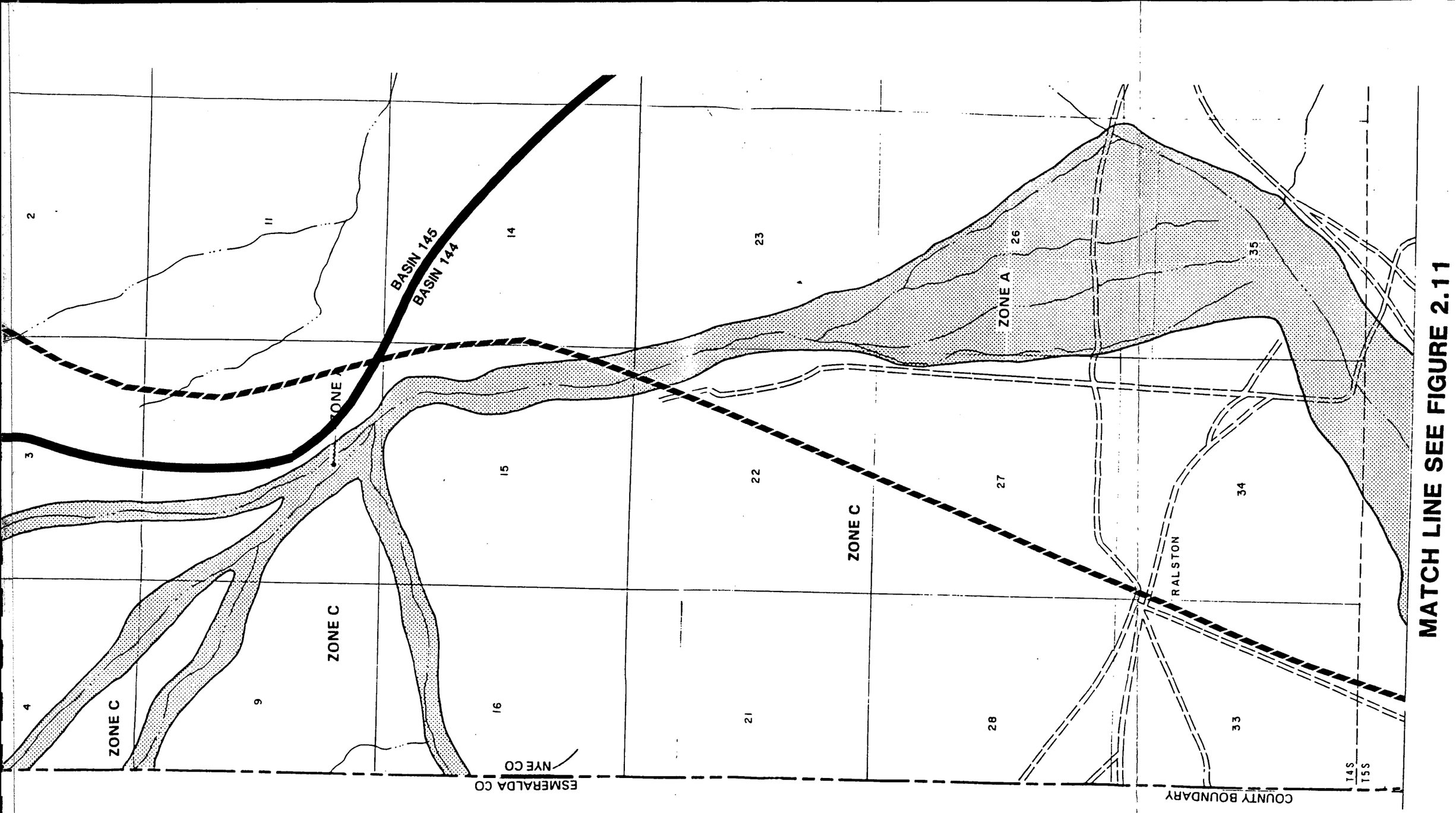
Caliente Route

State Engineers Basin 144

K/J/C 897045.01

October, 1990

Figure 2.9



APPROXIMATE SCALE

0 2000 4000

SCALE: 1"=2000'

N

Source: Federal Emergency Management Agency
Firm Panel 320018 0115 B Date: April 12, 1983

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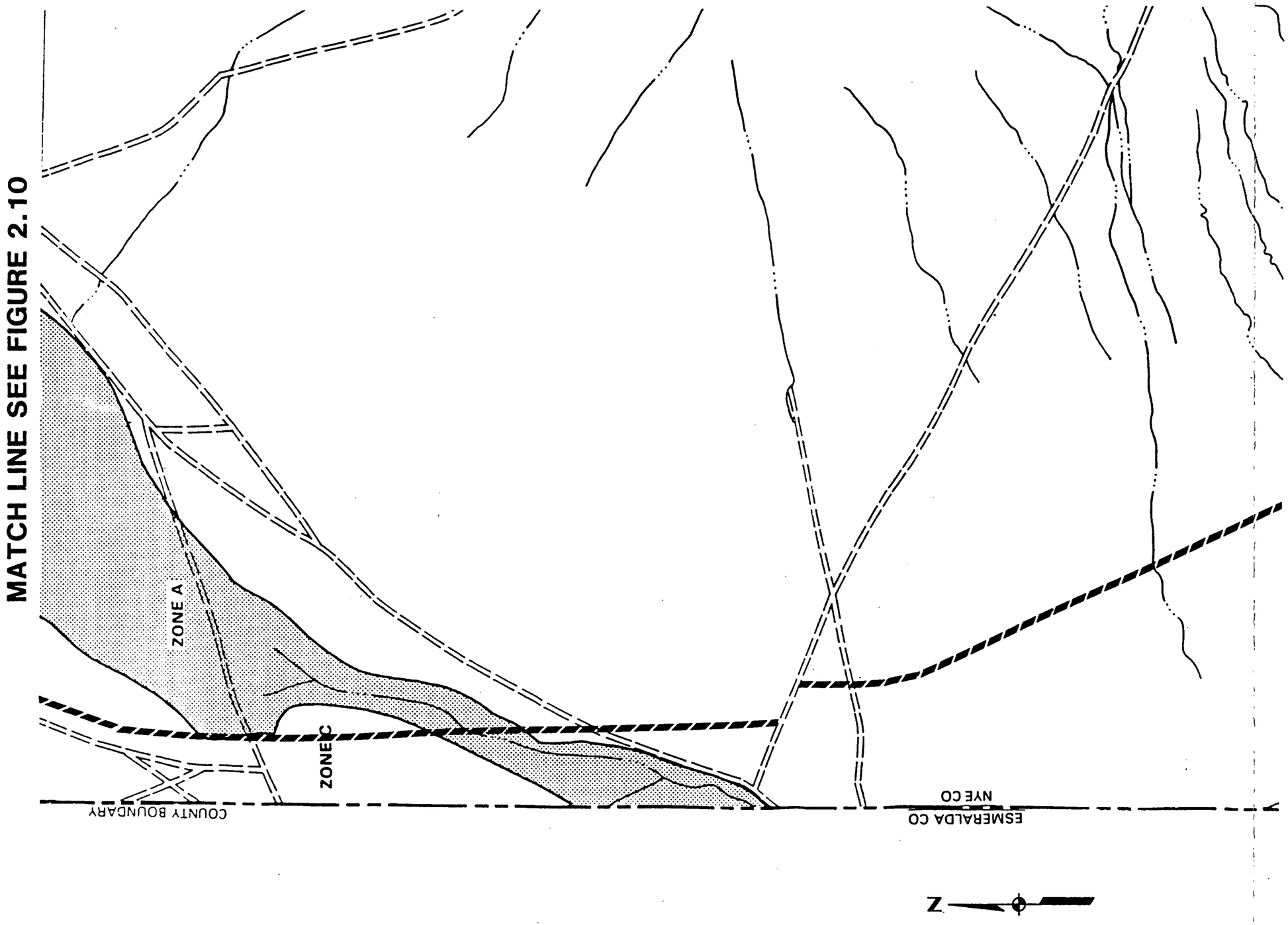
Yucca Mountain Rail Access Study
Caliente Route

FEMA Flood Insurance Rate Map

K/J/C 897045.01

October, 1990

FIGURE 2.10



APPROXIMATE SCALE

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SCALE: 1"=2000'

Source: Federal Emergency Management Agency
Firm Panel 320018 0121 B Date: April 12, 1983

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Caliente Route

FEMA Flood Insurance Rate Map

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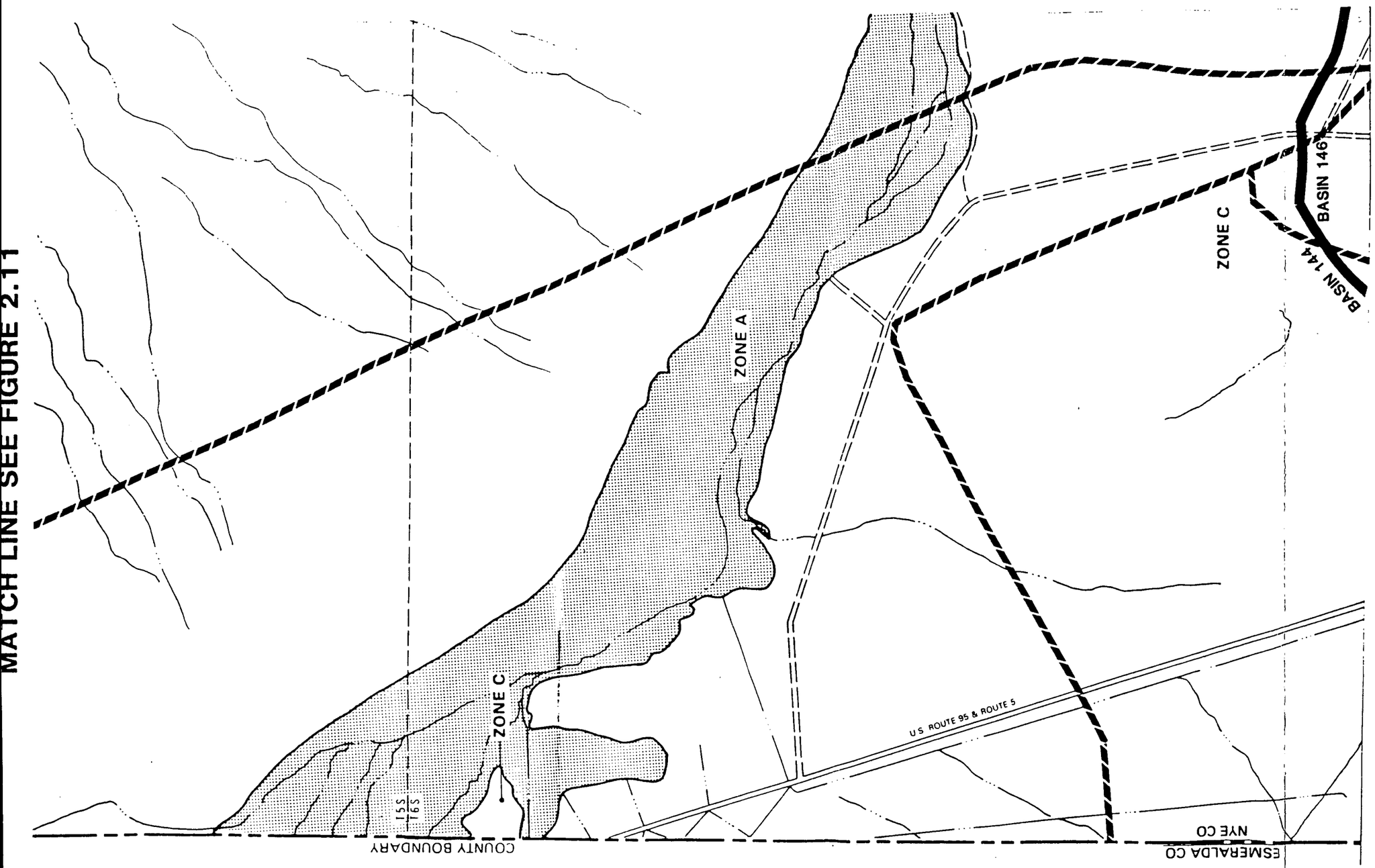
October, 1990

FIGURE 2.11



APPROXIMATE SCALE

0 2000 4000

SCALE: 1"=2000'

N

Source: Federal Emergency Management Agency
Firm Panel 320018 0121 B Date: April 12, 1983

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FEMA Flood Insurance Rate Map

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FIGURE 2.12

BASIN 145

Basin 145 is located near the western portion of the study area. This is a closed basin which drains to Stonewall Flat at the center of the basin. The proposed railway crosses through the extreme western portion of Basin 145. The drainage area that contributes to the proposed railway originates from the portion of the basin that is west of the alignment.

Description

Basin 145 (Figure 2.13) is approximately 25 miles long, 24 miles wide and is approximately 375 square miles in size. The basin is bounded on the north and east by the Cactus Range and on the south by Stonewall Mountain.

The prominent vegetation type in this watershed is desert shrub consisting primarily of greasewood, shadscale, bud sagebrush and rabbitbrush.

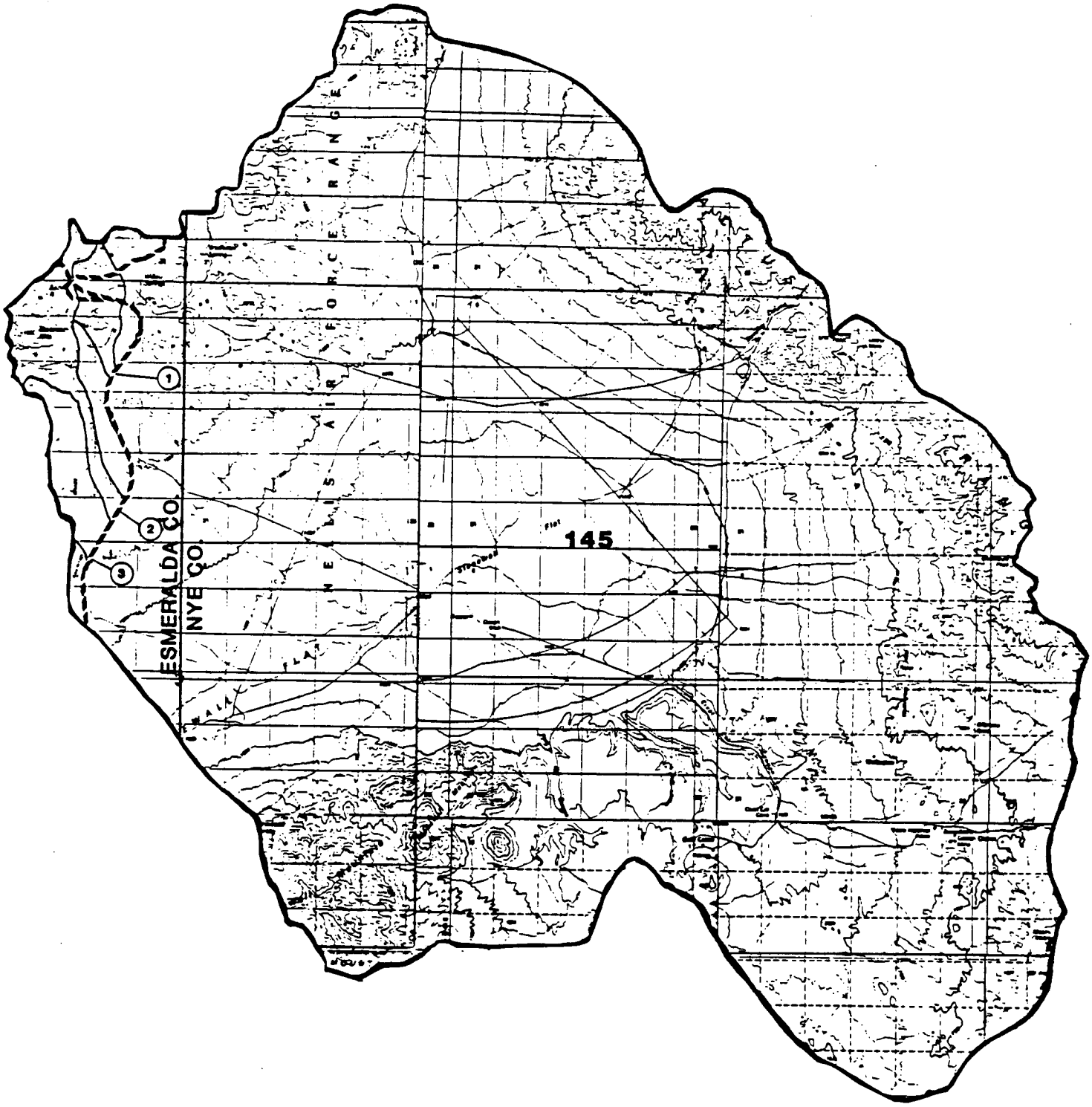
Average annual precipitation in the basin ranges from 7 inches on the valley floor to 12 inches on the highest portions of the surrounding mountain ranges.

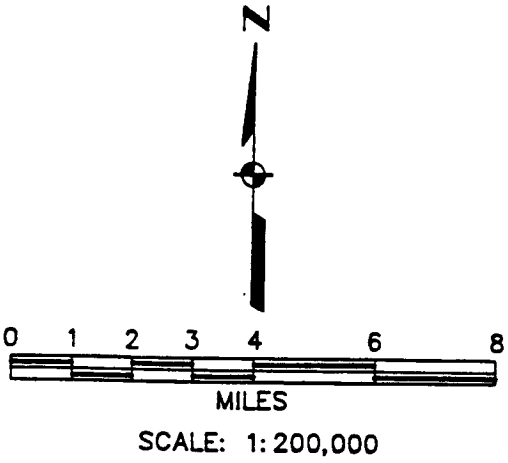
Other Studies

The FEMA flood hazard maps for Nye County do not identify any flood hazard areas in the portion of Basin 145 transected by the proposed railway. Additional flood hazard areas have been identified by FEMA for other portions of Nye County but are not shown on these figures.

Special Design Considerations

The drainages contributing to the proposed railway within this basin originate from relatively steep watersheds. Flows from extreme events will also be carrying a significant sediment load. Sudden changes to conveyance geometry can result in a change in flow velocity which in turn can result in deposition of sediment or additional scour. Drainage structures should be designed using sediment control considerations.





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Yucca Mountain Rail Access Study
Caliente Route

State Engineers Basin 145

K/J/C 897045.01

October, 1990

Figure 2.13

BASIN 146

Basin 146 is located near the southwestern portion of the study area. This is a closed basin which drains to Sarcobatus Flat at the center of the basin. The proposed railway crosses through the center of Basin 146. The drainage area that contributes to the proposed railway originates north and east of the alignment.

Description

Basin 146 (Figure 2.14) is approximately 40 miles long, 28 miles wide and is approximately 790 square miles in size. Basin 144 also drains into this basin at the northwest corner. The basin is bounded on the north by the Stonewall Mountains, on the east by Pahute Mesa and on the south by the Bullfrog Hills in the Death Valley National Monument.

The prominent vegetation type in this watershed is desert shrub consisting primarily of greasewood, shadscale, bud sagebrush and rabbitbrush.

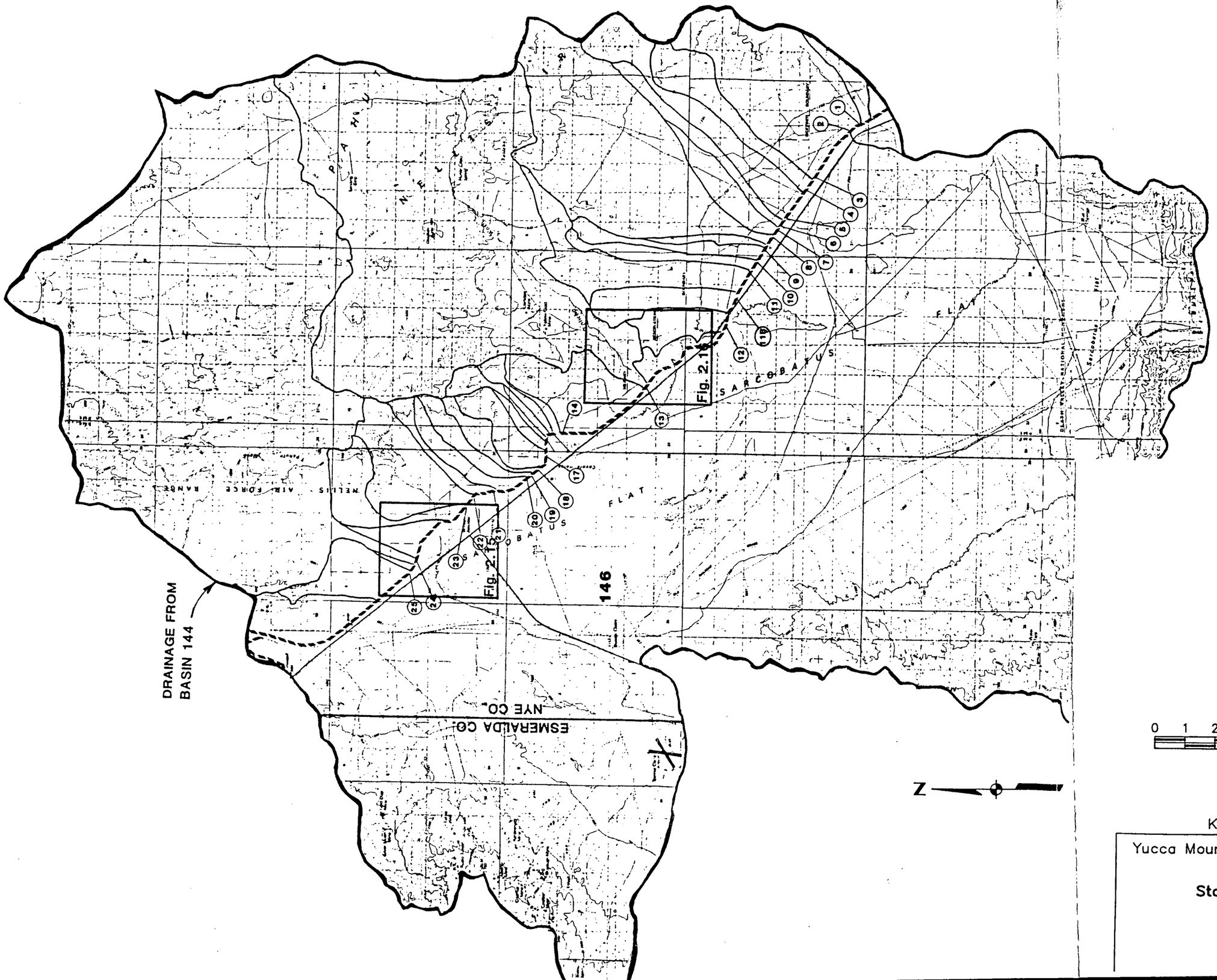
Average annual precipitation in the basin ranges from 6 inches on the valley floor to 11 inches on the highest portions of the surrounding mountain ranges.

Other Studies

The FEMA flood hazard maps identify flood hazard areas associated with Jackson and Tolicha Washes in the vicinity of the proposed railway. These flood hazard boundaries are based only on approximate studies and were not the result of any detailed analyses. The portions of the FEMA maps showing where the proposed railway crosses these flood hazard areas, have been reproduced as Figures 2.15 and 2.16. Additional flood hazard areas have been identified by FEMA for other portions of Nye County but are not shown on these figures.

Special Design Considerations

The drainages contributing to the proposed railway within this basin originate from relatively steep watersheds. Flows from extreme events will also be carrying a significant sediment load. Sudden changes to conveyance geometry can result in a change in flow velocity which in turn can result in deposition of sediment or additional scour. Drainage structures should be designed using sediment control considerations.



0 1 2 3 4 6 8
MILES
SCALE: 1:200,000

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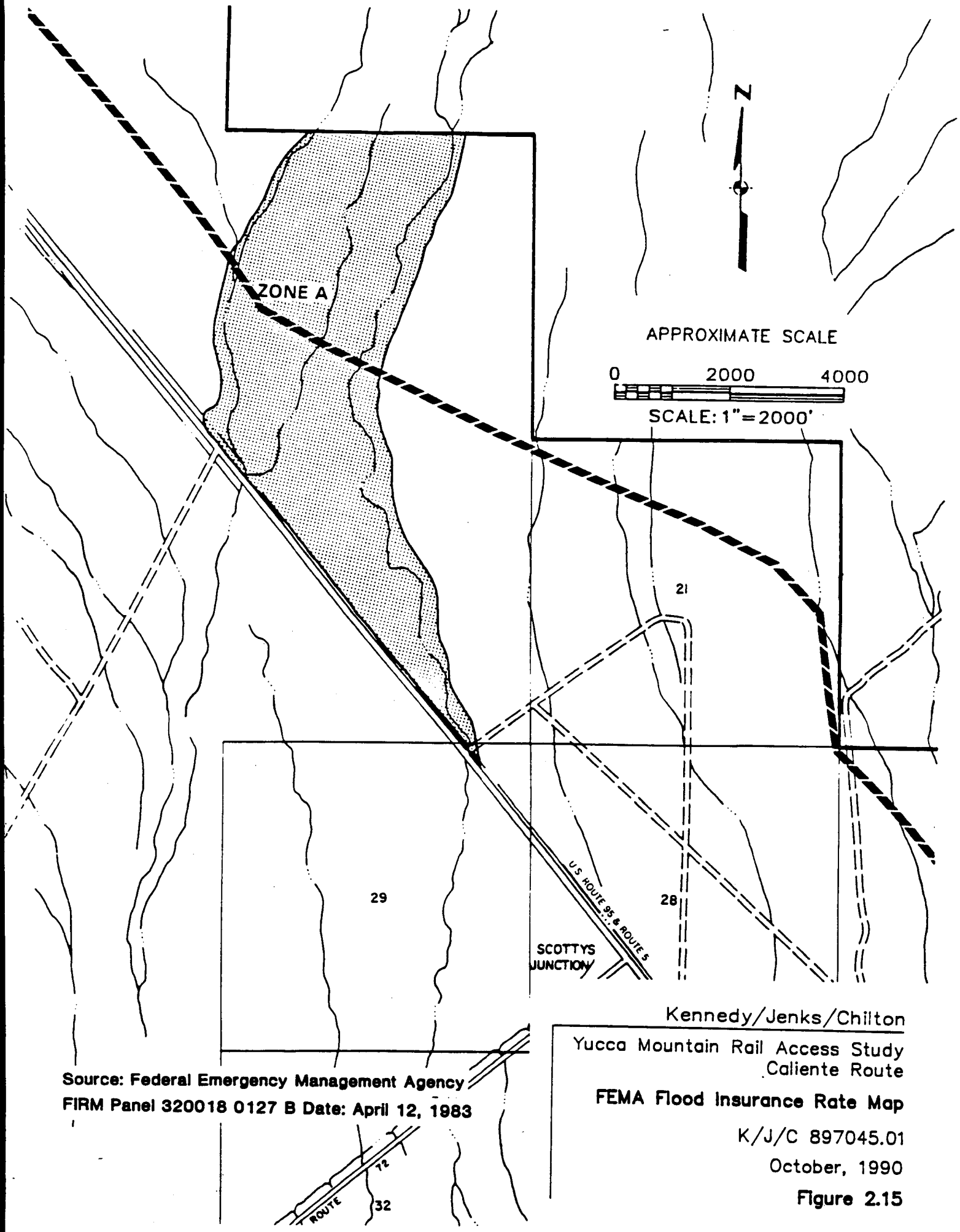
Yucca Mountain Rail Access Study
Caliente Route

State Engineers Basin 146

K/J/C 897045.01

October, 1990

Figure 2.14



Source: Federal Emergency Management Agency
FIRM Panel 320018 0127 B Date: April 12, 1983

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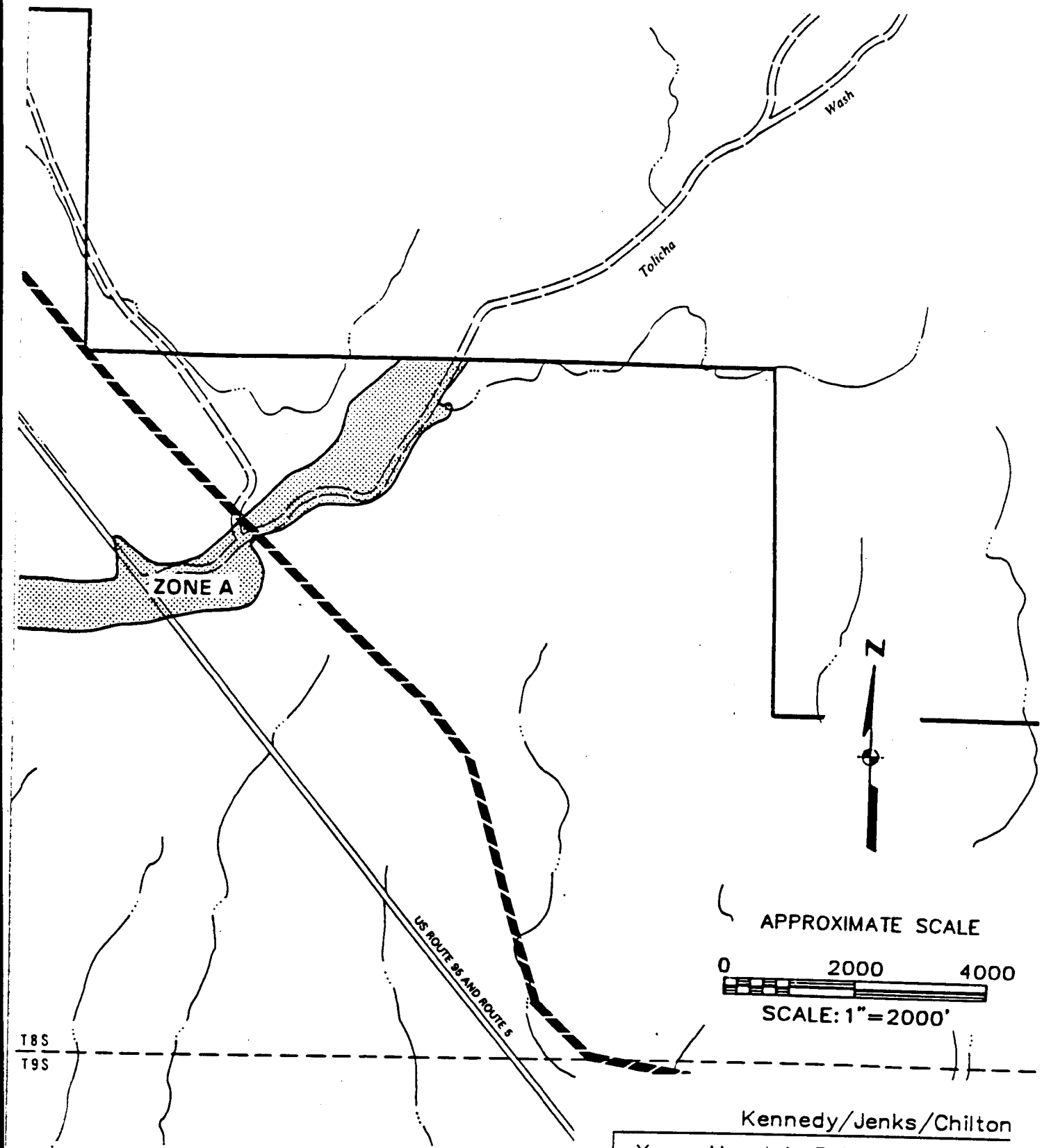
Caliente Route

FEMA Flood Insurance Rate Map

K/J/C 897045.01

October, 1990

Figure 2.15



Source: Federal Emergency Management Agency
FIRM Panel 320018 0134 B Date: April 12, 1983

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Caliente Route

FEMA Flood Insurance Rate Map

K/J/C 897045.01

October, 1990

Figure 2.16

BASIN 149

Basin 149 is located near the west-central portion of the study area. Basin 149 drains into Basin 141 at the southwest corner of the basin. The proposed railway crosses through the southern portion of Basin 149. The drainage area that contributes to the proposed railway originates south and east and also north of the alignment.

Description

Basin 149 (Figure 2.17) is approximately 64 miles long, 25 miles wide and is approximately 970 square miles in size. The basin is bounded on the west by the Monitor Range, on the east by the Hot Creek Range and on the south by the Cactus and Kawich Ranges.

The prominent vegetation type is desert shrub consisting primarily of bud sagebrush and rabbitbrush.

Average annual precipitation in the basin ranges from 8 inches on the valley floor to 17 inches on the highest portions of the surrounding mountain ranges.

Other Studies

The Nye County Flood Insurance Rate Maps, published by FEMA, show approximate flood limits for Stone Cabin Creek. These flood hazard boundaries are based only on approximate studies and were not the result of any detailed analyses.

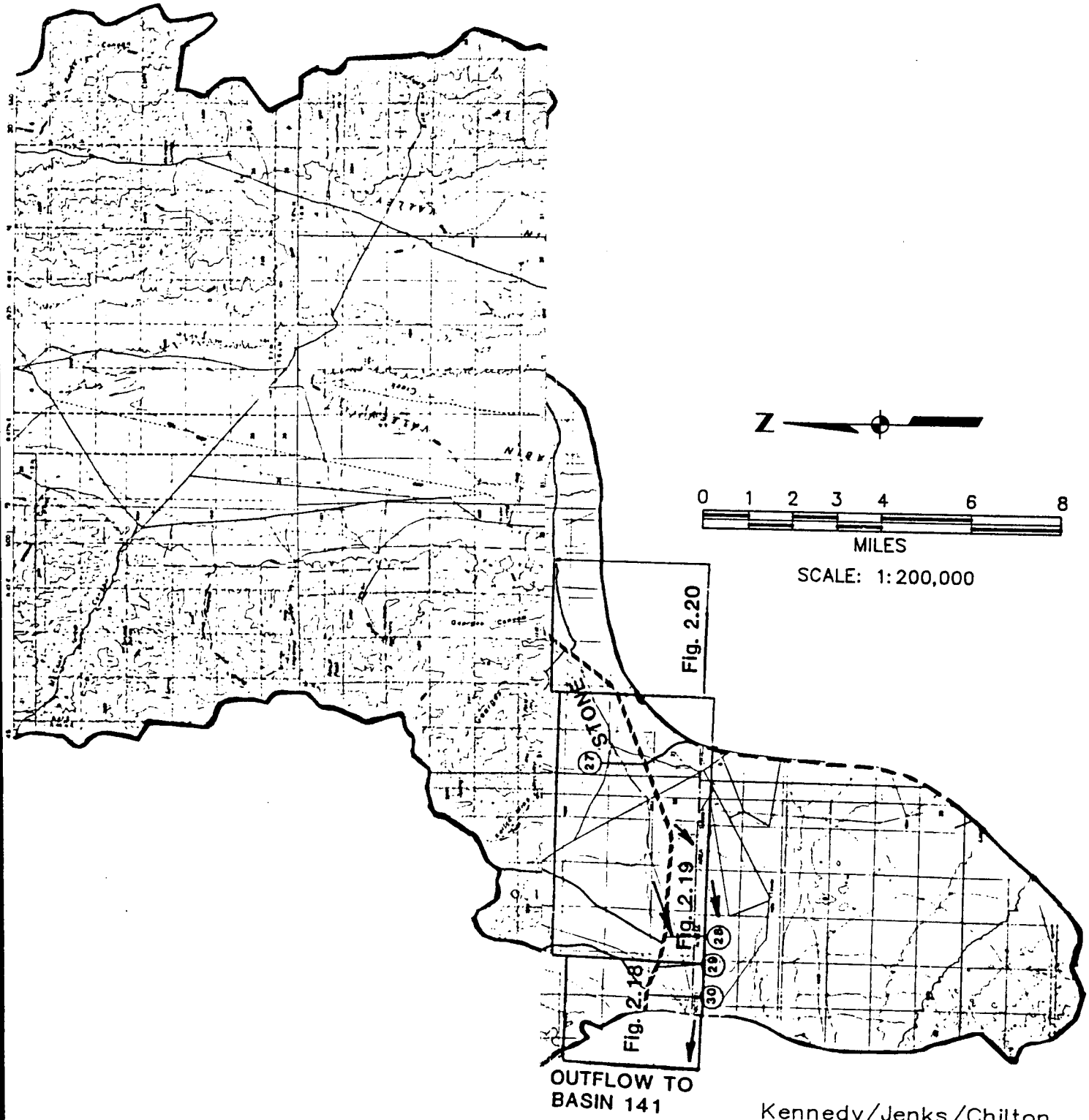
Figure 2.18, 2.19 and 2.20 show the locations where the proposed railway alignment cross the flood hazard areas identified by FEMA. Additional flood hazard areas have been identified by FEMA for other portions of Nye County but are not shown on these figures.

Special Design Considerations

The majority of the basin drains to Stone Cabin Creek which impacts the proposed railway at two primary locations; the location shown as 149-28 and another location approximately 3 miles east of that point. The flow magnitude at these locations is relatively high and it impacts the proposed railway as wide shallow flow.

Bellehelen Canyon (watershed 149-10) is an active alluvial fan. Flow patterns from the canyon could also impact concentration points 149-8 and 9. This fact should be considered in the design of these structures.

Many of the drainages contributing to the proposed railway within this basin originate from relatively steep alluvial watersheds. Flows from extreme events will also be carrying a significant sediment load. Sudden changes to conveyance geometry can result in a change in flow velocity which in turn can result in deposition of sediment or additional scour. Drainage structures should be designed using sediment control considerations.



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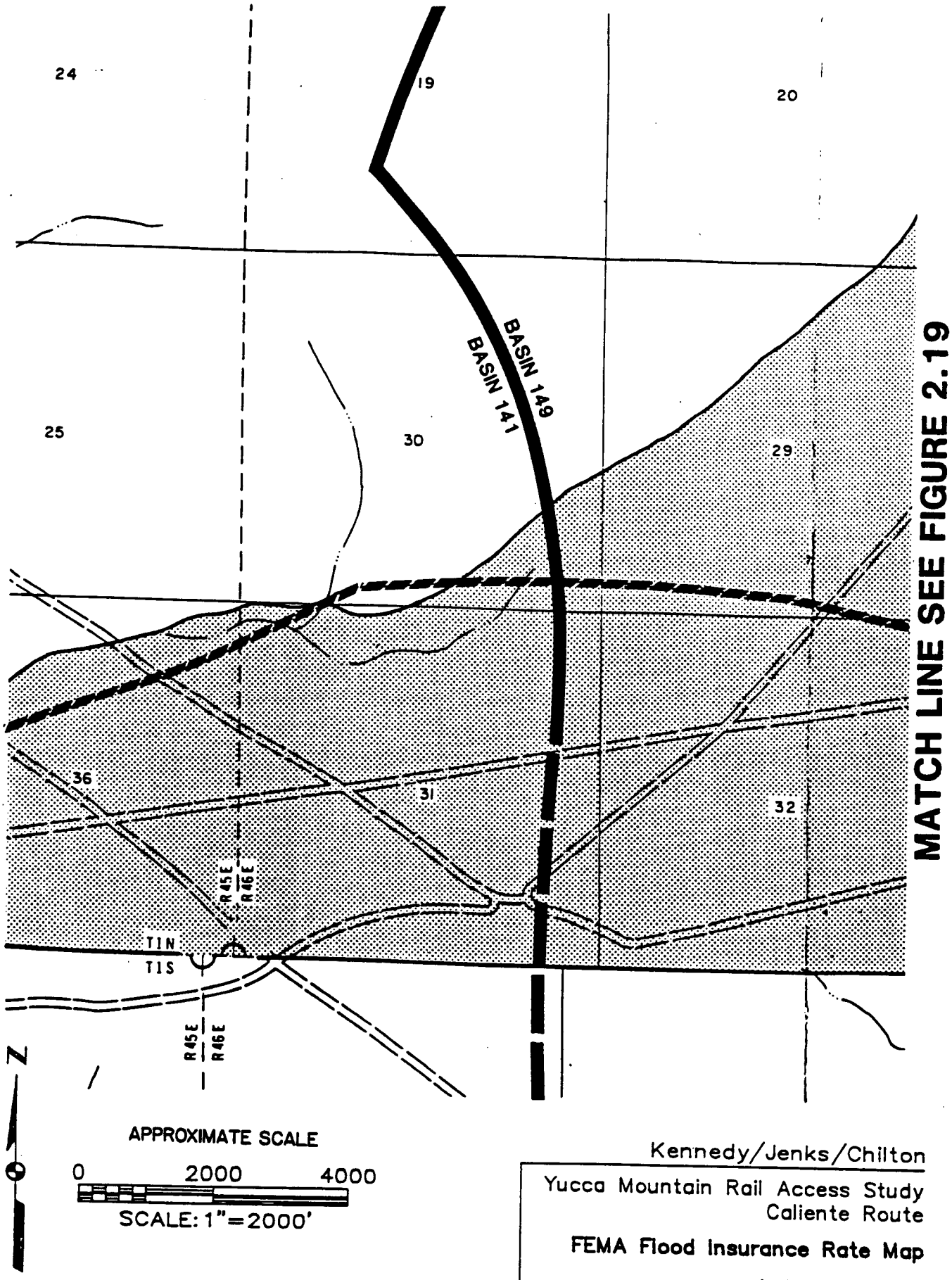
Caliente Route

State Engineers Basin 149

K/J/C 897045.01

October, 1990

Figure 2.17



Source: Federal Emergency Management Agency
FIRM Panel 320018 0104 B Date: April 12, 1983

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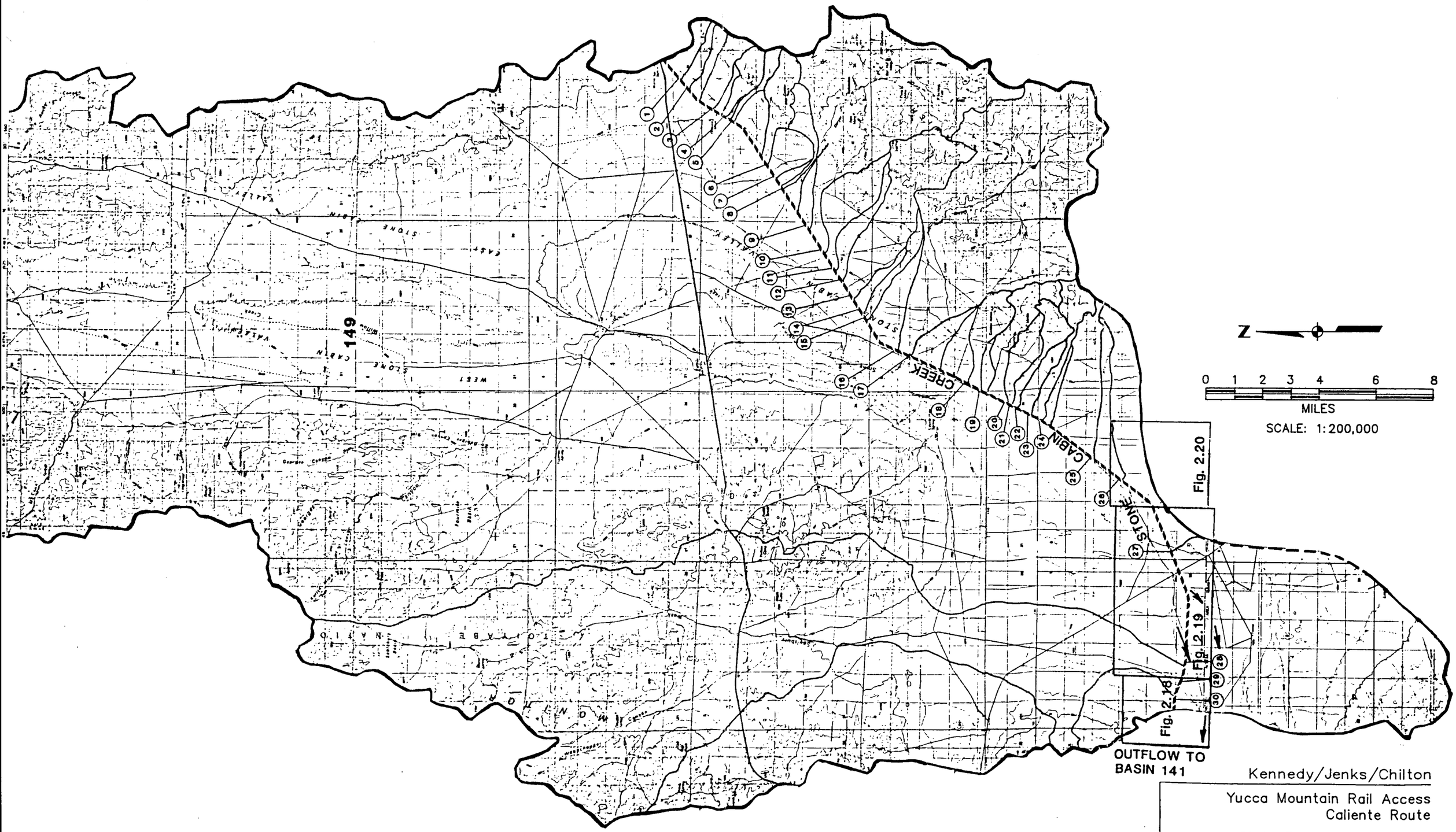
Caliente Route

FEMA Flood Insurance Rate Map

K/J/C 897045.01

October, 1990

Figure 2.18



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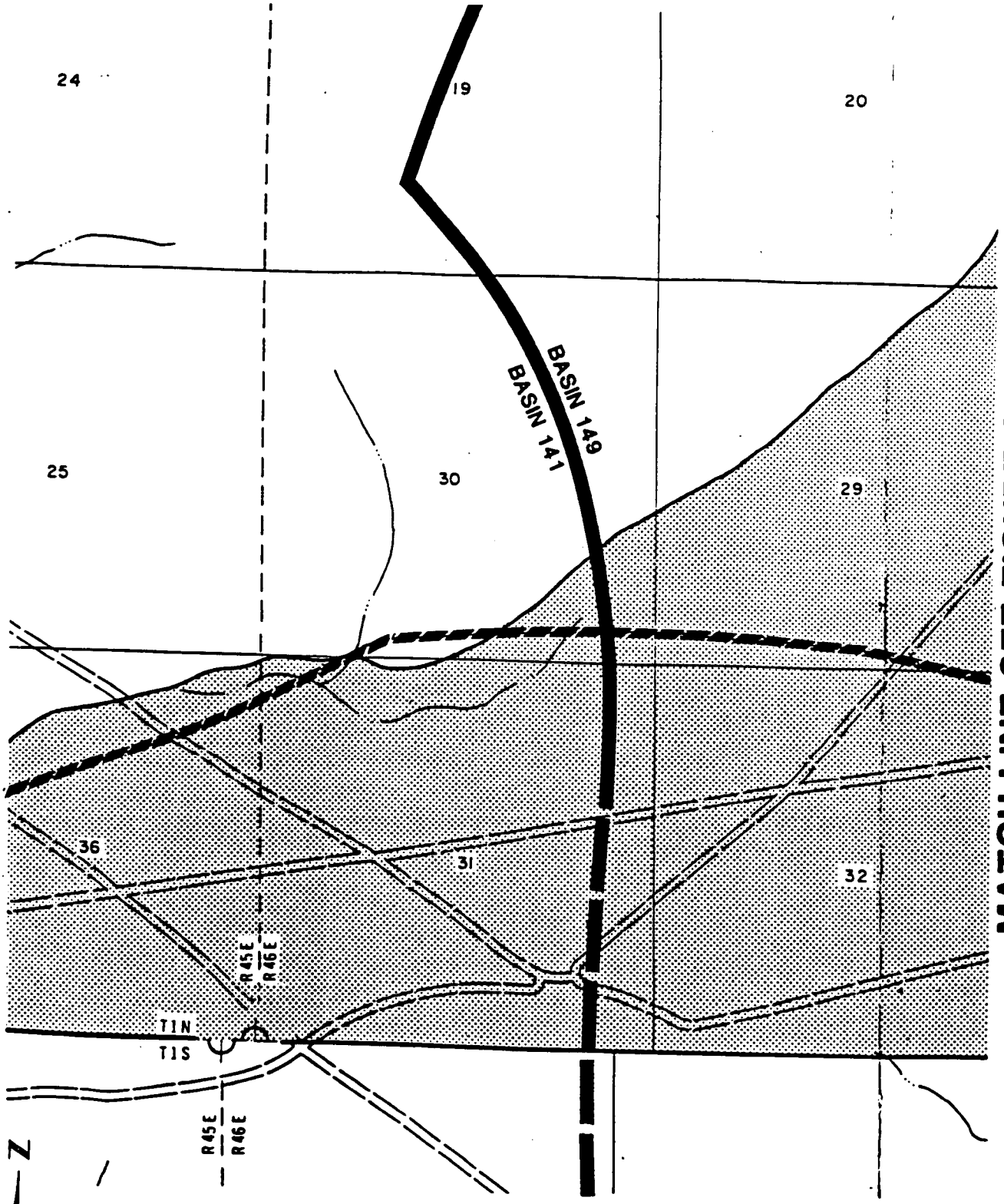
Caliente Route

State Engineers Basin 149

K/J/C 897045.01

October, 1990

Figure 2.17



N

APPROXIMATE SCALE

0 2000 4000

SCALE: 1"=2000'

Source: Federal Emergency Management Agency
FIRM Panel 320018 0104 B Date: April 12, 1983

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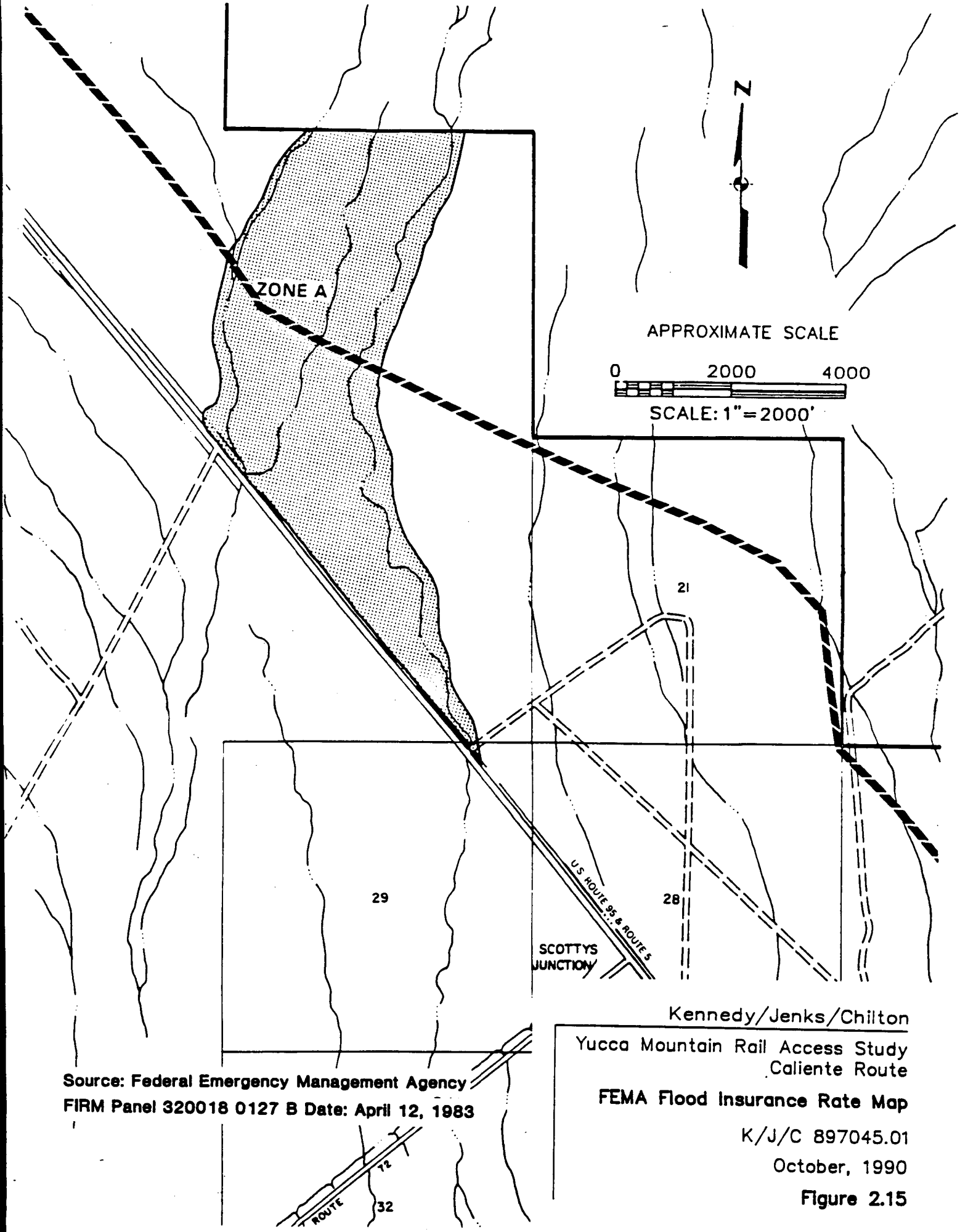
Caliente Route

FEMA Flood Insurance Rate Map

K/J/C 897045.01

October, 1990

Figure 2.18



Source: Federal Emergency Management Agency
FIRM Panel 320018 0127 B Date: April 12, 1983

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Caliente Route

FEMA Flood Insurance Rate Map

K/J/C 897045.01

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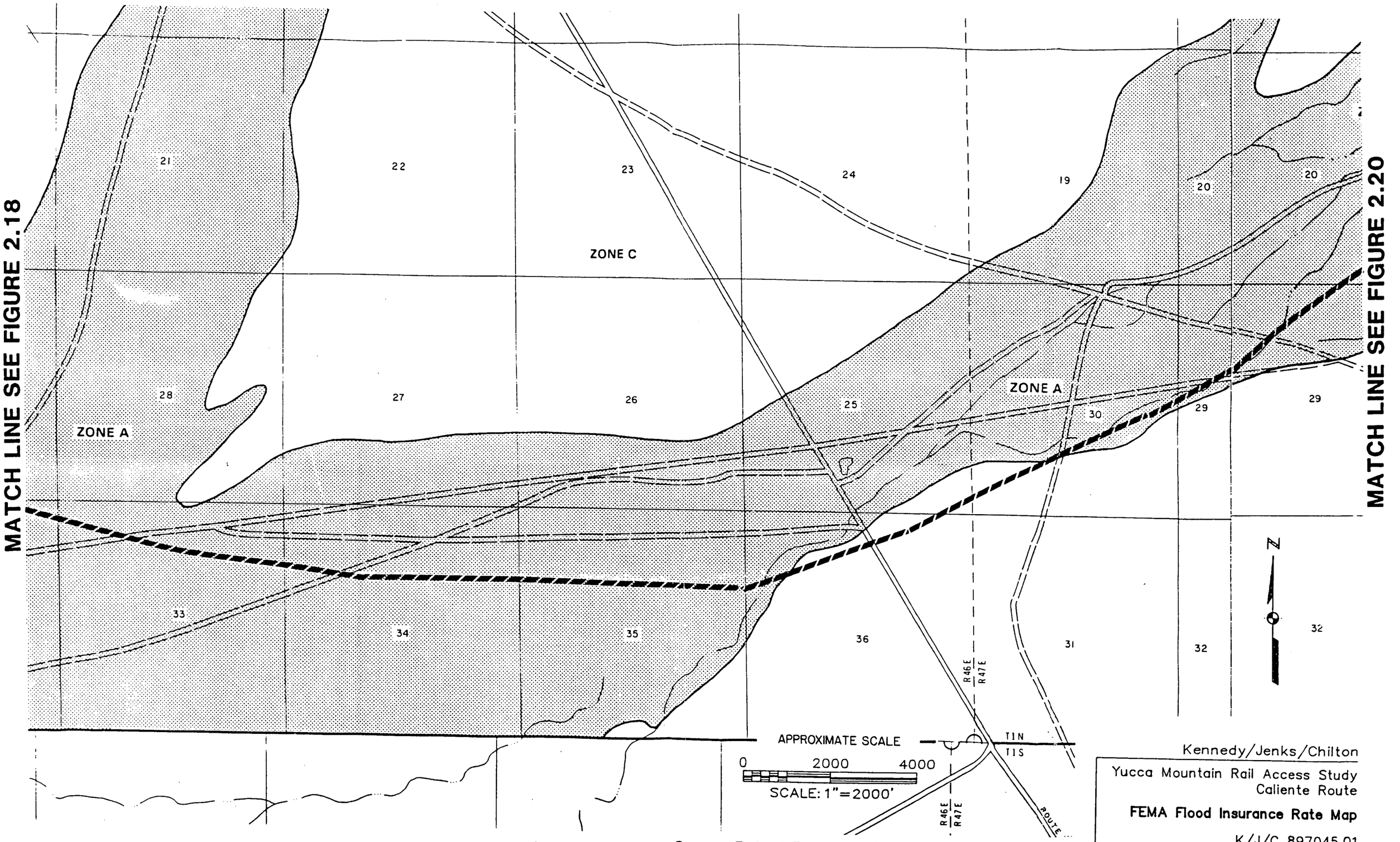
Figure 2.15



Source: Federal Emergency Management Agency
FIRM Panel 320018 0104 B Date: April 12, 1983
FIRM Panel 320018 0105 B Date: April 12, 1983

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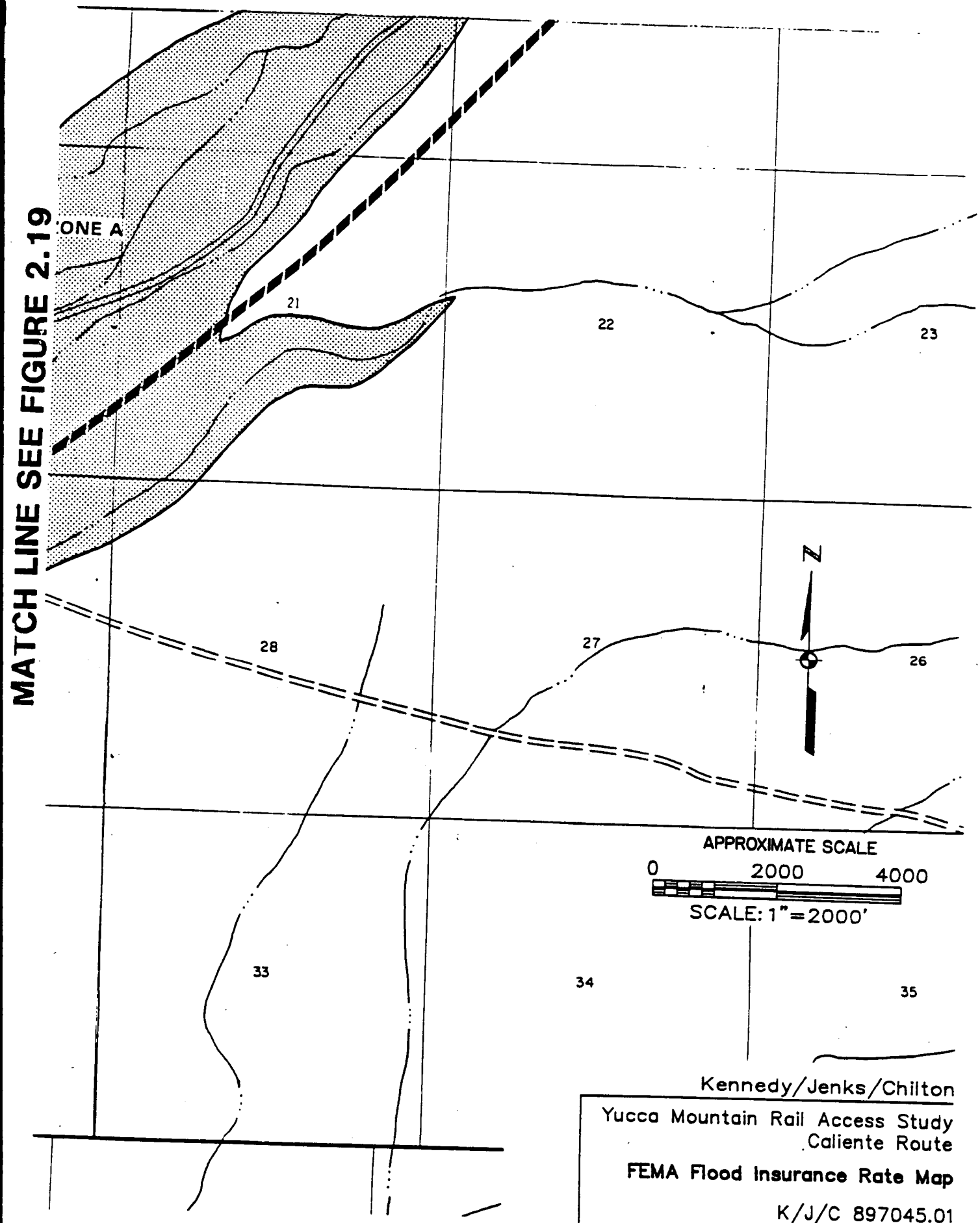
Yucca Mountain Rail Access Study
Caliente Route

FEMA Flood Insurance Rate Map

K/J/C 897045.01

October, 1990

Figure 2.19



Source: Federal Emergency Management Agency
FIRM Panel 320018 0105 B Date: April 12, 1983

Kennedy/Jenks/Chilton

Yucca Mountain Rail Access Study
Caliente Route

FEMA Flood Insurance Rate Map

K/J/C 897045.01

October, 1990

Figure 2.20

BASIN 156

Basin 156 is located near the central portion of the study area. The proposed railway crosses through the southern portion of Basin 156 in Reveille Valley. The drainage area that contributes to the proposed railway originates south and west of the alignment.

Description

Basin 156 (Figure 2.21) is approximately 72 miles long, 20 miles wide and is approximately 1000 square miles in size. The basin is bounded on the west by the Hot Creek Range, on the east by the Pancake and Reveille Ranges and on the south by the Kawich Range.

The prominent vegetation type in this watershed is desert shrub consisting primarily of greasewood, shadscale, bud sagebrush and rabbitbrush.

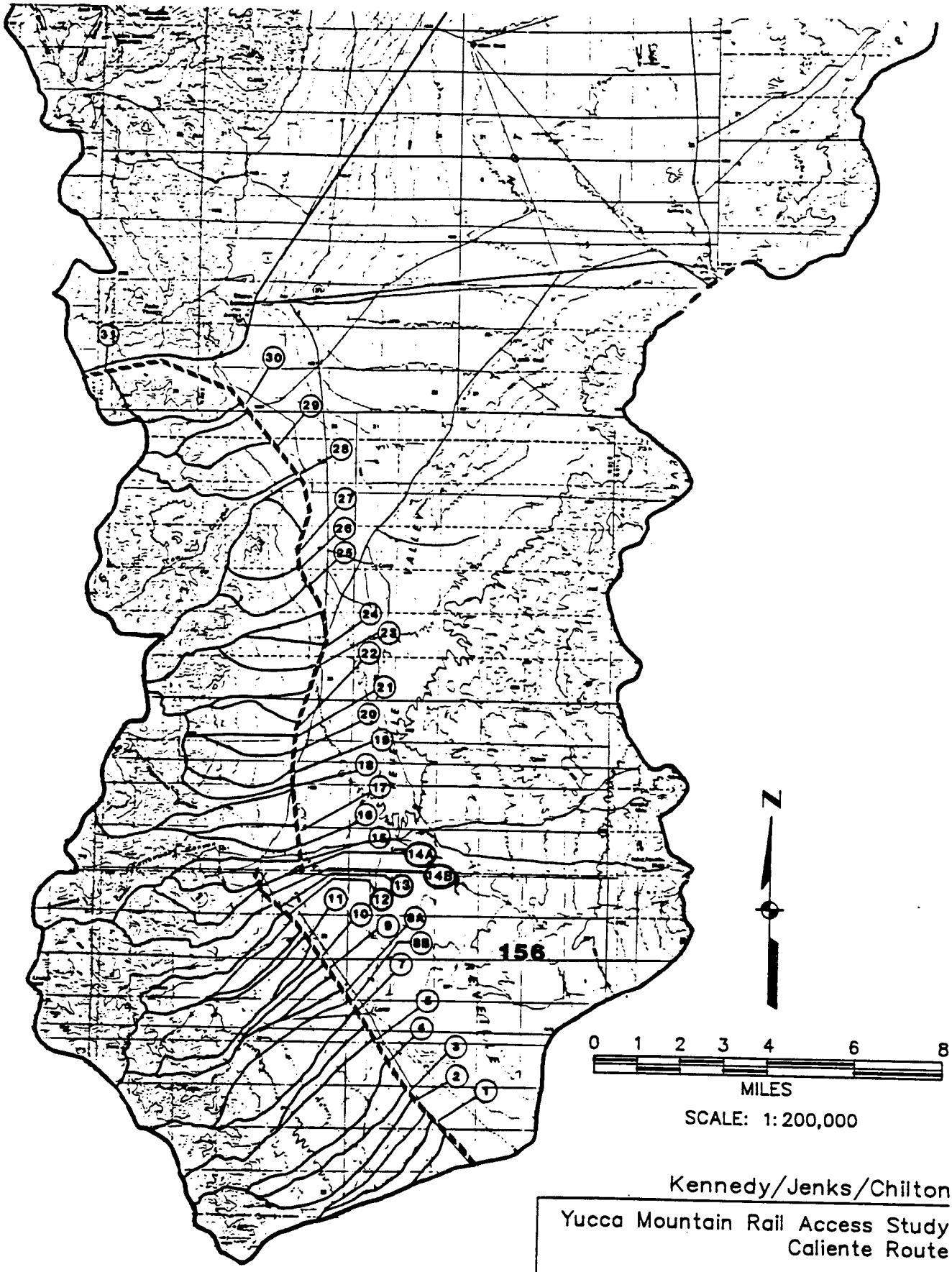
Average annual precipitation in the basin ranges from 8 inches on the valley floor to 17 inches on the highest portions of the surrounding mountain ranges.

Other Studies

The Nye County Flood Insurance Rate Maps, published by FEMA, do not show any approximate flood limits which would impact the portion of the railway alignment that is within Basin 156. These flood hazard maps do show flood hazards associated with the primary drainage in Reveille Valley, but the flood limits do not extend far enough south to impact the proposed railway. Additional flood hazard areas have been mapped within Nye County but are not shown on these figures.

Special Design Considerations

Many of the drainages contributing to the proposed railway within this basin originate from relatively steep alluvial watersheds. Flows from extreme events will also be carrying a significant sediment load. Sudden changes to conveyance geometry can result in a change in flow velocity which in turn can result in deposition of sediment or additional scour. Drainage structures should be designed using sediment control considerations.



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Yucca Mountain Rail Access Study
Caliente Route

State Engineers Basin 156

K/J/C 897045.01

October, 1990

Figure 2.21

BASIN 169A

Basin 169A is located near the central portion of the study area. The proposed railway crosses through the northern portion of Basin 169A in Tikaboo Valley. The drainage area that contributes to the proposed railway originates north of the alignment.

Description

Basin 169A (Figure 2.22) is approximately 45 miles long, 20 miles wide and is approximately 620 square miles in size. Basin 169A drains to the south into Desert Valley to the southeast of this basin. The basin is bounded on the west by the Groom and Desert Ranges, on the east by the Pahranagat and Mount Irish Ranges and on the north by the Timpahute Range.

The prominent vegetation type in this watershed is desert shrub consisting primarily of bud sagebrush and rabbitbrush.

Average annual precipitation in the basin ranges from 7 inches on the valley floor to 14 inches on the highest portions of the surrounding mountain ranges.

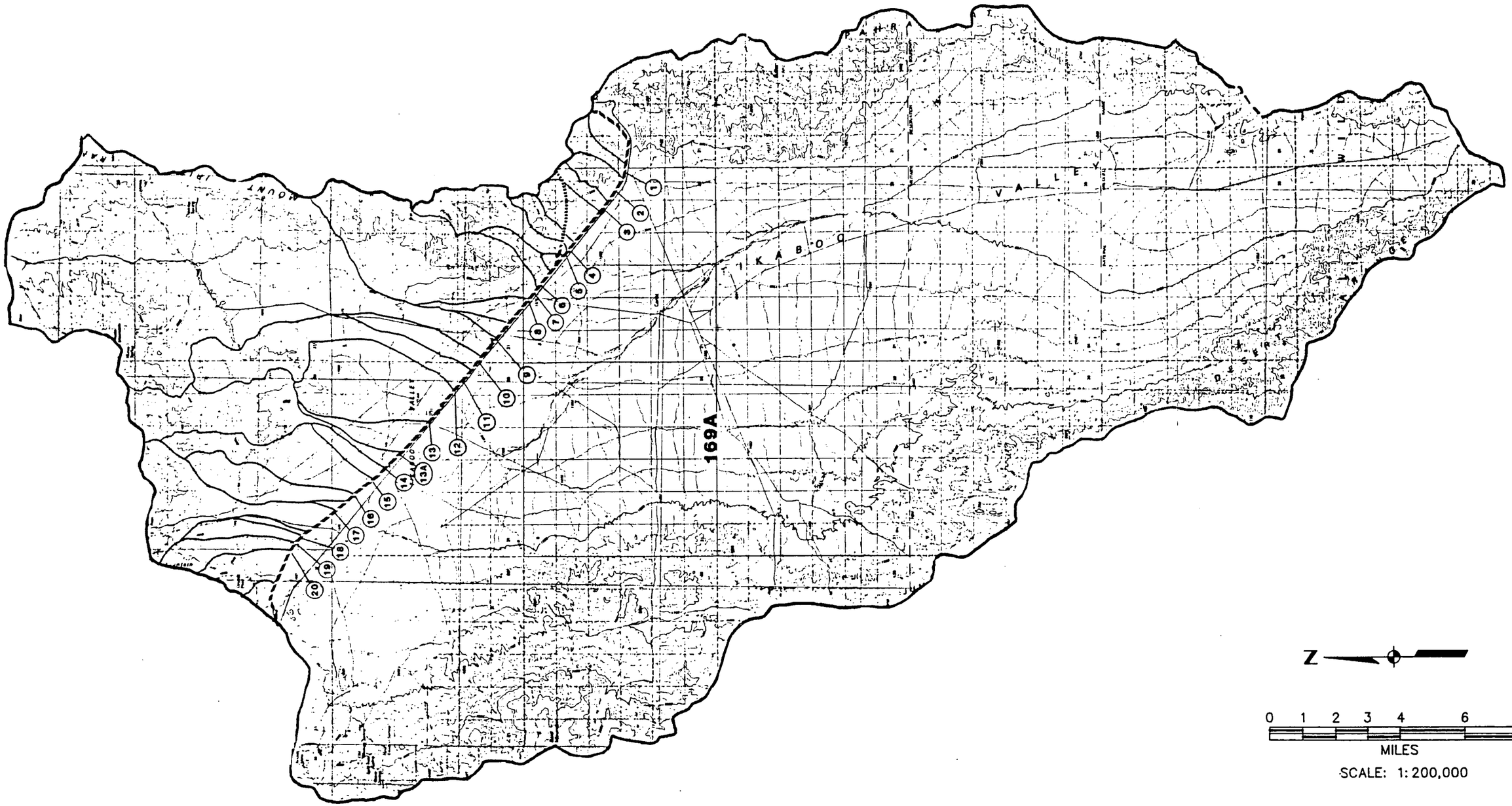
Other Studies

The Lincoln County Flood Insurance Rate Maps, published by FEMA, do not show any flood limits which would impact the portion of the railway alignment that is within Basin 169A. Additional flood hazard areas have been mapped within Lincoln County but are not shown on these figures.

Special Design Considerations

Many of the drainages contributing to the proposed railway within this basin originate from relatively steep alluvial watersheds. Flows from extreme events will also be carrying a significant sediment load. Sudden changes to conveyance geometry can result in a change in flow velocity which in turn can result in deposition of sediment or additional scour. Drainage structures should be designed using sediment control considerations.

Watershed 169A-9 is an active alluvial fan. Photographic evidence indicates that the fan's range includes drainage concentration points 169A-7, 8, 9 and 10.



Z

0 1 2 3 4 6 8

MILES

SCALE: 1:200,000

Kennedy/Jenks/Chilton

Yucca Mountain Rail Access Study
Caliente Route

State Engineers Basin 169A

K/J/C 897045.01

October, 1990

Figure 2.22

BASIN 170

Basin 170 is located near the central portion of the study area. Two separate proposed railway alignment alternatives cross through Basin 170; one near the northern portion of the basin and the other near the southern portion. The drainage area that contributes to the northern alternative alignment originates north of the alignment. The drainage area that contributes to the southern alternative alignment originates south of the alignment.

Description

Basin 170 (Figure 2.23) is approximately 38 miles long, 32 miles wide and is approximately 680 square miles in size. Basin 170 is a closed basin which drains to the playa at the center of Sand Spring Valley. The basin is bounded on the north and west by the Quinn Canyon Range and on the east by the Worthington Mountains and Timpahute Range.

The prominent vegetation type in this watershed is desert shrub consisting primarily of bud sagebrush and rabbitbrush.

Average annual precipitation in the basin ranges from 7 inches on the valley floor to 14 inches on the highest portions of the surrounding mountain ranges.

Other Studies

The Nye and Lincoln County Flood Insurance Rate Maps, published by FEMA, do not show any flood limits which would impact the portion of the railway alignment that is within Basin 170. Additional flood hazard areas have been mapped within Nye and Lincoln Counties but are not shown on these figures.

Special Design Considerations

Many of the drainages contributing to the proposed railway within this basin originate from relatively steep alluvial watersheds. Flows from extreme events will also be carrying a significant sediment load. Sudden changes to conveyance geometry can result in a change in flow velocity which in turn can result in deposition of sediment or additional scour. Drainage structures should be designed using sediment control considerations.

N

0 1 2 3 4 6 8

MILES

SCALE: 1:200,000

Kennedy/Jenks/Chilton

Yucca Mountain Rail Access Study
Caliente Route

State Engineers Basin 170

K/J/C 897045.01

October, 1990

Figure 2.23

BASIN 171

Basin 171 is located near the central portion of the study area. The proposed railway alignment crosses through northern portion of Basin 171. The drainage area that contributes to the proposed railway originates north of the alignment.

Description

Basin 171 (Figure 2.24) is approximately 40 miles long, 16 miles wide and is approximately 460 square miles in size. Basin 171 is a closed basin which drains to the playa at the center of Coal Valley. Basin 172 also drains into Basin 171 at the northwest corner of the basin. The basin is bounded on the west by the Golden Gate Range, on the east by the Seaman Range and on the south by the Mount Irish Range.

The prominent vegetation type in this watershed is desert shrub consisting primarily of bud sagebrush, big sagebrush and rabbitbrush.

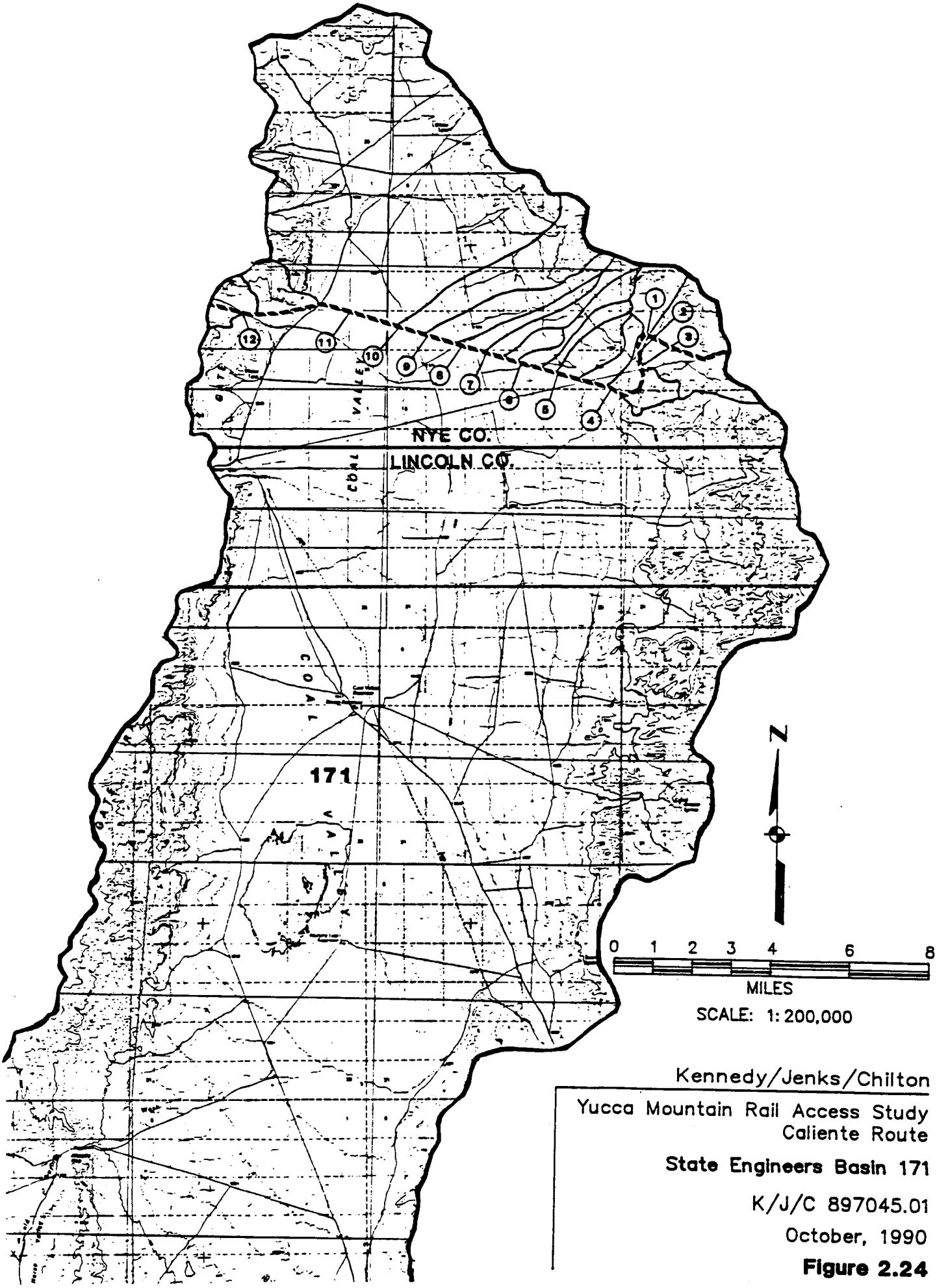
Average annual precipitation in the basin ranges from 8 inches on the valley floor to 17 inches on the highest portions of the surrounding mountain ranges.

Other Studies

The Nye and Lincoln County Flood Insurance Rate Maps, published by FEMA, do not show any flood limits which would impact the portion of the railway alignment that is within Basin 171. Additional flood hazard areas have been mapped within Nye and Lincoln Counties but are not shown on these figures.

Special Design Considerations

Many of the drainages contributing to the proposed railway within this basin originate from relatively steep alluvial watersheds. Flows from extreme events will also be carrying a significant sediment load. Sudden changes to conveyance geometry can result in a change in flow velocity which in turn can result in deposition of sediment or additional scour. Drainage structures should be designed using sediment control considerations.



Kennedy/Jenks/Chilton

Yucca Mountain Rail Access Study
Caliente Route

State Engineers Basin 171

K/J/C 897045.01

October, 1990

Figure 2.24

BASIN 172

Basin 172 is located near the east central portion of the study area. The proposed railway alignment crosses through center of Basin 172. The drainage area that contributes to the proposed railway originates north and west of the alignment.

Description

Basin 172 (Figure 2.25) is approximately 41 miles long, 21 miles wide and is approximately 500 square miles in size. Basin 172 drains east into Basin 171 to the playa at the center of Sand Spring Valley. The basin is bounded on the north by the Grant Range, on the west by the Quinn Canyon Range and the Worthington Mountains and on the east by the Golden Gate Range.

The prominent vegetation type in this watershed is desert shrub consisting primarily of bud sagebrush and rabbitbrush.

Average annual precipitation in the basin ranges from 8 inches on the valley floor to 17 inches on the highest portions of the surrounding mountain ranges.

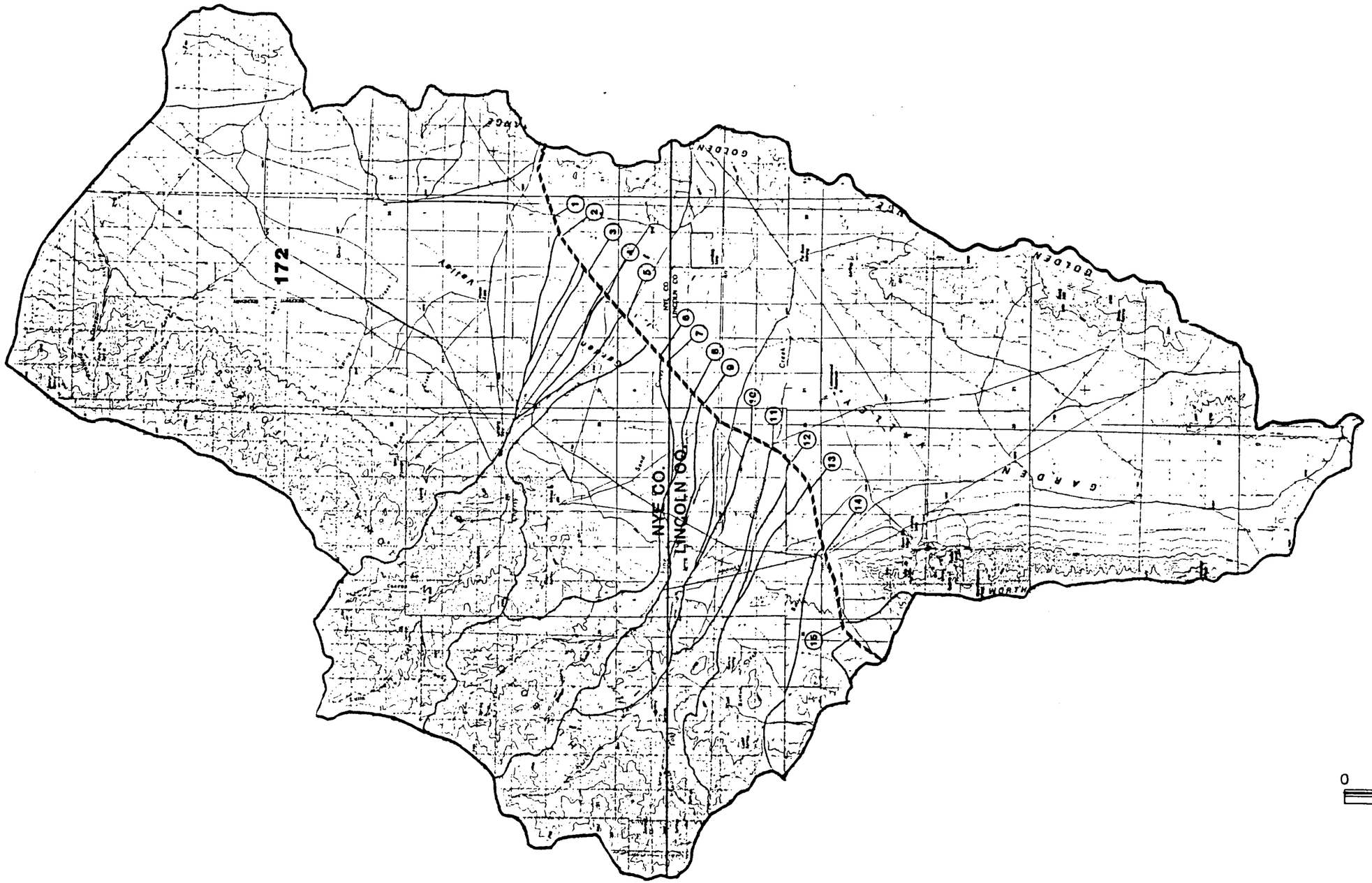
Other Studies

The Nye and Lincoln County Flood Insurance Rate Maps, published by FEMA, do not show any flood limits which would impact the portion of the railway alignment that is within Basin 172. Additional flood hazard areas have been mapped within Nye and Lincoln Counties but are not shown on these figures.

Special Design Considerations

This basin has three significant active alluvial fans; Cherry Creek (172-5), Pine Creek (172-8) and Cottonwood Creek (172-11). Due to the uncertainty regarding the location of the primary flow path during significant events, the drainage structures for adjacent locations where the proposed railway crosses these fans, will need to consider the possibility of significantly higher peak flows than what was estimated for those locations (172-7, 9, 10, and 12 and points in between).

Many of the drainages contributing to the proposed railway within this basin originate from relatively steep alluvial watersheds. Flows from extreme events will also be carrying a significant sediment load. Sudden changes to conveyance geometry can result in a change in flow velocity which in turn can result in deposition of sediment. Drainage structures should be designed using sediment control considerations.



N

0 1 2 3 4 6 8

MILES

SCALE: 1:200,000

Kennedy/Jenks/Chilton

Yucca Mountain Rail Access Study
Caliente Route

State Engineers Basin 172

K/J/C 897045.01

October, 1990

Figure 2.25

BASIN 173A

Basin 173A is located near the central portion of the study area. The proposed railway alignment crosses through southern portion of Basin 173A. The drainage area that contributes to the proposed railway originates south of the alignment.

Description

Basin 173A (Figure 2.26) is approximately 31 miles long, 26 miles wide and is approximately 600 square miles in size. Basin 173A is a closed basin which drains to a playa at the north central part of Railroad Valley. The basin is bounded on the east by the Quinn Canyon Range and on the west by the Kawich and Reveille Ranges.

The prominent vegetation type in this watershed is desert shrub consisting primarily of bud sagebrush and rabbitbrush.

Average annual precipitation in the basin ranges from 8 inches on the valley floor to 17 inches on the highest portions of the surrounding mountain ranges.

Other Studies

The Nye County Flood Insurance Rate Maps, published by FEMA, show approximate flood limits for the primary drainage in the southwestern portion of the basin. The portions of the flood hazard maps showing flood limits near the proposed alignment, have been reproduced as Figures 2.27 and 2.28. The locations of these maps have also been shown on Figure 2.26. Additional flood hazard areas have been mapped within Nye County but are not shown on these figures.

Special Design Considerations

Many of the drainages contributing to the proposed railway within this basin originate from relatively steep alluvial watersheds. Flows from extreme events will also be carrying a significant sediment load. Sudden changes to conveyance geometry can result in a change in flow velocity which in turn can result in deposition of sediment. Drainage structures should be designed using sediment control considerations.

N

0 1 2 3 4 6 8

MILES

SCALE: 1:200,000

Kennedy/Jenks/Chilton

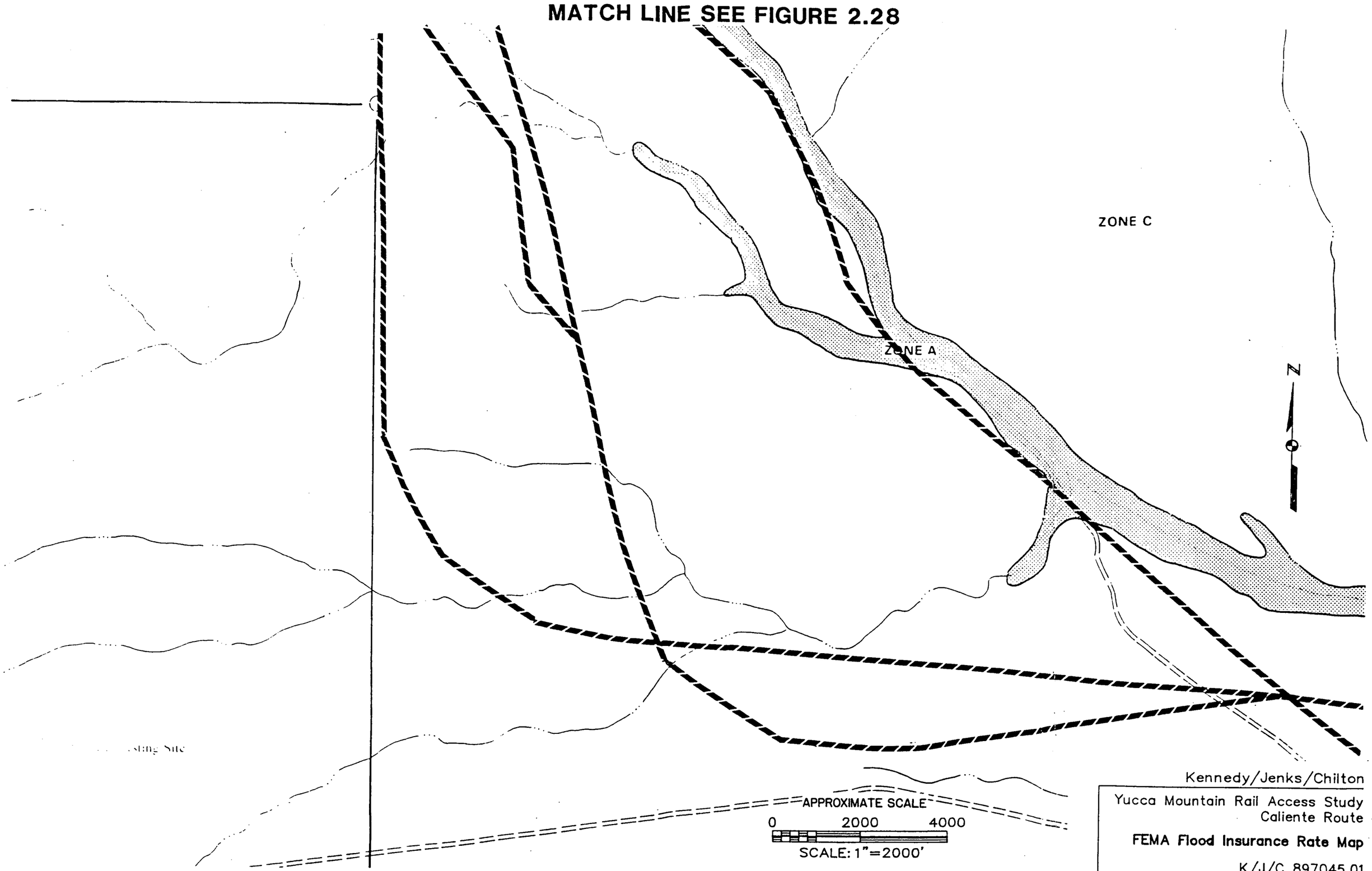
Yucca Mountain Rail Access Study
Caliente Route

State Engineers Basin 173A

K/J/C 897045.01

October, 1990

Figure 2.26



Source: Federal Emergency Management Agency
FIRM Panel 320018 0113 B Date: April 12, 1983

Kennedy/Jenks/Chilton

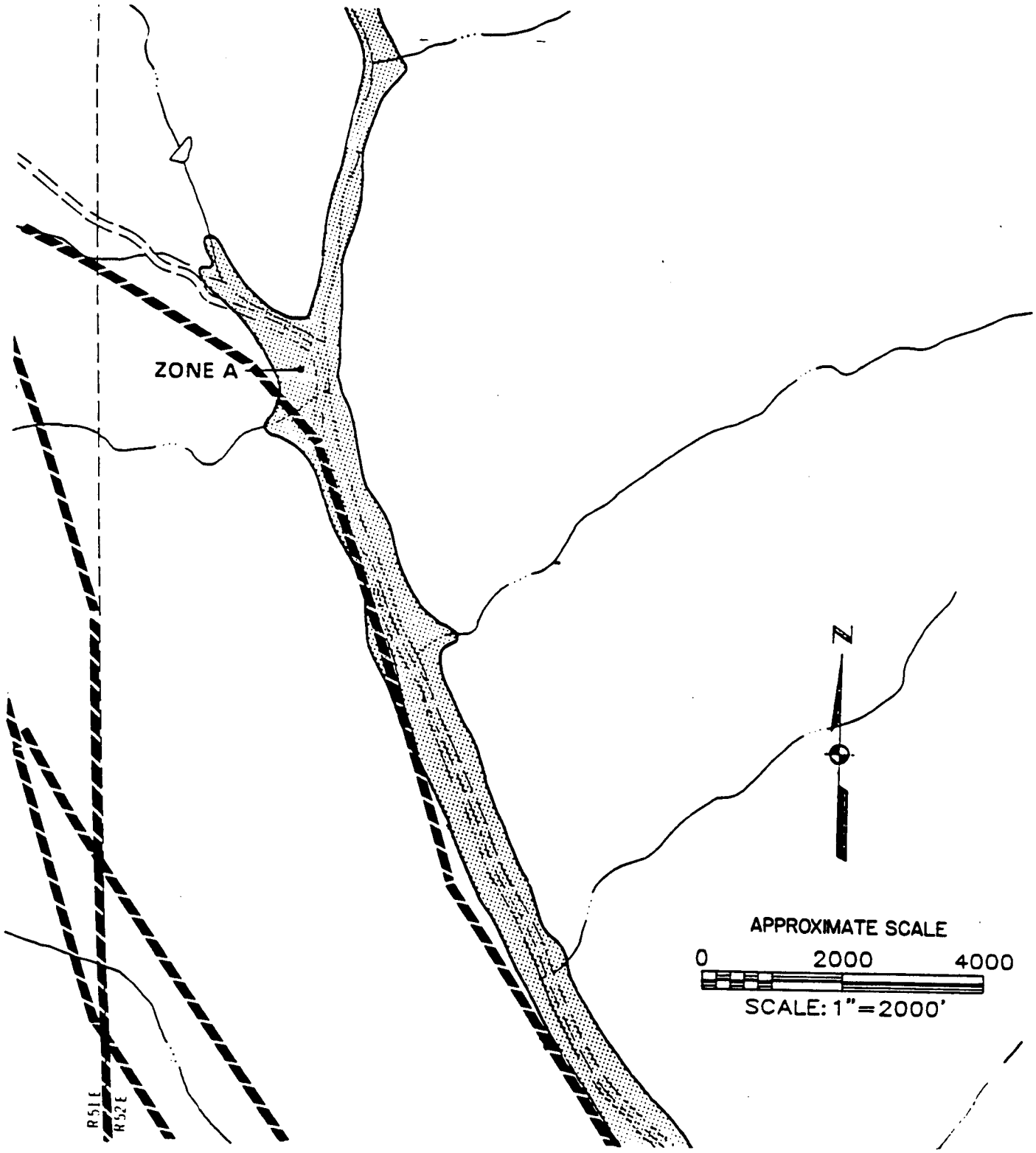
Yucca Mountain Rail Access Study
Caliente Route

FEMA Flood Insurance Rate Map

K/J/C 897045.01

October, 1990

Figure 2.27



MATCH LINE SEE FIGURE 2.27

Kennedy/Jenks/Chilton

Yucca Mountain Rail Access Study
Caliente Route

FEMA Flood Insurance Rate Map

K/J/C 897045.01

October, 1990

Figure 2.28

Source: Federal Emergency Management Agency
FIRM Panel 320018 0107 B Date: April 12, 1983

BASIN 181

Basin 181 is located near the eastern portion of the study area. Two separate proposed railway alignment alternatives cross through Basin 181; one near the central portion of the basin and the other near the southern portion. The drainage area that contributes to the northern alternative alignment originates north and east of the alignment. The drainage area that contributes to the southern alternative alignment originates south of the alignment.

Description

Basin 181 (Figure 2.29) is approximately 63 miles long, 20 miles wide and is approximately 875 square miles in size. Basin 181 is a closed basin which drains to the playa at the southern end of Dry Lake Valley. The basin is bounded on the west by the Schell Creek and North Pahroc Ranges and on the east by the Fairview, Bristol and Burnt Spring Ranges.

The prominent vegetation type in this watershed is desert shrub consisting primarily of bud sagebrush, big sagebrush and rabbitbrush.

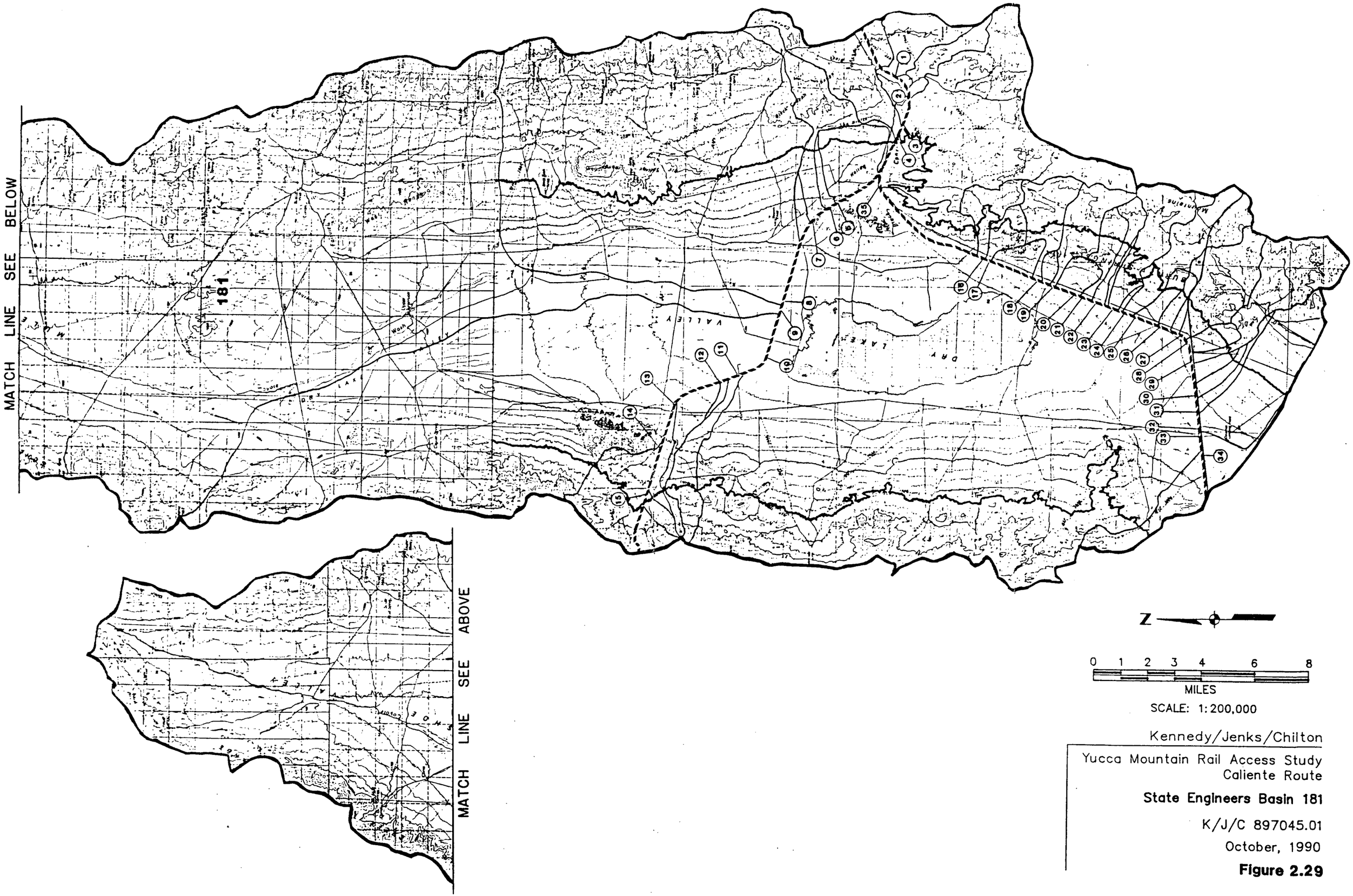
Average annual precipitation in the basin ranges from 9 inches on the valley floor to 17 inches on the highest portions of the surrounding mountain ranges.

Other Studies

The Nye and Lincoln County Flood Insurance Rate Maps, published by FEMA, do not show any flood limits which would impact the portion of the railway alignment that is within Basin 181. Additional flood hazard areas have been mapped within Nye and Lincoln Counties but are not shown on these figures.

Special Design Considerations

Many of the drainages contributing to the proposed railway within this basin originate from relatively steep alluvial watersheds. Flows from extreme events will also be carrying a significant sediment load. Sudden changes to conveyance geometry can result in a change in flow velocity which in turn can result in deposition of sediment or additional scour. Drainage structures should be designed using sediment control considerations.



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Yucca Mountain Rail Access Study
Caliente Route

State Engineers Basin 181

K/J/C 897045.01

October, 1990

Figure 2.29

BASIN 182

Basin 182 is located near the eastern portion of the study area. The proposed railway alignment crosses through Basin 182 near the northern portion of the basin. The drainage area that contributes to the proposed railway originates north of the alignment.

Description

Basin 182 (Figure 2.30) is approximately 32 miles long, 18 miles wide and is approximately 390 square miles in size. Basin 182 is a closed basin which drains to the Delamar Lake at the southern end of the basin and Delamar Valley. The basin is bounded on the north by the North Pahroc Range, on the west by the South Pahroc Range and on the east by the Delamar Mountains.

The prominent vegetation type in this watershed is desert shrub consisting primarily of bud sagebrush and rabbitbrush.

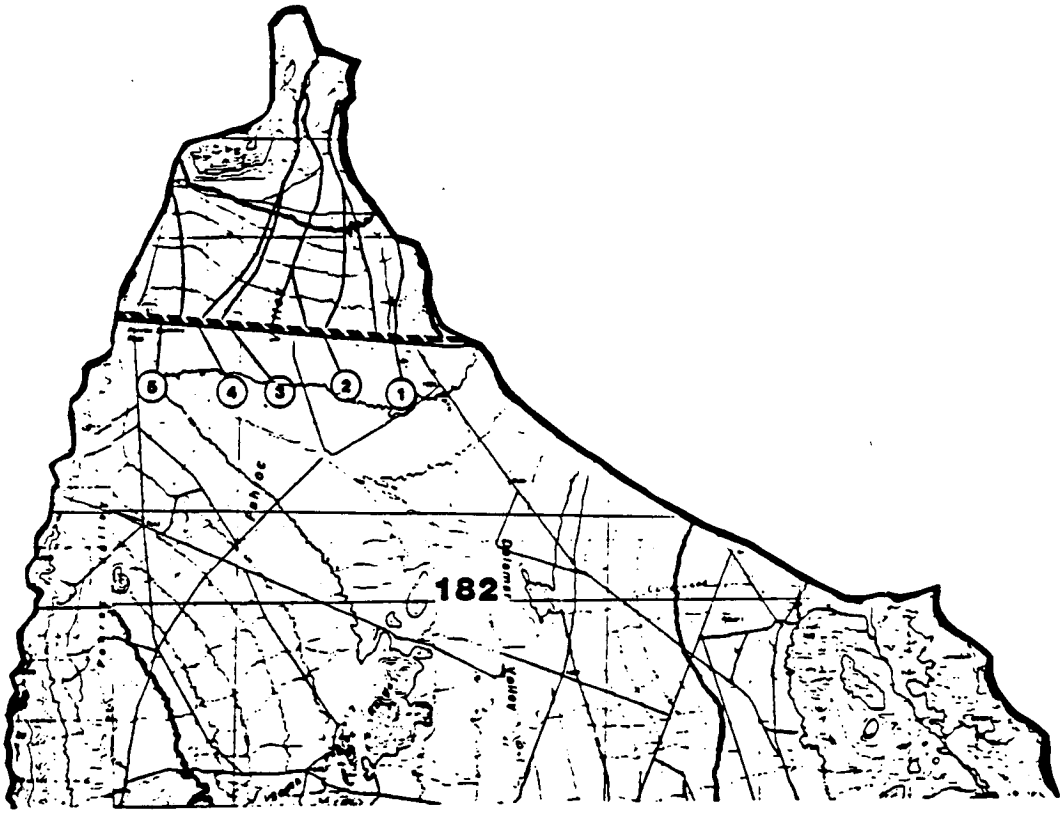
Average annual precipitation in the basin ranges from 8 inches on the valley floor to 17 inches on the highest portions of the surrounding mountain ranges.

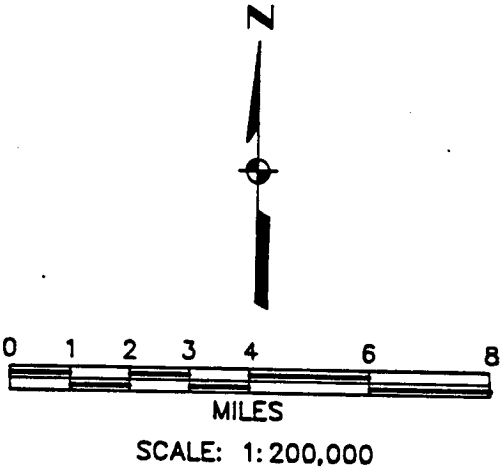
Other Studies

The Lincoln County Flood Insurance Rate Maps, published by FEMA, do not show any flood limits which would impact the portion of the railway alignment that is within Basin 182. Additional flood hazard areas have been mapped within Lincoln County but are not shown on these figures.

Special Design Considerations

Many of the drainages contributing to the proposed railway within this basin originate from relatively steep alluvial watersheds. Flows from extreme events will also be carrying a significant sediment load. Sudden changes to conveyance geometry can result in a change in flow velocity which in turn can result in deposition of sediment or additional scour. Drainage structures should be designed using sediment control considerations.





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Yucca Mountain Rail Access Study
Caliente Route

State Engineers Basin 182

K/J/C 897045.01

October, 1990

Figure 2.30

BASIN 197

Basin 197 is located at the extreme eastern portion of the study area. The proposed railway alignment crosses through Basin 197 near the southwest portion of the basin. The drainage area that contributes to the proposed railway originates south of the alignment.

Description

Basin 197 (Figure 2.31) is approximately 18 miles long, 9 miles wide and is approximately 105 square miles in size. Basin 197 is the western portion of a larger basin that is mostly in the state of Utah.

The prominent vegetation type in this watershed is pinion pine and juniper. Desert brushes such as big sagebrush and rabbitbrush are found in the lower elevations.

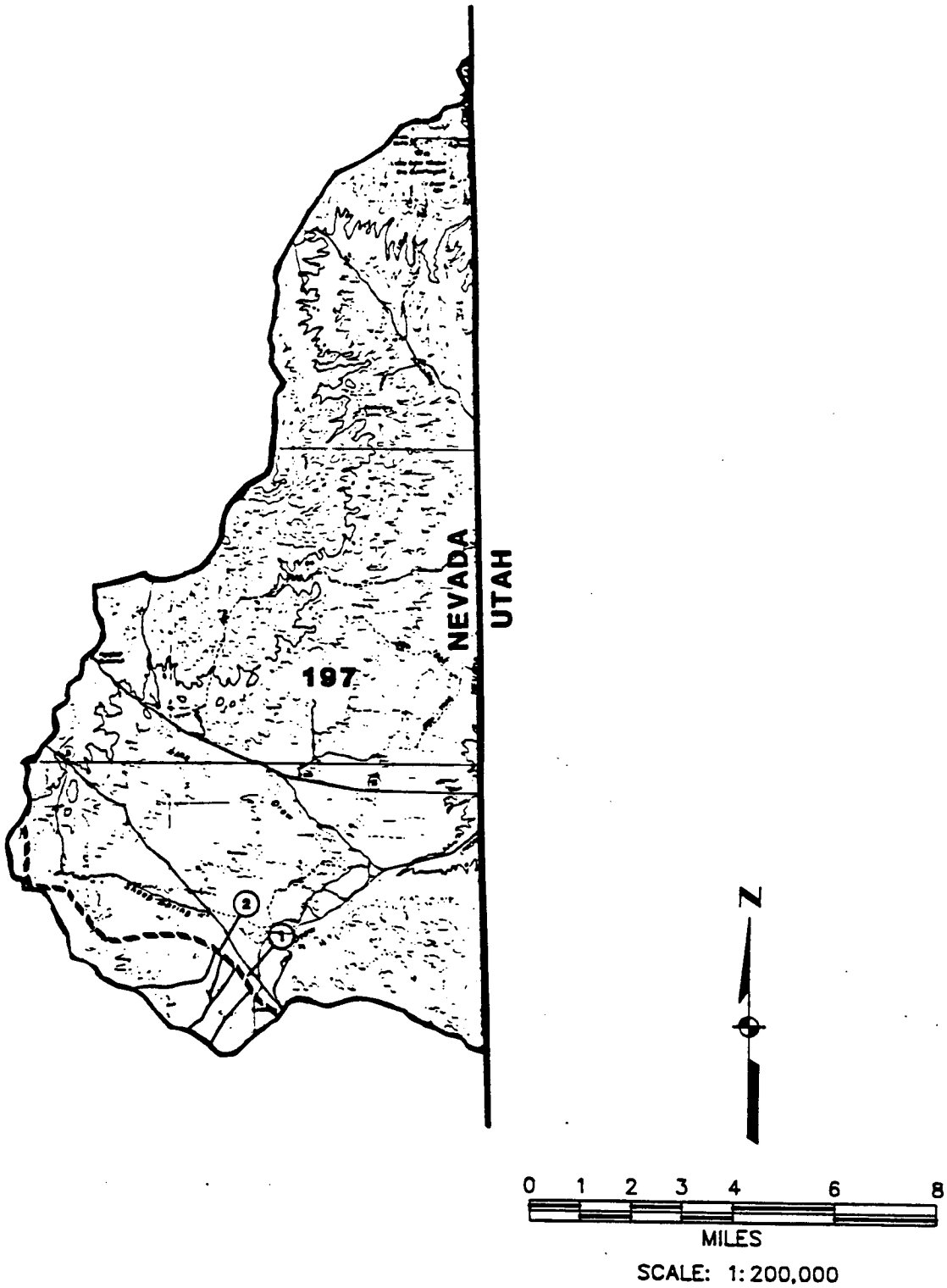
Average annual precipitation in the basin ranges from 10 inches on the lower elevations to 17 inches on the highest portions of the surrounding mountain ranges.

Other Studies

The Lincoln County Flood Insurance Rate Maps, published by FEMA, do not show any flood limits which would impact the portion of the railway alignment that is within Basin 197. Additional flood hazard areas have been mapped within Lincoln County but are not shown on these figures.

Special Design Considerations

Many of the drainages contributing to the proposed railway within this basin originate from relatively steep alluvial watersheds. Flows from extreme events will also be carrying a significant sediment load. Sudden changes to conveyance geometry can result in a change in flow velocity which in turn can result in deposition of sediment or additional scour. Drainage structures should be designed using sediment control considerations.



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Yucca Mountain Rail Access Study
Caliente Route

State Engineers Basin 197

K/J/C 897045.01

October, 1990

Figure 2.31

BASIN 203

Basin 203 is located near the eastern portion of the study area. The proposed railway alignment crosses through the central portion of Basin 203. The drainage area that contributes to the proposed railway originates north of the alignment.

Description

Basin 203 (Figure 2.32) is approximately 24 miles long, 25 miles wide and is approximately 345 square miles in size. The primary watercourse in Basin 203 is Meadow Valley Wash. Meadow Valley Wash enters the northern boundary of the basin and flows north to south through the central portion of the basin and exits the southern boundary where it flows through the City of Caliente. The basin is bounded on the north by the Pioche Hills, on the west by the Highland and Chief Ranges and on the east by Cow Mountain.

The prominent vegetation types are desert shrub consisting primarily of big sagebrush and rabbitbrush in the lower elevations and pinion pine and juniper in the upper elevations.

Average annual precipitation in the basin ranges from 8 inches on the valley floor to 17 inches on the highest portions of the surrounding mountain ranges.

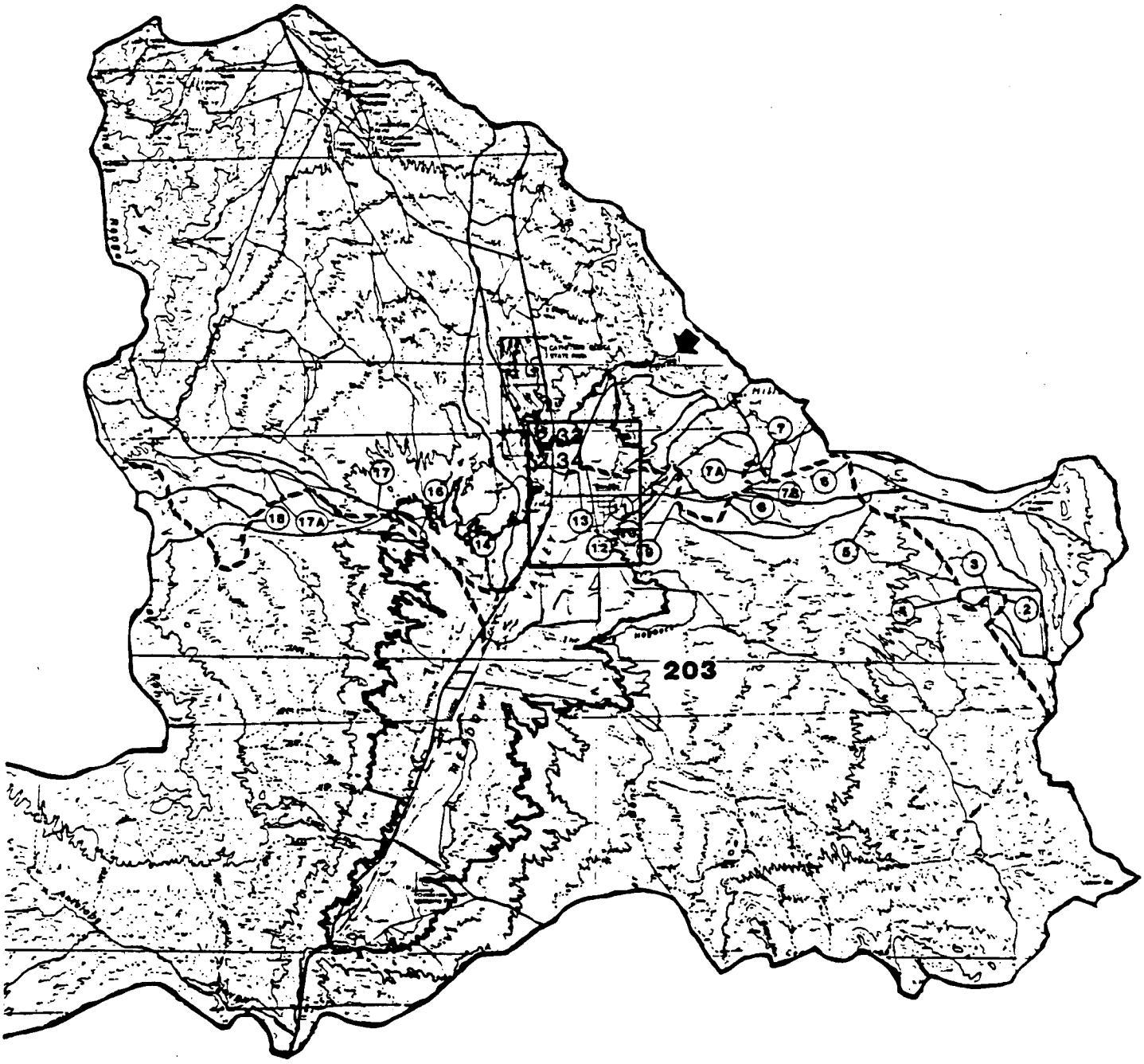
Other Studies

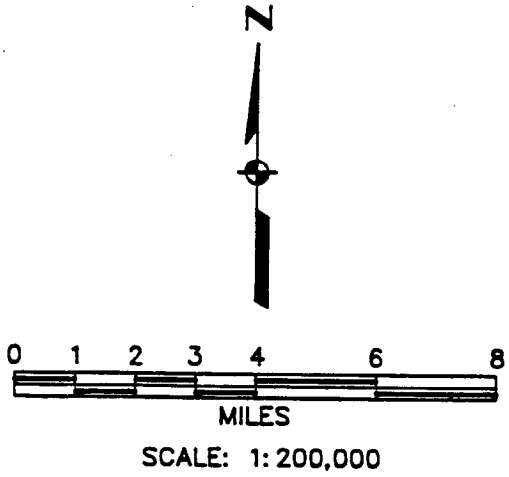
The Lincoln County Flood Insurance Rate Maps, published by FEMA, show 100-year and 500-year flood limits and a regulatory floodway for the portion of Meadow Valley Wash crossed by the proposed railway. These maps have been reproduced at a scale of 1"= 2000' as Figures 2.33 and 2.34. Figure 2.33 shows the 100- and 500-year floodplain boundaries. Figure 2.34 shows the location of the regulatory floodway. Additional flood hazard areas have been mapped within Lincoln County but are not shown on these figures.

Special Design Considerations

The bridge structure and associated embankment to be constructed across Meadow Valley Wash will need to be sufficiently sized to prevent more that a one foot increase in the water surface elevation in Meadow Valley Wash in the vicinity of the propose bridge. The final design configuration will need to be modeled with the Corps of Engineers water surface profile program HEC-2.

Many of the drainages contributing to the proposed railway within this basin originate from relatively steep alluvial watersheds. Flows from extreme events will also be carrying a significant sediment load. Sudden changes to conveyance geometry can result in a change in flow velocity which in turn can result in deposition of sediment or additional scour. Drainage structures should be designed using sediment control considerations.





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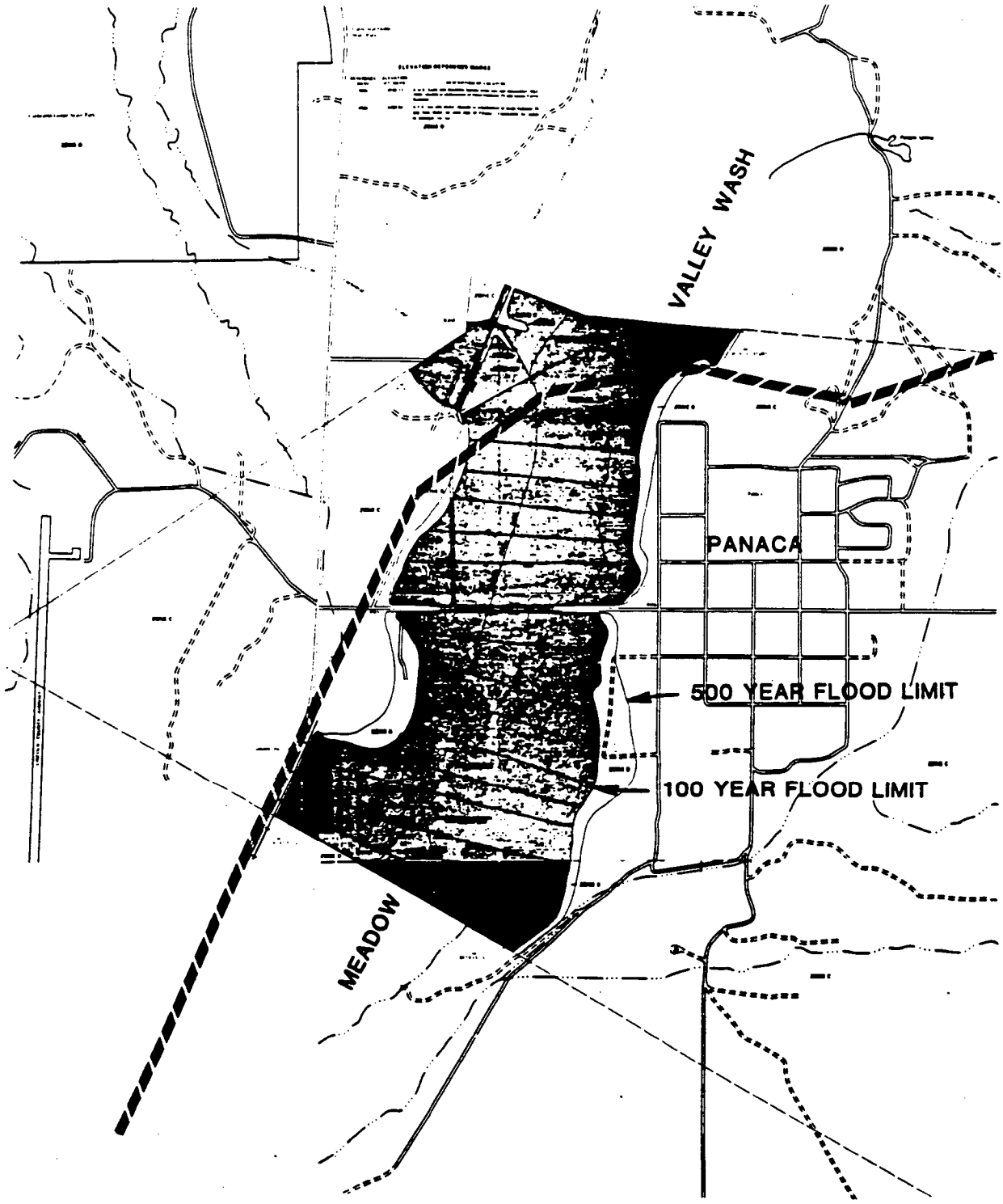
Yucca Mountain Rail Access Study
Caliente Route

State Engineers Basin 203

K/J/C 897045.01

October, 1990

Figure 2.32



N

APPROXIMATE SCALE

0 2000 4000

SCALE: 1"=2000'

Source: Federal Emergency Management Agency
FIRM Panel 320014 2241 Date: March 1, 1984
FIRM Panel 320014 2242 Date: March 1, 1984
FIRM Panel 320014 2244 Date: March 1, 1984

Kennedy/Jenks/Chilton

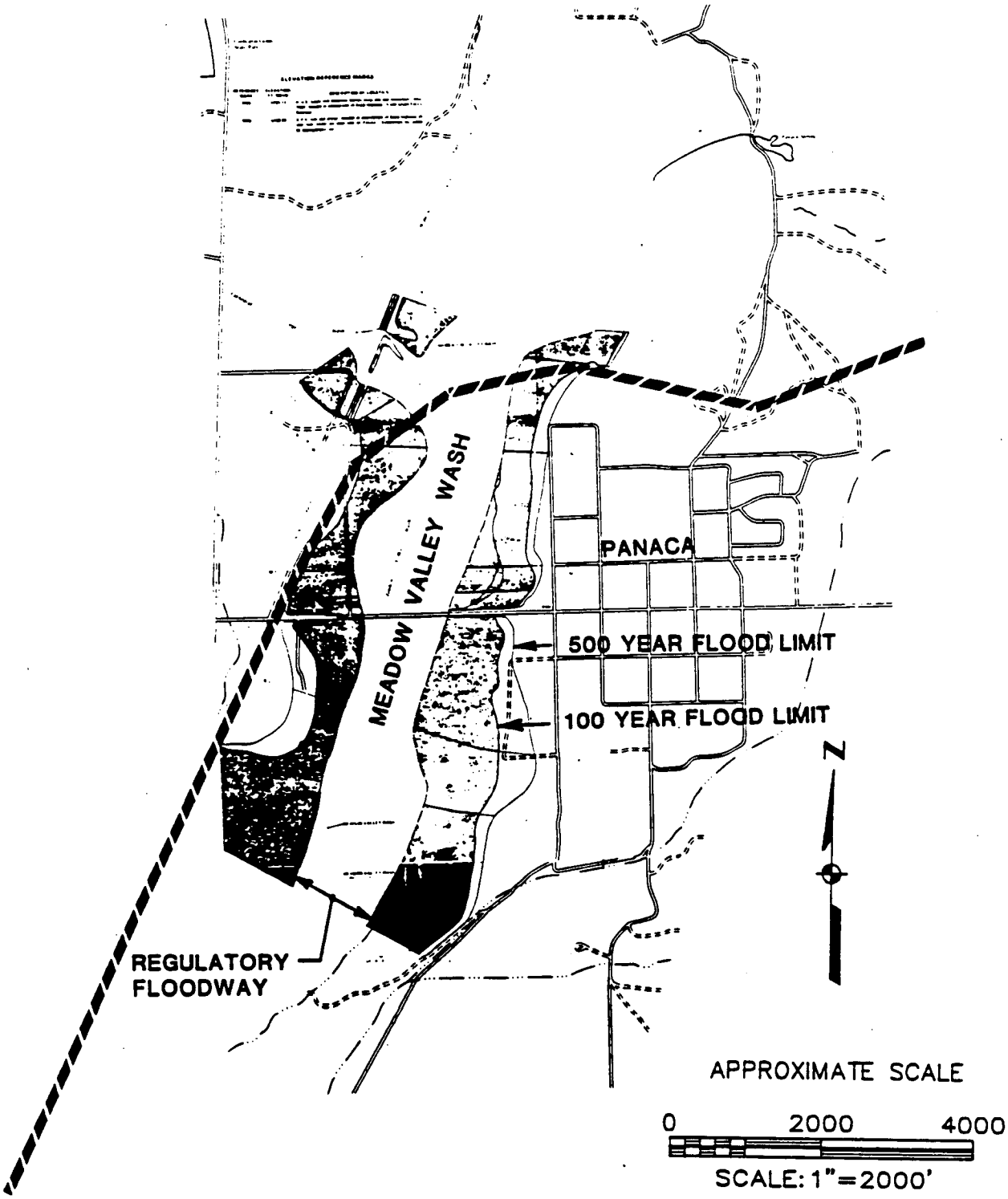
Yucca Mountain Rail Access Study
Caliente Route

FEMA Flood Insurance Rate Map

K/J/C 897045.01

October, 1990

Figure 2.33



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Yucca Mountain Rail Access Study
Caliente Route

FEMA Flood Insurance Rate Map

K/J/C 897045.01

October, 1990

Figure 2.34

Source: Federal Emergency Management Agency
FLOODWAY Panel 320014 2244 Date: March 1, 1984
FLOODWAY Panel 320014 2242 Date: March 1, 1984

BASIN 208

Basin 208 is located near the eastern portion of the study area. The proposed railway alignment crosses through the central portion of Basin 208. The drainage area that contributes to the proposed railway originates north of the alignment.

Description

Basin 208 (Figure 2.35) is approximately 42 miles long, 14 miles wide and is approximately 510 square miles in size. The primary watercourse in Basin 208 is White River. White River enters the northern boundary of the basin and flows north to south through the central portion of the basin and exits the southern boundary where it flows into Basin 209. The basin is bounded on the west by the Seaman Range and on the east by North Pahroc Range.

The prominent vegetation types are desert shrub consisting primarily of big sagebrush and rabbitbrush in the lower elevations and pinion pine and juniper in the upper elevations.

Average annual precipitation in the basin ranges from 8 inches on the valley floor to 17 inches on the highest portions of the surrounding mountain ranges.

Other Studies

The Nye County Flood Insurance Rate Maps show approximate flood limits for White River to Nye County/ Lincoln County boundary, which is a point just north of the proposed railway. The Lincoln County Flood Insurance Rate Maps, published by FEMA, do not show any flood limits in the vicinity of the proposed railway. Additional flood hazard areas have been mapped within Lincoln County but are not shown on these figures.

Special Design Considerations

Many of the drainages contributing to the proposed railway within this basin originate from relatively steep alluvial watersheds. Flows from extreme events will also be carrying a significant sediment load. Sudden changes to conveyance geometry can result in a change in flow velocity which in turn can result in deposition of sediment or additional scour. Drainage structures should be designed using sediment control considerations.

BASIN 209

Basin 209 is located near the eastern portion of the study area. Two alternative alignments for the proposed railway cross through the north central portion of Basin 209. The drainage area that contributes to these alignments originates north of the alignments.

Description

Basin 209 (Figure 2.36) is approximately 43 miles long, 22 miles wide and is approximately 760 square miles in size. The primary watercourse in Basin 209 is the White River. White River enters the northern boundary of the basin and flows north to south through the central portion of the basin and exits the southern boundary on its way to ultimately join with the Moapa River. The basin is bounded on the west by the Mount Irish and Pahranagat Ranges and on the east by the South Pahroc Range. This basin includes the communities of Hiko, Ash Springs and Alamo.

The prominent vegetation type in this watershed is desert shrub consisting primarily of big sagebrush and rabbitbrush. The portions of the basin that are above 6000 feet contain pinion pine and juniper.

Average annual precipitation in the basin ranges from 8 inches on the valley floor to 17 inches on the highest portions of the surrounding mountain ranges.

Other Studies

The Lincoln County Flood Insurance Rate Maps, published by FEMA, show 100- and 500-year flood limits for White River in the vicinity of Hiko. The northern limits of this floodplain study stop just south of the northern alternative of the proposed railway. Figure 2.37 shows the location of the 100- and 500-year flood limits. Figure 2.38 shows the location of the regulatory floodway for White River. The Lincoln County Flood Insurance Rate Maps do not show flood limits for White River in the vicinity of the southern alternative alignment within basin 209. Additional flood hazard areas have been mapped within Lincoln County but are not shown on these figures.

Special Design Considerations

Many of the drainages contributing to the proposed railway within this basin originate from relatively steep alluvial watersheds. Flows from extreme events will also be carrying a significant sediment load. Sudden changes to conveyance geometry can result in a change in flow velocity which in turn can result in deposition of sediment or additional scour. Drainage structures should be designed using sediment control considerations.

