Moccasin Diversion

Technical Support Data Notebook
Levee ID #800, Clark County, Nevada

Prepared for

Clark County Regional Flood Control District
600 South Grand Central Parkway, Suite 300
Las Vegas, Nevada 89106-4511

Prepared By:

2270 Corporate Circle, Suite 100
Henderson, Nevada 89074-6382

6380 South Polaris Avenue
Las Vegas, Nevada 89118

Levee Data and Documentation for the
National Flood Insurance Program

June 2010

REGIONAL FLOOD
CONTROL DISTRICT

June 23, 2010

Mr. Eric Simmons, CFM
National Flood Insurance Program
FEMA Region IX
1111 Broadway, Suite 1200
Oakland, CA 94607-4052

Subject: Levee Documentation Package: Levee ID #800 – Moccasin Diversion Clark County, Nevada

Dear Mr. Simmons:

I am pleased to present this Technical Support Data Notebook (TSDN) for the Moccasin Diversion (Levee #800) in Clark County, Nevada. On January 8, 2009, the Clark County Regional Flood Control District (the District) entered into an Agreement for Professional Services with PBS&J to prepare a levee documentation package for this levee structure.

The development of this levee documentation package was a collaborative effort between the District, the City of North Las Vegas, and the Consultant Team – PBS&J and Kleinfelder. Multiple reports, meetings, surveys, and site visits were necessary in order to present you with a complete and accurate submittal for the levee structure. Please refer to the cover letters from the City of North Las Vegas (CNLV) and the Consultant Team on the following pages for information about their roles and responsibilities related to this effort.

The Moccasin Diversion is eligible for District operation and maintenance funding because it is identified on the District's master plan of flood control facilities. Each year, CNLV executes a Maintenance Work Program interlocal funding contract and identifies this levee structure, among many others, for inspection and maintenance. The Operation and Maintenance manual and associated contract with CNLV are provided in the appendix for your review.

District acknowledges that currently there is no development on the public land upstream of the Moccasin Diversion. District in coordination with the levee owner (CNLV) and other involved local communities (Clark County and City of Las Vegas) will be responsible for monitoring development that occurs upstream of the levee to ensure that future changes in the watershed do not adversely impact the functionality of the levee or the analysis presented in the TSDN.

600 S. Grand Central Parkway, Suite 300 • Las Vegas, Nevada 89106-4511
(702) 685-0000 • FAX: (702) 685-0001
Website: *http://www.regionalflood.org*

As a community official responsible for floodplain management, I hereby acknowledge that we have received and reviewed the attached technical report and appendix. Based upon the review, we recommend that the structure should continue to be accredited as providing protection from the base flood.

Sincerely,

Kevin Eubanks, P.E., CFM
Assistant General Manager

c: Dr. Qiong Liu, City of North Las Vegas
Jennifer Doody, City of North Las Vegas

Enclosure(s)

P:\Letters and Memos\Engineering - General\2010\LeveeCoverLetter_CCRFCD_Moccasin.docx

Mayor
Shari L. Buck

Council Members
William E. Robinson
Robert L. Eliason
Anita G. Wood
Richard J. Cherchio

CITY OF
NORTH LAS VEGAS
Your Community of Choice

Acting City Manager
Maryann Ustick

Public Works Department – Dr. Qiong Liu, P.E., P.T.O.E., Director
2266 Civic Center Drive · North Las Vegas, Nevada 89030
Telephone: (702) 633-1200 · Fax: (702) 649-4696 · TDD: (800) 326-6868
www.cityofnorthlasvegas.com

June 21, 2010

Mr. Eric Simmons, CFM
National Flood Insurance Program
FEMA Region IX
1111 Broadway, Suite 1200
Oakland, CA 94607-4052

Subject: **Levee Documentation Package: Levee ID #800 – Moccasin Diversion Clark County, Nevada**

Dear Mr. Simmons,

This Technical Support Data Notebook (TSDN) has been prepared to show that the Moccasin Diversion (Levee #800) has been evaluated based on the criteria set forth in Section 65.10 of the National Flood Insurance Program (NFIP) regulations. Please refer to the attached cover letter and documentation that has been prepared by the Consultant Team for more detailed information.

Each year, the City of North Las Vegas (CNLV) enters into contract with the Clark County Regional Flood Control District to maintain flood control improvements within the city. The Moccasin Diversion is one of the many facilities that are included in the maintenance program. The maintenance for this structure has been performed and will continue to be performed in accordance with standards set forth in the District's Operations and Maintenance Manual.

We have received and reviewed this levee documentation package. To the best of our knowledge, the Moccasin Diversion meets the criteria of 44 CFR 65.10. This levee is currently designated as a Provisionally Accredited Levee (PAL) based on a letter from FEMA dated January 29, 2009. We hereby submit to FEMA before the designated 2-year deadline (December 16, 2010) and recommend that the structure should continue to be accredited as providing protection from the base flood.

Sincerely,

FOR QL.

Dr. Qiong Liu, P.E. PTOE
Public Works Director

PBS&J
An employee-owned company

June 23, 2010

Mr. Eric Simmons, CFM
National Flood Insurance Program
FEMA Region IX
1111 Broadway, Suite 1200
Oakland, CA 94607-4052

Subject: Levee ID #800 – Moccasin Diversion, Clark County, Nevada

Dear Mr. Simmons,

This letter and the accompanying Moccasin Diversion Technical Support Data Notebook (TSDN) provide data and documentation to show that the Moccasin Diversion (Levee #800) has been evaluated based on the criteria set forth in Section 65.10 of the National Flood Insurance Program (NFIP) regulations and is recommended for accreditation by the Federal Emergency Management Association (FEMA). This levee is currently designated as a Provisionally Accredited Levee (PAL) based on a letter from FEMA dated January 29, 2009.

The Moccasin Diversion (MD) is located in the far northwest portion of the Las Vegas Valley in the City of Las Vegas, Clark County, Nevada. The MD is owned and maintained by the City of North Las Vegas while the City of Las Vegas is the responsible community. The MD structure was constructed in 1993 to intercept tributary runoff and convey it east across the adjacent alluvial fan to the Upper Las Vegas Wash Detention Basin, which is located approximately 1.2 miles southeast of the downstream end of the MD.

The MD is an earthen diversion structure consisting of an 8- to 10-foot high embankment approximately 9,300 feet in length with a 12-inch thick roller-compacted concrete lining protecting the north face. The diversion structure was designed with a 3:1 side slope (horizontal to vertical) on the waterside and a variable side slope on the landside no steeper than 3:1. The crest of the structure is unpaved and varies in width from 13 feet to greater than 30 feet.

In coordination with the Clark County Regional Flood Control District, the City of North Las Vegas, and Kleinfelder, PBS&J provided technical services for the research, review, and development of the attached supporting documentation for the MD. These services included field reconnaissance and survey, data collection and review, hydraulic and hydrologic analysis, and sediment transport analysis. Kleinfelder worked in close coordination with PBS&J on this project and was primarily responsible for the geotechnical aspects related to the levee evaluation.

The attached TSDN discusses in depth the FEMA levee requirements from Section 65.10 and includes summary descriptions of all relevant requirements and describes the engineering analyses conducted. TSDN appendices include supporting documentation such as FEMA correspondence, as-built plans, maintenance manuals/documentation, H&H analysis, geotechnical data, and sediment transport/erosion analysis.

Based on review of the as-built plans, the current on-site conditions, and the technical analyses presented in the attached TSDN, this levee system does, as of the date of this letter, meet the minimum criteria set forth in paragraphs *(b)(1)Freeboard* and *(b)(3)Embankment Protection* in the Code of Federal Regulations (44 CFR 65.10).

Refer to the attached cover letter from Kleinfelder for information about the geotechnical data and documentation related to the levee criteria described in paragraphs *(b)(4)Embankment and foundation stability* and *(b)(5)Settlement*. It should be noted that the other criteria described in paragraphs *(b)(2)Closures*, *(b)(6)Interior Drainage*, and *(b)(7)Other Design Criteria* are not applicable to this levee system.

This letter does not constitute any warranty or guarantee of performance, expressed or implied. Rather, it is a statement that the data presented in the attached TSDN is accurate to the best of Project Team's knowledge.

The review of available technical data associated with the design and construction of this levee was completed in accordance with sound engineering practices and with a standard of care that is commensurate with industry practices. The submitted documentation is for the sole purpose of establishing appropriate risk zone determinations for NFIP maps and does not represent a determination by PBS&J or its subcontractors as to how a structure or system will perform during any flood event. The analysis presented in the TSDN is based on the existing condition upstream of the Moccasin Diversion. Any future development should be regulated to ensure that changes in the watershed do not adversely impact the functionality of the levee or the analysis presented in the TSDN.

The City of North Las Vegas is the levee owner and is responsible for proper maintenance of the levee to ensure the stability, height, and overall integrity of the levee and its associated structures and systems are maintained.

Sincerely,

PROFESSIONAL ENGINEER - STATE OF NEVADA
HARSHAL B. DESAI
Exp. 12-31-10
CIVIL
No. 17468

06-23-2010

Brian Rowley, P.E., CFM
Project Engineer

Harshal Desai, P.E., CFM
Water Resources Group Manager

KLEINFELDER
Bright People. Right Solutions.

June 23, 2010

Mr. Eric Simmons, CFM
National Flood Insurance Program
FEMA Region IX
1111 Broadway, Suite 1200
Oakland, CA 94607-4052

Subject: Levee #800 – Moccasin Diversion, Clark County, Nevada

Dear Mr. Simmons,

This letter and the accompanying Appendix I of the Moccasin Diversion Technical Support Data Notebook (TSDN) provide geotechnical data and documentation to show that the Moccasin Diversion (Levee #800) has been evaluated based on the criteria set forth in Section 65.10 of the National Flood Insurance Program (NFIP) regulations and is recommended for accreditation by the Federal Emergency Management Association (FEMA).

In coordination with the Clark County Regional Flood Control District (CCRFCD), the City of North Las Vegas (CNLV), and PBS&J, Kleinfelder provided geotechnical exploration and analyses of the Moccasin Diversion and was responsible for geotechnical aspects of the levee evaluation and compliance determination.

Based on review of the as-built plans, the current on-site conditions, and the technical analyses presented in Appendix I of the attached TSDN, this levee system does, as of the date of this letter, meet the minimum criteria set forth in paragraphs *(b)(4)Embankment and foundation stability* and *(b)(5)Settlement*.

This letter does not constitute any warranty or guarantee of performance, expressed or implied. Rather, it is a statement that the data presented in Appendix I of the attached TSDN is accurate to the best of Project Team's knowledge.

The review of available technical data associated with the design and construction of this levee was completed in accordance with sound engineering practices and with a standard of care that is commensurate with industry practices. The submitted documentation is for the sole purpose of establishing appropriate risk zone determinations for NFIP maps and does not represent a determination by Kleinfelder or PBS&J as to how a structure or system will perform during any flood event.

The City of North Las Vegas is the levee owner and is responsible for proper maintenance of the levee to ensure the stability, height, and overall integrity of the levee and its associated structures and systems are maintained.

Sincerely,

KLEINFELDER

Ann Backstrom

PROFESSIONAL ENGINEER - STATE OF NEVADA
ANN
BACKSTROM
Exp: 12/31/2010
GEOLOGICAL
No. 10099
6/23/2010

Ann L. Backstrom, P.E.
Senior Professional

Steven M. Myers

Steven R. Myers, P.G.
Regional Manager

Table of Contents

List of Figures

List of Tables

Appendices*

Appendix I **Geotechnical Evaluation**

- Geotechnical Evaluation Report by Kleinfelder
- Geotechnical Appendix A – Field Exploration
- Geotechnical Appendix B – Laboratory Testing
- Geotechnical Appendix C – Seepage Analysis Results
- Geotechnical Appendix D – Slope Stability Analysis Results

Appendix II **As-Built Plans**

Appendix III **FEMA Documents**

- PAL agreement letter
- FIRM Panels (FIRMettes)
- LOMR

Appendix IV **Maintenance Documentation**

- Operation and Maintenance Manual
- Annual Maintenance Contract
- On-Site Maintenance Coordination Sign-in Sheet
- Site Photos and Photo Location Figure
- July 1998 Rainfall Event Report

Appendix V **Engineering Analysis**

- **Hydraulics –** Supporting Documentation, 1998 TSDN Reference Material, HEC-2 Model, HEC-RAS Model, and Freeboard Calculations
- **Hydrology** – Supporting Documentation, Predesign Report for the Upper Las Vegas Wash Detention Basin, HEC-1 Model
- **Survey** – Electronic Survey Data, Datum Conversion Letter, Survey Cross Section Location Figure, Survey Profile Comparison Figure

Appendix VI **Reference Material**

- Upper Las Vegas Wash FIS Restudy, TSDN, April 20, 1998
- MD Bid Opening, Specs, and Geotechnical Report, March 10, 1992
- Construction Testing and DWR Correspondence

***NOTE: Because of substantial amounts of data and documentation, all appendix material is included electronically on a CD provided at the end of this report. Appendices I and II are the only appendices printed in hard copy format and are included at the end of the report for reference. An electronic version (PDF file) of the entire report is also included on the CD.**

Acronyms and Abbreviations

CFR 65.10	Title 44, Chapter 1 of the Code of Federal Regulations, Section 65.10, *Mapping of Areas Protected by Levees*
ac-ft	acre-ft
CCRFCD	Clark County Regional Flood Control District
CFR	Code of Federal Regulations
cfs	Cubic feet per second
CLV	City of Las Vegas, Nevada
CNLV	City of North Las Vegas, Nevada
COH	City of Henderson, Nevada
Design Manual	CCRFCD Hydrologic Criteria and Drainage Design Manual, 1999
DWR	Department of Water Resources
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
ft	feet
GIS	Geographic Information System
HEC-1	U.S. Army Corps of Engineers hydrologic modeling program
HEC-2	U.S. Army Corps of Engineers hydraulic modeling program
HEC-RAS	Hydrologic Engineering Centers River Analysis System
LOMR	Letter of Map Revision
MD	Moccasin Diversion
NAVD 88	North American Vertical Datum of 1988
NFIP	National Flood Insurance Program
NGVD 29	National Geodetic Vertical Datum of 1929
NHC	Northwest Hydraulic Consultants
PAL	Provisionally Accredited Levees
RCC	Roller-Compacted Concrete
SFHA	Special Flood Hazard Area
TSDN	Technical Support Data Notebook
ULVDB	Upper Las Vegas Wash Detention Basin
ULVW	Upper Las Vegas Wash
USACE	U.S. Army Corps of Engineers
WSE	Water Surface Elevation

Section 1
Introduction

1.1. Project Overview

As part of the Flood Map Modernization effort, the US Department of Homeland Security's Federal Emergency Management Agency (FEMA) has implemented procedures to verify that levee systems shown on effective National Flood Insurance Program (NFIP) flood maps as providing protection from the 1-percent-annual-chance flood continue to meet the levee requirements outlined in the NFIP regulations. The regulatory requirements for FEMA to accredit a levee system as providing flood protection are found in Title 44, Chapter 1 of the Code of Federal Regulations, Section 65.10 (CFR 65.10), *Mapping Areas Protected by Levee Systems*.

FEMA does not certify a levee or perform levee evaluations; rather, it is the responsibility of the levee owner or community seeking recognition of the levee to document compliance with CFR 65.10. FEMA will then review the information provided and either accredit the levee system as providing 1-percent-annual-chance flood protection on the flood map or if the levee system is shown to be inadequate, to reveal the risk of flooding by "de-accrediting" the levee and re-mapping the landside of the levee as within the Special Flood Hazard Area (SFHA).

FEMA has identified the Moccasin Diversion (MD), sometimes referred to as the Upper Las Vegas Wash Interception Berm/Channel, as one of several levee structures in Clark County, Nevada that provide flood protection and impact the flood hazard information presented on the effective flood maps. The MD has been assigned unique levee ID number of 800 by FEMA. FEMA has requested that this structure be investigated to determine if it can be reaccredited as compliant with the CFR 65.10 criteria. On January 8, 2009 the Clark County Regional Flood Control District (CCRFCD) entered into an Agreement for Professional Services with PBS&J to compile a levee documentation package and evaluate the MD relative to the criteria outlined in CFR 65.10.

This effort involved field inspection of the structure, and collecting, developing, and working with effective Flood Insurance Study data, available design data, as-built plans, construction testing, geotechnical data, operation and maintenance manuals, hydrologic and hydraulic data, existing topography, and survey data of the structure. This data was used to determine if the structure is compliant with established levee criteria (CFR 65.10) and to support the recommendation that the structure should continue to be accredited by FEMA.

This report has been prepared to summarize the results of this investigation and to present the MD data and documentation related to the minimum design, operation, and maintenance standards as specified in CFR 65.10. The applicable FEMA criteria for the MD includes requirements for freeboard, embankment protection, embankment and foundation stability, and settlement.

1.2. Report Organization

As discussed above, this report has been prepared to document and describe the evaluation of the MD, to determine compliance with the criteria outlined in CFR 65.10, and to present the basis for recommending that the subject levee be reaccredited. The following is a basic outline of the information presented herein:

- Section 2 – Overview of applicable design criteria from CFR 65.10
- Section 3 – Engineering analysis (survey data, site visits, H&H analysis, etc.)
- Section 4 – Geotechnical evaluation summary

References are listed at the end of the report followed by the appendices. Essential portions of the appendices have been printed and included in hard copy format. Other supporting information and reference material has been provided electronically on a CD at the end of the report for practical purposes. The Appendices page at the beginning of this report identifies the files and material included electronically on the CD. An electronic version (PDF file) of the entire report is also included on the CD.

1.3. Levee Description

FEMA has indicated that the MD along the Upper Las Vegas Wash is one of the structures in Clark County, Nevada which they believe warrants reaccreditation. This structure is located in the far northwest portion of the Las Vegas Valley, starting at a point 2,000 feet east of the intersection of Durango Drive and Moccasin Road and extending approximately 1.75 miles to the east (see **Figure 1-1**). FEMA has assigned an identification number of 800 to the MD, which is owned, maintained, and operated by the City of North Las Vegas (CNLV) while the City of Las Vegas (CLV) is the responsible community. This facility is located within Sections 1 through 4 of T19S, R60E. The MD structure was constructed to intercept tributary runoff and convey it east to the Upper Las Vegas Wash Detention Basin (ULVDB), which is located approximately 1.2 miles southeast of the downstream end of the MD. The MD is also known as the Upper Las Vegas Wash Interception Berm/Channel.

The MD is currently designated as a Provisionally Accredited Levee (PAL). A PAL is a levee that FEMA has previously accredited as providing flood protection on a flood map and for which FEMA is awaiting data/documentation to demonstrate that the levee system is compliant with CFR 65.10. This designation allows a levee to continue to be shown on a DFIRM as providing flood protection while the levee owner or community compiles the data/documentation. The area landside of the PAL is shown on the flood map as shaded Zone X (outside of the SFHA).

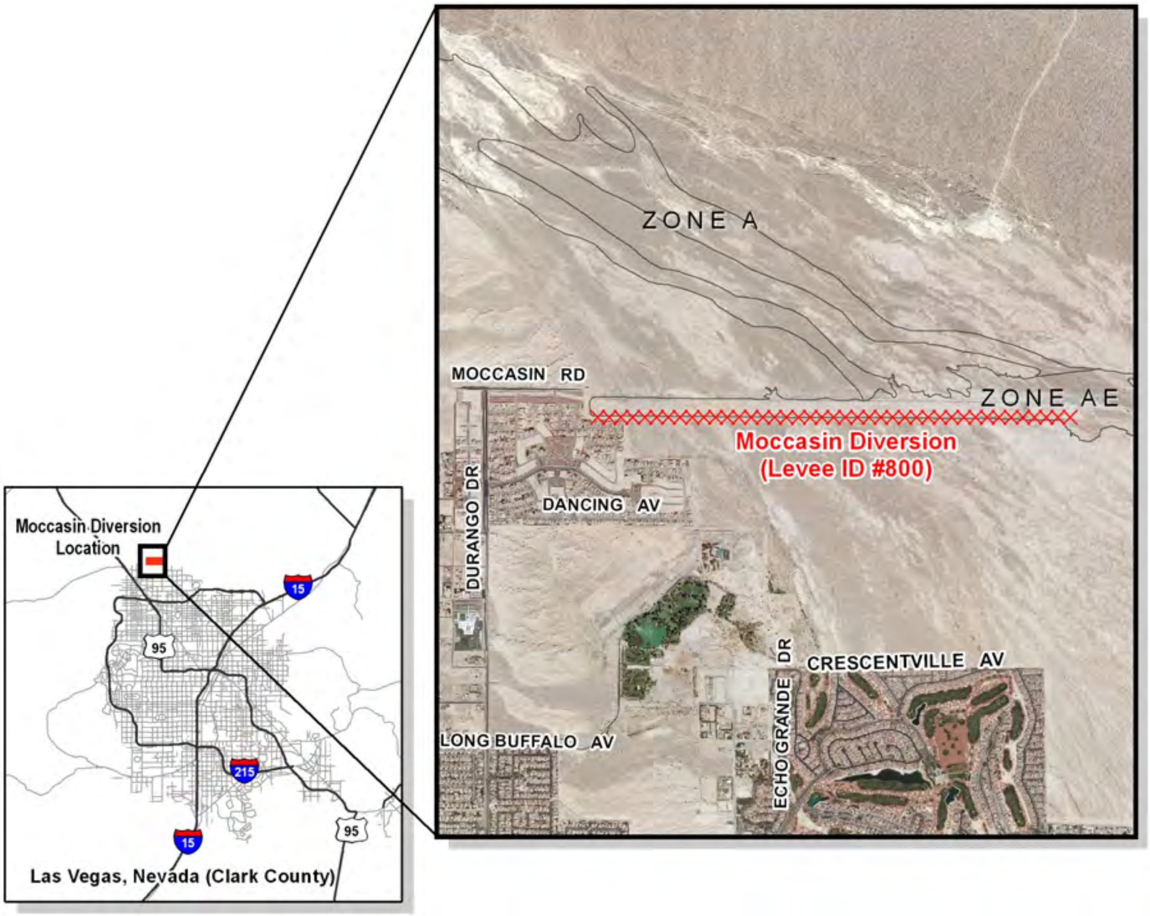


Figure 1-1 Moccasin Diversion Location and Vicinity Map

In a letter dated September 17, 2008, FEMA gave the CNLV and CLV the opportunity to receive PAL designation for this levee. CNLV (owner) and CLV (community) signed the PAL agreement for this levee and submitted it to FEMA with the required attachments. Afterward, FEMA accepted the agreement and confirmed PAL status for this levee in a letter dated January 29, 2009. A copy of this letter and the PAL agreement form is included in **Appendix III**, and a summary of the important milestones and dates for reaccreditation of this levee is provided in **Table 1-1**.

Table 1-1 Key Milestones for Moccasin Diversion Reaccreditation

Date	Milestone
9/17/2008	Date of FEMA PAL offer letter
12/11/2008	Date that the community/levee owner signed the PAL Agreement
12/18/2008	Date that FEMA received the signed PAL Agreement
12/16/2008	90-day deadline of PAL offer period and start date of 2-year PAL period
12/16/2009	1-year deadline for submitting progress report to FEMA
12/16/2010	2-year deadline for submitting all 44 CFR 65.10 data to FEMA

The MD is an earthen diversion structure consisting of an 8- to 10-foot high embankment approximately 9,300 feet in length with a 12-inch thick roller-compacted concrete (RCC) lining protecting the north (waterside) face. The diversion structure was designed with a 3:1 side slope (horizontal to vertical) on the waterside and a variable side slope on the landside no steeper than 3:1. The crest of the structure is unpaved and varies in width from 13 feet to greater than 30 feet. The crest also serves as the access road for operation and maintenance vehicles. Typical MD levee characteristics are provided on the next page in **Table 1-2**.

Constructed in conjunction with the MD, the associated interception and diversion channel is an earthen channel that runs adjacent to the waterside toe-of-levee; therefore, the levee embankment also serves as the channel's right bank while looking in the downstream direction. Typical channel characteristics are summarized in **Table 1-3**.

Table 1-2 Typical Moccasin Diversion Characteristics

Levee Characteristic	Description
Cross-Section	Trapezoidal
Length	Approximately 1.75 miles
Height	Approximately 8-10 feet
Levee Top Width	Approximately 13 feet to 30 feet
Side Slope (landside)	3.5H:1V or flatter
Side Slope (waterside)	Approximately 3H:1V
Embankment Armoring	12-inch RCC

Table 1-3 Typical Moccasin Diversion Channel Characteristics

Channel Characteristic	Description
Cross-Section	Trapezoidal
Bottom Width	Approximately 300 feet
Side Slope (left bank)	Approximately 3H:1V
Side Slope (right bank)	Approximately 3H:1V
Channel Bottom Lateral Slope	Flat
Longitudinal Slope	0.67%
Embankment Armoring	12-inch RCC (right bank only)

This structure was planned in 1989 when Black and Veatch submitted a flood control planning study to CNLV recommending MD as a part of a broader network of facilities to control flooding on the Las Vegas Wash. Due to the ephemeral nature of the Upper Las Vegas Wash and the relative infrequency with which this area receives rainfall, the MD and ULVDB are dry between storm events. The MD and ULVDB facilities were ultimately designed by Black and Veatch and construction was completed in October 1993.

In December of 1995, Northwest Hydraulic Consultants (NHC) was selected by FEMA to perform a detailed flood insurance re-study of the flood hazard areas in Clark County, Nevada. The purpose was to evaluate flood hazard areas in the developed areas of the community or those areas which were likely to develop in the near future. The study area included the area tributary to the MD. NHC presented their results in the Upper Las Vegas Wash Flood Insurance Restudy (Technical Support Data Notebook, Volumes 1-10, April 20th, 1998).

Following the completion of the Upper Las Vegas Wash Flood Insurance Restudy, a Letter of Map Revision (LOMR) was issued by FEMA on February 16th, 1999. This LOMR was issued to show the effects of the MD and other flood control projects constructed in the watershed, as documented in the Restudy. The MD is shown on the current, effective Flood Insurance Rate Map (FIRM) Panel Number(s) 32003C1734 E and 32003C1753 E dated September 27, 2002. Refer to **Appendix III** for a copy of the LOMR and the effective FIRM Maps (in FIRMette format).

1.4. Project Team and Coordination

This Technical Support Data Notebook (TSDN) was prepared by PBS&J in association with Kleinfelder. As the Prime Consultant, PBS&J was responsible for the coordination, management, progress, and development of the data and documentation presented herein. Specifically, PBS&J evaluated the design criteria related to freeboard and embankment protection. The main tasks preformed by PBS&J included:

- Data collection and review
- Detailed field surveys and investigation
- On-site inspections and coordination with maintenance personnel
- Hydrologic and hydraulic analysis
- Review of Operation and Maintenance Manual
- Documentation and report preparation
- Researching past flood performance data

Kleinfelder was responsible for geotechnical investigation and all geotechnical analysis/review related to the levee evaluation effort. Kleinfelder performed a geotechnical study of the MD to obtain subsurface information within the levee embankment and underlying foundation materials and to evaluate if the levee meets FEMA geotechnical requirements as outlined in CFR 65.10. Specifically, Kleinfelder focused on assessing levee seepage and stability for the 100-year design water surface elevation (WSE) and flood duration, provided by PBS&J. Settlement potential was also evaluated. The study performed by Kleinfelder included:

- Reviewing previous geotechnical work performed during design and construction of the MD structure
- Site reconnaissance and a geotechnical inspection of the MD structure

- Drilling six exploratory borings along the alignment on the levee crest
- Conducting laboratory testing on representative samples obtained from the borings
- Conducting seepage and slope stability analyses using SEEP/W and SLOPE/W computer programs, respectively
- Evaluating settlement potential

The compilation, review, and assessment of all necessary levee data and documentation were performed in close coordination with CCRFCD staff and other representatives from the CNLV and the CLV. Many progress meeting were held and representatives of these agencies were informed of project progress and given the opportunity to review and comment on the information collected and developed during the course of the project.

1.5. Flood Performance History

Interviews with representatives of CCRFCD, CNLV, and CLV indicate that only minor maintenance has been required since the time of construction.

A significant storm occurred during the week of July 20-24, 1998, when 1.73 inches of total rainfall were recorded at CCRFCD rain gage 4044 (Castle Rock), which is located just upstream of the MD. The most intense rainfall to impact the MD during this week occurred on the evening of July 23rd, when a fairly intense storm moved across the north edge of the Las Vegas Valley. Gage 4044 recorded more than 0.6 inches in 15 minutes, while other CCRFCD gages in the area recorded more than one inch of rainfall in a 20 minute period. These rainfall depths and intensities are roughly equivalent to a 10-year recurrence interval, based on Table 505 in the CCRFCD Drainage Design Manual.

A drive-by inspection of flood control facilities associated with the Upper Las Vegas Wash Detention Basin was performed after this storm and indicated that the facilities functioned as designed with no major problems reported. For more information about this storm, refer to the Rainfall Event Report (in **Appendix IV**) prepared by Tim Sutko, Hydrologist, CCRFCD.

PBS&J also reviewed rainfall gage data from other CCRFCD weather stations in the vicinity of the MD. Based on the gage data, another significant rainfall event in the vicinity of the MD occurred in December 2004, with a 24-hour total rainfall depth of 1.69 inches, which is roughly equivalent to a 5-year recurrence interval according to Table 505 in the CCRFCD Drainage Design Manual. No significant maintenance was necessary after the storm.

Section 2

CFR 65.10 Design Criteria

FEMA is verifying that all levees recognized as providing protection from the base flood meet the requirements outlined in CFR 65.10. This section of the report presents a general overview of the design criteria in relation to the MD.

Direct excerpts from CFR 65.10 are quoted throughout this section in *"italics"*. The specific paragraph letter/number from CFR 65.10 is shown in bold at the beginning of each excerpt. Below each excerpt is a brief summary discussion of the key considerations and conclusions related to compliance of the MD. More detailed documentation and engineering analysis is presented in subsequent sections of this report and/or in the appendices.

2.1. General

(a). *For purposes of the NFIP, FEMA will only recognize in its flood hazard and risk mapping effort those levee systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with the level of protection sought through the comprehensive flood plain management criteria established by §60.3 of this subchapter. Accordingly, this section describes the types of information FEMA needs to recognize, on NFIP maps, that a levee system provides protection from the base flood. This information must be supplied to FEMA by the community or other party seeking recognition of such a levee system at the time a flood risk study or restudy is conducted, when a map revision under the provisions of part 65 of this subchapter is sought based on a levee system, and upon request by the Administrator during the review of previously recognized structures. The FEMA review will be for the sole purpose of establishing appropriate risk zone determinations for NFIP maps and shall not constitute a determination by FEMA as to how a structure or system will perform in a flood event.*

2.2. Design Criteria

(b). *For levees to be recognized by FEMA, evidence that adequate design and operation and maintenance systems are in place to provide reasonable assurance that protection from the base flood exists must be provided.*

2.2.1. Freeboard

Riverine Levees

(b)(1)(i). *Riverine levees must provide a minimum freeboard of three feet above the water-surface level of the base flood. An additional one foot above the minimum is required within 100 feet in either side of structures (such as bridges) riverward of the levee or wherever the flow is constricted. An additional one-half foot above the minimum at the upstream end of the levee, tapering to not less than the minimum at the downstream end of the levee, is also required.*

PBS&J performed a survey of the MD in September 2009 to support the hydraulic evaluation and assessment of levee freeboard. The survey data consisted of cross-sections at 24 locations, including survey of the landside top/toe of levee, waterside top/toe of levee, crest widths/elevations, adjacent channel geometry and embankment, and other points as necessary to adequately define the levee geometry.

After the survey data was obtained, it was reviewed and compared to the as-built data to verify that the as-built plans reasonably reflect the current condition of the MD. Based on the comparison, the existing levee geometry is comparable to the design levee geometry as shown on the as-built plans. This structure is approaching 17 years in age and the comparison revealed no signs of long-term aggradation or degradation trends.

Using the survey data, an updated hydraulic model of the MD was created for use in the assessment of freeboard. The 100-year flow input into the HEC-RAS model was based on the FIS discharge from the 1998 Upper Las Vegas Wash Flood Insurance Restudy, prepared by NHC, dated April 20, 1998. The model was executed and a freeboard analysis was performed by comparing the levee crest elevation, toe elevation, and 100-year water surface in tabular format and plotting a levee profile.

The results of this analysis show that the MD is compliant with the CFR 65.10 requirement of having a minimum freeboard of 3 feet above the base flood elevation (or 100-year WSE) along the entire length of the levee and an additional one-half foot at the upstream end.

Note that additional analysis and review was performed to consider the effects of potential long-term degradation/aggradation trends which could limit or reduce available freeboard. The analysis confirmed that deposition will not occur and that sediment will not negatively impact or reduce available freeboard.

Refer to **Section 3** for more information about the survey data comparisons, the H&H analysis, the assessment of freeboard, and the sediment considerations. The as-built plans for the MD are included in **Appendix II.**

Exceptions

(b)(1)(ii). *Occasionally, exceptions to the minimum riverine freeboard requirement described in paragraph (b)(1)(i) of this section, may be approved. Appropriate engineering analyses demonstrating adequate protection with a lesser freeboard must be submitted to support a request for such an exception. The material presented must evaluate the uncertainty in the estimated base flood elevation profile and include, but not necessarily be limited to an assessment of statistical confidence limits of the 100-year discharge; changes in stage-discharge relationships; and the sources, potential, and magnitude of debris, sediment, and ice accumulation. It must be also shown that the levee will remain structurally stable during the base flood when such additional loading considerations are imposed. Under no circumstances will freeboard of less than two feet be accepted.*

Riverine freeboard exceptions are not anticipated for this levee system.

Coastal Levees and Exceptions

(b)(1)(iii). *For coastal levees, the freeboard must be established at one foot above the height of the one percent wave or the maximum wave run-up (whichever is greater) associated with the 100-year stillwater surge elevation at the site.*

(b)(1)(iv). *Occasionally, exceptions to the minimum coastal levee freeboard requirement described in paragraph (b)(1)(iii) of this section, may be approved. Appropriate engineering analyses demonstrating adequate protection with a lesser freeboard must be submitted to support a request for such an exception. The material presented must evaluate the uncertainty in the estimated base flood loading conditions. Particular emphasis must be placed on the effects of wave attack and overtopping on the stability of the levee. Under no circumstances, however, will a freeboard of less than two feet above the 100-year still water surge elevation be accepted.*

This requirement is not applicable for this levee system.

2.2.2. Closures

(b)(2). *All openings must be provided with closure devices that are structural parts of the system during operation and design according to sound engineering practice.*

No openings exist on the MD. This requirement is not applicable for this levee system.

2.2.3. Embankment Protection

(b)(3). *Engineering analyses must be submitted that demonstrate that no appreciable erosion of the levee embankment can be expected during the base flood, as a result of either currents or waves, and that anticipated erosion will not result in failure of the levee embankment or foundation directly or indirectly through reduction of the seepage path and subsequent instability. The factors to be addressed in such analyses include, but are not limited to: Expected flow velocities (especially in constricted areas); expected wind and wave action; ice loading; impact of debris; slope protection techniques; duration of flooding at various stages and velocities; embankment and foundation materials; levee alignment, bends, and transitions; and levee side slopes.*

NHC included a summary of design and supporting documents in the Upper Las Vegas Wash Flood Insurance Restudy (1998 TSDN). In a summary letter to Les Sakumoto, FEMA Region IX, dated August 29, 1996, it states that the Black and Veatch pre-design and supplemental material to the CLOMR (by Black and Veatch, 1991) indicated channel velocities along the adjacent channel of 10 to 11 feet per second. The effective hydraulic model completed for the 1998 TSDN suggests that discharges within the channel adjacent to the levee are subcritical (with only one location indicating critical depth in the subcritical model). Velocities vary from 7.9 to 11.3 feet per second.

The updated hydraulic model prepared by PBS&J produced similar results with velocities ranging from 8.8 to 11.9 feet per second. Therefore, higher velocities associated with supercritical flow are not anticipated adjacent to the levee.

The MD waterside slope face (north side) is protected with a 12-inch thick RCC lining. The RCC lined embankment has a toe down (RCC slope protection below grade) which extends 6 feet vertically below (or 18 feet parallel to slope) the channel invert. Based on field investigations, the RCC armoring is intact with no major cracking or significant deficiencies. Based on the Table 703 – Maximum Permissible Mean Channel Velocities – in the CCRFCD Drainage Design

Manual, embankments that are fully lined with this material are stable when experiencing the anticipated flow velocities described above.

Erosion resulting from wind and wave action, ice loading, and debris impact is not expected. Further, the MD alignment is relatively straight with no curves substantial enough to cause local erosion as a result of flow around a bend or transition.

Major storm events occurring within the arid southwest are typically short in duration. Accordingly, the design storm used within the jurisdiction of CCRFCD Design Manual is the 6-hour duration storm. Therefore, a prolonged, multi-day flood scenario impacting the embankment protection along the MD is not anticipated. The geotechnical analysis indicates that only the outermost portions of the waterside slope would be saturated during the limited time of the design flood.

The MD meets the embankment protection criteria based on the anticipated flow velocity, straight alignment of the levee, thickness of the RCC, and the relatively good condition of the lining noted during field observations. No appreciable erosion of the levee embankment is expected during the base flood.

2.2.4. Embankment and Foundation Stability

(b)(4). *Engineering analyses that evaluate levee embankment stability must be submitted. The analyses provided shall evaluate expected seepage during loading conditions associated with the base flood and shall demonstrate that seepage into or through the levee foundation and embankment will not jeopardize embankment or foundation stability. An alternative analysis demonstrating that the levee is designed and constructed for stability against loading conditions for Case IV as defined in the U.S. Army Corps of Engineers (COE) manual, ''Design and Construction of Levees'' (EM 1110–2–1913, Chapter 6, Section II), may be used. The factors that shall be addressed in the analyses include: Depth of flooding, duration of flooding, embankment geometry and length of seepage path at critical locations, embankment and foundation materials, embankment compaction, penetrations, other design factors affecting seepage (such as drainage layers), and other design factors affecting embankment and foundation stability (such as berms).*

Kleinfelder was responsible for the assessment and evaluation of embankment and foundation stability. For more detailed information about their geotechnical evaluation, refer to **Section 4** and the supporting documentation in **Appendix I**. The Kleinfelder analysis concluded that the MD was found to be stable as required by CFR 65.10.

2.2.5. Settlement

(b)(5). *Engineering analyses must be submitted that assess the potential and magnitude of future losses of freeboard as a result of levee settlement and demonstrate that freeboard will be maintained within the minimum standards set forth in paragraph (b)(1) of this section. This analysis must address embankment loads, compressibility of embankment soils, compressibility of foundation soils, age of the levee system, and construction compaction methods. In addition, detailed settlement analysis using procedures such as those described in the COE manual, ''Soil Mechanics Design— Settlement Analysis'' (EM 1100–2–1904) must be submitted.*

Kleinfelder was responsible for the assessment and evaluation of settlement potential. For more detailed information about their geotechnical evaluation, refer to **Section 4** and the supporting documentation in **Appendix I**.

Based on the geotechnical evaluation, settlement is anticipated to be complete and therefore, sufficient freeboard will be maintained. An excerpt from Kleinfelder's report discussing settlement is provided below as a summary:

"The levee was constructed over ten years ago. Load-related settlement of the clayey foundations soil is anticipated to be complete. Soil deposits associated with a low to moderate hydrocollapse potential are present in the site area. Based on the hydrocollapse test results performed in 1991 as part of the MD and ULVDB project and the results of the 2009 exploration, we estimate that a future collapse potential of up to two inches may exist. No evidence of settlement of the MD structure or other ground surface irregularities associated with hydrocollapse, such as sinkholes, were noted during our site visits." (Page 35 of 43)

2.2.6. Interior Drainage

(b)(6). *An analysis must be submitted that identifies the source(s) of such flooding, the extent of the flooded area, and, if the average depth is greater than one foot, the water-surface elevation(s) of the base flood. This analysis must be based on the joint probability of interior and exterior flooding and the capacity of facilities (such as drainage lines and pumps) for evacuating interior floodwaters.*

This requirement is not applicable for this levee system because the MD does not have any openings and diverts runoff east directly to the Upper Las Vegas Wash Detention Basin.

An interior drainage area is defined as an area protected from direct riverine, lake, or tidal flooding by levees. Levees do not alleviate flooding that may occur from interior runoff and may aggravate the problem of interior flooding by blocking natural drainage paths or outlets. Interior drainage systems usually include facilities (e.g., storage areas, gravity outlets, pumping stations, or a combination thereof) to evacuate interior floodwaters that are stored in depressed areas or natural sinks. The MD system does not include any of these types of facilities and the area protected by the levee has positive drainage to the south (i.e., no depressions or interior drainage areas).

2.2.7. Other Design Criteria

(b)(7). *In unique situations, such as those where the levee system has relatively high vulnerability, FEMA may require that other design criteria and analyses be submitted to show that the levees provide adequate protection. In such situations, sound engineering practice will be the standard on which FEMA will base its determinations. FEMA will also provide the rationale for requiring this additional information.*

This requirement is not applicable for this levee system.

2.3. Operation Plans and Criteria

***(c).** For a levee system to be recognized, the operational criteria must be as described below. All closure devices or mechanical systems for internal drainage, whether manual or automatic, must be operated in accordance with an officially adopted operation manual, a copy of which must be provided to FEMA by the operator when levee or drainage system recognition is being sought or when the manual for a previously recognized system is revised in any manner. All operations must be under the jurisdiction of a Federal or State agency, an agency created by Federal or State law, or an agency of a community participating in the NFIP.*

This requirement is not applicable for this levee system.

2.3.1. Closures

***(c)(1).** Operation plans for closures must include the following:*

***(c)(1)(i).** Documentation of the flood warning system, under the jurisdiction of Federal, State, or community officials, that will be used to trigger emergency operation activities and demonstration that sufficient flood warning time exists for the completed operation of all closure structures, including necessary sealing, before floodwaters reach the base of the closure.*

***(c)(1)(ii).** A formal plan of operation including specific actions and assignments of responsibility by individual name or title.*

***(c)(1)(iii).** Provisions for periodic operation, at not less than one-year intervals, of the closure structure for testing and training purposes.*

2.3.2. Interior Drainage Systems

***(c)(2).** Interior drainage systems associated with levee systems usually include storage areas, gravity outlets, pumping stations, or a combination thereof. These drainage systems will be recognized by FEMA on NFIP maps for flood protection purposes only if the following minimum criteria are included in the operation plan:*

***(c)(2)(i).** Documentation of the flood warning system, under the jurisdiction of Federal, State, or community officials, that will be used to trigger emergency operation activities and demonstration that sufficient flood warning time exists to permit activation of mechanized portions of the drainage system.*

***(c)(2)(ii).** A formal plan of operation including specific actions and assignments of responsibility by individual name or title.*

***(c)(2)(iii).** Provision for manual backup for the activation of automatic systems.*

***(c)(2)(iv).** Provisions for periodic inspection of interior drainage systems and periodic operation of any mechanized portions for testing and training purposes. No more than one year shall elapse between either the inspections or the operations.*

This requirement is not applicable for this levee system.

2.3.3. Other Operation Plans and Criteria

***(c)(3).** Other operating plans and criteria may be required by FEMA to ensure that adequate protection is provided in specific situations. In such cases, sound emergency management practice will be the standard upon which FEMA determinations will be based.*

This requirement is not applicable for this levee system.

2.4. Maintenance Plans and Criteria

(d). *For levee systems to be recognized as providing protection from the base flood, the maintenance criteria must be as described herein. Levee systems must be maintained in accordance with an officially adopted maintenance plan, and a copy of this plan must be provided to FEMA by the owner of the levee system when recognition is being sought or when the plan for a previously recognized system is revised in any manner. All maintenance activities must be under the jurisdiction of a Federal or State agency, an agency created by Federal or State law, or an agency of a community participating in the NFIP that must assume ultimate responsibility for maintenance. This plan must document the formal procedure that ensures that the stability, height, and overall integrity of the levee and its associated structures and systems are maintained. At a minimum, maintenance plans shall specify the maintenance activities to be performed, the frequency of their performance, and the person by name or title responsible for their performance.*

CNLV has adopted the CCRFCD’s Operation and Maintenance Manual (O&M Manual) and is in compliance with maintenance criteria set forth in CFR 65.10.

The MD is eligible for CCRFCD’s operation and maintenance funding because it is identified on CCRFCD’s master plan of flood control facilities. Each year, CNLV executes a Maintenance Work Program interlocal funding contract and identifies this levee structure, among many others, for inspection and maintenance.

It should be noted that the O&M Manual was recently reviewed and revised by CCRFCD staff and the consultant team during this levee accreditation effort to ensure that maintenance activities described therein provide clear and comprehensive guidance on proper maintenance of levees. The revised O&M manual will be officially adopted in August, 2010. The final draft version of the revised O&M manual and the associated contract with CNLV are included in **Appendix IV**.

During this project, several maintenance inspections were performed on site with CNLV maintenance personnel to identify and correct any deficiencies along the MD. A post-maintenance inspection was also conducted to verify that the all identified deficiencies were remediated. Additional information about the site visits and maintenance inspections is included in **Section 3**.

2.5. Compliance Determination Summary

The data and documentation presented in this report show that the MD complies with the structural requirements set forth in CFR 65.10 paragraphs (b)(1) through (7) and has been sealed by the professional engineers responsible for its development (refer to cover letters at the beginning of the report).

The compilation, review, and assessment of all necessary levee data and documentation were performed in close coordination with CCRFCD staff and other representatives from CNLV and CLV. CCRFCD, CLV, and CNLV reviewed this TSDN and concur with the compliance determination.

Table 2-1 is a compliance checklist for the MD that summarizes the design, operation, and maintenance criteria as specified in CRF 65.10.

Table 2-1 CFR 65.10 Compliance Summary Table – Moccasin Diversion

44 CFR 65.10 Section Number	Criteria Description	Not Applicable	Acceptable	Unacceptable
Design Criteria (b)				
(b)(1)	3-ft minimum freeboard above BFE		X	
(b)(1)	Additional 1-ft freeboard within 100-ft of structures/constrictions	X		
(b)(1)	Additional 0.5-ft freeboard at upstream end of levee (tie-in)		X	
(b)(2)	All openings protected with closure devices	X		
(b)(3)	Embankment erosion protection analysis		X	
(b)(4)	Embankment and foundation stability analysis		X	
(b)(5)	Settlement analysis		X	
(b)(6)	Interior drainage analysis	X		
(b)(7)	Other design criteria and analyses (unique situations)	X		
Operation Plans and Criteria (c)				
Closures				
(c)(1)(i)	Documentation of flood warning system	X		
(c)(1)(ii)	Formal plan of operation	X		
(c)(1)(iii)	Provisions for periodic operation for testing/training (at least annual)	X		
Interior Drainage Systems				
(c)(2)(i)	Documentation of interior drainage flood warning system	X		
(c)(2)(ii)	Formal plan of operation for interior drainage	X		
(c)(2)(iii)	Provisions for manual backup for activation of automatic systems	X		
(c)(2)(iv)	Provisions for periodic operation for testing/training (at least annual)	X		
(c)(3)	Other operation plans and criteria required in specific situations	X		
Maintenance Plans and Criteria (d)				
(d)	Levee system maintained in accordance with officially adopted plan		X	
(d)	Copy of maintenance plan provided to FEMA		X	
(d)	Maintenance under jurisdiction of Federal/State/Community in NFIP		X	
(d)	Plan documents formal procedure to ensure structural integrity		X	
(d)	Plan specifies type of activities, frequency, and person responsible		X	
Certification Requirements (e)				
(e)	Certified as-built plans		X	

Section 3
Engineering Analysis

This section includes a summary of the data collection, field reconnaissance, engineering analysis, and investigations that were performed to determine compliance and support the recommendation to reaccredit the MD.

3.1. Summary of Collected Data

Several documents were collected and reviewed in relation to the design and construction of the MD. Requests were made for all available information from CCRFCD, CLV and CNLV. A summary of the relevant data collected is provided in **Table 3-1** below. The documents listed in the table are included in the appendix in either electronic or hard copy format for reference.

Table 3-1 Summary of Collected Data for the Moccasin Diversion

Document Title	Prepared By	Date	Appendix
Upper Las Vegas Wash Detention Basin and Interception Berm/Channel Record Drawings/As-Builts	Black and Veatch	10/26/93	II
Upper Las Vegas Wash Flood Insurance Restudy, Volume(s) 1 - 10	Northwest Hydraulic Consultants, Inc.	4/20/98	VI
Bid Opening: Bid No. 817, Clark County Regional Flood Control District	Black & Veatch	3/10/92	VI
Geotechnical Investigation, Proposed Upper Las Vegas Wash Detention Basin Cark County, Nevada	Kleinfelder	5/6/91	VI
Construction Quality Control Testing Results, Volume 1	Kleinfelder	6/92 – 6/93	VI
FEMA Letters (LOMR) for 1998 FIS	FEMA	9/17/99	III
FEMA FIRM Panel No.(s) 1753 E and 1734 E	FEMA	9/17/02	III
Predesign Report for the Upper Las Vegas Wash Detention Basin	Black and Veatch	3/30/91	V
Provisionally Accredited Levee Agreement Form (PAL Agreement)	CLV, Public Works/Engineering	12/10/08	III
FEMA Response to signed PAL Agreement	FEMA	1/29/09	III

3.2. Field Reconnaissance

An inspection of the MD was conducted by PBS&J on March 4th, 2009. A separate geotechnical inspection of the MD was performed by Kleinfelder on March 25th, 2009 in order to assess the condition of the structure relative to geotechnical factors outlined in CFR 65.10. A summary of Kleinfelder's observations and descriptions from their inspection are included in **Section 2** of the Geotechnical Evaluation Report included **Appendix I**. PBS&J's observations from the field inspection are summarized below. Photographs from the field visit as well as a Photograph Location Figure are provided in **Appendix IV**.

The field inspection performed by PBS&J focused on apparent, surficial levee and channel conditions that relate to the established FEMA levee criteria. Overall, the integrity of the structure appeared to be intact and functioning as designed. The waterside of the levee did not show any signs of significant sedimentation or aggradation. There were some locations near the toe of the waterside levee face where minor erosion was observed (refer to photo location 7425 in **Appendix IV**). This minor erosion appeared to be localized and likely the result of storm water runoff from the crest of the structure which was conveyed down the waterside face and longitudinally along the toe. The as-built drawings indicate that the RCC lining extends for an additional 6 (vertical) feet below the finished channel grade. Therefore, these areas of local erosion do not appear to threaten the structural integrity of the MD.

Signs of channel flow were evident in certain areas that were cracking due to the drying of previously saturated clay and silt channel material. These areas were generally located toward the center of the channel and indicate that during typical storm events ponding is not encountered against the levee. With a few exceptions, the waterside RCC lining was in good condition. The lining did appear to have some minor cracking of the sort normally associated with concrete curing and shrinkage (refer to photo locations 7361, 7439).

Vegetation within the channel and on the embankment ranged from light to moderate. Generally, there was very little vegetation observed on the crest of the levee structure (refer to photo locations 7361 – 7482). The vegetation did not appear to threaten the structural integrity of the levee or the conveyance capacity of the channel.

Some rutting and pot-holing present along portions of the levee crest were observed during the field inspection as well as three locations where such rutting/pot-holing appeared to cause some minor erosion on the landside (south) face. At these locations, ponded storm water appears to flow through the top of the embankment before breaking out onto the landside face of the structure, causing some minor piping, erosion, and rutting (refer to photo locations 7451, 7453, 7461, 7463). After the initial field inspection, a PBS&J biologist performed an independent survey of the MD on October 6, 2009 in order to specifically identify, document, and evaluate any animal burrowing activity on the MD. Two of the piping locations described in the paragraph above were judged to be related to animal activity, but no other animal-created penetrations were identified. Locations of the animal burrows were provided to CNLV for maintenance purposes.

The vegetation, erosion, rutting, pot-holing, and piping/burrows that were observed in the field were considered minor maintenance issues. Following the field inspections by PBS&J and Kleinfelder, representatives and maintenance personnel from CNLV met on site at the MD with representatives from CCRFCD, PBS&J, and Kleinfelder to go over the identified deficiencies, develop an action plan for addressing such deficiencies, and to coordinate levee maintenance-related activities. A copy of the attendee sign in sheet from this on-site maintenance coordination meeting is provided in **Appendix IV**.

Subsequent maintenance activities on the MD were completed by CNLV by March 2010. Photographs were taken to document the post-maintenance condition of the MD (refer to **Appendix IV**). Post maintenance inspections indicate that all deficiencies observed by Kleinfelder and PBS&J in March 2009 have been corrected.

3.3. Survey

PBS&J performed a survey of the MD in September 2009 to support the H&H analysis, geotechnical evaluation, and assessment of levee freeboard. Survey data was also used to verify that the existing condition geometry was consistent with as-built plans and to assess sedimentation impacts/trends over time.

The field survey services were completed under the supervision of a Nevada Professional Land Surveyor. Survey data consisted of cross-sections at 24 locations, including survey of the landside top/toe of levee, waterside top/toe of levee, crest widths/elevations, adjacent channel geometry and embankment, and other points as necessary to adequately define the levee geometry, grade breaks, transitions, etc. The horizontal survey datum was based on U.S. State Plane, Nevada East Zone, NAD 1983 datum. The elevation values in the survey data were referenced to the North American Vertical Datum of 1988 (NAVD88). When necessary, elevation values (from as-built plans, hydraulic models, etc.) were converted from the National Geodetic Vertical Datum of 1929 (NGVD29) to NAVD88 by adding 2.43 feet. This datum conversion was provided in a letter by Kenney Aerial Mapping Inc. documented in the 1998 TSDN. This letter is provided in **Appendix V**.

When the survey data was obtained, each surveyed cross section had a unique ID, ranging from 2 to 25, starting at the most downstream section. **Figure 1** in **Appendix V** (in the Survey folder) shows the locations and identification number for each of the surveyed cross sections. An electronic version of the survey data is also provided in **Appendix V**. Note that graphical depictions of all levee cross sections and detailed summaries of survey geometry and slope configurations are presented in the Geotechnical Evaluation Report in **Appendix I**.

The survey data was reviewed and compared to the as-built drawings and the 1998 TSDN effective hydraulic model. The Work Maps (Sheets 1-2), dated April 6th, 1998, provided in the TSDN show the cross section locations in the effective hydraulic model and were used to identify comparable surveyed cross sections. **Table 3-2** contains a list of the surveyed cross sections and comparable as-built stations and HEC-2 cross sections.

Comparable cross sections were not in identical locations, but they were judged to be close enough in proximity for reasonable comparison purposes (generally less than 60 feet apart).

Table 3-2 Cross Section ID and Corresponding Stations

Approximate As-Built Station	Survey Cross Section ID	Approximate HEC-2 Cross Section Station
3+20	25	74997
7+70	24	
9+00	23	
14+20	22	73765
16+20	21	
20+60	20	
26+50	19	72532
28+60	18	
32+80	17	
38+20	16	
41+40	15	71045
45+30	14	
51+50	13	
56+30	12	69560
63+40	11	
69+90	10	68187
74+20	9	
79+00	8	
84+00	7	66814
84+10	6	
84+40	5	
85+40	4	
85+80	3	66660
91+10	2	66061

*HEC-2 Cross Section ID relates to the identification numbers on the Work Maps provided in the 1998 TSDN. The Survey Cross Section ID relates to the identification numbers on Figure E-1. The As-built station related to the stationing as shown on the as-built plans.

Survey data was tabulated and a plot of the longitudinal profile of the MD was developed to compare the waterside top/toe levee elevations based on the survey data, HEC-2 data, and typical sections from the as-built drawings. The profiles of these three data sets are displayed on **Figure 2** in **Appendix V**. Based on the figure, the existing levee elevations are comparable to the design elevations. This structure is approaching 17 years in age and the profile shows only minor scour and no signs of long-term aggradation or degradation trends. Based on the overlay of the as-built data and the HEC-2 model data on the survey data, the design drawings appear to reasonably reflect the current condition of the MD.

3.4. Hydrologic Analysis

In December of 1995, NHC was selected by FEMA to perform a detailed flood insurance re-study of the flood hazard areas in Clark County, Nevada. The purpose was to evaluate flood hazard areas in the developed areas of the community or those areas which were likely to develop in the near future. The results of the flood insurance re-study were documented in the Technical Support Data Notebook (TSDN, volumes 1-10) dated April 20th, 1998.

The FIS discharges developed by NHC were based on the original hydrology (HEC-1) models prepared by James M. Montgomery (1991) and Black & Veatch (1993), which were described in the Predesign Report for the Upper Las Vegas Wash Detention Basin. Changes made to those models were summarized in Volume 4 of the 1998 TSDN. The changes included updates to modeled flood control facilities based on as-built plans versus the original models which were based on pre-design data. In addition, NHC extended the models where necessary to include the full range of flood frequencies required for the FIS. There were no changes made to previously defined model input parameters for rainfall, runoff or channel routing. According to NHC, all such parameters were consistent with CCRFCD Hydrologic Criteria and Drainage Design Manual (1990).

The FIS hydrologic model submitted in the 1998 TSDN was reviewed, and no updates to the model were necessary in relation to this project or the levee evaluation effort. The tributary area to the MD remains undeveloped and drainage patterns have not been significantly modified since the completion of the FIS hydrologic model. Therefore, the hydrologic parameters used in the FIS hydrologic model documented in the 1998 TSDN are still valid.

Based on the hydrologic analysis and HEC-1 models described above, the 100-year peak flow (base flood) impacting the MD is 14,737 cfs. This flow was used in the hydraulic model and freeboard capacity analysis. The 100-year hydrologic model completed for the 1998 TSDN and all supporting hydrologic documentation is provided in the Hydrology folder in **Appendix V**.

3.5. Hydraulic Analysis

The effective hydraulic model developed by NHC for the MD was completed using HEC-2 (‘ulvdv5.out’, Run Date: April 15th, 1998). A new hydraulic model was developed using the survey data to reflect the existing condition of the MD. This model was developed to determine anticipated flow velocities, to assess freeboard capacity based on existing levee geometry (as defined by survey), and to compare results with the effective HEC-2 hydraulic model.

HEC-RAS, version 4.0, was used to model the MD. The HEC-RAS model included survey cross sections 2 through 25 and was extended east, just downstream of the MD, to incorporate the subsequent downstream HEC-2 cross section 65055[1] from the 1998 TSDN. The levee embankment is generally located between cross section 2 through 25.

The geometry and Manning's n for cross section 65055 was referenced from the TSDN model. The Manning's n used for the MD was 0.035, consistent with the effective hydraulic model. However, the roughness coefficient for cross sections 4 and 5 were modified to 0.042 and the roughness coefficient at cross section 6 was modified to 0.02 to accurately model the RCC and riprap material on the grade control structure.

Ineffective flow boundaries were added to the hydraulic model because some cross sections areas contain water that is not actively being conveyed. According to the HEC-RAS hydraulic reference manual, ineffective areas are often used to describe portions of a cross section in which water will pond, but the velocity of that water in the downstream direction is effectively zero. These areas are not included as part of the active flow area. Ineffective areas were added between cross sections 7 through 11 as necessary where the flow is not contained by the north channel bank.

This hydraulic modeling effort was a steady state analysis simulated under subcritical flow regime using the 100-year flow of 14,737 cfs. The hydraulic model was run in a subcritical flow regime to attain the most conservative flow depth along the MD. The water surface elevation produced in the 1998 TSDN hydraulic model at cross section 65055 was used as the downstream boundary condition. The subcritical analysis determined a flow depth range of 4.4 feet to 5.7 feet along the MD. A summary of the model results is provided in **Table 3-3**.

Figure 3-1 compares the 100-year water surface elevations from the updated HEC-RAS model (using survey data) and the 100-year water surface elevations from the HEC-2 model (1998 TSDN). This profile also displays the comparative profiles of the top/toe levee elevations between the survey data and the HEC-2 model data.

The supporting documentation from the 1998 TSDN, the effective hydraulic model (HEC-2), and the updated hydraulic model (HEC-RAS) are included in the Hydraulics folder in **Appendix V**.

3.6. Freeboard Analysis

A freeboard analysis was performed to verify that the MD provides a minimum freeboard of three feet above the water-surface level of the base flood and an additional one-half foot of freeboard at the upstream end of the levee, as outlined in CFR 65.10.

The freeboard for the MD was computed at every cross section using the 100-year water surface elevation from the updated hydraulic model (HEC-RAS) in conjunction with the highest surveyed top of levee elevation (landside or waterside). The results of the analysis show that the MD has at least 3 feet of freeboard along the entire length of the levee

---

[1] Effective HEC-2 model cross section 65055 was renamed to cross section -1 in the new hydraulic model (HEC-RAS).

structure and an additional one-half feet of freeboard at the upstream end. The MD is not impacted by any structures (e.g., roads, bridges) that would cause flow constrictions. **Figure 3-2** shows the 100-year water surface from the HEC-RAS model versus the maximum allowable water surface (i.e., required freeboard of the structure). **Table 3-3** shows a summary of the survey data, hydraulic model results, and freeboard.

Table 3-3 Moccasin Diversion Hydraulic Analysis and Freeboard Summary

HEC-RAS/Survey Cross Section ID	Approximate HEC-2 Cross Section Station	Approximate As-Built Station	Highest Levee Crest Elevation	Levee Toe Elevation	Q Total	Channel Velocity	100-yr WSE	Flow Depth	Freeboard
			(ft)	(ft)	(cfs)	(ft/s)	(ft)	(ft)	(ft)
25	74997	3+20	2497.0	2488.9	14737	8.93	2493.4	5.64	3.58
24	--	7+70	2493.5	2485.6	14737	9.72	2490.4	5.23	3.14
23	--	9+00	2492.7	2484.7	14737	9.21	2489.6	5.22	3.10
22	73765	14+20	2489.2	2481.1	14737	10.11	2485.8	4.73	3.48
21	--	16+20	2487.8	2480.2	14737	9.36	2484.6	5.23	3.27
20	--	20+60	2484.9	2476.9	14737	9.77	2481.6	5.10	3.38
19	72532	26+50	2480.9	2472.2	14737	9.62	2477.4	5.16	3.47
18	--	28+60	2479.5	2470.5	14737	9.28	2476.2	5.71	3.27
17	--	32+80	2476.9	2468.3	14737	10.09	2473.0	4.77	3.86
16	--	38+20	2473.0	2464.4	14737	9.09	2469.6	5.26	3.38
15	71045	41+40	2470.9	2462.6	14737	9.57	2467.5	5.10	3.34
14	--	45+30	2468.3	2459.7	14737	9.65	2464.9	5.13	3.46
13	--	51+50	2464.6	2456.0	14737	9.77	2460.6	5.11	3.97
12	69560	56+30	2461.2	2452.0	14737	9.53	2457.2	5.25	3.93
11	--	63+40	2456.2	2447.5	14737	9.17	2452.7	5.27	3.51
10	68187	69+90	2451.5	2442.8	14737	9.72	2448.3	5.49	3.19
9	--	74+20	2448.8	2439.7	14737	9.96	2445.0	5.37	3.79
8	--	79+00	2445.7	2436.8	14737	8.79	2442.3	5.73	3.40
7	66814	84+00	2442.2	2433.8	14737	11.18	2437.9	4.43	4.31
6	--	84+10	2442.0	2433.6	14737	11.22	2437.7	4.51	4.31
5	--	84+40	2441.5	2431.1	14737	11.41	2434.1	4.80	7.46
4	--	85+40	2437.5	2427.8	14737	9.91	2432.9	5.06	4.64
3	66660	85+80	2436.4	2427.3	14737	9.98	2432.5	5.11	3.93
2	66061	91+10	2431.1	2423.4	14737	11.32	2427.1	4.49	3.92

3.7. Long-Term Degradation/Aggradation Considerations

In order to determine if there is a long-term degradation or aggradation trend within the MD channel that would impact available freeboard, the available historical, survey, and technical information was reviewed. As discussed previously in **Section 3.3**, PBS&J performed a survey of the MD in September 2009. **Figure 2** in **Appendix V** shows a longitudinal profile comparison of this survey data with the HEC-2 data and the typical sections from the as-built drawings. As illustrated on this figure, there has been no definitive degradation/aggradation trend over the past 17 years. There is some local degradation just upstream of the drop structure but there is no significant aggradation.

Based on the review of the *Pre-Design Report for the Upper Las Vegas Wash Detention Basin* prepared by Black & Veatch, dated March 30, 1991, the document does not include a sediment transport analysis and simply states that "*During final design, a sediment transport analysis will be conducted to optimize the channel geometry and minimize deposition and scour in the channel over a range of flows up to the 100-year flood.*" Additionally, the 1998 TSDN does not include a sediment transport analysis but does summarize the sediment transport analysis performed within the *Conditional Letter of Map Revision for the Upper Las Vegas Wash Detention Basin* prepared by Black & Veatch, dated 1991. Based on this summary, the analysis within the Conditional Letter of Map Revision (CLOMR) was performed using three methodologies: Meyer, Peter, and Muller (MPM); Toffaleti; and United States Bureau of Reclamation (USBR). The results of these methodologies indicate the MD can experience either deposition (up to 3-inches) or degradation (up to 8.7-feet).

The CLOMR decided to ignore the results of the MPM method because it showed only minor deposition (2 to 3 inches). The results of the Toffaleti method were also ignored because it showed degradation of 3.9 feet, which is within the range of degradation calculated by the USBR method. Based on the USBR methodology, the diversion would experience degradation within the range of 3.2 feet and 8.7 feet, and scour up to 4.7 feet. Since the 8.7 feet of degradation was calculated assuming no sediment inflow from the upstream fan, it was considered overly conservative. The CLOMR ultimately concluded that an average of the degradation calculated by the USBR method would be the most accurate estimate. As a result, it was determined that the MD would experience up to 6 feet of degradation. Therefore, the MD was designed with a 6 foot deep RCC waterside toe in order to protect the levee from the maximum anticipated degradation. Since the results of the analysis did not predict significant aggradation, no sediment deposition depth was included in the original freeboard calculations.

In addition, CNLV using CCRFCD maintenance funds maintains the MD structure and thus any observed degradation will be corrected long before the anticipated maximum degradation depth is reached. The existing 6 foot toe depth will provide sufficient protection against degradation. Furthermore, **Figure 2** in **Appendix V** illustrates that there has been no evidence of aggradation within the MD channel over the past 17 years. The design calculations performed for the MD indicate that any aggradation would be insignificant. Therefore, aggradation will not be an issue and sufficient freeboard will be maintained.

Figure 3-1 - Moccasin Diversion Water Surface Comparison

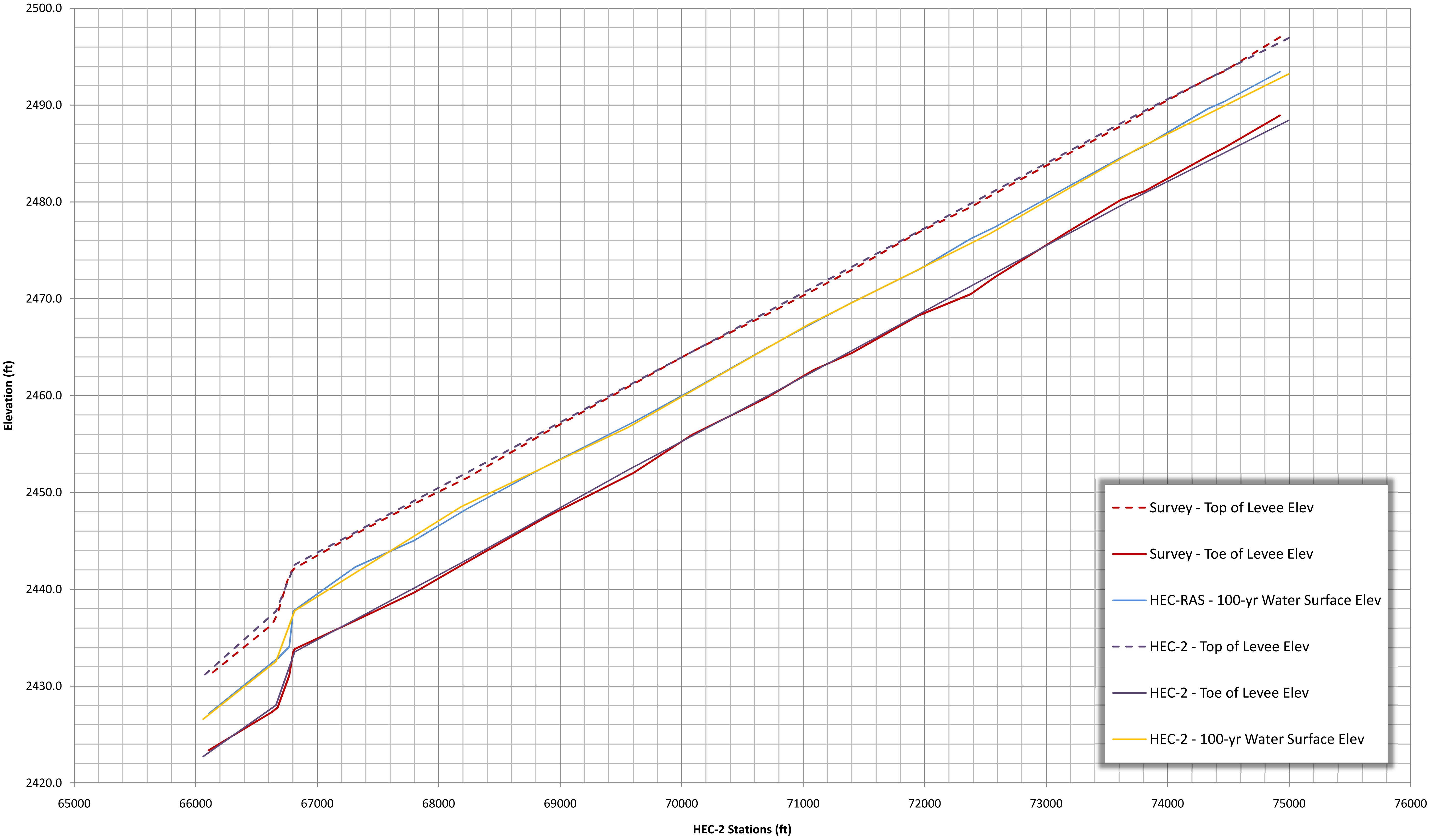
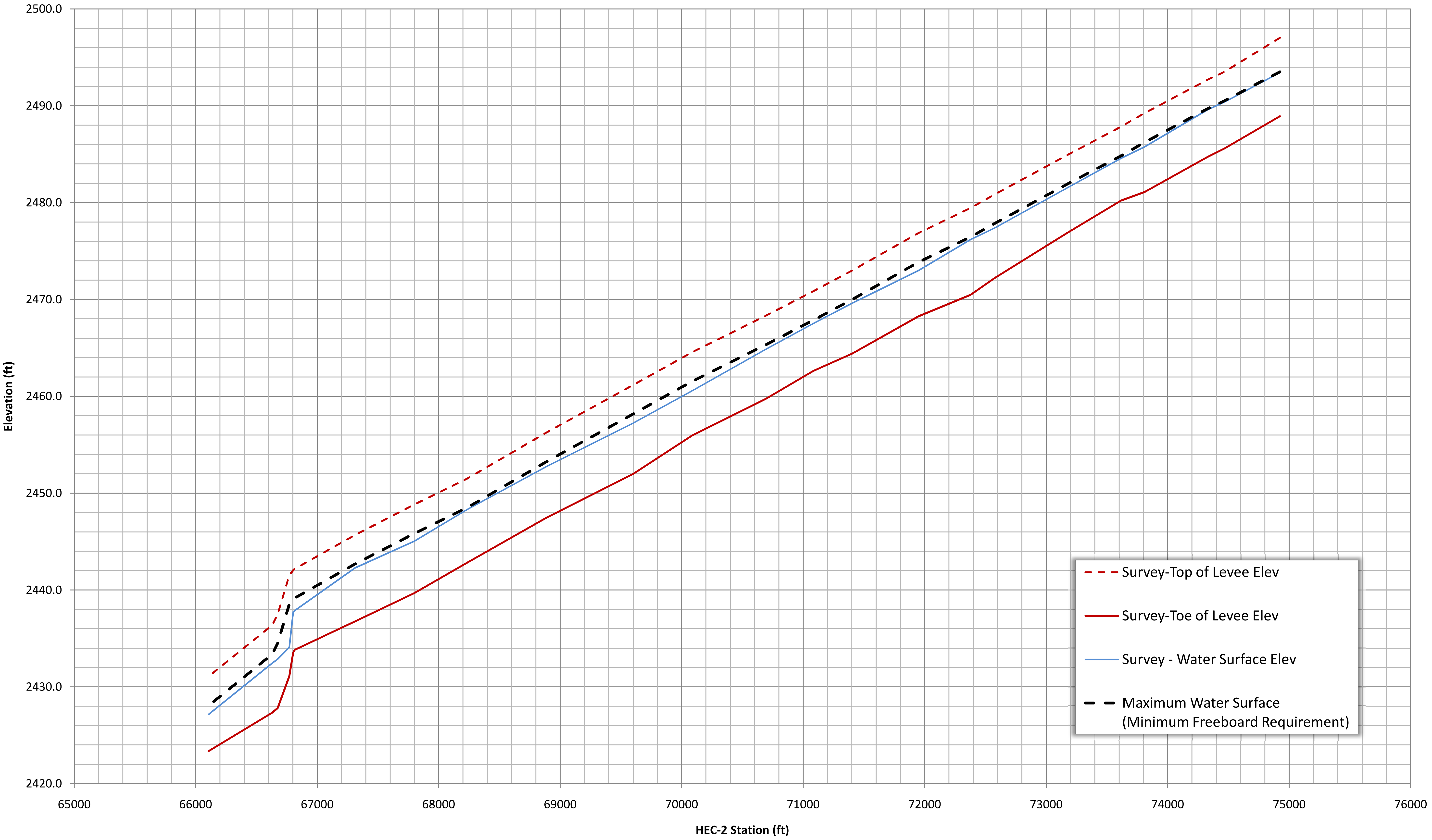


Figure 3-2 - Moccasin Diversion Freeboard



Section 4
Geotechnical Analysis

This report section is an executive summary and should be reviewed in conjunction with the attached Geotechnical Evaluation Report in **Appendix I** for a more detailed description of the geotechnical evaluation performed by Kleinfelder.

Geotechnical exploration for the MD alignment was previously performed by Kleinfelder in 1991 as part of the geotechnical work for the overall ULVDB project. Observation and testing during placement of fill soils and construction of the RCC armoring was performed by Kleinfelder in 1993.

For the current effort, Kleinfelder performed a geotechnical study of the MD to obtain subsurface information within the levee embankment and underlying foundation materials and to evaluate if the levee meets geotechnical requirements for FEMA levee certification as outlined in 44 CFR Section 65.10. Specifically, Kleinfelder's study focused on assessing levee seepage and stability considering United States Army Corps of Engineers (USACE) criteria outlined in its Levee Design Manual (EM 1110-2-1913) and Design Guidance for Levee Underseepage (ETL 1110-2-569) for the base flood elevation (100-year WSE) and flood duration, provided by the PBS&J team. Settlement potential of the levee was also evaluated.

Levee performance issues not addressed by Kleinfelder include presence of sufficient freeboard, impact of erosion, impacts of vegetation, and impacts from biological activity.

The Kleinfelder study included:

- Reviewing previous geotechnical work performed during design and construction of the MD structure;
- Site reconnaissance and a geotechnical inspection of the MD levee structure;
- Drilling six exploratory borings along the alignment on the levee crest;
- Conducting laboratory testing on representative samples obtained from the borings;
- Conducting seepage and slope stability analyses using SEEP/W and SLOPE/W computer programs, respectively;
- Evaluating settlement potential; and
- Researching past flood performance data.

The MD is an engineered structure with intact, waterside slope RCC armoring present for the entire length of the structure evaluated for this study. Approximately 40 percent of the MD alignment has a WSE less than one foot above the landside toe elevation. The base flood duration is approximately six hours. Two critical sections were selected for analysis based on slope inclination, height and WSE relative to landside toe.

A steady state seepage analysis was performed in accordance with USACE procedures and a transient analysis was performed to evaluate the time required for steady state seepage conditions to develop for comparison with the 100 year flood duration. Neglecting the RCC armoring, the transient seepage analyses based on the 100 year hydrograph data provided by PBS&J indicate that only the outermost portions of the waterside slope would be saturated. The seepage analyses also indicate a minimum time to steady state conditions of approximately six days and maximum steady state landside local exit gradients of 0.3 or less for the cases analyzed.

The slope stability analyses performed using phreatic surfaces obtained from the steady state seepage analyses indicate the slopes exceed USACE minimum criteria for the Steady State and Sudden Drawdown cases. The seismic stability exceeds the minimum factor of safety for Nevada Division of Water Resources Dam Guidelines for Design (http://water.nv.gov/Engineering/Dams/design.cfm).

The Kleinfelder analysis is judged to be conservative because the analysis does not take into account the RCC lining. Based on this approach, Kleinfelder judges that the MD is found to be stable as required by CFR 65.10.

Please refer to the Geotechnical Evaluation Report in **Appendix I** for more detailed information.

Section 5
References

Black & Veatch, 1991. Predesign Report for the Upper Las Vegas Wash Detention Basin. Prepared for City of North Las Vegas, March 1991.

CCRFCD, 1999. Hydrologic Criteria and Drainage Design Manual. Adopted August 12, 1999.

FEMA, 2003. Guidelines and Specifications for Flood Hazard Mapping Partners. Appendix H - Guidance for Mapping of Areas Protected by Levee Systems. April 2003.

FEMA, 2005. Procedure Memorandum 34 – Interim Guidance for Studies Including Levees. August 22, 2005.

FEMA, 2007. Revised Procedure Memorandum 43 – Guidelines for Identifying Provisionally Accredited Levees, March 16, 2007.

FEMA, 2008. Procedure Memorandum 45 – Revisions to Accredited Levee and Provisionally Accredited Levee Notation, May 12, 2008.

FEMA, 2009. Procedure Memorandum 51 – Guidance for Mapping of Non-Levee Embankments Previously Identified as Accredited. February 27, 2009.

FEMA, 2009. Procedure Memorandum 52 – Guidance for Mapping Processes Associated with Levee Systems. April 24, 2009.

FEMA, 2009. Procedure Memorandum 53 – Guidance for Notification and Mapping of Expiring Provisionally Accredited Levee Designations. April 24, 2009.

Kleinfelder, 1991. Geotechnical Investigation, Proposed Upper Las Vegas Wash Detention Basin, Clark County, Nevada. May 6, 1991.

Northwest Hydraulic Consultants, Inc., 1998. Upper Las Vegas Wash, Flood Insurance Restudy, Volumes 1 – 10. April 20, 1998.

Title 44, Chapter 1, Section 65.10 of the Code of Federal Regulations – “Mapping of Areas Protected by Levee Systems”

USACE, 2006. Levee Owner’s Manual for Non-Federal Flood Control Works. Public Law 84-99. March 2006.

APPENDIX I

Geotechnical Evaluation Report

Prepared by Kleinfelder

GEOTECHNICAL EVALUATION REPORT
MOCCASIN DIVERSION
CLARK COUNTY REGIONAL
FLOOD CONTROL DISTRICT
LAS VEGAS, NEVADA

Prepared for:

PBS&J
2270 Corporate Circle Suite 100
Henderson, Nevada 89074

Prepared by:

KLEINFELDER
6380 South Polaris Avenue
Las Vegas, Nevada 89118

Kleinfelder Project No. 101764

June 21, 2010

Only the Client or its designated representatives may use this document and only for the specific project for which this report was prepared.

KLEINFELDER
Bright People. Right Solutions.

June 21, 2010
Project No. 101764

Mr. Harshal Desai, PE
PBS&J
2270 Corporate Circle, Suite 100
Henderson, Nevada 89074

Subject: **Geotechnical Evaluation Report**
Moccasin Diversion
Clark County Regional Flood Control District
Las Vegas, Nevada

Dear Mr. Desai:

Kleinfelder is pleased to present this Geotechnical Evaluation Report for the Moccasin Diversion located in the City of Las Vegas, Clark County, Nevada. The purpose of this report is to summarize levee geotechnical conditions as identified in our geotechnical exploration and analyses. This report presents our findings regarding the geotechnical aspects of FEMA levee certification for the 100 year flood event. Based on our analyses, it is our opinion the earthen levee with waterside RCC armoring is stable in accordance with 44 CFR Section 65.10.

We appreciate the opportunity to work with you on this project. Should you wish to discuss this report or if we may be of further assistance, please contact the undersigned.

Sincerely,

KLEINFELDER

PROFESSIONAL ENGINEER - STATE OF NEVADA
ANN L. BACKSTROM
Exp: 12/31/201
GEOLOGICAL
No. 10099
6/21/2010

Jonathan Lehman-Svoboda, P.E.
Project Professional

Ann L. Backstrom, P.E.
Senior Engineer

ALB/jrs

TABLE OF CONTENTS

Section **Page**

TABLE OF CONTENTS (CONTINUED)

TABLES

PLATES

APPENDICES

EXECUTIVE SUMMARY

This report section is an executive summary and should be read in conjunction with the following report for a more detailed description of the geotechnical evaluation performed by Kleinfelder.

The Moccasin Diversion (MD) is a 9,300 long embankment which forms the right bank of a 300 foot wide interception/diversion channel and is considered a levee. The MD was designed and constructed in 1993 in conjunction with the Upper Las Vegas Detention Basin (ULVDB) and is located in the northwestern portion of the Las Vegas Valley in the City of Las Vegas, Clark County, Nevada. A Project Location map is presented on Plate 1. Geotechnical exploration for the MD alignment was previously performed by Kleinfelder in 1991 as part of the geotechnical work for the overall ULVDB project. Observation and testing during placement of fill soils and construction of the Roller Compacted Concrete (RCC) armoring was performed by Kleinfelder in 1993.

For the current effort, Kleinfelder performed a geotechnical study of the MD to obtain subsurface information within the levee embankment and underlying foundation materials and to evaluate if the levee meets geotechnical requirements for FEMA levee certification as outlined in 44 CFR Section 65.10. Specifically, our study focused on assessing levee seepage and stability considering United States Army Corps of Engineers (USACE) criteria outlined in its Levee Design Manual (EM 1110-2-1913) and Design Guidance for Levee Underseepage (ETL 1110-2-569) for the 100 year[1] design water surface elevation (WSE) and flood duration, provided by the PBS&J team. Settlement potential of the levee was also evaluated.

Levee performance issues not addressed by Kleinfelder include presence of sufficient freeboard, impact of erosion, impacts of vegetation, and impacts from biological activity.

MD is an earthen diversion structure which consists of an eight- to 10-foot high embankment approximately 9,300 feet in length, with a 12-inch thick RCC lining for protection of the north (waterside) face. The diversion structure was designed with a

---

[1] 100 year refers to a flooding event that has a percent chance of being equaled or exceeded in a particular location in any given year.

3:1 horizontal:vertical (H:V) side slope on the waterside and a variable side slope on the landside with a 3H:1V maximum. The RCC lining was designed to extend below the interception channel invert a minimum of 18 feet parallel to slope or six feet vertical. The crest of the structure is unpaved and varies in width from approximately 13 to greater than 30 feet. A typical section showing levee geometry is presented on Plate 2.

Our study included:

- reviewing previous geotechnical work performed during design and construction of the MD structure;
- site reconnaissance and a geotechnical inspection of the MD levee structure;
- drilling six exploratory borings along the alignment on the levee crest;
- conducting laboratory testing on representative samples obtained from the borings;
- conducting seepage and slope stability analyses using SEEP/W and SLOPE/W computer programs, respectively;
- evaluating settlement potential; and
- researching past flood performance data.

The MD is an engineered structure with intact, waterside slope RCC armoring present for the entire length of the structure evaluated for this study. Approximately 40 percent of the MD alignment has a WSE less than one foot above the landside toe elevation. The base flood duration is approximately six hours. Two critical sections were selected for analysis based on slope inclination, height and WSE relative to landside toe. A steady state seepage analysis was performed in accordance with USACE procedures and a transient analysis was performed to evaluate the time required for steady state seepage conditions to develop for comparison with the 100 year flood duration. Neglecting the RCC armoring, the transient seepage analyses based on the 100 year hydrograph data provided by PBS&J indicate that only the outermost portions of the waterside slope would be saturated. The seepage analyses also indicate a minimum time to steady state conditions of approximately six days and maximum steady state landside local exit gradients of 0.3 or less for the cases analyzed. The slope stability analyses performed using phreatic surfaces obtained from the steady state seepage analyses indicate the slopes exceed USACE minimum criteria for the Steady State and Sudden Drawdown cases. The seismic stability exceeds the minimum factor of safety for Nevada Division of Water Resources (DWR) Dam Guidelines for Design (http://water.nv.gov/Engineering/Dams/design.cfm). The Kleinfelder analysis is judged to be conservative because the analysis does not take into account the RCC lining. Based on this approach, Kleinfelder judges that the levees are found to be stable as required by 44 CFR 65.10.

The findings, conclusions, and recommendations presented in this report are based on the provisions and requirements outlined in the Limitations section of this report.

1.0 INTRODUCTION

1.1 LOCATION AND DESCRIPTION

The Moccasin Diversion (MD) is owned, maintained, and operated by the City of North Las Vegas (CNLV) and the City of Las Vegas (CLV) is the responsible community. This structure is located within Sections 1 through 4 of T19S, R60E. A Project Location map is presented on Plate 1.

The MD is a levee that intercepts tributary runoff along the Upper Las Vegas Wash (ULVW) drainage system resulting from intermittent storm events and conveys it to the Upper Las Vegas Detention Basin (ULVDB) located approximately 1.2 miles to the southeast. Due to the ephemeral nature of the ULVW and the relative infrequency with which this area receives rainfall, the MD and ULVDB are empty between storm events. Construction of the MD and ULVDB facilities was completed in October, 1993.

MD is an earthen diversion levee consisting of an 8- to 10-foot high embankment approximately 9,300 feet in length, and a 12-inch thick roller-compacted concrete (RCC) lining designed for protection of the north (waterside) face. The levee was designed with a 3:1 horizontal to vertical (H:V) slope inclination on the waterside and a variable slope inclination on the landside with a 3H:1V maximum. The crest of the structure is unpaved and varies in width from approximately 13 to greater than 30 feet.

Constructed in conjunction with the MD, the associated interception and diversion channel is a trapezoidal, earthen channel 300 feet wide that runs adjacent to the waterside toe-of-levee; the embankment, therefore, serves as the right bank of the channel while looking in the downstream direction. Both the right and left banks of the diversion channel were designed with 3H:1V waterside slopes. The RCC lining was designed to extend below the interception/diversion channel invert a minimum of 18 feet parallel to slope or six feet vertical. A plan and profile of the MD showing levee cross-sections at different stations and the associated interception and diversion channel are presented on Plates 2 through 5. The RCC lining is not represented on the cross-sections.

1.2 PURPOSE AND SCOPE

Kleinfelder performed a geotechnical study of the MD to obtain subsurface information within the levee embankment and underlying foundation materials and to evaluate if the levee meets FEMA geotechnical requirements as outlined in 44 CFR Section 65.10. Specifically, our study focused on assessing levee seepage and stability considering United States Army Corps of Engineers (USACE) criteria outlined in its Levee Design Manual (EM 1110-2-1913) and Design Guidance for Levee Underseepage (ETL 1110-2-569) for the 100 year design water surface elevation (WSE) and flood duration, provided by PBS&J. Settlement potential of the levee was also evaluated.