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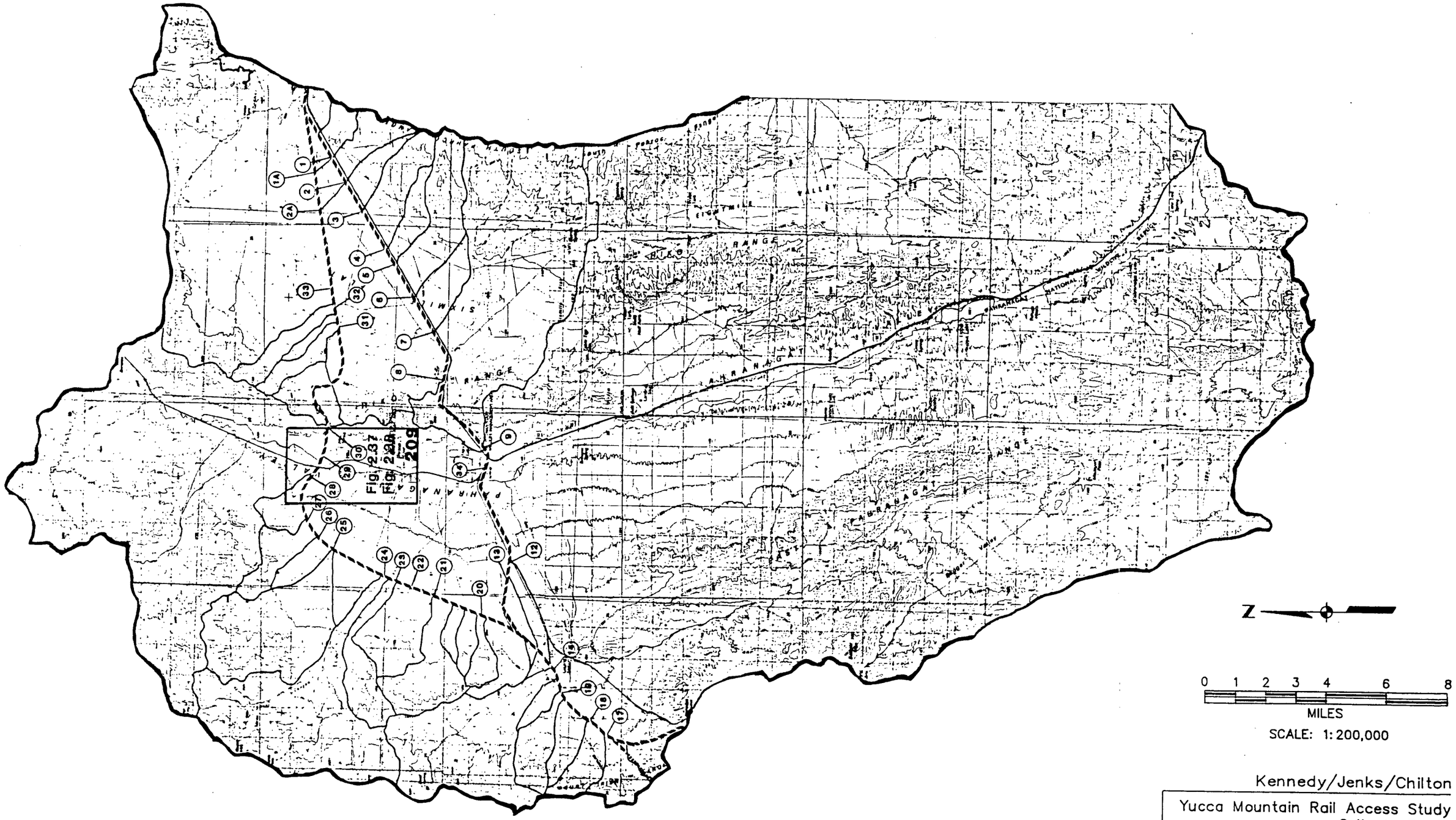
Yucca Mountain Rail Access Study
Caliente Route

State Engineers Basin 208

K/J/C 897045.01

October, 1990

Figure 2.35



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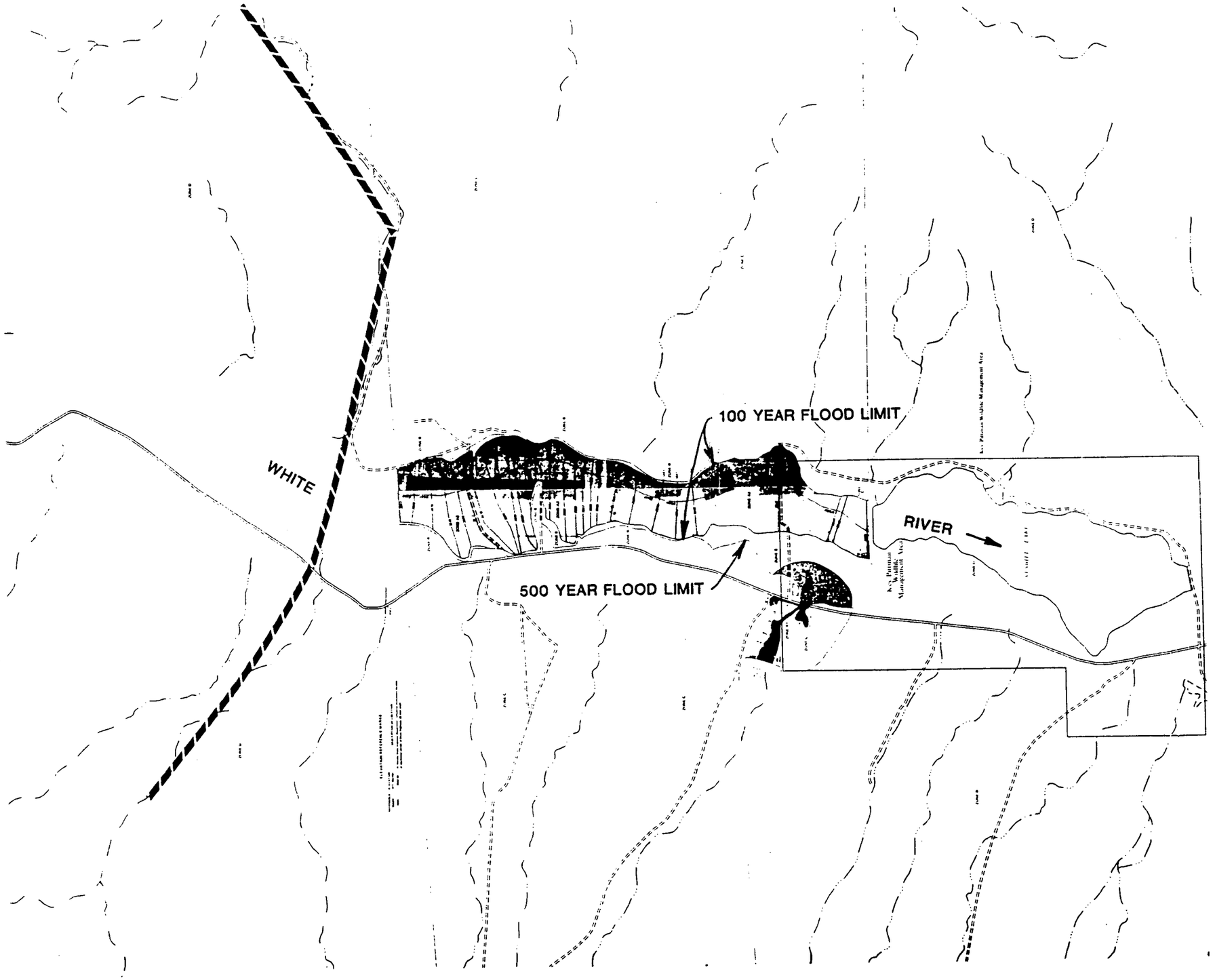
Yucca Mountain Rail Access Study
Caliente Route

State Engineers Basin 209

K/J/C 897045.01

October, 1990

Figure 2.36



N

APPROXIMATE SCALE

0 2000 4000

SCALE: 1"=2000'

Source: Federal Emergency Management Agency
FIRM Panel 320014 2876 B Date: March 1, 1984
FIRM Panel 320014 2877 B Date: March 1, 1984
FIRM Panel 320014 2878 B Date: March 1, 1984
FIRM Panel 320014 2879 B Date: March 1, 1984

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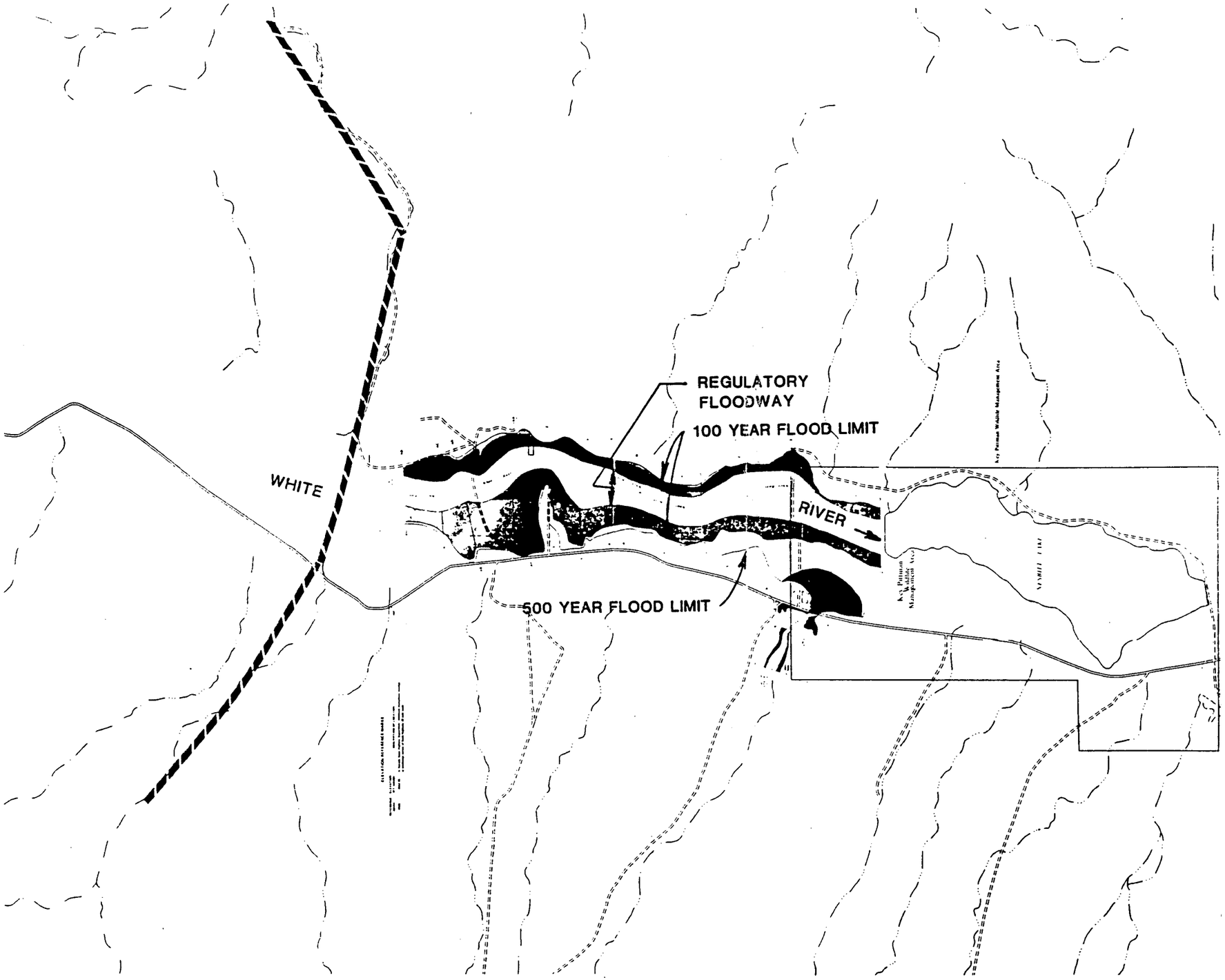
Yucca Mountain Rail Access Study
Caliente Route

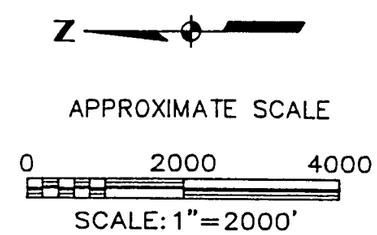
FEMA Flood Insurance Rate Map

K/J/C 897045.01

October, 1990

Figure 2.37





Source: Federal Emergency Management Agency
FLOODWAY Panel 320014 2876 Date: March 1, 1984
FLOODWAY Panel 320014 2877 Date: March 1, 1984
FLOODWAY Panel 320014 2878 Date: March 1, 1984
FLOODWAY Panel 320014 2879 Date: March 1, 1984

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Yucca Mountain Rail Access Study
Caliente Route

FEMA Flood Insurance Rate Map

K/J/C 897045.01

October, 1990

Figure 2.38

BASIN 227A

Basin 227A is located near the western portion of the study area and includes the Yucca Mountain proposed repository site which is the conclusion of the railway alignment. The proposed railway alignment crosses through the southern and western portion of Basin 227A. The drainage area that contributes to the proposed railway originates north and west of the alignment.

Description

Basin 227A (Figure 2.39) is approximately 24 miles long, 17 miles wide and is approximately 280 square miles in size. The primary watercourse in Basin 227A is Fortymile Wash. Fortymile Wash enters the northern boundary of the basin, flows north to south through the central portion of the basin and exits the southern boundary where it flows into the Amargosa Desert. The basin is bounded on the north by Shoshone Mountain, on the west by Yucca Mountain and on the east by Skull Mountain.

The prominent vegetation type in this watershed is desert shrub consisting primarily of greasewood, shadscale, bud sagebrush and rabbitbrush.

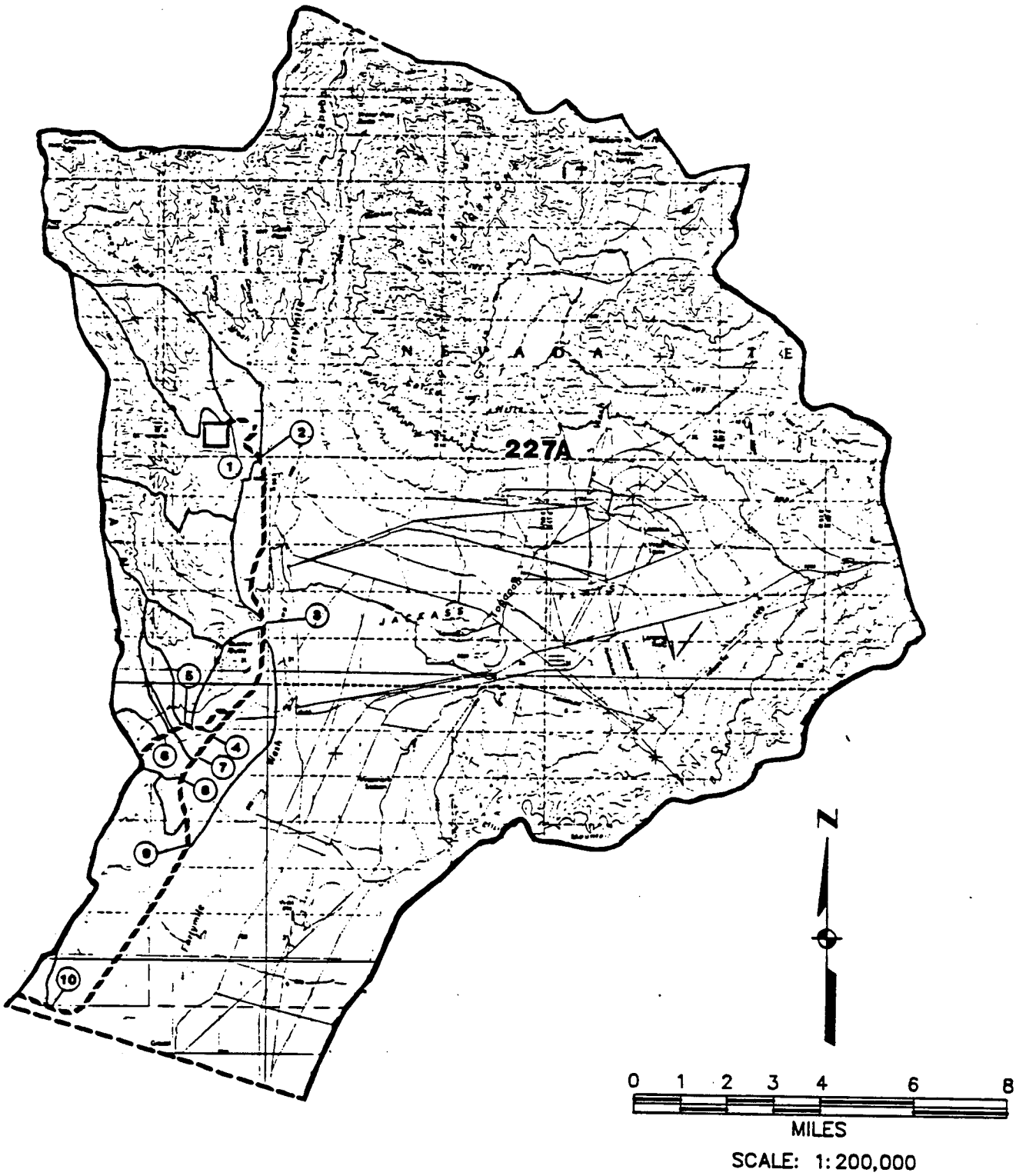
Average annual precipitation in the basin ranges from 5 inches on the valley floor to 10 inches on the highest portions of the surrounding mountain ranges.

Other Studies

The Nye County Flood Insurance Rate Maps, published by FEMA, do not show any approximate flood limits in the vicinity of the proposed alignment within this basin. Additional flood hazard areas have been mapped within Lincoln County but are not shown on these figures.

Special Design Considerations

Many of the drainages contributing to the proposed railway within this basin originate from relatively steep alluvial watersheds. Flows from extreme events will also be carrying a significant sediment load. Sudden changes to conveyance geometry can result in a change in flow velocity which in turn can result in deposition of sediment or additional scour. Drainage structures should be designed using sediment control considerations.



SCALE: 1:200,000

Kennedy/Jenks/Chilton

Yucca Mountain Rail Access Study
Caliente Route

State Engineers Basin 227A

K/J/C 897045.01

October, 1990

Figure 2.39

BASIN 228

Basin 228 is located near the western portion of the study area. The proposed railway alignment crosses through the south central portion of Basin 228. The drainage area that contributes to the proposed railway originates north and east of the alignment.

Description

Basin 228 (Figure 2.40) is approximately 32 miles long, 21 miles wide and is approximately 470 square miles in size. Basin 228 contains the headwaters for the Amargosa River. Drainage leaves the basin at the southern boundary via the Amargosa River. The basin is bounded on the north by Pahute Mesa, on the west by Bullfrog Hills and on the east by Timber Mountain.

The prominent vegetation type in this watershed is desert shrub consisting primarily of greasewood, shadscale, bud sagebrush and rabbitbrush.

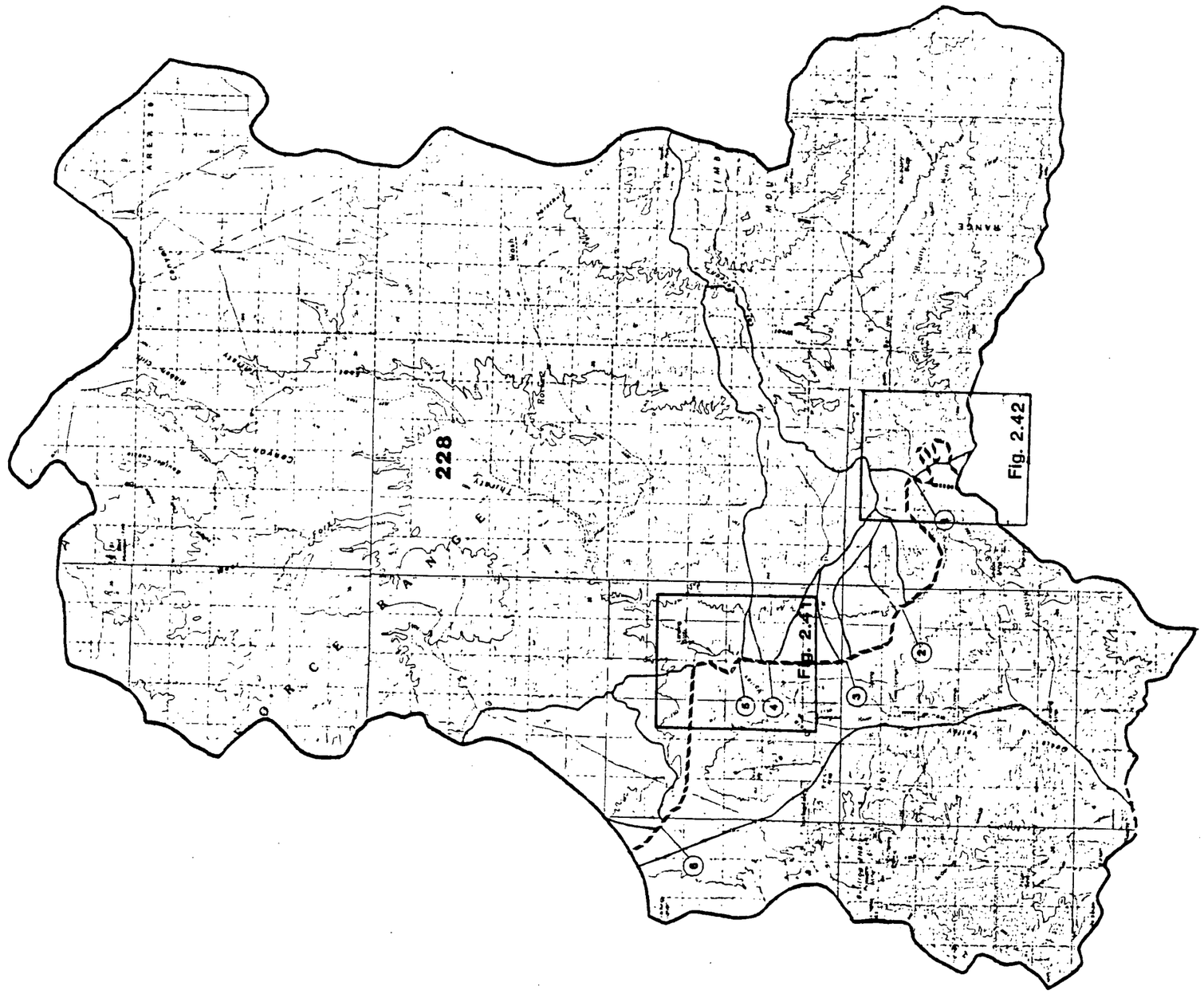
Average annual precipitation in the basin ranges from 5 inches on the valley floor to 10 inches on the highest portions of the surrounding mountain ranges.

Other Studies

The Nye County Flood Insurance Rate Maps, published by FEMA, show approximate flood limits for Thirsty Canyon (Figure 2.41) and Beatty Wash (Figure 2.42) in the vicinity of the proposed alignment within this basin. Additional flood hazard areas have been mapped within Lincoln County but are not shown on these figures.

Special Design Considerations

Many of the drainages contributing to the proposed railway within this basin originate from relatively steep alluvial watersheds. Flows from extreme events will also be carrying a significant sediment load. Sudden changes to conveyance geometry can result in a change in flow velocity which in turn can result in deposition of sediment or additional scour. Drainage structures should be designed using sediment control considerations.



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0 1 2 3 4 6 8
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Kennedy/Jenks/Chilton

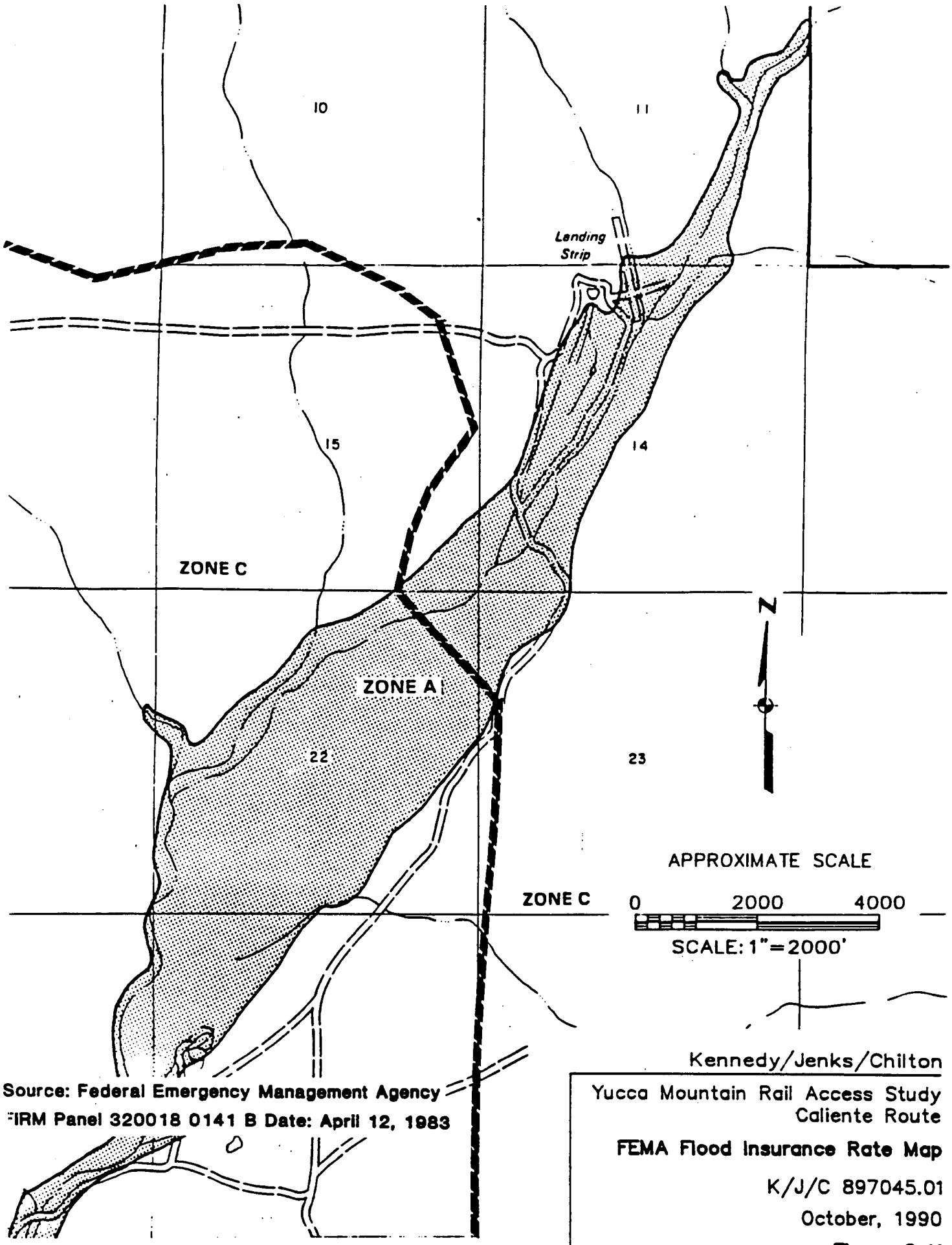
Yucca Mountain Rail Access Study
Caliente Route

State Engineers Basin 228

K/J/C 897045.01

October, 1990

Figure 2.40



Source: Federal Emergency Management Agency
FIRM Panel 320018 0141 B Date: April 12, 1983

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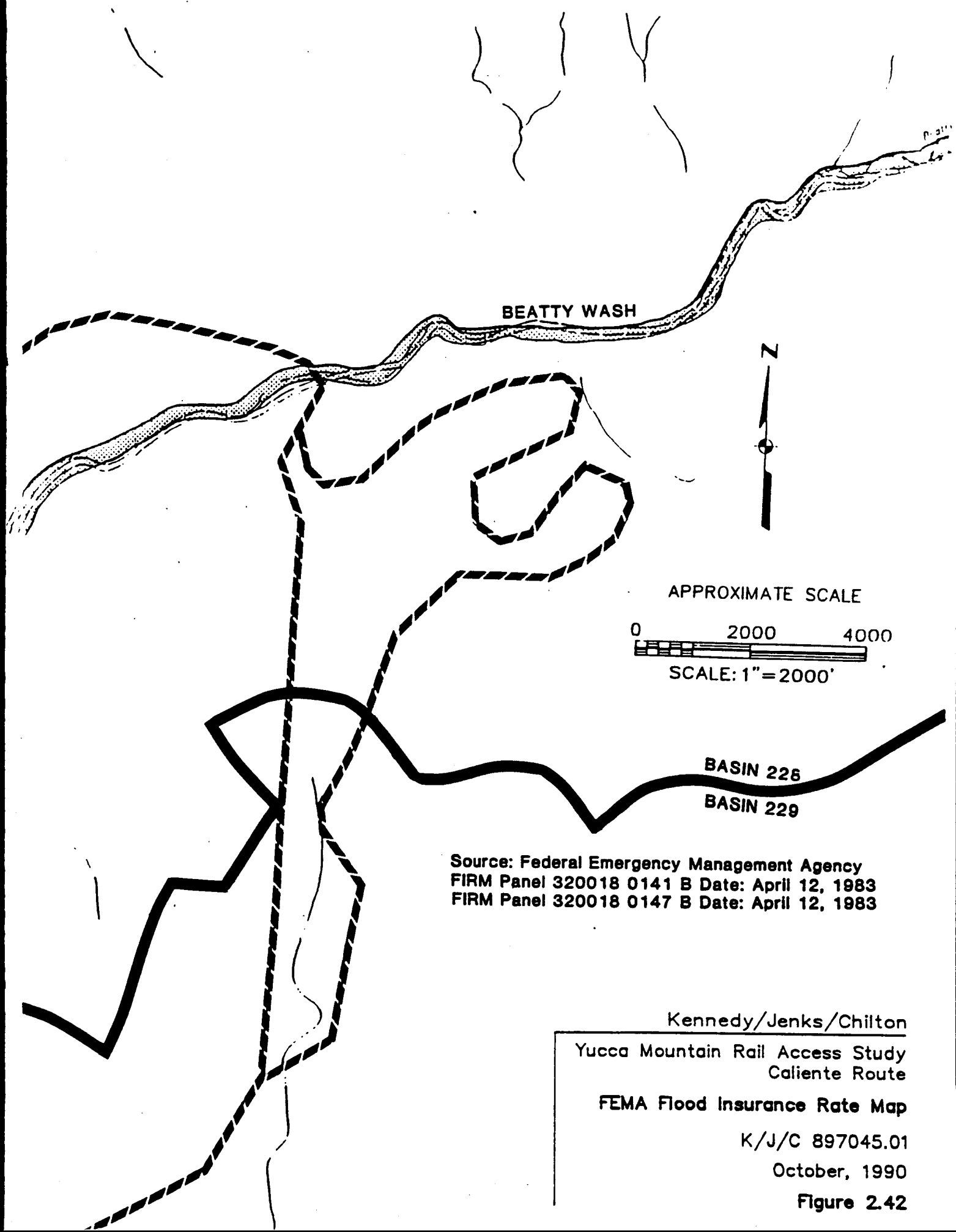
Yucca Mountain Rail Access Study
Caliente Route

FEMA Flood Insurance Rate Map

K/J/C 897045.01

October, 1990

Figure 2.41



Source: Federal Emergency Management Agency
FIRM Panel 320018 0141 B Date: April 12, 1983
FIRM Panel 320018 0147 B Date: April 12, 1983

Kennedy/Jenks/Chilton

Yucca Mountain Rail Access Study
Caliente Route

FEMA Flood Insurance Rate Map

K/J/C 897045.01

October, 1990

Figure 2.42

BASIN 229

Basin 229 is located near the western portion of the study area. The proposed railway alignment crosses through the center portion of Basin 229. The drainage area that contributes to the proposed railway originates north and east of the alignment.

Description

Basin 229 (Figure 2.43) is approximately 21 miles long, 13 miles wide and is approximately 180 square miles in size. Drainage from Basin 229 south exits the southern boundary where it flows into the Amargosa Desert. The basin is bounded on the north and east by Yucca Mountain and on the west by Bare Mountain.

The prominent vegetation type in this watershed is desert shrub consisting primarily of greasewood, shadscale, bud sagebrush and rabbitbrush.

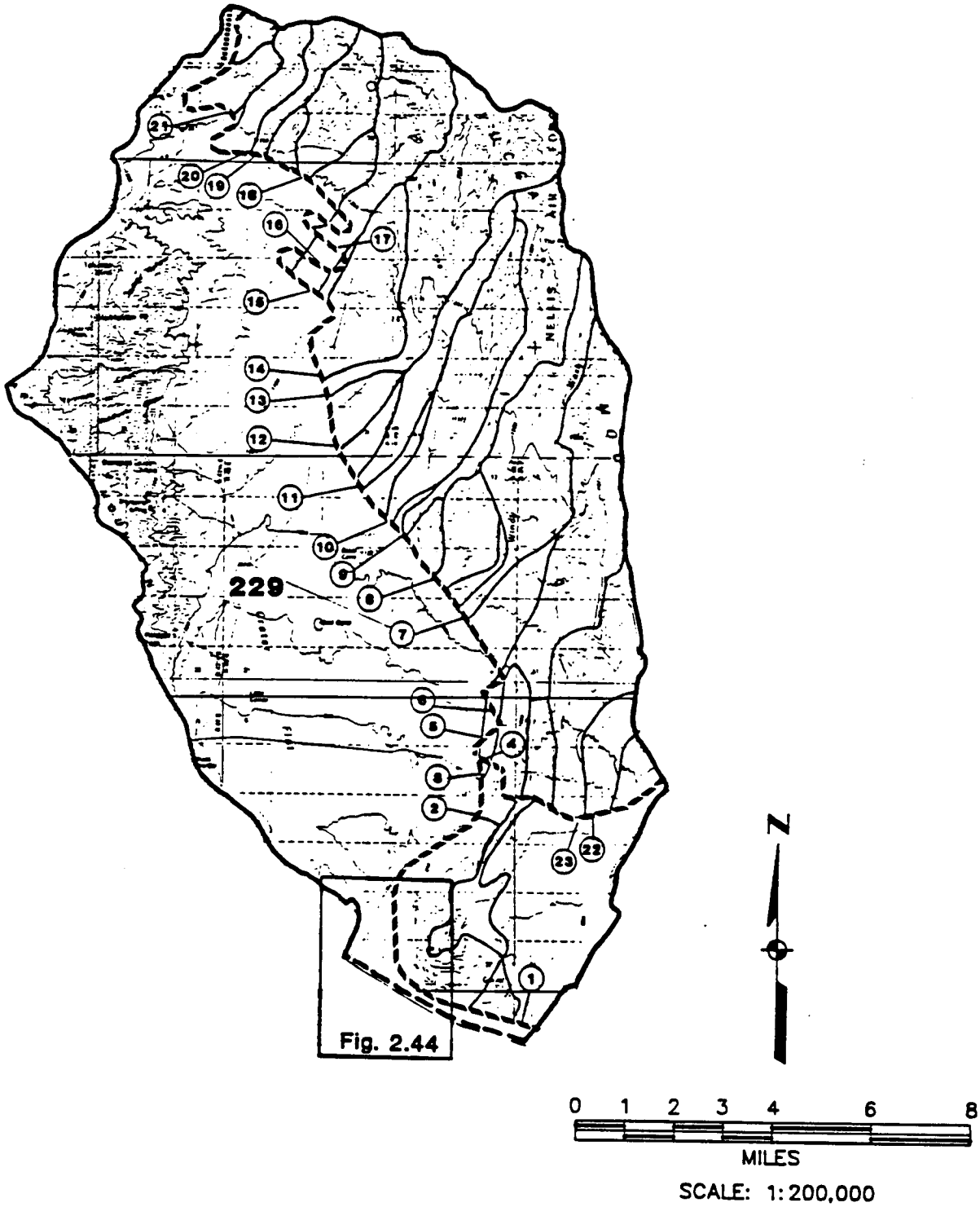
Average annual precipitation in the basin ranges from 5 inches on the valley floor to 8 inches on the highest portions of the surrounding mountain ranges.

Other Studies

The Nye County Flood Insurance Rate Maps, published by FEMA, show approximate flood limits for the watercourse that drains Basin 229 into Amargosa Valley. This flood hazard area is shown on Figure 2.44 in the vicinity of the proposed alignment. Additional flood hazard areas have been mapped within Lincoln County but are not shown on these figures.

Special Design Considerations

Many of the drainages contributing to the proposed railway within this basin originate from relatively steep alluvial watersheds. Flows from extreme events will also be carrying a significant sediment load. Sudden changes to conveyance geometry can result in a change in flow velocity which in turn can result in deposition of sediment or additional scour. Drainage structures should be designed using sediment control considerations.



Kennedy/Jenks/Chilton

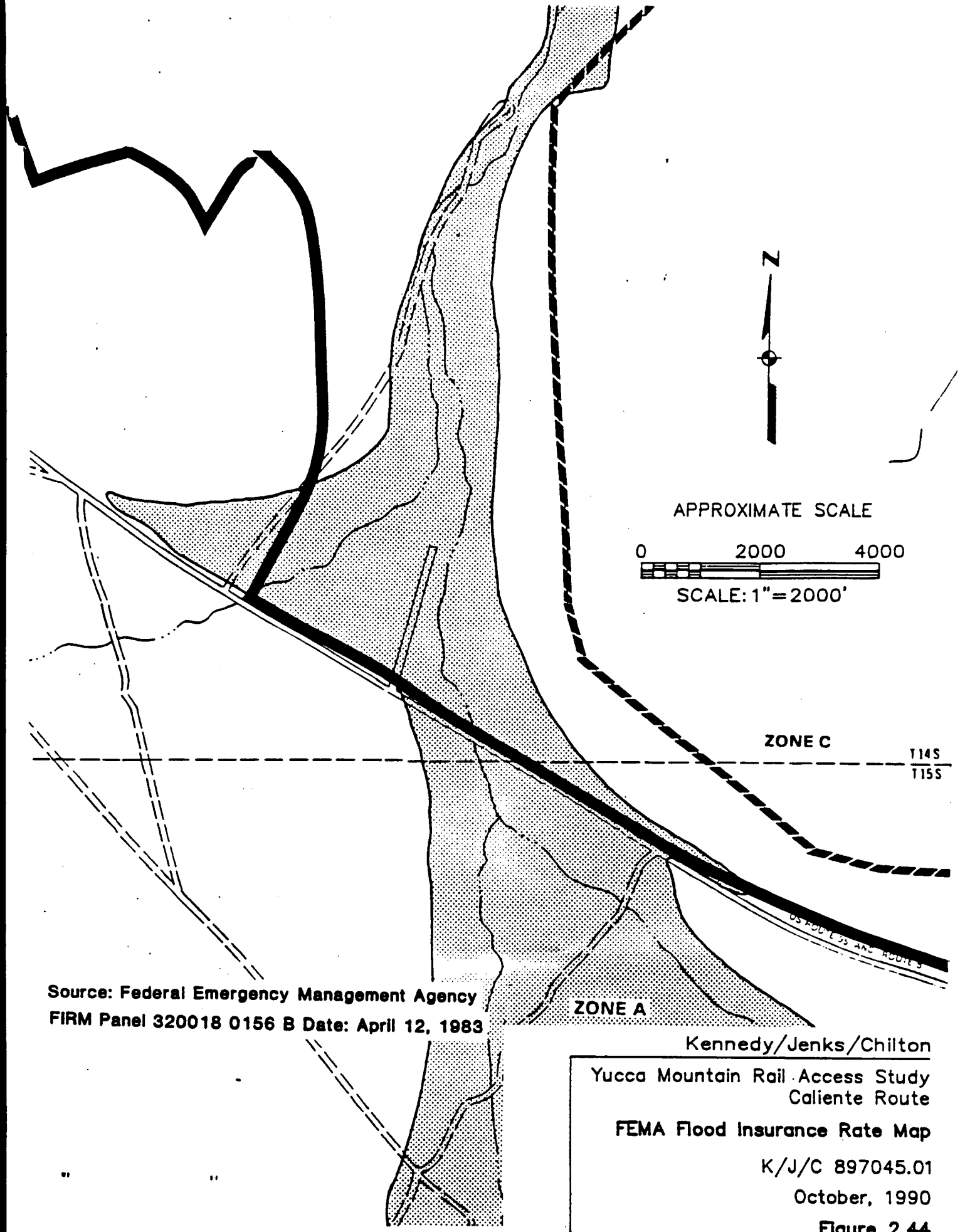
Yucca Mountain Rail Access Study
Caliente Route

State Engineers Basin 229

K/J/C 897045.01

October, 1990

Figure 2.43



Source: Federal Emergency Management Agency
FIRM Panel 320018 0156 B Date: April 12, 1983

Kennedy/Jenks/Chilton

Yucca Mountain Rail Access Study
Caliente Route

FEMA Flood Insurance Rate Map

K/J/C 897045.01

October, 1990

Figure 2.44

CHAPTER 3

HYDROLOGIC ANALYSIS

INTRODUCTION

The hydrologic analysis performed as a part of this study is intended to provide the following information:

- Peak discharge values computed using the Corps of Engineers Flood Hydrograph Package, HEC-1 for all drainage areas contributing to the proposed alignments which are greater than five square miles in size.

- Regional regression equations suitable for use in estimation of 100-year peak discharge values for drainage areas contributing to the alignment which are greater than one square mile but less than five square miles in size.

- Estimated peak discharge values for the drainage areas contributing to the alignment which are greater than one square mile but less than five square miles in size based upon the regional regression equations developed with this study.

- Identification of closed basin lakes which could potentially produce a 100-year lake level which would encroach upon the proposed railway alignment.

This chapter will provide an overview of the methods and critical assumptions used in the development of this information. Chapter 4 presents the results of the hydrologic analysis.

RECURRENCE INTERVAL

The recurrence interval of primary interest for this study was defined to be the 100-year event. The 100-year event is defined as the event which has a 1% chance of being equaled or exceeded during any given year. In the absence of sufficient data to determine the 100-year peak discharge using statistical methods, it is generally assumed that a 100-year rainfall event will produce a reasonable estimate of the 100-year peak discharge from the watershed. This assumption requires the use of a method or hydrologic model which translates the rainfall depth to a corresponding runoff depth from the watershed and ultimately a peak discharge. Hydrologic models are also used to develop hydrographs for various storm durations and patterns, which are needed to evaluate reservoir operation.

CHOICE OF HYDROLOGIC MODEL

With exception of White River and Meadow Valley Wash, there are very few stream gages within the study area with an adequate period of record to allow the use of statistical methods to estimate the peak discharges needed for this study. Use of statistical methods would be the preferred method of determining 100-year peak discharges for the larger watercourses in the study area. As is the case with most of the southwestern states, there are few stream gages in operation and even fewer with an adequate period of record. Therefore, it was necessary to use a hydrologic model to estimate the 100-year peak discharges for this study.

In the arid southwestern United States, most natural streams only flow after rainfall events. Southern Nevada experiences two basic types of storm events; general rain and convective thunderstorms. General rain events occur as the result of large frontal air masses that generally move across the area from the west. These types of events occur most frequently during the winter season. The general rain event is characterized by long duration (24 hours to 10 days) and relatively low intensity rainfall.

Thunderstorms are common in southern Nevada during the summer season. Moist air flows from the Gulf of California northeasterly through Arizona and southern Nevada. This moist air, combined with local convection, results in intense, short duration (24 hours or less) rainfall events. These intense, short duration events result in "flash floods" in arid southwest streams.

Runoff resulting from a storm event is the portion of the rainfall that is left after the losses due to evaporation, depression storage, interception by vegetation canopies and infiltration occurs. The amount of the rainfall that is lost to these sources is dependant on soil type and moisture content, vegetation type and cover density, rainfall rate and duration and amount and location of impervious surfaces. These losses are also not constant since they decrease during the passage of the rainfall event.

Many methods have been developed for estimating the runoff rate and volume from a watershed in response to rainfall. These methods include; empirical or graphical relationships based upon historic data, regional regression equations based upon statistical analysis and mathematical models.

The most commonly used models for rainfall/runoff modeling are the Corps of Engineers' Flood Hydrograph Package, HEC-1 and the Soil Conservation Service (SCS) runoff model TR-20. TR-20 uses the SCS curve number method for computing rainfall excess and the SCS dimensionless unit hydrograph for computation of the hydrograph shape.

HEC-1 provides several options for describing the rainfall/runoff process. The options available in HEC-1 for computing rainfall losses include:

- SCS Curve Number Method
- Initial and Constant Loss Rate
- Exponential Loss Rate
- Green and Ampt Parameters
- Holtan Loss Rate

The options available in HEC-1 for computing the hydrograph shape include:

- SCS dimensionless unit graph
- Direct input of a unit graph (developed from an S-Graph or other technique and input directly into HEC-1 as a unit graph)
- Clark unit graph
- Snyder unit graph

The Clark and Snyder unit graphs require two input parameters, the SCS dimensionless unit graph requires a single input parameter.

In addition to the unit graph options in HEC-1, there is also the kinematic wave option. This method describes the watershed using a series of overland flow planes connected by channels or pipes. This method produces best results when applied to small urbanized watersheds.

HEC-1 also has several options for routing the computed hydrograph through a channel reach or reservoir. These options include:

- Muskingum method (channels)
- Muskingum/Cunge method (channels)
- Kinematic Wave (channels or pipes)
- Working R & D (storage routing of channels)
- Modified Puls (level pool reservoir)

The U.S. Army Corps of Engineers Flood Hydrograph Package, HEC-1 has become a very well accepted standard tool for use in hydrologic studies in the western states. Because of the HEC-1's versatility, it was the model selected for use in this study. Due to the type of data available, the SCS curve number method was chosen as the most defensible method of computing rainfall losses.

METHODS OF COMPUTING FLOOD HYDROGRAPH

The methods selected for computing the 100-year flood hydrographs, using the HEC-1 model described above, were based on the SCS methods (Refs. 21 and 22). The SCS curve number method was used to determine loss rates and the resulting rainfall excess. The SCS curve number method computes rainfall excess based upon relative soil moisture, soil type, percentage of the watershed area that is impervious and vegetation type and cover density. The SCS "lag time" and the SCS dimensionless unit hydrograph were used to develop the hydrograph shape.

The models use the following input parameters to compute the runoff hydrographs utilizing these methods:

1. Watershed area (square miles)

2. Curve number - Estimated based upon soil type, relative soil moisture content and vegetation type and cover density (dimensionless)

3. SCS watershed lag time - Defined as the time difference between the center of mass of the rainfall excess and the time of peak discharge (hours)

4. Rainfall depth for period of interest (inches)

5. Time distribution of rainfall - Input as a mass curve or incremental rainfall depths when using a predefined distribution or input as depths for durations of five minutes to the period of interest when the hypothetical storm option is used. The hypothetical storm option was used in this study.

6. Spatial distribution of rainfall - Input as a storm area in square miles when the hypothetical storm option is used. HEC-1 then uses the depth-area reduction factors presented in NOAA Atlas 2 (HEC, 1988).

WATERSHED AREA

The watersheds were delineated on USGS 7.5 minute quadrangle maps. The area of each watershed was measured from the 7.5 minute quadrangle maps using a digital planimeter.

CURVE NUMBER

The curve number is based upon soil type, relative soil moisture content, vegetation type and vegetation cover density.

Soil Type - is typically derived from the U.S. Soil Conservation Service soil surveys. The soils identified in the survey are classified into one of four "hydrologic soil groups"; A, B, C and D. Type A soils have a very low runoff potential because they are very porous such as sandy soils. Type D soils are soils which have a high runoff potential such as very rocky soils or soils with a shallow impervious layer.

The Soil Conservation Service has published two soil surveys for portions of the study area. Other portions of the study area have been surveyed but the data was only available in the form of preliminary soil surveys. These soil surveys include a description of each major association and its characteristics and hydrologic soil group. Other portions of the study area have not yet been surveyed. Soil types for these areas were determined from field reconnaissance and comparative analysis.

Relative Soil Moisture Content is described by the SCS using the term "antecedent moisture condition" (AMC). Three different antecedent moisture conditions are identified for estimation of curve number; AMC I, AMC II, and AMC III. AMC I is a condition in which the soil moisture has been depleted by a relatively long period of no rainfall. This condition is assumed to represent the condition in which the soil's infiltration capacity is at the highest point. AMC III is the condition in which soil moisture is high due to recent rainfall or snowmelt. This condition is assumed to be the condition in which the soil infiltration capacity is at its lowest point. AMC II is an average condition and is the condition usually assumed to be present in the watershed for most hydrologic studies of this type. AMC II was the condition used in this study.

Vegetation Type refers to the basic type of plant community which occupies the watershed. The SCS has identified curve numbers for various typical plant communities. The vegetation types which best describe the plant communities encountered in the study area include; sagebrush with grass understory, desert shrub, and pinion/juniper.

Vegetation Cover Density refers to the average percentage of the soil surface covered by plant canopy and litter. The plant canopy and litter intercept a portion of the rainfall which reduces the runoff potential. A vegetation type with a thick and absorbent plant canopy would have a lower curve number than a vegetation type with a sparse canopy for the same hydrologic soil group and cover density.

Vegetation type and cover density were determined from field reconnaissance. This field data was also supplemented with the use of aerial photographs and LANDSAT imagery.

Using the selected soil types, AMC II condition and identified vegetation types, the curve number for each watershed was estimated based on data in the SCS NEH-4 and SCS TR-55 handbook.

Since very little development has occurred in the study area, impervious cover was not an important factor in the hydrologic models developed as a part of this study.

WATERSHED LAG TIME

Watershed lag time is defined by the SCS as the time difference between the centroid of the rainfall excess and the peak runoff from the watershed. Time of concentration is defined as the time required for a particle of water to travel from the hydraulically most distant point in the watershed to the watershed outlet. The SCS has developed an empirical relationship between the time of concentration and the lag time for a typical watershed. This relationship is:

$$Lag = 0.6\ T_c$$

where:

T_c = time of concentration in hours
Lag = watershed lag time in hours

The SCS has identified two basic methods for computing time of concentration and lag time; the curve number method and upland method. The curve number method uses average watershed slope, hydraulic length and curve number in an empirical relationship to estimate lag time. The upland method uses the relationship between the slope of the primary flow path and the conditions of the flow path to estimate the velocity of each individual reach of the longest flow path encountered in the watershed. The sum of the travel times for each reach is the estimated time of concentration. The relationship between slope and velocity is typically taken from a chart contained in the SCS National Engineering Handbook (Figure 15.2 of Ref. 21).

Both of these methods are based upon overland flow being the dominant condition in the watershed. TR-55 recommends that a reach by reach analysis be performed when using the upland method and velocities be based upon approximate or surveyed cross sections when channel flow is encountered (velocity method). McCuen, Wong and Rawls (1984) also concluded that the velocity method was the most accurate method of estimating time of concentration when the velocities in the channel reaches are estimated based on the channel conditions.

Time of concentration for this study was based upon a reach by reach velocity method analysis using typical channel geometry and roughness values obtained using aerial photographs, field inspection and topographic maps.

RAINFALL DEPTH

Rainfall depths for each duration and recurrence interval were computed using NOAA Atlas 2 (NWS, 1973). Proper application of NOAA Atlas 2 requires reading the approximate values for the six and 24 hour durations for each of the recurrence intervals, from the maps contained

in NOAA Atlas. These values are plotted on a graph contained in NOAA Atlas. A "best fit" line is drawn to obtain the "corrected" values. Then corrected values are applied to a series of equations to estimate the values for the other durations and recurrence intervals. This method was utilized to develop the five minute to 24 hour rainfall depths used in this study.

TIME DISTRIBUTION OF RAINFALL

The HEC-1 model also requires the use of a historic or synthetic distribution to distribute the total rainfall depth over the time period of interest. As indicated earlier, the hypothetical storm option in HEC-1 was used to distribute 100-year rainfall depths in this study. Use of this option results in a time distribution of rainfall which has the greatest intensity (five minute depth) in the center of the 24 hour time period. By subtracting the five minute depth from the 15 minute depth, the expected depth for the last 10 minutes of the 15 minute period is obtained. This depth is divided by two and placed on either side of the five minute depth in the distribution. This process is continued for the entire 24 hour period. The resulting rainfall pattern is triangular in shape with the peak intensity at the center of the 24 hour period. Use of this type of distribution is generally conservative, since it assumes that a 100-year, 24 hour event would also include 100-year depths for the shorter durations as well. The short duration, 100-year values would typically be produced only by shorter duration storms.

SPATIAL DISTRIBUTION OF RAINFALL

The 100-year rainfall values obtained from NOAA Atlas 2 are statistical point rainfall depths. A storm that would produce this rainfall depth will typically have an elliptical shape and pattern. In mountainous regions the shape and pattern of the rainfall event can be more complex since the pattern may be governed by orographic influences. The depths within a storm pattern will decrease as you move away from the storm center. This spatial distribution of rainfall is usually represented in the form of a reduction factor versus storm area relationship. The point rainfall value is reduced based on the storm area that is representative for the watershed of interest. In many cases it is assumed that the
storm area and watershed area are equivalent. In the case of a long and narrow watershed with a storm pattern that is elliptically shaped and oriented perpendicular to the watershed, the storm area could be significantly greater than the watershed area. Assuming that storm area is equivalent to watershed area, would often be a conservative assumption.

Aerial reduction factors have been developed by NOAA for use in reducing point rainfall values based upon storm area. The first set of curves were developed with NOAA Technical Paper 40 (TP-40). These factors were based primarily on data from the eastern United States and were re-evaluated by NOAA during the studies which produced the NOAA Atlas 2 series for the western United States. It was concluded by NOAA, that

the original curves, developed with TP-40, were representative of the available data for the West. Therefore, the aerial reduction factors published with NOAA Atlas 2 are identical to the factors published in TP-40. HEC-1 utilizes these factors when the hypothetical storm option is selected.

In 1984 NOAA conducted a study (NWS Hydro-40, Ref. 38) of spatial distribution of rainfall in Southern Arizona and New Mexico. The depth-area relations for thunderstorm events in this region differed from the depth-area relations shown in NOAA Atlas 2 and TP-40. However, this report cautions against the use of these curves for parts of northern Arizona and other states since there is insufficient evidence to suggest that these curves are applicable for any other areas in the southwest. Thunderstorm rainfall in Arizona and New Mexico is strongly influenced by southern air flow patterns from the Gulf of California and exhibits characteristics that are unique to that region.

Aerial reduction of rainfall for single basin models developed with this study, was based upon watershed area unless unusual watershed geometry warranted the use of a larger storm area. For large watersheds that required subdivision into smaller sub-basins, aerial reduction was based upon a storm center approach. The aerial reduction was increased moving away from the storm center by applying a greater storm area as you move away from the storm center (elliptically shaped storm oriented parallel to the watershed).

METHODS FOR ROUTING HYDROGRAPHS THROUGH CHANNEL REACHES

Routing of hydrographs from one concentration point to another was performed using the Muskingum Method (USCOE, 1960). The Muskingum method uses the following parameters in the routing computations:

1. Muskingum X - Muskingum parameter X is a dimensionless empirical value based upon depth of flow and channel geometry. This value is determined from calibration if observed data is available. In the absence of calibration data, this parameter can be estimated from channel conditions. This value varies from 0 to 0.5 with the value of 0 being representative of a reservoir and 0.5 is representative of a channel with little or no available storage which results in the hydrograph being translated through the reach with no change in shape. The lower the value of X, the more attenuation of the hydrograph occurs.

2. Muskingum K - K is the storage time coefficient for the channel reach. It can be shown that K is approximately equivalent to the travel time of the flood wave through the channel reach (USCOE, 1960). With available data, K would be obtained from calibration. In the absence of calibration data, K can be estimated by estimating the travel time of the flood wave through the routing reach using the velocity method and a factor that relates the velocity of the flood wave to the channel velocity (based on channel geometry).

The translation time of the hydrograph peak is related to the value of K.

3. NSTPS - This parameter is the number of steps in the routing reach computations (HEC, 1988). This parameter is a HEC-1 input variable that is obtained from an iterative solution of a set of equations presented in the HEC-1 manual. The solution of NSTPS is based upon X, K and the computational time interval selected in the model. If the time interval, X or K are modified, NSTPS may also need to be modified. The equations presented in the HEC-1 manual will often yield a range of possible values for this parameter. The selected value must be within this range in order to assure computational stability. The greater the number of steps selected, the more attenuation of the hydrograph will occur.

The value of X was estimated based on channel conditions. A value of X near the high end of the range of possible values was selected in all cases.

The value of the parameter K was estimated based on a reach by reach velocity method analysis. NSTPS was computed based upon the equations contained in the HEC-1 manual and the computational time interval used in the HEC-1 model for that watershed and the estimated values of K and X.

RESERVOIR ROUTING

Reservoir routing was performed using the modified Puls reservoir routing method. This method is also referred to as the storage indication method. The model inputs include:

1. Stage-Storage Data. The model requires information on the available storage in the reservoir for each elevation from the elevation at the top of the Dam to the lowest point in the reservoir. This can be input as elevation vs. storage data or the user can input elevation vs. area data (area under each contour of interest). The elevation vs. area data is converted by HEC-1 into elevation vs. storage data using the conic method.

2. Stage-Discharge Data. The model requires information on the outflow from the reservoir's low level and spillway outlets for each elevation of interest. The data can be input in this format or the dimensions of the structures can be input to allow HEC-1 to apply the orifice and weir flow equations to compute the needed data.

These data are used by HEC-1 to model outflow from the reservoir using a form of the basic continuity equation; Inflow - Outflow = Change in Storage (I - O = S).

This method of hydrograph routing was applied to model the effect of storage on the outflow from Stonewall Flat and for computation of the maximum pool elevation of Mud Lake.

REGIONAL REGRESSION ANALYSIS

Regional regression analysis is a method of developing a mathematical relationship of a population of data based upon certain characteristics of that population. This analysis provides the mathematical relationship that best describes the data from the population.

In flood frequency analysis, regional regression equations generally relate peak discharge from a watershed to several readily identifiable watershed characteristics such as; area, elevation, slope, precipitation, latitude, watercourse length, etc. Development of regional regression equations requires peak discharge and the corresponding watershed characteristic data for many similar watersheds. These watersheds should be similar in region, physical characteristics and meteorological characteristics. A regional regression equation only provides an approximate value for peak discharge. These equations exclude many important watershed factors in the estimate and statistical analysis, such as, soil type, vegetation type and density, antecedent moisture condition, differences in primary channel conditions, differences in watershed geometry, etc.

The purpose of the regional regression analysis, conducted as a part of this study, was to develop a set of regional equations for use on the watersheds in the study area that were less than five square miles in size. The goal of the analysis was to develop equations that would produce results that are reasonably comparable to the value that would be computed using HEC-1. This was accomplished by using HEC-1 input data and results developed as a part of this study as the basic data set for the analysis. This data set was supplemented with HEC-1 data from other studies in southern Nevada (Refs. 4 & 16). The regression analysis was performed using the Multiple Linear Regression Program (MLRP) developed by the Hydrologic Engineering Center of the Corps of Engineers. The results of this analysis are presented in Chapter 4.

HYDROLOGIC ANALYSIS OF SMALL BASINS

The peak discharge values for the small basins were estimated using the regional regression equations described above. The equations developed relate peak discharge to watershed area, average watershed slope and 100-year, 6 hour precipitation depth. Watershed areas were measured from the USGS 7.5 minute topographic quadrangle maps using a digital planimeter. The watershed length and elevation data for use in computing average watershed slope were also derived from the 7.5 minute USGS topographic maps. Precipitation depth was estimated using NOAA Atlas 2.

CLOSED BASIN LAKE ANALYSIS

Mud Lake, located in the southern portion of Basin 141, was the only closed basin lake considered to be of concern to the currently proposed railway alignment. The purpose of the analysis of Mud Lake was to estimate the 100-year lake level. The 100-year lake level would be the water surface elevation in the lake that would have a 1% chance of being equalled or exceeded in any given year.

Determination of an accurate estimate of the 100-year lake level would require a minimum of 20 years of annual maximum lake level elevations. This data would be used in a flood frequency analysis to estimate the lake level elevation that has a one percent chance of being equaled or exceeded in any given year. In the absence of such data, estimation of this elevation is very difficult and very imprecise. In absence of lake level elevation data, estimation of the 100-year lake level must be performed with mathematical models of the watershed.

Use of a continuous event model would allow the modeler to compute a series of lake level responses to historic rainfall events. The resulting maximum annual levels would then be used in a flood frequency analysis. However, continuous event models require a considerable amount of soil moisture accounting and precipitation data in order to accurately model the watershed's response to rainfall. Adequate data for application of a continuous event model is rarely available. In the absence of data for a continuous event model, a 100-year lake level for a closed basin lake with a relatively small contributing area can be approximated using a single event model combined with adequate assumptions regarding potential carryover storage.

For the purposes of this study, the lake level was estimated by computing the range of possible runoff volumes that could result from a long duration 100-year rainfall event (10 days). These runoff volumes were added to an estimate of potential carry-over storage in the lake from the previous year.

Estimate of Runoff Volume to Mud Lake

Use of the SCS curve number for storm durations greater than 24 hours, produces questionable runoff volume results. The curve number charts published by the SCS are based upon a 24 hour rainfall event. Use of the method requires that the curve number be adjusted down depending upon storm length and soil/vegetation type. There have not been any published studies that would provide an approach to reduce the curve number accordingly.

During the preparation of a Flood Insurance Re-study for Washoe County (Ref. 20), it was found that a better fit to historic data could be accomplished with the use of the constant and initial loss rate option in HEC-1. The runoff volume from an extreme event is only sensitive to the value of the constant loss rate. The study for Washoe County concluded that the constant loss rate values calibrated from the 1986 event ranged from 0.07 to 0.14 inches/hr. The constant loss rates determined by the Corps of Engineers for the Truckee River basin (Ref.

34) ranged from 0.05 to 0.23 inches/hr. The Corps of Engineers concluded that the constant loss rate in the Humboldt River basin (Ref. 35) ranged from 0.05 to 0.15 inches/hr. From reconstitution of several historic events in the Las Vegas Valley, the Corps of Engineers concluded that the constant loss rates in this area ranged from 0.35 to 0.40 inches/hr.

This data was used to develop a series of HEC-1 models of the 1950 square mile watershed which contributes to Mud Lake. These models vary the value of the constant loss rate to determine the sensitivity of this parameter on the predicted runoff volume and resulting lake level. A series of models were also developed for decreasing values of curve number.

Computation of Lake Level in Mud Lake

The computed runoff volume must be translated into a lake level using the 7.5 minute USGS topographic maps. Spot elevations shown on the maps were used to estimate the locations of the contour lines not shown. These estimated contours along with the contours shown, were used to develop an elevation-surface area relationship for the playa. This elevation-area data was input into HEC-1 using the reservoir routing option. The playa was then modeled as a reservoir with no outflow. HEC-1 utilizes the elevation-area data to compute elevation-volume data for the playa based upon the conic method. The volume data is used in conjunction with the inflow hydrograph to monitor lake level. The maximum lake level occurs at the end of the runoff event when the entire runoff volume has reached the playa.

CHAPTER 4

RESULTS OF HYDROLOGIC ANALYSIS

INTRODUCTION

This chapter presents the results of the hydrologic analysis performed as a part of this study. Table 4.1 presents the estimated peak discharges for each of the concentration points identified on the maps in Chapter 2. Chapter 3 describes the methods and critical assumptions used in each portion of the analysis.

The discharges presented in this report are approximate peak discharges intended for a planning level study and should not be used for final design.

RESULTS OF HEC-1 ANALYSIS OF LARGER WATERSHEDS

The results obtained using HEC-1 were evaluated for reasonableness by comparing the results with results obtained in other studies and with the performance of a sensitivity analysis for the less certain variables. The sensitivity analysis evaluates the reproducability of the results by determining the range of results that could occur when different engineers/hydrologists utilize the same methods of analysis. The comparison of the results with other studies provides a means of evaluating the reasonableness of the results with respect to a range of possible "true" values. This section describes the results of that comparison and the final results for each concentration point impacting the proposed railway.

Sensitivity Analysis

A sensitivity analysis was performed to evaluate the range in the results that would occur from a reasonable range of the possible variables used in calculation of model input parameters. The sensitivity analysis was limited to the variables that would cause the greatest impact on the model results. This analysis would indicate what range of results that could be obtained by different engineers/hydrologists performing the analysis using the same basic methods. This analysis does not define the range of error of the results with respect to a "true" value.

Many of the larger watersheds to be analyzed using HEC-1 needed to be subdivided into subbasins in order to determine peak discharges at intermediate points, route flow through playas or to divide the watershed into more homogeneous units. Including these subbasins, approximately 160 watersheds were modeled using HEC-1. Chapter 3 describes the data required to model these basins using the SCS curve number method.

YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

TABLE 4.1
SUMMARY OF DISCHARGES

CONC. POINT	AREA (SQ. MI)	SHEET NUMBER	DISCHARGE (CFS)	COMMENTS:
BASIN 141				
1	768.0	5	28790 (1)	Wide, shallow and slow
2	116.3	5	4160 (1)	
3	1.6	5	340 (2)	
4	3.6	5	660 (2)	
5	15.7	5	2460 (1)	
6	1.8	5	830 (2)	
7	1.6	5	700 (2)	
8	1.4	5	520 (2)	
9	1.5	5	590 (2)	
10	2.2	5	1050 (2)	
11	3.8	5	1300 (2)	
12	1.5	5	550 (2)	
BASIN 142				
1	20.7	5	4400 (1)	
2	2.1	5	300 (2)	
3	2.3	5	330 (2)	
4	48.6	5	10170 (1)	
5	10.3	5	1690 (1)	
6	1.6	5	320 (2)	
7	1.2	5	230 (2)	
8	9.6	5	1980 (1)	
9	2.4	5	590 (2)	

(1) DISCHARGE ESTIMATED USING CORPS OF ENGINEERS HYDROLOGIC PACKAGE HEC-1.
(2) DISCHARGE ESTIMATED USING REGRESSION EQUATION GENERATED FROM SIMILAR WATERSHEDS IN SOUTHERN NEVADA.
(3) FEDERAL EMERGENCY MANAGEMENT AGENCY - LINCOLN CO. F.I.S.

YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

TABLE 4.1
SUMMARY OF DISCHARGES

CONC. POINT	AREA (SQ. MI)	SHEET NUMBER	DISCHARGE (CFS)	COMMENTS:
BASIN 142				
10	3.9	5	920 (2)	
11	4.4	5	1230 (2)	
12	2.1	5	600 (2)	
13	2.1	5	840 (2)	
14	1.2	5	440 (2)	
15	5.9	5	1200 (1)	
16	3.2	5	1680 (2)	
17	1.3	5	700 (2)	
18	5.6	5	2160 (2)	
19	1.4	5	670 (2)	
20	3.4	5	1600 (2)	
21	1.1	5	540 (2)	
22	1.2	5	750 (2)	
23	2.6	5	1430 (2)	
BASIN 143				
1	2.2	5	1630 (2)	
2	3.3	5	1850 (2)	
3	3.7	5	1900 (2)	
4	1.2	5	1110 (2)	
BASIN 144				
1	522.0	4	29800 (1)	Jackson Wash
	3.2	4	1700 (2)	

(1) DISCHARGE ESTIMATED USING CORPS OF ENGINEERS HYDROLOGIC PACKAGE HEC-1.
(2) DISCHARGE ESTIMATED USING REGRESSION EQUATION GENERATED FROM SIMILAR WATERSHEDS IN SOUTHERN NEVADA.
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YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

TABLE 4.1
SUMMARY OF DISCHARGES

CONC. POINT	AREA (SQ. MI)	SHEET NUMBER	DISCHARGE (CFS)	COMMENTS:
BASIN 144				
3	1.5	4	810 (2)	
4	2.6	4	1120 (2)	
5	70.6	5	3220 (1)	Stonewall Flat outflow
6	1.6	5	980 (2)	
7	2.1	5	990 (2)	
8	38.7	5	7220 (1)	
9	1.4	4	700 (2)	
10	1.4	4	740 (2)	
11	2.1	4	870 (2)	
12	1.5	4	770 (2)	
13	3.0	4	1050 (2)	
14	1.7	4	630 (2)	
15	3.6	4	1170 (2)	
16	6.2	4	1720 (1)	
17	3.8	4	1170 (2)	
18	1.0	4	280 (2)	
19	1.1	4	440 (2)	
20	338.0	4	29300 (1)	Jackson Wash
21	1.4	4	390 (2)	
22	14.7	5	2670 (1)	
23	2.4	5	460 (2)	
24	25.4	5	5340 (1)	

(1) DISCHARGE ESTIMATED USING CORPS OF ENGINEERS HYDROLOGIC PACKAGE HEC-1.
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YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

TABLE 4.1
SUMMARY OF DISCHARGES

CONC. POINT	AREA (SQ. MI)	SHEET NUMBER	DISCHARGE (CFS)	COMMENTS:
BASIN 144				
25	25.9	5	5330 (1)	
26	13.1	5	2800 (1)	
26B	12.9	5	2810 (1)	
27	40.9	5	8880 (1)	
27A	26.6	5	7300 (1)	
28	15.6	5	5560 (1)	
29	1.4	5	1160 (2)	
30	2.5	4	1120 (2)	
31	5.5	4	1350 (1)	
32	1.8	4	510 (2)	
BASIN 145				
1	2.3	5	1470 (2)	
2	5.2	5	2060 (1)	
3	3.3	5	1120 (2)	
BASIN 146				
1	1.7	3	650 (2)	
2	3.6	3	1090 (2)	
3	21.2	3	5820 (1)	
4	6.0	3	1050 (1)	
5	7.9	3	1410 (1)	
6	3.4	3	740 (2)	

(1) DISCHARGE ESTIMATED USING CORPS OF ENGINEERS HYDROLOGIC PACKAGE HEC-1.
(2) DISCHARGE ESTIMATED USING REGRESSION EQUATION GENERATED FROM SIMILAR WATERSHEDS IN SOUTHERN NEVADA.
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YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

TABLE 4.1
SUMMARY OF DISCHARGES

CONC. POINT	AREA (SQ. MI)	SHEET NUMBER	DISCHARGE (CFS)	COMMENTS:
BASIN 146				
7	3.1	3	600 (2)	
8	31.0	3	5670 (1)	
9	2.4	3	650 (2)	
10	2.3	3	570 (2)	
11	8.6	3	1530 (1)	
11B	3.5	3	660 (2)	
12	3.1	3	900 (2)	
13	85.6	3	14820 (1)	Tolicha Canyon
14	7.1	3	3450 (1)	
15	1.4	3	710 (2)	
16	1.5	3	720 (2)	
17	3.5	4	1440 (2)	
18	1.7	4	810 (2)	
19	2.5	4	930 (2)	
20	2.5	4	940 (2)	
21	1.4	4	590 (2)	
22	8.4	4	2770 (1)	
23	4.4	4	1250 (2)	
24	671.7	4	34600 (1)	Jackson Wash (from Bsn 144)
25	4.1	4	1550 (2)	
BASIN 149				
1	1.1	8	980 (2)	

(1) DISCHARGE ESTIMATED USING CORPS OF ENGINEERS HYDROLOGIC PACKAGE HEC-1.
(2) DISCHARGE ESTIMATED USING REGRESSION EQUATION GENERATED FROM SIMILAR WATERSHEDS IN SOUTHERN NEVADA.
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YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

TABLE 4.1
SUMMARY OF DISCHARGES

CONC. POINT	AREA (SQ. MI)	SHEET NUMBER	DISCHARGE (CFS)	COMMENTS:
BASIN 149				
2	0.9	8	760 (2)	
3	2.1	8	1240 (2)	
4	1.6	8	1170 (2)	
5	1.3	8	1000 (2)	
6	2.4	8	1550 (2)	
7	1.7	8	1080 (2)	
8	1.5	8	760 (2)	Part of Active Alluvial Fan
9	1.1	8	280 (2)	Part of Active Alluvial Fan
10	24.3	8	6430 (1)	Active Alluvial Fan
11	3.1	8	850 (2)	
12	1.8	8	530 (2)	
13	11.0	8	4290 (1)	
14	0.7	8	170 (2)	
15	1.2	8	300 (2)	
16	2.6	8	400 (2)	
17	37.7	8	9910 (1)	
18	2.1	8	420 (2)	
19	2.5	8	680 (2)	
20	3.5	6	940 (2)	
21	1.9	6	520 (2)	
22	1.9	6	600 (2)	
23	1.2	6	330 (2)	

(1) DISCHARGE ESTIMATED USING CORPS OF ENGINEERS HYDROLOGIC PACKAGE HEC-1.
(2) DISCHARGE ESTIMATED USING REGRESSION EQUATION GENERATED FROM SIMILAR WATERSHEDS IN SOUTHERN NEVADA.
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YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

TABLE 4.1
SUMMARY OF DISCHARGES

CONC. POINT	AREA (SQ. MI)	SHEET NUMBER	DISCHARGE (CFS)	COMMENTS:
BASIN 149				
24	2.5	6	750 (2)	
25	5.9	6	1880 (1)	
26	2.0	6	460 (2)	
27	7.1	6	800 (1)	
28	732.7	6	42720 (1)	Stone Cabin Creek
29	128.3	6	9850 (1)	Salsbury Wash
30	6.5	6	870 (1)	
BASIN 156				
1	1.4	6	330 (2)	
2	3.8	6	1410 (2)	
3	2.0	6	730 (2)	
4	1.6	6	740 (2)	
5	5.4	6	2530 (1)	
7	2.6	6	1430 (2)	
8A	4.1	6	1380 (1)	
8B	3.1	6	1760 (1)	
9	0.8	6	290 (2)	
10	1.6	6	870 (2)	
11	3.8	6	2080 (2)	
12	2.5	6	1240 (2)	
13	10.0	6	3050 (1)	
14A	1.2	6	1210 (2)	

(1) DISCHARGE ESTIMATED USING CORPS OF ENGINEERS HYDROLOGIC PACKAGE HEC-1.
(2) DISCHARGE ESTIMATED USING REGRESSION EQUATION GENERATED FROM SIMILAR WATERSHEDS IN SOUTHERN NEVADA.
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YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

TABLE 4.1
SUMMARY OF DISCHARGES

CONC. POINT	AREA (SQ. MI)	SHEET NUMBER	DISCHARGE (CFS)	COMMENTS:
BASIN 156				
14B	2.4	6	1990 (2)	
15	1.6	8	1050 (2)	
16	6.5	8	2070 (1)	Cottonwood Canyon
17	0.9	8	400 (2)	
18	5.2	8	2620 (1)	
19	0.8	8	760 (2)	
20	1.8	8	1220 (2)	
21	0.9	8	710 (2)	
22	1.5	8	1070 (2)	
23	3.1	8	1960 (2)	
24	1.3	8	1010 (2)	
25	2.8	8	1910 (2)	
26	1.9	8	1510 (2)	
27	2.0	8	1790 (2)	
28	10.2	8	3950 (1)	Cow Canyon
29	3.1	8	2030 (2)	
30	1.4	8	1250 (2)	
31	0.9	8	950 (2)	
BASIN 169A				
1	1.1	10	830 (2)	
2	1.4	10	1510 (2)	
3	1.0	10	950 (2)	

(1) DISCHARGE ESTIMATED USING CORPS OF ENGINEERS HYDROLOGIC PACKAGE HEC-1.
(2) DISCHARGE ESTIMATED USING REGRESSION EQUATION GENERATED FROM SIMILAR WATERSHEDS IN SOUTHERN NEVADA.
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YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

TABLE 4.1
SUMMARY OF DISCHARGES

CONC. POINT	AREA (SQ. MI)	SHEET NUMBER	DISCHARGE (CFS)	COMMENTS:
BASIN 169A				
4	1.2	10	1070 (2)	
5	4.0	10	2210 (2)	
6	1.2	10	870 (2)	
7	14.7	10	4000 (1)	Part of Active Alluvial Fan
8	1.1	10	270 (2)	Part of Active Alluvial Fan
9	56.4	10	10320 (1)	Active Alluvial Fan
10	1.7	10	400 (2)	Part of Active Alluvial Fan
11	8.4	10	1480 (1)	
12	9.4	10	2090 (1)	
13	2.1	9	620 (2)	
13A	8.7	9	3130 (1)	
14	1.0	9	380 (2)	
15	5.5	9	1740 (1)	
16	3.9	9	1950 (2)	
17	6.6	9	2620 (1)	
18	1.5	9	720 (2)	
19	2.2	9	1400 (2)	
20	2.4	9	1880 (2)	
BASIN 170				
1	2.9	9	1570 (2)	
2	3.2	9	1770 (2)	
3	9.9	9	5210 (1)	Davis Creek

(1) DISCHARGE ESTIMATED USING CORPS OF ENGINEERS HYDROLOGIC PACKAGE HEC-1.
(2) DISCHARGE ESTIMATED USING REGRESSION EQUATION GENERATED FROM SIMILAR WATERSHEDS IN SOUTHERN NEVADA.
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YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

TABLE 4.1
SUMMARY OF DISCHARGES

CONC. POINT	AREA (SQ. MI)	SHEET NUMBER	DISCHARGE (CFS)	COMMENTS:
BASIN 170				
4	2.9	9	1440 (2)	
5	2.6	9	1710 (2)	
6	1.2	9	880 (2)	
7	6.7	9	3140 (1)	
8	1.4	9	1000 (2)	
9	26.1	9	10840 (1)	Quinn Canyon
10	4.6	9	2330 (2)	
11	4.2	9	2420 (2)	
12	3.9	9	1740 (2)	
13	1.7	9	880 (2)	
14	2.3	9	1530 (2)	
15	1.2	9	780 (2)	
16	2.3	9	1350 (2)	
17	1.4	9	1170 (2)	
18	1.5	9	850 (2)	
19A	1.7	9	710 (2)	
19B	1.7	9	690 (2)	
20	4.3	9	840 (2)	
21	1.7	9	340 (2)	
22	36.0	9	4440 (1)	
23	23.8	9	3740 (1)	
24	162.0	9	13940 (1)	

(1) DISCHARGE ESTIMATED USING CORPS OF ENGINEERS HYDROLOGIC PACKAGE HEC-1.
(2) DISCHARGE ESTIMATED USING REGRESSION EQUATION GENERATED FROM SIMILAR WATERSHEDS IN SOUTHERN NEVADA.
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YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

TABLE 4.1
SUMMARY OF DISCHARGES

CONC. POINT	AREA (SQ. MI)	SHEET NUMBER	DISCHARGE (CFS)	COMMENTS:
BASIN 170				
25	19.5	9	6520 (1)	
26	1.8	9	1510 (2)	
27	2.7	9	2200 (2)	
BASIN 171				
1	1.5	11	1100 (2)	
2	1.5	11	1080 (2)	
3	4.6	11	2660 (2)	
4	7.3	11	3960 (1)	
5	1.5	11	670 (2)	
6	1.2	11	630 (2)	
7	1.5	11	760 (2)	
8	1.3	11	580 (2)	
9	2.3	11	890 (2)	
10	5.6	11	1570 (1)	
11	42.7	11	5980 (1)	
12	1.0	11	1000 (2)	
BASIN 172				
1	157.9	11	16520 (1)	
2	1.2	11	290 (2)	
3	3.2	11	660 (2)	
4	1.8	11	400 (2)	
5	27.7	11	6700 (1)	Active Alluvial Fan

(1) DISCHARGE ESTIMATED USING CORPS OF ENGINEERS HYDROLOGIC PACKAGE HEC-1.
(2) DISCHARGE ESTIMATED USING REGRESSION EQUATION GENERATED FROM SIMILAR WATERSHEDS IN SOUTHERN NEVADA.
(3) FEDERAL EMERGENCY MANAGEMENT AGENCY - LINCOLN CO. F.I.S.

YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

TABLE 4.1
SUMMARY OF DISCHARGES

CONC. POINT	AREA (SQ. MI)	SHEET NUMBER	DISCHARGE (CFS)	COMMENTS:
BASIN 172				
6	27.2	11	6370 (1)	Sand Creek
7	1.5	11	310 (2)	Part of Active Alluvial Fan
8	20.5	11	5740 (1)	Active Alluvial Fan
9	8.5	11	2410 (1)	Part of Active Alluvial Fan
10	5.8	11	1270 (2)	Part of Active Alluvial Fan
11	26.7	11	6430 (1)	Active Alluvial Fan
12	1.5	9	360 (2)	Part of Active Alluvial Fan
13	17.5	9	5010 (1)	
14	7.7	9	2810 (1)	
15	2.4	9	1270 (2)	
BASIN 173A				
1	2.0	9	970 (2)	
2	4.0	9	1790 (2)	
3	1.9	9	1380 (2)	
4	6.7	9	2880 (1)	
4A	3.0	9	1330 (2)	
8	41.6	6	6660 (1)	
9	129.4	6	15490 (1)	
9A	72.3	6	12100 (1)	
18	5.8	6	2040 (1)	
18A	3.5	6	1470 (2)	
19	1.1	6	410 (2)	

(1) DISCHARGE ESTIMATED USING CORPS OF ENGINEERS HYDROLOGIC PACKAGE HEC-1.
(2) DISCHARGE ESTIMATED USING REGRESSION EQUATION GENERATED FROM SIMILAR WATERSHEDS IN SOUTHERN NEVADA.
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YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

TABLE 4.1
SUMMARY OF DISCHARGES

CONC. POINT	AREA (SQ. MI)	SHEET NUMBER	DISCHARGE (CFS)	COMMENTS:
BASIN 173A				
20	1.2	6	480 (2)	
21	1.9	6	780 (2)	
22	3.9	6	1950 (2)	
23	7.0	6	2200 (1)	
24	4.0	6	1390 (2)	
25	3.9	6	1760 (2)	
26	7.7	6	2710 (1)	
27	4.5	6	2490 (2)	
28	12.5	6	4140 (1)	
29	6.5	6	2320 (1)	
30	6.4	6	2660 (1)	
31	6.8	6	2670 (1)	
32	21.9	6	5470 (1)	
33	7.6	6	2800 (1)	
34	17.5	6	5520 (1)	
35	2.5	6	900 (2)	
36	1.5	6	900 (2)	
37	3.3	6	1570 (2)	
38	13.9	6	2410 (1)	
39	1.7	6	390 (2)	
40	3.1	6	1310 (2)	
41	2.1	6	1080 (2)	

(1) DISCHARGE ESTIMATED USING CORPS OF ENGINEERS HYDROLOGIC PACKAGE HEC-1.
(2) DISCHARGE ESTIMATED USING REGRESSION EQUATION GENERATED FROM SIMILAR WATERSHEDS IN SOUTHERN NEVADA.
(3) FEDERAL EMERGENCY MANAGEMENT AGENCY - LINCOLN CO. F.I.S.

YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

TABLE 4.1
SUMMARY OF DISCHARGES

CONC. POINT	AREA (SQ. MI)	SHEET NUMBER	DISCHARGE (CFS)	COMMENTS:
BASIN 181				
1	4.6	13	2200 (2)	
2	2.7	13	1720 (2)	
3	8.6	13	4420 (1)	
4	9.5	13	4720 (1)	Black Canyon
5	5.5	13	2750 (1)	
6	0.9	13	340 (2)	
7	7.0	13	2380 (1)	
8	99.1	13	8850 (1)	
9	324.7	13	16650 (1)	
10	107.2	13	6730 (1)	
11	4.2	13	1490 (2)	
12	3.1	13	1220 (2)	
13	11.2	13	3890 (1)	
14	10.1	13	4070 (1)	
15	1.0	13	900 (2)	
16	3.2	13	1710 (2)	
17	2.0	13	1690 (2)	
18	4.1	13	1970 (2)	
19	4.4	13	2280 (2)	
20	1.5	13	1230 (2)	
21	2.1	13	1470 (2)	
22	1.8	13	1030 (2)	

(1) DISCHARGE ESTIMATED USING CORPS OF ENGINEERS HYDROLOGIC PACKAGE HEC-1.
(2) DISCHARGE ESTIMATED USING REGRESSION EQUATION GENERATED FROM SIMILAR WATERSHEDS IN SOUTHERN NEVADA.
(3) FEDERAL EMERGENCY MANAGEMENT AGENCY - LINCOLN CO. F.I.S.

YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

TABLE 4.1
SUMMARY OF DISCHARGES

CONC. POINT	AREA (SQ. MI)	SHEET NUMBER	DISCHARGE (CFS)	COMMENTS:
BASIN 181				
23	6.3	13	2210 (1)	
24	7.3	13	3500 (1)	
25	1.2	13	780 (2)	
26	1.0	13	710 (2)	
27	7.5	13	4060 (1)	
28	1.5	13	1290 (2)	
29	9.0	13	4330 (1)	
30	0.8	13	350 (2)	
31	1.3	13	590 (2)	
32	12.2	13	1420 (1)	
33	12.9	13	2380 (1)	
34	4.8	13	1510 (1)	
35	50.0	13	14120 (1)	
BASIN 182				
1	1.3	13	480 (2)	
2	3.1	13	970 (2)	
3	2.0	13	1010 (2)	
4	5.1	13	2350 (2)	
5	1.4	13	310 (2)	
BASIN 197				
1	0.8	13	640 (2)	
2	1.3	13	650 (2)	

(1) DISCHARGE ESTIMATED USING CORPS OF ENGINEERS HYDROLOGIC PACKAGE HEC-1.
(2) DISCHARGE ESTIMATED USING REGRESSION EQUATION GENERATED FROM SIMILAR WATERSHEDS IN SOUTHERN NEVADA.
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YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

TABLE 4.1
SUMMARY OF DISCHARGES

CONC. POINT	AREA (SQ. MI)	SHEET NUMBER	DISCHARGE (CFS)	COMMENTS:
BASIN 203				
2	1.0	13	960 (2)	
3	1.3	13	1140 (2)	
4	1.5	13	1150 (2)	
5	7.8	13	3930 (1)	
6	1.9	13	1110 (2)	
7	2.0	13	890 (2)	
7A	2.0	13	890 (2)	
7B	4.7	13	2020 (2)	
8	1.2	13	670 (2)	
9	2.4	13	530 (2)	
10	8.0	13	2490 (1)	
11	1.1	13	800 (2)	
12	3.0	13	1300 (2)	
13	969.0	13	10800 (3)	Meadow Valley Wash
14	72.8	13	14040 (1)	
16	10.3	13	3410 (1)	
17	8.9	13	3070 (1)	
17A	5.0	13	2190 (1)	
18	1.6	13	1240 (2)	
BASIN 208				
2	1.8	13	1220 (2)	
3	2.0	13	1210 (2)	

(1) DISCHARGE ESTIMATED USING CORPS OF ENGINEERS HYDROLOGIC PACKAGE HEC-1.
(2) DISCHARGE ESTIMATED USING REGRESSION EQUATION GENERATED FROM SIMILAR WATERSHEDS IN SOUTHERN NEVADA.
(3) FEDERAL EMERGENCY MANAGEMENT AGENCY - LINCOLN CO. F.I.S.

YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

TABLE 4.1
SUMMARY OF DISCHARGES

CONC. POINT	AREA (SQ. MI)	SHEET NUMBER	DISCHARGE (CFS)	COMMENTS:
BASIN 208				
4	0.9	13	720 (2)	
5	0.9	12	670 (2)	
6	1.0	12	820 (2)	
7	1800.0	12	9500 (3)	White R. Est. from FEMA data
8	0.9	12	760 (2)	
9	1.9	12	1440 (2)	
10	0.8	12	870 (2)	
11	2.5	12	1800 (2)	
12	5.6	11	2960 (2)	
13	3.7	11	2220 (2)	
14	1.2	11	1100 (2)	
15	1.5	11	1540 (2)	
16	1.9	11	2030 (2)	
BASIN 209				
1	1.4	9	1020 (2)	
1A	1.8	9	1170 (2)	
2	2.4	9	1320 (2)	
2A	3.3	9	2590 (2)	
3	1.7	9	850 (2)	
4	4.2	9	1680 (2)	
5	2.0	9	1360 (2)	
6	5.7	9	2480 (1)	

(1) DISCHARGE ESTIMATED USING CORPS OF ENGINEERS HYDROLOGIC PACKAGE HEC-1.
(2) DISCHARGE ESTIMATED USING REGRESSION EQUATION GENERATED FROM SIMILAR WATERSHEDS IN SOUTHERN NEVADA.
(3) FEDERAL EMERGENCY MANAGEMENT AGENCY - LINCOLN CO. F.I.S.

YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

TABLE 4.1
SUMMARY OF DISCHARGES

CONC. POINT	AREA (SQ. MI)	SHEET NUMBER	DISCHARGE (CFS)	COMMENTS:
BASIN 209				
7	3.0	9	1130 (2)	
8	97.4	9	12080 (1)	
9	132.1	9	15150 (1)	Crystal Wash
12	1.5	9	530 (2)	
13	1.0	9	410 (2)	
14	13.6	10	5820 (1)	
17	2.3	10	1370 (2)	
18	2.3	10	1560 (2)	
19	2.8	10	1970 (2)	
20	1.4	9	1270 (2)	
21	5.1	9	2780 (2)	
22	5.1	9	2680 (2)	
23	3.6	9	2110 (2)	
24	18.5	9	8150 (1)	
25	12.1	9	5020 (1)	
26	1.4	9	620 (2)	
27	2.5	9	1820 (2)	
28	1.8	9	1620 (2)	
29	2160.0	9	10000 (3)	White R. Est. from FEMA data
30	2.8	9	1710 (2)	
31	1.7	9	1090 (2)	
32	1.8	9	1040 (2)	

(1) DISCHARGE ESTIMATED USING CORPS OF ENGINEERS HYDROLOGIC PACKAGE HEC-1.
(2) DISCHARGE ESTIMATED USING REGRESSION EQUATION GENERATED FROM SIMILAR WATERSHEDS IN SOUTHERN NEVADA.
(3) FEDERAL EMERGENCY MANAGEMENT AGENCY - LINCOLN CO. F.I.S.

YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

TABLE 4.1
SUMMARY OF DISCHARGES

CONC. POINT	AREA (SQ. MI)	SHEET NUMBER	DISCHARGE (CFS)	COMMENTS:
BASIN 209				
33	58.2	9	9240 (1)	
34	2250.0	9	10000 (3)	White R. Est from FEMA data
BASIN 227A				
1	4.2	2	2340 (2)	
2	8.1	2	3390 (1)	
3	6.6	2	3180 (1)	
4	1.0	2	870 (2)	
5	2.1	2	1270 (2)	
6	2.3	2	1280 (2)	
7	3.1	2	1650 (2)	
8	3.6	2	1710 (2)	
9	12.5	2	3960 (1)	
10	19.5	2	3790 (1)	
BASIN 228				
1	77.4	2	15830 (1)	Beatty Wash
2	1.4	2	710 (2)	
3	1.6	3	660 (2)	
4	14.0	3	3860 (1)	
5	240.7	3	29190 (1)	Thirsty Canyon
6	9.5	3	3050 (1)	
BASIN 229				
1	19.8	2	3000 (1)	

(1) DISCHARGE ESTIMATED USING CORPS OF ENGINEERS HYDROLOGIC PACKAGE HEC-1.
(2) DISCHARGE ESTIMATED USING REGRESSION EQUATION GENERATED FROM SIMILAR WATERSHEDS IN SOUTHERN NEVADA.
(3) FEDERAL EMERGENCY MANAGEMENT AGENCY - LINCOLN CO. F.I.S.

YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

TABLE 4.1
SUMMARY OF DISCHARGES

CONC. POINT	AREA (SQ. MI)	SHEET NUMBER	DISCHARGE (CFS)	COMMENTS:
BASIN 229				
2	1.7	2	660 (2)	
3	8.6	2	1900 (1)	
4	8.4	2	1810 (1)	
5	8.4	2	2100 (1)	
6	8.3	2	2250 (1)	
7	6.5	2	1850 (1)	Windy Wash
8	2.1	2	1120 (2)	
9	5.0	2	1460 (1)	
10	5.3	2	1160 (1)	
11	3.1	2	920 (2)	
12	1.2	2	580 (2)	
13	9.2	2	2140 (1)	
14	4.4	2	1800 (2)	
15	5.1	2	2240 (2)	
16	4.8	2	2180 (2)	
17	4.5	2	2140 (2)	
18	3.0	2	1680 (2)	
19	1.7	2	1100 (2)	
20	1.3	2	760 (2)	
21	2.0	2	1000 (2)	
22	1.8	2	1100 (2)	
23	5.0	2	1510 (1)	

(1) DISCHARGE ESTIMATED USING CORPS OF ENGINEERS HYDROLOGIC PACKAGE HEC-1.
(2) DISCHARGE ESTIMATED USING REGRESSION EQUATION GENERATED FROM SIMILAR WATERSHEDS IN SOUTHERN NEVADA.
(3) FEDERAL EMERGENCY MANAGEMENT AGENCY - LINCOLN CO. F.I.S.

The parameters that are measured or obtained from an acceptable reference, such as basin area and rainfall, can be extracted or measured with a high degree of certainty. The curve number and lag time parameters require judgement with regards to the site conditions that would affect the value of these parameters. The important assumptions and impact on the final parameters were found to be as follows:

1) Curve number is based upon soil type (hydrologic soil group), vegetation type and cover density. Using the hydrologic soil group, vegetation type and vegetative cover density, the curve number can be selected from the graphs and tables contained in the SCS references (Refs. 21 and 22).

   Vegetation type was determined from field inspection with one of three options available; pinion/juniper, desert brush and sagebrush with a grass understory. All three types are encountered in the study area. The pinion/juniper cover type is encountered at elevations above 5500 to 6000 feet with variable densities depending upon orientation of exposure, soils and other factors. This cover type is readily distinguishable in aerial photography. The sage cover type is encountered in the eastern and central portions of the study area. The desert shrub cover type is encountered in the southeastern and western portions of the study area.

   Soil type was determined from soil surveys where available. Where soil surveys were not available, hydrologic soil groups were selected based upon comparison with the soils mapped in the adjoining surveys. The most difficult hydrologic soil groups to distinguish without extensive field surveys, are the hydrologic soil group B and C boundaries. When areas were encountered that were difficult to distinguish, the more conservative soil group was used.

   Utilizing the assumption that the graphs and tables in the SCS references are accurate. Table 4.2 summarizes the range of possible values and degree of certainty with the selection of the critical variables needed to use the SCS graphs and tables, to select curve number with the limitations described above. Table 4.2 indicates that the largest difference is in the selection of the curve number for B soils when the vegetation type might fit either the desert brush or sage category. However, the amount of B soils in a single basin is generally very low. The difference in curve number would be more dependent upon the dominate soil (C or D in most cases). The results indicated on Table 4.2 suggest that the curve number selected should be within 3% of the value selected by another engineer of hydrologist. Only a small portion of the study are would be subject to this uncertainty since the vegetation type was relatively easy to distinguish. In the central area where small bud sagebrush is encountered, an engineer may be

inclined to use the sagebrush/grass curve numbers. However, this small bud sagebrush has such a sparse canopy, it would have the interception characteristics of the desert shrub type of vegetation.

TABLE 4.2

ACCURACY OF CURVE NUMBER VARIABLES

Factor	Range of Possible Values	Resulting Change in Curve Number	Percentage Change in Curve Number
Selection of Vegetation Type For B Soil	67 to 77	+- 5	+- 7%
Selection of Vegetation Type For C Soil	80 to 85	+- 2.5	+- 3%
Selection of Vegetation Type For D Soil	85 to 88	+- 1.5	+- 2%
Selection of Vegetation Cover Density	10 to 20%	+- 1	+- 1%
Selection of Soil Type for Uncertain Areas	20 to 40% of WS	+- 3	+- 3%

2) Lag time is a function of stream channel geometry, channel roughness, discharge rate and slope for each segment of the primary watercourse. Channel slope can be measured from the topographic maps. Channel geometry and roughness was approximated from stereo photographs, orthophotos and field investigation. The channels were approximated with triangular, trapezoidal and rectangular channel geometries. The hydrologic analysis for final design may require a more detailed verification of channel geometry and roughness.

Table 4.3 summarizes the range of possible values and degree of certainty with the estimation of the parameters used in computation of lag time based upon the limitations and assumptions described above. Using the velocity method, the results are most sensitive to Manning's roughness value. The error value of +-12% is based upon an upward or downward adjustment of roughness values for each segment. Actually the estimates will be high in some segments and low in

others and would tend to balance each other rather than the cumulative error indicated in Table 4.3. The actual error associated with the estimate of this parameter is probably closer to +- 3% to 6%.

TABLE 4.3

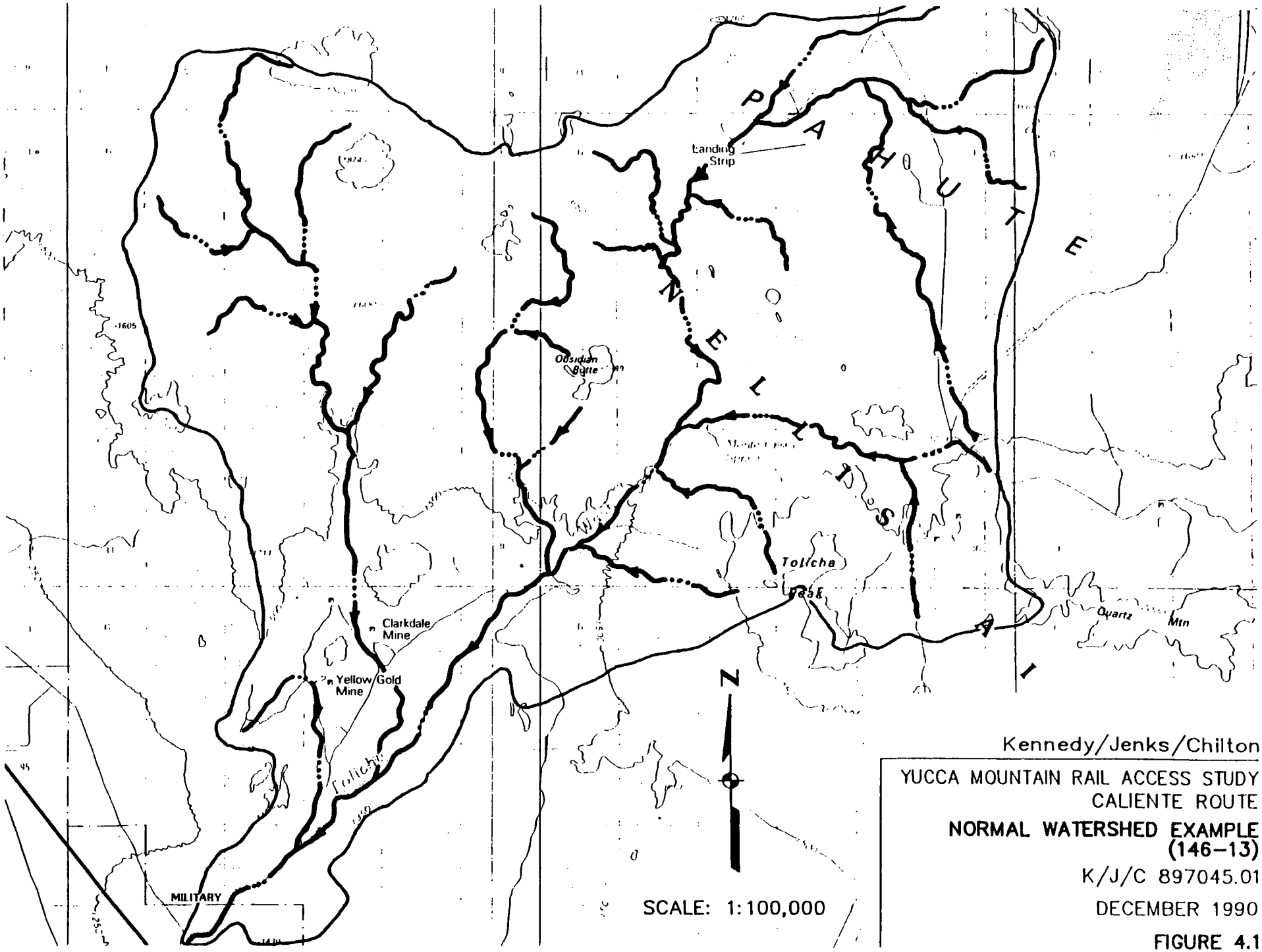
ACCURACY OF LAG TIME VARIABLES

Factor	Range of Possible Error	Percentage Change in Lag Time
Selection of Roughness Values	.005 to .015	+- 12%
Selection of Discharge for Reach Segment	5 to 20%	+- 4%
Variation in Channel Geometry	N/A	+- 5%

As indicated in Chapter 3, two basic type of watersheds are encountered in the study area which are reflected in the lag time parameter. The first type of watershed is the "normal" watershed. This watershed has a dendritic drainage pattern which is a drainage pattern with a tree-like structure. This structure usually has a single primary drainage channel with many branches and sub-branches radiating from the primary channel. The primary channel is often well defined. Figure 4.1 is a watershed map for Tolicha Wash (the watershed contributing to point #146-13) with the channel network highlighted. This watershed provides an example of a typical "normal" watershed.

The second basic type of watershed encountered in the study area is the "alluvial" watershed type. This type of watershed is characterized by multiple primary channels flowing parallel to one another only to combine near the watershed outlet. The channels are often wide and shallow or braided. Figure 4.2 is a typical example of this type of watershed (example is the watershed contributing to point #170-22).

The difference between these types of watersheds are exhibited in the lag time estimate. The normal watershed has a network that results in all of the flow from the watershed entering the primary channel at points along its entire length. The higher discharge in the primary channel combined with the well defined primary channel, results in relatively high flow velocities and relatively short watershed travel time estimates. The alluvial type watershed with its multiple primary channels and wider and shallower channel flow depths, have relatively low flow velocities and relatively longer watershed travel time estimates. The lower channel velocities in the alluvial watersheds are also influenced by the fact that these primary channels have smaller contributing areas to each of the primary channels which results in lower channel discharges in combination with the shallower flow.



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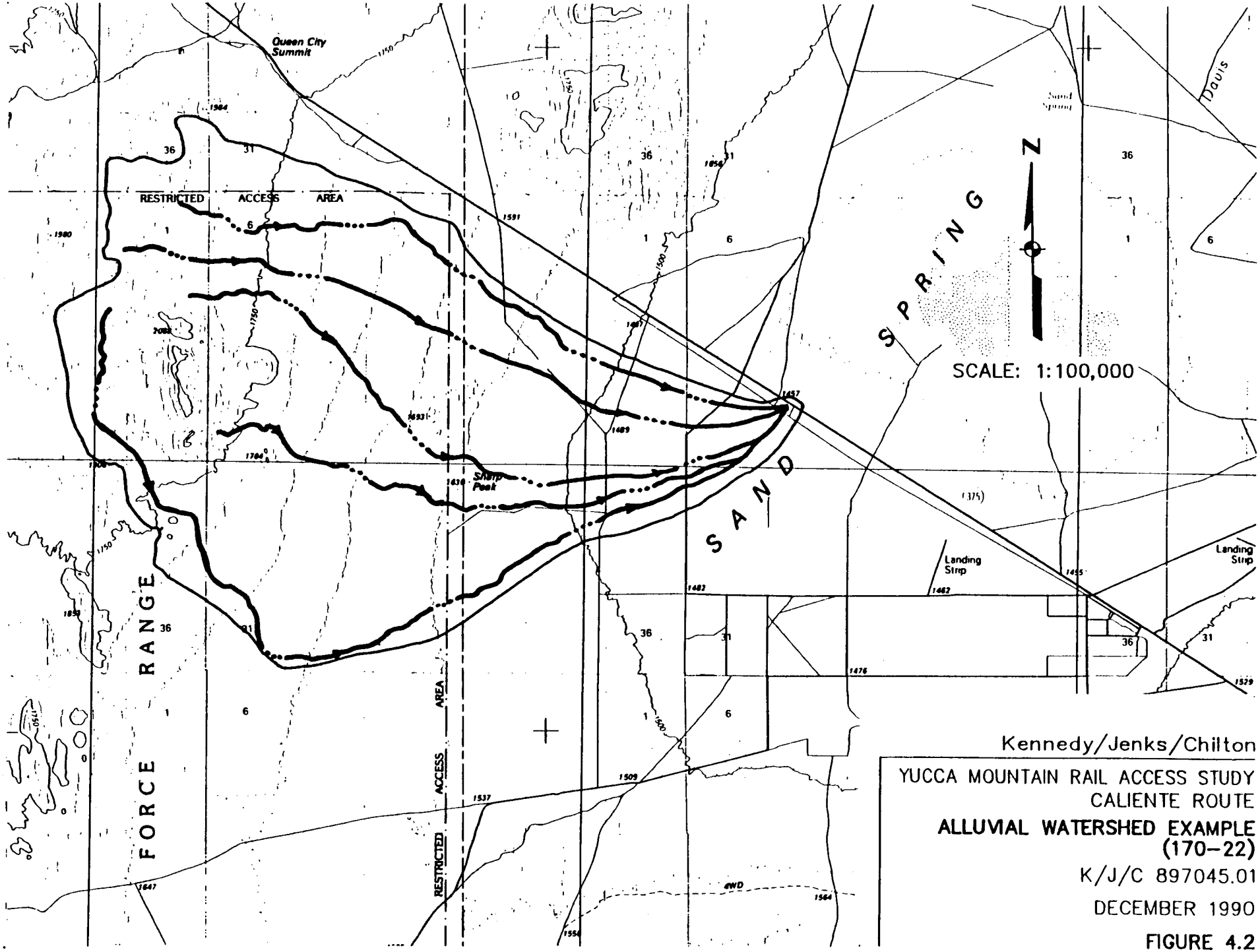
YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE

NORMAL WATERSHED EXAMPLE (146-13)

K/J/C 897045.01

DECEMBER 1990

FIGURE 4.1



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YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE

ALLUVIAL WATERSHED EXAMPLE (170–22)

K/J/C 897045.01

DECEMBER 1990

FIGURE 4.2

Using the average velocities computed for each of the watersheds included in this study, Figure 4.3 shows the range results obtained. This range in due to the variability in the watershed conditions encountered in the study area. Alluvial watersheds exhibit a very low velocity/slope relationship when compared to the normal watershed type. There are also many watershed which have the dendritic drainage pattern but have wide shallow alluvial channels in the lower reaches. Other watersheds (such as many of the watersheds in Basin 173) have well defined channels in older alluvial fan surfaces that have become incised in the fan surface. This high degree in condition variability results in a high degree of variability in the velocity/slope relationship as exhibited in Figure 4.3. Such differences in watershed conditions make regional methods of analysis undependable for accurate peak discharge estimations.

Results of Sensitivity Analysis

Using the range of input parameters identified in the sensitivity analysis, five watersheds between 5 and 24 square miles in size were selected for testing the impact this range of input values would have on the final results. Table 4.4 presents the results of this analysis.

TABLE 4.4

RESULTS OF SENSITIVITY ANALYSIS

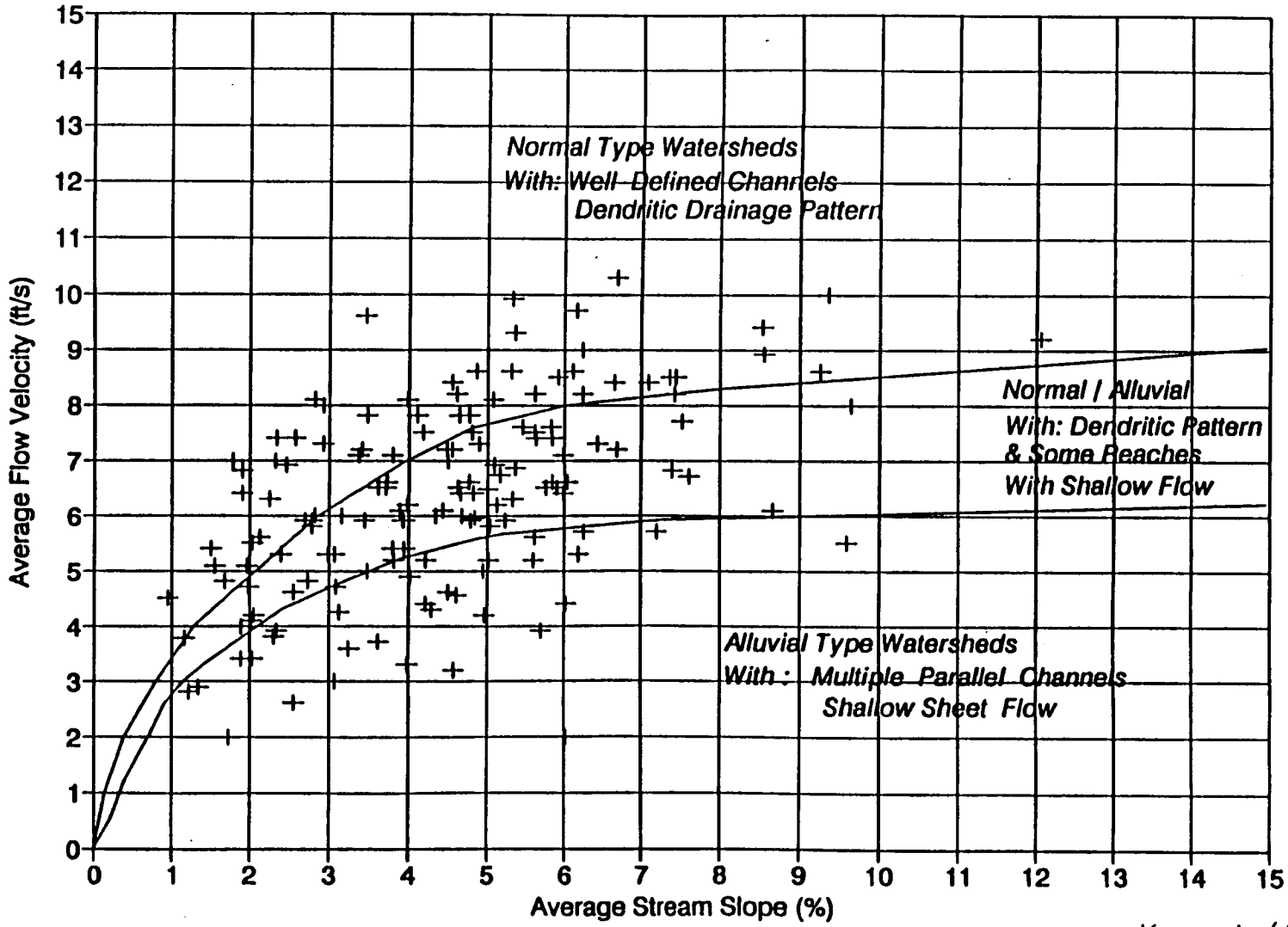
Curve Number Change

% Change in Parameter	% Change in Q
- 5%	-25% to -30%
- 2%	- 9% to -11%
+ 2%	+ 8% to +10%
+ 5%	+18% to +22%

Lag Time Change

% Change in Parameter	% Change in Q
-10%	+ 6% to + 7%
- 5%	+ 3% to + 4%
- 2%	+ 1% to + 2%
+ 2%	- 1% to - 2%
+ 5%	- 3% to - 4%
+10%	- 7% to - 8%

Based upon the results of the sensitivity analysis, it appears that the results of this study should be within +- 10% to 15% of the results that would be obtained by other engineers/hydrologists using the same basic



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Yucca Mountain Rail Access Study
Caliente Route
Comparison of Slope and Velocity For Study Watersheds
K/J/C 897045.01
December 1990

Figure 4.3

methods of analysis. As indicated earlier, the results presented in this report are intended for a planning level study and should not be used for final design of the railway. Final design hydrology should refine the uncertain parameters, utilize HEC-1 or another acceptable method of analysis on the smaller basins and refine the data for areas with other unusual conditions.

An example of an area with unusual conditions is the watershed contributing to point #144-5. The discharge at this location is reduced significantly by storage that occurs in the playa upstream of this point. The amount of attenuation that occurs in the playa is a function of storage and outflow characteristics. For the purpose of this study, the 7.5 minute USGS topography was used to determine the storage characteristics. The storage and outflow characteristics will need to be refined during the preparation of final design hydrology.

Comparison of Results With Other Studies

The results obtained using HEC-1 were compared with the results for similar watersheds in other parts of southern Nevada. The results obtained from the analysis were also compared with the results obtained by the Corps of Engineers using statistical analysis of gage data for watersheds in the Southwest. The Corps of Engineers used the data from this statistical analysis to develop a regional relationship between discharge per unit area (cfs/mi^2) and area (mi^2). Figure 4.5 (at the end of this chapter) is a plot of the results of this study compared with the curve developed by the Corps of Engineers and the results of other studies. As can be seen from the plotted results, the values obtained from this study compare well with the results from other studies. It should also be noted, that there is considerable variability in the results due to the variability in watershed conditions within the study area as indicated above in the discussion of lag time estimates.

REGIONAL REGRESSION ANALYSIS

As described in Chapter 3, the regional regression analysis was conducted using the Corps of Engineers Multiple Linear Regression program MLRP. The results from the HEC-1 analysis were sorted into the two watershed categories described above; alluvial watersheds (watersheds with a poorly defined primary channel or several parallel primary channels with long and narrow contributing drainage areas) and normal watersheds (which exhibited a normal dendritic drainage pattern with a well defined primary channel).

The analysis was first performed using the entire data set for each watershed type. The results from the first analysis were reviewed and the outliers with extremely high percentage differences between the actual and predicted values were removed, starting with the negative outliers. The final results were based upon the analysis with the extreme outliers removed.

Alluvial watersheds

The alluvial watersheds have abnormally long lag times resulting from low average channel velocities. These low velocities are due to either; significant portions of the channel which are subject to shallow sheet flow or watershed drainage patterns that result in many parallel channels with narrow contributing drainage areas. The longer lag time in these watersheds results in lower peak discharges than "normal" watersheds.

The easily identifiable watershed characteristics that were found to be most statistically significant are; watershed area, 100-year, 6 hour precipitation depth, average slope of the longest watercourse and length of the longest watercourse. Addition of the fourth independent variable (length) was not found to produce significantly better results.

The analysis was conducted using both linear and non-linear relationships. The results of the analysis are presented in Table 4.5.

Normal watersheds

Normal watersheds are drainage basins with a typical dendritic drainage pattern with a well defined main branch channel. This pattern results in higher average channel velocities than the alluvial type of watershed. The higher average velocities result in shorter lag times and higher peak discharges.

The easily identifiable watershed characteristics that were found to be most statistically significant are; watershed area, 100-year, 6 hour precipitation depth, average slope of the longest watercourse and length of the longest watercourse. Addition of the fourth independent variable (length) was not found to produce significantly better results.

The analysis was conducted using both linear and non-linear relationships. The results of the analysis are presented in Table 4.5.

TABLE 4.5

RESULTS OF MULTIPLE REGRESSION ANALYSIS

WATERSHED TYPE	# OF OBSERVATIONS	r^2	STANDARD ERROR (cfs)
Alluvial - Non Linear	31	0.9253	229
Alluvial - Linear	31	0.9133	246
Normal - Non Linear	67	0.9503	360
Normal - Linear	67	0.8711	579

As can be seen from the computed statistics, the non-linear regression analysis produced the best fit to the data set. The equations used to estimate the discharges for the watersheds in this study which are greater than one square mile and less than five square miles in size, were based upon the results of the non-linear analysis. These equations are as follows:

Alluvial watersheds: $Q = 75.556(A^{0.768})(S^{0.633})(P^{1.311})$

Normal watersheds: $Q = 224.916(A^{0.741})(S^{0.450})(P^{0.586})$

Where:

Q = 100-year peak discharge in cubic feet per second
A = watershed area in square miles
S = average slope of the longest watercourse (%)
P = 100-year, 6 hour precipitation depth in inches

HYDROLOGIC ANALYSIS OF SMALL BASINS

The peak discharge values for the small basins were estimated using the regional regression equations described above. The equations developed relate peak discharge to watershed area, average watershed slope and 100-year, 6 hour precipitation depth. Watershed areas were measured from the USGS 7.5 minute topographic quadrangle maps using a digital planimeter. The watershed length and elevation data for use in computing average watershed slope were also derived from the 7.5 minute USGS topographic maps. Precipitation depth was estimated using NOAA Atlas 2. The map contained in NOAA Atlas 2 for 100-year, 6 hour precipitation depth, has been digitized and reproduced at a more convenient scale of 1:500,000. This map is included as Figure 4.4.

The data used in calculation of the discharges for the small basins has been included in Appendix A of this volume of the report in tabular format.

CLOSED BASIN LAKE ANALYSIS

As described in Chapter 3, a series of analyses were performed to estimate the volume of runoff that would occur from the watershed which contributes to Mud Lake at the southern end of Basin 141, as the result of a 100-year, 10 day storm event.

An elevation for the initial lake level needed to be estimated. This estimate should be based upon potential carry over storage from the previous year and runoff events that may have proceeded the 10 day event being modeled. An initial lake level of 5185.0 was selected as a "worst case" initial lake level. The runoff volume from the 10 day event is added to this initial storage volume (8100 acre feet) to get the peak storage volume and corresponding peak lake elevation.

The results of these analyses are summarized in Table 4.6.

TABLE 4.6

RESULTS OF RUNOFF VOLUME ANALYSES FOR MUD LAKE

Curve Number	Constant Loss Rate	Predicted Peak Storage Volume (acre feet)	Predicted Lake Level (ft abv MSL)
78	----	152,680	5195.1
80	----	181,350	5196.9
83	----	189,010	5197.4
--	0.05	119,870	5193.0
--	0.10	92,110	5191.2
--	0.15	79,120	5190.4

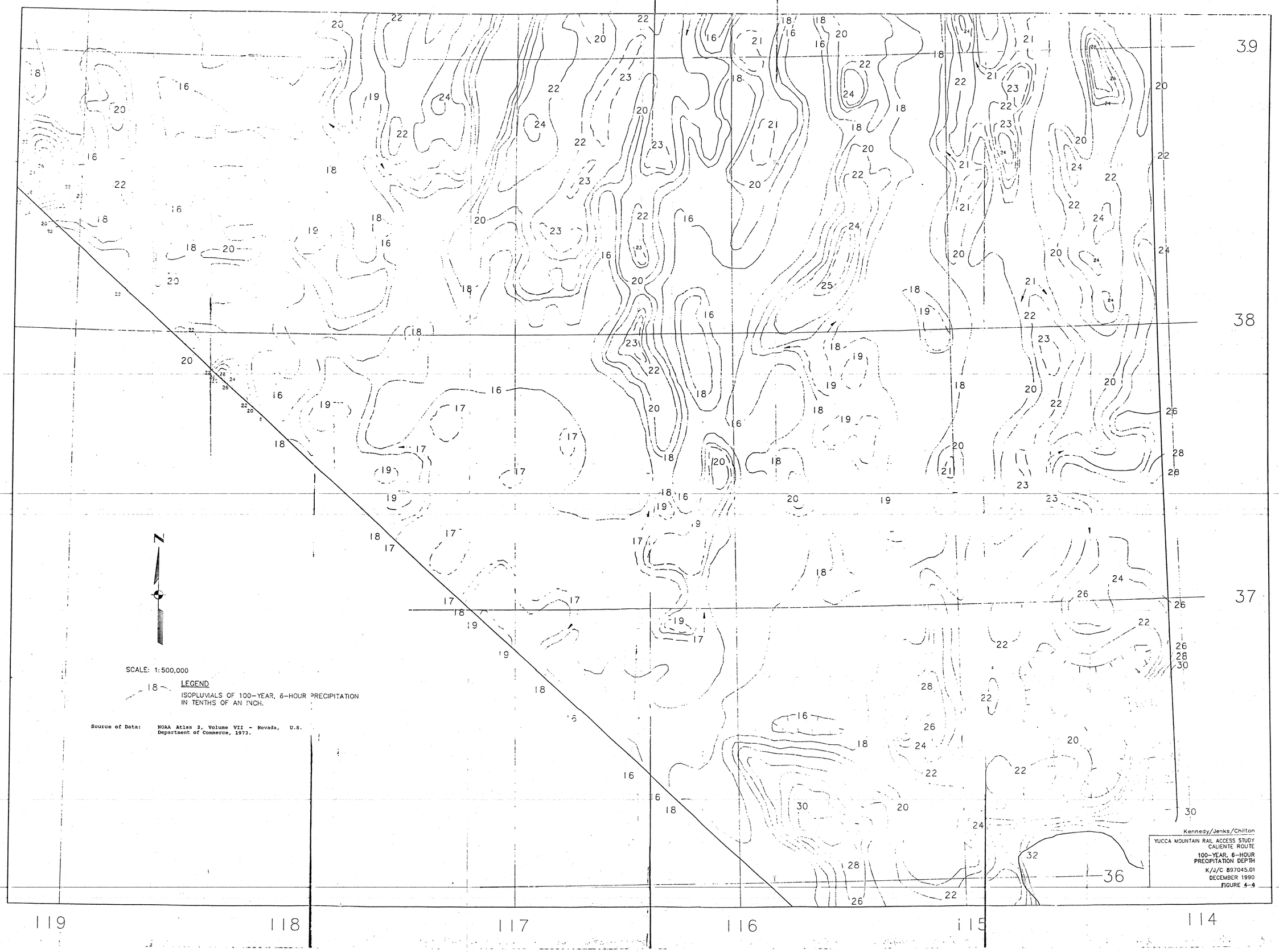
longer duration event is likely to saturate the watershed prior e occurrence of the peak rainfall period, the constant loss rate of as considered to be the most reasonable value for this analysis. ss rate results in a peak lake elevation of 5193. It is mended that a minimum peak lake level value of 5195 be used for the ses of this study. This lake level elevation does not appear to the proposed railway alignment.

DISCHARGES REPORTED BY FEMA

.1 includes the discharges reported by FEMA for White River 208 and 209) and Meadow Valley Wash (Basin 203). The FEMA arges were used to develop the floodplain and floodway maps which produced in Chapter 2. These values are the minimum regulatory ges which must be used for floodplain management purposes.

EMA discharge per unit area values for these watercourses are ely low in comparison to the Corps' adopted curve (Figure 4.5). the Corps' adopted curve, the White River 100-year peak discharge be approximately 15,000 to 16,000 cfs in comparison to the 10,000 icated by FEMA. The Meadow Valley Wash discharge per unit area s also below the Corps' curve. Utilizing the Corps' curve, the arge estimate for point 203-13 would be approximately 15,000 cfs in son to the 10,800 cfs value published by FEMA.

EMA estimate is the minimum value to be used for design and ification of the impacts on the floodplain caused by the project. purpose of this project the higher estimate may be the desirable discharge.


39
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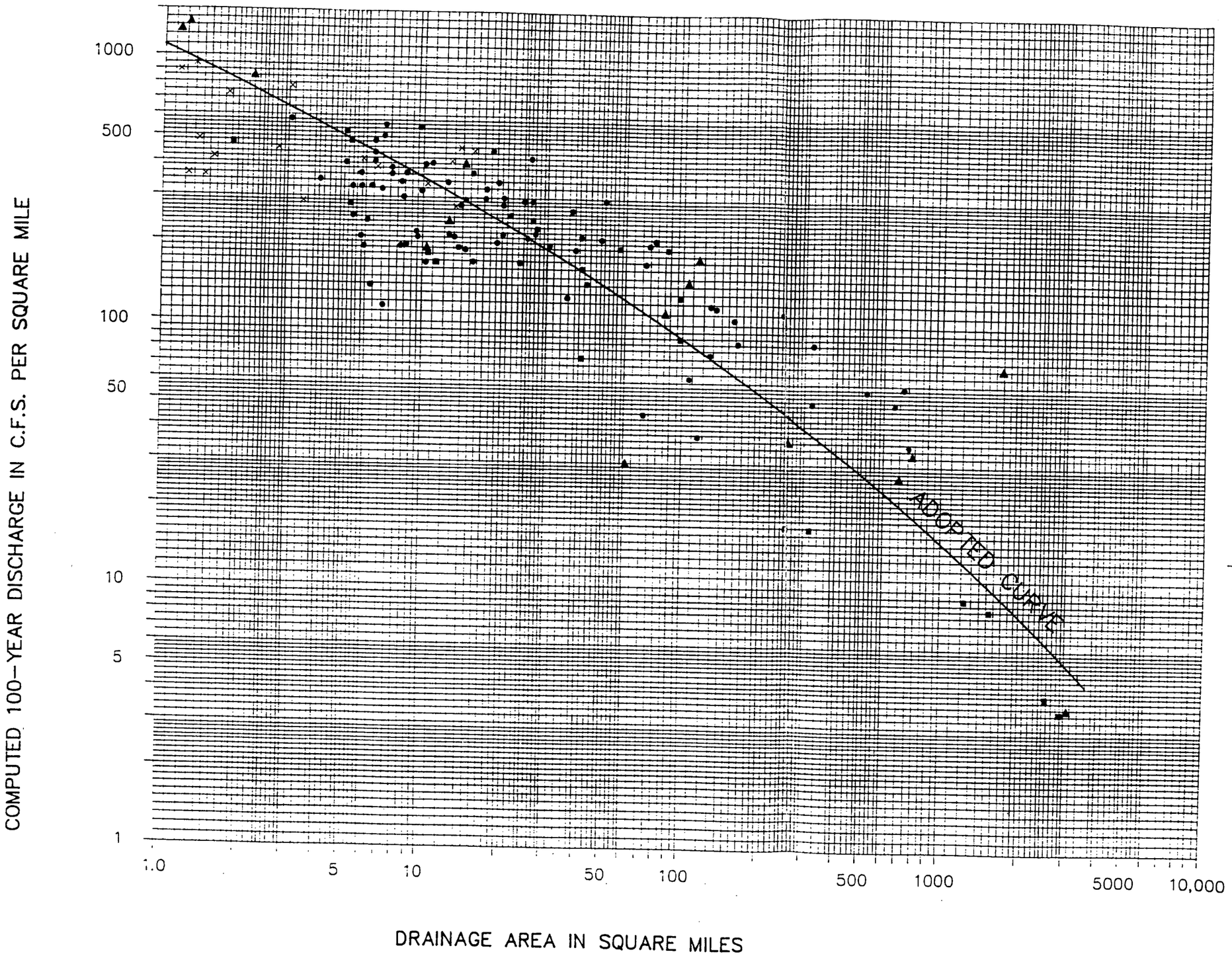
SCALE: 1:500,000
LEGEND
18
ISOPLUVIALS OF 100-YEAR, 6-HOUR PRECIPITATION IN TENTHS OF AN INCH.
Source of Data: NOAA Atlas 2, Volume VII - Nevada, U.S. Department of Commerce, 1973.
Kennedy/Jenks/Chilton
YUCCA MOUNTAIN RAIL ACCESS STUDY
CALIENTE ROUTE
100-YEAR, 6-HOUR PRECIPITATION DEPTH
K/J/C 897045.01
DECEMBER 1990
FIGURE 4-4



LEGEND

- • YUCCA MOUNTAIN RAIL ACCESS STUDY
- ▪ LINCOLN CO. FLOOD INSURANCE STUDY
- × LAS VEGAS BELTWAY STUDY
- ▲ VALUES USED BY C.O.E. IN DEVELOPMENT OF CURVE

Kennedy/Jenks/Chilton

Yucca Mountain Rail Access Study
Caliente Route

C.O.E. 100 Yr. Peak Discharge Versus Drainage Area Curve

K/J/C 897045.01
October, 1990

Figure 4.5

APPENDIX A - BIBLIOGRAPHY

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APPENDIX B - SMALL WATERSHED DATA

YUCCA MOUNTIAN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

SUMMARY OF DATA FOR DRAINAGE AREAS:
1 mi^2 < AREA < 5 mi^2

CP	Watershed Area (mi^2)	Stream Length (ft)	Max El. (ft)	Min El. (ft)	Slope (%)	100-Yr 6- Hr Rainfall (in)	Approx. 100-Yr Peak Q (cfs)	Eqn Type
Basin 141								
3	1.60	6,375	5233	5205	0.44	1.55	284	N
4	3.63	30,800	6000	5205	2.58	1.55	659	A
6	1.84	19,282	6000	5275	3.76	1.55	828	N
7	1.59	18,000	5880	5295	3.25	1.55	699	N
8	1.37	8,500	5450	5265	2.18	1.56	523	N
9	1.54	10,388	5450	5210	2.31	1.57	587	N
10	2.15	18,652	6165	5280	4.74	1.59	1051	N
11	3.84	28,883	6175	5340	2.89	1.60	1295	N
12	1.48	13,615	5760	5480	2.06	1.60	548	N
BASIN 142								
2	2.08	26,200	5430	5060	1.41	1.58	301	A
3	2.28	28,900	5480	5050	1.49	1.58	333	A
6	1.57	26,000	5580	5005	2.21	1.59	324	A
7	1.17	16,800	5310	4995	1.88	1.58	231	A
9	2.35	37,400	6220	4965	3.36	1.61	585	A
10	3.85	40,000	6460	4950	3.78	1.61	921	A
11	4.36	46,800	7320	4930	5.11	1.61	1227	A
12	2.07	30,600	6200	4920	4.18	1.60	605	A
13	2.14	36,400	7388	4915	6.79	1.60	844	A
14	1.23	29,000	6340	4905	4.95	1.58	444	A
16	3.16	31,800	7216	4890	7.31	1.56	1678	N

YUCCA MOUNTIAN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

SUMMARY OF DATA FOR DRAINAGE AREAS:
1 mi^2 < AREA < 5 mi^2

CP	Watershed Area (mi^2)	Stream Length (ft)	Max El. (ft)	Min El. (ft)	Slope (%)	100-Yr 6- Hr Rainfall (in)	Approx. 100-Yr Peak Q (cfs)	Eqn Type
BASIN 142 cont.								
17	1.25	14,800	5640	4930	4.80	1.55	695	N
18	5.57	25,800	7300	5150	8.33	1.58	1970	A
19	1.35	25,600	7400	5300	8.20	1.60	668	A
20	3.35	27,000	8074	5440	9.76	1.63	1535	A
21	1.07	8,600	5610	5320	3.37	1.59	537	N
22	1.16	11,300	6060	5360	6.19	1.59	749	N
23	2.61	15,900	6820	5770	6.60	1.64	1432	N
BASIN 143								
1	2.16	21,000	8373	5880	11.87	1.65	1627	N
2	3.30	29,000	8100	5920	7.52	1.70	1845	N
3	3.71	16,600	6987	5880	6.67	1.69	1900	N
4	1.24	11,800	7400	5960	12.20	1.69	1107	N
BASIN 144								
2	3.20	29,000	7885	4660	11.12	1.70	1701	A
3	1.52	17,000	6200	4750	8.53	1.69	806	A
4	2.59	19,800	6200	4720	7.47	1.69	1116	A
6	1.64	10,800	5400	4755	5.97	1.67	980	N
7	2.14	15,400	5400	4795	3.93	1.67	989	N
9	1.37	16,400	5290	4675	3.75	1.68	698	N
10	1.35	11,800	5200	4680	4.41	1.68	743	N

YUCCA MOUNTIAN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

SUMMARY OF DATA FOR DRAINAGE AREAS:
1 mi^2 < AREA < 5 mi^2

CP	Watershed Area (mi^2)	Stream Length (ft)	Max El. (ft)	Min El. (ft)	Slope (%)	100-Yr 6- Hr Rainfall (in)	Approx. 100-Yr Peak Q (cfs)	Eqn Type
BASIN 144 cont.								
11	2.11	21,200	5320	4690	2.97	1.68	866	N
12	1.48	22,200	5600	4690	4.10	1.68	770	N
13	3.01	28,200	6300	4695	5.69	1.68	1046	A
14	1.65	26,200	6090	4700	5.31	1.68	630	A
15	3.55	30,400	6400	4710	5.56	1.68	1169	A
17	3.75	38,200	6700	4715	5.20	1.68	1169	A
18	0.99	18,000	5200	4715	2.69	1.68	277	A
19	1.07	13,400	4980	4715	1.98	1.68	436	N
21	1.44	9,800	5600	5315	2.91	1.68	388	A
23	2.41	29,000	5800	5225	1.98	1.69	456	A
29	1.40	18,000	8080	6080	11.11	1.69	1161	N
30	2.52	25,400	5640	4655	3.88	1.69	1118	N
32	1.75	13,200	4780	4615	1.25	1.69	512	N
BASIN 145								
1	2.26	15,300	6800	5460	8.76	1.66	1472	N
3	3.30	24,600	5680	5040	2.60	1.65	1124	N
BASIN 146								
1	1.65	18,400	4460	4025	2.36	1.69	653	N
2	3.60	21,800	4460	4020	2.02	1.69	1085	N
6	3.38	44,400	5280	3985	2.92	1.66	737	A

YUCCA MOUNTIAN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

SUMMARY OF DATA FOR DRAINAGE AREAS:
1 mi^2 < AREA < 5 mi^2

CP	Watershed Area (mi^2)	Stream Length (ft)	Max El. (ft)	Min El. (ft)	Slope (%)	100-Yr 6- Hr Rainfall (in)	Approx. 100-Yr Peak Q (cfs)	Eqn Type
BASIN 146 cont.								
7	3.10	29,600	4660	3985	2.28	1.67	595	A
9	2.42	37,200	5300	3995	3.51	1.67	646	A
10	2.26	37,800	5220	4005	3.21	1.65	571	A
11B	3.54	27,800	4680	4030	2.34	1.65	658	A
12	3.08	20,200	4380	4020	1.78	1.66	904	N
15	1.36	18,600	5540	3990	8.33	1.65	707	A
16	1.53	23,400	5740	3985	7.50	1.65	724	A
17	3.48	21,400	5700	3970	8.08	1.66	1437	A
18	1.70	24,000	5820	3975	7.69	1.67	810	A
19	2.53	27,200	5600	3985	5.94	1.67	933	A
20	2.46	28,400	5760	3990	6.23	1.67	941	A
21	1.43	26,800	5560	4020	5.75	1.67	590	A
23	4.37	33,400	5680	4065	4.84	1.67	1246	A
25	4.09	24,400	5020	4135	3.63	1.68	1547	N
BASIN 149								
1	1.06	13,380	7524	6240	9.60	2.00	976	N
2	0.92	15,000	7280	6240	6.93	2.00	761	N
3	2.14	17,200	7039	6160	5.11	2.00	1237	N
4	1.62	17,450	7360	6160	6.88	2.05	1167	N
5	1.33	18,020	7360	6160	6.66	2.05	994	N
6	2.41	23,350	7610	6000	6.90	2.01	1551	N

YUCCA MOUNTIAN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

SUMMARY OF DATA FOR DRAINAGE AREAS:
1 mi^2 < AREA < 5 mi^2

CP	Watershed Area (mi^2)	Stream Length (ft)	Max El. (ft)	Min El. (ft)	Slope (%)	100-Yr 6- Hr Rainfall (in)	Approx. 100-Yr Peak Q (cfs)	Eqn Type
BASIN 149 cont.								
7	1.73	9,760	6560	5960	6.15	1.79	1076	N
8	1.50	23,520	7340	5960	5.87	1.95	759	A
9	1.06	11,850	6200	5880	2.70	1.60	275	A
11	3.08	25,570	6840	5750	4.26	1.62	845	A
12	1.76	23,320	6720	5720	4.29	1.58	534	A
14	0.72	14,850	5980	5680	2.02	1.57	166	A
15	1.22	21,820	6240	5660	2.66	1.60	303	A
16	2.62	22,760	6000	5620	1.67	1.57	396	A
18	2.07	15,860	5940	5560	2.40	1.58	418	A
19	2.46	21,400	6400	5535	4.04	1.60	676	A
20	3.46	27,800	6640	5520	4.03	1.69	942	A
21	1.94	19,200	6200	5517	3.56	1.61	524	A
22	1.86	20,400	6360	5510	4.17	1.70	602	A
23	1.17	18,100	6100	5510	3.26	1.59	331	A
24	2.54	29,200	6630	5510	3.84	1.75	754	A
26	1.97	28,400	6280	5430	2.99	1.58	464	A
BASIN 156								
1	1.39	21,300	6680	6175	2.37	1.69	334	A
2	3.80	35,100	8000	6140	5.30	1.90	1405	A
3	2.02	23,600	7200	6130	4.53	1.80	730	A
4	1.64	26,600	7560	6100	5.49	1.88	743	A

YUCCA MOUNTIAN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

SUMMARY OF DATA FOR DRAINAGE AREAS:
1 mi^2 < AREA < 5 mi^2

CP	Watershed Area (mi^2)	Stream Length (ft)	Max El. (ft)	Min El. (ft)	Slope (%)	100-Yr 6- Hr Rainfall (in)	Approx. 100-Yr Peak Q (cfs)	Eqn Type
BASIN 156 cont.								
7	2.62	34,400	8400	6050	6.83	2.12	1432	A
9	0.75	15,700	6600	6030	3.63	1.75	286	A
10	1.58	28,200	8090	6030	7.30	1.89	871	A
11	3.79	28,840	8640	6020	9.08	1.98	2082	A
12	2.50	22,160	7620	6040	7.13	1.91	1238	A
14A	1.20	14,000	7920	6050	13.36	1.90	1205	N
14B	2.40	20,500	8530	6040	12.15	2.00	1990	N
15	1.57	14,800	7520	5920	10.81	1.81	1050	A
17	0.85	13,390	6600	5920	5.08	1.80	403	A
19	0.83	14,960	7782	5870	12.78	1.90	763	A
20	1.80	14,570	7522	5836	11.57	1.81	1218	A
21	0.93	12,200	7160	5800	11.15	1.80	711	A
22	1.47	15,510	7500	5800	10.96	1.89	1066	A
23	3.06	20,500	7320	5710	7.85	2.01	1963	N
24	1.30	12,000	6680	5690	8.25	1.85	1014	N
25	2.76	25,400	7727	5590	8.41	2.07	1908	N
26	1.86	12,830	6920	5560	10.60	1.91	1508	N
27	1.97	12,050	7240	5530	14.19	1.91	1794	N
29	3.14	20,000	7300	5560	8.70	1.91	2034	N
30	1.40	15,000	7290	5600	11.27	1.89	1248	N
31	0.92	11,000	7524	6240	11.67	1.95	946	N

YUCCA MOUNTIAN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

SUMMARY OF DATA FOR DRAINAGE AREAS:
1 mi^2 < AREA < 5 mi^2

CP	Watershed Area (mi^2)	Stream Length (ft)	Max El. (ft)	Min El. (ft)	Slope (%)	100-Yr 6- Hr Rainfall (in)	Approx. 100-Yr Peak Q (cfs)	Eqn Type
BASIN 169								
1	1.13	12,600	5610	4755	6.79	1.82	829	N
2	1.38	8,400	6235	4645	18.93	1.79	1510	N
3	1.02	11,600	5905	4610	11.16	1.79	952	N
4	1.21	14,000	6105	4560	11.04	1.78	1071	N
5	4.02	27,200	6620	4560	7.57	1.79	2209	N
6	1.15	15,800	5710	4530	7.47	1.78	865	N
8	1.07	16,000	4840	4510	2.06	1.77	266	A
10	1.72	24,800	5180	4635	2.20	1.78	402	A
13	2.13	25,200	5540	4700	3.33	1.78	616	A
14	0.99	14,400	5480	4920	3.89	1.78	377	A
16	3.86	30,200	6800	5020	5.89	1.85	1952	N
18	1.52	20,000	6440	5260	5.90	1.85	718	A
19	2.18	23,000	7840	5300	11.04	1.84	1400	A
20	2.37	13,600	7020	5320	12.50	1.80	1877	N
BASIN 170								
1	2.88	20,000	6640	5580	5.30	2.00	1568	N
2	3.23	21,500	6800	5560	5.77	2.00	1773	N
4	2.89	21,000	6440	5520	4.38	2.00	1442	N
5	2.62	17,000	6840	5520	7.76	1.95	1710	N
6	1.17	10,200	6226	5520	6.92	1.90	880	N
8	1.37	14,000	6540	5540	7.14	1.90	1003	N

YUCCA MOUNTIAN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

SUMMARY OF DATA FOR DRAINAGE AREAS:
1 mi^2 < AREA < 5 mi^2

CP	Watershed Area (mi^2)	Stream Length (ft)	Max El. (ft)	Min El. (ft)	Slope (%)	100-Yr 6- Hr Rainfall (in)	Approx. 100-Yr Peak Q (cfs)	Eqn Type
BASIN 170 cont.								
10	4.63	30,400	7400	5640	5.79	2.01	2326	N
11	4.15	23,600	7560	5620	8.22	1.89	2423	N
12	3.92	24,400	7600	5620	8.11	1.79	1742	A
13	1.73	24,000	7600	5680	8.00	1.72	875	A
14	2.29	21,600	7600	5680	8.89	1.72	1528	N
15	1.19	14,200	6569	5740	5.84	1.72	778	N
16	2.32	14,400	6680	5720	6.67	1.71	1351	N
17	1.44	10,800	6800	5640	10.74	1.70	1172	N
18	1.52	17,500	7090	5410	9.60	1.66	848	A
19A	1.66	21,800	6760	5240	6.97	1.60	706	A
19B	1.70	24,300	6760	5160	6.58	1.60	694	A
20	4.25	37,000	5920	4830	2.95	1.60	842	A
21	1.73	24,000	5280	4770	2.13	1.60	344	A
26	1.75	19,400	7820	5200	13.51	1.71	1506	N
27	2.71	17,500	7840	5300	14.51	1.78	2203	N
BASIN 171								
1	1.50	10,400	6700	5880	7.88	1.83	1097	N
2	1.52	12,000	6700	5800	7.50	1.83	1083	N
3	4.58	14,000	6960	5680	9.14	1.80	2657	N
5	1.49	14,700	6200	5360	5.71	1.80	669	A
6	1.17	20,600	6700	5250	7.04	1.80	634	A

YUCCA MOUNTIAN RAIL ACCESS STUDY
CALIENTE ROUTE
HYDROLOGIC ANALYSIS
KENNEDY/JENKS/CHILTON

SUMMARY OF DATA FOR DRAINAGE AREAS:
1 mi^2 < AREA < 5 mi^2

CP	Watershed Area (mi^2)	Stream Length (ft)	Max El. (ft)	Min El. (ft)	Slope (%)	100-Yr 6- Hr Rainfall (in)	Approx. 100-Yr Peak Q (cfs)	Eqn Type
BASIN 171 cont.								
7	1.51	22,575	6700	5160	6.82	1.80	756	A
8	1.25	19,660	6200	5080	5.70	1.80	583	A
9	2.25	27,290	6500	5020	5.42	1.80	888	A
12	1.03	7,470	6160	5250	12.18	1.80	1000	N
BASIN 172								
2	1.23	19,200	5560	5190	1.93	1.82	294	A
3	3.20	27,000	5690	5210	1.78	1.99	655	A
4	1.77	22,600	5640	5240	1.77	1.92	396	A
7	1.50	19,000	5560	5280	1.47	1.90	306	A
10	5.81	35,200	6290	5420	2.47	1.98	1267	A
12	1.46	23,000	5880	5440	1.91	1.93	361	A
15	2.35	18,200	7160	5760	7.69	1.95	1272	A
BASIN 173								
1	2.04	14,200	6200	5635	3.98	1.70	970	N
2	3.98	21,800	6680	5555	5.16	1.70	1790	N
3	1.91	14,200	6970	5580	9.79	1.69	1381	N
4A	3.00	21,400	6428	5440	4.62	1.62	1342	N
18A	3.48	36,596	7400	6080	3.61	1.90	1472	N
19	1.13	19,200	6450	6120	1.72	1.59	412	N
20	1.15	24,000	6670	6150	2.17	1.70	482	N

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CP	Watershed Area (mi^2)	Stream Length (ft)	Max El. (ft)	Min El. (ft)	Slope (%)	100-Yr 6- Hr Rainfall (in)	Approx. 100-Yr Peak Q (cfs)	Eqn Type
BASIN 173 cont.								
21	1.91	26,200	6820	6170	2.48	1.80	772	N
22	3.85	31,500	7920	6180	5.52	1.95	1951	N
24	3.95	33,841	6960	5960	2.95	1.70	1385	N
25	3.87	38,170	7700	5990	4.48	1.90	1756	N
27	4.54	35,415	8400	5930	6.97	2.00	2486	N
35	2.46	18,600	6680	5560	6.02	1.64	899	A
36	1.52	11,800	6180	5518	5.61	1.68	904	N
37	3.25	17,200	6460	5470	5.76	1.62	1573	N
39	1.71	21,400	6040	5476	2.64	1.60	390	A
40	3.12	24,800	6500	5480	4.11	1.61	1307	N
41	2.11	17,000	6300	5440	5.06	1.62	1077	N
BASIN 181								
1	4.59	21,000	6435	5475	4.57	2.21	2197	N
2	2.65	28,000	7240	5400	6.57	2.20	1717	N
6	0.88	16,000	5360	4860	3.13	1.97	343	A
11	4.21	38,400	6710	4625	5.43	1.85	1490	A
12	3.10	36,000	6710	4665	5.68	1.86	1221	A
15	0.95	12,000	6480	5180	10.83	1.83	902	N
16	3.19	19,200	5880	4820	5.52	1.97	1708	N
17	1.99	13,000	6320	4800	11.69	1.97	1685	N
18	4.07	25,000	5960	4720	4.96	2.00	1967	N

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CP	Watershed Area (mi^2)	Stream Length (ft)	Max El. (ft)	Min El. (ft)	Slope (%)	100-Yr 6- Hr Rainfall (in)	Approx. 100-Yr Peak Q (cfs)	Eqn Type
BASIN 181 cont.								
19	4.41	31,400	6560	4780	5.67	2.10	2279	N
20	1.49	8,000	5490	4750	9.25	1.98	1228	N
21	2.12	20,200	6280	4770	7.48	2.02	1468	N
22	1.83	22,000	6280	4780	6.82	2.04	1032	A
25	1.22	14,000	5800	4855	6.75	2.09	776	A
26	0.98	12,200	5840	4910	7.62	2.09	707	A
28	1.51	12,200	6120	4940	9.67	2.04	1288	N
30	0.82	16,000	5440	4895	3.41	2.00	348	A
31	1.26	26,400	6060	4855	4.56	2.00	585	A
BASIN 182								
1	1.30	24,000	5880	4995	3.69	1.88	483	A
2	3.06	27,500	6060	4990	3.89	1.88	965	A
3	1.98	25,000	6740	4960	7.12	1.88	1013	A
4	5.11	34,000	6840	4960	5.53	1.87	2350	N
5	1.38	13,000	5180	4958	1.71	1.87	309	A
BASIN 197								
1	0.83	9,000	6320	5960	4.00	2.62	643	N
2	1.28	13,000	6220	5960	2.00	2.62	649	N

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CP	Watershed Area (mi^2)	Stream Length (ft)	Max El. (ft)	Min El. (ft)	Slope (%)	100-Yr 6- Hr Rainfall (in)	Approx. 100-Yr Peak Q (cfs)	Eqn Type
BASIN 203								
2	0.96	8,200	6940	6145	9.70	2.20	961	N
3	1.26	10,400	6940	6000	9.04	2.20	1139	N
4	1.45	13,400	6940	5960	7.31	2.20	1151	N
6	1.87	25,200	6800	5535	5.02	2.01	1114	N
7	2.00	10,000	5500	5225	2.75	1.99	888	N
7A	2.05	12,200	5500	5175	2.66	1.99	891	N
7B	4.68	38,200	6800	5185	4.23	1.99	2023	N
8	1.19	17,000	5680	5080	3.53	1.97	673	N
9	2.44	22,400	5080	4935	0.65	1.97	532	N
11	1.07	13,600	5810	4990	6.03	1.99	794	N
12	2.97	19,000	5380	4740	3.37	1.99	1303	N
18	1.64	14,000	6160	5210	6.79	2.25	1237	N
BASIN 208								
2	1.84	16,500	6400	5200	7.27	1.80	1219	N
3	2.01	20,000	6280	5040	6.20	1.79	1207	N
4	0.92	9,800	5700	5000	7.14	1.78	719	N
5	0.85	15,670	6000	4920	6.89	1.79	669	N
6	0.97	12,500	6000	4920	8.64	1.79	817	N
8	0.85	22,430	6940	4880	9.18	1.79	761	N
9	1.86	19,450	6920	4880	10.49	1.78	1440	N
10	0.77	8,800	6400	5120	14.55	1.80	873	N

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CP	Watershed Area (mi^2)	Stream Length (ft)	Max El. (ft)	Min El. (ft)	Slope (%)	100-Yr 6- Hr Rainfall (in)	Approx. 100-Yr Peak Q (cfs)	Eqn Type
BASIN 208 cont.								
11	2.50	18,000	7000	5220	9.89	1.87	1797	N
12	5.62	33,070	7725	5220	7.57	1.93	2960	N
13	3.70	28,740	7880	5430	8.52	1.83	2220	N
14	1.15	15,350	7280	5460	11.86	1.88	1100	N
15	1.53	18,110	8440	5690	15.18	1.92	1538	N
16	1.94	13,540	8400	5840	18.91	1.92	2025	N
BASIN 209								
1	1.39	11,000	5640	4830	7.36	1.88	1022	N
1A	1.82	14,400	5640	4720	6.39	1.88	1170	N
2	2.40	19,200	6400	4800	8.33	1.90	1315	A
2A	3.32	27,000	9000	4560	16.44	1.90	2594	A
3	1.66	19,600	6080	4720	6.94	1.85	852	A
4	4.19	27,800	6400	4560	6.62	1.85	1683	A
5	2.03	19,200	6045	4520	7.94	1.80	1364	N
7	2.96	16,600	5400	4440	5.78	1.79	1133	A
12	1.50	24,800	5200	4240	3.87	1.82	533	A
13	1.04	16,800	4960	4300	3.93	1.82	406	A
17	2.30	14,600	6135	5185	6.51	1.81	1373	N
18	2.25	15,000	6425	5102	8.82	1.84	1564	N
19	2.77	18,800	6890	4955	10.29	1.87	1974	N
20	1.40	13,200	6080	4480	12.12	1.85	1273	N

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CP	Watershed Area (mi^2)	Stream Length (ft)	Max El. (ft)	Min El. (ft)	Slope (%)	100-Yr 6- Hr Rainfall (in)	Approx. 100-Yr Peak Q (cfs)	Eqn Type
BASIN 209 cont.								
21	5.08	22,600	6200	4400	7.96	1.89	2775	N
22	5.06	20,800	5960	4370	7.64	1.85	2682	N
23	3.64	32,200	6800	4390	7.48	1.90	2114	N
26	1.40	12,700	5010	4340	5.28	1.83	620	A
27	2.54	18,400	6160	4280	10.22	1.82	1816	N
28	1.81	13,600	5880	3960	14.12	1.80	1624	N
30	2.77	16,000	5400	4120	8.00	1.78	1712	N
31	1.71	19,200	5600	4360	6.46	1.78	1087	N
32	1.82	23,800	5600	4340	5.29	1.78	1041	N
BASIN 227								
1	4.24	23,500	5680	3650	8.64	1.67	2341	N
4	1.03	11,412	4250	3070	10.34	1.62	873	N
5	2.10	18,101	4500	3180	7.29	1.62	1266	N
6	2.27	25,578	4850	3180	6.53	1.62	1276	N
7	3.13	21,000	4500	3060	6.86	1.61	1649	N
8	3.63	31,000	4850	3040	5.84	1.61	1712	N
BASIN 228								
2	1.39	13,000	4580	4080	3.85	1.67	711	N
3	1.56	24,000	4600	3945	2.73	1.67	664	N

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BASIN 229								
2	1.65	16,600	3320	2890	2.59	1.60	659	N
8	2.11	14,000	4110	3330	5.57	1.60	1117	N
11	3.12	36,600	5200	3430	4.84	1.62	924	A
12	1.24	11,000	3820	3480	3.09	1.61	580	N
14	4.36	23,600	4680	3555	4.77	1.63	1803	N
15	5.08	31,400	5600	3740	5.92	1.65	2243	N
16	4.77	28,500	5600	3835	6.19	1.65	2184	N
17	4.53	26,400	5600	3900	6.44	1.65	2139	N
18	2.96	18,500	5500	4080	7.68	1.64	1683	N
19	1.73	20,500	5560	4080	7.22	1.64	1099	N
20	1.25	15,700	4880	4030	5.41	1.64	759	N
21	1.96	11,800	4682	4120	4.76	1.64	1000	N
22	1.75	15,000	4100	3020	7.20	1.61	1095	N

Equation Type: N = Normal Watershed Type
A = Alluvial Watershed Type

APPENDIX A

QA: N/A

YUCCA MOUNTAIN RAIL ACCESS

CALIENTE ROUTE CONCEPTUAL PLANS

PREPARED FOR:
SCIENCE APPLICATIONS
INTERNATIONAL CORPORATION

LAS VEGAS, NEVADA

DE LEUW, CATHER & COMPANY

SAN FRANCISCO, CALIFORNIA

JUNE 1, 1992

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FILE 1/DRAWER 4

SHEET NUMBER	DRAWING NUMBER	TITLE		
1	G02-011	DRAWING INDEX		SHEET 1
2	G02-012	DRAWING INDEX		SHEET 2
3	G02-005	LOCATION PLAN, SYMBOLS & GENERAL NOTES		
4	G01-001	SHEET LAYOUT KEY		SHEET 1
5	G01-002	SHEET LAYOUT KEY		SHEET 2
6	G01-003	SHEET LAYOUT KEY		SHEET 3
7	G91-001	SHEET LAYOUT KEY		SHEET 4
8	G02-024	SHEET LAYOUT KEY		SHEET 5
9	D02-001	TYPICAL SECTIONS		
10	L01-001	PLAN & PROFILE		STA. 1500+00 - STA. 1550+00
11	L01-002	PLAN & PROFILE		STA. 1550+00 - STA. 1660+00
12	L01-003	PLAN & PROFILE		STA. 1660+00 - STA. 1800+00
13	L01-004	PLAN & PROFILE		STA. 1800+00 - STA. 1940+00
14	L01-005	PLAN & PROFILE		STA. 1940+00 - STA. 2080+00
15	L01-006	PLAN & PROFILE		STA. 2080+00 - STA. 2210+00
16	L01-007	PLAN & PROFILE		STA. 2210+00 - STA. 2350+00
17	L01-008	PLAN & PROFILE		STA. 2350+00 - STA. 2485+00
18	L01-009	PLAN & PROFILE		STA. 2485+00 - STA. 2600+00
18	L01-010	PLAN & PROFILE		STA. 2600+00 - STA. 2730+00
20	L01-011	PLAN & PROFILE		STA. 2730+00 - STA. 2870+00
21	L01-012	PLAN & PROFILE		STA. 2870+00 - STA. 3010+00
22	L01-013	PLAN & PROFILE	ROUTE B	STA. 3010+00 - STA. 3140+00
23	L01-014	PLAN & PROFILE	ROUTE B	STA. 3140+00 - STA. 3280+00
24	L01-015	PLAN & PROFILE	ROUTE B	STA. 3280+00 - STA. 3420+00
25	L01-016	PLAN & PROFILE	ROUTE B	STA. 3420+00 - STA. 3560+00
26	L01-017	PLAN & PROFILE	ROUTE B	STA. 3560+00 - STA. 3700+00
27	L01-018	PLAN & PROFILE	ROUTE B	STA. 3700+00 - STA. 3840+00
28	L01-019	PLAN & PROFILE	ROUTE B	STA. 3840+00 - STA. 3965+00
29	L01-020	PLAN & PROFILE	ROUTE B	STA. 3965+00 - STA. 4080+00
30	L01-021	PLAN & PROFILE	ROUTE B	STA. 4080+00 - STA. 4210+00
31	L01-022	PLAN & PROFILE	ROUTE B	STA. 4210+00 - STA. 4325+00
32	L01-023	PLAN & PROFILE	ROUTE B	STA. 4325+00 - STA. 4450+00
33	L01-024	PLAN & PROFILE	ROUTE B	STA. 4450+00 - STA. 4590+00
34	L01-025	PLAN & PROFILE	ROUTE B	STA. 4590+00 - STA. 4730+00
35	L01-026	PLAN & PROFILE	ROUTE B	STA. 4730+00 - STA. 4860+00
36	L01-027	PLAN & PROFILE	ROUTE B	STA. 4860+00 - STA. 4980+00
37	L01-028	PLAN & PROFILE	ROUTE B	STA. 4980+00 - STA. 5100+00
38	L01-029	PLAN & PROFILE	ROUTE B	STA. 5100+00 - STA. 5170+00
39	L01-030	PLAN & PROFILE	ROUTE B	STA. 5170+00 - STA. 5295+00
40	L01-031	PLAN & PROFILE	ROUTE B	STA. 5295+00 - STA. 5430+00
41	L01-032	PLAN & PROFILE	ROUTE B	STA. 5430+00 - STA. 5560+00
42	L01-033	PLAN & PROFILE	ROUTE B	STA. 5560+00 - STA. 5680+00
43	L01-034	PLAN & PROFILE	ROUTE B	STA. 5680+00 - STA. 5810+00
44	L01-035	PLAN & PROFILE	ROUTE B	STA. 5810+00 - STA. 5950+00
45	L01-036	PLAN & PROFILE	ROUTE B	STA. 5950+00 - STA. 6090+00
46	L01-037	PLAN & PROFILE	ROUTE B	STA. 6090+00 - STA. 6230+00
47	L01-038	PLAN & PROFILE	ROUTE B	STA. 6230+00 - STA. 6360+00
48	L01-039	PLAN & PROFILE	ROUTE B	STA. 6360+00 - STA. 6500+00
49	L01-040	PLAN & PROFILE	ROUTE B	STA. 6500+00 - STA. 6640+00
50	L01-041	PLAN & PROFILE	ROUTE B	STA. 6640+00 - STA. 6780+00
51	L01-042	PLAN & PROFILE	ROUTE B	STA. 6780+00 - STA. 6910+00
52	L01-043	PLAN & PROFILE	ROUTE B	STA. 6910+00 - STA. 7050+00
53	L01-044	PLAN & PROFILE	ROUTE B	STA. 7050+00 - STA. 7180+00
54	L01-045	PLAN & PROFILE	ROUTE B	STA. 7180+00 - STA. 7320+00
55	L01-046	PLAN & PROFILE	ROUTE B	STA. 7320+00 - STA. 7460+00
56	L01-047	PLAN & PROFILE	ROUTE B	STA. 7460+00 - STA. 7600+00
57	L01-048	PLAN & PROFILE	ROUTE B	STA. 7600+00 - STA. 7740+00
58	L01-049	PLAN & PROFILE	ROUTE B	STA. 7740+00 - STA. 7870+00
59	L01-050	PLAN & PROFILE	ROUTE B	STA. 7870+00 - STA. 8010+00
60	L01-051	PLAN & PROFILE	ROUTE B	STA. 8010+00 - STA. 8061+88
61	L01-101	PLAN & PROFILE	ROUTE A	STA. 4000+22 - STA. 4110+00
62	L01-102	PLAN & PROFILE	ROUTE A	STA. 4110+00 - STA. 4250+00
63	L01-103	PLAN & PROFILE	ROUTE A	STA. 4250+00 - STA. 4385+00
64	L01-104	PLAN & PROFILE	ROUTE A	STA. 4385+00 - STA. 4525+00
65	L01-105	PLAN & PROFILE	ROUTE A	STA. 4525+00 - STA. 4665+00
66	L01-106	PLAN & PROFILE	ROUTE A	STA. 4665+00 - STA. 4805+00
67	L01-107	PLAN & PROFILE	ROUTE A	STA. 4805+00 - STA. 4945+00
68	L01-108	PLAN & PROFILE	ROUTE A	STA. 4945+00 - STA. 5080+00
69	L01-109	PLAN & PROFILE	ROUTE A	STA. 5080+00 - STA. 5220+00
70	L01-110	PLAN & PROFILE	ROUTE A	STA. 5220+00 - STA. 5360+00
71	L01-111	PLAN & PROFILE	ROUTE A	STA. 5360+00 - STA. 5500+00
72	L01-112	PLAN & PROFILE	ROUTE A	STA. 5500+00 - STA. 5640+00
73	L01-113	PLAN & PROFILE	ROUTE A	STA. 5640+00 - STA. 5780+00
74	L01-114	PLAN & PROFILE	ROUTE A	STA. 5780+00 - STA. 5920+00
75	L01-115	PLAN & PROFILE	ROUTE A	STA. 5920+00 - STA. 6035+00
76	L01-116	PLAN & PROFILE	ROUTE A	STA. 6035+00 - STA. 6165+00
77	L01-117	PLAN & PROFILE	ROUTE A	STA. 6165+00 - STA. 6305+00
78	L01-118	PLAN & PROFILE	ROUTE A	STA. 6305+00 - STA. 6445+00
79	L01-119	PLAN & PROFILE	ROUTE A	STA. 6445+00 - STA. 6585+00
80	L01-120	PLAN & PROFILE	ROUTE A	STA. 6585+00 - STA. 6725+00
81	L01-121	PLAN & PROFILE	ROUTE A	STA. 6725+00 - STA. 6830+00
82	L01-122	PLAN & PROFILE	ROUTE A	STA. 6830+00 - STA. 6960+00
83	L01-123	PLAN & PROFILE	ROUTE A	STA. 6960+00 - STA. 7070+00
84	L01-124	PLAN & PROFILE	ROUTE A	STA. 7070+00 - STA. 7210+00
85	L01-125	PLAN & PROFILE	ROUTE A	STA. 7210+00 - STA. 7345+00
86	L01-126	PLAN & PROFILE	ROUTE A	STA. 7345+00 - STA. 7485+00
87	L01-127	PLAN & PROFILE	ROUTE A	STA. 7485+00 - STA. 7625+00
88	L01-128	PLAN & PROFILE	ROUTE A	STA. 7625+00 - STA. 7765+00
89	L01-129	PLAN & PROFILE	ROUTE A	STA. 7765+00 - STA. 7900+00
90	L01-130	PLAN & PROFILE	ROUTE A	STA. 7900+00 - STA. 8000+00

DESIGNED	BY J.SELIN	1/91	DATE
REVIEWED	BY K.MACDONALD	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE
DRAWING INDEX

SCALE NONE
DRAWING NO G02-011
SHEET NO

SHEET NUMBER	DRAWING NUMBER	TITLE		
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92	L01-132	PLAN & PROFILE	ROUTE A	STA. 8125+00 - STA. 8240+00
93	L01-133	PLAN & PROFILE	ROUTE A	STA. 8240+00 - STA. 8380+00
94	L01-134	PLAN & PROFILE	ROUTE A	STA. 8380+00 - STA. 8520+00
95	L01-135	PLAN & PROFILE	ROUTE A	STA. 8520+00 - STA. 8660+00
96	L01-136	PLAN & PROFILE	ROUTE A	STA. 8660+00 - STA. 8800+00
97	L01-137	PLAN & PROFILE	ROUTE A	STA. 8800+00 - STA. 8940+00
98	L01-138	PLAN & PROFILE	ROUTE A	STA. 8940+00 - STA. 9080+00
99	L01-139	PLAN & PROFILE	ROUTE A	STA. 9080+00 - STA. 9220+00
100	L01-140	PLAN & PROFILE	ROUTE A	STA. 9220+00 - STA. 9340+00
101	L01-141	PLAN & PROFILE	ROUTE A	STA. 9340+00 - STA. 9465+00
102	L01-142	PLAN & PROFILE	ROUTE A	STA. 9465+00 - STA. 9542+18
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104	L91-002	PLAN & PROFILE		STA. 11060+00 - STA. 11200+00
105	L91-003	PLAN & PROFILE		STA. 11200+00 - STA. 11340+00
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187	L02-037	PLAN & PROFILE	STA. 24160+00 - STA. 24300+00
188	L02-038	PLAN & PROFILE	STA. 24300+00 - STA. 24414+83
189	S02-001	TYPICAL RAILROAD BRIDGE OVER RIVER	
190	S02-002	TYPICAL RAILROAD BRIDGE OVER ROAD	

REV	DESCRIPTION	DATE	BY

DESIGNED	BY J.SELIN	1/91	DATE
REVIEWED	BY K.MACDONALD	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

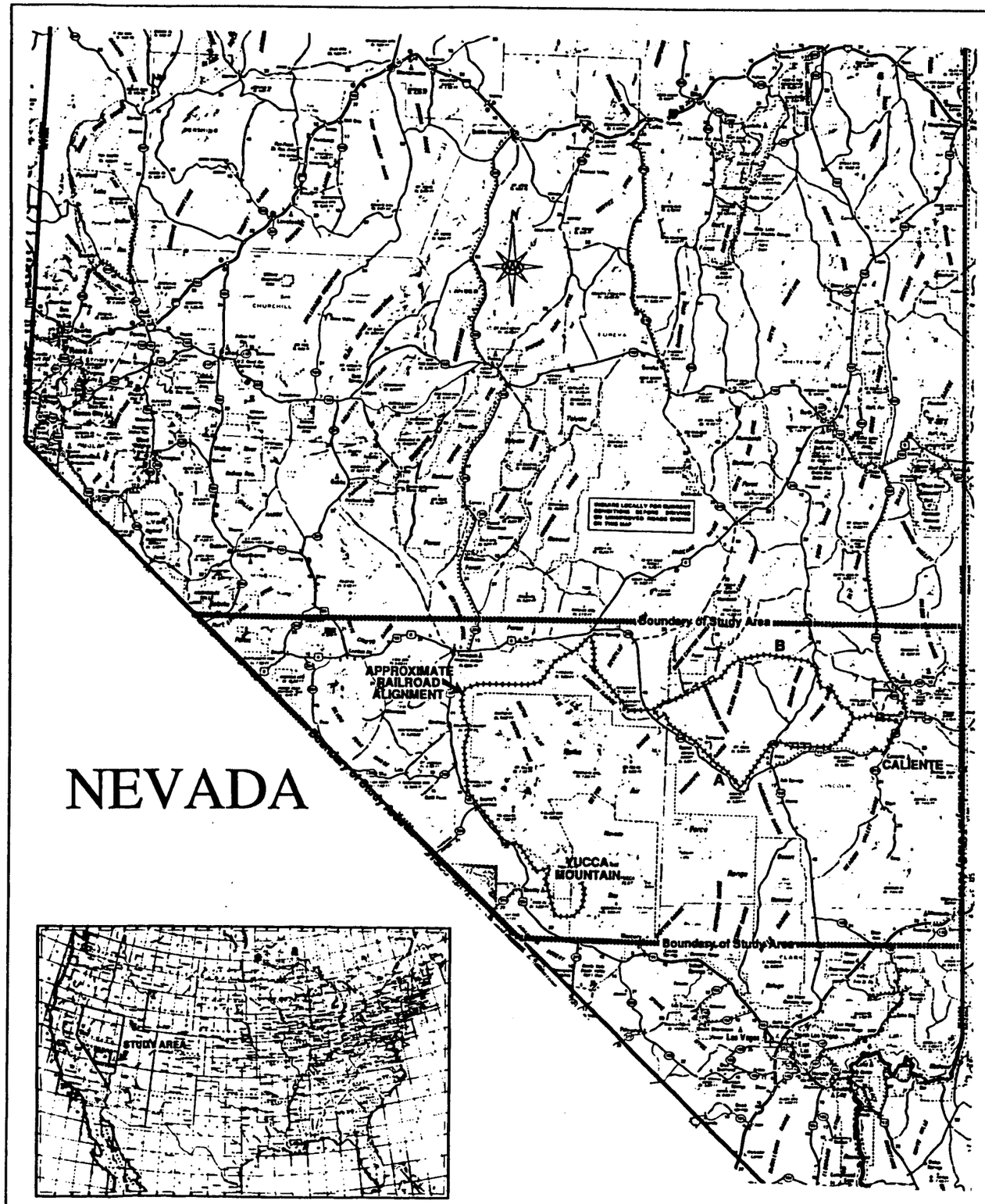
YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE
DRAWING INDEX

SCALE NONE

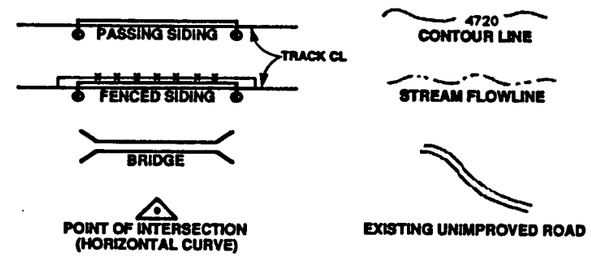
DRAWING NO. G02-012

SHEET NO.



SYMBOLS

PLAN VIEW



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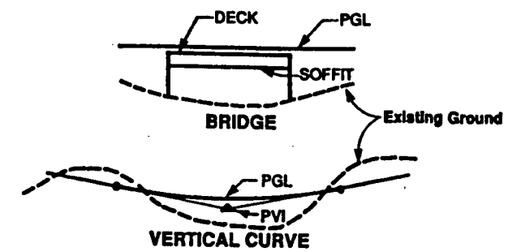

ABBREVIATIONS

AREA	American Railway Engineering Association
C-C	Center-to-Center
CL	Center Line
CWR	Continuously Welded Rail
D	Degree of Curve
EL	Elevation
MIN	Minimum
ML	Main Line
NTS	Not to Scale
PI	Point of Intersection
PVI	Point of Vertical Intersection
STA	Engineering Station
T/R	Top of Rail
TYP	Typical
VC	Vertical Curve
R/W	Right of Way
RE	Designation for Rail Shape
PGL	Profile Grade Line
AHD	Ahead
BK	Back
DWG	Drawing
N	North

GENERAL NOTES

1. Plans are conceptual only, not for construction.
2. Digitized base mapping is based on United States Geological Survey (USGS) 7.5 minute quadrangles, dated 1968 and after. Coordinates are based on the Universal Transverse Mercator (UTM) Coordinate System - Zone 11 (converted to feet). Vertical Datum is the National Geodetic Vertical Datum of 1929.
3. Minor drainage structures are not shown on drawings.

Map Source: AAA (Nevada); U.S. Geological Survey (U.S.)

Nevada Map copyrighted 1990 by the California State Automobile Association. Reproduced by permission.

REV	DESCRIPTION	DATE	BY

	BY	DATE
DESIGNED	K. MacDonald	1/91
REVIEWED	J. Selin	2/91
APPROVED		

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

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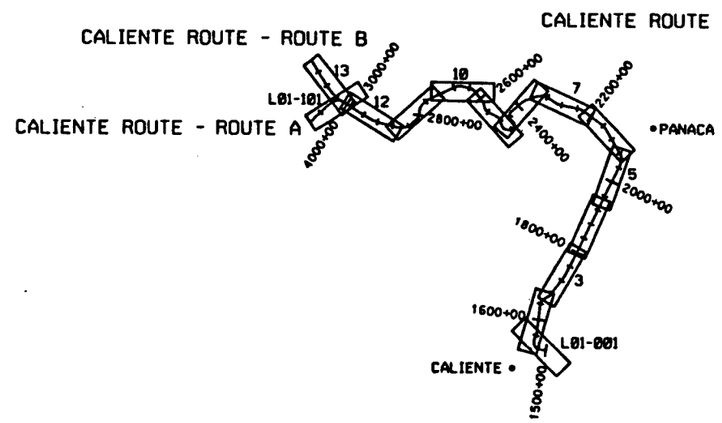
Engineers & Planners San Francisco, CA

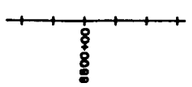
YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
LOCATION PLAN, SYMBOLS AND GENERAL NOTES

SCALE: NONE
DRAWING NO. G02-005
SHEET NO. 2 of 100

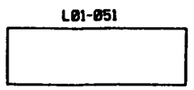


LEGEND

SYMBOLS ENLARGED FOR CLARITY



CENTERLINE OF TRACK WITH STATIONING



OUTLINE OF 1"=500' PLAN WITH DRAWING NUMBER

REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

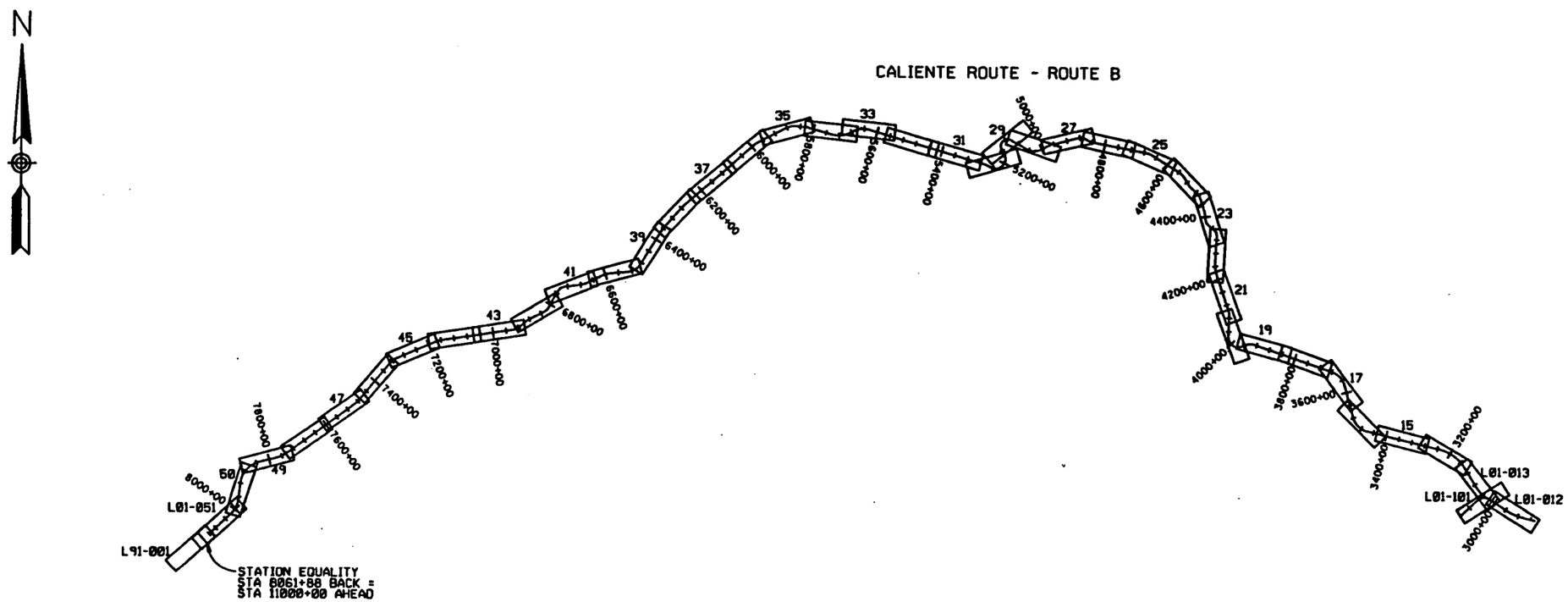
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

SHEET LAYOUT KEY
SHEET 1

SCALE 1"=20,000'
DRAWING NO. G01-001
SHEET NO. 1 OF 192



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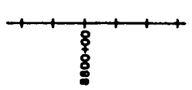
SYMBOLS ENLARGED FOR CLARITY



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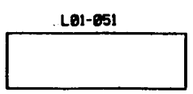

OUTLINE OF 1"=500' PLAN WITH DRAWING NUMBER

REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

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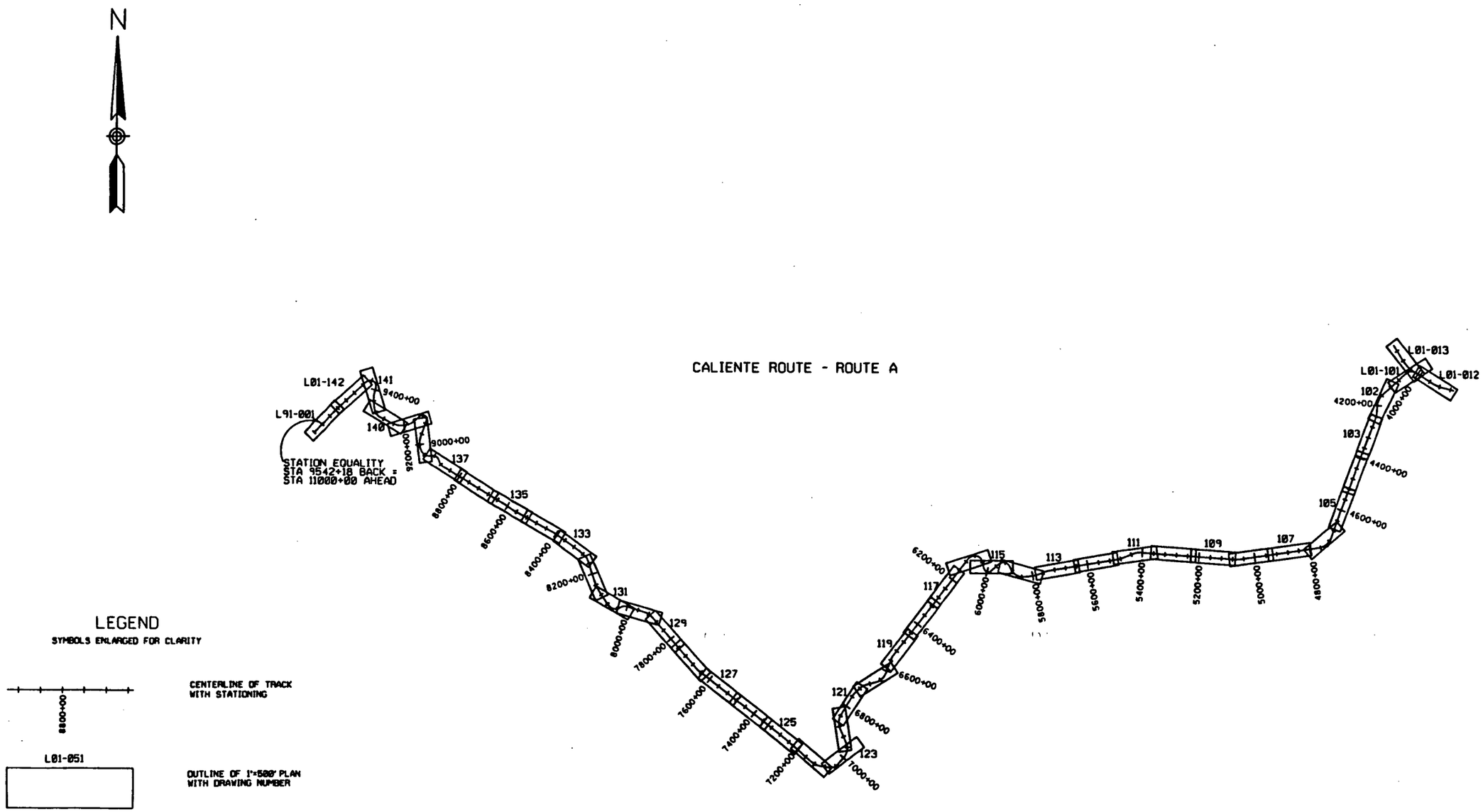
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

SHEET LAYOUT KEY
SHEET 2

SCALE 1"=20,000'
DRAWING NO. G01-002
SHEET NO 5 OF 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

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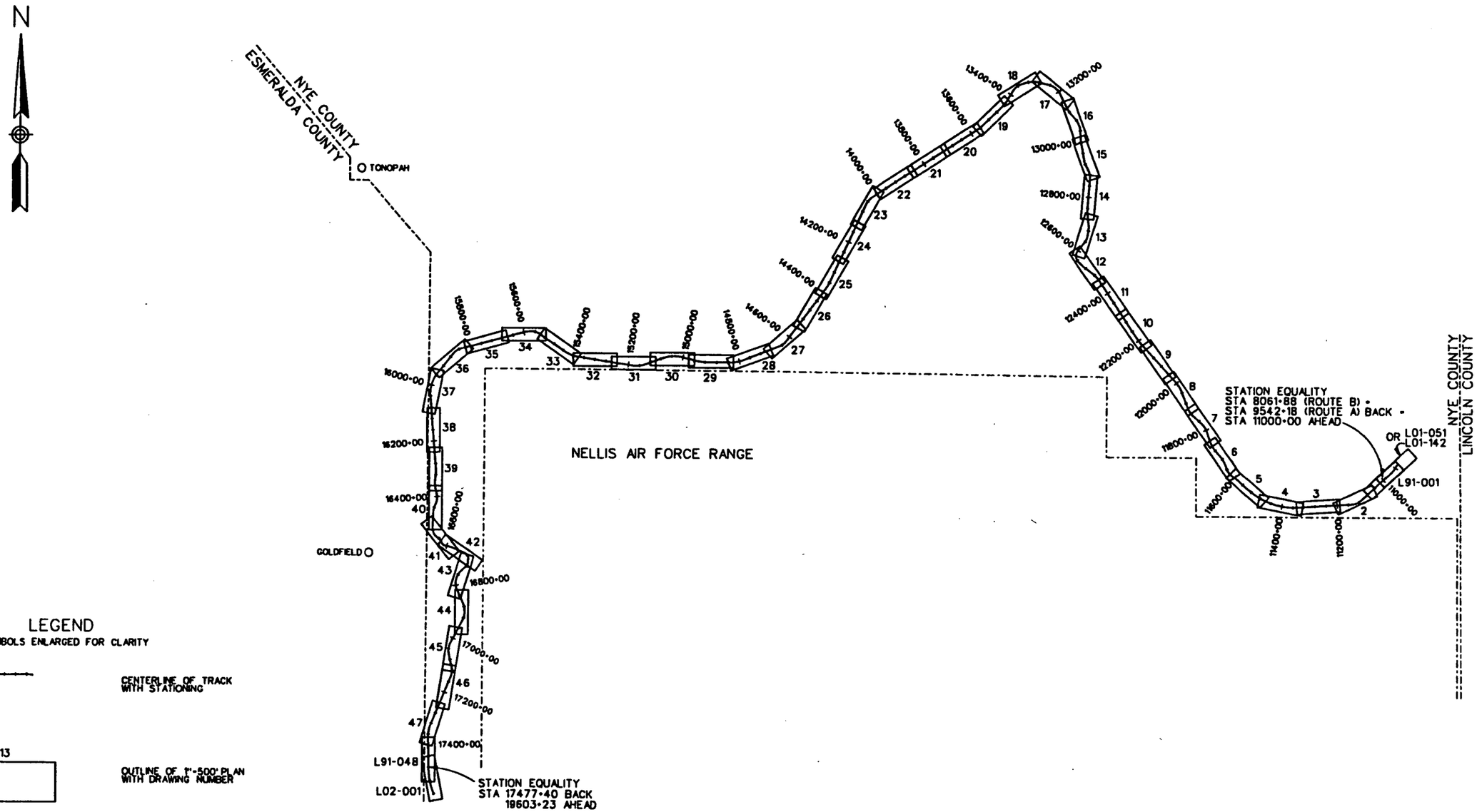
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

SHEET LAYOUT KEY
SHEET 3

SCALE 1"=20,000'
DRAWING NO G01-003
SHEET NO



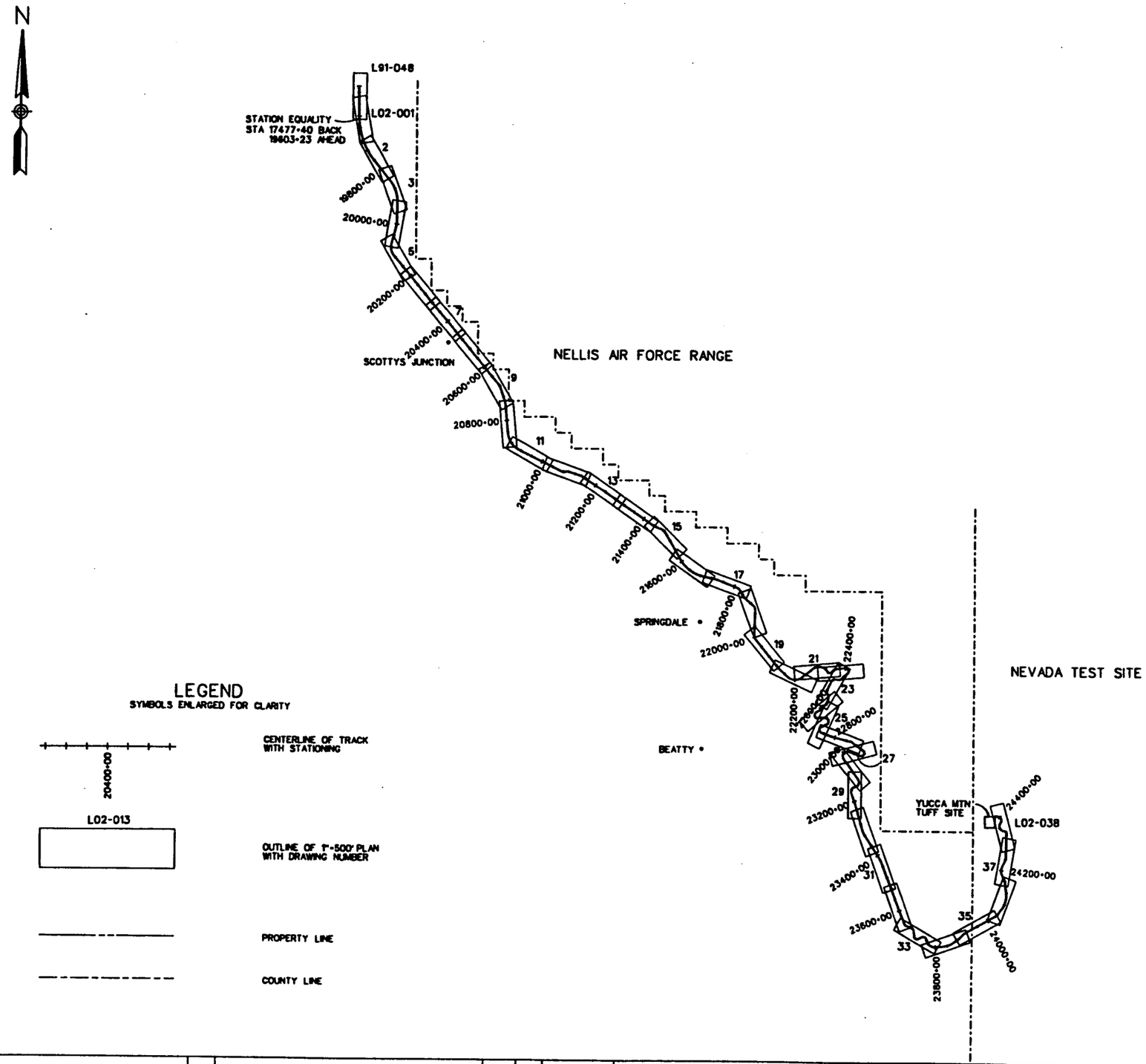
REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	DATE	CHECKED	2/91	DATE	Prepared for: Science Applications International Corporation, Las Vegas, Nevada
REVIEWED	BY T. DANIEL	DATE	BY	2/91	DATE	DeLEUW, CATHER & COMPANY Engineers & Planners San Francisco, CA
APPROVED	BY	DATE	BY		DATE	

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

SHEET LAYOUT KEY
SHEET 4

SCALE 1"=20,000'
DRAWING NO G91-001
SHEET NO 7 of 100



REV	DESCRIPTION	DATE	BY

	BY	DATE
DESIGNED	K.MACDONALD	1/91
REVIEWED	J.SELIN	2/91
APPROVED		

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

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Engineers & Planners San Francisco, CA

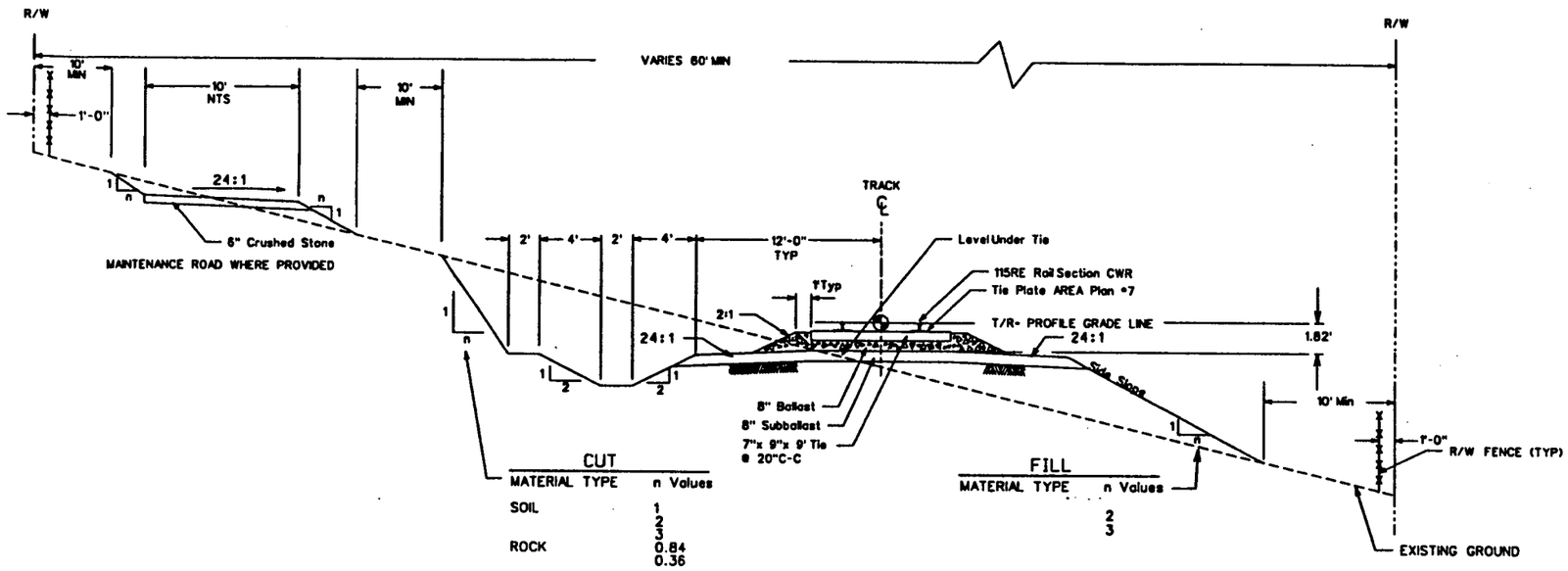
YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

SHEET LAYOUT KEY

SCALE 1"=20,000

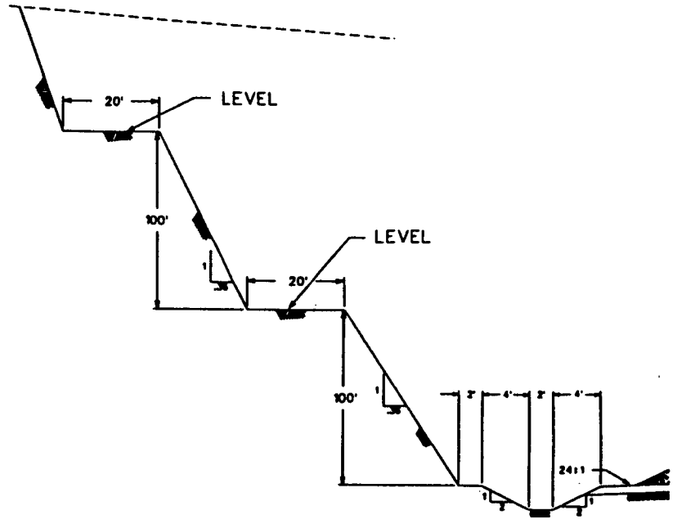
DRAWING NO. G02-024

SHEET NO



MAIN LINE

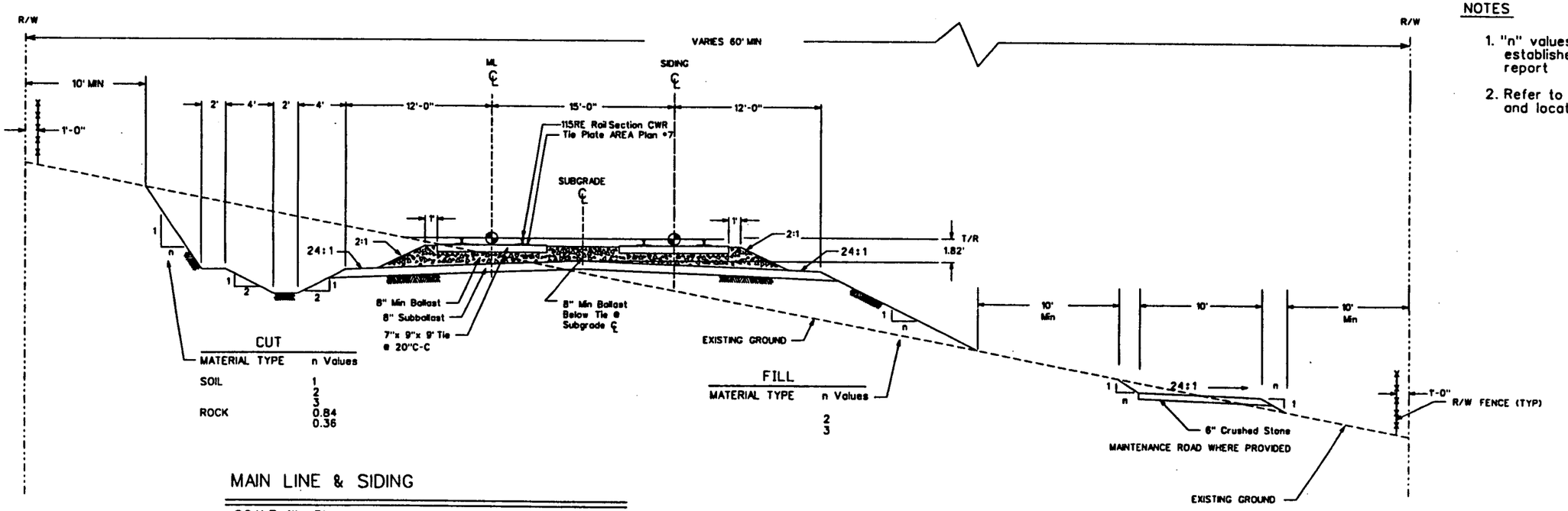
SCALE 1"= 5'



BENCH DETAIL

(Crescent Reservoir Quadrangle)

NO SCALE



MAIN LINE & SIDING

SCALE 1"= 5'

NOTES

1. "n" values for the side slopes were established from data in the geotechnical report
2. Refer to geotechnical report for soil symbols and locations of "n" values in cut and fill.

REV	DESCRIPTION	DATE	BY

DESIGNED	BY M.QUANDEE	12/90	DATE
REVIEWED	BY J.SELIN	2/91	DATE
APPROVED	BY		DATE

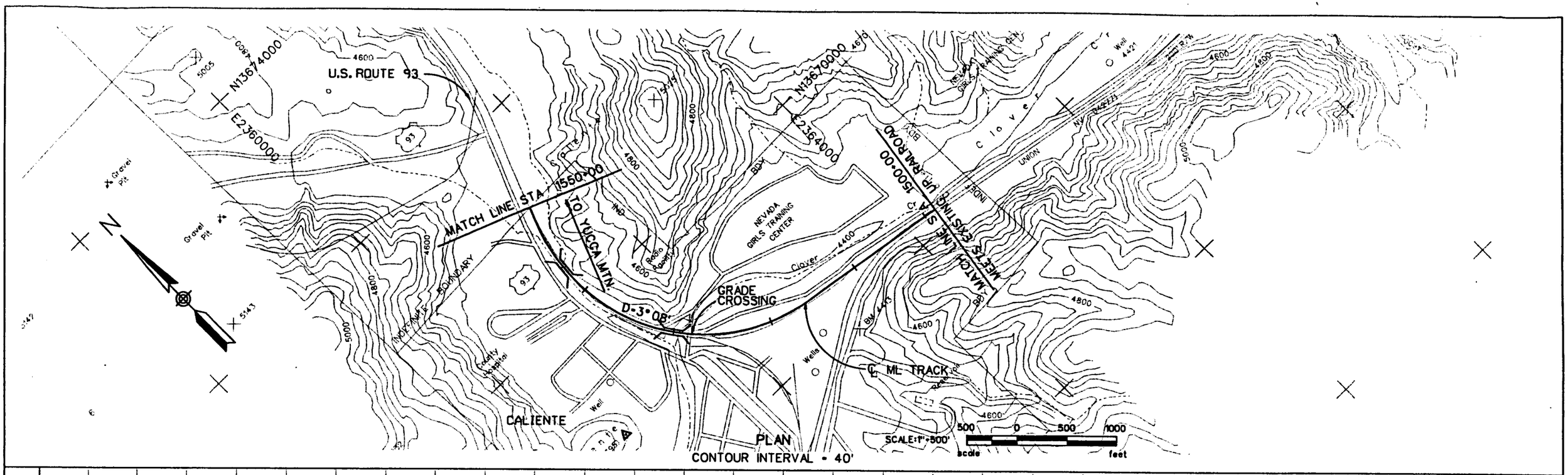
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

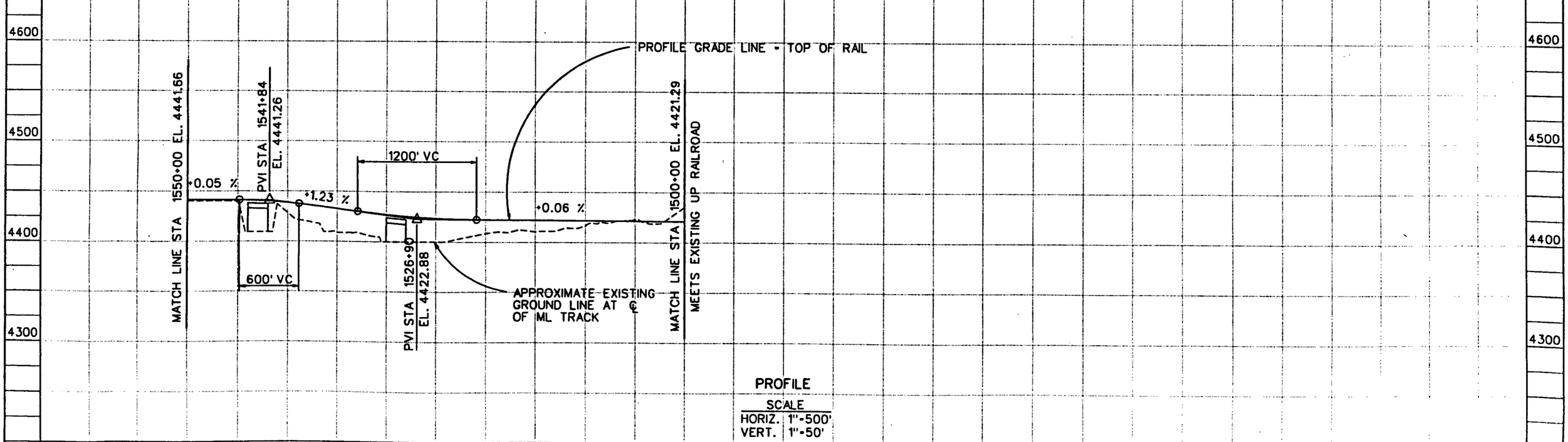
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE
TYPICAL SECTIONS

SCALE: AS NOTED
DRAWING NO. 002-001
SHEET NO.





PROFILE

SCALE	
HORIZ.	1"=500'
VERT.	1"=50'

REV	DESCRIPTION	DATE	BY

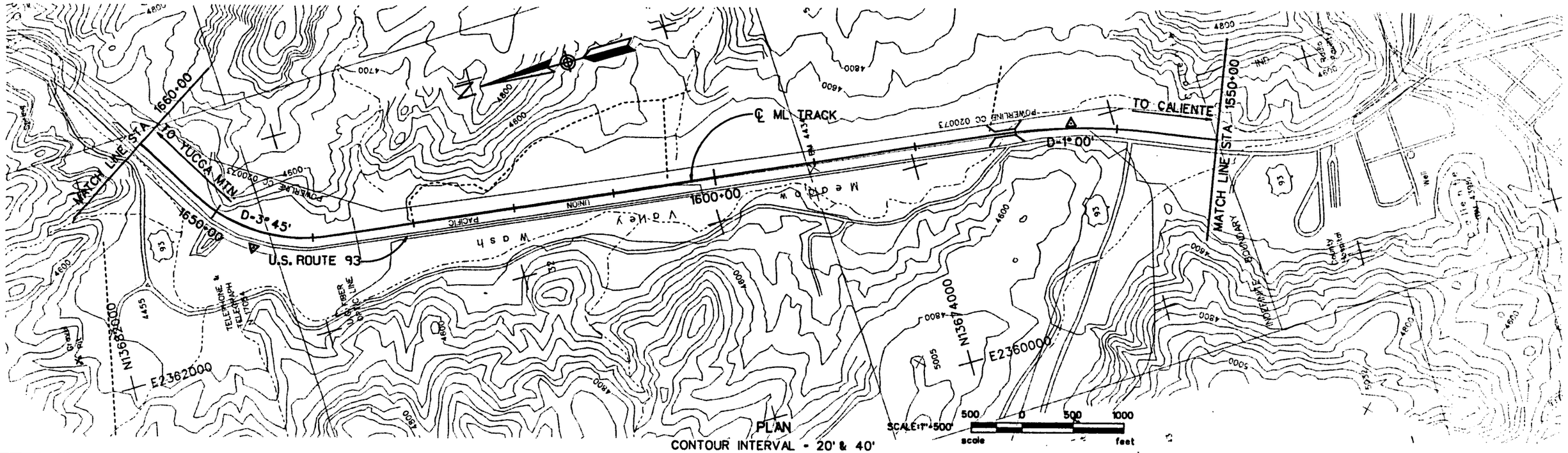
DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

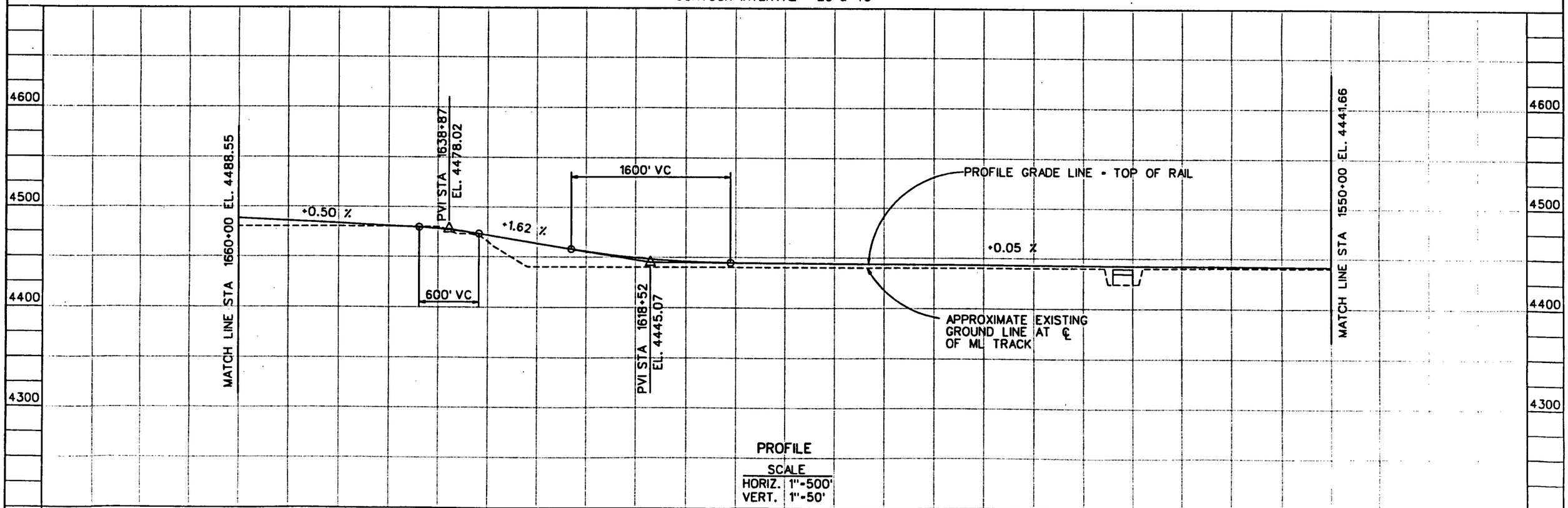
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA 1500+00 - STA 1550+00

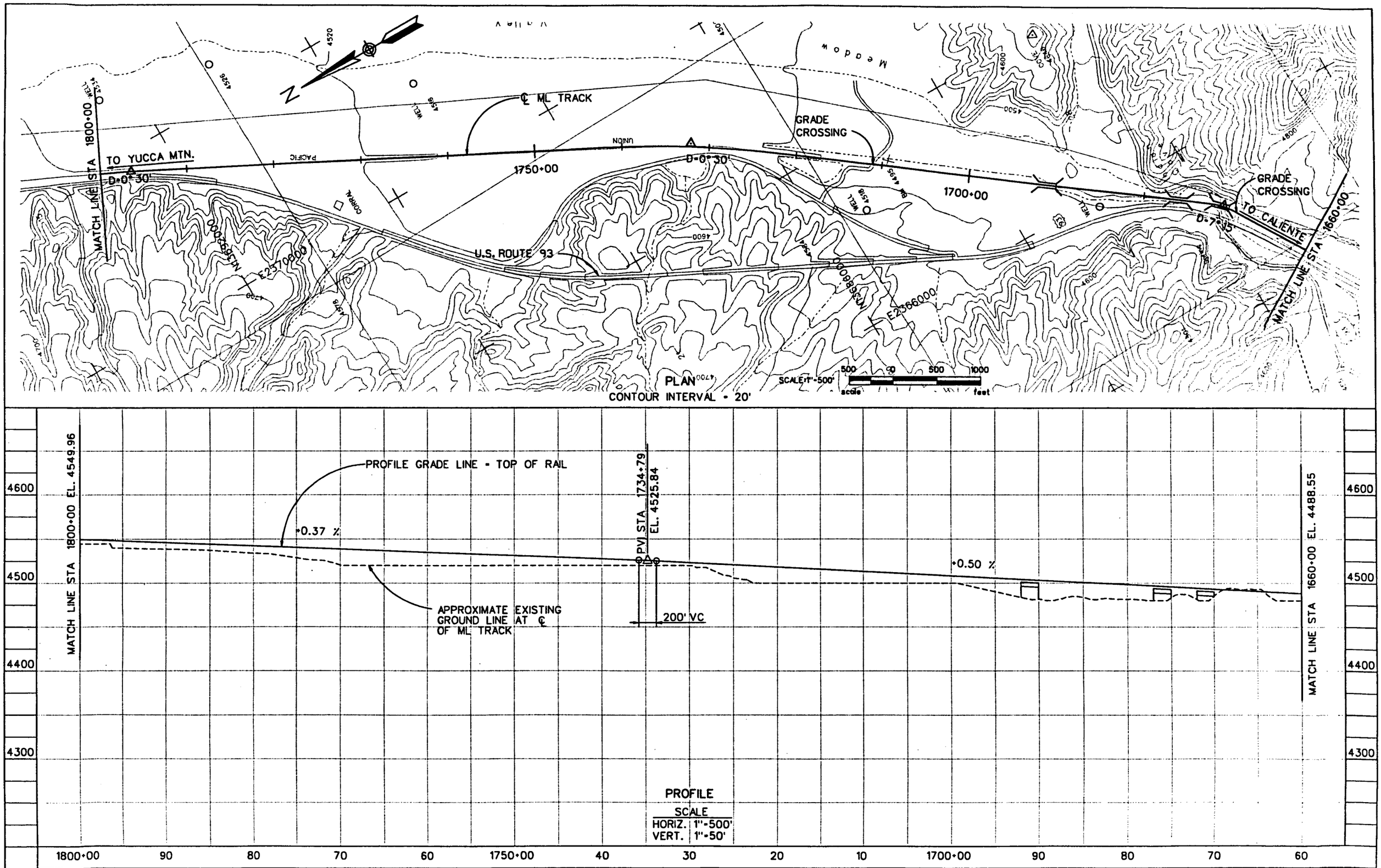
SCALE: as noted
DRAWING NO: L01-001
SHEET NO: 10 of 190





DESIGNED	BY K. CHIU	02/91 DATE	Prepared for: Science Applications International Corporation, Las Vegas, Nevada	YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
REVIEWED	BY A. BOLCHAZY	02/91 DATE	DeLEUW, CATHER & COMPANY	CALIENTE ROUTE PLAN & PROFILE

SCALE as noted
DRAWING NO L01-002



DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

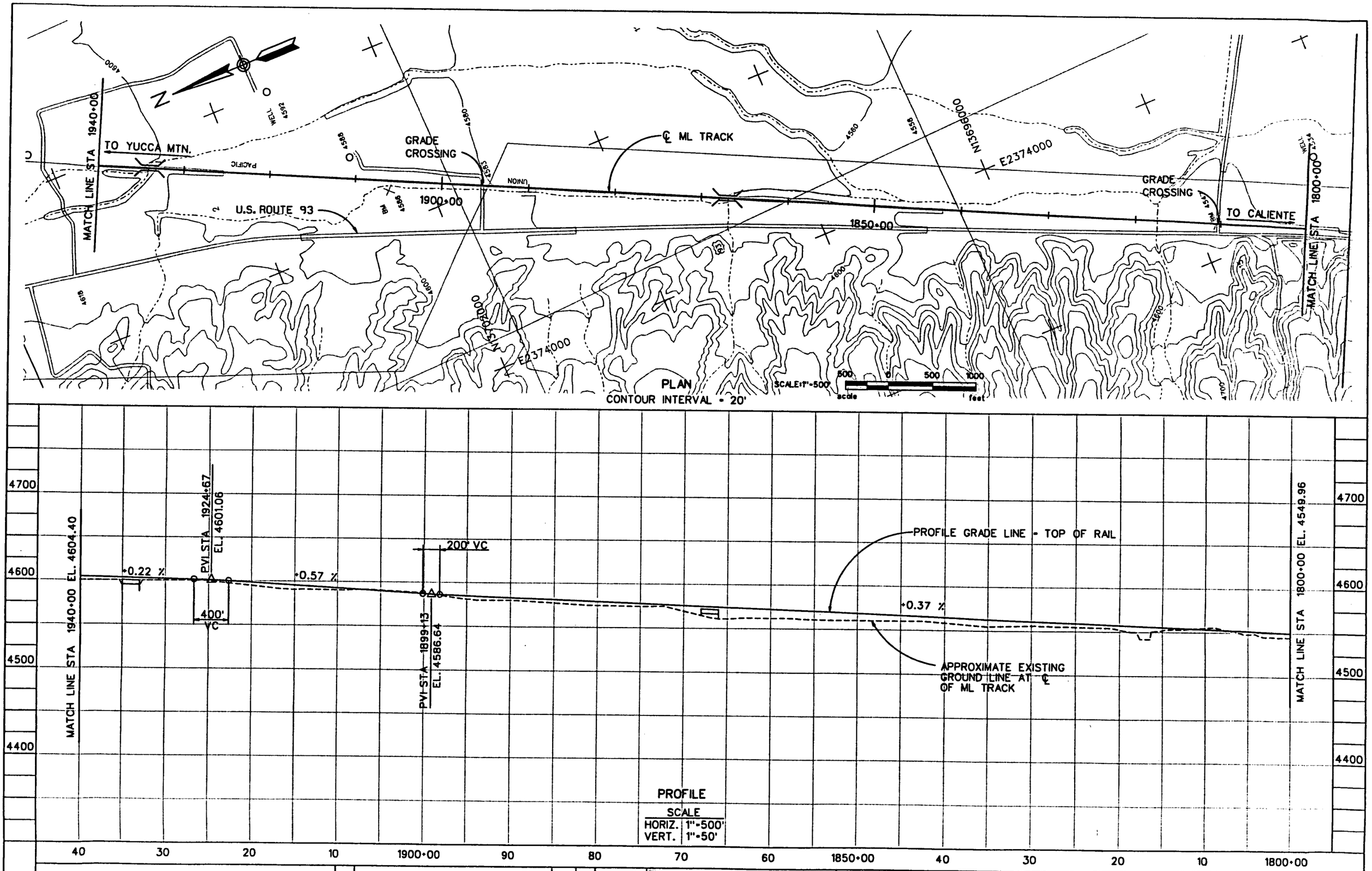
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE
PLAN & PROFILE

SCALE as noted
DRAWING NO. L01-003
SHEET NO. 12 of 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

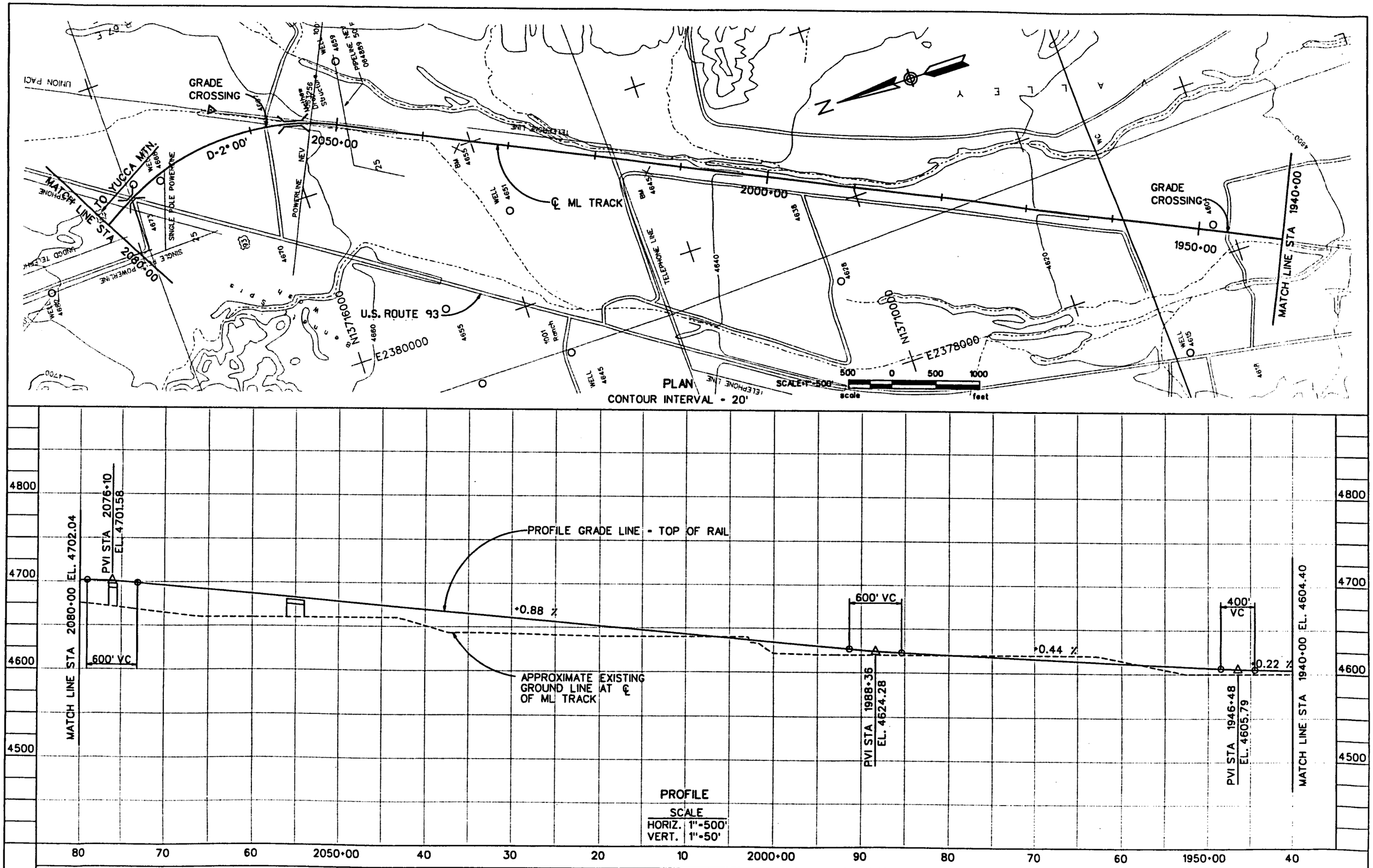
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE
PLAN & PROFILE

SCALE as noted
DRAWING NO. L01-004
SHEET NO.



DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Los Vegas, Nevada

DeLEUW, CATHER & COMPANY

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

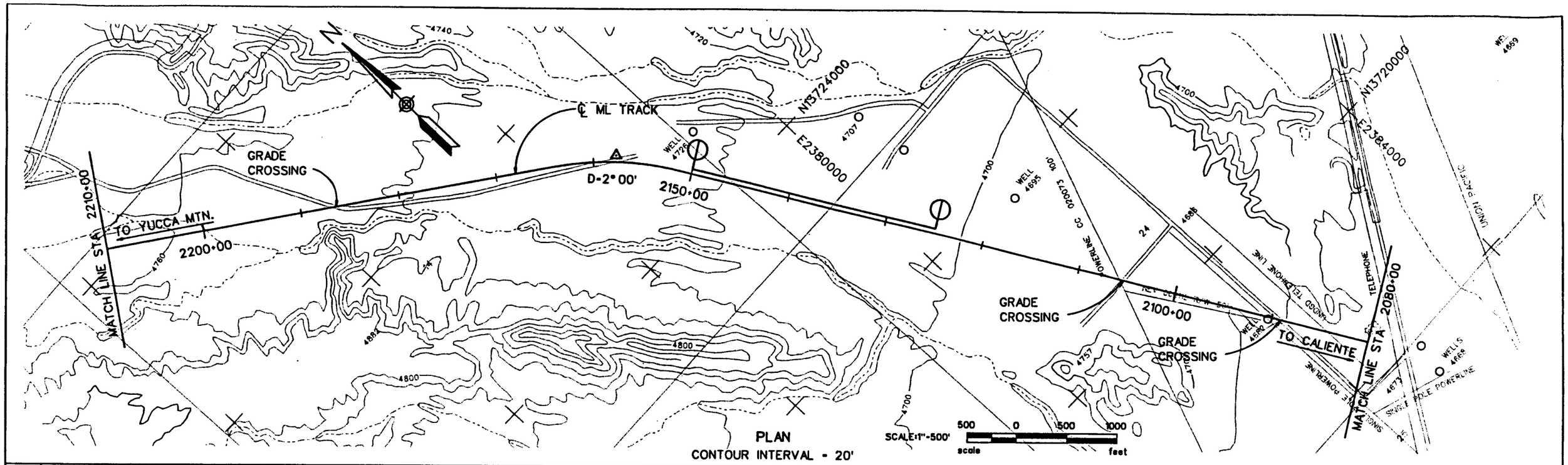
CALIENTE ROUTE
PLAN & PROFILE

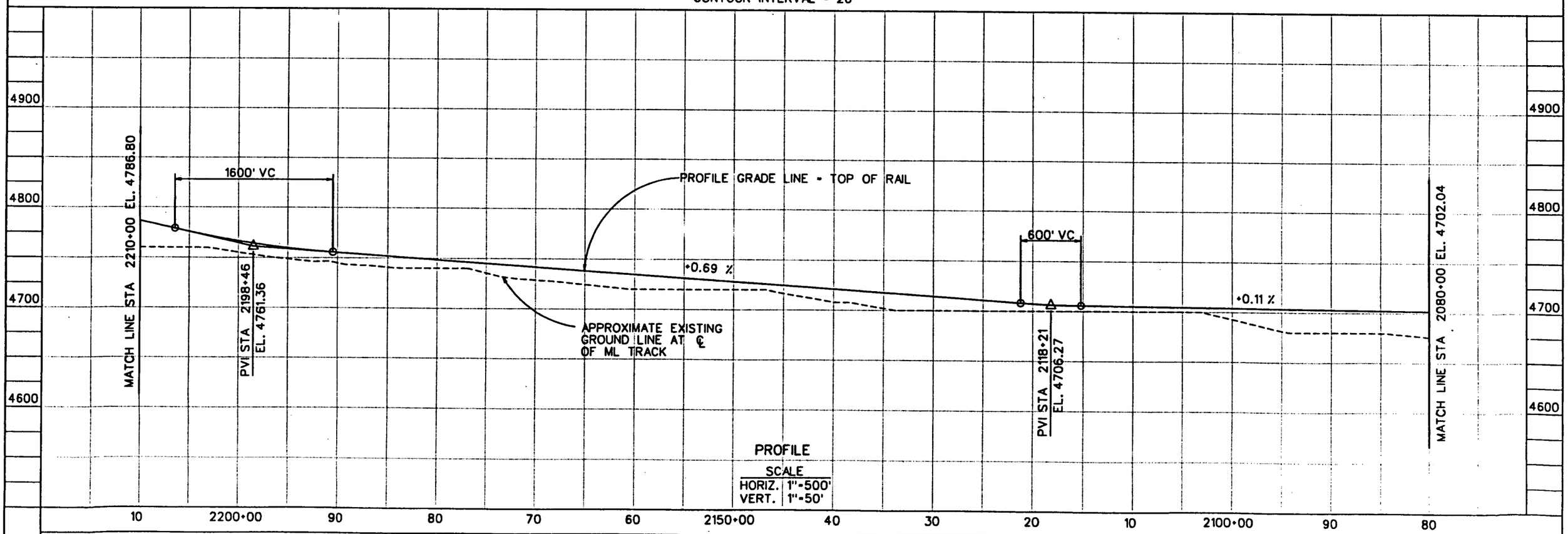
SCALE as noted

DRAWING NO. L01-005

SHEET NO.

DATE PLOTTED 20-FEB-1991





REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

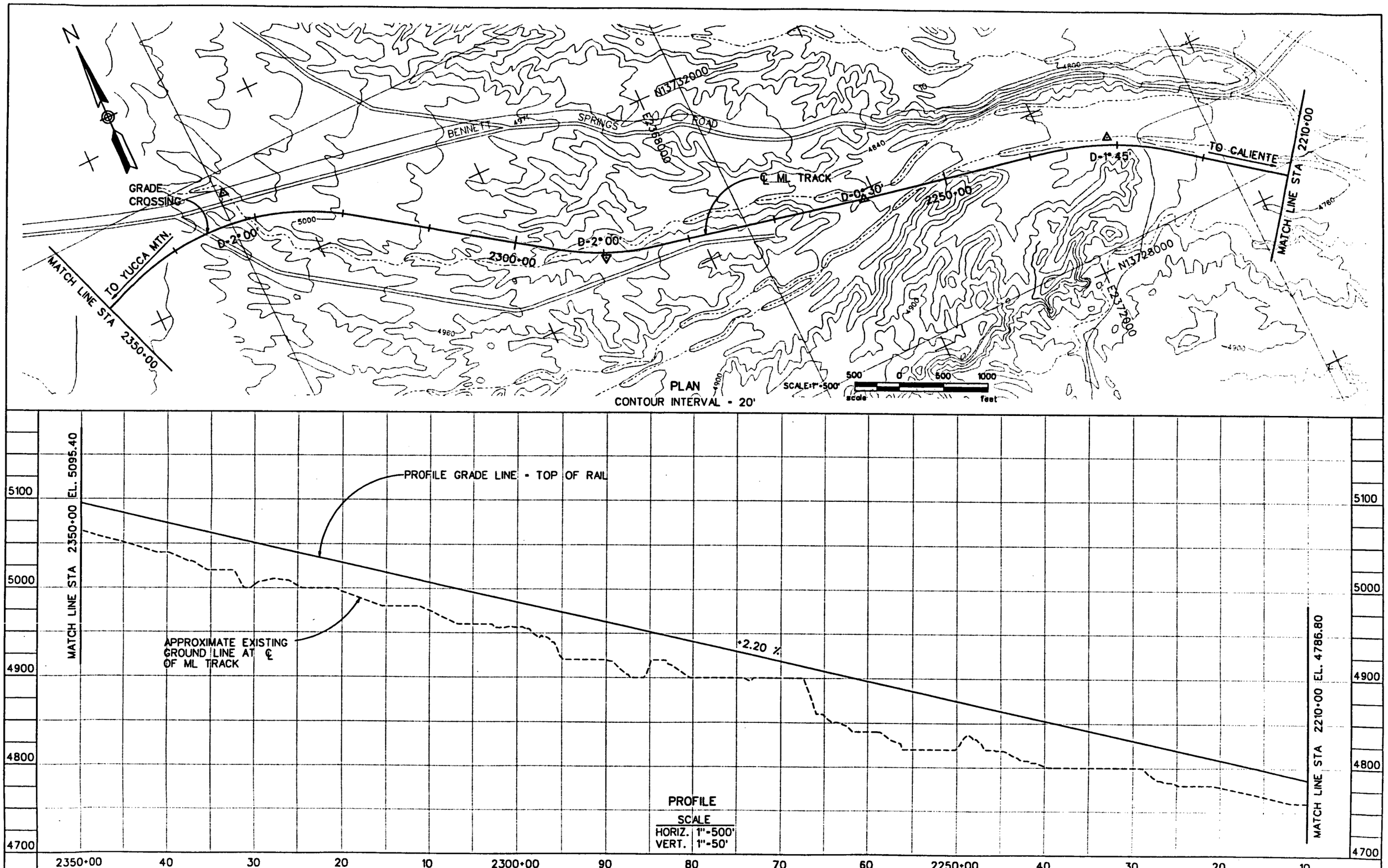
CALIENTE ROUTE PLAN & PROFILE

STA 2080+00 - STA 2210+00

SCALE: as noted

DRAWING NO. L01-006

SHEET NO. 15 of 190



DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

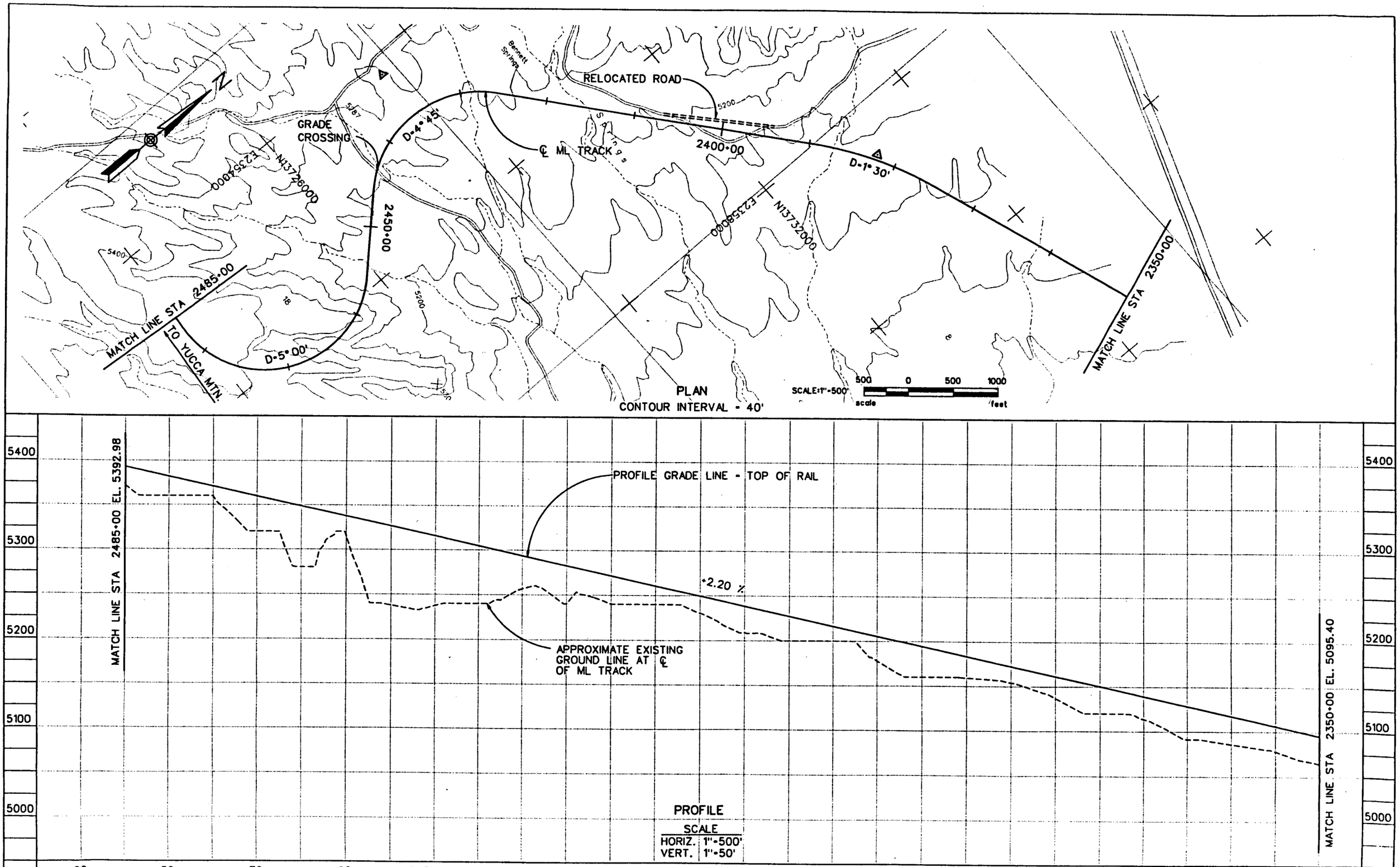
CALIENTE ROUTE PLAN & PROFILE

SCALE: as noted

DRAWING NO. L01-007

SHEET NO.

DATE PLOTTED 21-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE PLAN & PROFILE

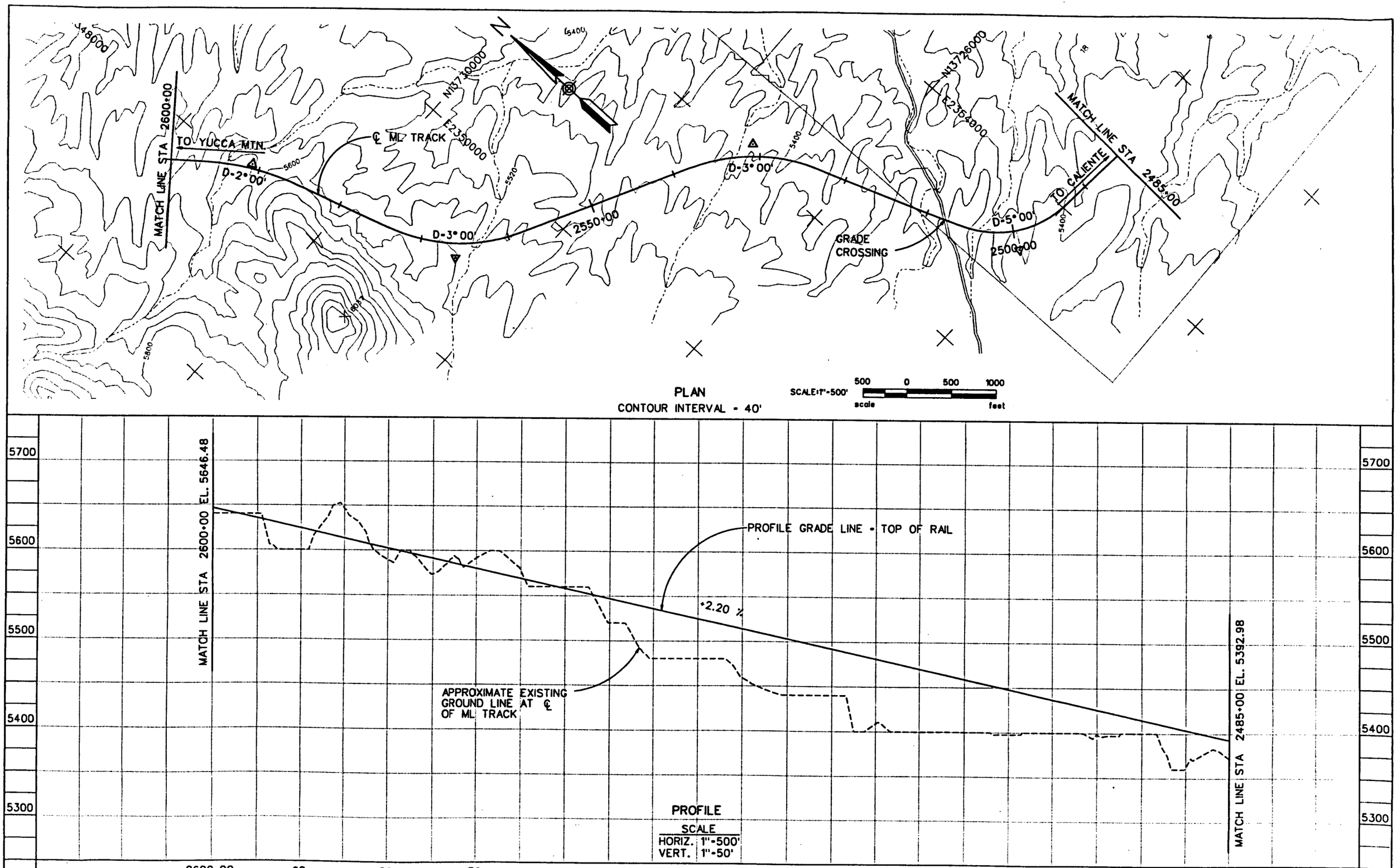
STA 2350+00 - STA 2485+00

SCALE: as noted

DRAWING NO. L01-008

SHEET NO. 17 of 190

DATE PLOTTED 25-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

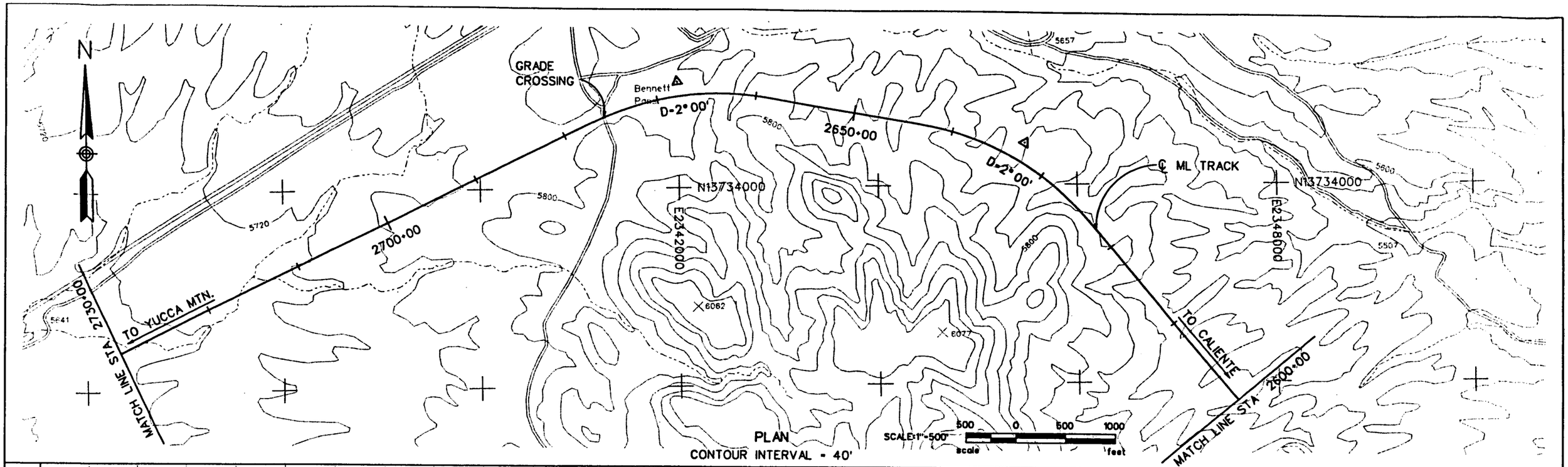
YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE PLAN & PROFILE

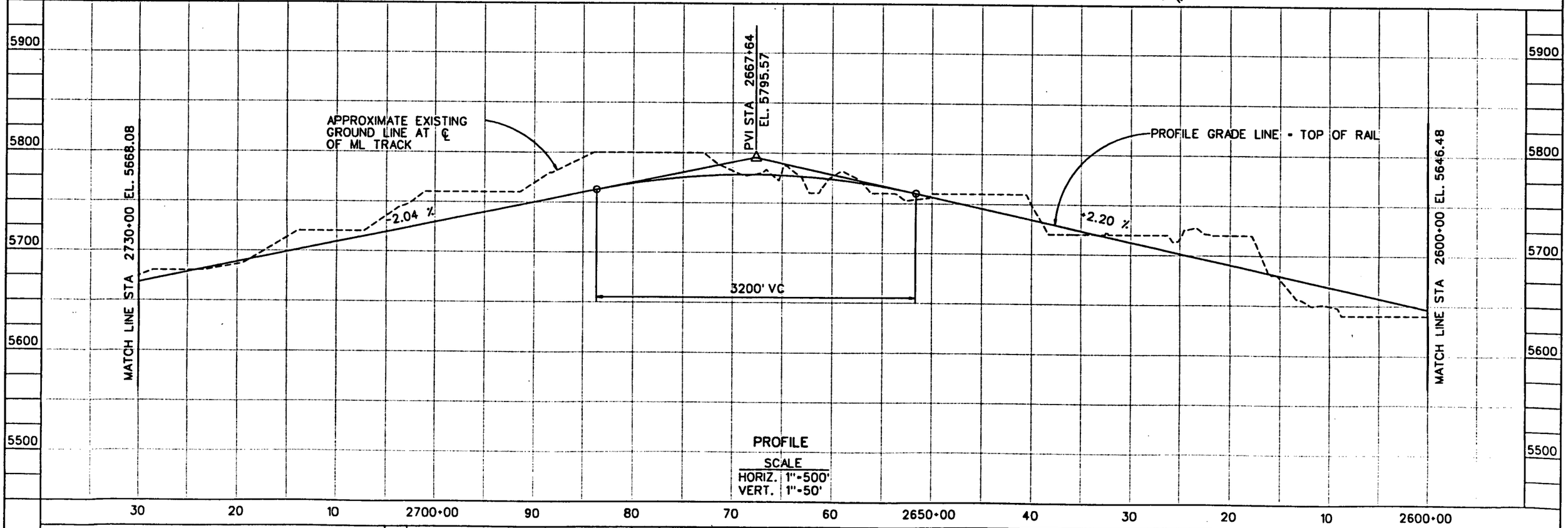
SCALE: as noted

DRAWING NO. L01-009

SHEET NO.



PLAN
CONTOUR INTERVAL - 40'
SCALE 1"=500'



PROFILE

SCALE	
HORIZ.	1"=500'
VERT.	1"=50'

REV	DESCRIPTION	DATE	BY

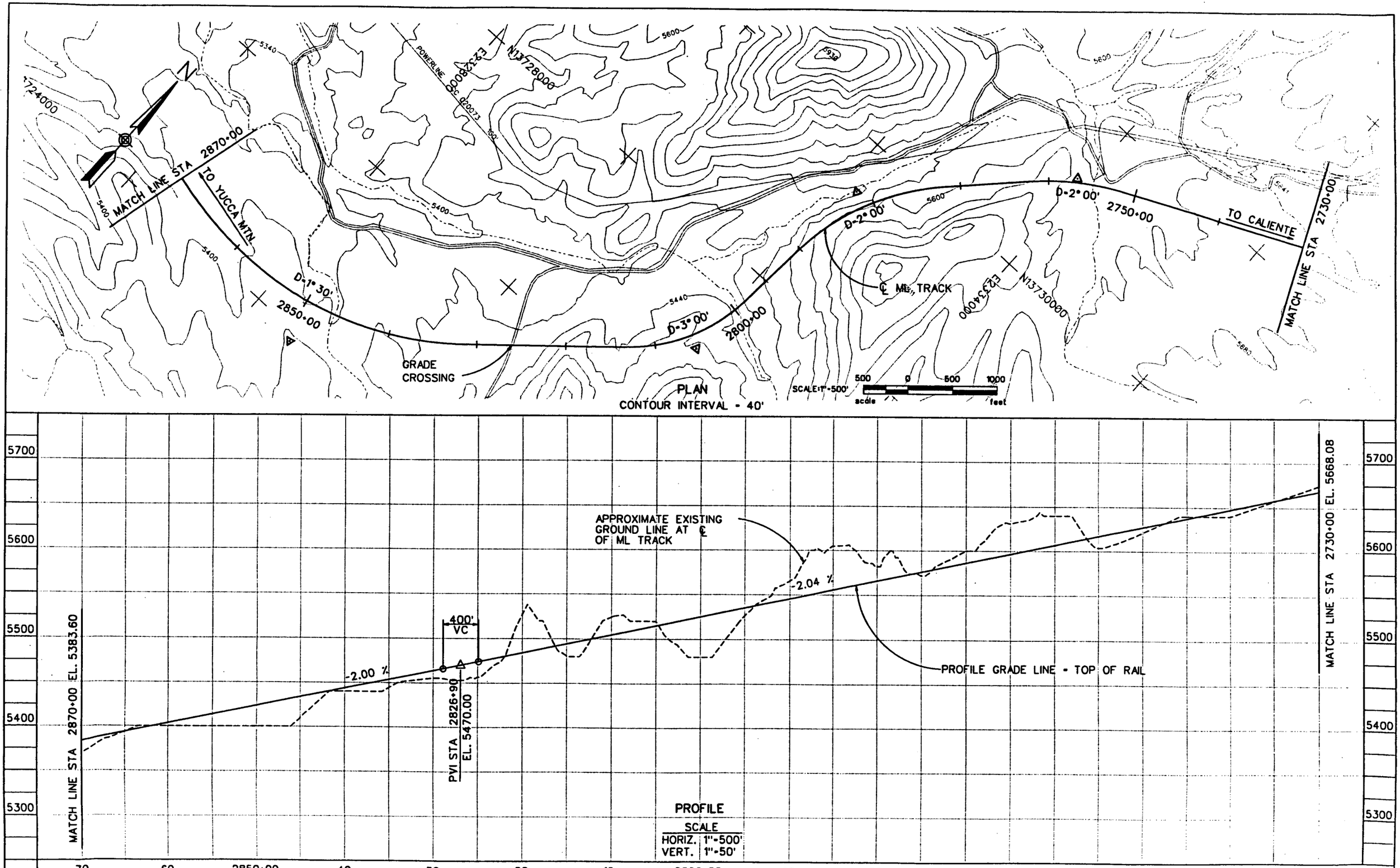
DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA 2600+00 - STA 2730+00

SCALE as noted
DRAWING NO. L01-010
SHEET NO. 10 ~ 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

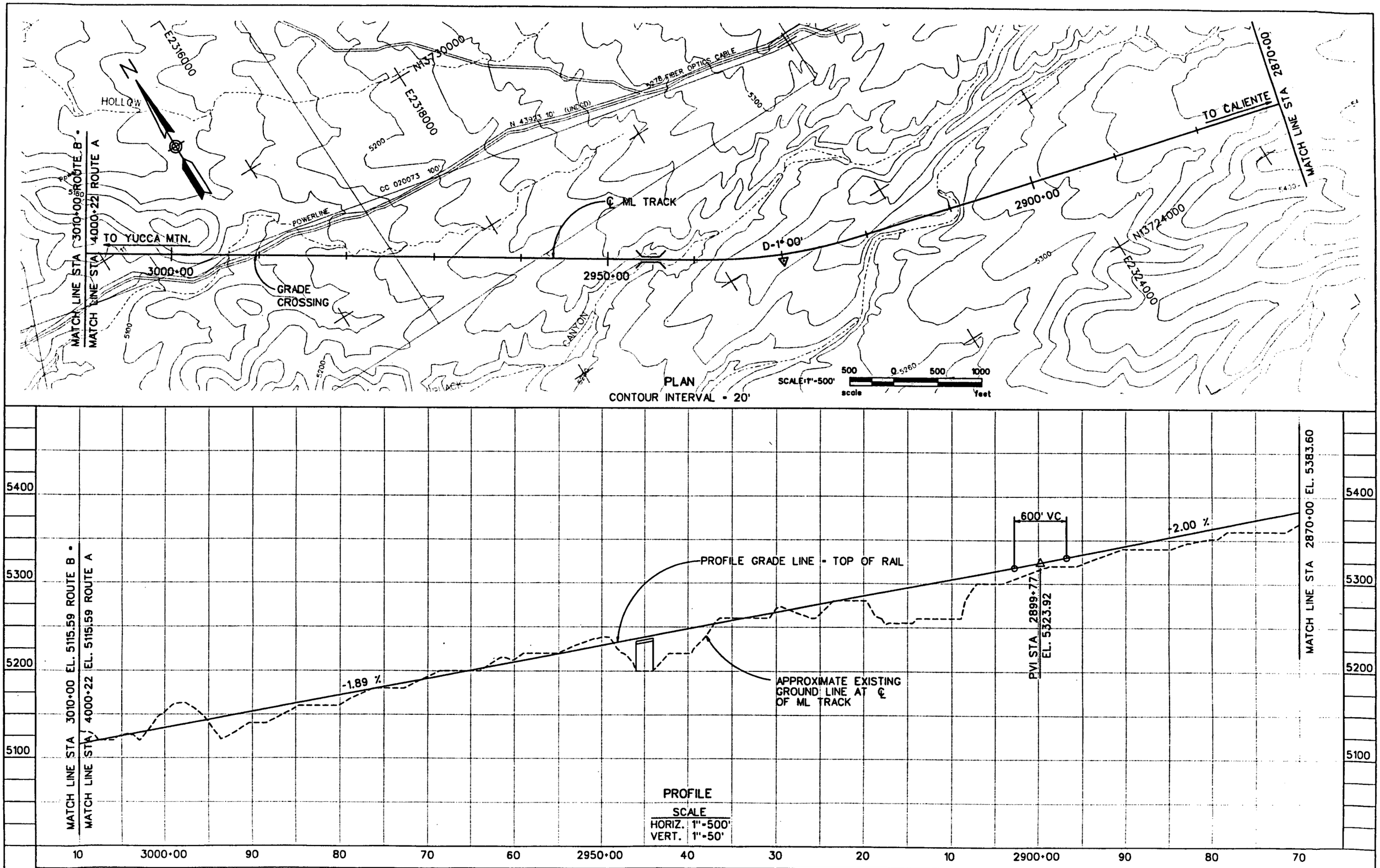
CALIENTE ROUTE PLAN & PROFILE

STA 2730+00 - STA 2870+00

SCALE as noted

DRAWING NO L01-011

SHEET NO 20 OF 192



REV	DESCRIPTION	DATE	BY

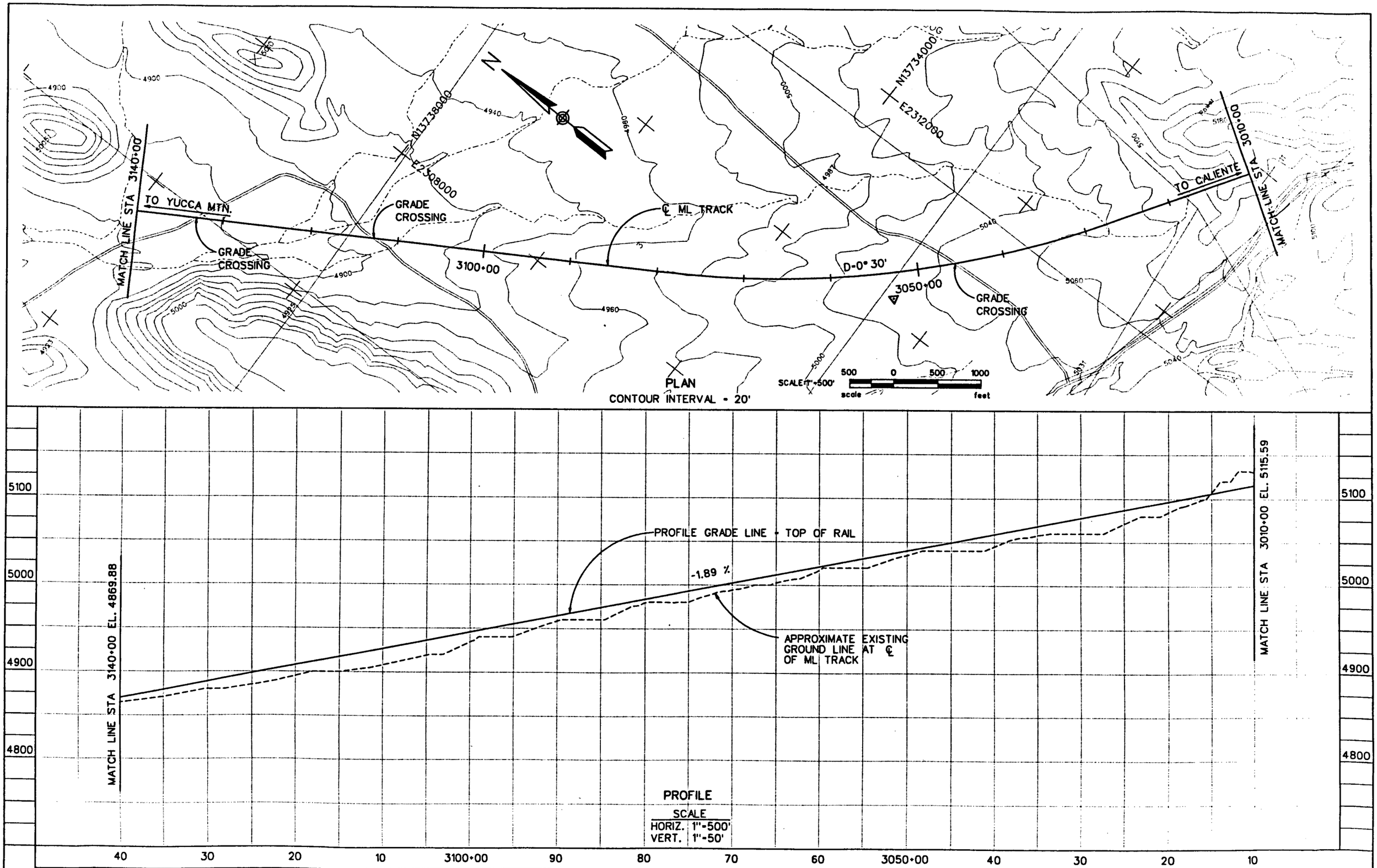
DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE

SCALE as noted
DRAWING NO. L01-012
SHEET NO. 21 of 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

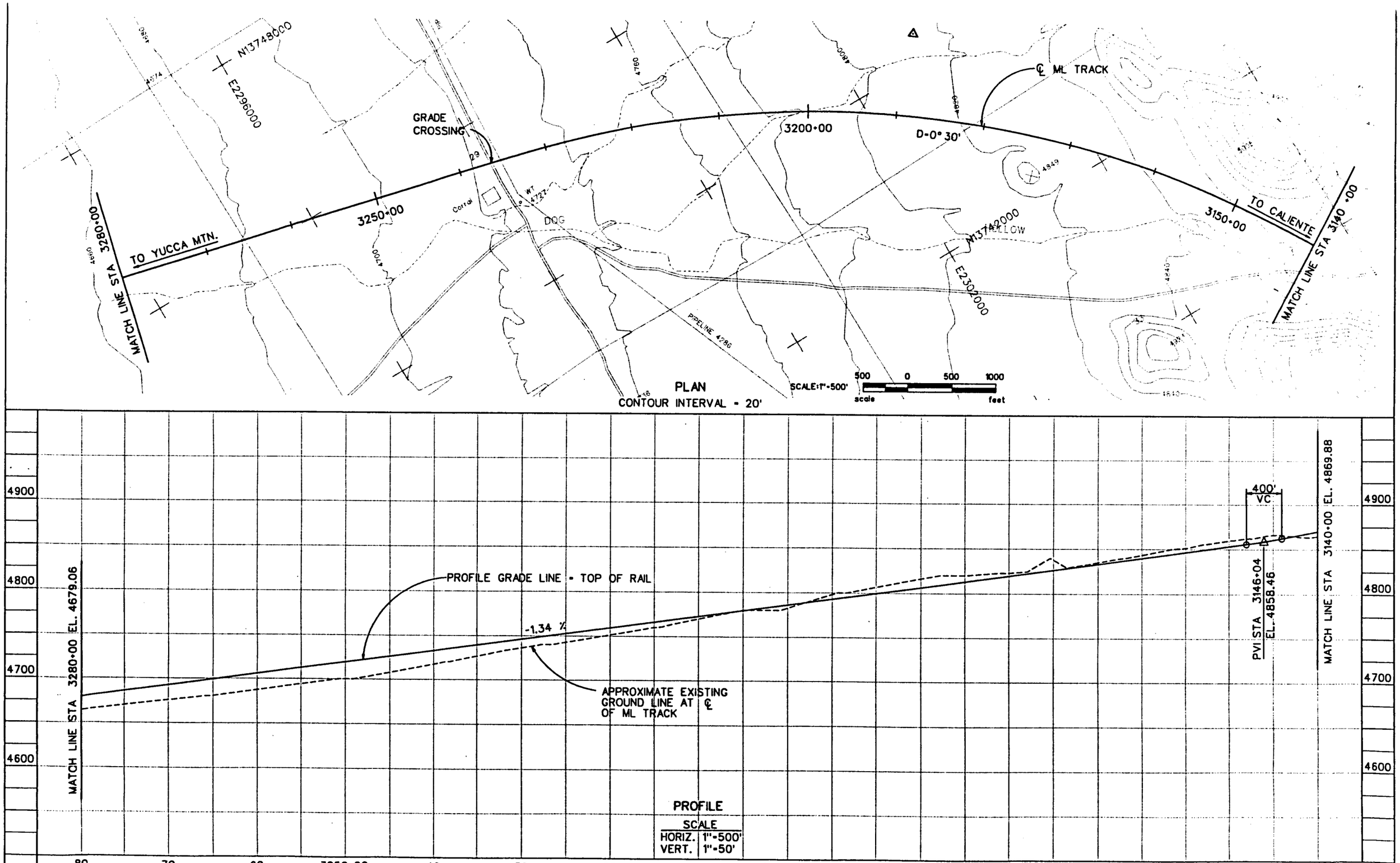
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE

SCALE as noted
DRAWING NO L01-013
SHEET NO 22 of 100

DATE PLOTTED 21-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

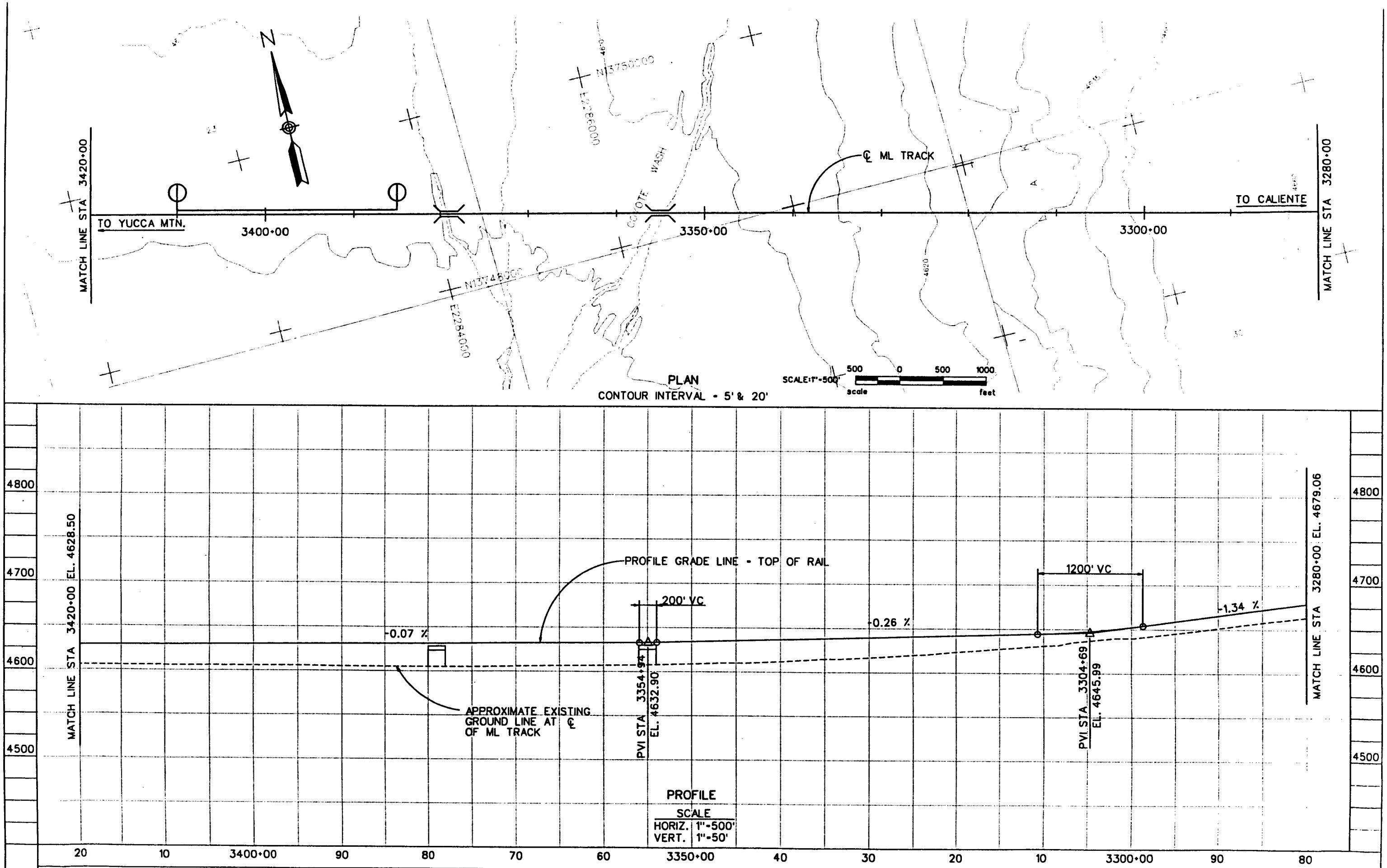
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA. 3140+00 - STA. 3280+00

SCALE: as noted
DRAWING NO. L01-014
SHEET NO. 23 OF 190

DATE PLOTTED 21-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

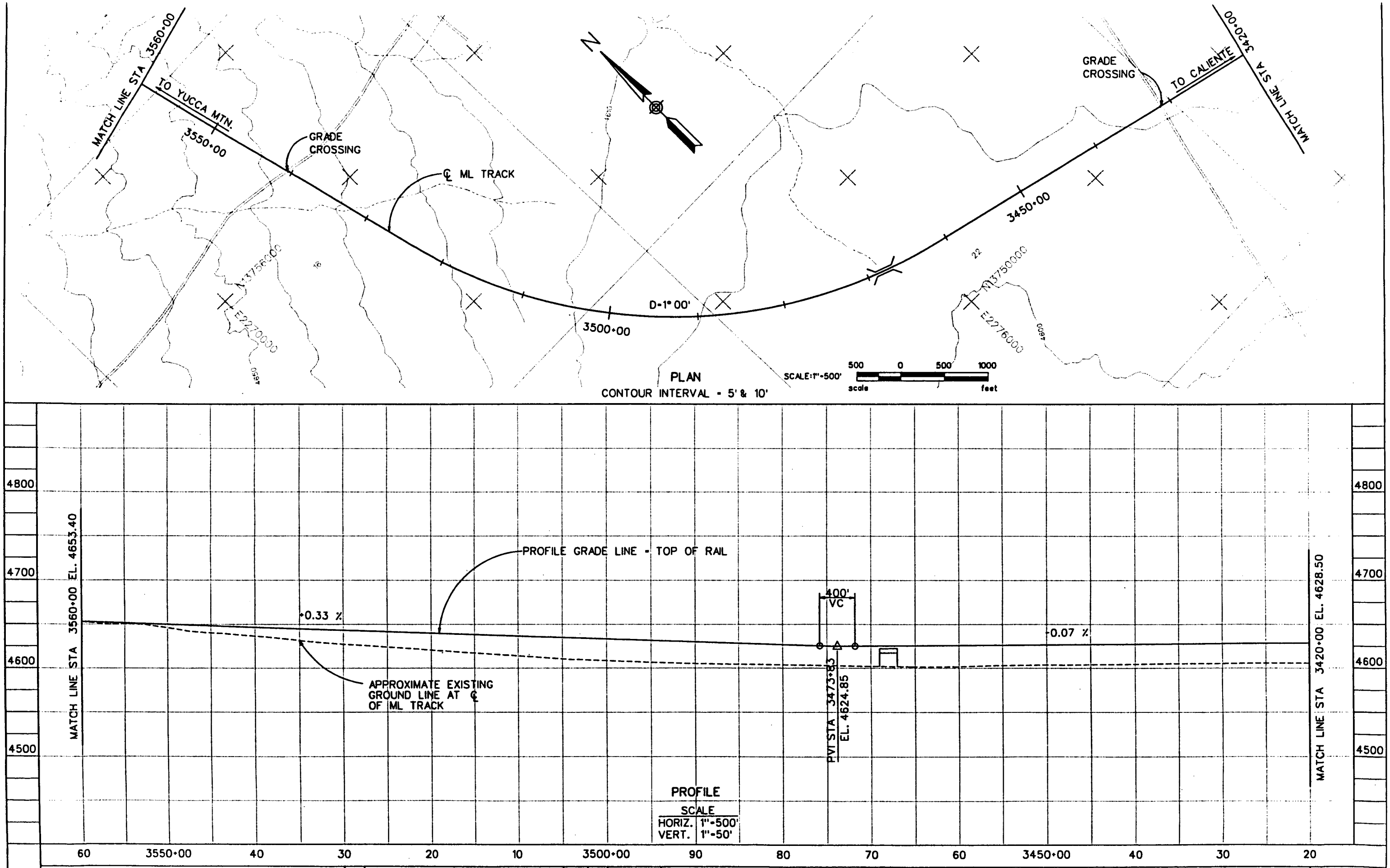
YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE

STA. 3280+00 - STA. 3420+00

SCALE as noted
DRAWING NO. L01-015
SHEET NO. 24 OF 190

DATE PLOTTED 26-FEB-1991



REV	DESCRIPTION	DATE	BY

	BY		DATE
DESIGNED	K. CHIU	02/91	
REVIEWED	A. BOLCHAZY	02/91	
APPROVED			

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

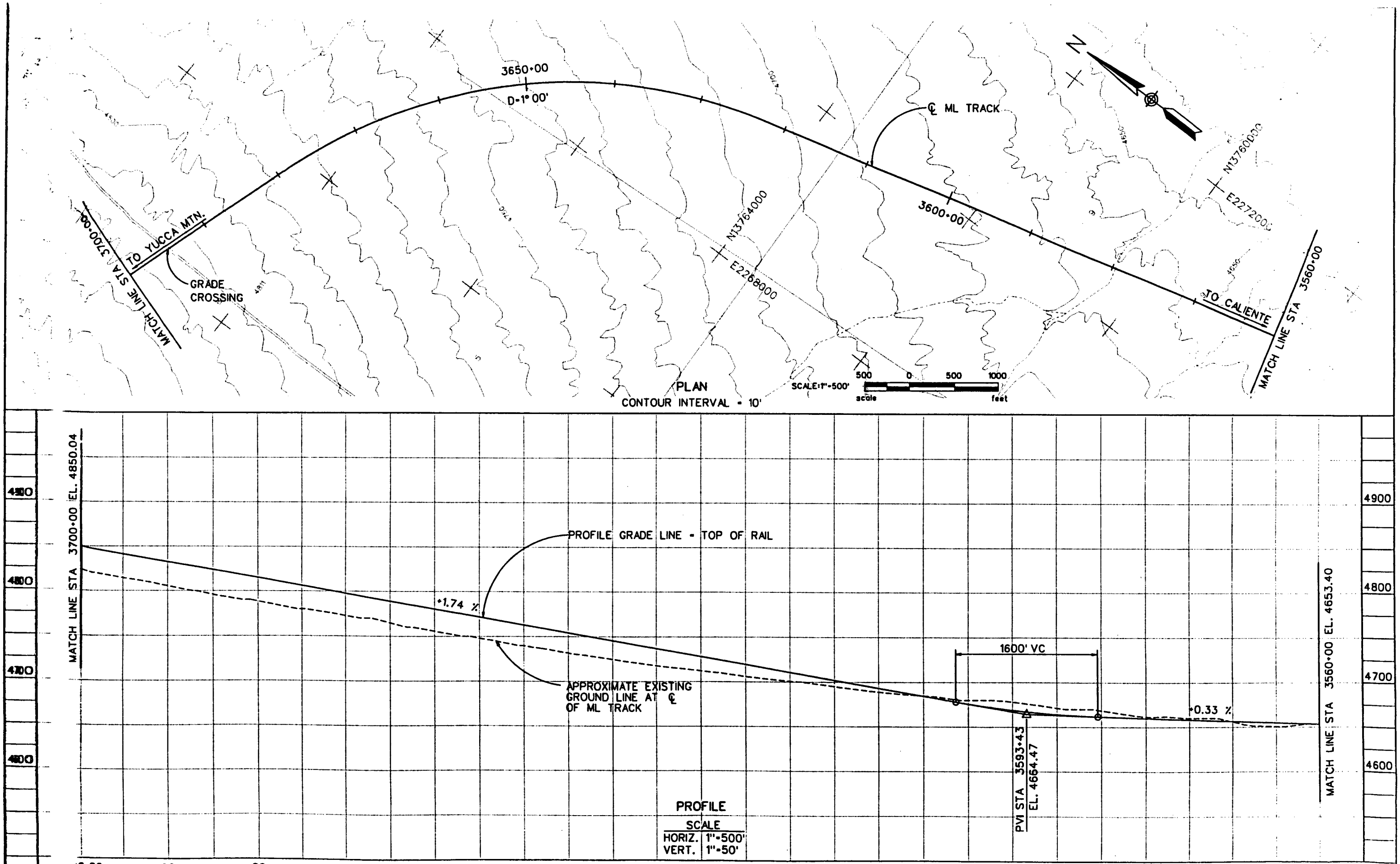
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA. 3420+00 - STA. 3560+00

SCALE: as noted
DRAWING NO. L01-016
SHEET NO. 25 OF 190

DATE PLOTTED 21-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

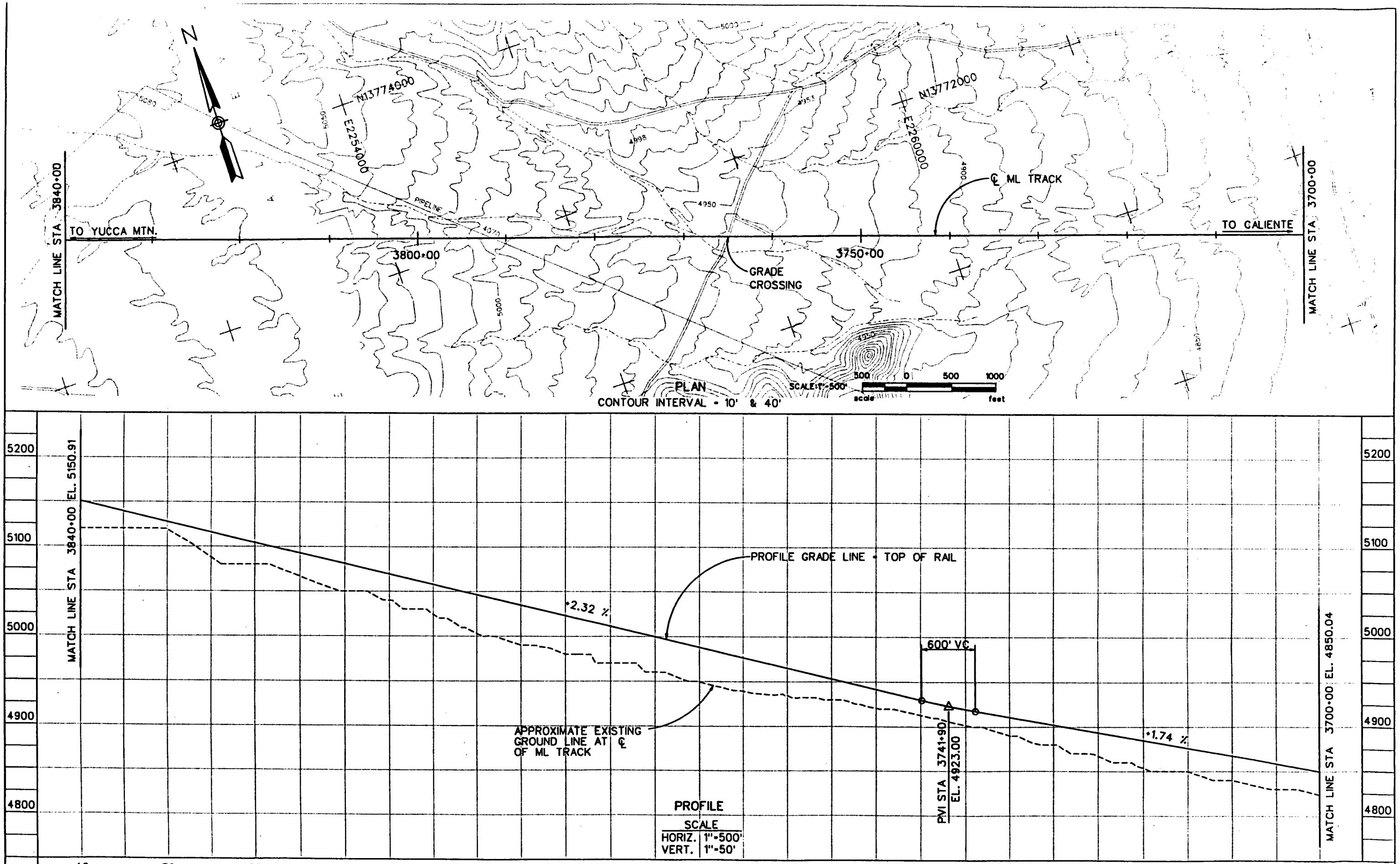
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA. 3560+00 - STA. 3700+00

SCALE: as noted
DRAWING NO. L01-017
SHEET NO. 26 of 190

DATE PLOTTED 21-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

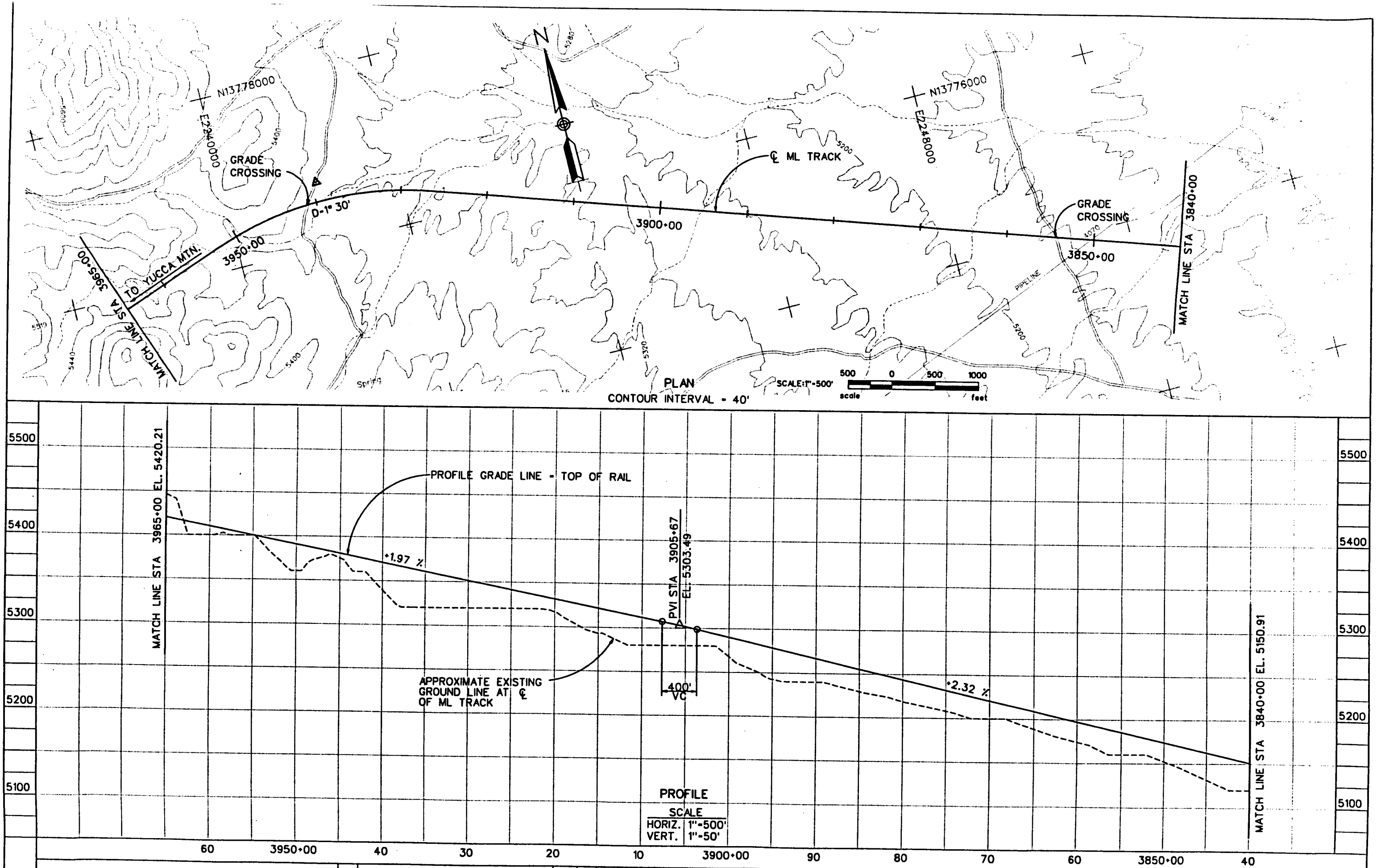
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA. 3700+00 - STA. 3840+00

SCALE: as noted
DRAWING NO. L01-018
SHEET NO. 27 OF 190

DATE PLOTTED 21-FEB-1991



REV	DESCRIPTION	DATE	BY

	BY		DATE
DESIGNED	K. CHIU	02/91	
REVIEWED	A. BOLCHAZY	02/91	
APPROVED			

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

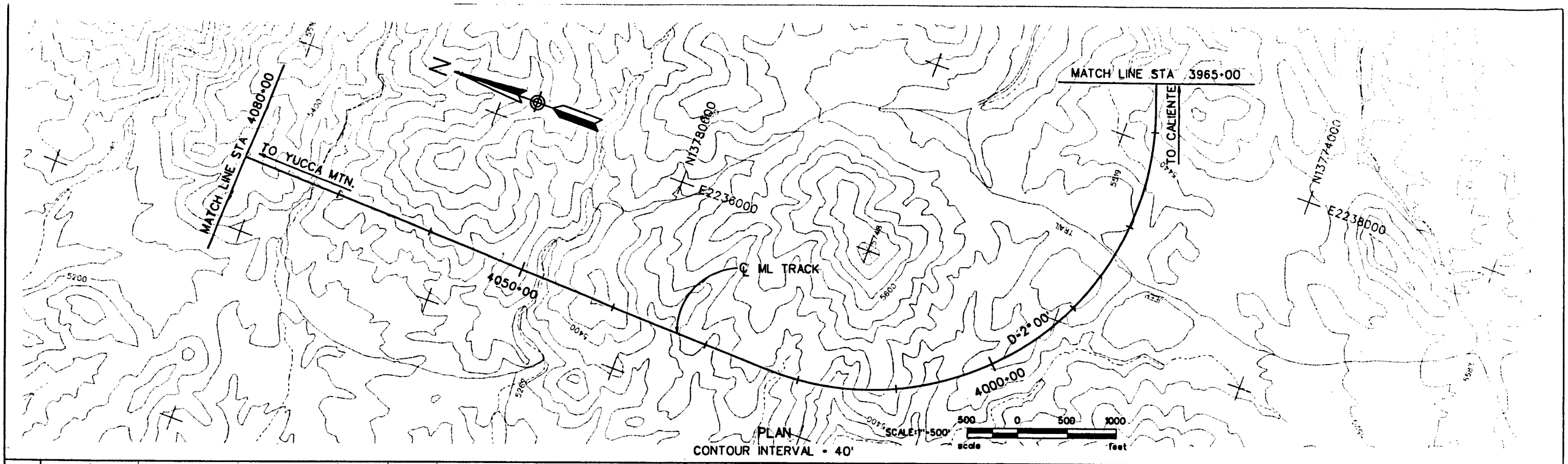
YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE

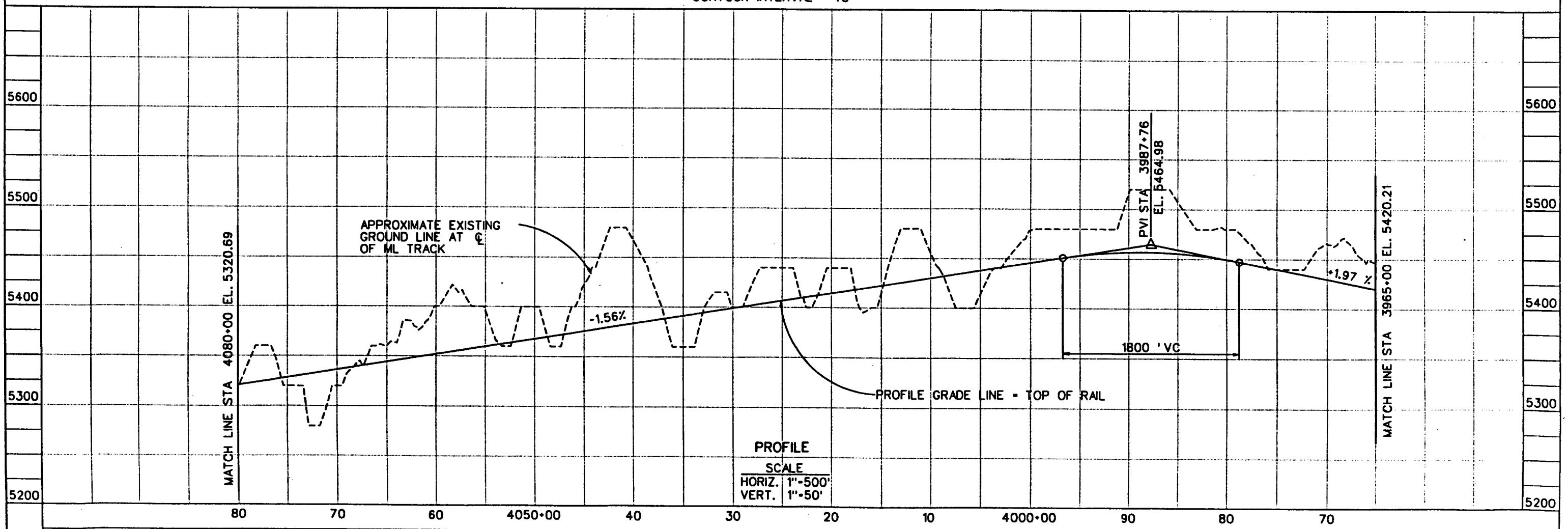
STA 3840+00 - STA 3965+00

SCALE: as noted
DRAWING NO. L01-019
SHEET NO. 28 of 190

DATE PLOTTED 21-FEB-1991



PLAN
CONTOUR INTERVAL = 40'



PROFILE
SCALE
HORIZ. 1"=500'
VERT. 1"=50'

REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

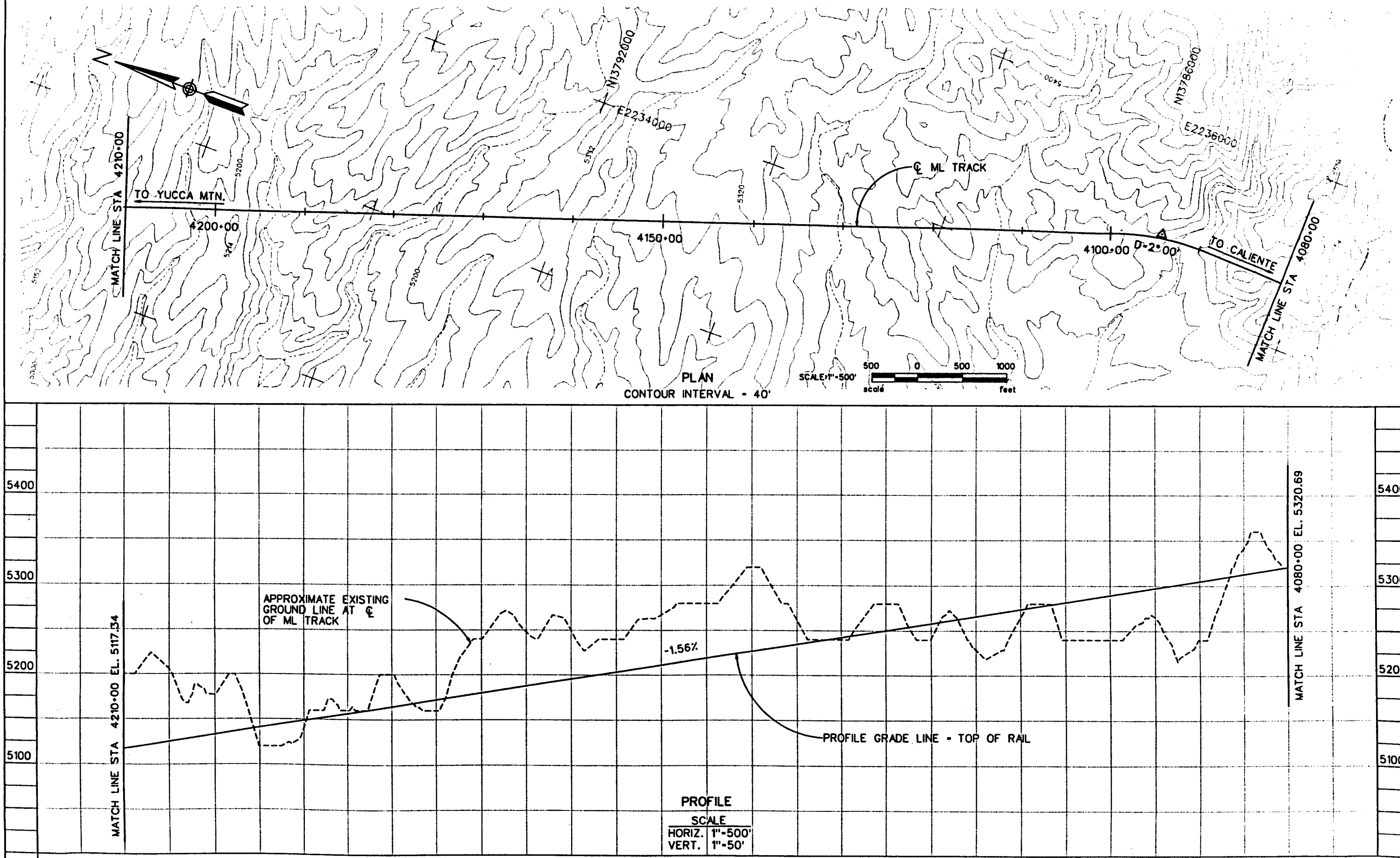
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA. 3965+00 - STA. 4080+00

SCALE as noted
DRAWING NO. L01-020
SHEET NO. 29 OF 190

DATE PLOTTED 21-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

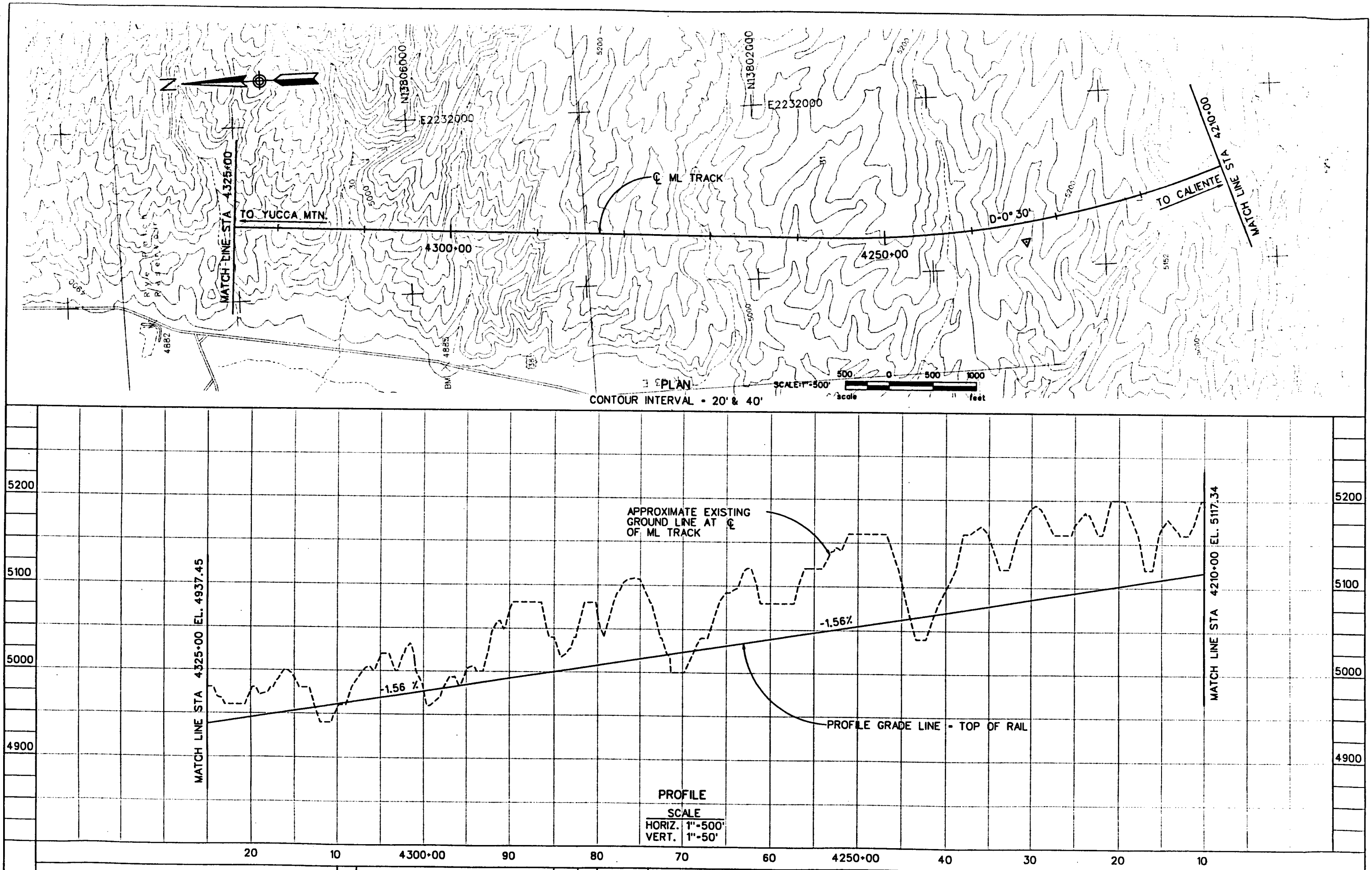
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA. 4080+00 - STA. 4210+00

SCALE as noted
DRAWING NO L01-021
SHEET NO 30 OF 190

DATE PLOTTED 21-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

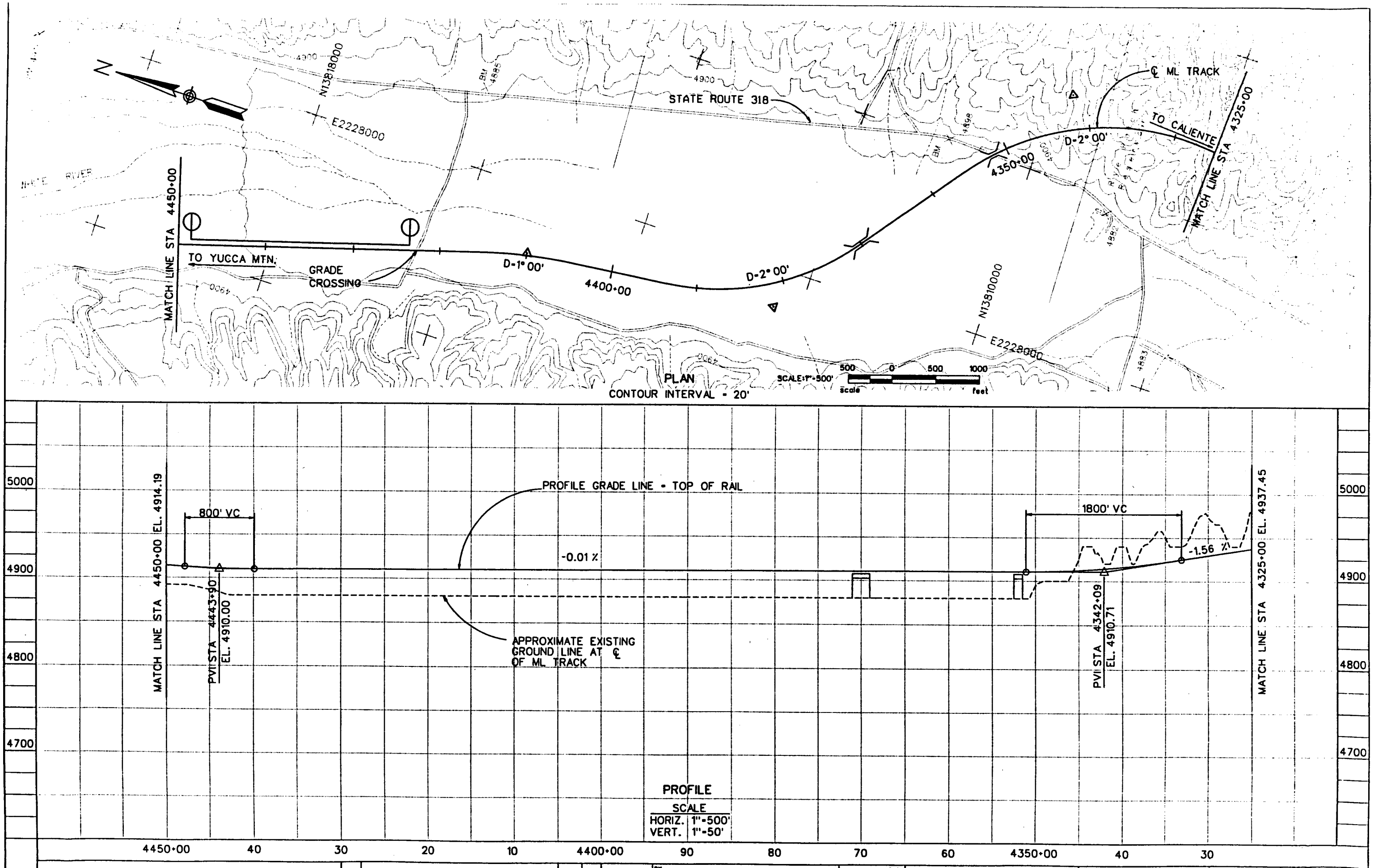
CALIENTE ROUTE - ROUTE B PLAN & PROFILE

SCALE as noted

DRAWING NO. L01-022

SHEET NO.