Our study included:

- reviewing previous geotechnical work performed during design and construction of the MD structure;
- site reconnaissance and a geotechnical inspection of the MD structure;
- drilling six exploratory borings along the alignment on the levee crest;
- conducting laboratory testing on representative samples obtained from the borings;
- conducting seepage and slope stability analyses using SEEP/W and SLOPE/W computer programs, respectively;
- evaluating settlement potential; and
- researching past flood performance data.

The recommendations contained in this report are subject to the limitations presented in the 'Limitations' section of this report. In addition, a brochure prepared by ASFE (The Association of Engineering Firms Practicing the Geosciences) has been included behind the cover sheet of this report. We recommend that all individuals using this report read the limitations along with the attached document.

1.3 PROJECT ELEVATIONS

PBS&J performed a survey of the MD to support the hydrologic and geotechnical evaluations by PBS&J and Kleinfelder, respectively. The survey data provided by

PBS&J for Kleinfelder's use consisted of cross-sections at 24 locations, including survey of landside toe and further afield; landside slope; crest width and elevation; waterside slope; waterside toe; channel; and further waterside afield. Kleinfelder provided input to PBS&J for survey locations. The WSE used in our analyses were provided by PBS&J and are discussed further in Section 5.2. Elevation references in this report are in feet and are based on the North American Vertical Datum of 1988 (NAVD88). A tabulated summary of the surveyed existing slope configurations and the WSE at each section provided by PBS&J is presented in Table 5.2. A graphical depiction of the levee section at each location surveyed, including the corresponding WSE, is presented on Plates 2 through 5.

1.4 LEVEE PERFORMANCE ISSUES NOT ADDRESSED

Levee performance issues not addressed by Kleinfelder include presence of sufficient freeboard, impact of erosion, impacts of vegetation, and impacts of biological activity.

2.0 BACKGROUND INFORMATION

2.1 PREVIOUS WORK

As part of the PBS&J design team, Kleinfelder previously performed a background (Phase I) study for this project. The objectives for Kleinfelder in the study included:

1. Collecting and reviewing existing reference material, design/construction documentation, data, and other information pertaining to the MD, including the documents listed in Table 2.1.1.
2. Performing a geotechnical inspection of the MD.
3. Documenting compliance with the levee requirements outlined in CFR 65.10 or assessing that further study will be required.

Table 2.1.1 MD Documents

Document Title	Prepared By	Date
Geotechnical Investigation, Proposed Upper Las Vegas Wash Detention Basin, Clark County, Nevada	Kleinfelder	May 6, 1991
Technical Report: In-Place Field Density Tests of Compacted Structural Fill for Upper Las Vegas Wash Detention Basin Project	Kleinfelder	January 15, 1993
Upper Las Vegas Wash Detention Basin and Interception Berm/Channel Record Drawings/As-Builts	Black and Veatch	October 26, 1993

Prior maintenance records were not available for the MD. In addition, there were no written records of previous flooding or documents available which described past performance history of MD, including erosion during flood events. Interviews with representatives of Clark County Regional Flood Control District, City of Las Vegas, and City of North Las Vegas indicate that very little maintenance has been required and performed at MD since construction.

A discussion of our observations and findings during the background study are presented in the following Sections 2.1.1 through 2.1.4.

2.1.1 2009 Geotechnical Field Inspection

A geotechnical inspection of the MD was performed by Kleinfelder on March 25, 2009. Geotechnical observations made during the inspection include three small holes at the landside edge of the crest; rutting on the crest; localized bulging and raveling of the RCC slope protection; and exposure of the upper portion of the RCC below the channel invert. Details of the observations are provided in the following paragraphs.

A small hole was noted at the edge of the landside crest in three locations between approximate Station 70+00 and Station 74+00. Each hole was semi-circular, up to approximately six inches in diameter with an upper opening at the levee crest, and a lower opening on the landside slope face generally three to four feet below the levee crest. Ruts in the levee crest ranging from ½ to one foot deep were present in the general area where the holes were observed. Rutting of lesser magnitude was also present at other locations on the levee crest throughout the MD alignment. A biologist of PBS&J interpreted the holes to be possible tortoise burrows; it is also possible the holes were small erosional features resulting from downslope percolation of ponded water in the ruts on the crest.

As-built drawings indicate the RCC was designed for slope protection. The RCC was generally intact for the length of the MD alignment. A slight bulging of the RCC slope facing perpendicular to slope was observed over a horizontal distance of approximately 20 to 30 feet in two locations, near Station 74+00 and Station 82+00, respectively. The maximum displacement was estimated to be less than three inches measured perpendicular to slope. These areas correspond to locations where the levee berm is constructed predominantly in native (cut), clayey soils. Evidence of dessication cracking was not observed during our site visits. Raveling, or minor weathering of concrete and aggregate, was also observed at RCC construction joints in several locations. The upper portion of the RCC below the channel invert was exposed in several areas of the waterside toe to typical depths of approximately ½ foot vertical or approximately 1-½ feet parallel to the 3H:1V slope face.

Since the time of our inspection, maintenance activities at the MD have been performed. Kleinfelder's post-maintenance inspection indicates that the crest rutting, landside crest holes, and exposure of RCC cut off at the waterside toe of slope have been remediated through site grading.

2.1.2 Summary of 1991 Geotechnical Report

A geotechnical exploration for design of the MD was performed in 1991 by Kleinfelder and consisted of excavating 13 borings to a depth of 21 feet and seven test pits to backhoe refusal at depths of three to nine feet. These explorations represent a portion of the explorations performed for the overall ULVDB project. Four of the MD borings were drilled along the levee alignment; the remaining MD explorations were performed in the MD interception/diversion channel alignment and were located at typical intervals of approximately 600 feet. The borings were drilled with a Failing 1250 rotary air drill rig equipped with a 350-pound hammer. Surveyed ground surface elevations rounded to the nearest foot are presented on the exploration logs, referenced to the National Geodetic Vertical Datum of 1929 (NGVD29). The conversion between NGVD29 and NAVD88 at the MD is approximately 2.4 feet.

Information on the exploration logs indicates that the on-site soils are highly variable, consisting of granular and fine-grained soils of differing interlayered proportions. The granular soils logged range from clean sand and gravel to silty and clayey sand and gravel. The granular soils encountered are generally noted to be loose to depths ranging between one and three feet and predominantly medium dense to very dense below three feet. The interlayered fine-grained soils are noted as silty and sandy clay and clayey and sandy silt and are typically firm to stiff in consistency, with zones of porosity noted in areas. Cementation is not noted on any of the boring logs; however, backhoe refusal on cemented sand/gravel or caliche occurred in all the test pits at depths ranging between three and nine feet.

Laboratory testing performed on samples obtained from the borings and trench excavations included six gradation analyses, one sieve wash, 10 Atterberg Limits tests, four remolded direct shear strength tests, two consolidation/collapse tests, four maximum dry density-optimum moisture content curves, two laboratory falling-head permeability tests, and three soluble sulfate content tests. Gradation test results indicate gravel contents in the range of five to 75 percent, sand contents in the range of 10 to 65 percent, and fines contents in the range of five to 35 percent. Soil friction angles (phi) in the range of 20 degrees to 40 degrees with cohesions in the range of

150 to 650 pounds per square foot (psf) were reported for the remolded direct shear results on samples screened over a No. 4 sieve. Maximum dry densities (ASTM D1557) in the range of 110 and 139 pounds per cubic foot (pcf) were reported for the fine-grained and coarse granular materials at the site, respectively. The collapse potential results indicated volume decreases of less than one percent upon saturation under a load of approximately 1,200 psf on the two samples tested. Additional hydrocollapse testing for the ULVDB project downstream of MD indicated hydrocollapse potentials up to four percent under the same load. Water soluble sulfate contents of less than 0.1 percent were reported.

Permeability values of 2 X 10^{-4} and 4 X 10^{-5} cm/sec were reported for the laboratory falling head permeability test results on silty gravel and silty sand samples, respectively. The test results include a note that the samples were remolded to between 90 percent and 95 percent of maximum dry density per ASTM D1557.

Levee Underseepage The geotechnical report does not state that a seepage analysis was performed for the levee.

Slope Stability Analyses A slope stability analysis was not provided in the geotechnical report.

2.1.3 Construction Observation and Materials Testing Records

Construction observation and materials testing services for the ULVW Detention Basin and Interception Berm/Channel (MD) were performed by Kleinfelder. Volume 1 of the Construction Quality Control Testing Results was obtained from the State Engineer's office by PBS&J. Testing results provided in Volume 1 include sieve analyses; optimum moisture content / maximum dry density curve relationships; concrete compression test results; RCC compression test results; and RCC aggregate sieve analyses. Field density test results for placed fill were not included in Volume 1.

A document prepared for Black and Veatch, the Project Engineer, titled "Kleinfelder Technical Report of In-Place Field Density Tests of Compacted Structural Fill" prepared by Kleinfelder was obtained during research of Kleinfelder's in-house project records. The report indicates that a total of 85 field density tests were performed on the MD between November 1992 and May, 1993. A total of 82 out of 85 of the compaction test results indicate dry densities in the range of 90 percent to 98 percent of maximum dry density (ASTM D1557). Of the remaining three tests, two indicate dry densities of 85 percent of maximum dry density and one test indicates a compaction of 84 percent of maximum dry density. Retests at these locations were not included in the test summary.

2.2 LEVEE GEOMETRY

The MD is approximately 9,300 feet in length. A summary of existing MD slope geometry based on survey data is presented in Table 2.2.1. Graphical depictions of the levee section at each location surveyed, including the corresponding WSE, are presented on Plates 2 through 5.

Table 2.2.1 MD Slope Geometry Summary

MD Station	Surveyed Landside Slope (H:V)	Landside Height* (feet)	Surveyed Waterside Slope (H:V)	Waterside Height* (feet)	Crest Width* (feet)
3+20	7.2:1	2	3.6:1	8	23
7+70	7.3:1	3	3.3:1	8	22
9+00	3.6:1	9	3.6:1	8	25
14+20	5:1	6	3.2:1	8	27
16+20	4.7:1	6	3.5:1	8	26
20+60	6.3:1	4	3.2:1	8	28
26+50	7.6:1	3	4.2:1	9	20
28+60	>10:1	<1	3.2:1	9	>30
32+80	>10:1	<1	3.1:1	9	>30
38+20	4.2:1	1	3.2:1	9	24
41+40	8.5:1	3	3.3:1	8	25
45+30	3.7:1	5	3.2:1	9	13
51+50	4.1:1	6	3.2:1	8	16
56+30	3.8:1	6	3.2:1	9	16
63+40	3.5:1	6	3.1:1	9	14
69+90	3.7:1	6	3.4:1	9	15
74+20	4.3:1	4	3.5:1	9	15
79+00	4.3:1	5	3.5:1	9	14
84+00	4.7:1	5	2.8:1	8	25
84+10	4.7:1	5	2.8:1	8	25
84+40	6.2:1	5	3.7:1	10	16
85+40	>10:1	1	3.6:1	10	25

Table 2.2.1 MD Slope Geometry Summary (Continued)

MD Station	Surveyed Landside Slope (H:V)	Landside Height* (feet)	Surveyed Waterside Slope (H:V)	Waterside Height* (feet)	Crest Width* (feet)
85+80	>10:1	1	3.3:1	9	25
91+10	>10:1	<1	3.4:1	8	27

**Rounded to the nearest foot*

Based on the survey data, the landside slope of the levee has a maximum height of approximately nine feet and inclinations that range from approximately 3.5:1 to greater than 10:1 (H:V). The crest width varies from 13 to greater than 30 feet. The waterside slope has a maximum height of 10 feet with slope inclinations that range from approximately 2.8:1 to 4.2:1 (H:V).

The project plans indicate that the MD was constructed of a combination of cut and fill, with fill thickness in the range of four to eight feet. Two zones of the MD were constructed predominantly of cut, approximate Station 28+00 to 36+00 and approximate Station 88+00 to 91+50. Cuts of less than five feet deep were required to bring the majority of the channel alignment to grade.

3.0 REGIONAL AND SITE GEOLOGY

3.1 GEOLOGY

The MD is located within the northwestern portion of the Las Vegas Valley, a north to northeast trending elongate valley characteristic of the Basin and Range physiographic province. The Las Vegas Valley is filled with Quaternary- to Tertiary-aged unconsolidated to partially consolidated sediments derived from erosion of the mountains surrounding the valley. The sediments become increasingly fine-grained with distance from the source area and are several thousand feet thick in the low-lying central portion of the valley. Progressively more steeply sloping alluvial fans composed of coarser-grained materials surround the central valley floor.

The MD site is mapped on the Geologic Map of the Tule Springs Park Quadrangle (Bell and others, 1998, 1:24,000) and on the Geologic Map of the Las Vegas 30'X60' Quadrangle, Clark and Nye Counties, Nevada and Inyo County, California (Page et al, 2005, 1:100,000). The published geologic map data indicates that the site is predominantly underlain by Quaternary-age alluvium and older, finer grained spring and marsh deposits. The alluvium is mapped as active wash deposits, alluvial fan deposits, and stream terrace deposits of the Las Vegas Wash. The finer-grained ancient spring and marsh deposits occur at the surface in isolated areas along the alignment and are part of a laterally extensive, fine-grained valley-bottom filling in the upper Las Vegas Valley related to extensive groundwater discharge in the past (Bell and others, 1998). The alluvial deposits typically occur in channel areas and alluvial plains eroded into the finer-grained, older spring and marsh deposits, and as localized elevated stream terrace deposits.

In addition to review of the published geologic map data, Kleinfelder obtained pairs of aerial photos of the MD site area (Continental Aerial Surveys; 1962, 1981, 1984, 1990, and 1999; photo scales as referenced in Section 8.0) for stereoscopic review. Surface geology in the area of the MD alignment based on the published data supplemented by our geologic site reconnaissance and the aerial photo review is presented on Plate 6, Site Plan with Explorations and Geology.

The Quaternary-age alluvium units shown on Plate 6 are undifferentiated in the following discussion and collectively referred to as "alluvium"; the older spring and marsh deposits have also been grouped together and referred to as "fine-grained deposits." The following paragraphs provide a description of each of the geologic units mapped on Plate 6 from youngest to oldest:

Fill (Qaf): The fill materials of the levee embankment are approximately two to 12 feet thick and generally consist of a mixture of silty and clayey gravel and sand and lean clay with sand and gravel. The observed fill materials appear to be a mix of local alluvial soils. Based on the observed fill composition, and review of the original, 1991 geotechnical report for the project (Kleinfelder, 1991), the levee was likely constructed from excavation during construction of the ULVW detention basin and associated channels.

Alluvium (Qa, Qsp, and Qlv): The alluvium as described on the published mapping and encountered in our borings generally consisted of grey to brown, clayey and silty gravel and sand with zones of cobbles. Locally, the alluvial deposits contain higher proportions of fines where derived from the older fine-grained deposits. The alluvium occurs in active washes (Qa), alluvial fan deposits (Qsp), and as stream terrace deposits of the Las Vegas Wash (Qlv). The alluvial deposits range from non-stratified and unconsolidated, active younger deposits to well-stratified, partially cemented older alluvial fan, and stream terrace deposits. The alluvial deposits are described in the published mapping as having a combined total thickness in the range of 10 to 20 feet.

Fine-Grained Deposits (Qts): The fine-grained deposits are described on the mapping as consisting of silt, sandy silt and organic-rich, fossiliferous mud and clay deposits with lenses of coarse sand to cobbly gravel and layers of calcium carbonate cementation. Where encountered at the site, the fine-grained deposits occurred as brown to olive-brown clay with sand and silt and light brown to brown silt with clay, sand, and gravel. Lenses of gravel with sand, silt, and clay up to several feet thick were also encountered within the fine-grained deposits. Zones of partial cementation with calcium carbonate are associated with the fine-grained deposits and were encountered in the explorations.

3.2 GEOMORPHOLOGY

The MD traverses the northwest to southeast draining Las Vegas Wash system. The alignment falls in elevation from west to east at an average slope of approximately 0.7 percent from a high of approximately 2490 feet to a low of approximately 2420 feet.

3.3 FAULTING

Based on the previously referenced published map data, no mapped faults traverse the MD alignment. The closest Quaternary fault shown in the Nevada Bureau of Mines and Geology on-line database is an unnamed fault mapped approximately ¾ mile south of the center of the MD (Nevada Bureau of Mines and Geology, 2010, Quaternary Faults in Nevada – Online Interactive Map, accessed Feb 15, 2010, from Nevada Bureau of Mines and Geology web site: http//gis3.nbmg.unr.edu/0F09_9/). This unnamed fault is thought to be mid-Quaternary in age with a last rupture greater than 750,000 years ago.

The nearest fault included in the United States Geologic Survey Quaternary fault database is the Eglington Fault, located approximately 5-1/2 miles southeast of the east end of the MD (U.S. Geological Survey and Nevada Bureau of Mines and Geology, 2010, Quaternary fault and fold database for the United States, accessed Feb 16, 2010, from USGS web site: http//earthquake.usgs.gov/regional/qfaults/). The Eglington Fault is believed to have a latest ground surface rupture of less than 15,000 years ago (dePolo, 2008).

The latitude and longitude coordinates of the western and eastern ends of the MD alignment correspond to approximately 36.3344/-115.2715 degrees and 36.3341/-115.2437 degrees, respectively. A peak bedrock ground acceleration (PGA) value of 0.10 was obtained at both locations for an event with a ten percent probability of exceedance in 50 years using the United States Geological Survey (USGS) 2002 Seismic Hazard Curves and Uniform Hazard Response Spectra calculator v.5.0.9 (http://earthquake.usgs.gov/research/hazmaps/design/), dated October 21, 2009, accessed February, 2010.

3.4 REGIONAL GROUNDWATER

Groundwater was not encountered within the borings drilled for this exploration. A search of the U.S. Geological Survey, 2001, National Water Information System (NWISWeb) web site http://waterdata.usgs.gov/nwis/ indicates the closest well in the database is located approximately one-half mile south of the MD. Groundwater in this well was measured at a depth of 83 feet below the ground surface in August, 2009 (USGS well reference 361939115154801).

4.0 SITE CHARACTERIZATION

4.1 SITE EXPLORATION

The subsurface exploration program consisted of drilling and logging six hollow-stem auger borings. The boring locations were selected considering site geology; levee geometry based on the results of the survey; and the presence of features of interest such as major wash crossings and the areas of the observed slope bulging.

The exploratory borings were drilled using a Diedrich truck-mounted drill rig equipped with six-inch diameter hollow-stem augers. The borings were located using Kleinfelder's Trimble Global Positioning System (GPS) in conjunction with aerial imagery provided by PBS&J. Borings were drilled and sampled to a depth of 21-½ to 25-½ feet below levee crest. The approximate locations of the borings are presented on Plate 6, Site Plan with Explorations and Geology. The approximate locations of the previous 1991 explorations (borings and trenches) are also included on Plate 6.

The borings performed as part of the MD evaluation were logged by registered engineers or geologists from Kleinfelder in general accordance with Unified Soil Classified System (USCS) methods and general procedures established in ASTM D2488. The results of our laboratory testing were used to refine the field classifications which are presented on the logs. In-place soil samples were obtained using either a Standard Penetration (SPT) or California-type sampler with liners driven a total of 18 inches (or until practical refusal) into the undisturbed soil at the bottom of the boring. The soil sampled by the SPT (two-inch O.D., 1-3/8-inch I.D.) or California sampler (three-inch O.D., 2.4-inch I.D.) was returned to our laboratory in Las Vegas, Nevada for testing. The sampler was driven using a hydraulically-actuated 140-pound "automatic" hammer falling 30 inches. The total number of hammer blows required to drive the sampler the final 12 inches is termed the blow count and is recorded on the boring logs at the respective sampling depths. Bulk samples of the soils were retrieved directly from the auger blades. Borings were backfilled with hydrated bentonite chips to within three feet of the levee crest. The remaining three feet was backfilled with the auger cuttings.

A Key to Soil Symbols and Terms used on the boring logs is presented on Plate A-1 in Appendix A. The logs of borings are presented on the Boring Log and Test Summary sheets on Plates A-2 through A-7. The logs of borings and trenches from the previous 1991 explorations are presented after Plate A-7.

4.2 LABORATORY TESTING

Geotechnical laboratory tests were performed on selected soil samples collected from the borings to evaluate the physical characteristics and engineering properties of the samples. The tests were conducted to support soil parameter selection for the geotechnical analyses. The laboratory program consisted of the following tests:

- Six unit weight tests (ASTM Test Method D2937) performed to evaluate the in-situ unit weight of the sampled soils at various depths.
- Fifteen moisture content tests (ASTM Test Method D2216) performed to evaluate moisture content of various sampled soils at various depths.
- Four grain size analyses (ASTM Test Method C117 and C136) performed to evaluate the gradation of sampled soils and to aid in soil classification.
- Ten grain size with hydrometer analyses (ASTM Test Method D422) performed to evaluate the gradation of sampled soils and to aid in soil classification.
- Sixteen Atterberg Limits tests (ASTM Test Method D4318) performed to aid in soil classification.
- Six expansion tests (Southern Nevada Amendments to 2006 International Building Code: Section 1802.3.3) performed to measure the expansion potential of the embankment soils in the area of the observed RCC bulging.
- Four chemical tests (AWWA Test Methods 3500-NAD, 4500E, and 2540C) performed to measure solubility and sodium sulfate contents in the area of observed RCC bulging.

The results of the laboratory tests are presented on the boring logs in Appendix A and on Plates B-1 through B-6 in Appendix B. Chemical test results are presented following Plate B-6. The 1991 laboratory tests are presented following the chemical test data with the 1991 laboratory results corresponding to the MD area shaded.

4.3 SUBSURFACE CONDITIONS

The transition between the levee fill and the native soil was distinguished considering information presented on the project plans and observations made during drilling. This contact should be considered approximately located. The levee embankment fill was encountered along the alignment to depths ranging between two and 12 feet below the levee crest and consisted of slightly moist to moist, medium dense to very dense and stiff to very stiff, silty and clayey combinations of sand and gravel, and sandy and gravelly lean clay. The USCS classifications of the levee embankment materials vary, consisting of CL, SC-SM, SC, GM and GC. Blow counts greater than 45 were measured in the levee embankment fill in all cases except one location in B-6 at a depth of two feet near the transition to native materials, where a blow count of 27 was measured.

The native soils encountered underlying the levee embankment generally consist of interlayered zones of gravel, clay, and silt. The fines content of the gravel layers range from approximately 10 percent to nearly 50 percent silt and clay. The gravel layers are typically dense to very dense in consistency and contain zones of partial cementation. The clay and silt layers were typically stiff to very stiff in consistency, low plasticity, and contained five to 25 percent sand and gravel. Groundwater was not encountered during our field exploration. Based on well data cited previously, groundwater is anticipated to be present at a depth of approximately 80 feet below natural grade at the site.

The laboratory testing program included six expansion tests from Borings B-5 and B-6, drilled in areas where a bulge in the waterside slope face was observed, as described in Section 2.1.1. The expansion tests indicated swells in the range of five percent to nine percent when tested from an oven-dried condition under a 60 psf surcharge. These results correspond to a moderate to high potential for expansion by Clark County standards (Southern Nevada Amendments to 2006 IBC; Table 1805.8.2).

5.0 GEOTECHNICAL EVALUATION

5.1 ANALYSIS CRITERIA

There are no formal published design guidelines specifically for levee certification analyses in Southern Nevada. For the purposes of this evaluation, the USACE levee design criteria has been considered for general guidelines in the evaluation of the MD performance for the 100 year design WSE.

The project design criteria discussed in the following sections is based on the following USACE Engineering Manuals (EM) and Engineering Technical Letters (ETL):

- EM 1110-2-1913 "Design and Construction of Levees," dated 30 April 2000
- ETL 1110-2-569 "Design Guidance for Levee Underseepage," dated 1 May 2005

Seepage and slope stability analyses were performed to evaluate through and underseepage, and stability of the MD embankments. Steady state seepage analyses were performed following USACE guidelines. A transient analysis was performed to estimate both maximum saturation during the 100 year flood duration and the time for steady state conditions to develop under a sustained WSE.

The USACE Manual EM 1110-2-1913 identifies four types (Cases) of loading conditions for slope stability analyses described below. The minimum slope stability Factor of Safety (FOS) against failure for each of the cases is summarized in Table 5-1.

Case I: End of Construction This case addresses slope stability at the immediate end of construction of the levee and is not required for longer term post-construction levee evaluation.

Case II: Sudden Drawdown This case represents a condition where the flood stage fully saturates a majority of the levee embankment, followed by a stage where the water falls faster than the soil can drain. A FOS of 1.0 applies to the case where pool levels prior to drawdown are unlikely to persist for long periods preceding drawdown and is judged to be applicable to the MD.

Case III Steady State Seepage from Full Flood Stage This condition occurs when the water remains at or near flood stage levels, fully saturating the embankment soils. A steady state seepage condition then occurs. The minimum required slope stability FOS against failure for this case of 1.4 has been used in our evaluation.

Case IV Earthquake (Seismic) This case is currently under revision by the USACE and no minimum FOS is provided in the guidance documents. A seismic slope stability analysis was performed based on one-half the peak ground acceleration (PGA) of 0.10g. The seismic horizontal force coefficient used in the earthquake (seismic) analysis was taken as one-half the PGA (i.e., 0.05g). Nevada Division of Water Resources (DWR) Dam Guidelines for Design (http://water.nv.gov/Engineering/Dams/design.cfm, accessed February, 2010) minimum factor of safety for seismic stability was used as a guideline for this analysis.

Table 5-1
Minimum Required Slope Stability Factor of Safety

Case	Minimum Factor of Safety
Case I – End of Construction	(not applicable to this levee)
Case II – Sudden Drawdown	1.0
Case III – Steady State Seepage	1.4
Case IV – Earthquake (Seismic)	1.0

In addition to the minimum required slope stability factors of safety, the USACE criterion of allowable exit gradient ≤0.3 at the levee landside toe was considered in our seepage analyses.

5.2 SELECTION OF CROSS-SECTIONS FOR ANALYSES

Ground surface and water surface elevations (WSE) used in our analyses for the MD were provided by PBS&J. We understand the WSE is based on 100-year hydrology combined with assumptions regarding upstream basin/levee performance. This water surface is referred to as the 100-year WSE in this report and is referenced to NAVD88 elevations. We understand the WSE and survey data were provided with the level of detail required for the evaluation of the civil engineering components of the MD. A summary of the slope configuration and WSE for the MD is presented in the following

Table 5-2. Graphical representations of the surveyed sections, including the WSE at each location, are presented on Plates 2 through 5.

Table 5-2
Summary of Slope Configuration for Seepage and Stability Analysis

Station No. (Approx.)	100 yr WSE (feet)	Crest Width (feet)	Waterside					Landside				
			Crest Elevation	Toe Elevation	Height	Slope Ratio	Water Height Above Toe	Crest Elevation	Toe Elevation	Height	Slope Ratio	Water Height Above Toe
			(feet)	(feet)	(feet)	(H:V)	(feet)	(feet)	(feet)	(feet)	(H:V)	(feet)
3+20	2493.4	23	2496.7	2488.9	8	3.6:1	5	2497	2494.9	2	7.2:1	--
7+70	2490.4	22	2493.4	2485.6	8	3.3:1	5	2493.5	2490.1	3	7.3:1	0.3
9+00	**2489.6**	**25**	**2492.7**	**2484.7**	**8**	**3.6:1**	**5**	**2492.4**	**2483.4**	**9**	**3.6:1**	**6.2**
14+20	2485.8	27	2489.2	2481.1	8	3.2:1	5	2489.2	2483.1	6	5.0:1	2.7
16+20	2484.6	26	2487.8	2480.2	8	3.5:1	4	2487.8	2481.5	6	4.7:1	3.1
20+60	2481.6	28	2484.9	2476.9	8	3.2:1	5	2484.8	2480.6	4	6.3:1	1
26+50	2477.4	20	2480.9	2472.2	9	4.2:1	5	2480.9	2477.7	3	7.6:1	--
28+60	2476.2	30	2479.3	2470.5	9	3.2:1	6	2479.3	2478.6	<1	>10:1	--
32+80	2473	30	2476.8	2468.3	9	3.1:1	5	2476.8	2476	<1	>10:1	--
38+20	2469.6	24	2473	2464.4	9	3.2:1	5	2472.3	2470.9	1	4.2:1	--
41+40	2467.5	25	2470.7	2462.6	8	3.3:1	5	2470.9	2468.4	3	8.5:1	--
45+30	2464.9	13	2468.3	2459.7	9	3.2:1	5	2468.2	2462.9	5	3.7:1	2
51+50	2460.6	16	2464.4	2456	8	3.2:1	5	2464.6	2459	6	4.1:1	1.6
56+30	2457.2	16	2461	2452	9	3.2:1	5	2461.2	2455	6	3.8:1	2.2
63+40	2452.7	14	2456.2	2447.5	9	3.1:1	5	2456.2	2450.2	6	3.5:1	2.5
69+90	2448.3	15	2451.4	2442.8	9	3.4:1	5	2451.5	2445.6	6	3.7:1	2.7
74+20	2445	15	2448.7	2439.7	9	3.5:1	5	2448.8	2444.6	4	4.3:1	0.4
79+00	2442.3	14	2445.6	2436.8	9	3.5:1	6	2445.7	2440.6	5	4.3:1	1.7
84+00	2437.9	25	2442.1	2433.8	8	2.8:1	4	2442.2	2437.6	5	4.7:1	0.3
84+10	**2437.7**	**25**	**2442**	**2433.6**	**8**	**2.8:1**	**4**	**2442**	**2437**	**5**	**4.7:1**	**0.7**
84+40	2434.1	16	2441.2	2431.1	10	3.7:1	3	2441.5	2436.9	5	6.2:1	--
85+40	2432.9	25	2437.5	2427.8	10	3.6:1	5	2437.5	2436.5	1	>10:1	--
85+80	2432.5	25	2436.3	2427.3	9	3.3:1	5	2436.5	2435.5	1	>10:1	--
91+10	2427.1	27	2431.1	2423.4	8	3.4:1	4	2431	2430.6	1	>10:1	--

Note: Shaded cross-sections were selected for analysis.

As summarized in the above table and shown graphically on Plates 2 through 5, the waterside heights along the alignment generally range from eight feet to 10 feet. Landside heights vary from one to nine feet, with the maximum height of nine feet at Station 9+00. As shown in Table 5-2, the maximum WSE relative to the landside toe is 6.2 feet, located at Station 9+00. The levee cross-section at Station 9+00 was judged to be a critical section based on the landside slope height and inclination and WSE relative to landside toe and, therefore, selected for our seepage and slope stability analyses.

The steepest waterside slope corresponds to Station 84+10, with a surveyed height of eight feet at this location. A slope stability analysis was, therefore, performed for this station. The difference in elevation between the landside toe and WSE is approximately one foot at Station 84+10. The section at this station is not judged to be a critical case for seepage estimates.

Slope angles and heights as surveyed were used in our analyses. A crest width of 12 feet was conservatively used for all analyses; as shown in Table 2.2.1, surveyed crest widths ranged from 13 to greater than 30 feet with 16 of the 24 locations surveyed at 20 feet or more. The locations of the cross-sections analyzed are included on Plate 2, Plate 5, and Plate 6.

5.3 SEEPAGE AND STABILITY ANALYSES

Transient and steady state seepage analyses along with slope stability analyses were performed on two cross-sections of the MD as discussed in Section 5.2 and indicated on Table 5-2. The RCC lining was neglected in both the seepage and slope stability analyses performed. Details regarding the analyses performed, material properties used in the analyses, boundary conditions assumed in the analyses, and the results of the analyses are presented in the following Sections 5.3.1 through 5.3.6.

5.3.1 Analyses Details

Seepage and slope stability analyses were performed to evaluate through and underseepage, and stability of the MD embankments. A transient analysis was performed for both cross-sections to estimate both maximum saturation during the 100 year flood duration and the time for steady state conditions to develop under a sustained WSE. Design parameters input into the seepage analysis and slope stability model included the embankment geometry, the approximate unit weight, and other physical properties of the native and embankment fill soils. The WSE used in our analyses was previously discussed in Section 5.2.

Seepage analyses were performed using SEEP/W, a component of the GeoStudio 2007 Suite v.7.16. Slope stability analyses were conducted using the software program SLOPE/W, also a component of the GeoStudio 2007 suite. The FOS against slope failure was calculated using the SLOPE/W entry/exit search routine to determine the critical failure surface by Spencer's method. Failures originating at the crest (entry point) and exiting near the toe which were a minimum of five feet thick were considered in our analyses. Shallow failures or failures impacting only part of the slope were judged to be maintenance issues and not a true slope failure. Spencer's method is a two-dimensional limit-equilibrium method that satisfies force equilibrium of slices and overall moment equilibrium of the potential sliding mass.

For the Sudden Drawdown Case, the "three-stage procedure" required by the USACE is adopted. Pre- and post-drawdown pore water pressures were computed by SLOPE/W based on the input water surface elevations as defined by the "three-stage procedure." The pre-drawdown water surface is based on an estimated phreatic surface within the embankment as determined in the steady-state seepage analysis using the maximum WSE provided for the 100 year event. The post-drawdown water level is computed assuming a phreatic surface is present in the embankment and the channel is empty.

Input parameters to the slope stability analysis include the levee slope configuration, unit weight, shear strength properties of levee embankment and foundation materials, and the location of the phreatic surface for each case analyzed. After a potential failure surface has been assumed, the soil mass located above the failure surface is divided into a series of vertical slices. Forces acting on each slice include the slice weight, the pore pressure, the normal force on the base, the mobilized shear force (including both cohesion and friction), and the horizontal side forces due to earth pressures.

The FOS is calculated by determining the ratio of the resisting force (friction and/or cohesion along the failure surface) to the driving forces about the center of the assumed failure surface. The computer program performs automatic searches of different potential failure surfaces to compute the lowest FOS corresponding to a critical failure surface for a particular analysis condition.

Pore water pressure distribution as calculated by SEEP/W was used in the slope stability analysis with steady state seepage conditions for the maximum saturation case.

An embankment WSE equal to that of the design flood was used for the Sudden Drawdown analysis. As described in Section 5.1, our analyses considered three types of loading conditions: Steady Seepage from Full Flood Stage (Steady State), Sudden Drawdown, and Earthquake (Seismic).

5.3.2 Soil Models

Soil parameters were selected for the levee cross-sections analyzed at Stations 9+00 and 84+00 considering the results from the recent 2009 and previous 1991 field explorations, the laboratory testing programs, density test data for the embankment fill soils from the materials testing report, and our experience with similar soil types. Two soil models were developed and analyzed for the Station 9+00 geometry and reflect the results of the 2009 and 1991 explorations as well as our understanding of the site geology.

Boring B-1 (Plate A-2) was drilled at Station 9+00. The embankment fill encountered was heterogeneous, consisting of interlayered low plasticity cohesive soils and granular soils with silty and clayey fines. Lab test data from the 2009 explorations indicates that the embankment materials have fines contents between 30 and 55 percent. In Boring B-1, the native soils encountered generally consisted of gravel with varying amounts of silt and clay at depths greater than the landside embankment toe, underlain by very stiff, low to moderately plastic clayey soils. Lab test data indicates fines contents in the native cohesive and granular soils ranging from 70 to 95 and 10 to 50 percent, respectively. Results of explorations and lab testing from the previous 1991 explorations performed prior to construction of the MD indicate that the near surface soils at wash crossings were generally granular with fines contents as low as five percent.

The two soil models Case I and Case II developed for the levee geometry at Station 9+00 are based on the following considerations. The results of 2009 explorations and lab test data indicate that the embankment fill is a heterogeneous combination of silt, clay, sand and gravel, consistent with construction from a blended mixture of on-site materials. Based on the results of the explorations and our understanding of the site geology, the native soils present in the cut portions of the embankment consist of fine-grained clay with lesser amounts of interlayered silt and the more granular stream terrace deposits of the Las Vegas Wash overlying the fine-grained soils. This is consistent with our understanding of site geology, which indicates that the native fine-grained spring and marsh deposits present on the site occur both as localized high areas eroded by the Las Vegas Wash drainage system and underlying the higher surfaces of the Las Vegas Wash stream terrace deposits.

Two types of materials were selected to model the embankment materials: clay and clayey gravel. The foundation materials were modeled as clean gravel over clay and as full depth clay. Case I is represented as clay embankment with a foundation consisting of gravel over clay to represent the Station 9+00 where a major drainage passes beneath the embankment. Case II is represented as a clayey gravel embankment over a clay foundation. A profile consisting of full-depth clay was used for the soil model at Station 84+10.

An interpretive profile of the MD alignment incorporating preconstruction site topography, current topography, geology, and the results of explorations is presented on Plate 7, Interpretive Geologic Profile. As shown on Plate 7, a localized native area formed from predominantly granular deposits underlies the embankment between approximate Stations 28+00 and 39+00. Even though the embankment materials are granular, the levee cross-sections shown on Plate 3 indicate that the landside portion of the levee in this portion of the alignment is higher than the WSE; this case was, therefore, not included as a soil model for analysis.

5.3.3 Material Properties – Seepage Analysis

The results of 2009 and 1991 explorations and laboratory data, as well as the 1992/93 density test data from construction records were used to estimate hydraulic conductivity, unit weight and porosity for the seepage modeling. Based on the 2009 explorations and laboratory test data, three general material types are identified; clay; clayey gravel/sand; and gravel with low fines content. Modeled material properties of clay and clayey gravel were generally estimated based on averaged 2009 lab data and 1992/93 density test data from construction records. Material properties of the clean gravel were estimated based on the borings and lab test data from the 1991 geotechnical report with an emphasis on test results showing the greatest D_{10} value (i.e. coarsest material).

Horizontal hydraulic conductivity values, K_h, presented in Figure 3-5 of the USACE EM 1110-2-1913 apply to D_{10} values between approximately 0.06 and 1.0 mm; K_h estimates for D_{10} values within this range were obtained using Figure 3-5. D_{10} values for the clay and clayey gravel which both occur in the embankment and foundation fell outside this range; K_h values for these materials at saturation were estimated using an approach based on the Kozeny-Carman method (Carrier, 2003), with the assumption that the values developed are representative of the silty soils and conservative for the clayey soils. Spherical grain shapes were assumed. A summary of the material properties used in the seepage analysis is presented in the following table.

Table 5-3
Summary of Soil Parameters Used in Seepage Analysis

Material Type	Average Dry Unit Weight (pcf)	Horizontal Hydraulic Conductivity, K_h (ft/day)	Ratio of Horizontal to Vertical Conductivity, K_h/K_v
Clayey Embankment (CL to CL-ML)	108	0.037	10
Clayey Gravel Embankment (GC)	119	0.16	4
Gravel (5% fines) Native Foundation (GP)	121	170*	4
Clayey Foundation (CL to CL-ML)	108	0.037	10

* *Based on USACE EM 1110-2-1913 Figure 3-5; other results are an average value calculated based on Kozeny-Carman*

The parameters summarized in Table 5-3 represent the estimated properties of the various materials under saturated flow conditions. Hydraulic functions that relate unsaturated permeability to soil moisture suction are incorporated in SEEP/W. The volumetric water content and hydraulic conductivity functions used were selected based on grain size distribution data from the laboratory tests, porosity calculated using average dry density from the compaction test data, and published coefficient of volume compressibility values for the soil types modeled (Bell, 1981).

5.3.4 Material Properties – Slope Stability Analysis

Blowcount data obtained in the 2009 explorations were corrected for measured hammer efficiencies, drill rod string, and overburden. The corrected blowcount data, $(N_1)_{60}$, were used to estimate the embankment and native soil strength parameters following correlations presented in Das, Principles of Geotechnical Engineering, 6th Edition. The results of the correlated internal angle of friction indicate granular embankment and native soils have a lower bound friction angle of approximately 36 degrees. This value correlates well with the average phi angle of 37 degrees obtained from direct shear results performed on remolded samples of granular soils obtained in the 1991 explorations for the MD and ULVDB.

Clay embankment and foundation effective stress strength parameters were estimated using a relationship between liquid limit, clay fraction, and residual friction angle (Sabatini, et al, 2002). An apparent cohesion of 50 psf was assigned to account for emplacement stresses during construction. The same magnitude of apparent cohesion was used in the clayey foundation soils and is considered conservative based on geologic and climatic stress history. Total stress clay strengths were based on a reduction of friction angle and increase in apparent cohesion using engineering judgment.

Tabulated below are unit weight and strength parameters used in the slope stability analyses:

Table 5-4
Summary of Soil Parameters and Material Properties for Slope Stability Analyses

Material Type	**Unit Weight (pcf)**	**Effective Stress**		**Total Stress**	
		Friction Angle (degrees)	**Apparent Cohesion (psf)**	**Friction Angle (degrees)**	**Apparent Cohesion (psf)**
Clayey Embankment (CL to CL-ML)	124	25	50	20	150
Clayey Gravel Embankment (GC)	134	36	0	36	0
Gravel (5% fines) in Native Foundation (GP)	130	36	0	36	0
Clayey Foundation (CL to CL-ML)	124	25	50	20	150

5.3.5 Seepage Model Boundary Conditions

A zero flux (i.e. no flow) boundary condition was imposed on the landside, waterside and bottom edges of the model for transient seepage estimates during the 100 year flood event. To estimate the time required to reach steady state and to estimate steady state vertical exit gradients in the transient analysis, zero flux boundaries for the landside and bottom edges, as described above, were used. The WSE was used for the waterside edge boundary condition to estimate time required to reach steady state and the steady state local vertical exit gradients.

As previously discussed, water elevation versus time for the 100 year event was estimated using hydrograph and maximum water surface elevation data provided by PBS&J. For estimating the time required to steady state, the levee is assumed to be impounded at the WSE until reaching an approximate steady state solution. An initial groundwater elevation equal to 80 feet below the modeled landside ground surface was used in the transient 100 year event and the estimated time to steady state seepage analyses.

The landside of the levee and the landside ground surface were modeled as potential seepage surfaces (i.e. seepage extends to ground surface). These nodes are assigned a zero unit flux boundary condition that is automatically adjusted by SEEP/W to a constant head boundary based on the iterative results of successive finite element runs. The calculated pressure head at each node is compared to the elevation head of each iteration. If the pressure head is positive at the node, the node becomes a constant head node with head equal to the ground surface elevation, thus allowing water to seep from the modeled surface.

A global mesh size of three feet and a mesh size constraint equal to 1.5 feet were applied to the levee edges as well as the waterside edge used in modeling transient seepage during the 100 year event and to estimate the time to steady state. The same global mesh size was used without mesh constraints for the steady state analyses. Secondary nodes and higher order elements were defined throughout the mesh.

To reduce the potential for numerical errors due to boundary effects, the models were extended approximately 1,000 and 2,000 feet landward from the centerline of the existing levee for the transient and steady state seepage analyses, respectively.

5.3.6 Seepage and Slope Stability Analyses Results

The results of the seepage analyses are shown on Plates C-1 and C-2 in Appendix C. A graph of water elevation versus time used as input for the seepage analyses is presented on Plate C-3. The maximum wetting front, or furthest progression of the phreatic surface in the embankment during the base flood, was analyzed and is represented as the transient seepage case. As shown in the transient seepage results in the upper left diagram on Plates C-1 and C-2, the wetting front saturates only the outermost portions of the waterside slope during the base flood period. The time to steady state seepage and the magnitude and location of the maximum local vertical exit gradient, $(i_y)_{max}$ during steady state seepage are also shown. The time to steady state seepage is greater than six days for the soil cases modeled. A plot of the vertical exit gradient at nodes along the modeled land surface generated by SEEP/W was used to select the location and maximum magnitude of $(i_y)_{max}$. As previously described, the difference in elevation between the landside toe and the WSE was approximately one foot at Station 84+10; a seepage analysis was, therefore, not performed at this location.

The results of the slope stability analyses for steady state, sudden drawdown and seismic conditions are shown on Plates D-1 through D-3 in Appendix D. These plates also show the model geometry, material properties and the phreatic surface(s) used in the analysis. The failure surface for the zone depicted as having the lowest FOS is shown for each case.

Tables 5-5 and 5-6 summarize the results for the seepage and stability analyses, respectively, for the cross-sections analyzed. The seepage analyses indicate that the maximum vertical exit gradient at the landside toe of levee is less than or equal to the USACE maximum allowable exit gradient of 0.3. The slope stability analyses indicate the cross-sections have FOS greater than 1.4 for the Steady State Case (static stability analysis), and greater than 1.0 for the Sudden Drawdown and Seismic Cases. The waterside FOS for steady state seepage was lower than the landside at Station 84+00 and is therefore presented.

Table 5-5
Summary of Seepage Analyses

Station	Closest Boring	Levee Crest Elevation (ft)	Landside Toe Elevation (ft)	WSE (feet)	Estimated Time to Steady State Seepage (days)	Computed Maximum Vertical Landside Exit Gradient
9+00 – Case I	B-1	2492.7	2483.4	2489.6	>6	0.1
9+00 – Case II	B-1	2492.7	2483.4	2489.6	>90	0.3

Table 5-6
Summary of Slope Stability Analyses

Station No.	Closest Boring	Calculated Steady State FOS	Required Steady State FOS	Calculated Sudden Drawdown FOS	Required Sudden Drawdown FOS*	Calculated Seismic FOS	Required FOS (NDWR)
9+00 – Case I	B-1	2.8	≥1.4	2.2	≥1.0	2.3	≥1.0
9+00 – Case II	B-1	2.5	≥1.4	2.4	≥1.0	2.8	≥1.0
84+10	B-6	1.9	≥1.4	1.8	≥1.0	1.8	≥1.0

*Note: *A minimum Factor of Safety of 1.0 applies to pool levels prior to drawdown for conditions where these water levels are unlikely to persist for long periods preceding drawdown.*

5.4 LIQUEFACTION POTENTIAL

Liquefaction describes a phenomenon in which saturated soil loses shear strength and deforms as a result of increased pore water pressure induced by strong ground shaking during an earthquake. Dissipation of the excess pore pressures produces volume changes within the liquefied soil layer which can cause settlement of the levee. Shear strength reduction combined with inertial forces from the ground motion may result in lateral migration (lateral spreading), extensional ground cracking of liquefied material, and slope failure. Factors known to influence liquefaction include soil type, structure, grain size, relative density, confining pressure, depth to groundwater, and the intensity and duration of ground shaking. Soils most susceptible to liquefaction are saturated, loose sandy soils and low to non-plastic silt.

A review of the soil types and consistencies as assessed by field blow count data in the soil borings for this project indicates that the majority of the subsurface soils consist of stiff to very stiff clay soils, dense to very dense, coarse grained granular soils, and stiff silt. As previously discussed, the groundwater level in the project area is 80 feet below the existing ground surface. Due to the depth of groundwater and consistency of the on-site soils, it is our opinion that the liquefaction potential for the site is low.

5.5 SETTLEMENT

The subsurface soils at the site are predominantly stiff to very stiff clay with interlayered granular soil layers and zones of calcium carbonate cementation. The levee was constructed greater than 10 years ago. No evidence of settlement of the MD was observed during our site visits. Load-related settlement within the clay foundation soils is expected to have already occurred.

Hydrocollapse or hydrocompaction refers to a condition where soils undergo a rapid decrease in volume upon wetting due to a collapse in soil structure. Soils that are typically associated with this condition are loess deposits and weakly cemented fine sands and silts where the cementing agent is a soluble mineral. Layers of silt are present in the site area; a low plastic, native silt layer four feet thick was identified in Boring B-4 at a depth of six feet below the crest. As described previously, collapse test results from the 1991 geotechnical exploration indicated collapse of less than one percent under a 1,200 psf surcharge in two samples tested from the borings in the MD area. Additional hydrocollapse testing for the ULVDB project downstream of MD indicated hydrocollapse potentials up to four percent. Evidence of embankment settlement or other ground surface irregularities, such as sinkholes or depressions associated with collapsible soil deposits, were not observed during our site reconnaissance along the existing levee alignment.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 GENERAL CONCLUSIONS

The findings, conclusions, and recommendations presented in this report are integral with the provisions and requirements outlined in the Limitations section of this report.

6.1.1 Levee Characterization

The results of the explorations suggest that the MD embankment fill is composed of a heterogeneous mix of clay, silt, sand and gravel, consistent with construction from a blended mix of on-site materials. Blow counts greater than 45 were measured in the levee embankment fill in all cases except one location in B-6 at a depth of two feet near the transition to native materials, where a blow count of 27 was measured. These results are generally consistent with the density test data from the construction records.

The native soils encountered in the cut portions of the MD consist predominantly of clay, with lesser amounts of interlayered silt. The MD foundation soils encountered in the exploration borings consist of interlayered dense to very dense and stiff to very stiff gravel, clay, and silt. These results are consistent with our understanding of site geology, which indicates that the native fine-grained spring and marsh deposits present on the site occur as localized high areas incised by downcutting of the Las Vegas Wash drainage system.

The MD was designed and constructed with a 12-inch thick RCC lining protecting the waterside slope face. The RCC lining was designed to extend below the interception channel invert a minimum of 18 feet parallel to slope or a vertical distance of six feet. The RCC lining was intact at the time of our inspection, with cracking and minor raveling judged to be commensurate with normal aging. In two areas, a bulge in the RCC lining was observed. The bulging occurred over a distance of approximately 20 feet, and was estimated to be a maximum of three inches perpendicular to slope at the greatest point. Borings B-5 and B-6 were drilled in these areas. Native clay soils with a moderate to high potential for expansion comprise the embankment in these areas. It is our opinion that the bulging is the result of expansion of the native soils. The RCC lining was neglected in the seepage and slope stability analyses performed, which is conservative.

Prior maintenance records or records of previous flooding or documents available which describe past performance history, including erosion during flood events, were not available for the MD. Interviews with representatives of Clark County Regional Flood Control District, City of Las Vegas, and City of North Las Vegas indicate that very little maintenance has been required at MD since construction.

A geotechnical inspection of the MD was performed by Kleinfelder prior to conducting subsurface exploration. Geotechnical observations made during the inspection included three small holes at the landside edge of the crest; rutting on the crest; localized bulging and raveling of the RCC slope protection; and exposure of the upper portion of the RCC below the channel invert. Due to the presence of expansive clay soils, the MD structure was observed for evidence of dessication cracking. Evidence of cracking in the embankment was not observed during any of our site visits. Since the time of our inspection, maintenance activities at the MD have been performed. A post-maintenance inspection indicates that the crest rutting, landside crest holes, and exposure of RCC cut off at the waterside toe of slope has been remediated through site grading.

6.1.2 Seepage and Slope Stability

Neglecting the RCC lining, the transient seepage analysis for all sections analyzed indicates that only the outermost portion of the waterside slope would be saturated during the limited time of the design flood. Our analyses indicate that it takes a minimum of six days of sustained exposure to the maximum WSE to attain a steady state seepage condition for clayey gravel and clay embankments, as modeled. The seepage analyses indicate that the maximum local vertical exit gradient at the landside toe of levee for the two cases analyzed is ≤ 0.3.

Levee certification evaluations of the Range Wash Levee and the Equestrian Levee, located in the Las Vegas Valley approximately five miles east and 15 miles southeast of MD, respectively, are being performed by Kleinfelder concurrent with the study for MD. Both of these levees have embankment and foundation materials composed of clean granular soils which have been modeled with hydraulic conductivity values equal to or greater to that of the clean gravel foundation materials in the MD Case I soil model analyzed for Station 9+00. The transient seepage analyses for these two levees also show that greater than four days are required for steady state conditions to develop. Reports of these findings are being prepared and will be submitted following the MD study. Although a hydraulic conductivity sensitivity study for MD was not performed, the results of the two concurrent studies support the findings of the transient analyses for MD and the approach selected that considers flood duration as part of the analysis.

The slope stability analyses indicate that the three cases analyzed meet or exceed the minimum Factors of Safety (FOS) required for the Steady State Case and the Sudden Drawdown Cases by USACE and meet or exceed the minimum FOS for seismic according to Nevada Division of Water Resources (DWR) Dam Guidelines for Design (http://water.nv.gov/Engineering/Dams/design.cfm, accessed October 22, 2009). The sections analyzed included slopes as steep as 2.8:1 (H:V), based on the survey data.

6.1.3 Settlement

The levee was constructed over ten years ago. Load-related settlement of the clayey foundations soil is anticipated to be complete. Soil deposits associated with a low to moderate hydrocollapse potential are present in the site area. Based on hydrocollapse test results performed in 1991 as part of the MD and ULVDB projects and the results of the 2009 explorations, we estimate that a future collapse potential of up to two inches may exist. No evidence of settlement of the MD structure or other ground surface irregularities associated with hydrocollapse, such as sinkholes, were noted during our site visits.

6.1.4 Other Potential Considerations

Levee performance issues not addressed by Kleinfelder include presence of sufficient freeboard, impact of erosion, impacts of vegetation, and impacts of animal burrows. Additional discussion of the items not addressed is presented below.

- We understand the freeboard analysis, survey data and WSEs were provided with the level of detail required for the evaluation of the civil engineering components of the basin. Site conditions, WSEs or freeboard different than those provided may invalidate the results presented in this report.

- Erosion: We understand that this issue will be addressed as part of the overall levee performance assessment performed by others. As previously described, the MD was designed and constructed with RCC armoring on the waterside slope.
- Operation and Maintenance, and Past Performance: Limited information regarding past performance, repairs, and maintenance was available for this levee.

6.2 RECOMMENDATIONS AND CERTIFICATION

Based on our evaluation and findings of this study, it is our opinion that the MD meets the current USACE and State of Nevada DWR design criteria for seepage and slope stability and, therefore, meets FEMA requirements for geotechnical components of levee certification in accordance with 44 CFR Section 65.10. A steady state seepage analysis was performed in accordance with USACE EM procedures. A transient analysis was performed to evaluate when steady state conditions would develop and these results were compared to the 100 year flood duration. The Kleinfelder analyses are judged to be conservative because the RCC lining was neglected. Based on this approach, the MD levee is found to be stable in accordance with 44 CFR 65.10.

As shown on Plate 6, a combined total of 26 borings and test pits was performed along the MD alignment in the previous 1991 and recent 2009 explorations. Although the distribution and depth of the explorations performed are not consistent with the requirements of USACE ETL 1110-2-569, based on the borings, explorations from previous Kleinfelder projects in the project area, and our understanding of the geology in the vicinity of the site, it is our opinion the soil characteristics observed and tested in our borings are representative of the levee embankment soils and underlying alluvium to the depths modeled.

We recommend that MD be considered for certification for the following reasons:

- The MD is an engineered structure with intact, waterside slope RCC armoring present for the entire length of the structure evaluated for this study. Design plans show an RCC thickness of 12 inches and a design depth below the interception channel invert of 18 feet parallel to slope, or a vertical depth of six feet.

- Construction observation and materials testing was performed and the density test results indicate that over 95 percent of the tests taken within the MD embankment fill and subgrade met the required compaction.

- Blow count data from the embankment fill in the 2009 borings indicate uncorrected N values of 45 or greater in all areas but one, where an N value of 27 was measured near the transition to native soils. These results are judged to be consistent with the construction records.

- The base flood duration is approximately six hours. Neglecting the RCC armoring, the transient seepage analyses based on the 100 year hydrograph data provided by PBS&J, indicate that only the outermost portions of the waterside slope are saturated.

- The seepage analyses indicate a minimum time to steady state conditions of six days and maximum steady state landside vertical exit gradients of 0.3 or less for the cases analyzed.

- The slope stability analyses performed using phreatic surfaces obtained from the seepage analyses indicate the slopes exceed USACE minimum criteria for the Steady State and Sudden Drawdown cases. Subjected to the lateral force generated by the event with a 10 percent probability of exceedance in 50 years, the seismic stability exceeds the minimum FOS requirement for Nevada Division of Water Resources (DWR) Dam Guidelines for Design.

The operation and maintenance recommendations outlined below should be included in guidelines being prepared for future satisfactory performance of the MD.

Operation and maintenance inspections should be performed after a rainfall or flood event and on a time-based criteria (annually or less) to evaluate distress such as erosion, slope condition, and rodent burrows. Inspections for and evaluations of dessication cracks should be performed. Inspections should be recorded and photographs taken to document current conditions. Additionally, we recommend inspection and any needed operation and maintenance be performed subsequent to an earthquake event with an epicenter near the vicinity of the site. We recommend the Operation and Maintenance Plan also include documentation of the lateral and vertical limits of repairs using survey as a means to further assess and document levee performance. The repair procedure should outline a plan for fixing and maintaining washout erosional areas, gullies, dessication and/or other cracking, animal burrows, etc. Repair methods could consist of excavating and infilling erosional features with compacted soil, or track walking the levee faces with heavy equipment, as determined by the type and size of repair. These repairs should be performed in a prompt manner after the occurrence. Existing slope inclinations should be maintained to the present grade or flatter, and a maintenance program should include periodic survey to identify areas where slopes begin to steepen or where the RCC armoring appears to be undergoing weathering or distress. Damage to the RCC lining should be repaired as part of the maintenance program.

7.0 LIMITATIONS

Recommendations contained in this report are based on our limited field observations and subsurface explorations, limited laboratory tests, review of limited construction details and documentation, and our present knowledge of the subject levee. It is possible that soil conditions vary between or beyond the points explored. If soil or groundwater conditions are encountered that differ from those described, we should be notified immediately in order that a review may be made and any supplemental recommendations provided.

Kleinfelder did not provide surveying services. An opinion regarding the accuracy of the surface location or elevations with respect to the approved plans and current site surveying is not provided. We understand the survey data and WSE were provided with the level of detail required for the evaluation of the civil engineering components of the basin. Site conditions, WSEs and/or freeboard different than those provided may invalidate the results presented in this report.

Information and recommendations presented in this report should not be extrapolated to other areas or be used for other projects without our prior review and response. The client has the responsibility to see that all parties to the project, including the designer, contractor, subcontractors, etc., are made aware of this report in its entirety. This report contains information that may be useful in the preparation of contract specifications; however, the report is not designed as a specification document and may not contain sufficient information for this use without proper modification.

Our evaluation of subsurface conditions at the site has considered subgrade soil and groundwater conditions present at the time of our exploration. The influence(s) of post-construction changes to these conditions, such as introduction of water into the subsurface, will likely influence future performance of the proposed project. Our scope of services addresses present groundwater conditions; whereas future irrigation, broken water pipelines, etc., may adversely influence the project and should be addressed and mitigated, as needed.

Other standards or documents referenced in any given standard cited in this report, or otherwise relied upon by the authors of this report, are only mentioned in the given standard; they are not incorporated into it or "included by reference", as the latter term is used relative to contracts or other matters of law.

We have presented the findings, conclusions and recommendations in this report in a manner consistent with the standards of care and skill ordinarily exercised by members of Kleinfelder's profession practicing under similar conditions in Clark County, Nevada, and at the time the services were performed. No warranty, express or implied, is made.

This report may be used only by the client and only for the purposes stated, within a reasonable time from its issuance, but in no event later than one year from the date of the report. Land use, site conditions (both on-site and off-site) or other factors may change over time, and additional work may be required with the passage of time. Any party other than the client who wishes to use this report shall notify Kleinfelder of such intended use. Based on the intended use of the report, Kleinfelder may require that additional work be performed and that an updated report be issued. Non-compliance with any of these requirements by the client or anyone else will release Kleinfelder from any liability resulting from the use of this report by any unauthorized party, and client agrees to defend, indemnify, and hold harmless Kleinfelder from any claim or liability associated with such unauthorized use or non-compliance.

The scope of our geotechnical services did not include any environmental site assessment for the presence or absence of hazardous/toxic materials. Kleinfelder will assume no responsibility or liability whatsoever for any claim, damage, or injury which results from pre-existing hazardous materials being encountered or present on the project site, or from the discovery of such hazardous materials.

8.0 REFERENCES CITED

ASTM, 2009, Annual Book of ASTM Standards.

Bell, John W, 1981, Bulletin 95, Subsidence in Las Vegas Valley, Nevada Bureau of Mines and Geology, Bulletin 95, 84 pp.

Bell, John W. Ramelli, Alan R., and S. John Casey, 1998, Geologic Map of the Tule Springs Quadrangle, Nevada, Nevada Bureau of Mines and Geology Map 113, 1:24,000.

Black and Veatch, 1993, Upper Las Vegas Wash Detention Basin and Interception Berm/Channel Record Drawings/As-Builts, Black and Veatch Project No. 17149, October 26, 1993.

Carrier, W.D., 2003, Goodbye, Hazen; Hello, Kozeny-Carman, J. Geotechnical and Geoenvironmental Eng., 129(11), 1054-1056.

Continental Aerial Photographs:

Date	Photo Number	Scale
6/11/1962	2, 3, 4	1:24,000
9/23/1981	2-14, 2-16	1:40,000
7/7/1984	LV-3, LV-4, LV-5, LV-6	1:14,400
1/28/1990	5-13, 5-14	1:20,000
10/4/1999	C-137-4-27, C-137-4-28	1:24,000

Das, Braja M., 2006, Principles of Geotechnical Engineering, Sixth Edition, Thomson, 686 pp.

DePolo, Craig M. 2008, Quaternary Faults of Nevada, Nevada Bureau of Mines and Geology Map 167, 1:1,000,000.

Kleinfelder, 1991, Geotechnical Investigation, Proposed Upper Las Vegas Wash Detention Basin, Clark County, Nevada, Kleinfelder Project No. 31-128109, May 6, 1991.

Kleinfelder, 1993, Technical Report: In-Place Field Density Tests of Compacted Structural Fill for Upper Las Vegas Wash Detention Basin Project, Kleinfelder Project No. 31-128114, January 15, 1993.

Nevada Bureau of Mines and Geology, 2010, Quaternary Faults in Nevada – Onlne Interactive Map, from Nevada Bureau of Mines and Geology, data available on the World Wide Web, accessed February 15, 2010 at URL http://gis3.nbmg.unr.edu/OF09_9/.

Page, William R., Lundstrom, Scott C., Harris, Anita G., Langenheim, Victoria E., Workman, Jeremiah B., Mahan, Shannon A., Paces, James B., Dixon, Gary L., Rowley, Peter D., Burchfiel, B. C., Bell, John W., and Eugene I. Smith, 2005, Geologic and Geophysical Maps of the Las Vegas 30' X 60' Quadrangle, Clark and Nye Counties, Nevada, and Inyo County, California, 1:100,000.

Sabatini, P.J., Bachus, R.C., Mayne, P.W., Schneider, J.A., Zettler, T.E., April 2002, Geotechnical Engineering Circular No. 5, Evaluation of Soil and Rock Properties, FHWA-IF-02-034, 266 pp

Southern Nevada Amendments to 2006 International Building Code, Table 1805.8.2.

USACE, 2000, "Design and Construction of Levees," US Army Corps of Engineers Engineering Manual EM 1110-2-1913, dated April 30, 2000.

USACE, 2003, "Slope Stability," US Army Corps of Engineers Engineering Manual EM 1110-2-1902, dated November 14, 2003.

USACE, 2005, "Design Guidance for Levee Underseepage," US Army Corps of Engineers Technical Letter ETL 1110-2-569, dated May 1, 2005.

United States Geological Survey (USGS) 2002 Seismic Hazard Curves and Uniform Hazard Response Spectra Calculator v.5.0.9, data available on the World Wide Web, accessed February, 2010 at URL http://earthquake.usgs.gov//research/hazmaps/design/

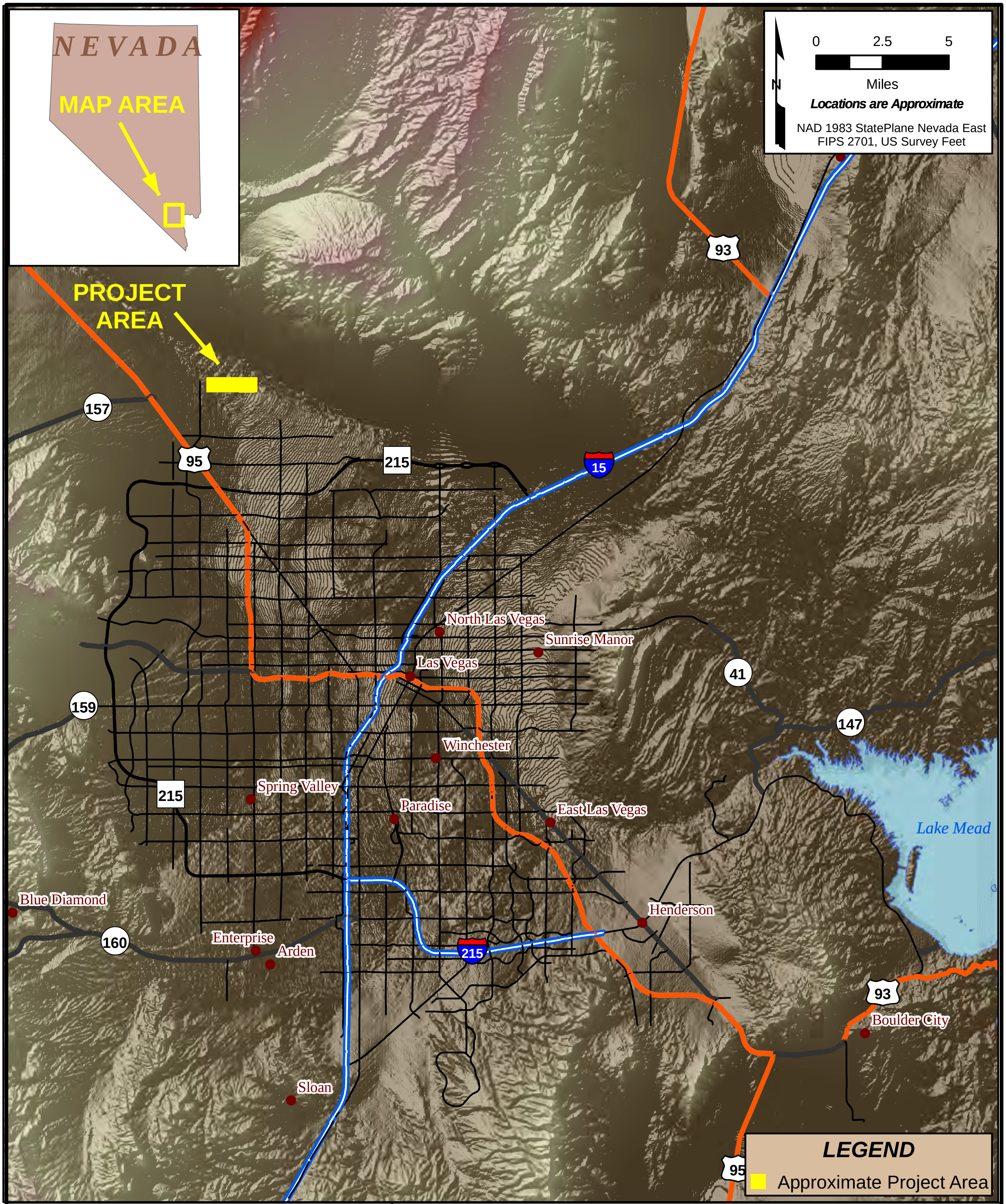
United States Geological Survey and Nevada Bureau of Mines and Geology, 2010, Quarternary Fault and Fold Database for the United States, data available on the World Wide Web, accessed February 16, 2010, from USGS URL http://earthquake.usgs.gov/regional.qfaults/

U.S. Geological Survey, 2001, National Water Information System (NWISWeb), data available on the World Wide Web, accessed January 29, 2010 at URL http://waterdata.usgs.gov/nwis/.

9.0 ACRONYMS DEFINED

ASFE	Association of Engineering Firms Practicing the Geosciences
CLV	City of Las Vegas
CNLV	City of North Las Vegas
DWR	Division of Water Resources
EM	United States Army Corps of Engineers Engineering Manuals
ETL	United States Army Corps of Engineers Engineering Teaching Letters
FEMA	Federal Emergency Management Agency
FOS	Factor of Safety
MD	Moccasin Diversion
RCC	Roller Compacted Concrete
ULVDB	Upper Las Vegas Detention Basin
ULVW	Upper Las Vegas Wash
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
USGS	United States Geological Survey
WSE	Water Surface Elevation

PLATES



KLEINFELDER
6380 S Polaris Avenue
Las Vegas, NV 89118
Ph: (702) 736-2936 Fax: (702) 361-9094

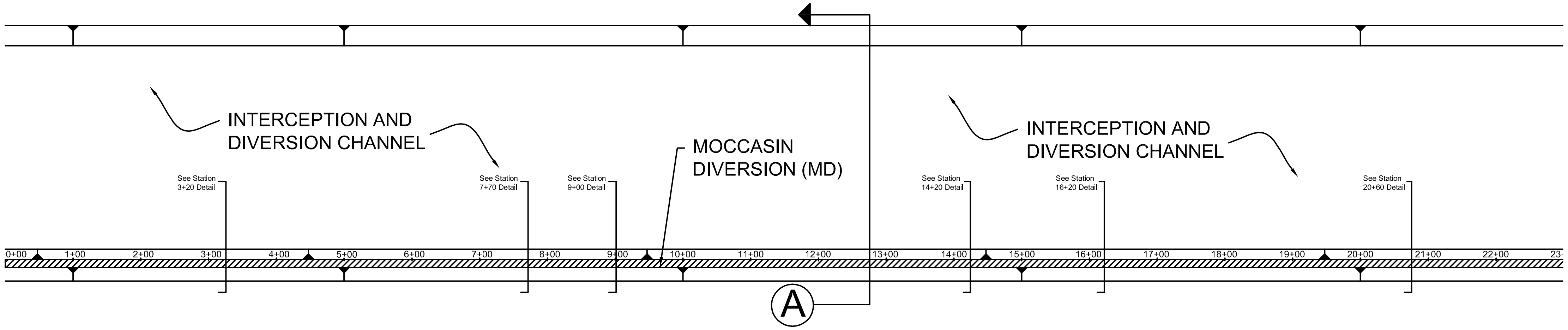
PROJECT LOCATION MAP

CCRFCD
Clark County Levee Certification Project
Moccasin Diversion
Las Vegas, Nevada

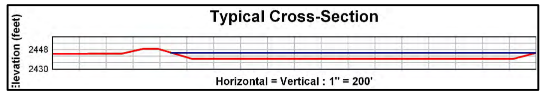
Plate
1

Drawn By: KFH | Reviewed By: ALB | Date: 06/02/10 | Project Number: 101764 | File: D:\...\101764...\Moccasin_vic.mxd

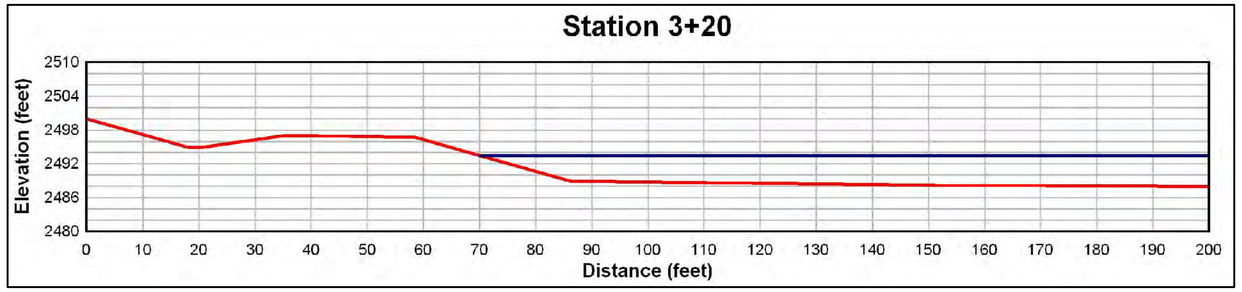
APPROXIMATE SCALE 1 inch = 200 feet

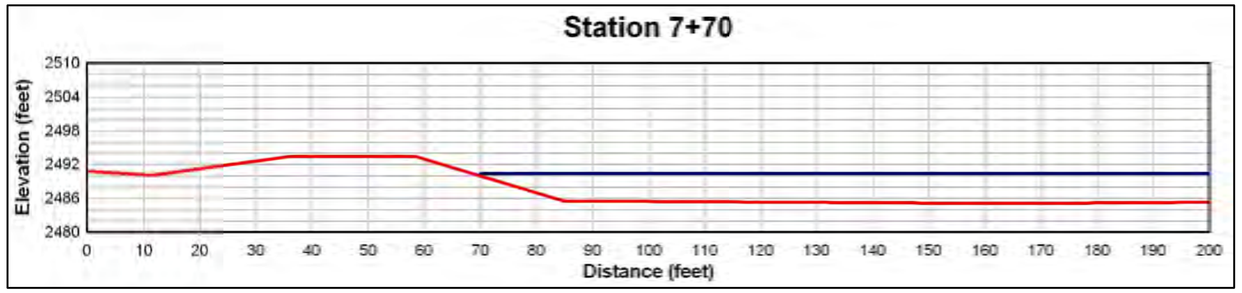


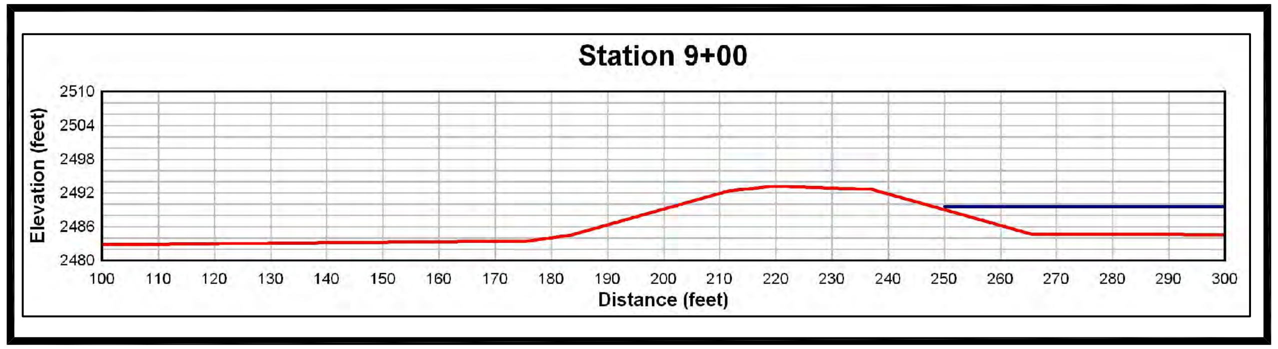
MOCCASIN DIVERSION (PLAN VIEW)
STATION 0+00 - 23+00

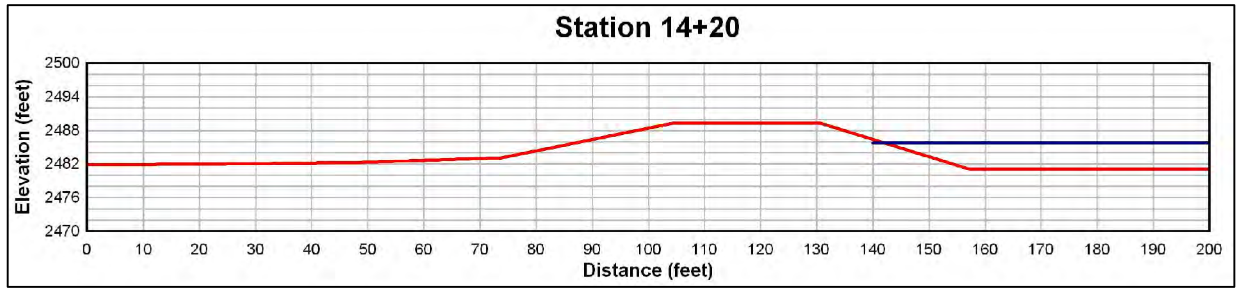


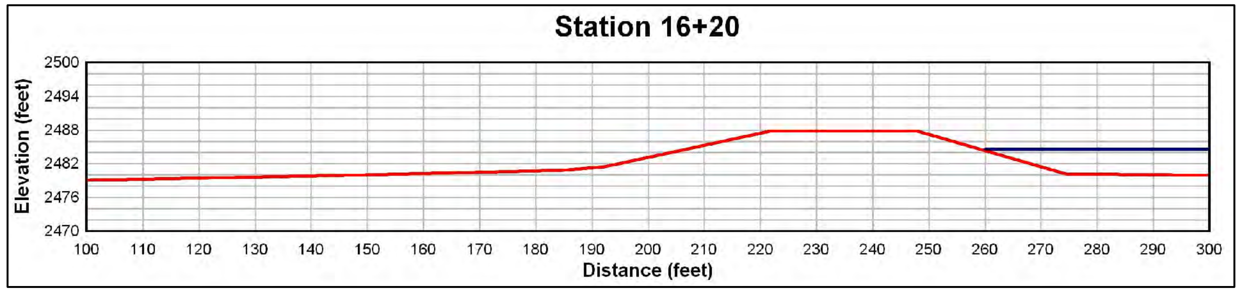
A TYPICAL CROSS-SECTION
SURVEYED CROSS-SECTIONS OF DIVERSION AS SHOWN (See Table 5-2 in report for elevation summary)

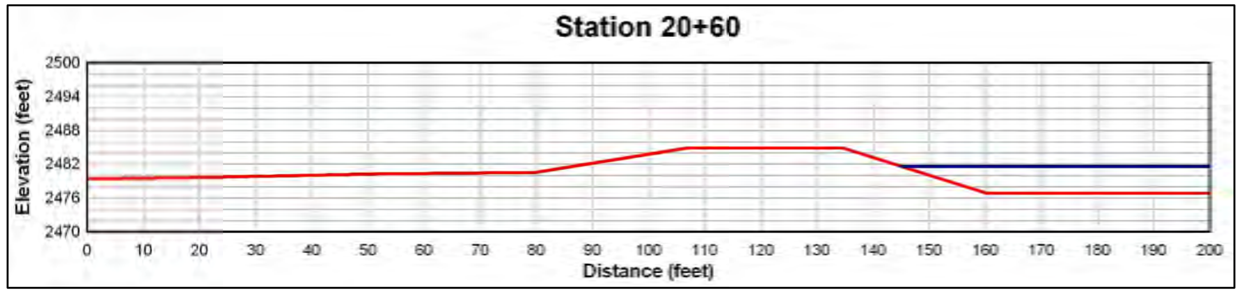

Station 3+20


Station 7+70


Station 9+00


Station 14+20


Station 16+20


Station 20+60

LEGEND:

🟥	-	LAND SURFACE
🟦	-	100 YEAR WATER SURFACE
▭	-	SELECTED CROSS-SECTION FOR STABILITY ANALYSIS (STA. 9+00)

KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

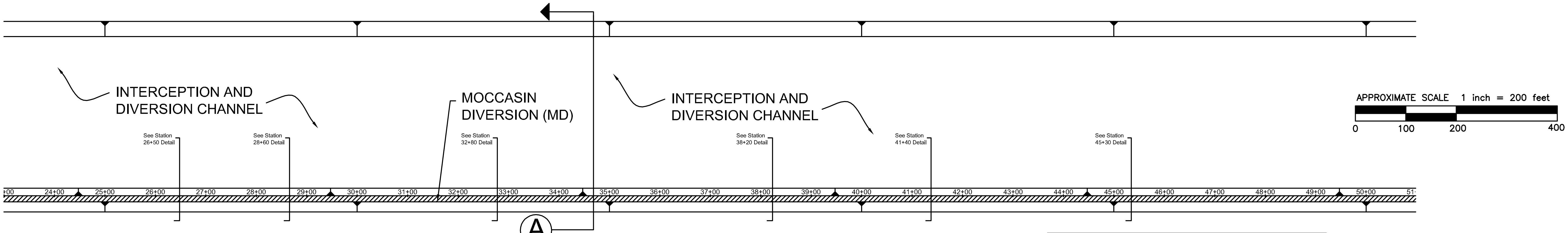
PROJECT NO.	101764.2
DRAWN:	04/30/2010
DRAWN BY:	DFR
CHECKED BY:	ALB

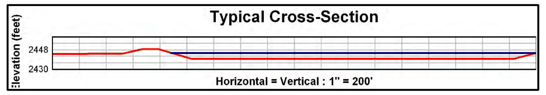
6380 SOUTH POLARIS AVE.
LAS VEGAS, NV 89118
(P) 702-736-2936 (F) 702-361-9094

Levee Survey Geometry
Station 0+00 - 23+00

CCRFCD
Clark County Levee Certification Project
Moccasin Diversion
Las Vegas, Nevada

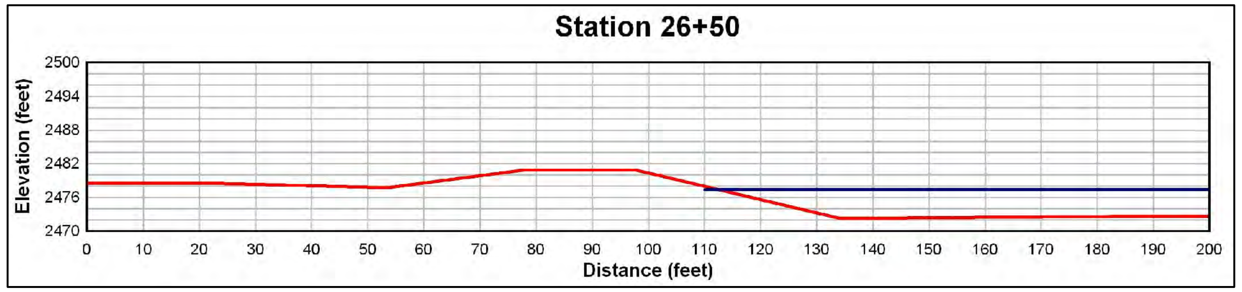
PLATE
2

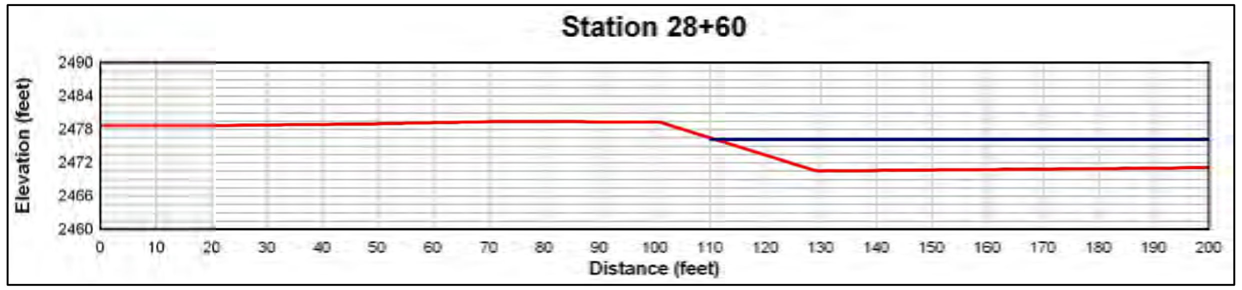


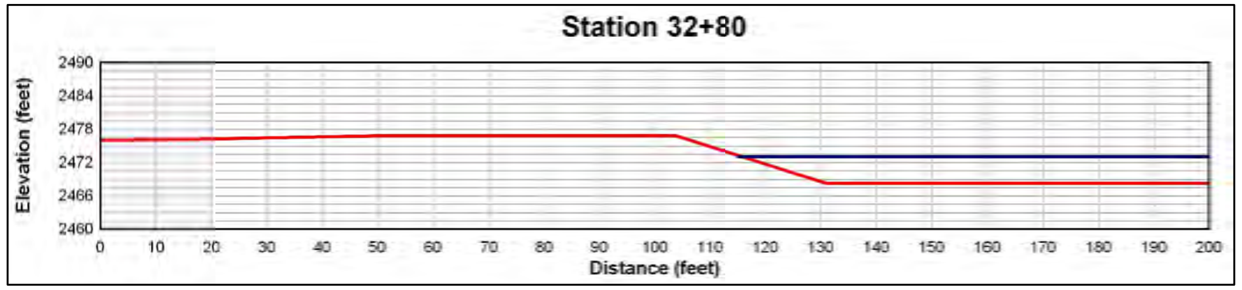


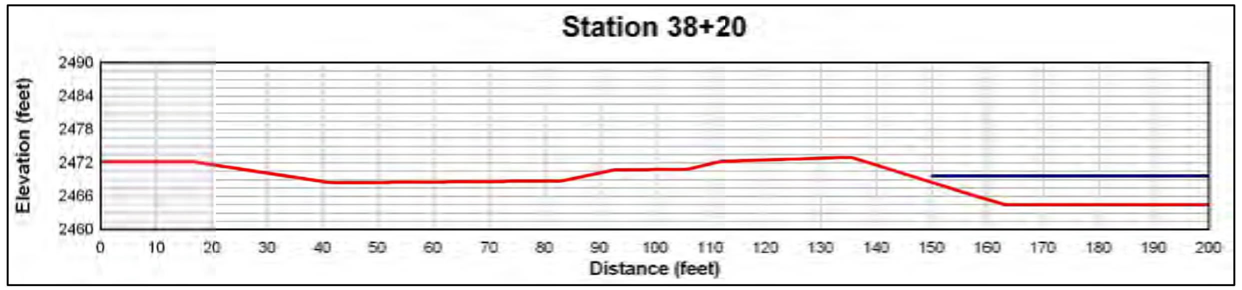
MOCCASIN DIVERSION (PLAN VIEW)
STATION 23+00 - 46+00

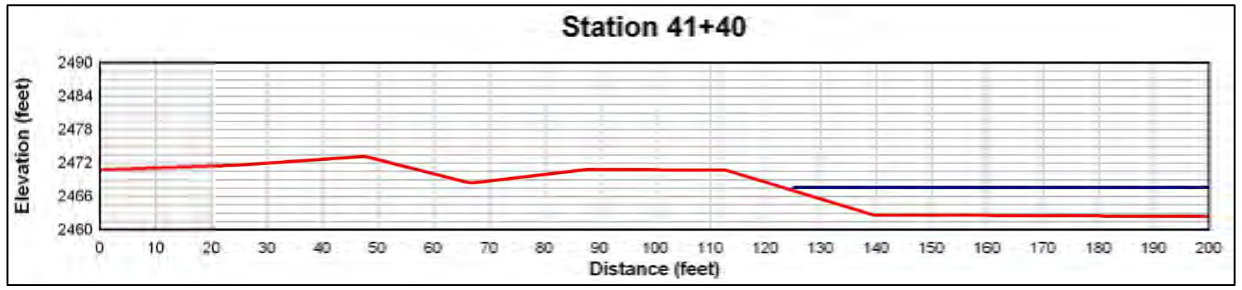
A TYPICAL CROSS-SECTION
SURVEYED CROSS-SECTIONS OF DIVERSION AS SHOWN (See Table 5-2 in report for elevation summary)

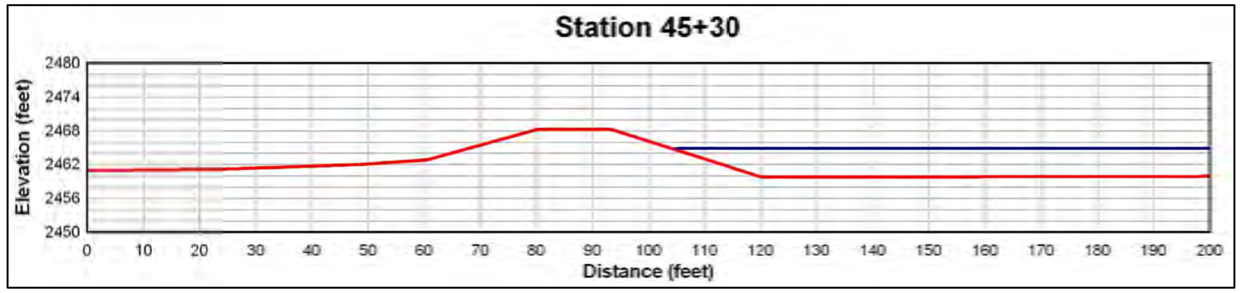












LEGEND:

— - LAND SURFACE
— - 100 YEAR WATER SURFACE

KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

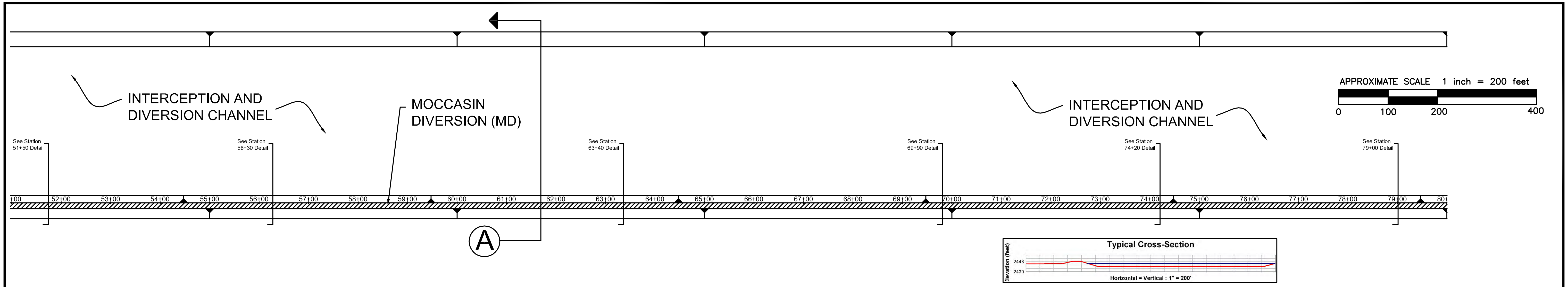
PROJECT NO.	101764.2
DRAWN:	04/30/2010
DRAWN BY:	DFR
CHECKED BY:	ALB

6380 SOUTH POLARIS AVE.
LAS VEGAS, NV 89118
(P) 702-736-2936 (F) 702-361-9094

Levee Survey Geometry
Station 23+00 - 51+00

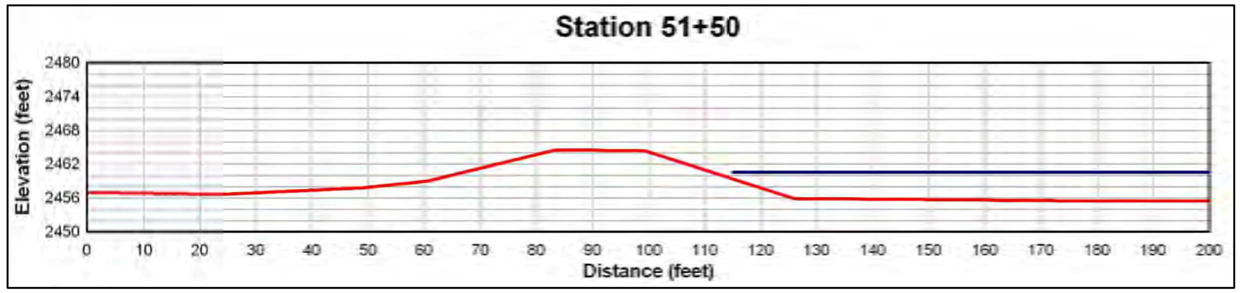
CCRFCD
Clark County Levee Certification Project
Moccasin Diversion
Las Vegas, Nevada

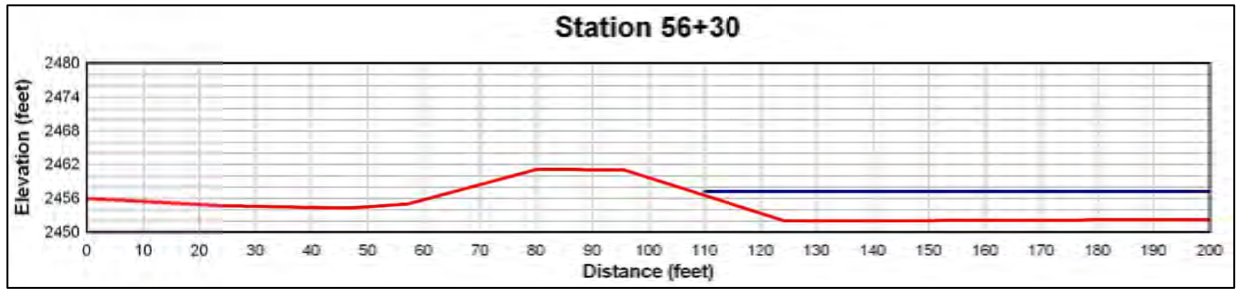
PLATE
3

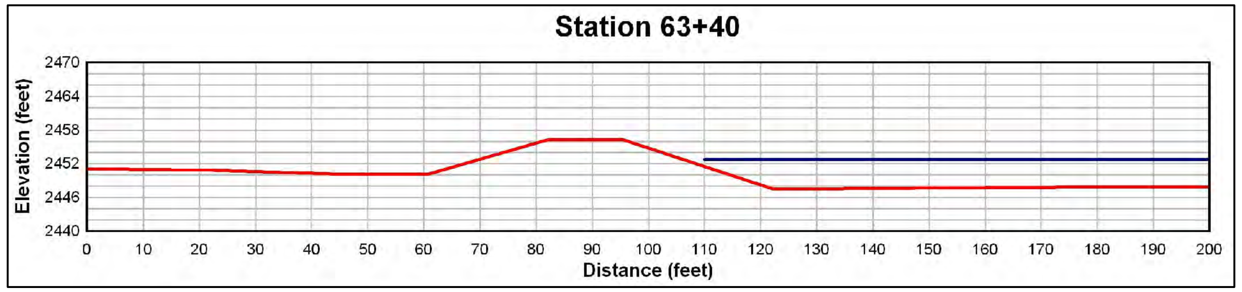


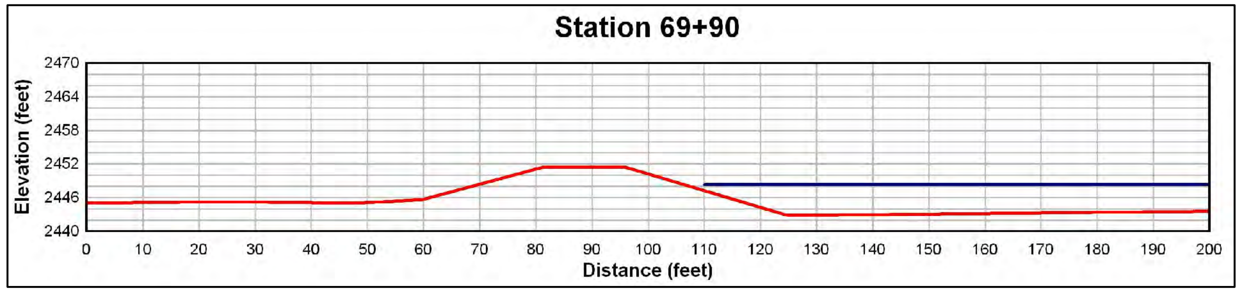
MOCCASIN DIVERSION (PLAN VIEW)
STATION 51+00 - 79+00

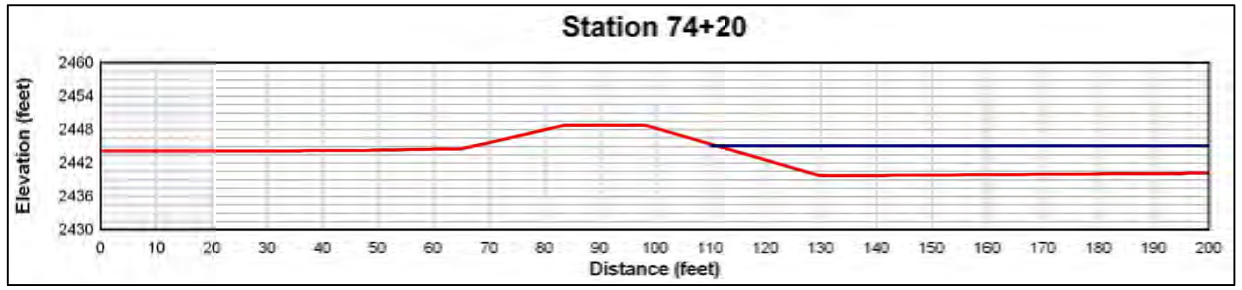
A TYPICAL CROSS-SECTION
SURVEYED CROSS-SECTIONS OF DIVERSION AS SHOWN (See Table 5-2 in report for elevation summary)

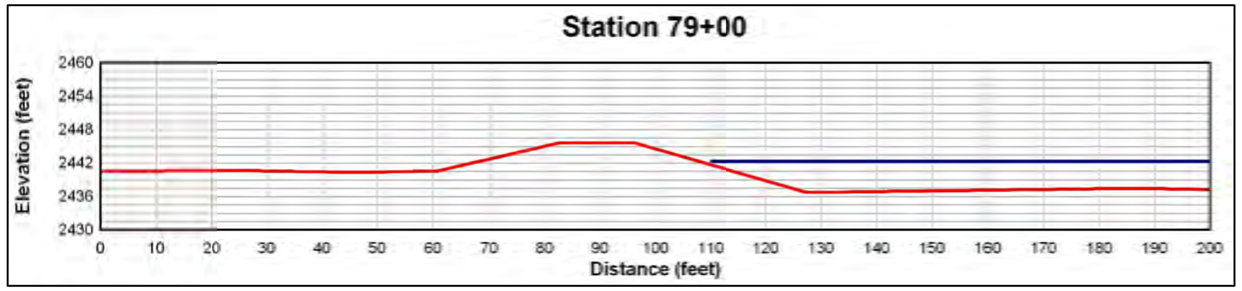

Station 51+50


Station 56+30


Station 63+40


Station 69+90


Station 74+20


Station 79+00

LEGEND:

🟥 - LAND SURFACE

🟦 - 100 YEAR WATER SURFACE

KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

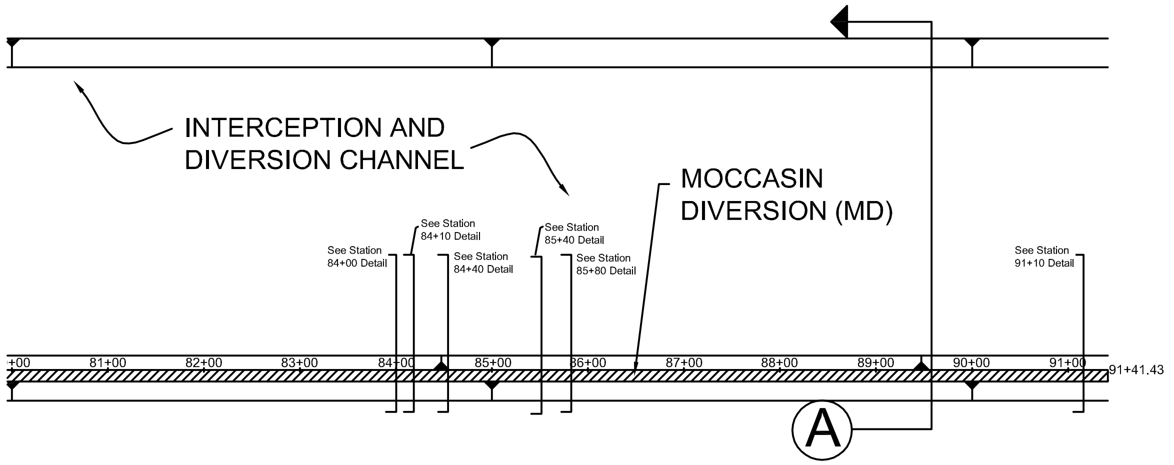
PROJECT NO.	101764.2
DRAWN:	04/30/2010
DRAWN BY:	DFR
CHECKED BY:	ALB

6380 SOUTH POLARIS AVE.
LAS VEGAS, NV 89118
(P) 702-736-2936 (F) 702-361-9094

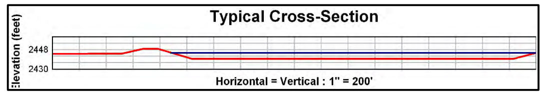
Levee Survey Geometry
Station 51+00 - 80+00

CCRFCD
Clark County Levee Certification Project
Moccasin Diversion
Las Vegas, Nevada

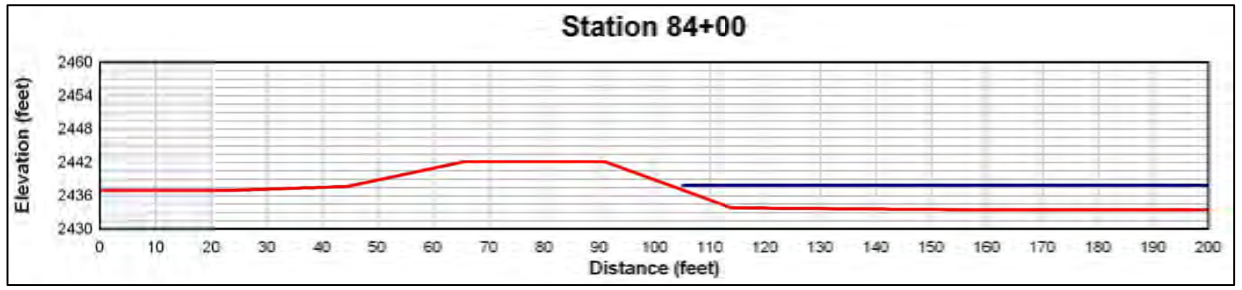
PLATE
4

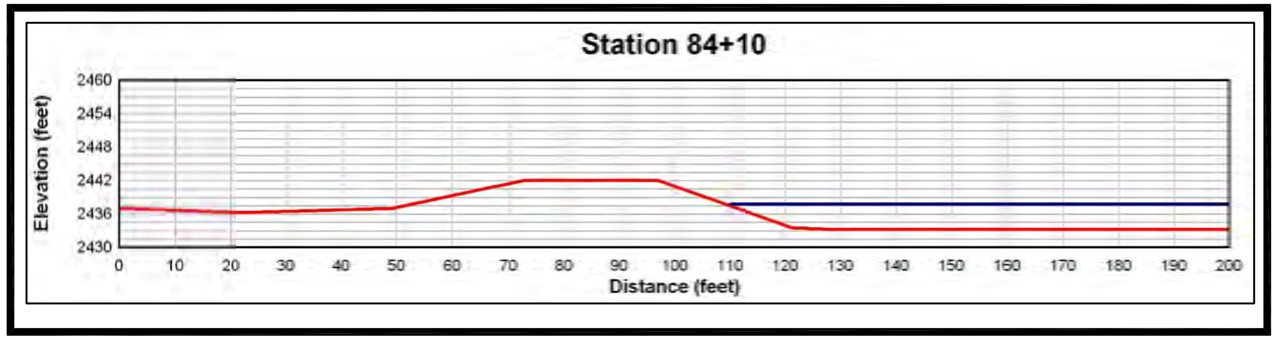


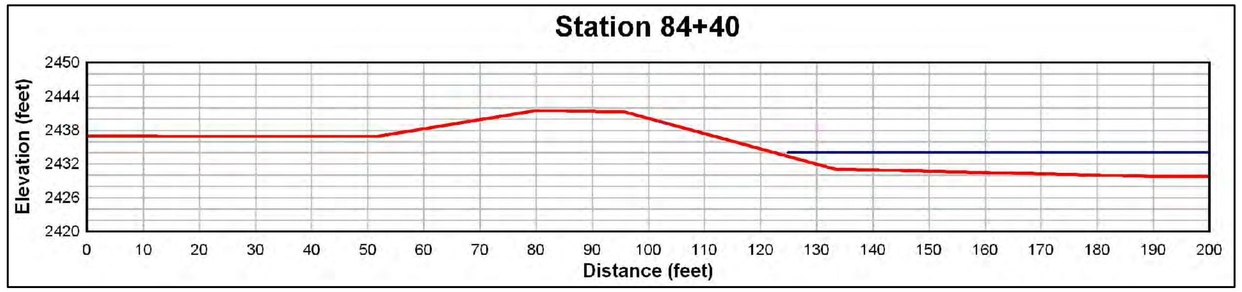
MOCCASIN DIVERSION (PLAN VIEW)
STATION 80+00 - 91+41.43

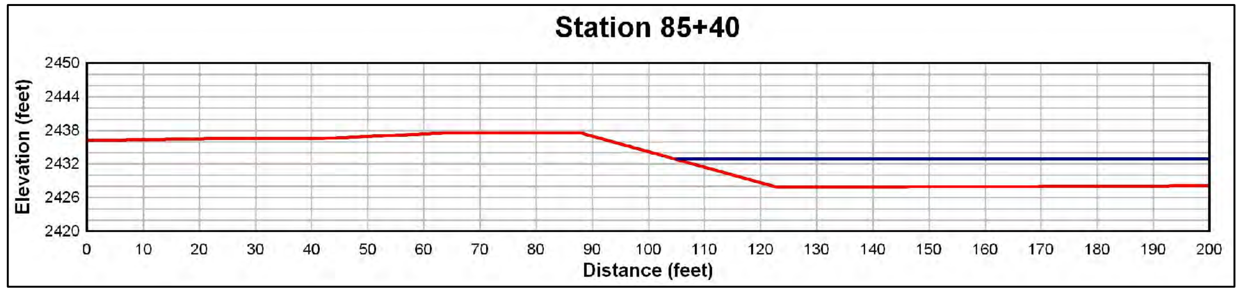


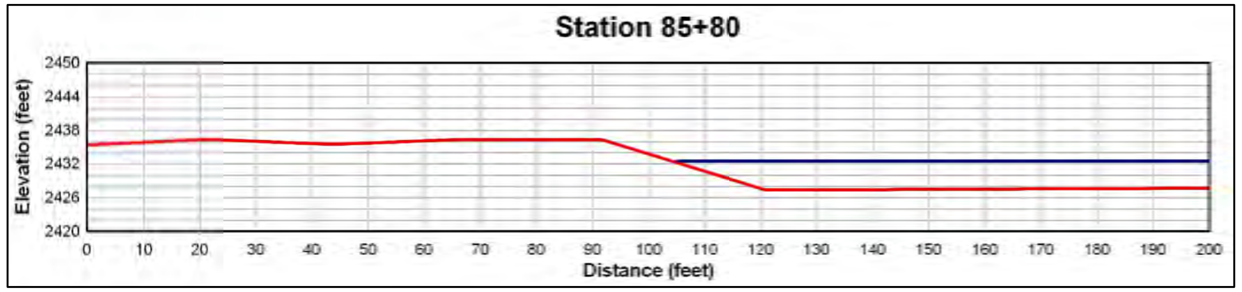
Ⓐ TYPICAL CROSS-SECTION
SURVEYED CROSS-SECTIONS OF DIVERSION AS SHOWN (See Table 5-2 in report for elevation summary)

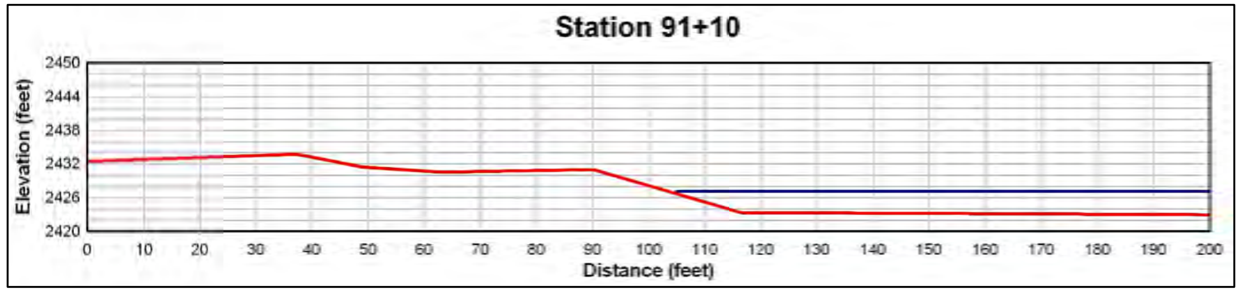

Station 84+00


Station 84+10


Station 84+40


Station 85+40


Station 85+80


Station 91+10

LEGEND:

🟥 -	LAND SURFACE
🟦 -	100 YEAR WATER SURFACE
▭ -	SELECTED CROSS-SECTION FOR STABILITY ANALYSIS (STA. 84+10)

KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

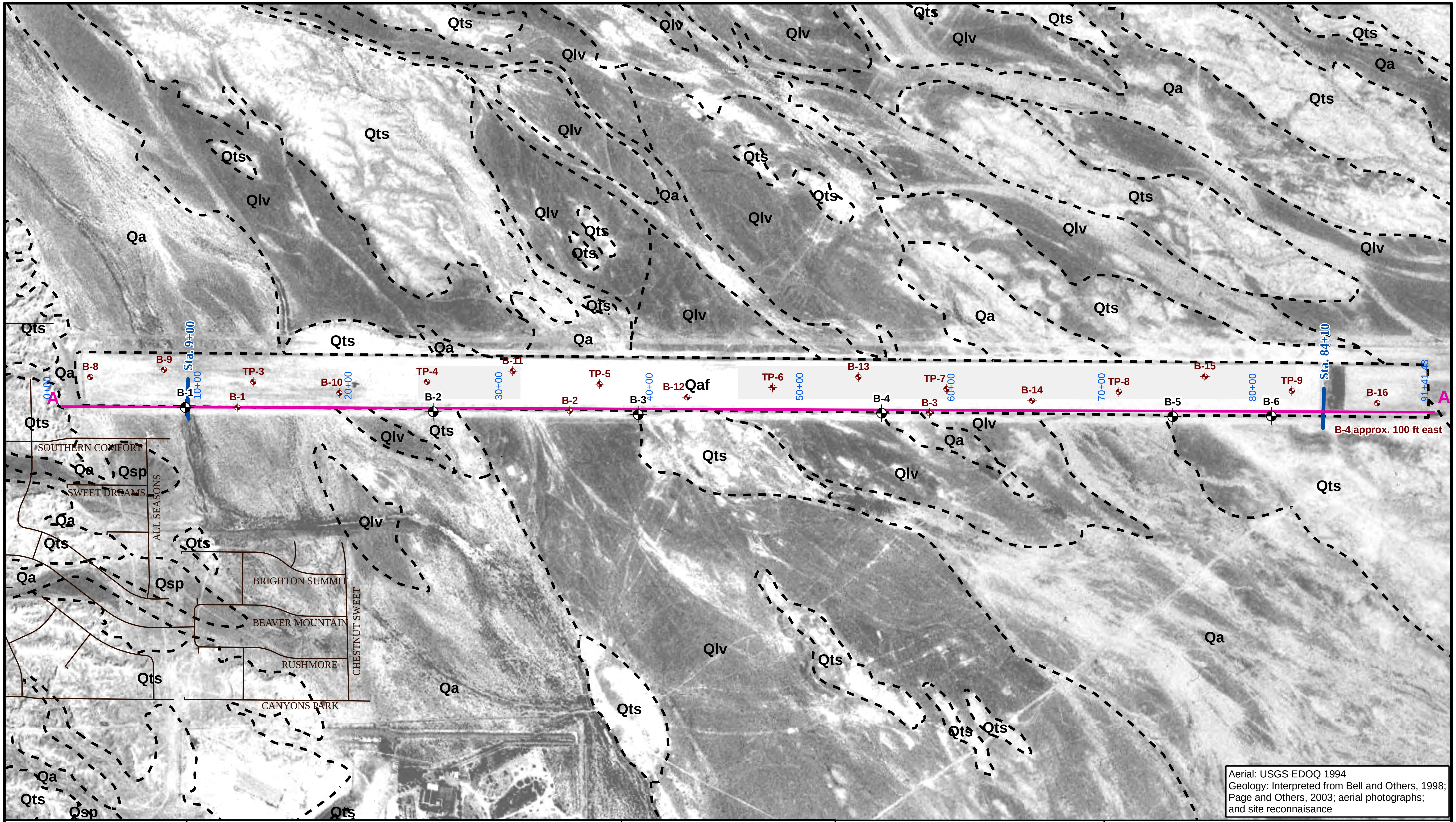
PROJECT NO. 101764.2
DRAWN: 04/30/2010
DRAWN BY: DFR
CHECKED BY: ALB

6380 SOUTH POLARIS AVE.
LAS VEGAS, NV 89118
(P) 702-736-2936 (F) 702-361-9094

Levee Survey Geometry
Station 80+00 - 91+41.43

CCRFCD
Clark County Levee Certification Project
Moccasin Diversion
Las Vegas, Nevada

PLATE
5



Aerial: USGS EDOQ 1994
Geology: Interpreted from Bell and Others, 1998; Page and Others, 2003; aerial photographs; and site reconnaissance

0 300 600
Feet

N

Locations are Approximate

NAD 1983 StatePlane Nevada East
FIPS 2701, US Survey Feet

LEGEND

⌖	Geotechnical Borings
⌖	Previous Explorations
━	Profile Line, see Plate 7
━	Cross Section
- -	Contact, Approximately Located

Geologic Units

Qaf - Fill
Qa, Qlv, Qsp - Alluvium
Qts - Fine-Grained Deposits

KLEINFELDER
6380 S Polaris Avenue
Las Vegas, NV 89118
Ph: (702) 736-2936 Fax: (702) 361-9094

Drawn By: KFH | Reviewed By: ALB | Date: 06/02/10

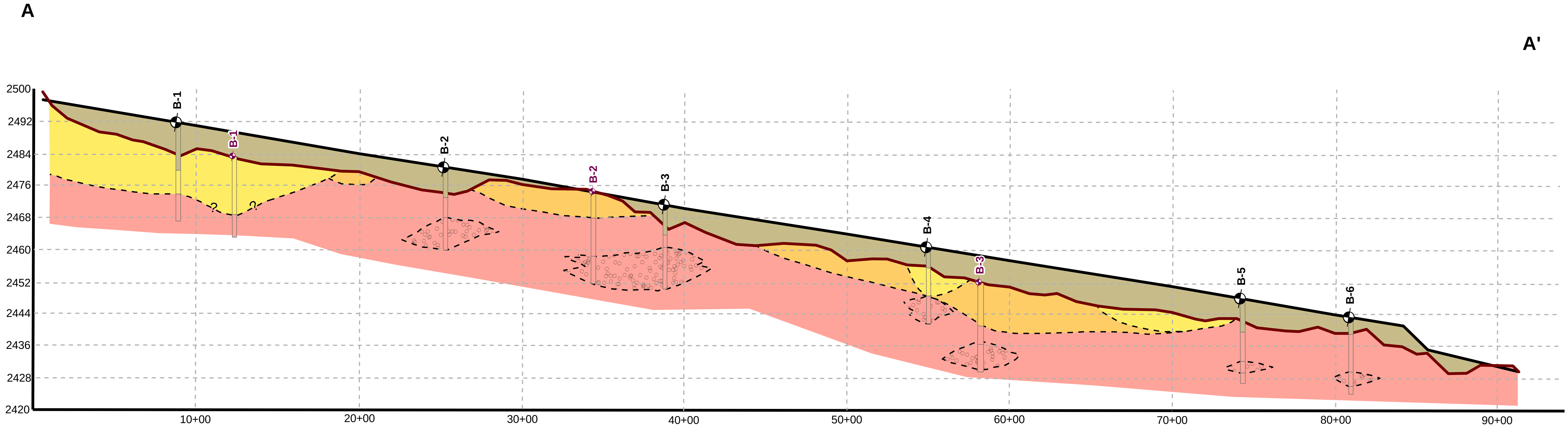
SITE PLAN WITH EXPLORATIONS AND GEOLOGY

CCRFCD
Clark County Levee Certification Project
Moccasin Diversion
Las Vegas, Nevada

Plate
6

Project No: 101764 | File: D:\...\101764...\Moccasin_geol.mxd

See Plate 6 for location of A - A'



Geology: Interpreted from Bell and Others, 1998;
Page and Others, 2003; aerial photographs;
and site reconnaissance

Horizontal

0 300 600

Feet

Locations are Approximate

LEGEND

⊕ Geotechnical Borings

✧ Previous Explorations

— Pre-Levee Ground Surface

— Moccasin Diversion Crest

- - - Geologic Contact, Interpreted

Geology

🟫 Qaf

🟨 Qa

🟧 Qlv

🟥 Qts

▨ Qts + fine gravel

KLEINFELDER
6380 S Polaris Avenue
Las Vegas, NV 89118
Ph: (702) 736-2936 Fax: (702) 361-9094

Drawn By: KFH | Reviewed By: ALB | Date: 06/02/10

INTERPRETIVE GEOLOGIC PROFILE

CCRFCD
Clark County Levee Certification Project
Moccasin Diversion
Las Vegas, Nevada

Project No: 101764 | File: D:\...\101764...\Moccasin_profile.mxd

Plate

7

APPENDIX A

THE UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS				Group Symbols		TYPICAL NAMES
COARSE GRAINED SOIL More than 50% of the material is LARGER than the No. 200 Sieve.	GRAVELS More than 50% of coarse part is LARGER than the No. 4 Sieve.	CLEAN GRAVELS Less than 5% finer than No. 200 Sieve.		GW	▒	Well graded gravels, gravel - sand mixtures, little or no fines, Cu>4 & 1<Cc<3
				GP	▬	Poorly graded gravels or gravel - sand mixtures, little or no fines Cu<4 or 1>Cc>3
		GRAVEL with fines More than 12% Finer than No. 200 Sieve.	PI <4	GM	▦	Silty gravels, gravel - sand - silt mixtures
			PI >7	GC	▨	Clayey gravels, gravel - sand - clay mixtures
	SANDS More than 50 % of coarse part is SMALLER than the No. 4 Sieve.	CLEAN SANDS Less than 5% Finer than No. 200 Sieve.		SW	░	Well graded sands, gravelly sands, little or no fines. Cu>6& 1<Cc<3
				SP	░	Poorly graded sands or gravelly sands, little or no fines. Cu<6 or 1>Cc>3
		SAND with fines More than 12% Finer than No. 200 Sieve.	PI <5	SM	▥	Silty sands, sand - silt mixtures
			PI >7	SC	▨	Clayey sands, sand - clay mixtures
FINE GRAINED SOIL More than 50 % of the material is SMALLER than the No. 200 Sieve	SILTS & CLAYS Liquid Limit LESS than 50		PI - Below A - Line	ML	▥	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with low plasticity
			PI - Above A - Line	CL	▨	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
				OL	▥	Organic silts and organic clays of low plasticity
	SILTS & CLAYS Liquid Limit GREATER than 50		PI - Below A - line	MH	▥	Inorganic silts, Micaceous or diatomaceous fine sands or silty soils, elastic silts
			PI - Above A - Line	CH	▨	Inorganic clays of high plasticity, fat clays
				OH	▭	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS				Pt	⁂	Peat and other highly organic soils

BOUNDARY CLASSIFICATIONS: Soils possessing characteristics of two groups are designated by combinations of group symbols.

PARTICLE SIZE LIMITS

CLAY	SILT	SAND			GRAVEL		COBBLES	BOULDERS
		Fine	Medium	Coarse	Fine	Coarse		

0.002 mm #200 #40 #10 #4 3/4" 3" 12"

U. S. Standard Sieve Size

Descriptive Terms Used With Soils

CONSISTENCY			Moisture Content	
	SILTS & CLAYS	SANDS & GRAVELS		
Strongest ↑	Very Stiff	Very Dense	Wettest ↑	Wet
				Very Moist
	Stiff	Dense		Moist
	Medium Stiff	Medium Dense		Slightly Moist
Weakest ↓	Soft	Loose	Driest ↓	Dry

	CALICHE	Cemented Sand & Gravel	
Strongest ↑	Very Hard	Very Hard	Requires many hammer blows to break.
	Hard	Hard	Breaks with few to many hammer blows
	Moderately Hard	Moderately Hard	Crumbles with few hammer blows
Weakest ↓	Partially cemented	Partially cemented	Crumbles with hand pressure

KEY TO SOIL SYMBOLS AND TERMS

PROJECT : Moccasin Diversion

PROJECT NO.: 101764

PLATE NO.: A-1

DATED DRILLED: 12/8/09
LOCATION: See Plate 6

BORING NO. B- 1

ELEVATION: 2492.5
HAMMER WEIGHT: 140 lbs

ELEV. MSL / DEPTH IN FEET 2492.5	FIELD MOISTURE (%)	Dry Unit Weight (pcf)	LAB TESTS *	DRILLING RATE (min./ft)	BLOWS per 6 INCH INCRE.	SAMPLES +	SYMBOL	SOIL DESCRIPTION	MOISTURE	CONSIST.
0								**Levee Embankment FILL** - gravel with sand and silt, brown	slightly moist	
				0.4	45 50/2"			- silty gravel with sand, trace clay, color change to light brown below 2 feet - lean clay with sand, light brown to tan, trace gravel		
2487.5 5	3		M	0.3	30 29 18					
	6		M, A, G, H	0.5	11 40 50/5"			- sandy lean clay with gravel, light brown to brown		
				0.4	61 37 20			- clayey gravel with sand, light brown to brown		
2482.5 10				0.6	26 34 34			- less clay below 10 feet		
			A, G, H	0.8	23 39 41			**Clayey GRAVEL with Sand (GC)** - light brown		very dense
2477.5 15	2	125	G, A M, D	0.9	17 52 60			**Poorly Graded GRAVEL with Clay and Sand (GP-GC)** - brown		
					40 50/1"			**Silty GRAVEL with Sand (GM)** - zones of partial cementation, light brown to olive brown		very dense to moderately hard
	12	96	M, D	0.6	17 20 32			**Lean CLAY (CL)** - olive brown		very stiff
2472.5 20					10 10 12			- color change to brown below 20 feet		
				0.3	6 19 50/2"			- increased gravel and zones of partial cementation below 22 feet	moist	very stiff to moderately hard
2467.5 25					10 12 11					very stiff

Bottom of boring at depth of 25.5 feet

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

* **LAB TESTS:** G=Grain Size Distribution, H=Hydrometer, M=Moisture Content, D=Density, A=Atterberg, E=Expansion, Ch=Chemical Test

NOTES: Boring located at approximate MD Station 9+00. Groundwater not encountered during drilling.

\+ **SAMPLER TYPE:** ■ Drive Sample 2.42" I.D. ▤ Grab ▯ Shelby Tube ⧗ SPT Sample 1.375" I.D. ▨ Bulk

KLEINFELDER

BORING LOG AND TEST SUMMARY

PROJECT: Moccasin Diversion

PROJECT NO. 101764

PLATE

A-2

DATED DRILLED: 12/9/09
LOCATION: See Plate 6

BORING NO. B- 2

ELEVATION: 2481.5
HAMMER WEIGHT: 140 lbs

ELEV. MSL DEPTH IN FEET	FIELD MOISTURE (%)	Dry Unit Weight (pcf)	LAB TESTS *	DRILLING RATE (min./ft)	BLOWS per 6 INCH INCRE.	SAMPLES +	SYMBOL	SOIL DESCRIPTION	MOISTURE	CONSIST.
2481.5 0								**Levee Embankment FILL** - silty gravel, sub-rounded gravel, olive to olive brown	slightly moist	
				0.8	4 41 50/4"					
2476.5 5				0.6	14 50/2"			- lean clay with gravel, olive brown		
	2		M, A, G, H	0.7	44 52 33			- silty clayey sand with gravel, olive brown		
	2		M		7 4 9			**Lean CLAY with Sand (CL)** - olive-brown		stiff
2471.5 10				1.1	13 16 16					very stiff
	7	96	A, G, H M, D	0.9	5 21 49			**Clayey GRAVEL (GC)** - olive-brown		very dense
2466.5 15				1.3	27 40 31			**Silty GRAVEL with Sand (GM)** - olive-brown		
				1.2	50 69 58			- possible cobbles below 16 feet		
				1.3	17 20 23			- zones of trace cementation noted in auger cuttings below 18 feet		dense
2461.5 20					40 48 49					very dense

Bottom of boring at depth of 21.5 feet

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

* **LAB TESTS:** G=Grain Size Distribution, H=Hydrometer, M=Moisture Content, D=Density, A=Atterberg, E=Expansion, Ch=Chemical Test

NOTES: Boring located at approximate MD Station 25+40. Groundwater not encountered during drilling.

\+ **SAMPLER TYPE:** ■ Drive Sample 2.42" I.D. ▤ Grab ▯ Shelby Tube ⧗ SPT Sample 1.375" I.D. ▨ Bulk

KLEINFELDER

BORING LOG AND TEST SUMMARY

PROJECT: Moccasin Diversion

PROJECT NO. 101764

PLATE

A-3

DATED DRILLED: 12/9/09
LOCATION: See Plate 6

BORING NO. B- 3

ELEVATION: 2472.5
HAMMER WEIGHT: 140 lbs

ELEV. MSL / DEPTH IN FEET	FIELD MOISTURE (%)	Dry Unit Weight (pcf)	LAB TESTS *	DRILLING RATE (min./ft)	BLOWS per 6 INCH INCRE.	SOIL DESCRIPTION	MOISTURE	CONSIST.
2472.5 0						**Levee Embankment FILL** - clayey gravel, olive brown	slightly moist	
				0.6	20 15 37	- lean clay with gravel, olive brown		
2467.5 5	2		M, A, G, H	1.1	6 20 50	- clayey sand with gravel, zones of carbonate/salt encrustation, light brown		
				0.9	4 39 31			
				0.7	7 19 16	**Silty CLAY with Sand (CL-ML)**- brown		very stiff
2462.5 10	4	96	A, G, H M, D	1.0	23 44 73			
						Clayey GRAVEL (GC) - brown		very dense
				0.6	12 27 28	**Lean CLAY (CL)** - brown		very stiff
						Clayey GRAVEL (GC) - sub-rounded, partially cemented, brown		very dense to moderately hard
2457.5 15				1.1	35 70/3"			
			G, A		18 30 24	**Clayey GRAVEL with Sand (GC)** - light brown		very dense
				1.3	25 23 70			
2452.5 20					12 14 14	- rounded to sub-rounded below 20 feet		medium dense

Bottom of boring at depth of 21.5 feet

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

*** LAB TESTS:** G=Grain Size Distribution, H=Hydrometer, M=Moisture Content, D=Density, A=Atterberg, E=Expansion, Ch=Chemical Test

+ SAMPLER TYPE: ■ Drive Sample 2.42" I.D. ▤ Grab ▯ Shelby Tube ◆ SPT Sample 1.375" I.D. ▨ Bulk

NOTES: Boring located at approximate MD Station 39+00. Groundwater not encountered during drilling.

KLEINFELDER

BORING LOG AND TEST SUMMARY

PROJECT: Moccasin Diversion

PROJECT NO. 101764

PLATE

A-4

DATED DRILLED: 12/9/09
LOCATION: See Plate 6

BORING NO. B- 4

ELEVATION: 2461.5
HAMMER WEIGHT: 140 lbs

ELEV. MSL / DEPTH IN FEET	FIELD MOISTURE (%)	Dry Unit Weight (pcf)	LAB TESTS *	DRILLING RATE (min./ft)	BLOWS per 6 INCH INCRE.	SOIL DESCRIPTION	MOISTURE	CONSIST.
2461.5 0						**Levee Embankment FILL** - silty gravel, olive brown	slightly moist to moist	
				0.4	15 33 50/5"	- lean clay with gravel, brown	slightly moist	
2456.5 5				1.1	7 29 29	- with coarse sub-rounded gravel and cobbles below 4 feet		
	5		M, A, G, H	1.6	6 7 7	**SILT with Sand (ML)** - light brown		stiff
				0.7	7 8 7			stiff to very stiff
2451.5 10					13 15 19	**Sandy Lean CLAY (CL)** - brown to yellow brown		very stiff
	2	119	A, G, H M, D	1.2	52 57 70/5"	**Clayey GRAVEL with Sand (GC)** - zones of partial cementation, light brown		very dense to moderately hard
			G, A		33 50/4"	- color change to light brown to yellow brown below 14 feet	slightly moist to moist	
2446.5 15				1.6	28 61 70/3"			
				1.4	24 31 25			very dense
2441.5 20					40 62 70/4"			very dense to moderately hard

Bottom of boring at depth of 21.3 feet

*** LAB TESTS:** G=Grain Size Distribution, H=Hydrometer, M=Moisture Content, D=Density, A=Atterberg, E=Expansion, Ch=Chemical Test

NOTES: Boring located at approximate MD Station 55+20. Groundwater not encountered during drilling.

+ SAMPLER TYPE: ■ Drive Sample 2.42" I.D. ▤ Grab ▯ Shelby Tube ⧗ SPT Sample 1.375" I.D. ▨ Bulk

KLEINFELDER

BORING LOG AND TEST SUMMARY

PROJECT: Moccasin Diversion

PROJECT NO. 101764

PLATE
A-5

DATED DRILLED: 12/10/09
LOCATION: See Plate 6

BORING NO. B- 5

ELEVATION: 2448.5
HAMMER WEIGHT: 140 lbs

ELEV. MSL DEPTH IN FEET	FIELD MOISTURE (%)	Unit Weight (pcf)	LAB TESTS *	DRILLING RATE (min./ft)	BLOWS per 6 INCH INCRE.	% RECOVERED	SAMPLES +	SYMBOL	SOIL DESCRIPTION	MOISTURE	CONSIST.
2448.5 0									**Levee Embankment FILL** - clayey gravel, brown to light brown	slightly moist	
	10		M, A, E, Ch	0.5	10 25 35	100			- lean clay, light brown		
2443.5 5				0.8	15 17 35	100			- poorly-graded gravel with sand, light brown - lean clay, light brown		
			E, Ch	0.9	56 44 31	67					
	7		M, A, G, H	1.0	9 15 15	100			**Lean CLAY (CL)** - light brown		very stiff
2438.5 10	6	99	M, D	1.2	6 24 85	100					very stiff to moderately hard
				1.6	16 19 28	100			- increased gravel below 12 feet with zones of partial cementation		
2433.5 15					110/4"	100					
					27 58 36	100			**Poorly-Graded GRAVEL with Silt and Sand (GP-GM)**		very dense
					28 42 39	100			**Gravely Lean CLAY (CL)** - light brown - decreased gravel below 19 feet		very stiff
2428.5 20					47 17 19	78					

Bottom of boring at depth of 21.5 feet

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

* **LAB TESTS:** G=Grain Size Distribution, H=Hydrometer, M=Moisture Content, D=Density, A=Atterberg, E=Expansion, Ch=Chemical Test

+ **SAMPLER TYPE:** ■ Drive Sample 2.42" I.D. ▤ Grab ▯ Shelby Tube ⧗ SPT Sample 1.375" I.D. ▨ Bulk

NOTES: Boring located at approximate MD Station 74+50. Groundwater not encountered during drilling.

KLEINFELDER

BORING LOG AND TEST SUMMARY

PROJECT: Moccasin Diversion

PROJECT NO. 101764

PLATE

A-6

DATED DRILLED: 12/10/09
LOCATION: See Plate 6

BORING NO. B- 6

ELEVATION: 2444
HAMMER WEIGHT: 140 lbs

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

ELEV. MSL / DEPTH IN FEET	FIELD MOISTURE (%)	Dry Unit Weight (pcf)	LAB TESTS *	DRILLING RATE (min./ft)	BLOWS per 6 INCH INCRE.	SAMPLES +	SYMBOL	SOIL DESCRIPTION	MOISTURE	CONSIST.
2444.0 0								**Levee Embankment FILL** - lean clay with sand and gravel, brown	moist	
	11		M, A, E, Ch	0.8	6 10 17					
			E		5 6 8			**Lean CLAY (CL)** - brown	slightly moist to moist	stiff
2439.0 5										
	12		M, A, E, G, Ch, H	0.3	6 10 15			- increased sand below 6 feet		very stiff
			E	0.3	6 10 10					
2434.0 10					7 13 21				slightly moist	
					6 9 10			- color change to brown below 12 feet		
					5 79 70/2"			**Clayey GRAVEL (GC)** - some sand, zones of partial cementation, brown		very dense to moderately hard
2429.0 15										
			A, G		27 44 31					
					24 34 28			**Gravelly Lean CLAY with Sand (CL)** - brown - decreased gravel below 19 feet		very stiff
2424.0 20					14 15 15					

Bottom of boring at depth of 21.5 feet

*** LAB TESTS:** G=Grain Size Distribution, H=Hydrometer, M=Moisture Content, D=Density, A=Atterberg, E=Expansion, Ch=Chemical Test

+ SAMPLER TYPE: ■ Drive Sample 2.42" I.D. ▤ Grab ▯ Shelby Tube ⧗ SPT Sample 1.375" I.D. ▨ Bulk

NOTES: Boring located at approximate MD Station 81+00. Groundwater not encountered during drilling.

KLEINFELDER

BORING LOG AND TEST SUMMARY

PROJECT: Moccasin Diversion

PROJECT NO. 101764

PLATE

A-7

PREVIOUS EXPLORATIONS

DATED DRILLED: 9/20/90
LOCATION: See Plate 1

BORING NO. B-1

ELEVATION: Approx. 2482 ft.
** HAMMER WEIGHT: 350 lb.

DEPTH IN FEET	FIELD MOISTURE (%)	DRY DENSITY (pcf)	OTHER TESTS *	BLOWS/ FOOT **	SAMPLES +	SOIL DESCRIPTION	MOISTURE	CONSIST.
0						**SAND (SP)** -with gravel, (desert pavement), brown	slightly moist	loose
						GRAVELLY SAND (SW) -trace silt, brown		medium dense to dense
5						**SANDY GRAVEL (GW)** -trace clay, light brown		dense to very dense
10				12	☒			very dense
				6	☒			
						CLAYEY SILT (ML) -trace sand, tan to light brown		very stiff
15	3	97	A, C	22	■			
						SILTY GRAVEL (GM) -trace clay, light brown	moist	loose
20	4		G, S	7	■			
						Bottom at 21 feet.		
25								

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

* OTHER TESTS: C = CONSOLIDATION, A = ATTERBERG, S = SHEAR, G = GRAIN SIZE, E = EXPANSION, CH = CHEMICAL, SOL = SOLUBILITY

\+ SAMPLER TYPE: ■ Drive Sample 2.625" I.D. ▧ Shelby Tube ▨ Bulk ☒ No Recovery

NOTES: **Ground water not encountered during drilling.**

APPROV: WEV

BY:

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

BORING LOG AND TEST SUMMARY

PLATE 2

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

DATED DRILLED: 9/20/90
LOCATION: See Plate 1

BORING NO. B-2

ELEVATION: Approx. 2473 ft.
** HAMMER WEIGHT: 350 lb.

DEPTH IN FEET	FIELD MOISTURE (%)	DRY DENSITY (pcf)	OTHER TESTS *	BLOWS/ FOOT **	SAMPLES +	SOIL DESCRIPTION	MOISTURE	CONSIST.
0						**SANDY GRAVEL (GP)** -some silt, (desert pavement), light brown	slightly moist	loose
						SILTY SAND (SM) -brown -occasional large cobbles and gravel		medium dense to dense
5						**SANDY CLAY (CL)** -with silt, porous, tan to light brown		firm
	5	95	C	15	■			
10						**SILTY CLAY (CL)** -trace sand, trace gravel, porous, light brown		
	12	109	A	13	■			
						CLAYEY GRAVEL (GC) -trace sand, trace silt, light brown to reddish brown		medium dense
15								
				17	☒			
						-large cobble		dense
20				17	☒			medium dense
						Bottom at 21 feet.		
25								

* OTHER TESTS: C=CONSOLIDATION, A=ATTERBERG, S=SHEAR, G=GRAIN SIZE, E=EXPANSION, CH=CHEMICAL, SOL=SOLUBILITY

+ SAMPLER TYPE: ■ Drive Sample 2.625" I.D. ▧ Shelby Tube ▨ Bulk ☒ No Recovery

NOTES: **Ground water not encountered during drilling.**

APPROV: 4/3/2

BY:

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

BORING LOG AND TEST SUMMARY

PLATE 3

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

DATED DRILLED: 9/20/90
LOCATION: See Plate 1

BORING NO. B-3

ELEVATION: Approx. 2451 ft.
** HAMMER WEIGHT: 350 lb.

DEPTH IN FEET	FIELD MOISTURE (%)	DRY DENSITY (pcf)	OTHER TESTS *	BLOWS/ FOOT **	SAMPLES +	SYMBOL	SOIL DESCRIPTION	MOISTURE	CONSIST.
0							**SANDY SILT (ML)** -little gravel, brown	slightly moist	soft
	1			7	■				
							SILTY SAND (SM) -brown		medium dense
5				18	☒				
							SANDY GRAVEL (GW) -trace clay, brown		dense
10									
	5	106		37	■		**SILTY CLAY (CL)** -gray		very stiff
15									
							SILTY GRAVEL (GM) -with clay, brown		dense
20									
							Bottom at 21 feet.		
25									

* OTHER TESTS: C=CONSOLIDATION, A=ATTERBERG, S=SHEAR, G=GRAIN SIZE, E=EXPANSION, CH=CHEMICAL, SOL=SOLUBILITY

\+ SAMPLER TYPE: ■ Drive Sample 2.625" I.D. ▧ Shelby Tube ▨ Bulk ☒ No Recovery

NOTES: **Ground water not encountered during drilling.**

APPROV:

BY:

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

BORING LOG AND TEST SUMMARY

PLATE
4

DATED DRILLED: 9/20/90
LOCATION: See Plate 1

BORING NO. B-4

ELEVATION: Approx. 2421 ft.
** HAMMER WEIGHT: 350 lb.

DEPTH IN FEET	FIELD MOISTURE (%)	DRY DENSITY (pcf)	OTHER TESTS *	BLOWS/ FOOT **	SAMPLES +	SYMBOL	SOIL DESCRIPTION	MOISTURE	CONSIST.
0						▒	**SILTY SAND (SM)** -with gravel, (desert pavement), light brown	slightly moist	loose
						▒			dense
	0	138	G	30	▮	▒			
						▒			very dense
5						▒			
10						▒			
						▒	-color change to gray, some silt at 14 feet		
15						▒			
						▨	**GRAVELLY CLAY (CL)** -with silt, brown		very stiff
				9	☒	▨			
20				27	☒	▨			
							Bottom at 21 feet		
25									

* OTHER TESTS: C = CONSOLIDATION, A = ATTERBERG, S = SHEAR, G = GRAIN SIZE, E = EXPANSION, CH = CHEMICAL, SOL = SOLUBILITY

\+ SAMPLER TYPE: ▮ Drive Sample 2.625" I.D. ⧅ Shelby Tube ▒ Bulk ☒ No Recovery

NOTES: **Ground water not encountered during drilling.**

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

APPROV: CJEV

BY:

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

BORING LOG AND TEST SUMMARY

PLATE 5

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

DATED DRILLED: 2/6/91
LOCATION: See Plate 1

BORING NO. B-8

ELEVATION: Approx. 2492 ft.
** HAMMER WEIGHT: 350 lb.

DEPTH IN FEET	FIELD MOISTURE (%)	DRY DENSITY (pcf)	OTHER TESTS *	BLOWS/ FOOT **	SAMPLES +	SYMBOL	SOIL DESCRIPTION	MOISTURE	CONSIST.
0						▒	**GRAVELLY SAND (SP)** - trace clay, brown	slightly moist	loose
						▒			firm to stiff
						▨	**CLAY (CL)** - trace sand, light brown		very stiff
5	4	119		30/6	■	▨			
10	4	93		23	■	▨			
						▨	- some gravel, brown to gray		
15	3	108		50	■	▨			
						▨	- some sand, dark brown		
20	3	90		35	■	▨			
							Bottom at 21 feet		
25									

* OTHER TESTS: C = CONSOLIDATION, A = ATTERBERG, S = SHEAR, G = GRAIN SIZE, E = EXPANSION, CH = CHEMICAL, SOL = SOLUBILITY

+ SAMPLER TYPE: ■ Drive Sample 2.625" I.D. ⧅ Shelby Tube ▒ Bulk ☒ No Recovery

NOTES: **Ground water not encountered during drilling.**

APPROV:

BY:

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

BORING LOG AND TEST SUMMARY

PLATE
9

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

DATED DRILLED: 2/6/91
LOCATION: See Plate 1

BORING NO. B-9

ELEVATION: Approx. 2487 ft.
** HAMMER WEIGHT: 350 lb.

DEPTH IN FEET	FIELD MOISTURE (%)	DRY DENSITY (pcf)	OTHER TESTS *	BLOWS/ FOOT **	SAMPLES +	SYMBOL	SOIL DESCRIPTION	MOISTURE	CONSIST.
0							**SANDY GRAVEL (GP)** - occasional cobbles, brown	slightly moist	loose
1							**CLAYEY GRAVEL (GC)** - trace sand, brown		
3							**SANDY GRAVEL (GP)** -		medium dense
5				10	☒				
10				10	☒				
11					▨		**CLAYEY GRAVEL (GC)** - trace sand, brown		
13					▨		**GRAVELLY CLAY (CL)** - trace sand, brown		stiff
14				4	☒				
15					▨				
20					☒				
21							Bottom at 21 feet		
25									

* OTHER TESTS: C=CONSOLIDATION, A=ATTERBERG, S=SHEAR, G=GRAIN SIZE, E=EXPANSION, CH=CHEMICAL, SOL=SOLUBILITY

\+ SAMPLER TYPE: ■ Drive Sample 2.625" I.D. ⧄ Shelby Tube ▨ Bulk ☒ No Recovery

NOTES: Ground water not encountered during drilling.

APPROV: WRV

BY:

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

BORING LOG AND TEST SUMMARY

PLATE 10

DATED DRILLED: 1/26/91
LOCATION: See Plate 1

BORING NO. B-10

ELEVATION: Approx. 2479 ft.
** HAMMER WEIGHT: 350 lb.

DEPTH IN FEET	FIELD MOISTURE (%)	DRY DENSITY (pcf)	OTHER TESTS *	BLOWS/ FOOT **	SAMPLES +	SOIL DESCRIPTION	MOISTURE	CONSIST.
0						**CLAY (CL)** - trace sand, brown	slightly moist	stiff
						GRAVEL (GP) - trace clay, trace sand, brown		medium dense
5								
				11	■			
								very dense
10	1			45	☒			
15	1	131		50	■			
20	3	131		50	☒			
						Bottom at 21 feet		
25								

* OTHER TESTS: C=CONSOLIDATION, A=ATTERBERG, S=SHEAR, G=GRAIN SIZE, E=EXPANSION, CH=CHEMICAL, SOL=SOLUBILITY

+ SAMPLER TYPE: ■ Drive Sample 2.625" I.D. ⧅ Shelby Tube ▨ Bulk ☒ No Recovery

NOTES: **Ground water not encountered during drilling.**

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

APPROV: LJEV

BY:

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

BORING LOG AND TEST SUMMARY

PLATE 11

DATED DRILLED: 1/26/91
LOCATION: See Plate 1

BORING NO. B-11

ELEVATION: Approx. 2375 ft.
** HAMMER WEIGHT: 350 lb.

DEPTH IN FEET	FIELD MOISTURE (%)	DRY DENSITY (pcf)	OTHER TESTS *	BLOWS/ FOOT **	SAMPLES +	SYMBOL	SOIL DESCRIPTION	MOISTURE	CONSIST.
0							**SANDY GRAVEL (GP)** - light brown	slightly moist	loose
									medium dense
									dense
5				20	☒				
					▨		**CLAYEY SAND (SC)** - some gravel, light brown		
									medium dense
10	3	135		12	■				
							GRAVELLY SAND (SP) - trace clay, light brown		
15	4	133		11	■		**GRAVEL (GP)** - trace sand, brown		
									very dense
20	3	126		50	■				
							Bottom at 21 feet		
25									

* OTHER TESTS: C = CONSOLIDATION, A = ATTERBERG, S = SHEAR, G = GRAIN SIZE, E = EXPANSION, CH = CHEMICAL, SOL = SOLUBILITY

\+ SAMPLER TYPE: ■ Drive Sample 2.625" I.D. ◪ Shelby Tube ▨ Bulk ☒ No Recovery

NOTES: **Ground water not encountered during drilling.**

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

APPROV: W/EV

BY:

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

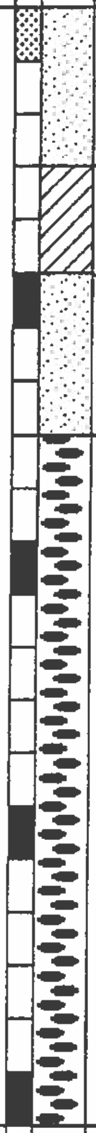
BORING LOG AND TEST SUMMARY

PLATE 12

DATED DRILLED: 1/26/91
LOCATION: See Plate 1

BORING NO. B-12

ELEVATION: Approx. 2467 ft.
** HAMMER WEIGHT: 350 lb.



DEPTH IN FEET	FIELD MOISTURE (%)	DRY DENSITY (pcf)	OTHER TESTS *	BLOWS/ FOOT **	SAMPLES +	SOIL DESCRIPTION	MOISTURE	CONSIST.
0	1				▨	**GRAVELLY SAND (SP)** - trace silt, brown	slightly moist	loose
						CLAY (CL) - some sand, trace silt, gray - some gravel		stiff
5			S	37	■	**SAND (SP)** - trace silt, trace gravel, brown		very dense
						SANDY GRAVEL (GP) - trace silt, brown		dense
10	3			28	■			
15	2	134		30	■			
20	2	131		30	■			
						Bottom at 21 feet		
25								

* OTHER TESTS: C = CONSOLIDATION, A = ATTERBERG, S = SHEAR, G = GRAIN SIZE, E = EXPANSION, CH = CHEMICAL, SOL = SOLUBILITY

+ SAMPLER TYPE: ■ Drive Sample 2.625" I.D. ▧ Shelby Tube ▨ Bulk ☒ No Recovery

NOTES: **Ground water not encountered during drilling.**

APPROV: 4/E1/

BY:

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

BORING LOG AND TEST SUMMARY

PLATE
13

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

DATED DRILLED: 1/25/91
LOCATION: See Plate 1

BORING NO. B-13

ELEVATION: Approx. 2455 ft.
** HAMMER WEIGHT: 350 lb.

DEPTH IN FEET	FIELD MOISTURE (%)	DRY DENSITY (pcf)	OTHER TESTS *	BLOWS/ FOOT **	SAMPLES +	SOIL DESCRIPTION	MOISTURE	CONSIST.
0	1				▨	**SILTY SAND (SM)** - trace clay, light brown	slightly moist	loose
1								loose to medium dense
3						**GRAVELLY SAND (SP)** - dark brown		medium dense
5				10	☒			
7						**SANDY GRAVEL (GP)** - some clay, brown		
9						**GRAVEL (GW)** - trace sand, trace clay, dark brown		dense
10	3			10	■			
14								very dense
15	2			28	■			
17								dense
20	2			22	▨			
21						Bottom at 21 feet		
25								

* OTHER TESTS: C=CONSOLIDATION, A=ATTERBERG, S=SHEAR, G=GRAIN SIZE, E=EXPANSION, CH=CHEMICAL, SOL=SOLUBILITY

\+ SAMPLER TYPE: ■ Drive Sample 2.625" I.D. ◸ Shelby Tube ▨ Bulk ☒ No Recovery

NOTES: **Ground water not encountered during drilling.**

APPROV:

BY:

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

BORING LOG AND TEST SUMMARY

PLATE
14

DATED DRILLED: 1/25/91
LOCATION: See Plate 1

BORING NO. B-14

ELEVATION: Approx. 2444 ft.
** HAMMER WEIGHT: 350 lb.

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

DEPTH IN FEET	FIELD MOISTURE (%)	DRY DENSITY (pcf)	OTHER TESTS *	BLOWS/ FOOT **	SAMPLES +	SYMBOL	SOIL DESCRIPTION	MOISTURE	CONSIST.
0							**GRAVEL (GP)** - some sand, desert pavement	slightly moist	loose
							CLAYEY SAND (SC) - some gravel, light brown		medium dense
							CLAYEY GRAVEL (GC) - some sand, brown		
5			S	17	☒				
				12	▨				
							GRAVEL (GP) - some sand, brown		
10				4	☒				
							SANDY GRAVEL (GW) - some clay, some silt, light brown		dense
15				23	☒				
20				26	■				
							Bottom at 21 feet		
25									

* OTHER TESTS: C = CONSOLIDATION, A = ATTERBERG, S = SHEAR, G = GRAIN SIZE, E = EXPANSION, CH = CHEMICAL, SOL = SOLUBILITY

\+ SAMPLER TYPE: ■ Drive Sample 2.625" I.D. ◺ Shelby Tube ▨ Bulk ☒ No Recovery

NOTES: **Ground water not encountered during drilling.**

APPROV: LJEV

BY:

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

BORING LOG AND TEST SUMMARY

PLATE
15

DATED DRILLED: 1/24/91
LOCATION: See Plate 1

BORING NO. B-15

ELEVATION: Approx. 2443 ft.
** HAMMER WEIGHT: 350 lb.

DEPTH IN FEET	FIELD MOISTURE (%)	DRY DENSITY (pcf)	OTHER TESTS *	BLOWS/ FOOT **	SAMPLES +	SYMBOL	SOIL DESCRIPTION	MOISTURE	CONSIST.
0							**SILTY SAND (SM)** - with gravel, some clay, light brown	slightly moist	loose to medium dense
							SANDY CLAY (CL) - light brown		stiff
									very stiff
5	4	102	S	50/9	■				
							SANDY GRAVEL (GP) - trace clay, brown		very dense
							- light brown		
							SANDY CLAY (CL) - light brown		very stiff
10	3	104		28	■				
15	3	119		37	■		- some gravel		
							GRAVEL (GP) - some clay, trace sand, brown		very dense
20	4	131		50/9	■				
							Bottom at 21 feet.		
25									

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

* OTHER TESTS: C = CONSOLIDATION, A = ATTERBERG, S = SHEAR, G = GRAIN SIZE, E = EXPANSION, CH = CHEMICAL, SOL = SOLUBILITY

\+ SAMPLER TYPE: ■ Drive Sample 2.625" I.D. ▨ Shelby Tube ▒ Bulk ☒ No Recovery

NOTES: **Ground water not encountered during drilling.**

APPROV: WEV

BY:

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

BORING LOG AND TEST SUMMARY

PLATE 16

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

DATED DRILLED: 1/24/91
LOCATION: See Plate 1

BORING NO. B-16

ELEVATION: Approx. 2432 ft.
** HAMMER WEIGHT: 350 lb.

DEPTH IN FEET	FIELD MOISTURE (%)	DRY DENSITY (pcf)	OTHER TESTS *	BLOWS/ FOOT **	SAMPLES +	SYMBOL	SOIL DESCRIPTION	MOISTURE	CONSIST.
0							SILTY GRAVEL (GM) - some clay, caliche gravels, light brown 3	slightly moist	dense
							SILTY CLAY (CL) - some caliche gravel, light brown		stiff
5	3	92		18	■				
							CLAYEY SAND (SC) - light reddish brown		dense
							CLAY (CL) - trace sand, light brown		very stiff
10	3	111		50	■				
							- gravelly, light brown		stiff
							- sandy, light brown		very stiff
15	3	101		35	■				
							- pockets of orange staining		
							SANDY GRAVEL (GP) - little clay, gray		very dense
20	4			50/9	■				
							Bottom at 21 feet.		
25									

* OTHER TESTS: C=CONSOLIDATION, A=ATTERBERG, S=SHEAR, G=GRAIN SIZE, E=EXPANSION, CH=CHEMICAL, SOL=SOLUBILITY

\+ SAMPLER TYPE: ■ Drive Sample 2.625" I.D. ▧ Shelby Tube ▒ Bulk ☒ No Recovery

NOTES: **Ground water not encountered during drilling.**

APPROV: W.E.V

BY:

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

BORING LOG AND TEST SUMMARY

PLATE 17

DATED EXCAVATED: 1/15/91
LOCATION: See Plate 1

TRENCH NO. T-3

ELEVATION: Approx. 2484 ft.
EQUIPMENT: Backhoe

DEPTH IN FEET	SAMPLES +	SYMBOL	SOIL DESCRIPTION	MOISTURE	CONSIST.	OTHER TESTS
0	▨		**SANDY GRAVEL (GP)** - occasional large cobbles, some roots, trace silt, light brown to gray	slightly moist	loose to medium dense	A,G,ASTM D-1557
	▨		**SILTY SAND (SM)** - some roots, light brown to gray			
5			**GRAVEL (GP)** - many cobbles, little sand, trace silt, brown and gray - sandy		medium dense to dense	
			cemented SAND & GRAVEL - brown and gray		hard	
10			Backhoe refusal at 9 feet on cemented SAND & GRAVEL			
15						

NOTES: **Ground water not encountered during trenching.**

+ SAMPLER TYPE: ■ Drive Sample 2.625" I.D. ▨ Bulk

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

APPROV: WEV

BY:

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

TRENCH LOG

PLATE
41

DATED EXCAVATED: 1/15/91
LOCATION: See Plate 1

TRENCH NO. T-4

ELEVATION: Approx. 2480 ft.
EQUIPMENT: Backhoe

DEPTH IN FEET	SAMPLES +	SYMBOL	SOIL DESCRIPTION	MOISTURE	CONSIST.	OTHER TESTS
0			SANDY SILT (ML) - with caliche nodules, light brown to white	slightly moist	firm	
			SILTY CLAY (CL) - porous to very porous, friable, light brown		firm to stiff	
5	▨		- very porous, fractured, desiccated			A,ASTM D-1557
			- partially cemented		very stiff	
			CALICHE - light brown to white Backhoe refusal at 8.5 feet on CALICHE		mod. hard	
10						
15						

NOTES: **Ground water not encountered during trenching.**

+ SAMPLER TYPE: ■ Drive Sample 2.625" I.D. ▨ Bulk

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

APPROV: WEV

BY:

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

TRENCH LOG

PLATE 42

DATED EXCAVATED: 1/15/91
LOCATION: See Plate 1

TRENCH NO. T-5

ELEVATION: Approx. 2469 ft.
EQUIPMENT: Backhoe

DEPTH IN FEET	SAMPLES *	SYMBOL	SOIL DESCRIPTION	MOISTURE	CONSIST.	OTHER TESTS
0			SANDY GRAVEL (GP) - with cobbles, trace silt, roots to 5.0 feet, brown to gray	slightly moist	medium dense	
	▨					A,G
			- finer grained with depth			
5			GRAVELLY SAND (SP) - trace silt, light brown			
			SANDY GRAVEL (GP) - trace silt, light brown to gray		med. dense ~~to dense~~ dense	
			cemented SAND & GRAVEL (GP) - trace silt, brown and gray		mod. hard	
			Backhoe refusal at 8.5 feet on cemented SAND & GRAVEL.			
10						
15						

NOTES: Ground water not encountered during trenching.

* SAMPLER TYPE: █ Drive Sample 2.625" I.D. ▨ Bulk

APPROV: WEV

BY:

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

TRENCH LOG

PLATE 43

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

DATED EXCAVATED: 1/15/91
LOCATION: See Plate 1

TRENCH NO. T-6

ELEVATION: Approx. 2462 ft.
EQUIPMENT: Backhoe

DEPTH IN FEET	SAMPLES +	SOIL DESCRIPTION	MOISTURE	CONSIST.	OTHER TESTS
0	▨	**SANDY GRAVEL (GP-GM)** - trace silt, roots to 1.0 foot, light brown and gray	slightly moist	loose to medium dense	A,G, Permeability
		SANDY SILT (ML) - some clay, porous, light brown - partially cemented - some gravel		firm to stiff	
5		**cemented SAND & GRAVEL** - light brown and gray		hard	
		Backhoe refusal at 5 feet on cemented *SAND & GRAVEL*			
10					
15					

NOTES: **Ground water not encountered during trenching.**

+ SAMPLER TYPE: ■ Drive Sample 2.625" I.D. ▨ Bulk

APPROV: WEV

BY:

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

TRENCH LOG

PLATE 44

DATED EXCAVATED: 1/15/91
LOCATION: See Plate 1

TRENCH NO. T-7

ELEVATION: Approx. 2449 ft.
EQUIPMENT: Backhoe

DEPTH IN FEET	SAMPLES +	SYMBOL	SOIL DESCRIPTION	MOISTURE	CONSIST.	OTHER TESTS
0	▨		**GRAVELLY SAND (SP)** - little silt, light brown	slightly moist	loose to medium dense	ASTM D-1557
			SILTY SAND (SM) - trace gravel, trace to some clay zones, slightly porous, light brown - partially cemented			
			SANDY CLAY (CL) - with silt, porous, friable, partially to fully cemented, occasional gravel, light brown		stiff hard	
			cemented SAND & GRAVEL - gray			
			Backhoe refusal at 3 feet on cemented SAND & GRAVEL			
5						
10						
15						

NOTES: **Ground water not encountered during trenching.**

+ SAMPLER TYPE: ■ Drive Sample 2.625" I.D. ▨ Bulk

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

APPROV: w'EV

BY:

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

TRENCH LOG

PLATE
45

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

DATED EXCAVATED: 1/15/91
LOCATION: See Plate 1

TRENCH NO. T-8

ELEVATION: Approx. 2440 ft.
EQUIPMENT: Backhoe

DEPTH IN FEET	SAMPLES +	SYMBOL	SOIL DESCRIPTION	MOISTURE	CONSIST.	OTHER TESTS
0			**SILTY SAND (SM)** - trace caliche gravel, some roots, light brown	slightly moist	loose to medium dense	
					medium dense	
	▨		- trace clay - partially cemented			A,G
5			**SILTY CLAY (CL)** - trace organics, porous, friable, partially cemented in zones, light brown		firm to stiff	
			- increasing cementation		stiff	
					hard	
			CALICHE - gray Backhoe refusal at 9 feet on CALICHE			
10						
15						

NOTES: **Ground water not encountered during trenching.**

+ SAMPLER TYPE: ■ Drive Sample 2.625" I.D. ▨ Bulk

APPROV: WEV

BY:

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

TRENCH LOG

PLATE 46

THIS SUMMARY APPLIES ONLY AT THIS LOCATION AND AT THE TIME OF LOGGING. CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH TIME. DATA PRESENTED IS A SIMPLIFICATION.

DATED EXCAVATED: 1/15/91
LOCATION: See Plate 1

TRENCH NO. T-9

ELEVATION: Approx. 2434 ft.
EQUIPMENT: Backhoe

DEPTH IN FEET	SAMPLES +	SYMBOL	SOIL DESCRIPTION	MOISTURE	CONSIST.	OTHER TESTS
0	▨		SILTY SAND (SM) - with caliche nodules, light gray	slightly moist	loose to medium dense	G,A
			SILTY CLAY (CL) - some sand, very porous, friable, light brown to gray		firm	
5	▨					A,ASTM D-1557, Permeability
			SANDY SILT (ML) - some clay, porous, light brown			
			cemented SAND & GRAVEL - gray		hard	
			Backhoe refusal at 8.5 feet on cemented SAND & GRAVEL			
10						
15						

NOTES: **Ground water not encountered during trenching.**

+ SAMPLER TYPE: ■ Drive Sample 2.625" I.D. ▨ Bulk

APPROV: 6/22

BY:

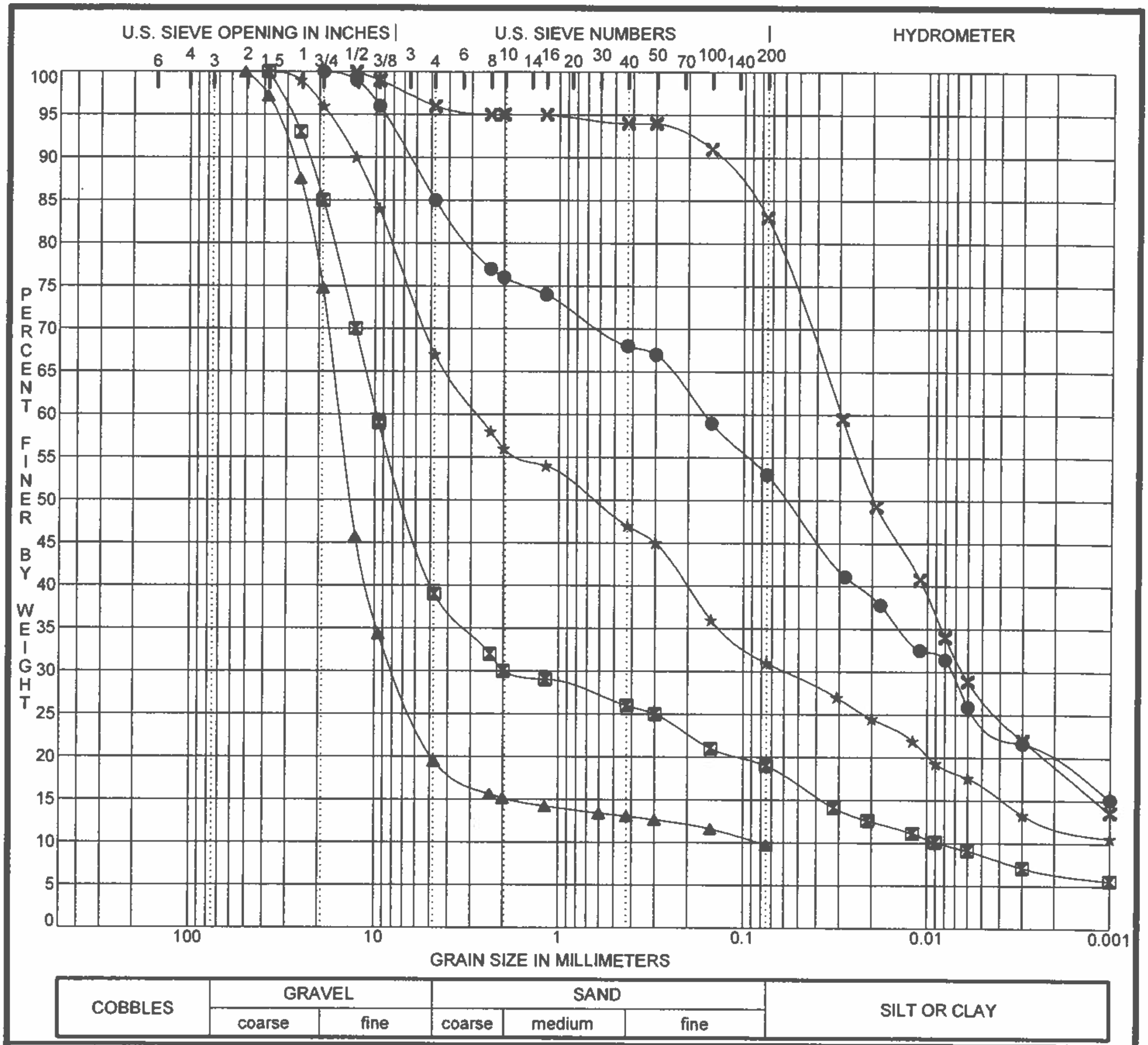
KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

TRENCH LOG

PLATE
47

APPENDIX B



	Exploration No.	Depth(ft)	Classification	LL	PL	PI	Cc	Cu
●	B- 1	6.0	FILL : SANDY LEAN CLAY with GRAVEL	26	14	12		
⊠	B- 1	12.0	CLAYEY GRAVEL with SAND (GC)	22	13	9	47.34	1131.3
▲	B- 1	14.0	POORLY GRADED GRAVEL with CLAY (GP-GC)	22	14	8	46.68	185.7
★	B- 2	6.0	FILL : SILTY, CLAYEY SAND with GRAVEL	18	11	7		
✕	B- 2	12.5	LEAN CLAY with SAND (CL)	34	16	18		

	Exploration No.	Depth(ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Silt	%Clay
●	B- 1	6.0	19.1	0.2	0.0		15	32	28	25
⊠	B- 1	12.0	38.1	9.8	2.0	0.01	61	20	10	9
▲	B- 1	14.0	50.8	15.5	7.8	0.08	81	10	10	
★	B- 2	6.0	38.1	2.8	0.1		33	36	15	16
✕	B- 2	12.5	12.7	0.0	0.0		4	13	56	27

KLEINFELDER

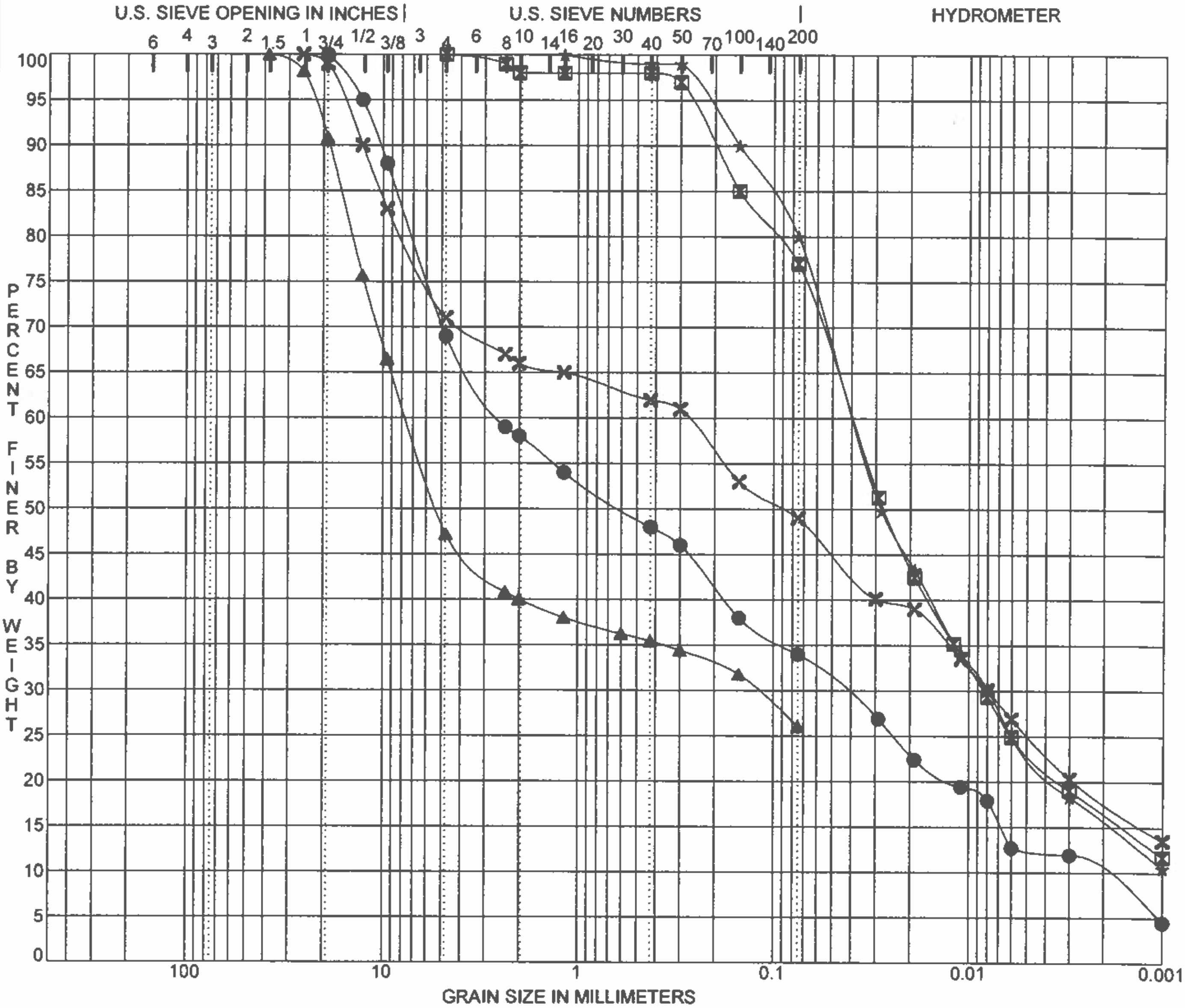
GRAIN SIZE ANALYSES

PROJECT: Moccasin Diversion

PROJECT NO. 101764

PLATE

B-1



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Exploration No.	Depth(ft)	Classification	LL	PL	PI	Cc	Cu
●	B- 3	4.0	FILL : CLAYEY SAND with GRAVEL	23	14	9	0.34	1118.6
⊠	B- 3	10.0	SILTY CLAY with SAND (CL-ML)	22	18	4		
▲	B- 3	16.0	CLAYEY GRAVEL with SAND (GC)	22	14	8		
★	B- 4	6.0	SILT with SAND (ML)	NP	NP	NP		
✕	B- 4	12.0	CLAYEY GRAVEL with SAND (GC)	30	13	17		

	Exploration No.	Depth(ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Silt	%Clay
●	B- 3	4.0	19.1	2.5	0.0	0.00	31	35	22	12
⊠	B- 3	10.0	4.8	0.0	0.0		0	23	54	23
▲	B- 3	16.0	38.1	7.5	0.1		53	21	26	
★	B- 4	6.0	1.2	0.0	0.0		0	20	57	23
✕	B- 4	12.0	25.4	0.3	0.0		29	22	24	25

KLEINFELDER

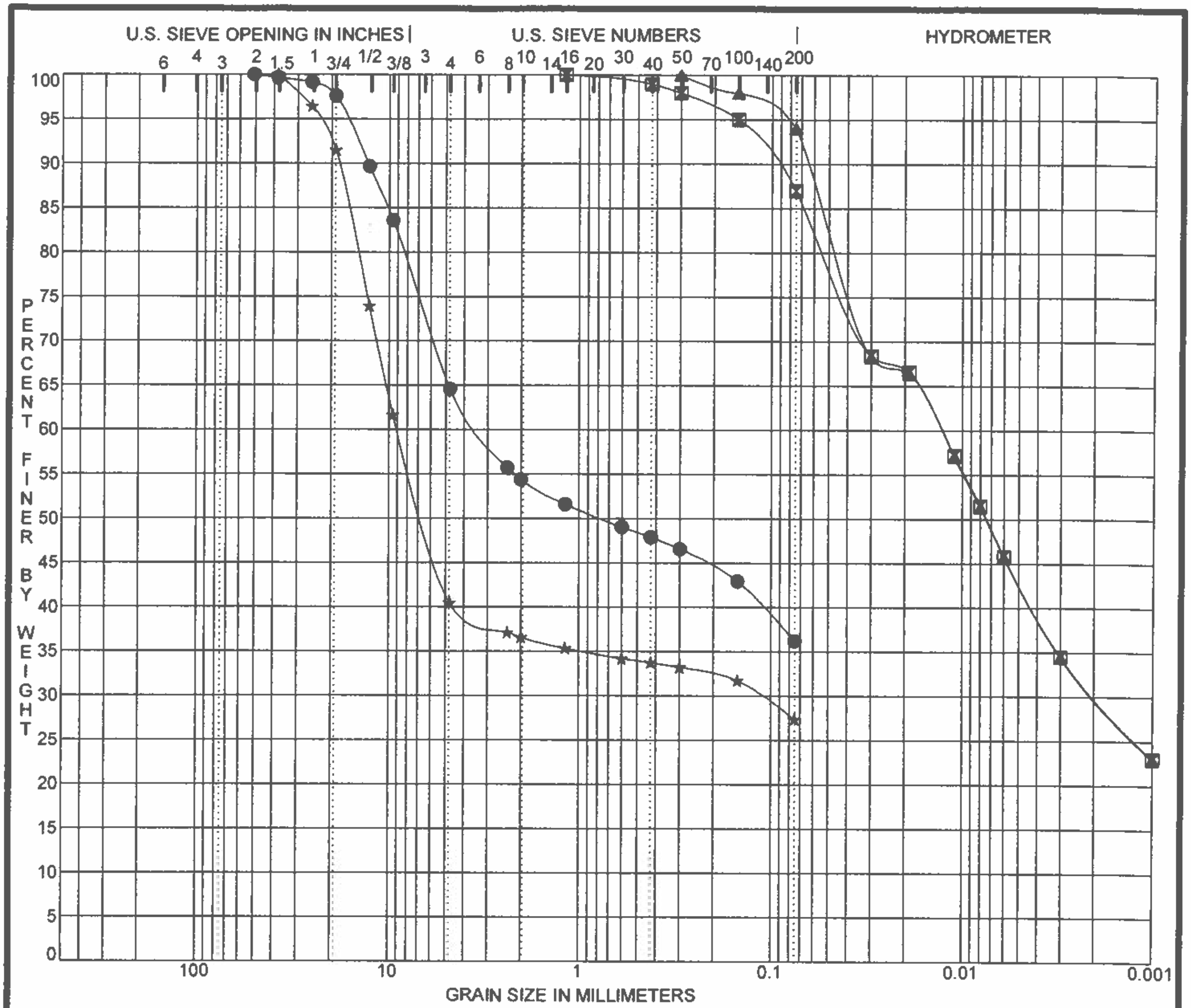
GRAIN SIZE ANALYSES

PROJECT: Moccasin Diversion

PROJECT NO. 101764

PLATE

B-2



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Exploration No.	Depth(ft)	Classification	LL	PL	PI	Cc	Cu
●	B- 4	14.0	CLAYEY GRAVEL with SAND (GC)	27	14	13		
☒	B- 5	8.0	LEAN CLAY (CL)	26	17	9		
▲	B- 6	6.0	LEAN CLAY (CL)	26	16	11		
★	B- 6	16.0	CLAYEY GRAVEL (GC)	31	15	16		

	Exploration No.	Depth(ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Silt	%Clay
●	B- 4	14.0	50.8	3.3			35	28	36	
☒	B- 5	8.0	1.2	0.0	0.0		0	13	44	43
▲	B- 6	6.0	0.3	0.0	0.0		0	6	51	43
★	B- 6	16.0	38.1	9.0	0.1		60	13	27	

KLEINFELDER

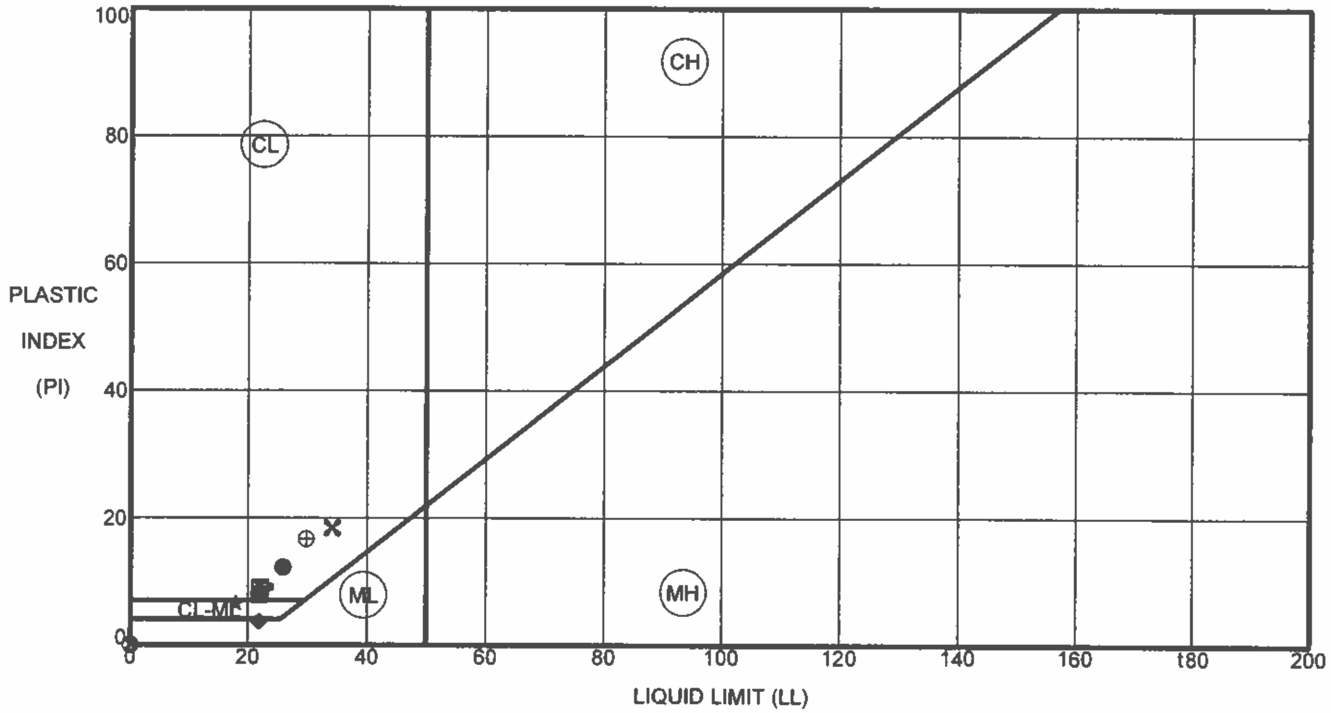
GRAIN SIZE ANALYSES

PROJECT: Moccasin Diversion

PROJECT NO. 101764

PLATE

B-3



	Exploration No.	Depth, ft.	LL	PL	PI	Fines	Classification
●	B- 1	6.0	26	14	12	53	FILL : SANDY LEAN CLAY with GRAVEL
⊠	B- 1	12.0	22	t3	9	19	CLAYEY GRAVEL with SAND (GC)
▲	B- 1	14.0	22	t4	8	10	POORLY GRADED GRAVEL with CLAY (GP-GC)
★	B- 2	6.0	18	11	7	31	FILL : SILTY, CLAYEY SAND with GRAVEL
✖	B- 2	12.5	34	16	18	83	LEAN CLAY with SAND (CL)
✿	B- 3	4.0	23	14	9	34	FILL : CLAYEY SAND with GRAVEL
◆	B- 3	10.0	22	18	4	77	SILTY CLAY with SAND (CL-ML)
■	B- 3	16.0	22	14	8	26	CLAYEY GRAVEL with SAND (GC)
⊗	B- 4	6.0	NP	NP	NP	80	SILT with SAND (ML)
⊕	B- 4	12.0	30	13	17	49	CLAYEY GRAVEL with SAND (GC)

Note: Liquid Limit Test was not performed on non-plastic (NP) soils.