DATE PLOTTED 21-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

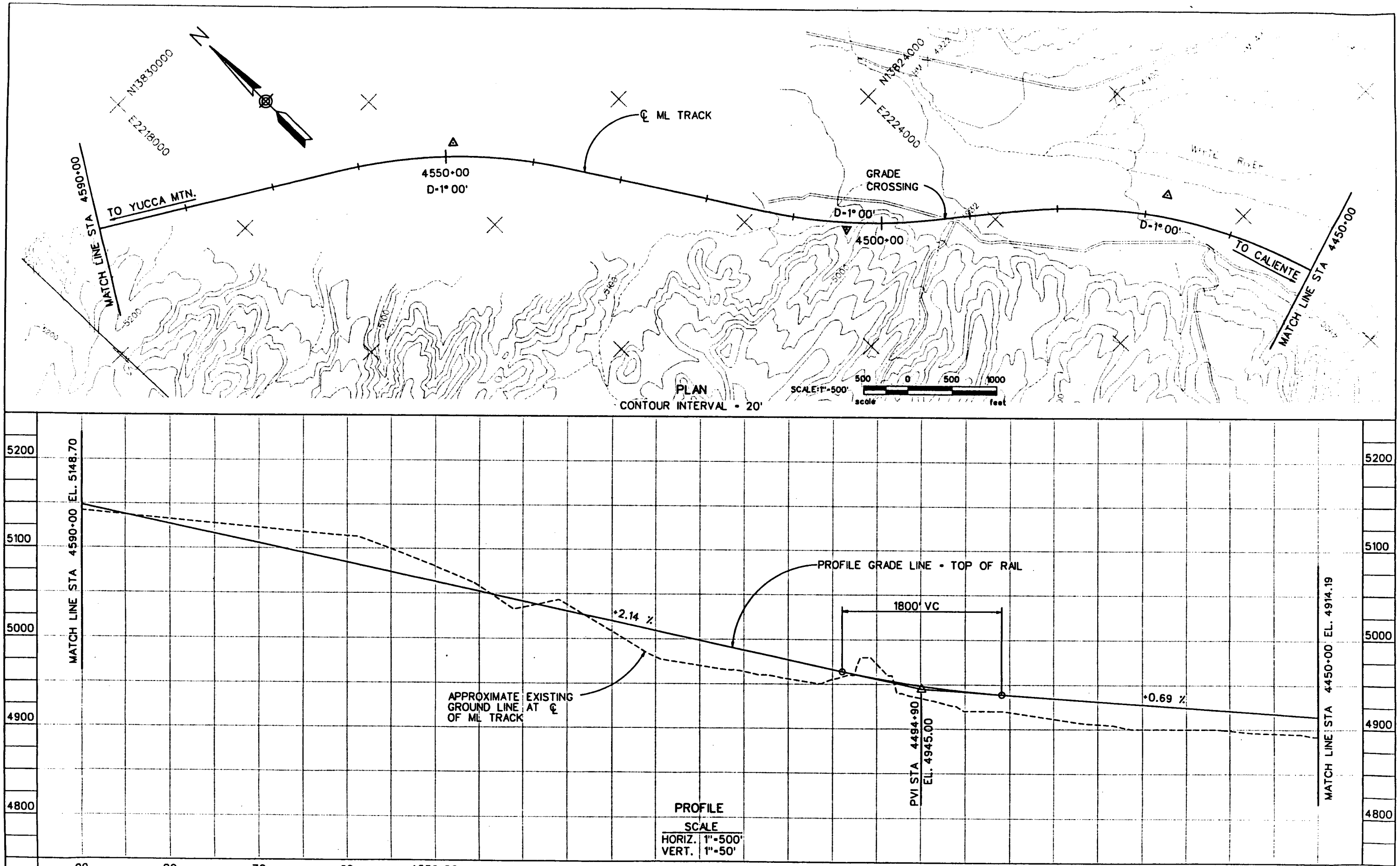
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA. 4325+00 - STA. 4450+00

SCALE as noted
DRAWING NO. L01-023
SHEET NO. 32 OF 190

DATE PLOTTED 25-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE

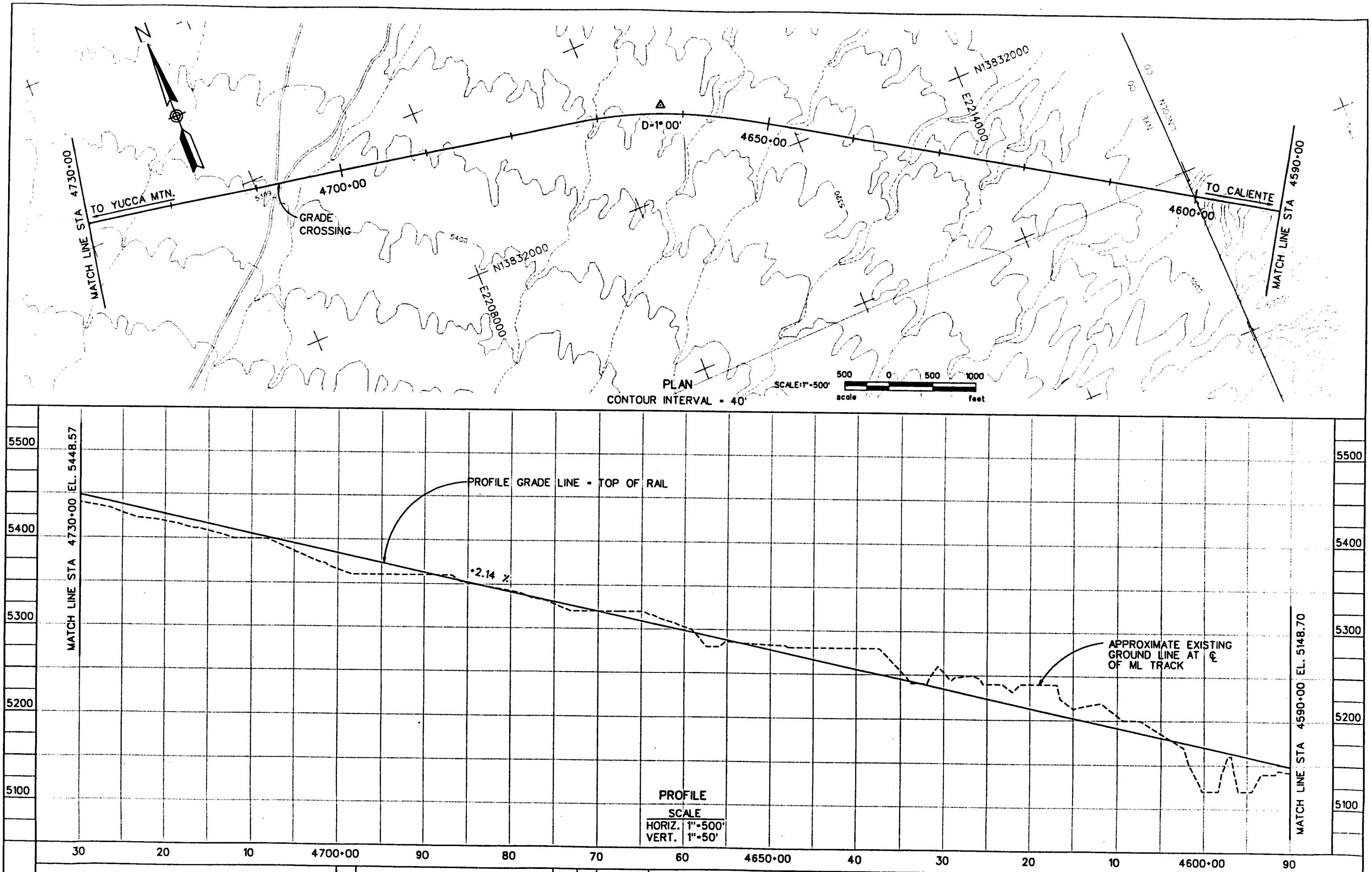
STA 4450+00 - STA 4590+00

SCALE: as noted

DRAWING NO. L01-024

SHEET NO. 23 OF 190

DATE PLOTTED 21-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

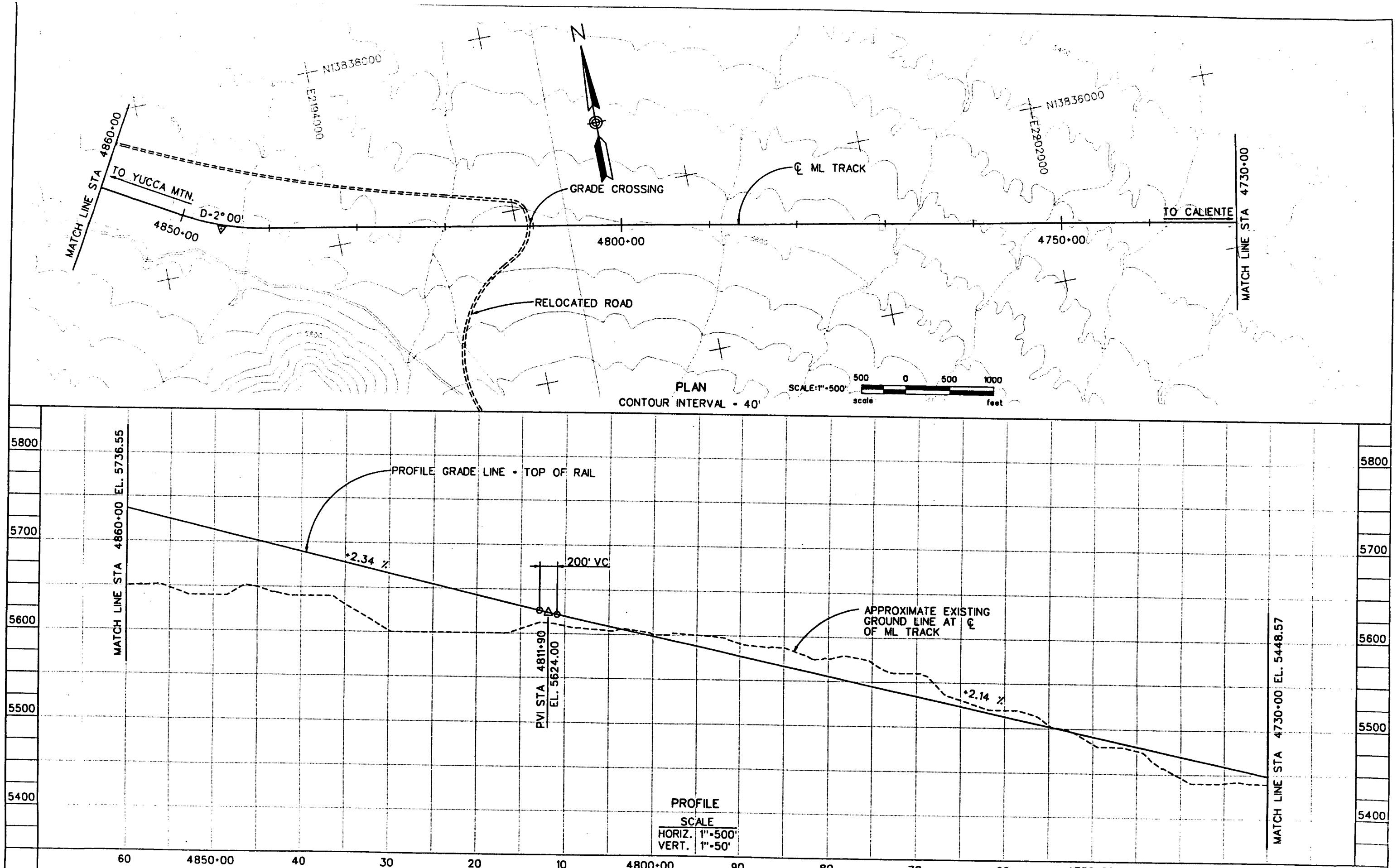
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA. 4590+00 - STA. 4730+00

SCALE as noted
DRAWING NO. L01-025
SHEET NO. 34 of 190

DATE PLOTTED 21-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B PLAN & PROFILE

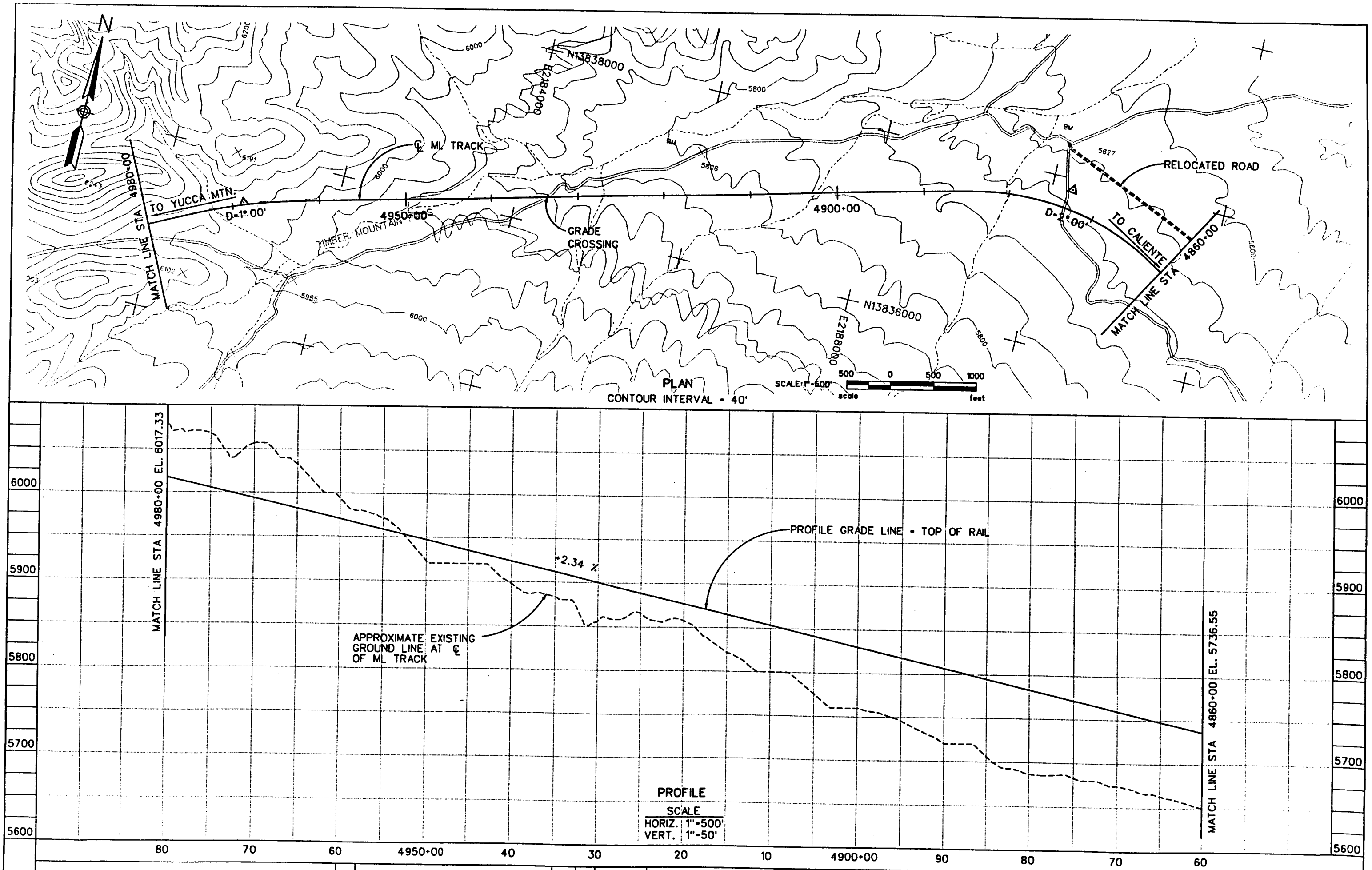
STA. 4730+00 - STA. 4860+00

SCALE: as noted

DRAWING NO. L01-026

SHEET NO. 35 OF 190

DATE PLOTTED 25-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

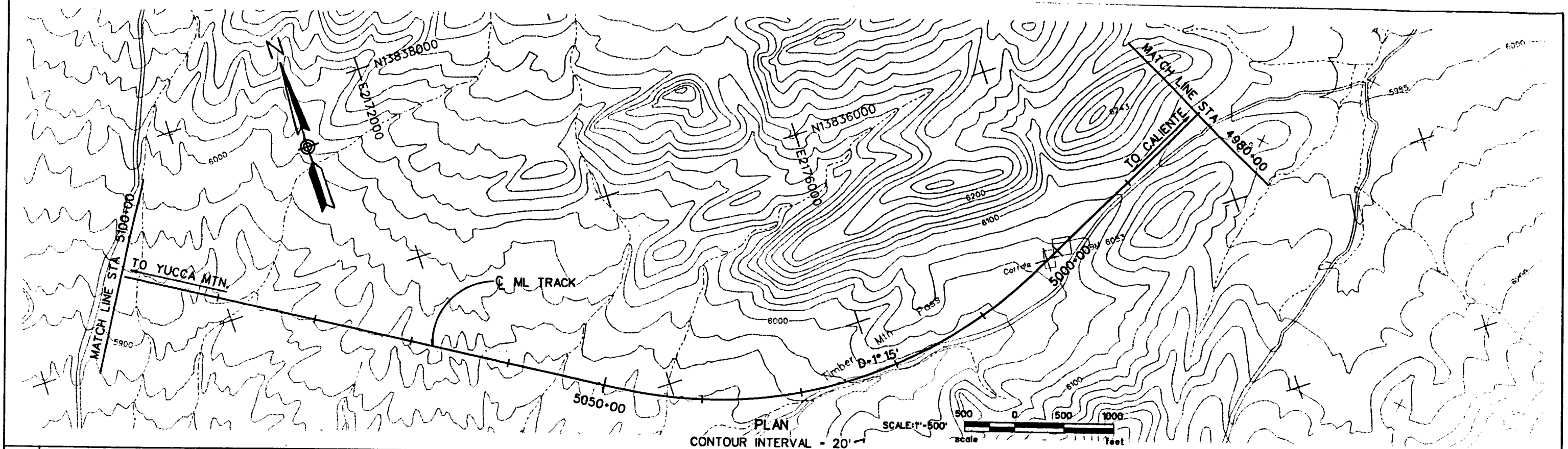
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

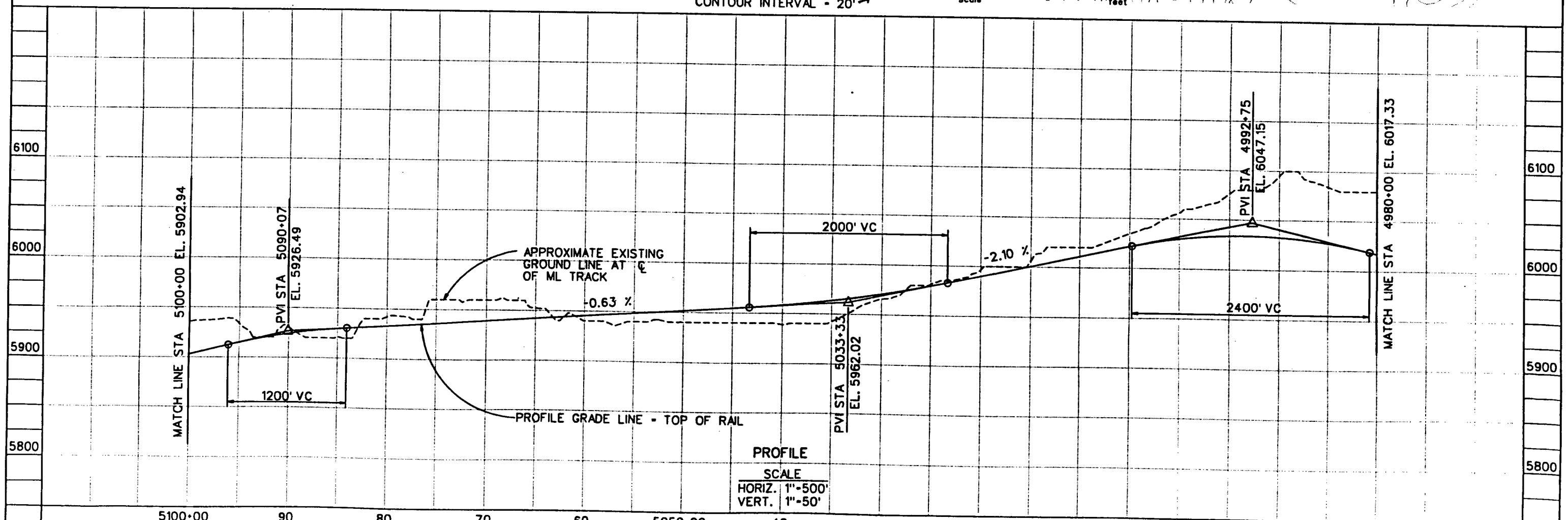
CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA 4860+00 - STA 4980+00

SCALE: as noted
DRAWING NO. L01-027
SHEET NO. 2 of 192



PLAN

CONTOUR INTERVAL - 20'



PROFILE

SCALE	
HORIZ.	1"=500'
VERT.	1"=50'

REV	DESCRIPTION	DATE	BY

	BY	DATE
DESIGNED	K. CHIU	02/91
REVIEWED	A. BOLCHAZY	02/91
APPROVED		

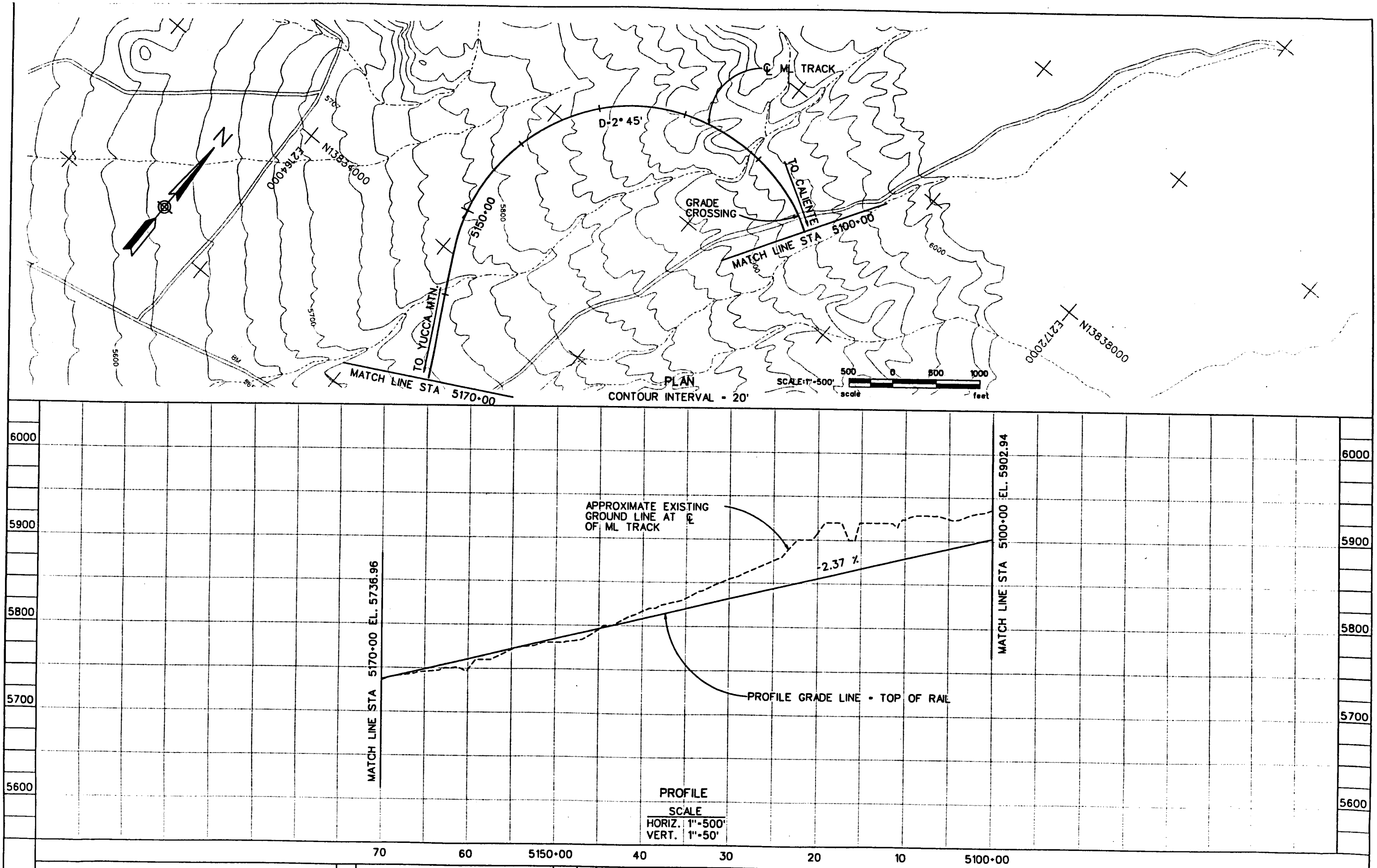
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA. 4980+00 - STA. 5100+00

SCALE: as noted
DRAWING NO. L01-028
SHEET NO. 37 of 190



REV	DESCRIPTION	DATE	BY

	BY		DATE
DESIGNED	K. CHIU	02/91	
REVIEWED	A. BOLCHAZY	02/91	
APPROVED			

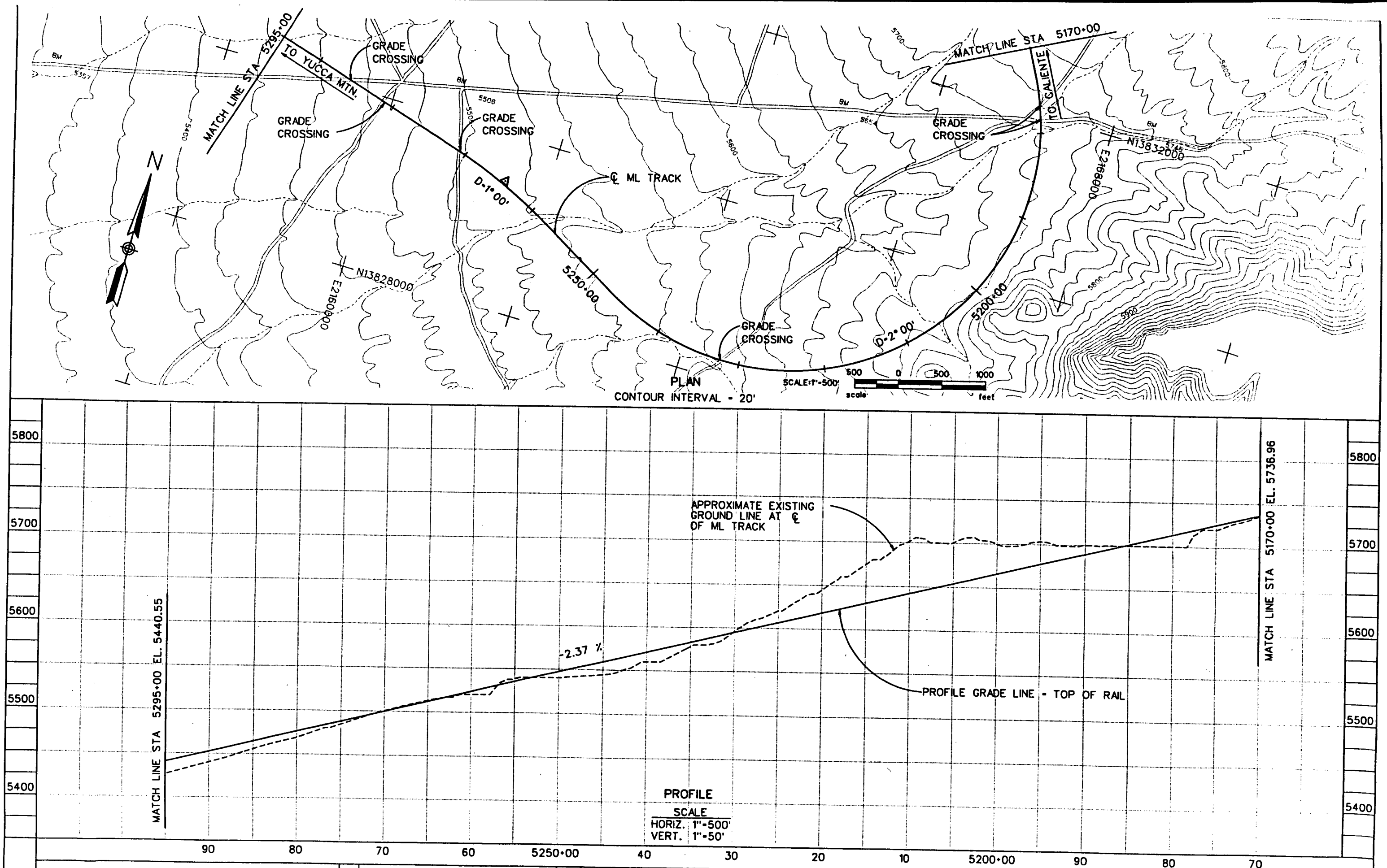
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA. 5100+00 - STA. 5170+00

SCALE: as noted
DRAWING NO. L01-029
SHEET NO. 38 of 191



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

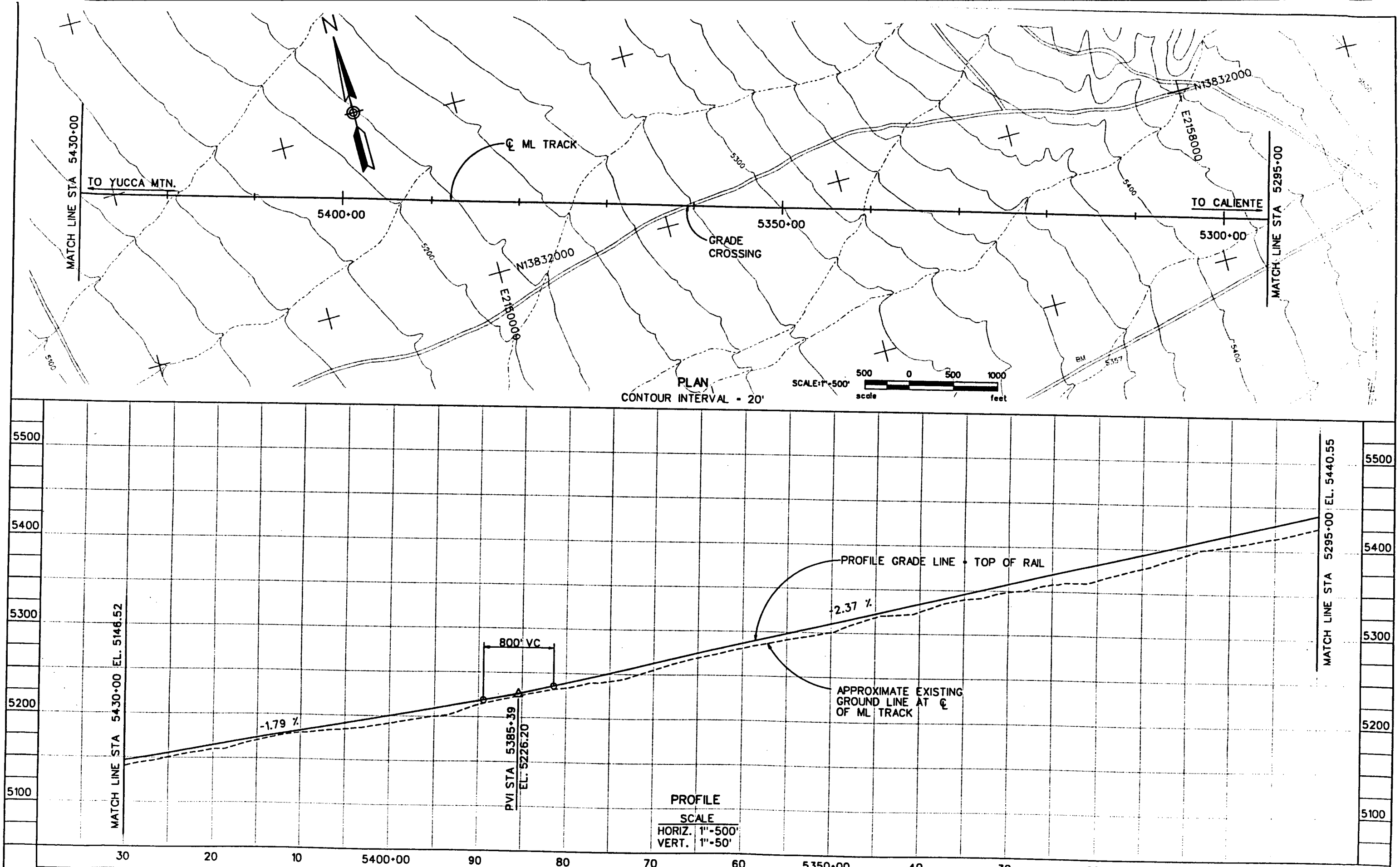
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA. 5170+00 - STA. 5295+00

SCALE: as noted
DRAWING NO: L01-030
SHEET NO: 39 OF 190

Project No. PI-4551



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

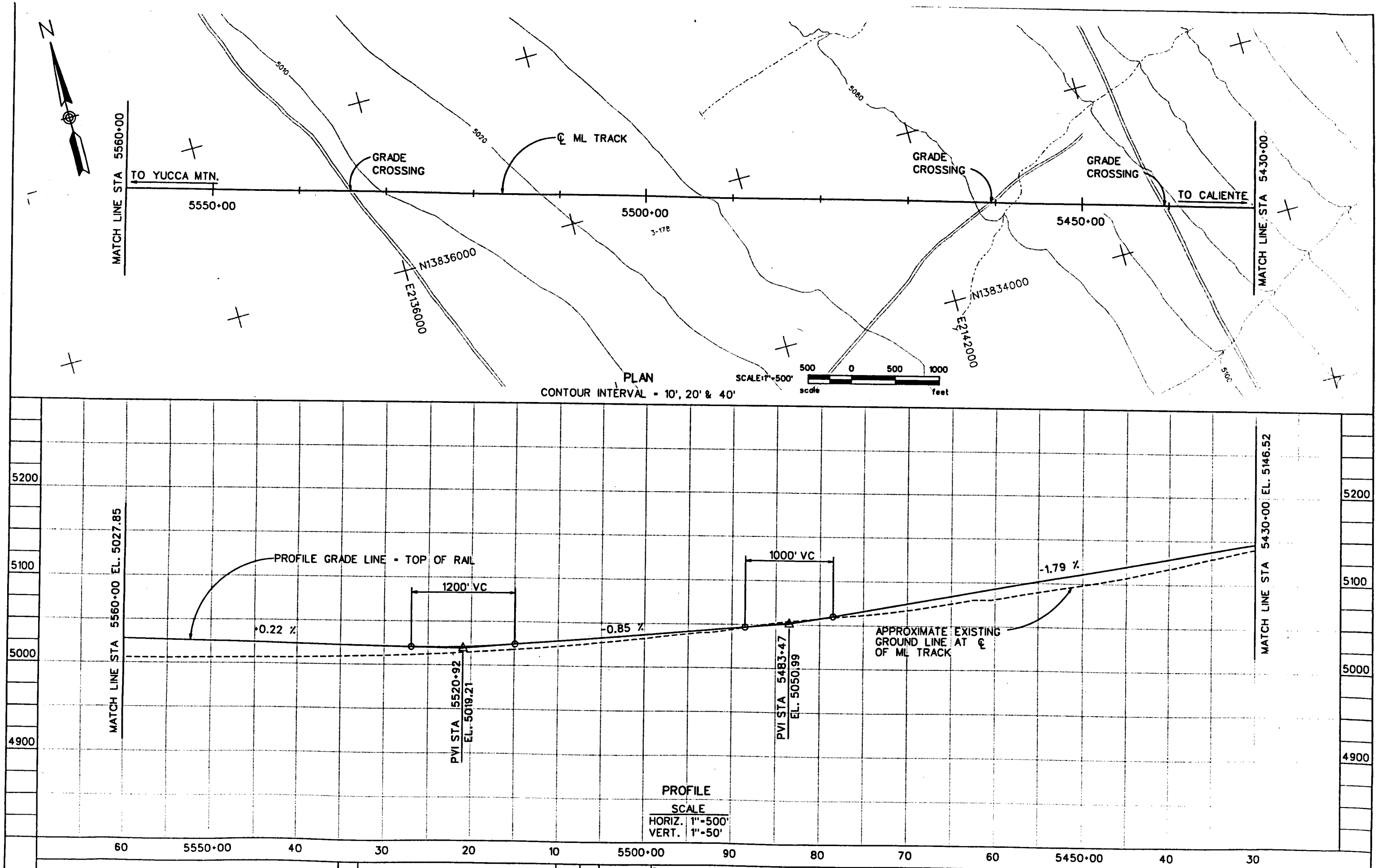
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA. 5295+00 - STA. 5430+00

SCALE: as noted
DRAWING NO. L01-031
SHEET NO. 40 OF 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

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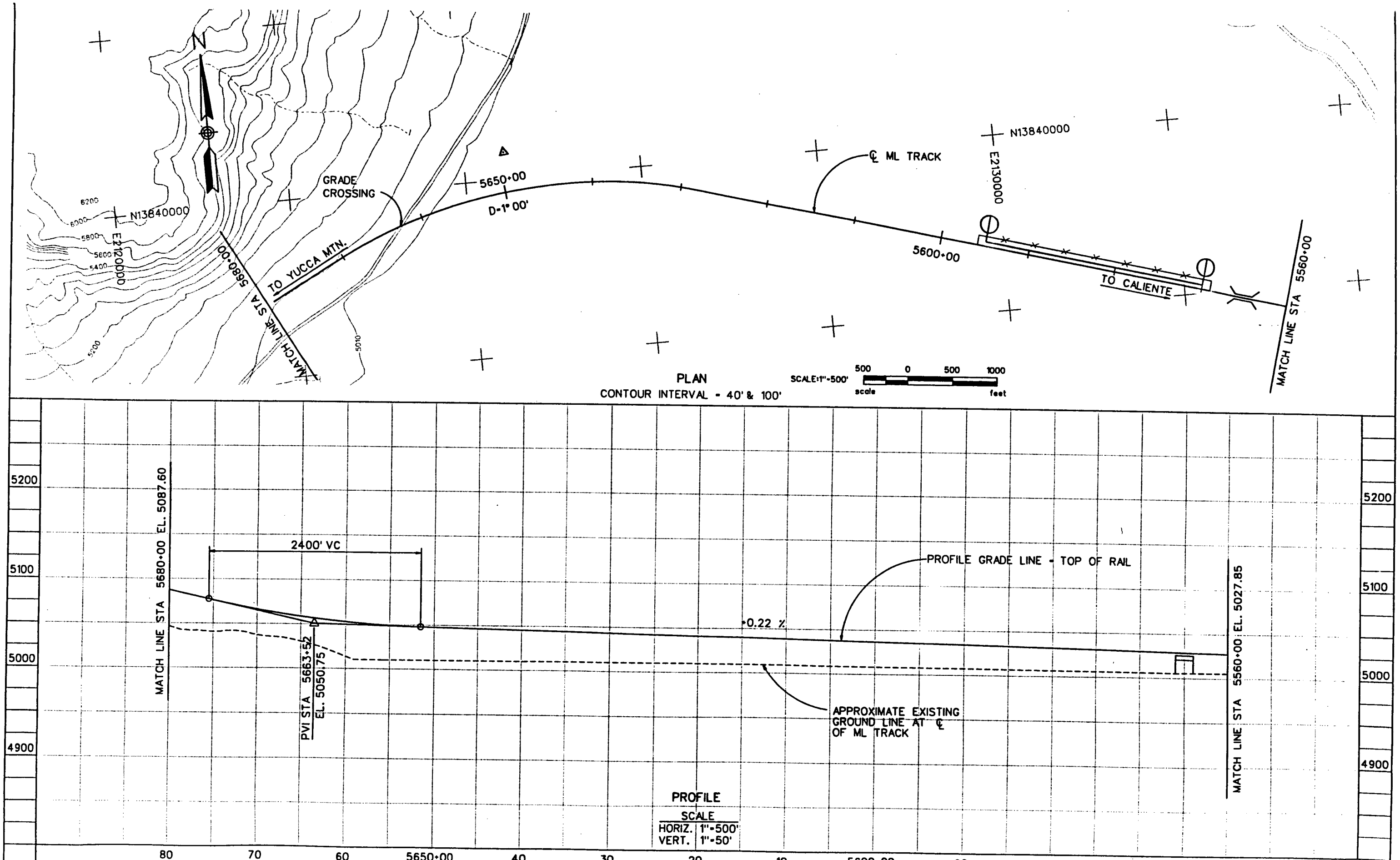
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA. 5430+00 - STA. 5560+00

SCALE: as noted
DRAWING NO: L01-032
SHEET NO: 41 OF 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

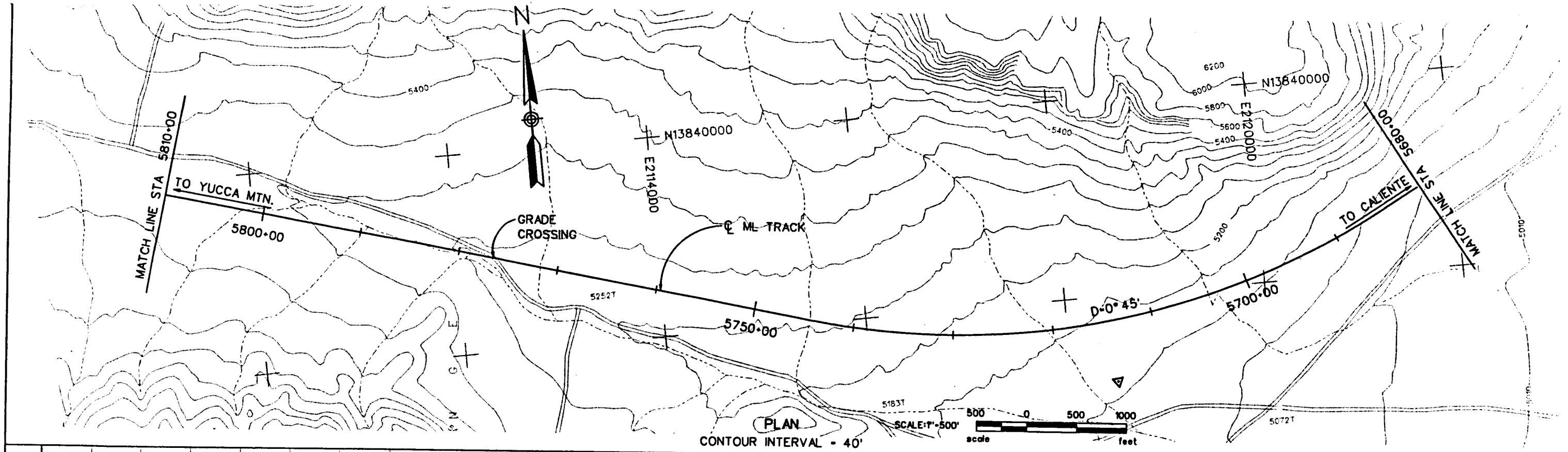
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

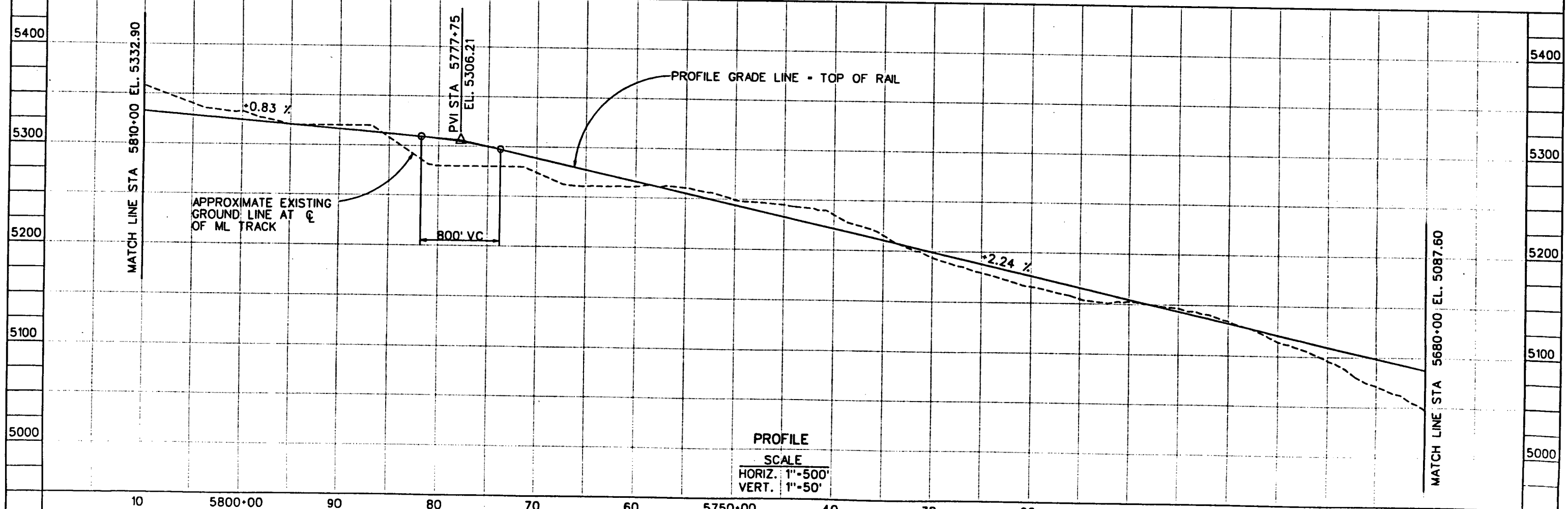
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA. 5560+00 - STA. 5680+00

SCALE as noted
DRAWING NO L01-033
SHEET NO 42 OF 190





REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

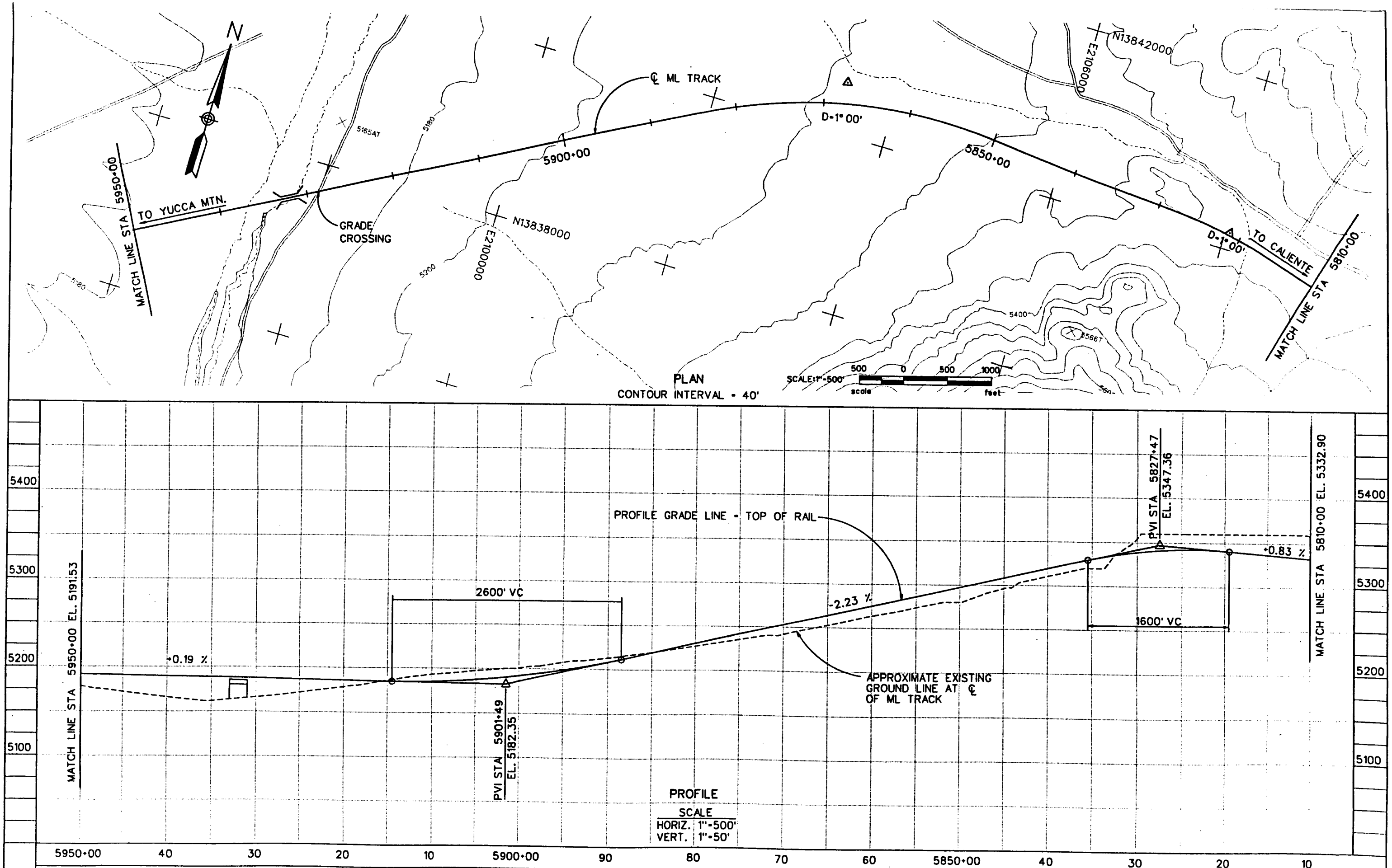
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA. 5680+00 - STA. 5810+00

SCALE: as noted
DRAWING NO: L01-034
SHEET NO: 43 OF 190

Project No 1(4155)



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

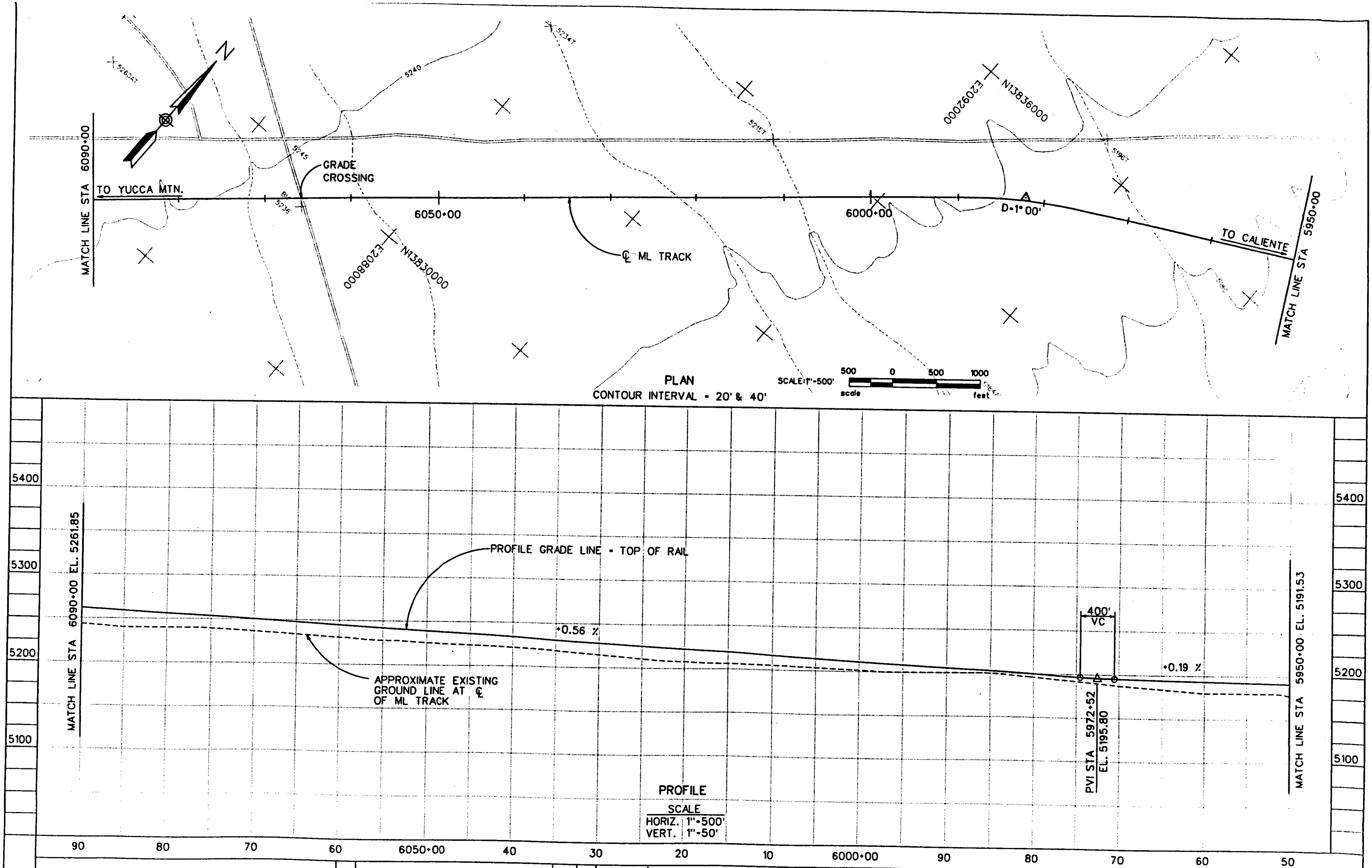
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA. 5810+00 - STA. 5950+00

SCALE as noted
DRAWING NO L01-035
SHEET NO 44 OF 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

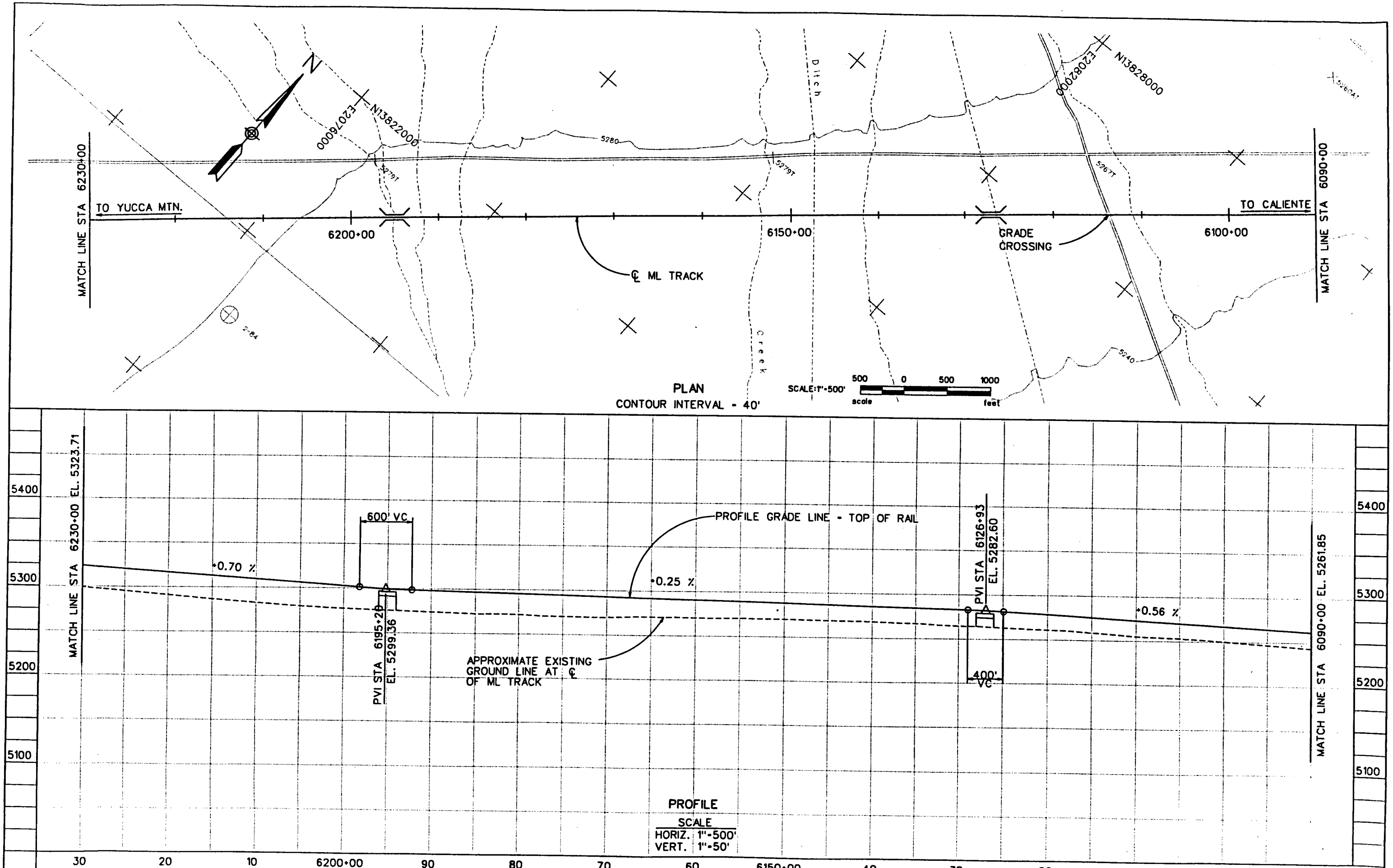
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA. 5950+00 - STA. 6090+00

SCALE: as noted
DRAWING NO: L01-036
SHEET NO: 4 of 19



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

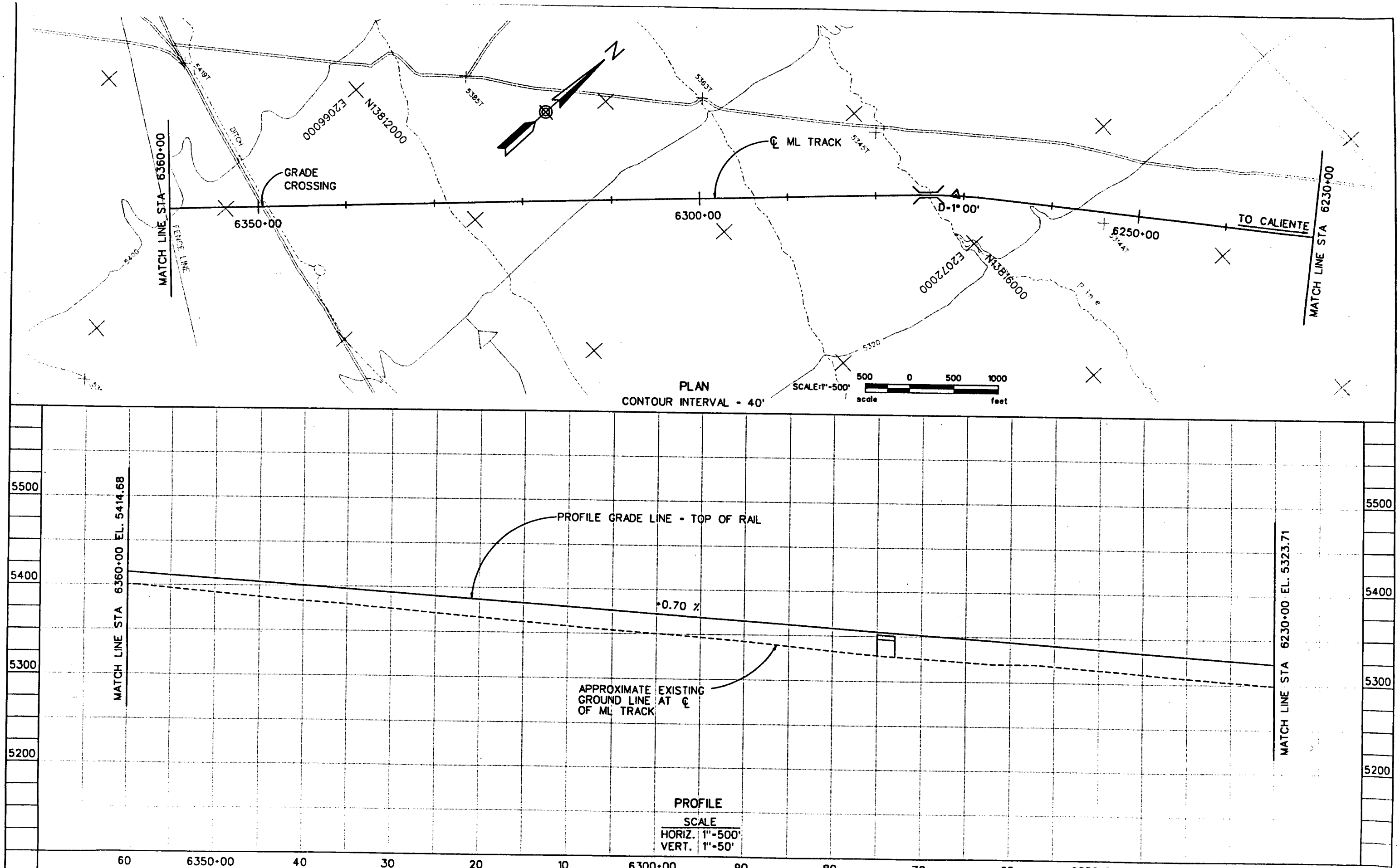
CALIENTE ROUTE - ROUTE B PLAN & PROFILE

STA 6090+00 - STA 6230+00

SCALE: as noted

DRAWING NO: L01-037

SHEET NO: 4/ ~ 10



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

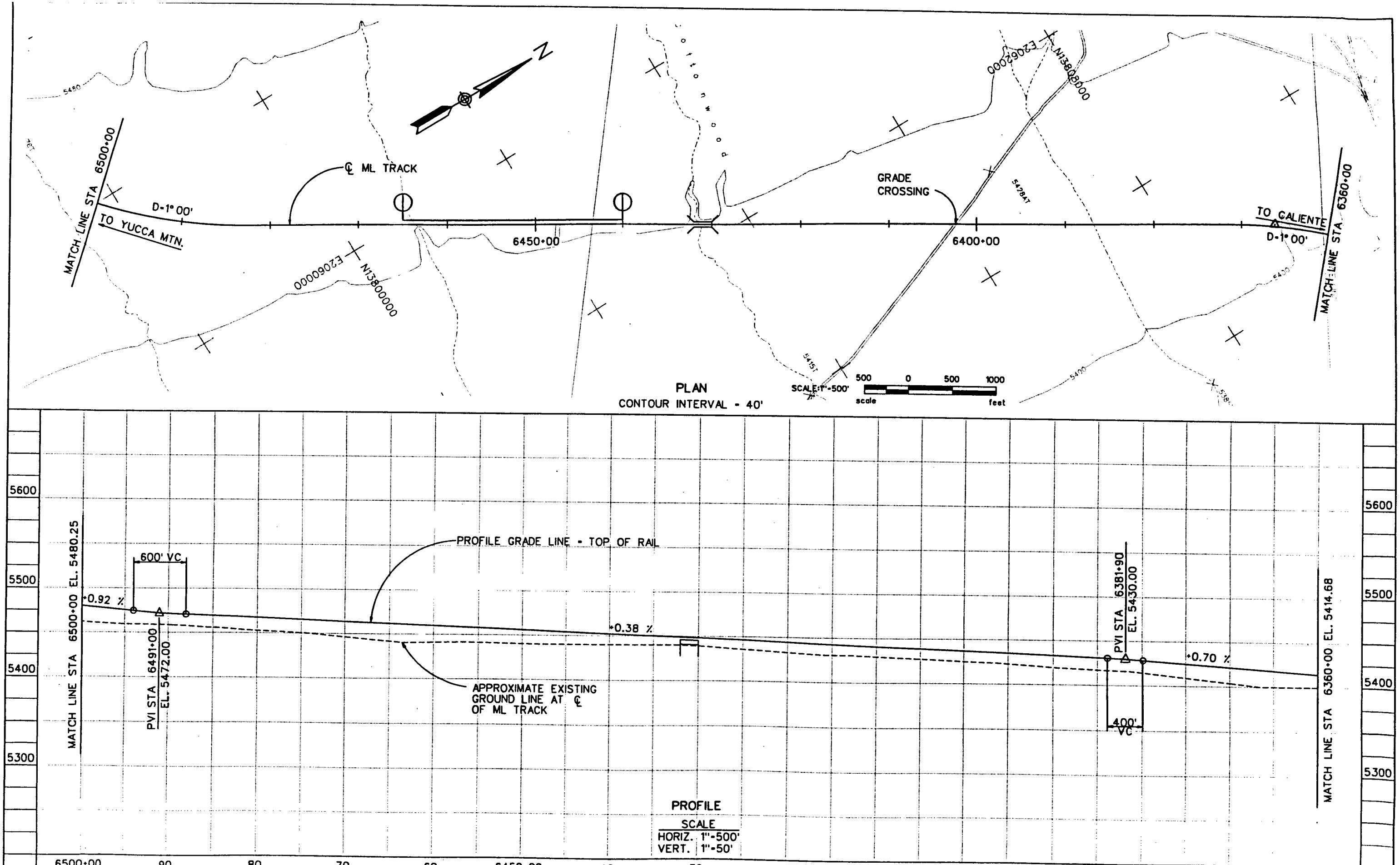
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA. 6230+00 - STA. 6360+00

SCALE as noted
DRAWING NO L01-038
SHEET NO 47 OF 19



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

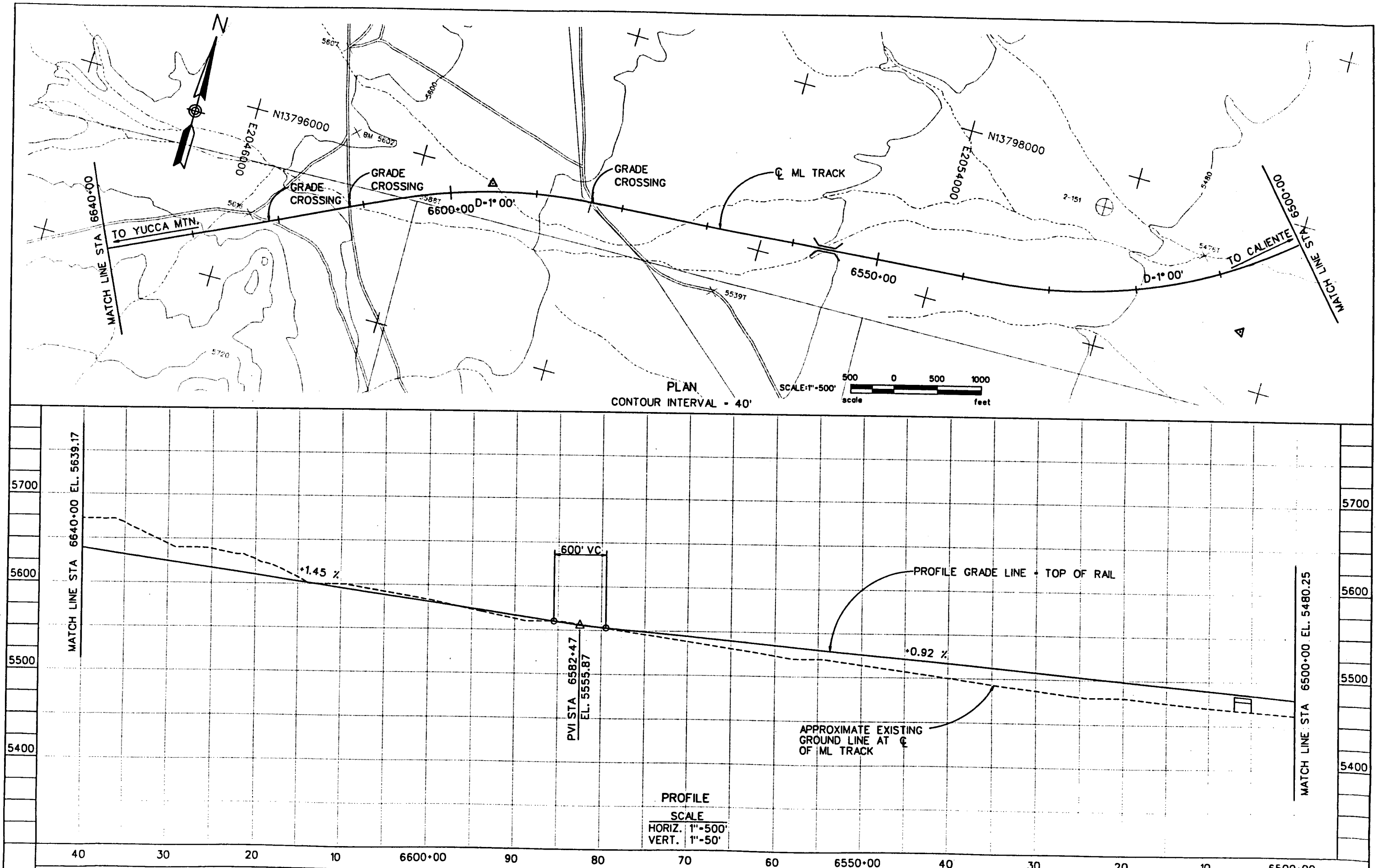
CALIENTE ROUTE - ROUTE B
PLAN & PROFILE

STA. 6360+00 - STA. 6500+00

SCALE: as noted

DRAWING NO: L01-039

SHEET NO: 4 of 10



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

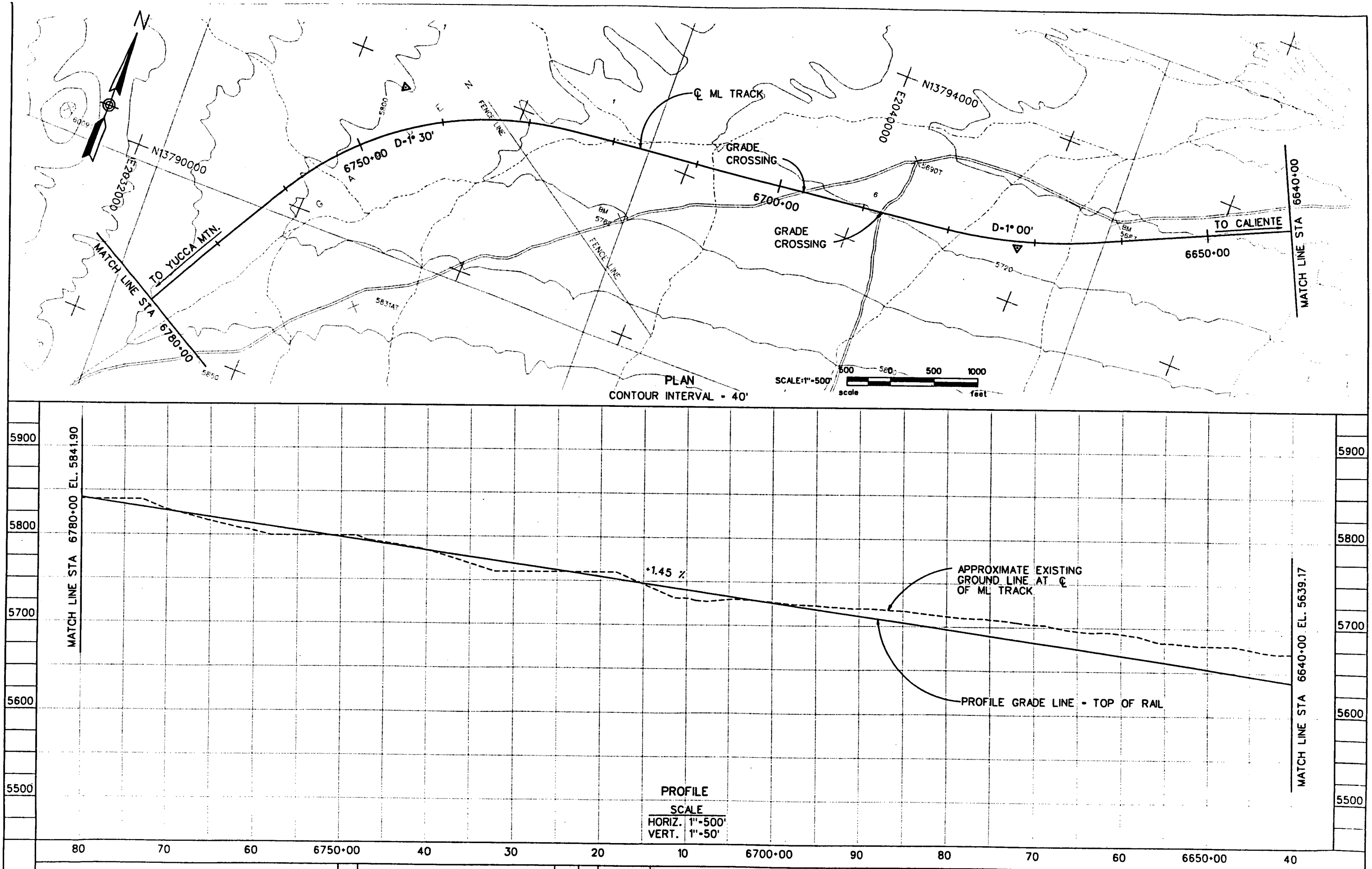
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE

STA. 6500+00 - STA. 6640+00

SCALE as noted
DRAWING NO L01-040
SHEET NO 49 OF 192



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

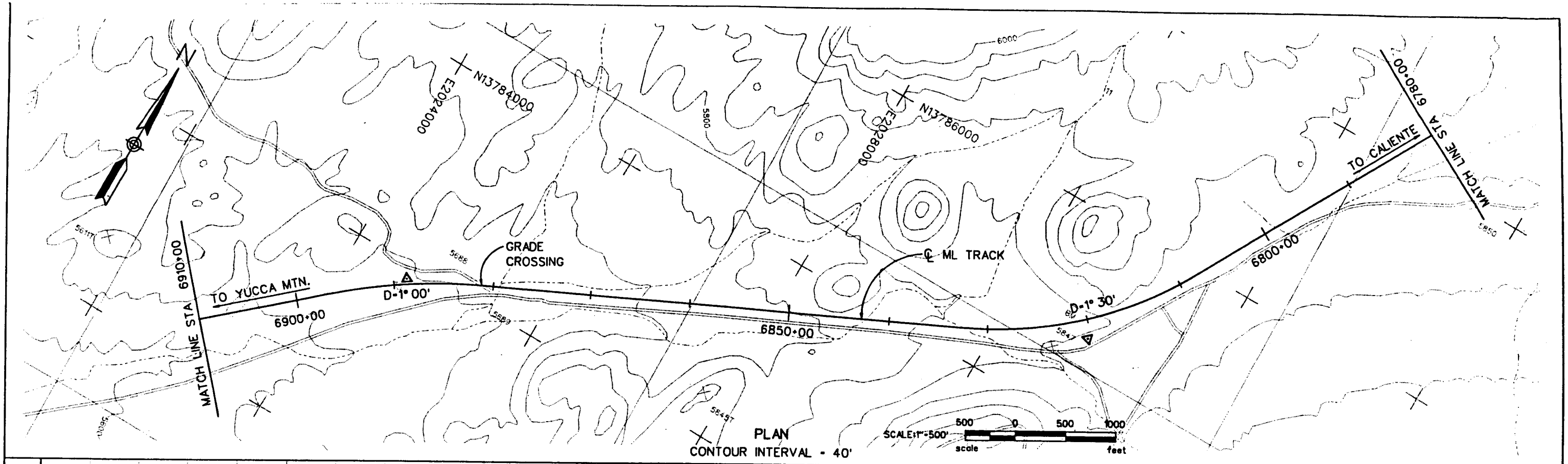
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

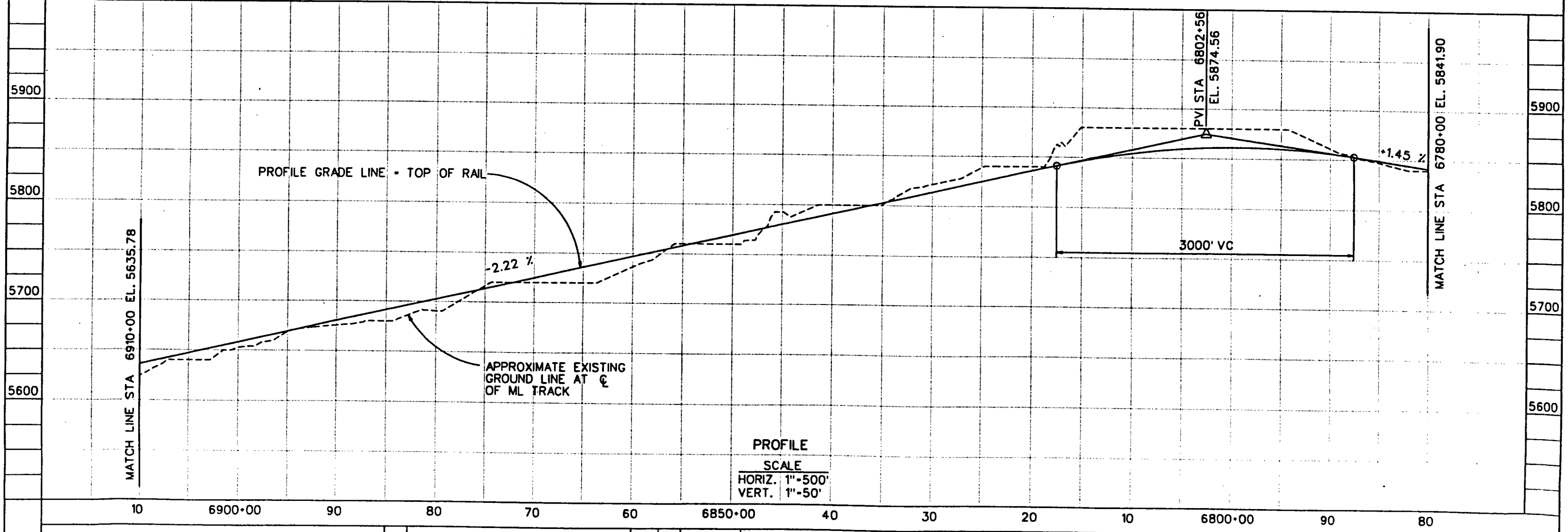
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA. 6640+00 - STA. 6780+00

SCALE as noted
DRAWING NO L01-041
SHEET NO 50 OF 190





REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

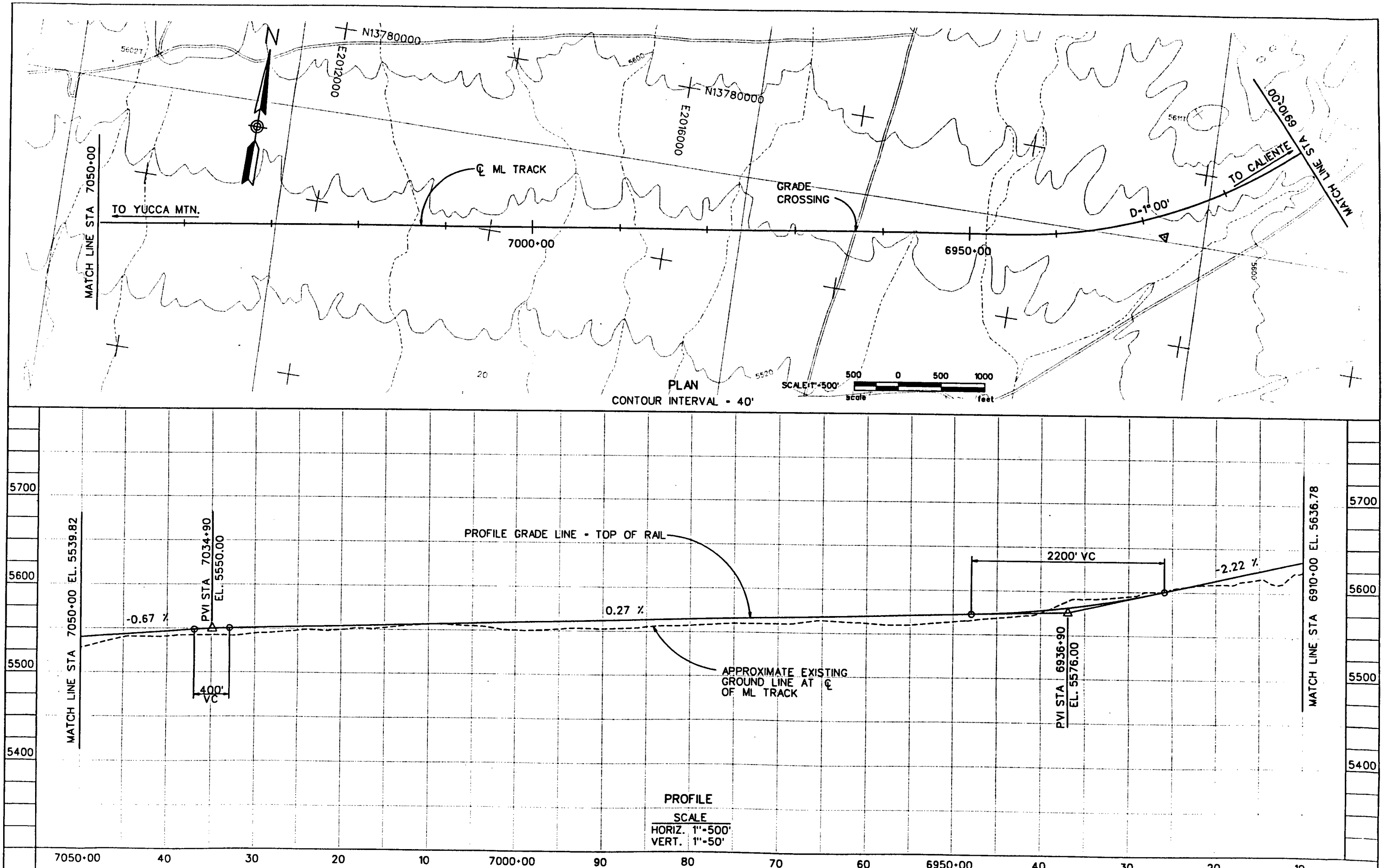
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA. 6780+00 - STA. 6910+00

SCALE as noted
DRAWING NO. L01-042
SHEET NO. 51 of 19



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

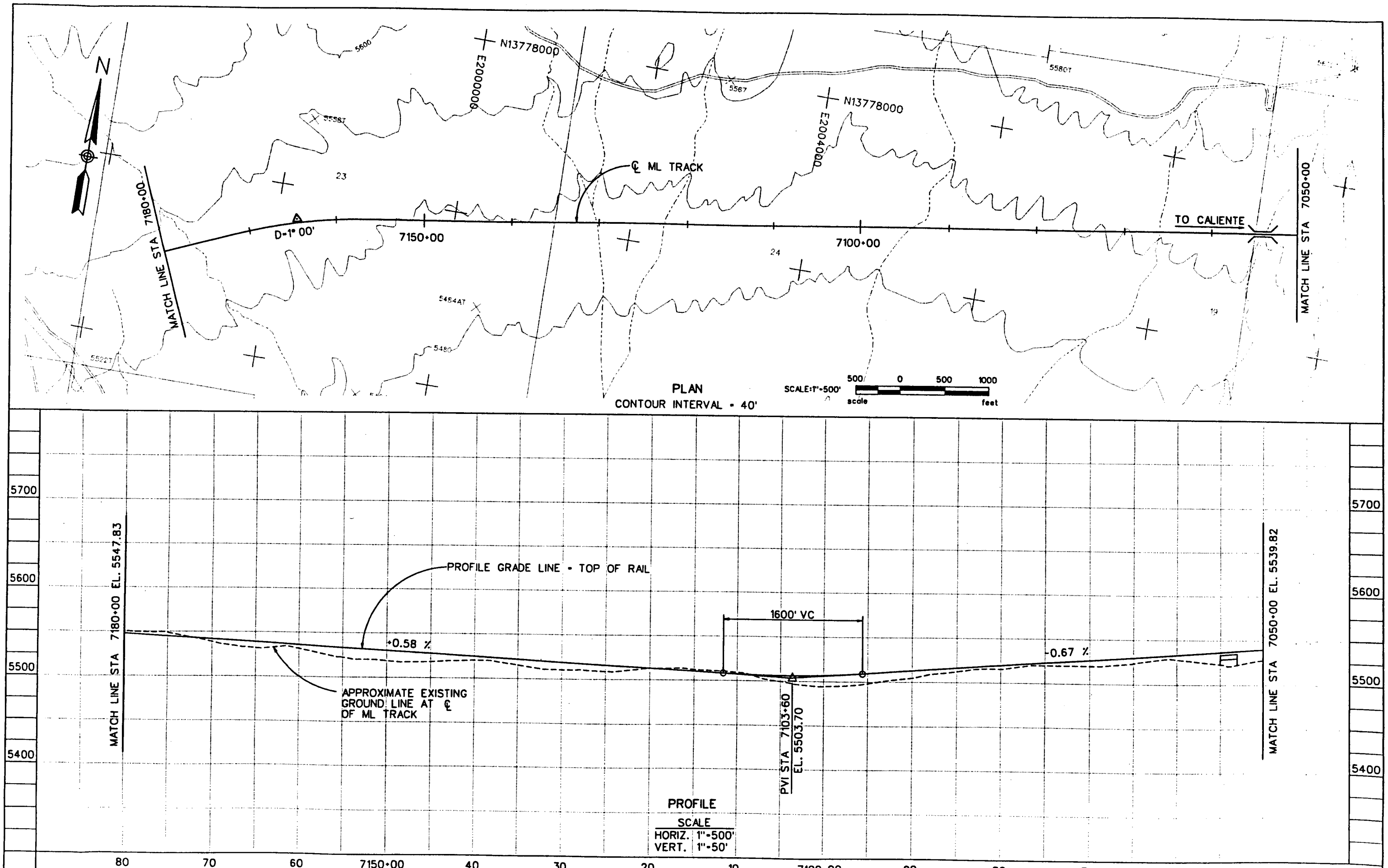
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA. 6910+00 - STA. 7050+00

SCALE as noted
DRAWING NO L01-043
SHEET NO. 52 OF 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

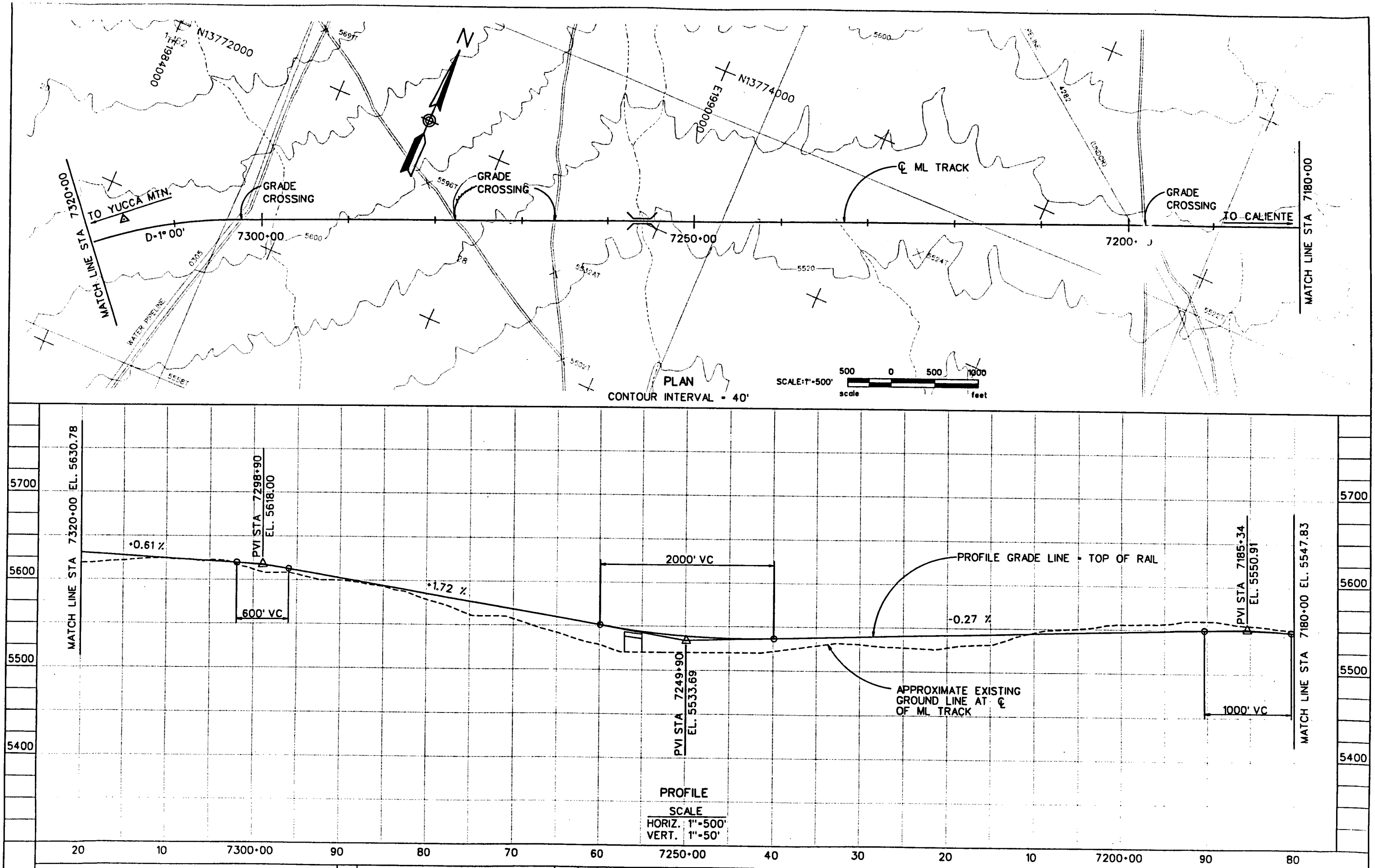
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA. 7050+00 - STA. 7180+00

SCALE as noted
DRAWING NO. L01-044
SHEET NO. 62 OF 150



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

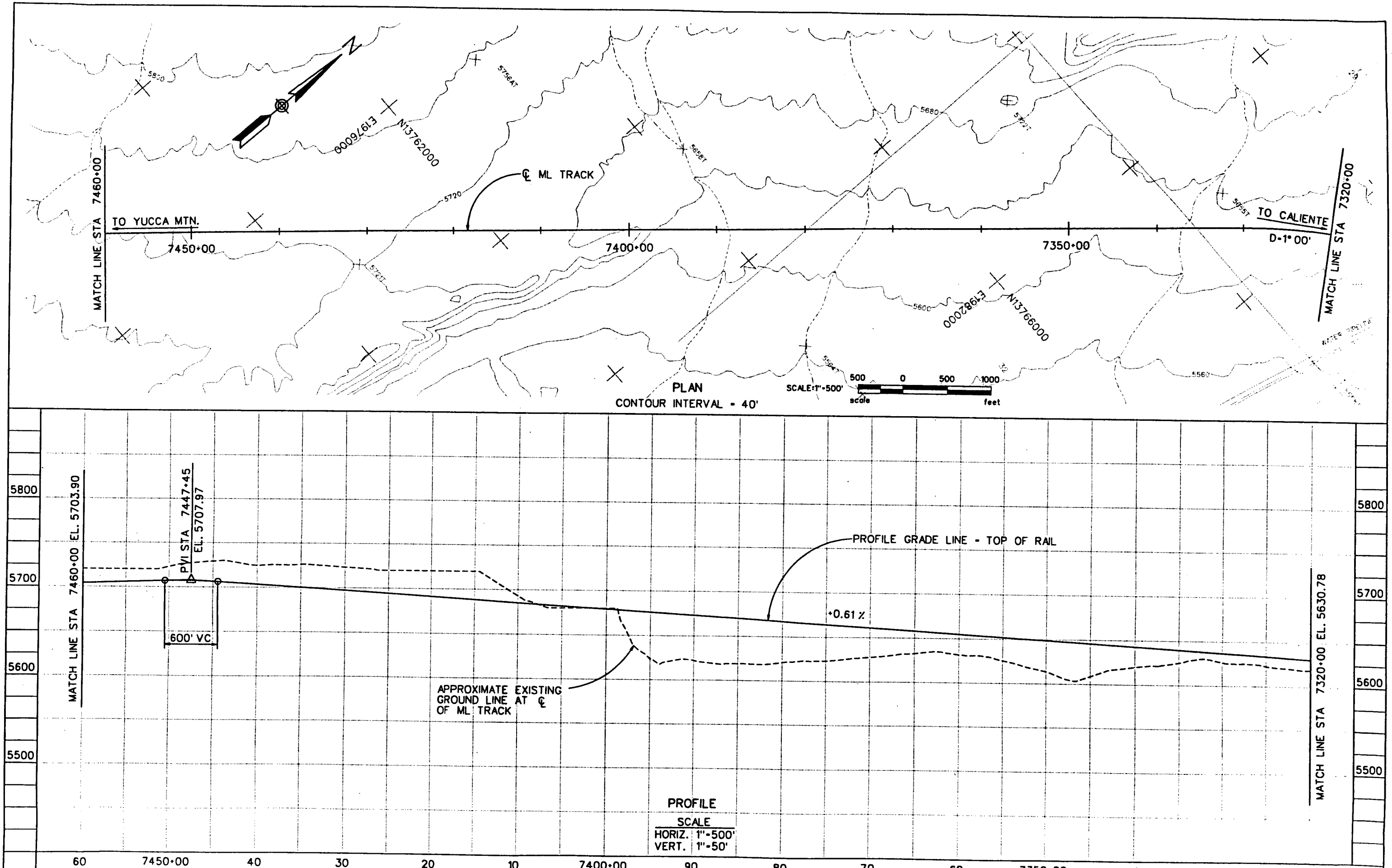
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA. 7180+00 - STA. 7320+00

SCALE as noted
DRAWING NO. L01-045
SHEET NO. 54 OF 195



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

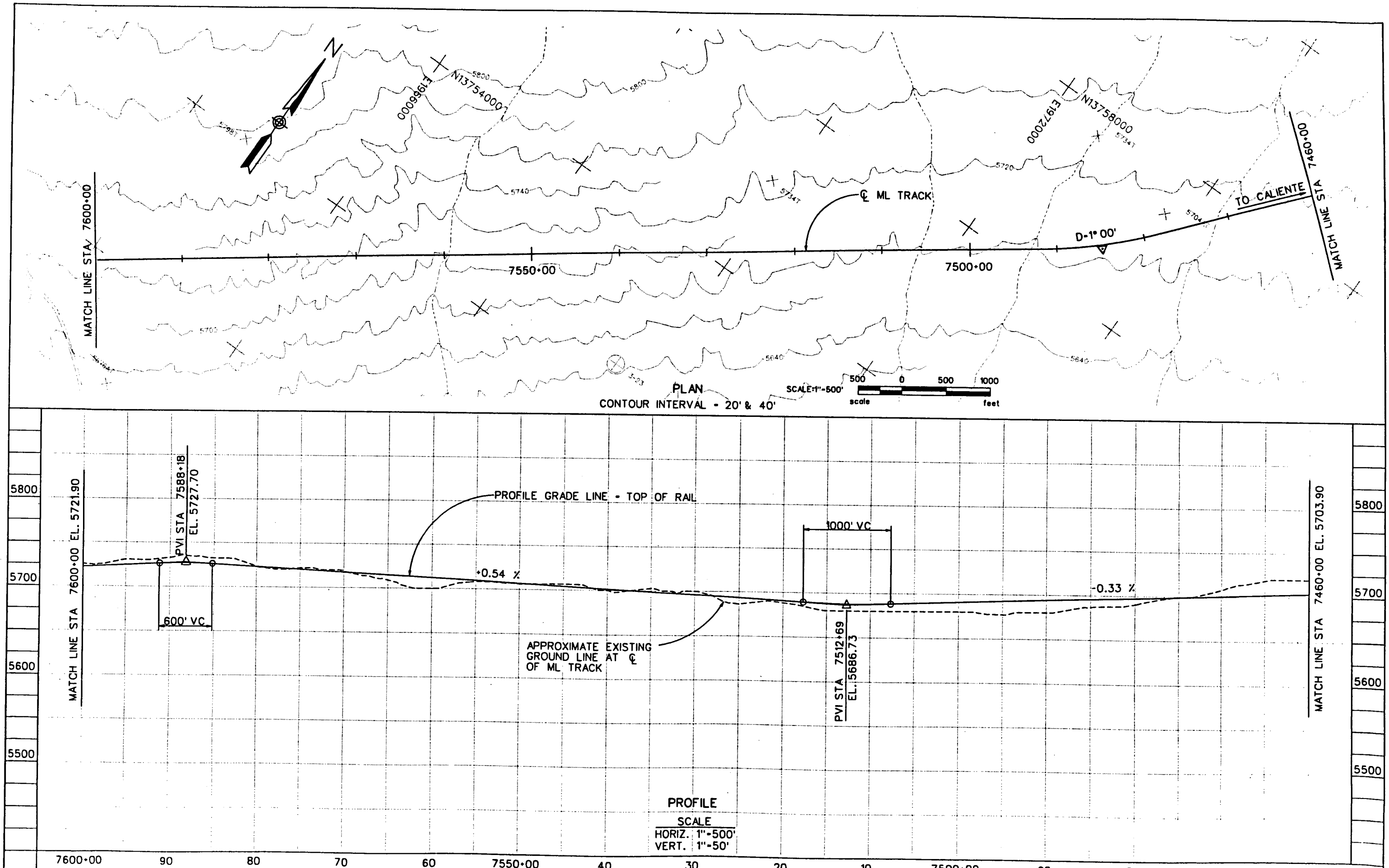
CALIENTE ROUTE - ROUTE B
PLAN & PROFILE

STA 7320+00 - STA 7460+00

SCALE: as noted

DRAWING NO: L01-046

SHEET NO: 05 of 102



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

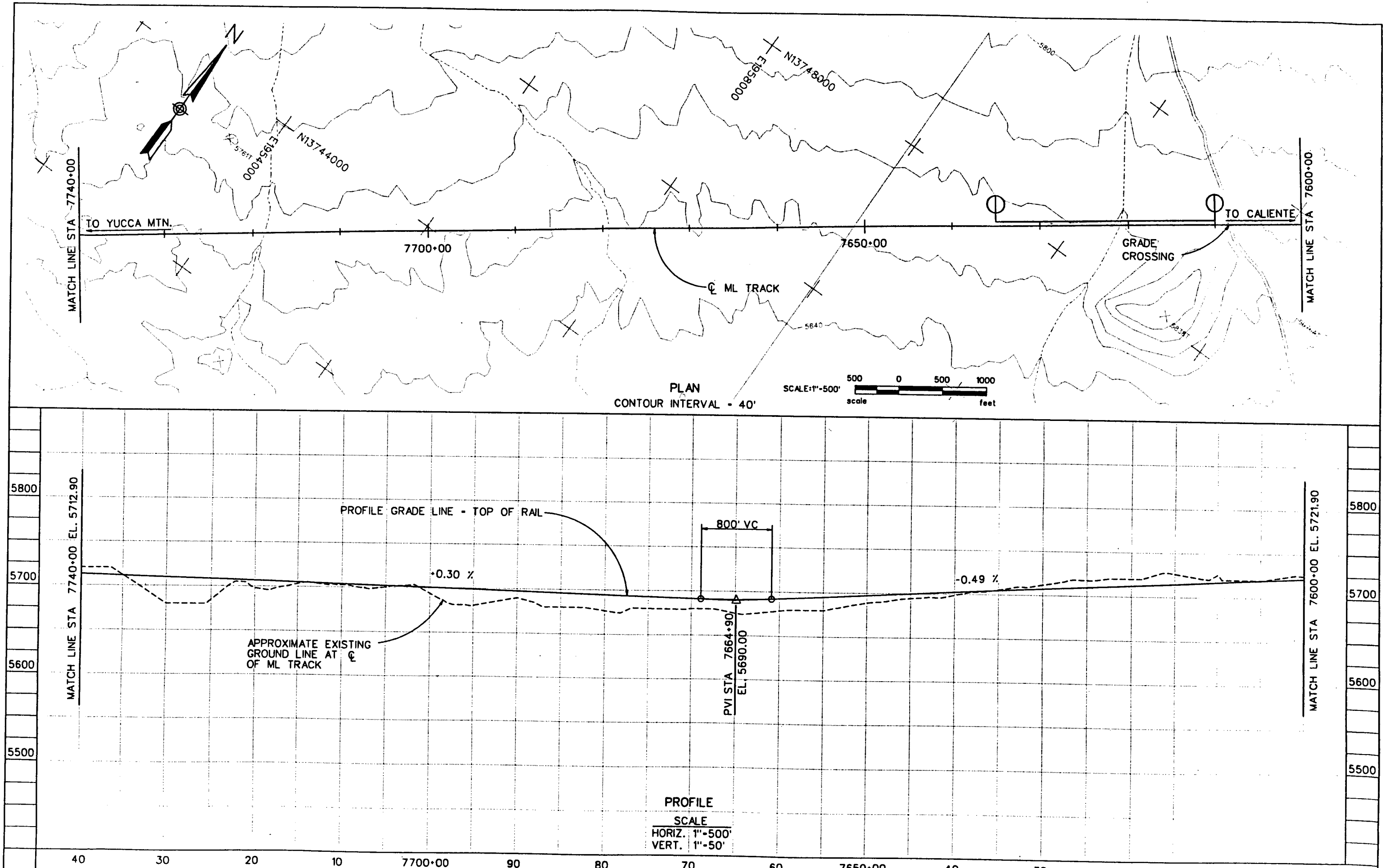
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA 7460+00 - STA 7600+00

SCALE as noted
DRAWING NO. L01-047
SHEET NO.



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

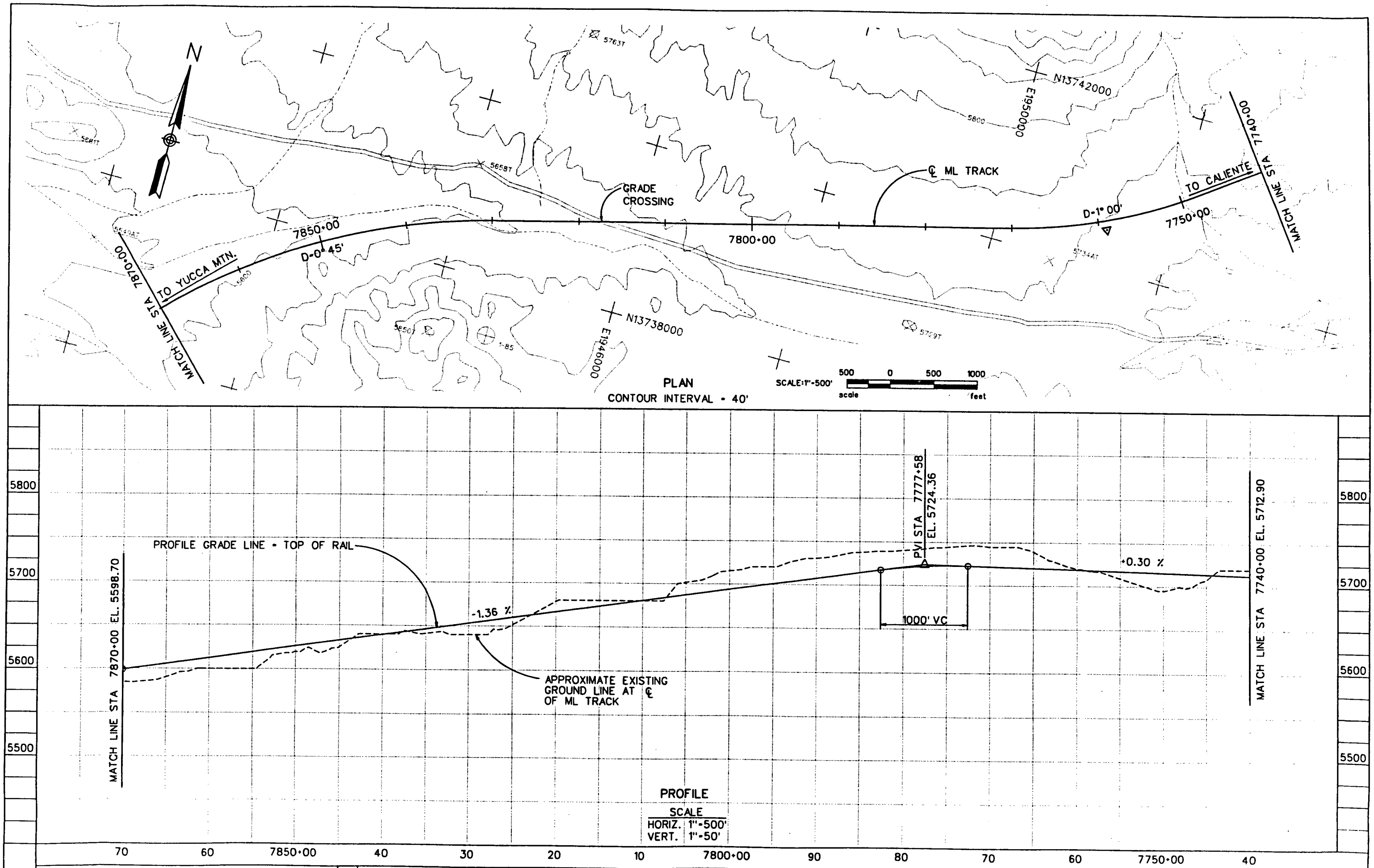
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE

SCALE: as noted
DRAWING NO. L01-048
SHEET NO.



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

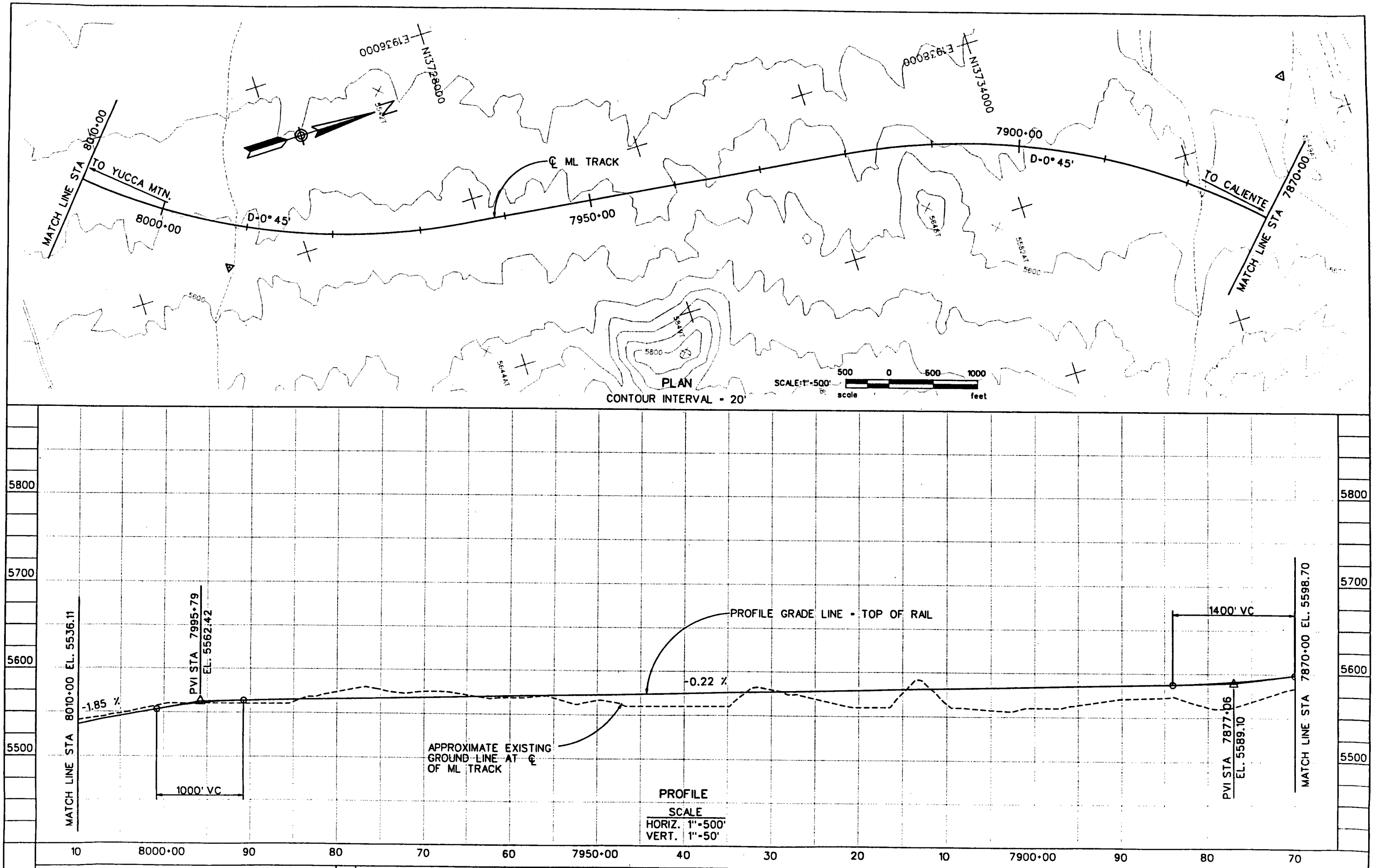
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA 7740+00 - STA 7870+00

SCALE as noted
DRAWING NO. L01-040
SHEET NO. 5 of 100



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

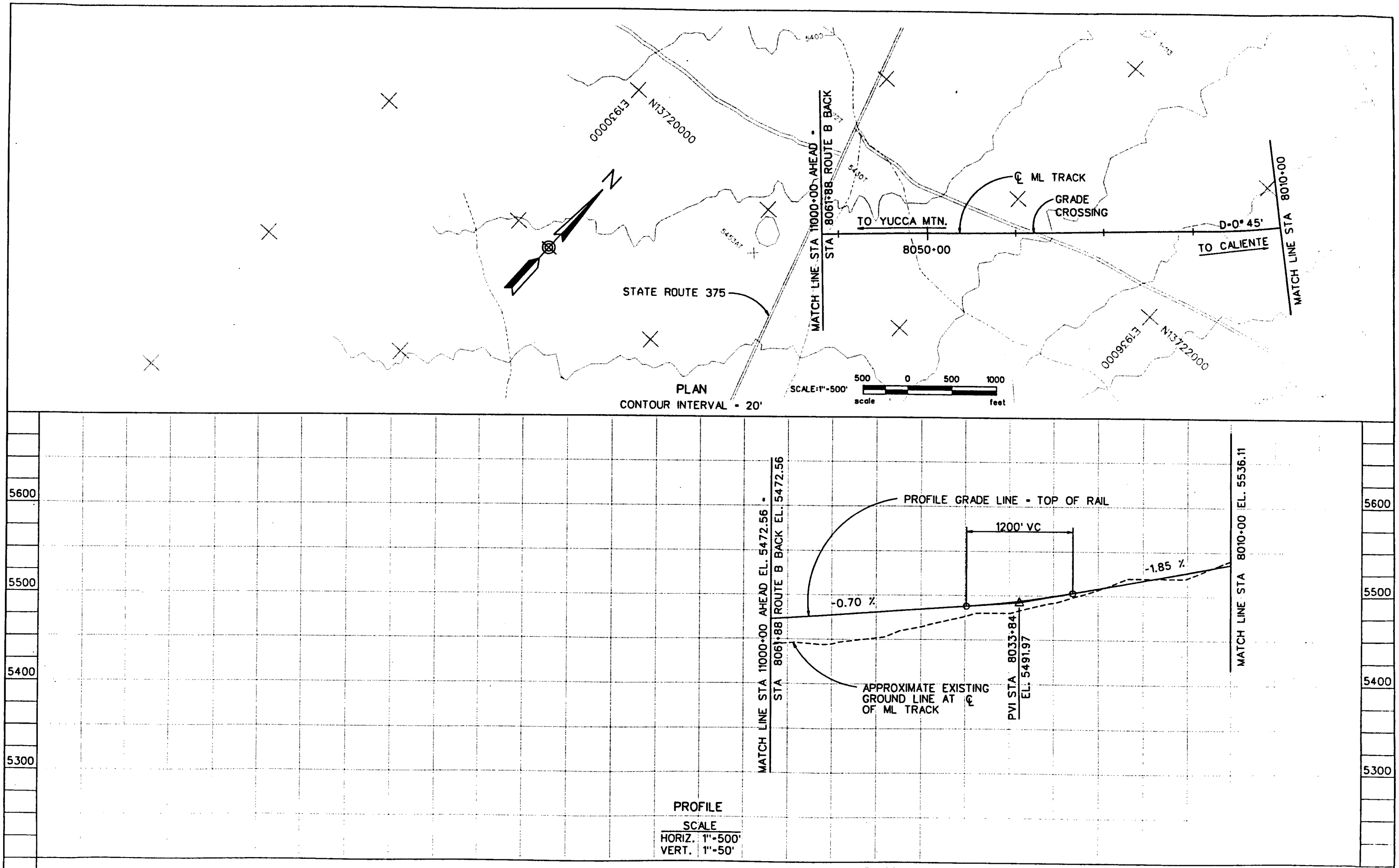
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE

SCALE: as noted
DRAWING NO. L01-050
SHEET NO.



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

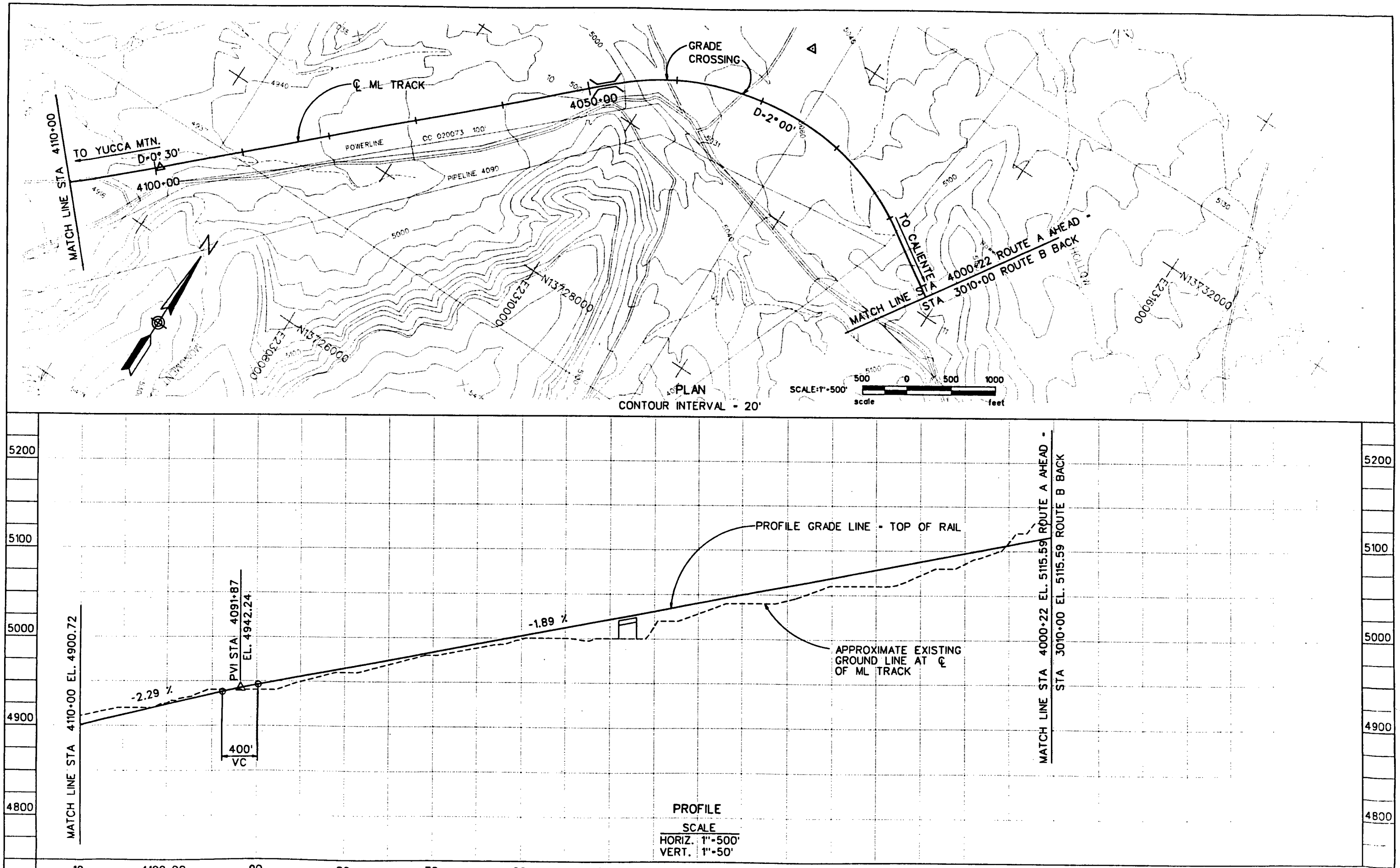
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE B
PLAN & PROFILE
STA 8010+00 - STA 8061.88

SCALE as noted
DRAWING NO L01 051
SHEET NO 60 of 103

DATE PLOTTED 25-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

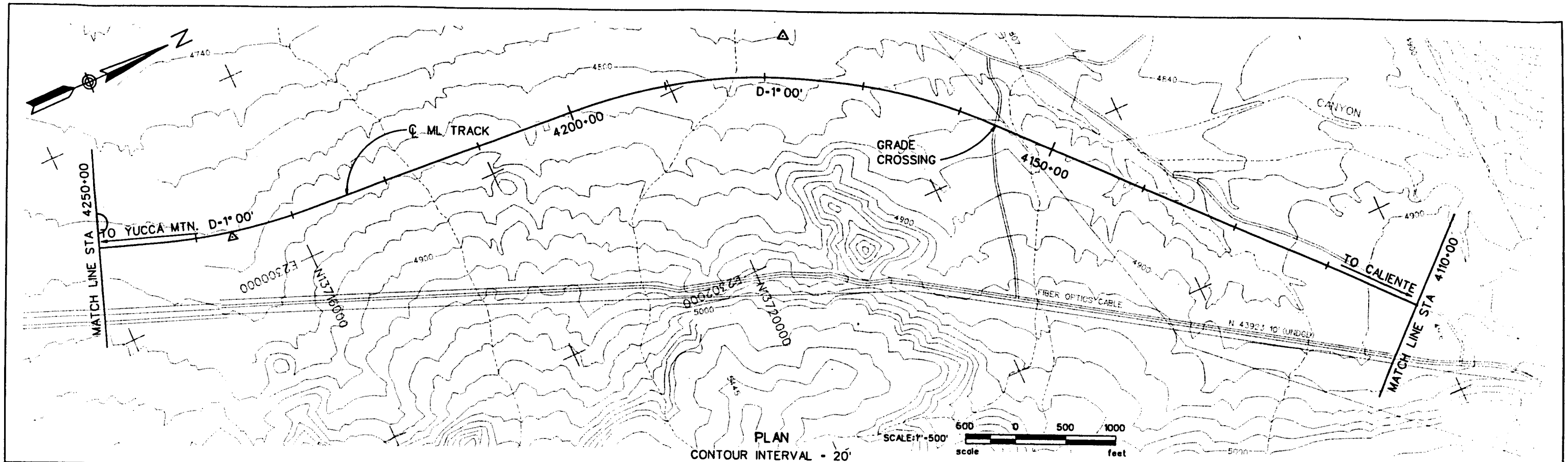
CALIENTE ROUTE - ROUTE A PLAN & PROFILE

STA 4000+22 STA 4110+00

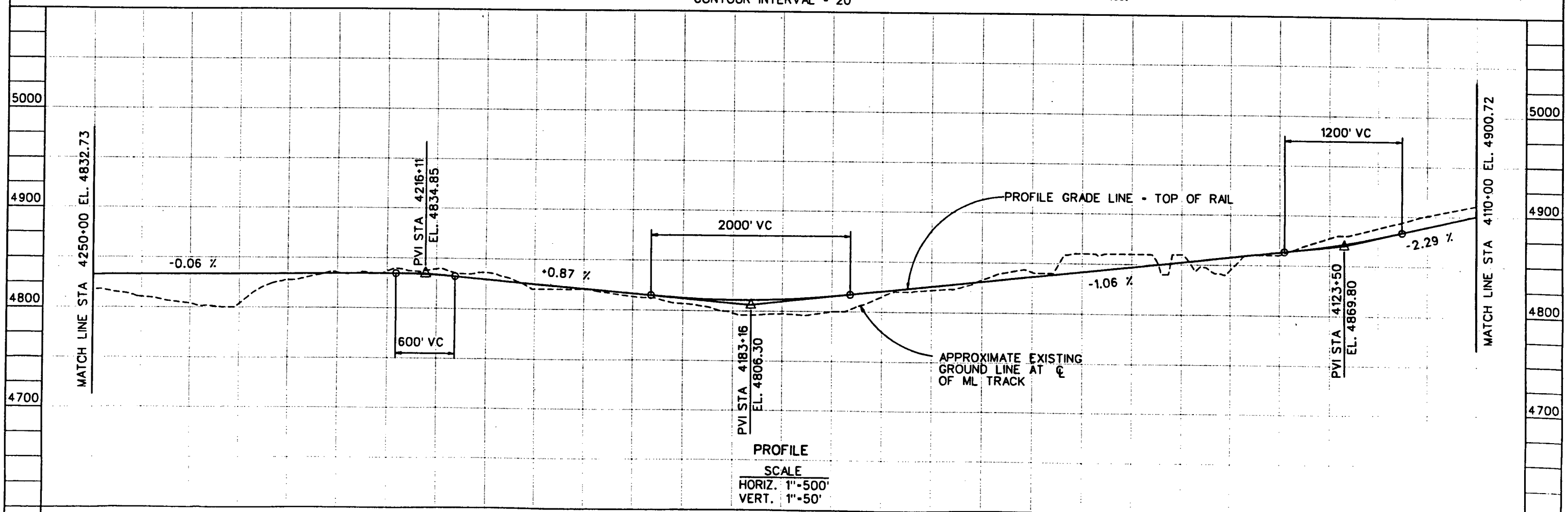
SCALE: as noted

DRAWING NO. L01-101

SHEET NO.



PLAN
CONTOUR INTERVAL - 20'



PROFILE

SCALE	
HORIZ.	1"=500'
VERT.	1"=50'

REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

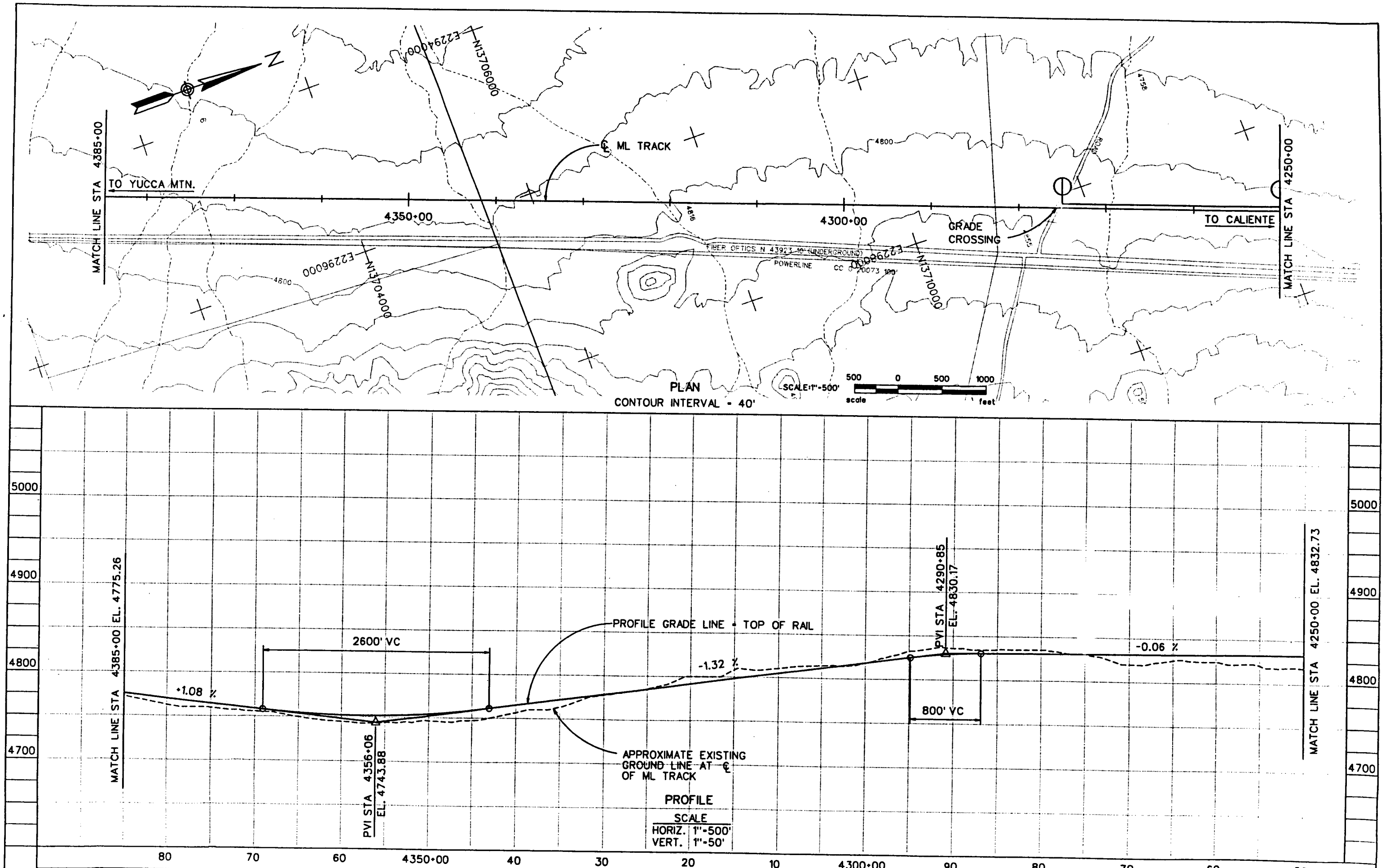
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE

STA. 4110+00 - STA. 4250+00

SCALE: as noted
DRAWING NO: L01-102
SHEET NO: 192



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

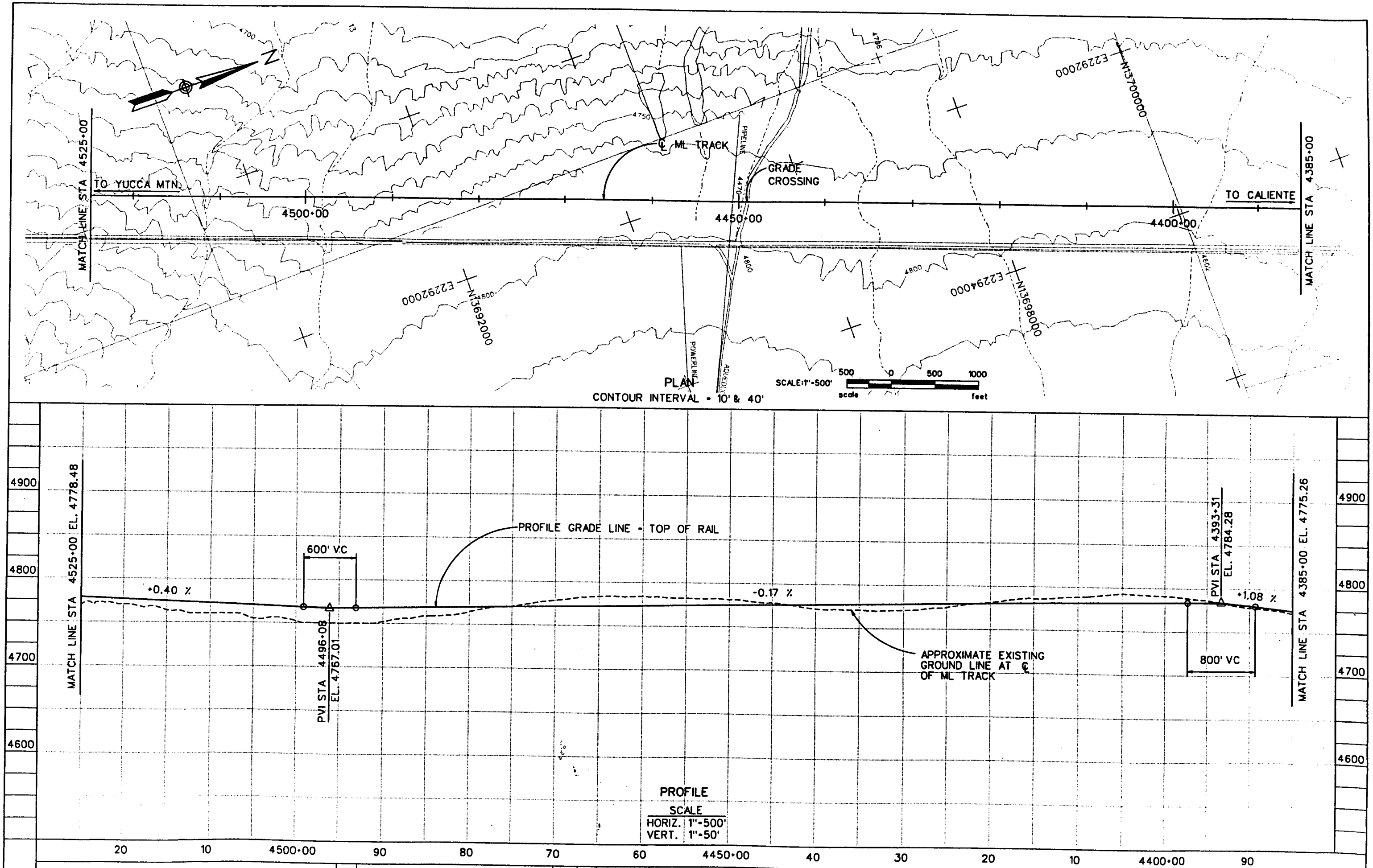
CALIENTE ROUTE - ROUTE A
PLAN & PROFILE

STA. 4250+00 - STA. 4385+00

SCALE: as noted

DRAWING NO. L01-10.3

SHEET NO. 62 OF 193



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

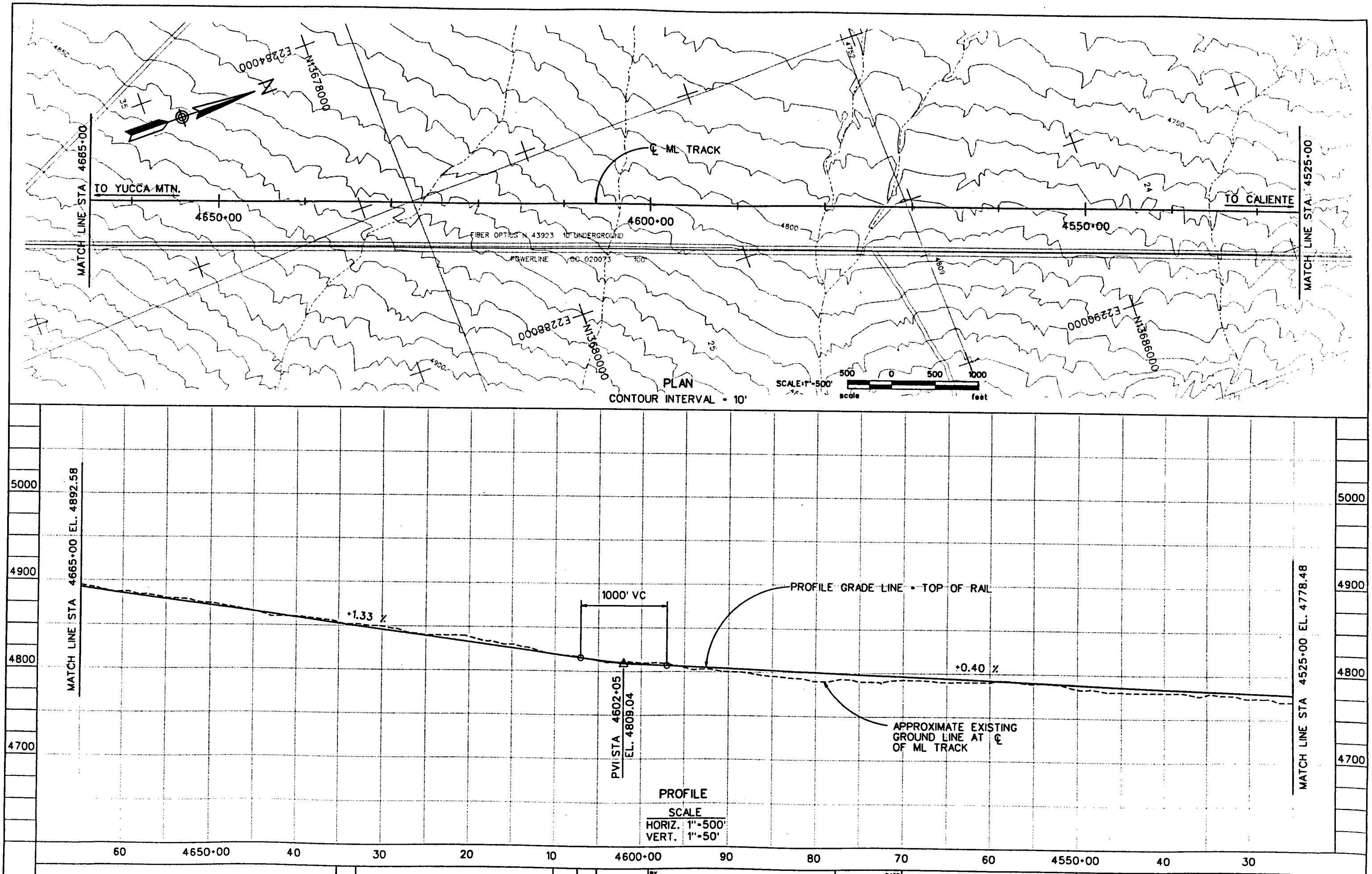
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA. 4385+00 - STA. 4525+00

SCALE: as noted
DRAWING NO: L01-104
SHEET NO: 60 OF 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

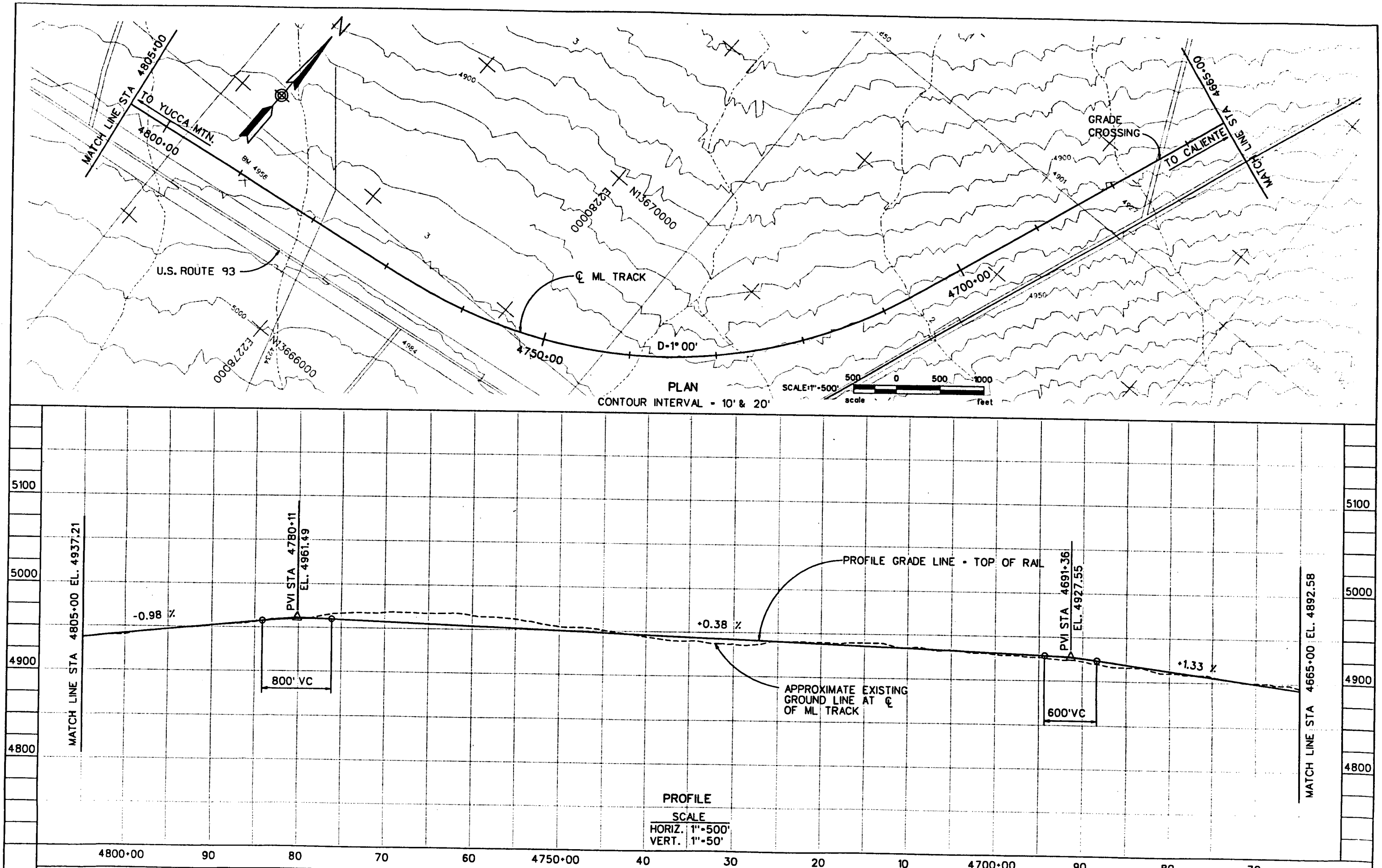
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA. 4525+00 - STA. 4665+00

SCALE as noted
DRAWING NO. L01-105
SHEET NO. 6 of 190

DATE PLOTTED 20-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

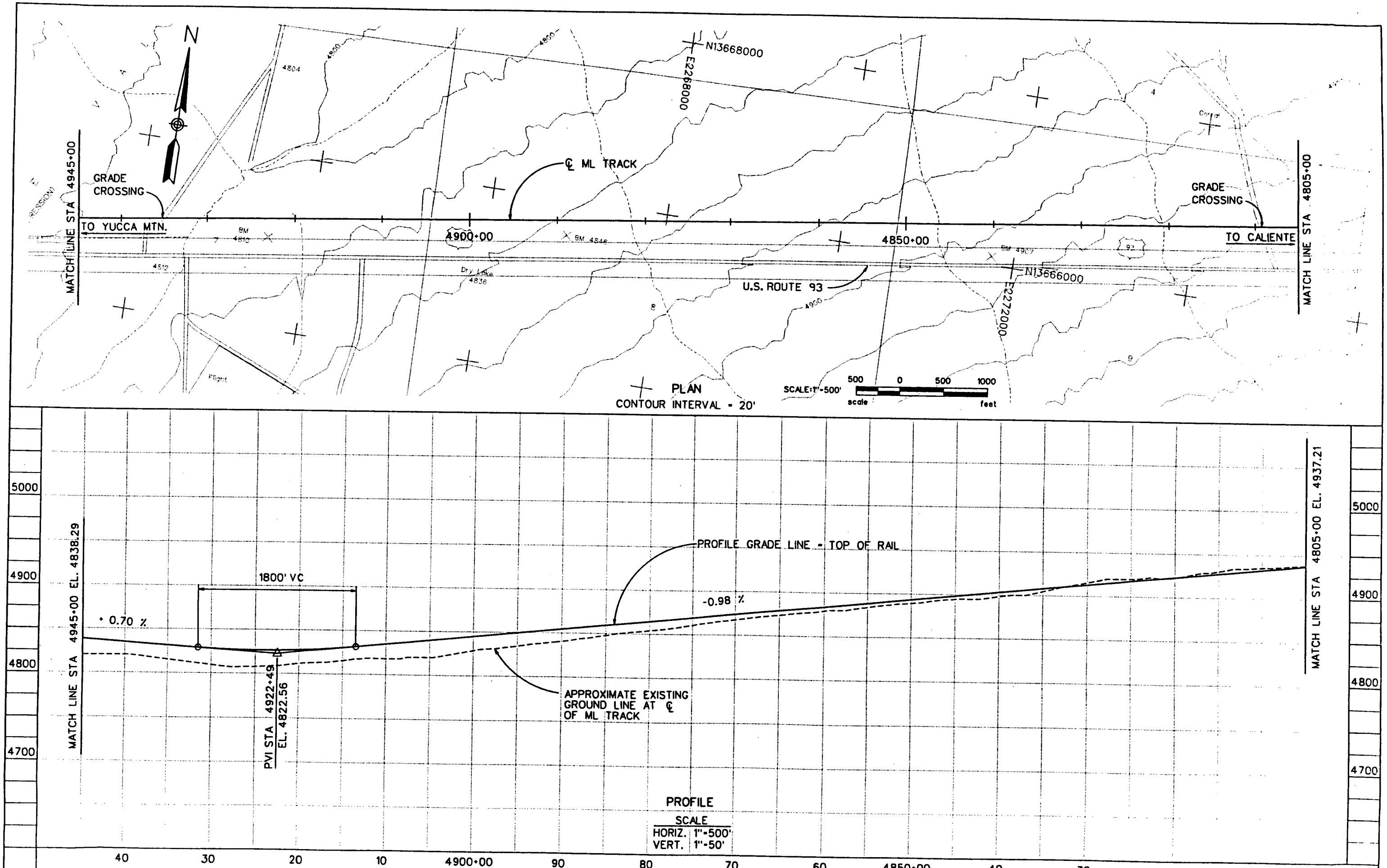
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A PLAN & PROFILE

STA 4665+00 - STA 4805+00

SCALE: as noted
DRAWING NO. L01-106
SHEET NO. 66 of 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

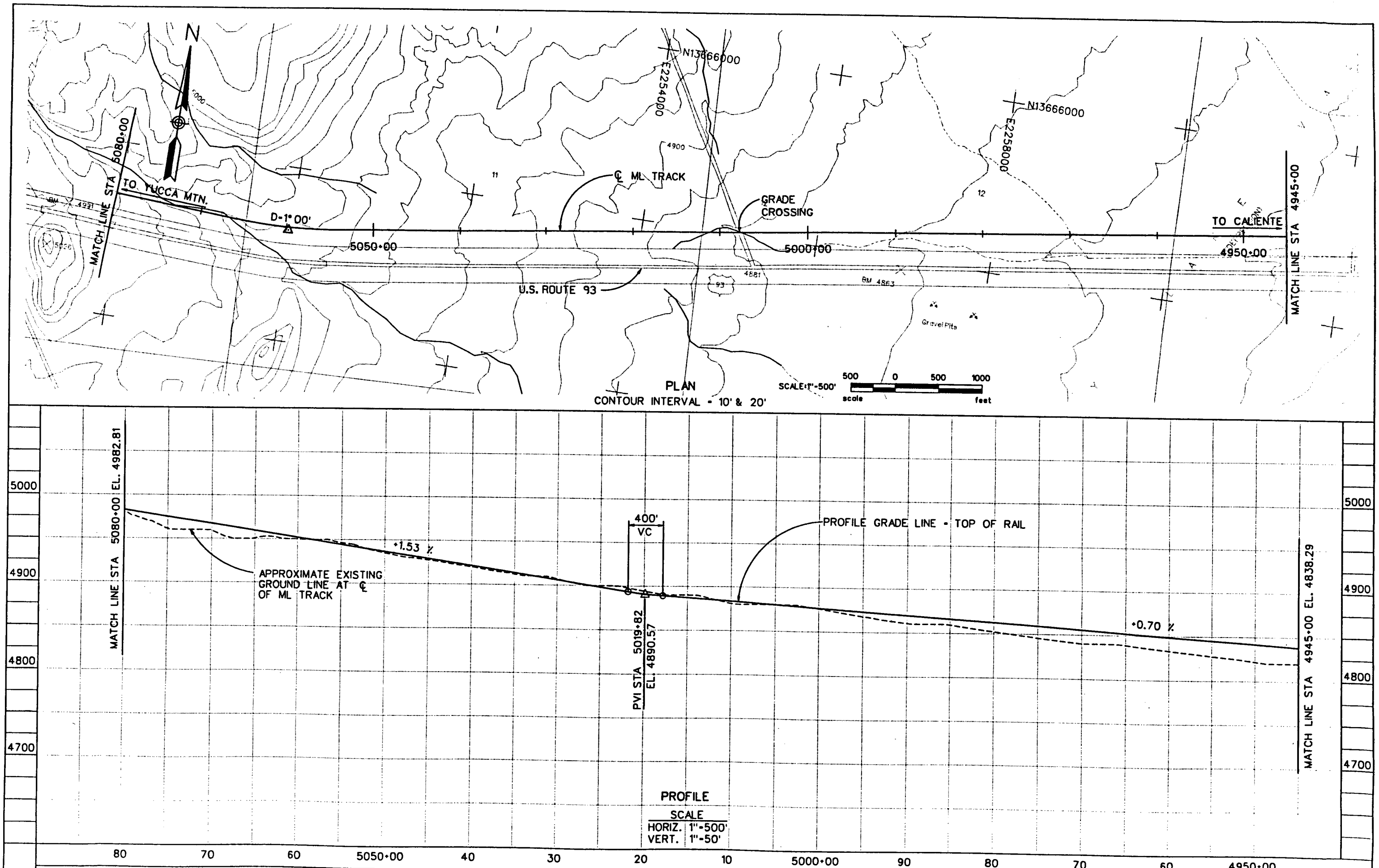
CALIENTE ROUTE - ROUTE A
PLAN & PROFILE

STA. 4805+00 - STA. 4945+00

SCALE as noted

DRAWING NO L01-107

SHEET NO 6 of 19



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

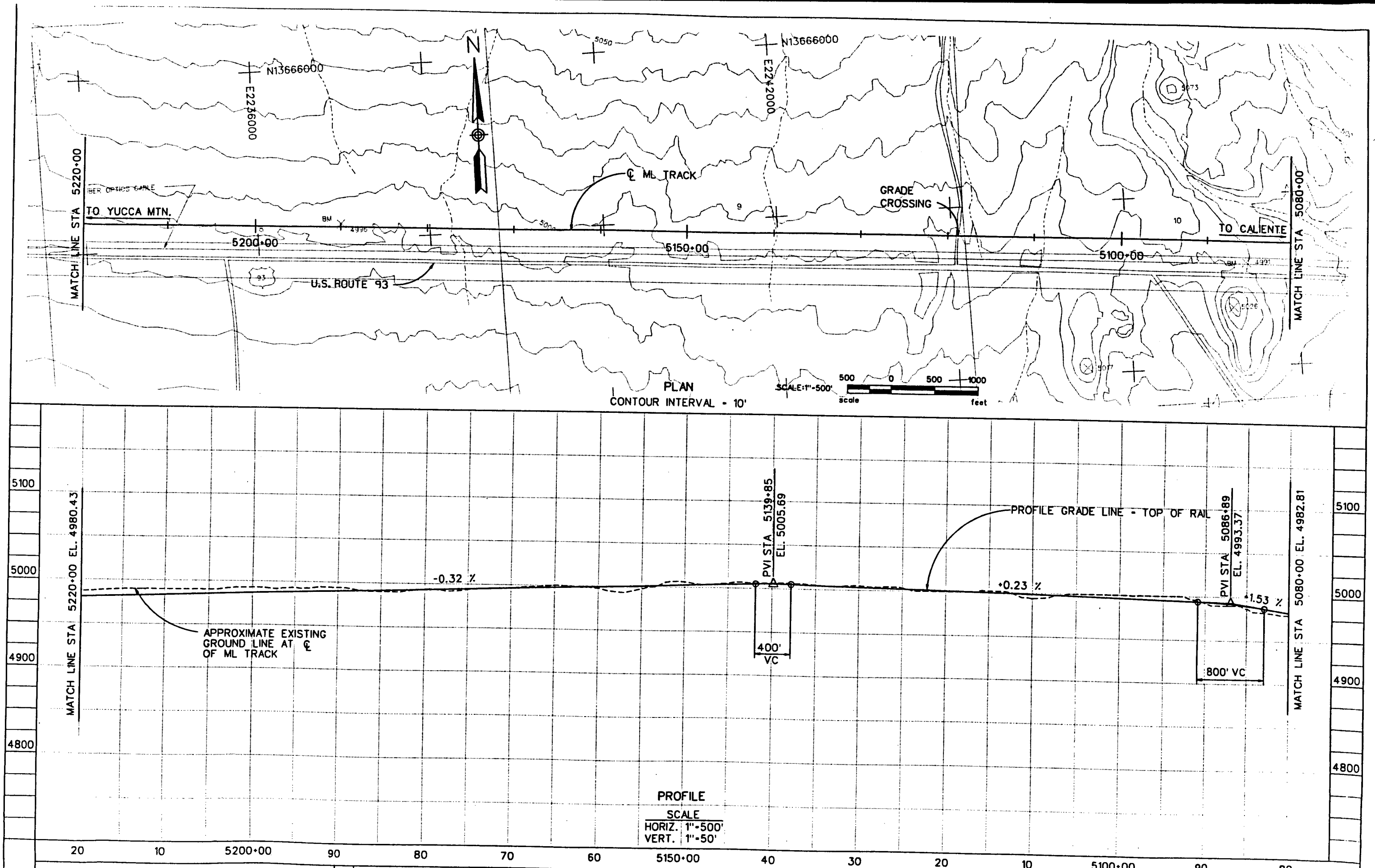
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA. 4945+00 - STA. 5080+00

SCALE as noted
DRAWING NO L01-108
SHEET NO 18 OF 19



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

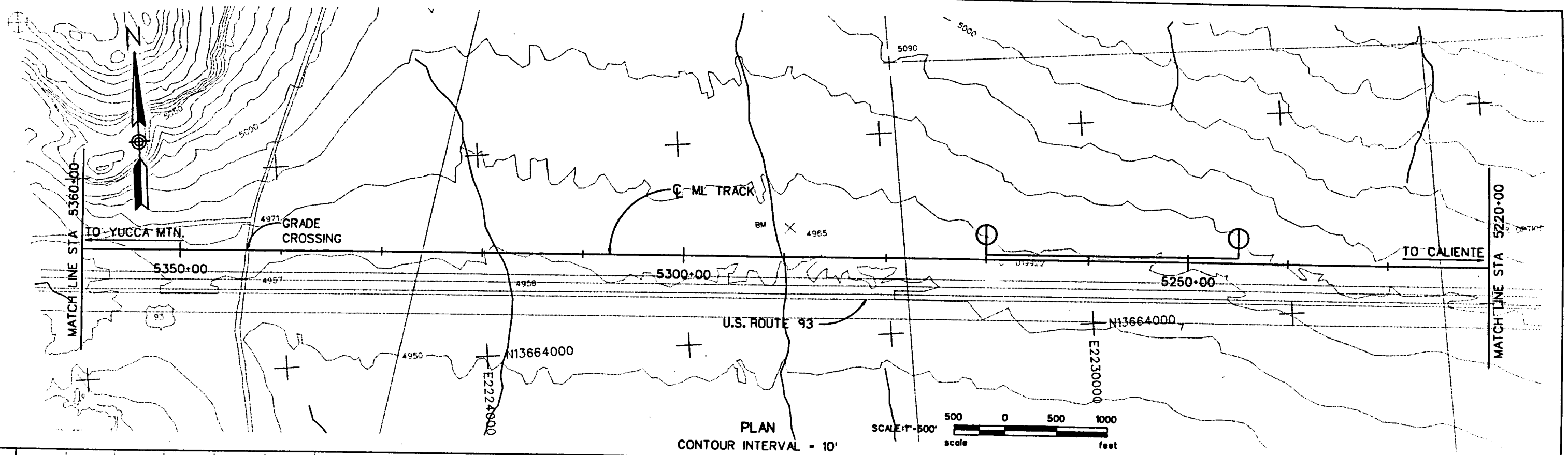
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

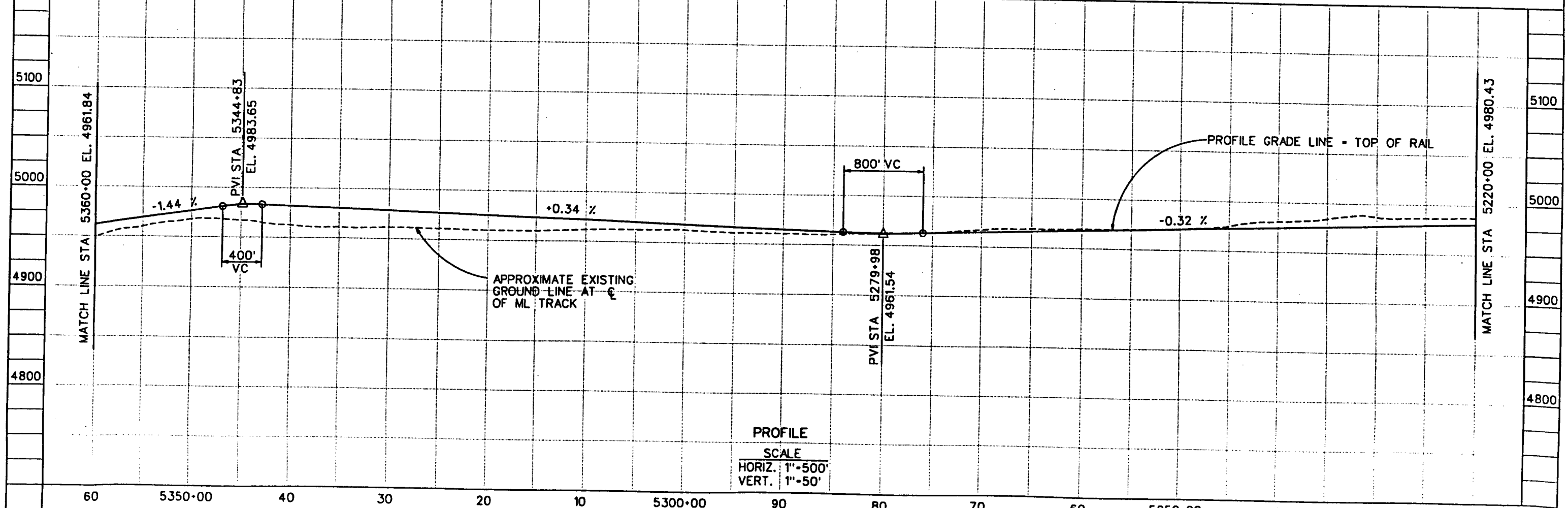
YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA. 5080+00 - STA. 5220+00

SCALE as noted
DRAWING NO L01-109
SHEET NO 69 of 190



PLAN
CONTOUR INTERVAL - 10'



PROFILE
SCALE
HORIZ. 1"=500'
VERT. 1"=50'

REV	DESCRIPTION	DATE	BY

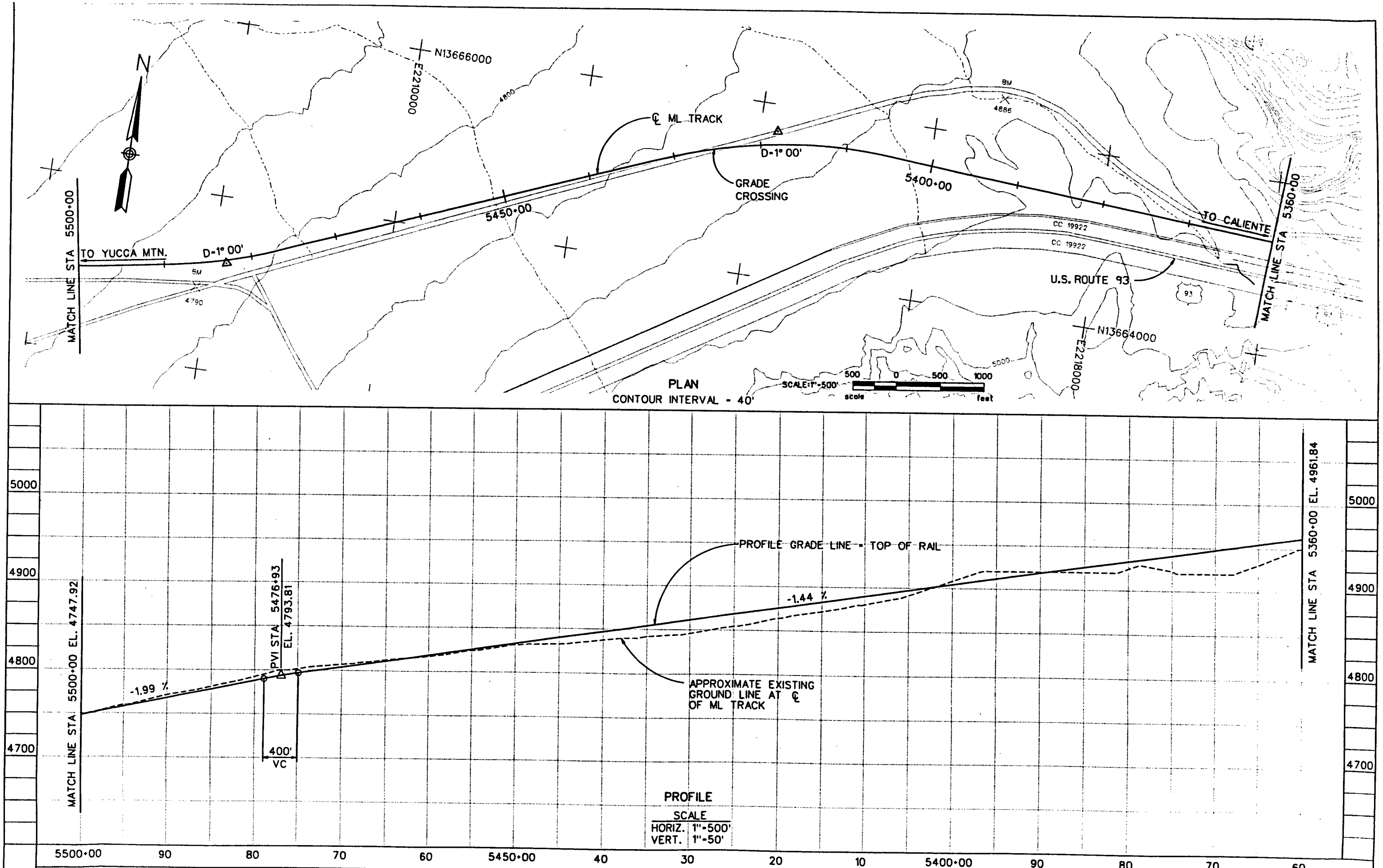
DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA. 5220+00 - STA. 5360+00

SCALE as noted
DRAWING NO. L01-110
SHEET NO. 70 of 192



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

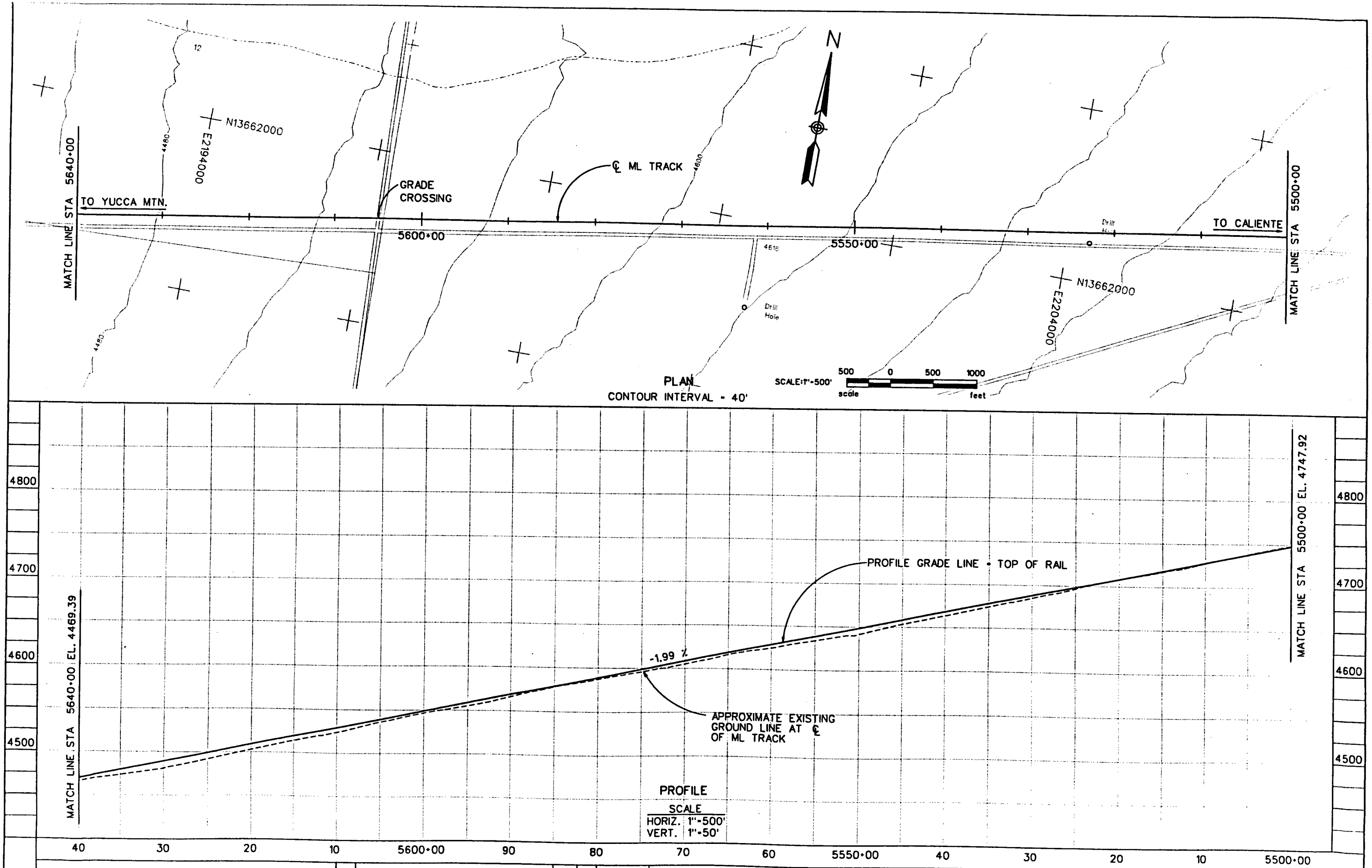
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA. 5360+00 - STA. 5500+00

SCALE: as noted
DRAWING NO: L01-111
SHEET NO: 1 OF 10



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

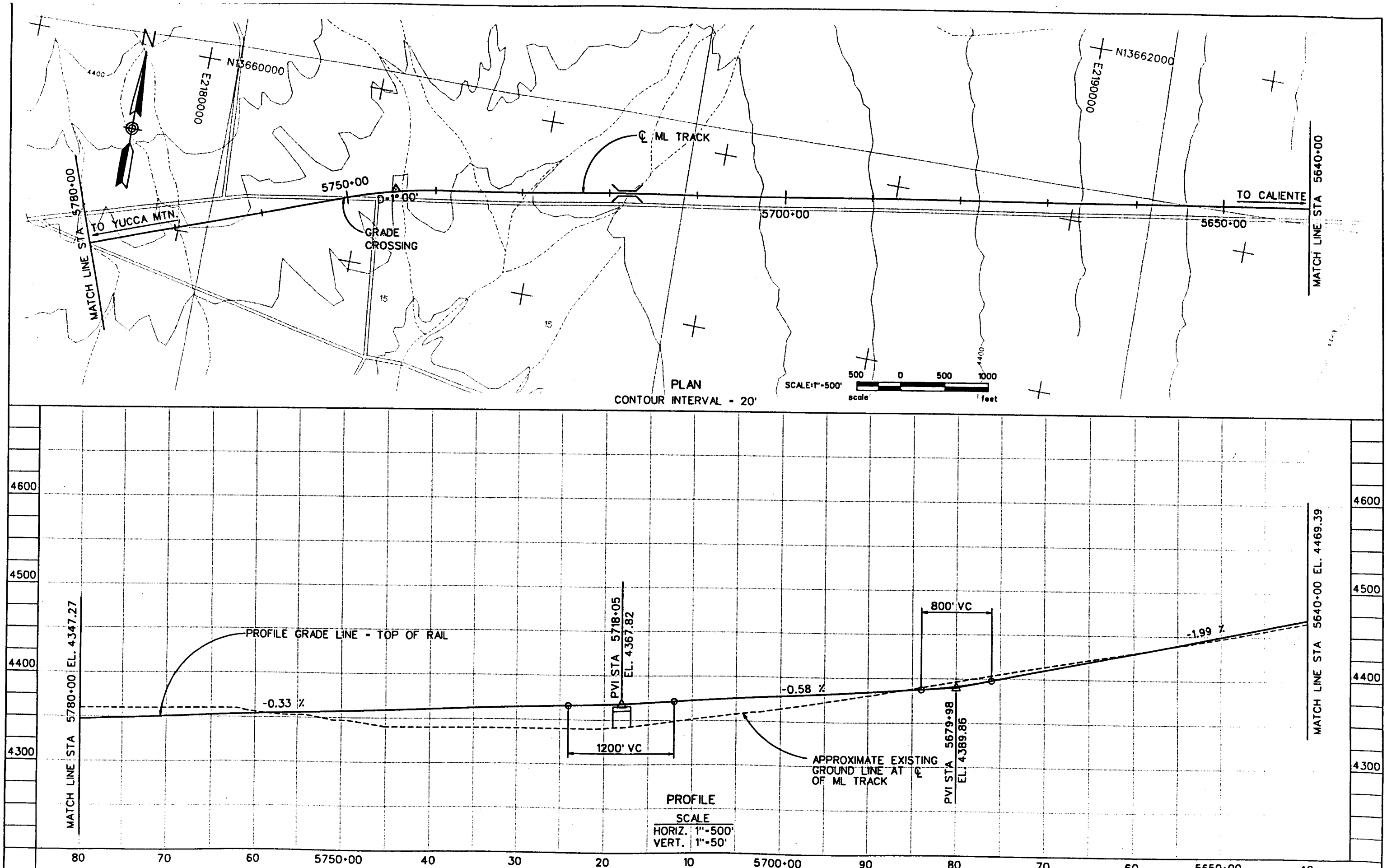
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA. 5500+00 - STA. 5640+00

SCALE as noted
DRAWING NO L01-112
SHEET NO 72 OF 190

DATE PLOTTED 25-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

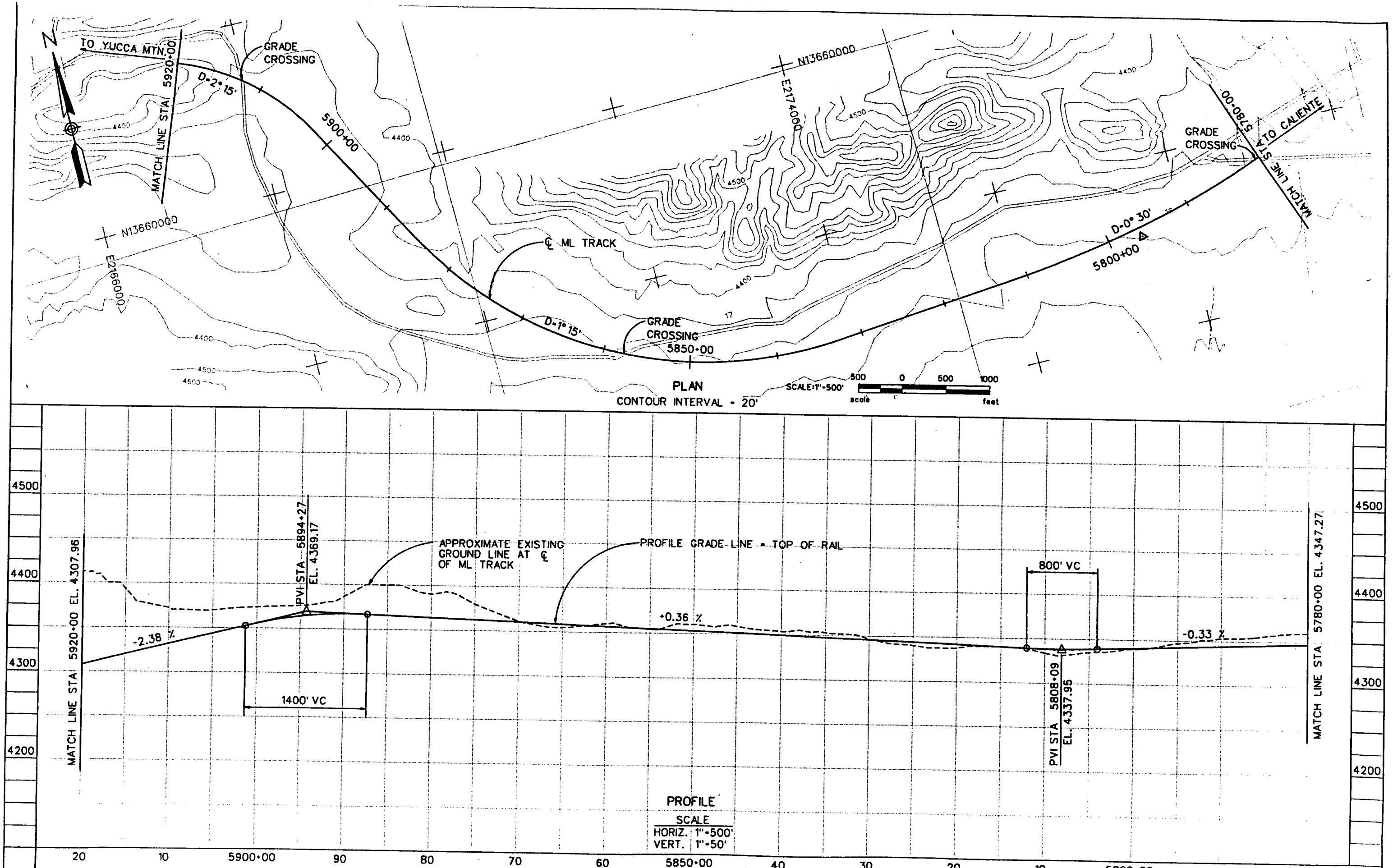
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE

STA. 5640+00 - STA. 5780+00

SCALE as noted
DRAWING NO L01-113
SHEET NO 72 OF 192



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

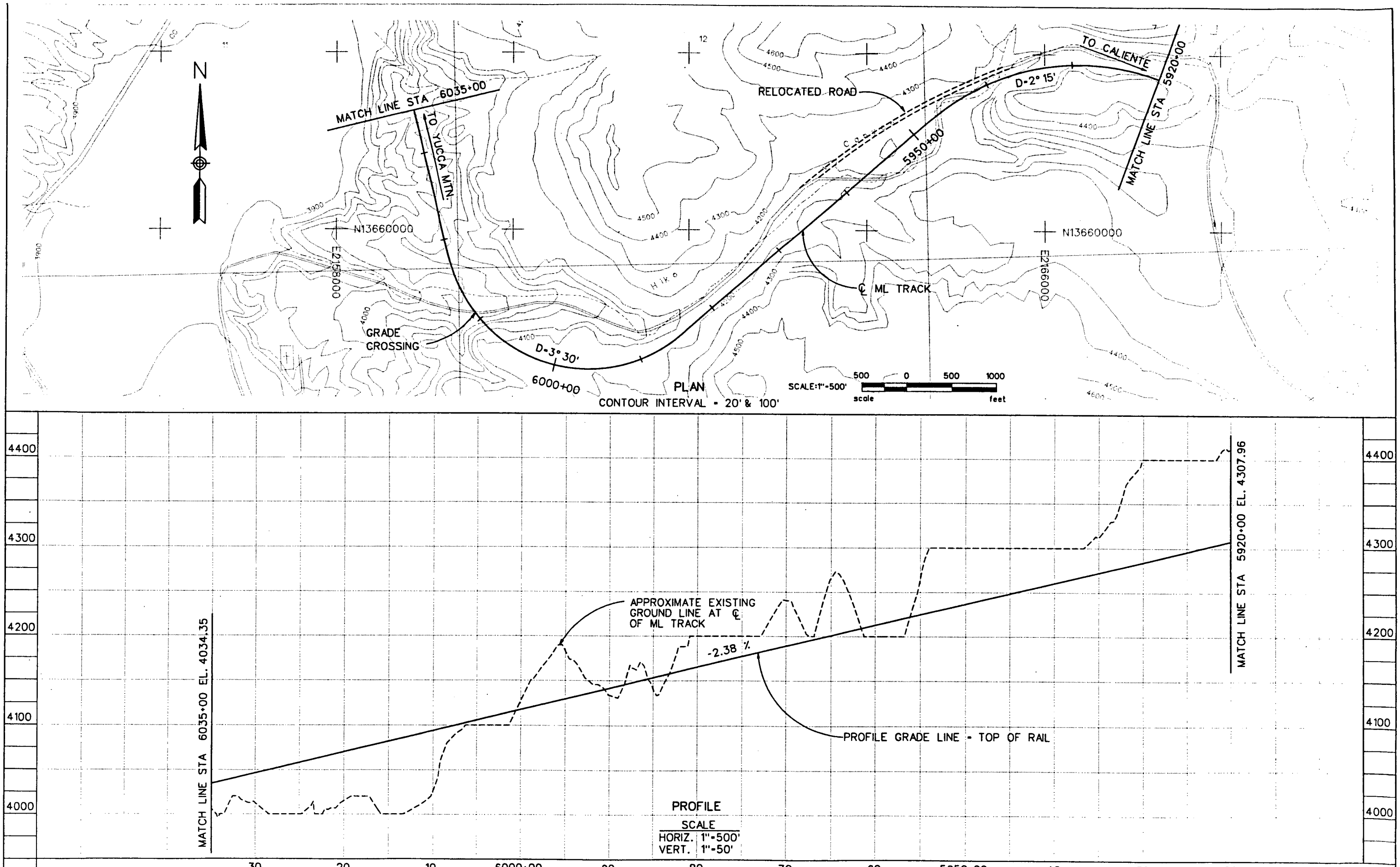
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA. 5780+00 - STA. 5920+00

SCALE as noted
DRAWING NO L01-114
SHEET NO 74 OF 192



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

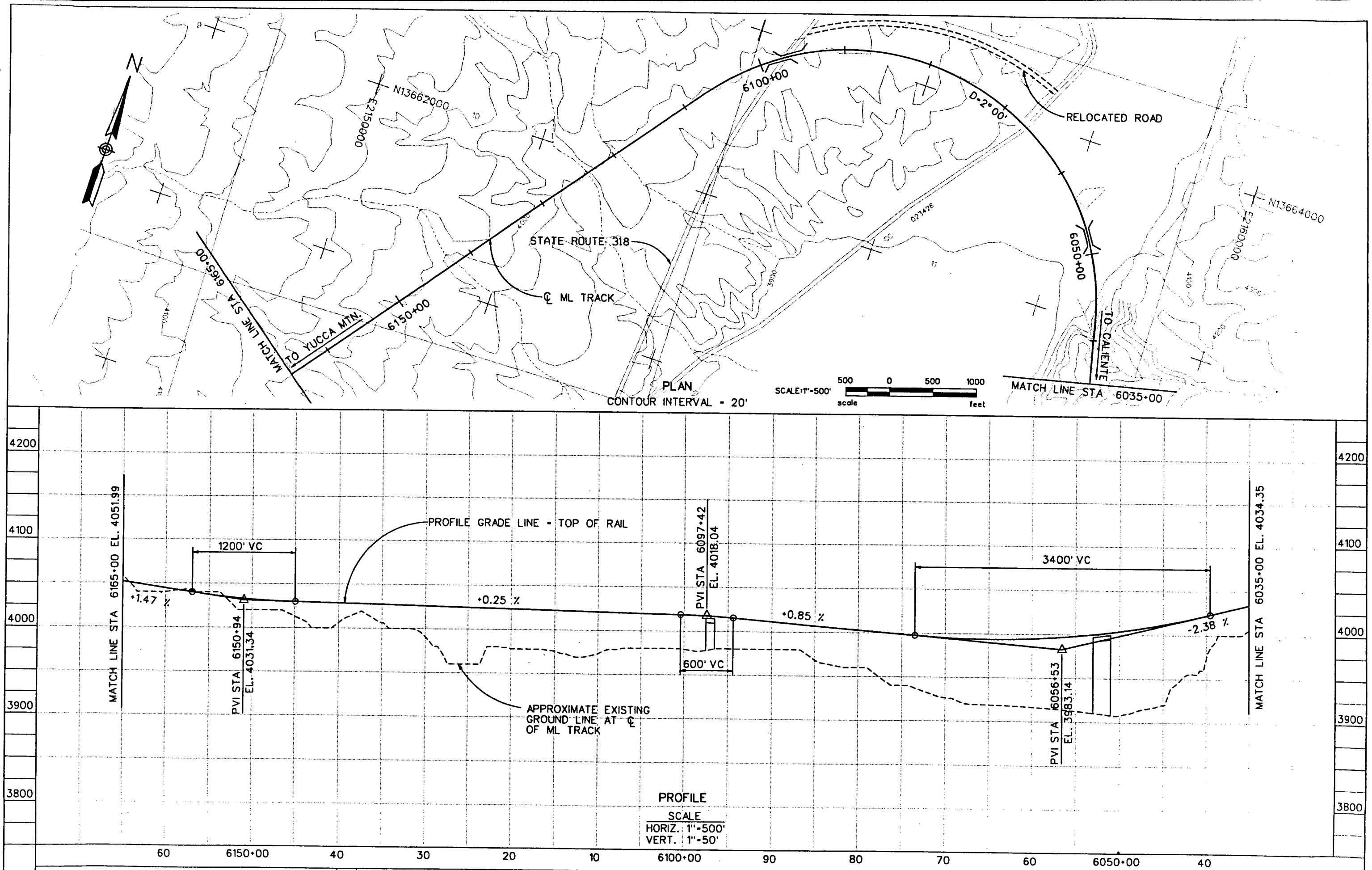
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA. 5920+00 - STA. 6035+00

SCALE as noted
DRAWING NO L01-115
SHEET NO 75 OF 190

DATE PLOTTED 25-FEB-1991



DATE PLOTTED 25-FEB-1991

REV	DESCRIPTION	DATE	BY

	BY		DATE
DESIGNED	K. CHIU	02/91	
REVIEWED	A. BOLCHAZY	02/91	
APPROVED			

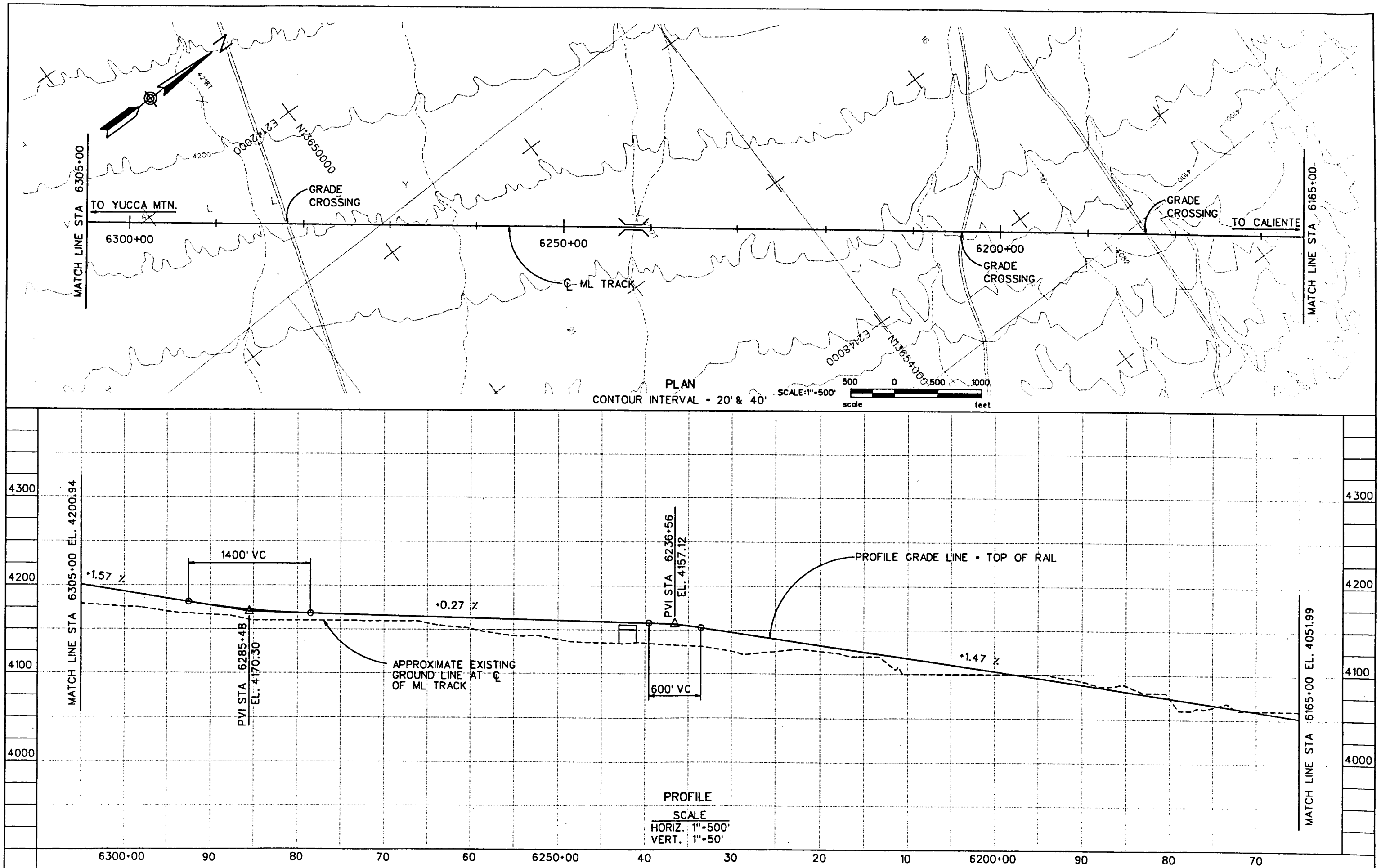
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA. 6035+00 - STA. 6165+00

SCALE as noted
DRAWING NO L01-116
SHEET NO



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

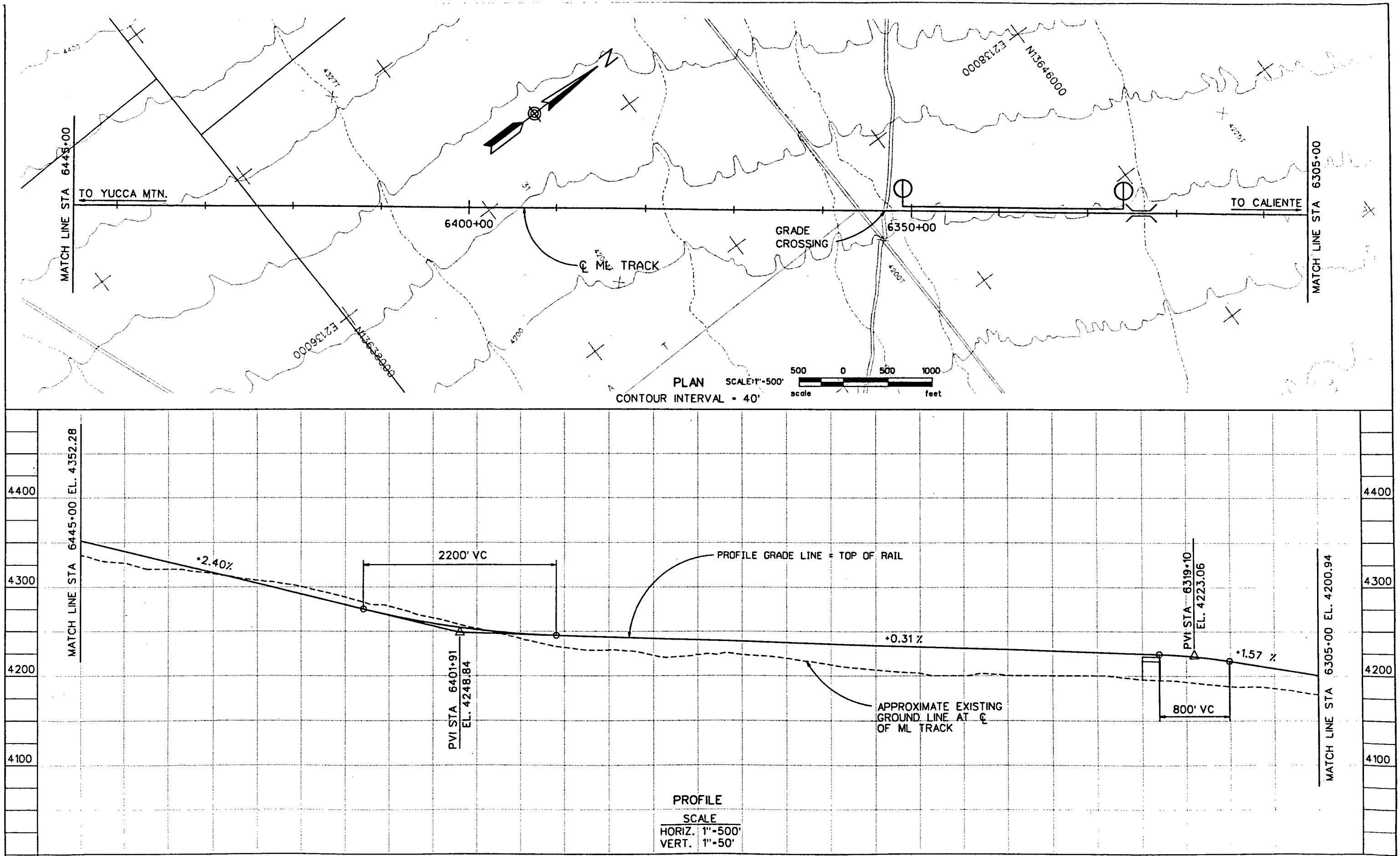
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA. 6165+00 - STA. 6305+00

SCALE as noted
DRAWING NO. L01-117
SHEET NO. 77 OF 190

DATE PLOTTED 20-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

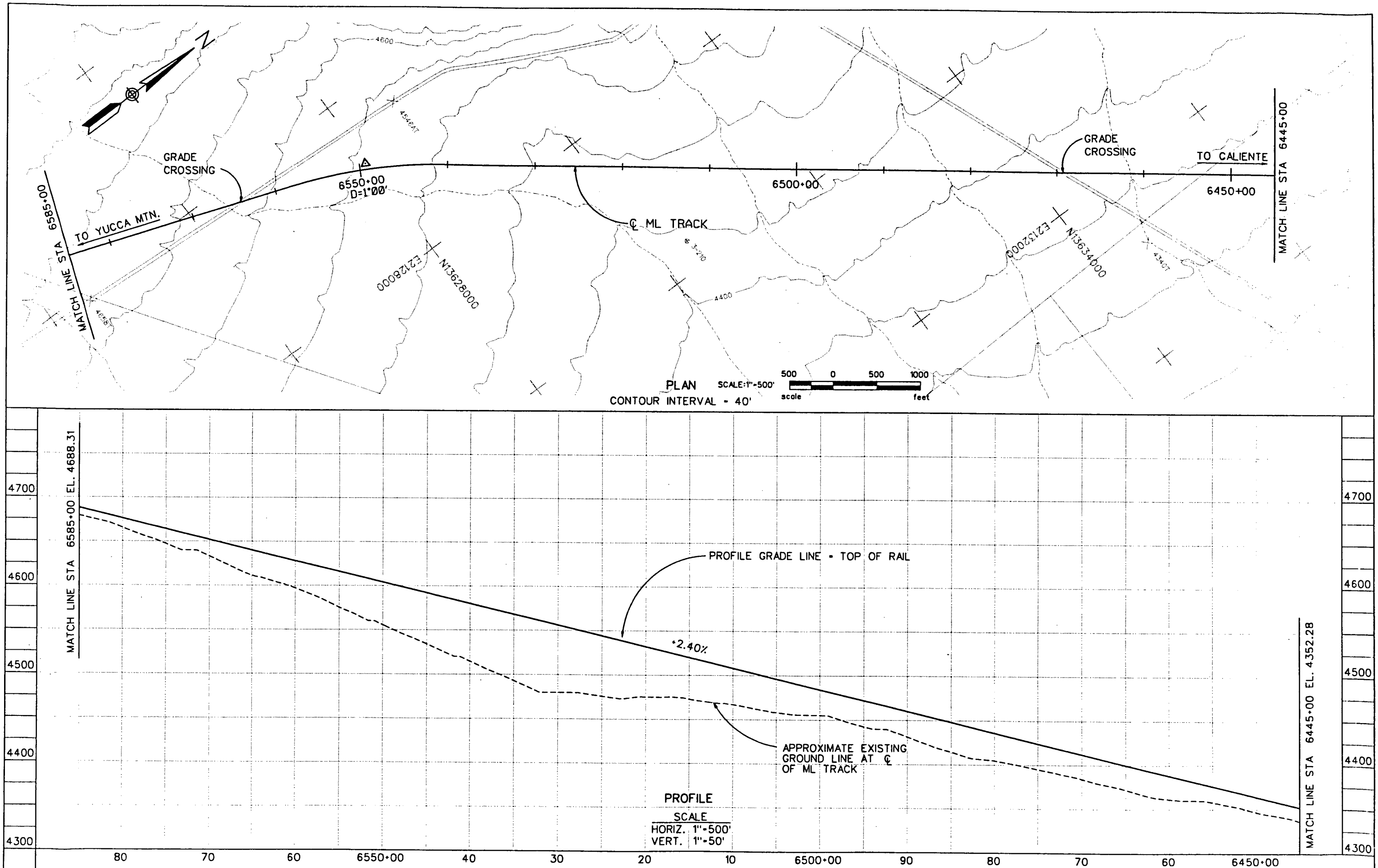
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA. 6305+00 - STA. 6445+00

SCALE as noted
DRAWING NO L01-118
SHEET NO 78 of 190

DATE PLOTTED 20-FEB-1991



DATE PLOTTED 25-FEB-1991

REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

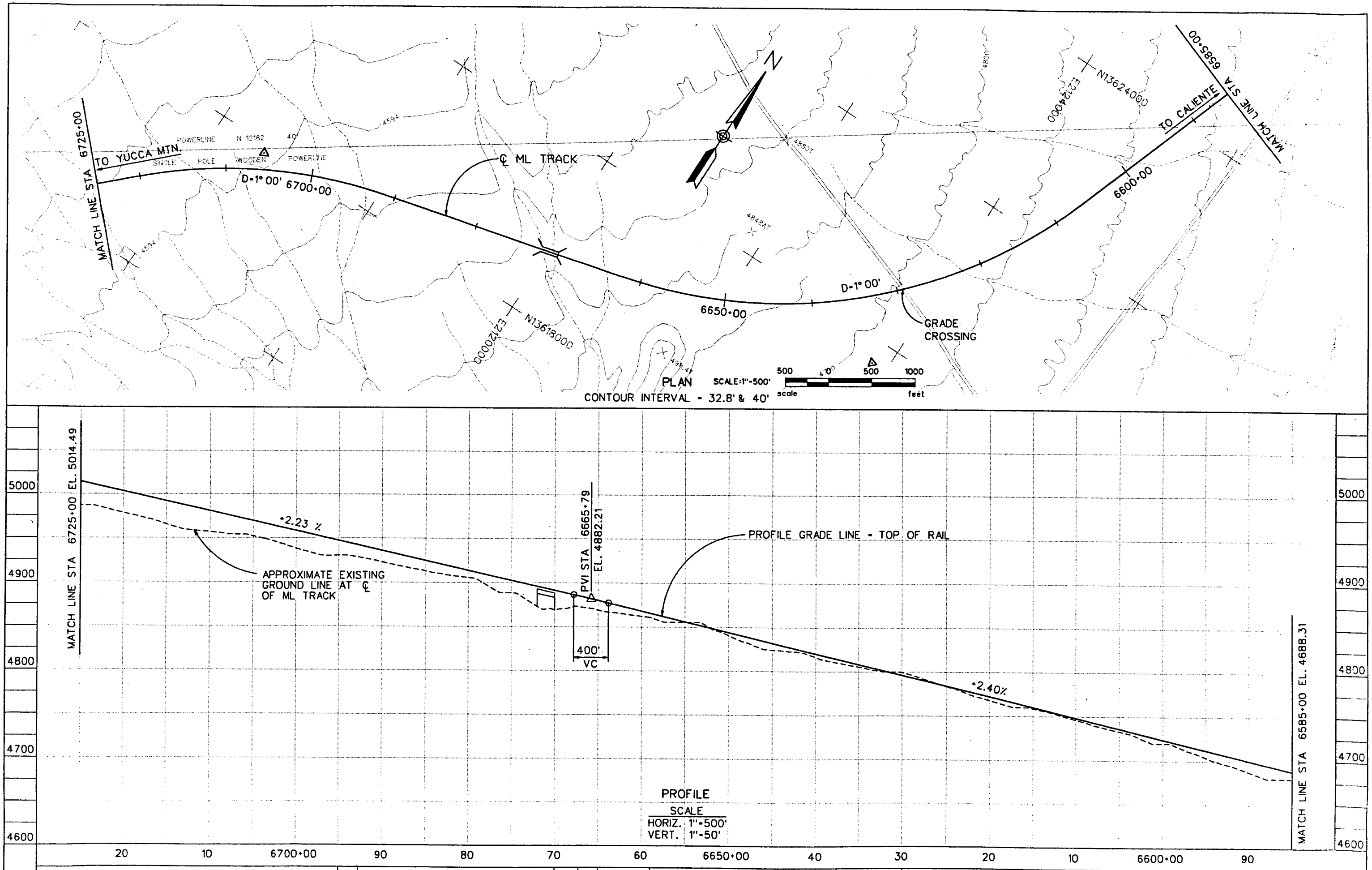
Prepared for: Science Applications International Corporation, Las Vegas, Nevada.

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA. 6445+00 - STA. 6585+00

SCALE as noted
DRAWING NO L01-119
SHEET NO 79 OF 190



DATE PLOTTED 25-FEB-1991

REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

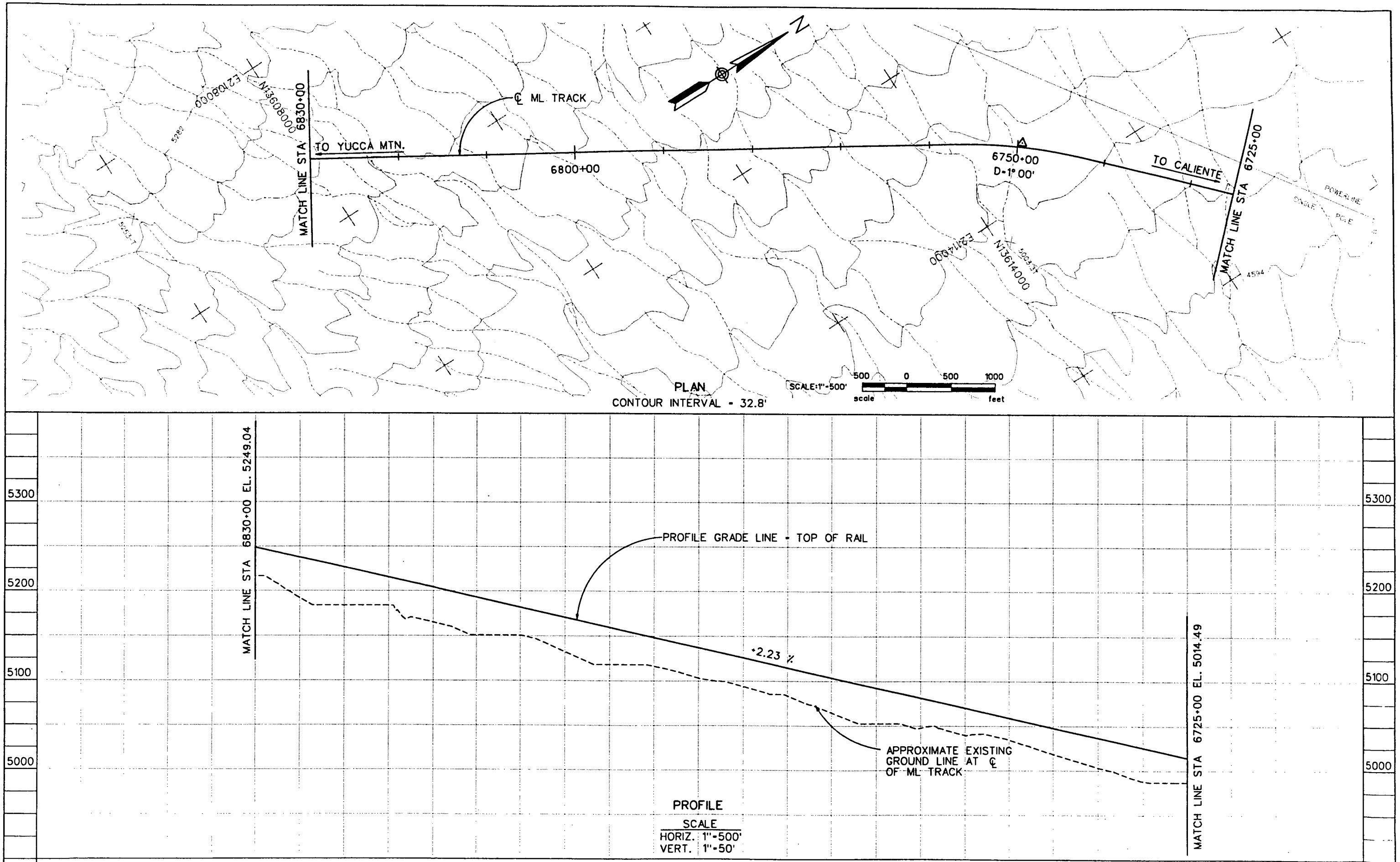
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA. 6585+00 - STA. 6725+00

SCALE as noted
DRAWING NO L01-120
SHEET NO 30 of 34



DATE PLOTTED 20-FEB-1991

REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

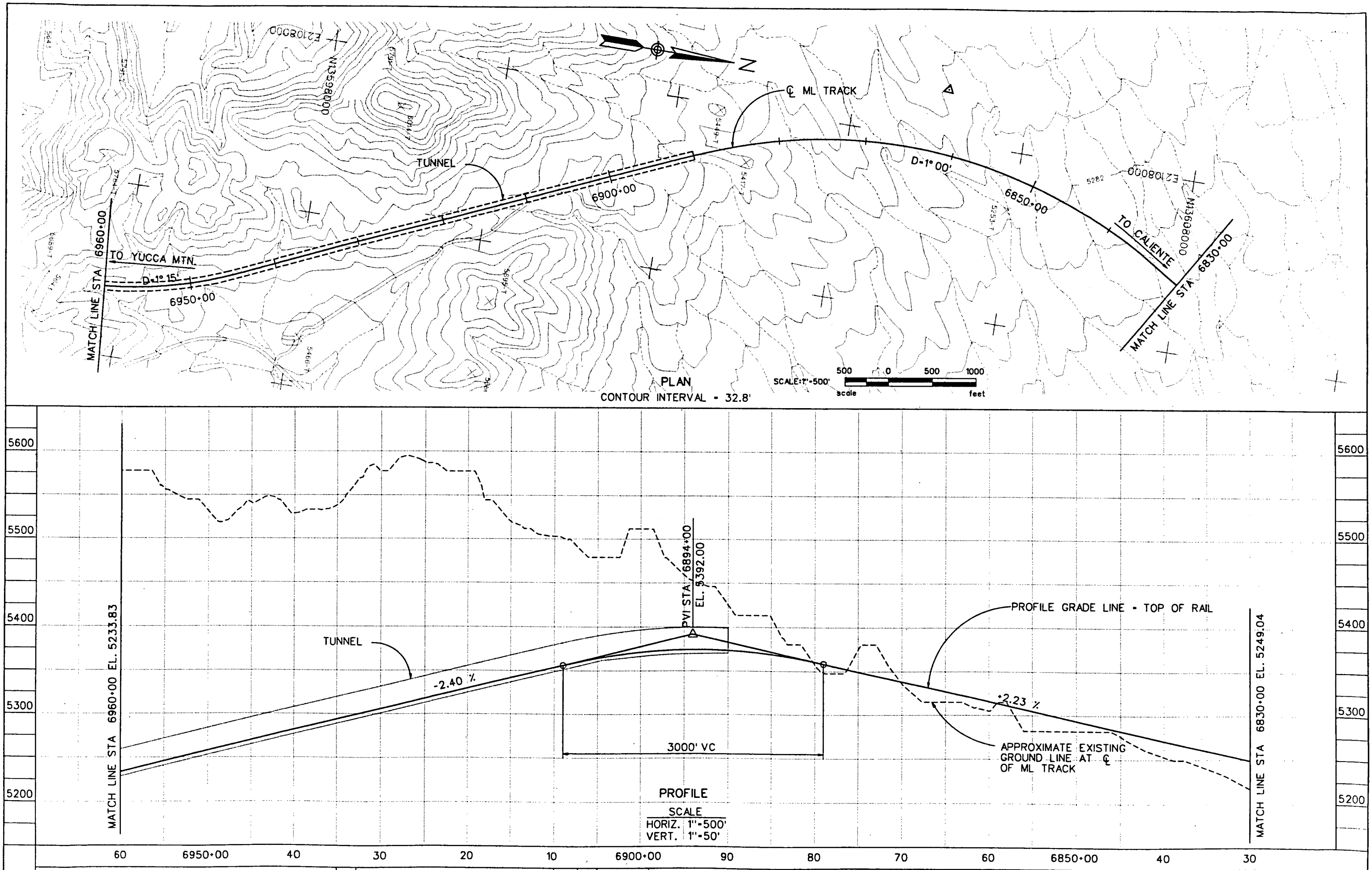
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA. 6725+00 - STA. 6830+00

SCALE as noted
DRAWING NO L01-12
SHEET NO 21 OF 19



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

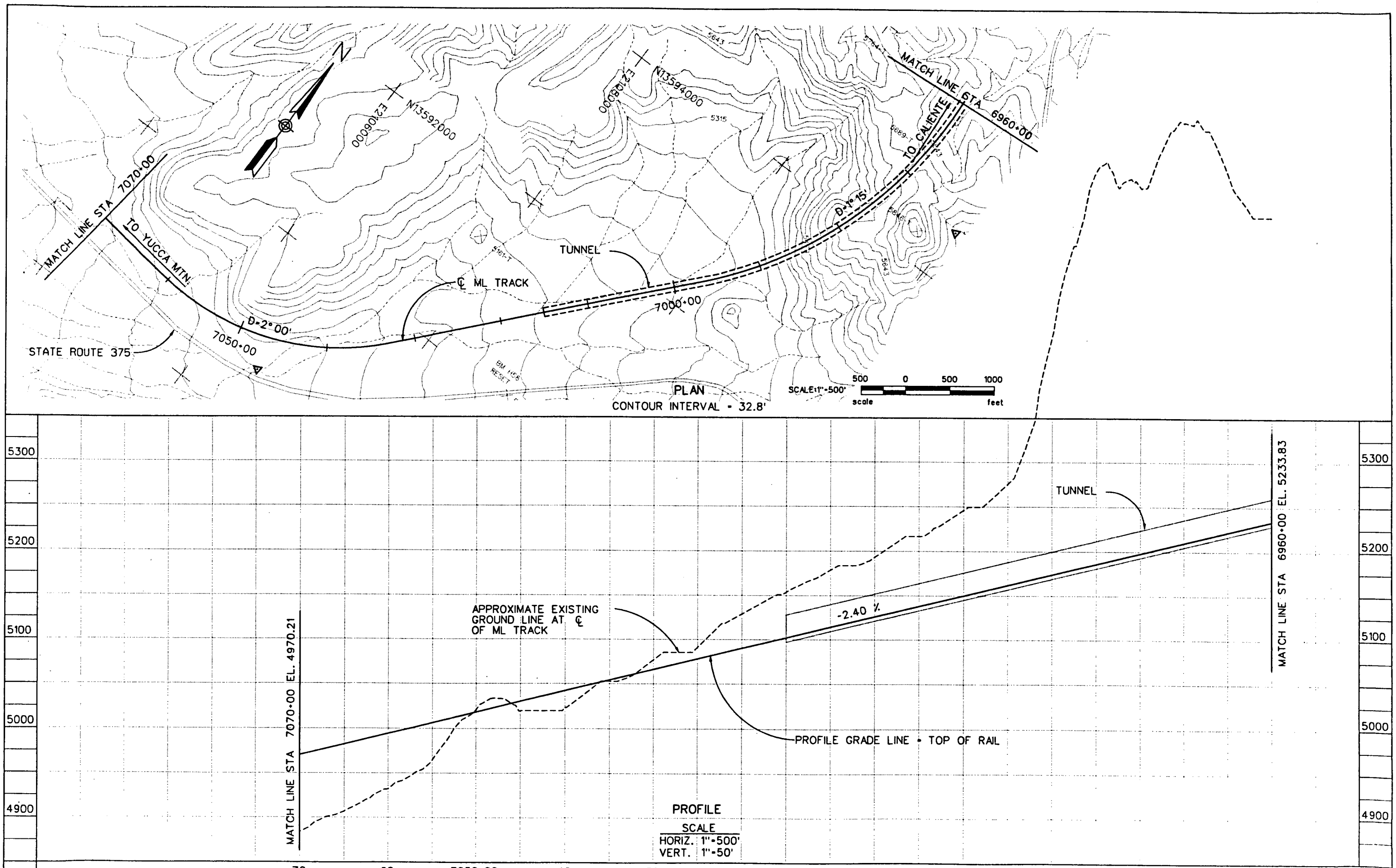
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA 6830+00 - STA 6960+00

SCALE: as noted
DRAWING NO. L01-122
SHEET NO. 82 OF 190

DATE PLOTTED 22-FEB-1991



DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

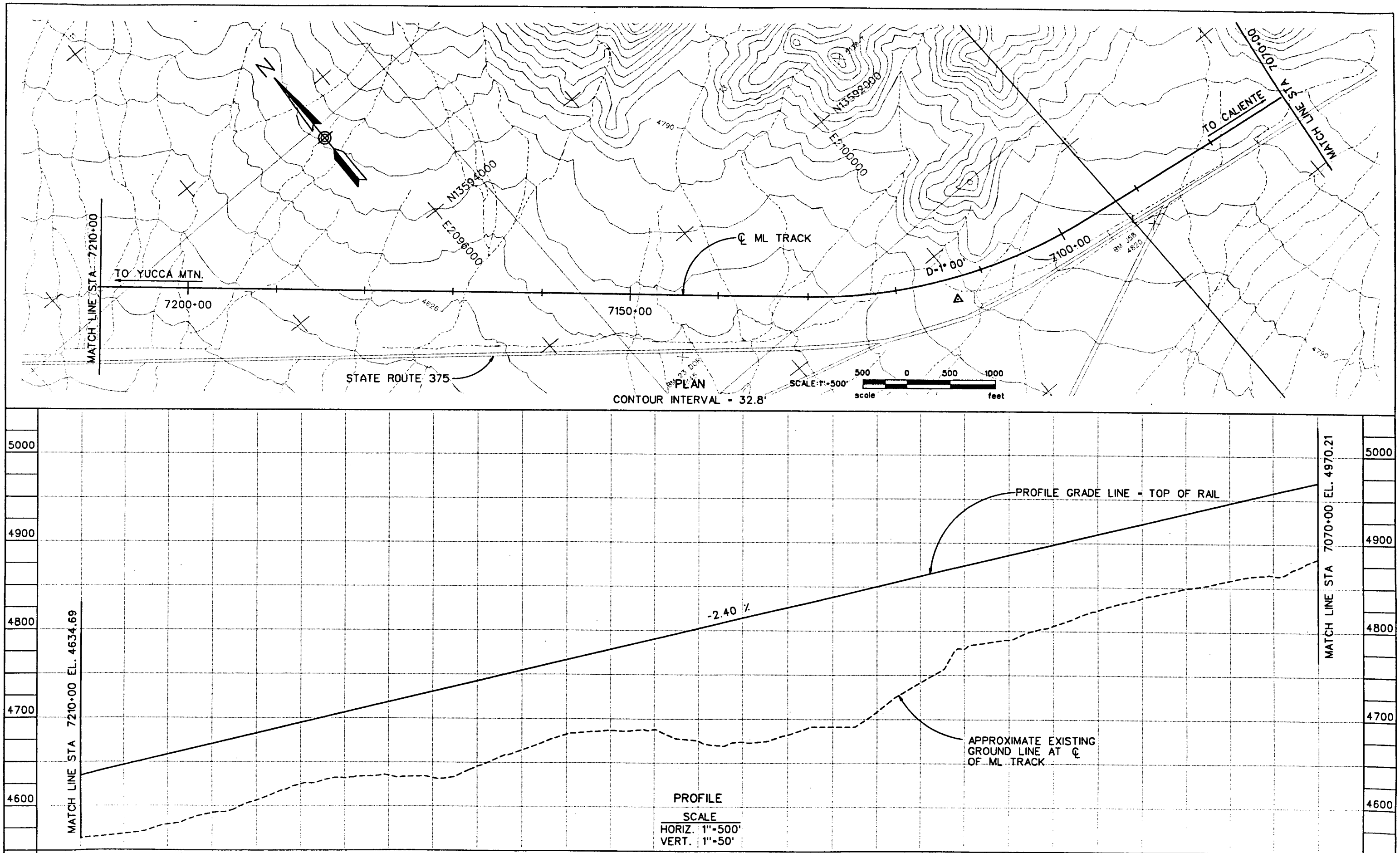
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE

SCALE as noted
DRAWING NO L01-123
SHEET NO

DATE PLOTTED 22-FEB-1991



DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

REV | DESCRIPTION | DATE | BY

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

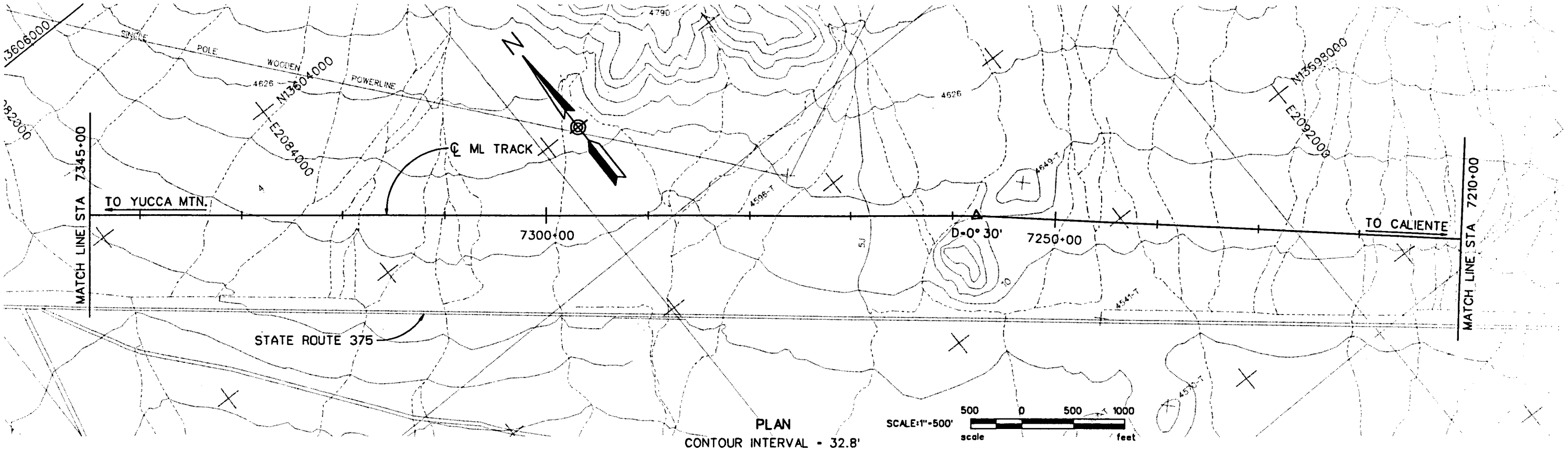
CALIENTE ROUTE - ROUTE A PLAN & PROFILE

SCALE: as noted

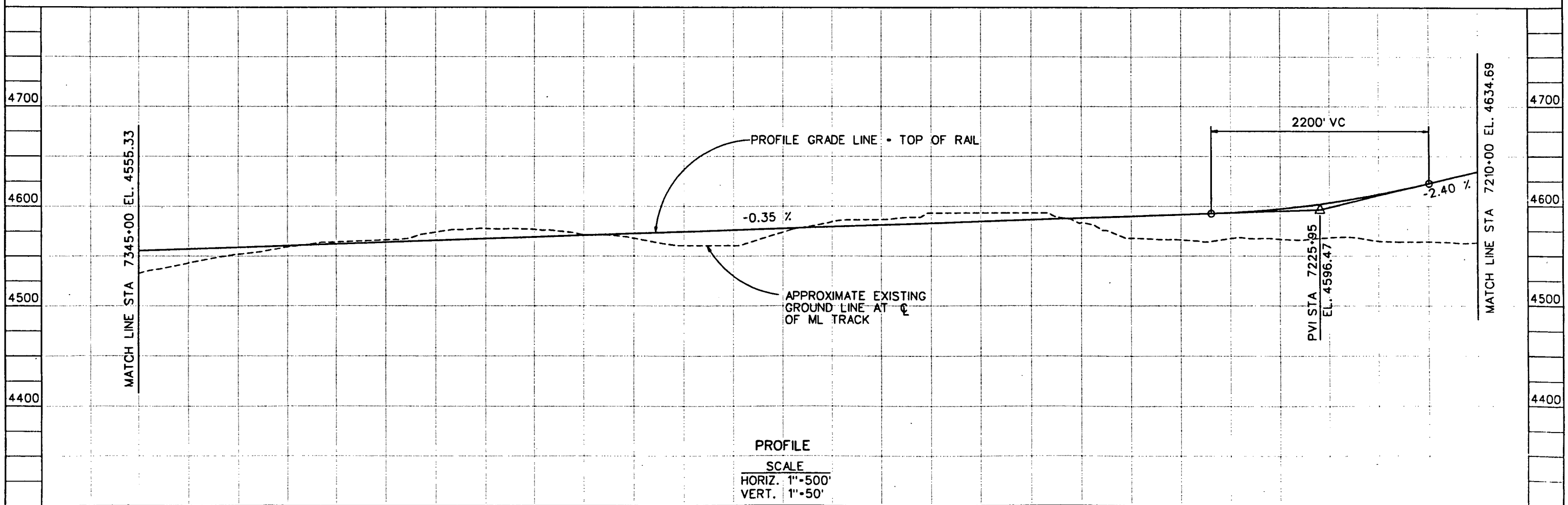
DRAWING NO. L01-124

SHEET NO

DATE PLOTTED 20-FEB-1991



PLAN
CONTOUR INTERVAL - 32.8'



PROFILE
SCALE
HORIZ. 1"=500'
VERT. 1"=50'

REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

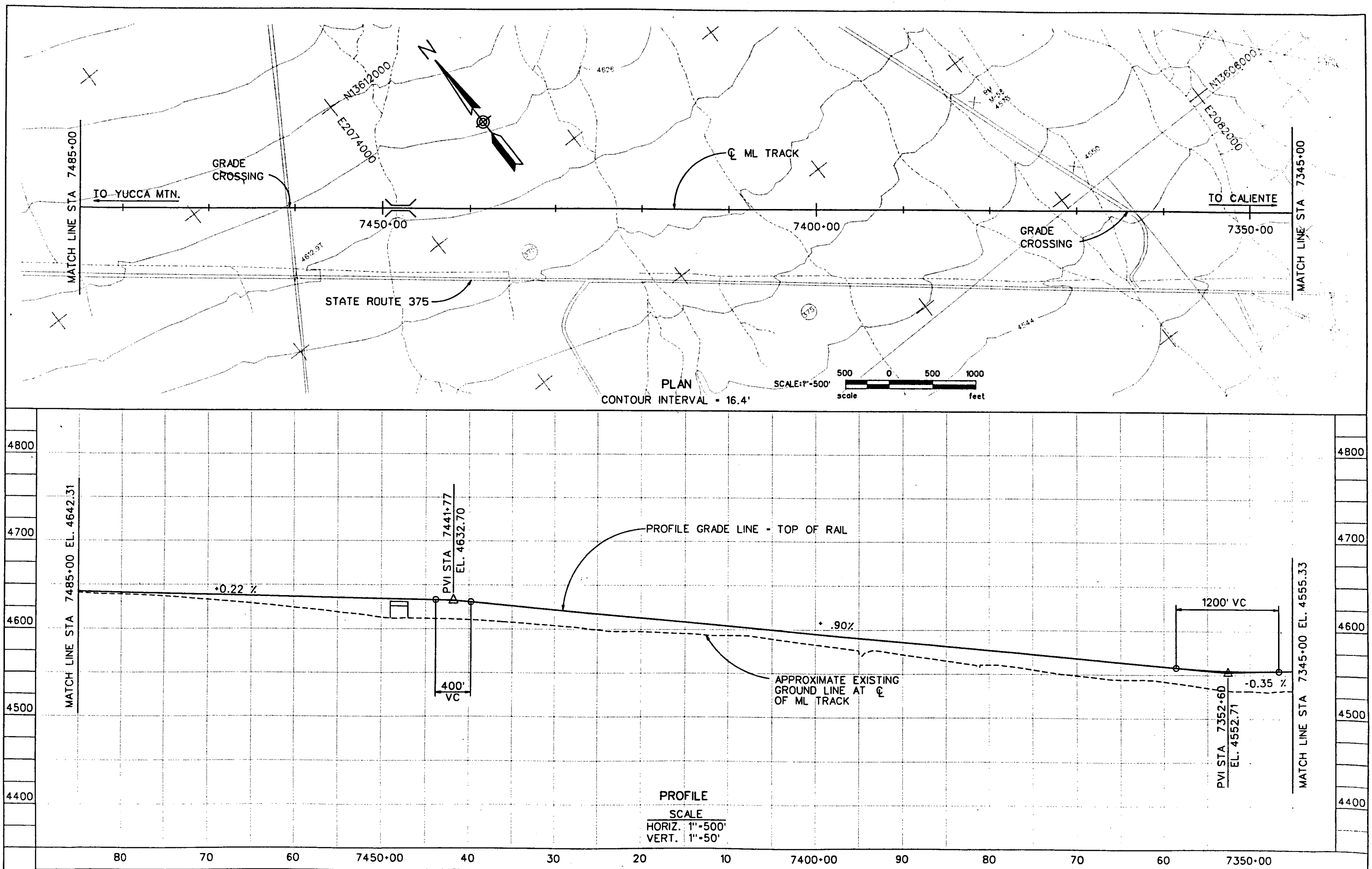
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA 7210+00 - STA 7345+00

SCALE as noted
DRAWING NO L01-12
SHEET NO OF

DATE PLOTTED 21-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE

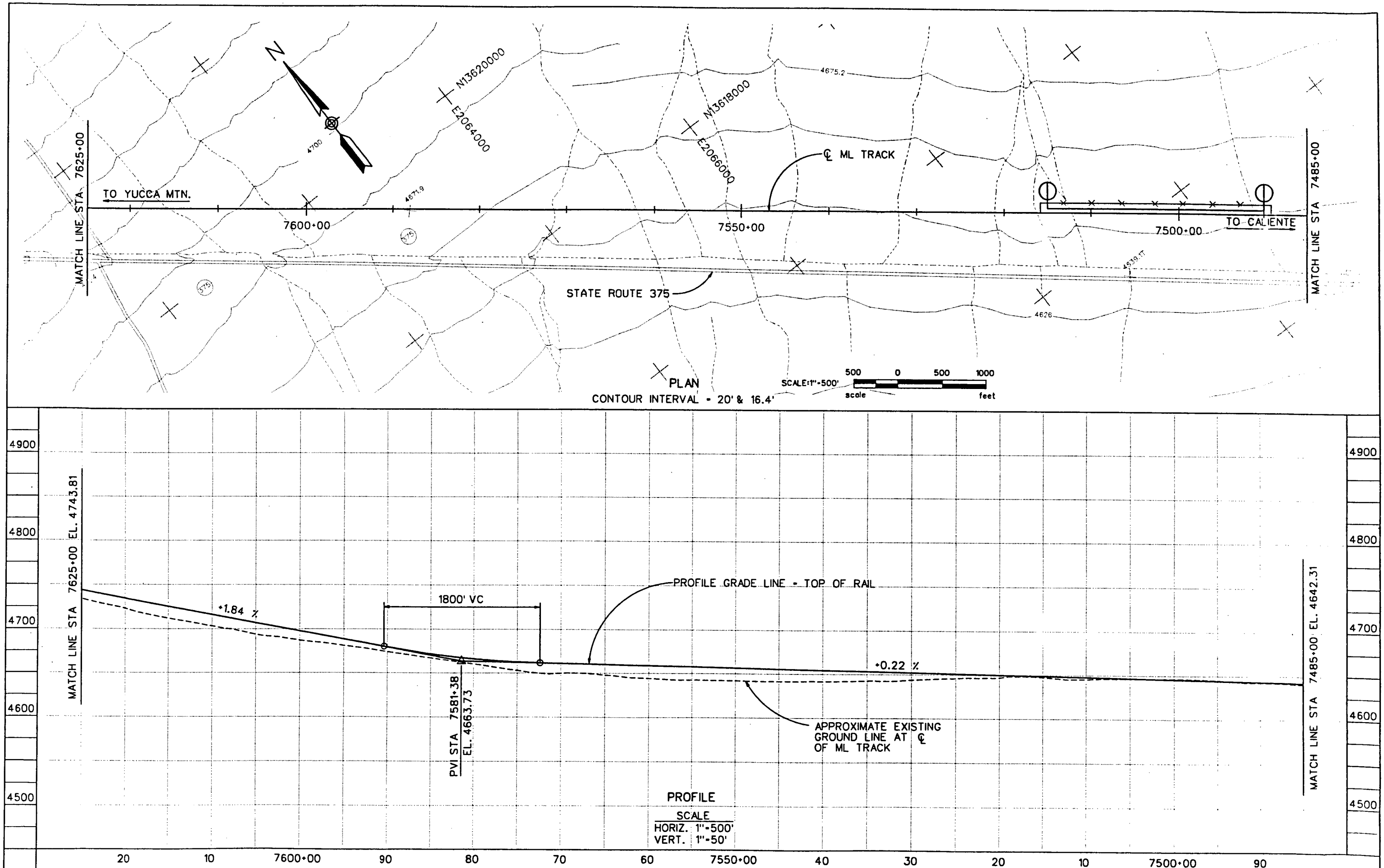
STA 7345+00 - STA 7485+00

SCALE as noted

DRAWING NO L01-12

SHEET NO 86 of 12

DATE PLOTTED 22-FEB-1991



DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

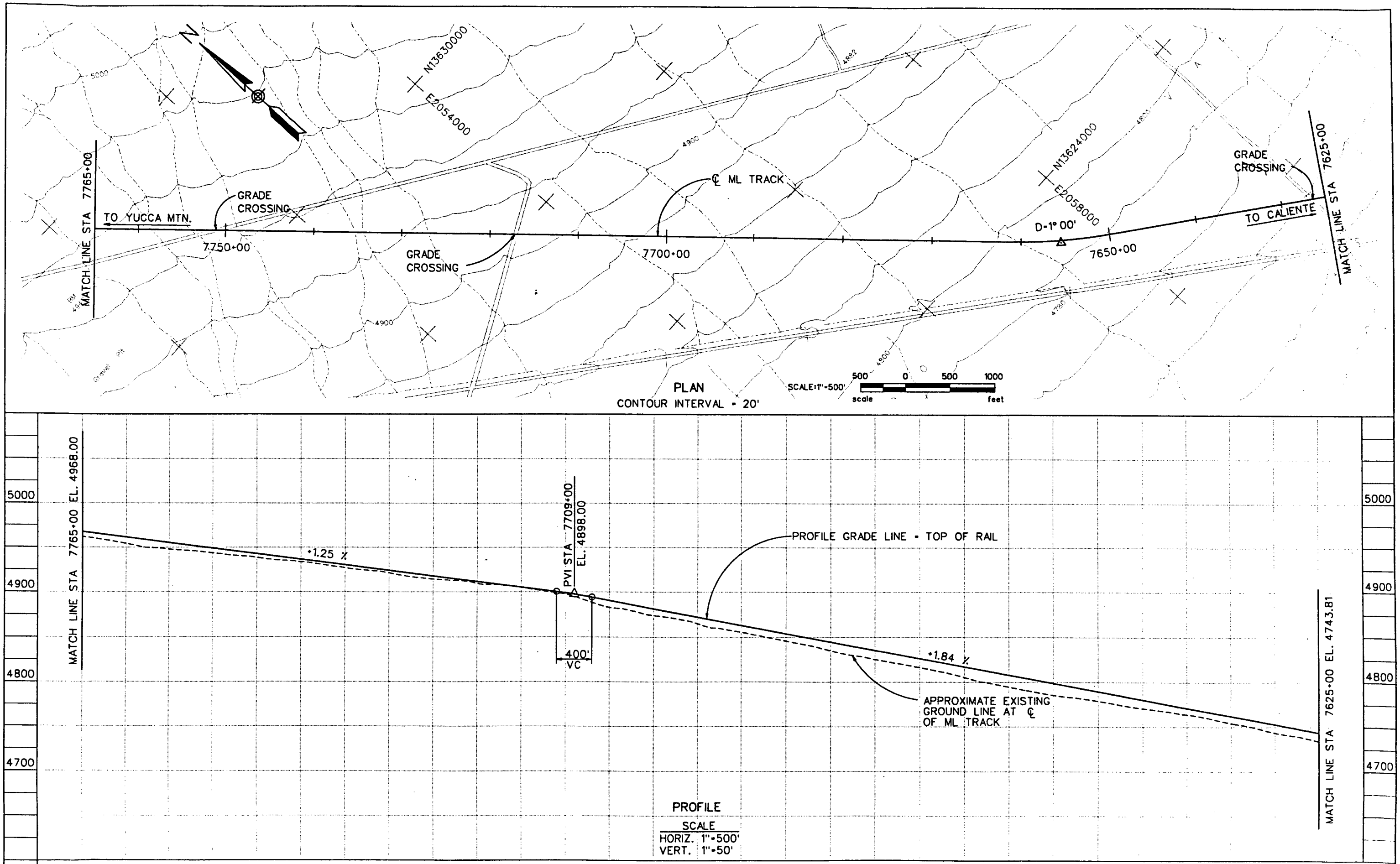
YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A PLAN & PROFILE

SCALE as noted

DRAWING NO L01-127

DATE PLOTTED 21-FEB-1991



DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

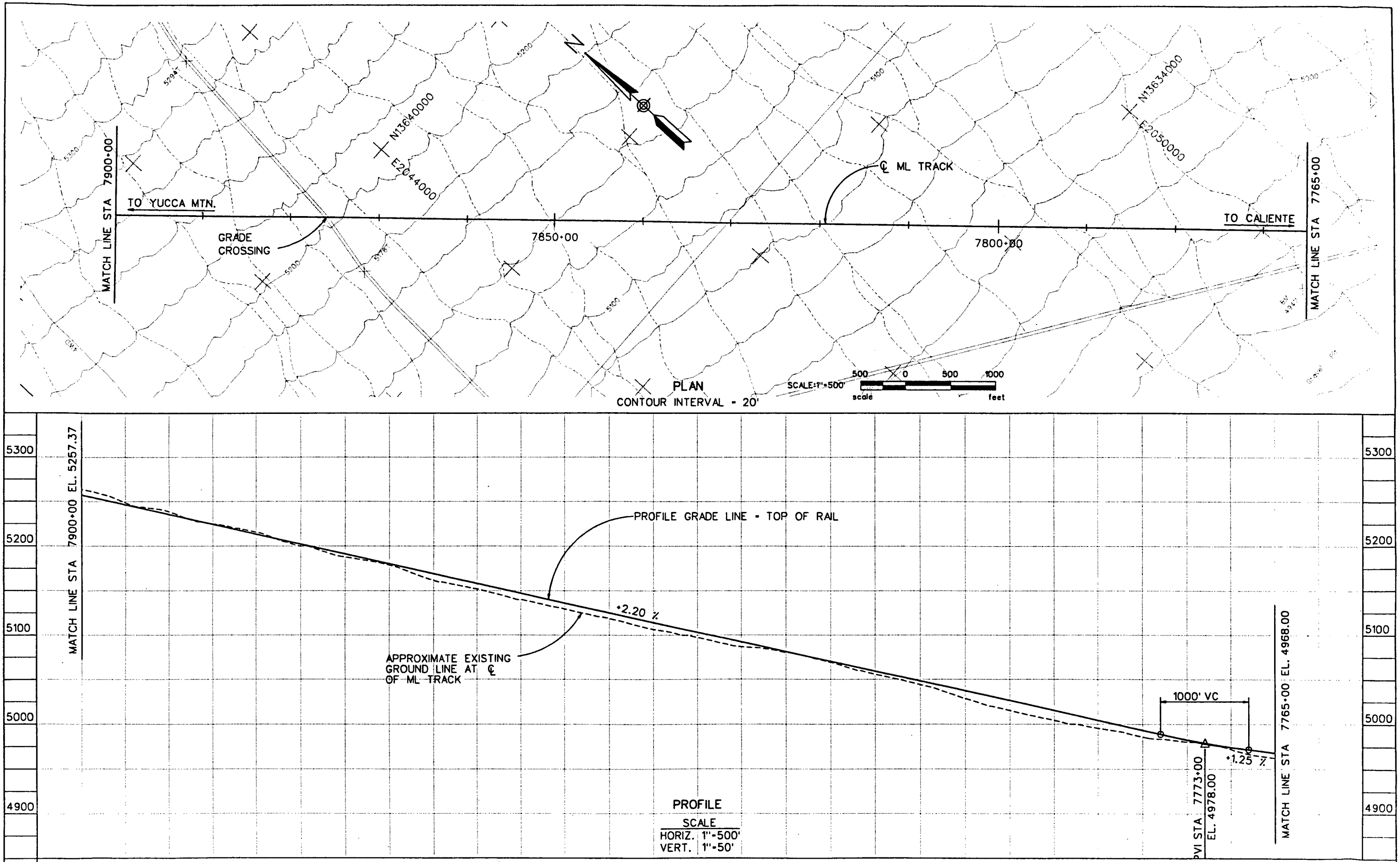
YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE

SCALE as noted

DRAWING NO L01-128

DATE PLOTTED 21-FEB-1991



DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

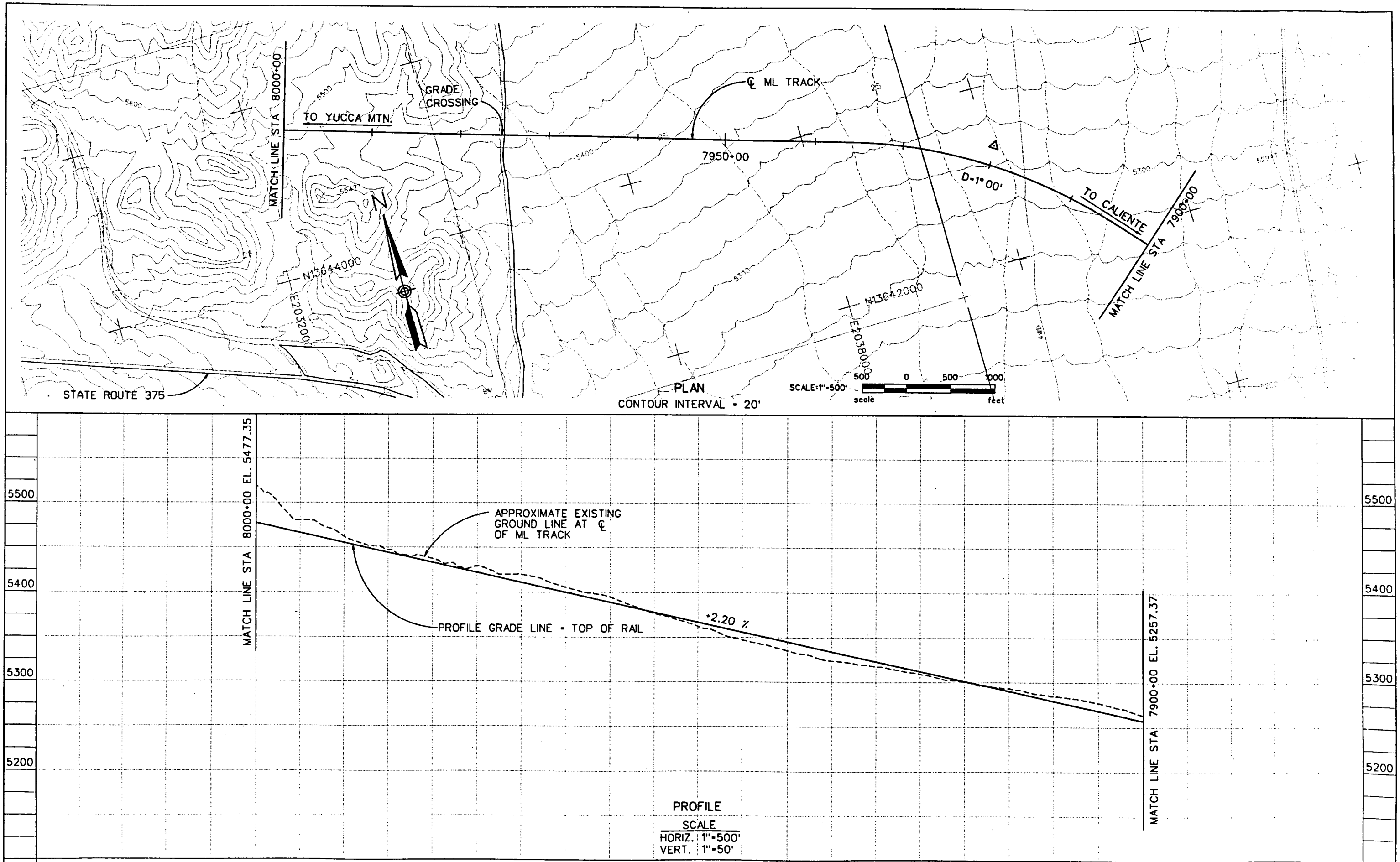
CALIENTE ROUTE - ROUTE A
PLAN & PROFILE

SCALE as noted

DRAWING NO L01-129

SHEET NO

DATE PLOTTED 21-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

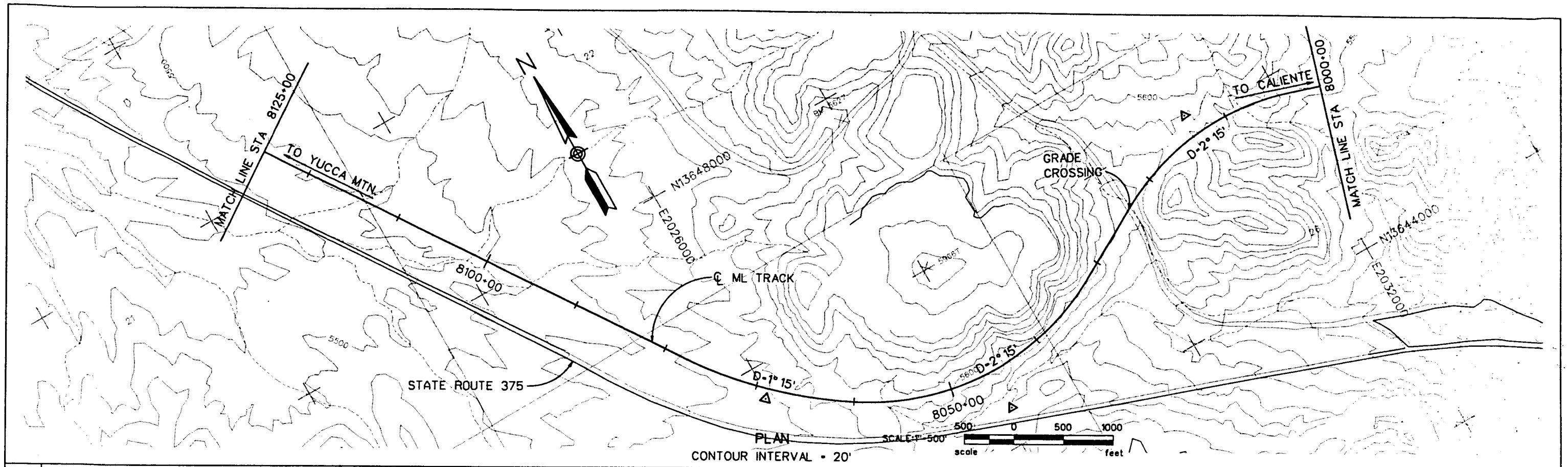
CALIENTE ROUTE - ROUTE A PLAN & PROFILE

SCALE: as noted

DRAWING NO: L01-130

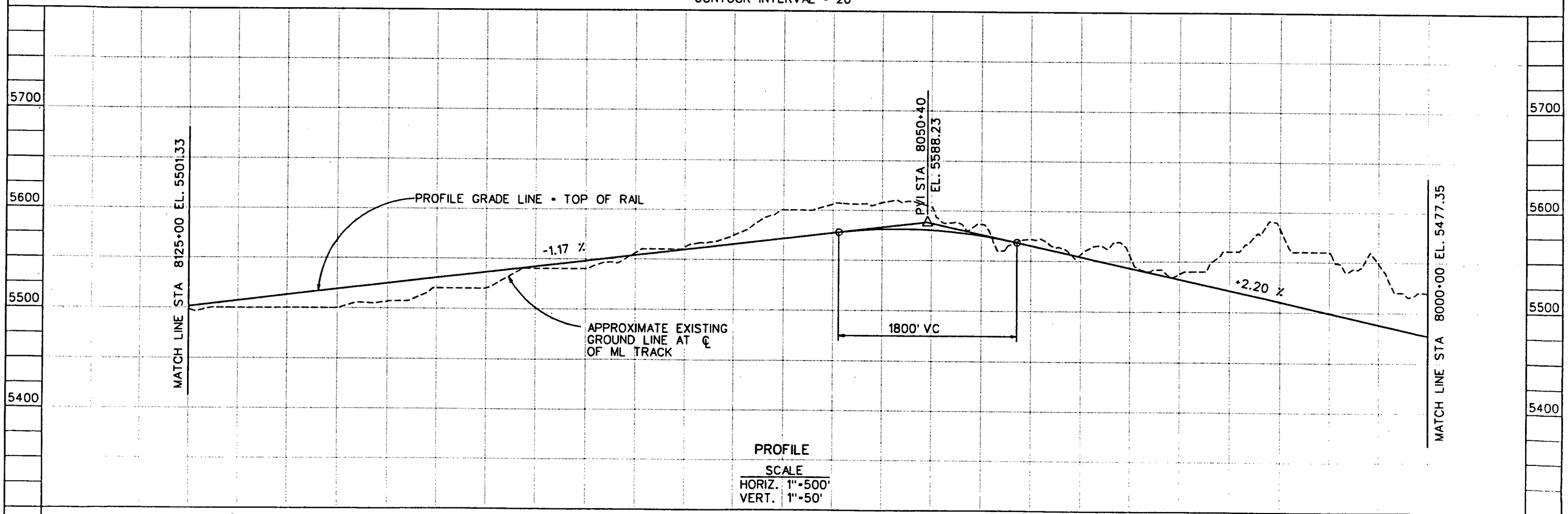
SHEET NO:

DATE PLOTTED 21-FEB-1991



PLAN

CONTOUR INTERVAL = 20'



PROFILE

SCALE	
HORIZ.	1"=500'
VERT.	1"=50'

REV	DESCRIPTION	DATE	BY

	BY		DATE
DESIGNED	K. CHIU	02/91	
REVIEWED	A. BOLCHAZY	02/91	
APPROVED			

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A PLAN & PROFILE

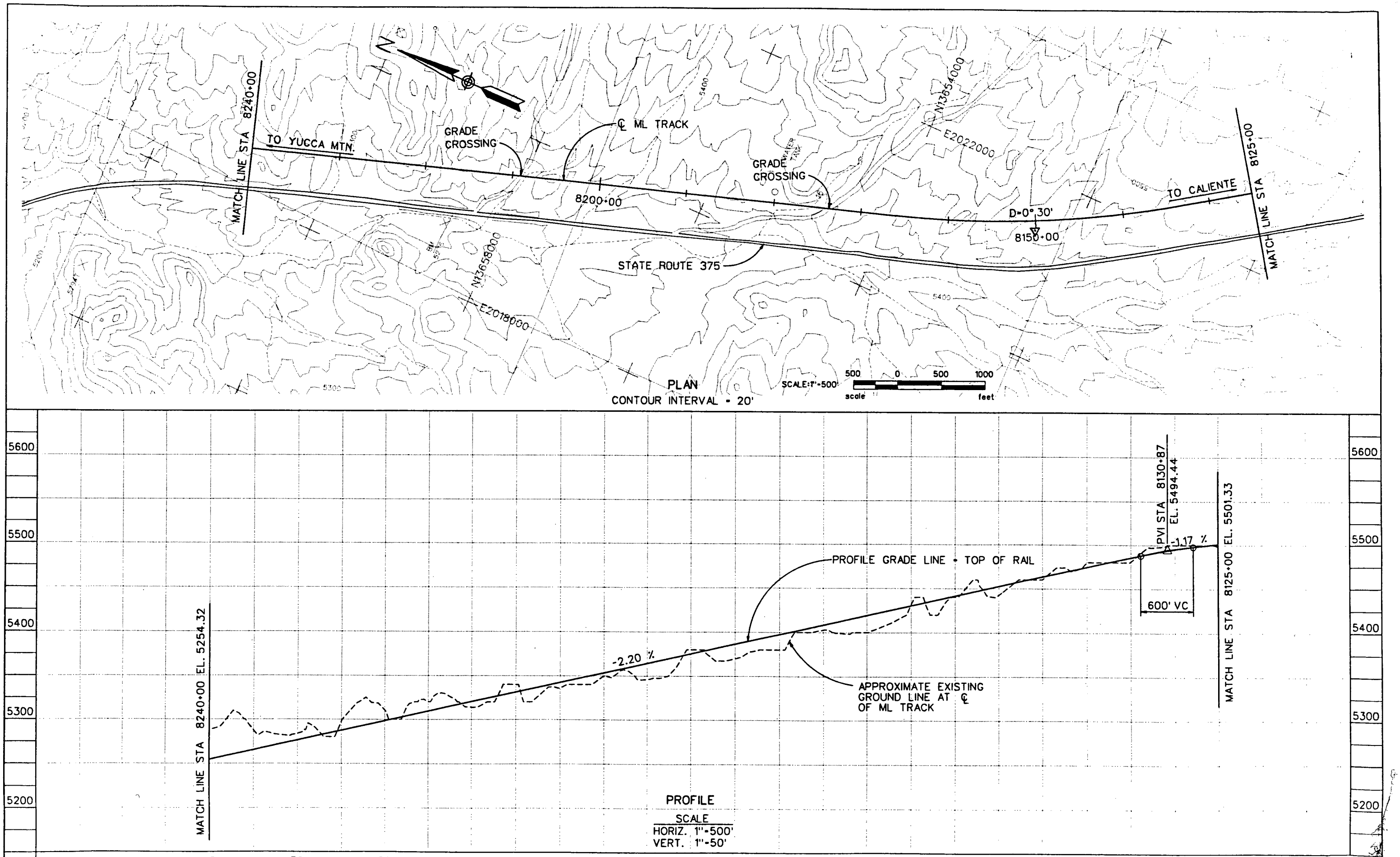
STA. 8000+00 - STA. 8125+00

SCALE: as noted

DRAWING NO: L01-131

SHEET NO: 01 OF 01

DATE PLOTTED 21-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

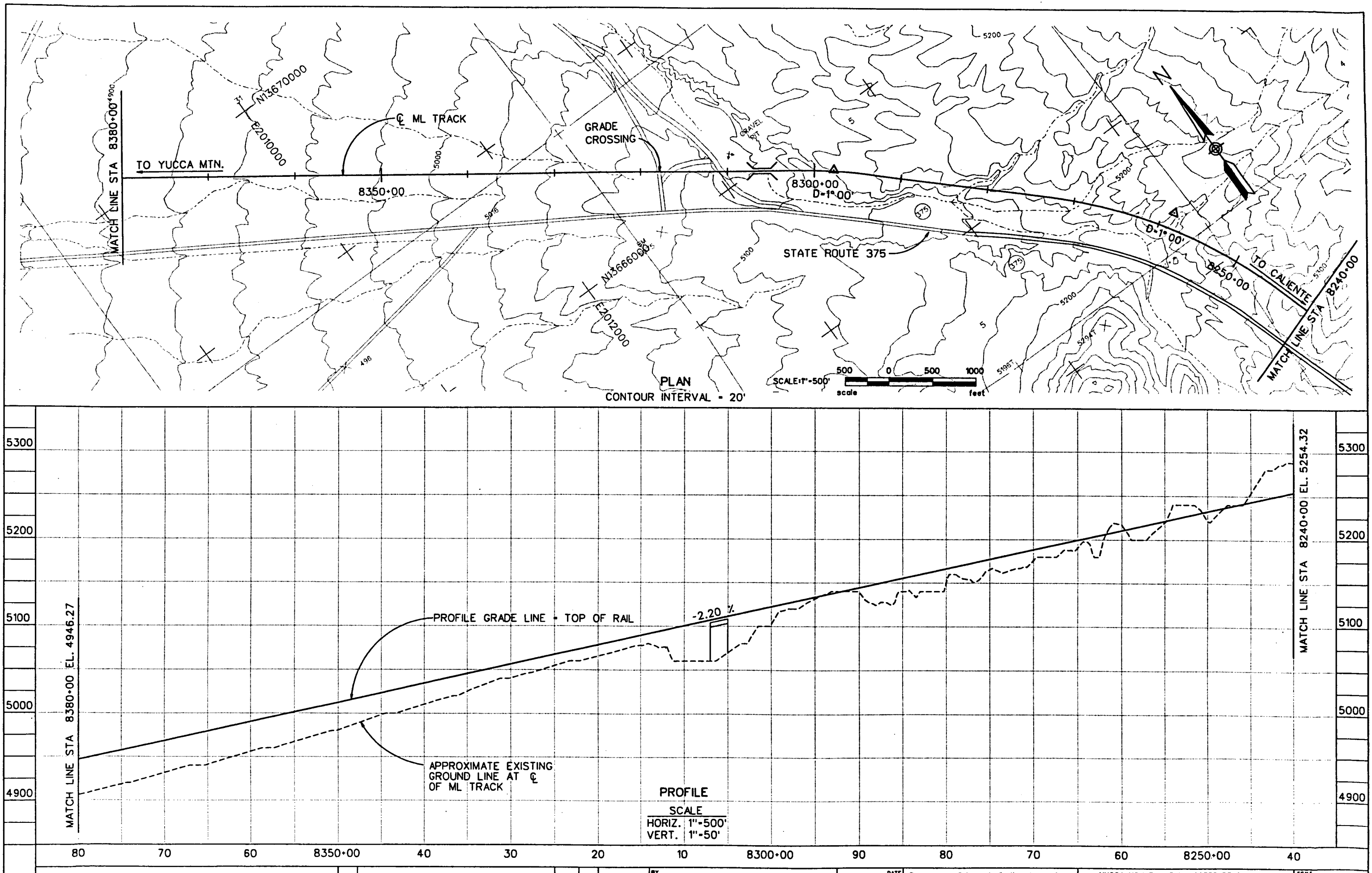
YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE

STA. 8125+00 — STA. 8240+00

SCALE: as noted
DRAWING NO: L01-132
SHEET NO:

DATE PLOTTED 21-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

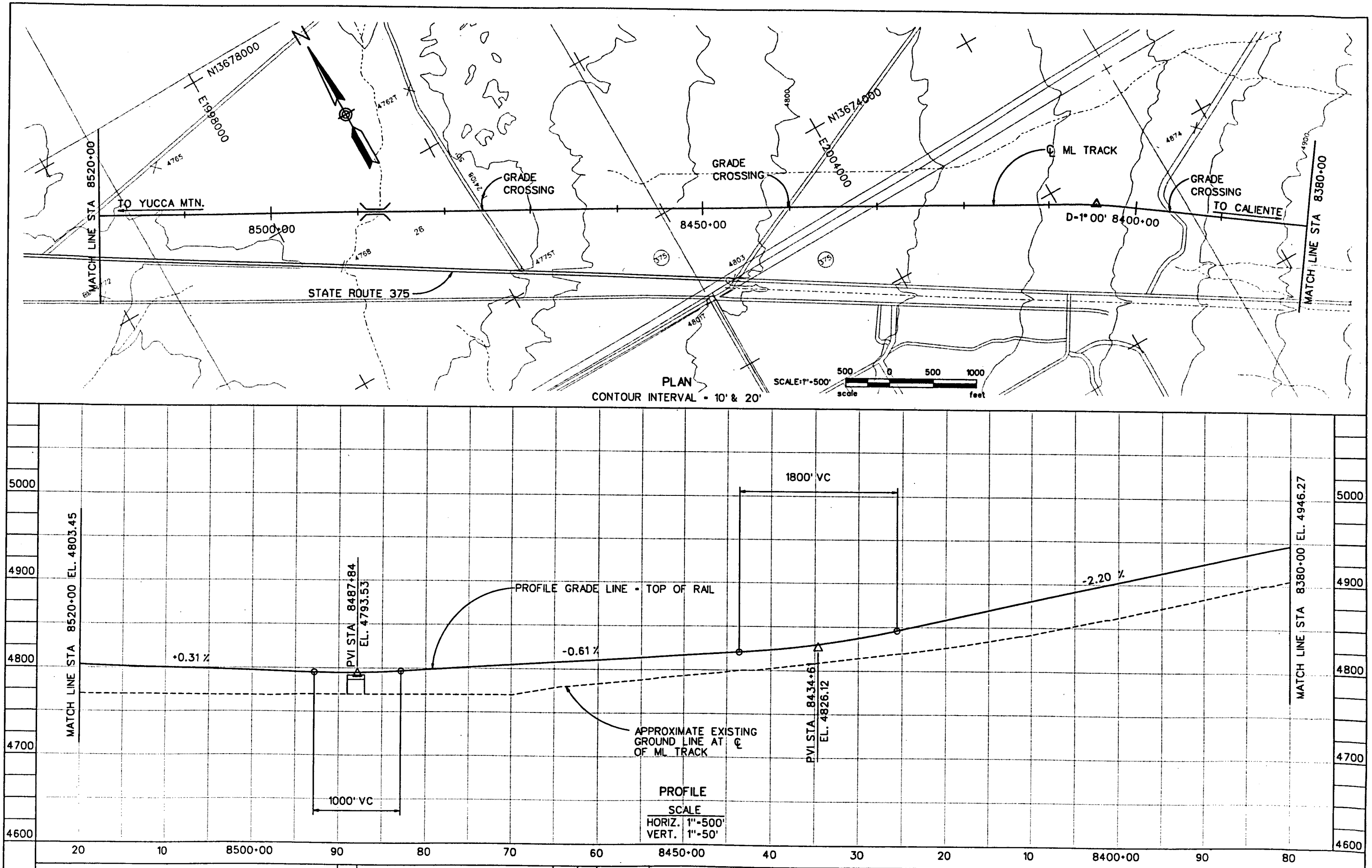
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA 8240+00 - STA 8380+00

SCALE as noted
DRAWING NO. L01-133
SHEET NO. 92 OF 190

DATE PLOTTED 22-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

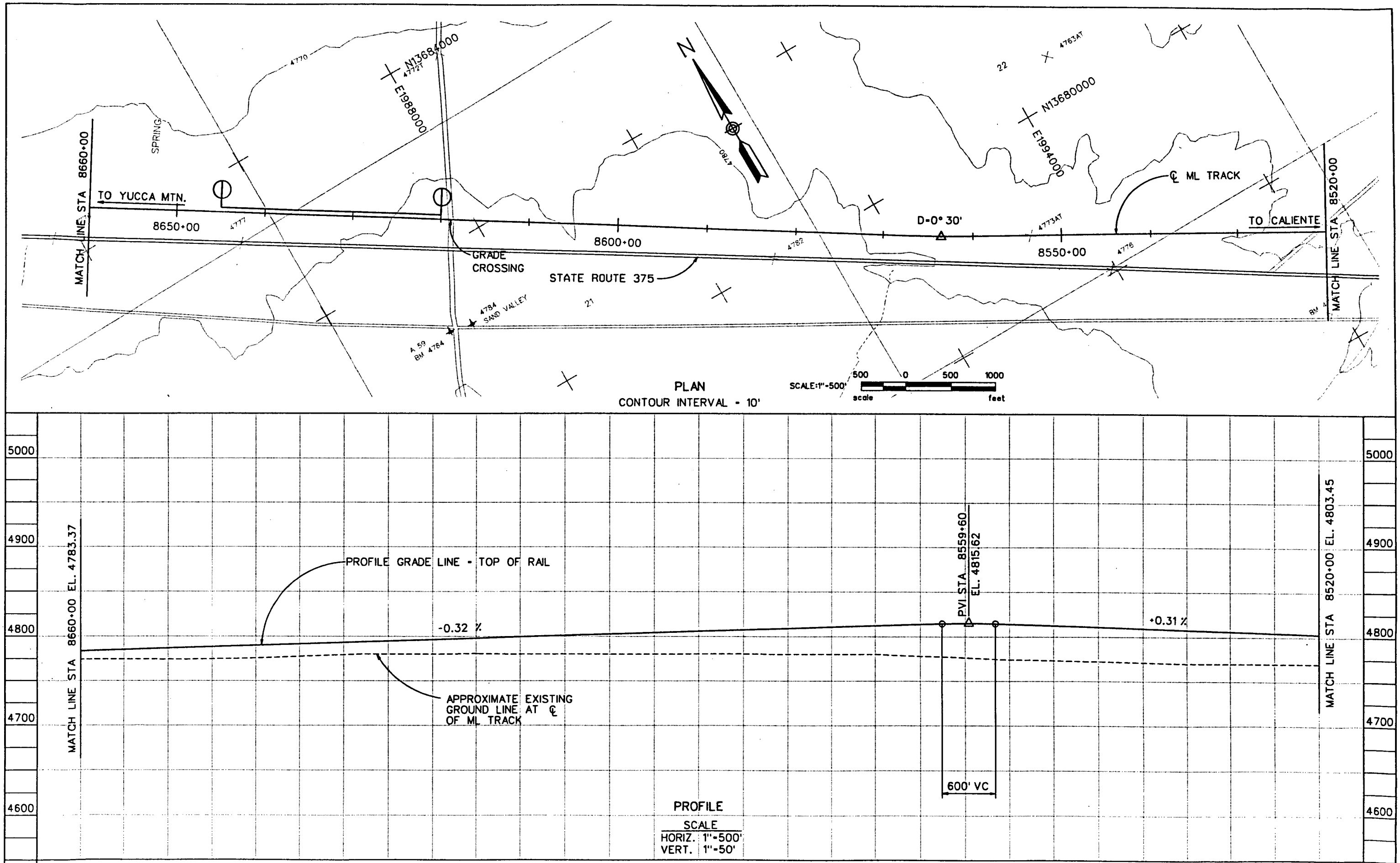
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA 8380+00 - STA 8520+00

SCALE: as noted
DRAWING NO. L01-134
SHEET NO. 94 of 190

DATE PLOTTED 21-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

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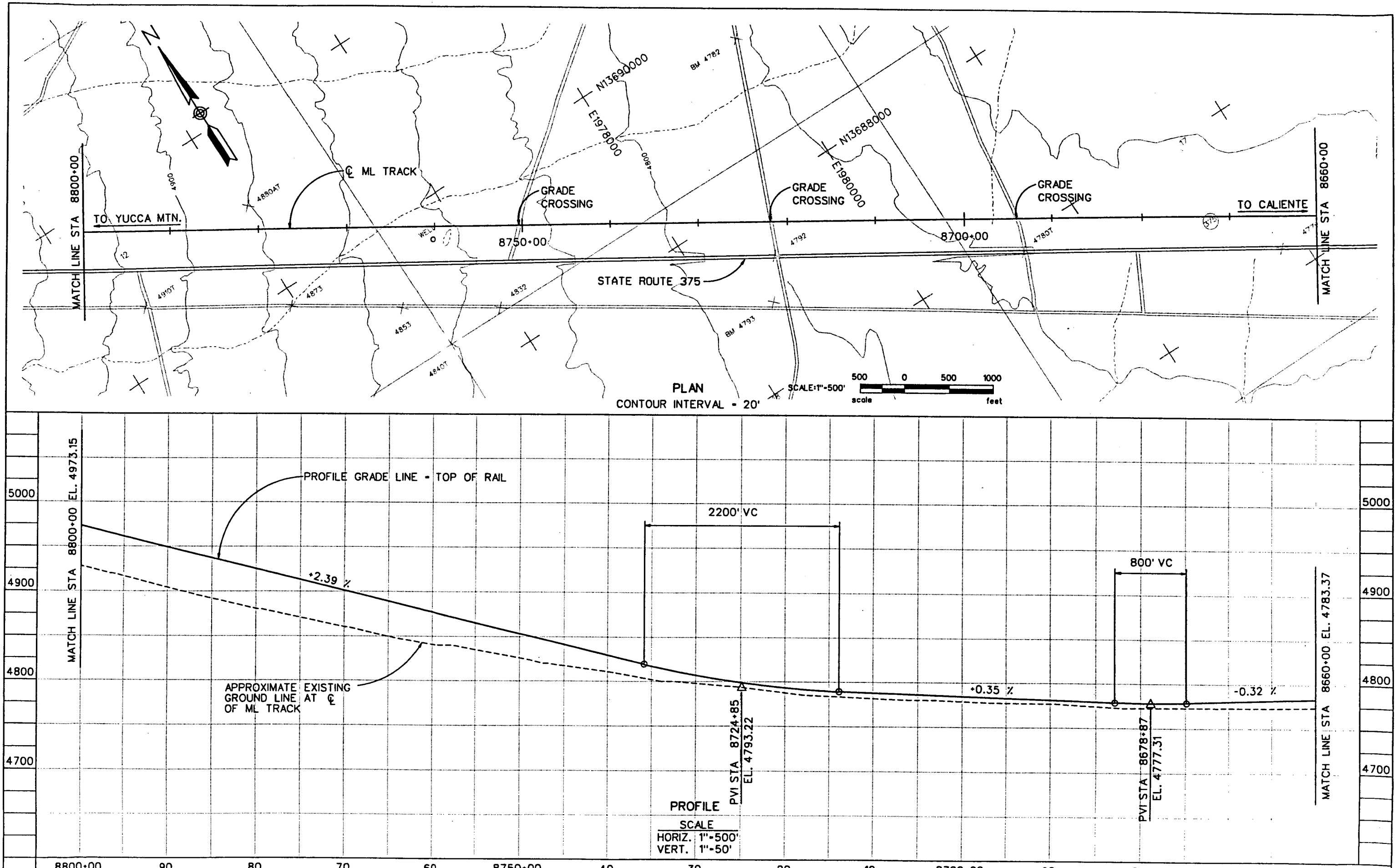
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA. 8520+00 - STA. 8660+00

SCALE as noted
DRAWING NO. L01-135
SHEET NO. 95 of 190

DATE PLOTTED 21-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

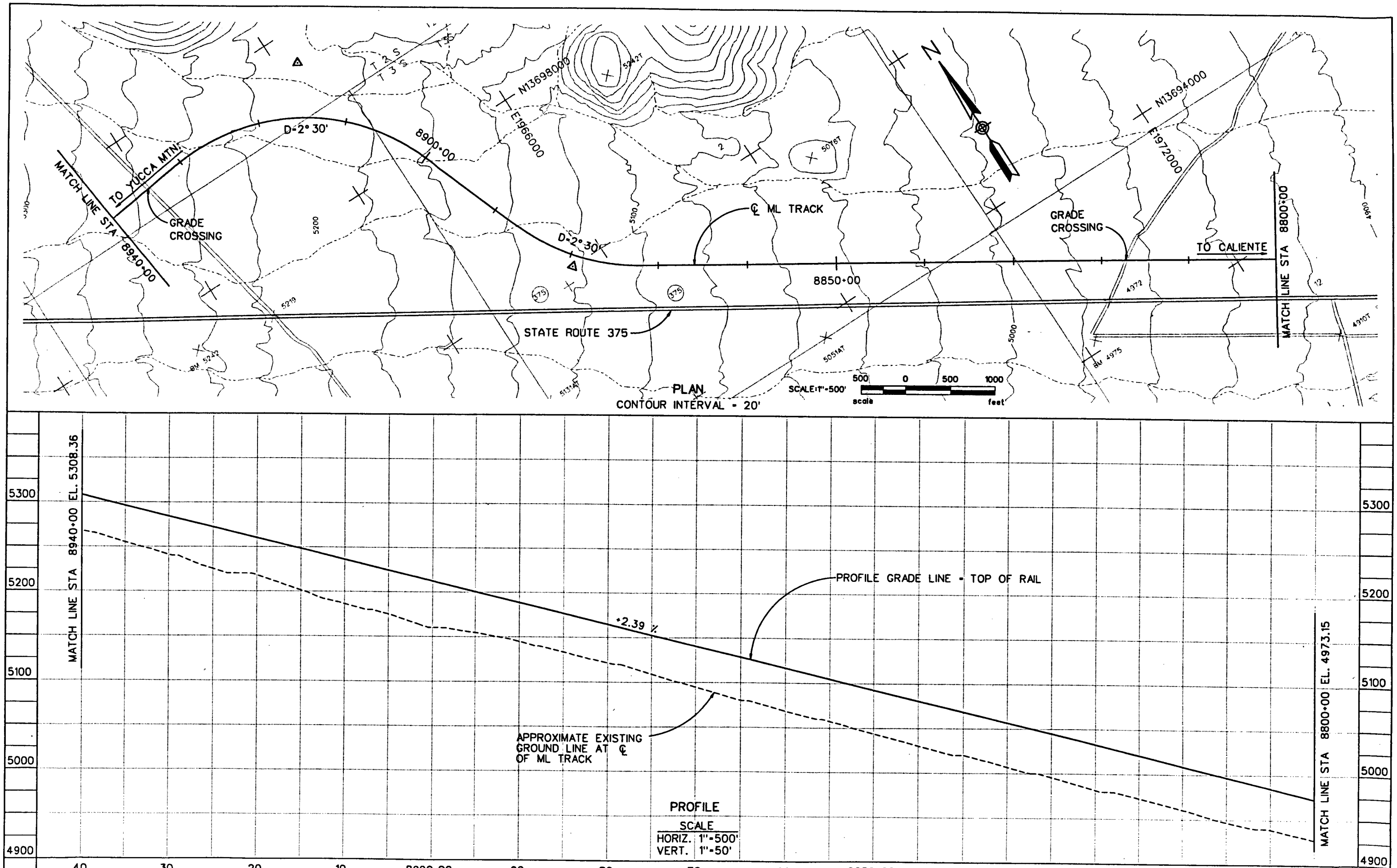
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA. 8660+00 - STA. 8800+00

SCALE: as noted
DRAWING NO. L01-136
SHEET NO. 96 OF 192

DATE PLOTTED 21-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

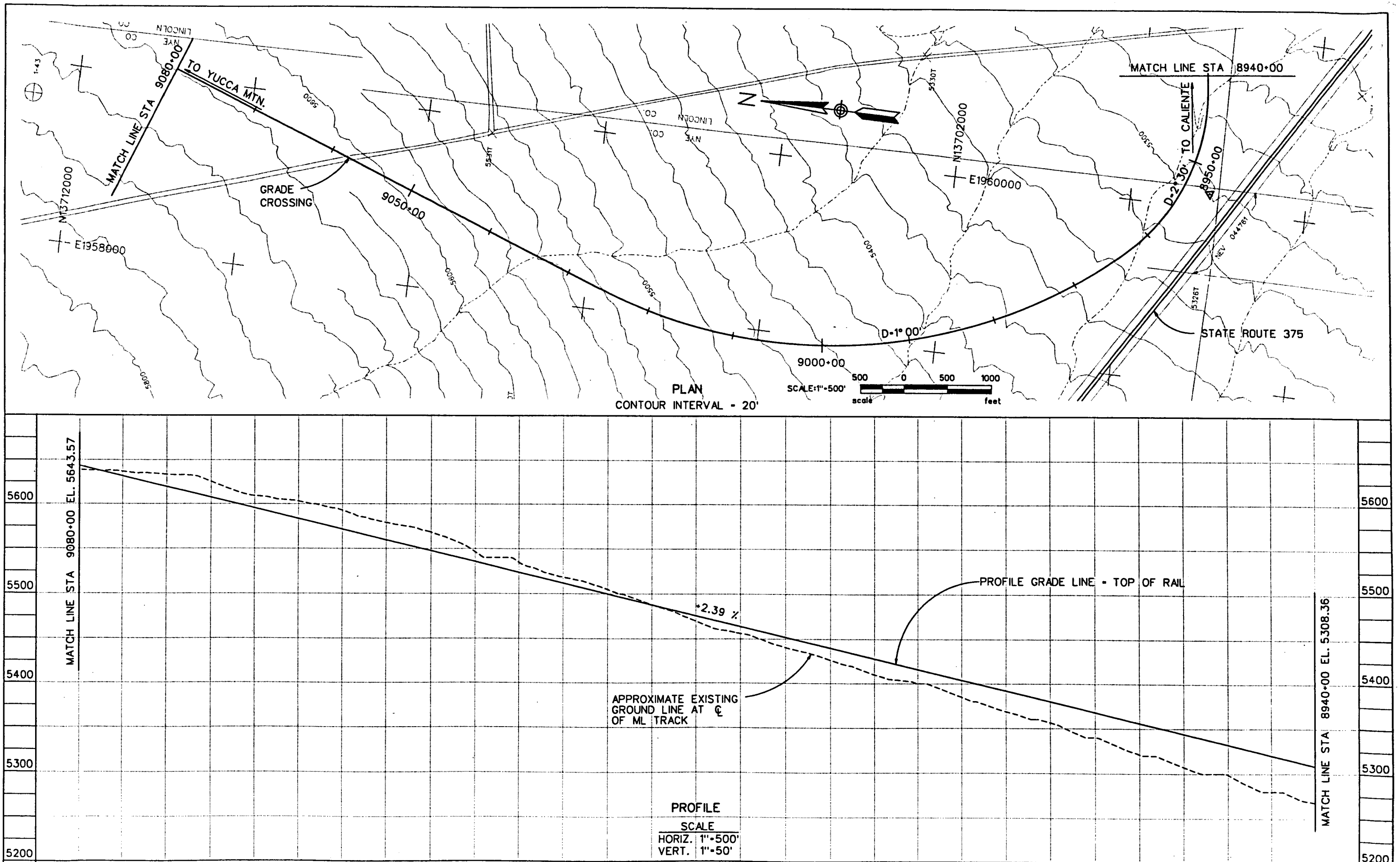
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA. 8800+00 - STA. 8940+00

SCALE as noted
DRAWING NO. L01-137
SHEET NO. 97 OF 190

DATE PLOTTED 21-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

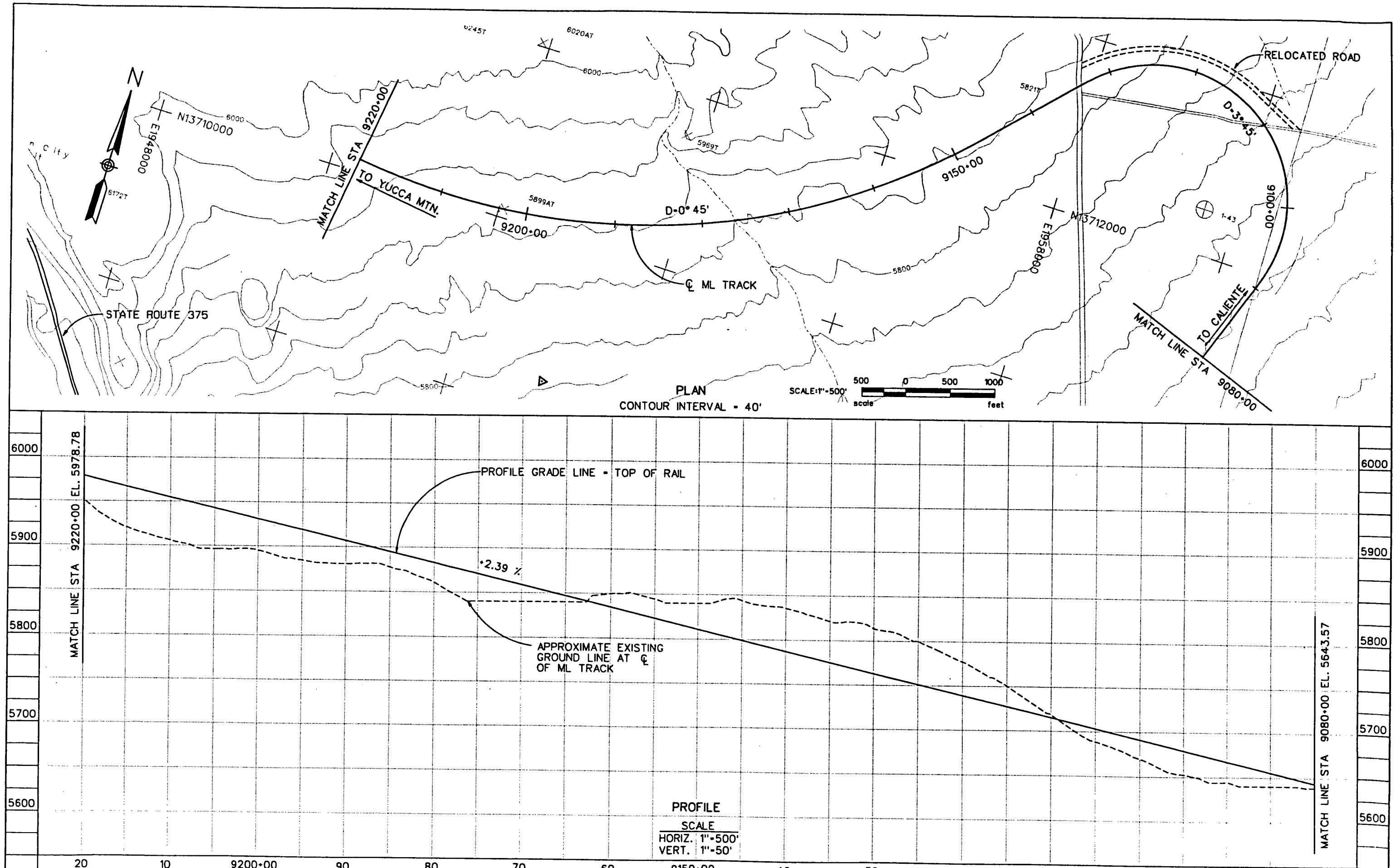
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA. 8940+00 - STA. 9080+00

SCALE: as noted
DRAWING NO. L01-138
SHEET NO. 98 OF 190

DATE PLOTTED 21-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

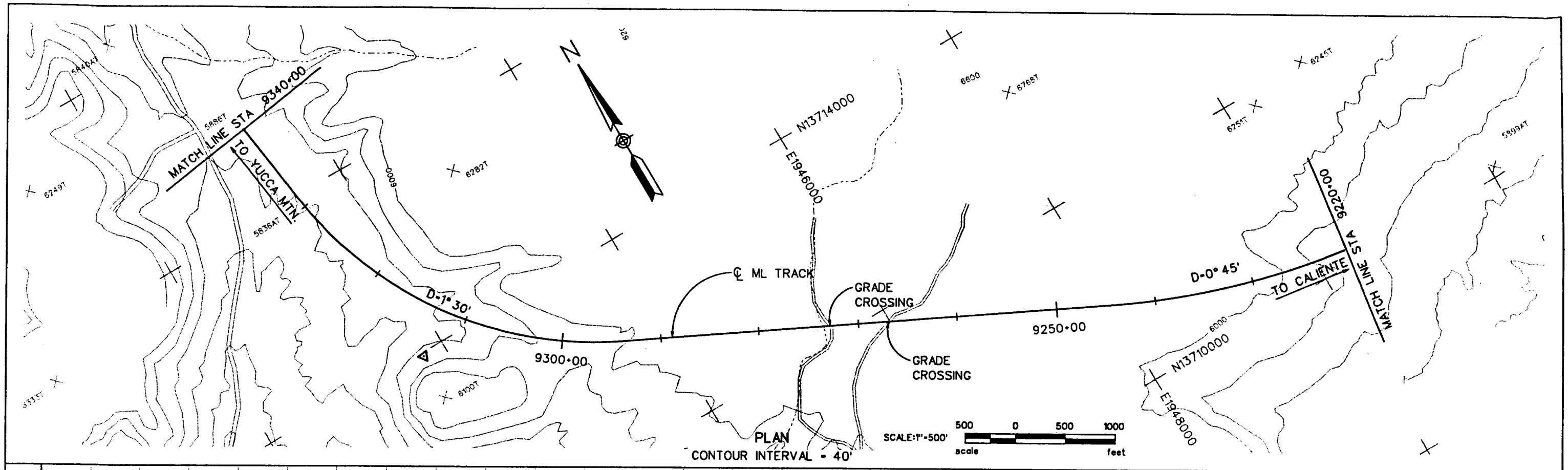
YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

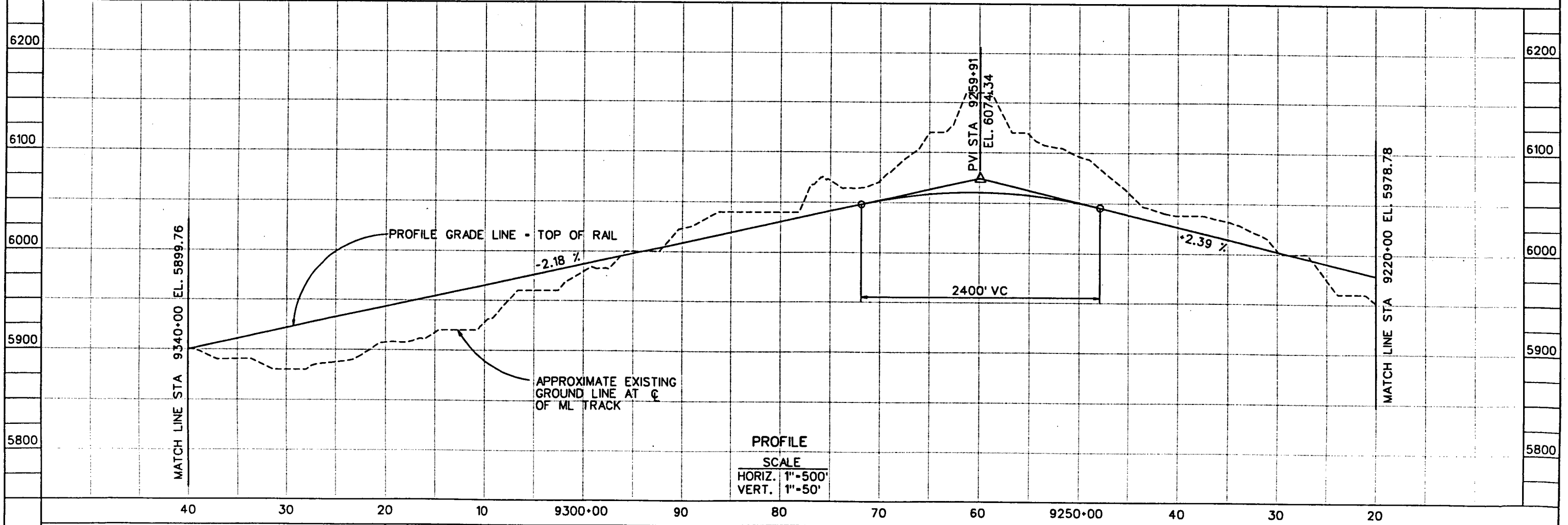
CALIENTE ROUTE - ROUTE A
PLAN & PROFILE

STA. 9080+00 - STA. 9220+00

SCALE: as noted
DRAWING NO. L01-139
SHEET NO. 99 of 190

DATE PLOTTED 25-FEB-1991





REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

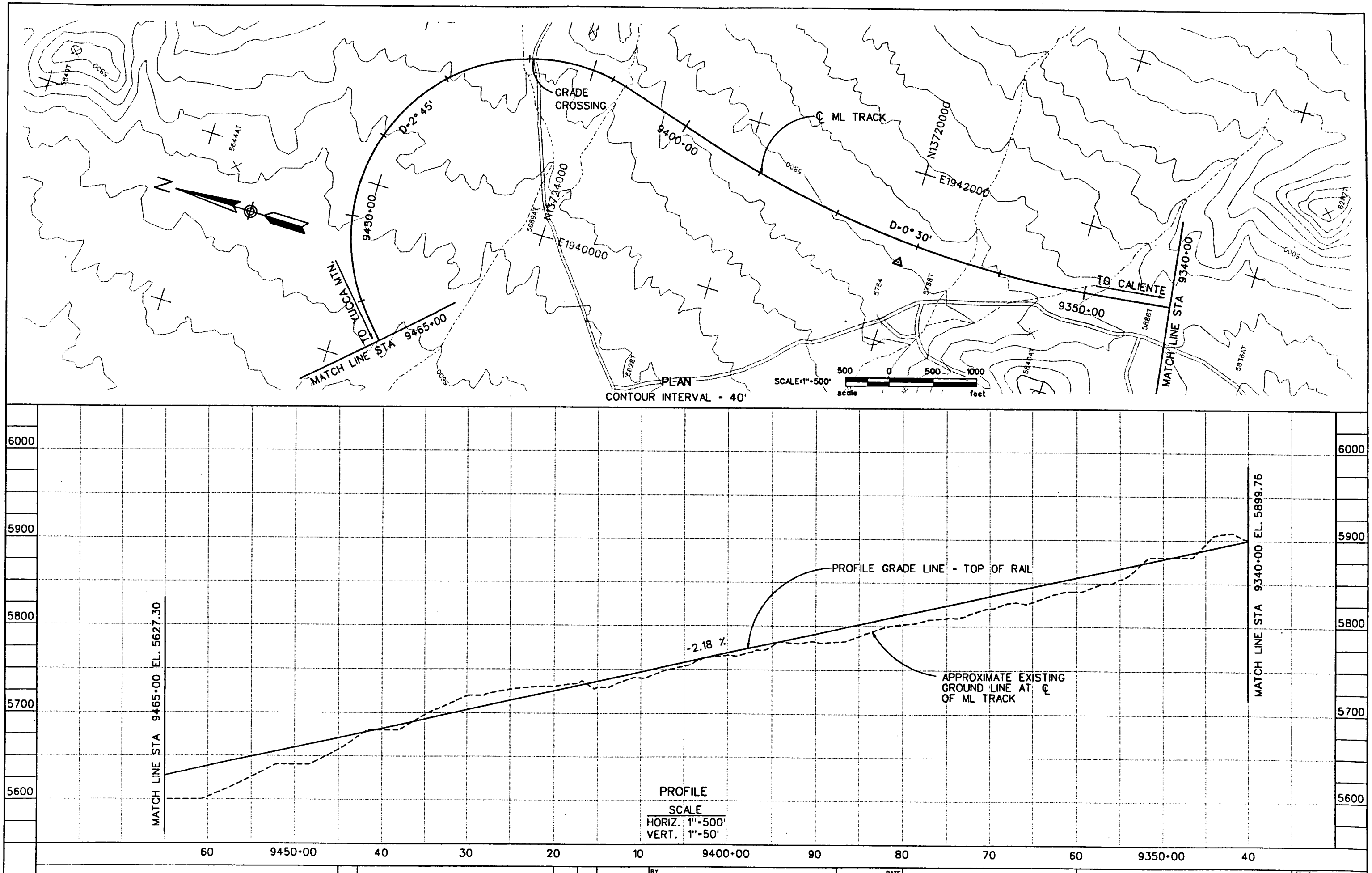
YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE

STA. 9220+00 - STA. 9340+00

SCALE: as noted
DRAWING NO. L01-140
SHEET NO. 100 OF 190

DATE PLOTTED 21-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

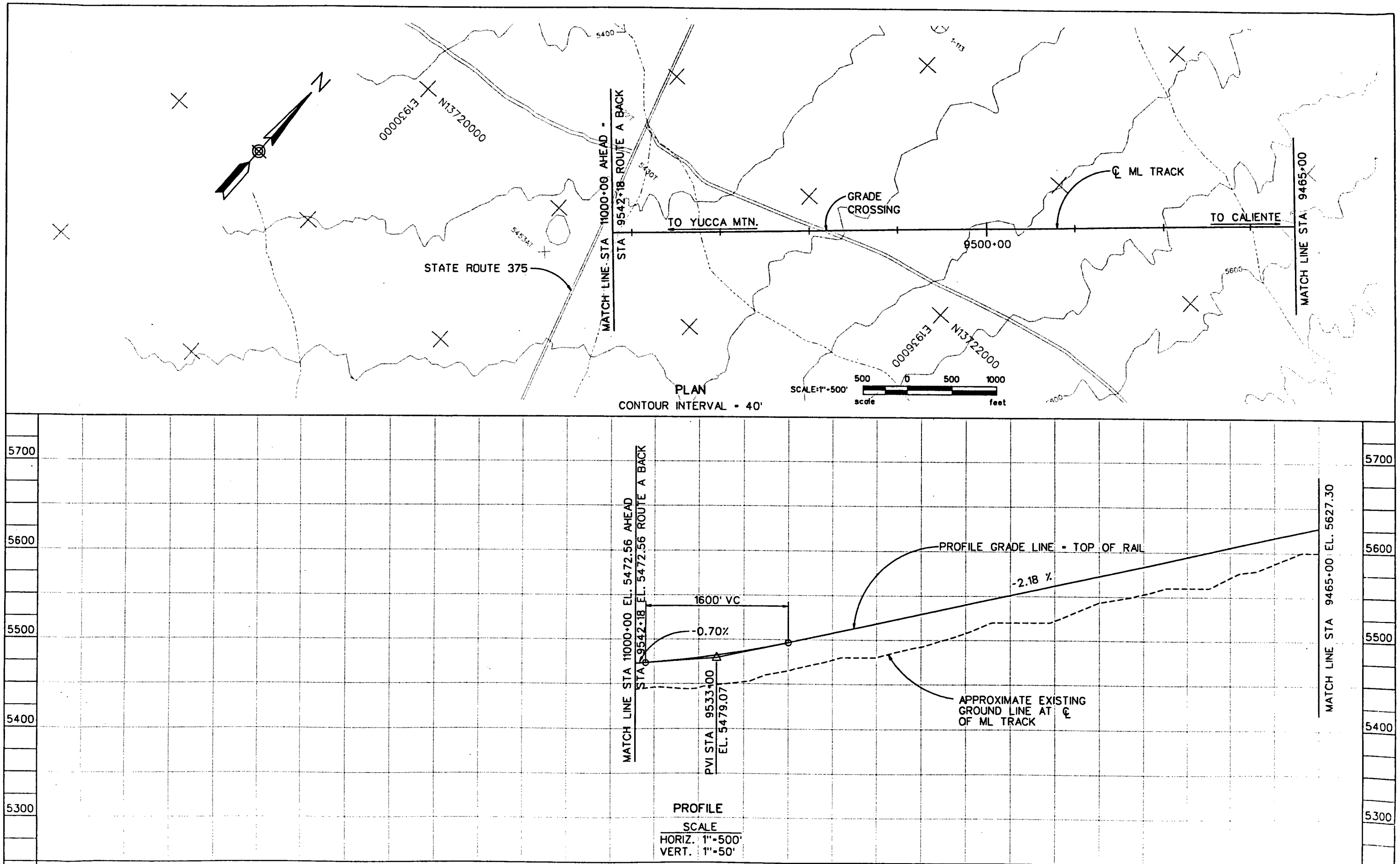
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A
PLAN & PROFILE
STA. 9340+00 - STA. 9465+00

SCALE: as noted
DRAWING NO. L01-141
SHEET NO. 101 OF 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K. CHIU	02/91	DATE
REVIEWED	BY A. BOLCHAZY	02/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE - ROUTE A PLAN & PROFILE

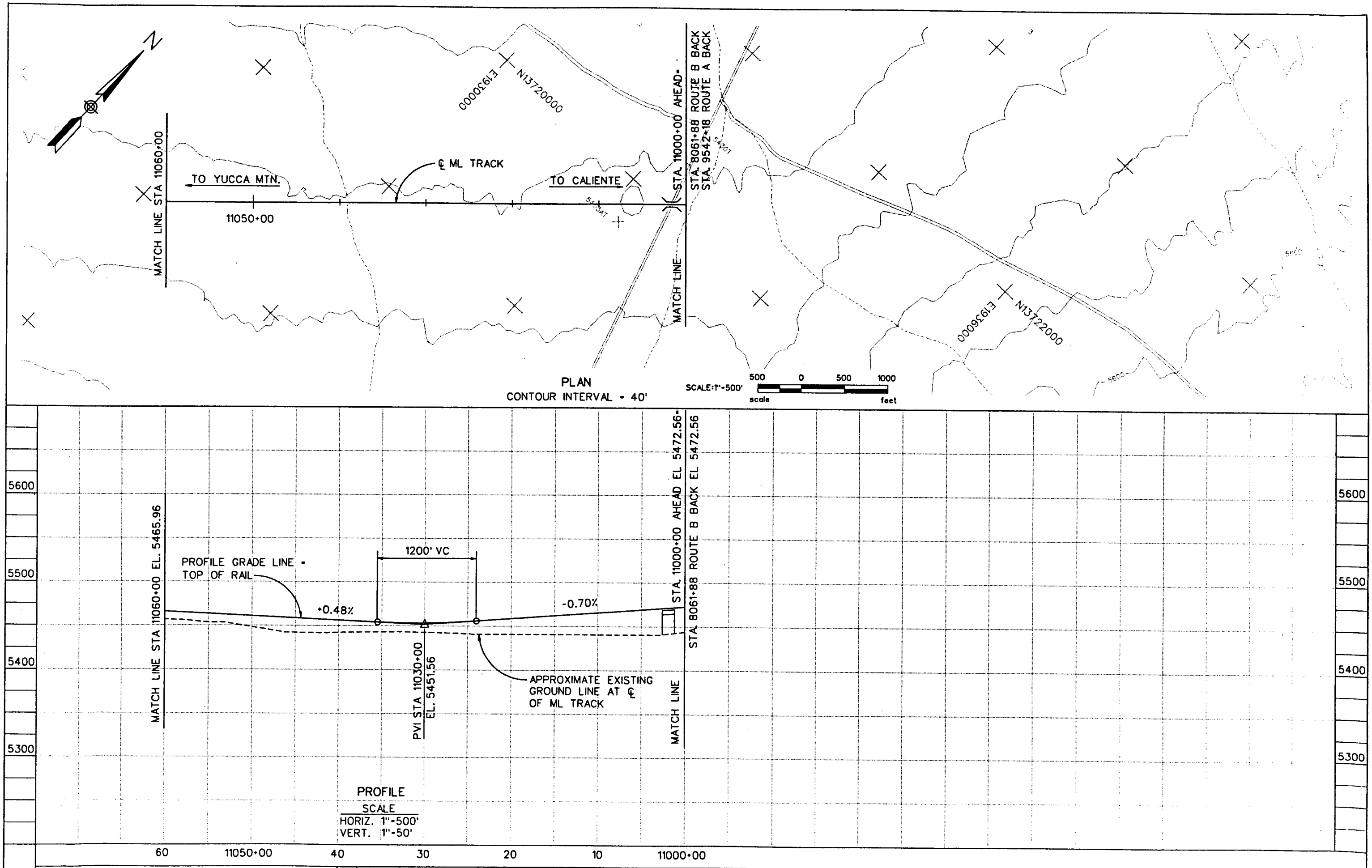
STA. 9465+00 - STA. 9542+18

SCALE as noted

DRAWING NO L01-142

SHEET NO 102 of 190

DATE PLOTTED 25-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

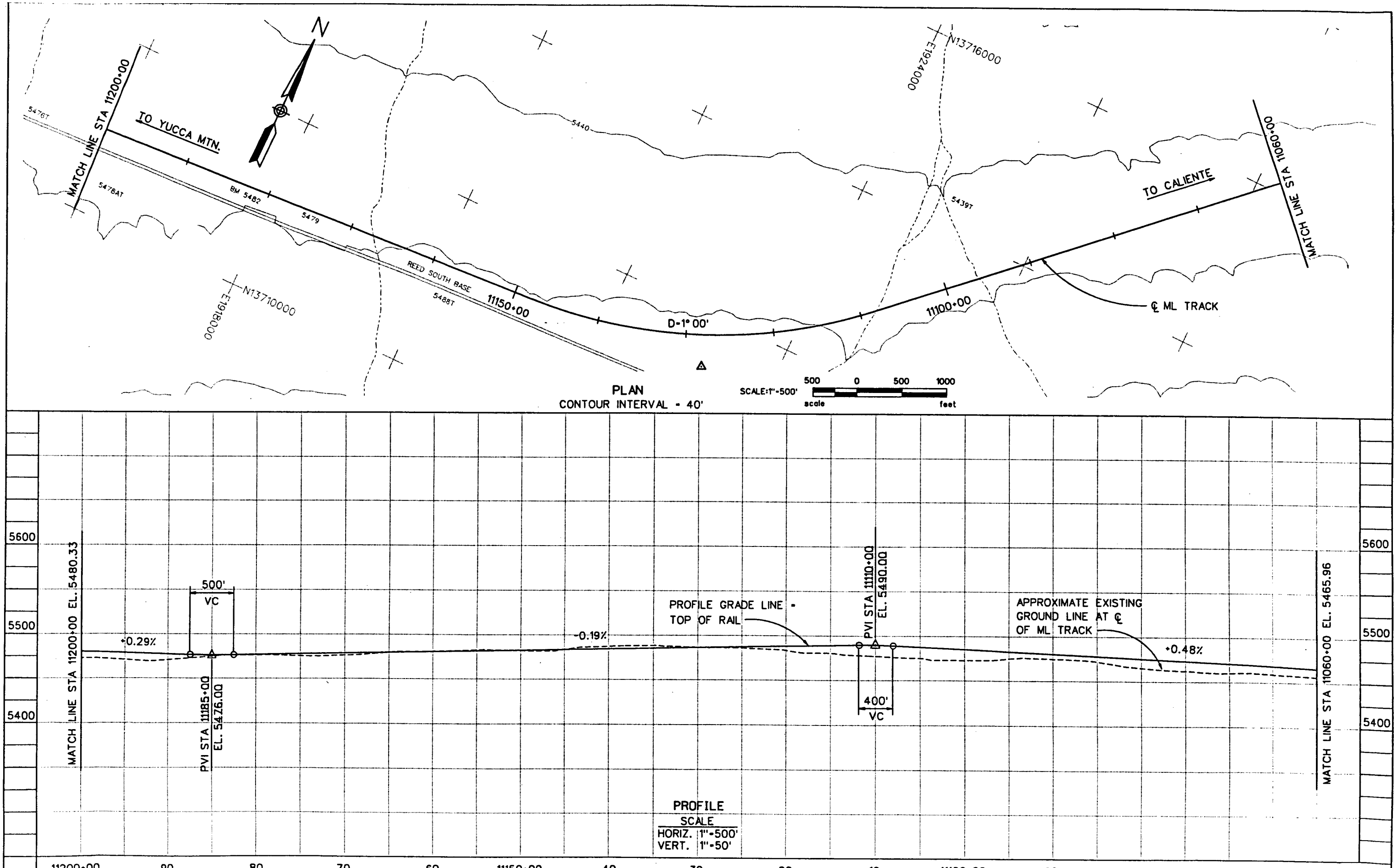
CALIENTE ROUTE PLAN & PROFILE

STA. 11000+00 - STA. 11060+00

SCALE: as noted

DRAWING NO. L91-001

SHEET NO. 102 of 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

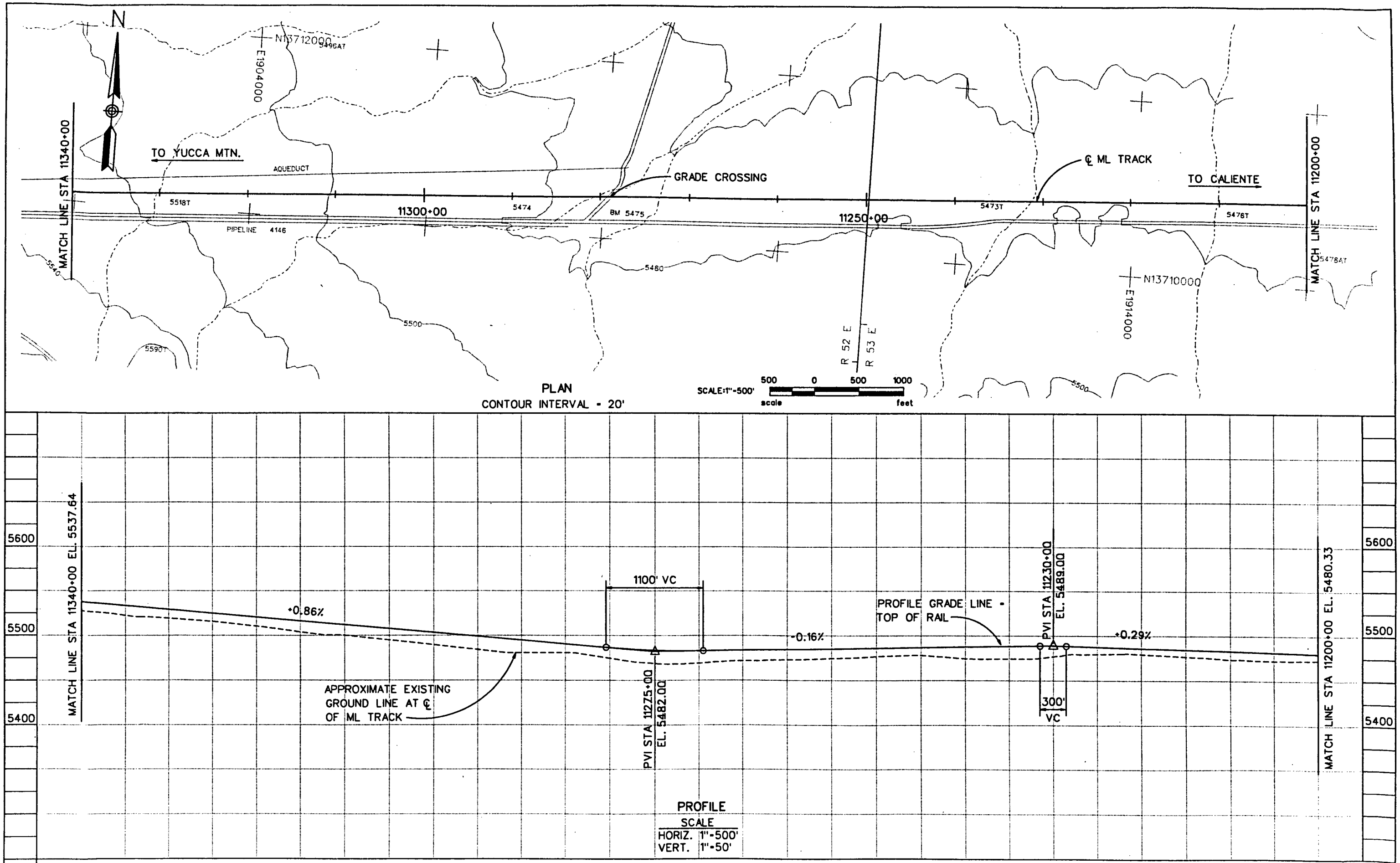
CALIENTE ROUTE PLAN & PROFILE

STA. 11060+00 - STA. 11200+00

SCALE: as noted

DRAWING NO. L91-002

SHEET NO. 104 of 100



REV	DESCRIPTION	DATE	BY

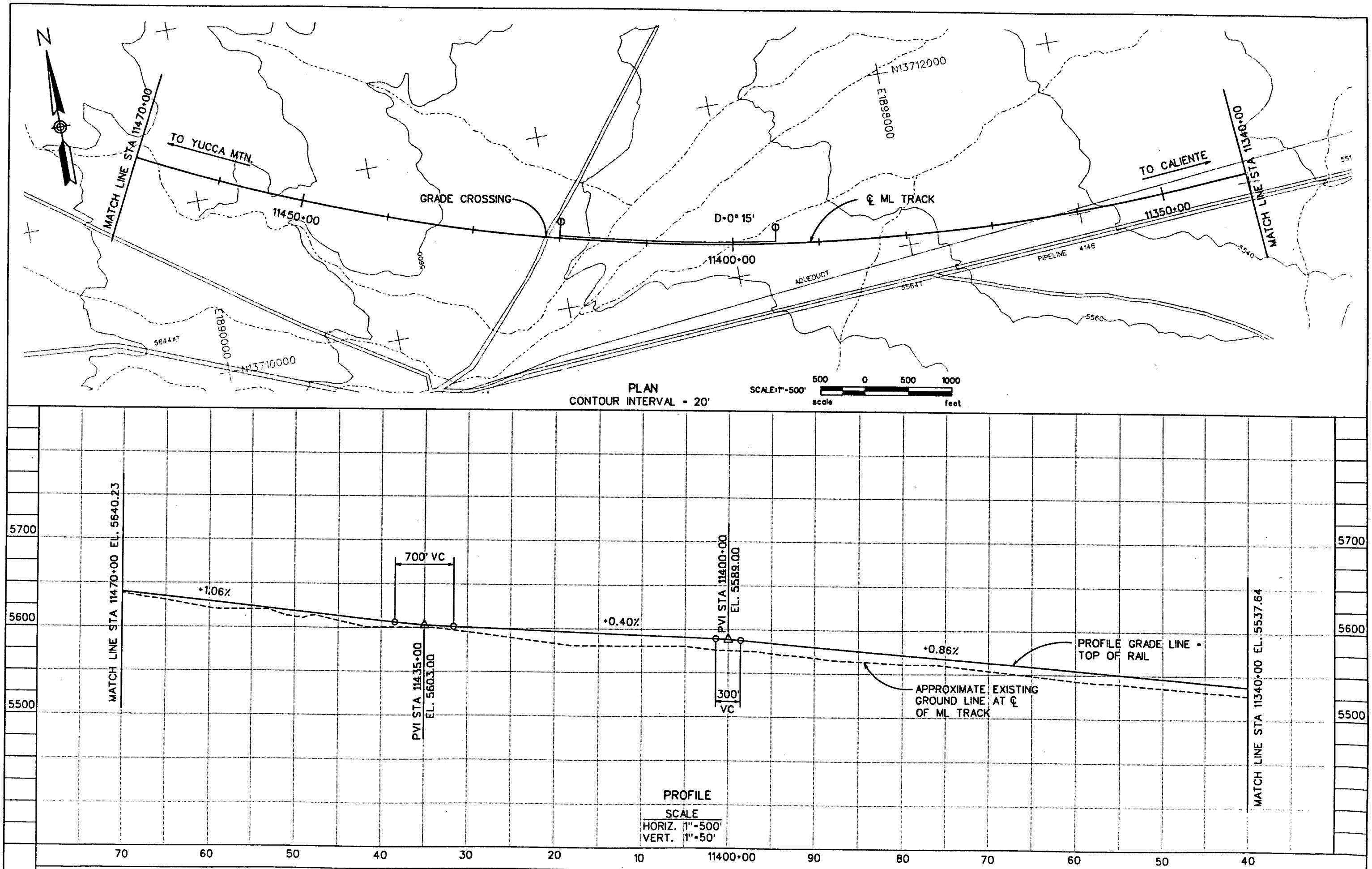
DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 11200+00 - STA. 11340+00

SCALE: as noted
DRAWING NO. L91-003
SHEET NO. 105 OF 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

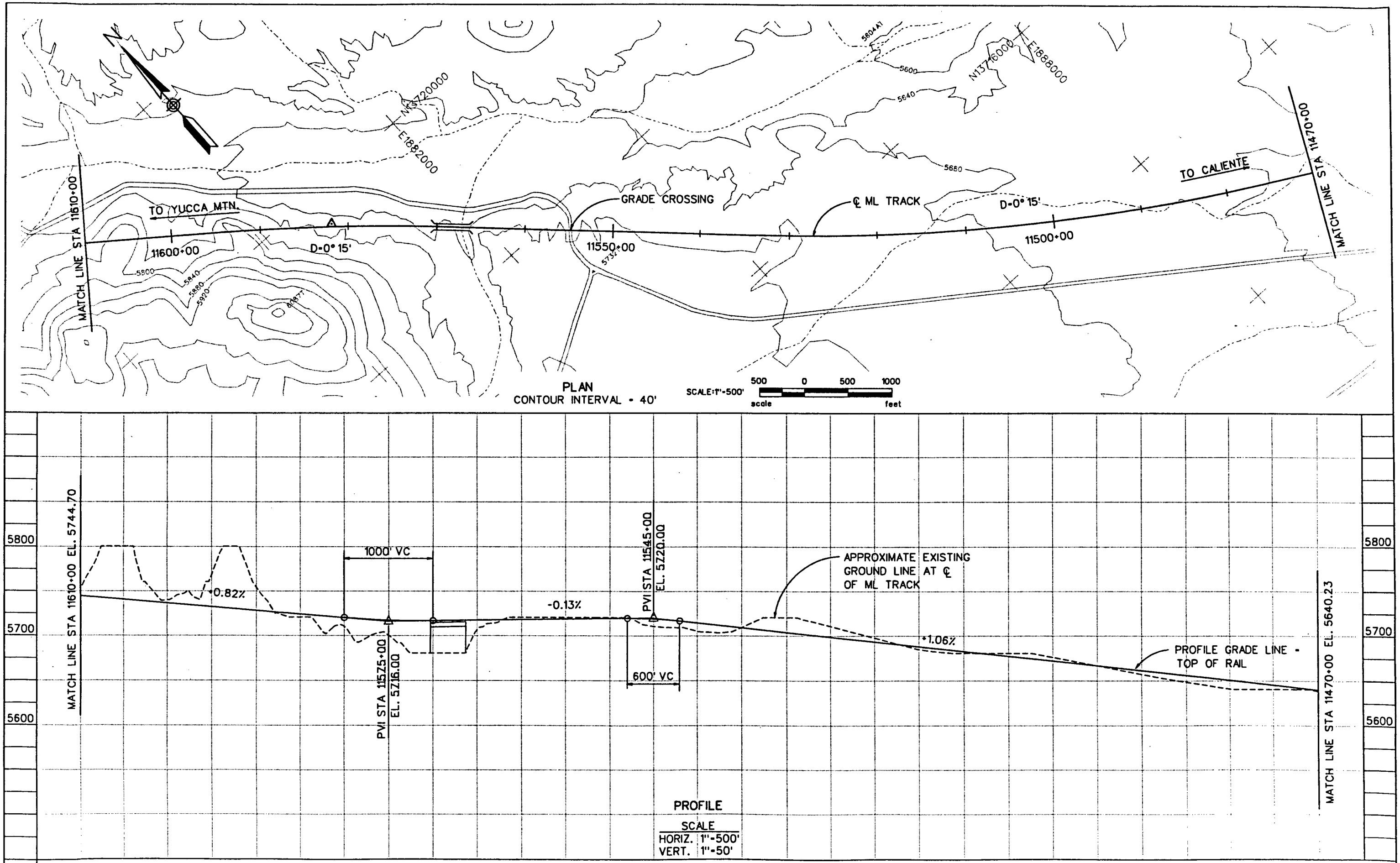
YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE PLAN & PROFILE

STA. 11340+00 - STA. 11470+00

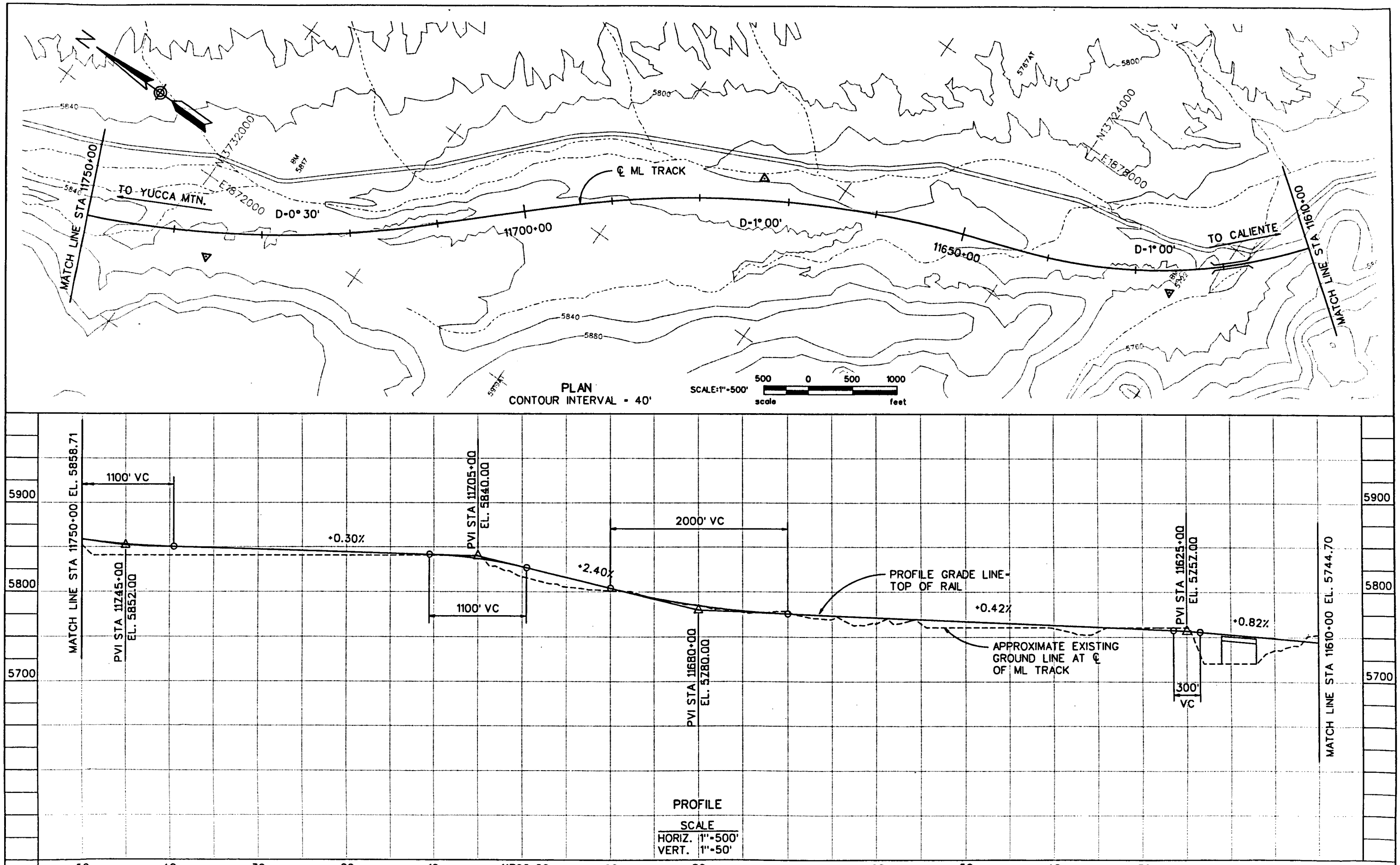
SCALE: as noted
DRAWING NO. L91-004
SHEET NO. 106 of 190

DATE PLOTTED 19-FEB-1991



DESIGNED	BY D. MOODY	2/91 DATE	Prepared for: Science Applications International Corporation, Las Vegas, Nevada	YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
REVIEWED	BY T. DANIEL	2/91 DATE	DeLEUW, CATHER & COMPANY Engineers & Planners San Francisco, CA	CALIENTE ROUTE PLAN & PROFILE
APPROVED	BY	DATE		SCALE as noted; DRAWING NO L91-005; SHEET NO

DATE PLOTTED 19-FEB-1991

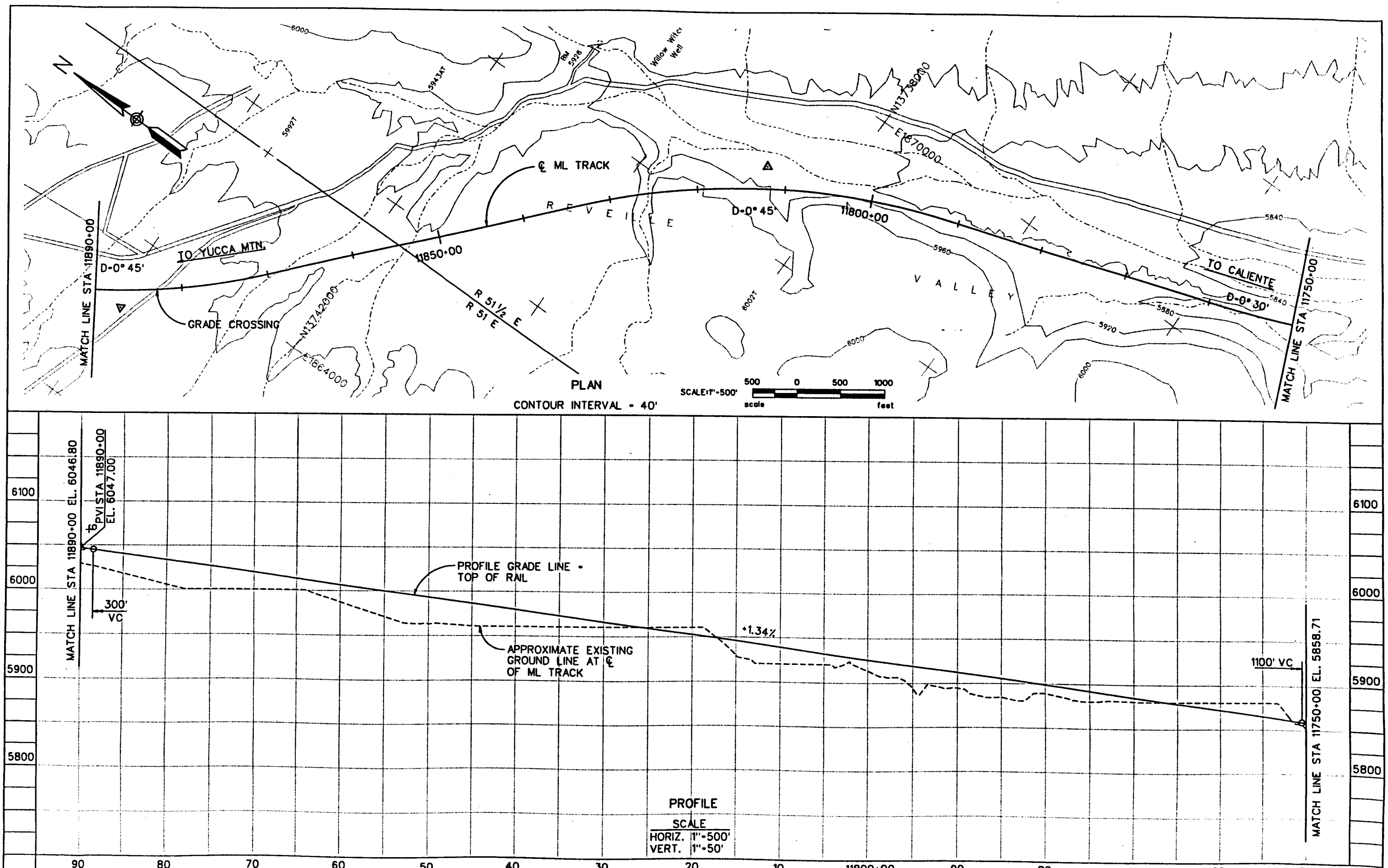


DESIGNED	BY D. MOODY	2/91 DATE	Prepared for: Science Applications International Corporation, Las Vegas, Nevada
REVIEWED	BY T. DANIEL	2/91 DATE	DeLEUW, CATHER & COMPANY Engineers & Planners San Francisco, CA
APPROVED	BY	DATE	

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE

SCALE as noted
DRAWING NO. L91-006
SHEET NO.

DATE PLOTTED 19-FEB-1991



REV	DESCRIPTION	DATE	BY

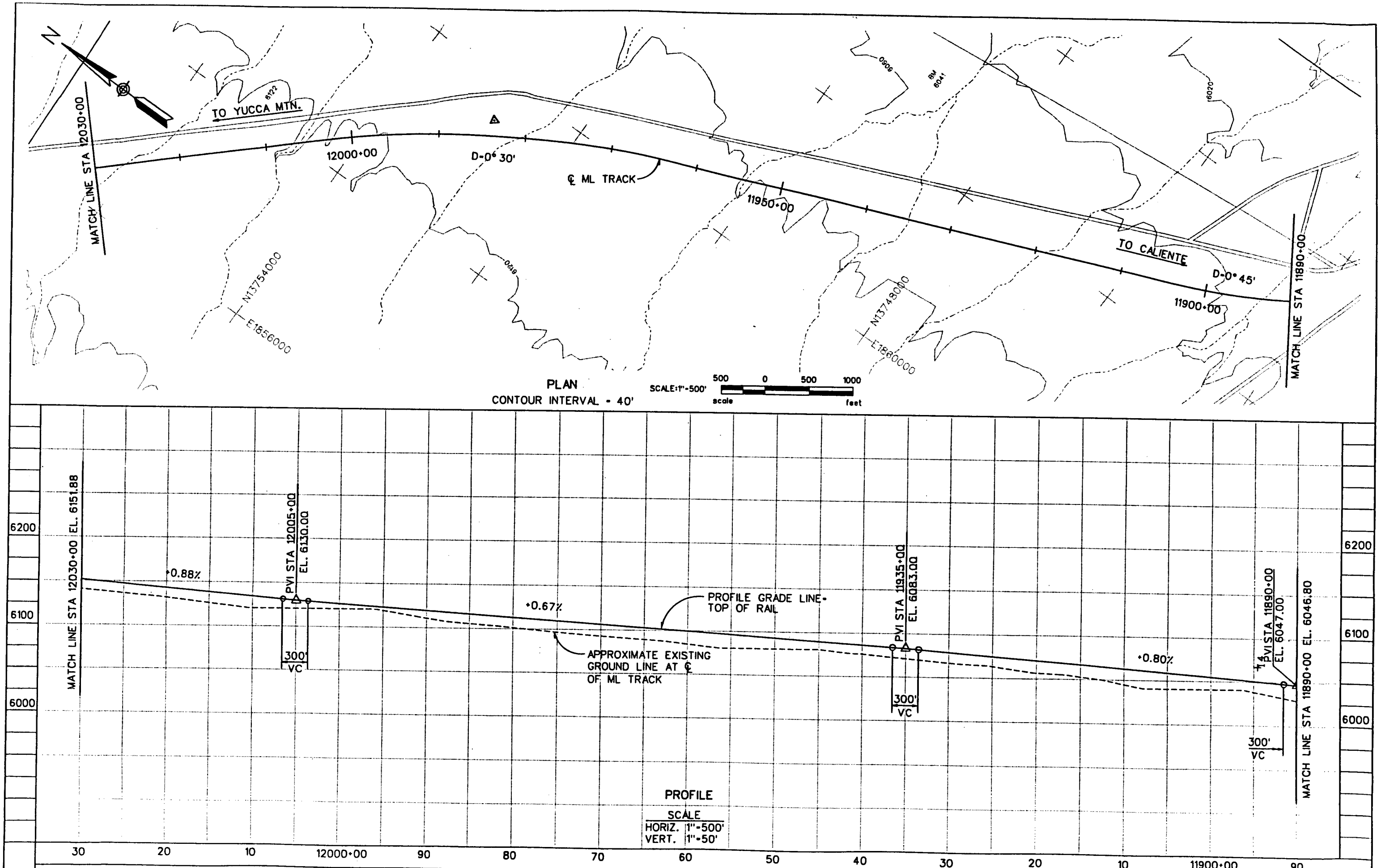
DESIGNED	BY D.MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE

SCALE as noted
DRAWING NO L91-007
SHEET NO.



REV	DESCRIPTION	DATE	BY

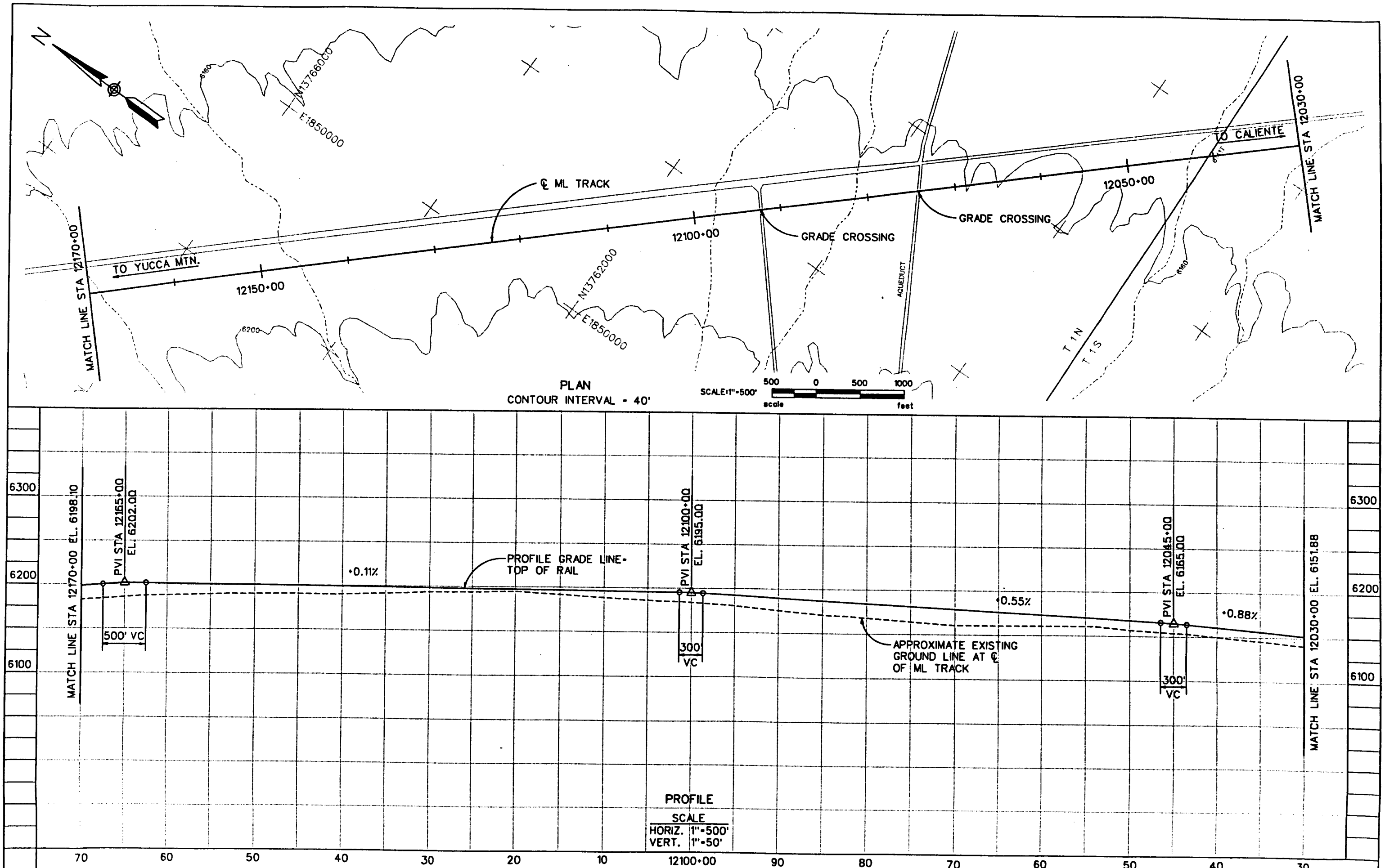
DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 11890+00 - STA. 12030+00

SCALE: as noted
DRAWING NO: L91-008
SHEET NO: 110 OF 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

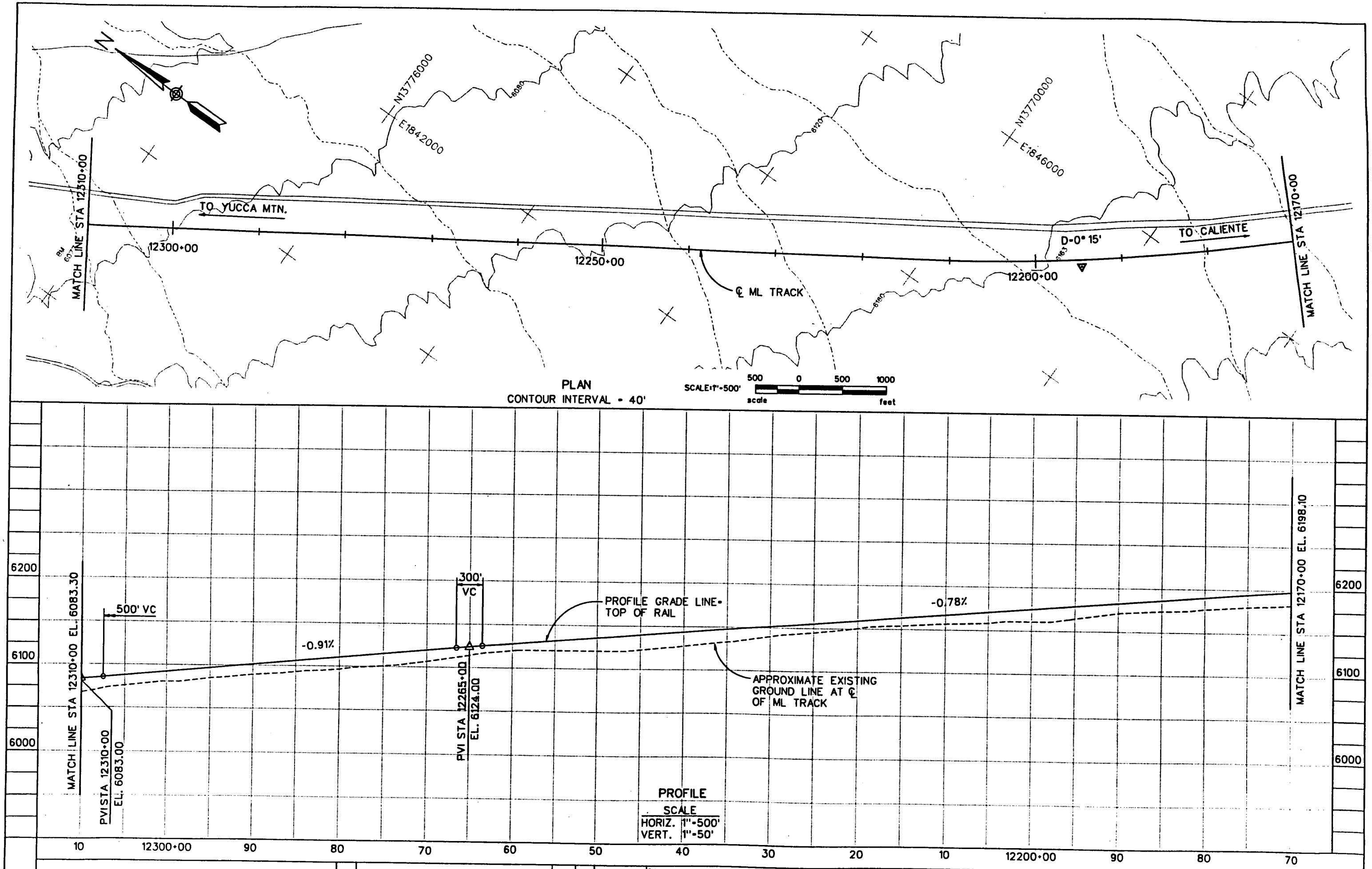
CALIENTE ROUTE PLAN & PROFILE

STA 12030+00 - STA 12170+00

SCALE: as noted

DRAWING NO. L91-009

SHEET NO. 1 of 100



REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

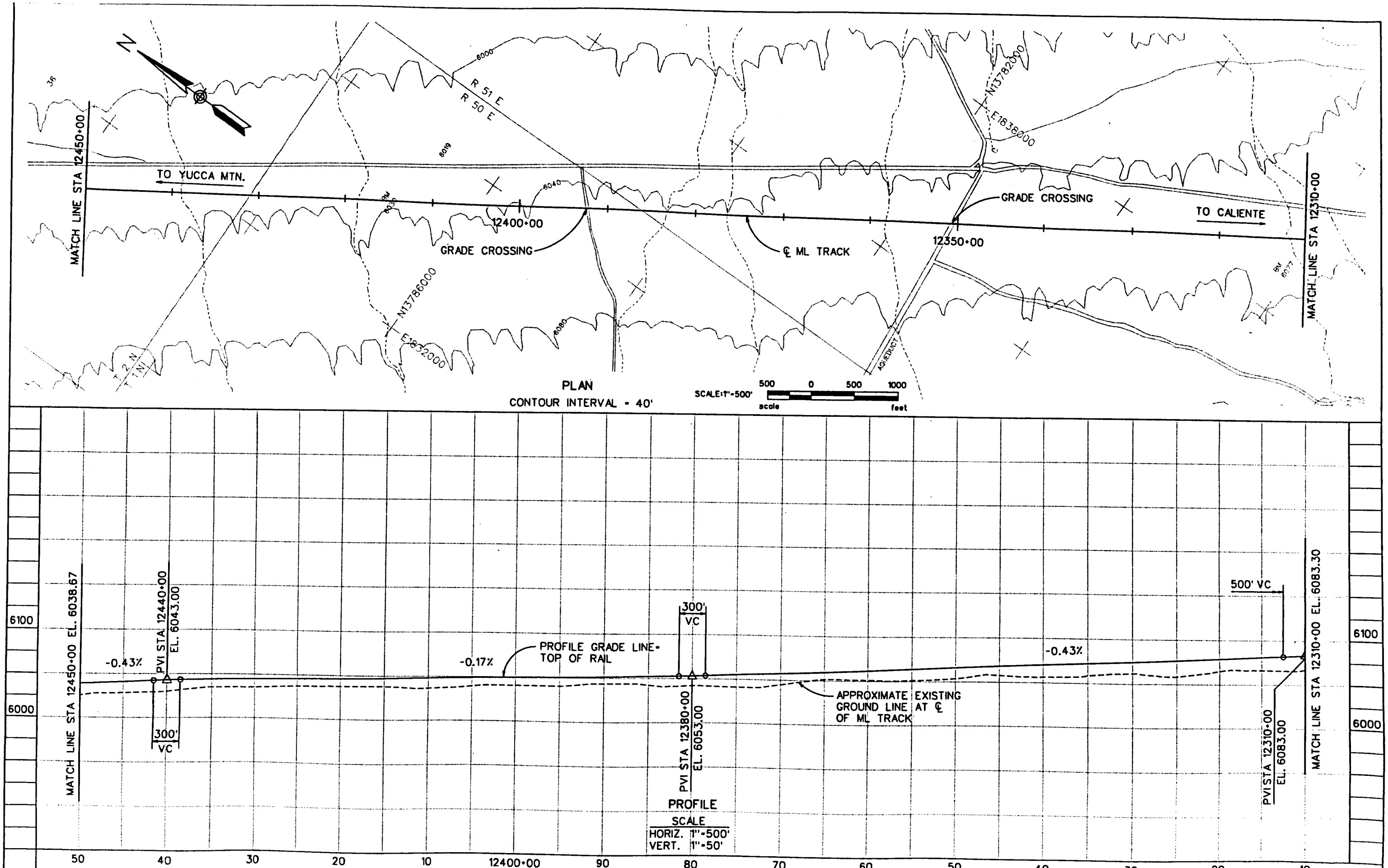
CALIENTE ROUTE
PLAN & PROFILE

STA. 12170+00 - STA. 12310+00

SCALE as noted

DRAWING NO. L91-010

SHEET NO. 112 of 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

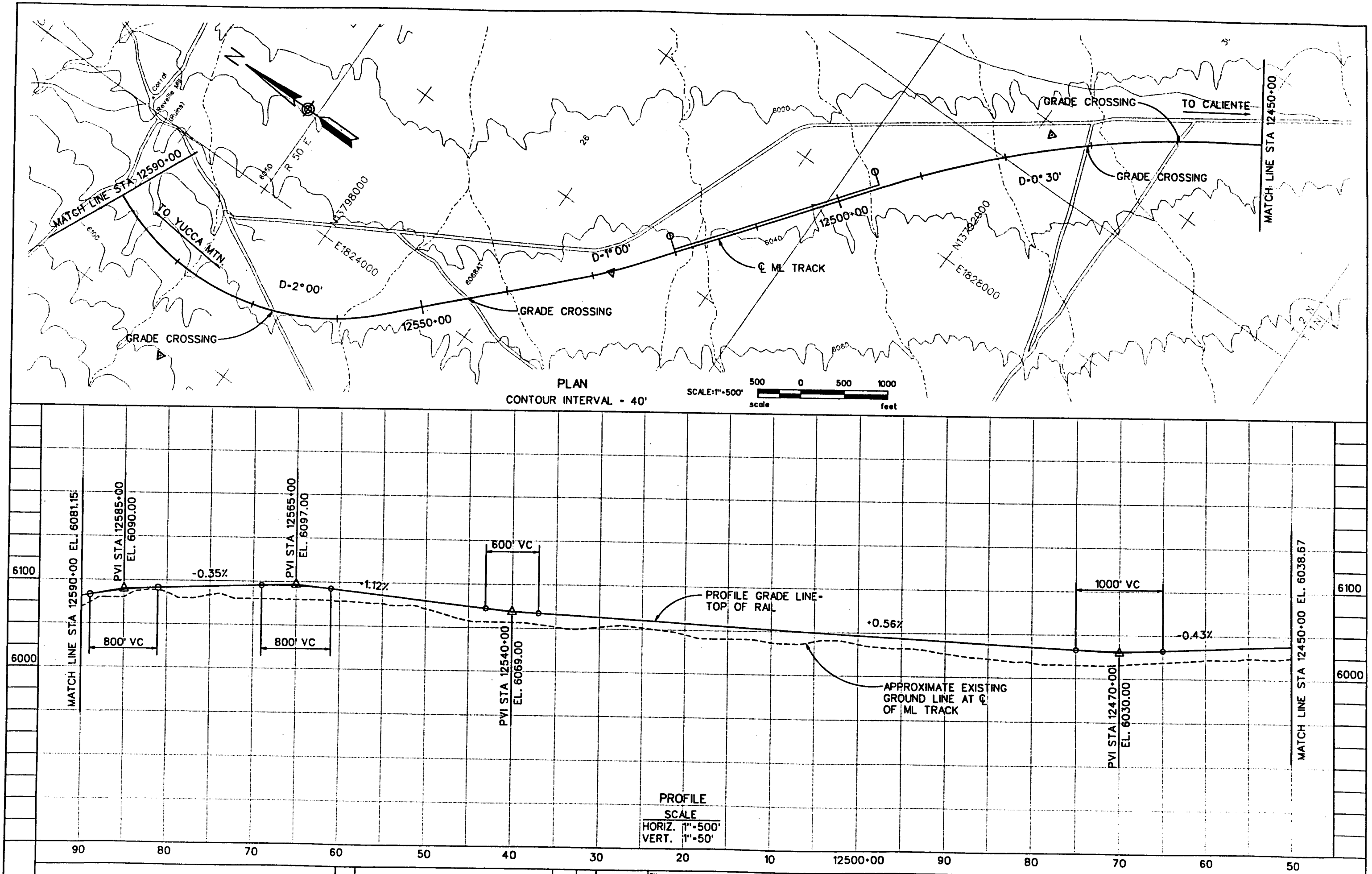
CALIENTE ROUTE PLAN & PROFILE

STA. 12310+00 - STA. 12450+00

SCALE: as noted

DRAWING NO. L91-011

SHEET NO. 113 of 190



REV	DESCRIPTION	DATE	BY

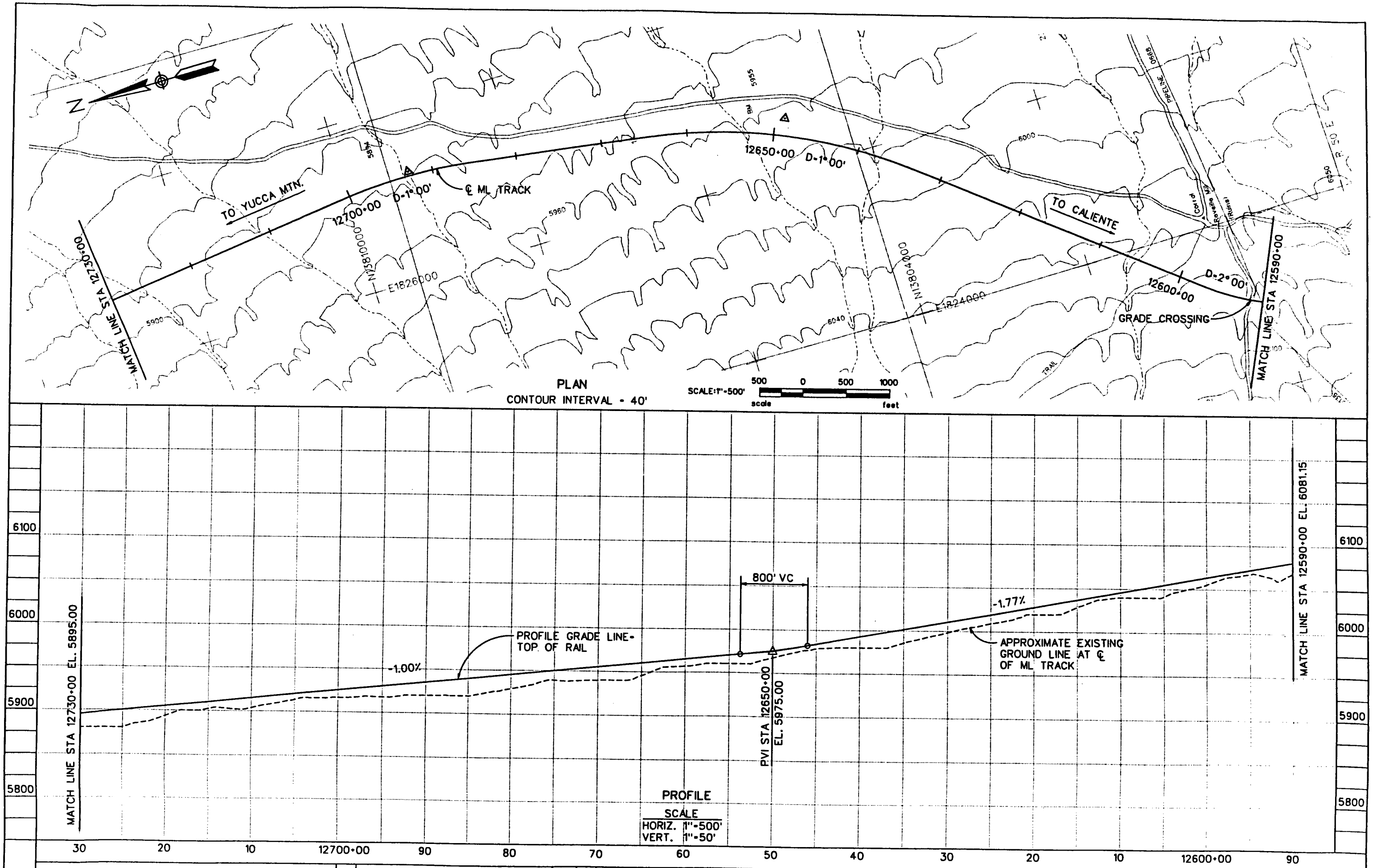
DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 12450+00 - STA. 12590+00

SCALE as noted
DRAWING NO L91-012
SHEET NO



REV	DESCRIPTION	DATE	BY

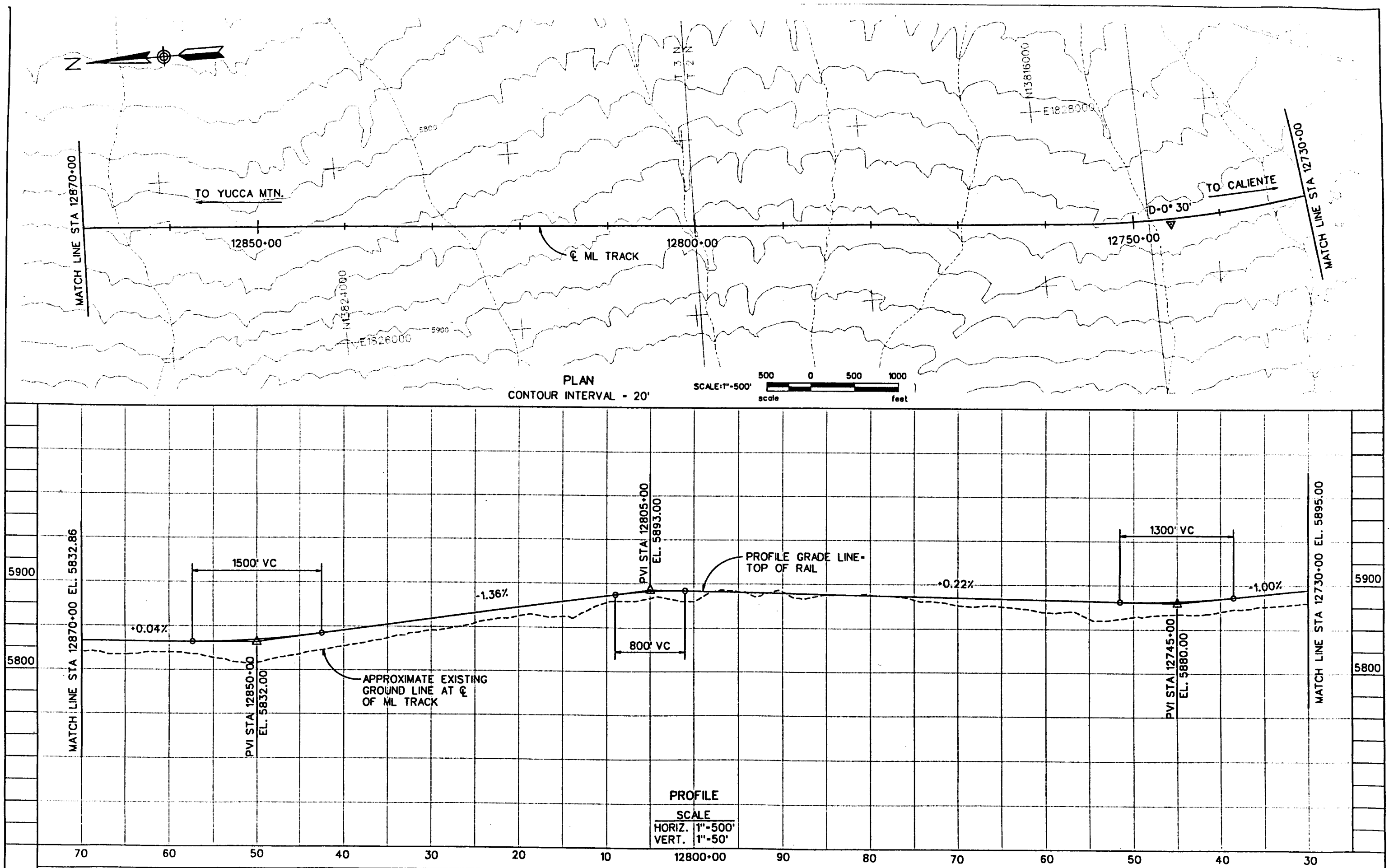
DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA 12590+00 - STA 12730+00

SCALE as noted
DRAWING NO L91-013
SHEET NO



REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

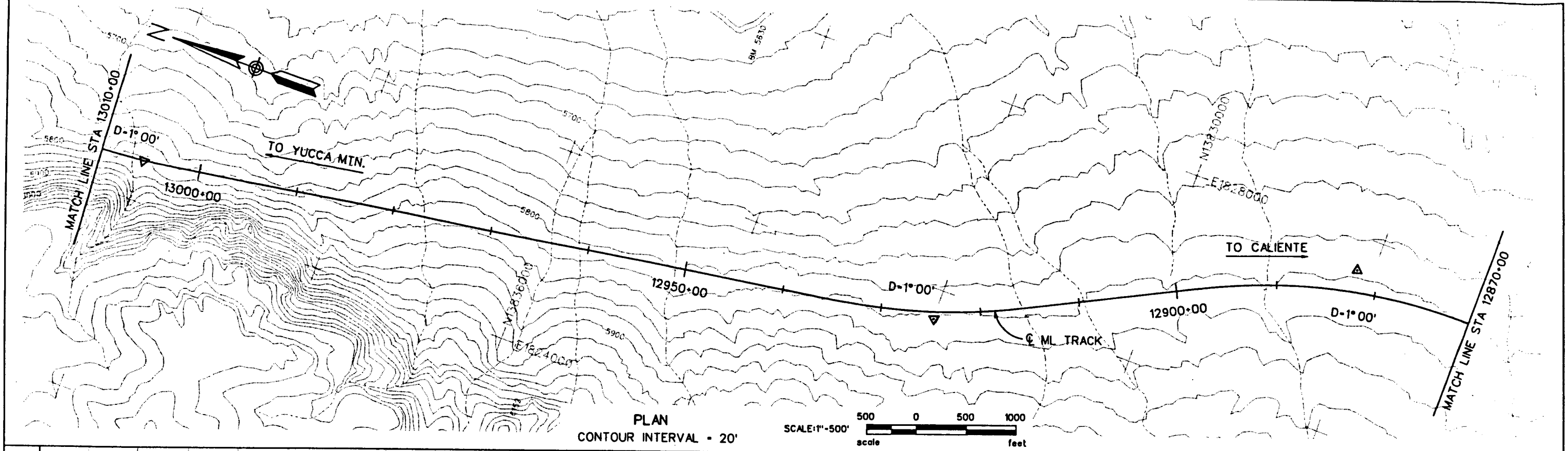
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 12730+00 - STA. 12870+00

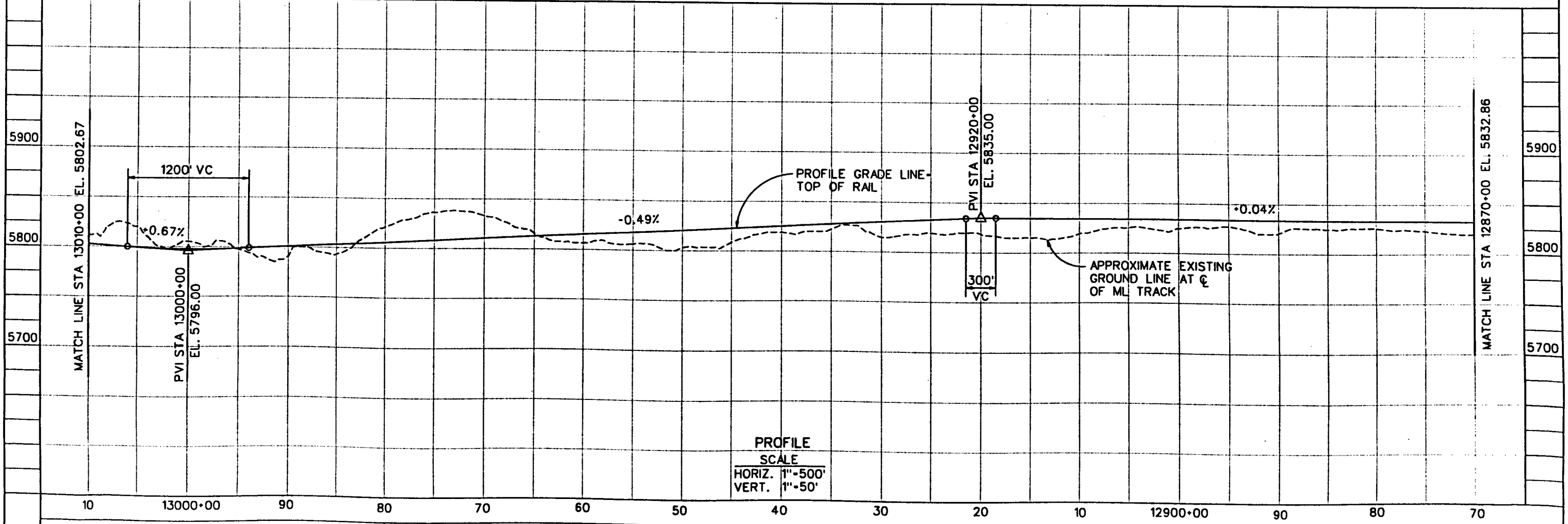
SCALE as noted
DRAWING NO. L91-014
SHEET NO. 116 OF 190

DATE PLOTTED 20-FEB-1991



PLAN
CONTOUR INTERVAL = 20'

SCALE: 1"=500'
500 0 500 1000
scale feet



PROFILE
SCALE
HORIZ. 1"=500'
VERT. 1"=50'

REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

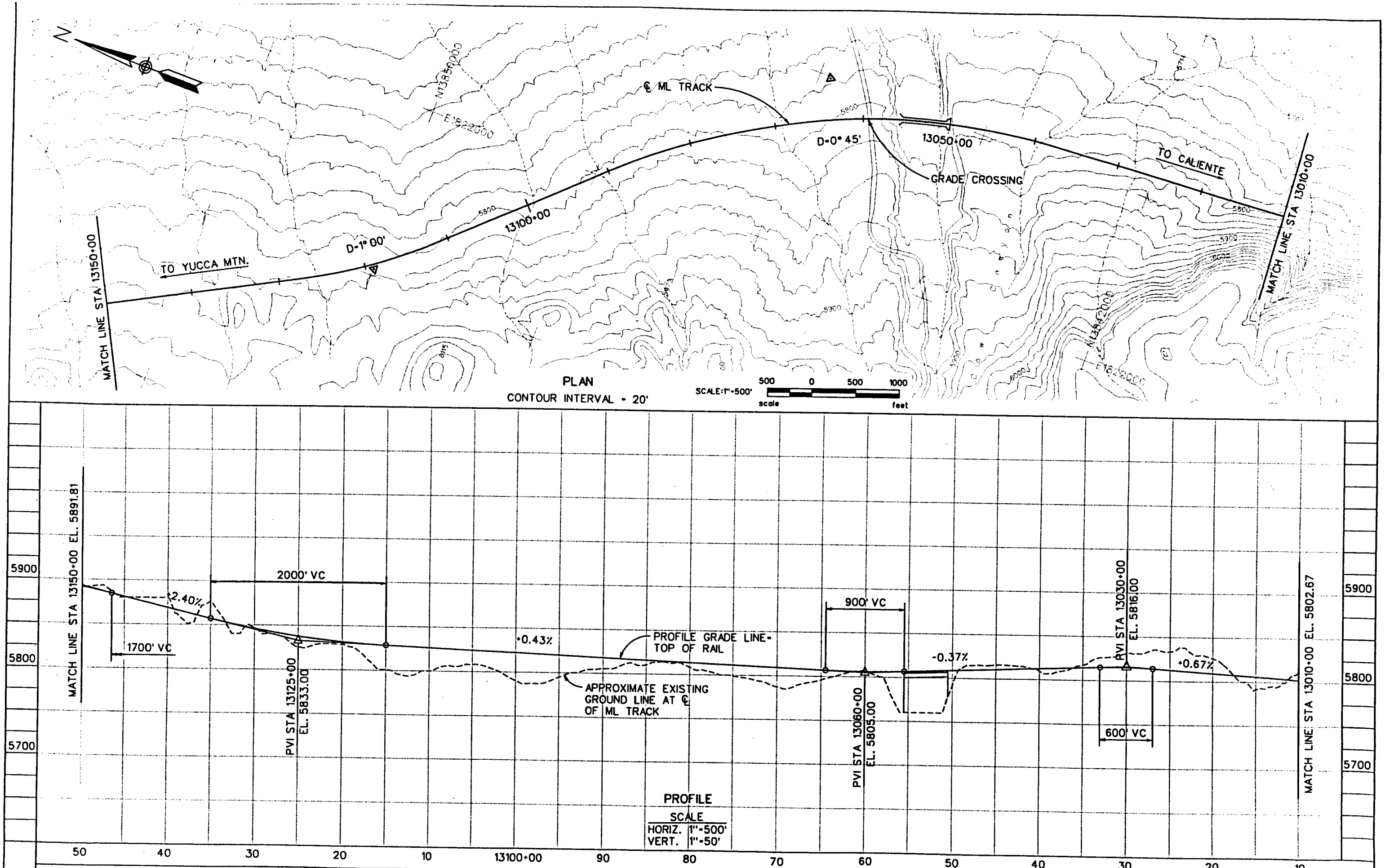
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 12870+00 - STA. 13010+00

SCALE as noted
DRAWING NO. L91-015
SHEET NO. 117 OF 190

DATE PLOTTED 19-FEB-1991



REV	DESCRIPTION	DATE	BY

	BY	DATE
DESIGNED	D. MOODY	2/91
REVIEWED	T. DANIEL	2/91
APPROVED		

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

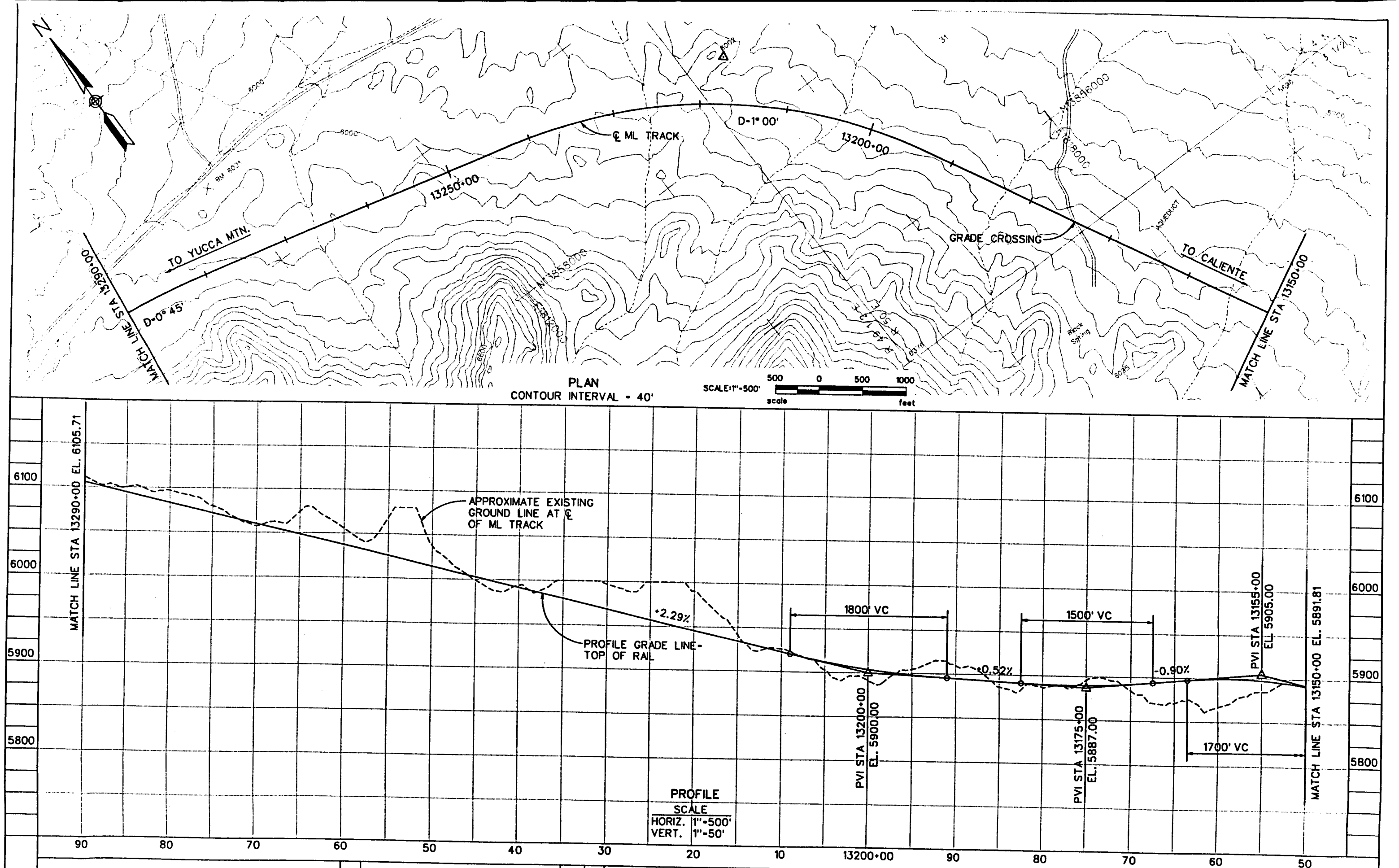
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE PLAN & PROFILE

STA. 13010+00 - STA. 13150+00

SCALE: as noted
DRAWING NO. L91-016
SHEET NO. 118 of 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

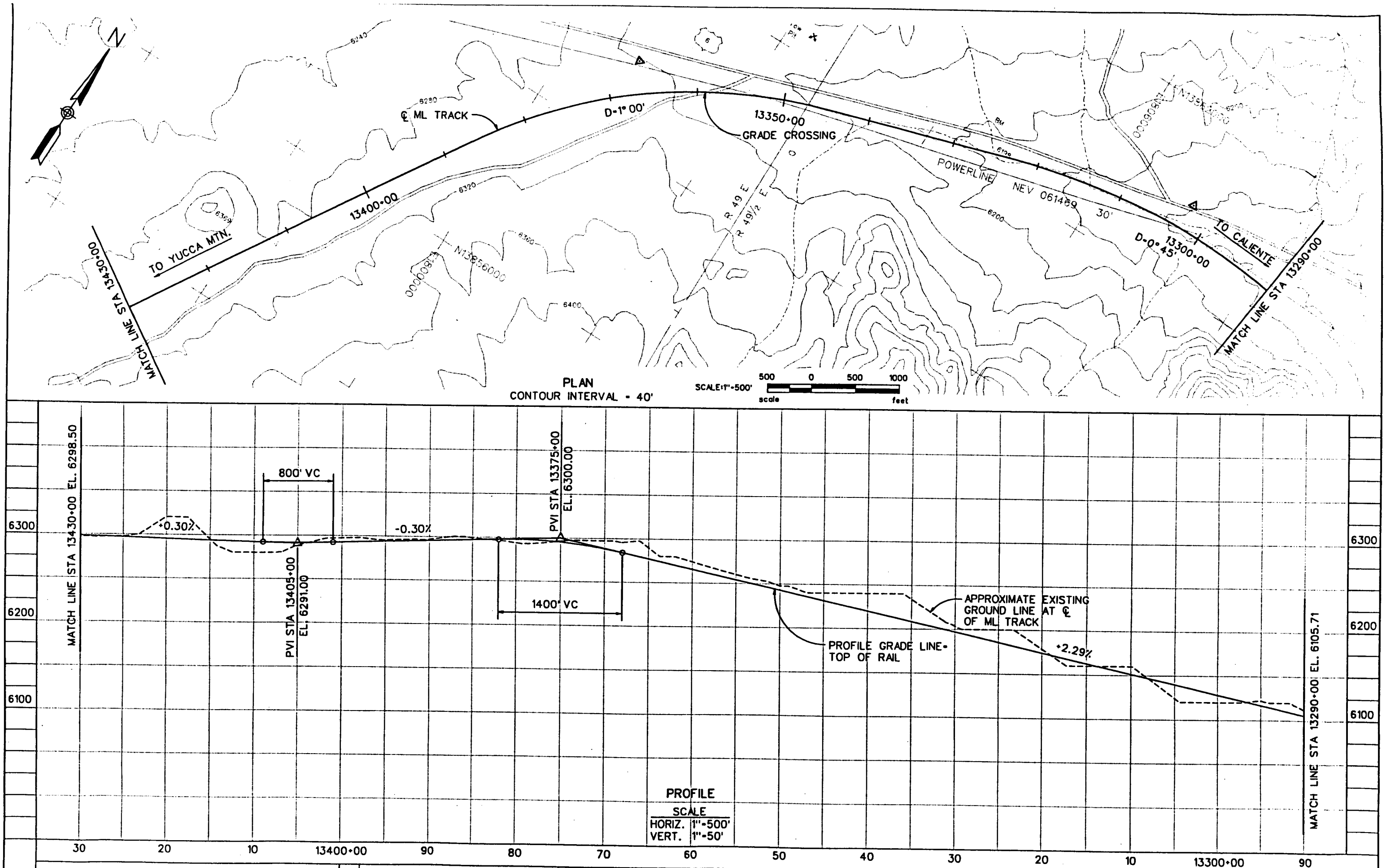
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE PLAN & PROFILE

STA. 13150+00 - STA. 13290+00

SCALE: as noted
DRAWING NO. L91-017
SHEET NO 119 OF 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

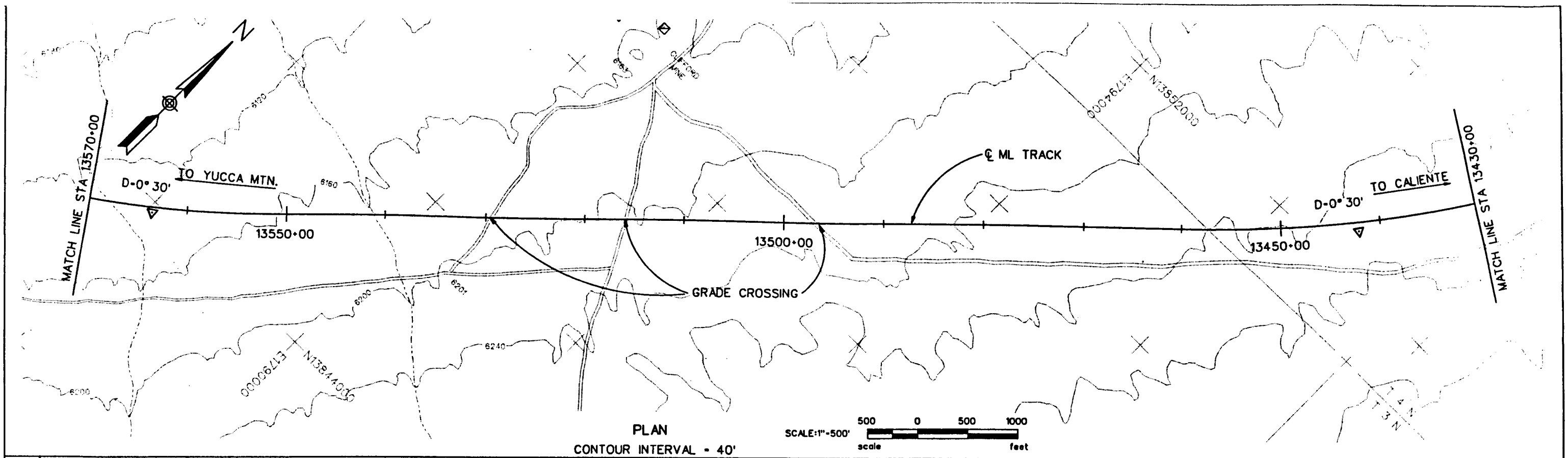
CALIENTE ROUTE PLAN & PROFILE

STA. 13290+00 - STA. 13430+00

SCALE as noted

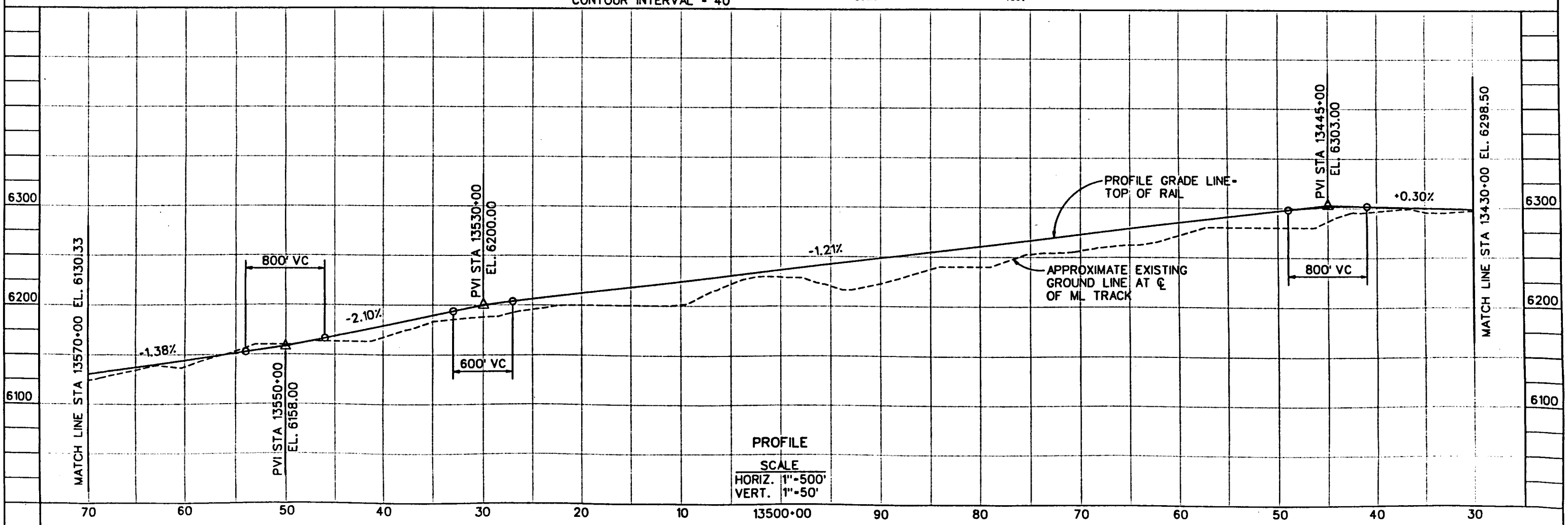
DRAWING NO. L91-018

SHEET NO. 120 OF 190



PLAN

CONTOUR INTERVAL = 40'



PROFILE

SCALE
HORIZ. 1"=500'
VERT. 1"=50'

REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
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APPROVED	BY		DATE

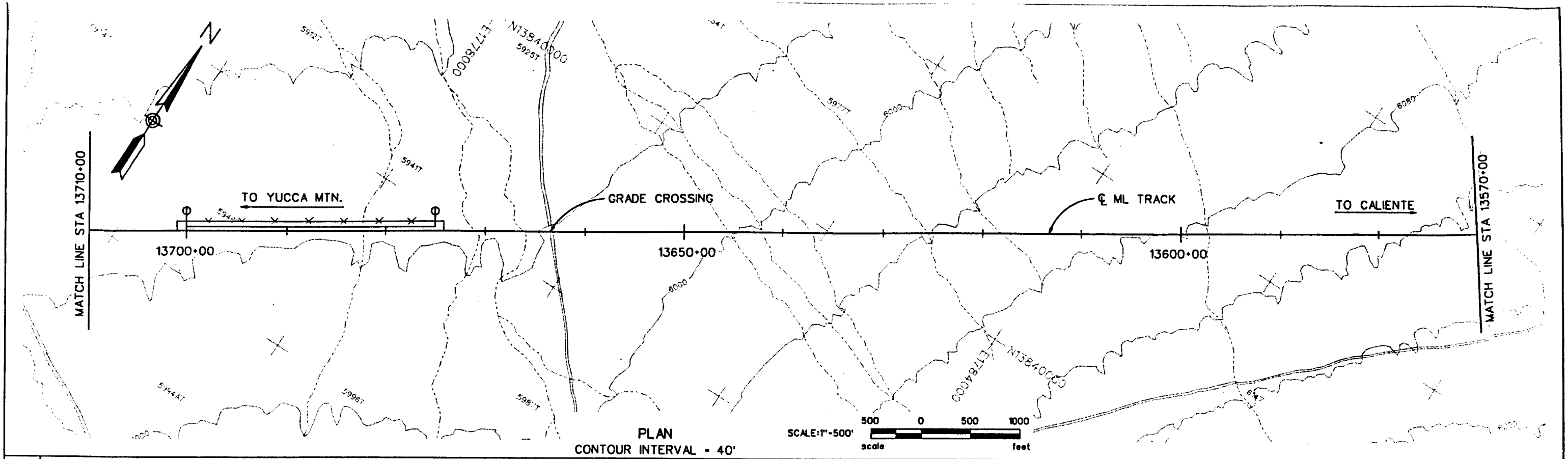
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

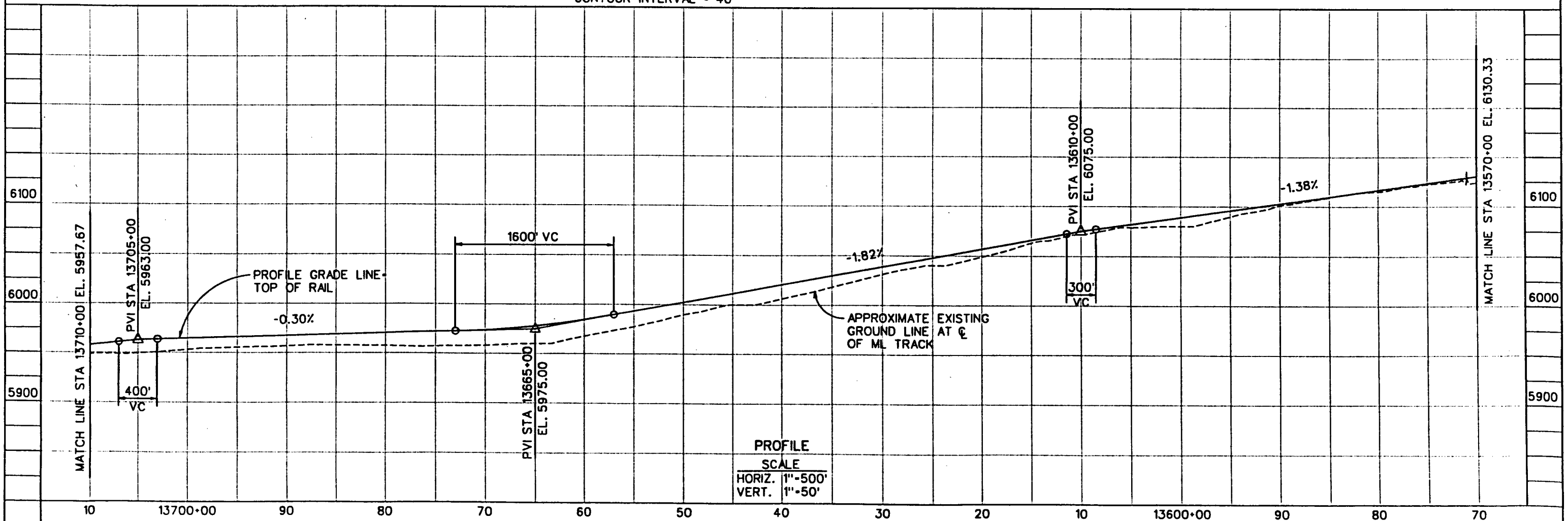
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 13430+00 - STA. 13570+00

SCALE as noted
DRAWING NO. L91-019
SHEET NO 121 OF 190

DATE PLOTTED 19-FEB-1991





REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

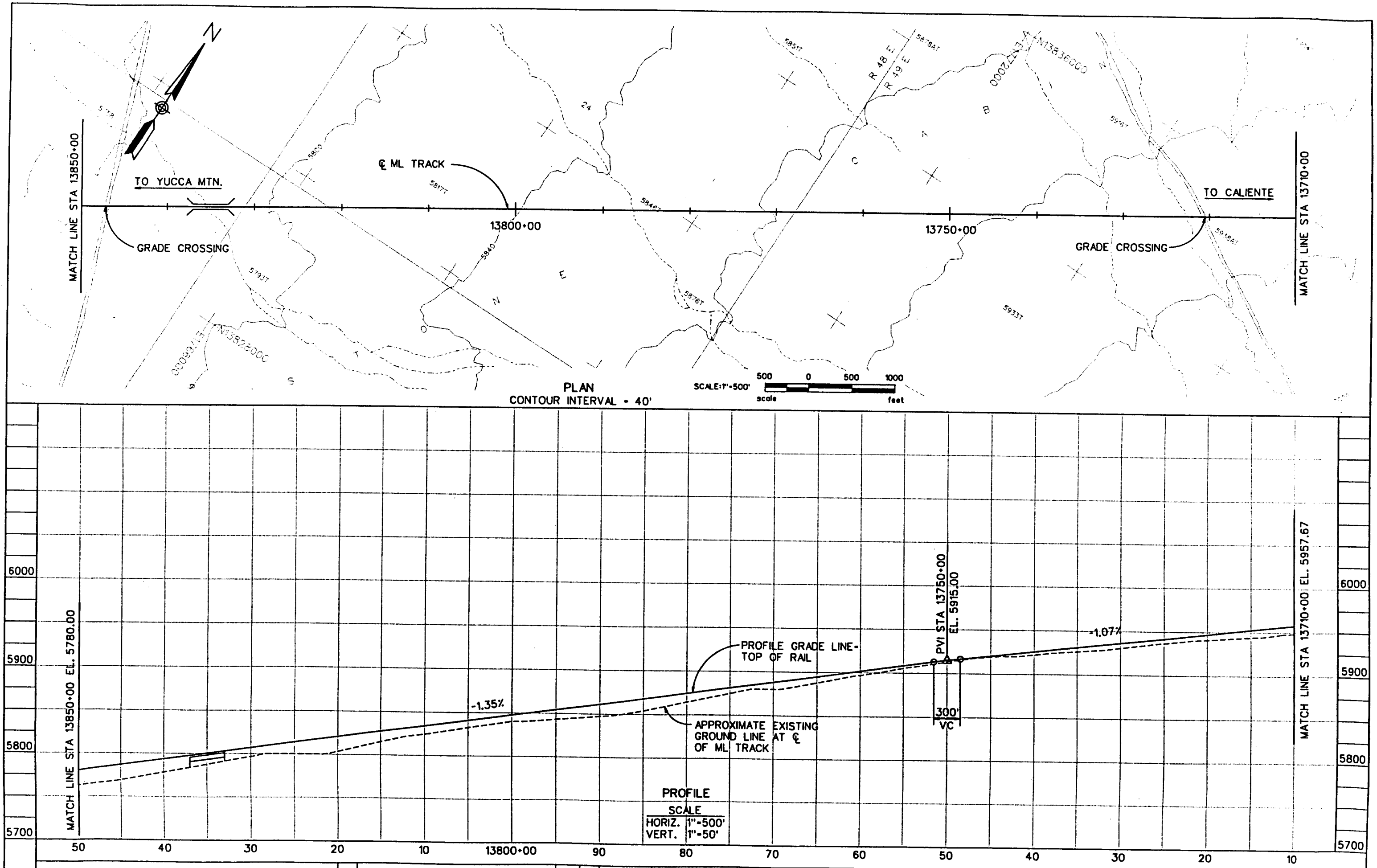
CALIENTE ROUTE PLAN & PROFILE

STA. 13570+00 - STA. 13710+00

SCALE: as noted

DRAWING NO. L91-020

SHEET NO. 122 of 190



REV	DESCRIPTION	DATE	BY

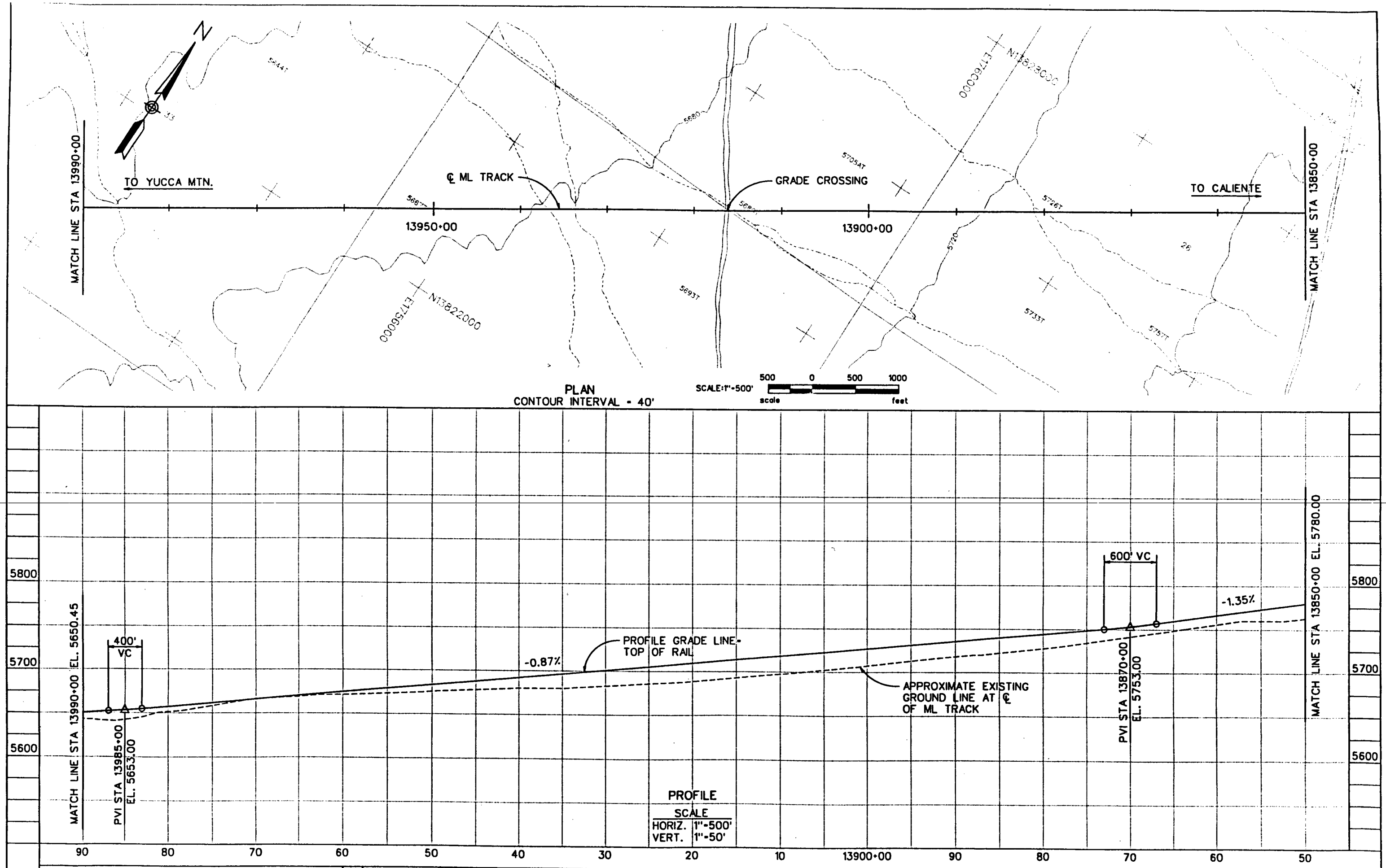
DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 13710+00 - STA. 13850+00

SCALE: as noted
DRAWING NO. L91-021
SHEET NO. 1 of 1



REV	DESCRIPTION	DATE	BY

	BY	DATE
DESIGNED	D. MOODY	2/91
REVIEWED	T. DANIEL	2/91
APPROVED		

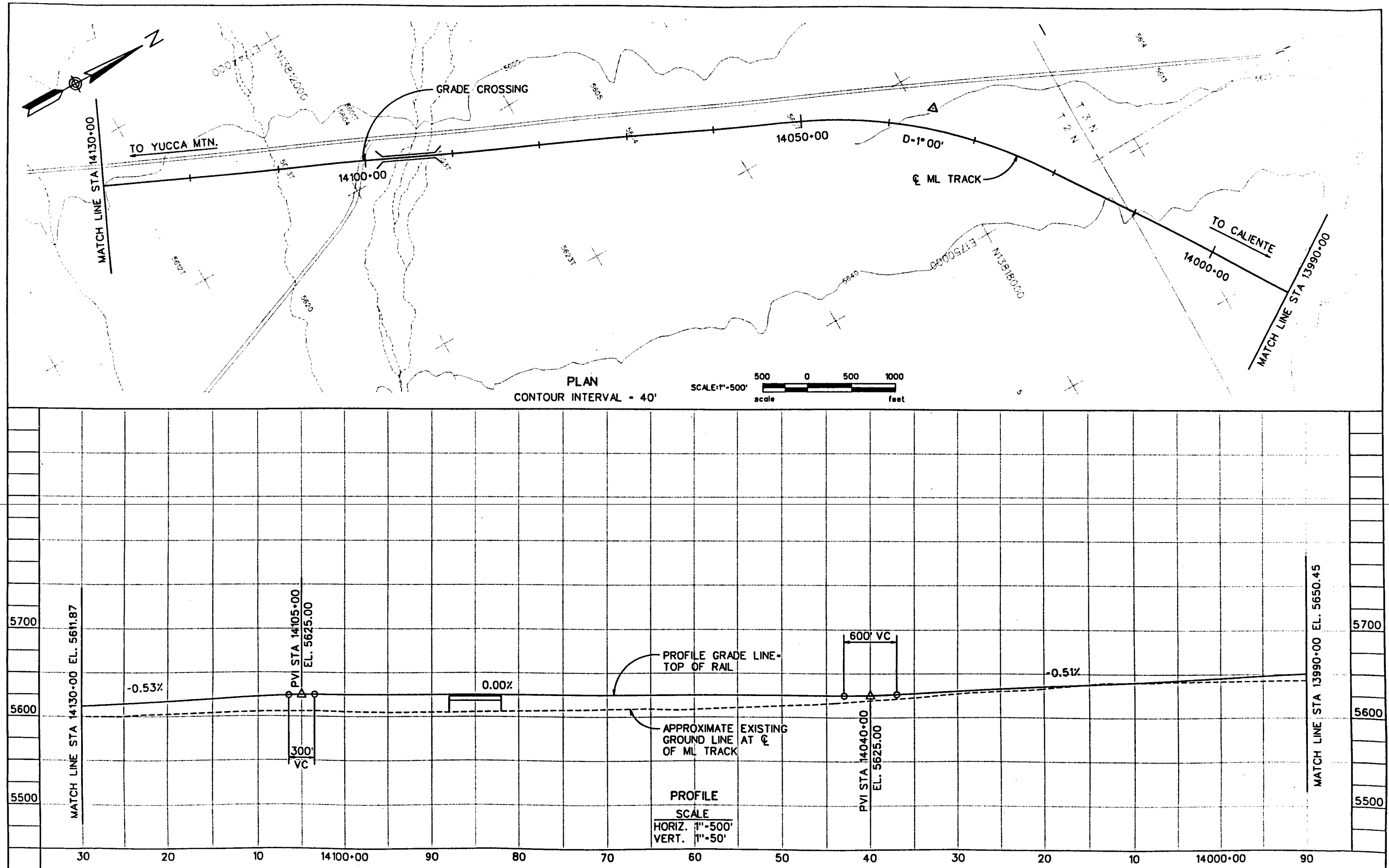
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 13850+00 - STA. 13990+00

SCALE: as noted
DRAWING NO. L91-022
SHEET NO. 124 of 190

DATE PLOTTED 20-FEB-1991



REV	DESCRIPTION	DATE	BY

	BY	DATE
DESIGNED	D. MOODY	2/91
REVIEWED	T. DANIEL	2/91
APPROVED		

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

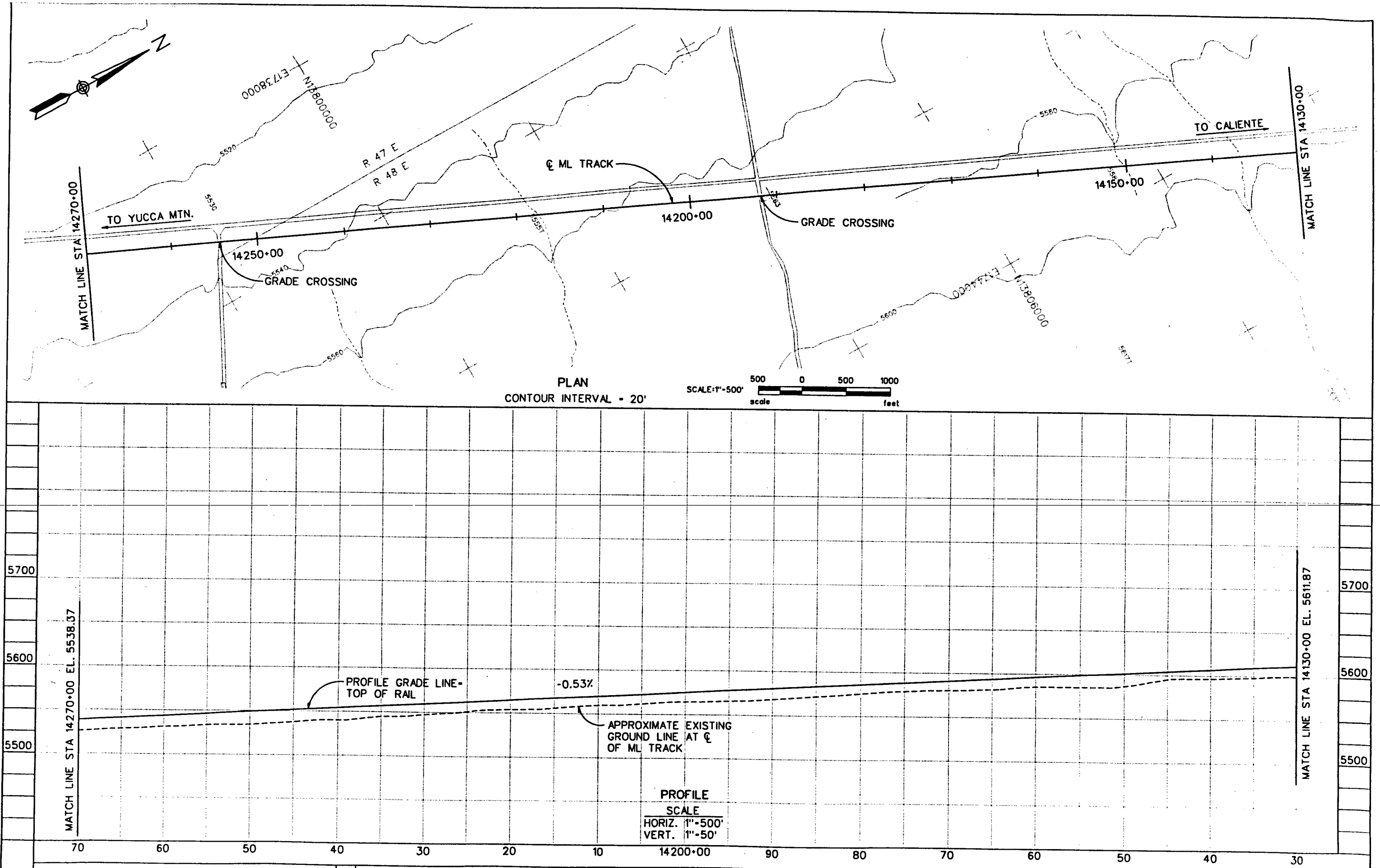
YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE PLAN & PROFILE