KLEINFELDER

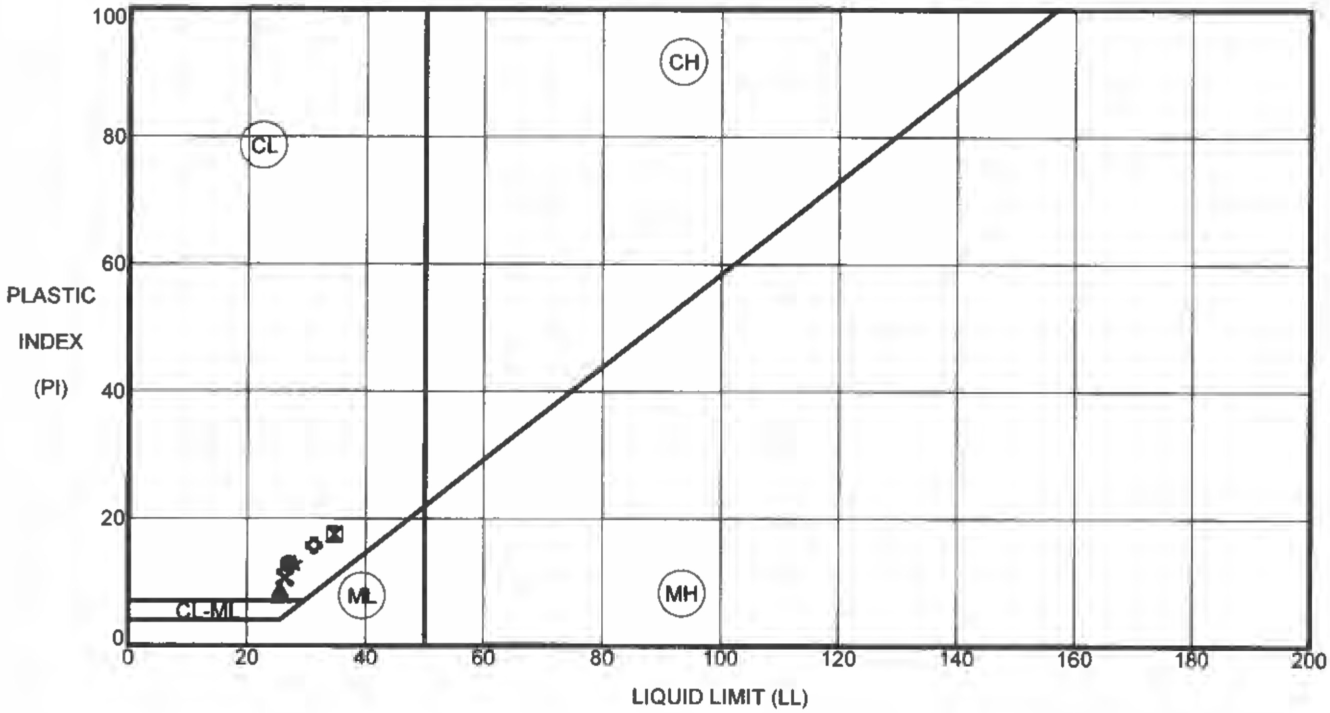
ATTERBERG LIMITS TEST RESULTS

PROJECT: Moccasin Diversion

PROJECT NO. 101764

PLATE

B-4



	Exploration No.	Depth, ft.	LL	PL	PI	Fines	Classification
●	B- 4	14.0	27	14	13	36	CLAYEY GRAVEL with SAND (GC)
⊠	B- 5	2.0	35	17	17		FILL: LEAN CLAY (CL)
▲	B- 5	8.0	26	17	9	87	LEAN CLAY (CL)
★	B- 6	2.0	28	15	13		FILL : LEAN CLAY
✕	B- 6	6.0	26	16	11	94	LEAN CLAY (CL)
✿	B- 6	16.0	31	15	16	27	CLAYEY GRAVEL (GC)

Note: Liquid Limit Test was not performed on non-plastic (NP) soils.

KLEINFELDER

ATTERBERG LIMITS TEST RESULTS

PROJECT: Moccasin Diversion

PROJECT NO. 101764

PLATE

B-5

EXPANSION TEST SUMMARY

Exploration No.	Sample Depth (ft)	SOIL DESCRIPTION	Remolded Dry Density (pcf)	*Remolded Moisture Content (%)	Final Moisture Content (%)	Expansion Under 60 psf Surcharge (%)
B- 5	2	FILL: LEAN CLAY (CL)	109	11	24	8
B- 5	6.5	FILL: LEAN CLAY (CL)	107	13	27	7
B- 6	2	FILL : LEAN CLAY	109	13	22	5
B- 6	4	LEAN CLAY (CL)	106	11	29	9
B- 6	6	LEAN CLAY (CL)	104	12	25	7
B- 6	8	LEAN CLAY (CL)	110	8	26	8

*Sample oven-dried prior to testing.

KLEINFELDER

PROJECT: Moccasin Diversion

PROJECT NO. 101764

PLATE

B-6

Atlas Consultants, Inc.

6000 S. Eastern Avenue, Suite 10J • Las Vegas, Nevada 89119
(702) 383-1199 • Fax (702) 383-4983

CHEMICAL
PHYSICAL

member of
AMERICAN SOCIETY FOR
TESTING MATERIALS

ACT LAB NO: 15741(b)

DATE: January 25, 2010

PROJECT NO: 101764

P.O.

SUBMITTED BY: KLEINFELDER

LAB ID: 30358

ANALYZED BY: Kurt D. Ergun

WATER SOLUBLE SALT ANALYSIS IN SOIL

1:5 (soil:water) Aqueous Extraction
AWWA 3500-Na D, AWWA 4500 E
AWWA 2540 C

SOIL SIEVE SIZE = -10 MESH

Sample No.	Location	Depth (feet)	Sodium (Percent)	Water Soluble Sulfate (SO_4) (Percent)	Total Available Water Soluble Sodium Sulfate (Na_2SO_4) (Percent)
30358	B-5	6.5-7.0	0.04	0.02	0.03

Solubility = 0.30%

Kurt D. Ergun

LABORATORY DIRECTOR

Notes: The results for each constituent denote the percentage of that analyte, at a 1:5 (soil:water) extraction ratio, which is present in the soil. Sodium was determined by flame photometry, sulfate turbidimetrically, and sodium sulfate by calculation.

Atlas Consultants, Inc.

6000 S. Eastern Avenue, Suite 10J • Las Vegas, Nevada 89119
(702) 383-1199 • Fax (702) 383-4983

CHEMICAL
PHYSICAL

member of
AMERICAN SOCIETY FOR
TESTING MATERIALS

ACT LAB NO: 15724(a)

DATE: January 5, 2010

PROJECT NO: 101764.3.2

P.O.

SUBMITTED BY: KLEINFELDER

LAB ID: 30349

ANALYZED BY: Kurt D. Ergun

WATER SOLUBLE SALT ANALYSIS IN SOIL

1:5 (soil:water) Aqueous Extraction
AWWA 3500-Na D, AWWA 4500 E
AWWA 2540 C

SOIL SIEVE SIZE = -10 MESH

Sample No.	Location	Depth (feet)	Sodium (Percent)	Water Soluble Sulfate (SO_4) (Percent)	Total Available Water Soluble Sodium Sulfate (Na_2SO_4) (Percent)
30349	B-5	2.0-3.5	0.03	0.02	0.03
Solubility = 0.32%					
30349	B-6	2.0-3.5	0.03	0.02	0.03
Solubility = 0.34%					
30349	B-6	6.0-7.5	0.03	0.02	0.03
Solubility = 0.29%					

Kurt D. Ergun

LABORATORY DIRECTOR

Notes: The results for each constituent denote the percentage of that analyte, at a 1:5 (soil:water) extraction ratio, which is present in the soil. Sodium was determined by flame photometry, sulfate turbidimetrically, and sodium sulfate by calculation.

PREVIOUS LABORATORY TEST RESULTS

Table 1: In Situ Infiltration Rate Test Results

Location	Depth To Bottom Of Screen (ft.)	Screen Length (ft.)	Test Head (ft.)	Infiltration Rate (gal./ft.^{2} min.)
B-6	40	10	40	0.51
B-20	12	10	See Note 1	
B-21	19.9	10	See Note 2	
B-22	11.3	5	14.5	0.38
B-26	16.9	10	20.1	0.05
B-27	6	5	See Note 2	
B-28	16.9	5	20.1	0.03

Note 1:	2/8/91	50-gallons water added @ 3 gal./min. could not fill pipe to ground surface.
	2/13/91	8:00 a.m. 171-gallons water added @ 5.4 to 7.3 gal./min. could not fill pipe.
	2/13/91	4:00 p.m. 494-gallons water added @ 15.8 to 20.0 gal./min. could not fill pipe. Infiltration rate greater than 1.3 gal./ft.^{2} min.
Note 2:		Bentonite well seal failed. Test abandoned.

Table 2: Laboratory Permeability Test Results

Locations	Depth	Description	Permeability (cm/sec)
B-37	10	Sandy Silt (ML)	2.2×10^{-6}
B-30	10	Silty Clay (CL)	1.4×10^{-6}
T-8	2	Silty Sand (SM), trace clay	4.3×10^{-5}
*T-6	1	poorly graded, Silty Gravel (GP-GM), trace clay	2.0×10^{-4}

* = Large diameter sample (12" diameter)

Table 3: Moisture/Density Relationship Test Results (ASTM D-1557)

Location	Depth (ft.)	Description	Optimum Moisture Percent (%)	Maximum Dry Density (pcf)
T-2	1	Sandy Gravel (GW)	8.8	130.0
T-3	1	Sandy Gravel (GP), silty with cobbles	7.3	138.9
T-4	5	Silty Clay (CL)	14.4	115.8
T-7	0	Gravelly Sand (SP)	7.1	137.7
T-9	4	Silty Clay (CL)	16.6	110.6
B-23	0	Silty Sand (SM), clayey, gravelly	13.5	117.6

Table 4: Trench Exploration In Situ Moisture Test Results (ASTM D-2216)

Location	Depth (ft.)	Moisture Content Percent (%) by Weight
T-3	1	0.2
T-3	3	1.1
T-4	5	3.7
T-5	1	0.3
T-6	1	0.7
T-7	0	0.3
T-8	2	1.9
T-9	0	1.3
T-9	4	6.0
T-11	5.5	6.1
T-13	0	1.5
T-15	3	0.3
T-15	6.5	4.5
T-16	1	1.3
T-16	6	6.4
T-16	9	6.4
T-17	5	0.7
T-17	8	5.3
T-18	0	1.0
T-18	4	0.9
T-18	9	0.3
T-19	2	0.6
T-19	9	3.5
T-20	3	0.8
T-22	3	1.0
T-23	2	2.1
T-24	2	5.1
T-24	7	7.9
T-25	4	5.8
T-25	8	3.8

Table 5: Minus No. 200 Sieve Wash Loss Test Results (ASTM D-1140)

Location	Depth (feet)	Soils Description	Wash Loss Percent (%)
B-1	20	Silty Gravel (GM)	19.9
T-15	6.5	Sandy Silt (ML)	65.9

Atlas Chemical Testing Laboratories

2120 Western Avenue, Suite C-6 • Las Vegas, Nevada 89102
(702) 383-1199 • Fax (702) 383-4983

CHEMICAL
PHYSICAL
FORENSIC

member of
AMERICAN SOCIETY FOR
TESTING MATERIALS

ACT LAB NO: 4124

DATE: 3/21/91

PROJECT NO: J28109

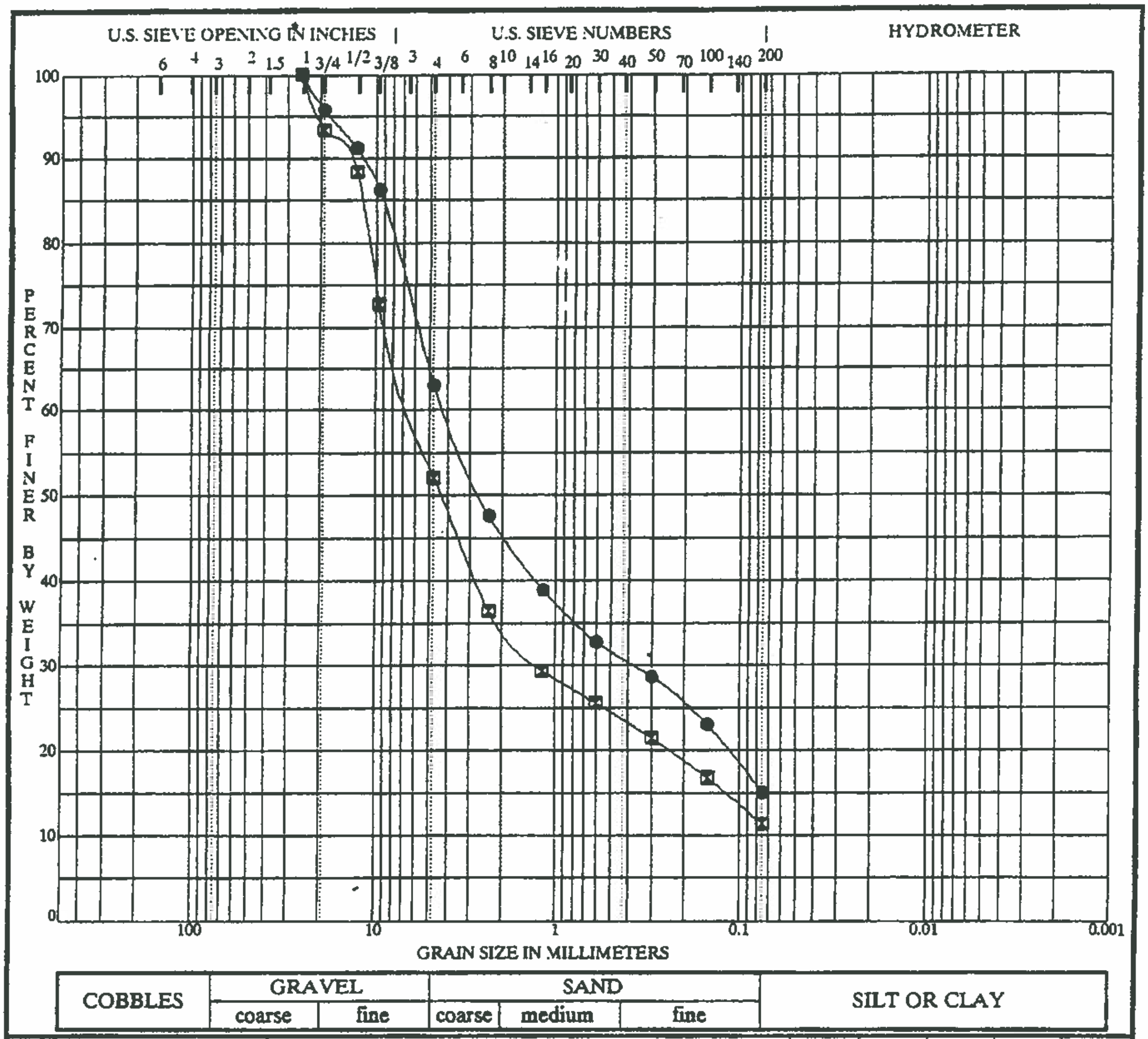
ANALYZED BY:

WATER SOLUBLE SALT ANALYSIS IN SOIL
1:5 (soil:water) Aqueous Extraction

ASTM D 1428, D 516

Sample No.	Location	Depth (Feet)	Sodium (Percent)	Sulfate (Percent)	Total Available Water Soluble Sodium Sulfate (Percent)
	B-8	3	0.02	0.04	0.07
	B-12	0	<0.01	0.04	<0.01
	B-15	5	0.02	0.03	0.06

Notes: The results for each constituent denote the percentage of that analyte, soluble in water at a 1:5 (soil:water) extraction ratio, which is present in the soil. Sodium was determined by flame photometry, sulfate turbidimetrically, and sodium sulfate by calculation.



	Exploration No.	Depth(ft)	Classification	LL	PL	PI	Cc	Cu
●	B-4	2.0	SILTY SAND with GRAVEL SM	NP	NP	NP		
☒	B-7	30.0	POORLY GRADED GRAVEL with SILT and SAND GP-GM	NP	NP	NP	3.68	88.6

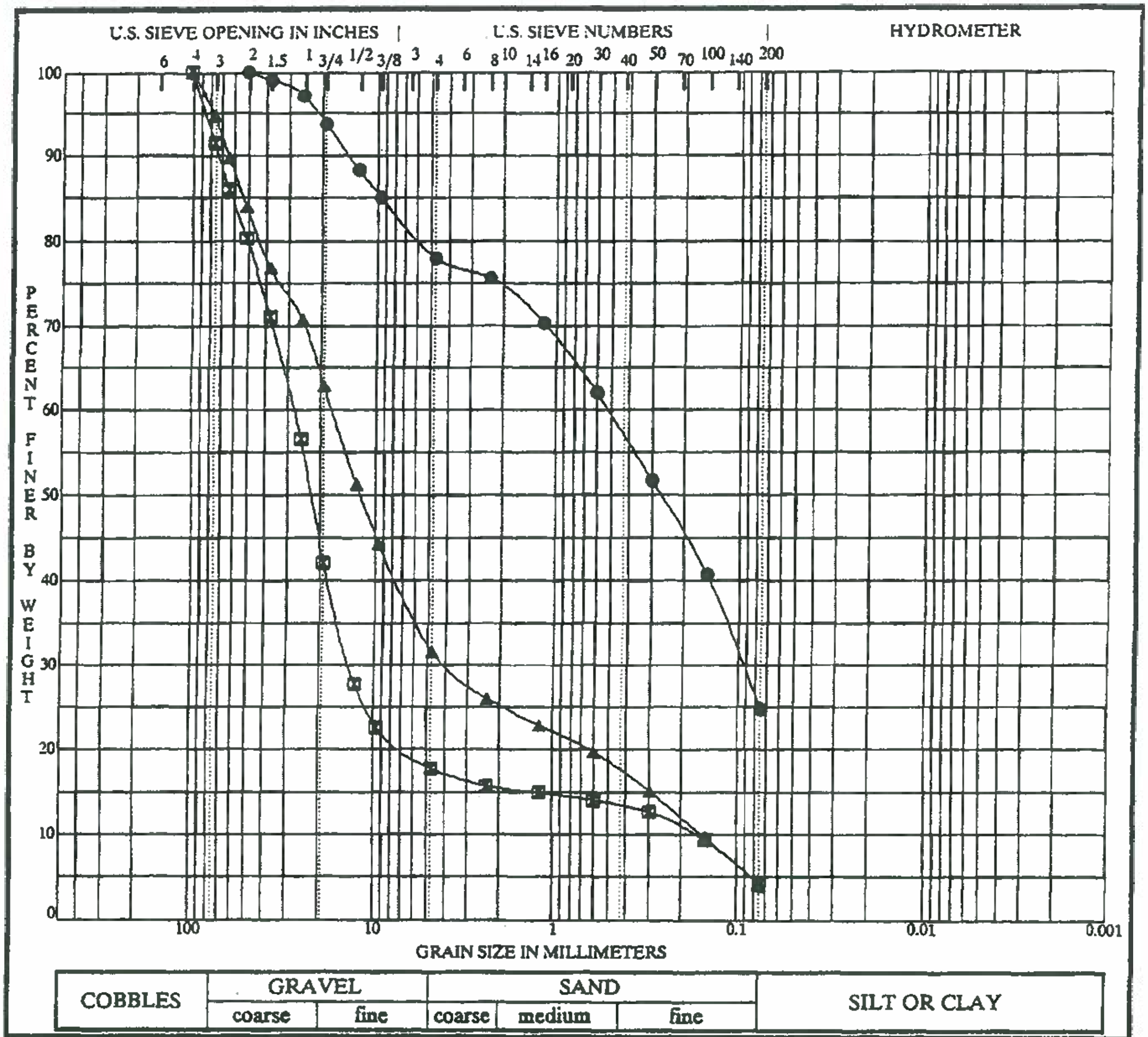
	Exploration No.	Depth(ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Silt	%Clay
●	B-4	2.0	25.40	4.15	0.378		37.0	48.0	15.0	
☒	B-7	30.0	25.40	6.20	1.263		47.9	40.8	11.3	

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

GRAIN SIZE ANALYSES

PLATE
65



Exploration No.	Depth(ft)	Classification	LL	PL	PI	Cc	Cu
● T-24	2.0	SILTY SAND with GRAVEL SM	NP	NP	NP		
⊠ T-3	1.0	POORLY GRADED GRAVEL (GP), with COBBLES	NP	NP	NP		
▲ T-5	1.0	POORLY GRADED GRAVEL (GP), with COBBLES	NP	NP	NP		

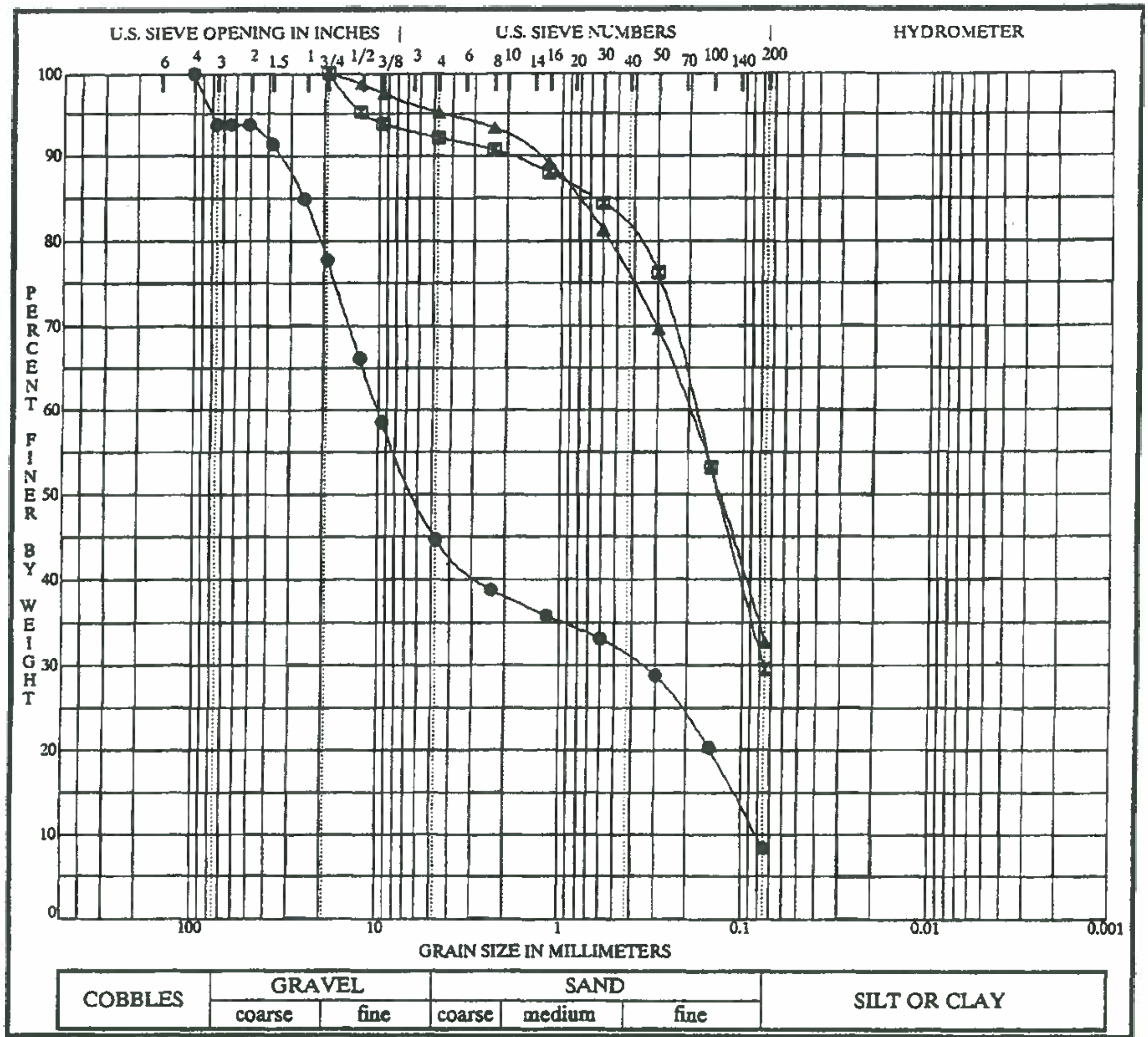
Exploration No.	Depth(ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Silt	%Clay
● T-24	2.0	50.80	0.52	0.094		22.1	53.2	24.7	
⊠ T-3	1.0	101.60	28.01	13.560	0.1708	73.2	13.6	4.1	
▲ T-5	1.0	101.60	17.29	3.890	0.1559	62.6	27.3	4.3	

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

GRAIN SIZE ANALYSES

PLATE
69



	Exploration No.	Depth(ft)	Classification	LL	PL	PI	Cc	Cu
●	T-6	1.0	POORLY GRADED, SILTY GRAVEL (GP-GM), with COBBLES	NP	NP	NP		
⊠	T-8	2.0	SILTY SAND SM	NP	NP	NP		
▲	T-9	0.0	SILTY SAND SM	NP	NP	NP		

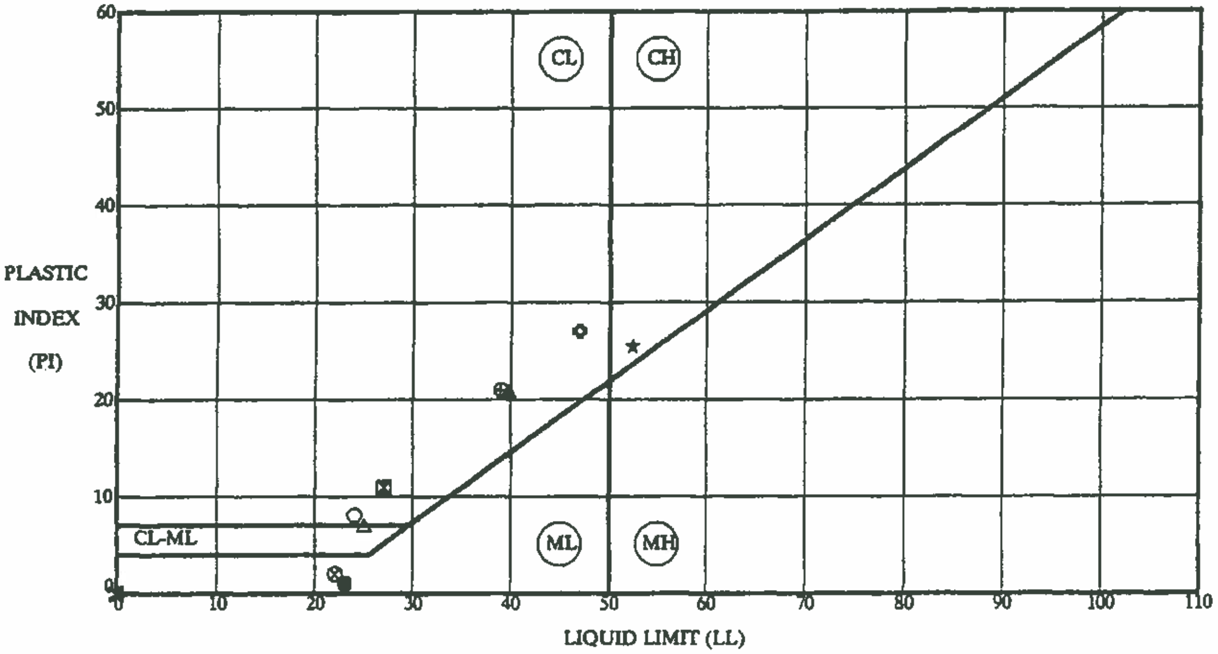
	Exploration No.	Depth(ft)	D100 (mm)	D60 (mm)	D30 (mm)	D10 (mm)	%Gravel	%Sand	%Silt	%Clay
●	T-6	1.0	101.60	10.05	0.364	0.0823	49.1	36.2	8.4	
⊠	T-8	2.0	19.10	0.18	0.076		7.9	62.6	29.5	
▲	T-9	0.0	19.10	0.20			4.9	62.4	32.7	

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

GRAIN SIZE ANALYSES

PLATE
70



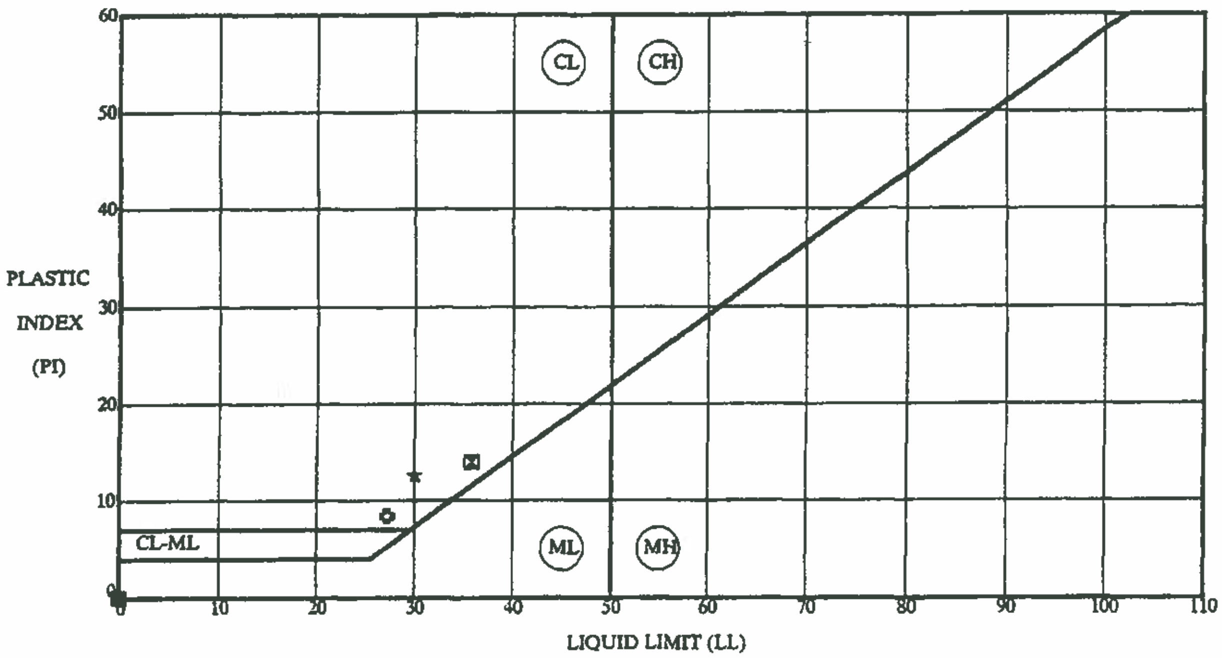
	Exploration No.	Depth(ft)	LL	PL	PI	Fines	Classification
●	B-1	15.0	23	22	1		LOW PLASTIC SILT (ML)
⊠	B-2	12.0	27	16	11		LOW PLASTIC CLAY (CL)
▲	B-29	10.0	40	19	21		LOW PLASTIC CLAY (CL)
★	B-34	10.0	52	27	26		HIGH PLASTIC CLAY (CH)
✕	B-4	2.0	NP	NP	NP	15.0	SILTY SAND with GRAVEL SM
✿	B-5	10.0	47	20	27		LOW PLASTIC CLAY (CL)
○	B-5	15.0	24	16	8		LOW PLASTIC CLAY (CL)
△	B-5	25.0	25	18	7		LOW PLASTIC SILTY CLAY (CL-ML)
⊗	B-5	30.0	22	20	2		LOW PLASTIC SILT (ML)
⊕	B-5	35.0	39	18	21		LOW PLASTIC CLAY (CL)

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

ATTERBERG LIMITS TEST RESULTS

PLATE
72



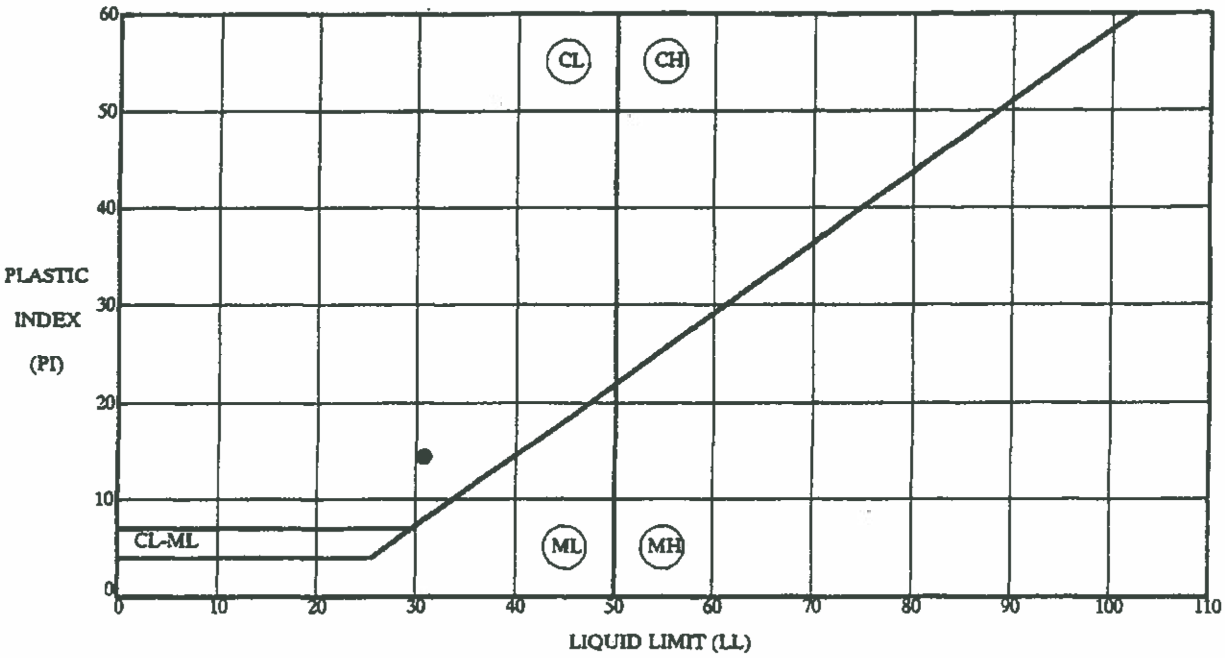
Exploration No.	Depth(ft)	LL	PL	PI	Fines	Classification
● T-22	3.0	NP	NP	NP	6.0	POORLY GRADED GRAVEL with SILT and SAND GP-GM
⊠ T-23	2.0	36	22	14		LOW PLASTIC CLAY (CL)
▲ T-24	2.0	NP	NP	NP	24.7	SILTY SAND with GRAVEL SM
★ T-25	8.0	30	17	13		LOW PLASTIC CLAY (CL)
✕ T-3	1.0	NP	NP	NP	4.1	POORLY GRADED GRAVEL (GP)-with cobbles
✿ T-4	5.0	27	19	8		LOW PLASTIC CLAY (CL)
○ T-5	1.0	NP	NP	NP	4.3	POORLY GRADED GRAVEL (GP) - with cobbles
△ T-6	1.0	NP	NP	NP	8.4	POORLY GRADED SILTY GRAVEL (GP-GM)-with cobbles
⊗ T-8	2.0	NP	NP	NP	29.5	SILTY SAND SM
⊕ T-9	0.0	NP	NP	NP	32.7	SILTY SAND SM

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

ATTERBERG LIMITS TEST RESULTS

PLATE
74



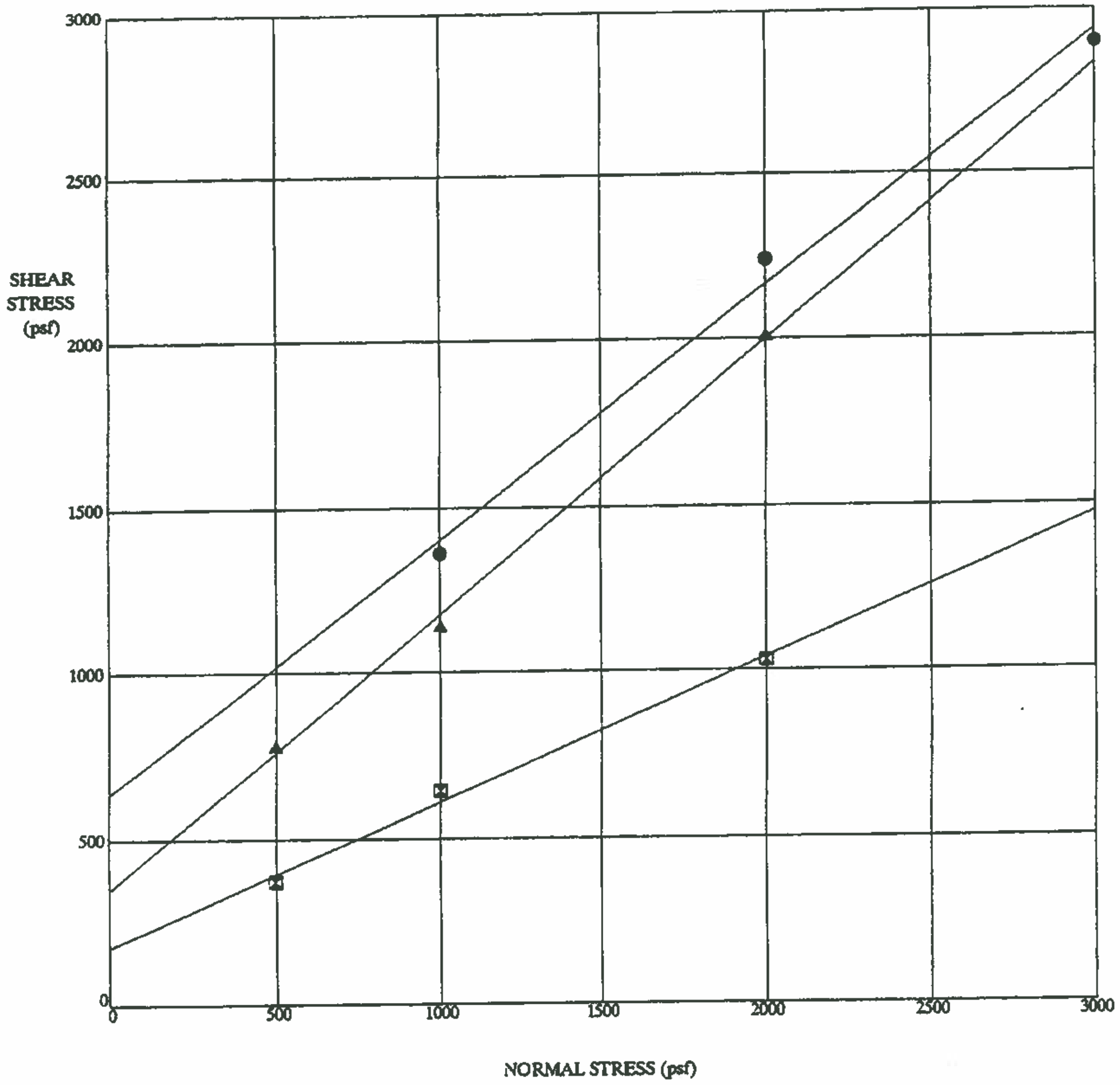
	Exploration No.	Depth(ft)	LL	PL	PI	Fines	Classification
●	T-9	5.0	31	16	14		LOW PLASTIC CLAY (CL)

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

ATTERBERG LIMITS TEST RESULTS

PLATE
75



Exploration No.	Depth (ft.)	Soil Description	PHI Angle Degrees	Cohesion (psf)
● B-1	20.0	SILTY GRAVEL (GM)	37.4	633.3
☒ B-12	5.0	[CD] SILTY CLAY (CL)/SAND (SP)	23.4	175.0
▲ B-15	5.0	SANDY CLAY, gravelly (CL)	39.5	345.0

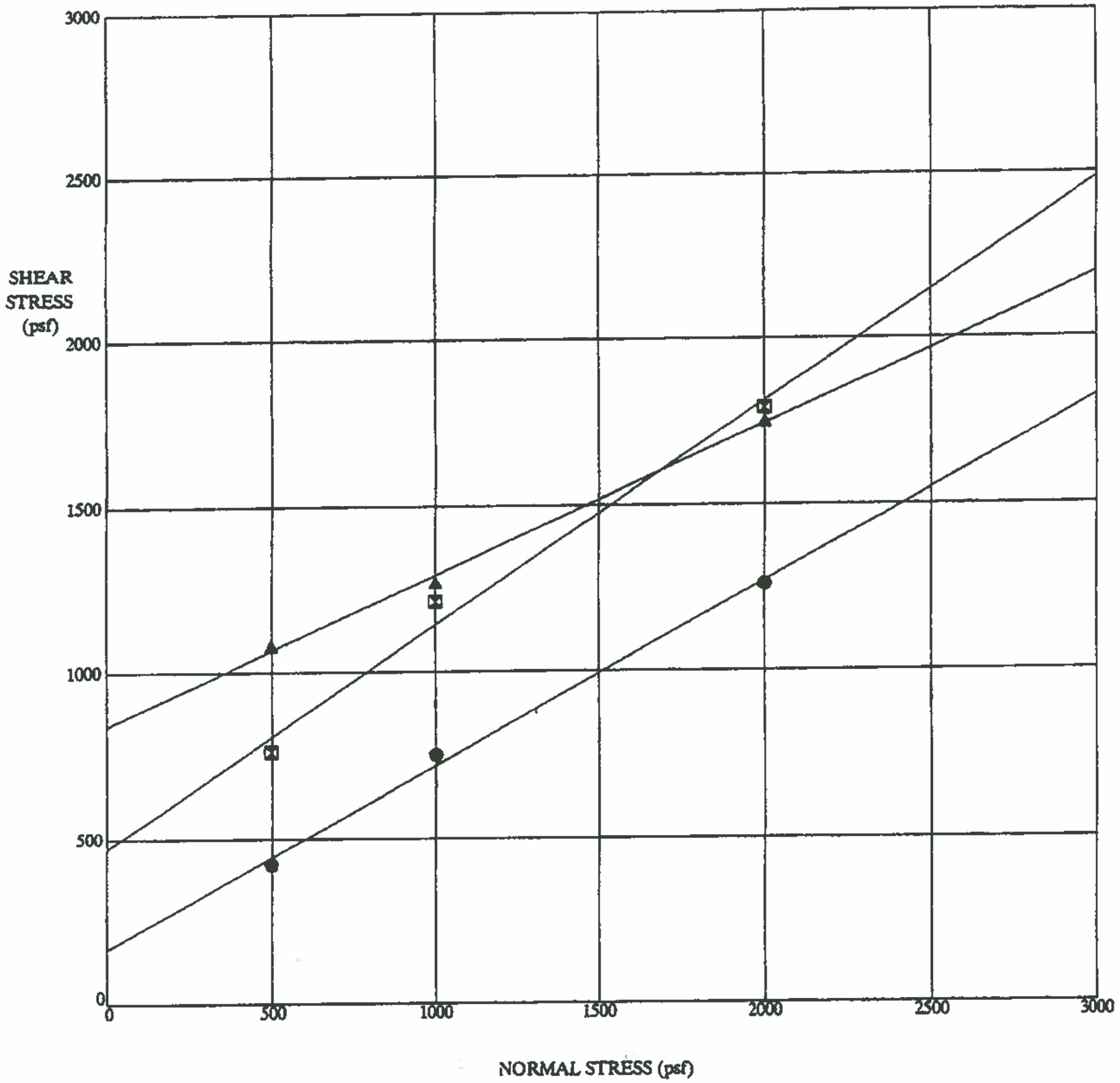
[CD]-consolidated drained
[UU]-unconsolidated undrained

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

DIRECT SHEAR TEST RESULTS

PLATE
76



Exploration No.	Depth (ft.)	Soil Description	PHI Angle Degrees	Cohesion (psf)
● B-15	5.1	[CD] SANDY CLAY, gravelly (CL)	28.9	165.0
☒ B-26	5.0	SANDY CLAY, gravelly (CL)	33.8	470.0
▲ B-5	10.0	SILTY CLAY (CL)	24.2	840.0

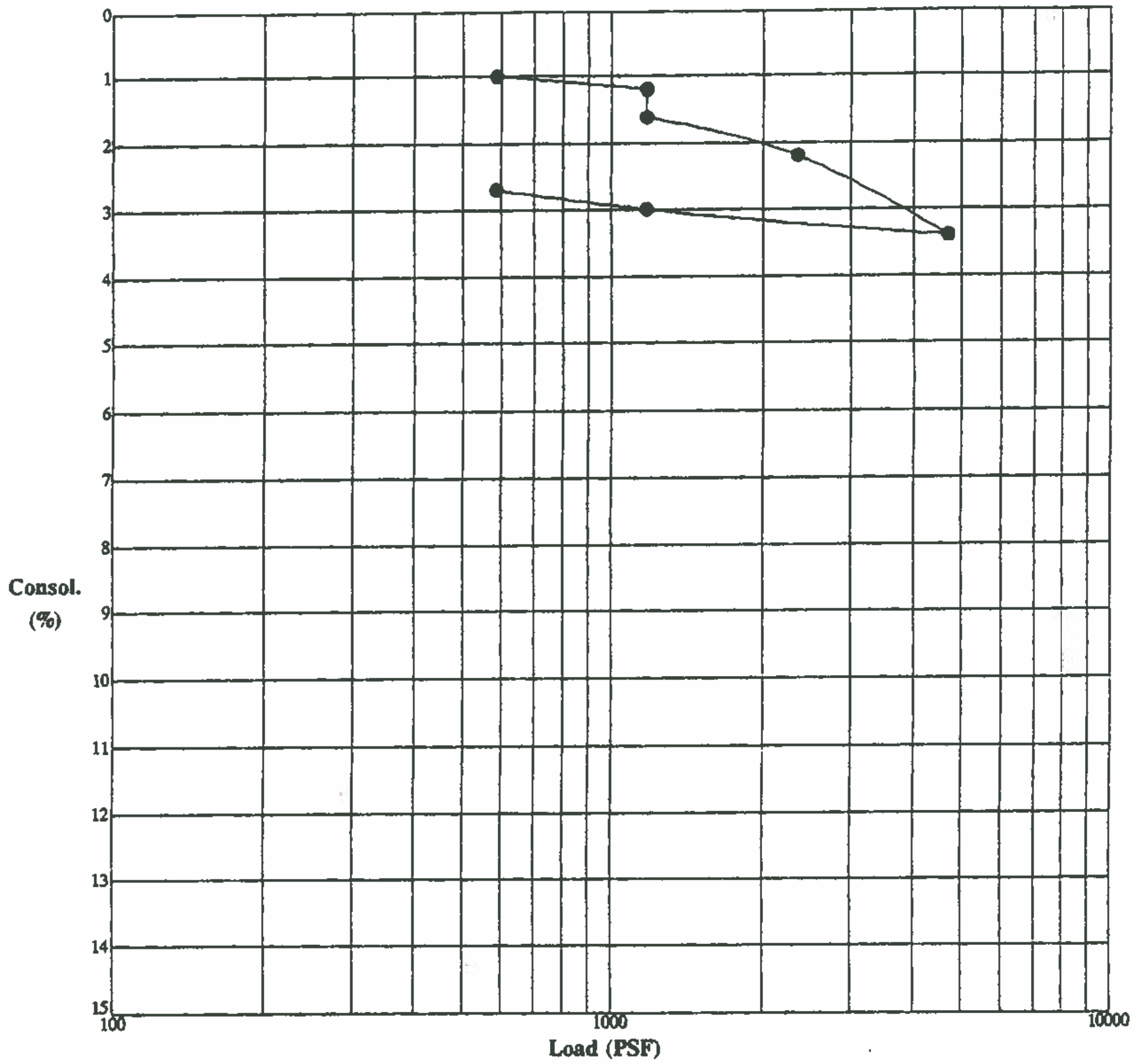
[CD]-consolidated drained
[UU]-unconsolidated undrained

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

DIRECT SHEAR TEST RESULTS

PLATE
77



CONSOLIDATION IN PERCENT OF SAMPLE HT.
vs
LOAD IN POUNDS PER SQUARE FOOT

Exploration No.	Depth (ft.)	Soil Description	Dry Density (pcf)	Moisture Content (%)
B-1	15.0	CLAYEY SILT (ML)	97	3

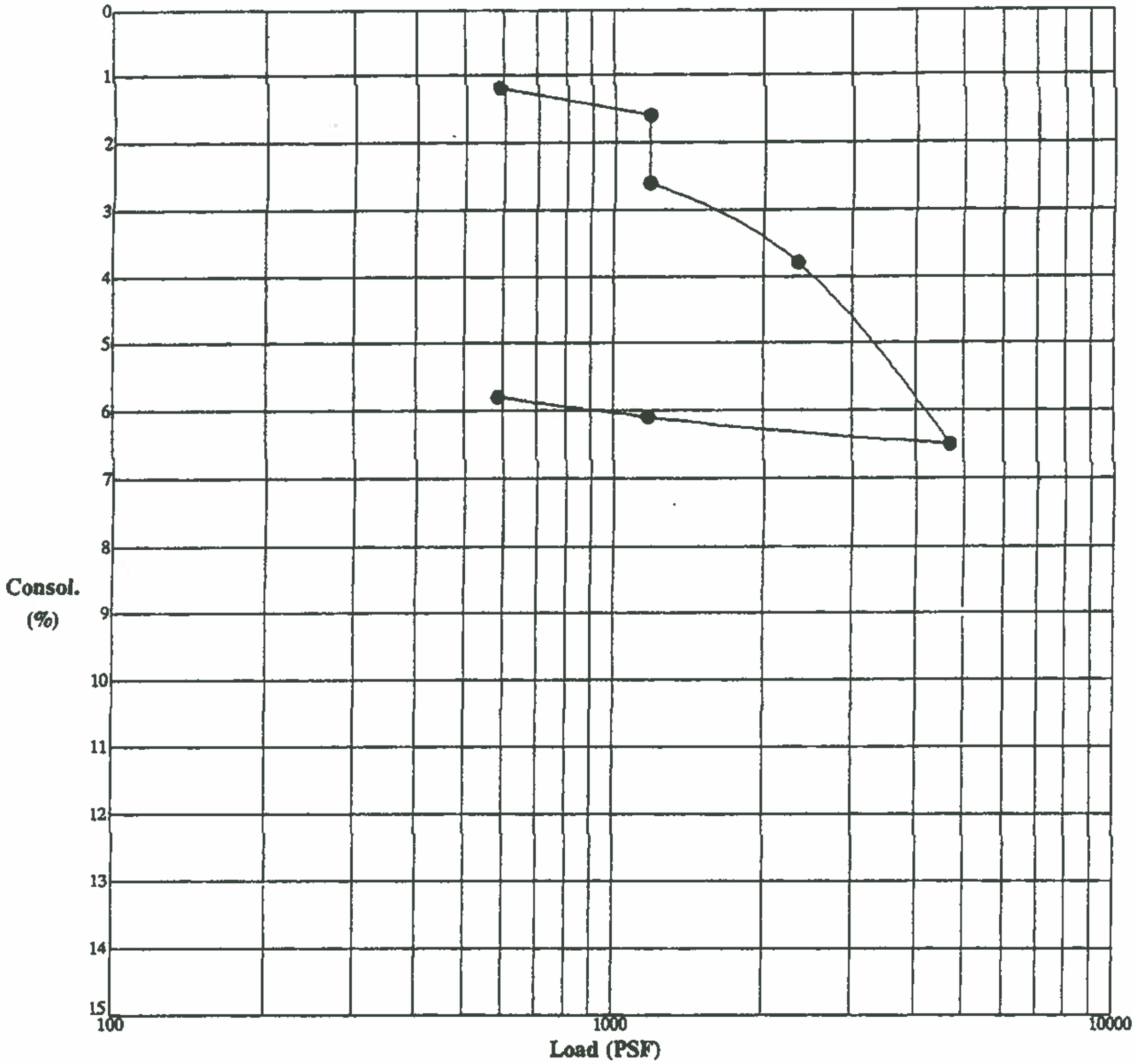
WATER ADDED @ 1170 psf

KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

CONSOLIDATION TEST DATA

PLATE
80



CONSOLIDATION IN PERCENT OF SAMPLE HT.

vs

LOAD IN POUNDS PER SQUARE FOOT

Exploration No.	Depth (ft.)	Soil Description	Dry Density (pcf)	Moisture Content (%)
B-2	7.0	SILTY CLAY (CL)	95	5

WATER ADDED @ 1170 psf

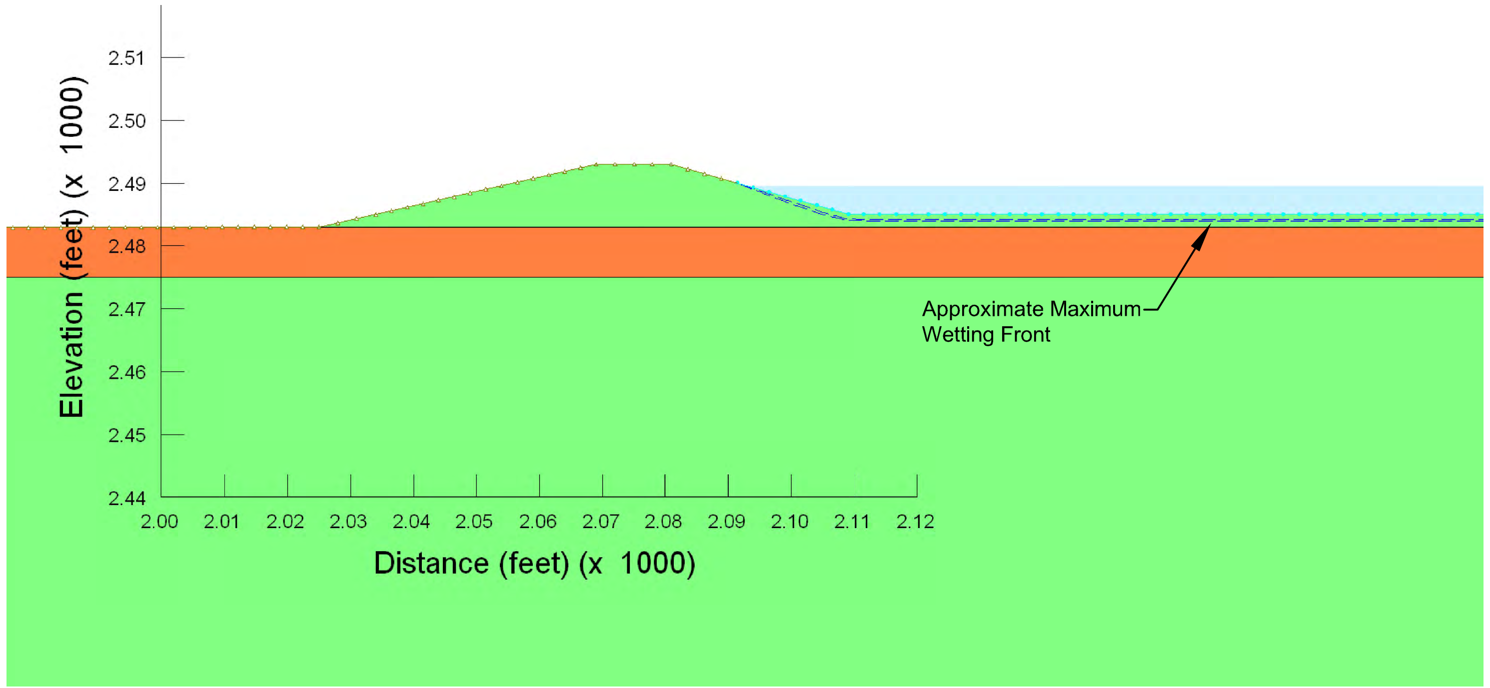
KLEINFELDER
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
SOILS AND MATERIALS TESTING

PROJECT NO. 31-128109

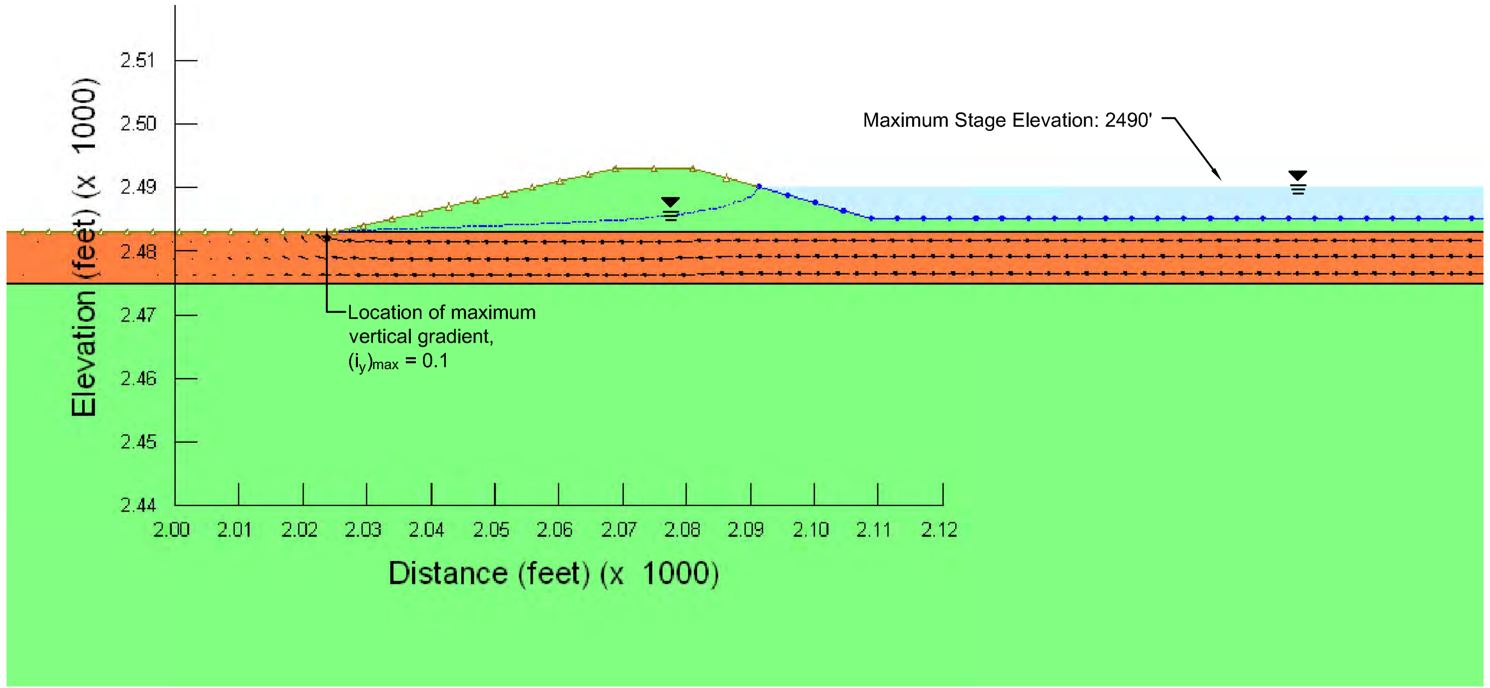
CONSOLIDATION TEST DATA

PLATE
81

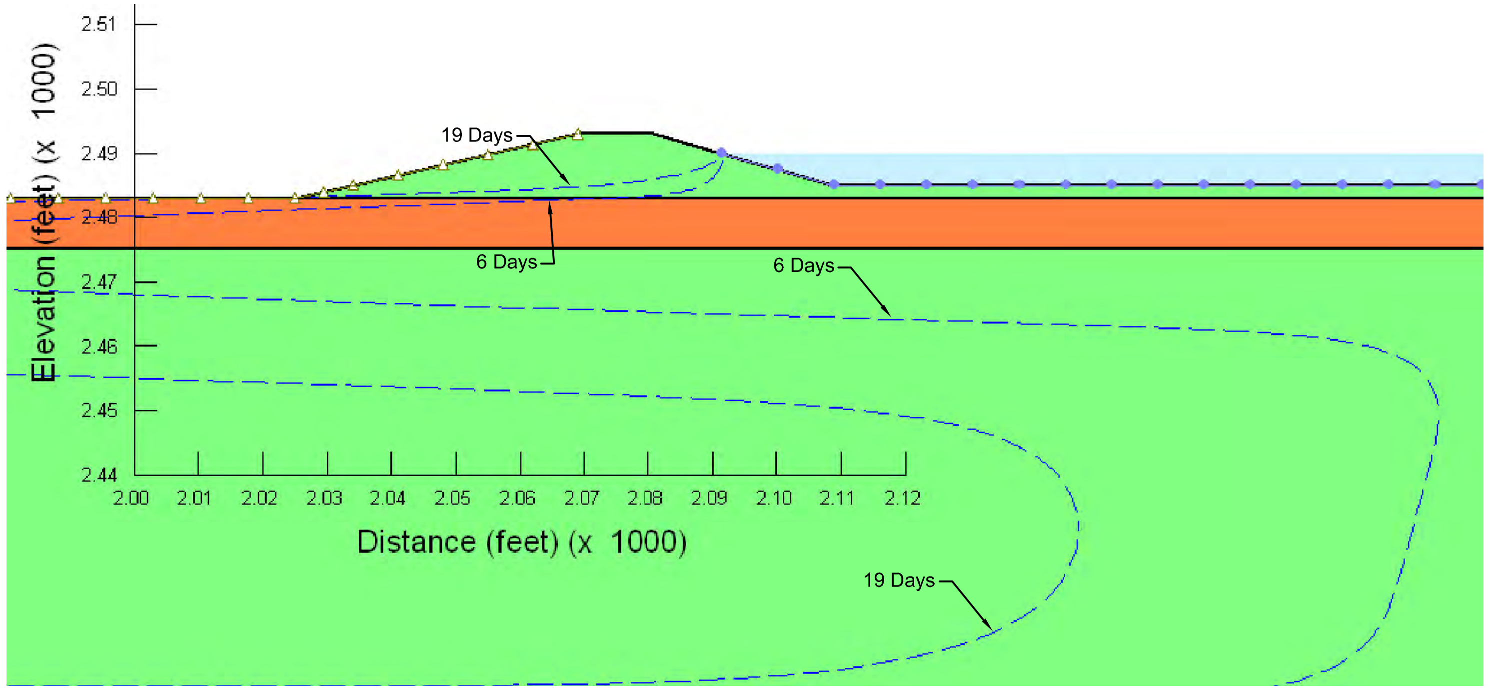
APPENDIX C



TRANSIENT SEEPAGE
STATION 9+00 - CASE 1



STEADY-STATE SEEPAGE
STATION 9+00 - CASE 1



TIME TO STEADY STATE SEEPAGE
STATION 9+00 - CASE 1

LEGEND:

▼ - SEEP\W PHREATIC SURFACE

– – – - SEEP\W WETTING FRONT

Hydraulic Properties

Material Type	Color	K_v (ft/day)*	K_h/K_v*
CLAY	🟩	0.037	10
GRAVEL (5% FINES)	🟧	170	4

*K_v = Vertical Hydraulic Conductivity
*K_h = Horizontal Hydraulic Conductivity

KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

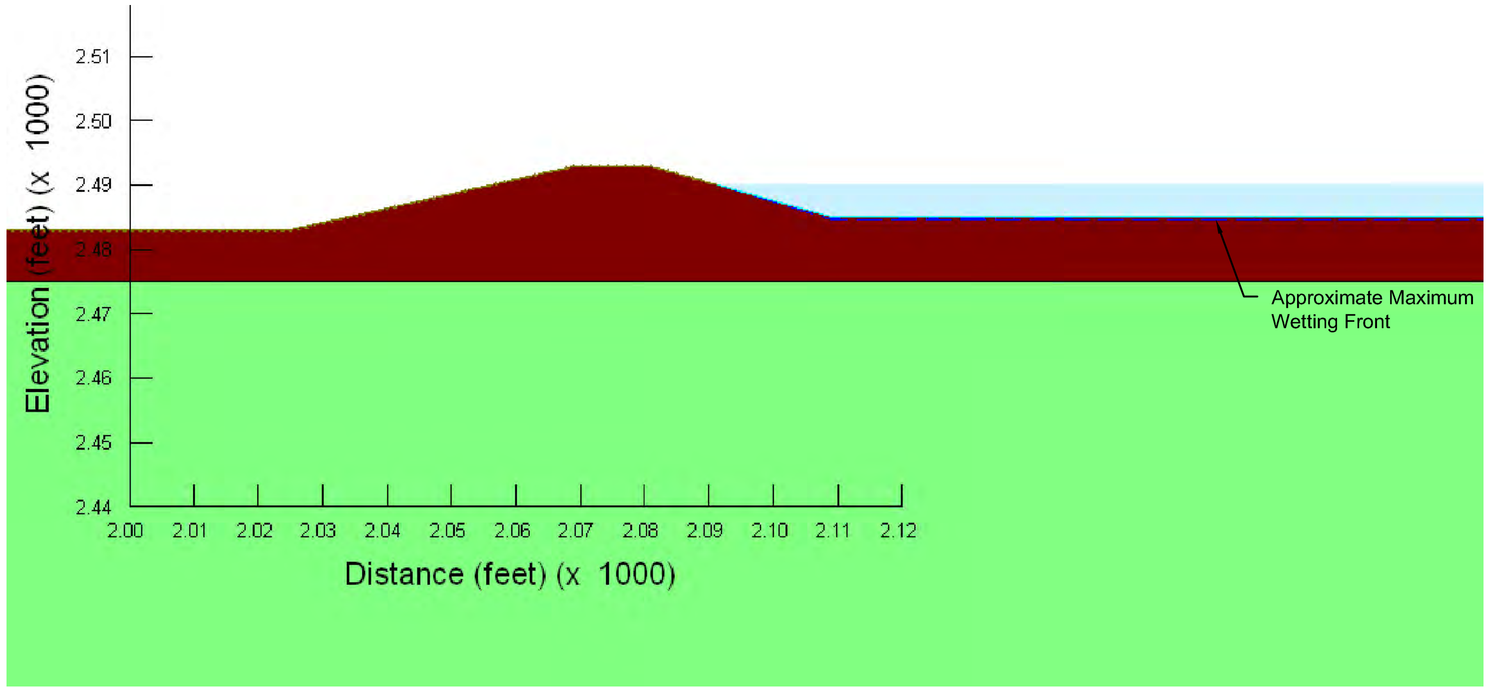
PROJECT NO. 101764.2
DRAWN: 03/29/2010
DRAWN BY: DFR
CHECKED BY: JLS

6380 SOUTH POLARIS AVE.
LAS VEGAS, NV 89118
(P) 702-736-2936 (F) 702-361-9094

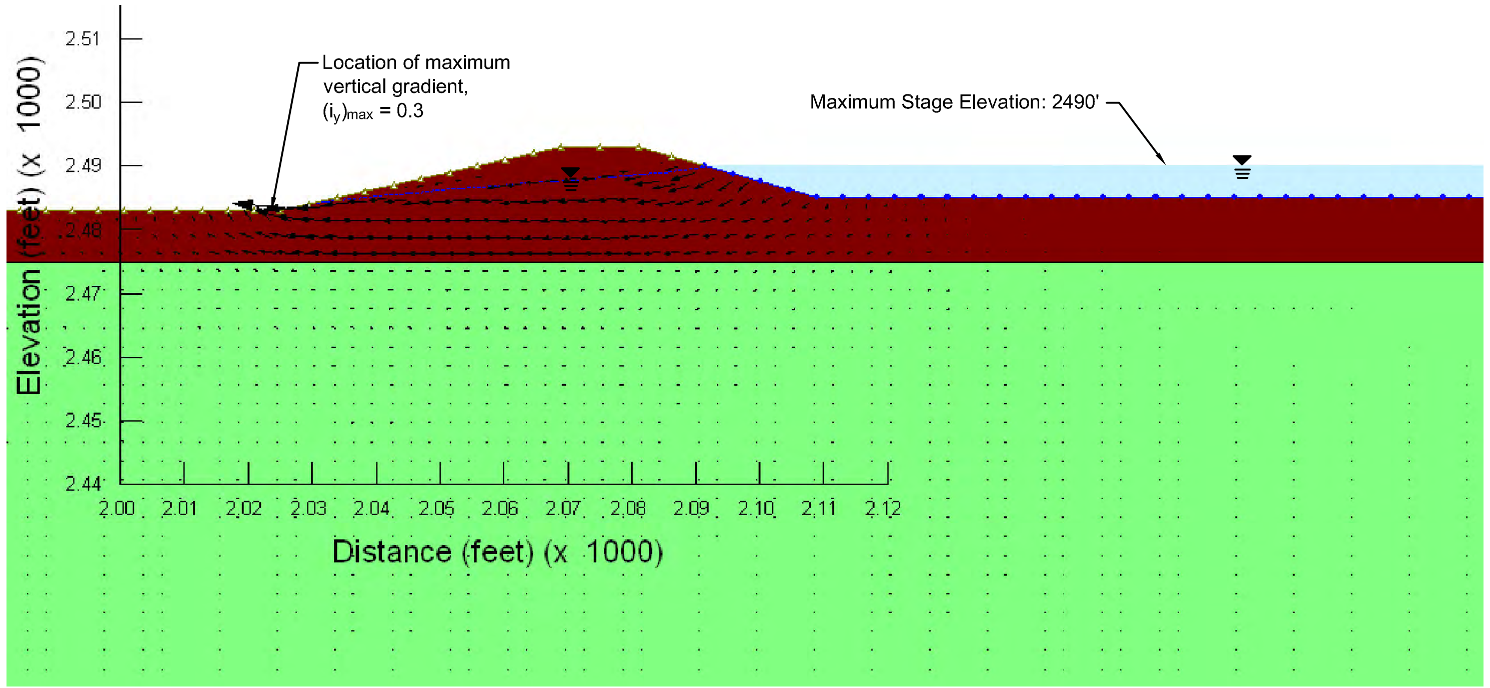
Seepage Analyses
Station 9+00 - Case 1

CCRFCD
Clark County Levee Certification Project
Moccasin Diversion
Las Vegas, Nevada

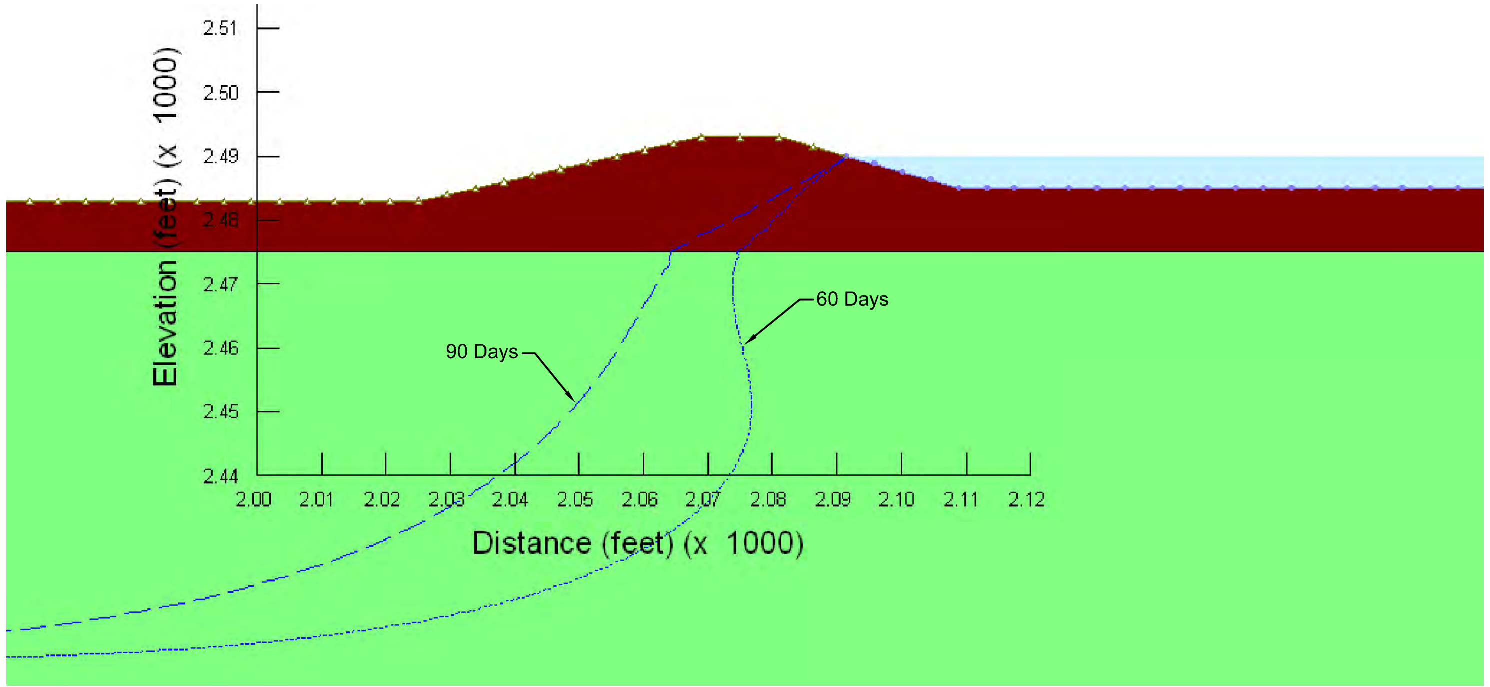
PLATE
C-1



TRANSIENT SEEPAGE
STATION 9+00 - CASE 2



STEADY-STATE SEEPAGE
STATION 9+00 - CASE 2



TIME TO STEADY STATE SEEPAGE
STATION 9+00 - CASE 2

LEGEND:

▼ - SEEP\W PHREATIC SURFACE

– – – – - SEEP\W WETTING FRONT

Hydraulic Properties			
Material Type	Color	K_v (ft/day)*	K_h/K_v*
CLAYEY GRAVEL	🟥	0.16	4
CLAY	🟩	0.037	10

$^*K_v$ = Vertical Hydraulic Conductivity
$^*K_h$ = Horizontal Hydraulic Conductivity

KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

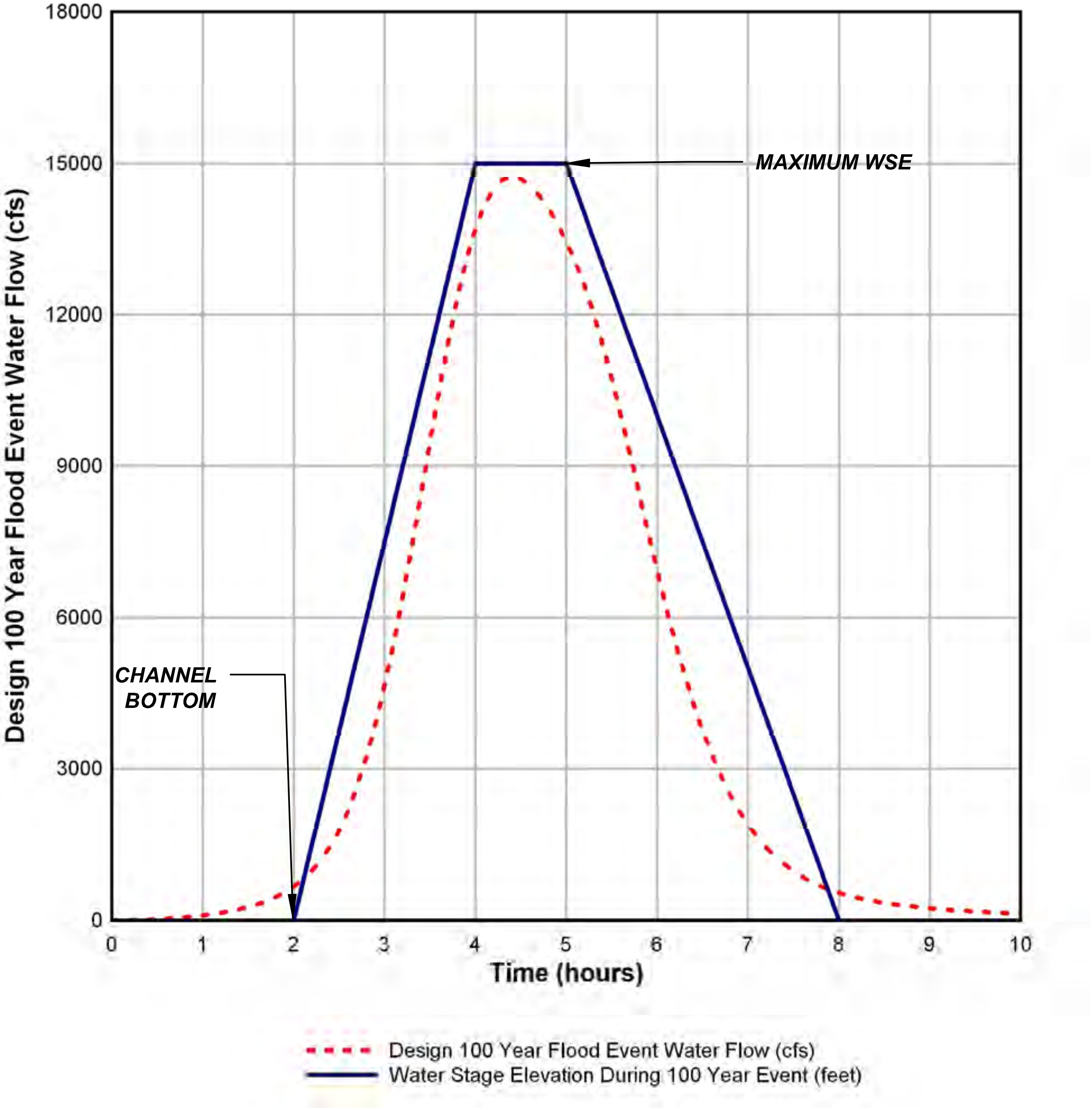
PROJECT NO. 101764.2
DRAWN: 03/29/2010
DRAWN BY: DFR
CHECKED BY: JLS

6380 SOUTH POLARIS AVE.
LAS VEGAS, NV 89118
(P) 702-736-2936 (F) 702-361-9094

Seepage Analyses
Station 9+00 - Case 2

CCRFCD
Clark County Levee Certification Project
Moccasin Diversion
Las Vegas, Nevada

PLATE
C-2



KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

PROJECT NO. 101764.2
DRAWN: 05/13/2010
DRAWN BY: DFR
CHECKED BY: JLS

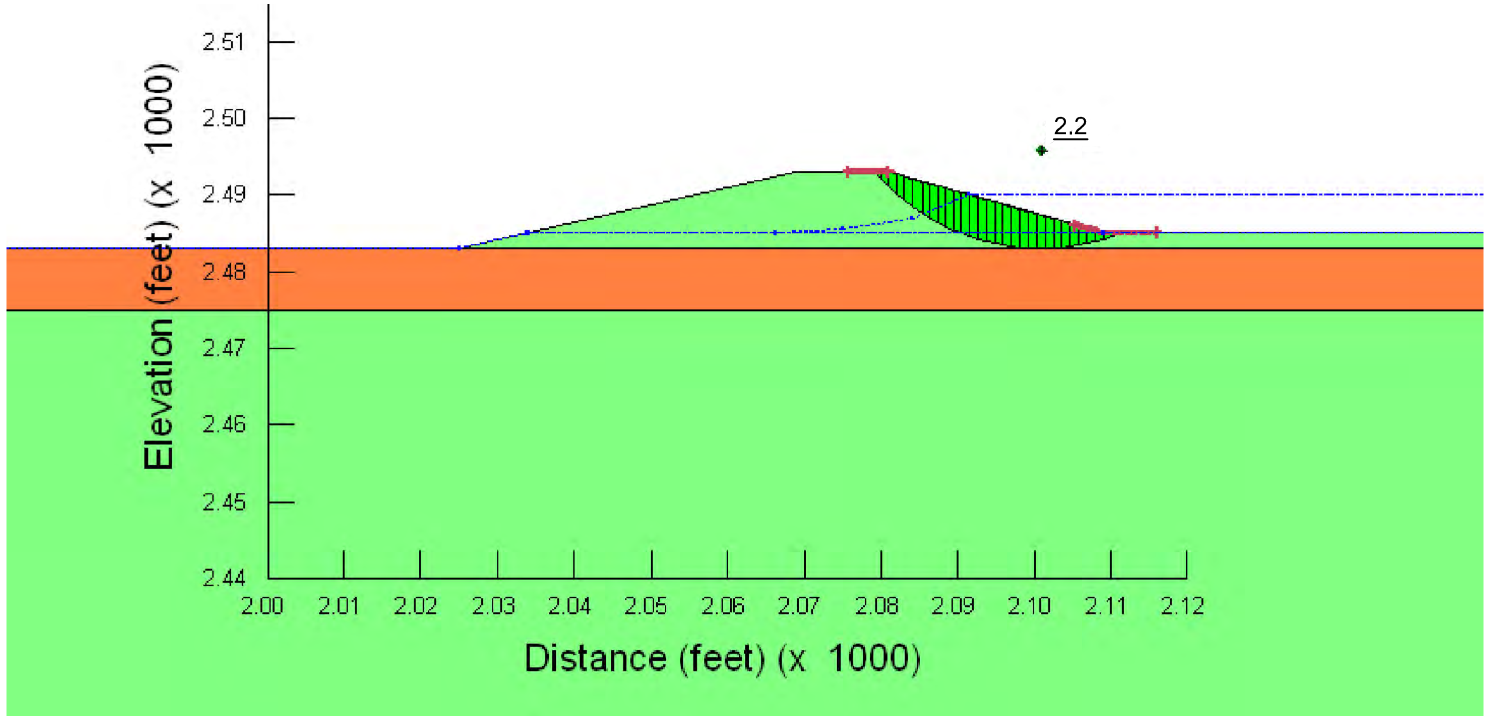
6380 South Polaris Avenue
Las Vegas, Nevada 89118
(P) 702-736-2936 (F) 702-361-9094

PBS&J Hydrograph with Simplified Water Stage vs Time

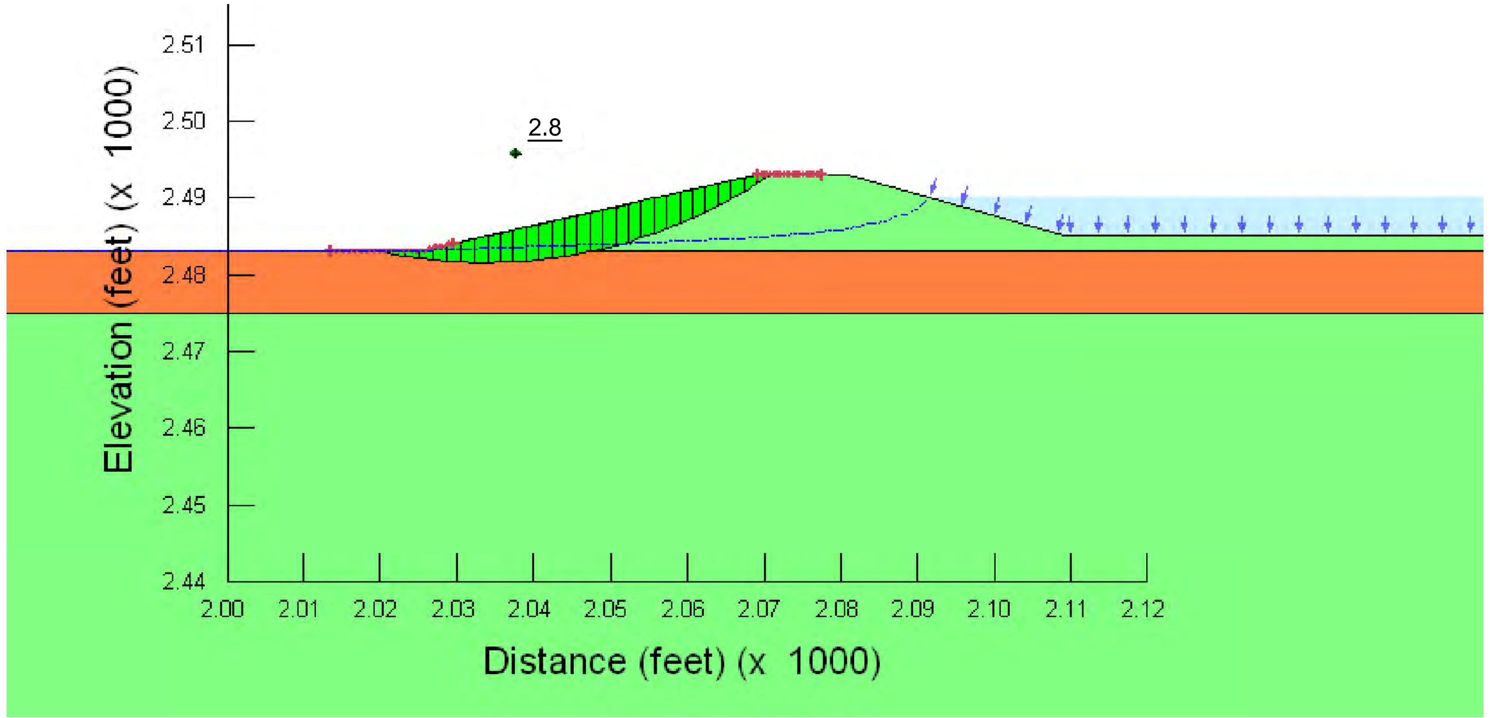
CCRFCD
Clark County Levee Certification Project
Moccasin Diversion
Las Vegas, Nevada

PLATE
C-3

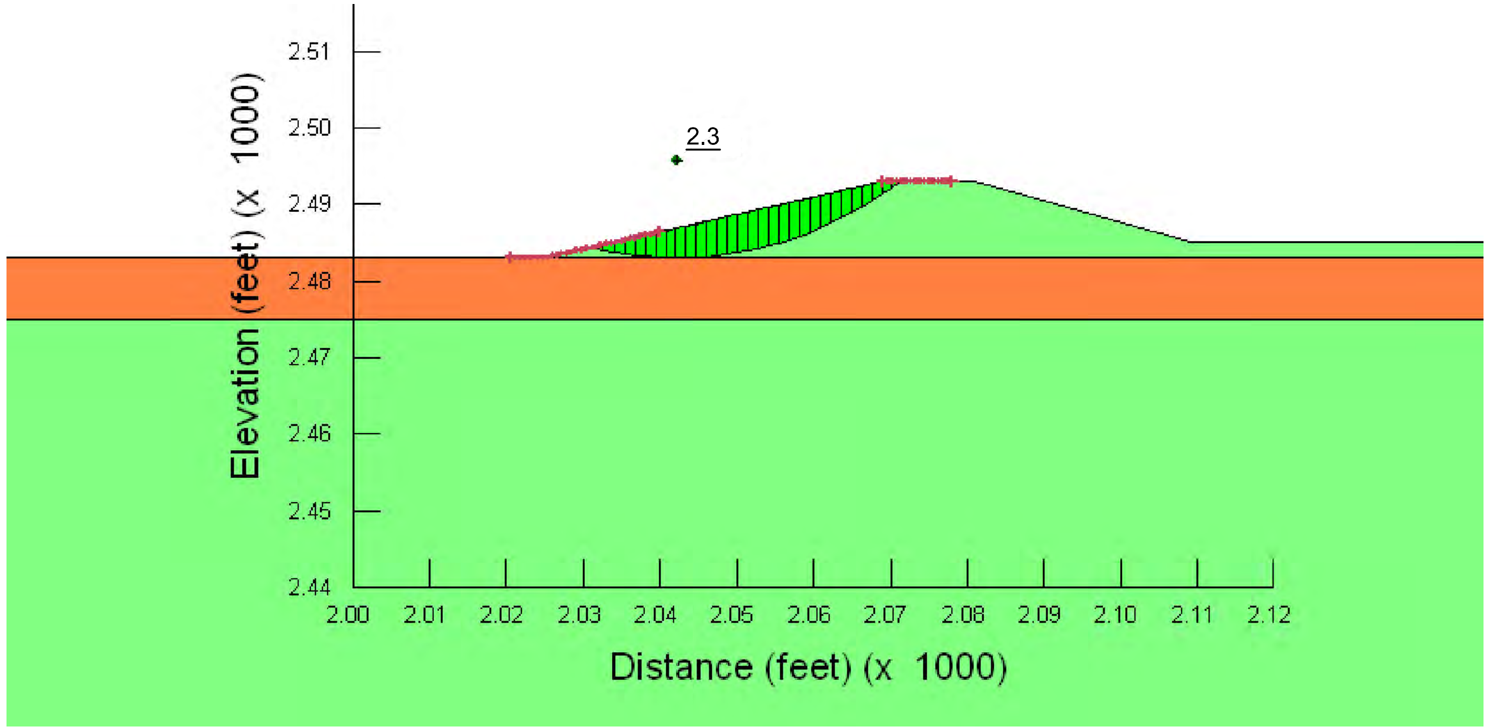
APPENDIX D



SUDDEN DRAW-DOWN SLOPE STABILITY
STATION 9+00 - CASE 1



STEADY STATE SLOPE STABILITY
STATION 9+00 - CASE 1



SEISMIC SLOPE STABILITY
STATION 9+00 - CASE 1

LEGEND:

● 2.2 - ESTIMATED FACTOR OF SAFETY

◡ - FAILURE SURFACE

-------- - MODELED PHREATIC SURFACE(S)

+——+ - ENTRY/EXIT SLIP SURFACE BOUNDARY CONDITION

Strength Properties

Material Type	Color	Unit Weight (pcf)	Effective Stress		Total Stress	
			Friction Angle (deg.)	Apparent Cohesion (psf)	Friction Angle (deg.)	Apparent Cohesion (psf)
CLAY	🟩	124	25	50	20	150
GRAVEL (5% FINES)	🟧	130	36	0	36	0

KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

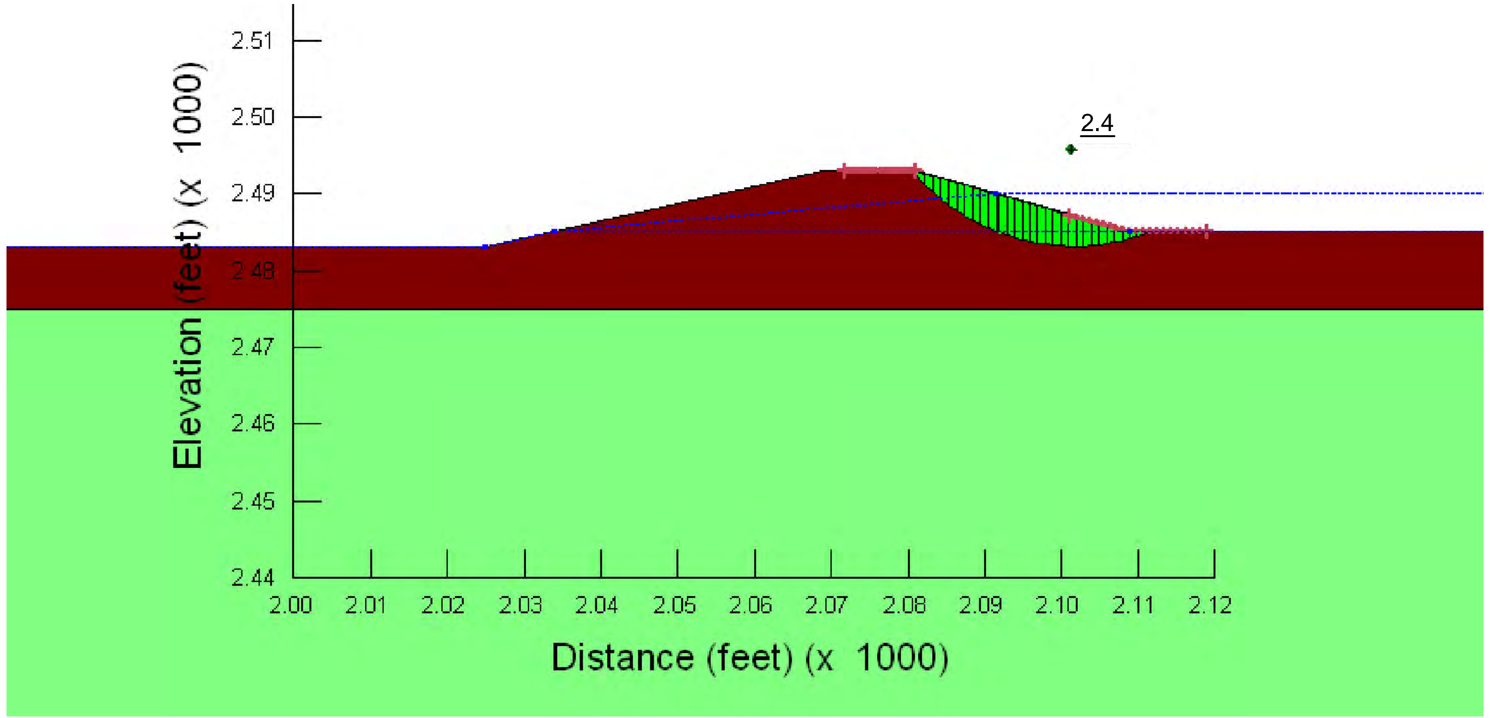
PROJECT NO. 101764.2
DRAWN: 03/29/2010
DRAWN BY: DFR
CHECKED BY: JLS

6380 SOUTH POLARIS AVE.
LAS VEGAS, NV 89118
(P) 702-736-2936 (F) 702-361-9094

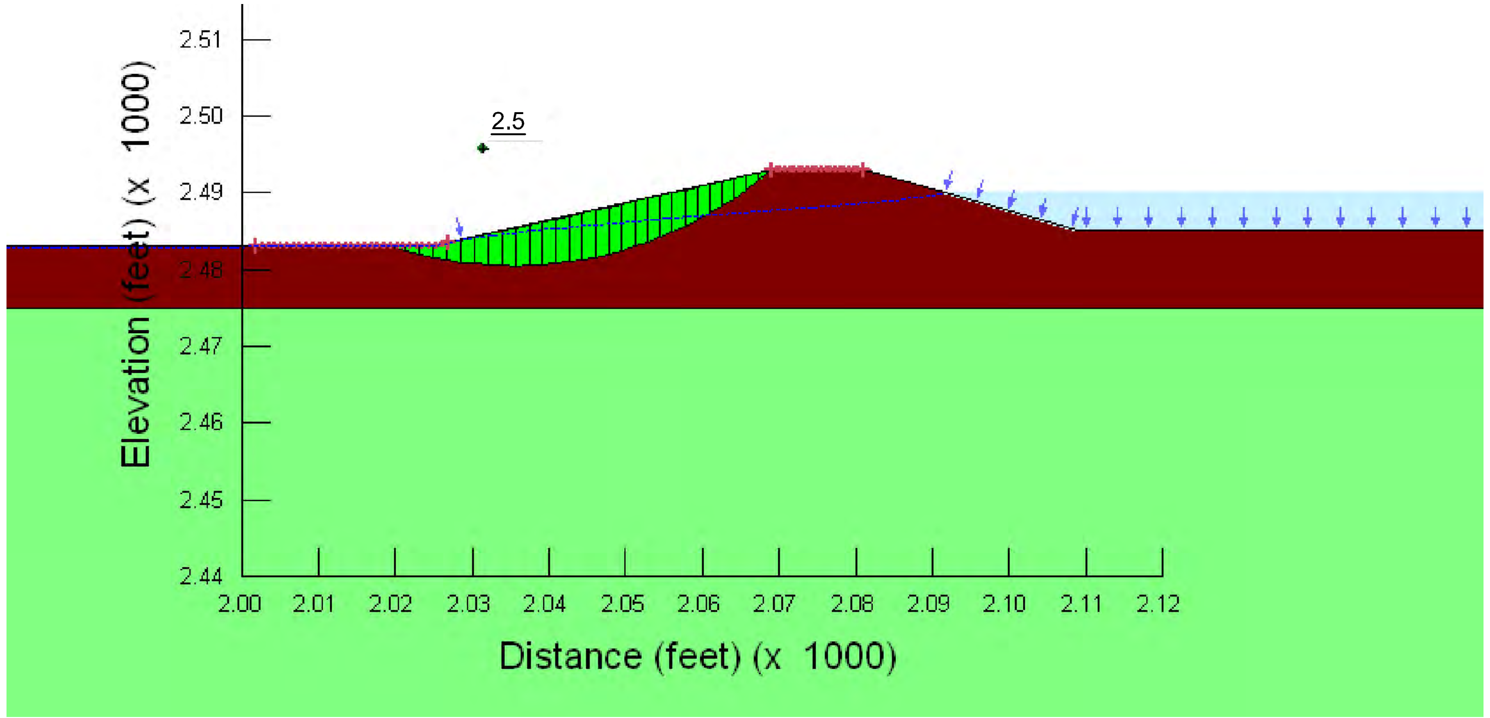
Slope Stability Analyses
Station 9+00 - Case 1

CCRFCD
Clark County Levee Certification Project
Moccasin Diversion
Las Vegas, Nevada

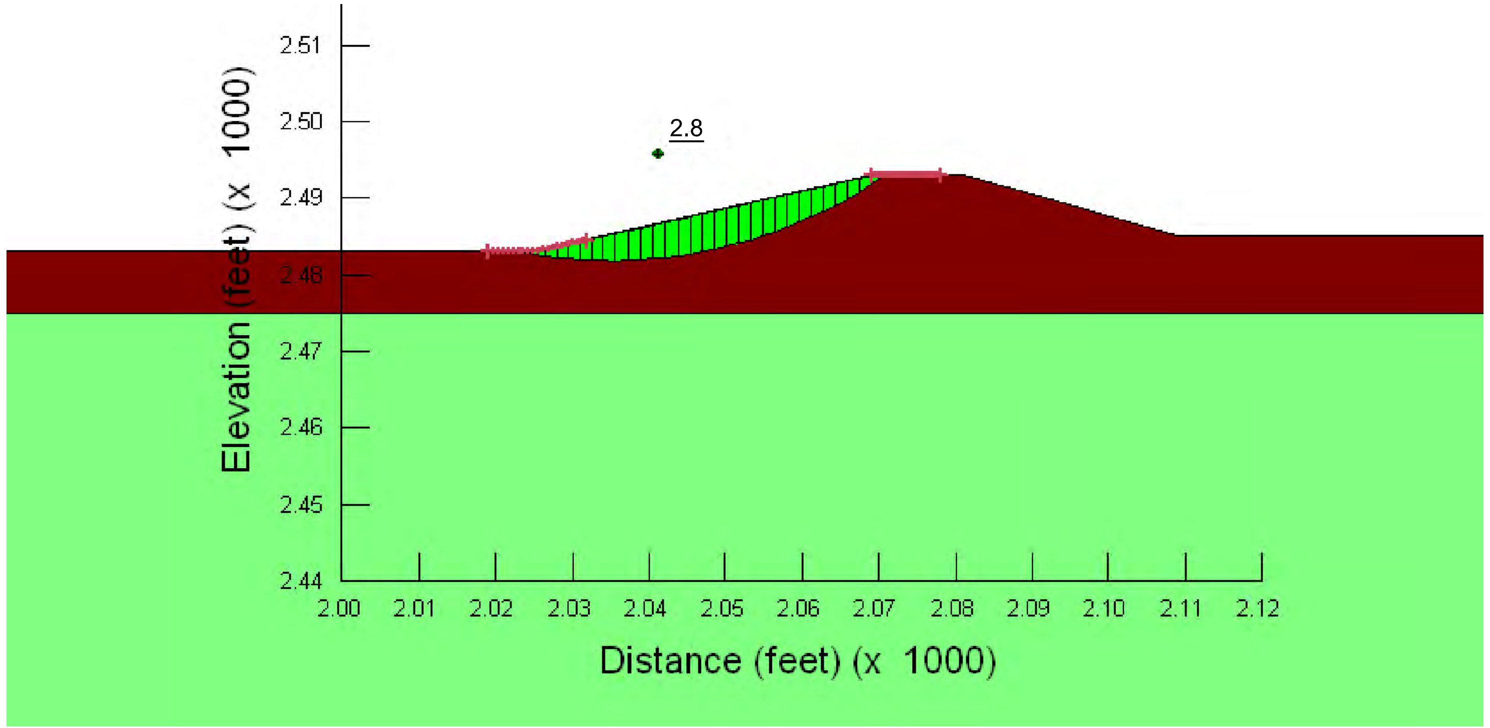
PLATE
D-1



SUDDEN DRAW-DOWN SLOPE STABILITY
STATION 9+00 - CASE 2



STEADY STATE SLOPE STABILITY
STATION 9+00 - CASE 2



SEISMIC SLOPE STABILITY
STATION 9+00 - CASE 2

LEGEND:

● 2.4 - ESTIMATED FACTOR OF SAFETY

◓ - FAILURE SURFACE

-------- - MODELED PHREATIC SURFACE(S)

+——+ - ENTRY/EXIT SLIP SURFACE BOUNDARY CONDITION

Strength Properties

Material Type	Color	Unit Weight (pcf)	Effective Stress		Total Stress	
			Friction Angle (deg.)	Apparent Cohesion (psf)	Friction Angle (deg.)	Apparent Cohesion (psf)
CLAYEY GRAVEL	🟫	134	36	0	36	0
CLAY	🟩	124	25	50	20	150

KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

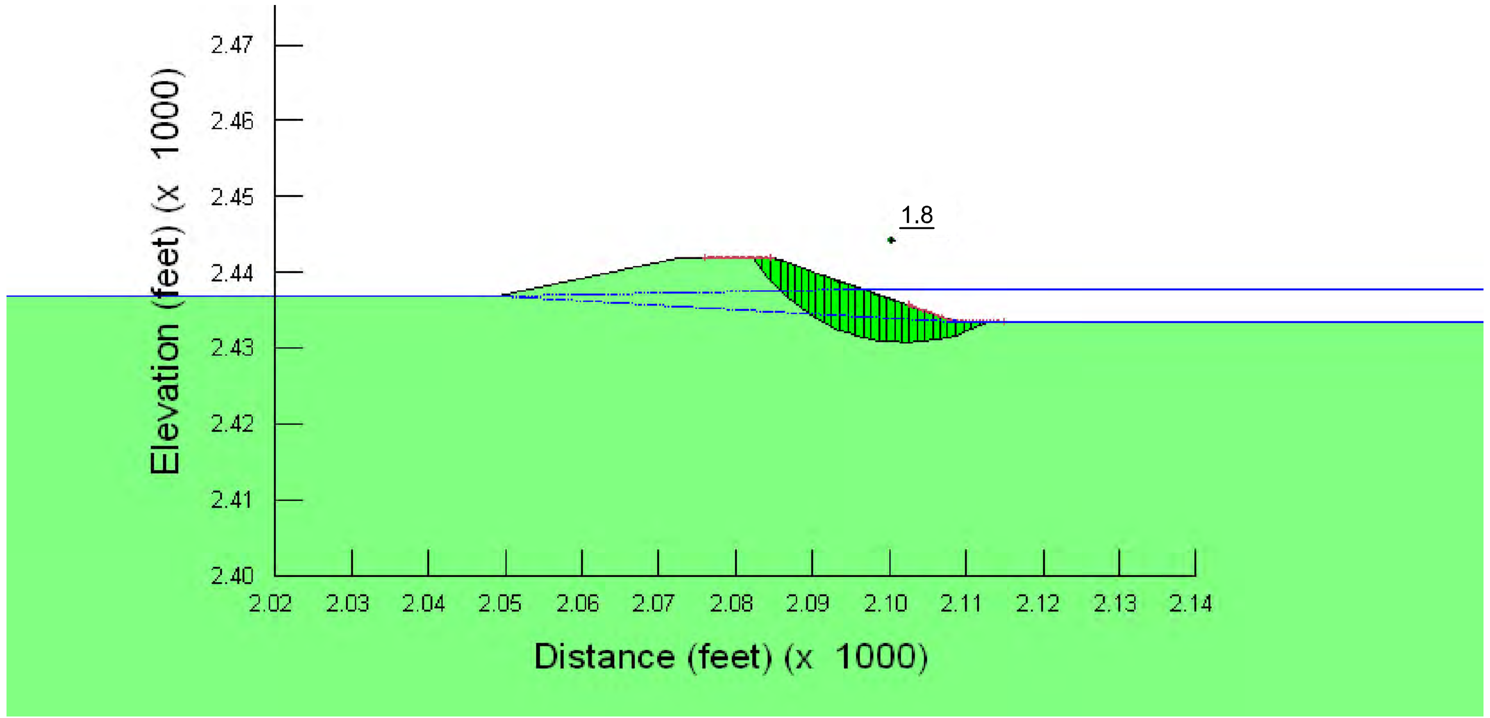
PROJECT NO. 101764.2
DRAWN: 03/29/2010
DRAWN BY: DFR
CHECKED BY: JLS

6380 SOUTH POLARIS AVE.
LAS VEGAS, NV 89118
(P) 702-736-2936 (F) 702-361-9094

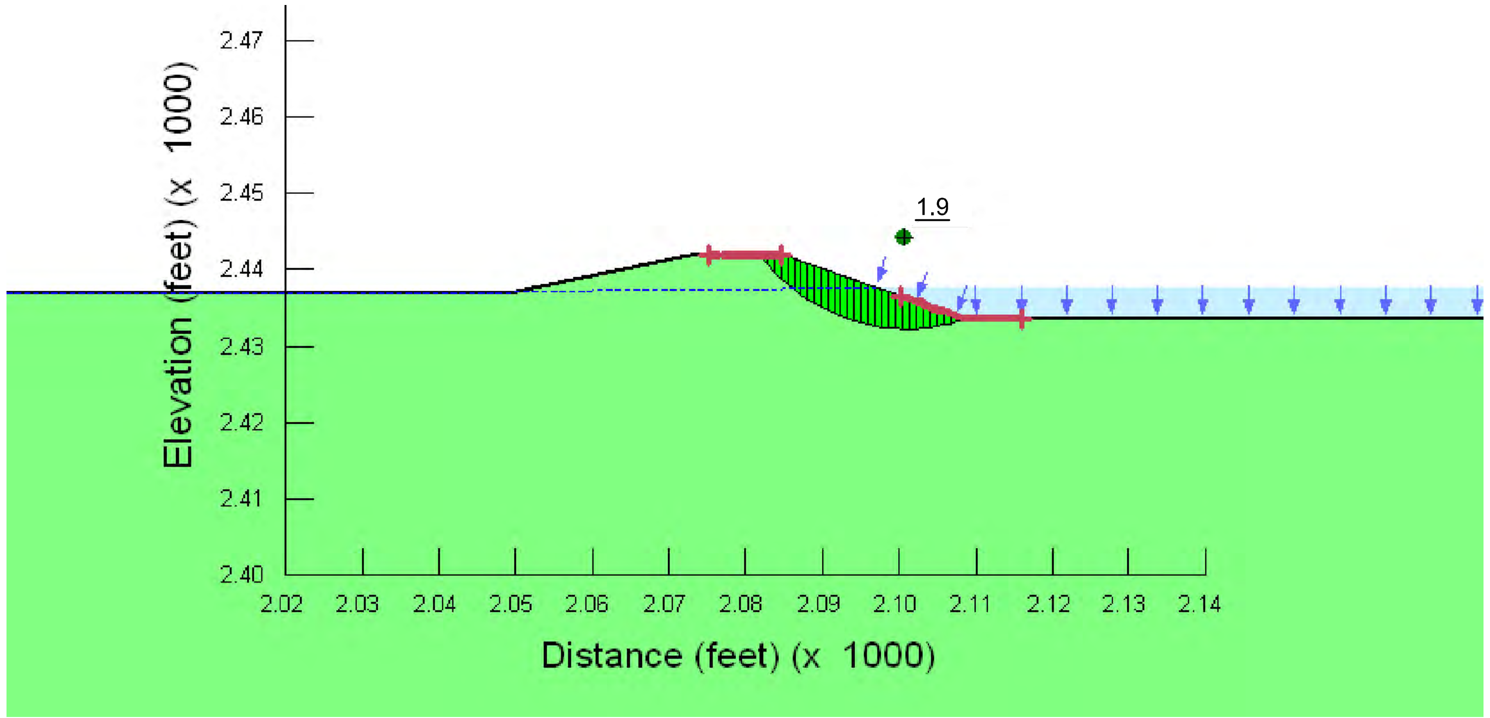
Slope Stability Analyses
Station 9+00 - Case 2

CCRFCD
Clark County Levee Certification Project
Moccasin Diversion
Las Vegas, Nevada

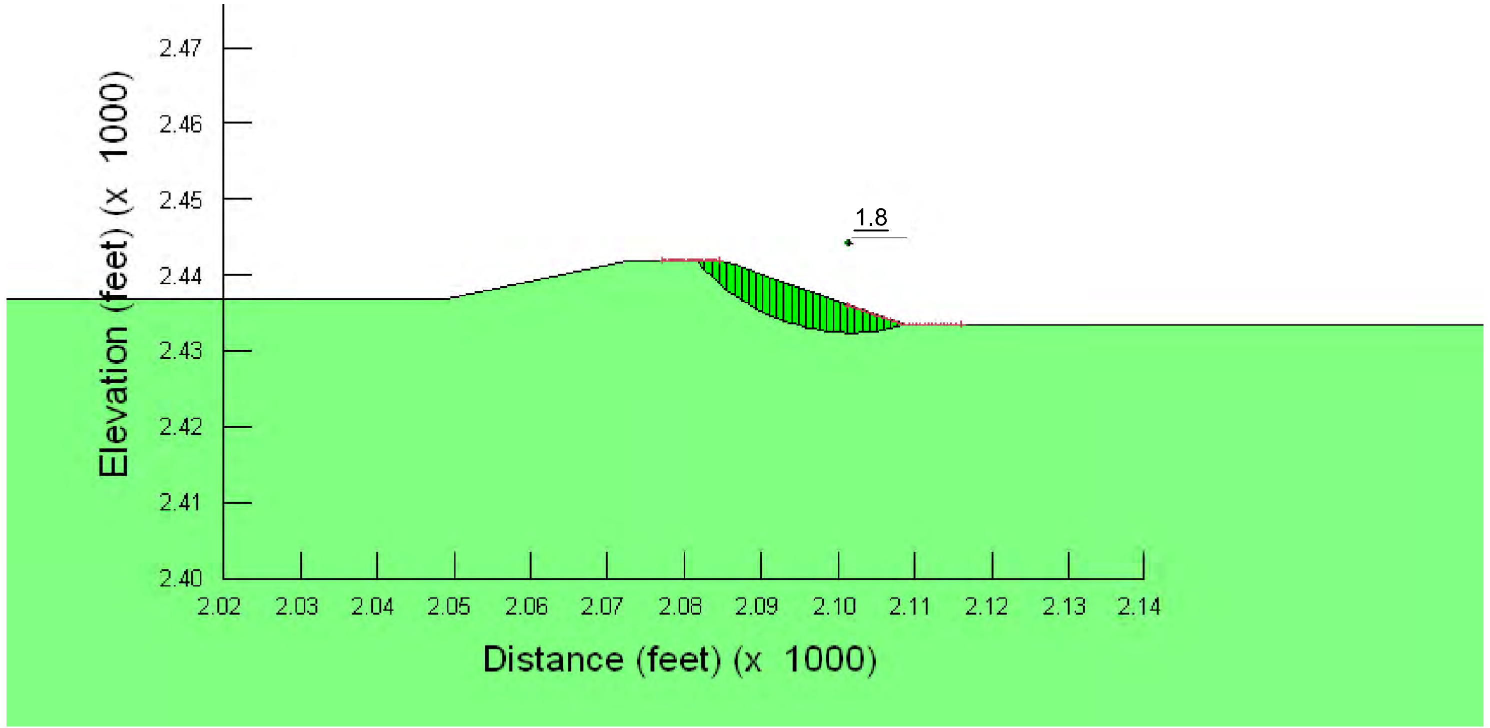
PLATE
D-2



SUDDEN DRAW-DOWN SLOPE STABILITY
STATION 84+10



STEADY STATE SLOPE STABILITY
STATION 84+10



SEISMIC SLOPE STABILITY
STATION 84+10

LEGEND:

● 1.8 - ESTIMATED FACTOR OF SAFETY

◡ - FAILURE SURFACE

- - - - - MODELED PHREATIC SURFACE(S)

+——+ - ENTRY/EXIT SLIP SURFACE BOUNDARY CONDITION

Strength Properties

Material Type	Color	Unit Weight (pcf)	Effective Stress		Total Stress	
			Friction Angle (deg.)	Apparent Cohesion (psf)	Friction Angle (deg.)	Apparent Cohesion (psf)
CLAY	🟩	124	25	50	20	150

KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

PROJECT NO. 101764.2
DRAWN: 03/29/2010
DRAWN BY: DFR
CHECKED BY: JLS

6380 SOUTH POLARIS AVE.
LAS VEGAS, NV 89118
(P) 702-736-2936 (F) 702-361-9094

Slope Stability Analyses
Station 84+10

CCRFCD
Clark County Levee Certification Project
Moccasin Diversion
Las Vegas, Nevada

PLATE
D-3

APPENDIX II

As-Built Plans

NLV.05.B.92

RECEIVED
NOV 23 1993
REGIONAL
FLOOD CONTROL DISTRICT

UPPE… AS VEGAS WASH
DETE… ON BASIN RECORD
DRAWINGS

03/23/91 22:15:51 VPL
03/23/91 21:23:57 ATSSK

CB000023

CITY OF NORTH LAS VEGAS

UPPER LAS VEGAS WASH DETENTION BASIN AND INTERCEPTION BERM/CHANNEL

BID NO. 817

FUNDED BY:
THE CLARK COUNTY REGIONAL FLOOD CONTROL DISTRICT

PLANS REVIEWED BY:

5-24-91
CITY OF LAS VEGAS DATE

4-23-91
SOUTHWEST GAS DATE

5/1/91
NEVADA POWER DATE

4-25-91
CENTEL DATE

J. Stephen Weaver 4/25/91
NEVADA DIVISION OF STATE PARKS DATE

5-21-91
CITY OF NORTH LAS VEGAS SUPT. OF QUALITY CONTROL DATE

Black & Veatch
Las Vegas, Nevada

PROJECT NO.17149
1991

APPROVALS:

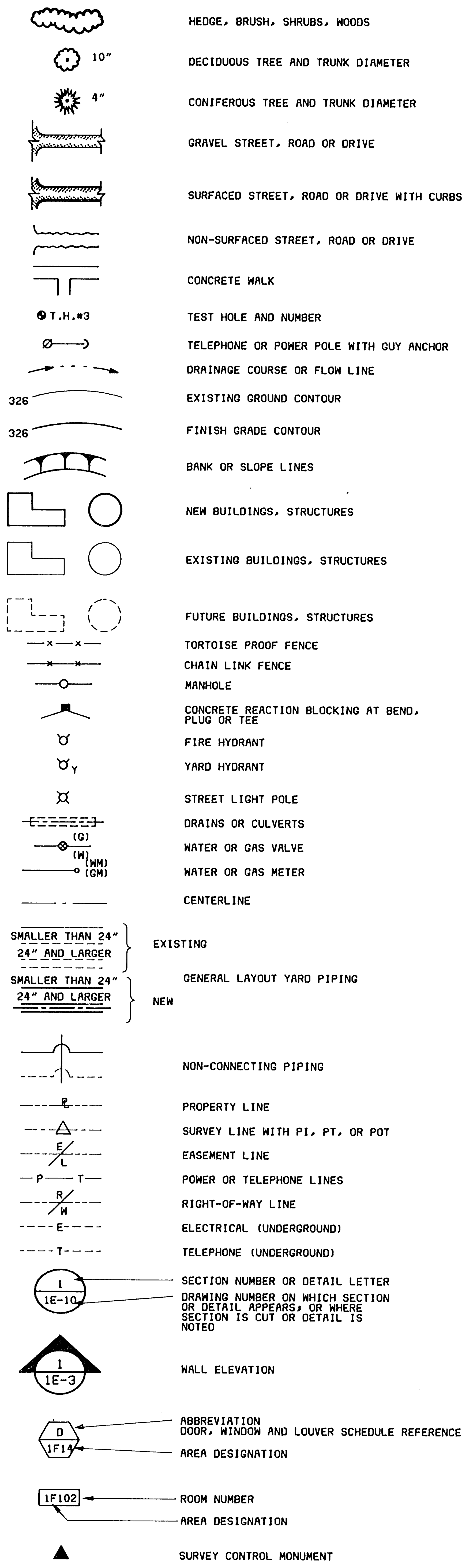
5.21.91
GARY W. HOLLER, R.P.E. #1920 DATE
DIRECTOR OF PUBLIC WORKS
CITY OF NORTH LAS VEGAS, NEVADA

1/22/92
VIRGINIA E. BAX VALENTINE, P.E. DATE
CLARK COUNTY REGIONAL
FLOOD CONTROL DISTRICT
GENERAL MANAGER/CHIEF ENGINEER

5/21/91
JAMES A. BELL, R.P.E. #4524 DATE
CITY ENGINEER
CITY OF NORTH LAS VEGAS, NEVADA

CCG. DWG. NO: 17149-350-208-C001

GENERAL SYMBOLS

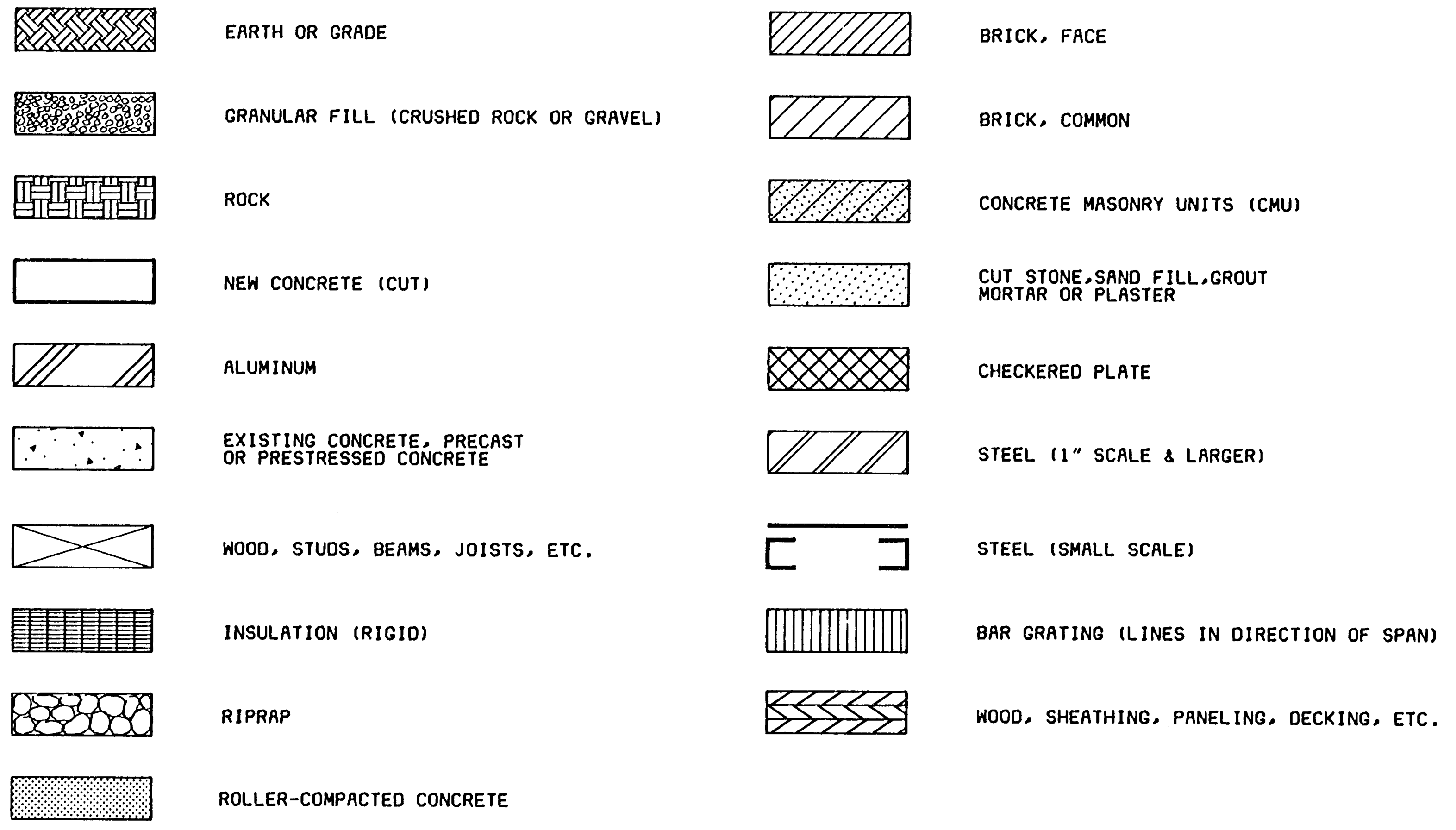


ABBREVIATIONS

AC	ACRE
AC FT	ACRE FEET
ALUM	ALUMINUM
APPROX	APPROXIMATE
B	BORING
BC	BEGINNING OF CURVE
BO	BOTTOM OF
C	CENTERLINE
CFS	CUBIC FEET PER SECOND
CJ	CONSTRUCTION JOINT
CM	CONCRETE SURVEY MONUMENT
CMP	CORRUGATED METAL PIPE
CONC	CONCRETE
CONST	CONSTRUCTION
CTR	CENTER
CU YD	CUBIC YARD
CLR	CLEARANCE
DET	DETAIL
DIA	DIAMETER
DIM	DIMENSION
E	EAST
EA	EACH
EF	EACH FACE
EL	ELEVATION
EW	EACH WAY
EXIST	EXISTING
EXP	EXPANSION
FG	FINISH GRADE
FL	FLOW LINE
GALV	GALVANIZED
GA	GAGE
H	HEIGHT
HORIZ	HORIZONTAL
HR	HANDRAIL
HT	HEIGHT
ID	INSIDE DIAMETER
INCL	INCLUDED
INV	INVERT
JT	JOINT
LS	LUMP SUM
LIN FT	LINEAR FOOT

MAX	MAXIMUM
MIN	MINIMUM
MISC	MISCELLANEOUS
N	NORTH
NO	NUMBER
NPC	NEVADA POWER COMPANY
NTS	NOT TO SCALE
O/S	OFF SET
PC	POINT OF CURVE
PI	POINT OF INTERSECTION
PL	PLATE
PLCS	PLACES
PMF	PROBABLE MAXIMUM FLOOD
PT	POINT OF TANGENT
PVC	POLYVINYL CHLORIDE
RCC	ROLLER COMPACTED CONCRETE
REINF	REINFORCING
REQ'D	REQUIRED
R/W	RIGHT OF WAY
S	SLOPE OR SOUTH
SEC	SECTION
SH	SHEET
SIM	SIMILAR
SPEC	SPECIFICATION
STA	STATION
STD	STANDARD
STR	STRUCTURAL
SQ	SQUARE
TO	TOP OF
T&B	TOP AND BOTTOM
TP	PIT OR TRENCH
TYP	TYPICAL
USGS	UNITED STATES GEOLOGICAL SURVEY
VERT	VERTICAL
W	WEST
W/	WITH
W/O	WITHOUT
YD	YARD
YR	YEAR
&	AND

MATERIALS



GENERAL NOTES

1. THE CONTRACTOR SHALL CONFINE CONSTRUCTION ACTIVITIES WITHIN THE PROJECT BOUNDARIES AS DEFINED BY THE LOCATION OF THE TORTOISE PROOF FENCE SHOWN ON SHT 3, EXCEPT ACCESS ROAD CONSTRUCTION.
2. PRIOR TO THE CONSTRUCTION OF THE USGS GAGE VAULT AND ALL AFFILIATED WORK, AS INDICATED ON SHTS 9, 18, & 23, THE CONTRACTOR SHALL CONTACT MR. DAVE BLACKSTUN OF THE USGS AT (702)-295-1770.
3. THE CONTOUR INTERVAL IS 2.0 FT, UNLESS OTHERWISE INDICATED.
4. STANDARD CONCRETE DETAILS ARE SHOWN ON SHEET 25.

SHEET LIST

SHEET NO.	TITLE
C	COVER SHEET
1	LEGEND, ABBREVIATIONS, GENERAL NOTES, SHEET LIST & APPROXIMATE QUANTITIES
2	MAPS, PERTINENT DATA & HYDROGRAPHS
3	SITE PLANS, SURVEY DATA & BORING LOCATIONS
4	INTERCEPTION BERM/CHANNEL PLAN & PROFILE STA 0+00 TO STA 32+00
5	INTERCEPTION BERM/CHANNEL PLAN & PROFILE STA 32+00 TO STA 64+00
6	INTERCEPTION BERM/CHANNEL PLAN & PROFILE STA 64+00 TO STA 91+41.43
7	INTERCEPTION BERM/CHANNEL SECTIONS & DETAILS
8	DAM EMBANKMENT GRADING PLAN NO. 1 STA 0+00 TO STA 18+50
9	DAM EMBANKMENT GRADING PLAN NO. 2 STA 18+50 TO STA 37+00
10	DAM EMBANKMENT GRADING PLAN NO. 3 STA 37+00 TO STA 65+93.92
11	DAM EMBANKMENT CENTERLINE PROFILE STA 0+00 TO STA 20+00 & STA 45+00 TO STA 65+93.92
12	DAM EMBANKMENT CENTERLINE PROFILE STA 20+00 TO STA 45+00
13	DAM EMBANKMENT TYPICAL CROSS SECTION & DETAILS
14	DAM EMBANKMENT CROSS SECTIONS STA 3+00 TO STA 19+00
15	DAM EMBANKMENT CROSS SECTIONS STA 22+00 TO STA 26+00
16	DAM EMBANKMENT CROSS SECTIONS STA 27+10 TO STA 33+00.65
17	DAM EMBANKMENT CROSS SECTIONS STA 33+50 TO STA 62+00
18	SPILLWAY PLAN
19	SPILLWAY SECTIONS
20	SPILLWAY SECTIONS & DETAILS
21	OUTLET WORKS SECTIONS & DETAILS
22	TRASH RACK PLAN SECTIONS & DETAILS
23	MISCELLANEOUS SECTIONS & DETAILS
24	MISCELLANEOUS SECTIONS & DETAILS
25	STANDARD CONCRETE SHEET

	SUMMARY OF APPROXIMATE QUANTITIES		
ITEM NO.	DESCRIPTION	QUANTITY	UNIT
1.	MOBILIZATION	1	LS
2.	SURVEYING	1	LS
3.	ACCESS ROADS	18,400	LIN FT
4.1	TEMPORARY TORTOISE PROOF FENCING	53,850	LIN FT
4.2	HANDRAIL AND CHAIN LINK FENCING WITH GATES	1,024	LIN FT
4.3	STEEL GATES	3	EACH
5.	STRIPPING	150	ACRES
6.	REMOVAL AND DISPOSAL OF EXISTING STRUCTURES AND DEBRIS	1	LS
EMBANKMENT QUANTITIES			
7.1	EMBANKMENT OVEREXCAVATION	274,000	CU YD
7.2	CUTOFF TRENCH FILL	54,000	CU YD
7.3	RANDOM ZONE FILL	470,000	CU YD
7.4	CORE ZONE FILL	83,000	CU YD
7.5	DRAINAGE BLANKET	26,150	CU YD
8.1	GENERAL EXCAVATION	310,000	CU YD
8.2	GENERAL FILL	90,000	CU YD
9.	12" CLASS "A" RIP RAP	82,400	SQ YD
SPILLWAY & OUTLET QUANTITIES			
10.1	INCLINED GRAVEL DRAIN	11,000	CU YD
10.2	GRADED GRAVEL BLANKET	3,500	CU YD
10.3	RCC FOR SPILLWAY	44,500	CU YD
10.4	TYPE II COLD JOINT PREPARATION	10,000	SQ FT
10.5	SHEET PILE CUTOFF	1	LS
10.6	TRASH RACK & OUTLET WORKS	1	LS
INTERCEPTION BERM/CHANNEL QUANTITIES			
11.	INTERCEPTION CHANNEL EXCAVATION	472,000	CU YD
12.	INTERCEPTION BERM GENERAL FILL	75,000	CU YD
13.	INTERCEPTION BERM RCC SLOPE PROTECTION	17,700	CU YD
14.	INTERCEPTION CHANNEL 18" CLASS "B" RIP RAP	39,000	SQ YD
15.	PORTLAND CEMENT FOR RCC	8,750	TON
16.	CONSTRUCTION CONFLICTS	1	LS

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10-26-93	AS BUILT		PT	SC	dck

DESIGNED PJR, SDC
DETAILED HLR
CHECKED DIH
APPROVED
DATE 5-28-91

Black & Veatch
Engineers-Architects
Las Vegas, Nevada

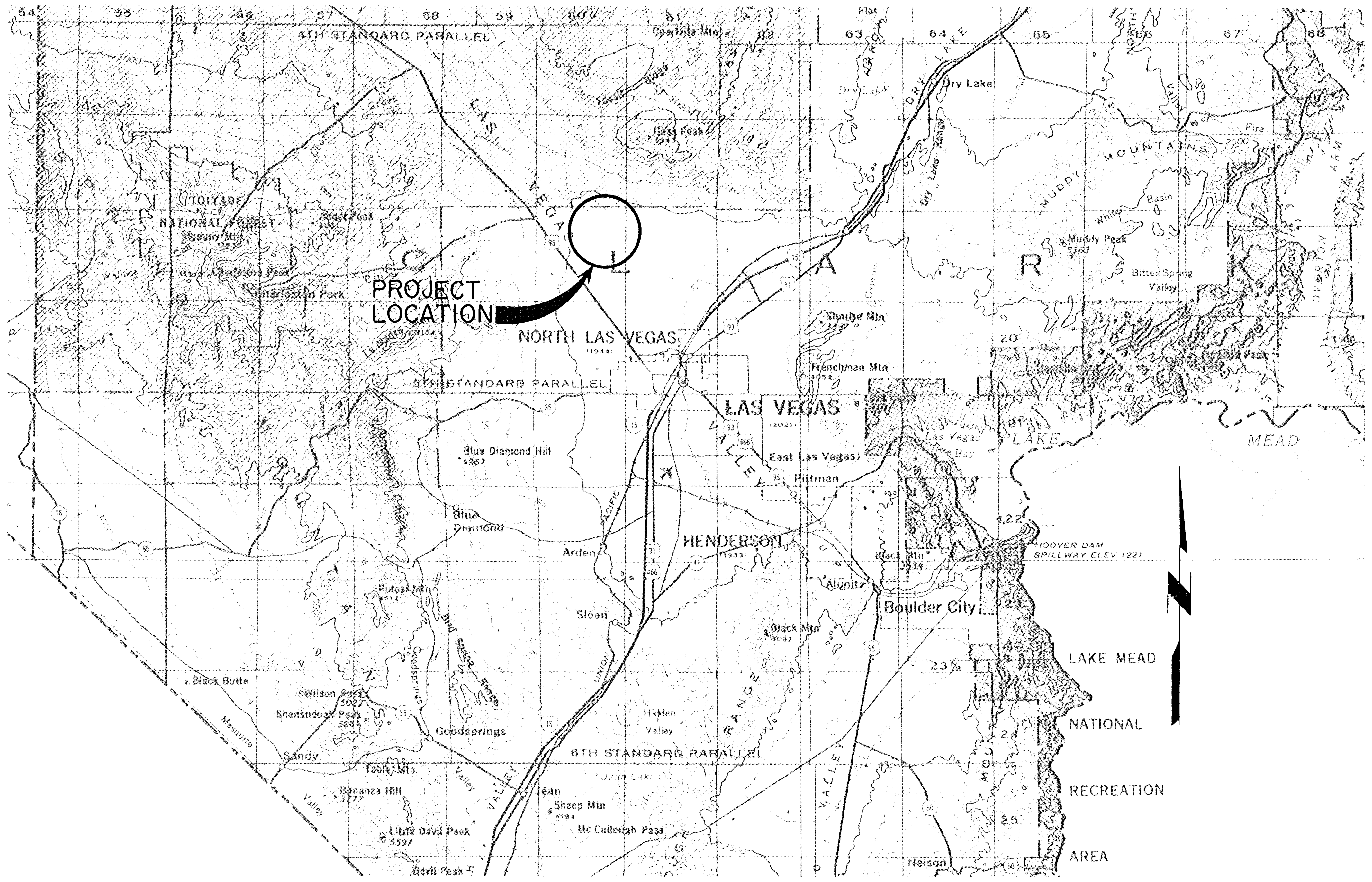
PROJECT NO.
17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH
DETENTION BASIN

LEGEND, ABBREVIATIONS, GENERAL NOTES, SHEET LIST & APPROXIMATE QUANTITIES

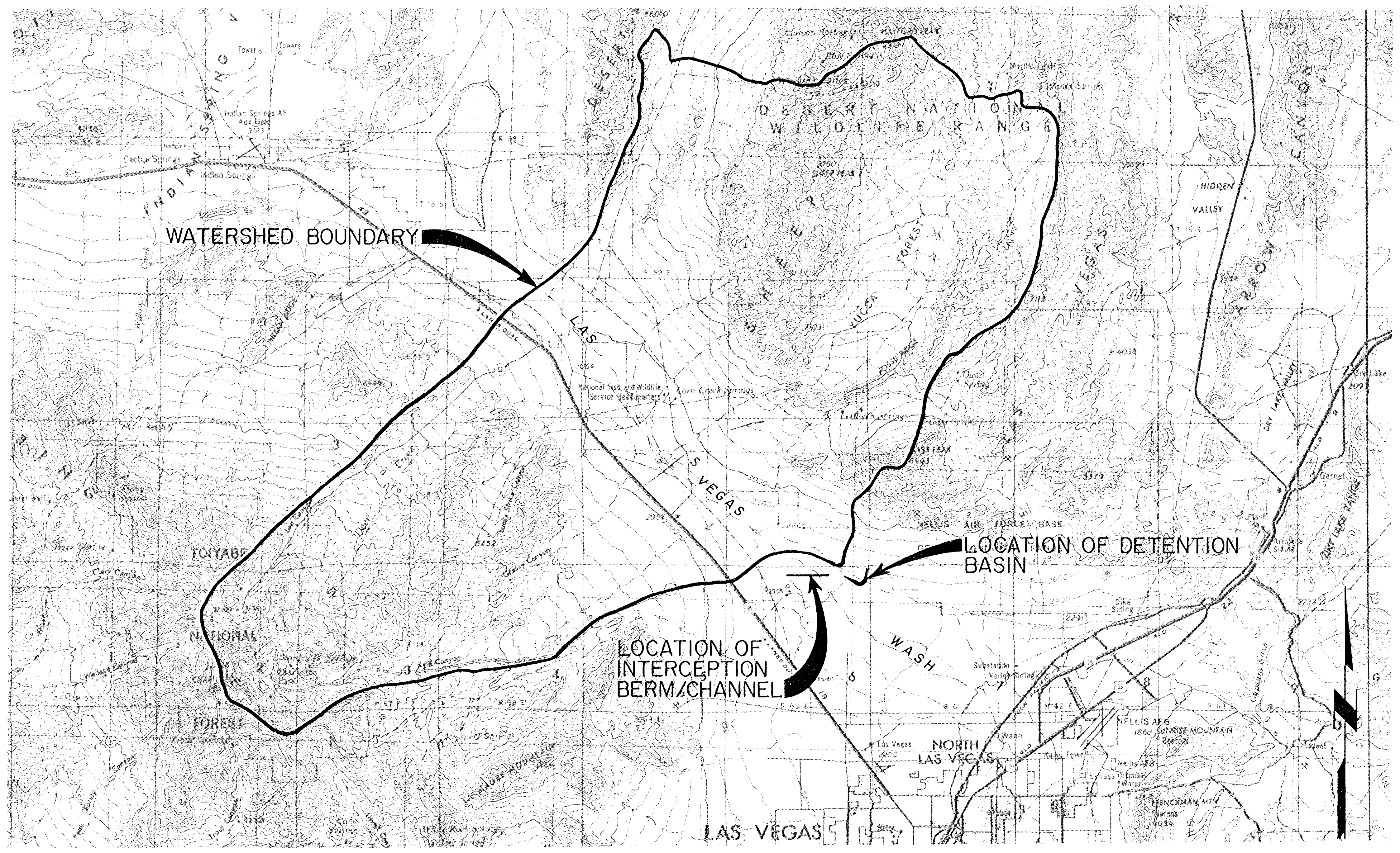
DANA Y. REEL
CIVIL
No. 7130
1-10-92

SHEET
1 OF 25



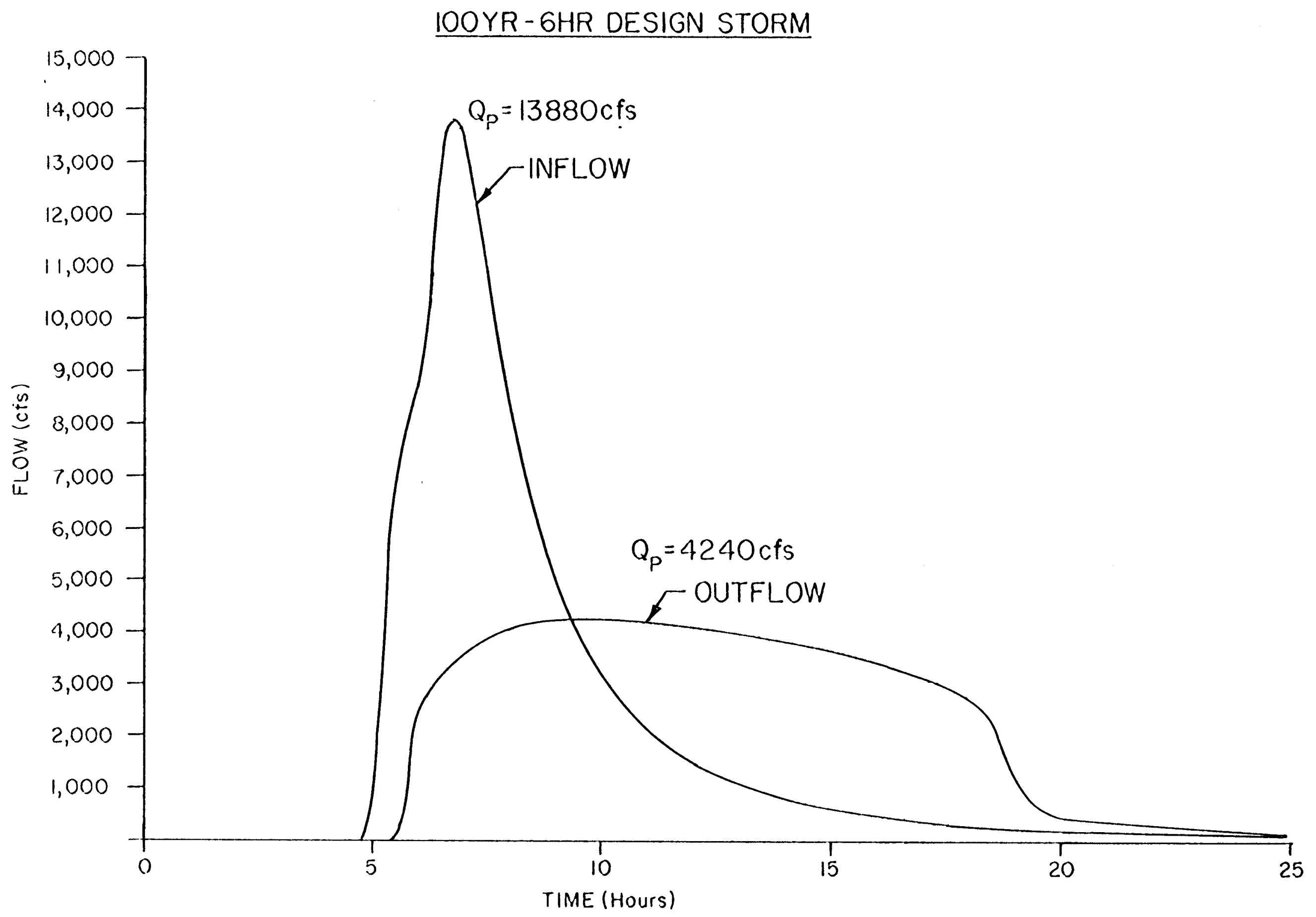
VICINITY MAP

4 0 12 MILES
6 2 6

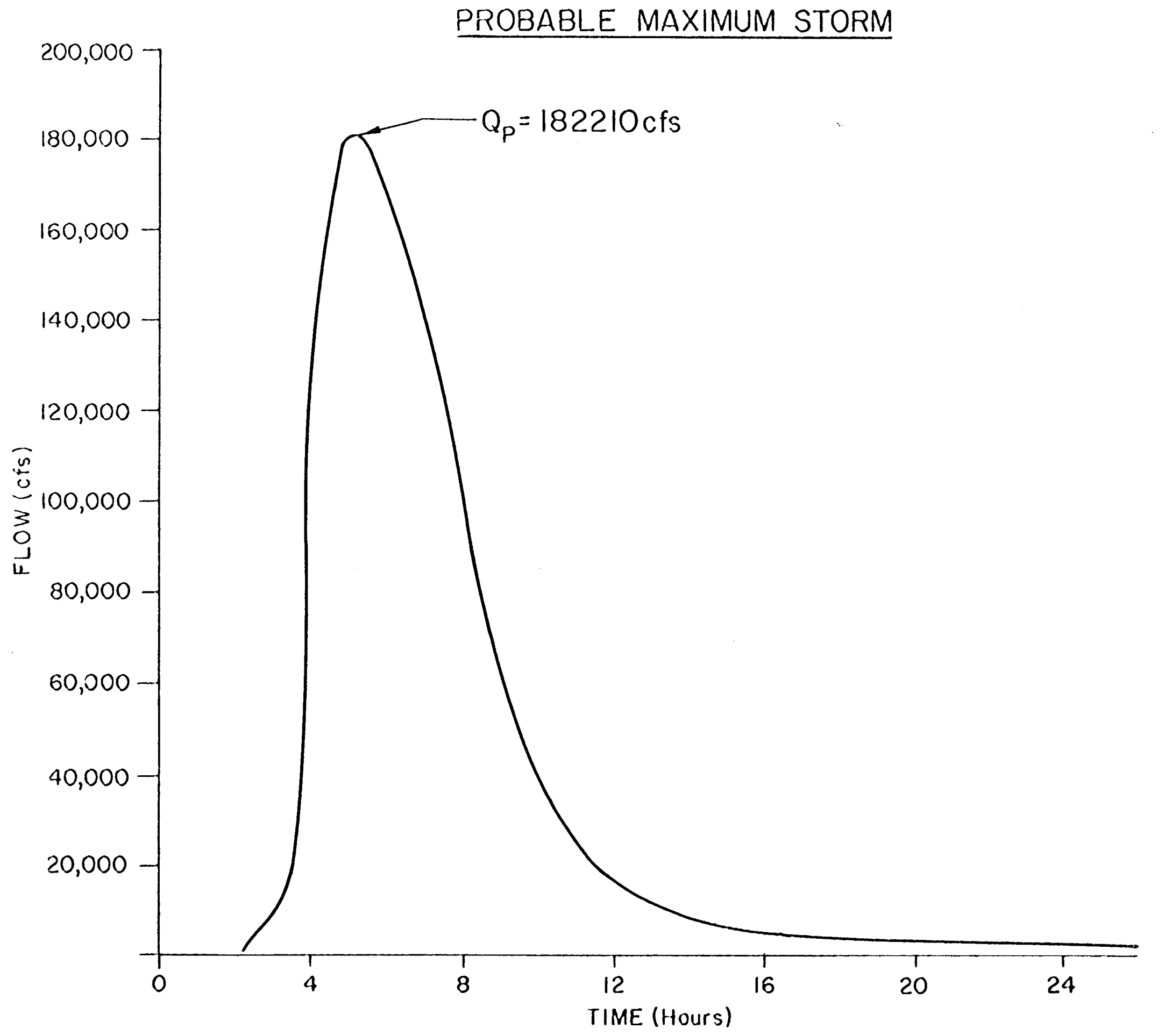


WATERSHED BOUNDARY MAP

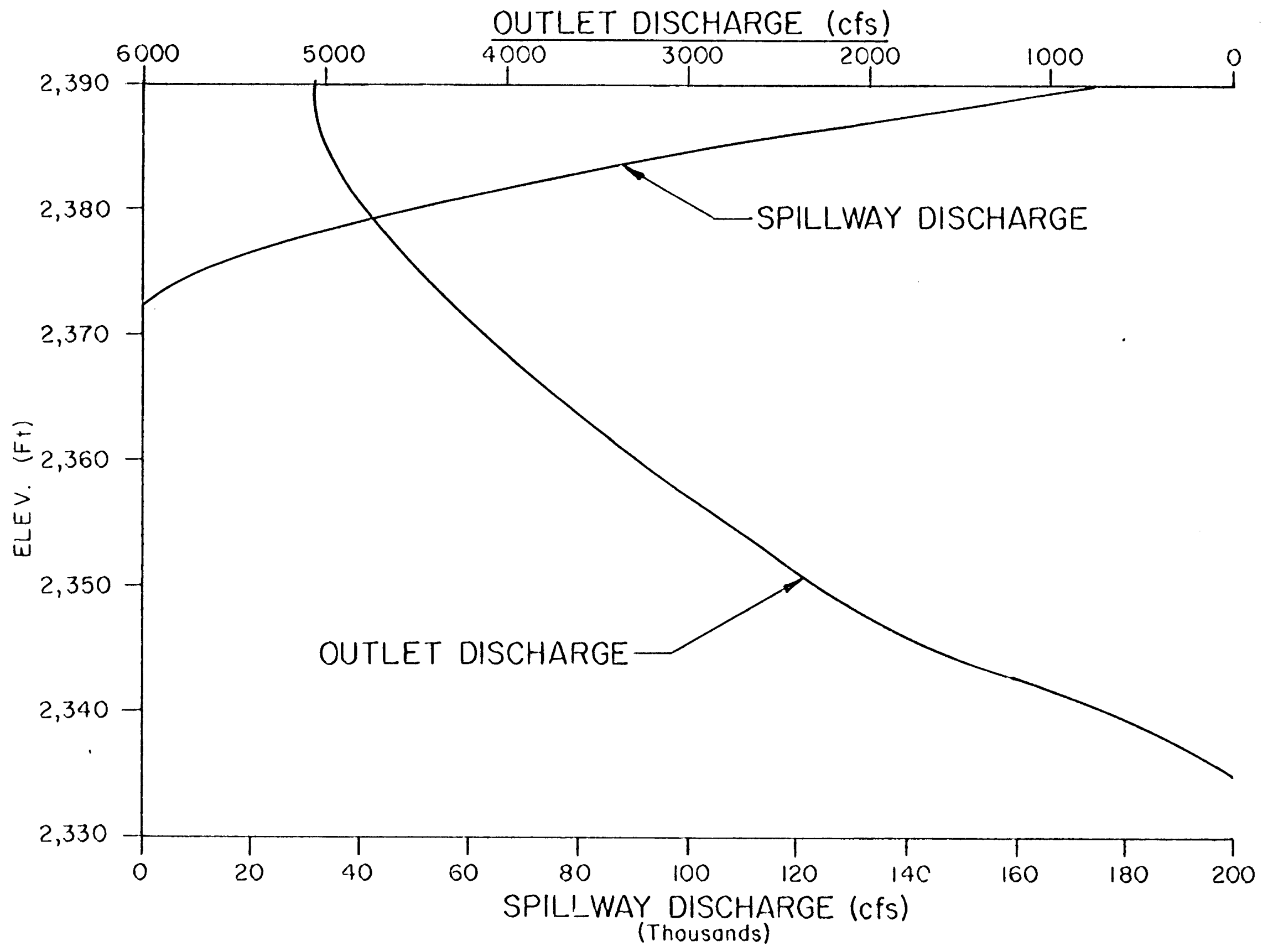
2 8 MILES
0 4



DETENTION BASIN INFLOW & OUTFLOW HYDROGRAPHS



EMERGENCY SPILLWAY DESIGN HYDROGRAPH



STAGE-DISCHARGE CURVES

PERTINENT DATA

LOCATION: TOWNSHIP 19 SOUTH, RANGE 60 EAST
CLARK COUNTY, NEVADA

DESIGN STORMS:

INFLOW DESIGN FLOOD - 100 YR-6 HR THUNDERSTORM
- STORM AREA - 144 sq mi
- PEAK INFLOW - 13,880 cfs
- TOTAL RAINFALL - VARIES 2.53 - 4.23 in
- VOLUME OF INFLOW HYDROGRAPH - 4,080 ac ft

SPILLWAY DESIGN FLOOD - PROBABLE MAXIMUM STORM
- STORM AREA - 516 sq mi
- PEAK INFLOW - 182,210 cfs
- TOTAL RAINFALL - 4.9 in
- VOLUME OF INFLOW HYDROGRAPH - 75,000 ac ft

DETENTION BASIN EMBANKMENT:
- TYPE: ZONED EARTHFILL WITH HORIZONTAL DRAINAGE BLANKET
- LENGTH: 6,593 ft
- MAXIMUM HEIGHT ABOVE GRADE: 49 ft
- TOP ELEVATION: 2,390 ft
- FREEBOARD:
  - FOR 100-YR - 6 HR STORM - 18.5 ft
  - FOR PROBABLE MAXIMUM STORM - 0 ft
- SLOPES:
  - UPSTREAM SLOPE - 3:1
  - DOWNSTREAM SLOPE - 2.5:1

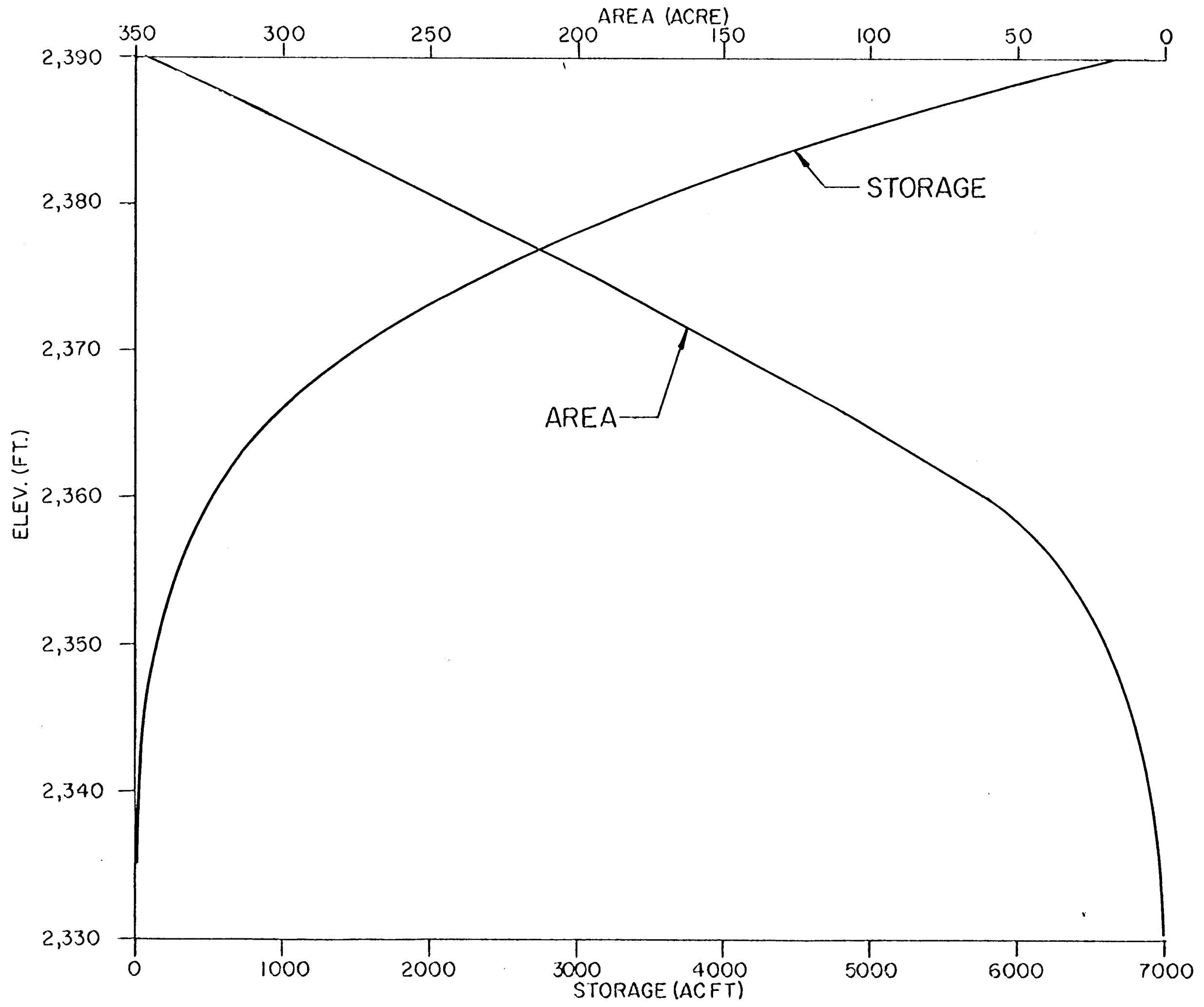
IMPOUNDMENT AREA:
- FOR 100 YR - 6 HR STORM
  - POOL ELEV - 2,371.5 ft
  - SURFACE AREA - 165 ac
  - VOLUME - 1,760 ac ft
- FOR THE PROBABLE MAXIMUM STORM
  - POOL ELEV - 2,390 ft
  - SURFACE AREA - 340 ac
  - VOLUME - 6,680 ac ft

SPILLWAY:
- TYPE: ROLLER-COMPACTED CONCRETE CAPPED BROAD-CRESTED WEIR
- CREST ELEVATION - 2,372 ft
- CREST LENGTH - 750 ft
- CREST WIDTH - 75 ft
- DISCHARGE CAPACITY AT 100-YR POOL - 0 cfs
- DISCHARGE CAPACITY AT PMF POOL - 175,650

OUTLET WORKS:
- TYPE: CAST-IN-PLACE CONCRETE BOX CULVERT
- CULVERT DIMENSIONS - 2 BARREL 8'-0" x 8'-0"
- DISCHARGE CAPACITY AT 100-YR POOL - 4,240 cfs
- DISCHARGE CAPACITY AT PMF POOL - 5,080 cfs

INTERCEPTION BERM:
- TYPE: EARTHEN EMBANKMENT WITH ROLLER COMPACTED CONCRETE SLOPE PROTECTION
- CREST WIDTH: 15 ft
- SIDE SLOPES: 3:1

INTERCEPTION CHANNEL:
- TYPE: TRAPEZOIDAL WITH UNLINED INVERT AND LINED SIDE SLOPES
- LENGTH: 9,100 ft
- DEPTH AT 100-YR FLOOD: 4.6 ft
- WIDTH: 300 ft
- FREEBOARD AT 100-YR FLOOD: 3.9 ft
- SLOPE: 0.0067 ft/ft



STAGE-STORAGE & STAGE-AREA CURVES

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10-26-93	AS BUILT		PT	SSC	ACR

DESIGNED PJR
DETAILED PAT
CHECKED DIH
APPROVED AC Ruvh
DATE 5-28-91

Black & Veatch
Engineers-Architects
Las Vegas, Nevada

PROJECT NO.
17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH
DETENTION BASIN

MAPS, PERTINENT DATA & HYDROGRAPHS

DANA V. REEL
CIVIL
No. 7132
1-10-92

SHEET
2 OF 25

INTERCEPTION BERM/CHANNEL SITE PLAN

1" = 300', CONTOUR INTERVAL = 10'

TEST HOLE LOCATION COORDINATES				
BORING NO.	NORTH COORDINATE	EAST COORDINATE	ELEVATION	DEPTH (ft)
B-1	576,870	593,100	2482	20
B-2	576,860	595,300	2473	20
B-3	576,830	597,700	2451	20
B-4	576,830	601,250	2421	20
B-5	573,425	608,435	2365	40
B-6	573,915	609,880	2335	40
B-7	575,200	610,775	2358	40
B-8	577,060	592,125	2492	20
B-9	577,130	592,625	2487	20
B-10	576,970	593,775	2479	20
B-11	577,110	594,925	2375	20
B-12	576,950	596,075	2467	20
B-13	577,070	597,225	2455	20
B-14	576,930	598,375	2444	20
B-15	577,075	599,525	2443	20
B-16	576,915	600,675	2432	20
B-17	574,050	607,480	2384	15
B-18	573,855	607,830	2381	15
B-19	573,680	608,180	2378	40
B-20	573,330	608,820	2370	40
B-21	573,795	609,730	2337	70
B-22	574,095	609,830	2339	70
B-23	574,270	609,960	2364	70
B-24	573,955	609,680	2337	15
B-25	573,760	609,830	2338	15
B-26	574,530	610,095	2341	40
B-27	574,090	610,010	2338	15
B-28	574,270	610,100	2345	20
B-29	574,450	609,460	2369	40
B-30	574,956	610,310	2359	40
B-31	574,415	610,540	2357	40
B-32	575,910	610,775	2369	40
B-33	576,215	610,870	2377	20
B-34	574,685	609,090	2373	20
B-35	574,925	609,665	2360	20
B-36	575,175	609,830	2352	20
B-37	573,710	609,350	2367	40
TRENCH NO.	NORTH COORDINATE	EAST COORDINATE	ELEVATION	DEPTH (ft)
TP-1	574,025	609,430	2340	3
TP-2	574,725	610,120	2344	7
TP-3	577,050	593,200	2484	9
TP-4	577,040	594,350	2480	8
TP-5	577,030	595,500	2469	8
TP-6	577,020	596,650	2462	5
TP-7	577,010	597,800	2449	3
TP-8	577,000	598,950	2440	9
TP-9	576,990	600,100	2434	8
TP-10	573,470	608,525	2374	10
TP-11	573,300	609,140	2387	10
TP-12	573,600	609,615	2364	10
TP-13	573,930	609,790	2336	10
TP-14	574,160	609,780	2345	10
TP-15	574,190	608,420	2347	10
TP-16	574,100	608,770	2345	10
TP-17	574,000	609,165	2341	10
TP-18	574,370	608,715	2348	10
TP-19	574,220	609,050	2345	10
TP-20	574,590	608,620	2350	6
TP-21	574,450	608,945	2348	10
TP-22	574,260	609,300	2348	10
TP-23	575,170	610,410	2370	9
TP-24	575,630	610,650	2362	10
TP-25	575,235	610,095	2368	10
TP-26	574,610	608,230	2341	10

EMBANKMENT CURVE DATA				
CURVE NO.	DELTA	RADIUS	CURVE LENGTH	TANGENT LENGTH
1	33°00'00"	1590'	915.77'	470.98'
2	92°30'00"	720'	1162.39'	752.12'

PROJECT BENCH MARK

REBAR WITH ALUMINUM CAP SET IN CONCRETE LOCATED AT THE POINT OF INTERSECTION OF EMBANKMENT CURVE 2, DESIGNATED CM3; N573,016.90; E609,339.40; ELEVATION 2364.98, MEAN SEA LEVEL.

BASIS OF BEARING

THE NORTH LINE OF THE NORTHEAST 1/4 OF SECTION 1, TOWNSHIP 19 SOUTH, RANGE 60 EAST, MOUNT DIABLO MERIDIAN, CLARK COUNTY, NEVADA.
BEARING: N89°32'08"W

LINE	BEARING	DISTANCE
L1	N89°14'03"E	124.20'
L2	N0°45'57"W	116.75'
L3	S89°03'01"W	162.84'
L4	NO°34'53"W	101.59'
L5	S89°03'01"W	164.41'
L6	N58°53'12"W	191.38'
L7	NO°29'13"W	167.09'
L8	SO°23'30"E	104.27'
L9	N1°04'47"W	97.04
L10	N1°42'39"W	97.07
L11	N1°42'33"W	97.07

LEGEND

⌒	℄ OF DAM EMBANKMENT & INTERCEPTION CHANNEL
◐	BORING
⊠	TRENCH OR PIT
▲	SURVEY MONUMENT
☐	PUBLIC LAND
▨	PRIVATE LAND
▩	PRIVATE LAND OBTAINED FOR DAM EMBANKMENT CONSTRUCTION
- - -	EXISTING UNIMPROVED ROAD
—	IMPROVED ACCESS ROADS
▨	FOSSIL BEARING AREA

DAM EMBANKMENT SITE PLAN

1" = 300', CONTOUR INTERVAL = 10'

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10-26-93	AS BUILT		PT		dck

DESIGNED SDC, PJR
DETAILED HLR
CHECKED DIH
APPROVED AC Roberts
DATE 5-23-91

Black & Veatch
Engineers-Architects
Las Vegas, Nevada

PROJECT NO.
17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH DETENTION BASIN
SITE PLANS, SURVEY DATA & BORING LOCATIONS

DANA V. HEEL
CIVIL
No. 7130

SHEET
3 OF 25

INTERCEPTION BERM ACCESS ROAD LOCATION DATA

P.I. NO.	NORTH COORDINATE	EAST COORDINATE
1	577,289.66	591,911.87
2	577,272.86	591,936.73
3	577,232.86	591,936.39
4	577,175.18	591,952.90
5	576,842.06	591,964.90

NOTE:
FOR SECTION LINES AND PROPERTY BOUNDARIES, SEE INTERCEPTION BERM/CHANNEL SITE PLAN, SH 3.

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10-26-93	AS BUILT		PT	SC	ACR

DESIGNED ALK, JWS
DETAILED HLR
CHECKED DIH
APPROVED AC Roberts
DATE 5-28-91

Black & Veatch
Engineers - Architects
Las Vegas, Nevada

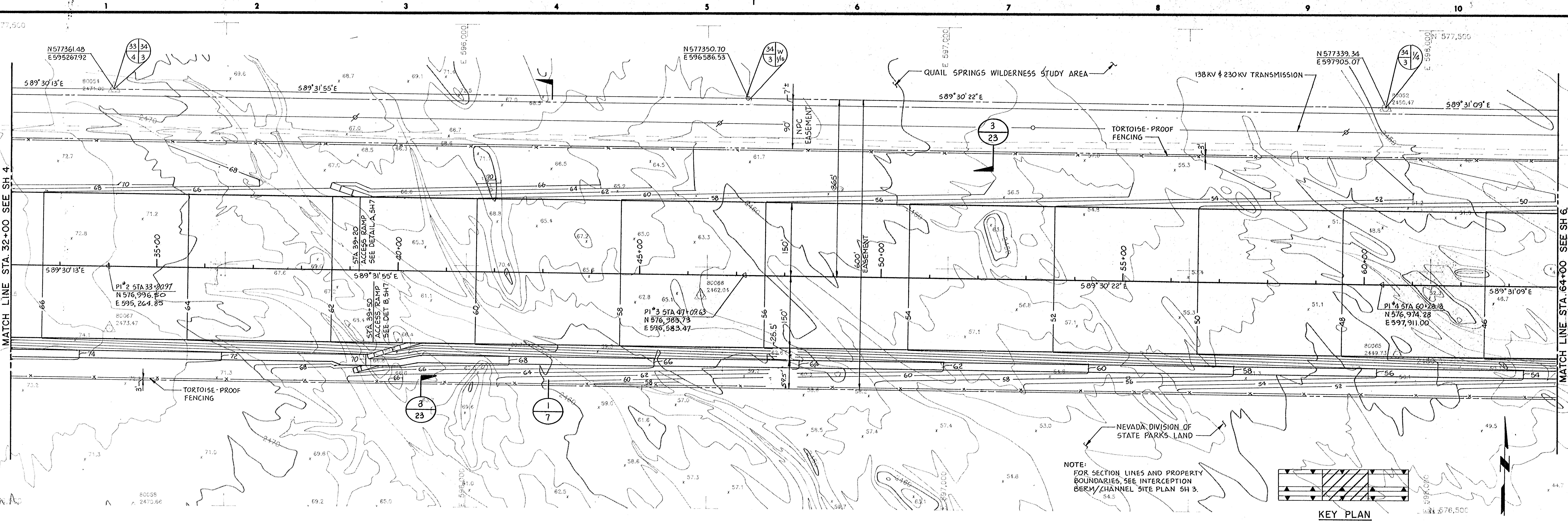
PROJECT NO.
17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH
DETENTION BASIN

INTERCEPTION BERM/CHANNEL
PLAN & PROFILE STA. 0+00 TO 32+00

DANA V. HEEL
CIVIL
No. 7138

SHEET
4 OF 25



DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10·26·93	AS BUILT		PT	SRC	ACR

DESIGNED ALK, JWS
DETAILED HLR
CHECKED DIH
APPROVED A C Roberts
DATE 5-28-91

Black & Veatch
Engineers - Architects
Las Vegas, Nevada

PROJECT NO.
17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH
DETENTION BASIN

INTERCEPTION BERM/CHANNEL
PLAN & PROFILE STA. 32+00 TO 64+00

DANA V. REEL
CIVIL
No. 7132

SHEET
5 OF 25

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10-26-93	AS BUILT		PT	DC	ACR

DESIGNED ALK, JWS, SDC
DETAILED HLR
CHECKED DIH
APPROVED AC Roberts
DATE 5-28-91

Black & Veatch
Engineers - Architects
Las Vegas, Nevada

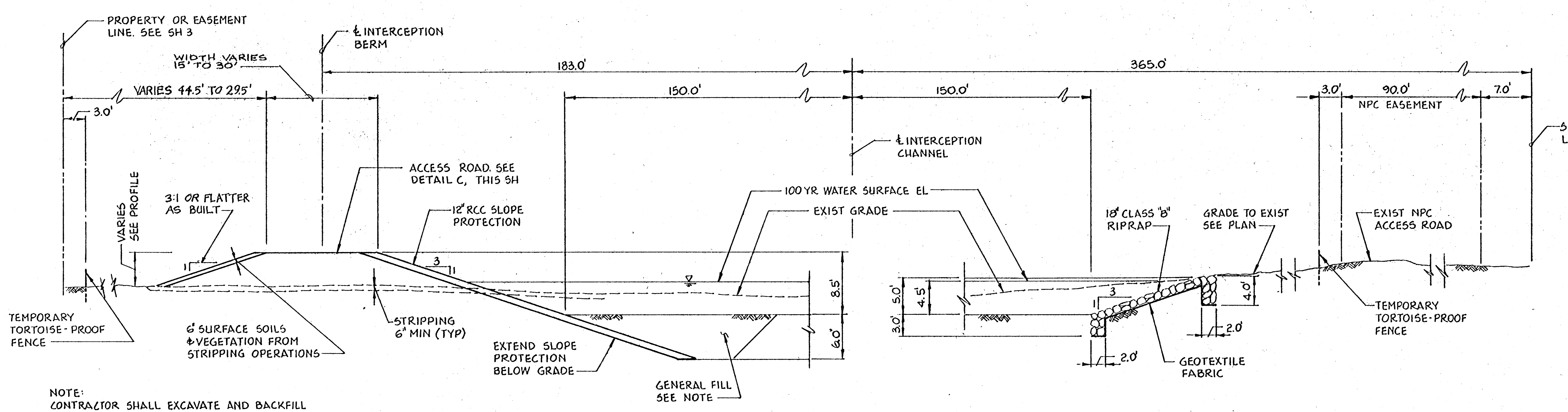
PROJECT NO.
17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH
DETENTION BASIN

INTERCEPTION BERM/CHANNEL
PLAN & PROFILE STA. 64+00 TO 93+00

DANA V. REEL
CIVIL

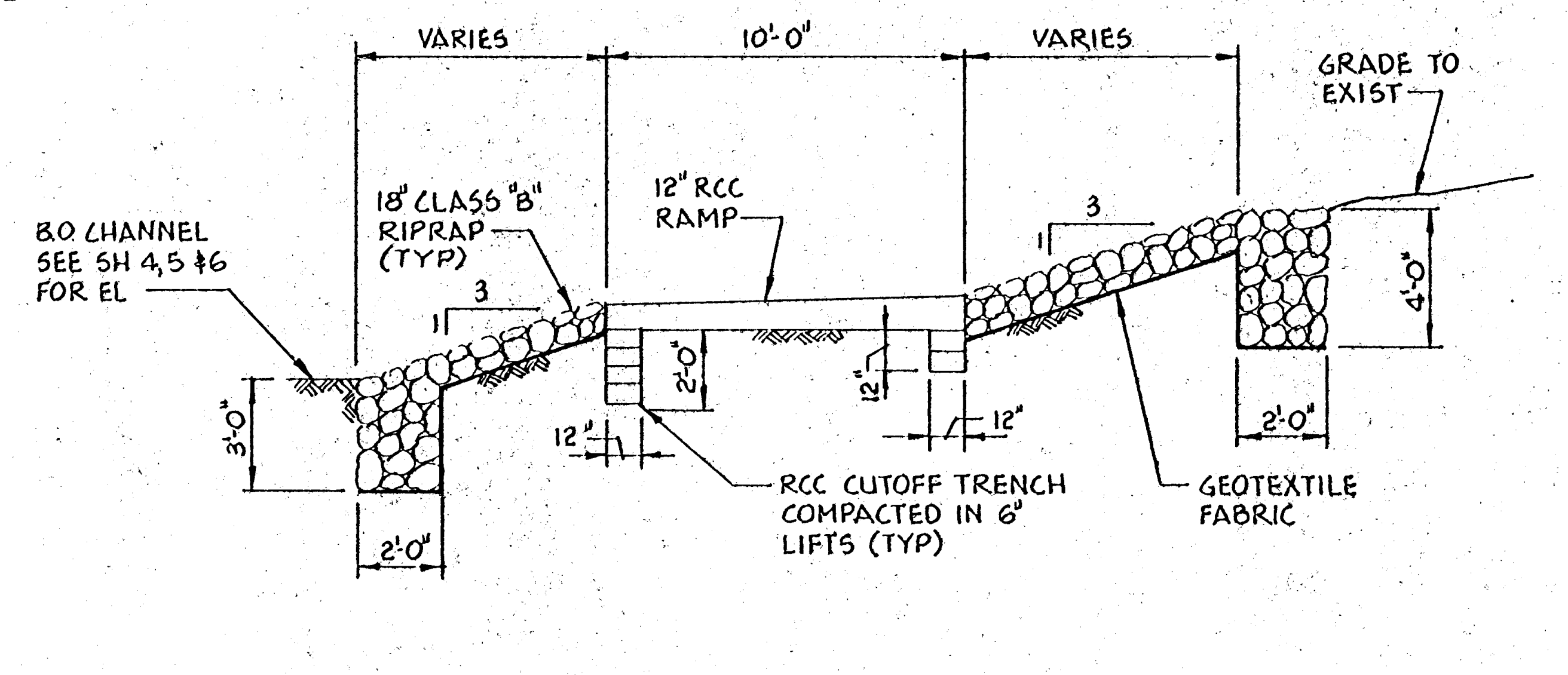
SHEET
6 OF 25



NOTE:
CONTRACTOR SHALL EXCAVATE AND BACKFILL TRENCH AT TOE OF BERM AS REQ'D TO EXTEND SLOPE PROTECTION BELOW GRADE.