STA. 13990+00 - STA. 14130+00

SCALE: as noted
DRAWING NO. L91-023
SHEET NO. 125 OF 190

DATE PLOTTED 20-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

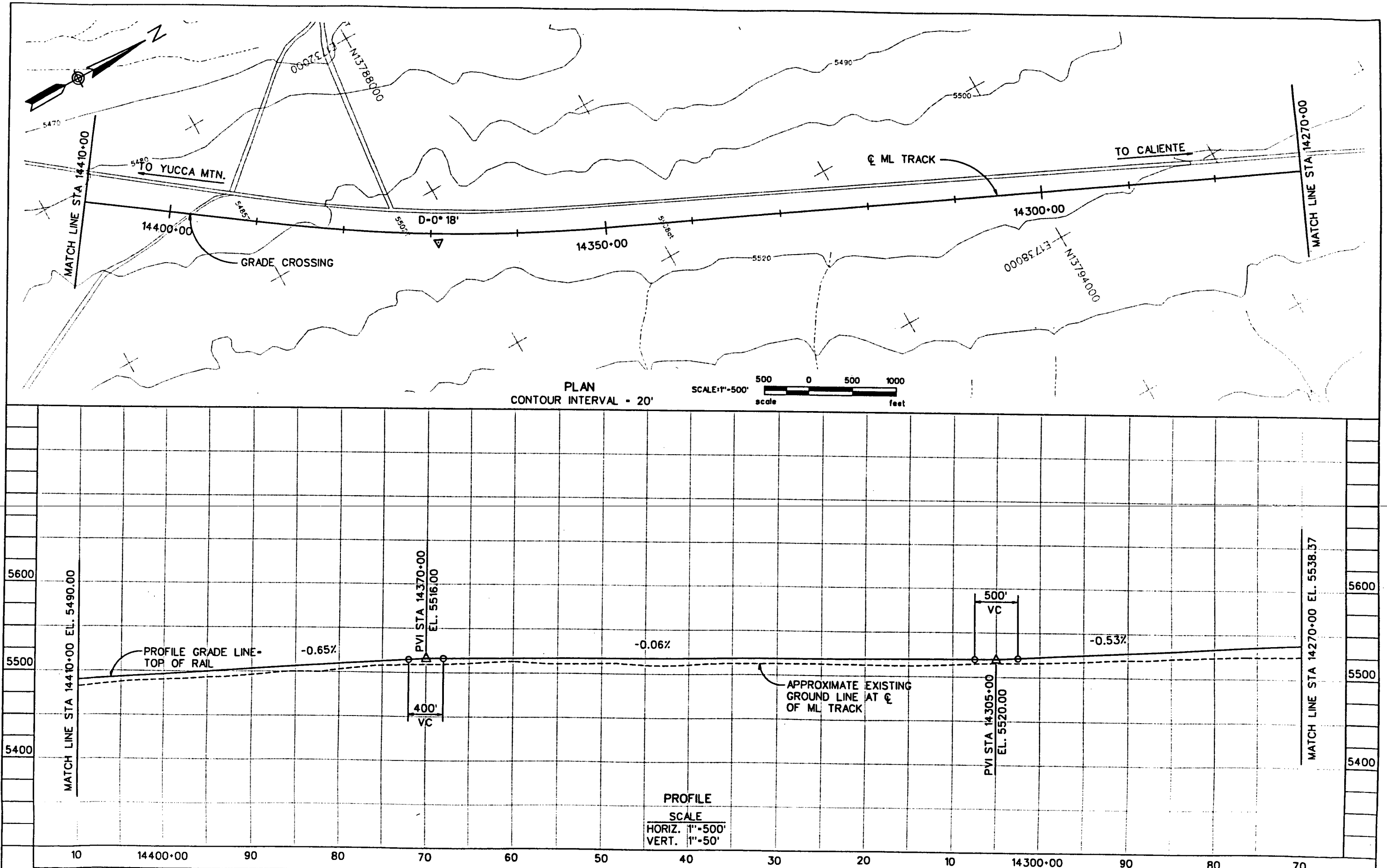
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 14130+00 - STA. 14270+00

SCALE as noted
DRAWING NO L91-024
SHEET NO 126 OF 190

DATE PLOTTED 20-FEB-1991



REV	DESCRIPTION	DATE	BY

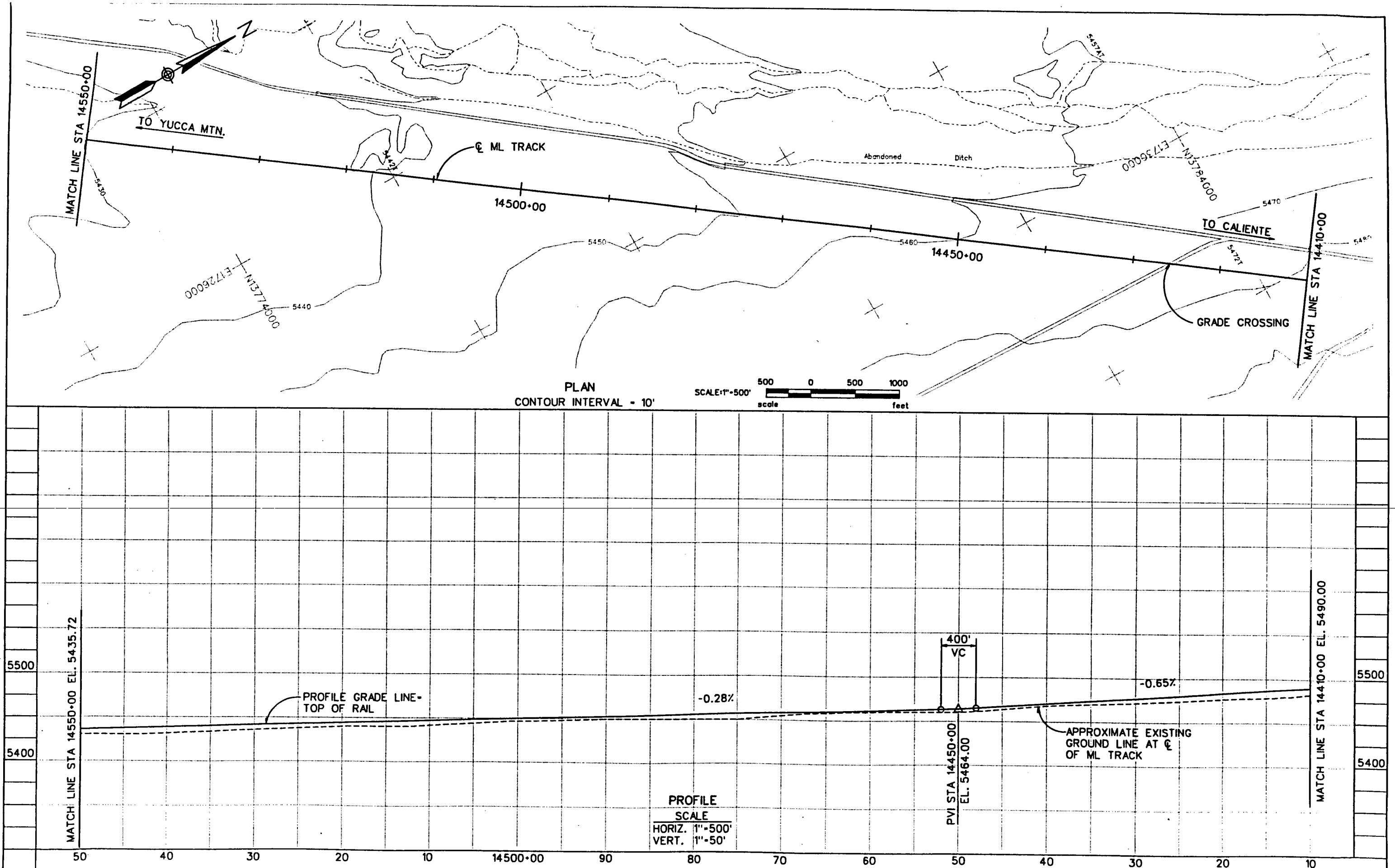
DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 14270+00 - STA. 14410+00

SCALE as noted
DRAWING NO L91-025
SHEET NO 127 of 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE PLAN & PROFILE

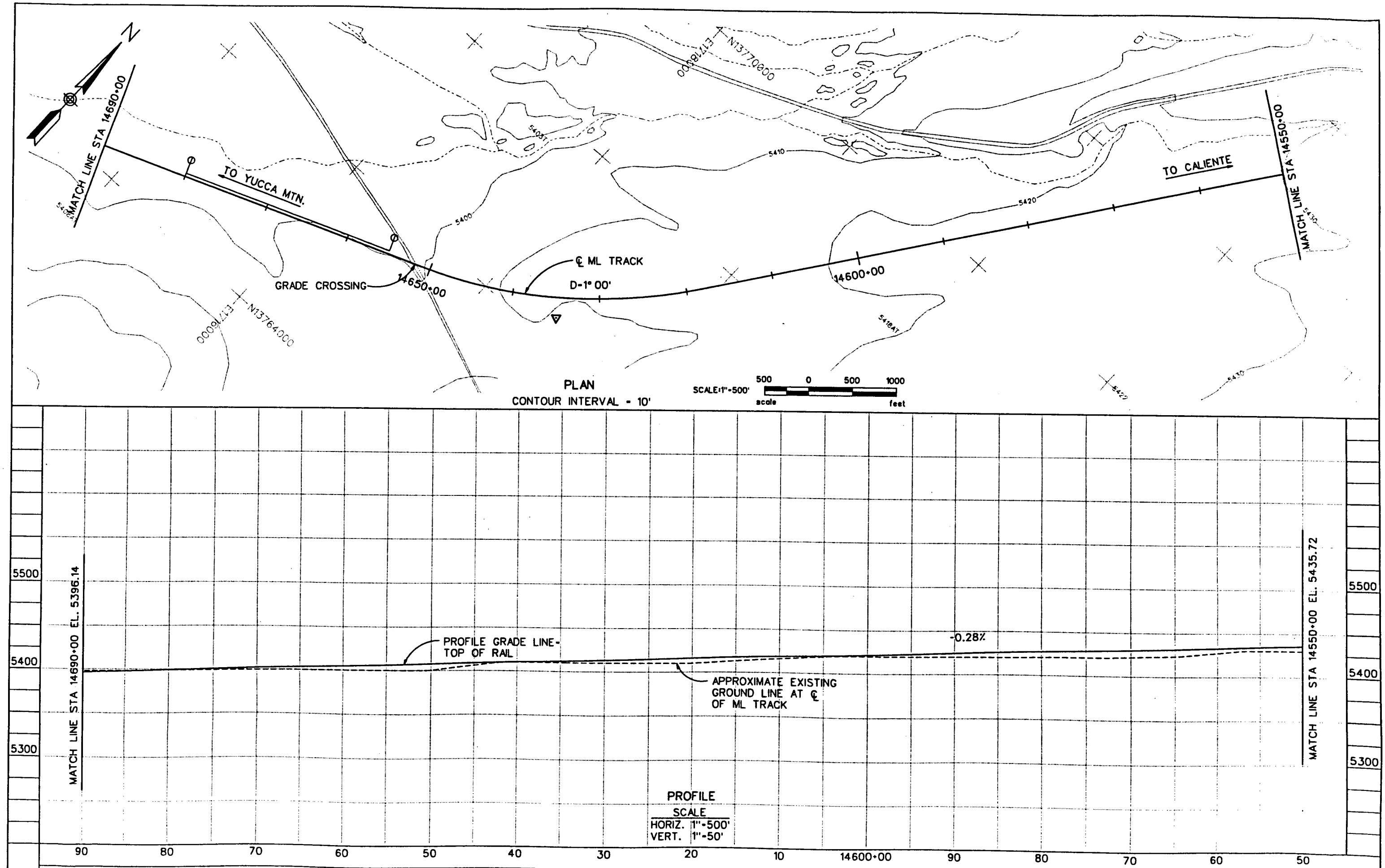
STA. 14410+00 - STA. 14550+00

SCALE: as noted

DRAWING NO. L91-026

SHEET NO. 128 of 190

DATE PLOTTED 20-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE PLAN & PROFILE

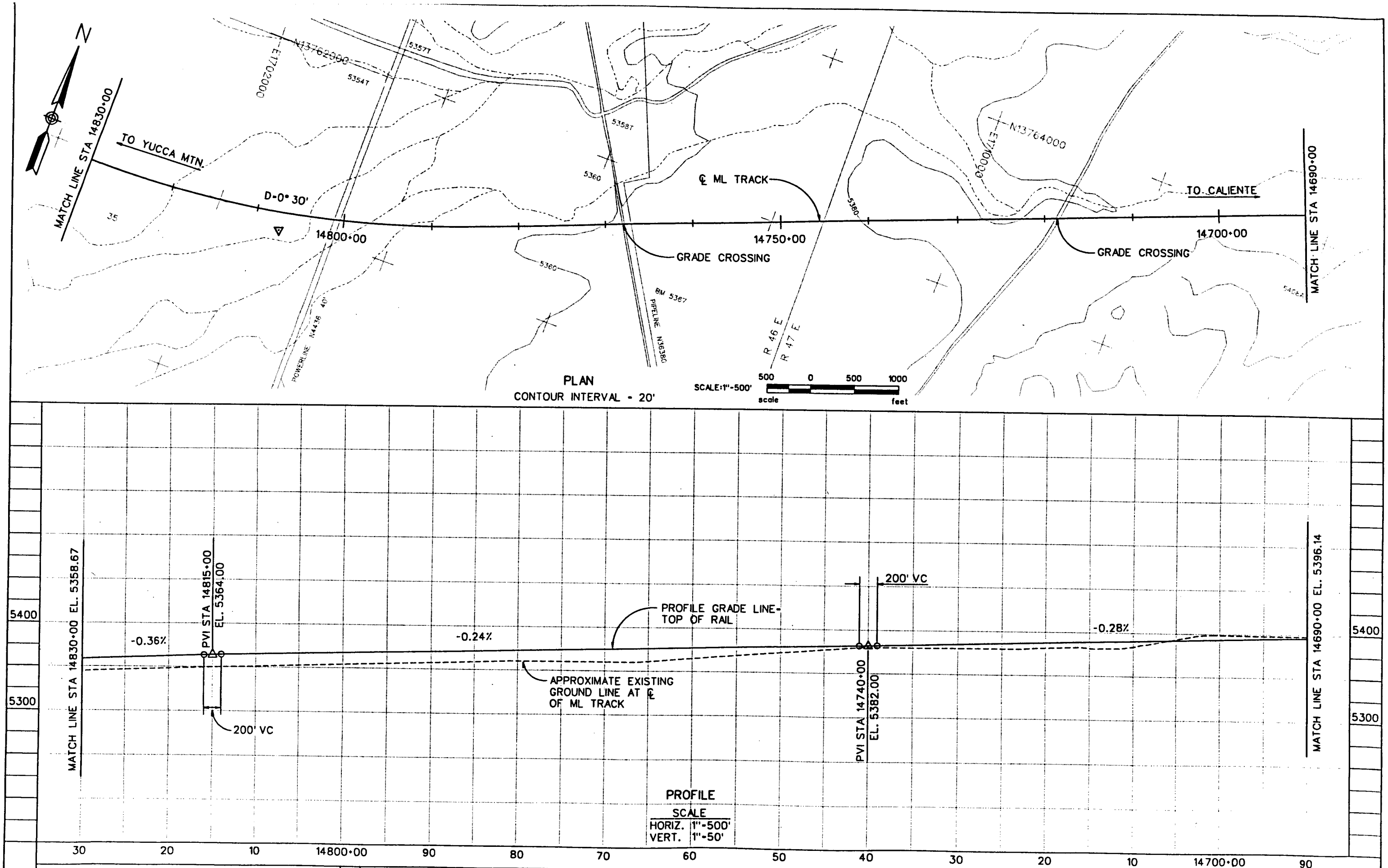
STA. 14550+00 - STA. 14690+00

SCALE: as noted

DRAWING NO: L91-027

SHEET NO: 1.9 of 1.90

DATE PLOTTED 20-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

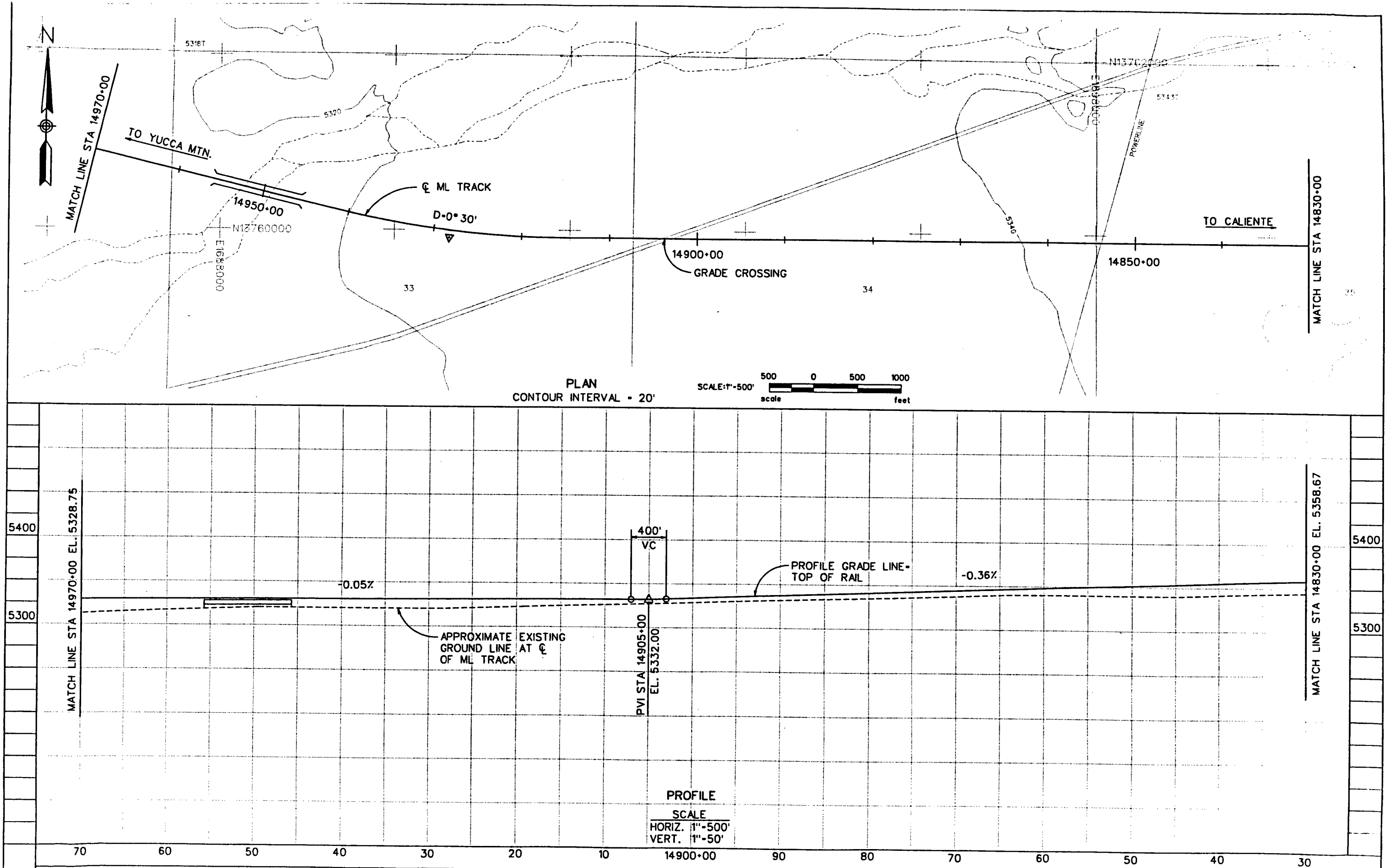
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 14690+00 - STA. 14830+00

SCALE as noted
DRAWING NO L91-028
SHEET NO 130 OF 190

DATE PLOTTED 20-FEB-1991



REV	DESCRIPTION	DATE	BY

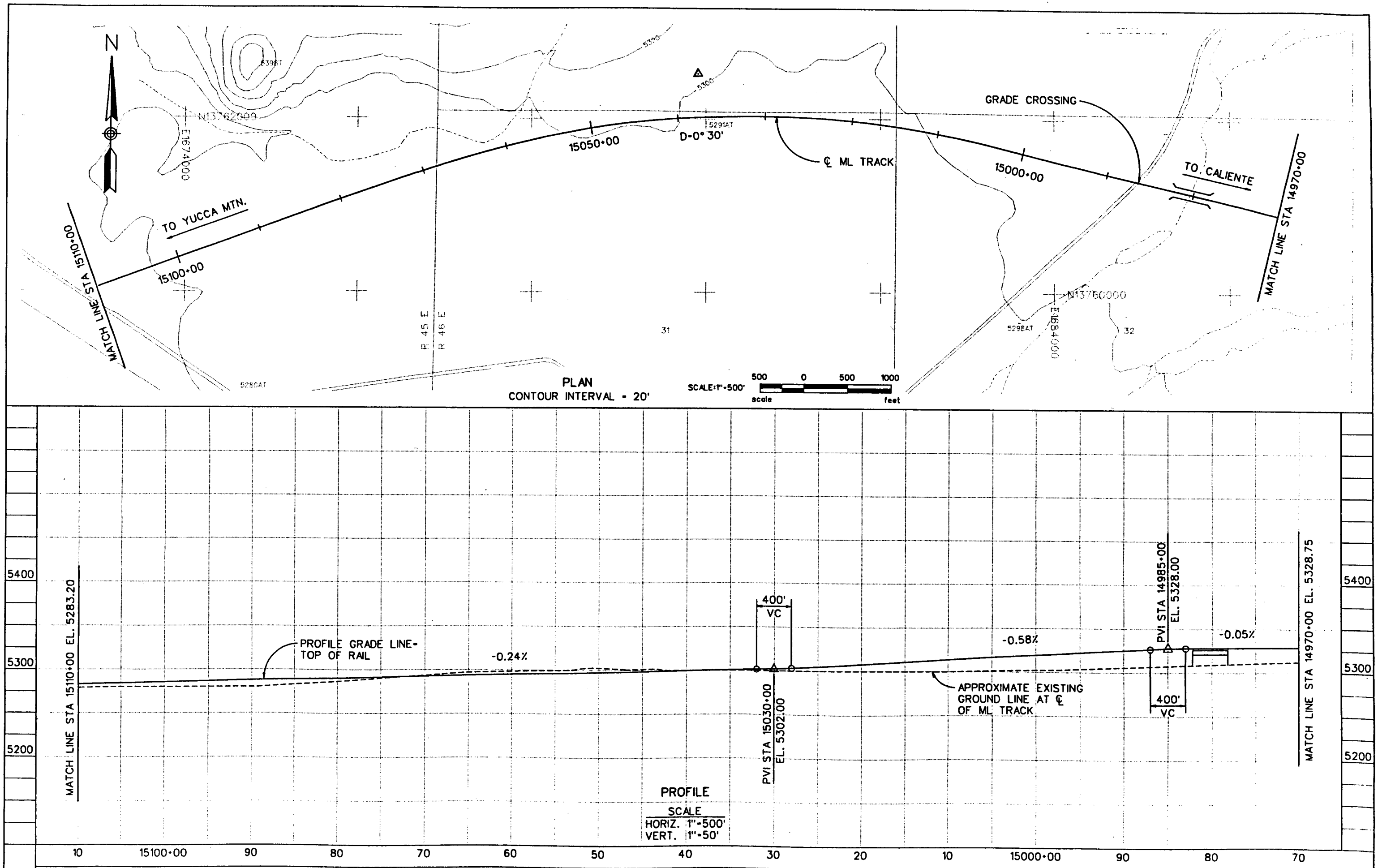
DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 14830+00 - STA. 14970+00

SCALE as noted
DRAWING NO L91 029
SHEET NO 131 OF 190



REV	DESCRIPTION	DATE	BY

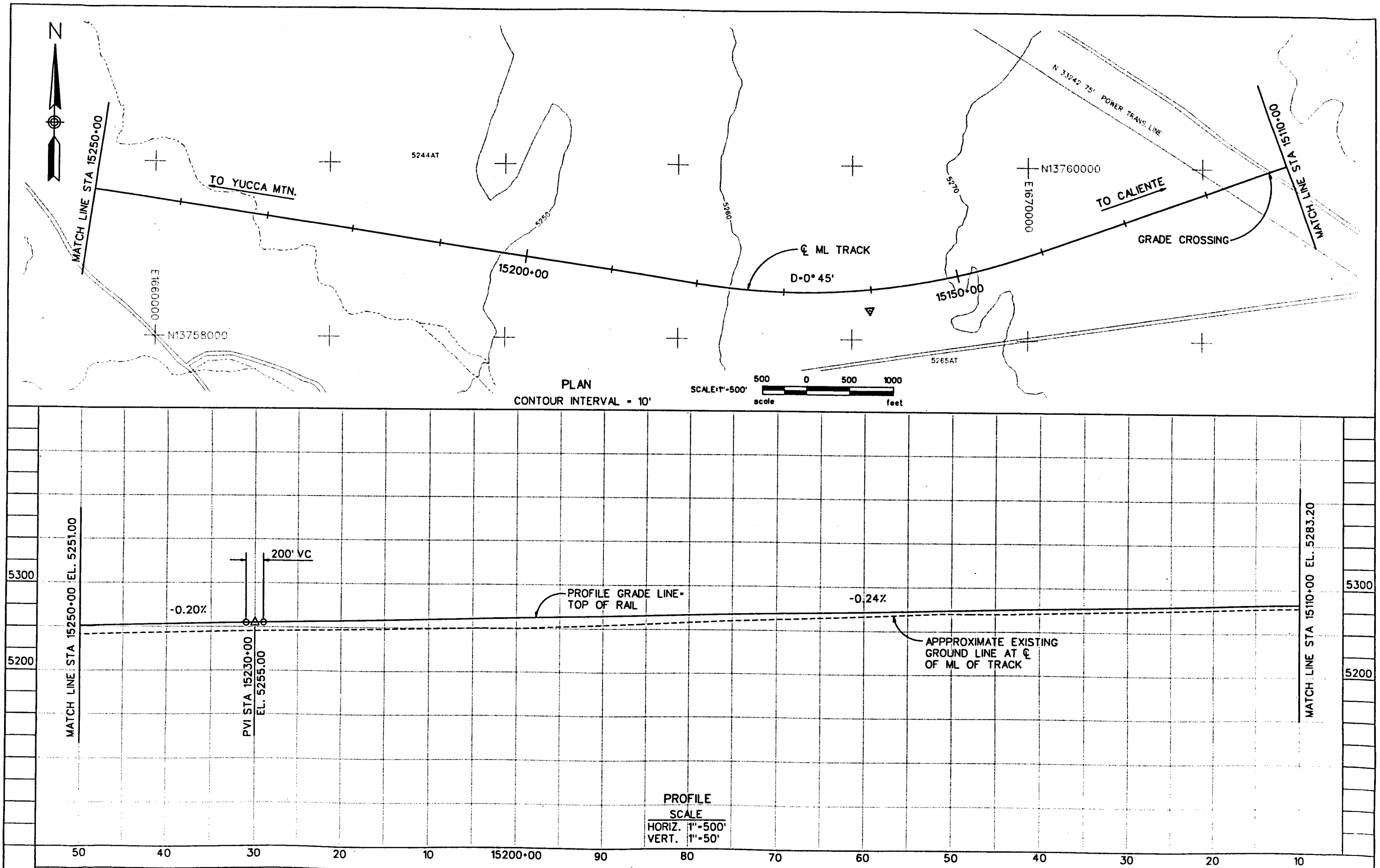
	BY	DATE
DESIGNED	D. MOODY	2/91
REVIEWED	T. DANIEL	2/91
APPROVED		

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 14970+00 - STA. 15110+00

SCALE: as noted
DRAWING NO: L91-0.50
SHEET NO: 137 of 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

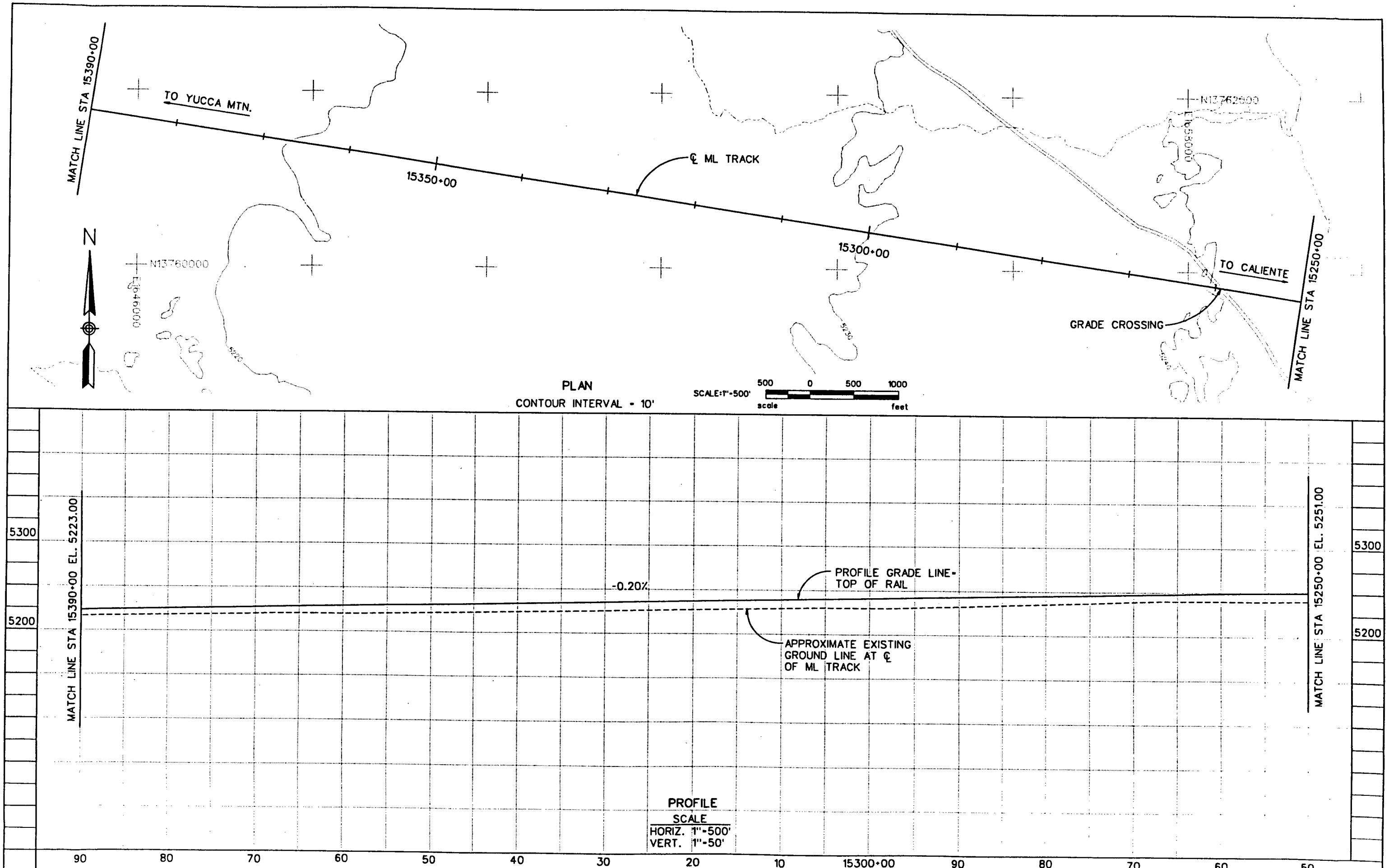
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE PLAN & PROFILE

SCALE: as noted
DRAWING NO. L91-031
SHEET NO. 122



REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

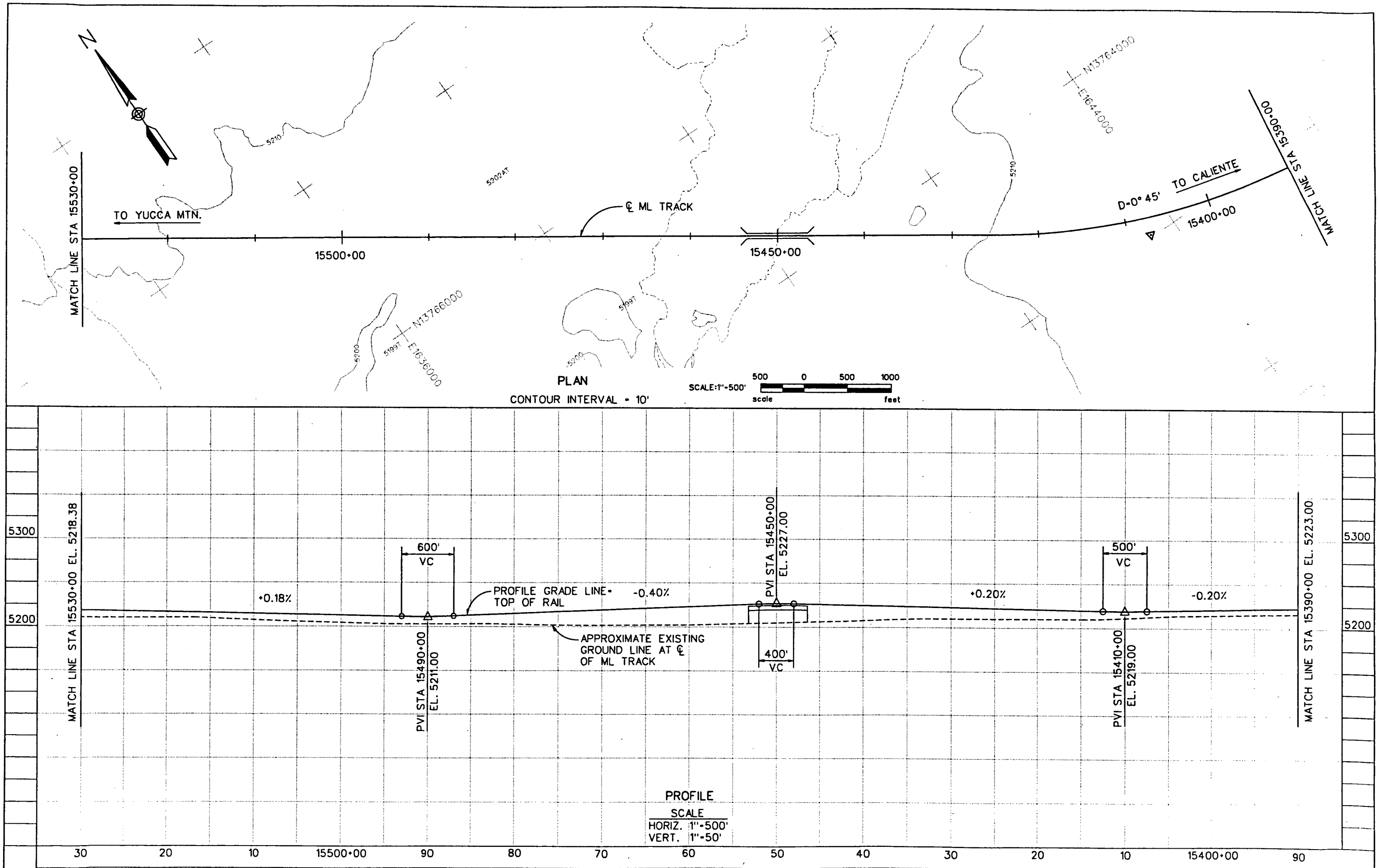
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE
PLAN & PROFILE
STA. 15250+00 - STA. 15390+00

SCALE as noted
DRAWING NO. L91-032
SHEET NO.



DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

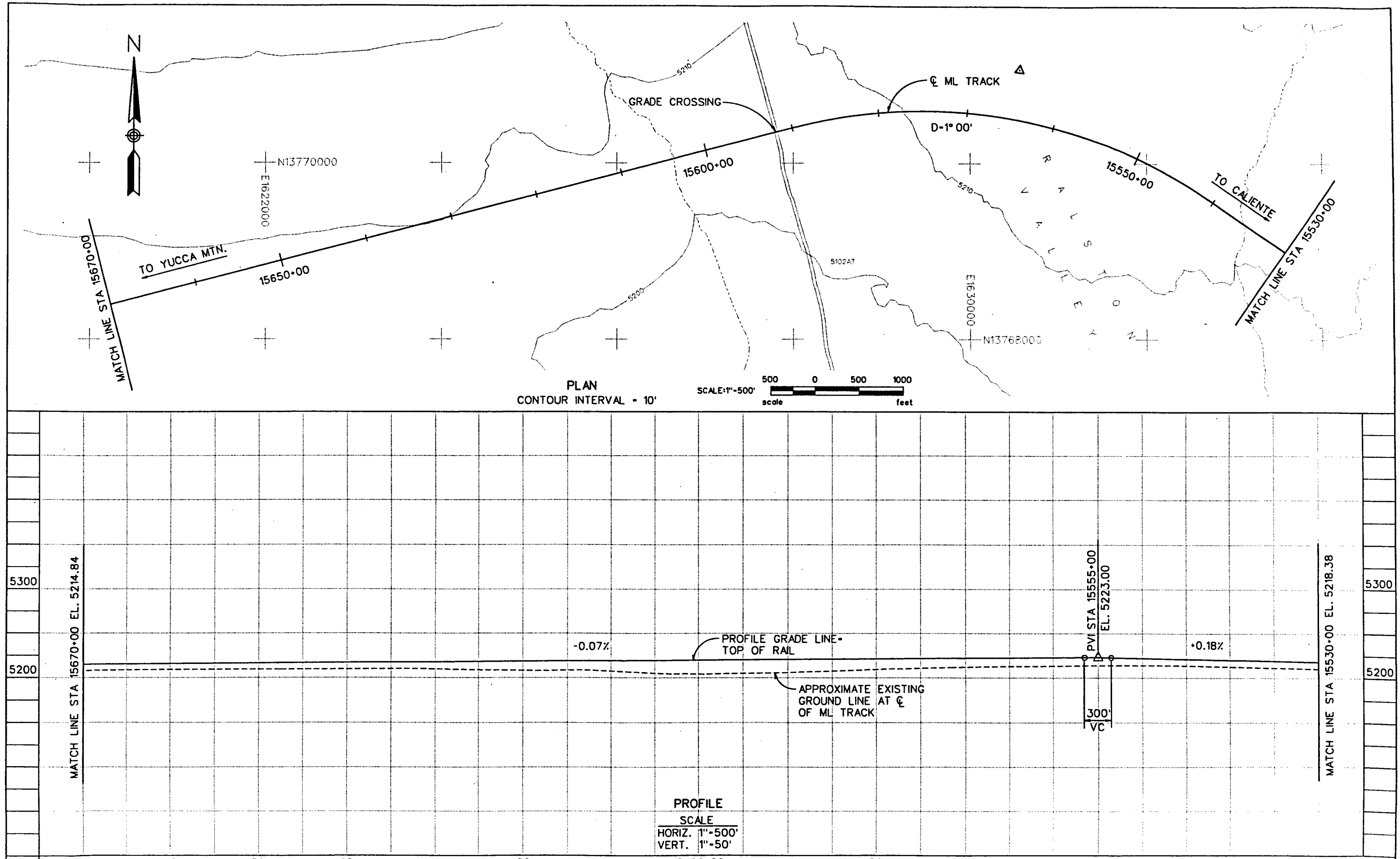
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE
PLAN & PROFILE

SCALE as noted
DRAWING NO L91-033
SHEET NO

DATE PLOTTED 20-FEB-1991



REV	DESCRIPTION	DATE	BY

	BY	DATE
DESIGNED	D. MOODY	2/91
REVIEWED	T. DANIEL	2/91
APPROVED		

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE PLAN & PROFILE

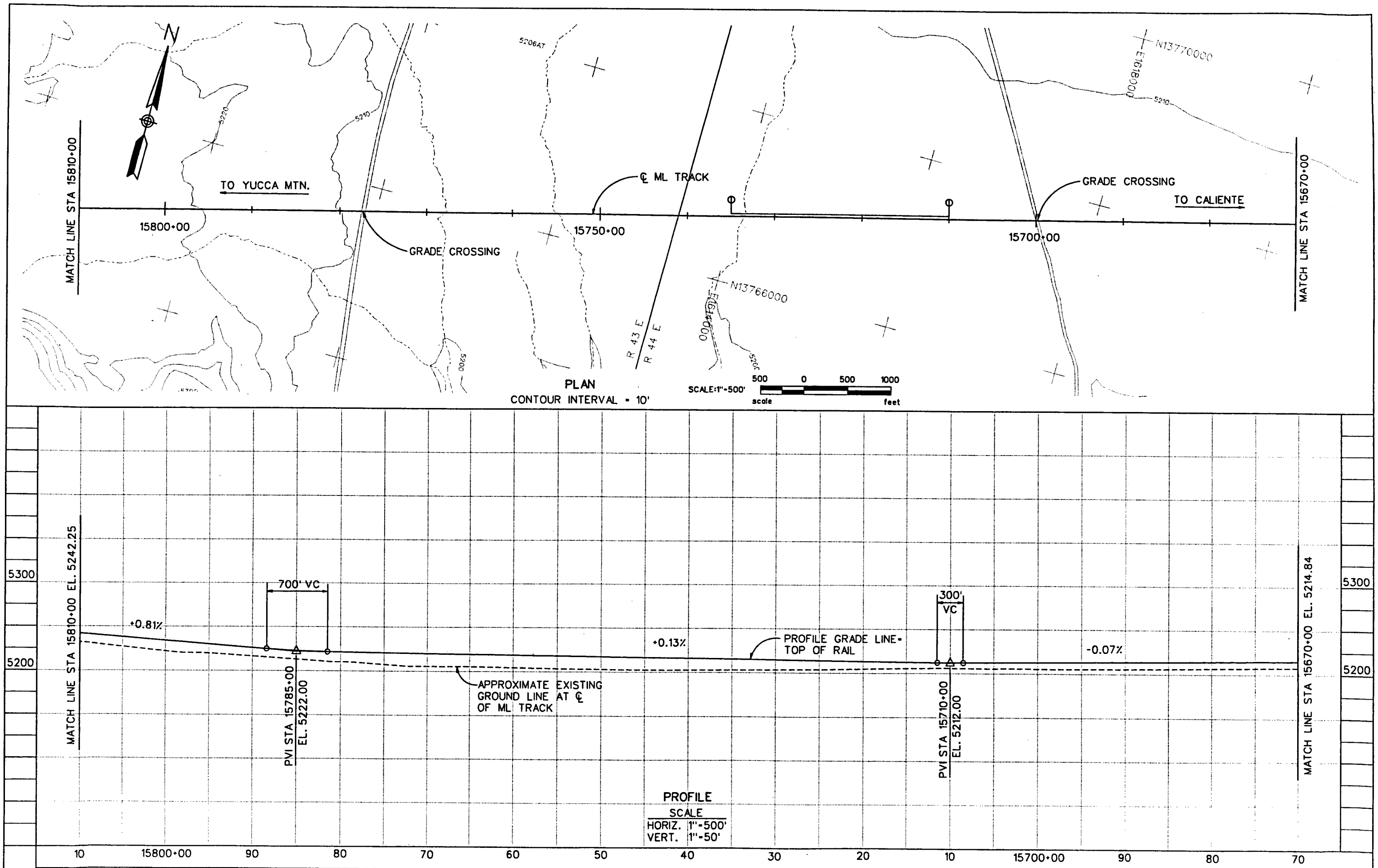
STA. 15530+00 - STA. 15670+00

SCALE: as noted

DRAWING NO. L91-034

SHEET NO. 136 OF 190

DATE PLOTTED 20-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

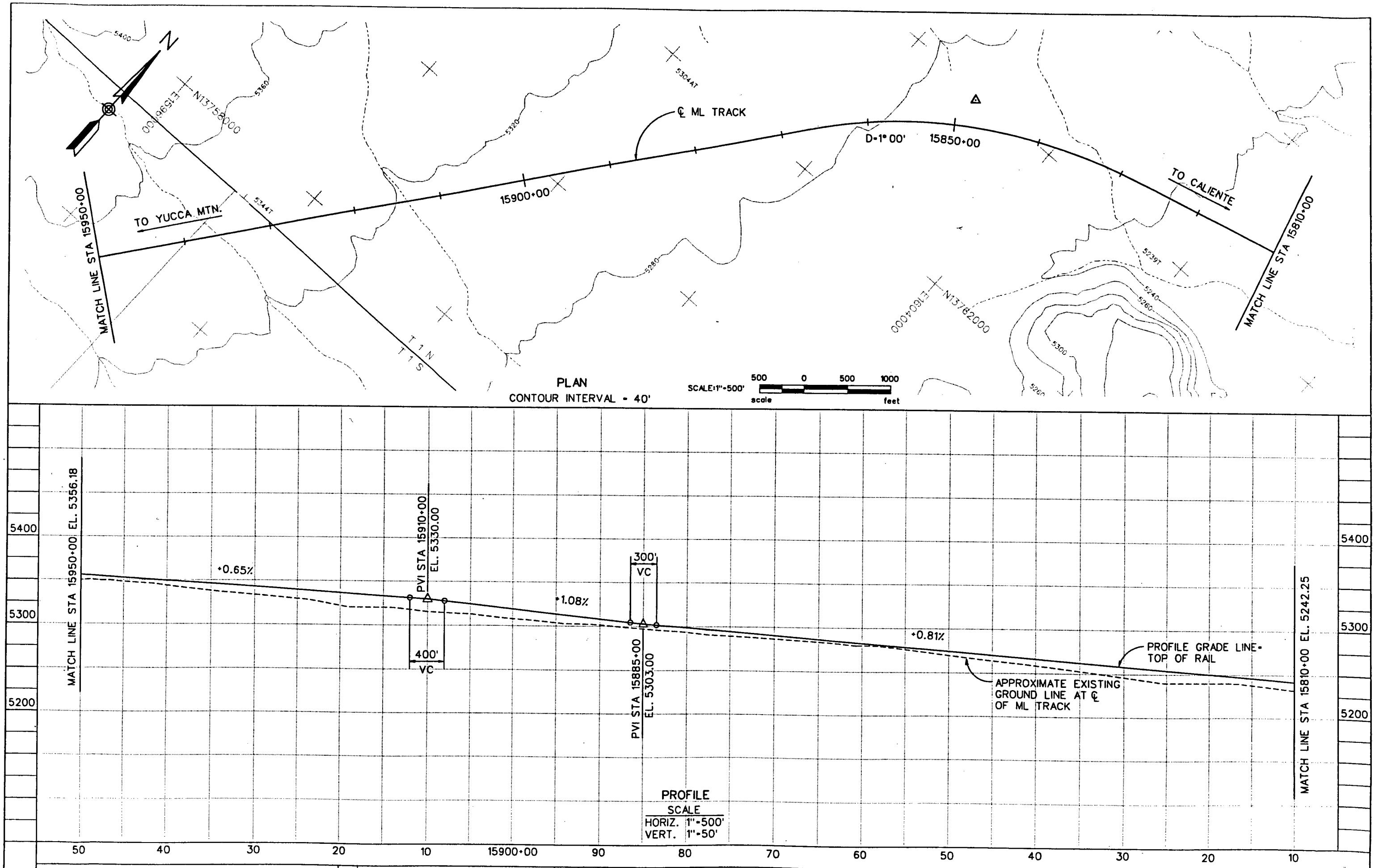
YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE PLAN & PROFILE

STA. 15670+00 - STA. 15810+00

SCALE: as noted
DRAWING NO: L91-035
SHEET NO: 137 OF 190

DATE PLOTTED 20-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

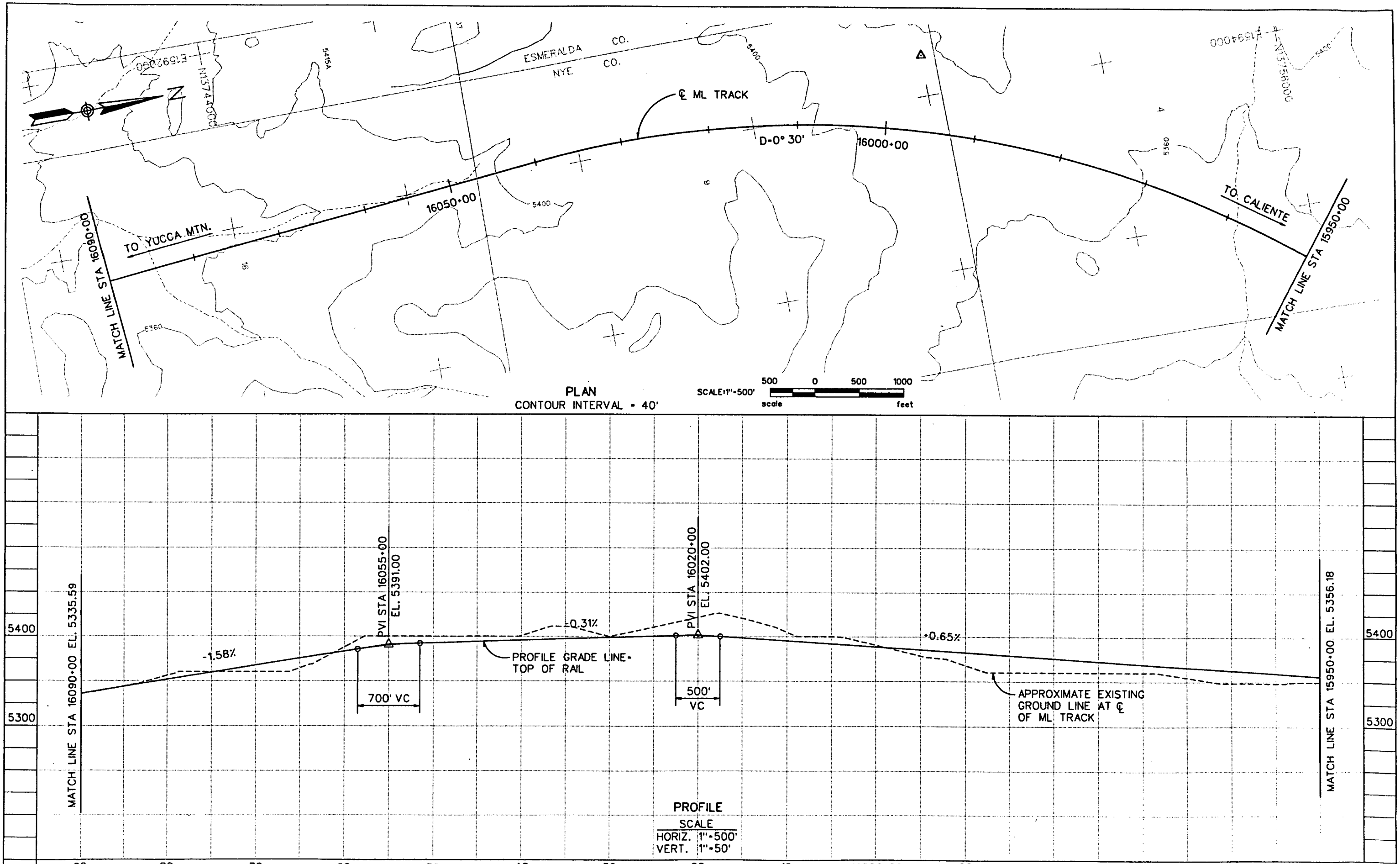
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE
PLAN & PROFILE
STA. 15810+00 - STA. 15950+00

SCALE: as noted
DRAWING NO. L91-036
SHEET NO. 138 OF 190

DATE PLOTTED 20-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

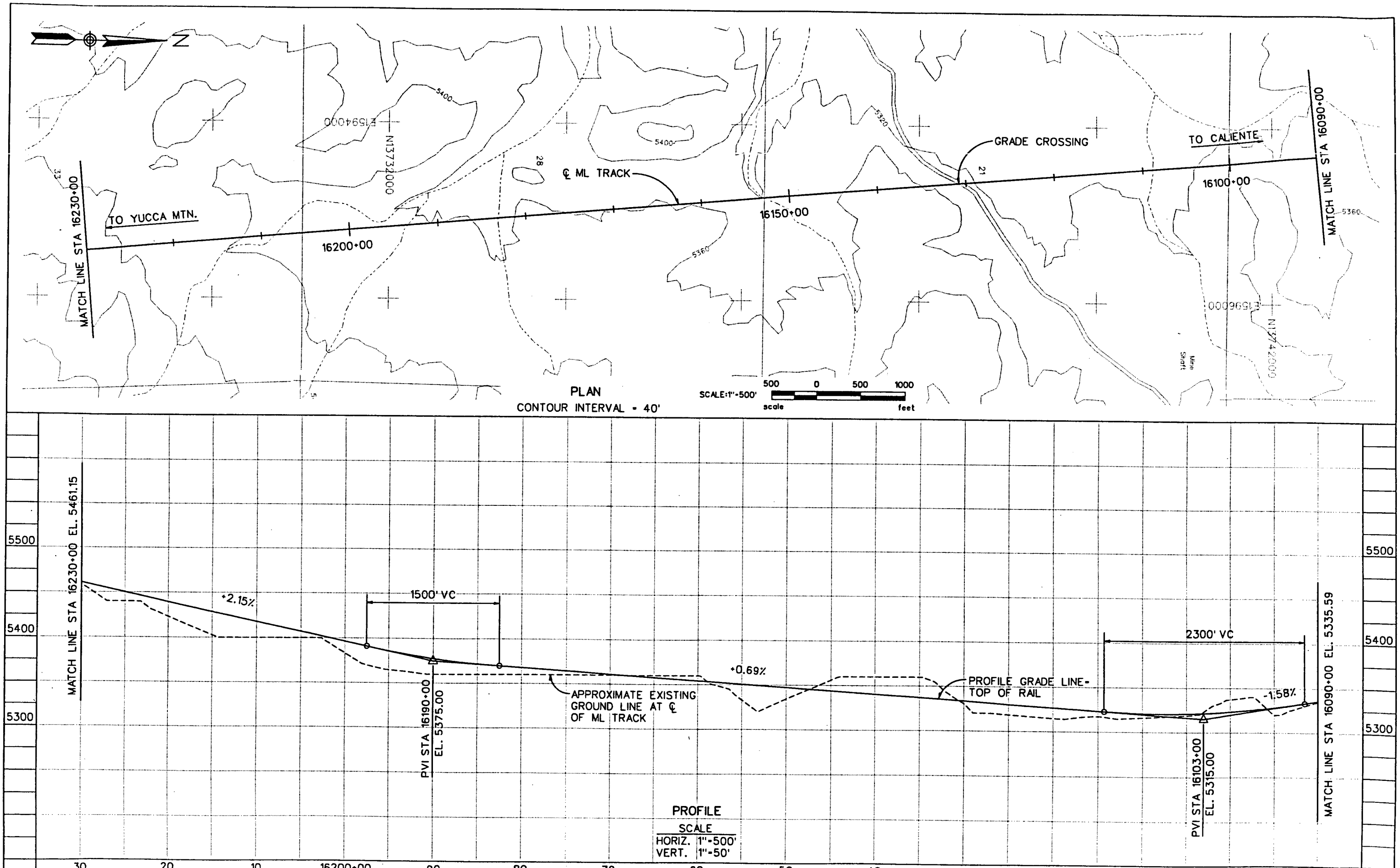
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE
PLAN & PROFILE
STA. 15950+00 - STA. 16090+00

SCALE as noted
DRAWING NO L91-037
SHEET 139 OF 190

DATE PLOTTED 20-FEB-1991



REV	DESCRIPTION	DATE	BY

	BY	DATE
DESIGNED	D. MOODY	2/91
REVIEWED	T. DANIEL	2/91
APPROVED		

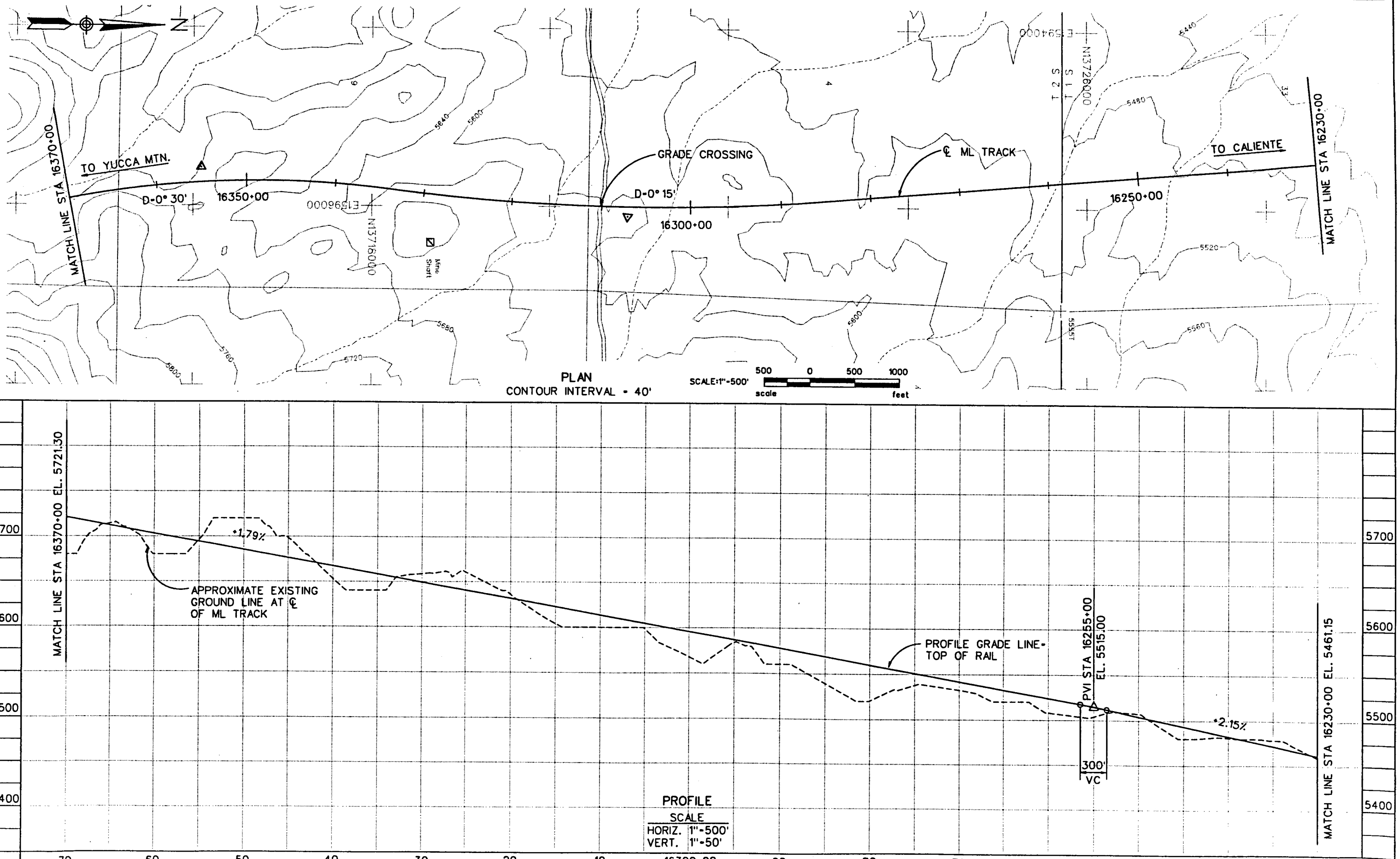
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 16090+00 - STA. 16230+00

SCALE: as noted
DRAWING NO: L91-038
SHEET NO: 140 OF 190

DATE PLOTTED 20-FEB-1991



REV	DESCRIPTION	DATE	BY

	BY		DATE
DESIGNED	D. MOODY	2/91	
REVIEWED	T. DANIEL	2/91	
APPROVED			

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE PLAN & PROFILE

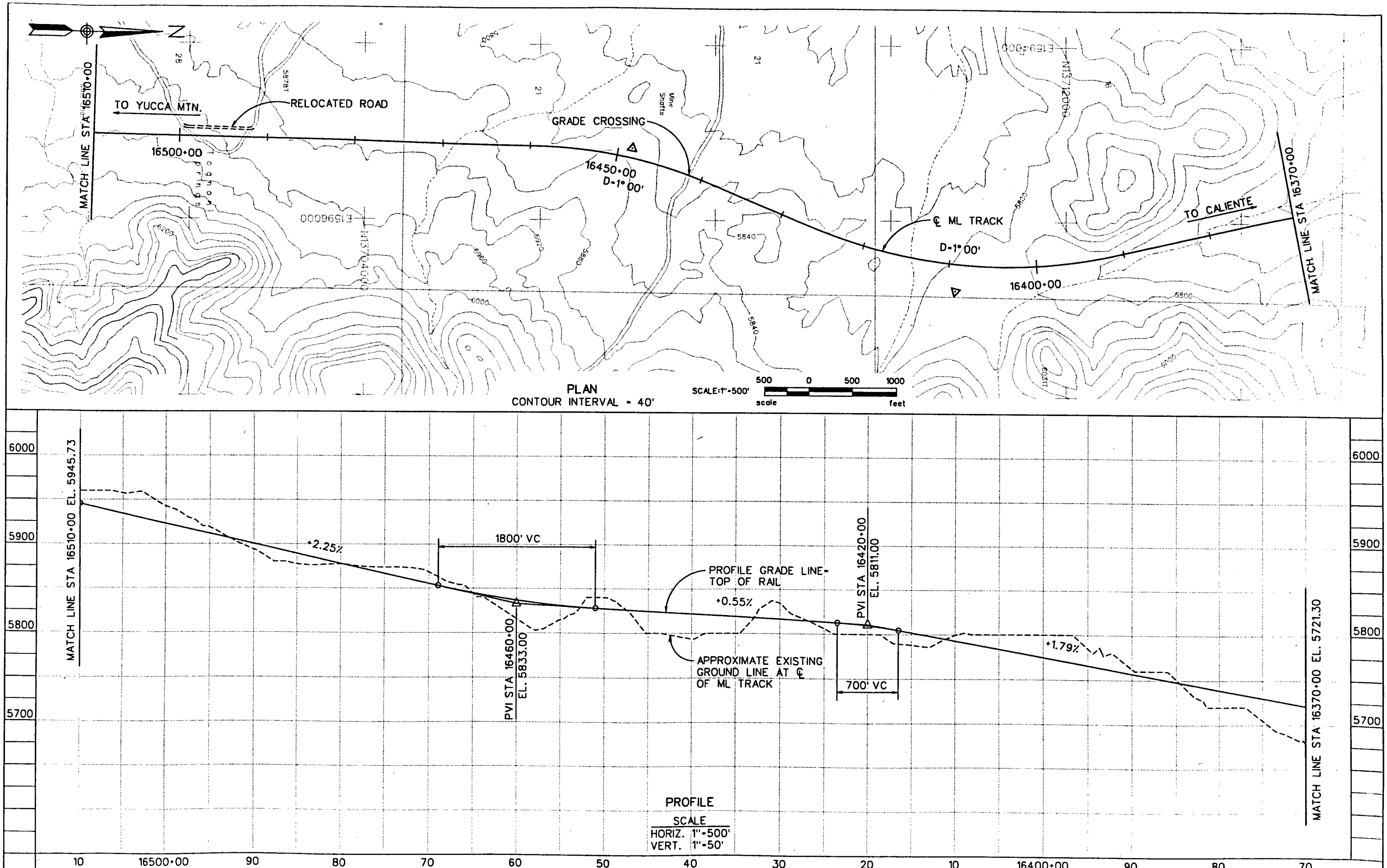
STA. 16230+00 - STA. 16370+00

SCALE: as noted

DRAWING NO. L91-039

SHEET NO. 141 OF 190

DATE PLOTTED 20-FEB-1991



REV	DESCRIPTION	DATE	BY

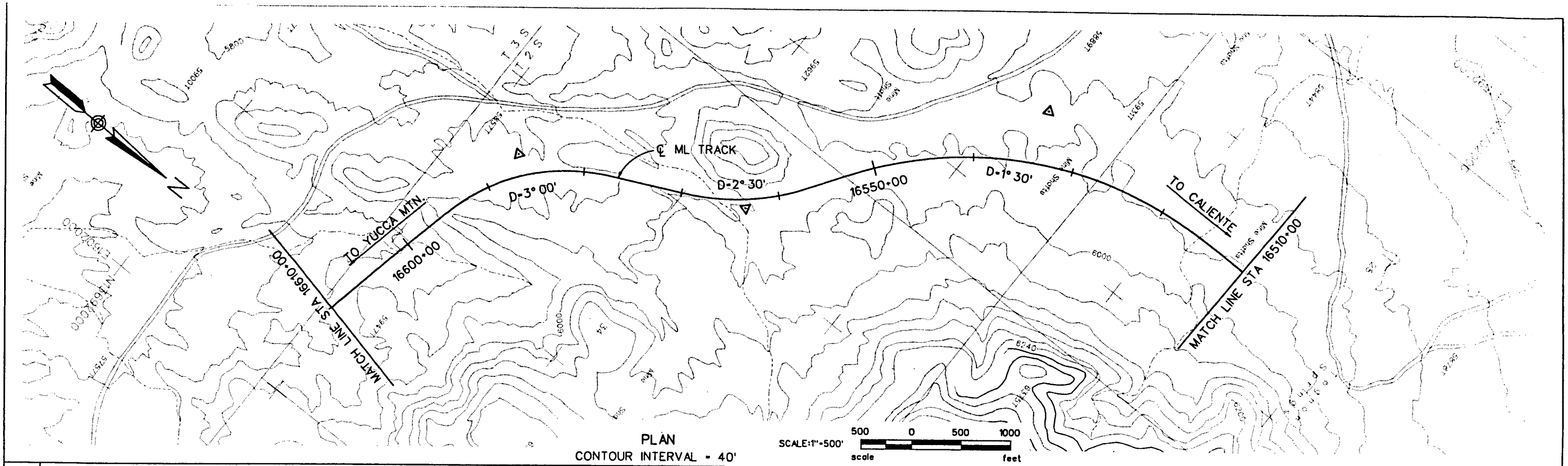
DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

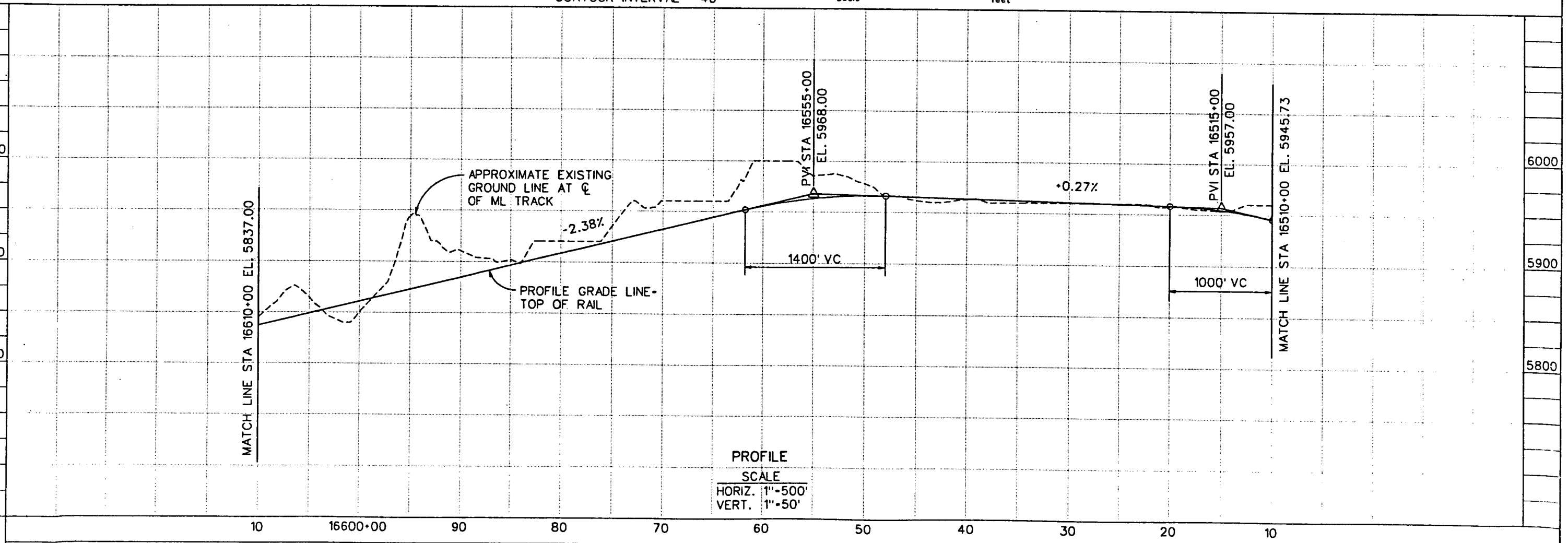
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 16370+00 - STA. 16510+00

SCALE as noted
DRAWING NO L91-040
SHEET NO 142 OF 190



PLAN
CONTOUR INTERVAL = 40'



PROFILE
SCALE
HORIZ. 1"=500'
VERT. 1"=50'

REV	DESCRIPTION	DATE	BY

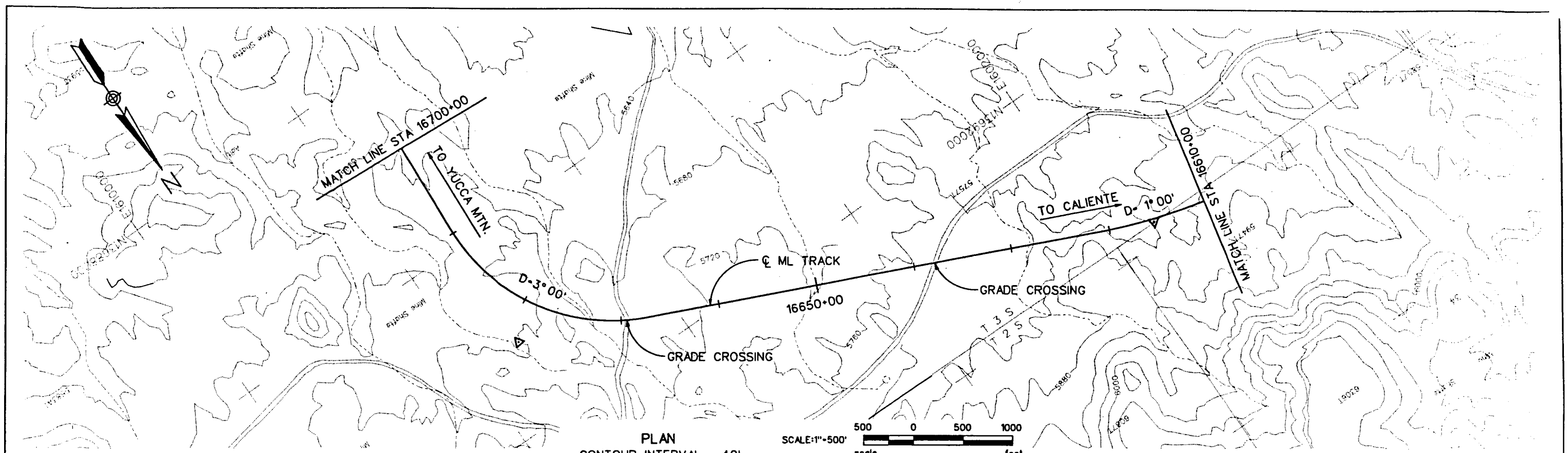
DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

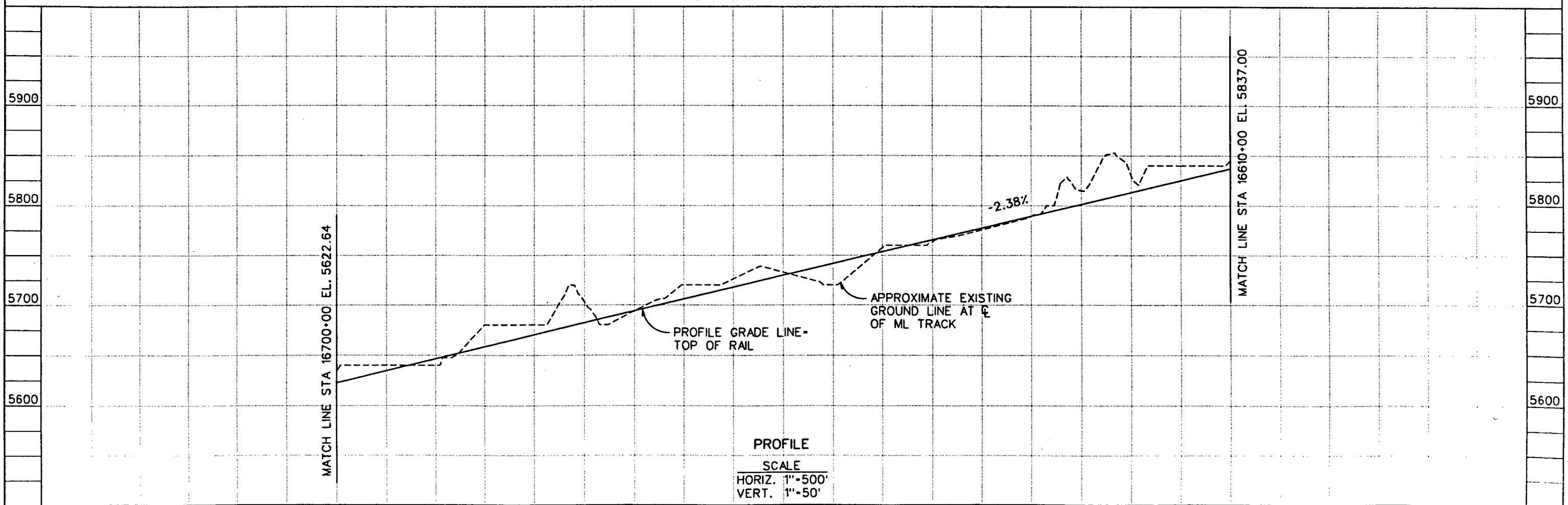
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 16510+00 - STA. 16610+00

SCALE as noted
DRAWING NO L91-041
SHEET NO 143 OF 190



PLAN
CONTOUR INTERVAL - 40'
SCALE:1"=500'



PROFILE
SCALE
HORIZ. 1"=500'
VERT. 1"=50'

REV	DESCRIPTION	DATE	BY

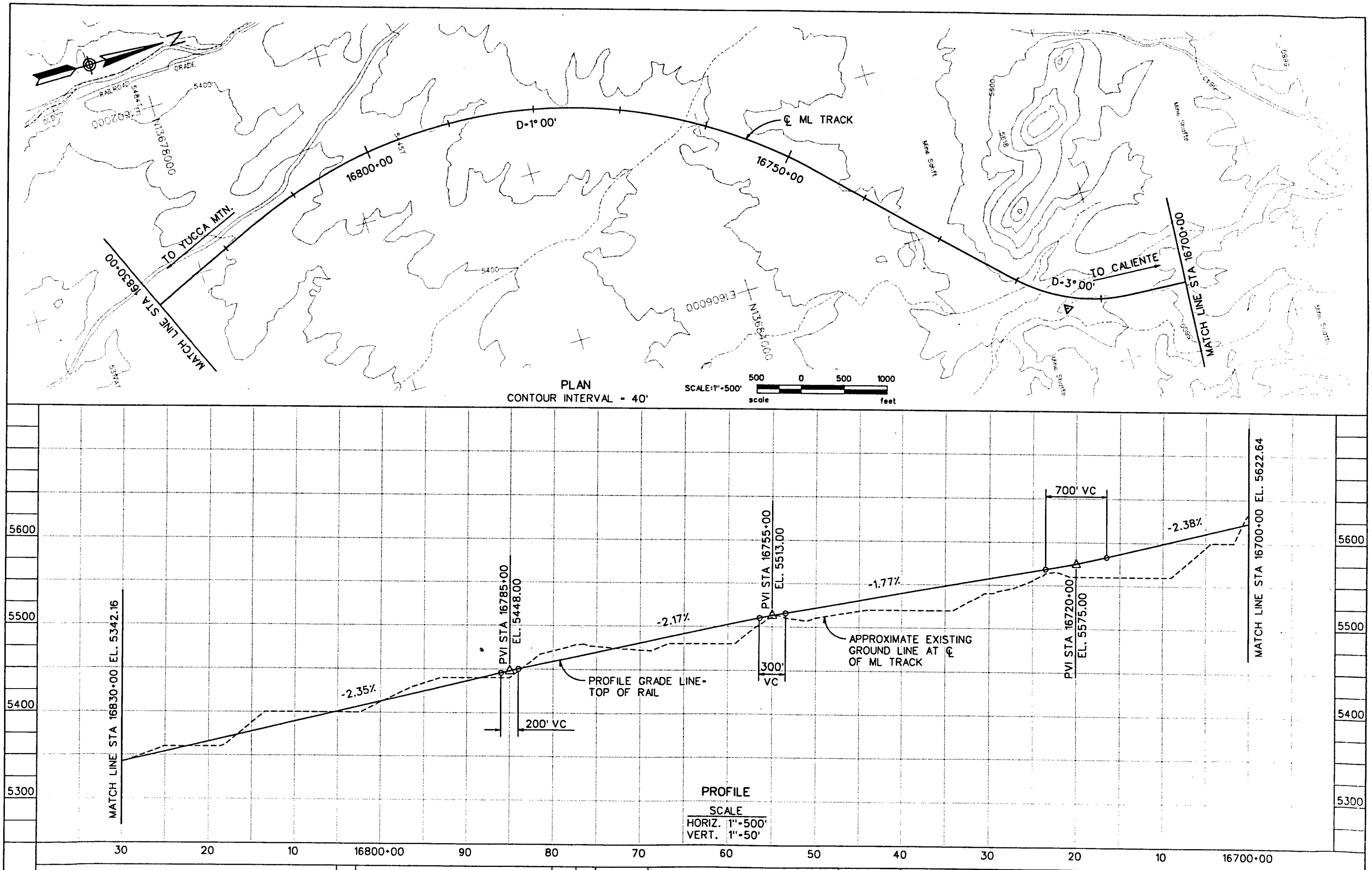
DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA 16610+00 - STA 16700+00

SCALE as noted
DRAWING NO L91-042
SHEET NO



REV	DESCRIPTION	DATE	BY

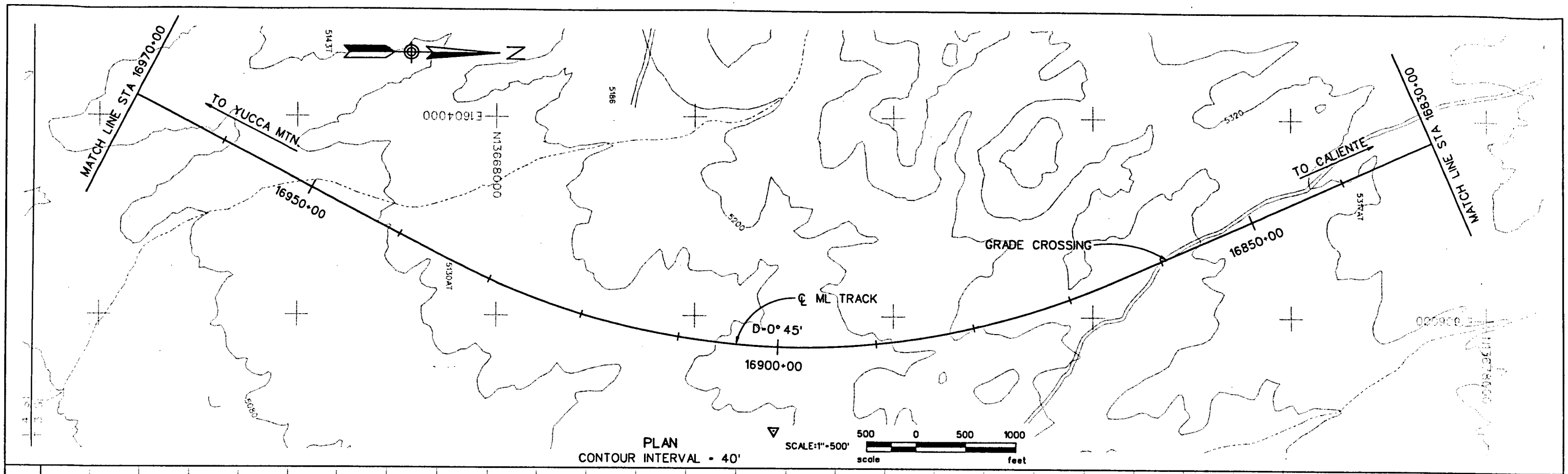
DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

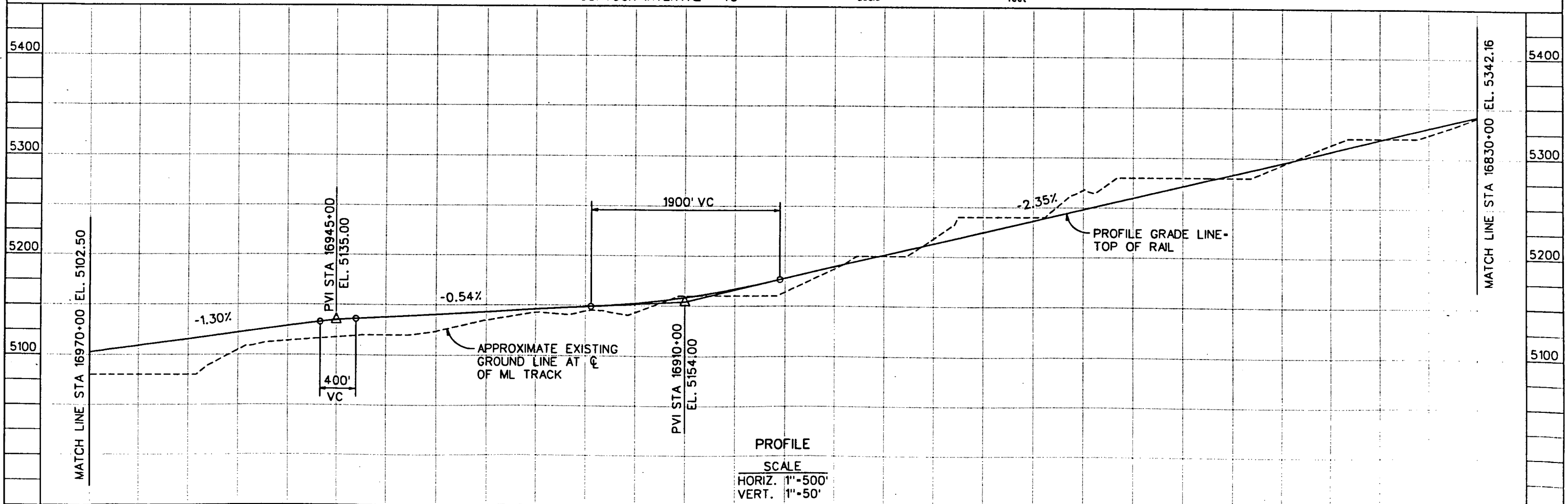
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 16700+00 - STA. 16830+00

SCALE: as noted
DRAWING NO: L91-043
SHEET NO:



PLAN
CONTOUR INTERVAL = 40'



PROFILE
SCALE
HORIZ. 1"=500'
VERT. 1"=50'

REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

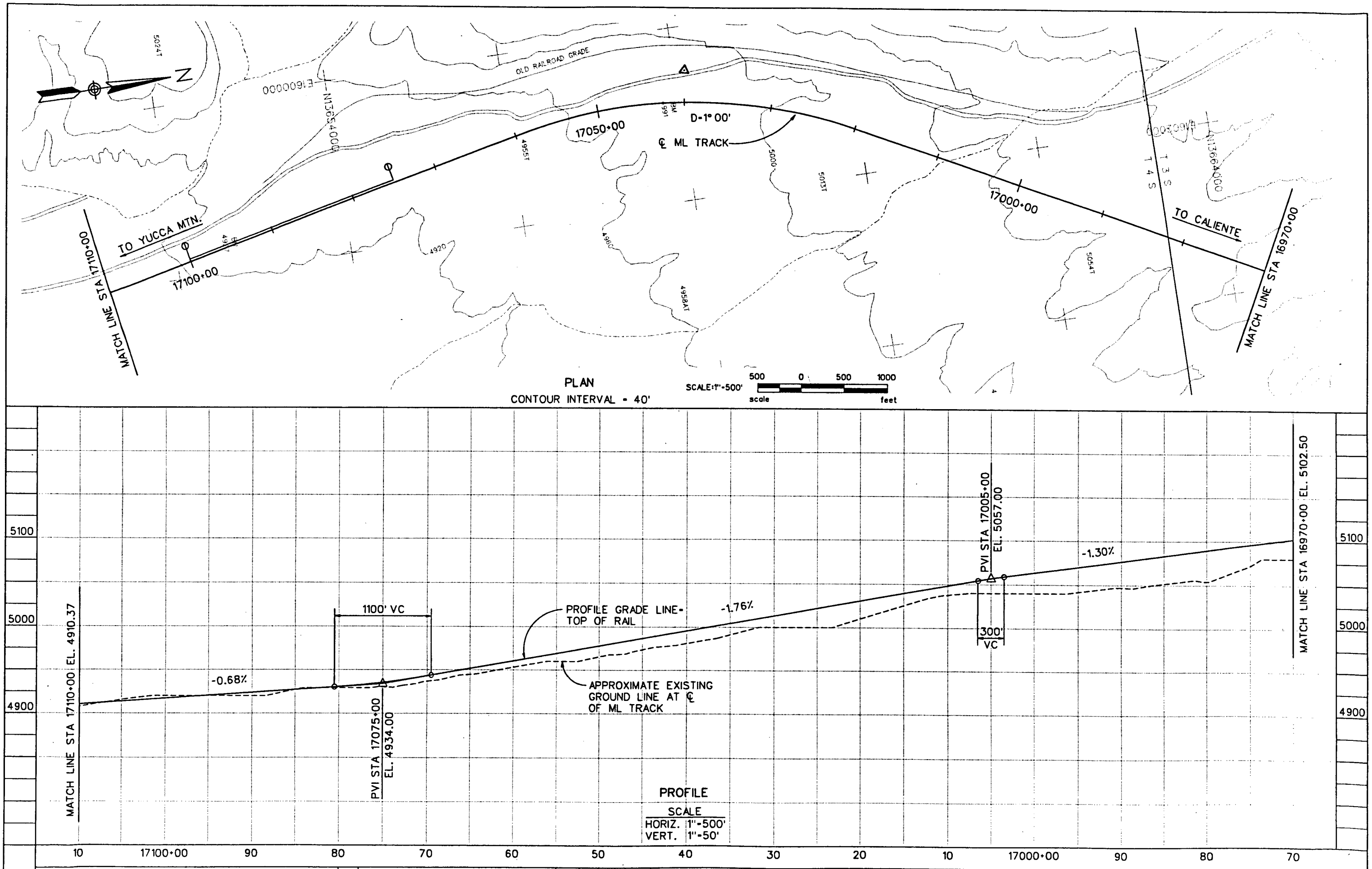
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 16830+00 - STA. 16970+00

SCALE as noted
DRAWING NO L91-044
SHEET NO 14 of 190

DATE PLOTTED 20-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

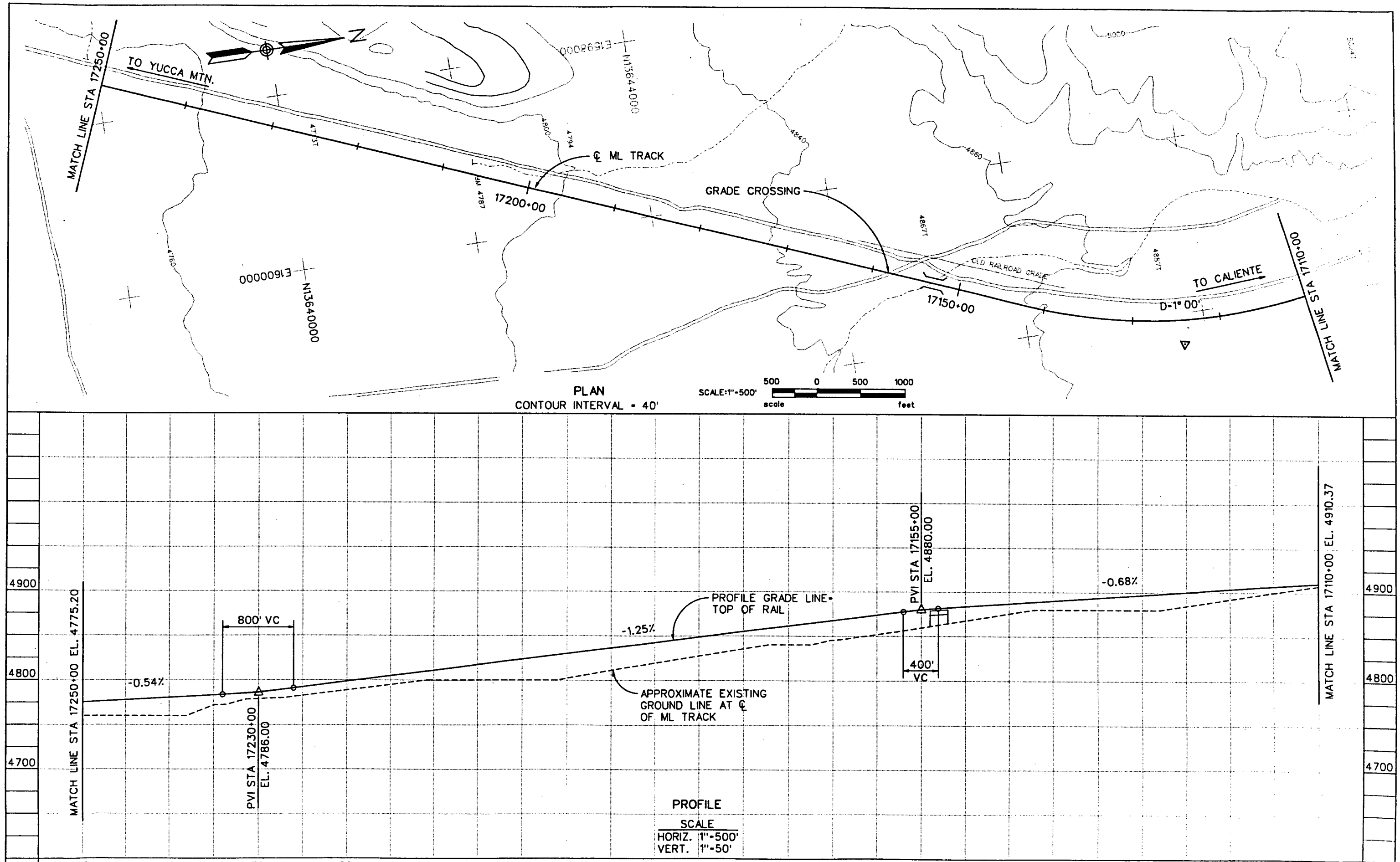
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE
PLAN & PROFILE
STA 16970+00 - STA. 17110+00

SCALE as noted
DRAWING NO L91-045
SHEET NO 147 of 192

DATE PLOTTED 20-FEB-1991



REV	DESCRIPTION	DATE	BY

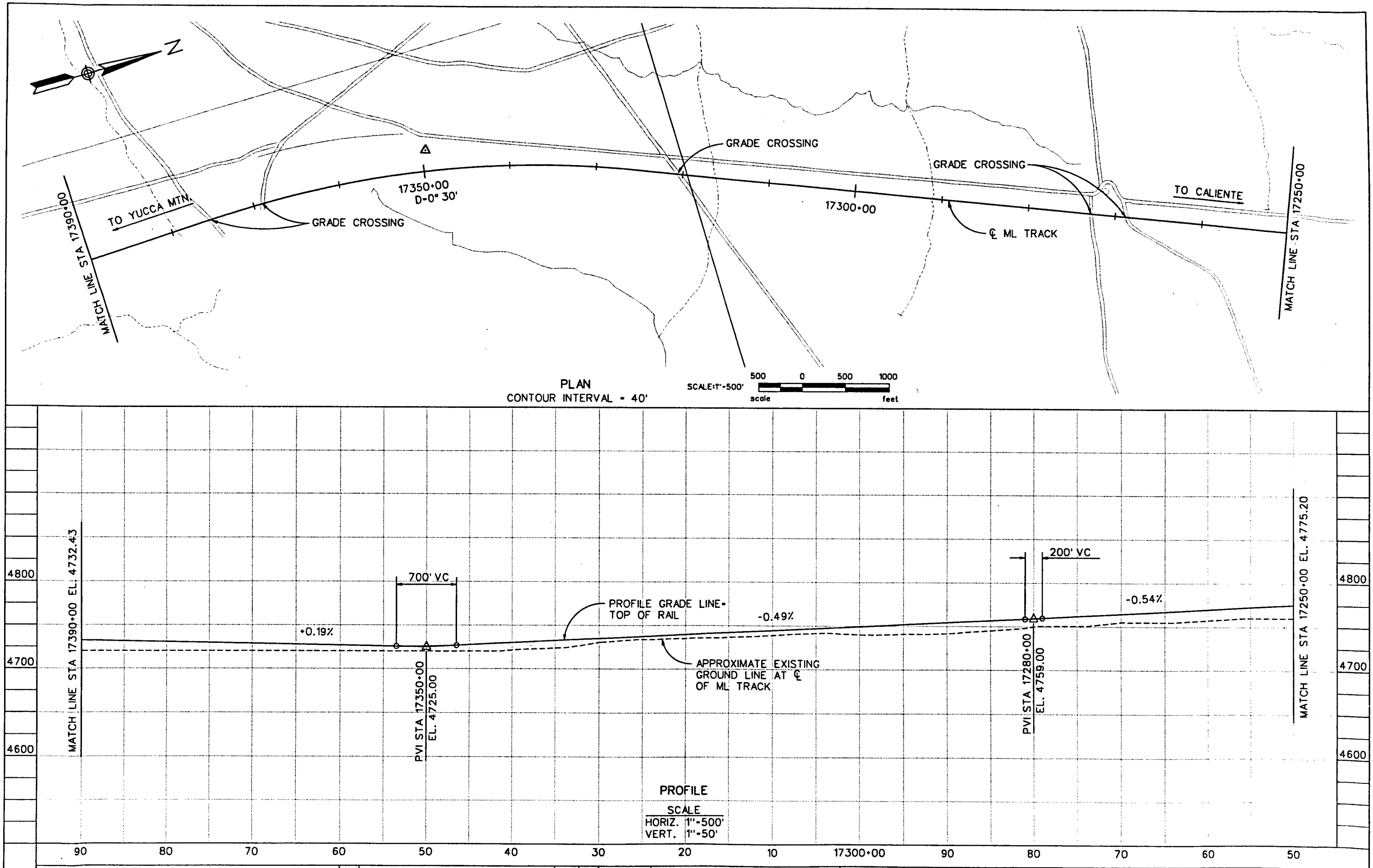
DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 17110+00 - STA. 17250+00

SCALE: as noted
DRAWING NO: L91-046
SHEET NO: 148 of 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY D. MOODY	2/91	DATE
REVIEWED	BY T. DANIEL	2/91	DATE
APPROVED	BY		DATE

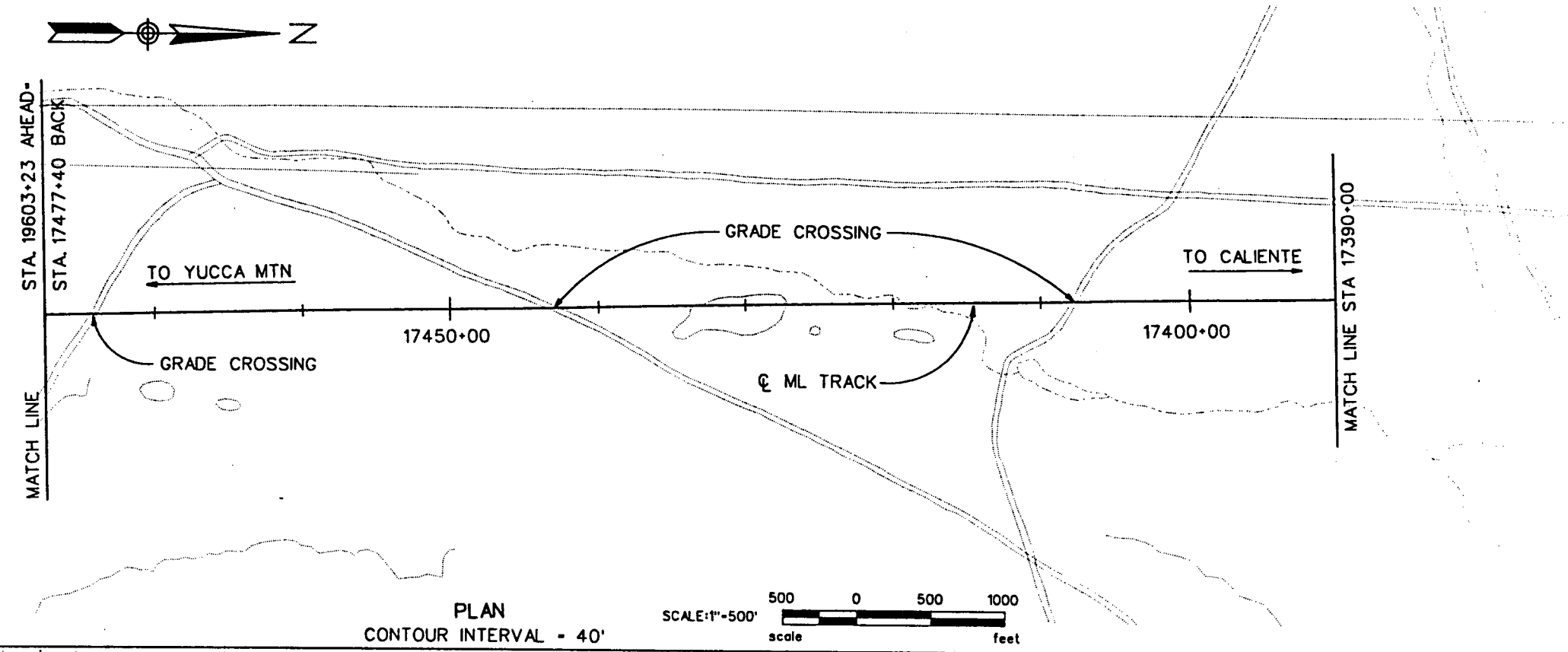
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 17250+00 - STA. 17390+00

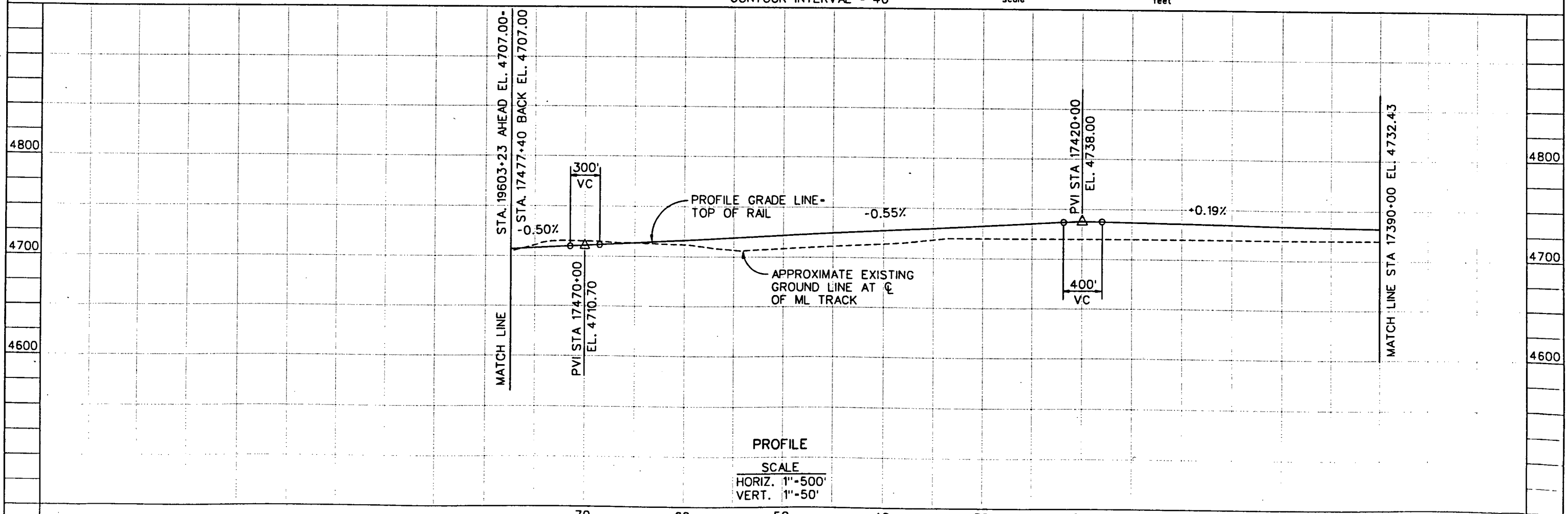
SCALE as noted
DRAWING NO L91-047
SHEET NO 149 of 190

DATE PLOTTED 20-FEB-1991



PLAN
CONTOUR INTERVAL = 40'

SCALE: 1"=500'
500 0 500 1000
scale feet



PROFILE

SCALE
HORIZ. 1"=500'
VERT. 1"=50'

REV	DESCRIPTION	DATE	BY

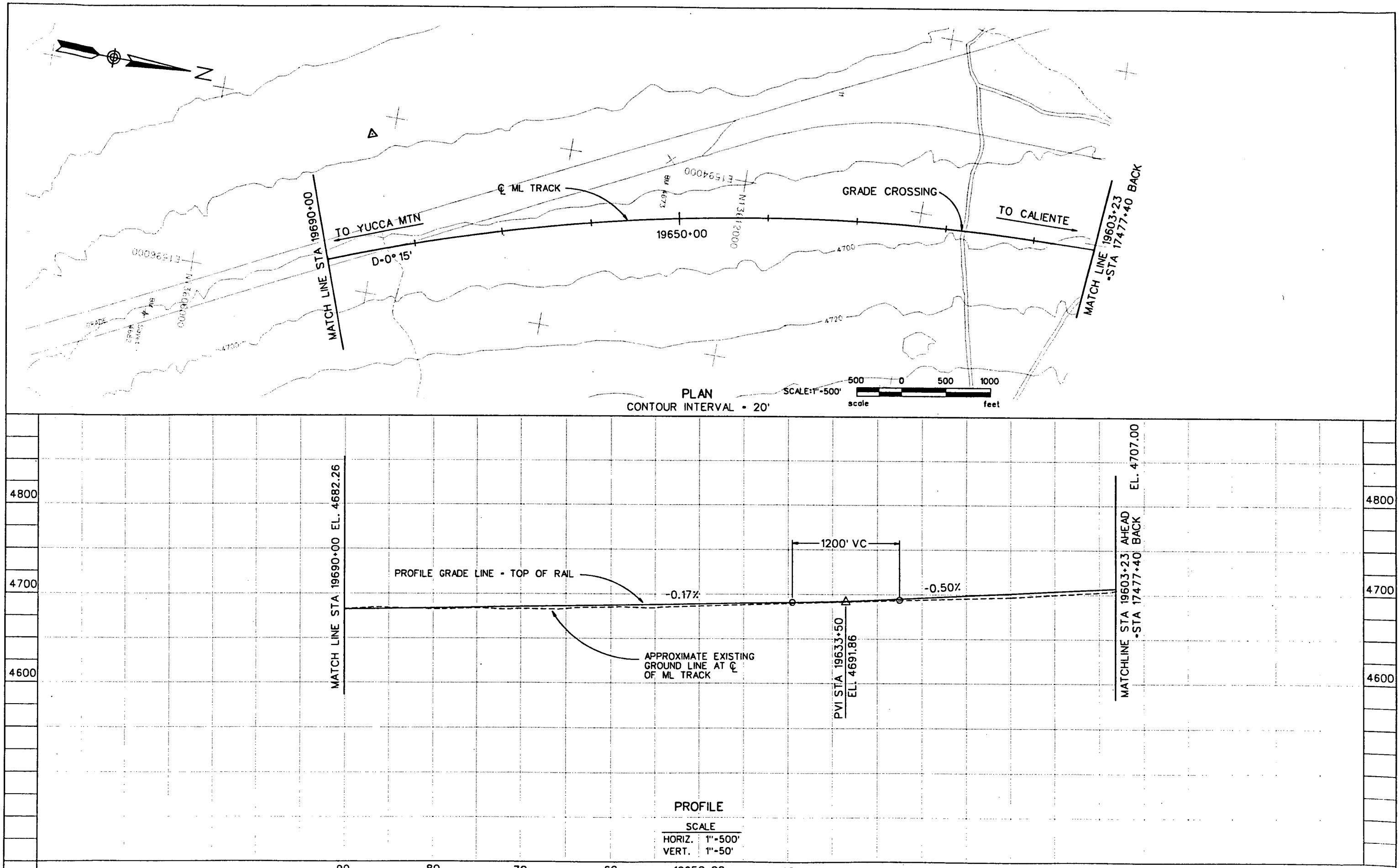
	BY	DATE
DESIGNED	D. MOODY	2/91
REVIEWED	T. DANIEL	2/91
APPROVED		

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 17390+00 - STA. 17477+40

SCALE: as noted
DRAWING NO: L91-048
SHEET NO: 150 of 190



REV	DESCRIPTION	DATE	BY

	BY		DATE
DESIGNED	K.MACDONALD	1/91	
REVIEWED	J.SELIN	2/91	
APPROVED			

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

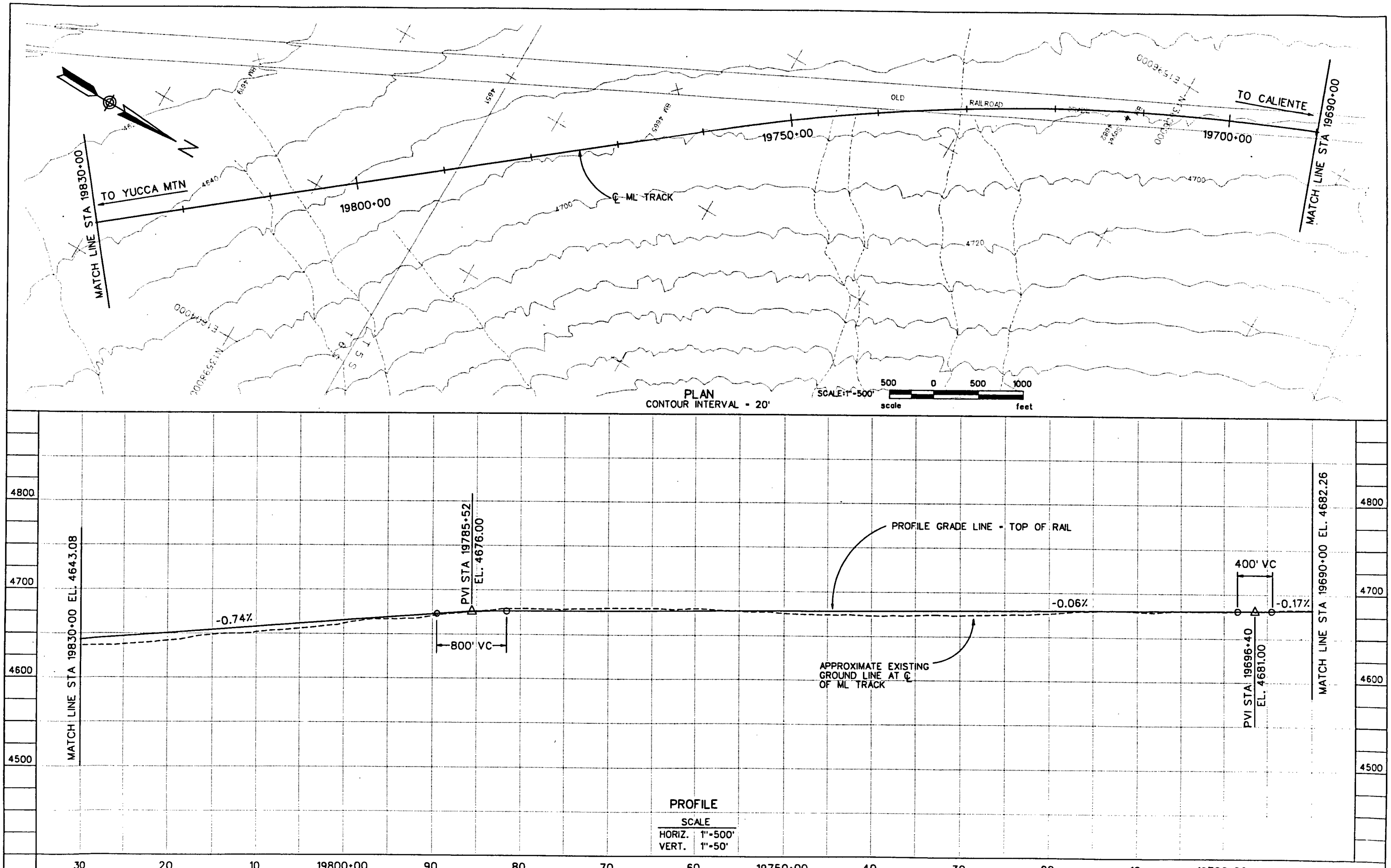
CALIENTE ROUTE PLAN & PROFILE

STA. 19603+23 - STA. 19690+00

SCALE: as noted

DRAWING NO: L02-001

SHEET NO: 151 of 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K.MACDONALD	1/91	DATE
REVIEWED	BY J.SELIN	2/91	DATE
APPROVED	BY		DATE

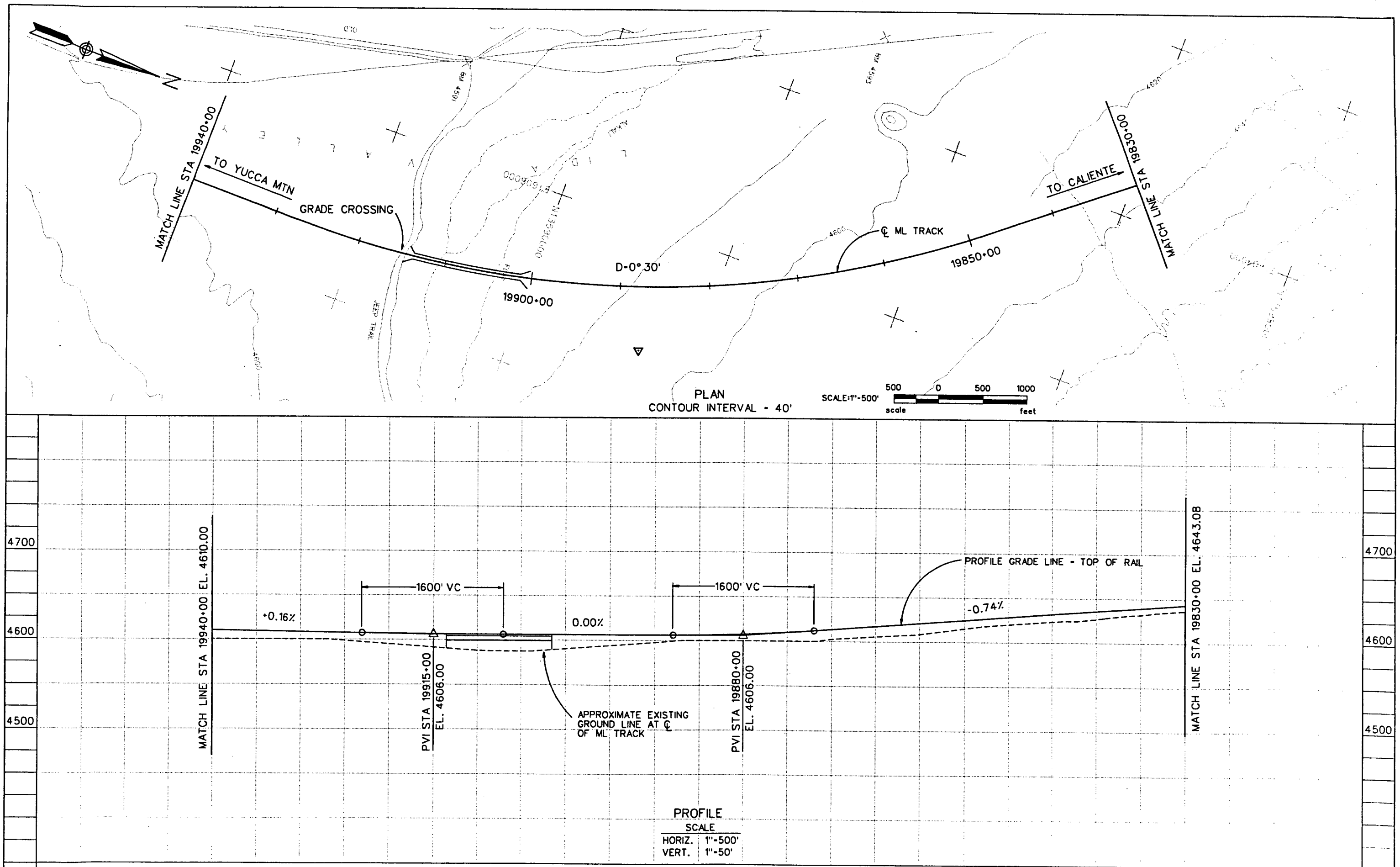
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 19690+00 - STA. 19830+00

SCALE as noted
DRAWING NO L02-002
SHEET NO 152 of 19

DATE PLOTTED 18-FEB-1991



REV	DESCRIPTION	DATE	BY

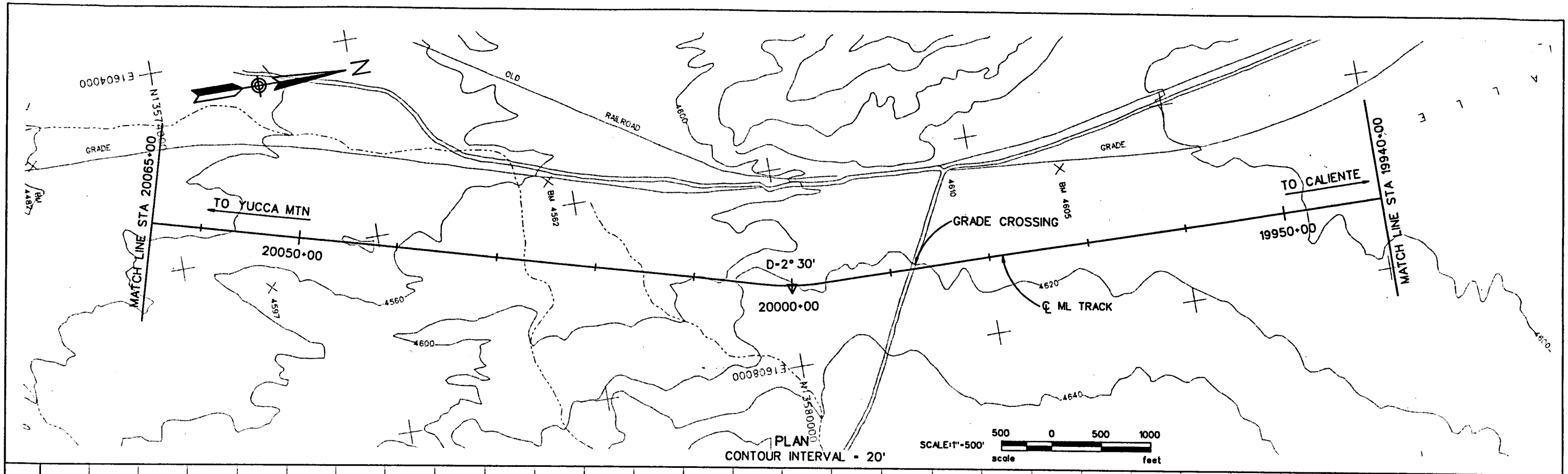
DESIGNED	BY K.MACDONALD	1/91	DATE
REVIEWED	BY J.SELIN	2/91	DATE
APPROVED	BY		DATE

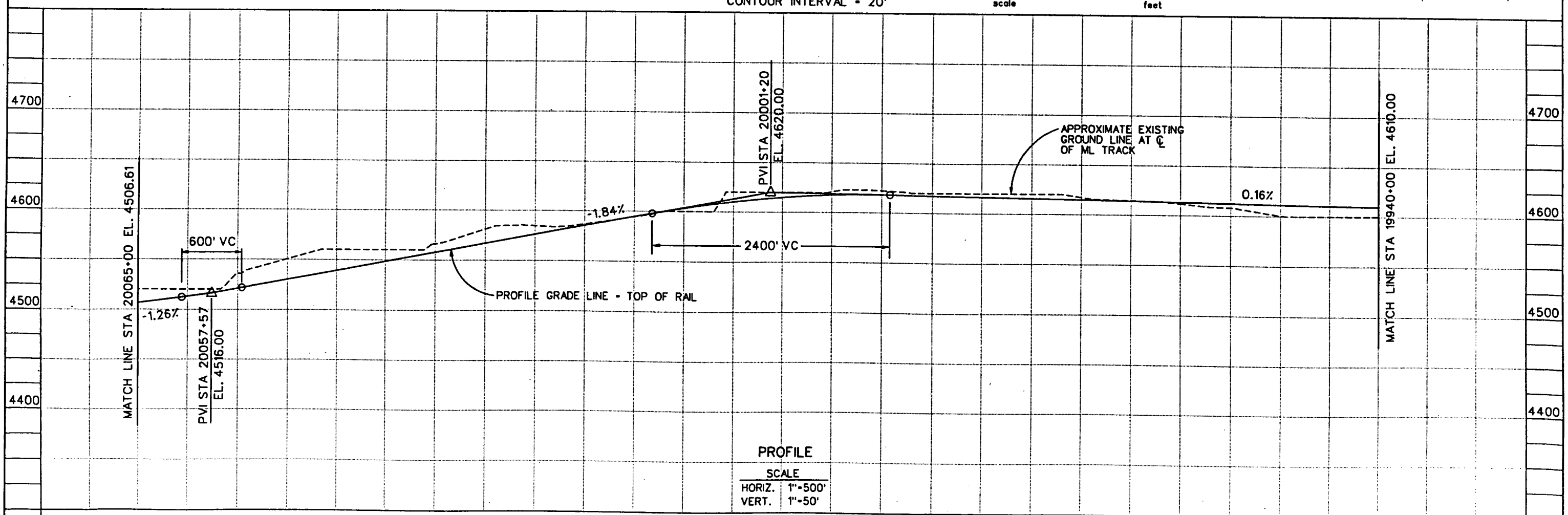
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 19830+00 - STA. 19940+00

SCALE as noted
DRAWING NO L02-013
SHEET NO 153 OF 197





REV	DESCRIPTION	DATE	BY

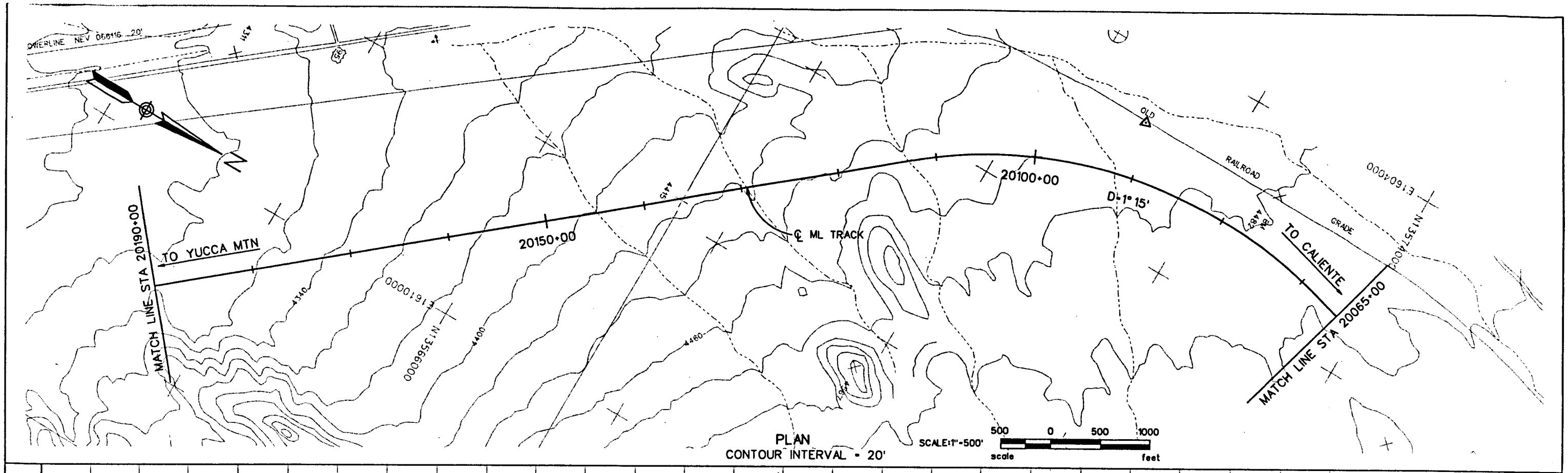
DESIGNED	BY K.MACDONALD	1/91	DATE
REVIEWED	BY J.SELIN	2/91	DATE
APPROVED	BY		DATE

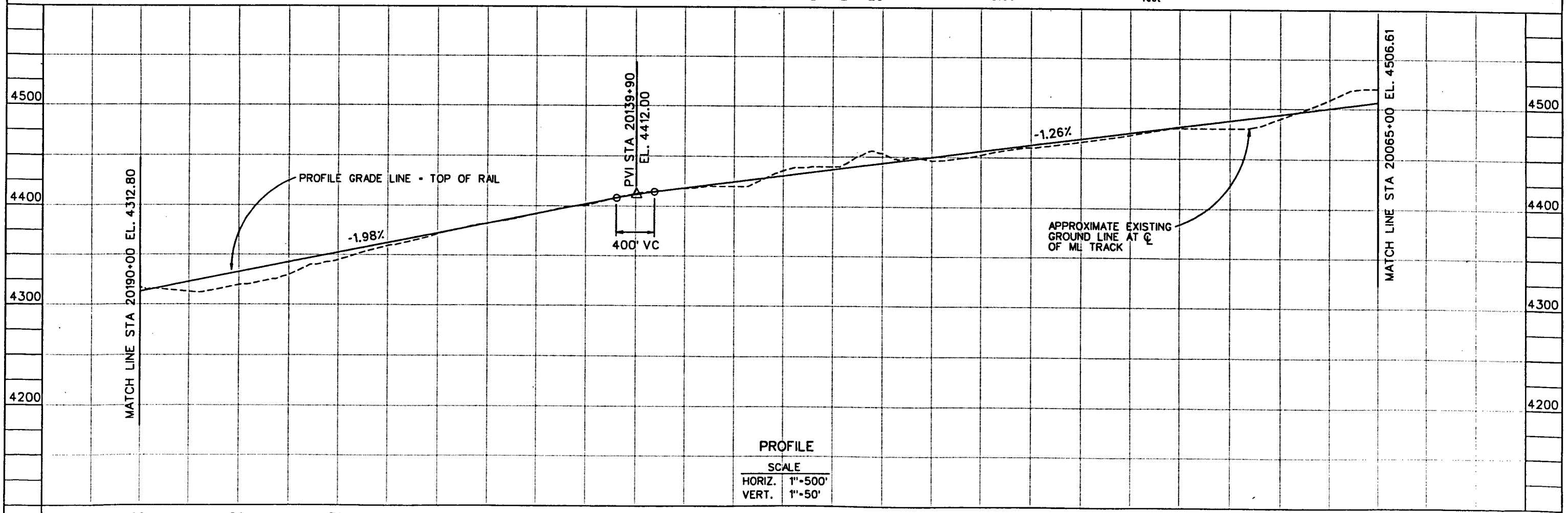
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 19940+00 - 20065+00

SCALE as noted
DRAWING NO. L02-004
SHEET NO. 154 OF 190





REV	DESCRIPTION	DATE	BY

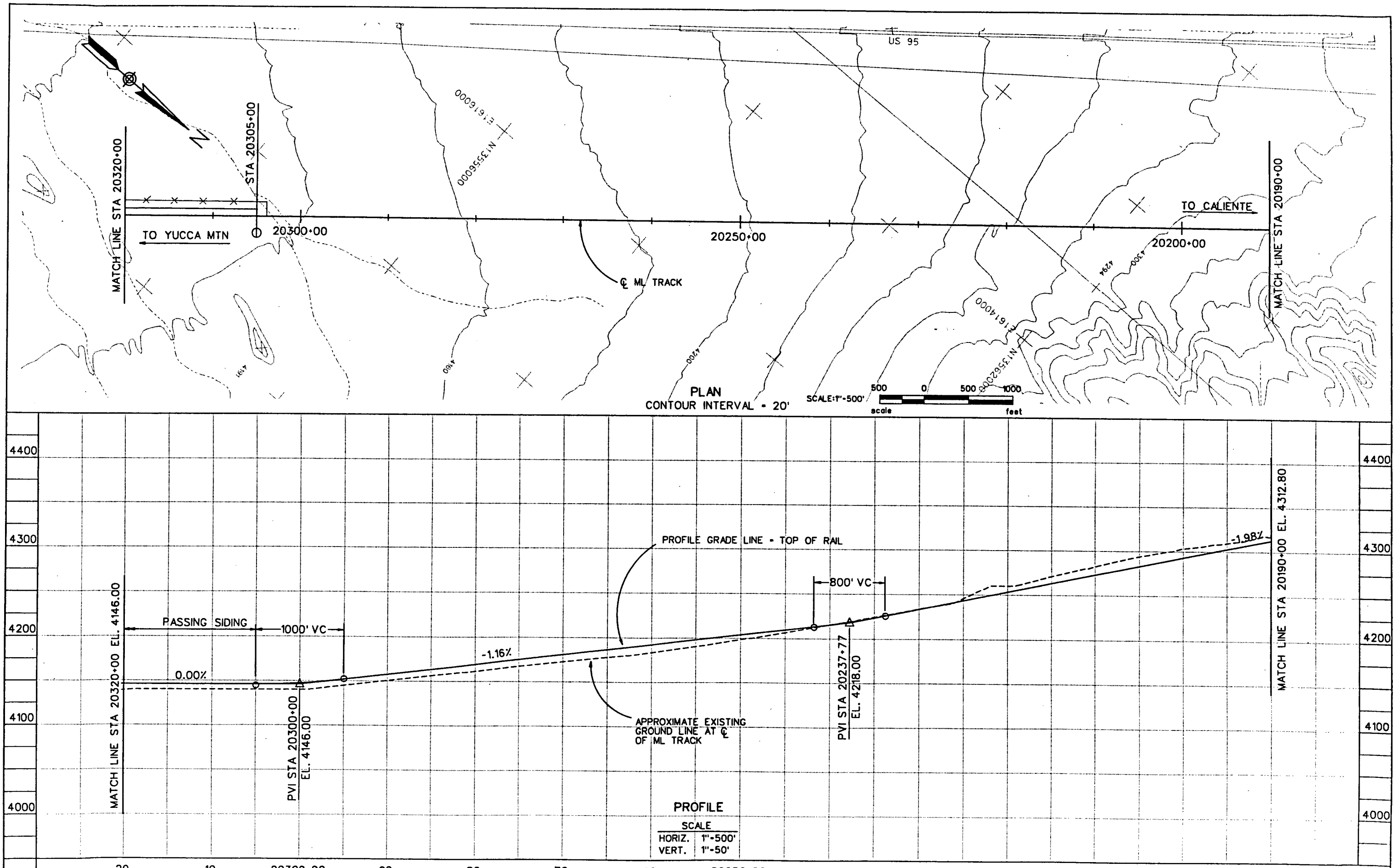
	BY	DATE
DESIGNED	K.MACDONALD	1/91
REVIEWED	J.SELIN	2/91
APPROVED		

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 20065+00 - 20190+00

SCALE: as noted
DRAWING NO. L02-005
SHEET NO. 155 OF 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K.MACDONALD	1/91	DATE
REVIEWED	BY J.SELIN	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

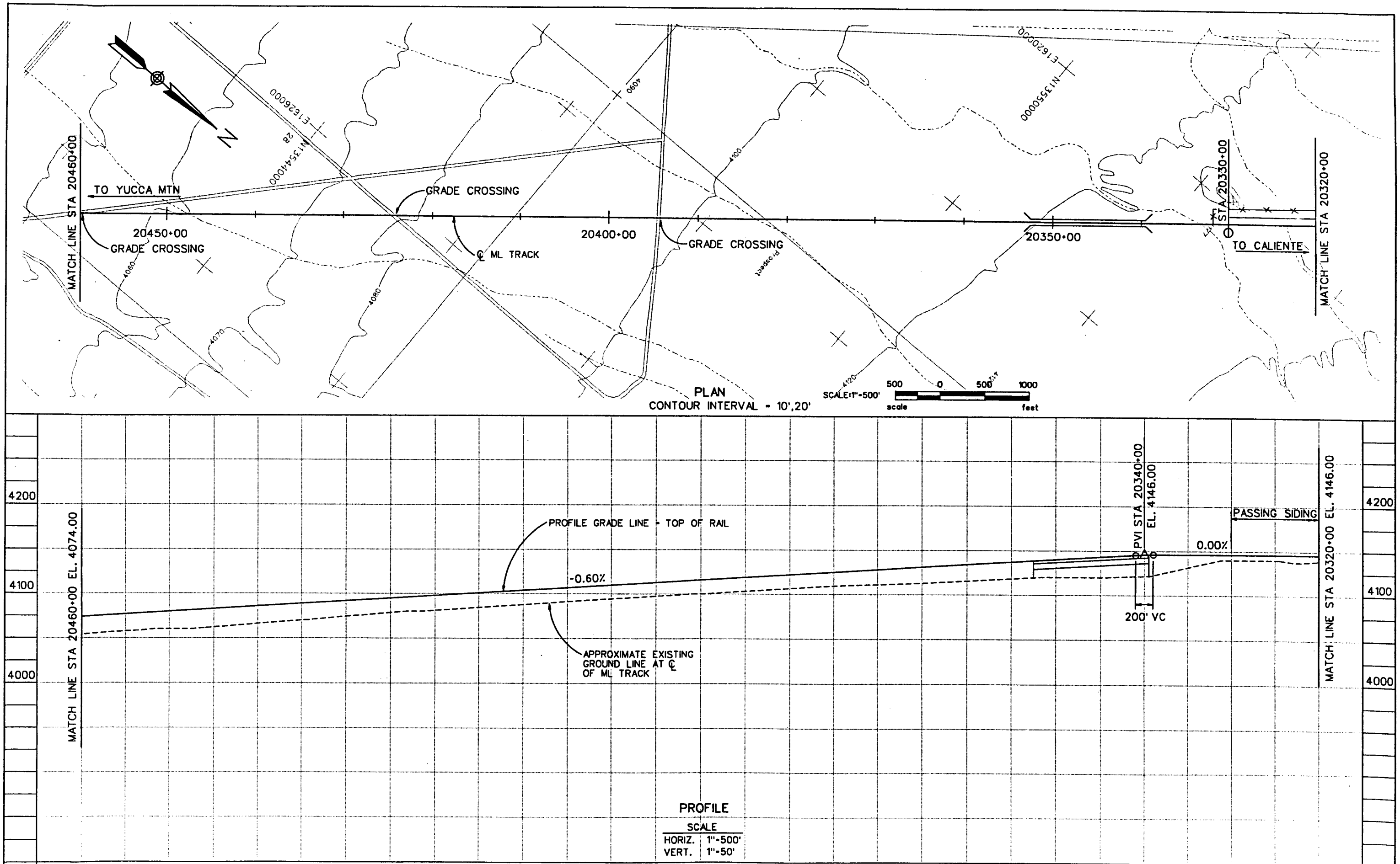
CALIENTE ROUTE PLAN & PROFILE

STA. 20190+00 - 20320+00

SCALE: as noted

DRAWING NO. L02-006

SHEET NO. 156 OF 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K.MACDONALD	1/91	DATE
REVIEWED	BY J.SELIN	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