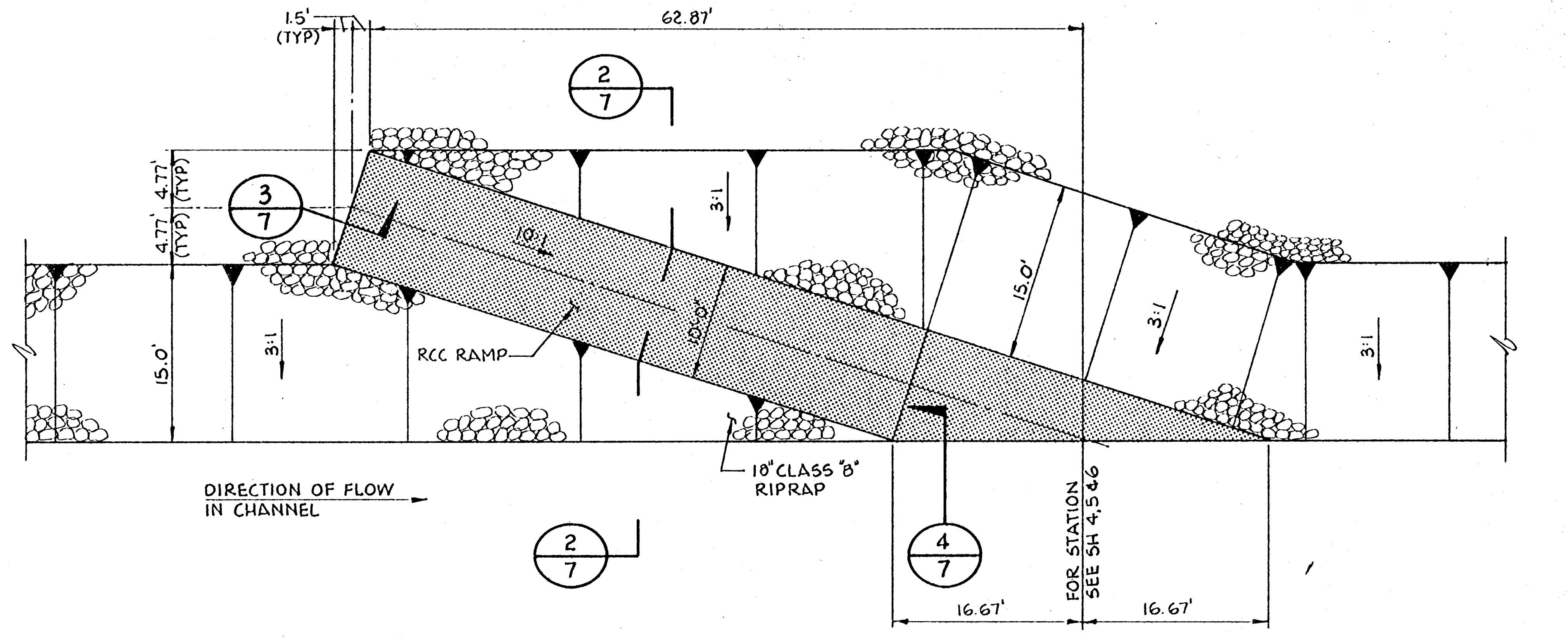
INTERCEPTION BERM/CHANNEL CROSS SECTION (1 / 4,5,6)

1"=10'



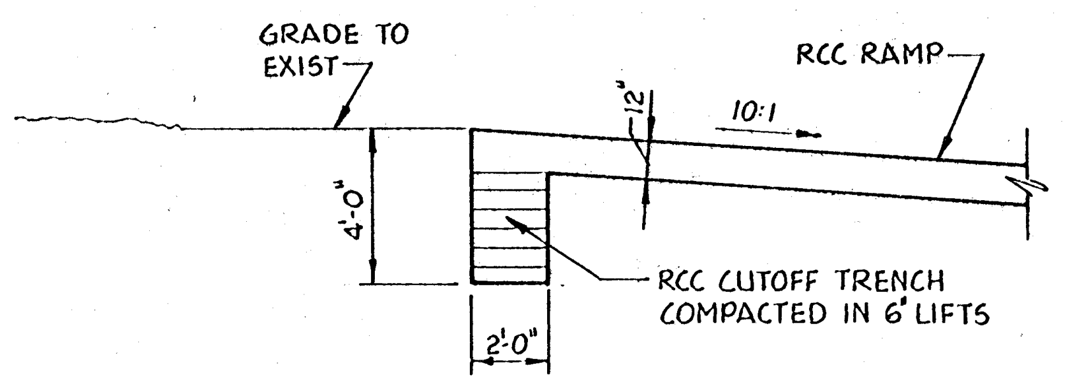
SECTION (2 / 7)

1"=5'



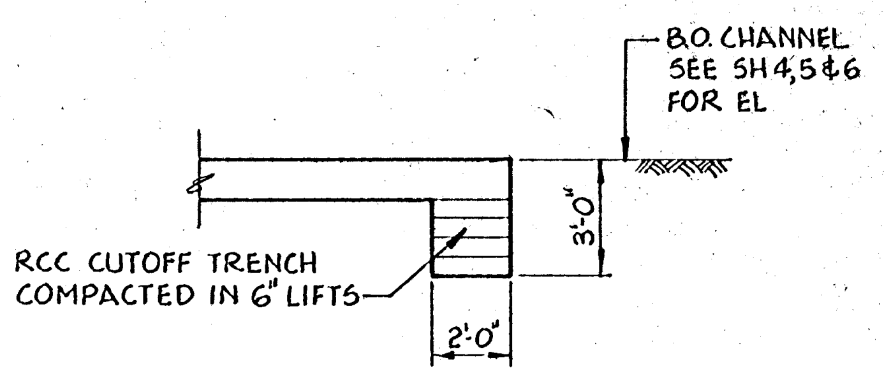
NORTH BANK ACCESS RAMP PLAN (A / 4,5,6)

1"=10'



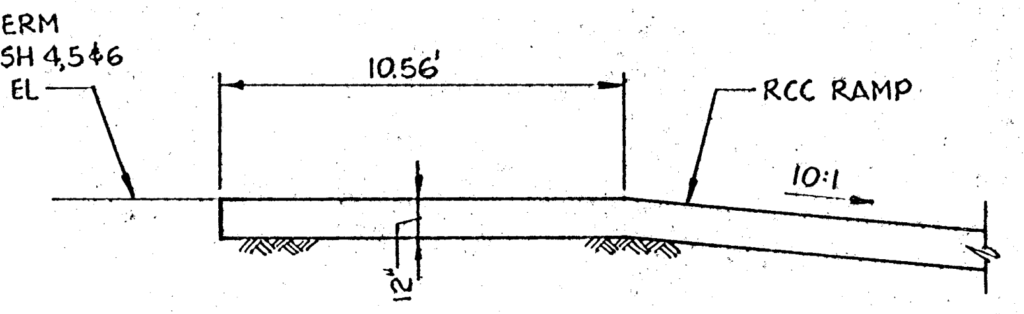
SECTION (3 / 7)

1"=5'



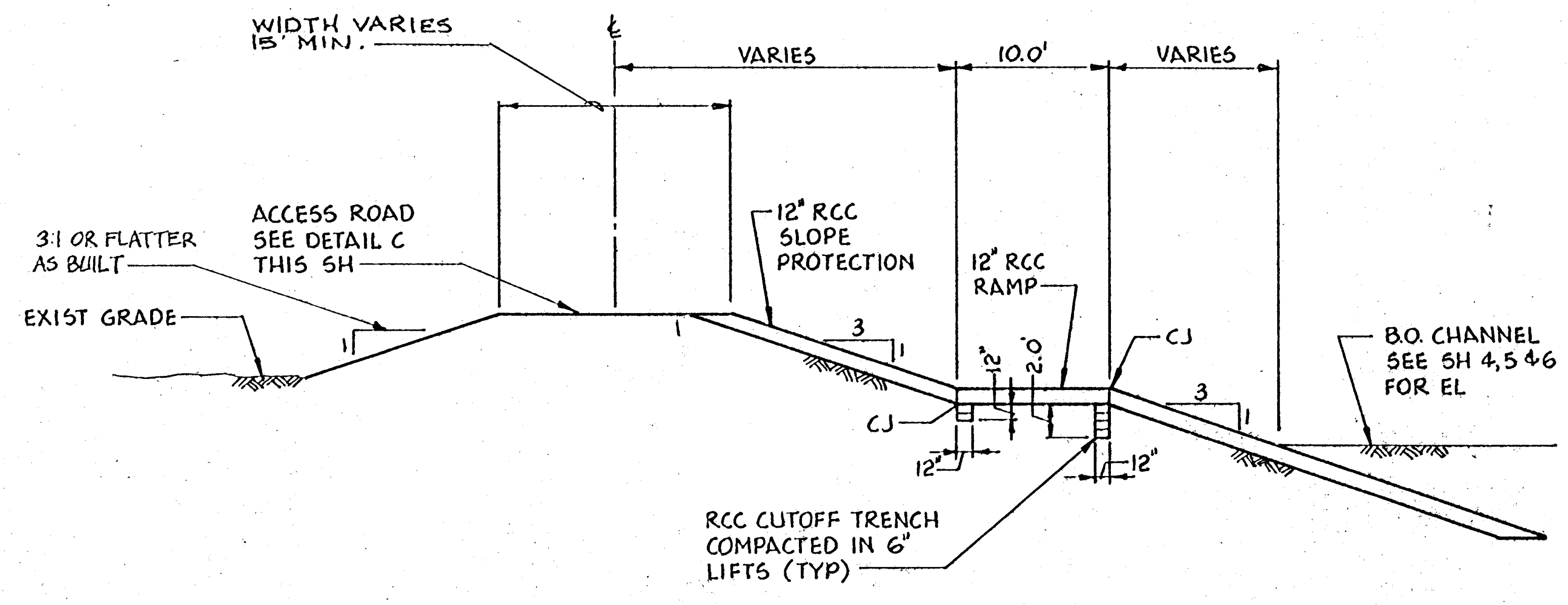
SECTION (4 / 7)

1"=5'



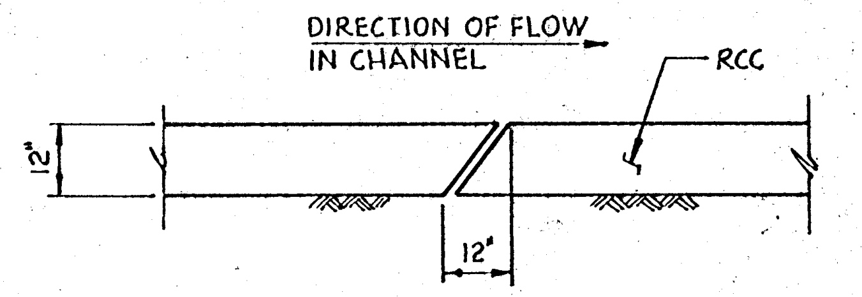
SECTION (5 / 7)

1"=5'



SECTION (6 / 7)

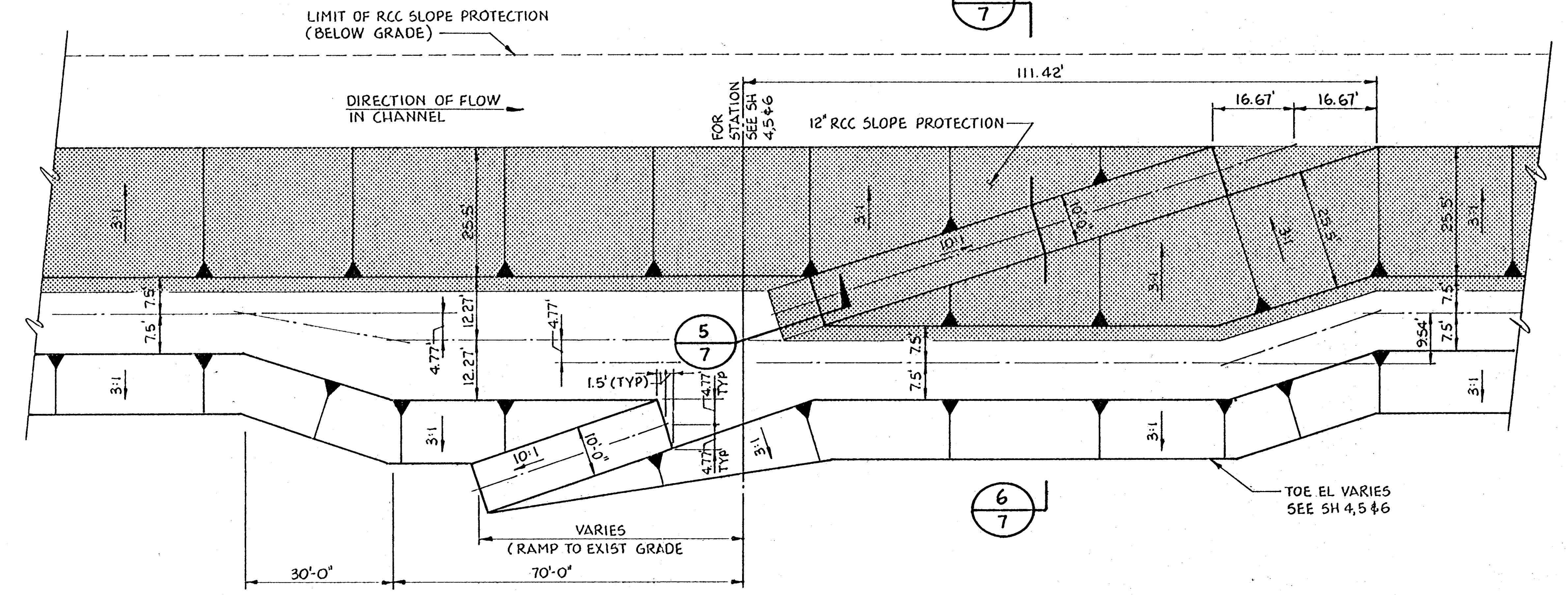
1"=10'



TYPICAL CONSTRUCTION JOINT DETAIL

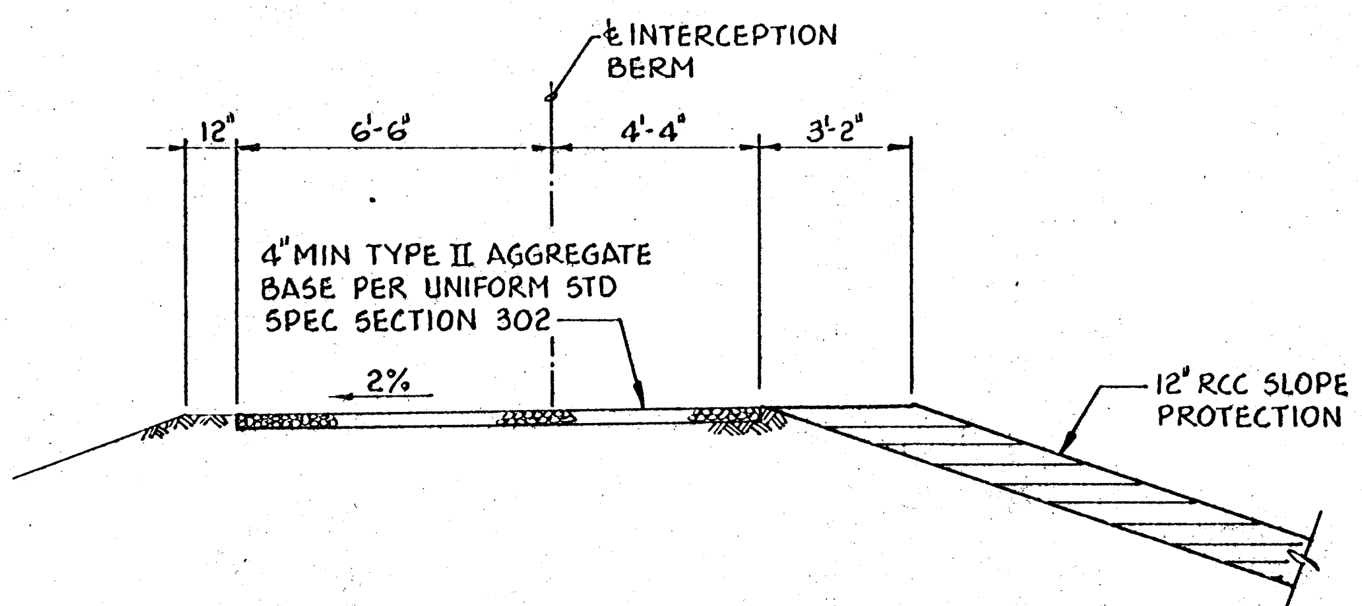
3/8"=1'-0"

NOTE: CONTRACTOR SHALL PROVIDE CONSTRUCTION JOINT AT THE END OF EACH SECTION OF RCC PLACED AND AT THE END OF EACH DAY.



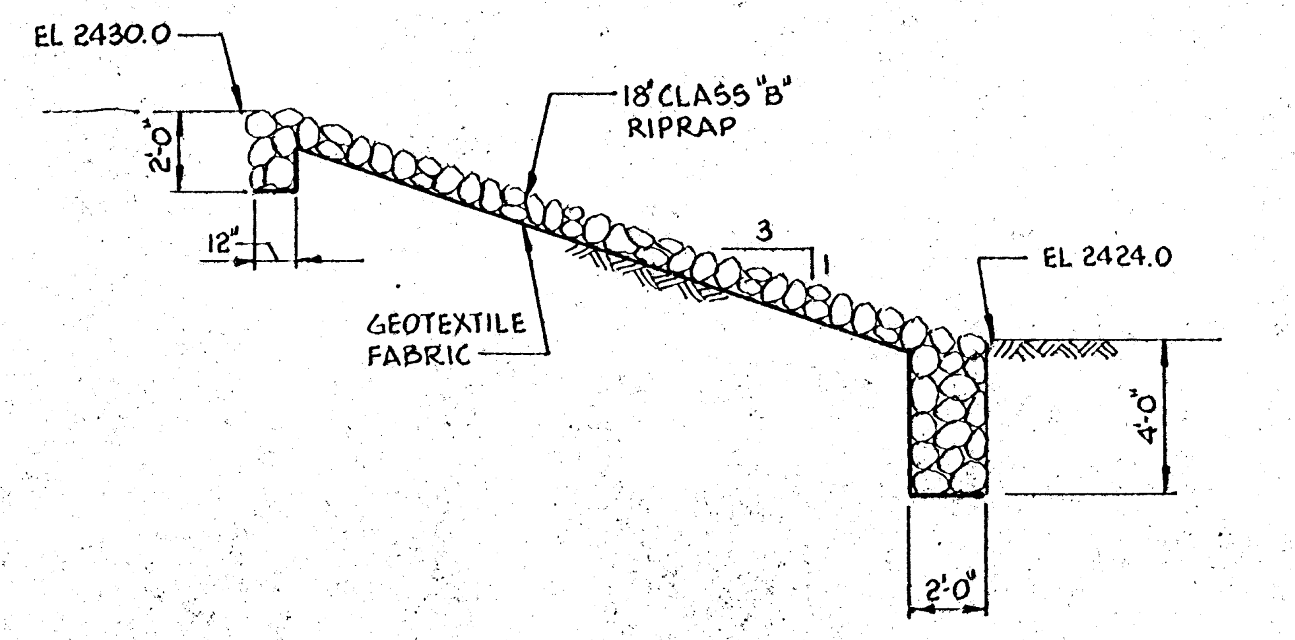
SOUTH BANK ACCESS RAMP PLAN (B / 4,5,6)

1"=20'



TYPICAL ACCESS ROAD CROSS SECTION (C / 4,5,6)

NO SCALE



SECTION (7 / 7)

1"=5'

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10-26-93	AS BUILT		PT	SDC	

DESIGNED ALK, SDC
DETAILED HLR
CHECKED DIH
APPROVED A C [illegible]
DATE 5-28-91

Black & Veatch
Engineers-Architects
Las Vegas, Nevada

PROJECT NO.
17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH
DETENTION BASIN

INTERCEPTION BERM/CHANNEL
SECTIONS & DETAILS

DANA V. REEL
CIVIL
No. 1138

SHEET
7 OF 25

B4V-C-2436-0

NOTES:

1. CONTRACTOR SHALL NOT DISTURB AREAS BEYOND LIMITS OF TORTOISE PROOF FENCE EXCEPT AS INDICATED ON THE DWGS.
2. CONTRACTOR SHALL NOT EXCAVATE BELOW FINISH CONTOUR ELEVATIONS WITHIN 200 FT OF THE UPSTREAM TOE OF EMBANKMENT SLOPE.
3. FOR LOCATION AND ELEVATION OF SURVEY CONTROL MONUMENTS, SEE SH.3.

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10-26-93	AS BUILT		PT	SC	RR

DESIGNED SDC
DETAILED HLR
CHECKED DIH
APPROVED A C Roberts
DATE 5-28-91

Black & Veatch
Engineers-Architects
Las Vegas, Nevada

PROJECT NO.
17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH
DETENTION BASIN

DAM EMBANKMENT GRADING PLAN NO.1
STA. 0+00 TO STA. 18+50

SHEET
8 OF 25

NOTES:

1. CONTRACTOR SHALL NOT DISTURB AREAS BEYOND LIMITS OF TORTOISE PROOF FENCE EXCEPT AS INDICATED ON THE DWGS.
2. CONTRACTOR SHALL NOT EXCAVATE BELOW FINISH CONTOUR ELEVATIONS WITHIN 200 FT OF THE UPSTREAM TOE OF EMBANKMENT SLOPE.
3. FOR LOCATION AND ELEVATION OF SURVEY CONTROL MONUMENTS, SEE SH 3.
4. FOR SPILLWAY FENCE TYPE AND LOCATION, SEE SH 18.
5. FOR SECTION LINES AND PROPERTY BOUNDARIES SEE DAM EMBANKMENT SITE PLAN SH 3.
6. DOWNSTREAM SLOPE OF DAM EMBANKMENT VARIES FROM 2.5:1 TO 4:1 BETWEEN STA 23+26.65 TO STA 24+76.65 & STA 33+00.65 TO STA 35+00.65 SEE SHTS 15, 16 & 17.
7. PARKING AREA SHALL BE SURFACED WITH A 4" MIN THICKNESS OF TYPE II AGGREGATE BASE PER UNIFORM STD SPEC SECTION 308.
8. THE CENTER QUARTER OF SECTION 1 SHALL BE REESTABLISHED FOLLOWING FINAL GRADING OF THE DETENTION BASIN IMPOUNDMENT AREA.

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10-26-93	AS BUILT		PT	SDC	DCR

DESIGNED SDC
DETAILED HLR
CHECKED DIH
APPROVED D C Roberts
DATE 5-20-91

Black & Veatch
Engineers-Architects
Las Vegas, Nevada

PROJECT NO.
17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH DETENTION BASIN
DAM EMBANKMENT GRADING PLAN NO. 2
STA. 18+50 TO STA. 37+00

DANA V. REEL
CIVIL
No. 7136
1-10-92

SHEET
9 OF 25

NOTES:

1. CONTRACTOR SHALL NOT DISTURB AREAS BEYOND LIMITS OF TORTOISE PROOF FENCE EXCEPT AS INDICATED ON THE DWGS.
2. CONTRACTOR SHALL NOT EXCAVATE BELOW FINISH CONTOUR ELEVATIONS WITHIN 200 FT OF THE UPSTREAM TOE OF EMBANKMENT SLOPE.
3. FOR LOCATION AND ELEVATION OF SURVEY CONTROL MONUMENTS SEE SH 3.
4. FOR SECTION LINES AND PROPERTY BOUNDARIES, SEE DAM EMBANKMENT SITE PLAN SH 3.

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10-26-93	AS BUILT		PT	SDC	CKR

DESIGNED SDC
DETAILED HLR
CHECKED DIH
APPROVED A C Roberts
DATE 5-28-91

Black & Veatch
Engineers-Architects
Las Vegas, Nevada

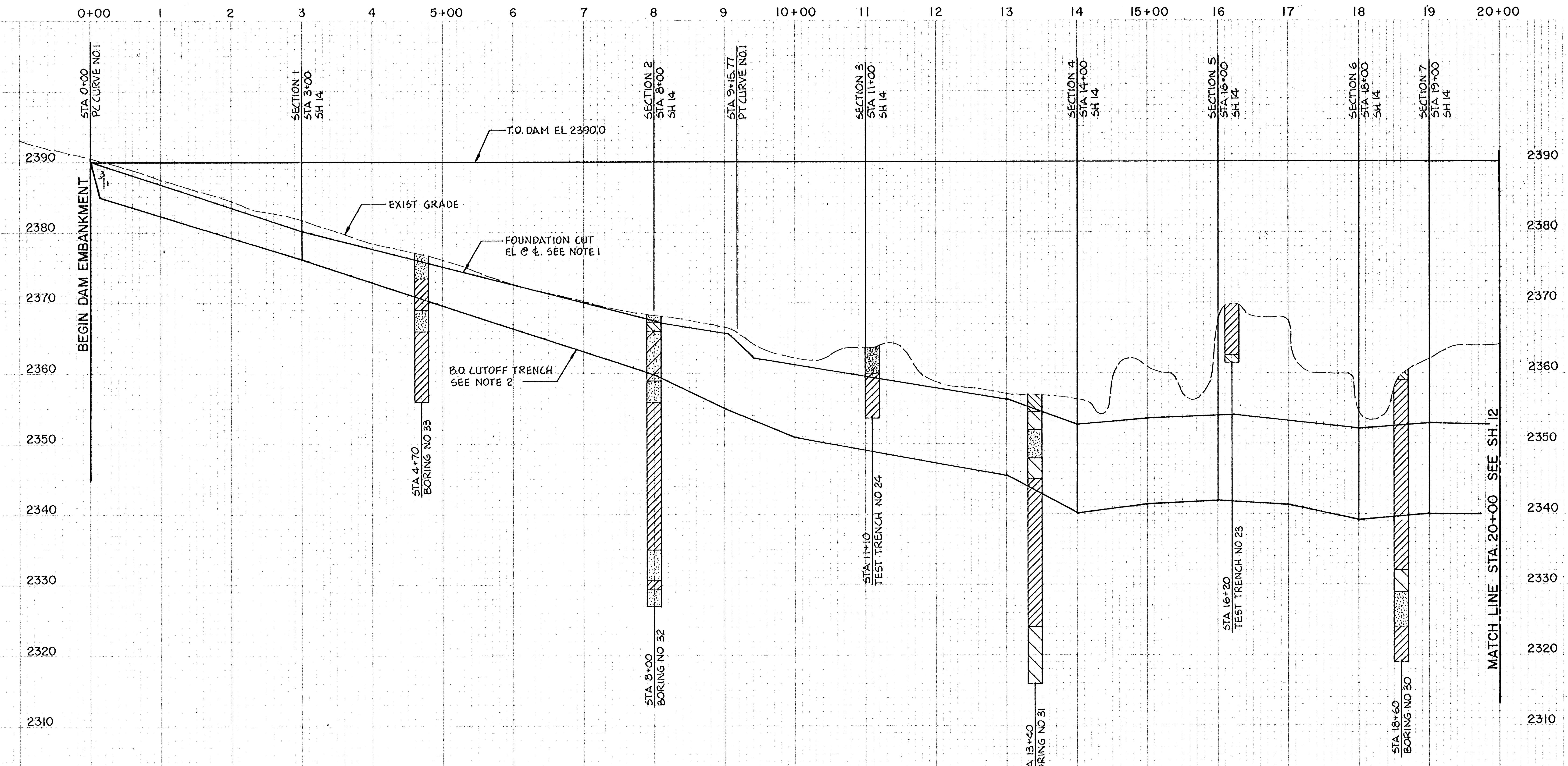
PROJECT NO.
17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH DETENTION BASIN

DAM EMBANKMENT GRADING PLAN NO. 3
STA. 37+00 TO STA. 65+93.92

DAN I V. REEL
CIVIL

SHEET
10 OF 25



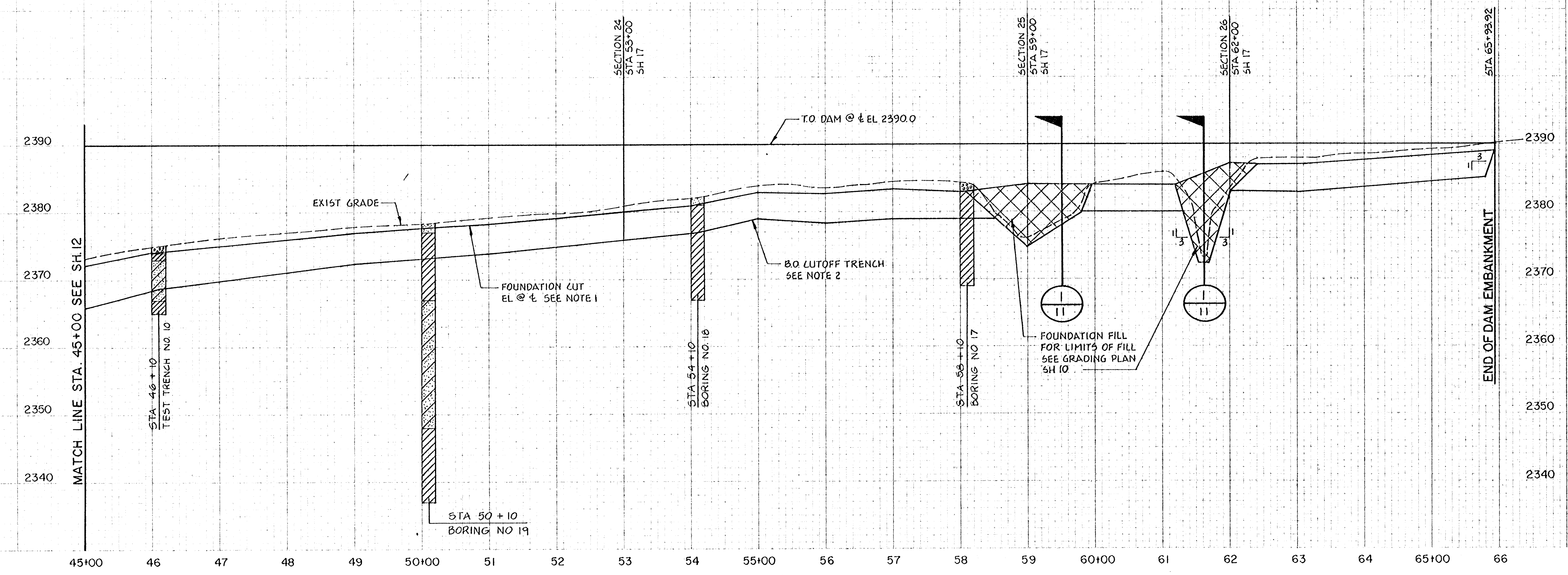
SCALE: HORIZ 1"=100'
VERT 1"=10'

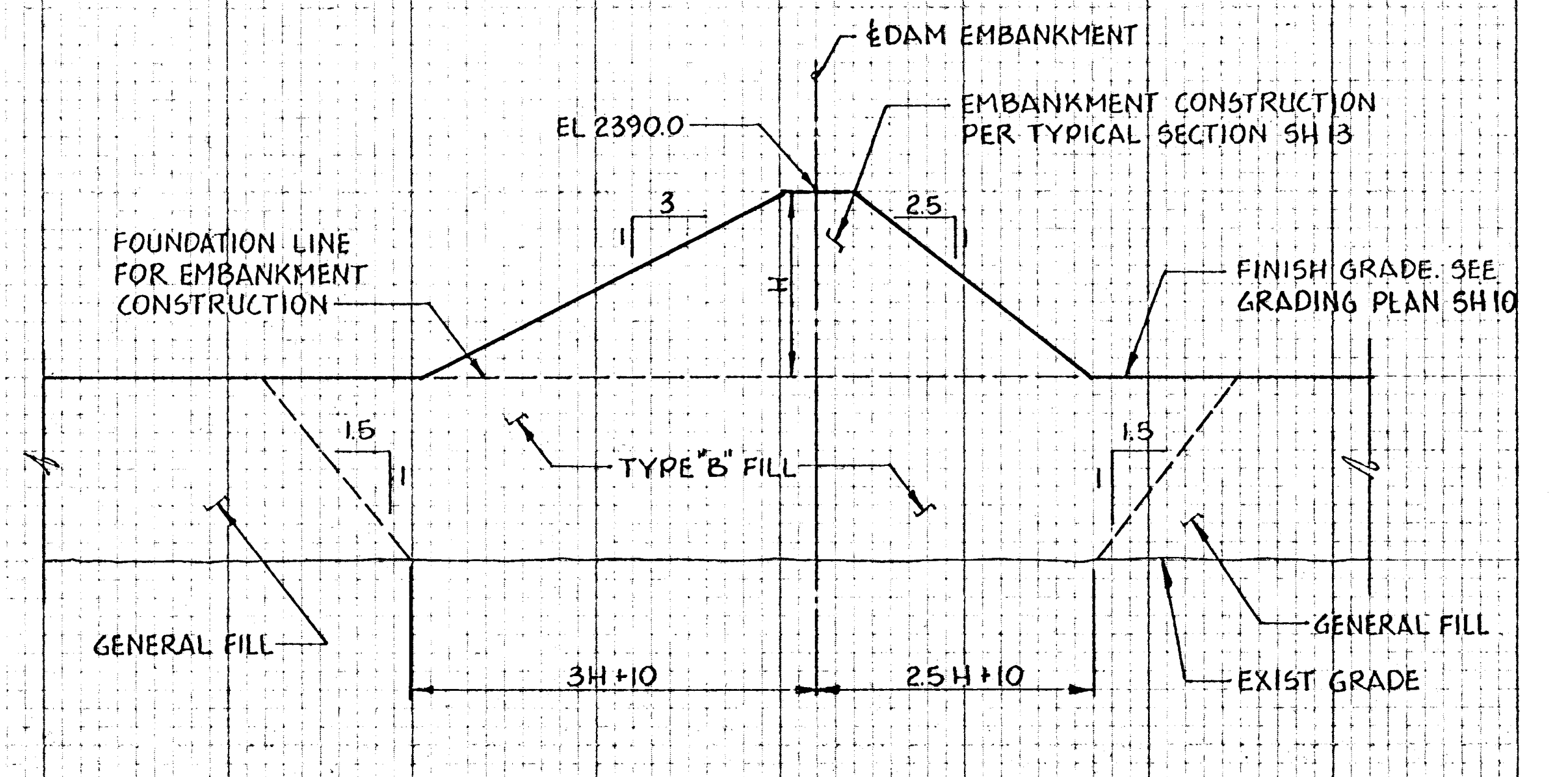
LEGEND

▨	CL	▩	SM/SC
▨	ML	▒	GM/GC
▧	SP	▧	GP

SOIL TYPE DESIGNATION PER UNIFIED SOIL CLASSIFICATION SYSTEM

NOTES:
1. FOR FOUNDATION CUT ELEVATIONS, SEE SECTIONS SH 14, 17
2. FOR CUTOFF TRENCH DIMENSIONS & LOCATION, SEE SECTIONS SH 14 & 17 & TYPICAL SECTION SH 13





SECTION 1/11
NO SCALE

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10-26-93	AS BUILT		PT	SDC	

DESIGNED SDC
DETAILED VEN, ULR
CHECKED DIH
APPROVED C.C. Roberts
DATE 5-20-91

Black & Veatch
Engineers-Architects
Las Vegas, Nevada

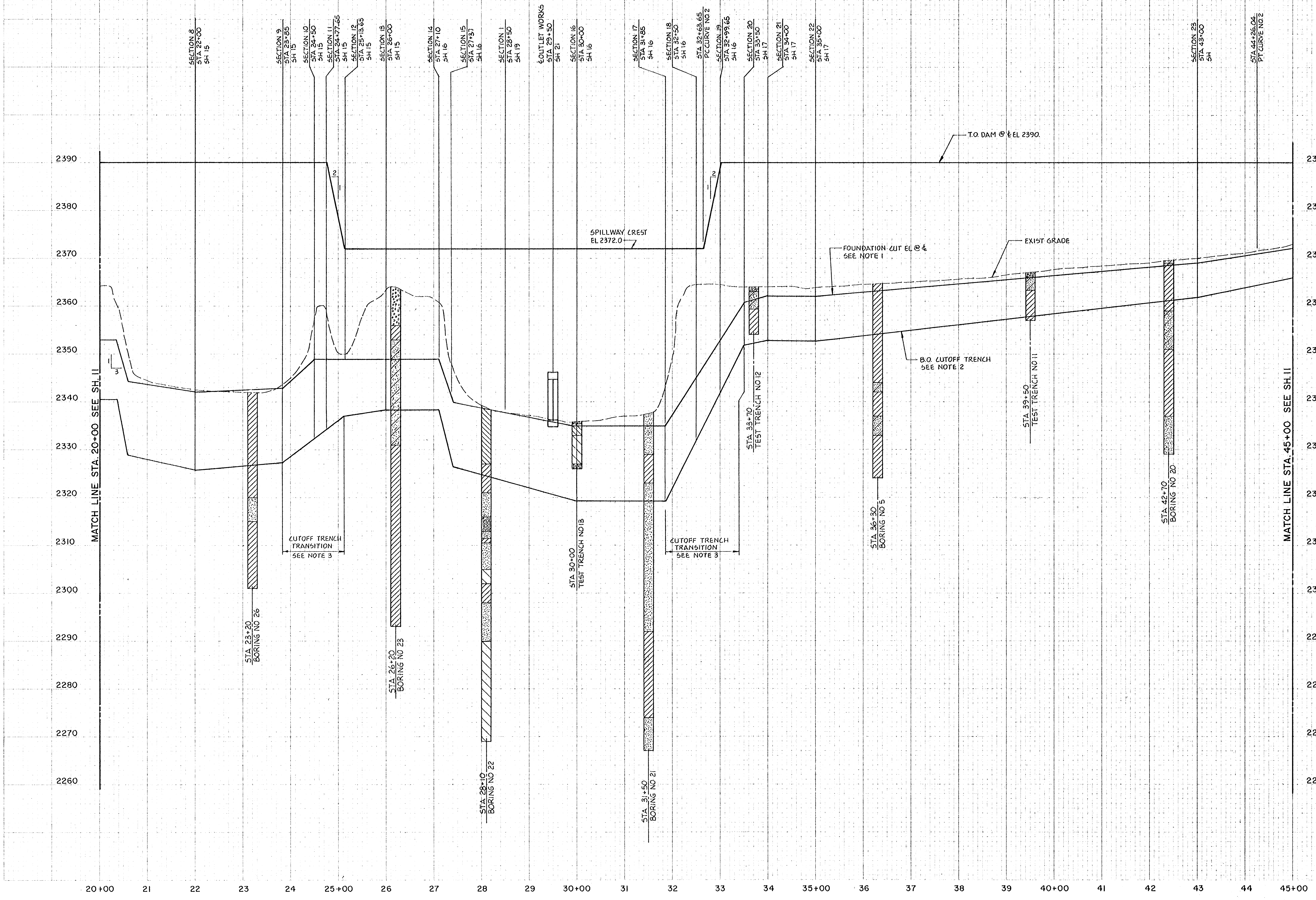
PROJECT NO.
17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH
DETENTION BASIN

DAM EMBANKMENT CENTER LINE PROFILE
STA 0+00 TO 20+00 &
STA 45+00 TO 65+93.92

DANA V. REEL
CIVIL
No. 1153

SHEET
11 OF 25



SCALE: HORIZ 1" = 100'
VERT 1" = 10'

LEGEND

▨	CL	▩	SM/SC
▨	ML	░	GM/GC
▧	SP	▧	GP

SOIL TYPE DESIGNATION PER UNIFIED
SOIL CLASSIFICATION SYSTEM

NOTES:

1. FOR FOUNDATION CUT ELEVATIONS, SEE SECTIONS SH 15, 16 & 17.
2. FOR CUTOFF TRENCH DIMENSIONS & LOCATION, SEE SECTIONS SH 15, 16, 17 & TYPICAL SECTION SH 13.
3. FOR CUTOFF TRENCH DEPTH, WIDTH & LOCATION IN TRANSITION, SEE SECTIONS 15 & 16.

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10-26-93	AS BUILT		PT	SDC	JCR

DESIGNED SDC
DETAILED HLR
CHECKED DIH
APPROVED J C Roberts
DATE 5-28-91

Black & Veatch
Engineers-Architects
Las Vegas, Nevada

PROJECT NO.
17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH
DETENTION BASIN

DAM EMBANKMENT CENTER LINE PROFILE
STA. 20+00 TO 45+00

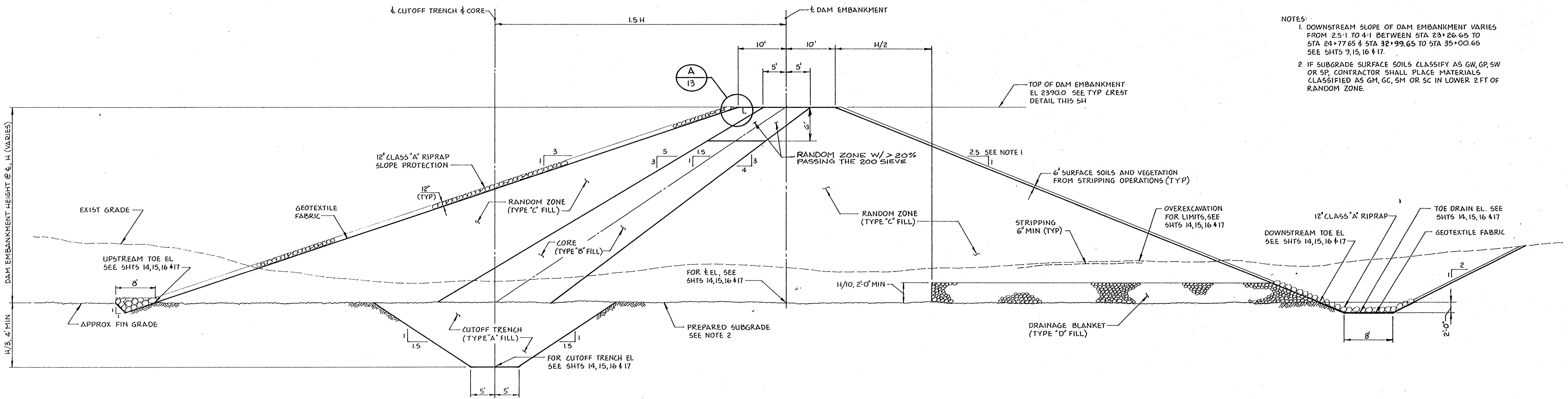
DANA V. REEL CIVIL No. 7138

SHEET
12 OF 25

B & V - C - 2436 - A

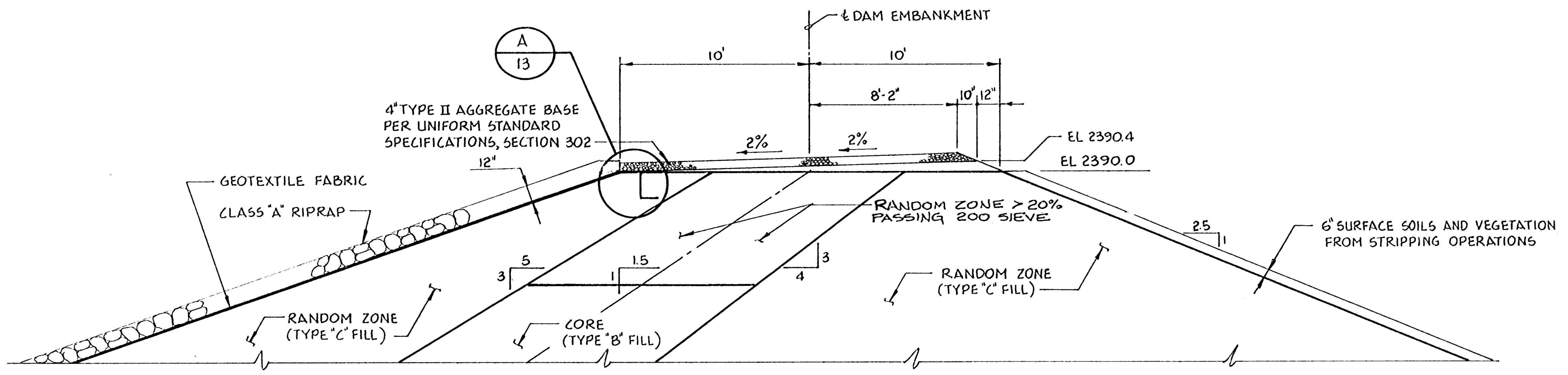
NOTES:

1. DOWNSTREAM SLOPE OF DAM EMBANKMENT VARIES FROM 2.5:1 TO 4:1 BETWEEN STA 23+26.65 TO STA 24+77 65 & STA 32+99.65 TO STA 35+00.65 SEE SHTS 9, 15, 16 & 17.
2. IF SUBGRADE SURFACE SOILS CLASSIFY AS GW, GP, SW OR SP, CONTRACTOR SHALL PLACE MATERIALS CLASSIFIED AS GM, GC, SM OR SC IN LOWER 2 FT OF RANDOM ZONE.



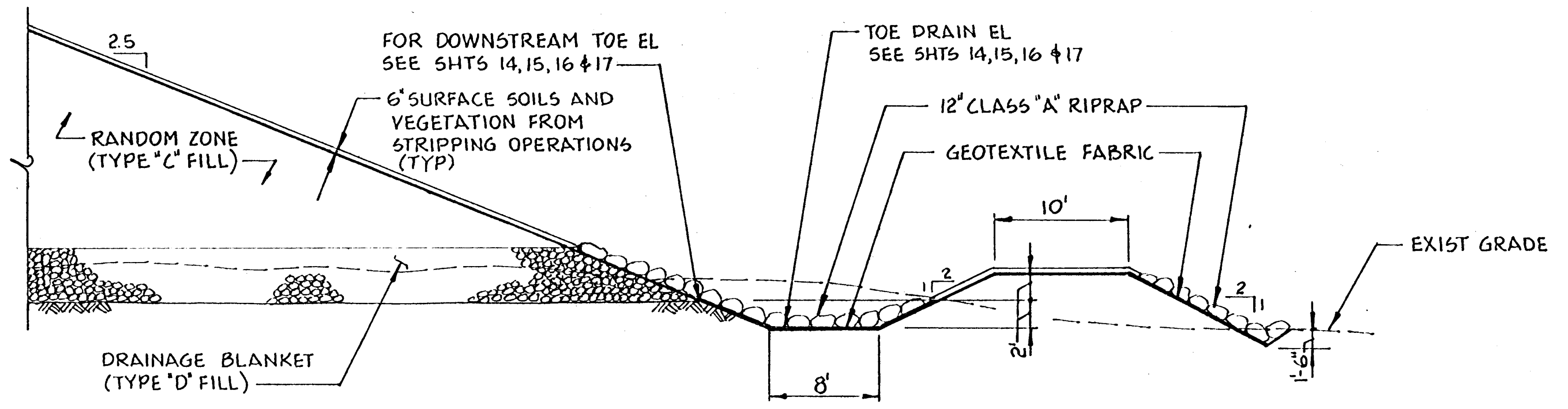
TYPICAL DAM EMBANKMENT CROSS SECTION

1" = 10'



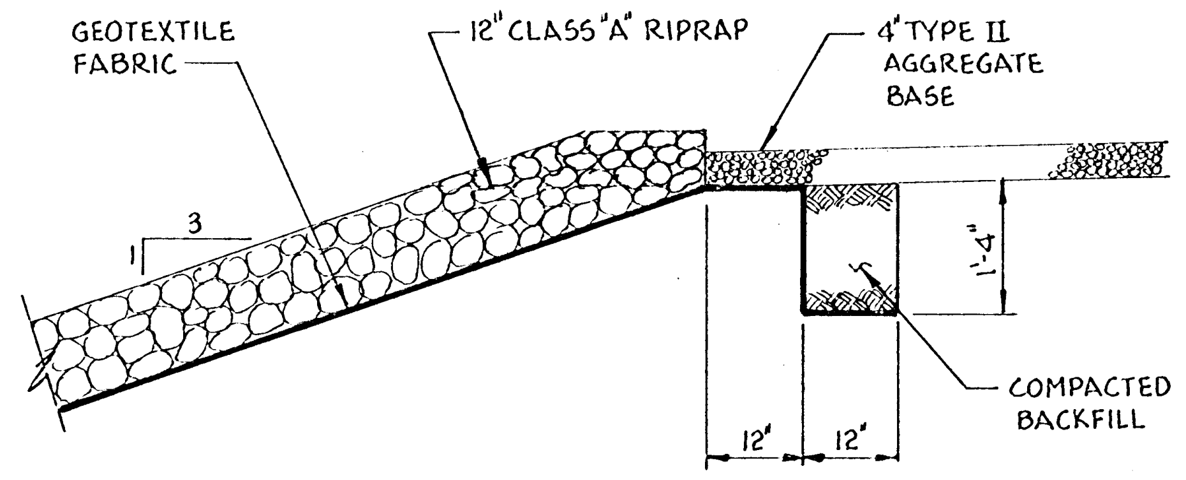
TYPICAL CREST DETAIL

1" = 5'



TYPICAL TOE DRAIN DETAIL
STA. 0+00 TO STA. 10+70

1" = 10'



GEOTEXTILE ANCHOR TRENCH DETAIL (A)

1/2" = 1'-0"

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10-26-93	AS BUILT		PT	SSC	[illegible]

DESIGNED PJR
DETAILED HLR
CHECKED DIH
APPROVED [illegible]
DATE 5-28-91

Black & Veatch
Engineers-Architects
Las Vegas, Nevada

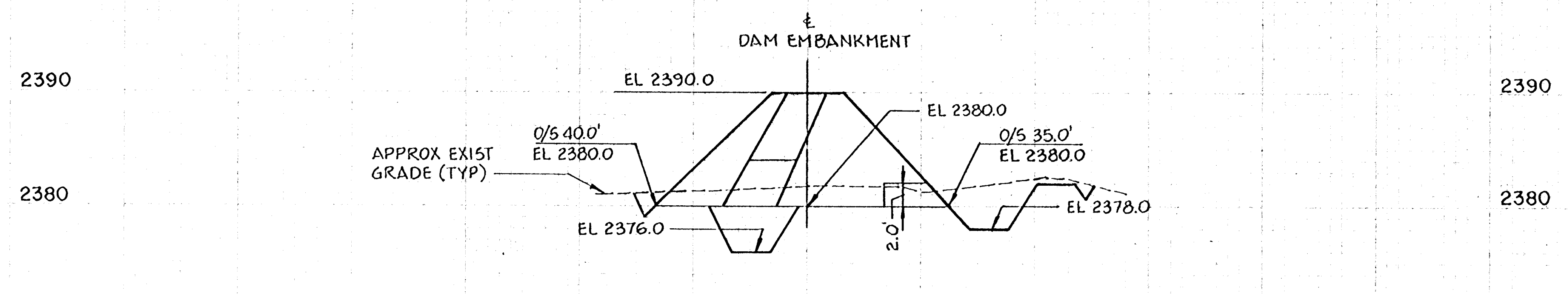
PROJECT NO.
17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH
DETENTION BASIN

DAM EMBANKMENT
TYPICAL CROSS SECTION & DETAILS

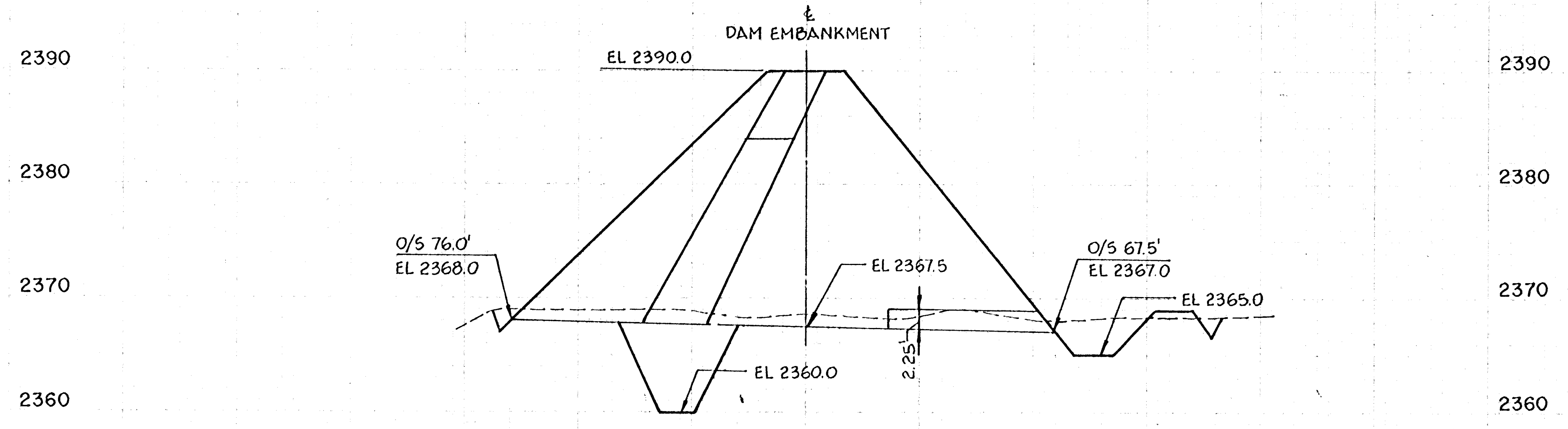
DANA V. REEL CIVIL No. 7138

SHEET
13 OF 25



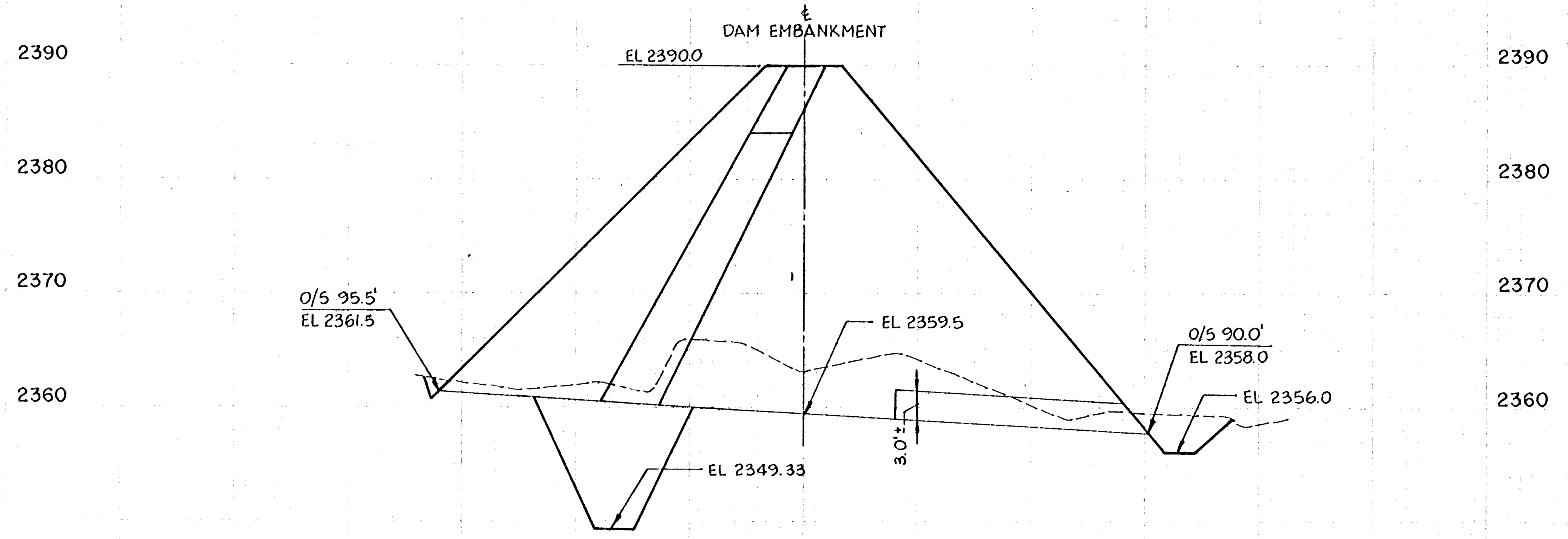
STA. 3+00

SECTION 1/8



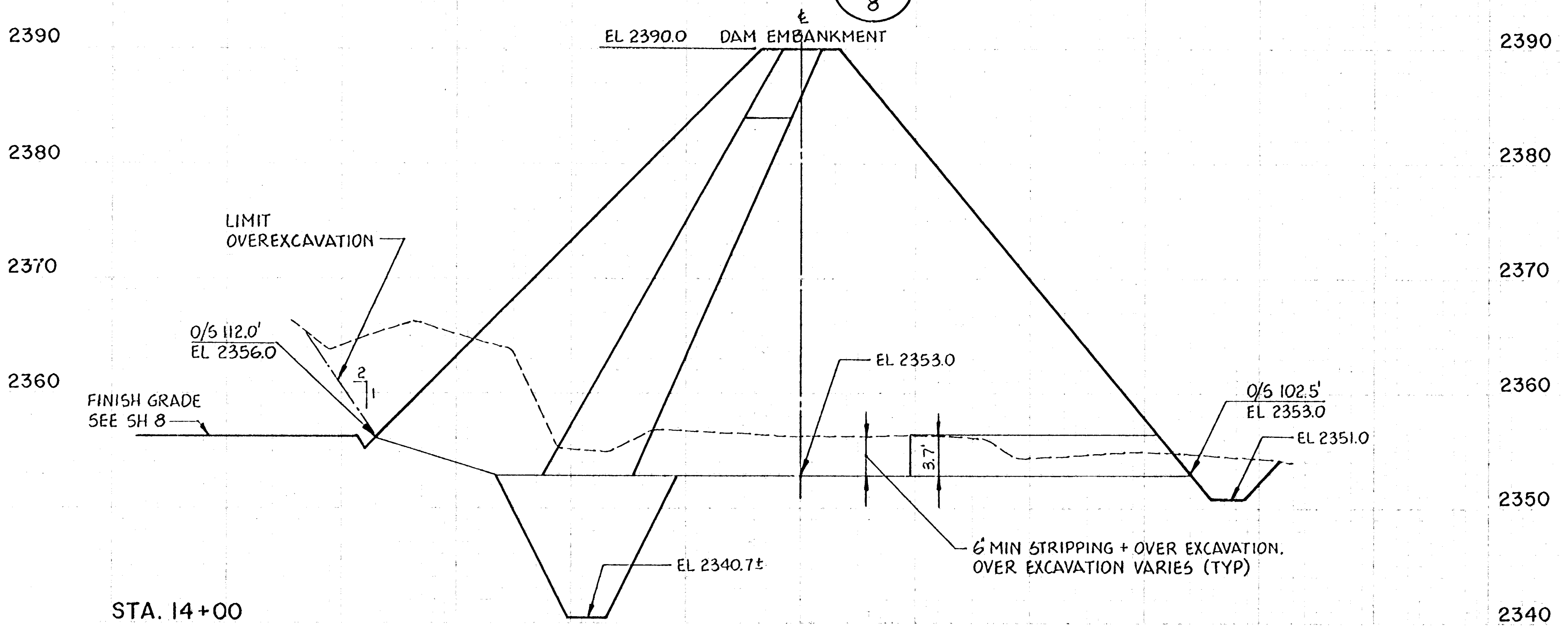
STA. 8+00

SECTION 2/8



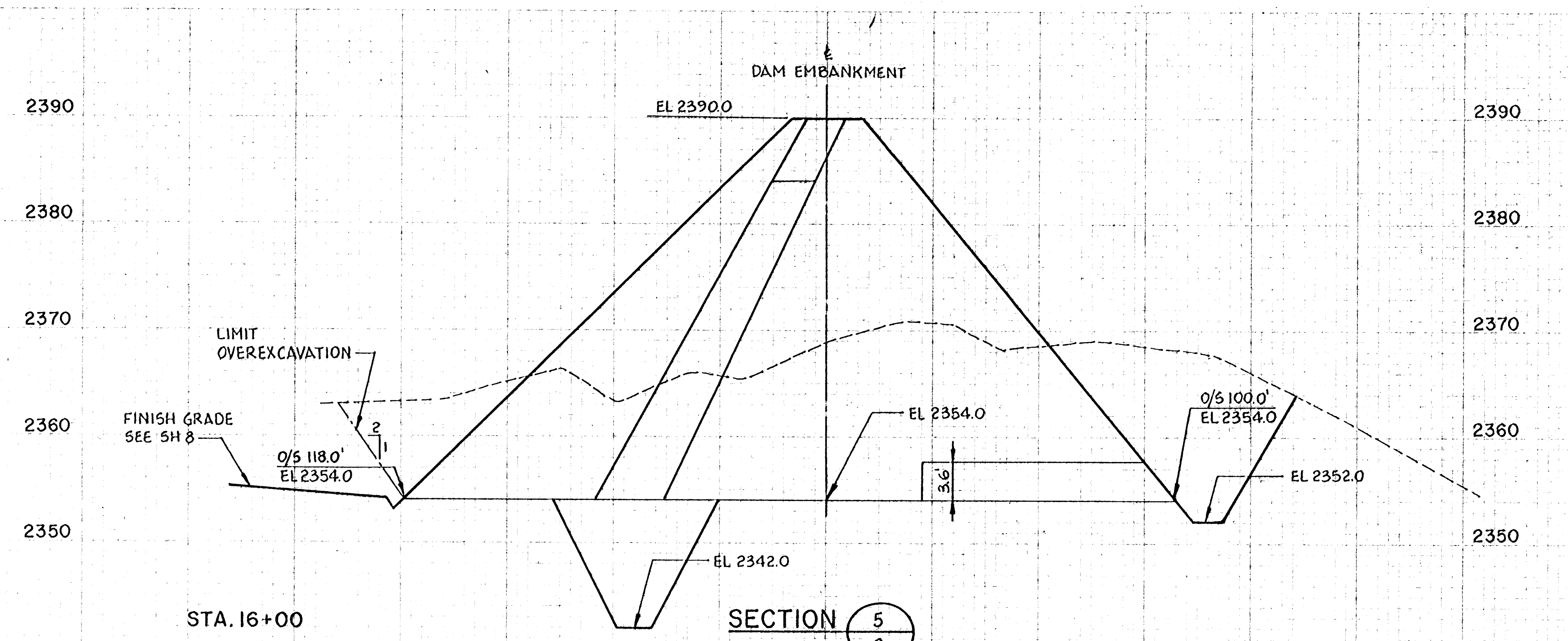
STA. 11+00

SECTION 3/8



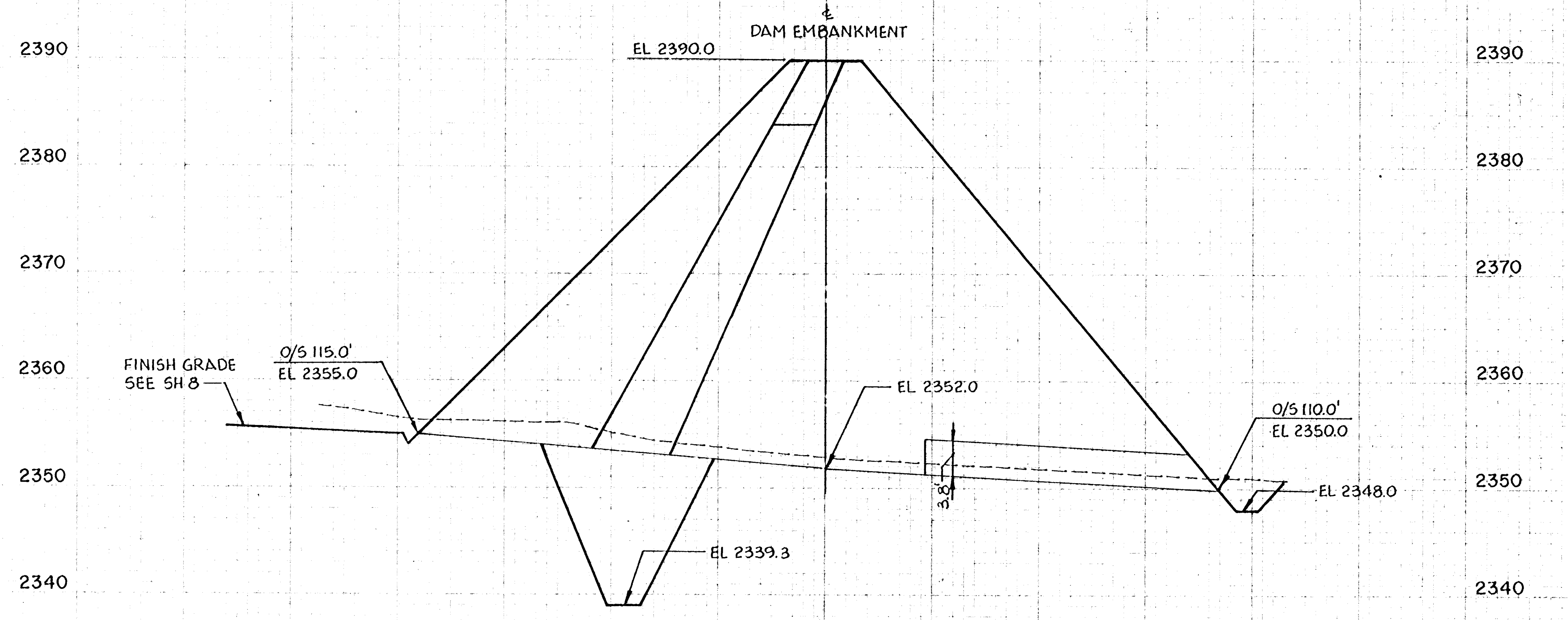
STA. 14+00

SECTION 4/8



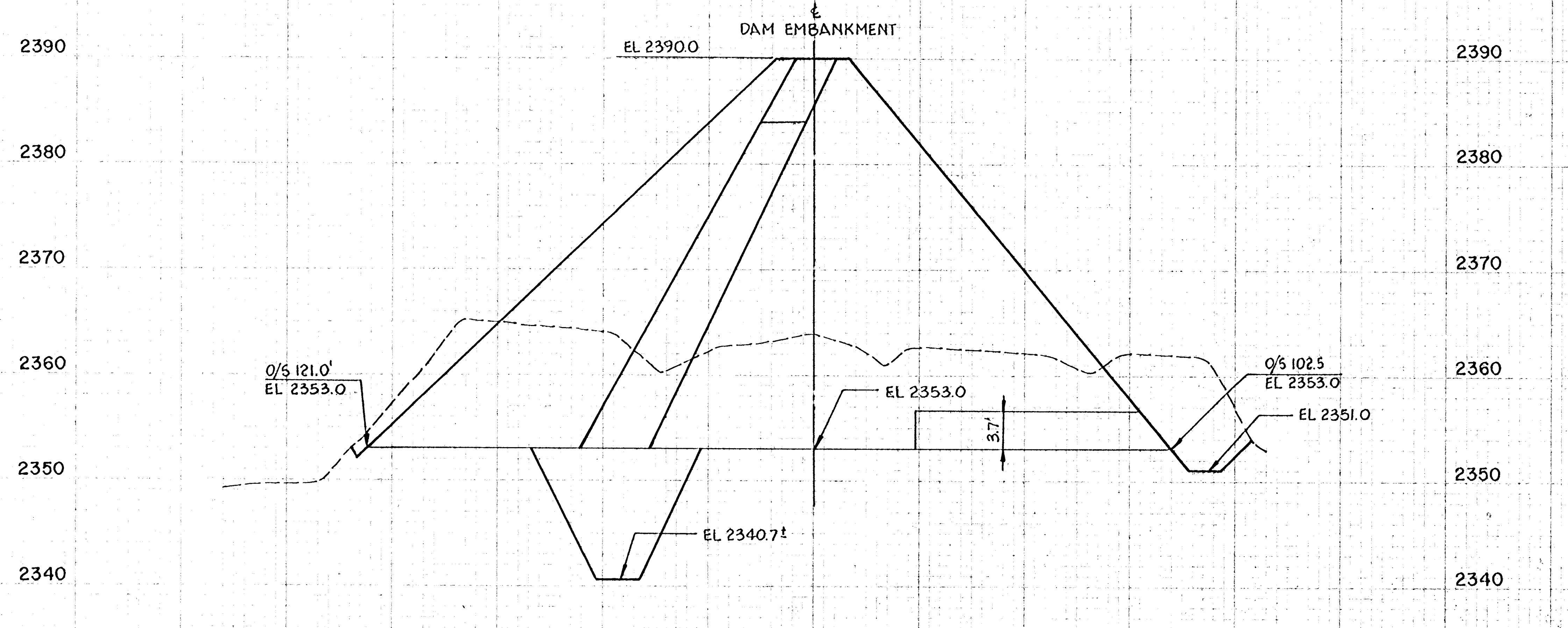
STA. 16+00

SECTION 5/8



STA. 18+00

SECTION 6/8



STA. 19+00

SECTION 7/9

SCALE: HORIZ. 1"=30'
VERT. 1"=10'

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10-26-93	AS BUILT		PT	[illegible]	CK

DESIGNED PJR
DETAILED HLR
CHECKED DIH
APPROVED [illegible]
DATE 5-28-91

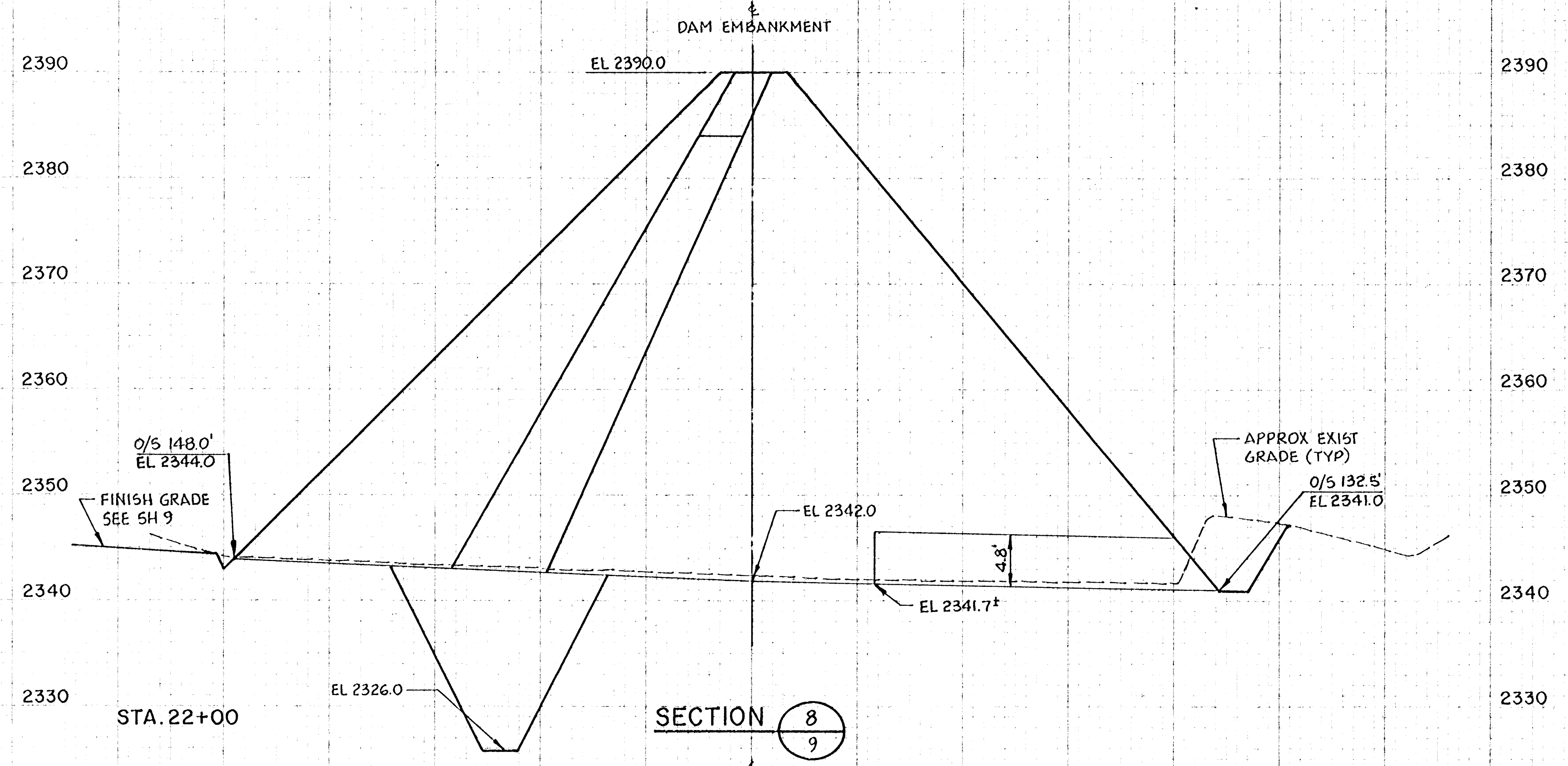
Black & Veatch
Engineers-Architects
Las Vegas, Nevada

PROJECT NO.
17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH DETENTION BASIN
DAM EMBANKMENT CROSS SECTIONS
STA. 3+00 TO STA. 19+00

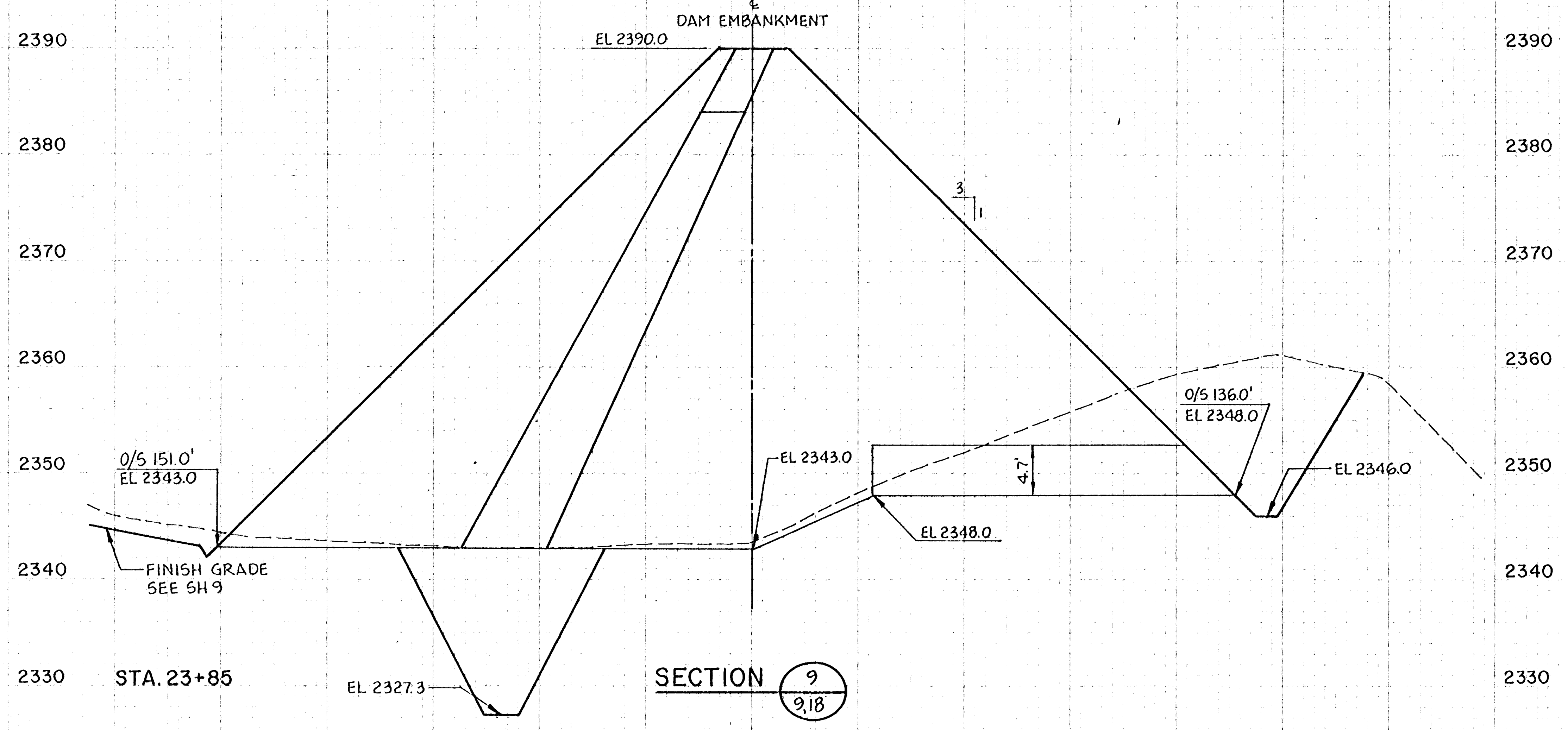
DANA V. REEL
No. 7138

SHEET
14 OF 25



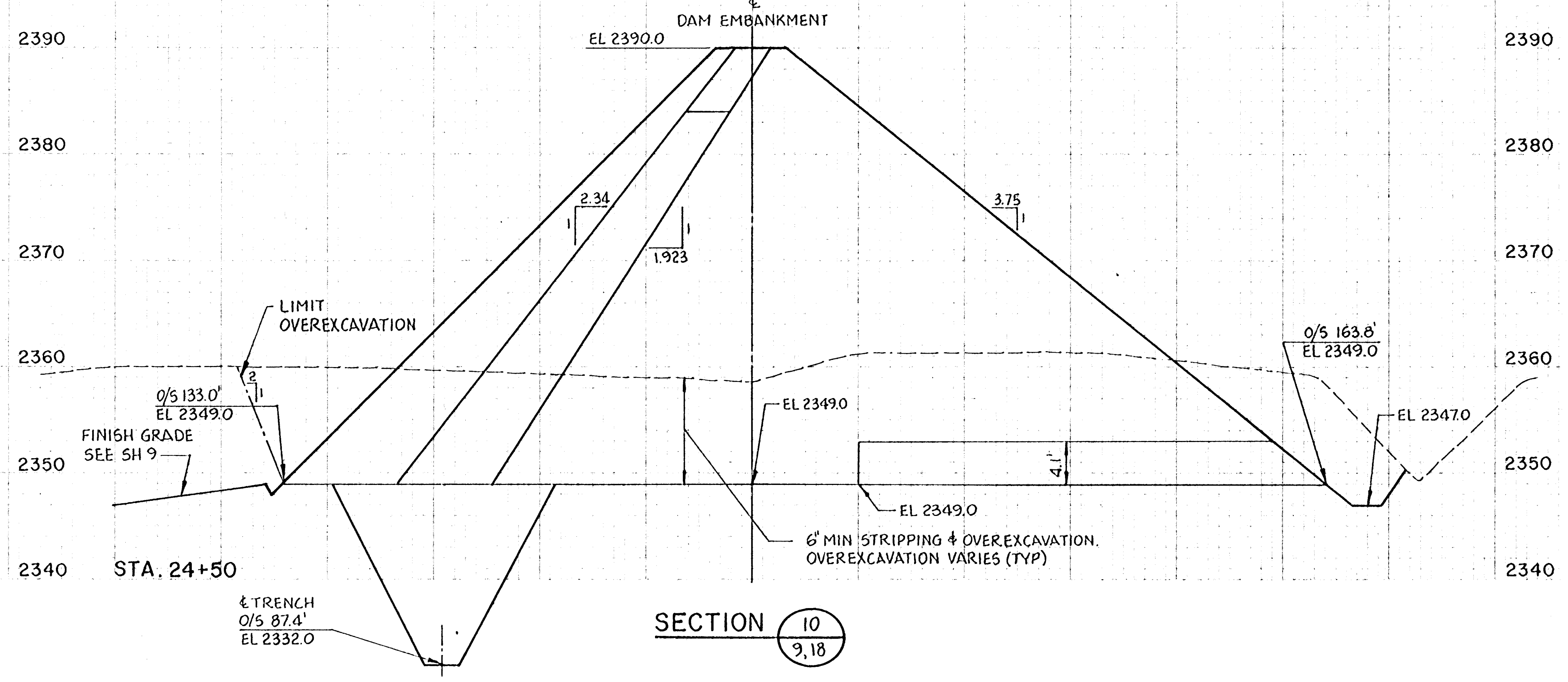
STA. 22+00

SECTION 8/9



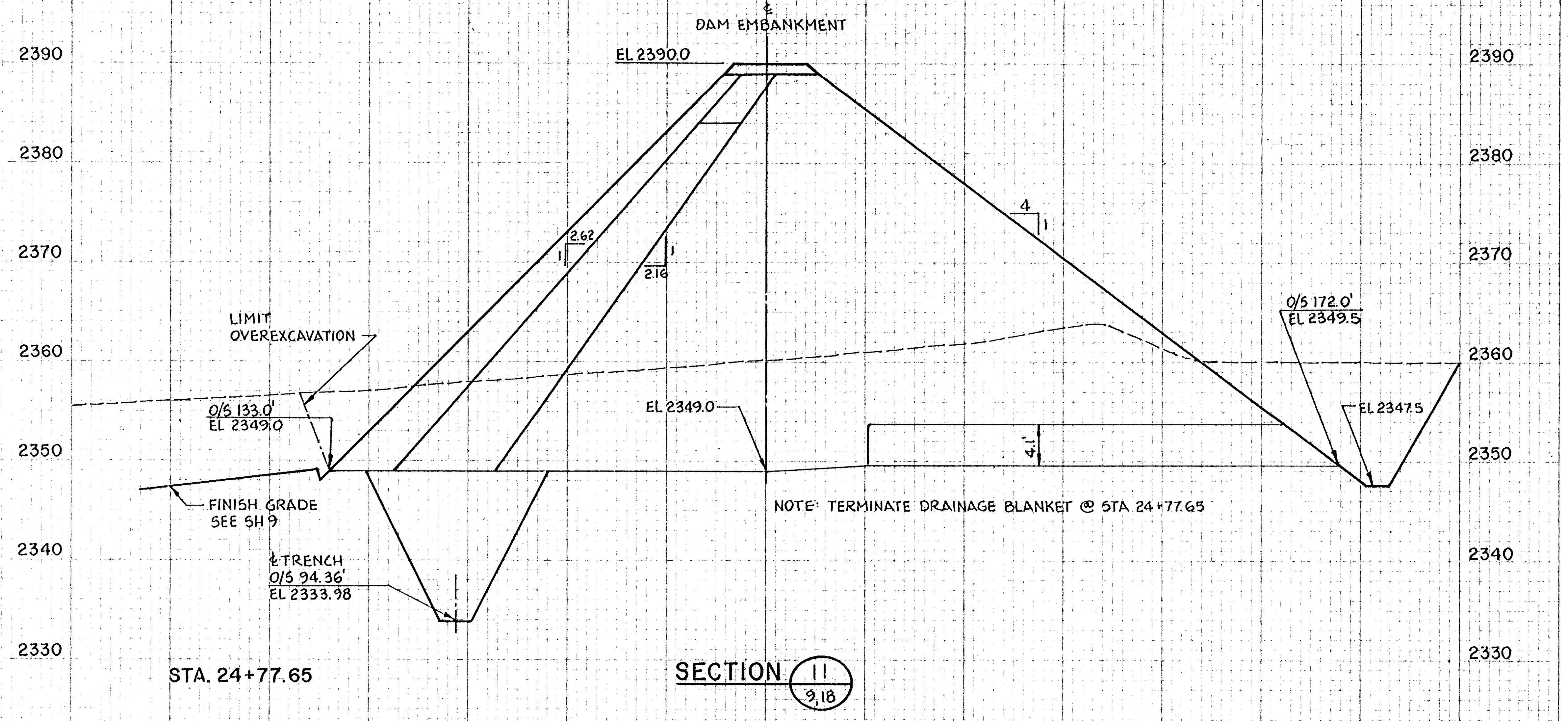
STA. 23+85

SECTION 9/9,18



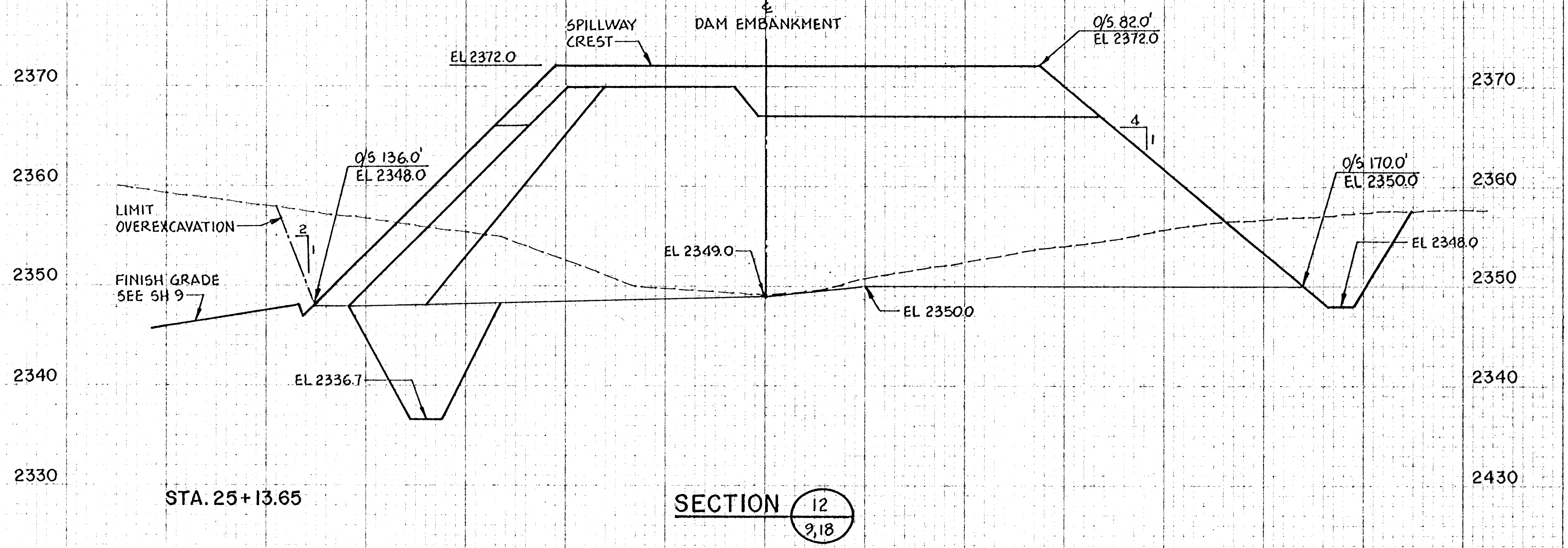
STA. 24+50

SECTION 10/9,18



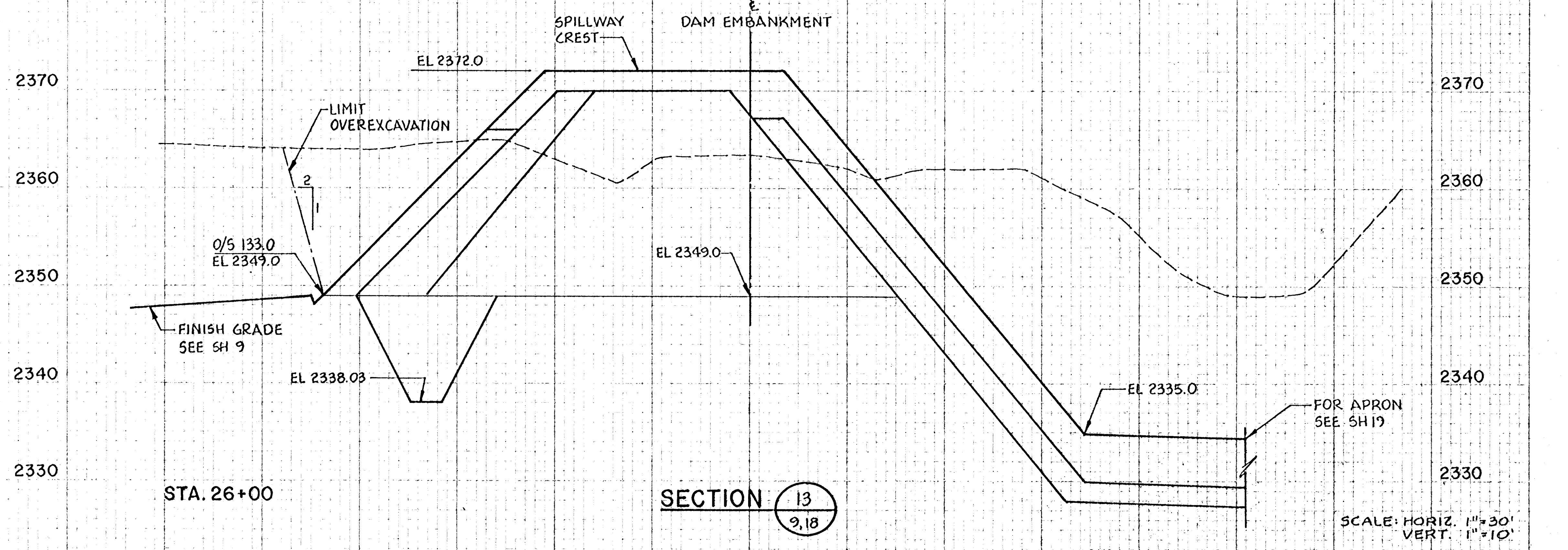
STA. 24+77.65

SECTION 11/9,18



STA. 25+13.65

SECTION 12/9,18



STA. 26+00

SECTION 13/9,18

SCALE: HORIZ. 1"=30'
VERT. 1"=10'

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10-26-93	AS BUILT		PT	SDC	CKA

DESIGNED PJR
DETAILED HLR
CHECKED DIH
APPROVED A C Roberts
DATE 5-28-91

Black & Veatch
Engineers-Architects
Las Vegas, Nevada

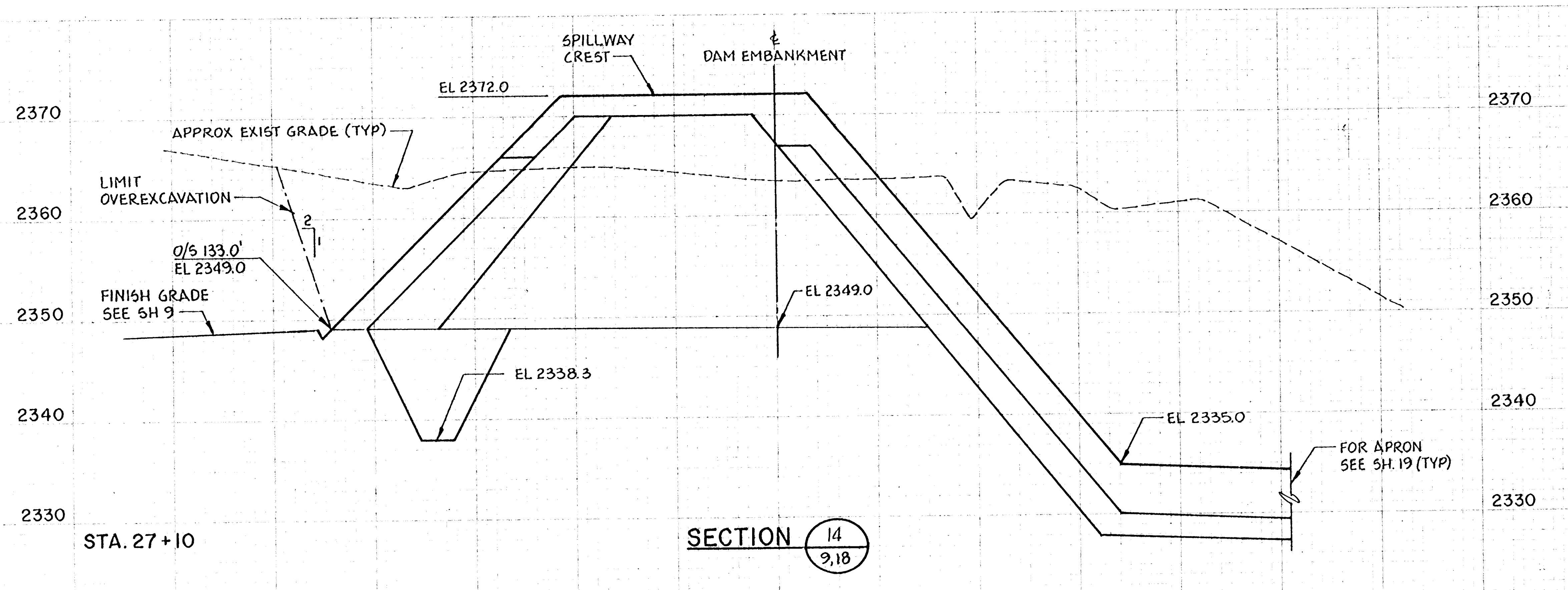
PROJECT NO.
17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH
DETENTION BASIN
DAM EMBANKMENT CROSS SECTIONS
STA. 22+00 TO STA. 26+00

DANA V. REEL
CIVIL
No. 7138

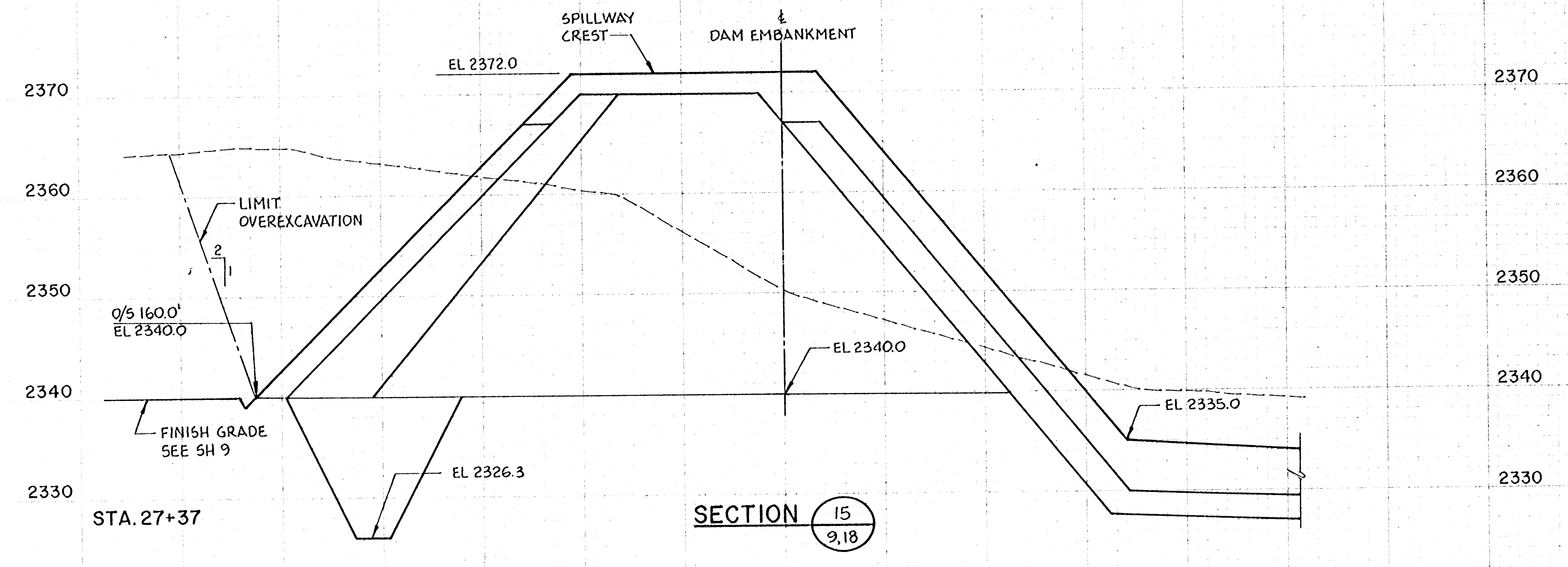
SHEET
15 OF 25

B&V-C-2436-A



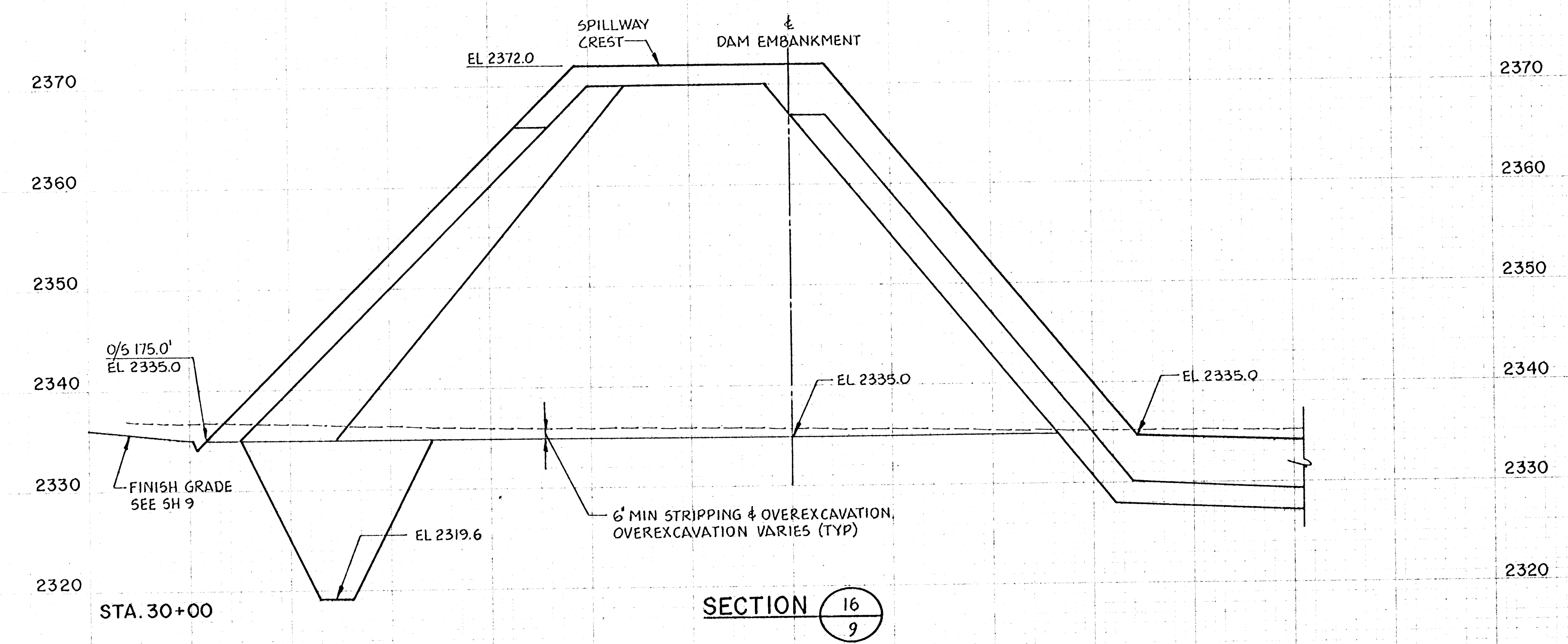
STA. 27+10

SECTION (14 / 9,18)



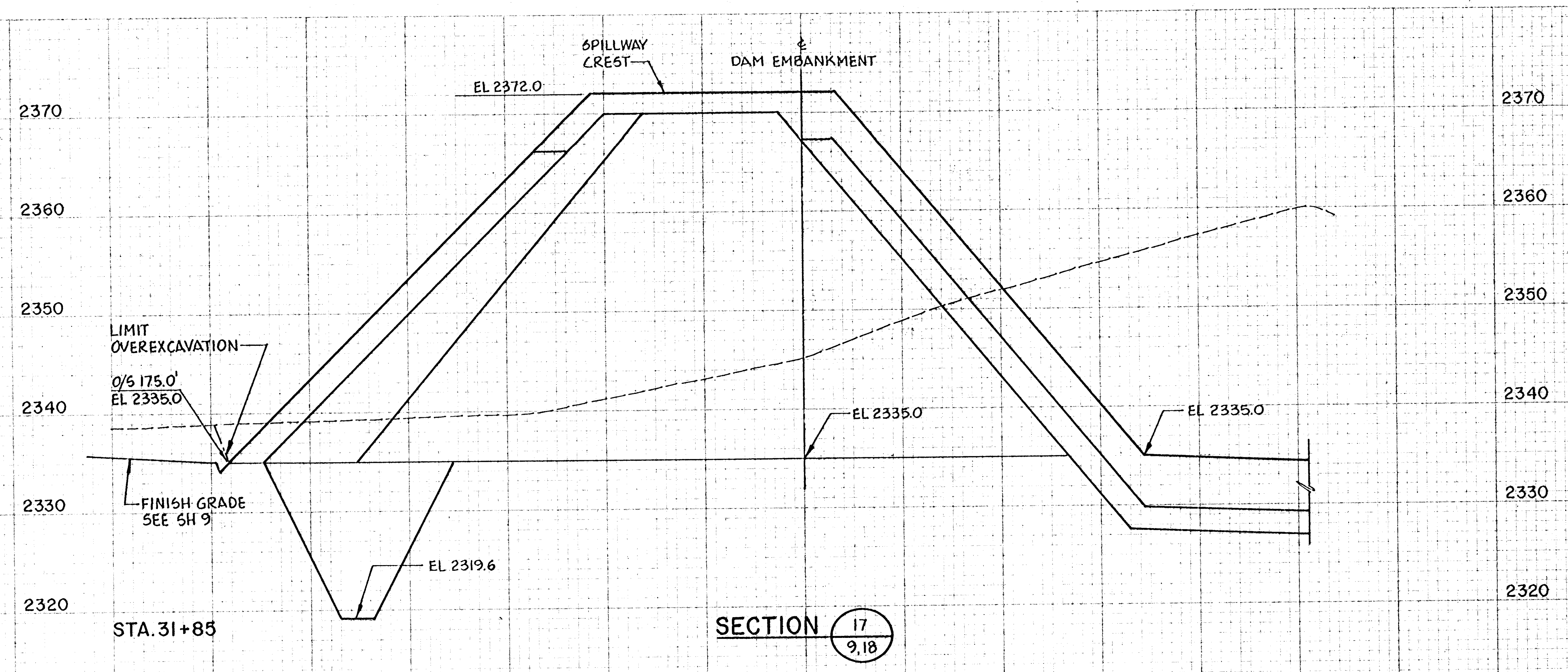
STA. 27+37

SECTION (15 / 9,18)



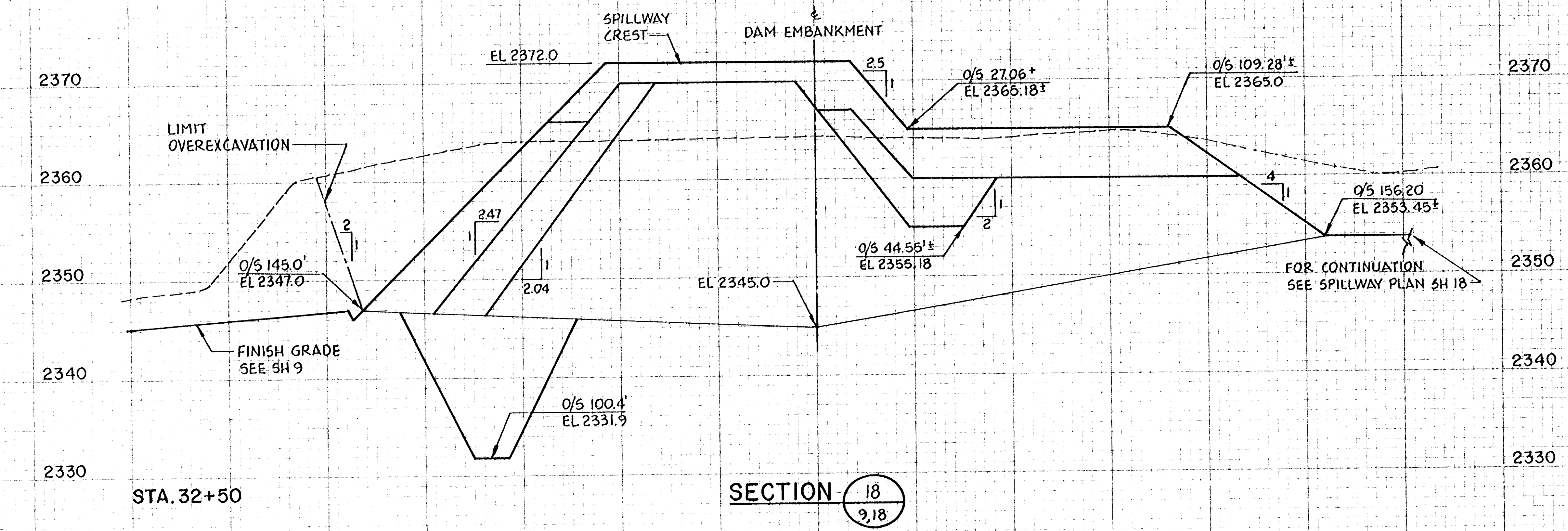
STA. 30+00

SECTION (16 / 9)



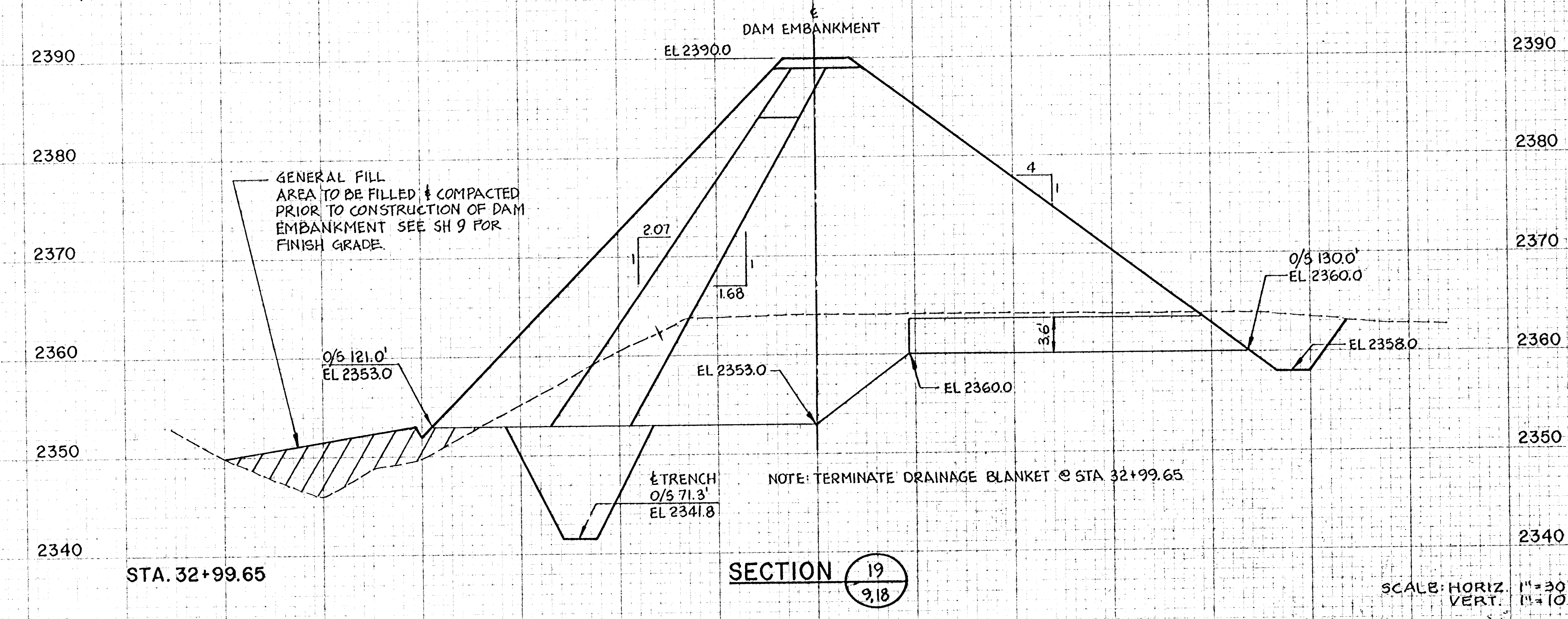
STA. 31+85

SECTION (17 / 9,18)



STA. 32+50

SECTION (18 / 9,18)



STA. 32+99.65

SECTION (19 / 9,18)

SCALE: HORIZ. 1"=30'
VERT. 1"=10'

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10-26-93	AS BUILT		PT	SDC	DCR

DESIGNED PJR
DETAILED HLR
CHECKED DIH
APPROVED A.C. Roberts
DATE 5-28-91

Black & Veatch
Engineers-Architects
Las Vegas, Nevada

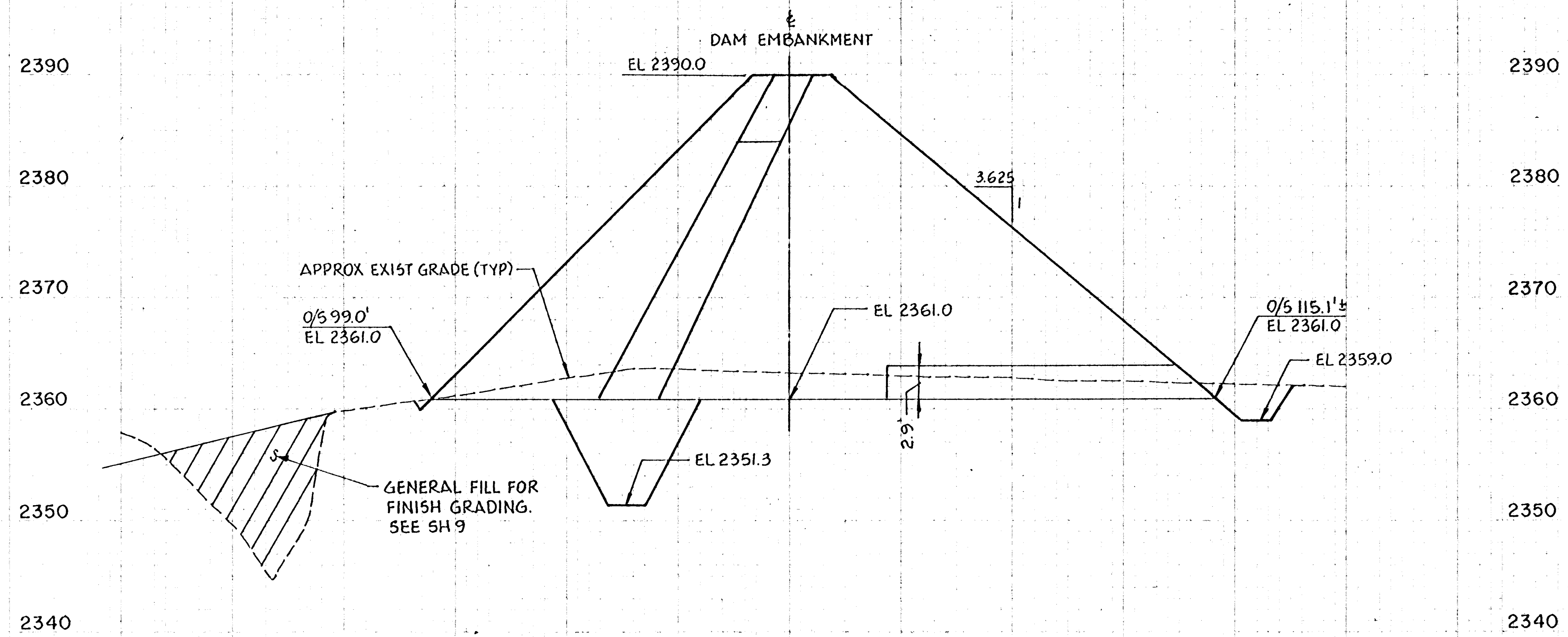
PROJECT NO. 17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH
DETENTION BASIN

DAM EMBANKMENT CROSS SECTIONS
STA. 27+10 TO STA. 33+00.65

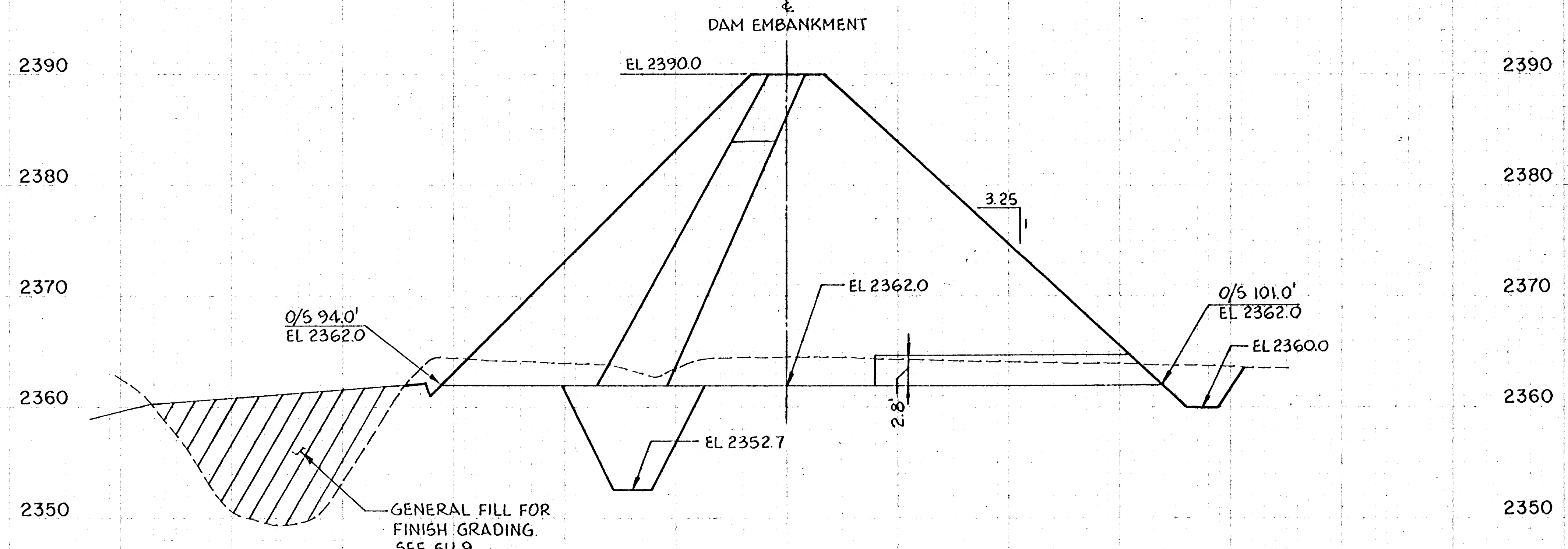
DANA V. REEL
CIVIL
No. 7138

SHEET 16 OF 25



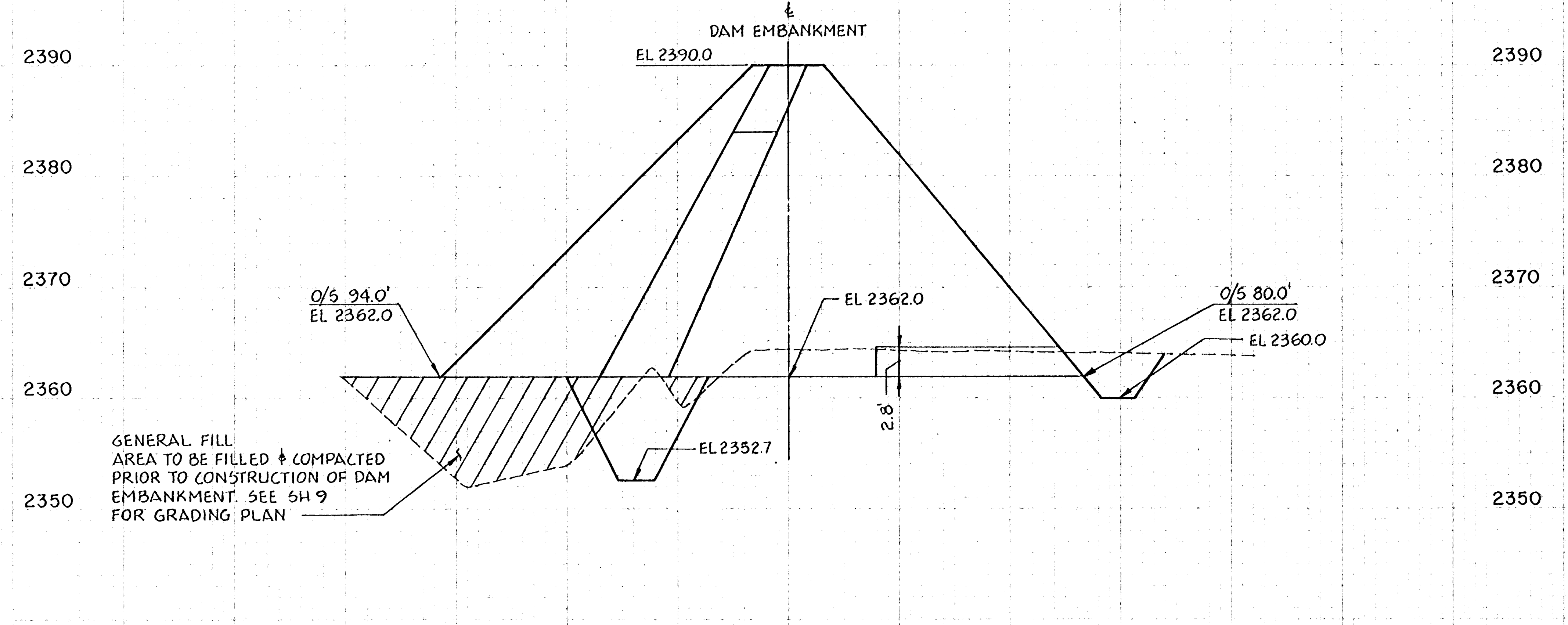
STA. 33+50

SECTION 20/9



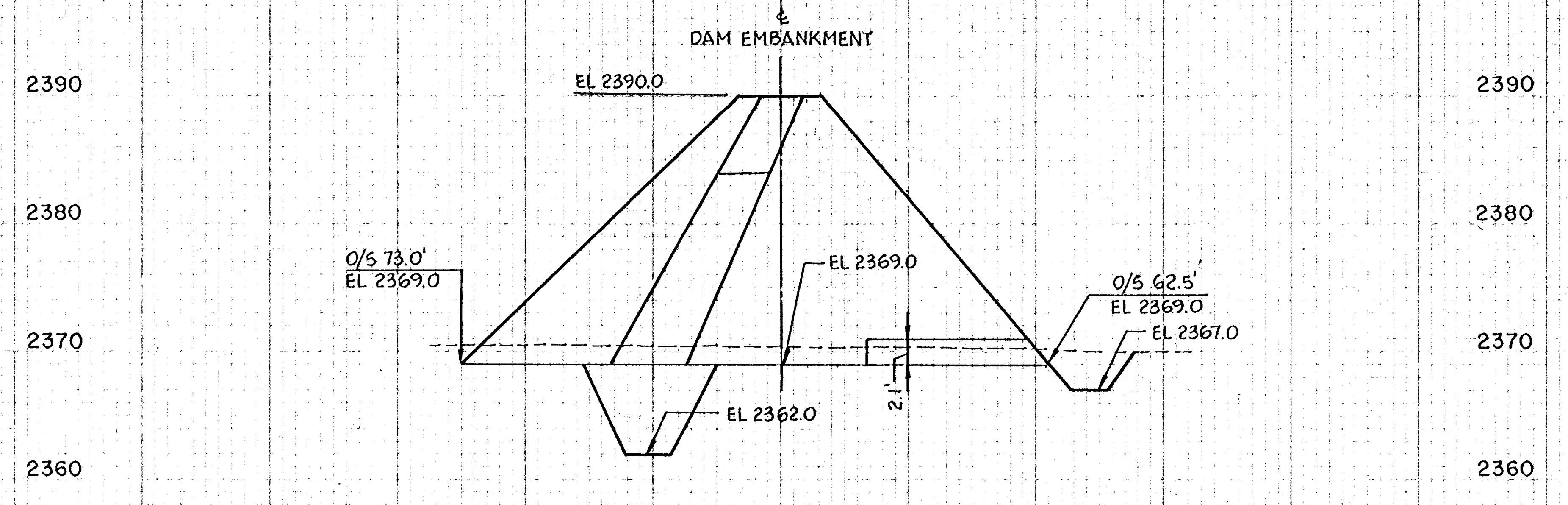
STA. 34+00

SECTION 21/9



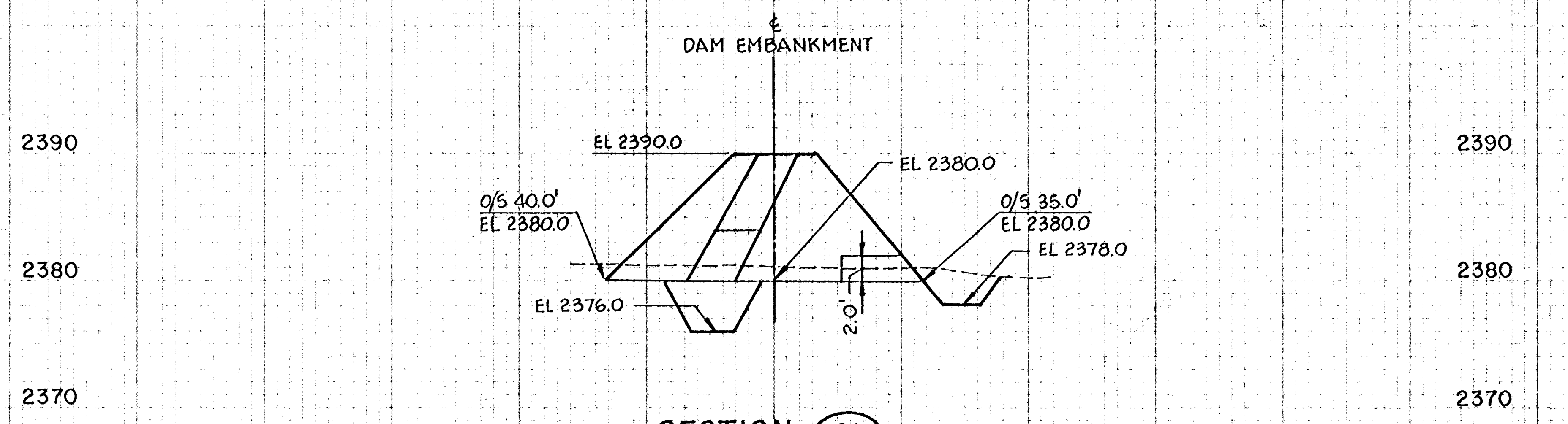
STA. 35+00

SECTION 22/9



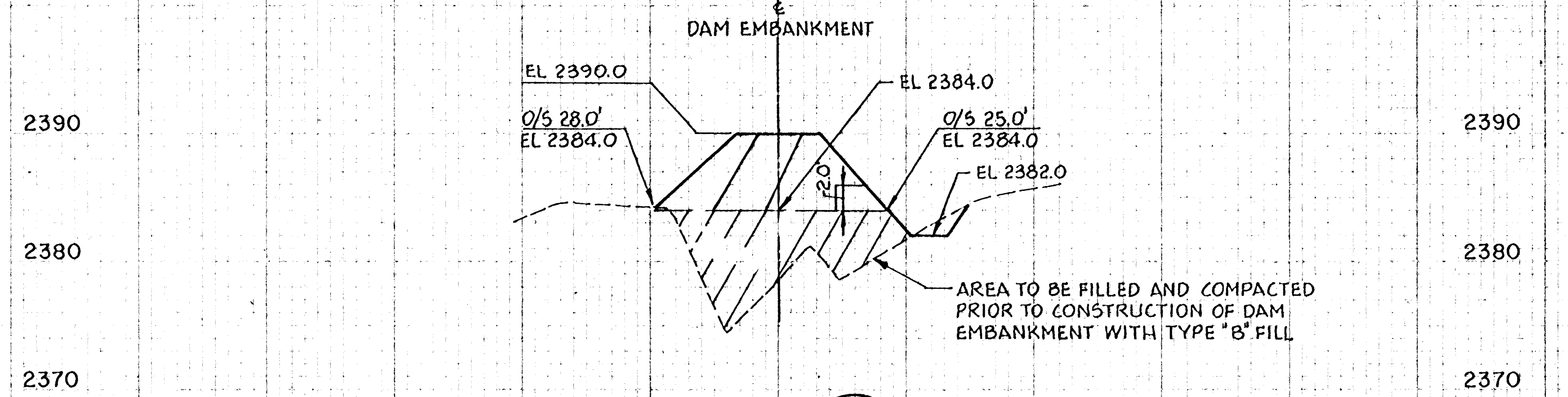
STA. 43+00

SECTION 23/10



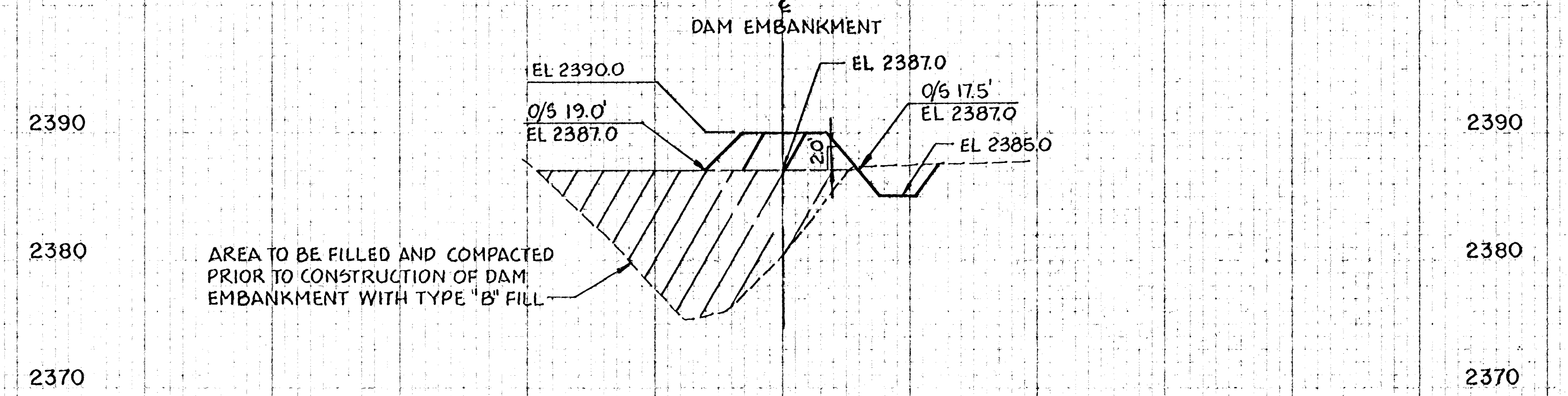
STA. 53+00

SECTION 24/10



STA. 59+00

SECTION 25/10



STA. 62+00

SECTION 26/10

SCALE: HORIZ. 1"=30'
VERT. 1"=10'

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10-26-93	AS BUILT		PT	[illegible]	[illegible]

DESIGNED PJR
DETAILED HLR
CHECKED DIH
APPROVED A.C. Roberts
DATE 5-28-91

Black & Veatch
Engineers-Architects
Las Vegas, Nevada

PROJECT NO.
17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH
DETENTION BASIN

DAM EMBANKMENT CROSS SECTIONS
STA. 33+50 TO STA. 62+00

REGISTERED PROFESSIONAL ENGINEER STATE OF NEVADA
DANA V. REEL
CIVIL
No. 7138

SHEET
17 OF 25

B&V-C-2436-A

SPILLWAY PLAN

1" = 30'

10-26-93	AS BUILT		PT	[illegible]	[illegible]
DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP

DESIGNED JWS
DETAILED AFV
CHECKED DIH
APPROVED A.C. Roberts
DATE 5-28-91

Black & Veatch
Engineers-Architects
Las Vegas, Nevada

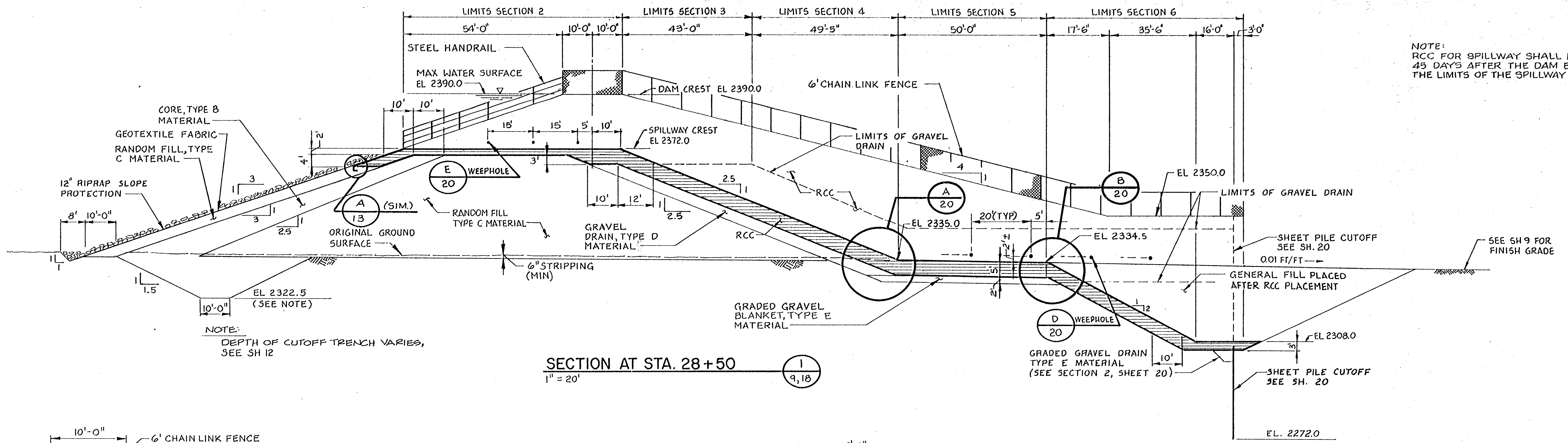
PROJECT NO. 17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH
DETENTION BASIN

SPILLWAY PLAN

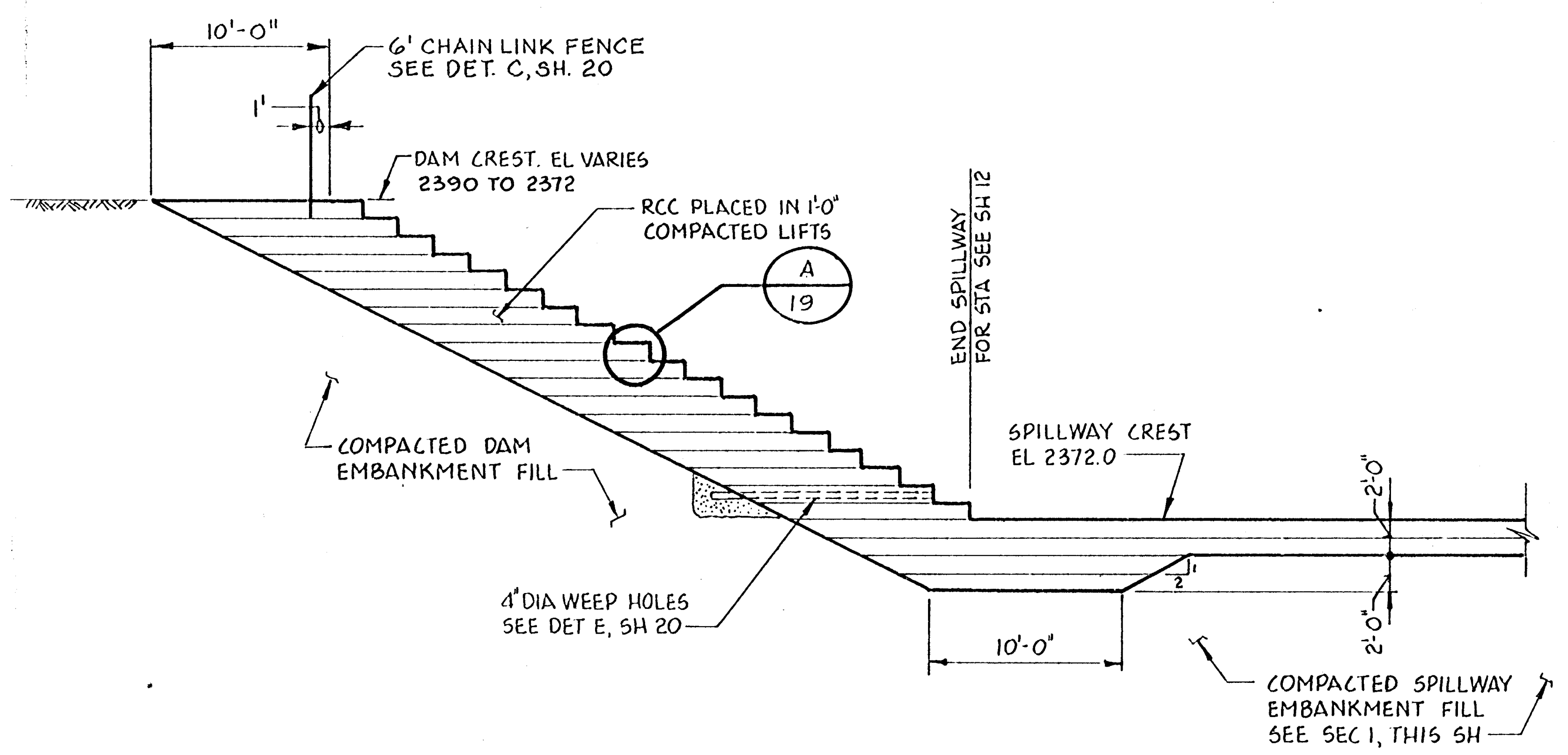
SHEET 18 OF 25

NOTE:
RCC FOR SPILLWAY SHALL NOT BE PLACED FOR 45 DAYS AFTER THE DAM EMBANKMENT WITHIN THE LIMITS OF THE SPILLWAY HAS BEEN COMPLETED.



SECTION AT STA. 28+50 (1 / 9,18)

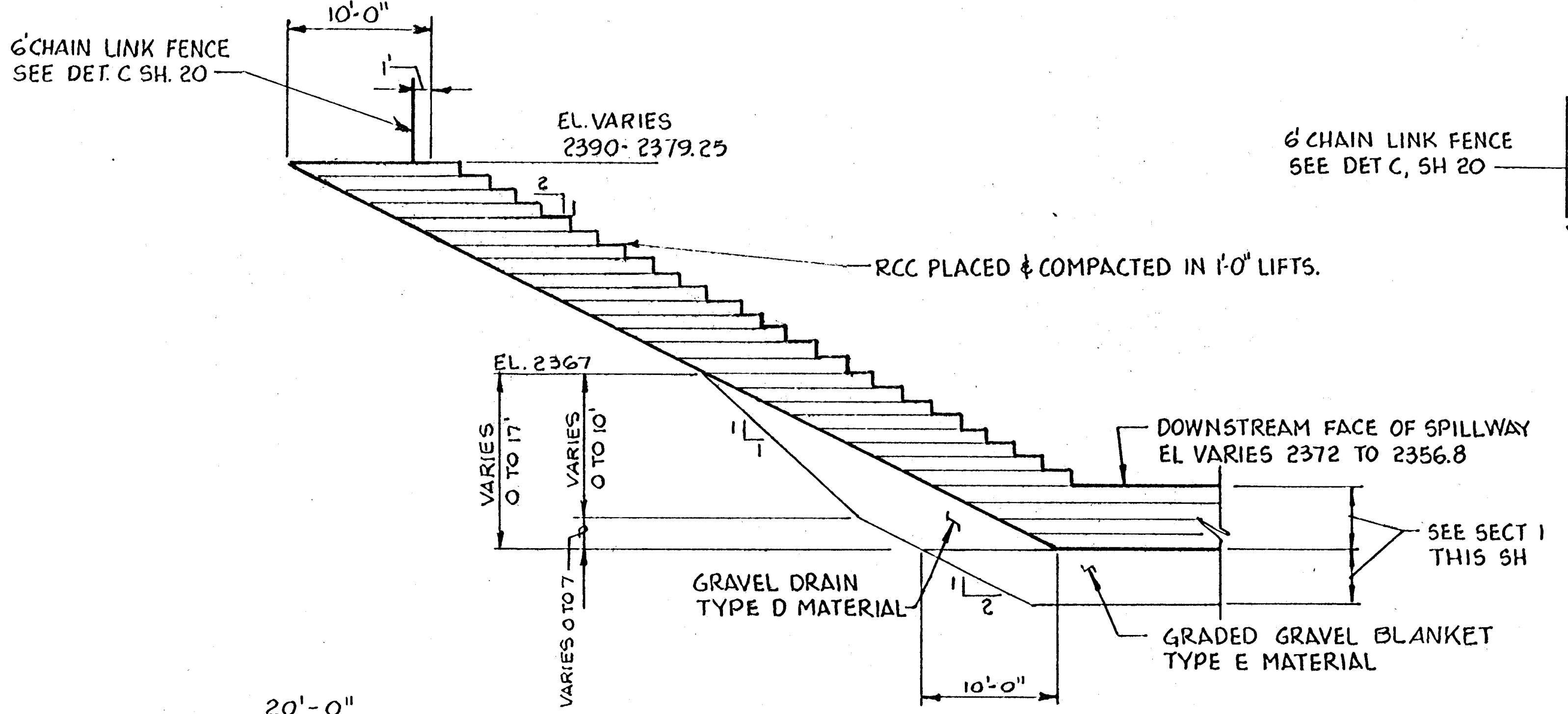
1" = 20'



SECTION (2 / 18)

1/8" = 1'-0"

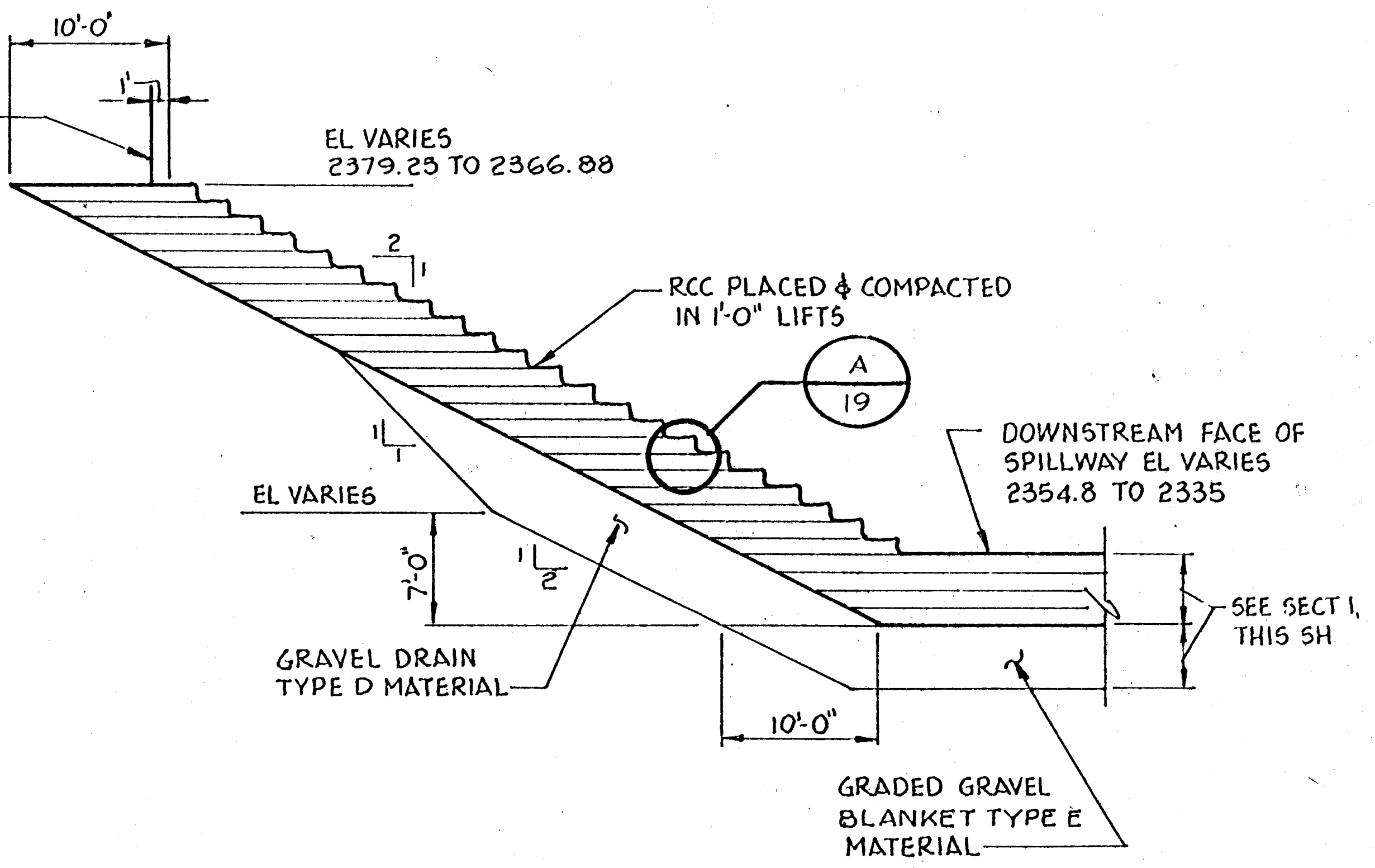
(OPPOSITE SIDE SIMILAR)



SECTION (3 / 18)

3/32" = 1'-0"

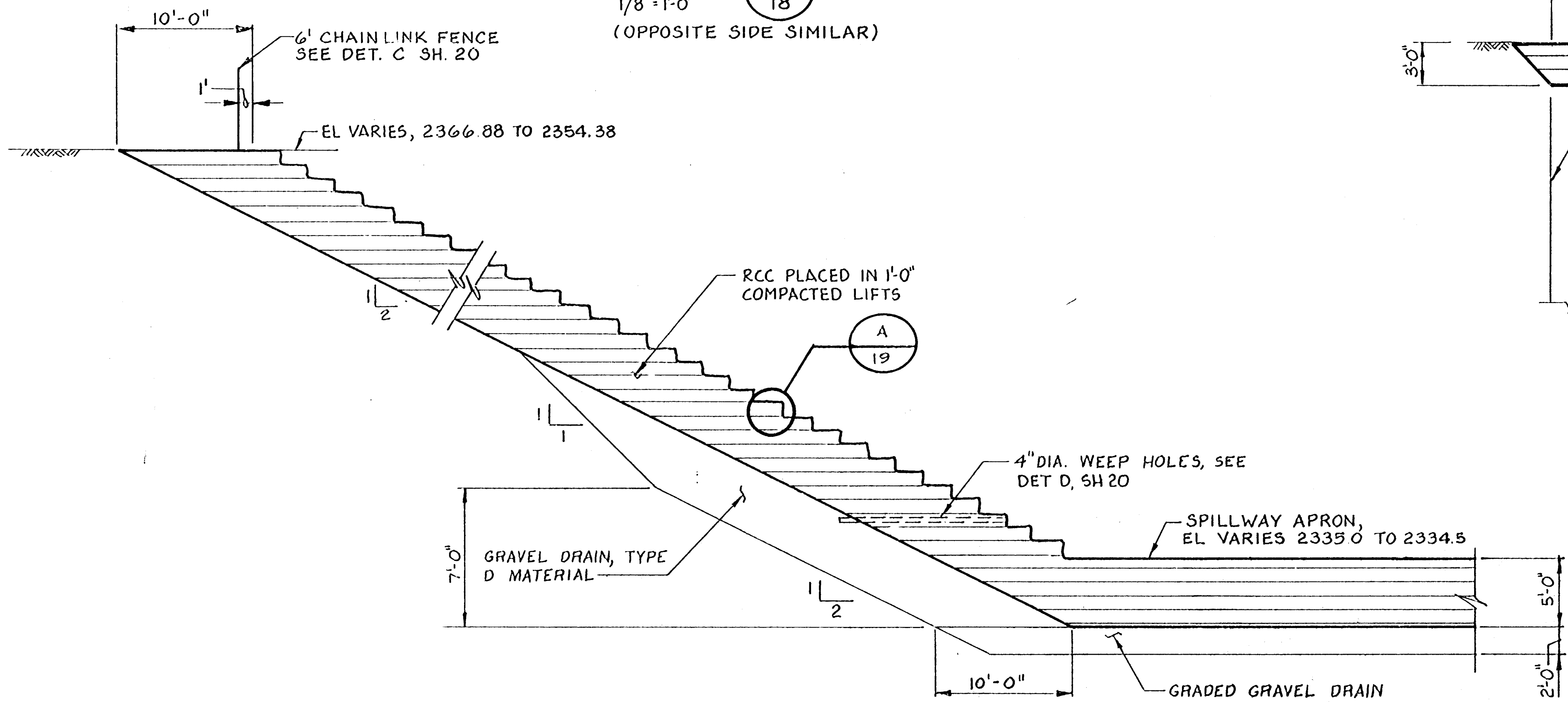
(OPPOSITE SIDE SIMILAR)



SECTION (4 / 18)

3/32" = 1'-0"

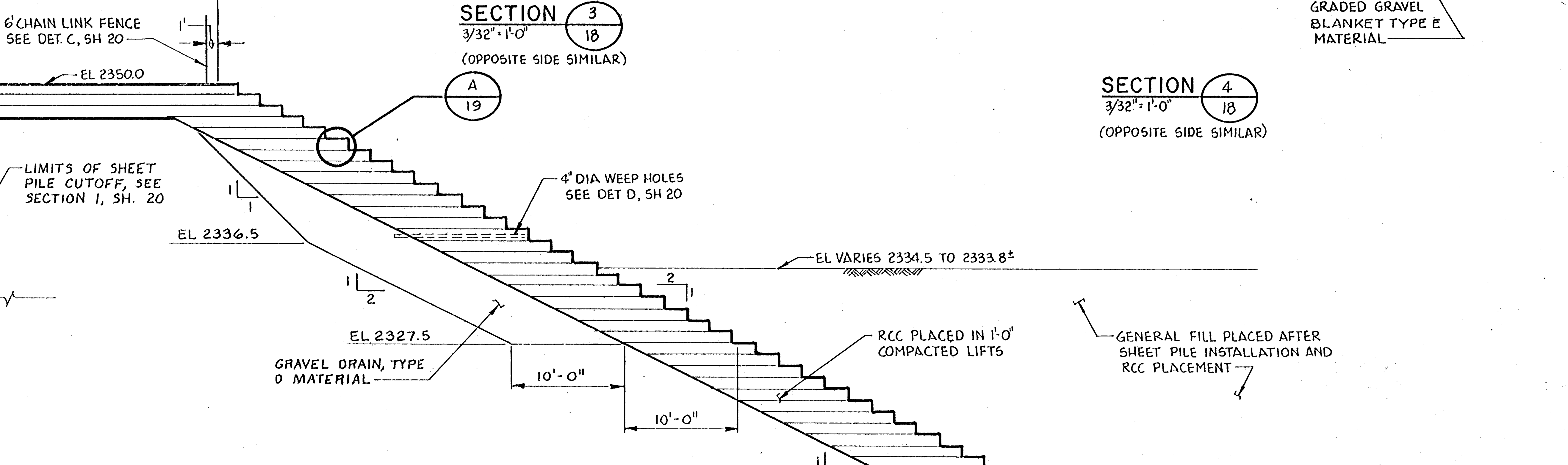
(OPPOSITE SIDE SIMILAR)



SECTION (5 / 18)

1/8" = 1'-0"

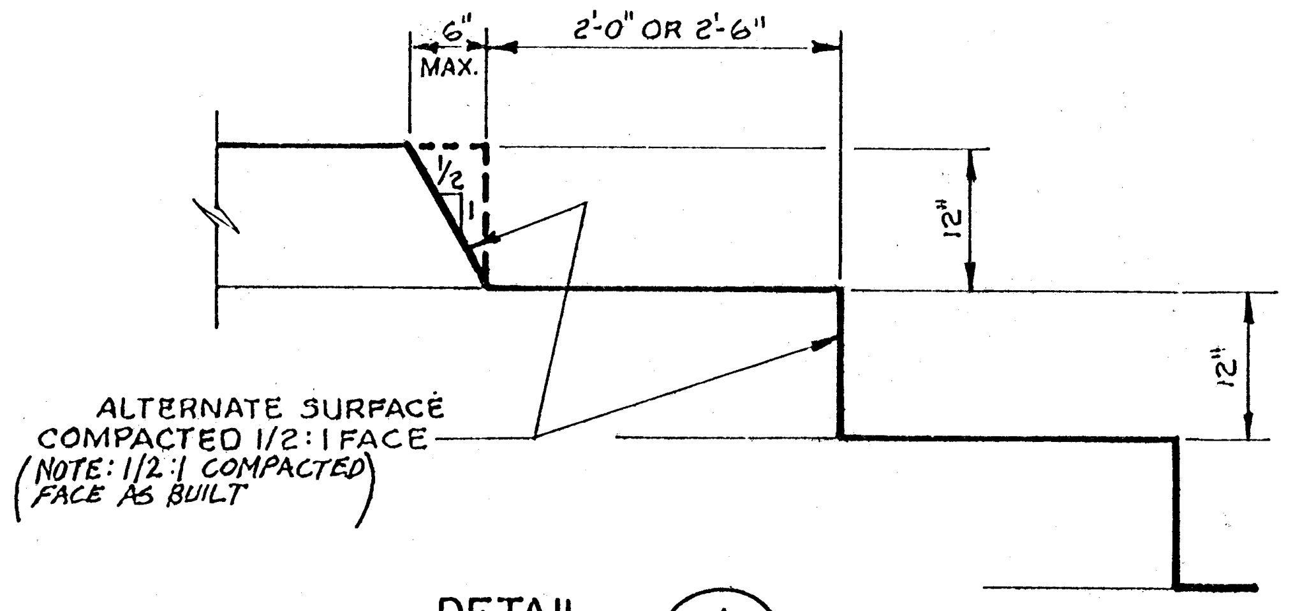
(OPPOSITE SIDE SIMILAR)



SECTION (6 / 18)

1/8" = 1'-0"

(OPPOSITE SIDE SIMILAR)



DETAIL (A / 19)

3/4" = 1'-0"

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10-26-93	AS BUILT		PT	[illegible]	[illegible]

DESIGNED JWS
DETAILED HLR
CHECKED DIH
APPROVED G.C. Roberts
DATE 5-28-91

Black & Veatch
Engineers-Architects
Las Vegas, Nevada

PROJECT NO.
17149

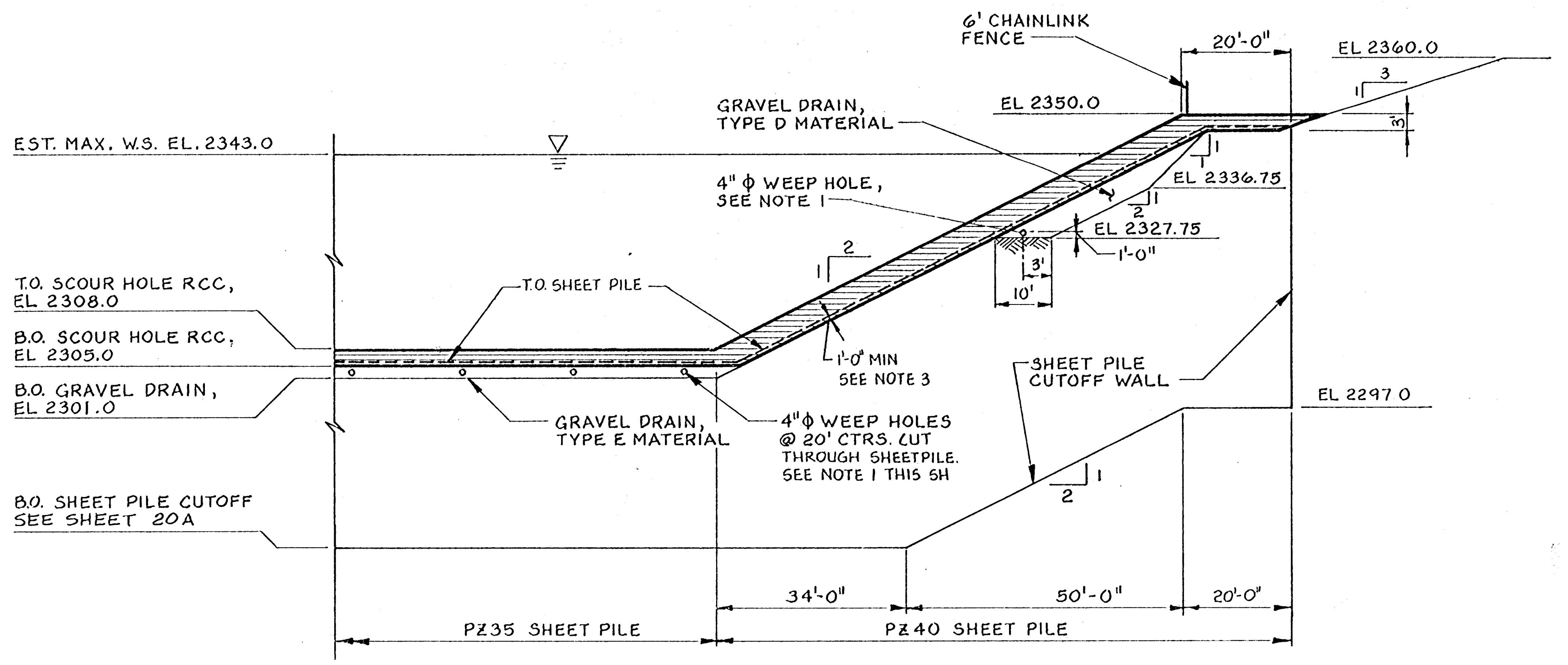
CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH
DETENTION BASIN

SPILLWAY SECTIONS

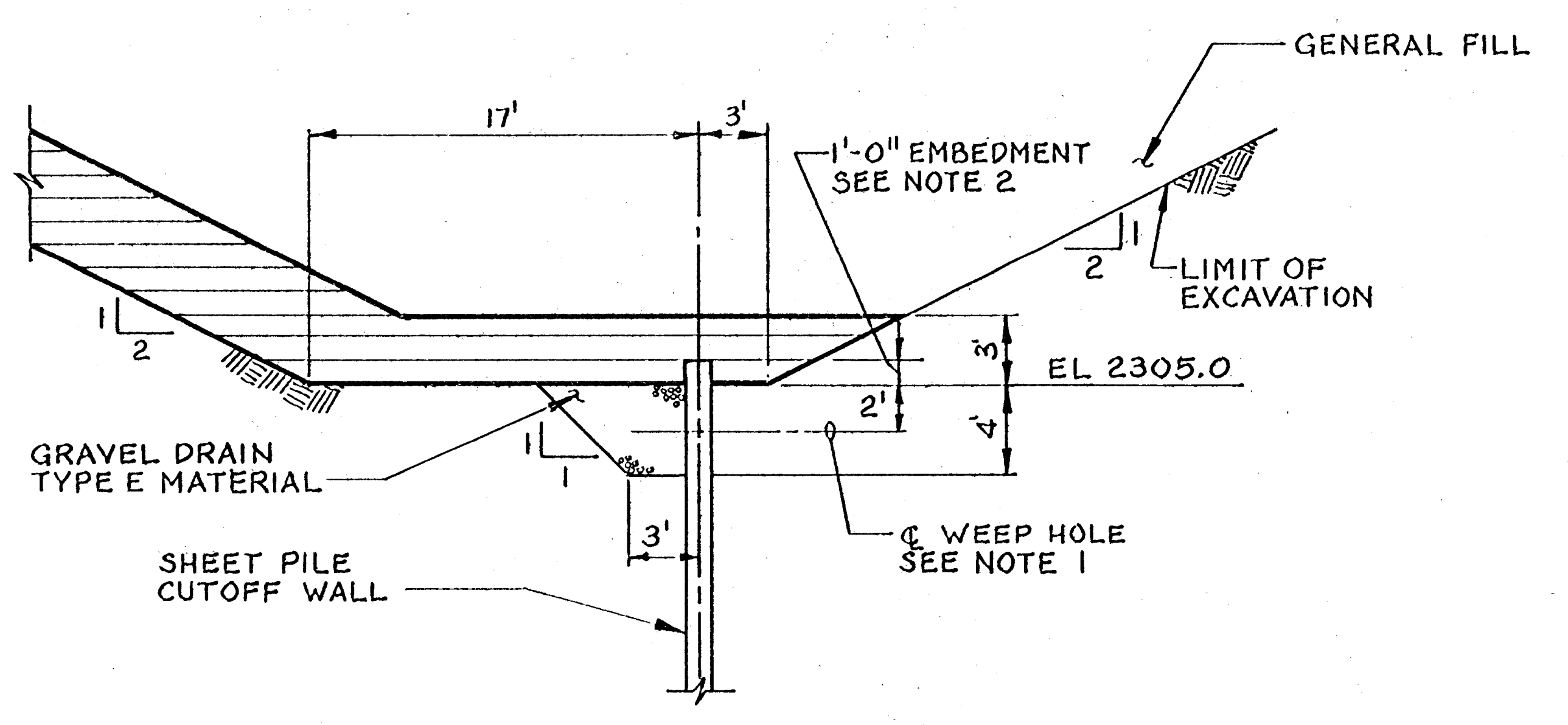
DANA V. REEL
CIVIL
No. 1138

SHEET
19 OF 25

B&V C-2436-D

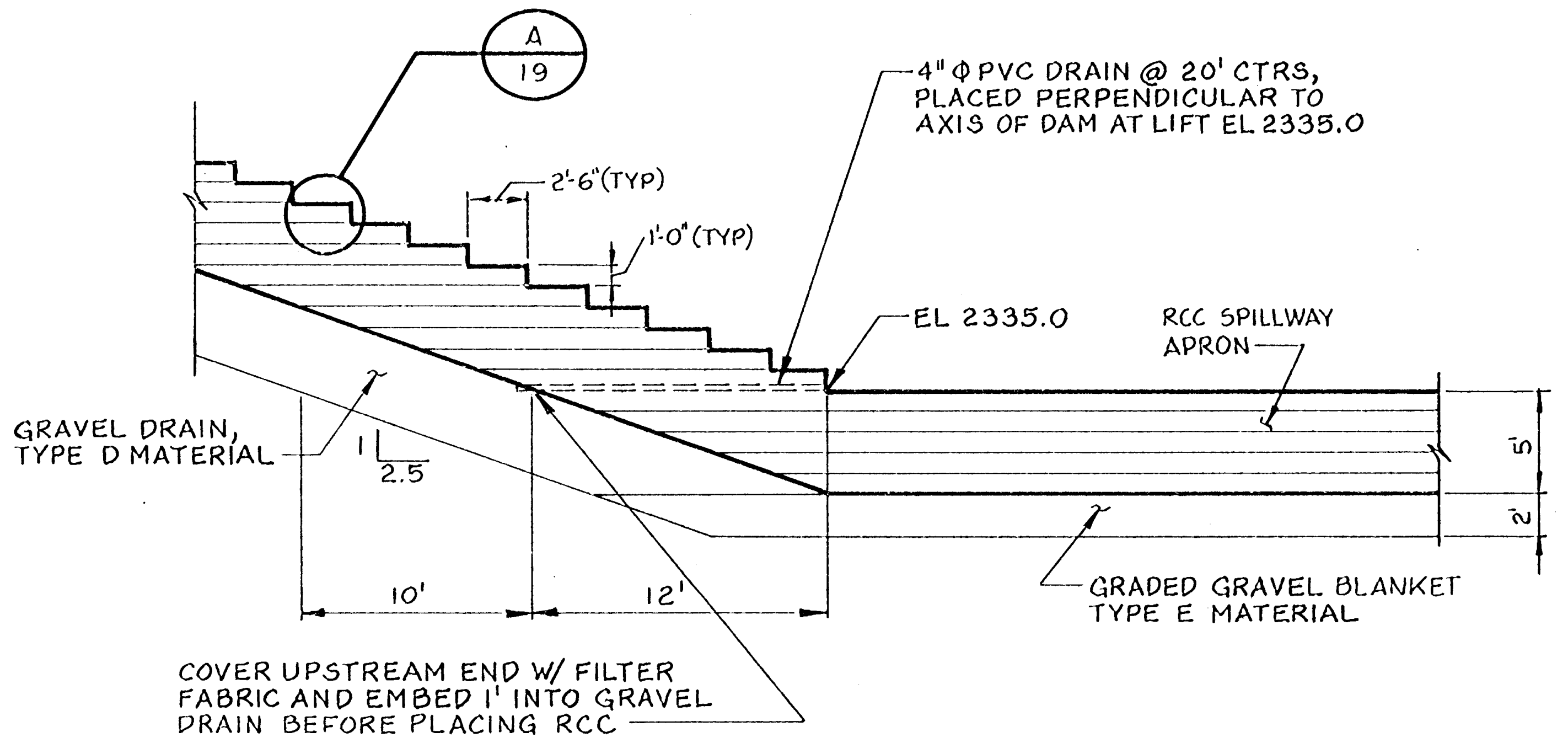


SECTION 1/18
1" = 20'
(OPPOSITE SIDE SIMILAR)

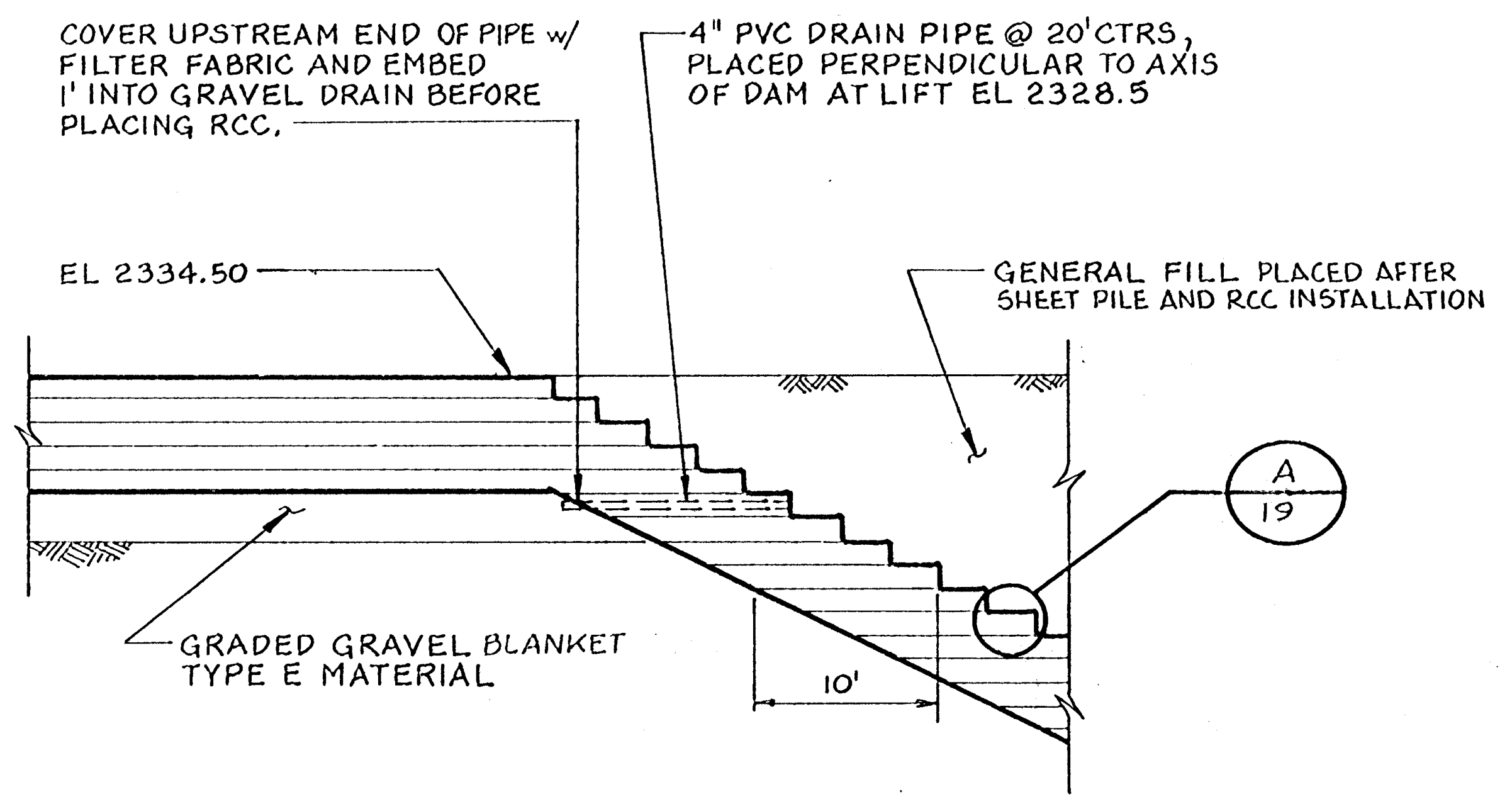


SECTION 2/18
1/8" = 1'-0"

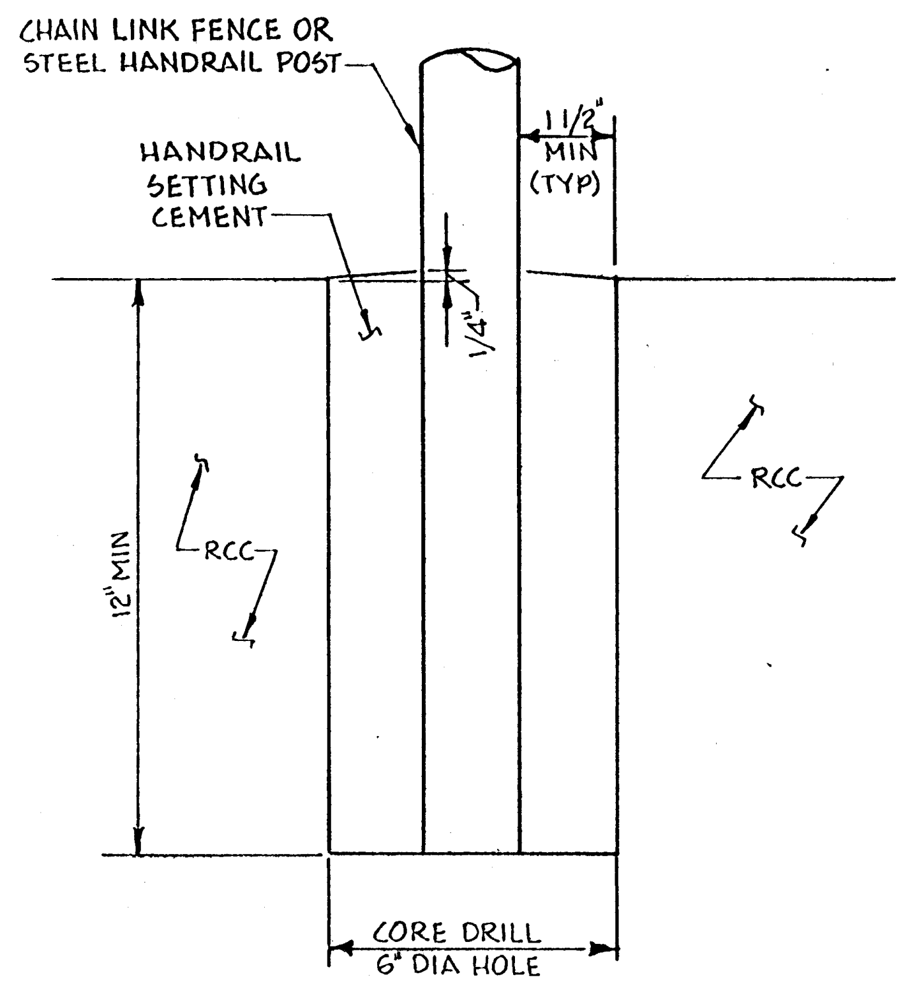
NOTES:
1. CUT 4" DIA WEEP HOLE THROUGH CENTER OF 1/2" THICK SECTION (CENTER SECTION) OF Z PILE. SECURE 12" SQUARE DRAINAGE NET (POLYNET 3000 OR EQUAL) TO UPSTREAM SIDE OF WEEP HOLE BEFORE BACKFILLING WITH TYPE D OR TYPE E MATERIAL.
2. FIRST LIFT OF RCC IN SCOUR HOLE AT EL 2305.0 AND ON 20' WIDE PAD AT EL 2350.0 MAY BE UP TO 1'-6" THICK TO PROVIDE COVER OVER SHEET PILING FOR COMPACTION EQUIPMENT.
3. CONTRACTOR SHALL HAND COMPACT THE RCC ADJACENT TO THE SLOPING TOP OF SHEET PILE CONCURRENTLY WITH PLACEMENT OF EACH LIFT OF RCC.



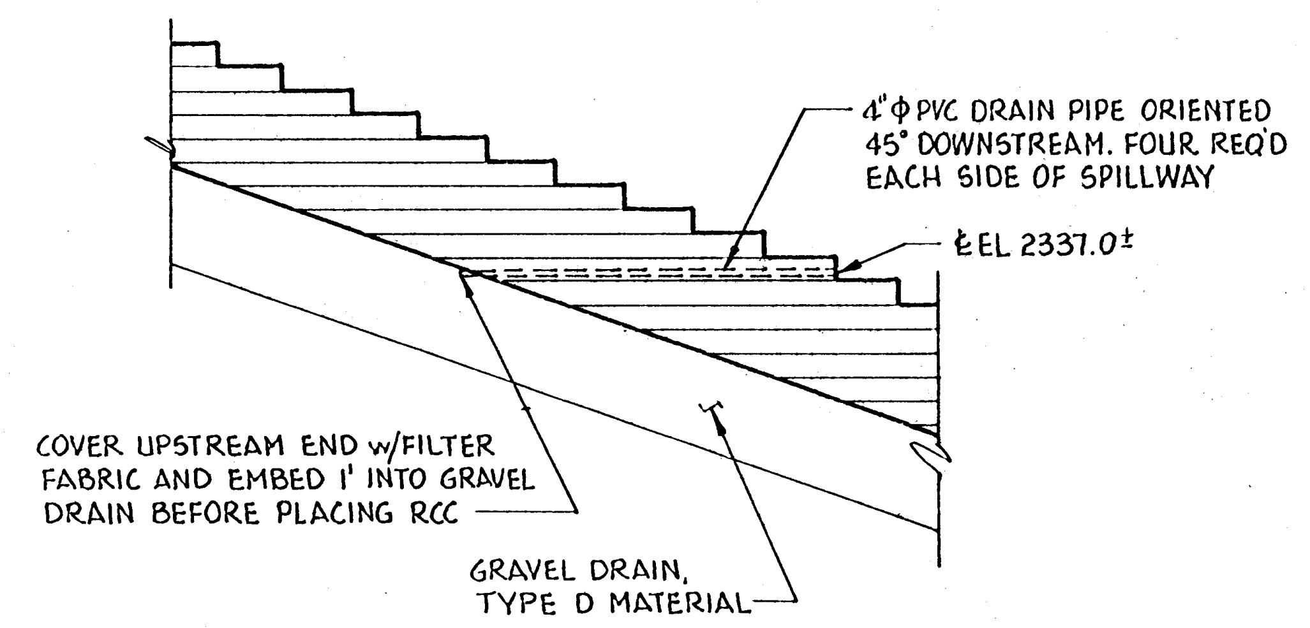
DETAIL A/19
1/8" = 1'-0"



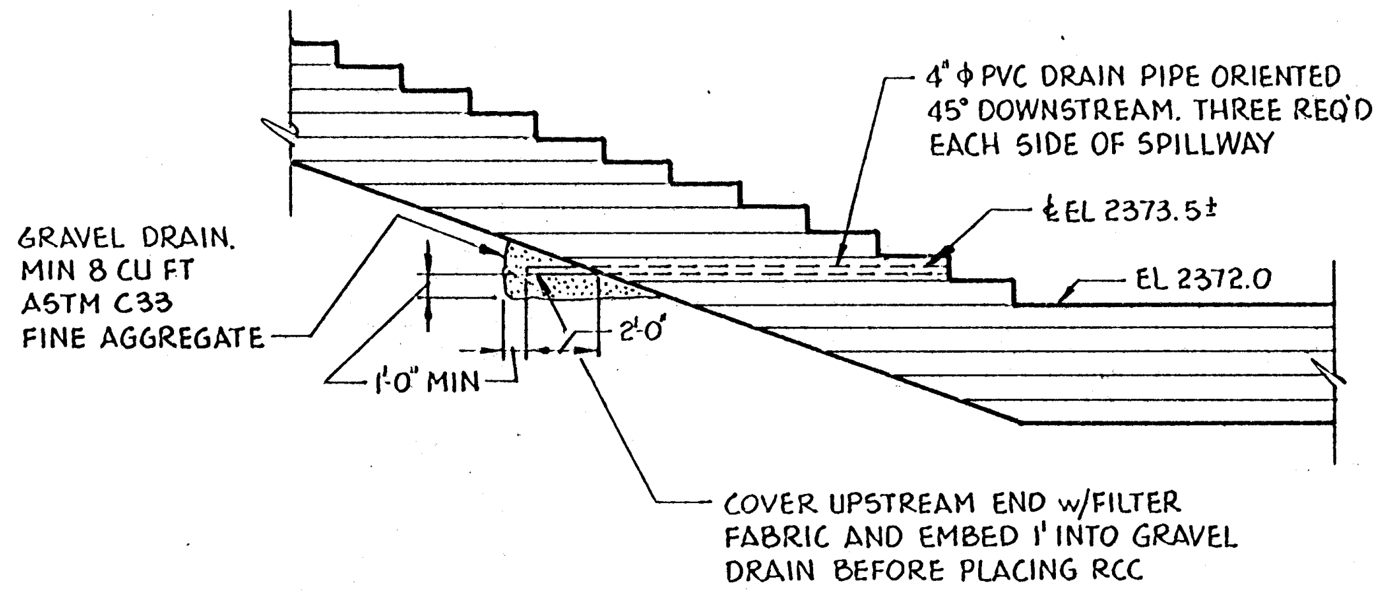
DETAIL B/19
1/8" = 1'-0"



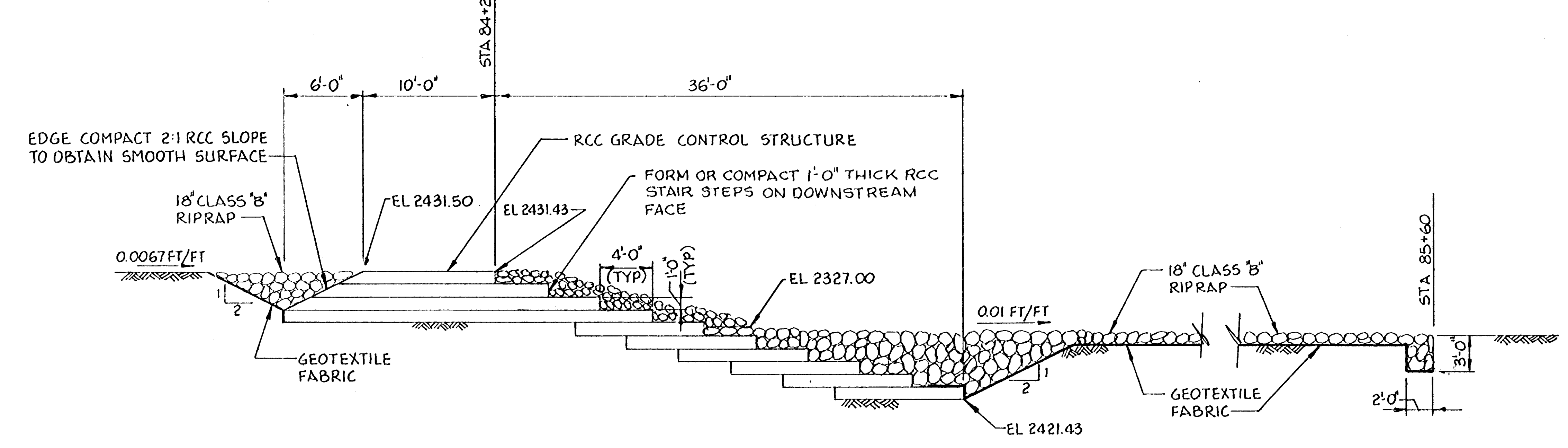
POST SETTING DETAIL C/19
3" = 1'-0"



DETAIL D/19
1/8" = 1'-0"

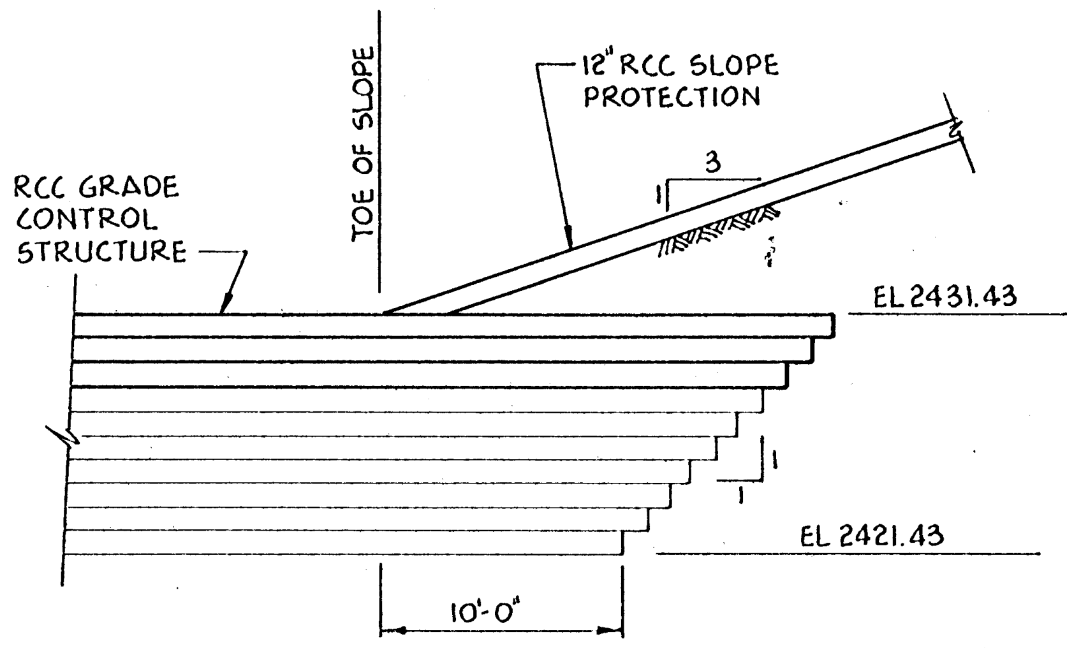


DETAIL E/19
1/8" = 1'-0"

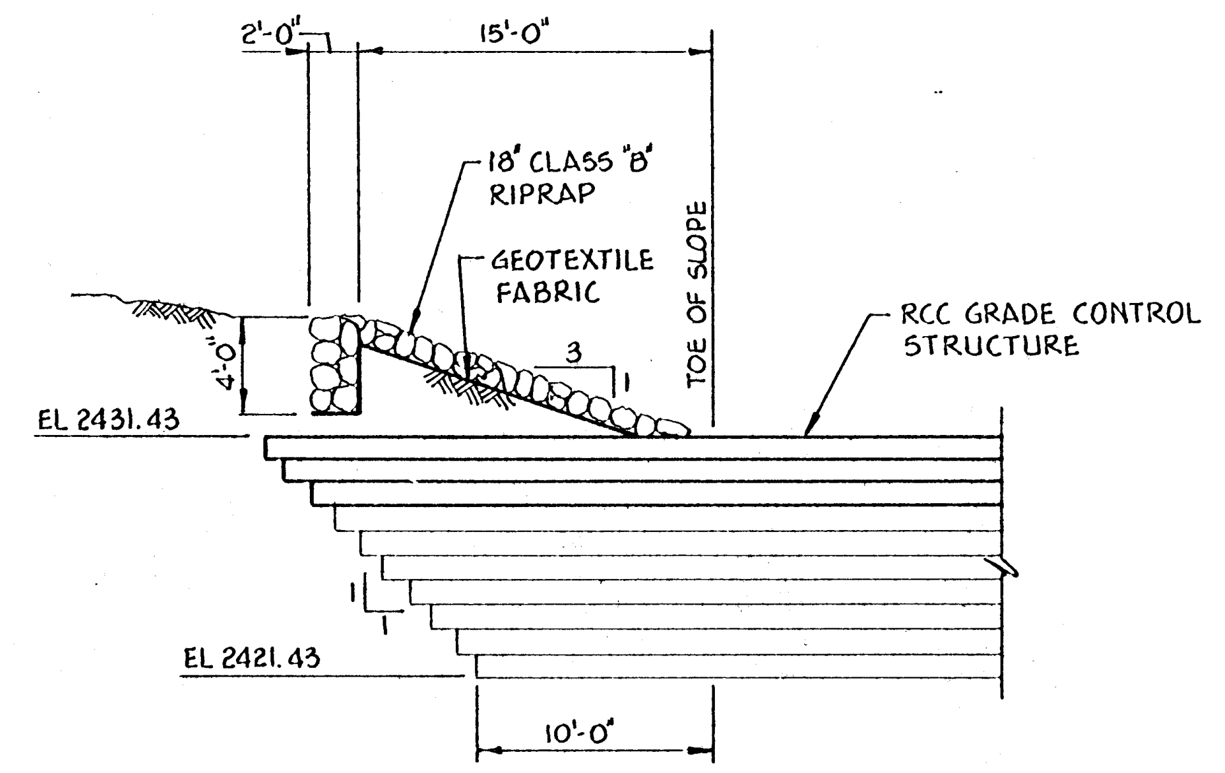


SECTION 3/6
1/8" = 1'-0"

NOTE:
GRADE CONTROL STRUCTURE SHALL SERVE AS RCC TEST SECTION AS REFERENCED IN THE SPECIFICATION.