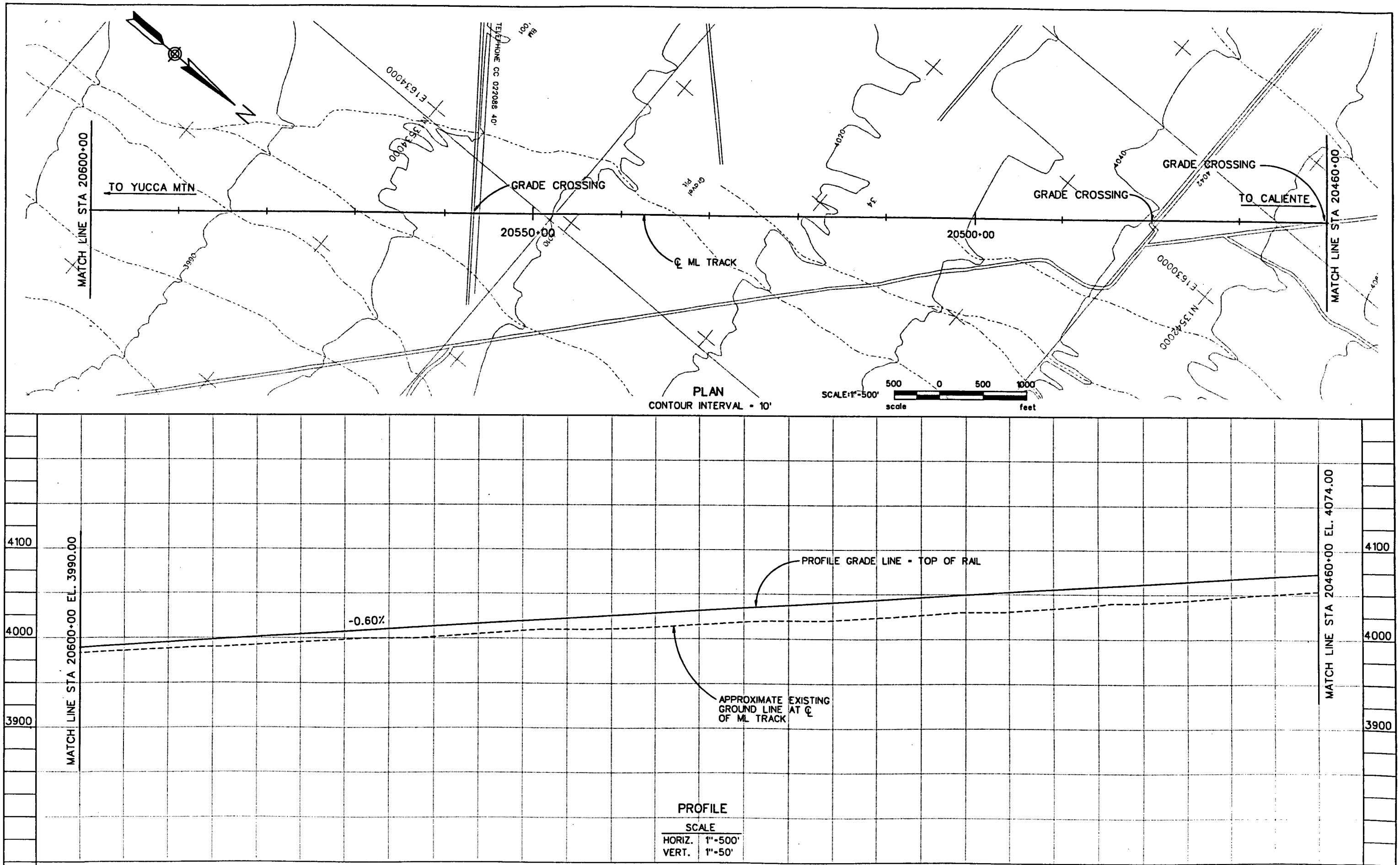
CALIENTE ROUTE PLAN & PROFILE

STA. 20320+00 - STA. 20460+00

SCALE: as noted

DRAWING NO: L02-007

SHEET NO.: 15 of 100



REV	DESCRIPTION	DATE	BY

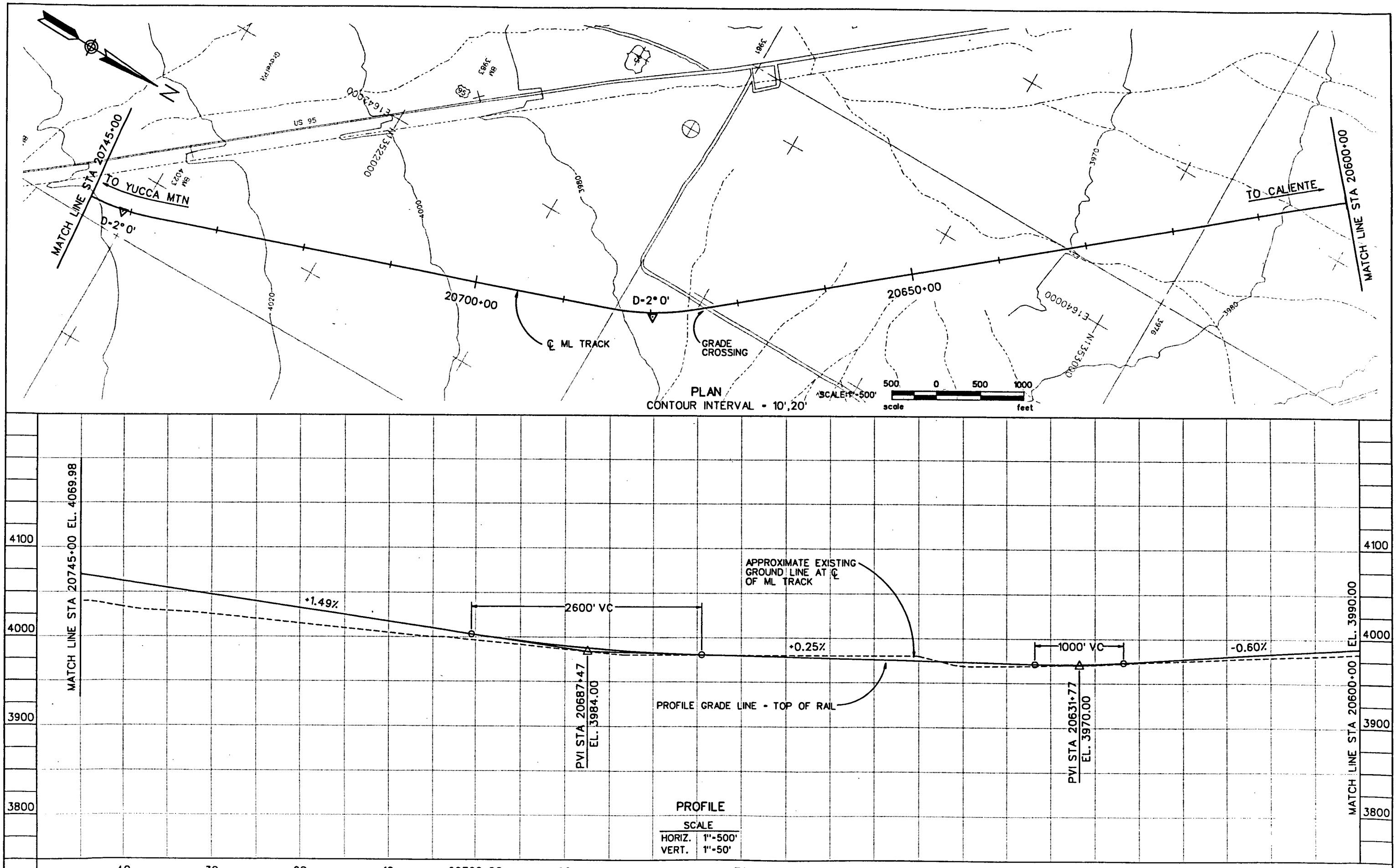
DESIGNED	BY K.MACDONALD	1/91	DATE
REVIEWED	BY J.SELIN	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA 20460+00 - STA 20600+00

SCALE as noted
DRAWING NO. L02-008
SHEET NO. 1 OF 1 OF 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K.MACDONALD	1/91	DATE
REVIEWED	BY J.SELIN	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

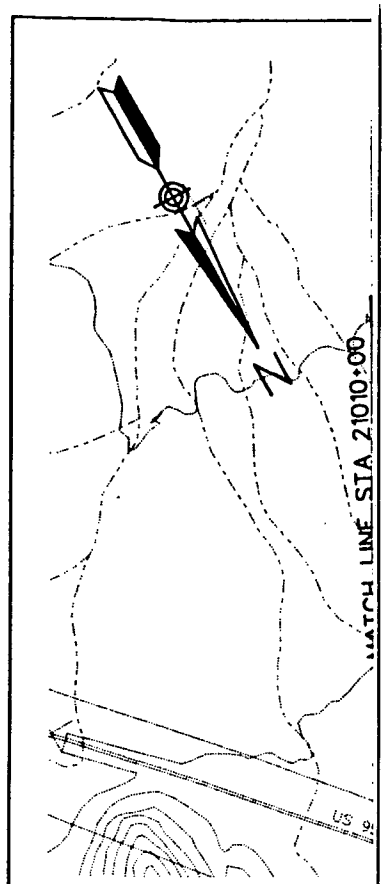
CALIENTE ROUTE PLAN & PROFILE

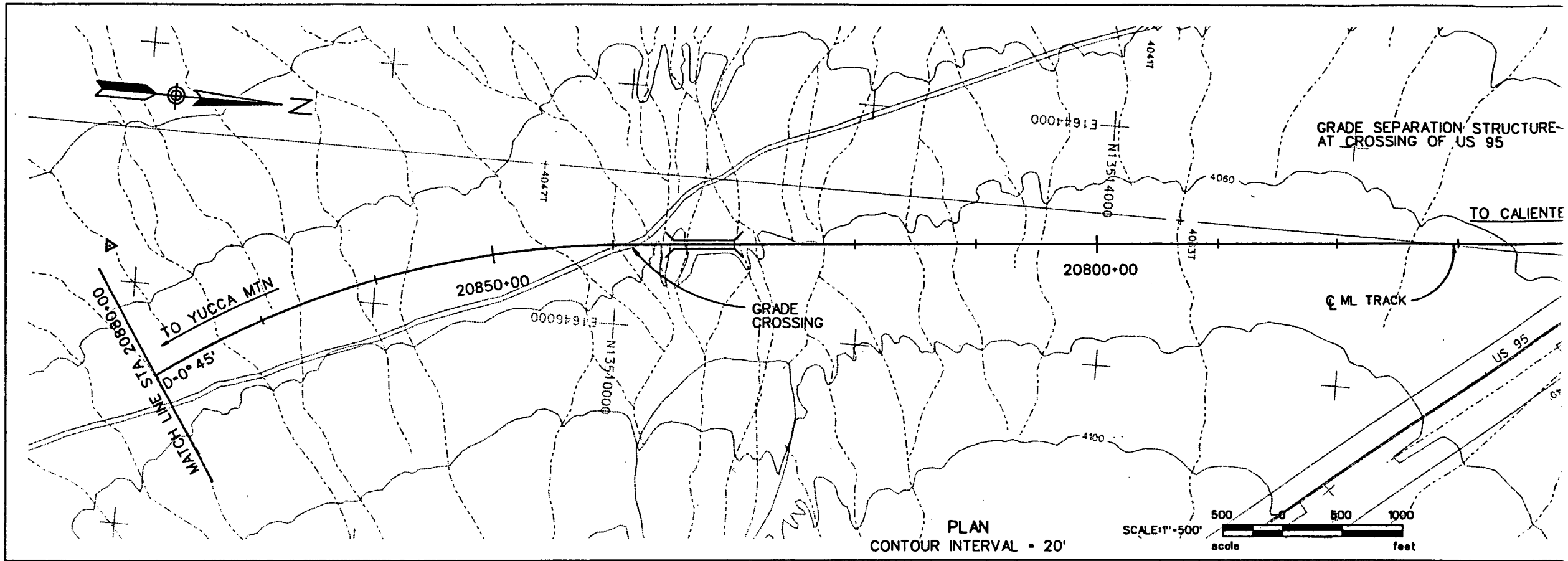
STA 20745+00 - STA 20600+00

SCALE: as noted

DRAWING NO. L02-009

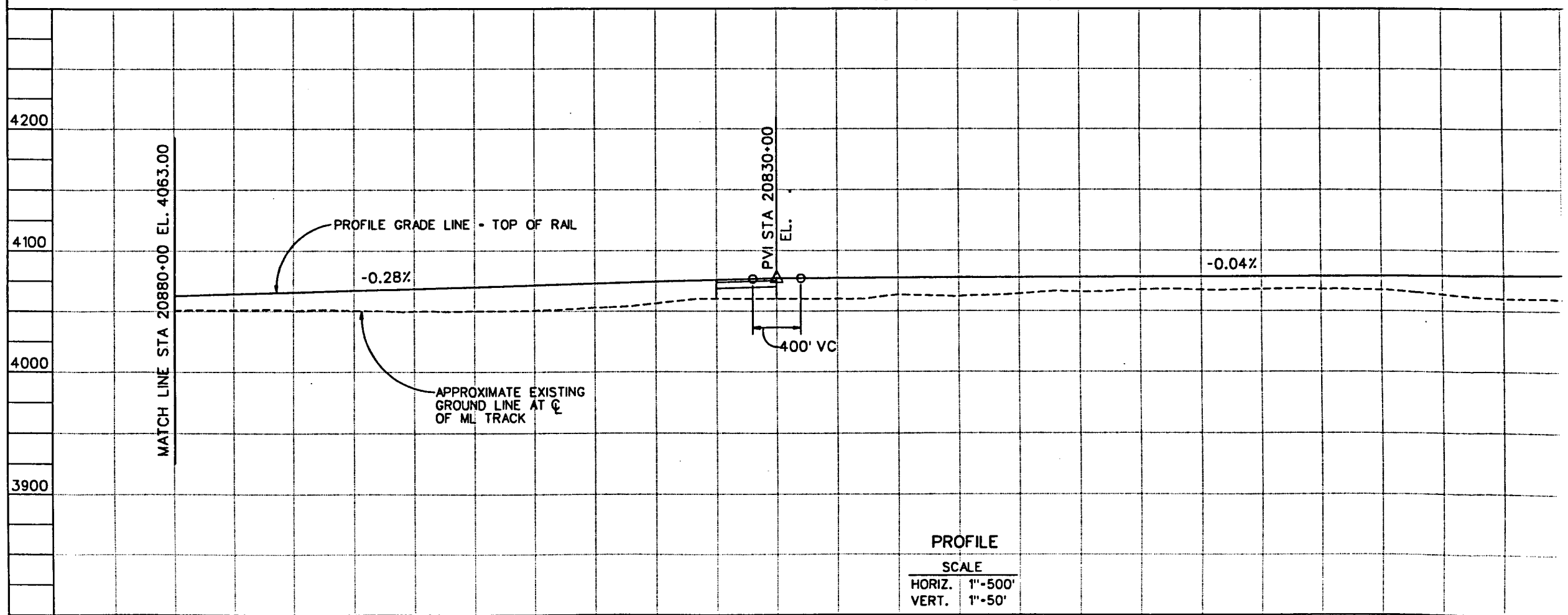
SHEET NO. 159 of 190





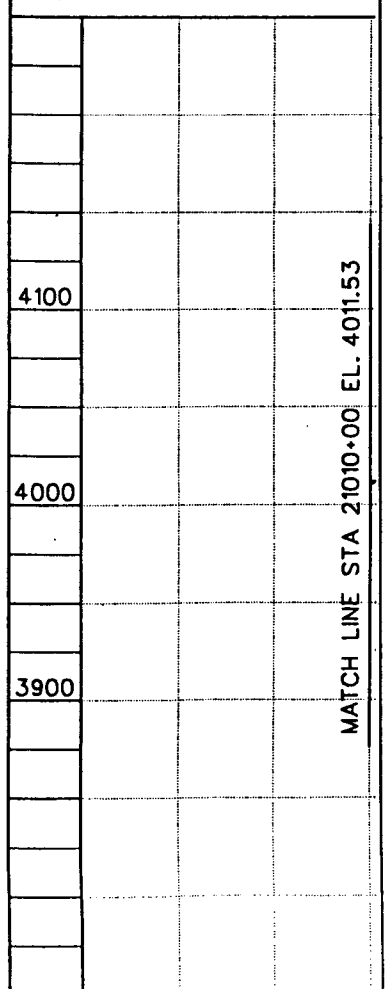
PLAN
CONTOUR INTERVAL - 20'

SCALE: 1"=500'
500 0 500 1000
scale feet



PROFILE

SCALE	
HORIZ.	1"=500'
VERT.	1"=50'



DATE PLOTTED 18-FEB-1991

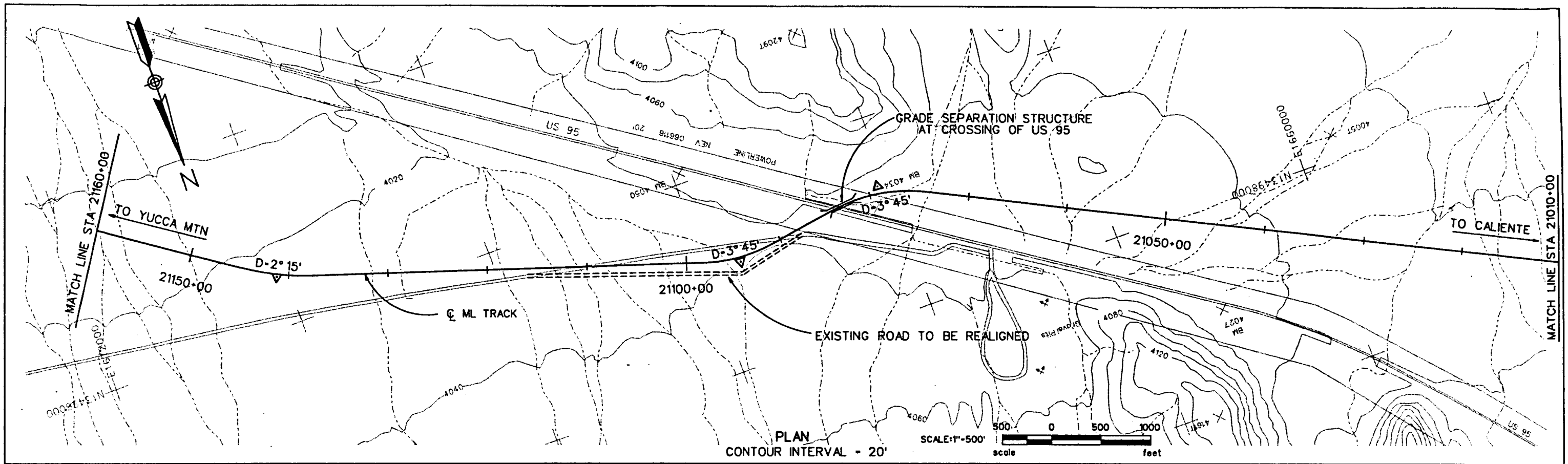
REV	DESCRIPTION	DATE	BY

	BY		DATE
DESIGNED	K.MACDONALD	1/91	
REVIEWED	J.SELIN	2/91	
APPROVED			

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCC



PLAN
CONTOUR INTERVAL - 20'

SCALE: 1"=500'
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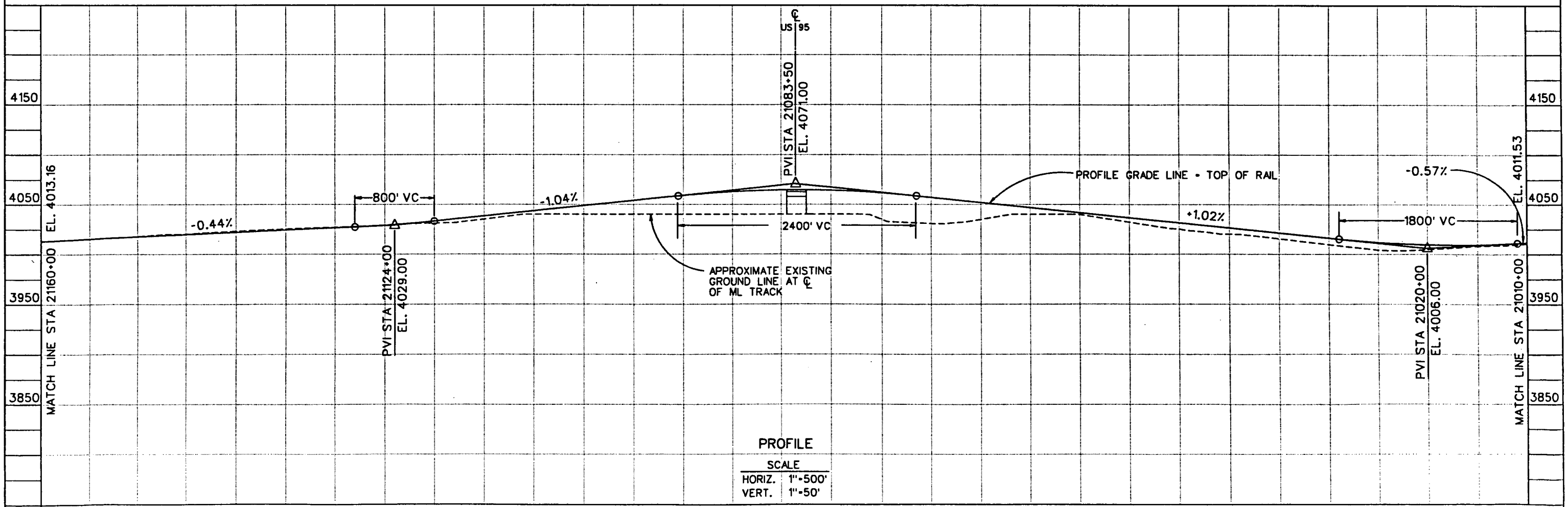
scale feet



PROFILE

SCALE	
HORIZ.	1"=500'
VERT.	1"=50'

REV	DESCRIPTION	DATE	BY

	BY		DATE
DESIGNED	K.MACDONALD	1/91	
REVIEWED	J.SELIN	2/91	
APPROVED			

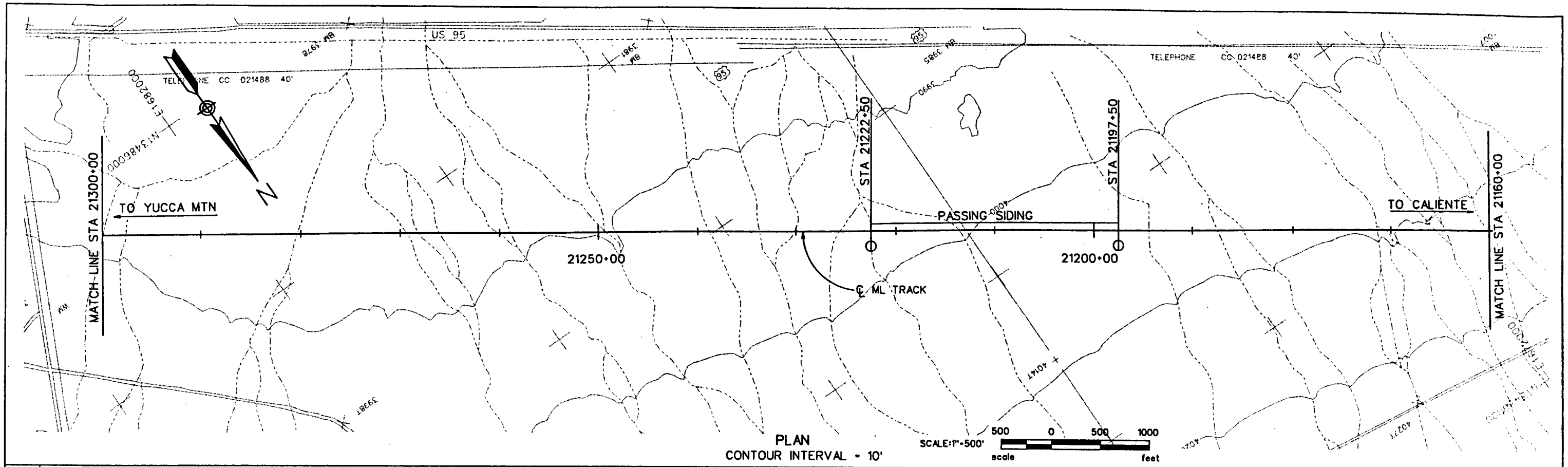
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

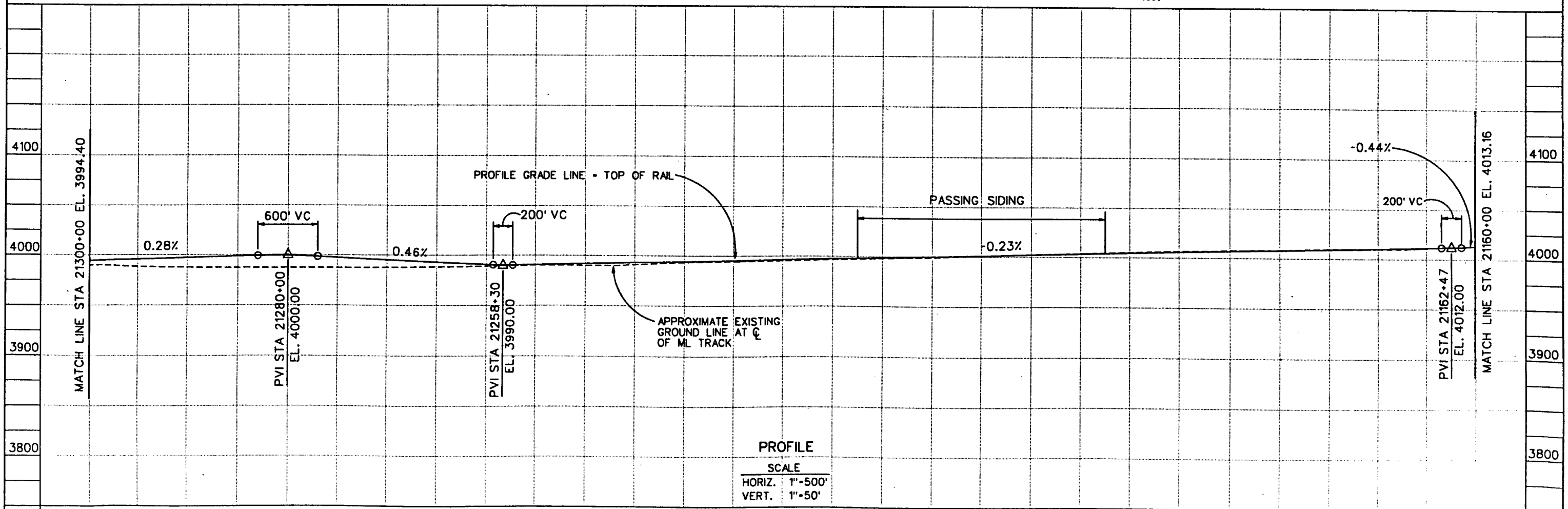
YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 21010+00 - STA. 21160+00

SCALE: as noted
DRAWING NO. L02-012
SHEET NO. 162 of 190

DATE PLOTTED 18-FEB-1991



PLAN
CONTOUR INTERVAL = 10'



PROFILE

SCALE	
HORIZ.	1"=500'
VERT.	1"=50'

REV	DESCRIPTION	DATE	BY

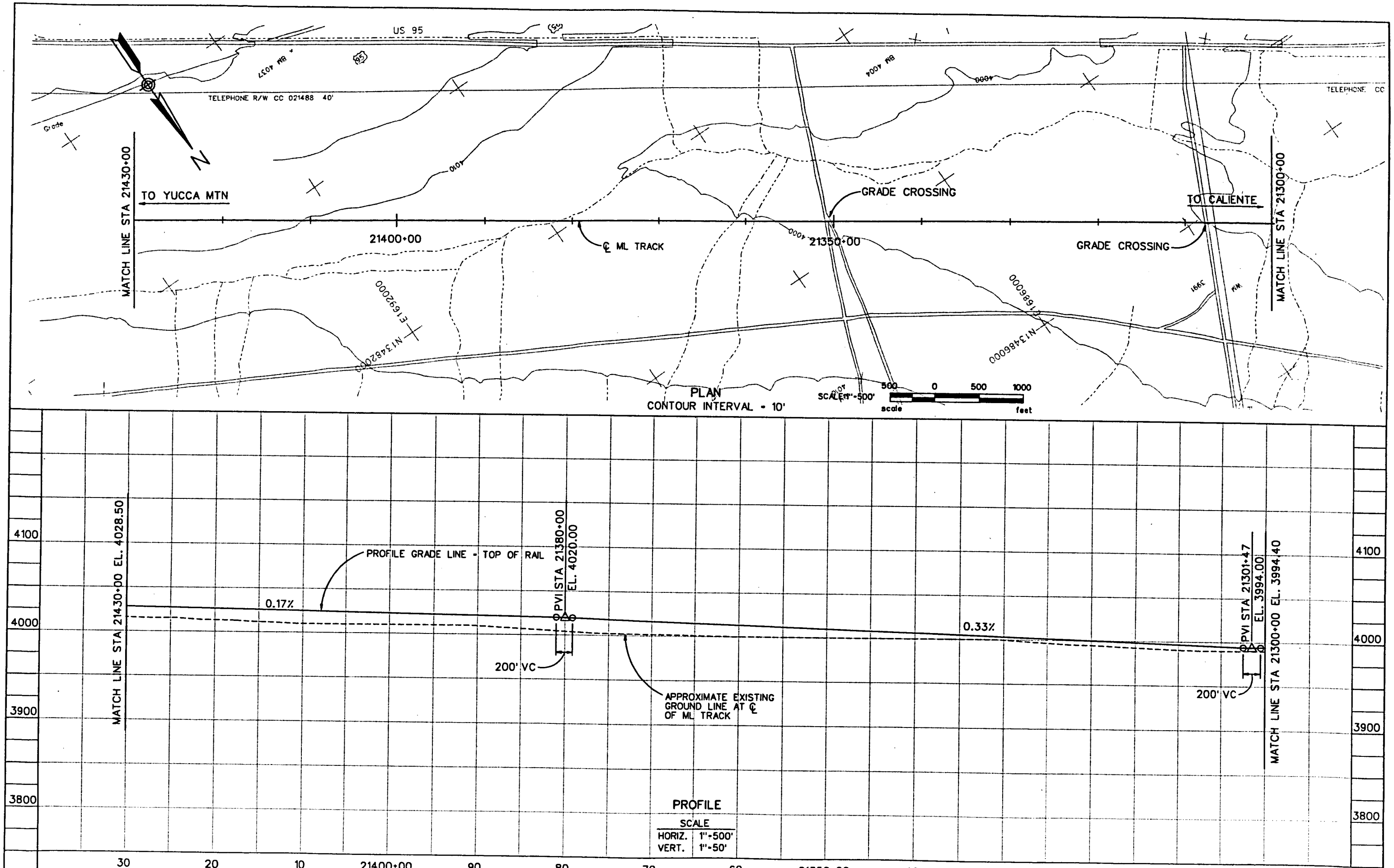
DESIGNED	BY K.MACDONALD	1/91	DATE
REVIEWED	BY J.SELIN	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 21160+00 - STA. 21300+00

SCALE as noted
DRAWING NO. L02-013
SHEET NO. 1 of 1



DATE PLOTTED 18-FEB-1991

REV	DESCRIPTION	DATE	BY

DESIGNED	BY K.MACDONALD	1/91	DATE
REVIEWED	BY J.SELIN	2/91	DATE
APPROVED	BY		DATE

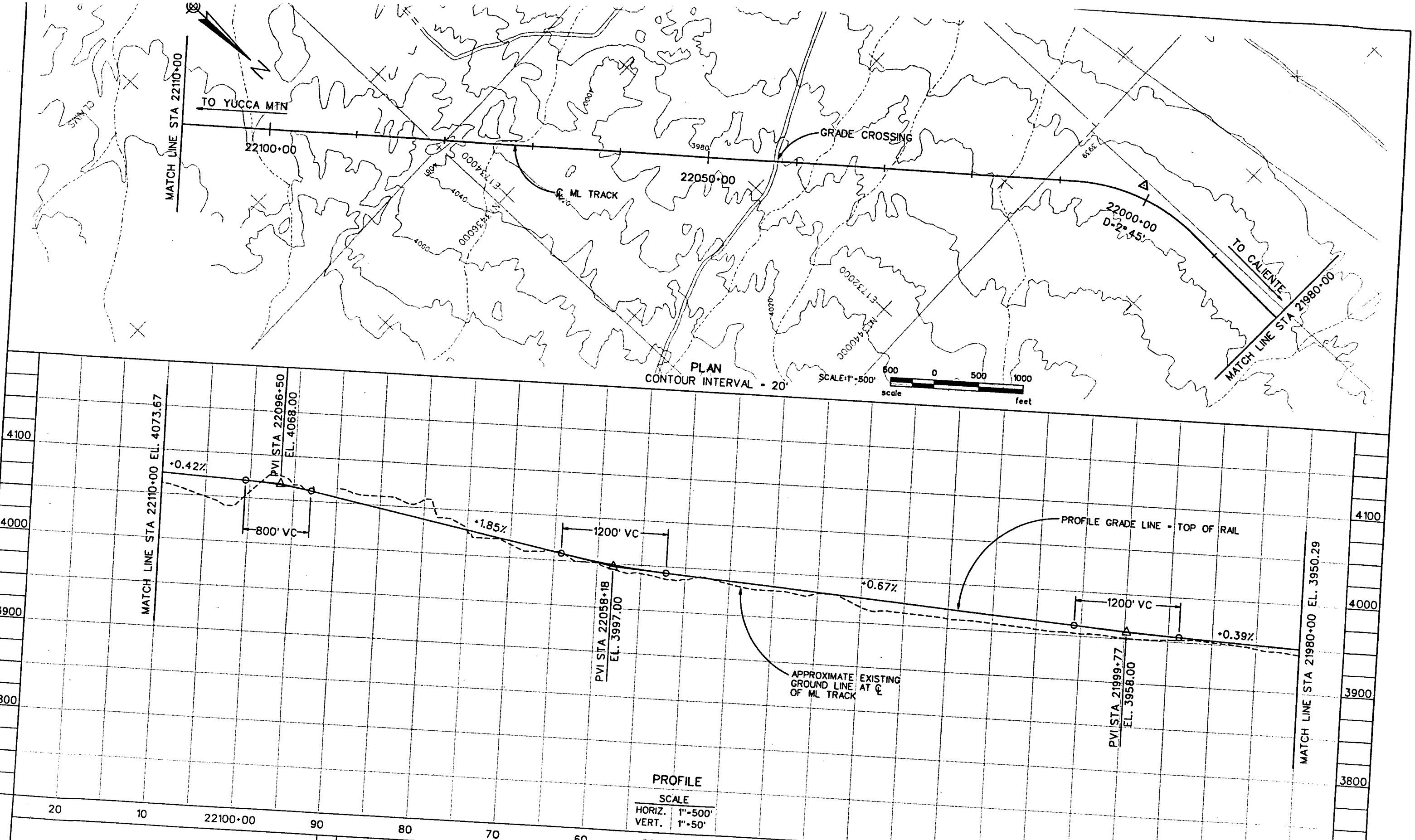
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE
PLAN & PROFILE
STA. 21300+00 - STA. 21430+00

SCALE as noted
DRAWING NO. L02-014
SHEET NO. 1 of 190



REV	DESCRIPTION	DATE	BY

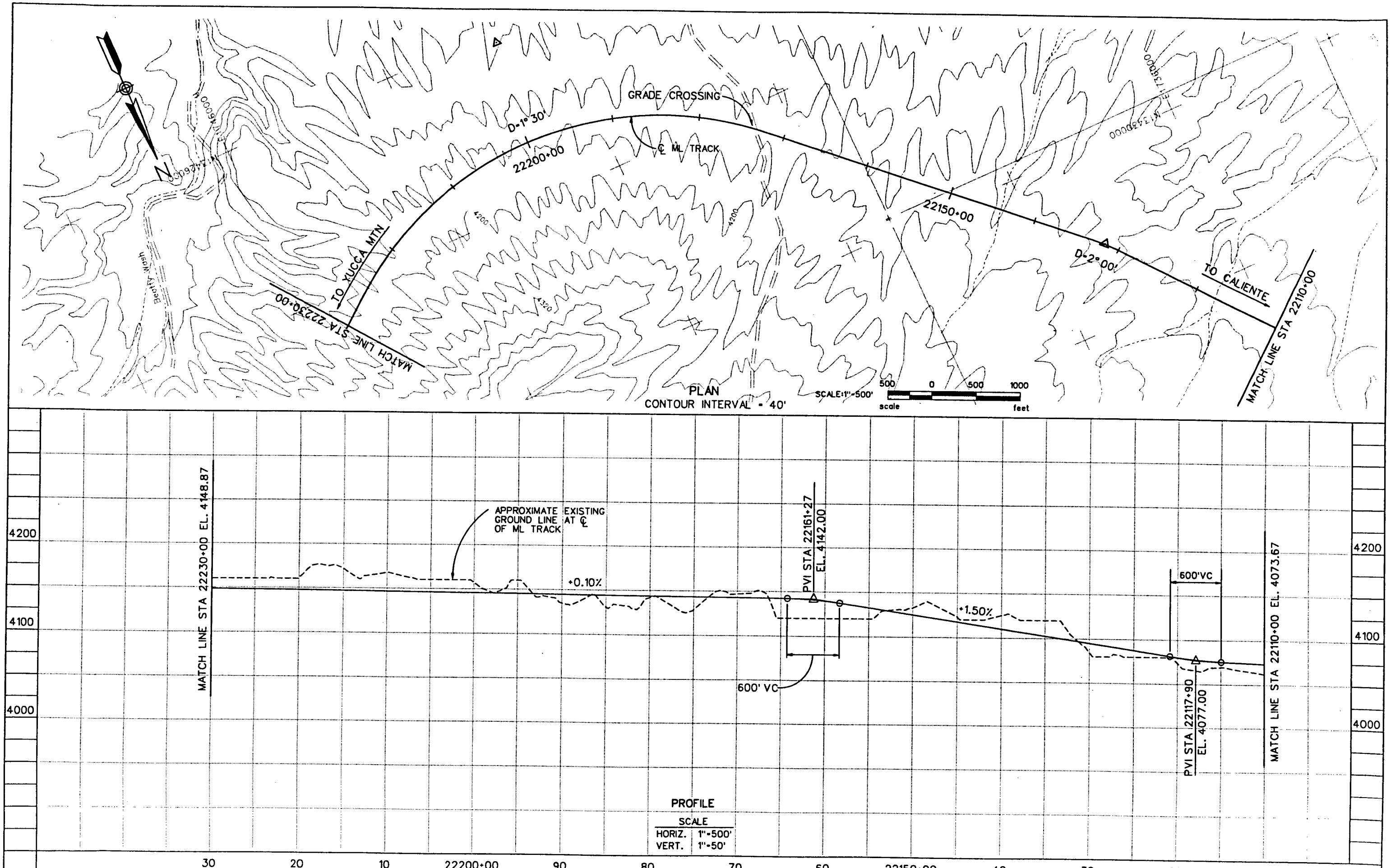
DESIGNED	BY K.MACDONALD	1/91	DATE
REVIEWED	BY J.SELIN	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 21980+00 - STA. 22110+00

SCALE as noted
DRAWING NO. L02-019
SHEET NO. 169 OF 190



REV	DESCRIPTION	DATE	BY

	BY		DATE
DESIGNED	K.MACDONALD	1/91	
REVIEWED	J.SELIN	2/91	
APPROVED			

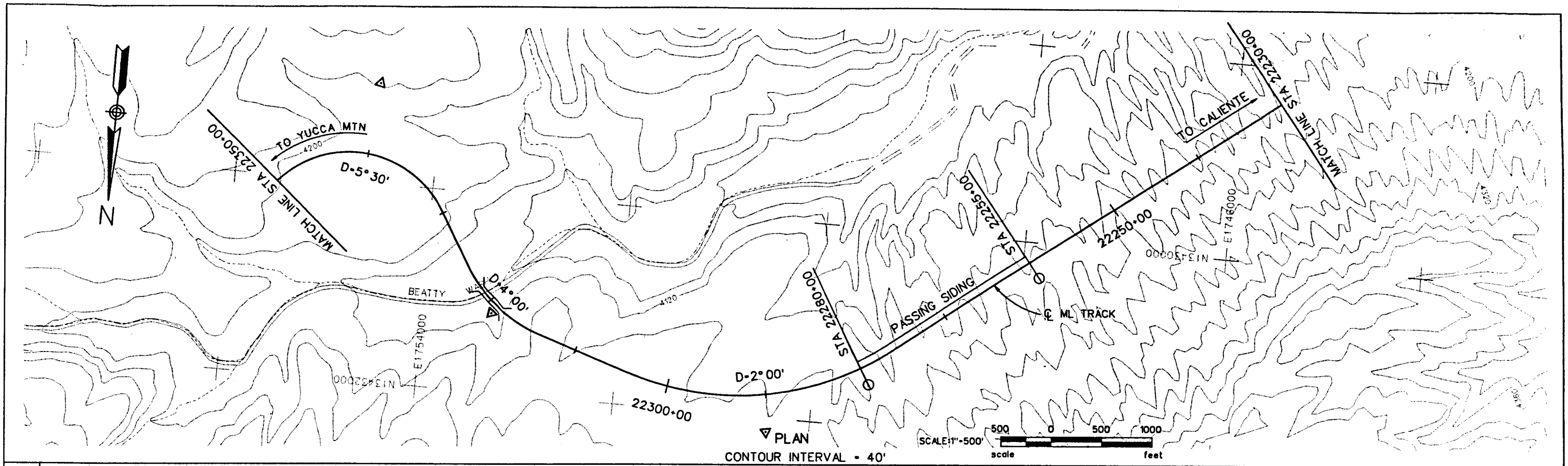
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

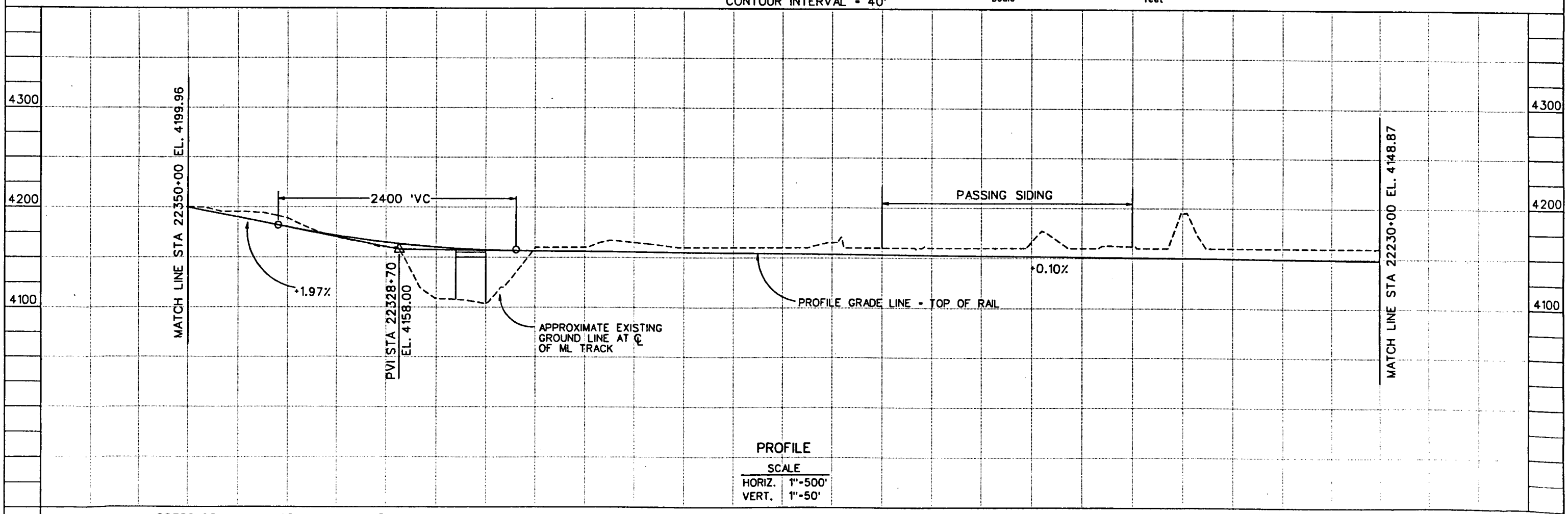
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE
PLAN & PROFILE
STA 22110+00 - STA 22230+00

SCALE: as noted
DRAWING NO: L02-020
SHEET NO:





REV	DESCRIPTION	DATE	BY

DESIGNED	BY K.MACDONALD	1/91	DATE
REVIEWED	BY J.SELIN	2/91	DATE
APPROVED	BY		DATE

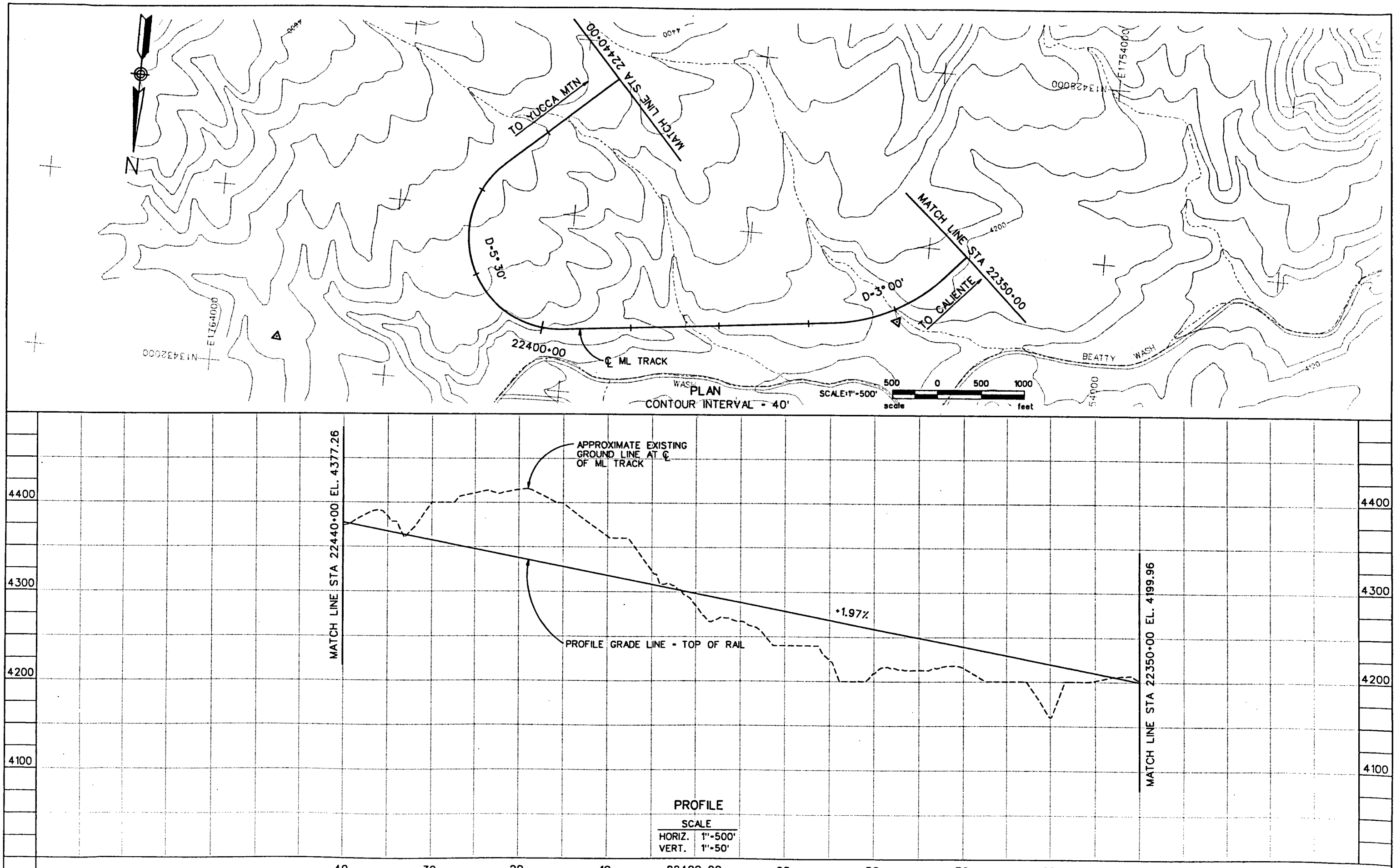
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE
PLAN & PROFILE
STA. 22230+00 - STA. 22350+00

SCALE as noted
DRAWING NO. L02-021
SHEET NO. 1 of 19



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K.MACDONALD	1/91	DATE
REVIEWED	BY J.SELIN	2/91	DATE
APPROVED	BY		DATE

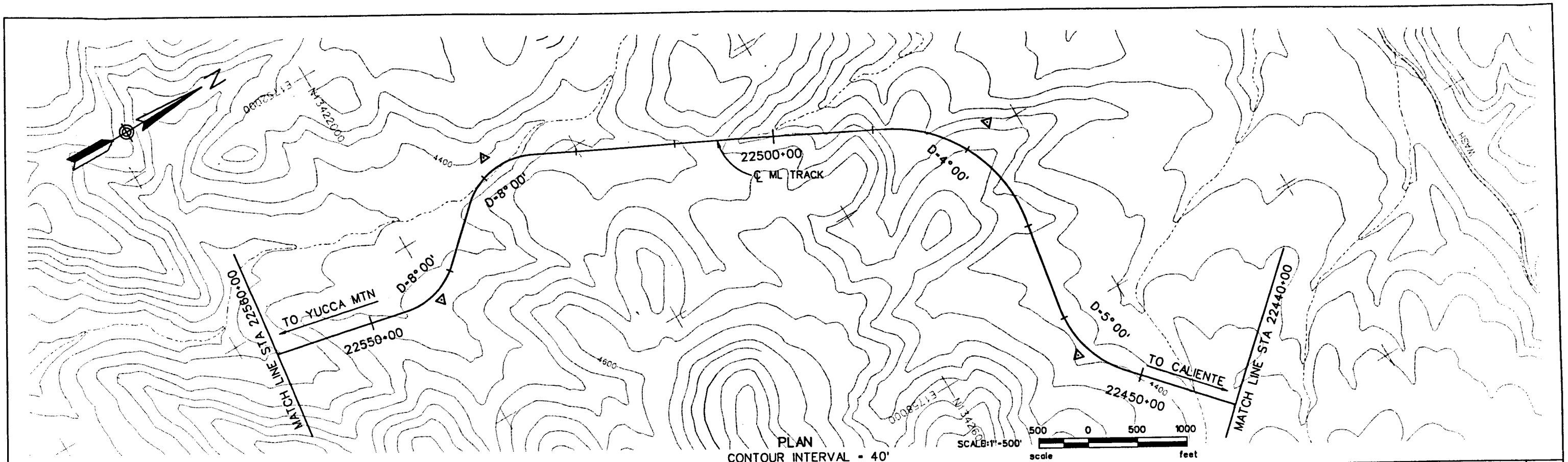
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

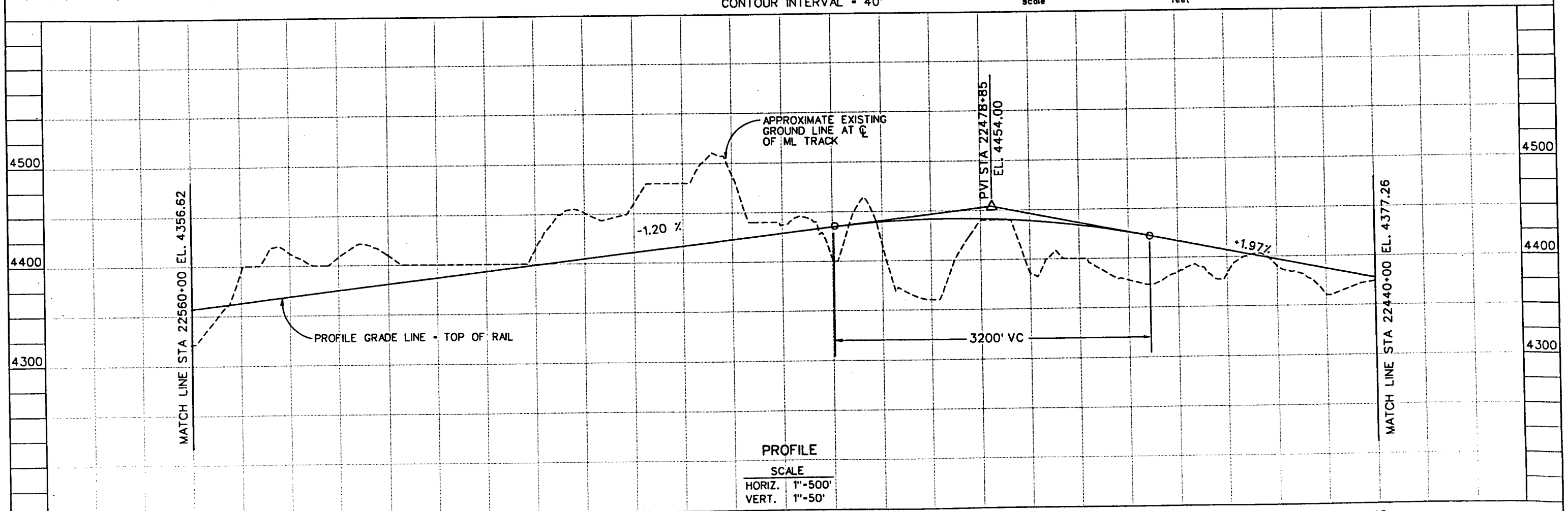
YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE
PLAN & PROFILE
STA 22350+00 - STA 22440+00

SCALE as noted
DRAWING NO. L02-022
SHEET NO.



PLAN
CONTOUR INTERVAL = 40'
SCALE: 1"=500'



PROFILE

SCALE	
HORIZ.	1"=500'
VERT.	1"=50'

REV	DESCRIPTION	DATE	BY

	BY		DATE
DESIGNED	K.MACDONALD	1/91	
REVIEWED	J.SELIN	2/91	
APPROVED			

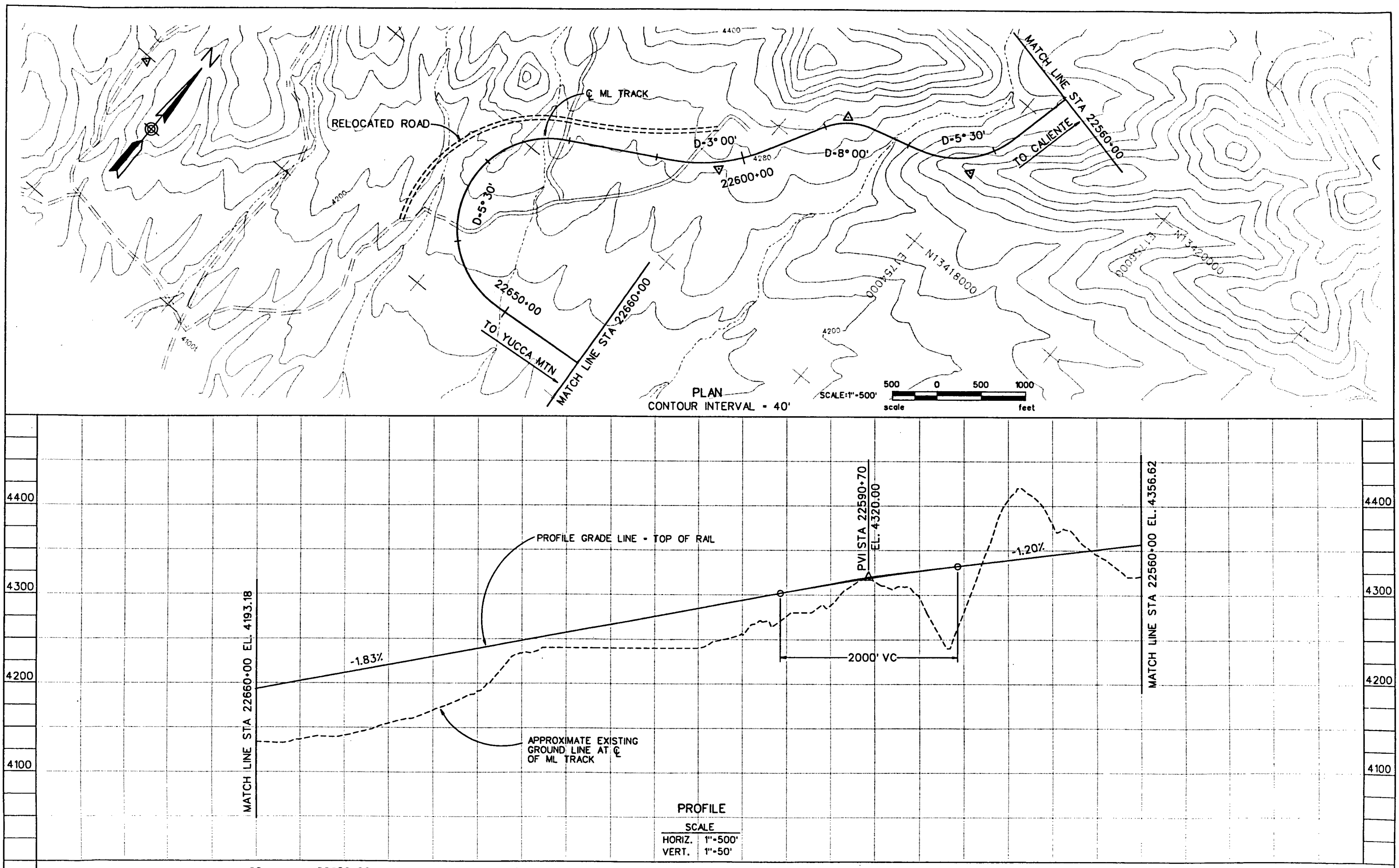
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA 22440+00 - STA 22560+00

SCALE: as noted
DRAWING NO: L02-023
SHEET NO: 172 - 10

DATE PLOTTED 18-FEB-1991



REV	DESCRIPTION	DATE	BY

	BY		DATE
DESIGNED	K.MACDONALD	1/91	
REVIEWED	J.SELIN	2/91	
APPROVED			

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

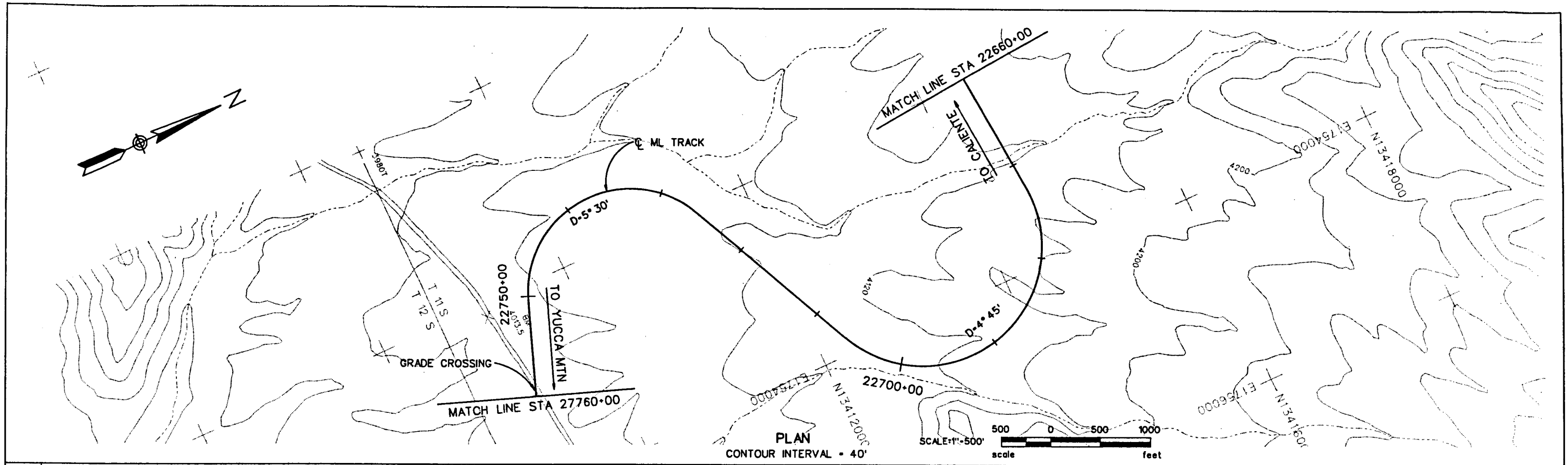
CALIENTE ROUTE PLAN & PROFILE

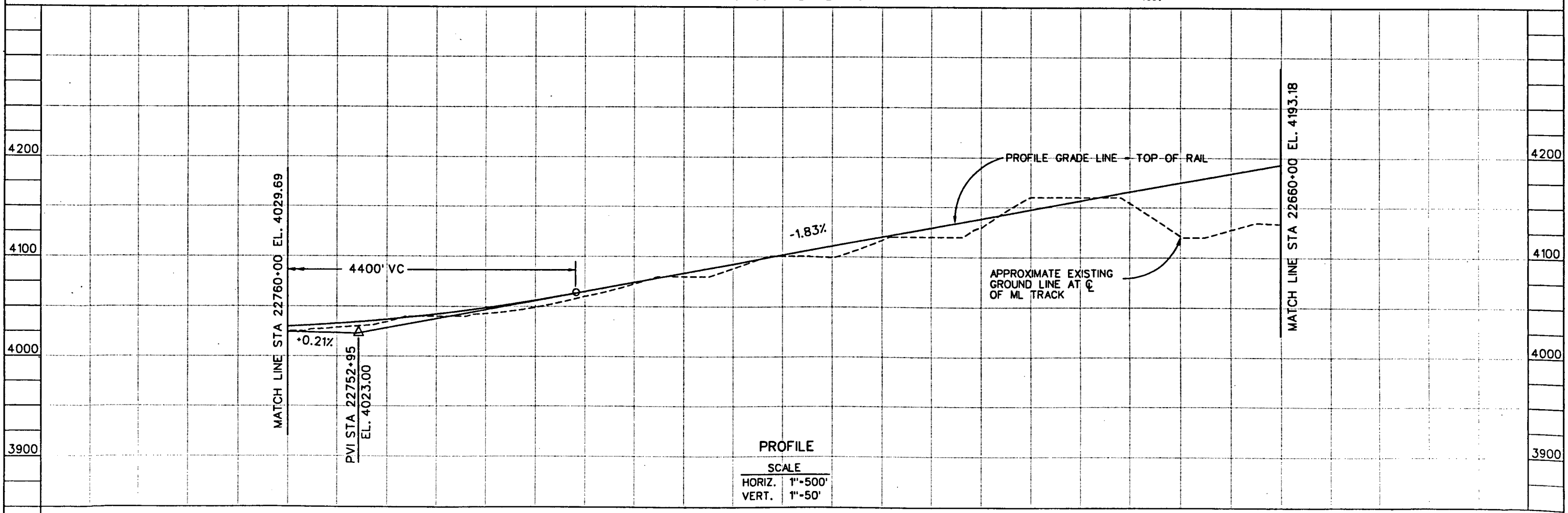
STA 22560+00 - STA 22660+00

SCALE: as noted

DRAWING NO. L02-024

SHEET NO. 174 of 190





REV	DESCRIPTION	DATE	BY

DESIGNED	BY K.MACDONALD	1/91	DATE
REVIEWED	BY J.SELIN	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

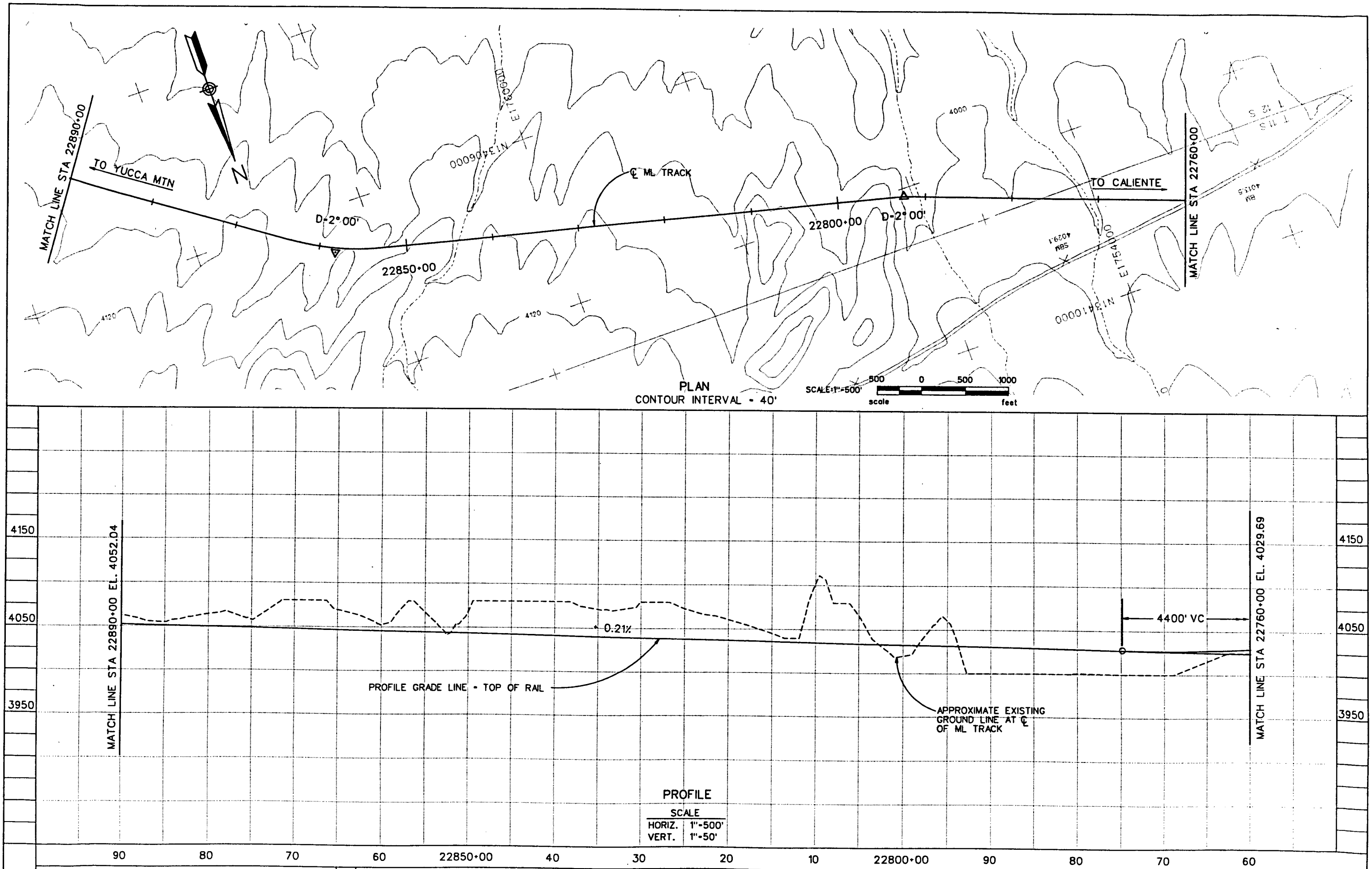
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE
PLAN & PROFILE

STA. 22660+00 - STA. 22760+00

SCALE: as noted
DRAWING NO. L02-025
SHEET NO. 175 of 180



REV	DESCRIPTION	DATE	BY

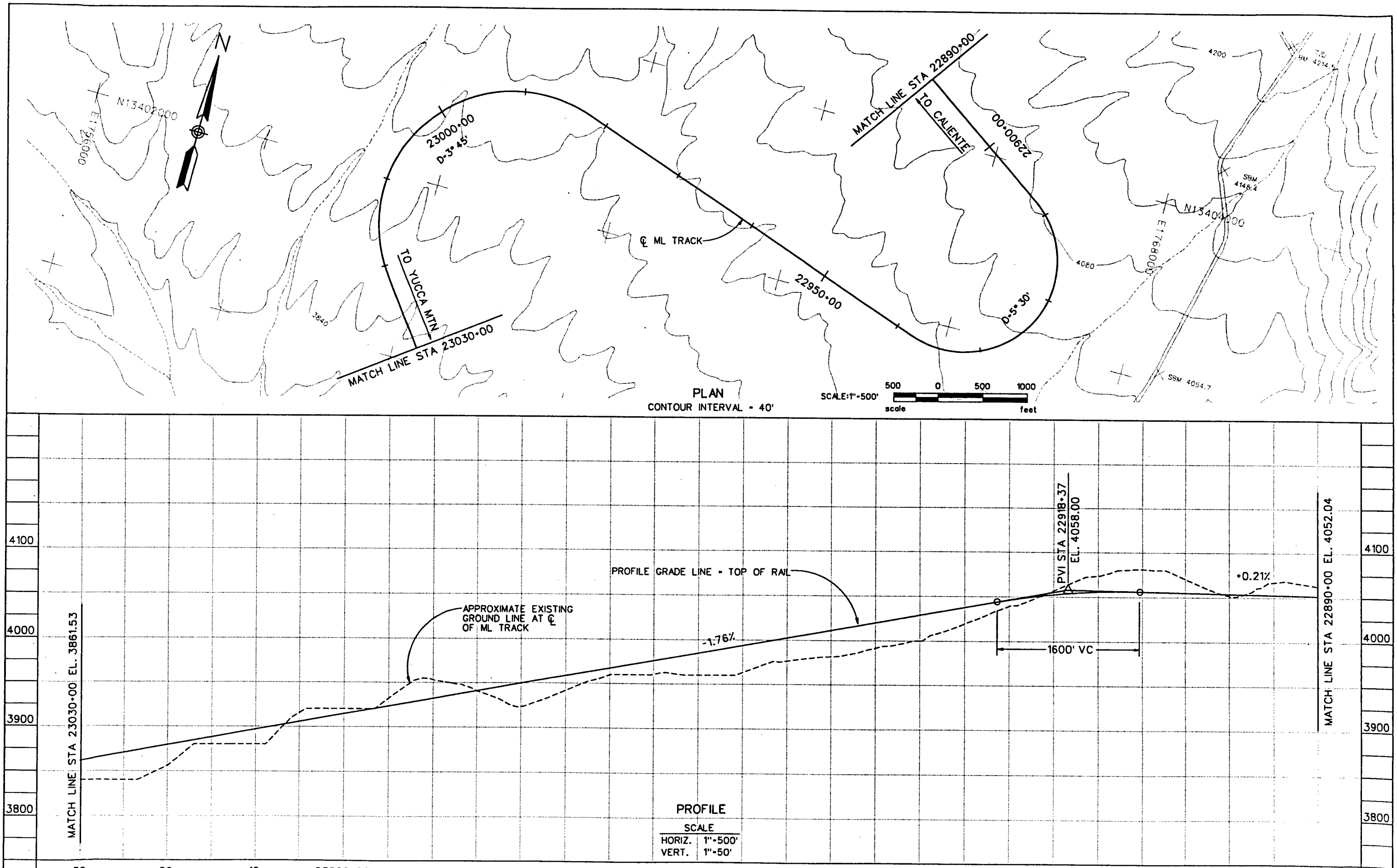
DESIGNED	BY K.MACDONALD	1/91	DATE
REVIEWED	BY J.SELIN	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 22760+00 - STA. 22890+00

SCALE as noted
DRAWING NO L02-026
SHEET NO 17/ of 192



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K.MACDONALD	1/91	DATE
REVIEWED	BY J.SELIN	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

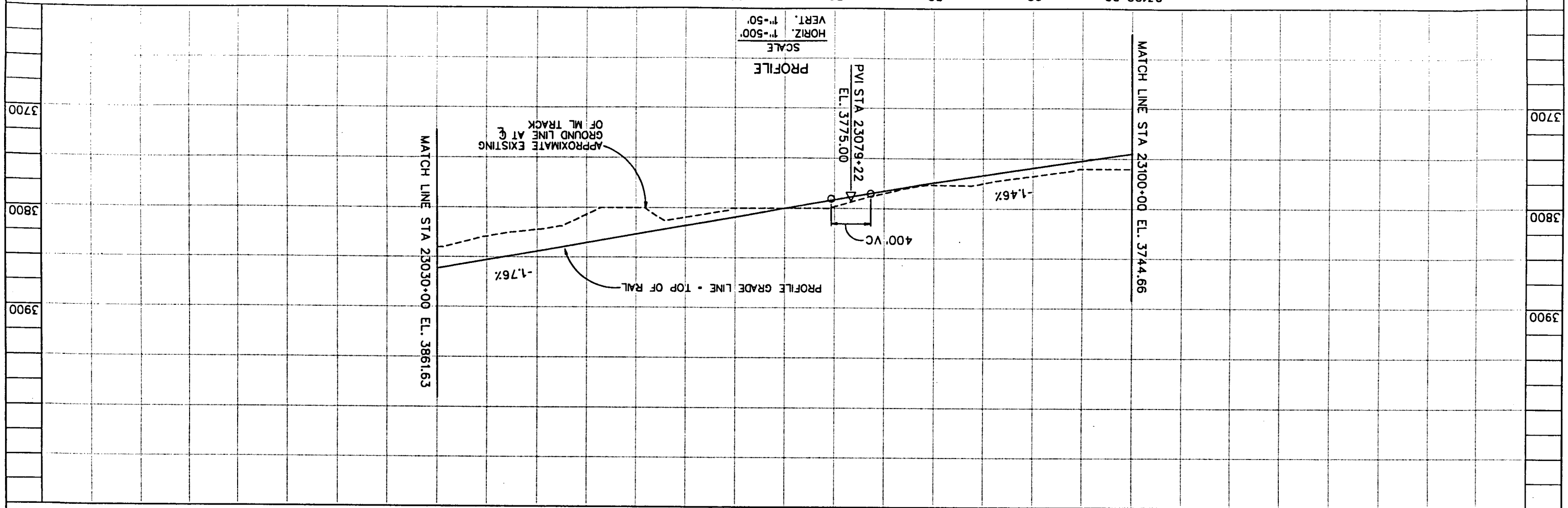
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

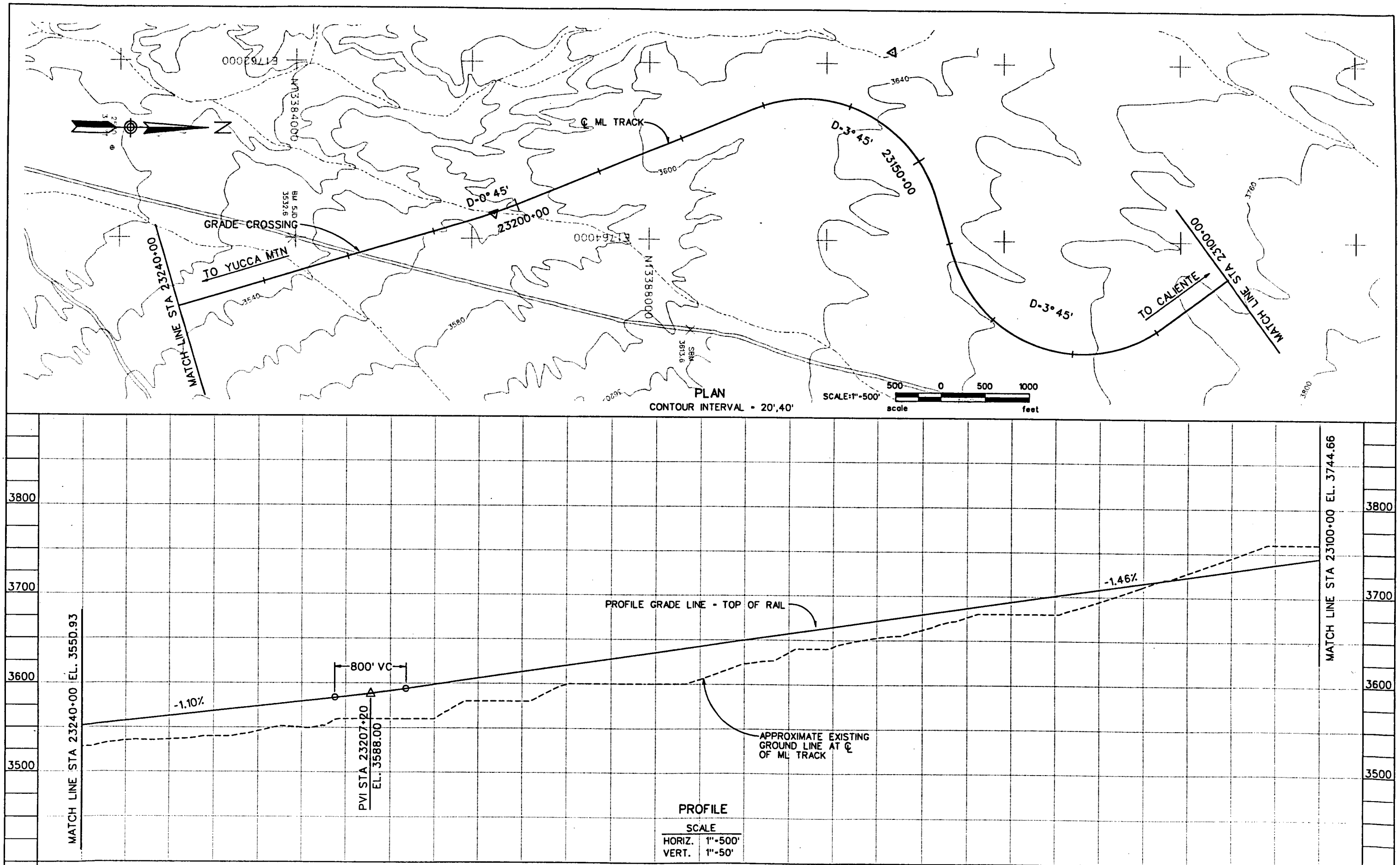
YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE

SCALE as noted
DRAWING NO. L02-027
SHEET NO

DATE PLOTTED 19-FEB-1991

DESIGNED	BY K.MACDONALD	DATE 1/91	Prepared for: Science Applications International Corporation, Las Vegas, Nevada	YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT		SCALE as noted	
REVIEWED	BY J.SELIN	DATE 2/91	DELEUW, CATHER & COMPANY Engineers & Planners San Francisco, CA	CALIENTE ROUTE PLAN & PROFILE		DRAWING NO L02-028	SHEET NO
APPROVED	BY	DATE					
REV	DATE	DESCRIPTION					





REV	DESCRIPTION	DATE	BY

	BY		DATE
DESIGNED	K.MACDONALD	1/91	
REVIEWED	J.SELIN	2/91	
APPROVED			

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE PLAN & PROFILE

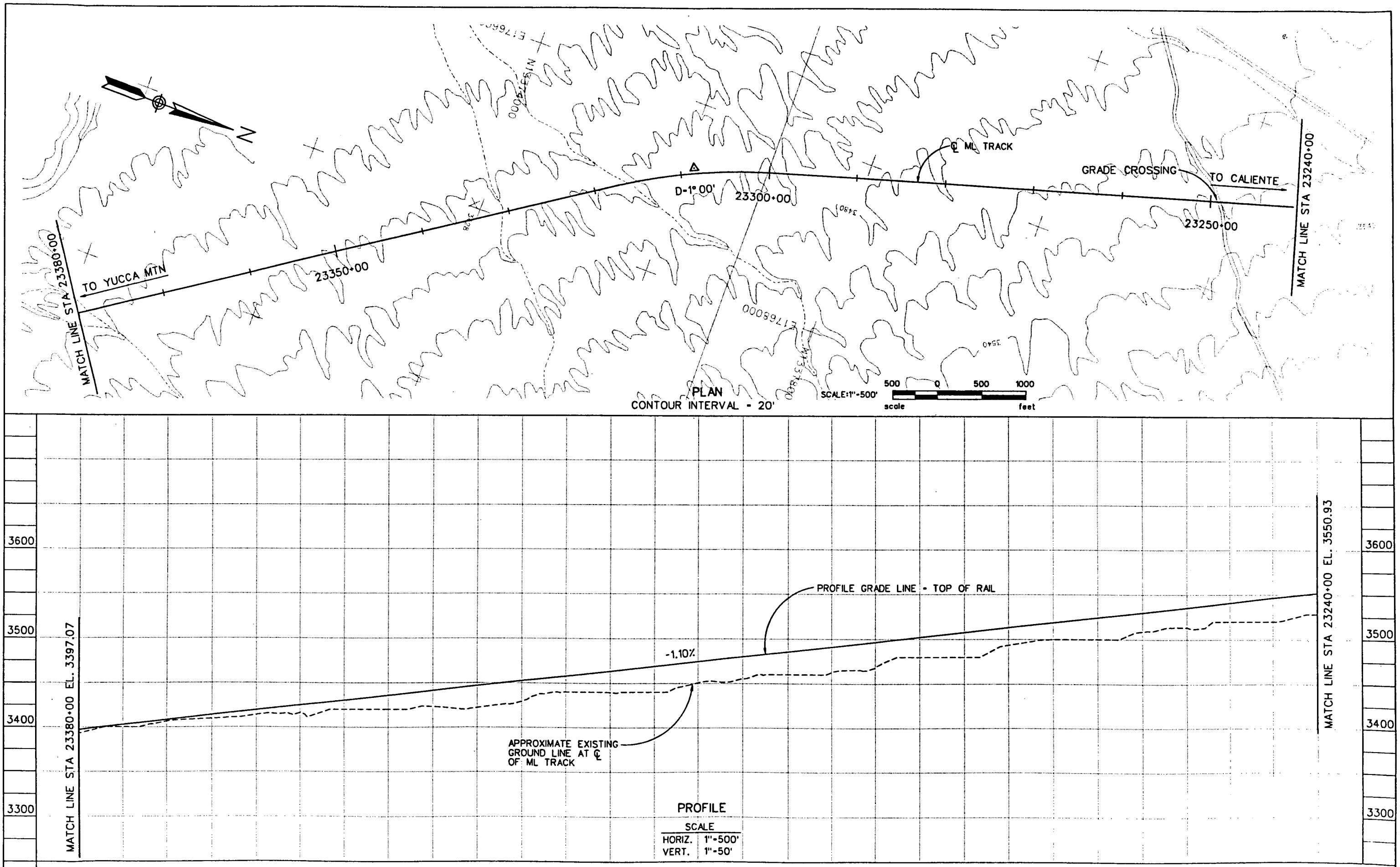
STA. 23100+00 - STA. 23240+00

SCALE: as noted

DRAWING NO. L02-029

SHEET NO. 179 OF 190

DATE PLOTTED 19-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K.MACDONALD	1/91	DATE
REVIEWED	BY J.SELIN	2/91	DATE
APPROVED	BY		DATE

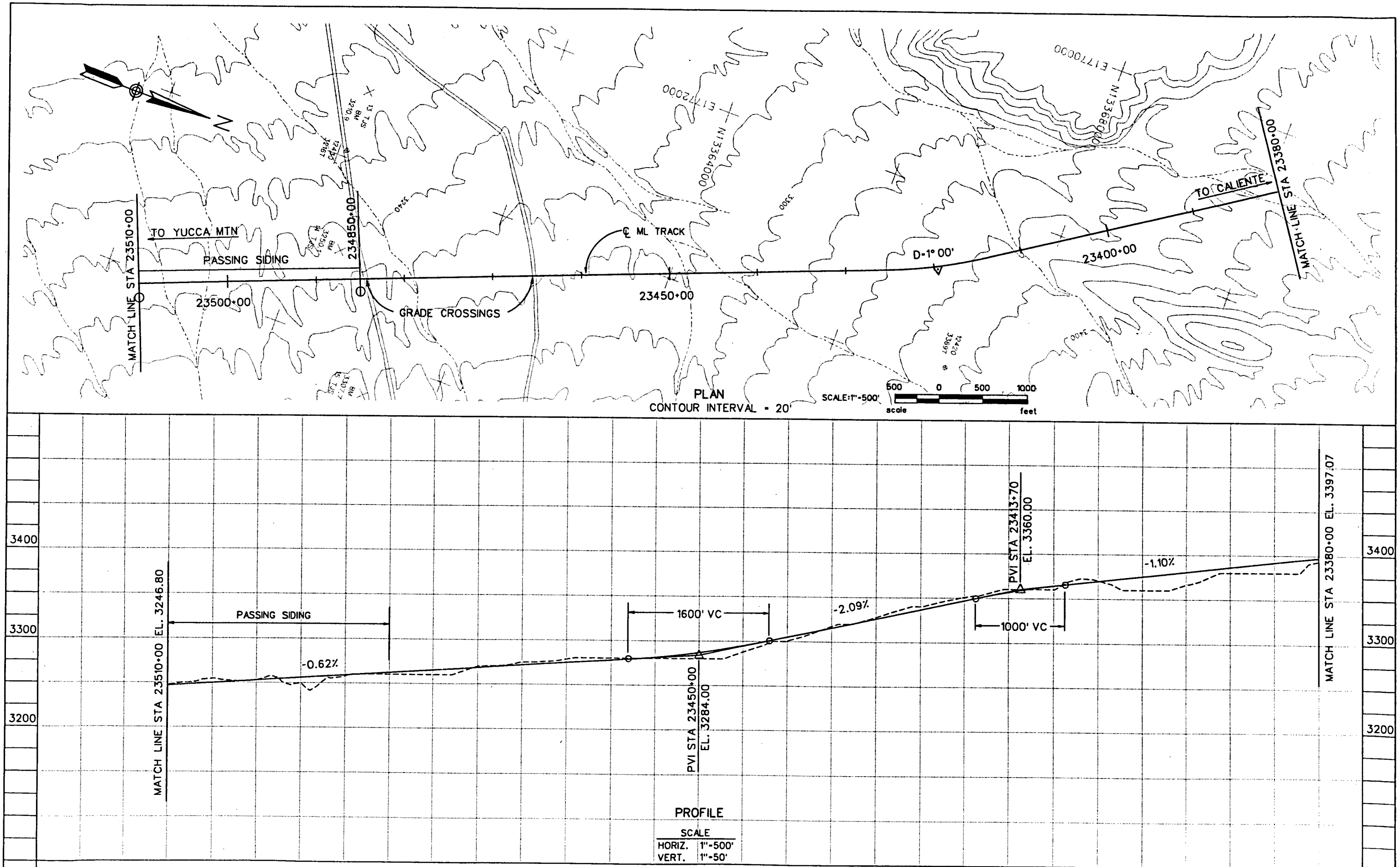
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE
PLAN & PROFILE
STA 23240+00 - STA 23380+00

SCALE as noted
DRAWING NO L02-030
SHEET NO



REV	DESCRIPTION	DATE	BY

	BY		DATE
DESIGNED	K.MACDONALD	1/91	
REVIEWED	J.SELIN	2/91	
APPROVED			

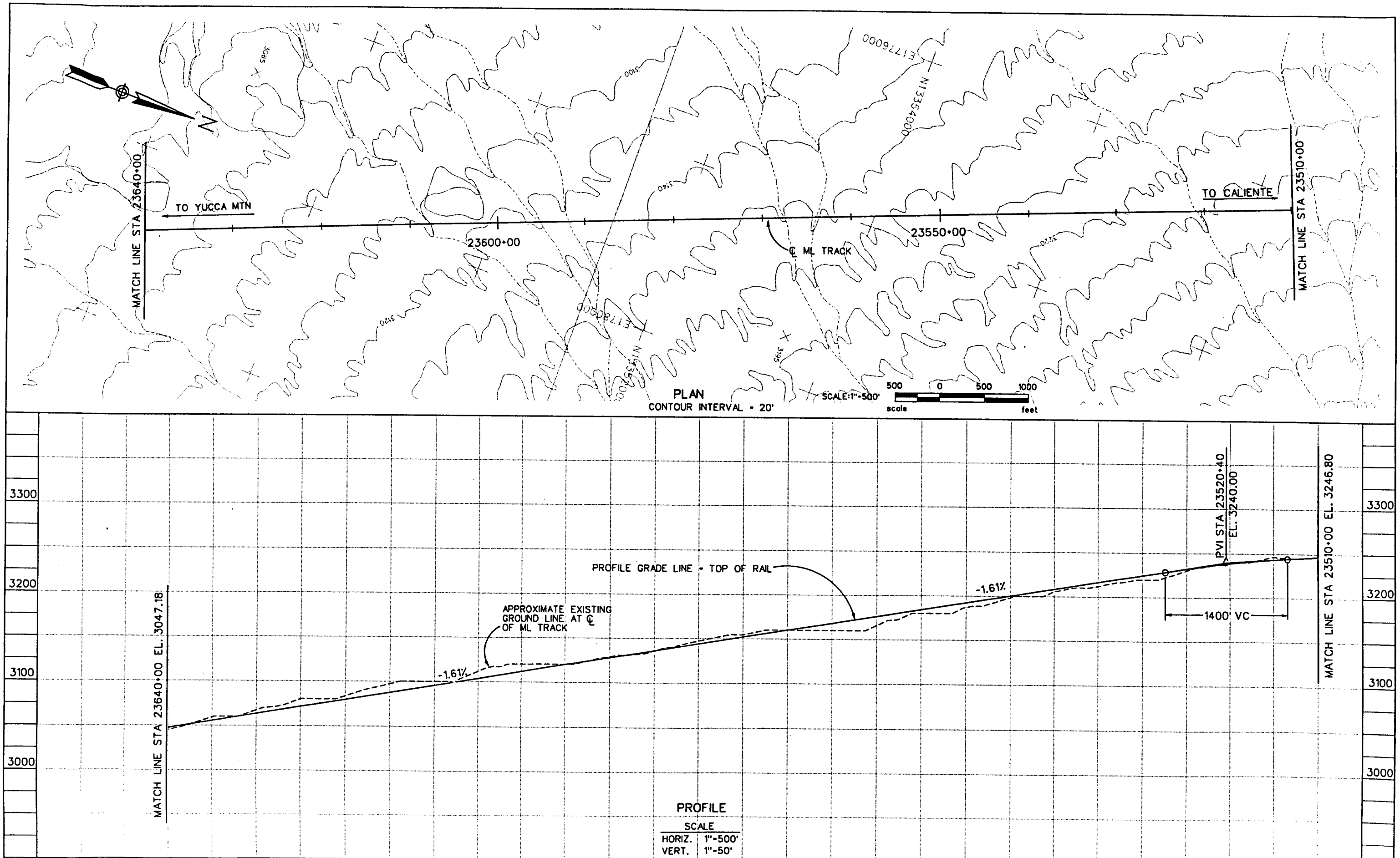
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA 23380+00 - STA 23510+00

SCALE as noted
DRAWING NO. L02-031
SHEET NO.

DATE PLOTTED 18-FEB-1991



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K.MACDONALD	1/91	DATE
REVIEWED	BY J.SELIN	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

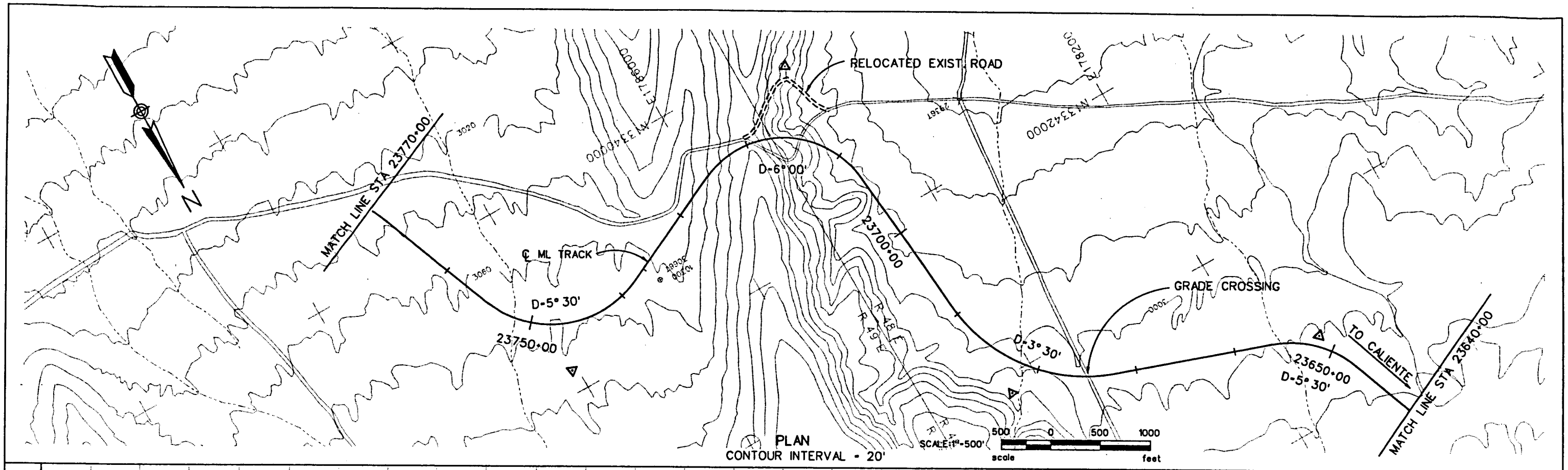
CALIENTE ROUTE PLAN & PROFILE

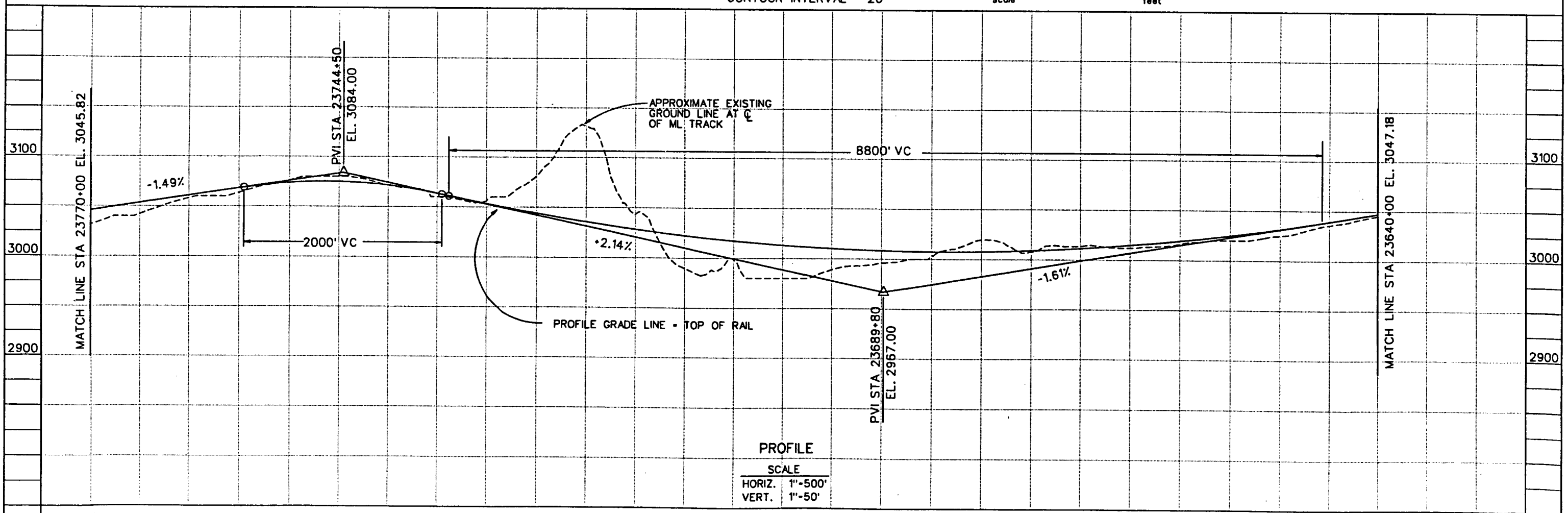
STA. 23510+00 - STA. 23640+00

SCALE as noted

DRAWING NO L02-032

SHEET NO 197 of 190





PROFILE

SCALE	
HORIZ.	1"-500'
VERT.	1"-50'

REV	DESCRIPTION	DATE	BY

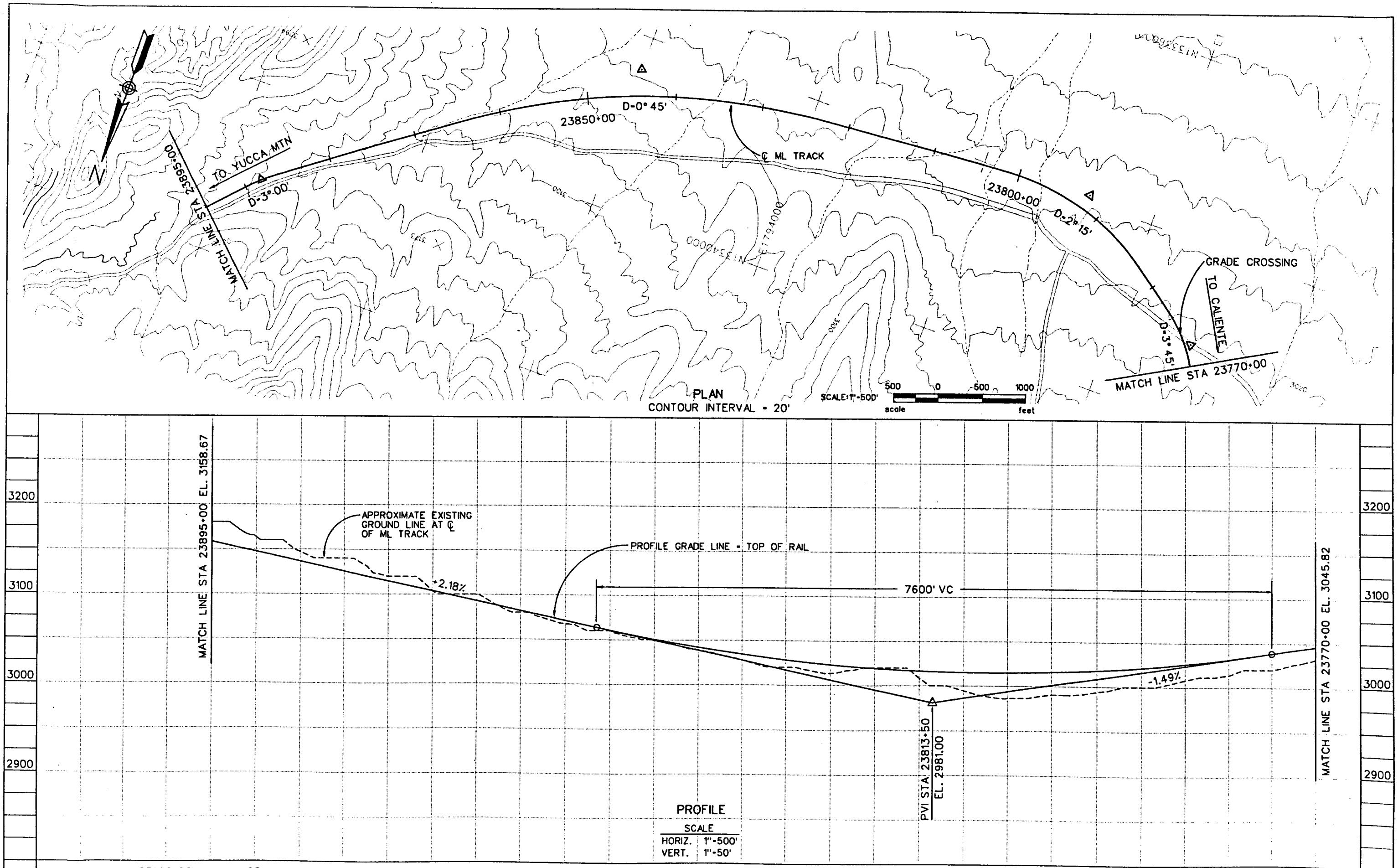
DESIGNED	BY K.MACDONALD	1/91	DATE
REVIEWED	BY J.SELIN	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA. 23640+00 - STA. 23770+00

SCALE as noted
DRAWING NO. L02-033
SHEET NO. 183 OF 190



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K.MACDONALD	1/91	DATE
REVIEWED	BY J.SELIN	2/91	DATE
APPROVED	BY		DATE

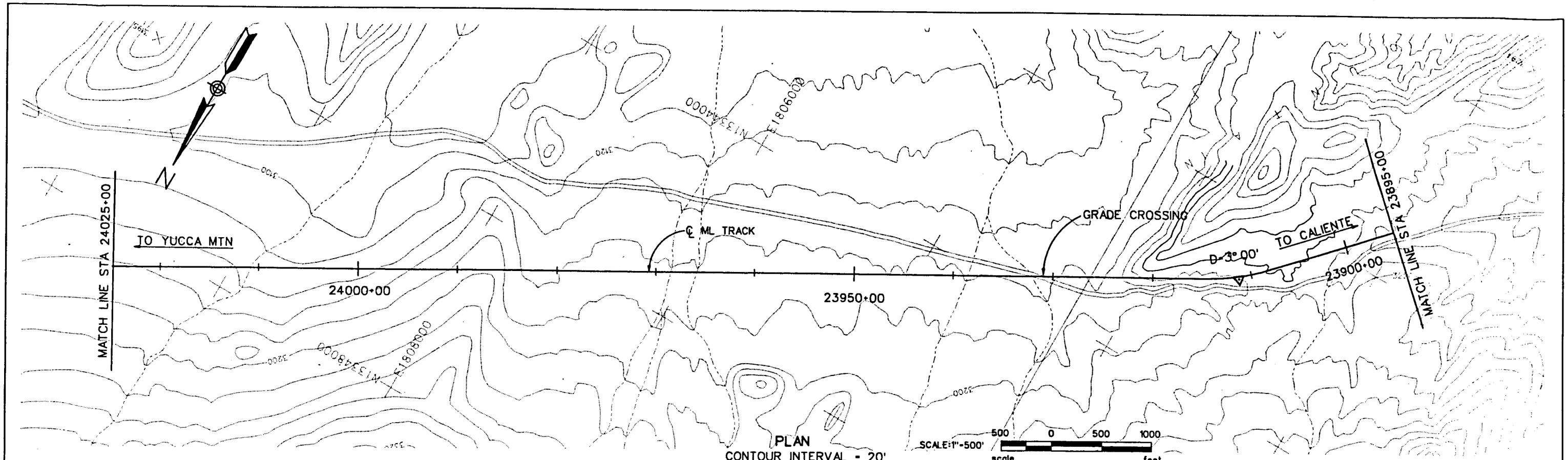
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

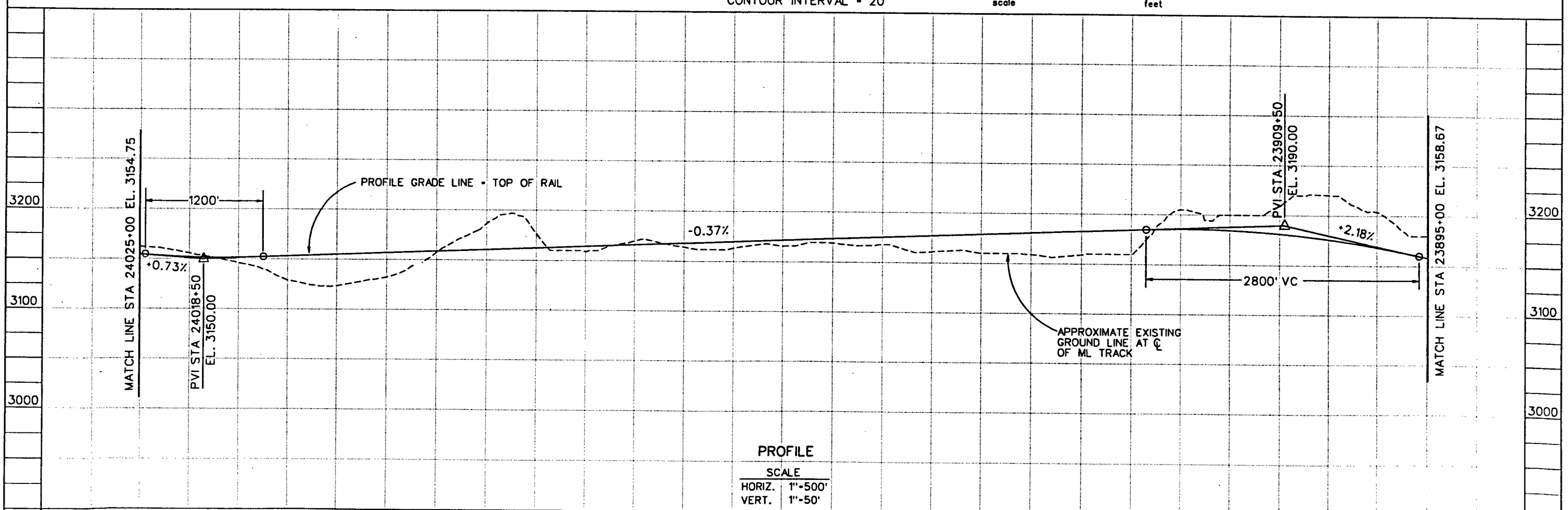
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

CALIENTE ROUTE
PLAN & PROFILE
STA. 23770+00 - STA. 23895+00

SCALE: as noted
DRAWING NO: L02-034
SHEET NO: 184 OF 190





REV	DESCRIPTION	DATE	BY

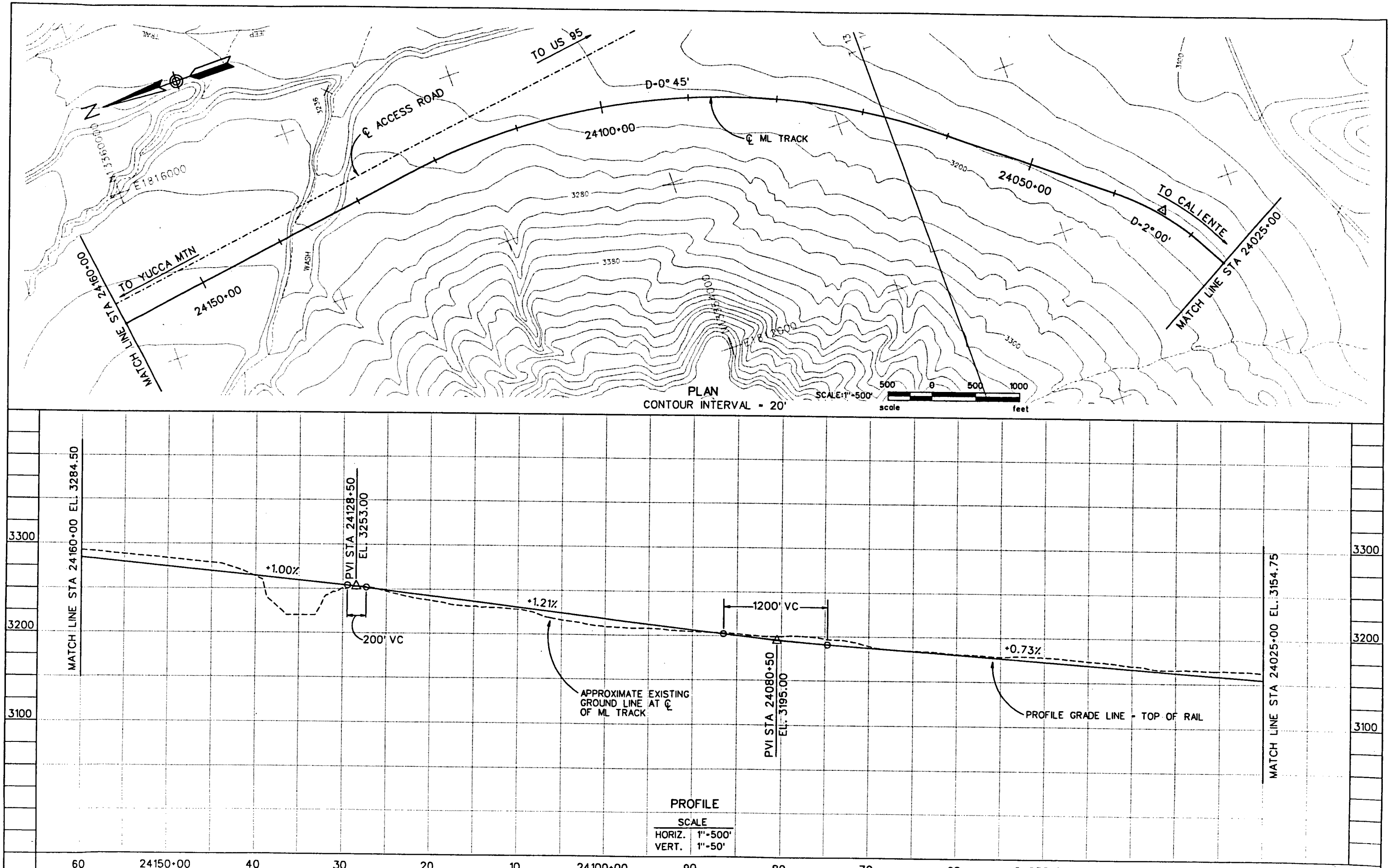
DESIGNED	BY K.MACDONALD	1/91	DATE
REVIEWED	BY J.SELIN	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA 23895+00 - STA 24025+00

SCALE as noted
DRAWING NO L02-035
SHEET NO



REV	DESCRIPTION	DATE	BY

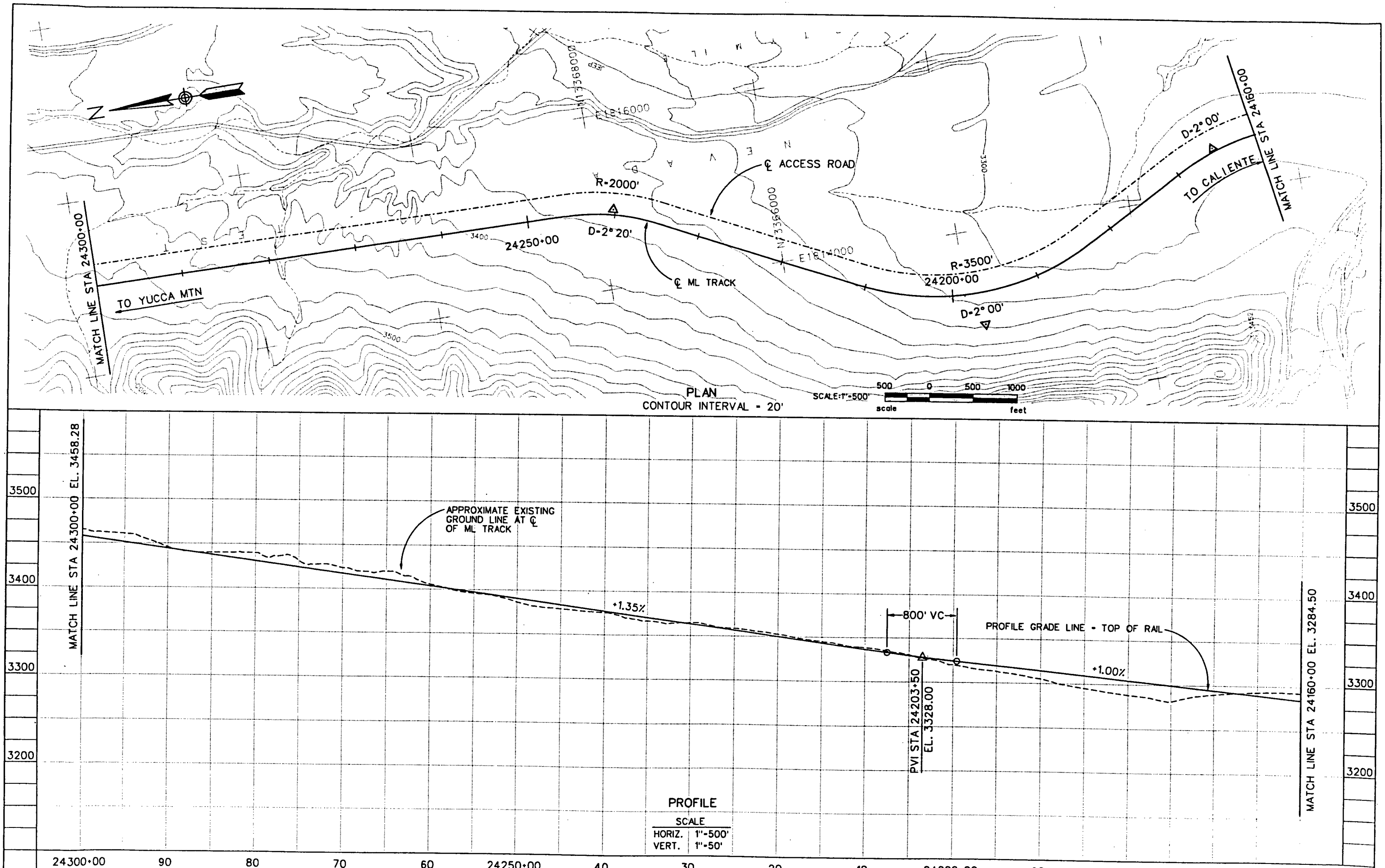
DESIGNED	BY K.MACDONALD	1/91	DATE
REVIEWED	BY J.SELIN	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA 24025+00 STA 24160+00

SCALE as noted
DRAWING NO. L02-036
SHEET NO.



REV	DESCRIPTION	DATE	BY

DESIGNED	BY K.MACDONALD	1/91	DATE
REVIEWED	BY J.SELIN	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

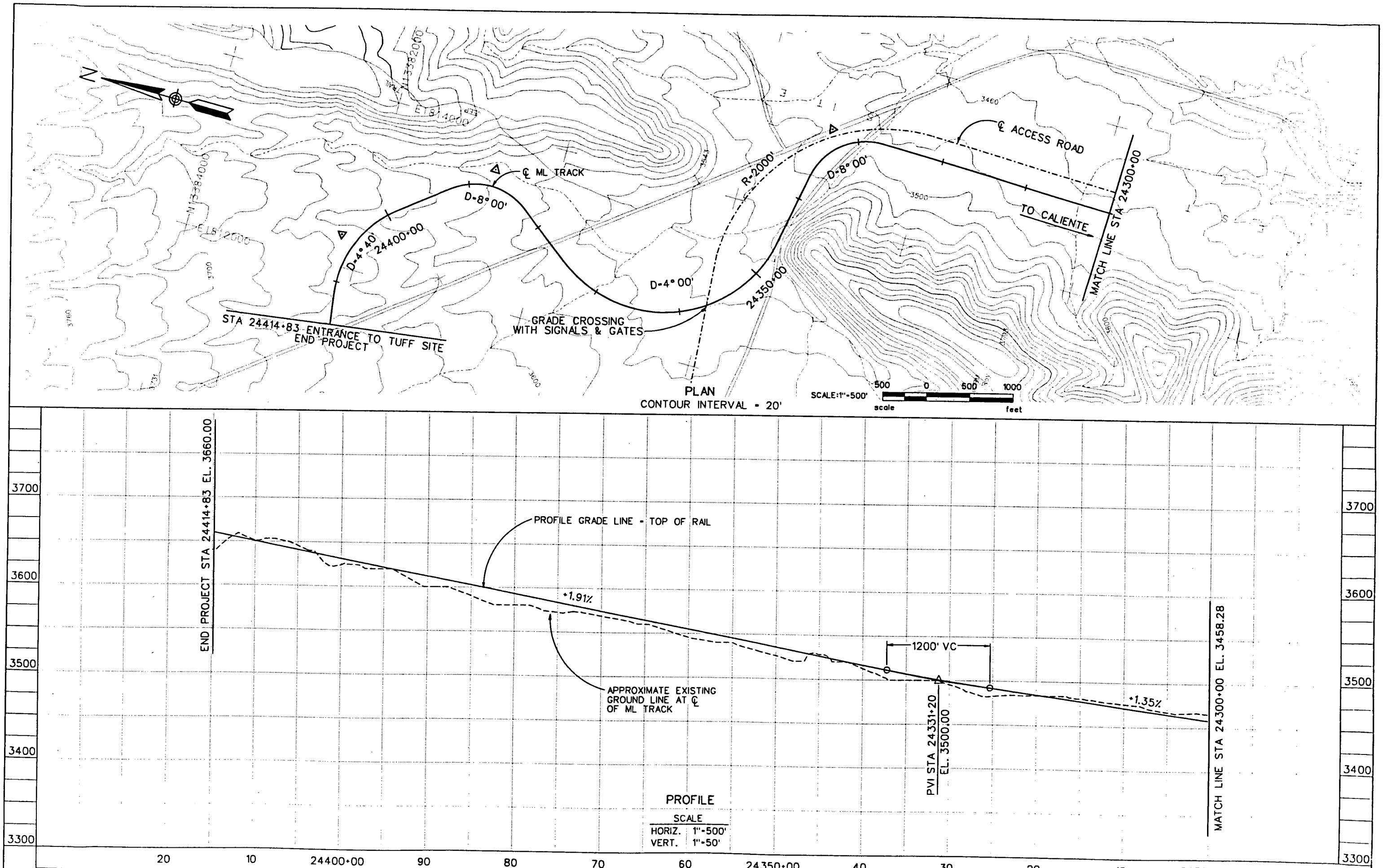
CALIENTE ROUTE PLAN & PROFILE

STA 24160+00 - STA 24300+00

SCALE: as noted

DRAWING NO. L02-037

SHEET NO. 127 of 190



REV	DESCRIPTION	DATE	BY

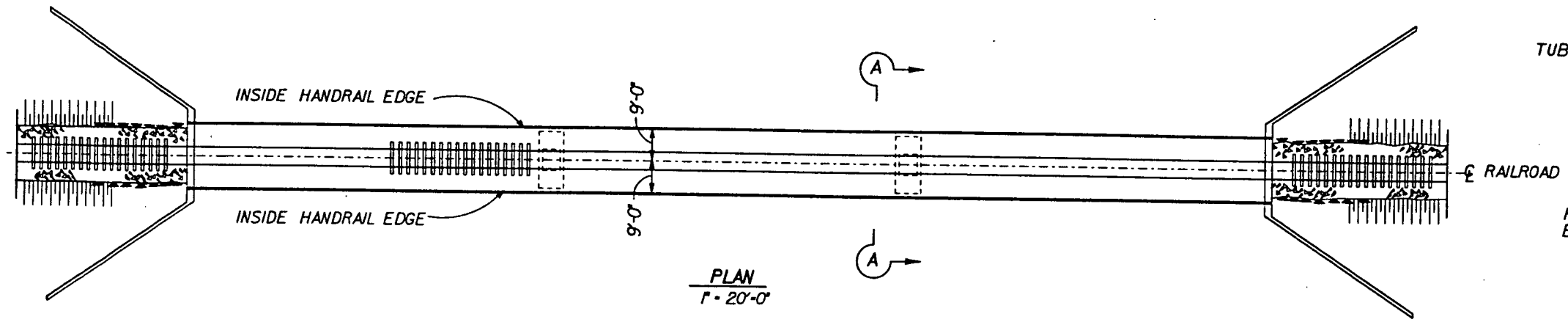
	BY	DATE
DESIGNED	K.MACDONALD	1/91
REVIEWED	J.SELIN	2/91
APPROVED		

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

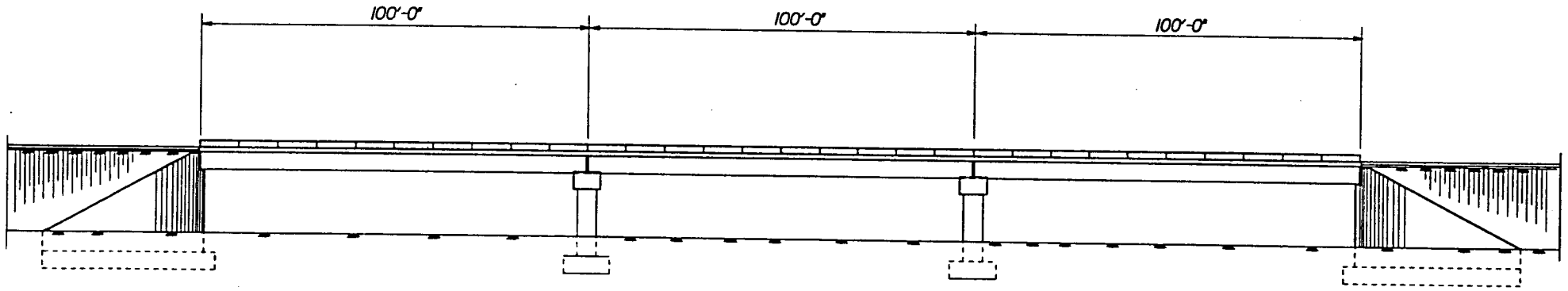
DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT
CALIENTE ROUTE
PLAN & PROFILE
STA 24300+00 - STA 24414+83

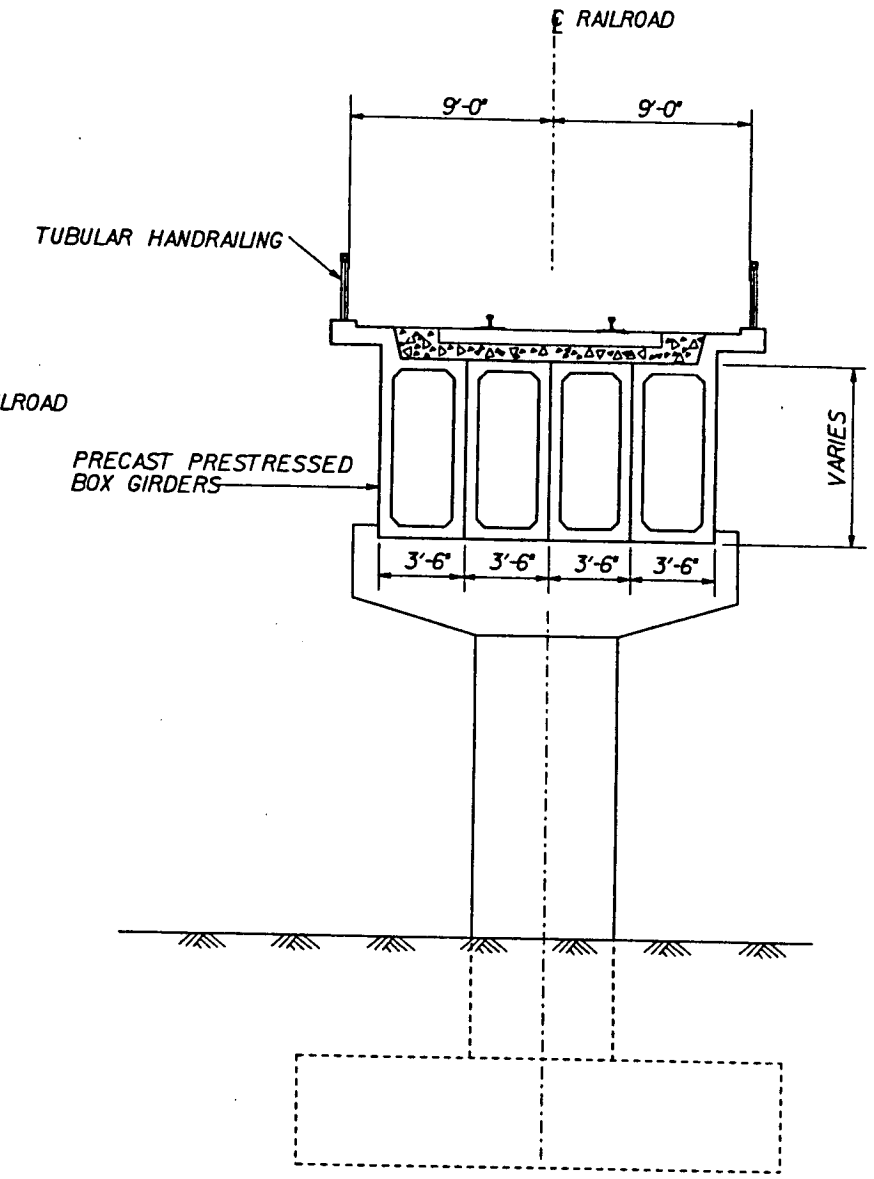
SCALE as noted
DRAWING NO L02-038
SHEET NO



PLAN
1" = 20'-0"



ELEVATION
1" = 20'-0"



SECTION A - A
1/4" = 1'-0"

REV	DESCRIPTION	DATE	BY

DESIGNED	BY M. MOORE	1 /91	DATE
REVIEWED	BY B. DYKES	2 /91	DATE
APPROVED	BY		DATE

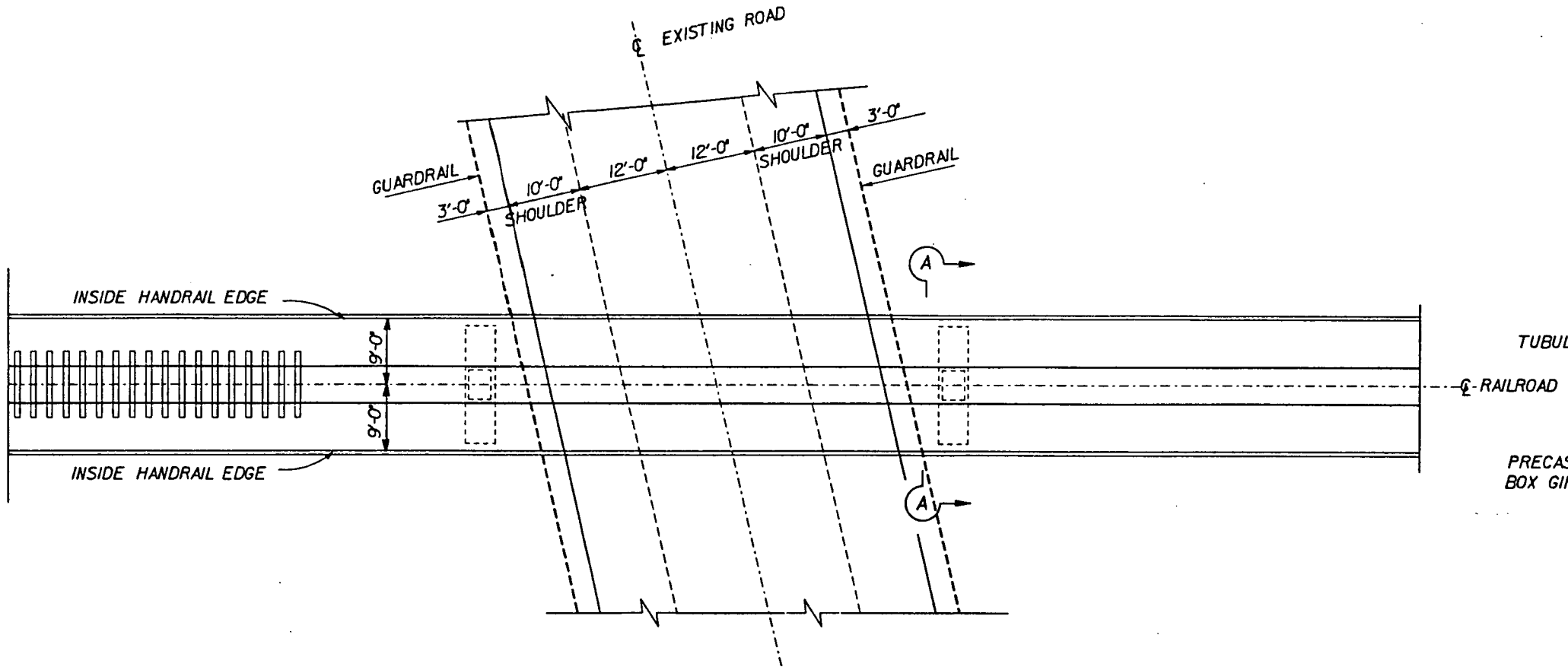
Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

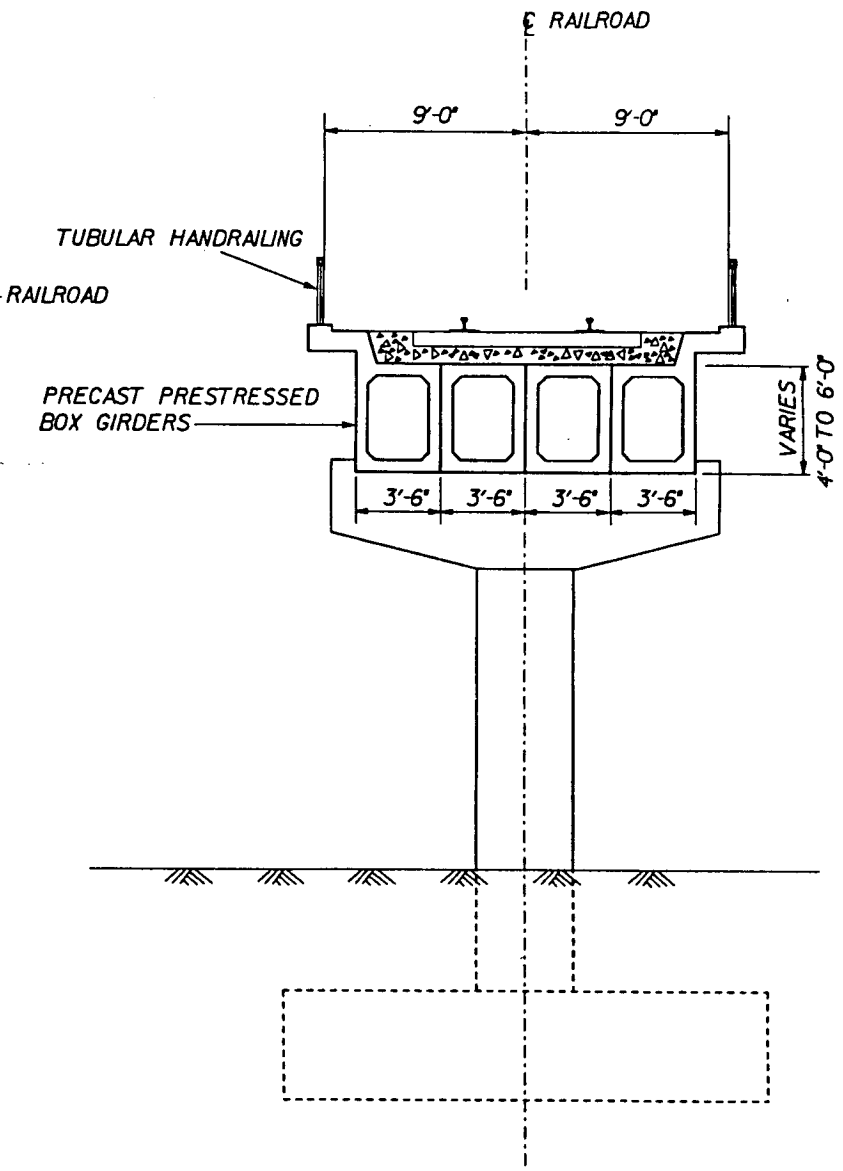
YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

TYPICAL RAILROAD BRIDGE OVER RIVER

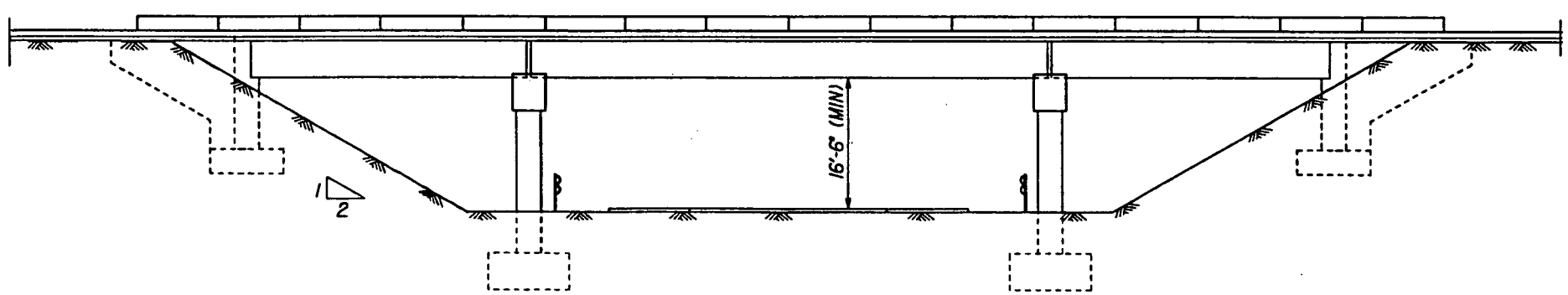
SCALE: as noted
DRAWING NO. S02-001
SHEET NO. 189 of 190



PLAN
1" = 10'-0"



SECTION A - A
1/4" = 1'-0"



ELEVATION
1" = 10'-0"

REV	DESCRIPTION	DATE	BY

DESIGNED	BY M. MOORE	1/91	DATE
REVIEWED	BY B. DYKES	2/91	DATE
APPROVED	BY		DATE

Prepared for: Science Applications International Corporation, Las Vegas, Nevada

DeLEUW, CATHER & COMPANY
Engineers & Planners San Francisco, CA

YUCCA MOUNTAIN RAIL ACCESS DEVELOPMENT

TYPICAL RAILROAD BRIDGE OVER ROAD

SCALE: as noted
DRAWING NO. S02-002
SHEET NO. 190 OF 190

Project No. P04353