SECTION 4/6
1/8" = 1'-0"



SECTION 5/6
1/8" = 1'-0"

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10-26-93	AS BUILT		PT	SDC	ACK

DESIGNED JWS, SDC
DETAILED AFV, HLR
CHECKED DIH
APPROVED AC Roberts
DATE 5-28-91

Black & Veatch
Engineers - Architects
Las Vegas, Nevada

PROJECT NO.
17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH
DETENTION BASIN

SPILLWAY
SECTIONS AND DETAILS

DANA V. REEL
CIVIL
No. 1138

SHEET
20 OF 25

SOUTH END

AS-BUILT PENETRATION EL (TYP)

NORTH END

LEGEND

PZ35
PZ40
XX SHEET PILE PAIR NUMBER
X NORTH (OR SOUTH) END

10-21-93	AS-BUILT		PAT	
DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK APP

DESIGNED
DETAILED PAT
CHECKED SDC
APPROVED
DATE

Black & Veatch
Las Vegas, Nevada

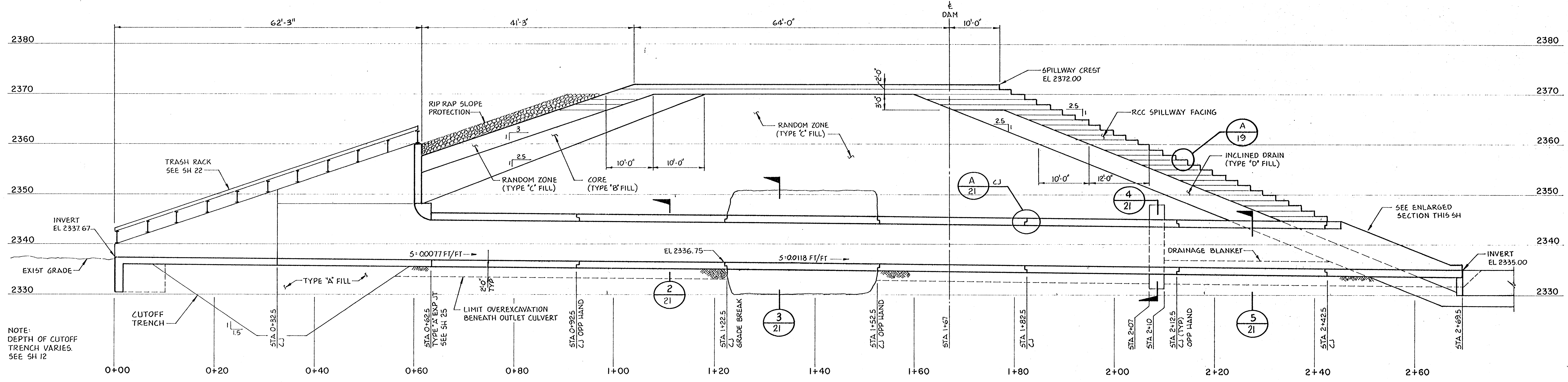
PROJECT NO.
17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH DETENTION BASIN

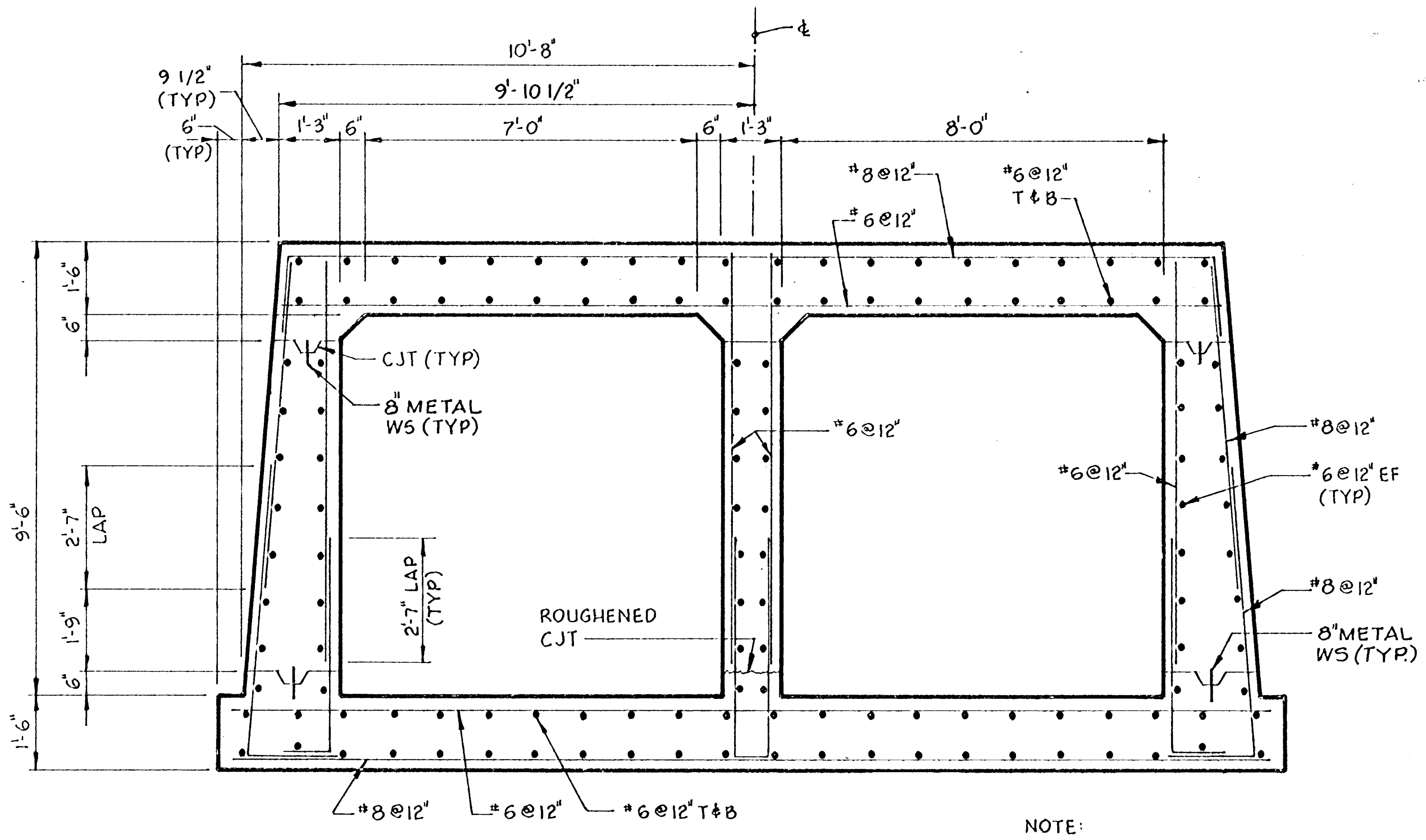
SHEET PILE CUTOFF WALL
AS BUILT PENETRATION

SHEET
20A OF 25

CCG. DWG. NO:XXX

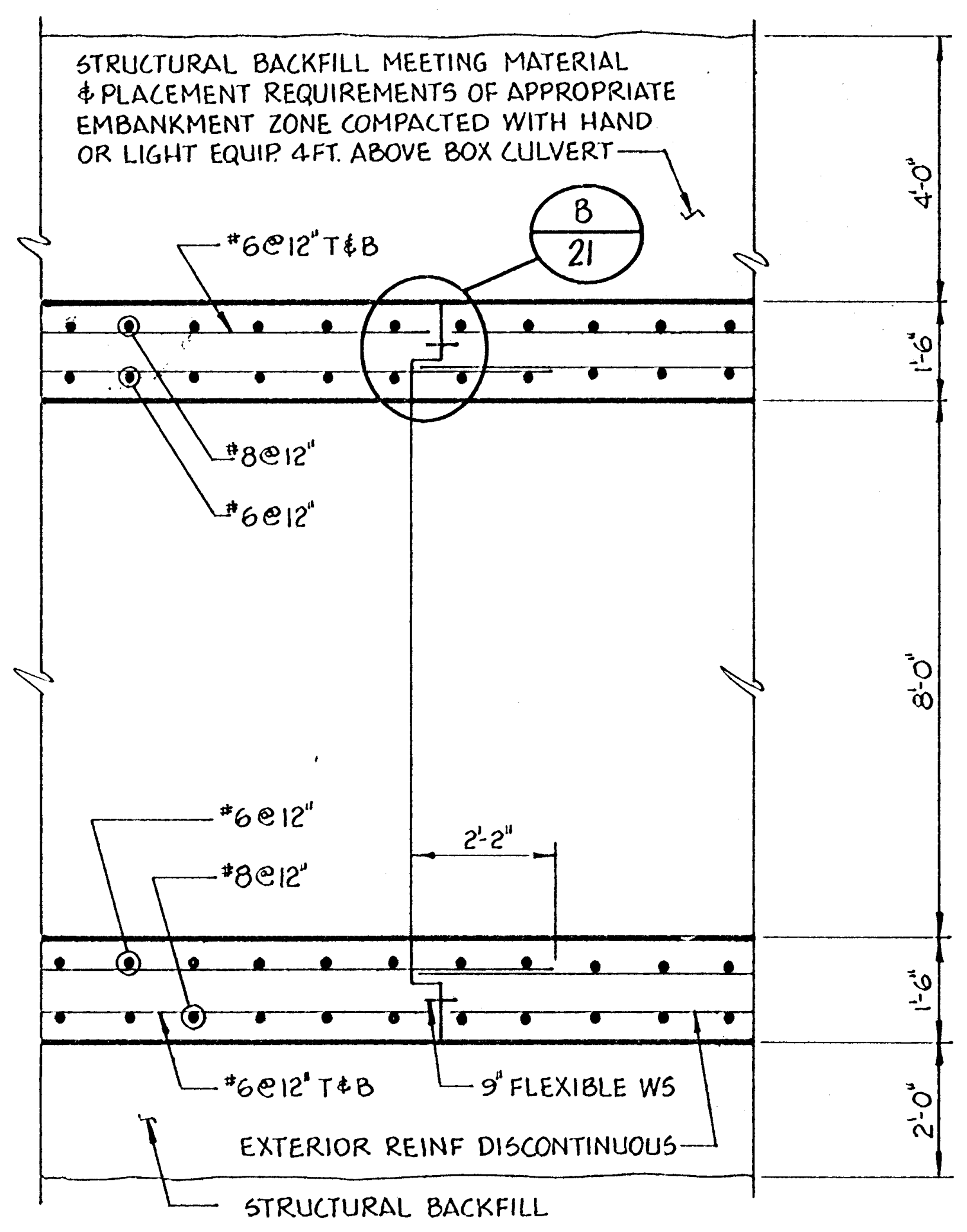


SECTION 1/18
1"=10'

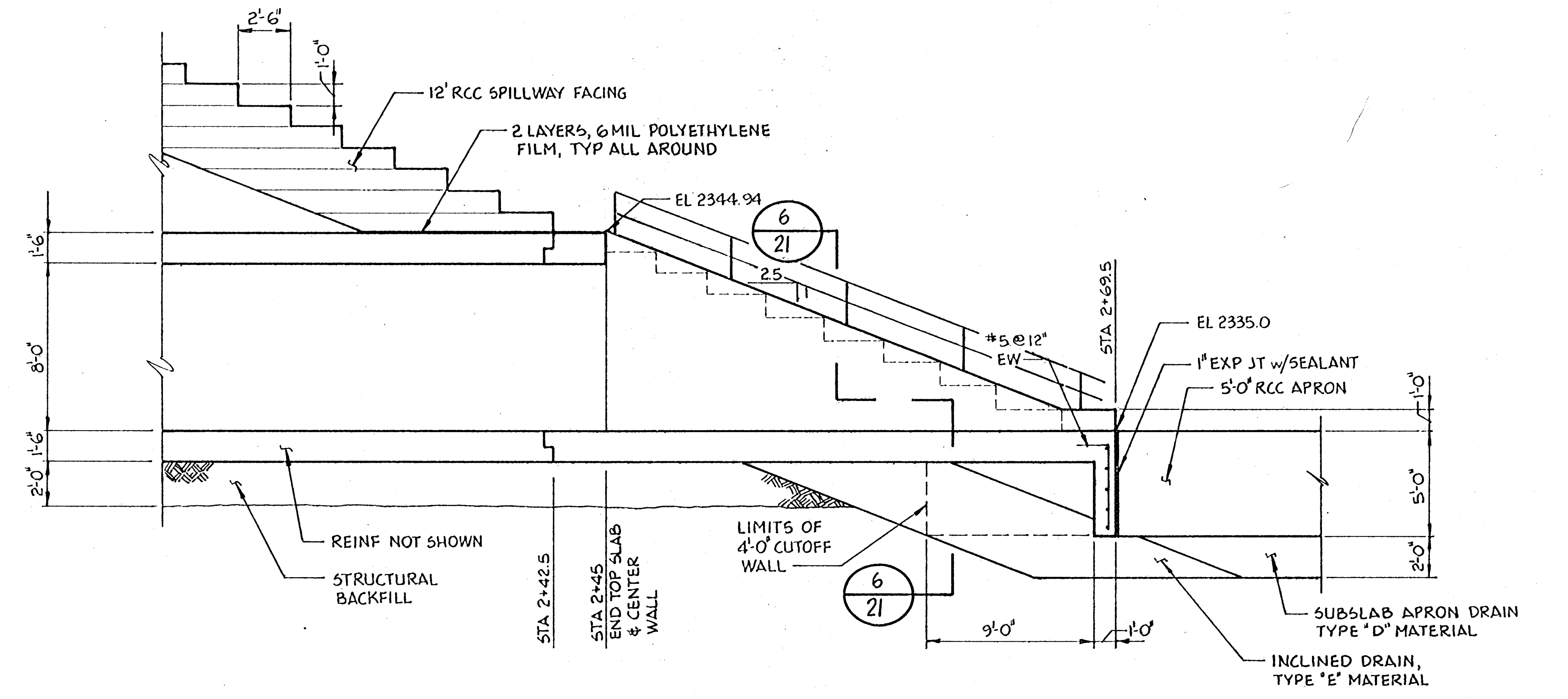


SECTION 2/21
3/8"=1'-0"

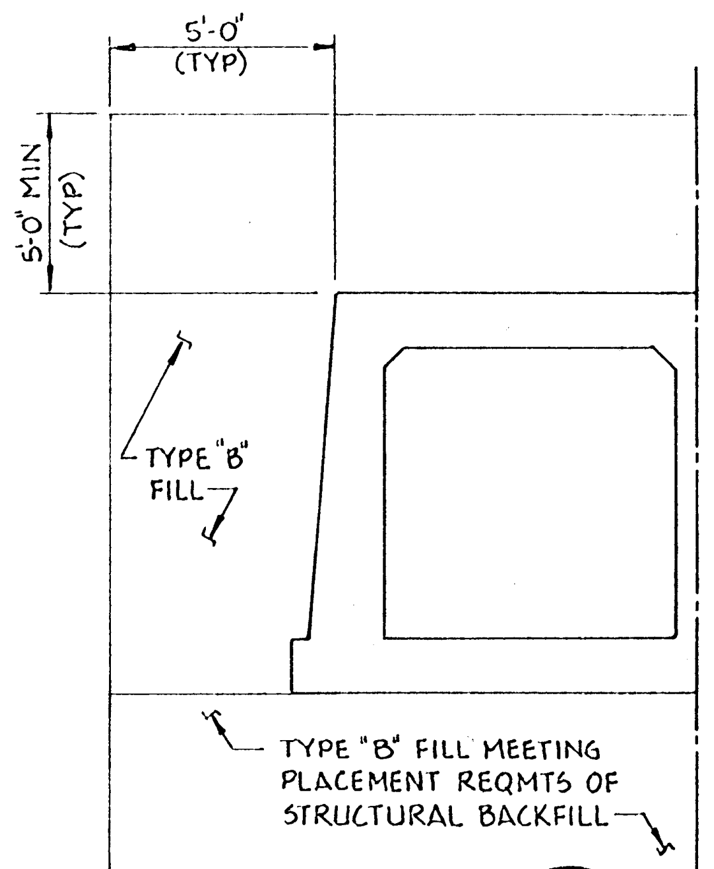
NOTE:
BACKFILL OF BOX CULVERT SHALL NOT BEGIN UNTIL THE ROOF SLAB IS IN PLACE AND HAS ACHIEVED 75% OF DESIGN STRENGTH



TYPICAL BOX CULVERT CONSTRUCTION JOINT DETAIL A/21
3/8"=1'-0"

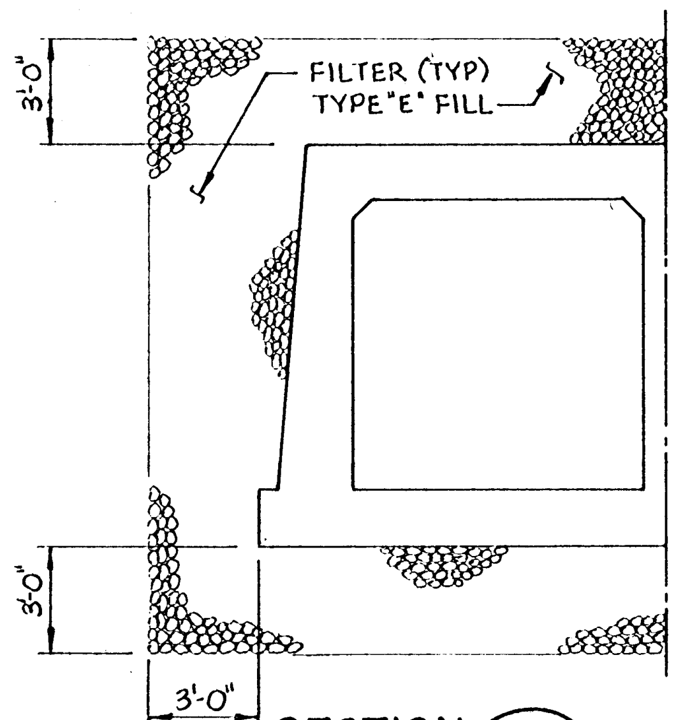


ENLARGED SECTION
3/16"=1'-0"



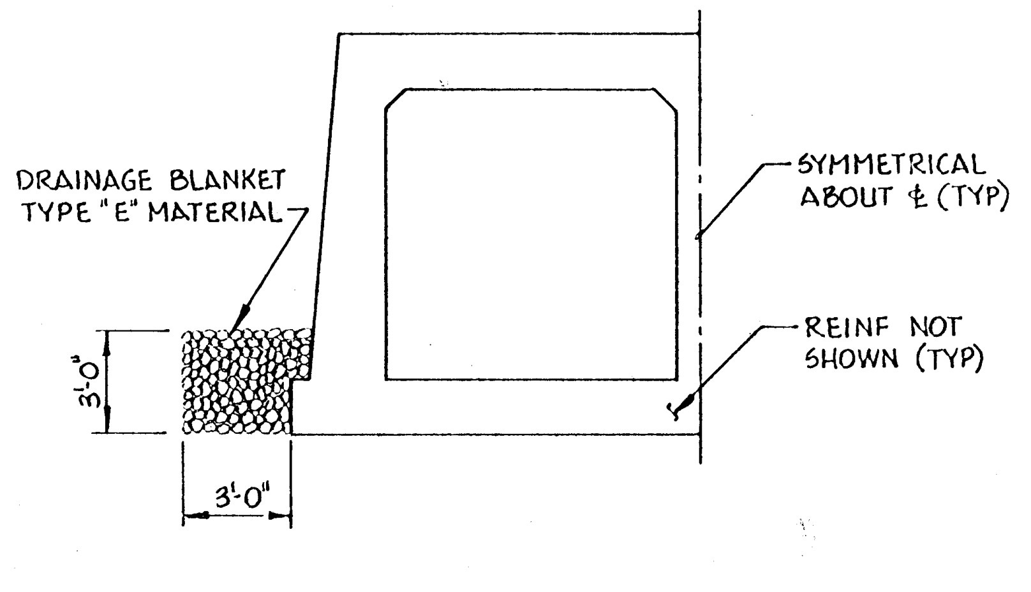
SECTION 3/21
3/16"=1'-0"

STA. 1+22.5 TO STA. 1+52.5



SECTION 4/21
3/16"=1'-0"

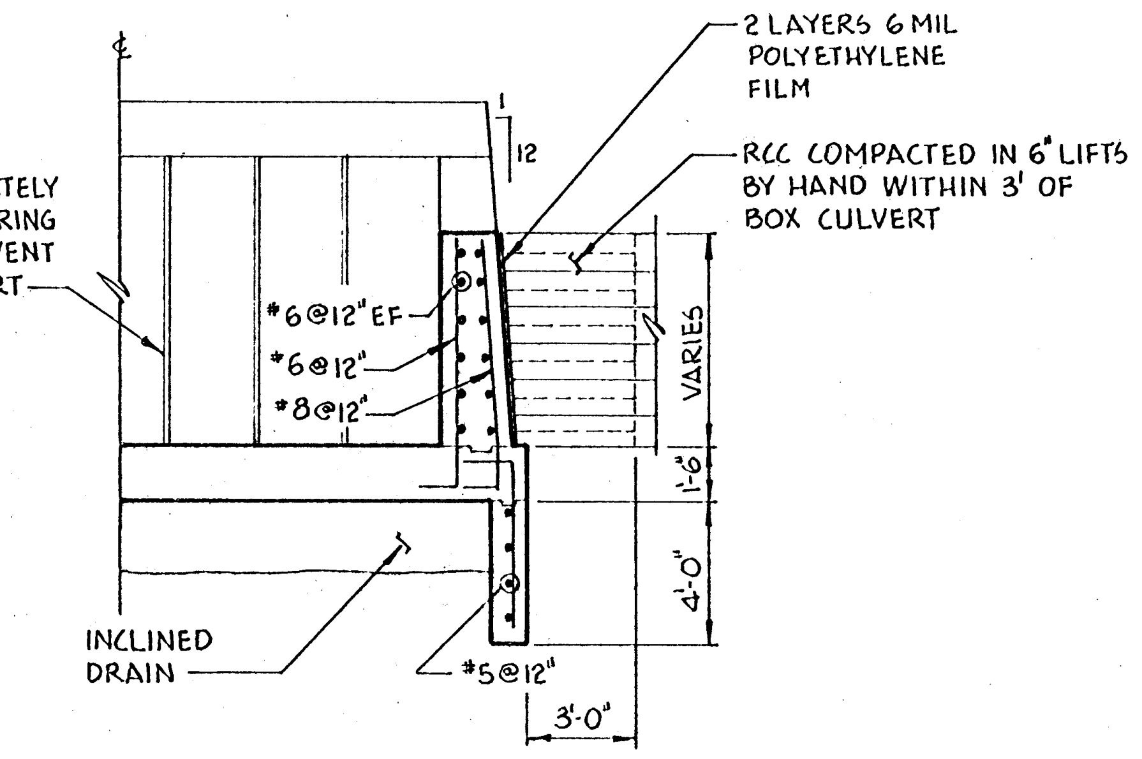
DRAINAGE COLLAR FROM STA. 2+07 TO STA. 2+10



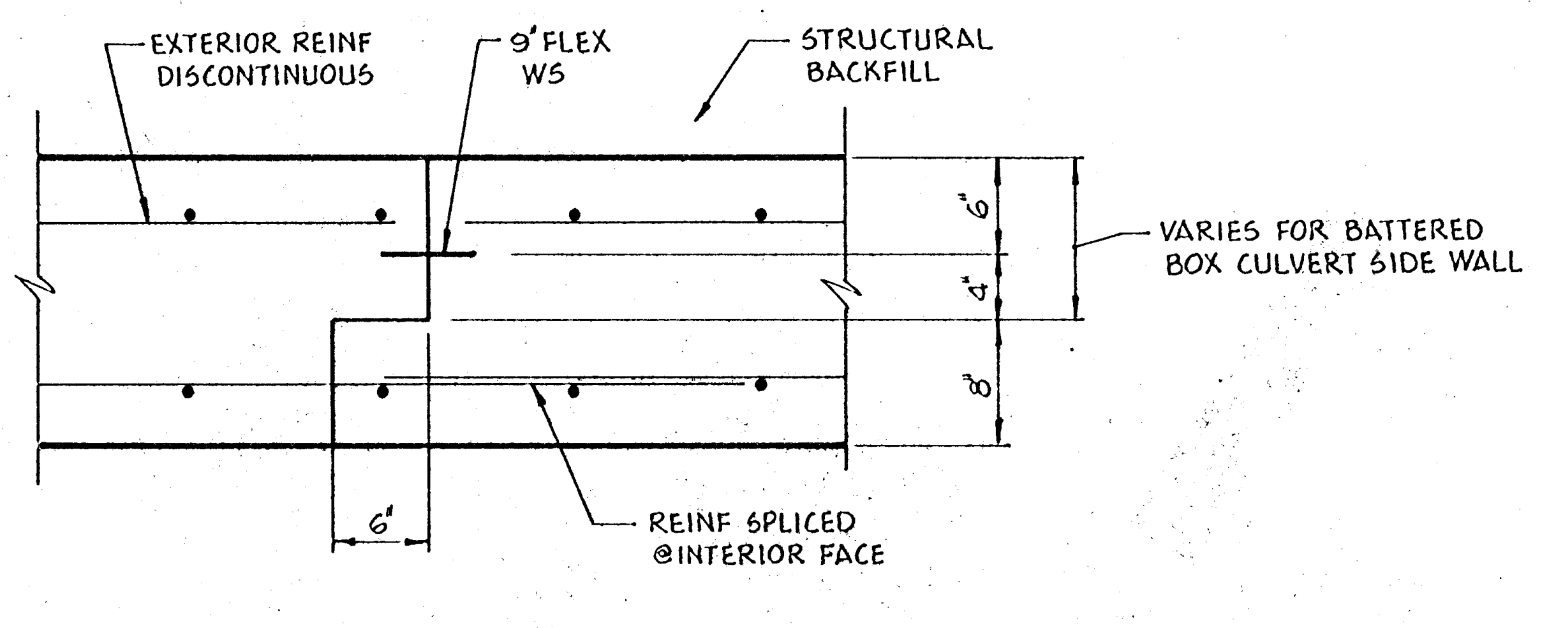
SECTION 5/21
3/16"=1'-0"

TYPICAL DRAINAGE BLANKET FROM STA. 2+10 TO STA. 2+60

NOTE:
CONTRACTOR TO ADEQUATELY SHORE BOX CULVERT DURING RCC PLACEMENT TO PREVENT DAMAGE TO BOX CULVERT



SECTION 6/21
3/16"=1'-0"



DETAIL 8/21
1"=1'-0"

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10-26-93	AS BUILT		PT	SPC	ACR

DESIGNED ALK
DETAILED HLR
CHECKED CJM
APPROVED AC Roberts
DATE 5-28-91

Black & Veatch
Engineers-Architects
Las Vegas, Nevada

PROJECT NO.
17149

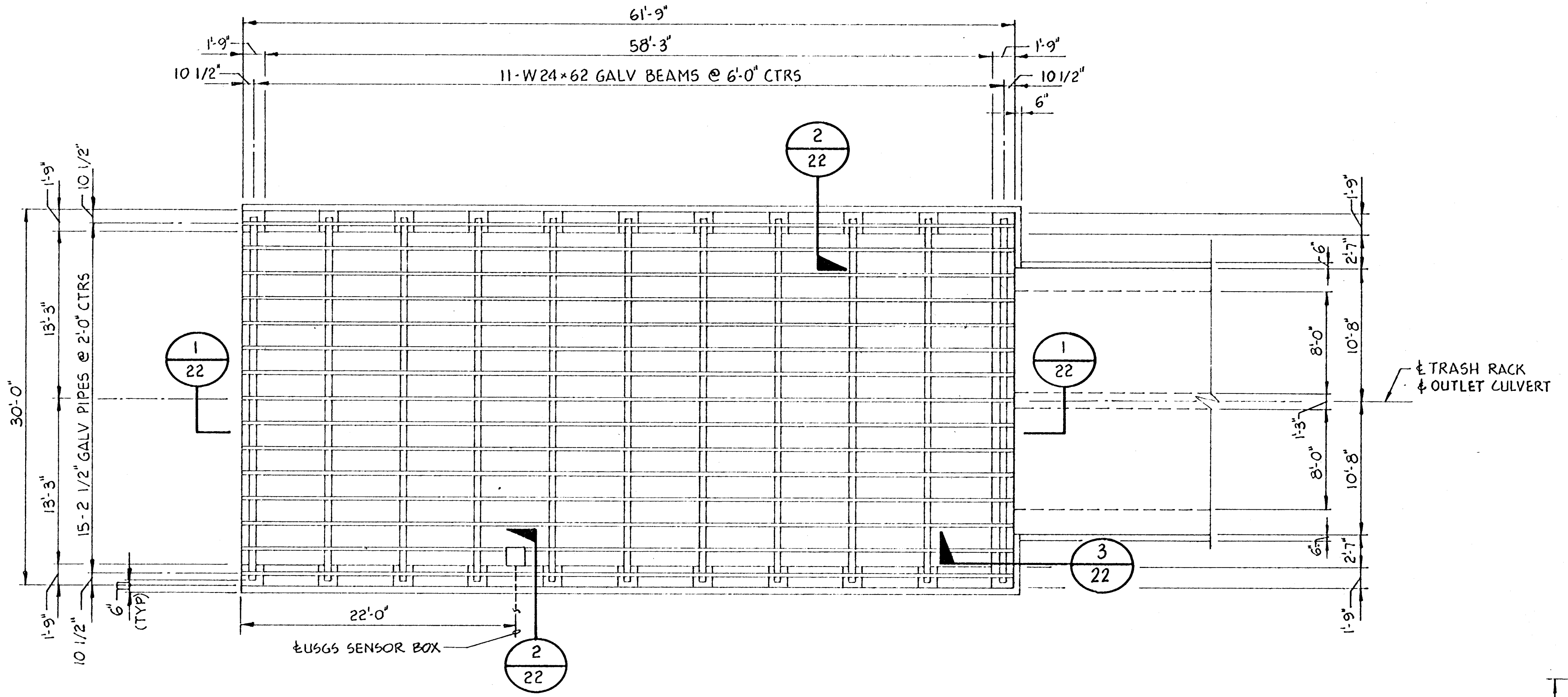
CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH
DETENTION BASIN

OUTLET WORKS
SECTIONS & DETAILS

DANA V. REEL
CIVIL
No. 7138

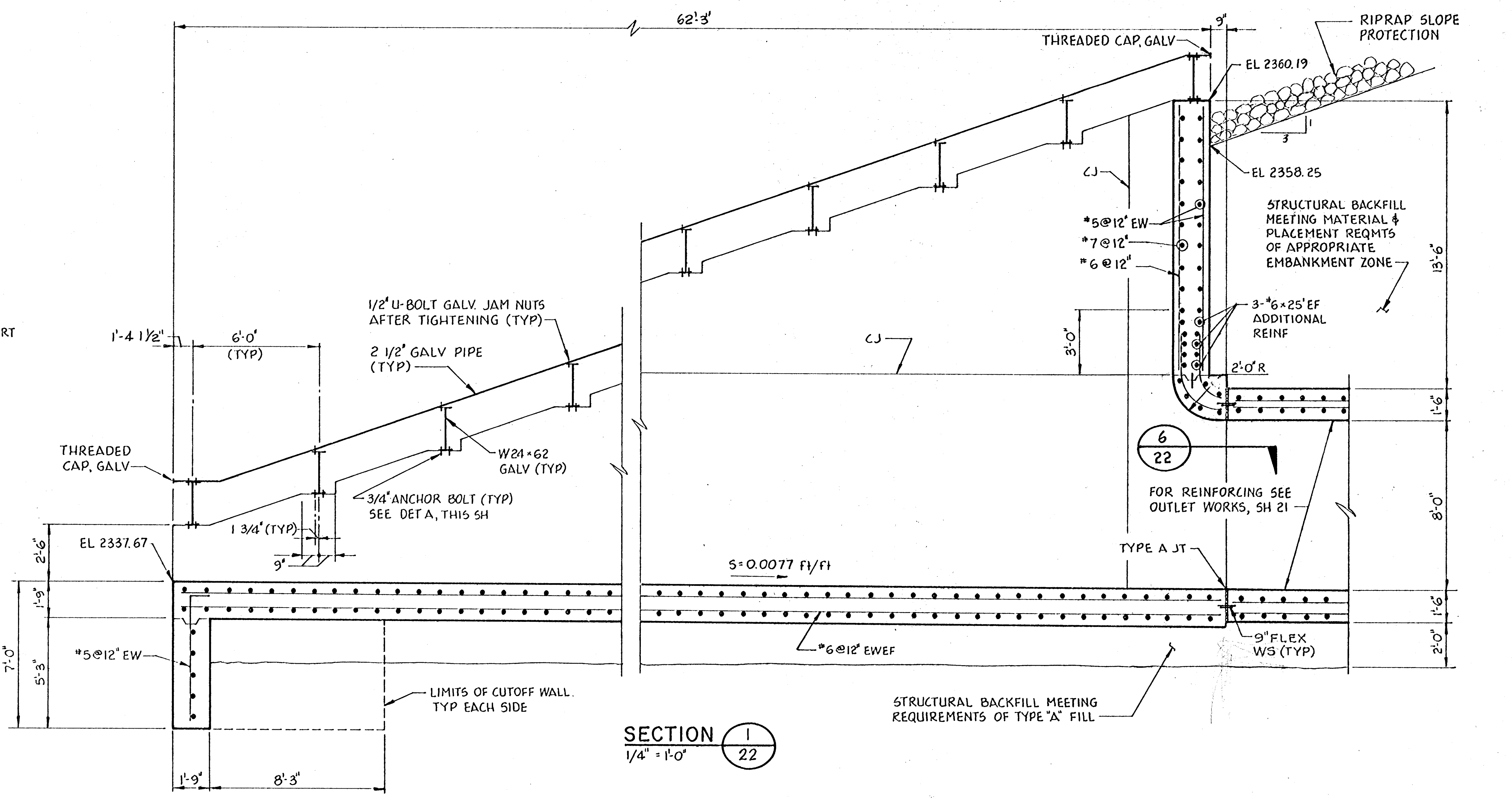
SHEET
21 OF 25

B&V-C-2436-D



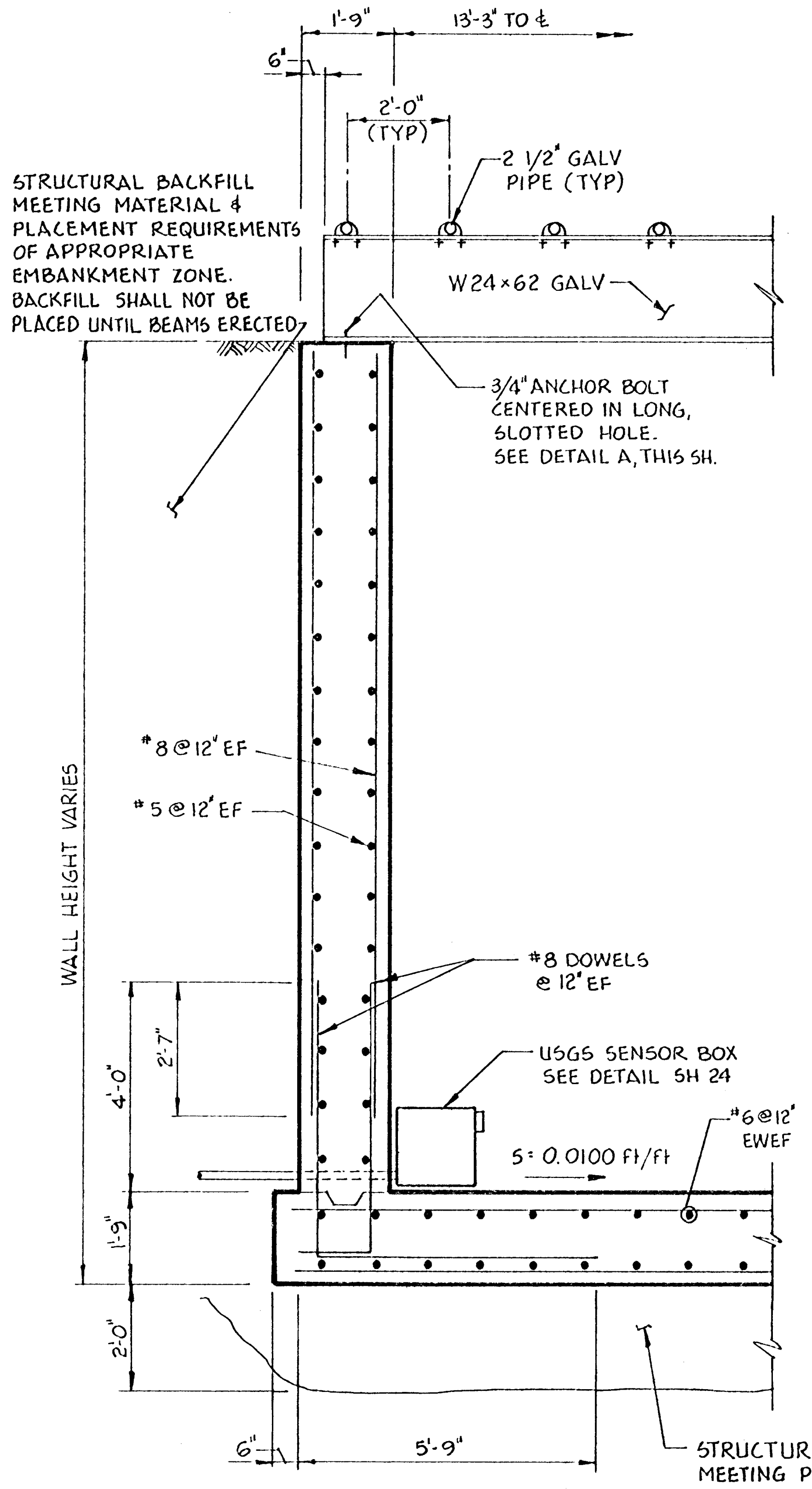
TRASH RACK PLAN

1/8" = 1'-0"



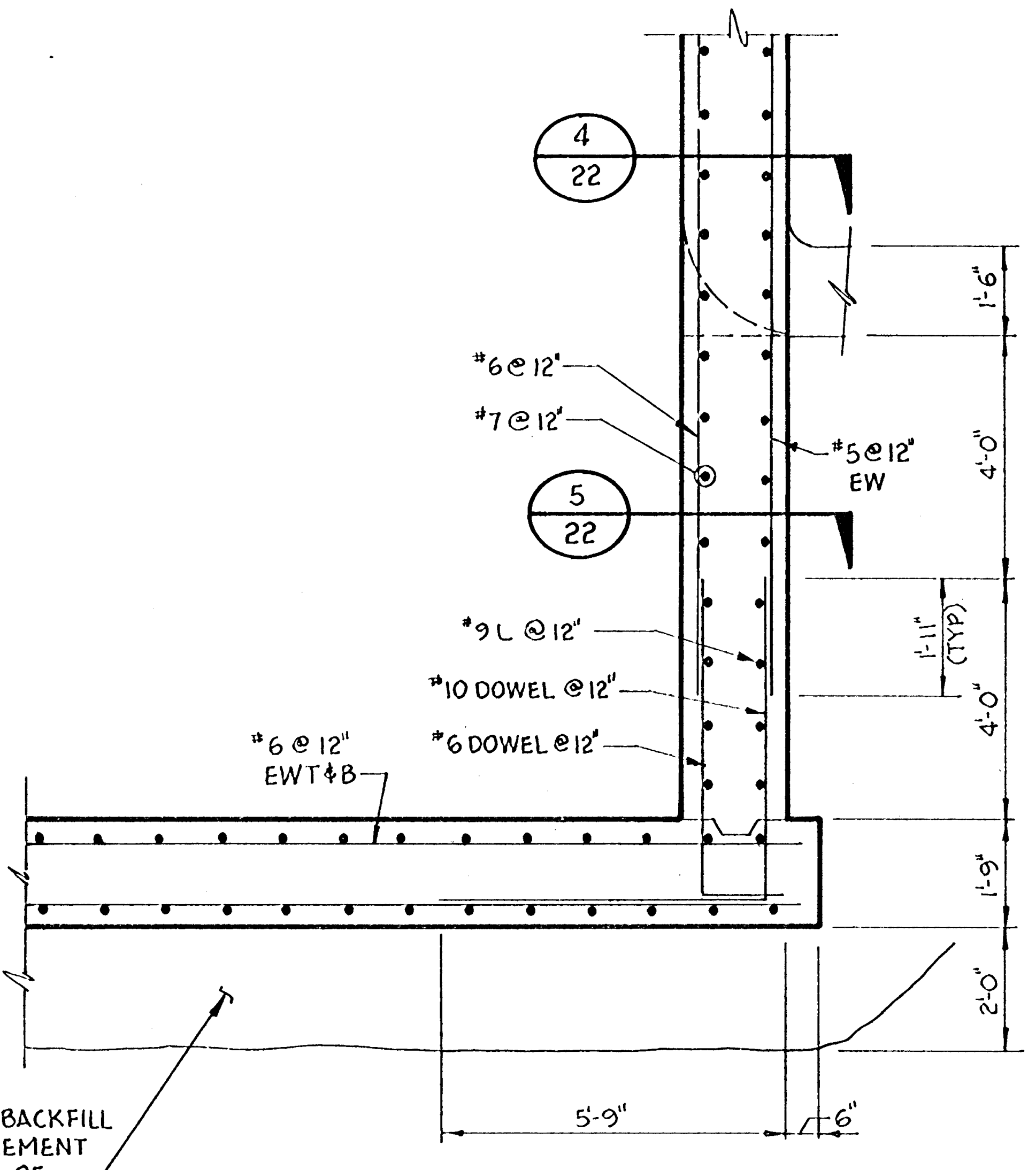
SECTION 1/22

1/4" = 1'-0"



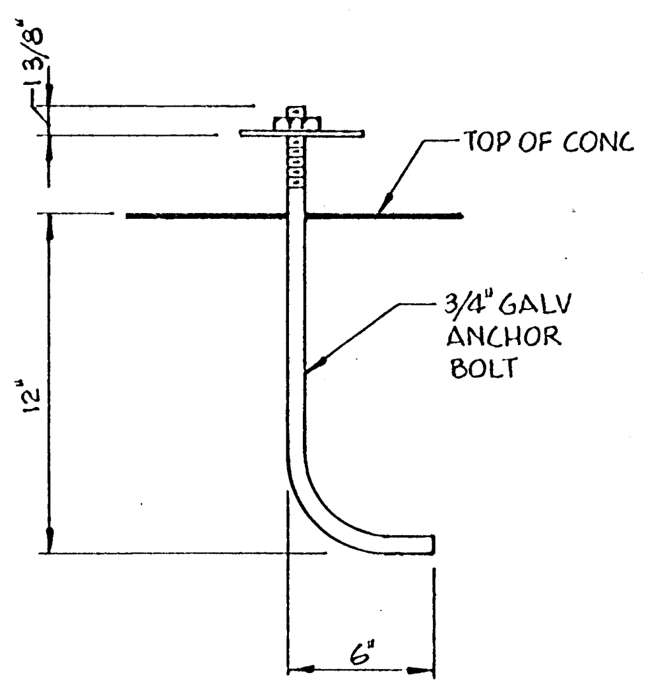
SECTION 2/22

3/8" = 1'-0"



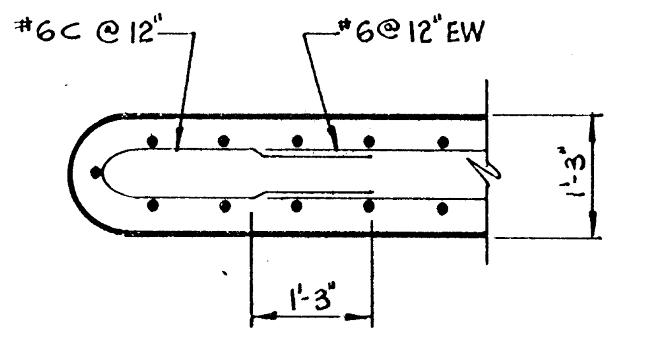
SECTION 3/22

3/8" = 1'-0"



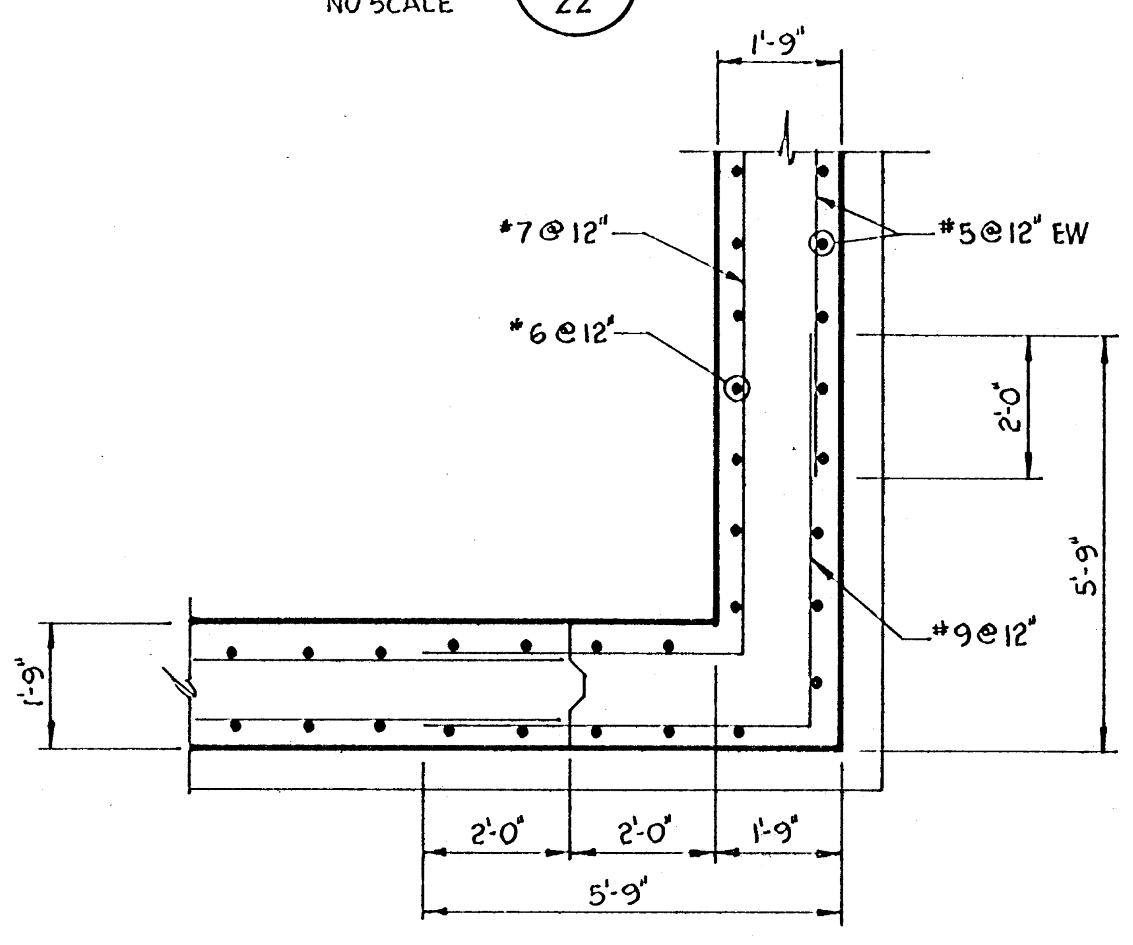
DETAIL A/22

NO SCALE



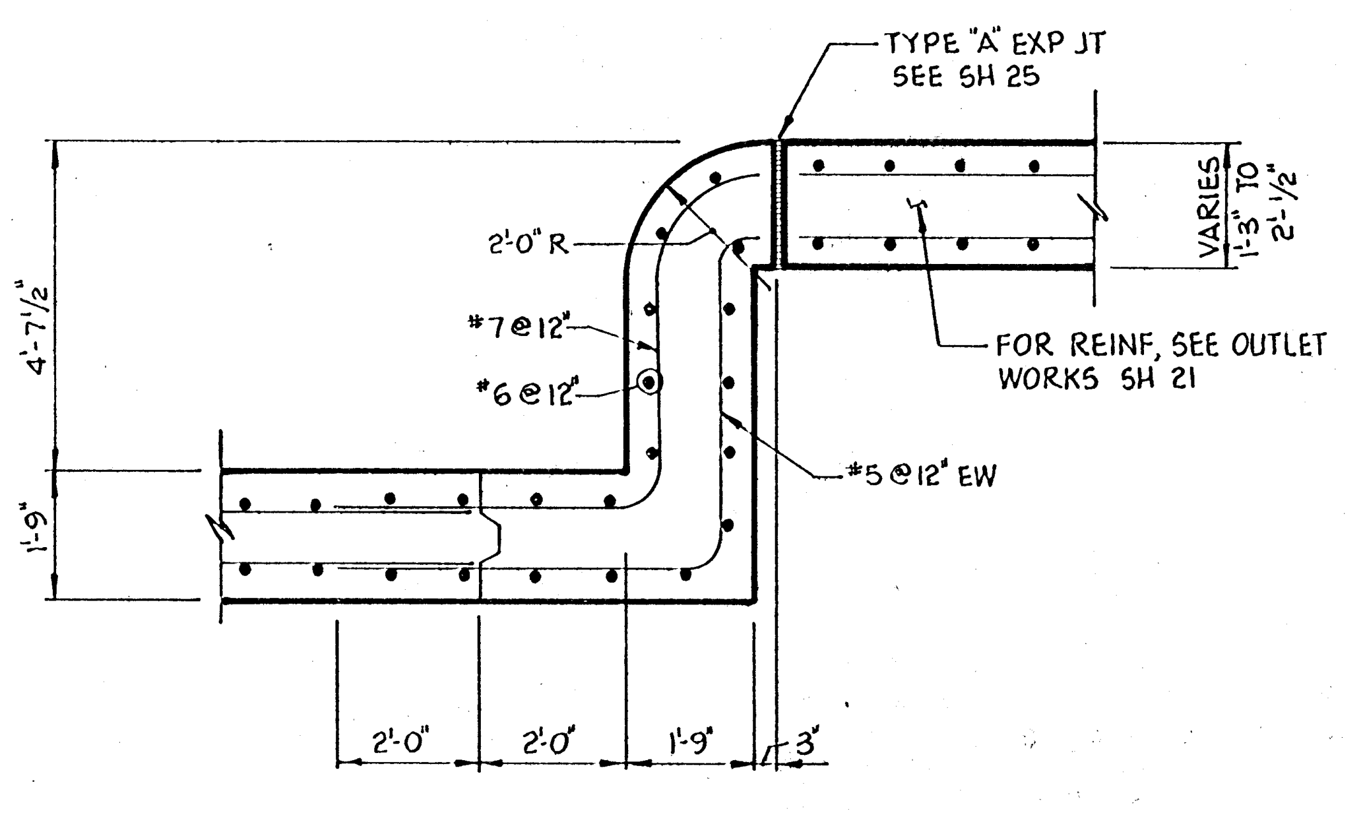
SECTION 6/22

1/2" = 1'-0"



SECTION 4/22

3/8" = 1'-0"



SECTION 5/22

3/8" = 1'-0"

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10-26-93	AS BUILT		PT	SDC	KCR

DESIGNED ALK
DETAILED HLR
CHECKED CJM
APPROVED A C Pybertt
DATE 5-20-91

Black & Veatch
Engineers-Architects
Las Vegas, Nevada

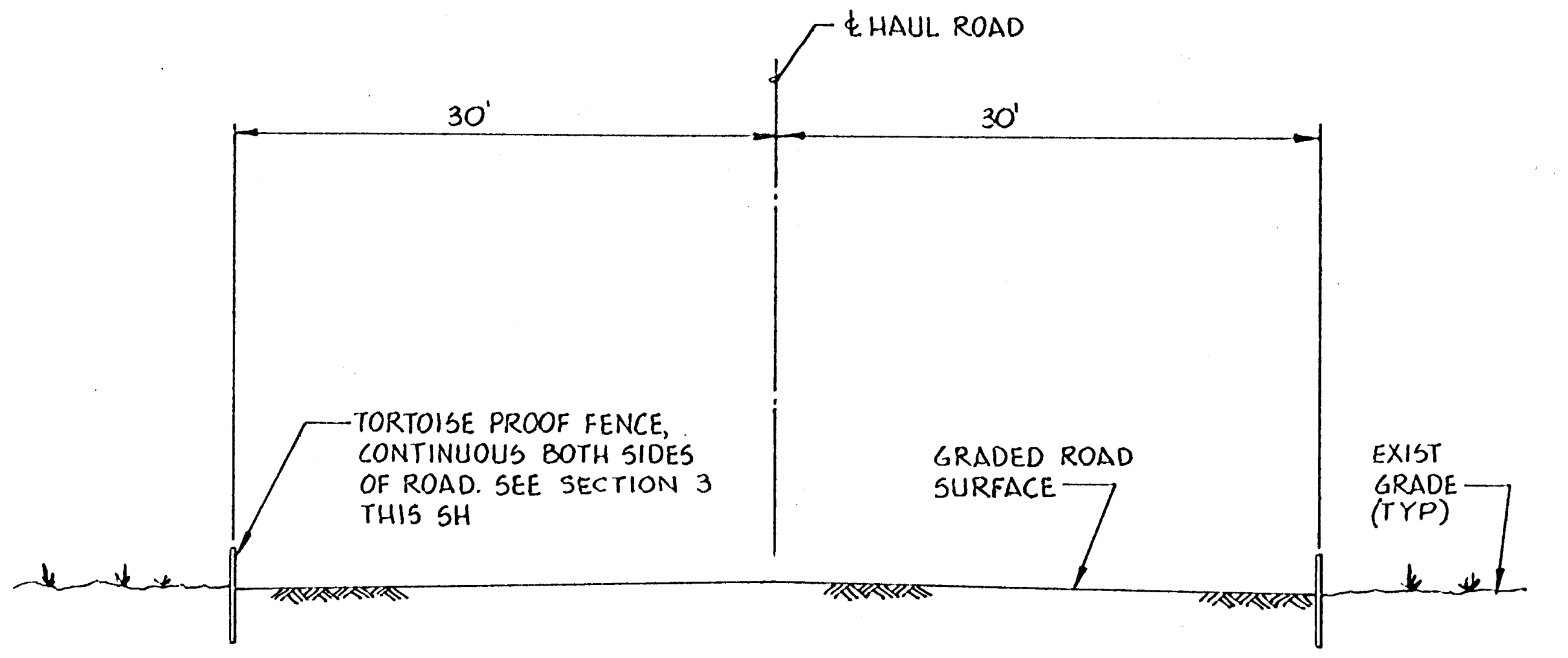
PROJECT NO.
17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH
DETENTION BASIN

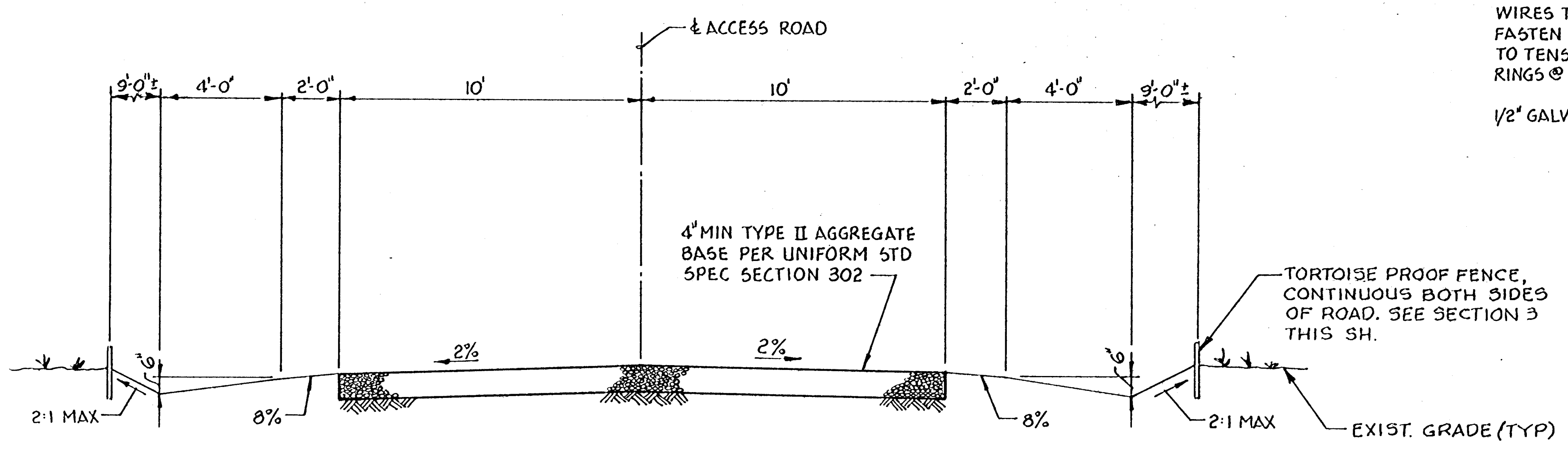
TRASH RACK
PLAN, SECTIONS & DETAILS

DANA V. REEL CIVIL No. 1133

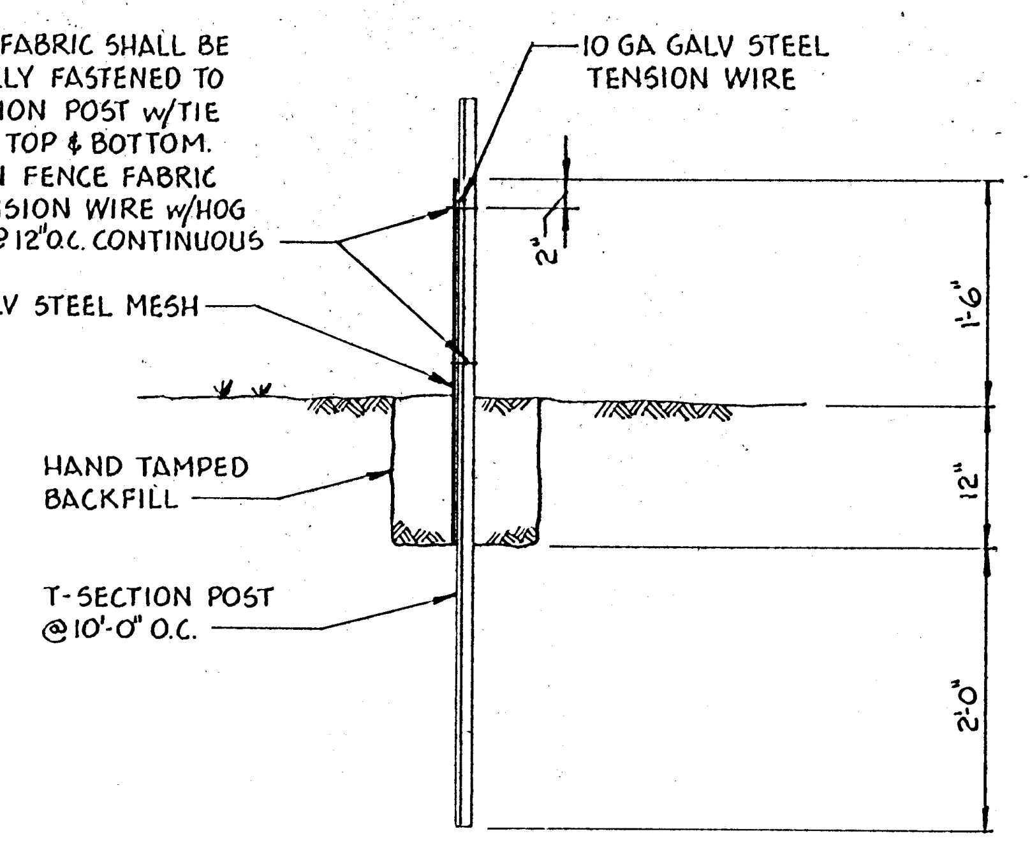
SHEET
22 OF 25



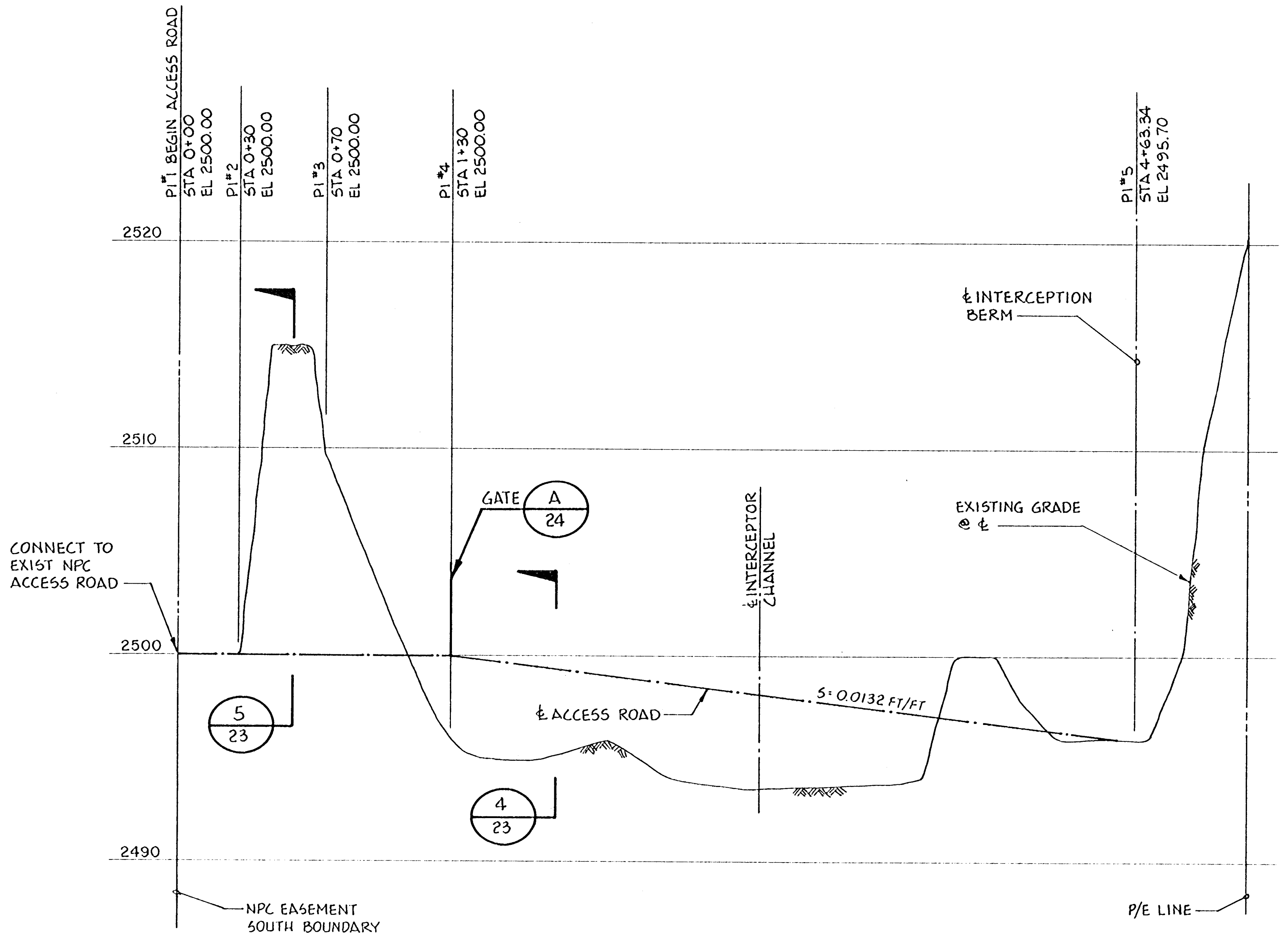
HAUL ROAD CROSS SECTION ① 3,10
1"=10'



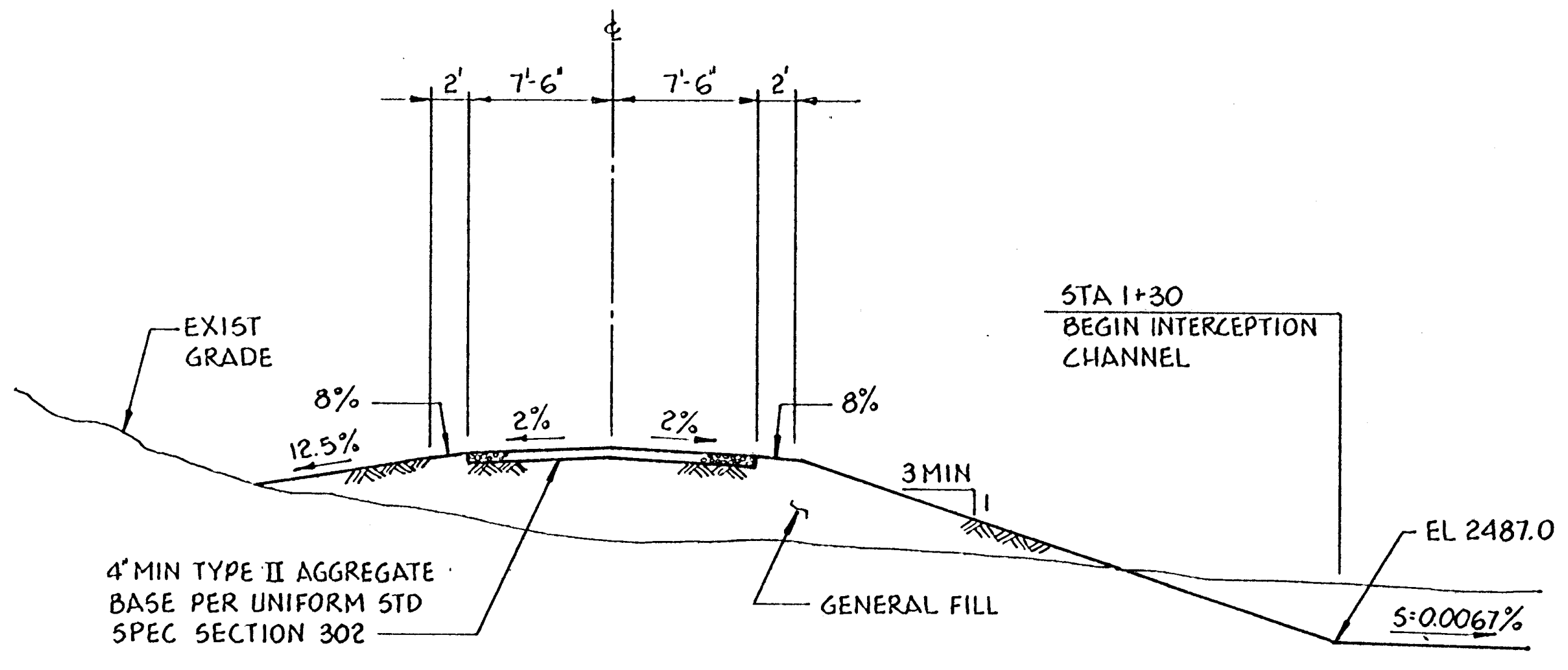
TYPICAL ACCESS ROAD CROSS SECTION ② 3,8,9,10
1/4"=1'-0"



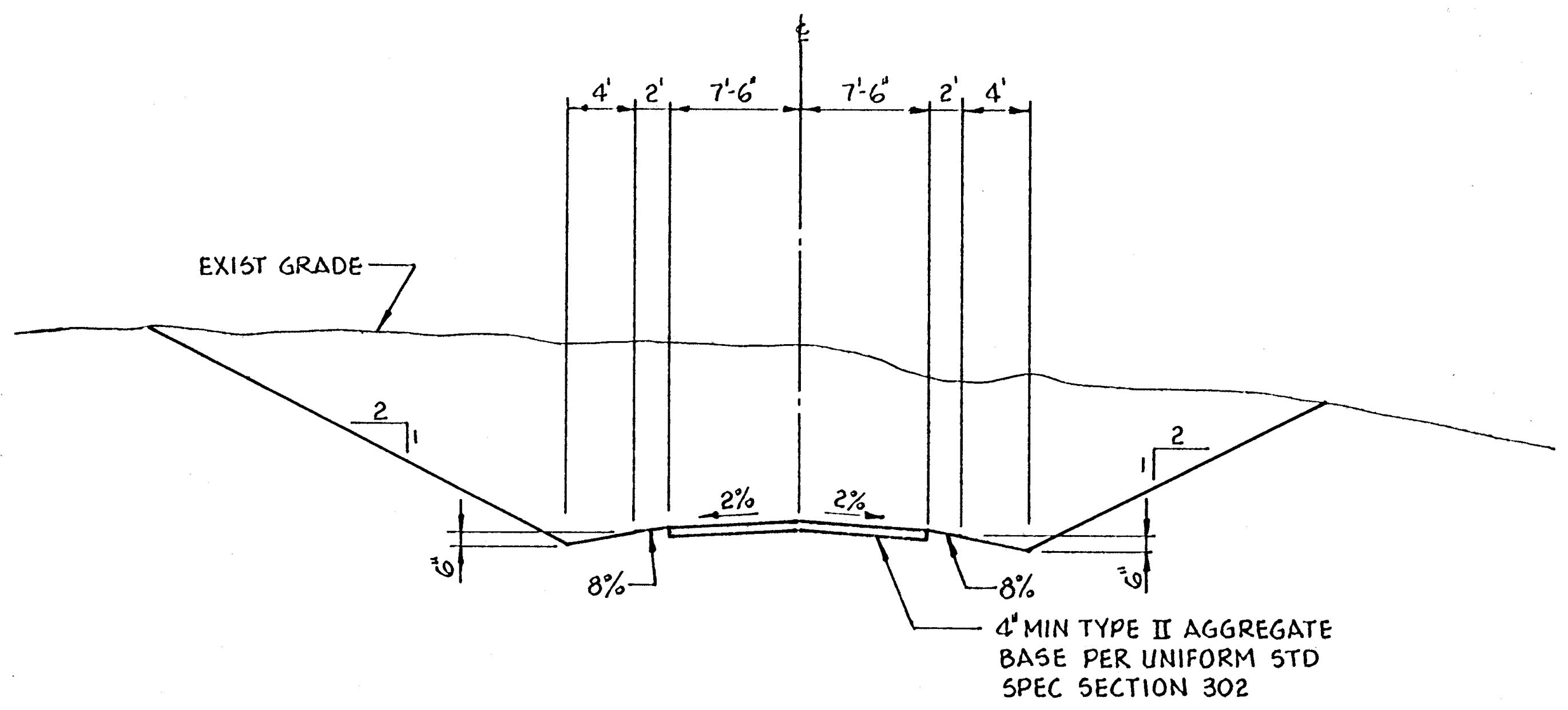
SECTION ③ 3,8,9,10
3/4"=1'-0"



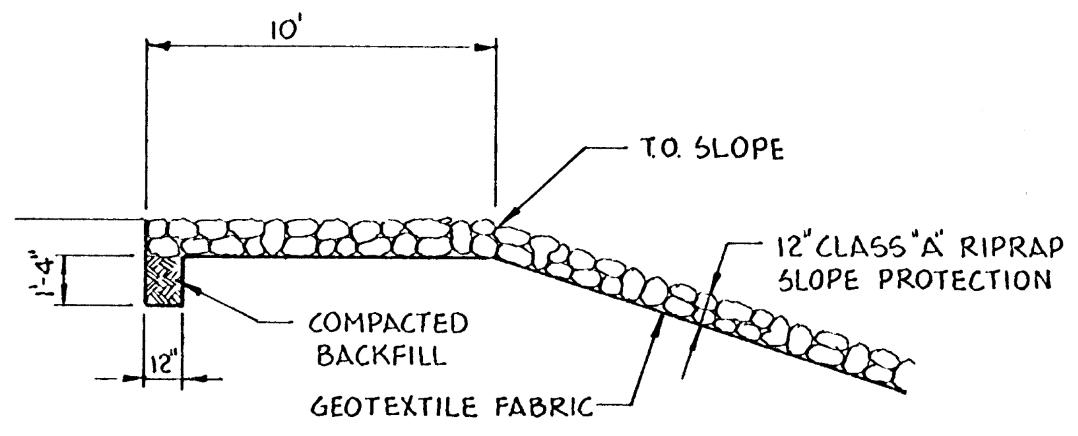
INTERCEPTION BERM WEST ACCESS ROAD PROFILE
1"=50'



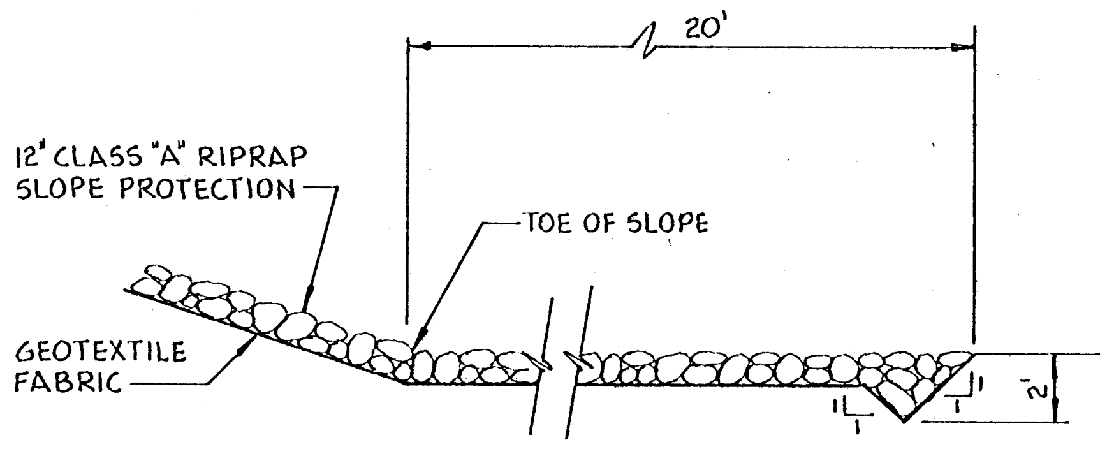
TYPICAL FILL SECTION ④ 23
NO SCALE



TYPICAL CUT SECTION ⑤ 23
NO SCALE



DETAIL Ⓐ 9,18
NO SCALE



DETAIL Ⓑ 9,18
NO SCALE

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10-26-93	AS BUILT		PT	SDC	

DESIGNED SDC
DETAILED HLR
CHECKED DIH
APPROVED
DATE 5-28-91

Black & Veatch
Engineers-Architects
Las Vegas, Nevada

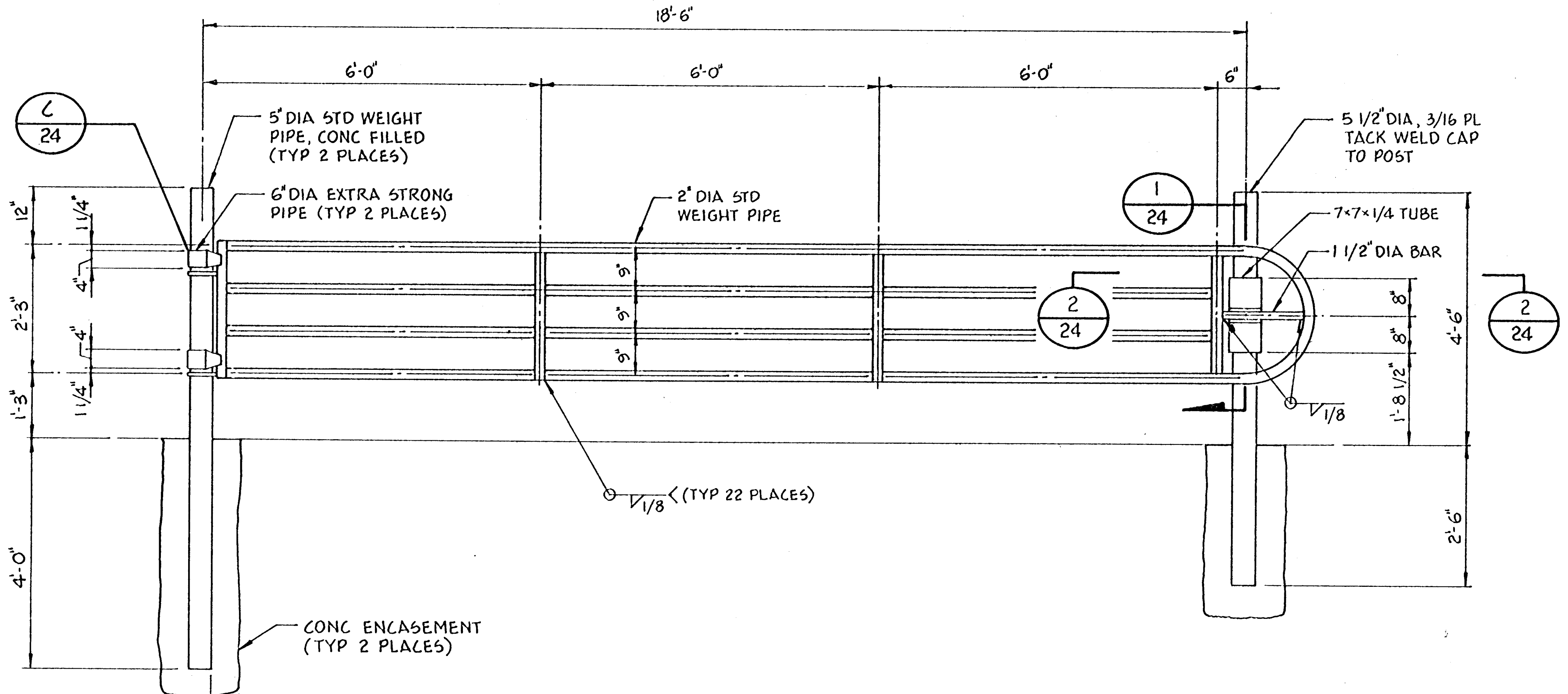
PROJECT NO.
17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH
DETENTION BASIN

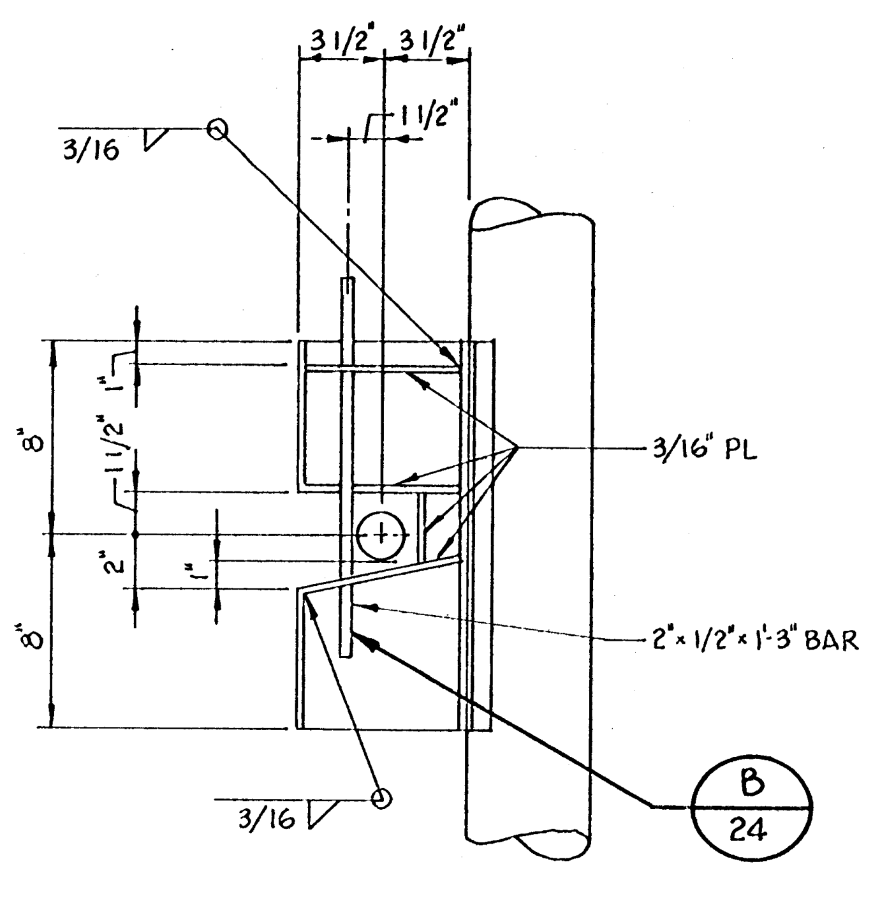
MISCELLANEOUS SECTIONS & DETAILS

DANA V. REEL
CIVIL
No. 1138

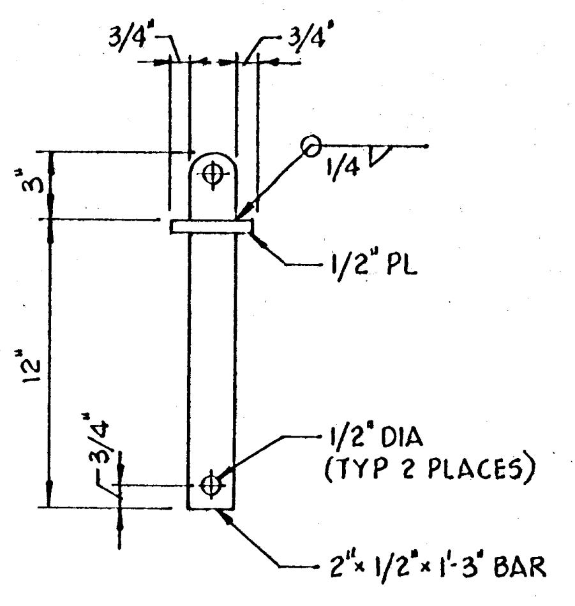
SHEET
23 OF 25



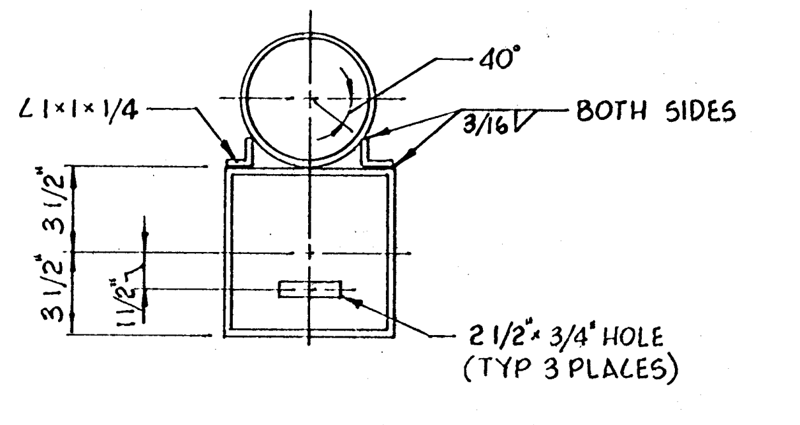
DETAIL A/24
1/2" = 1'-0"



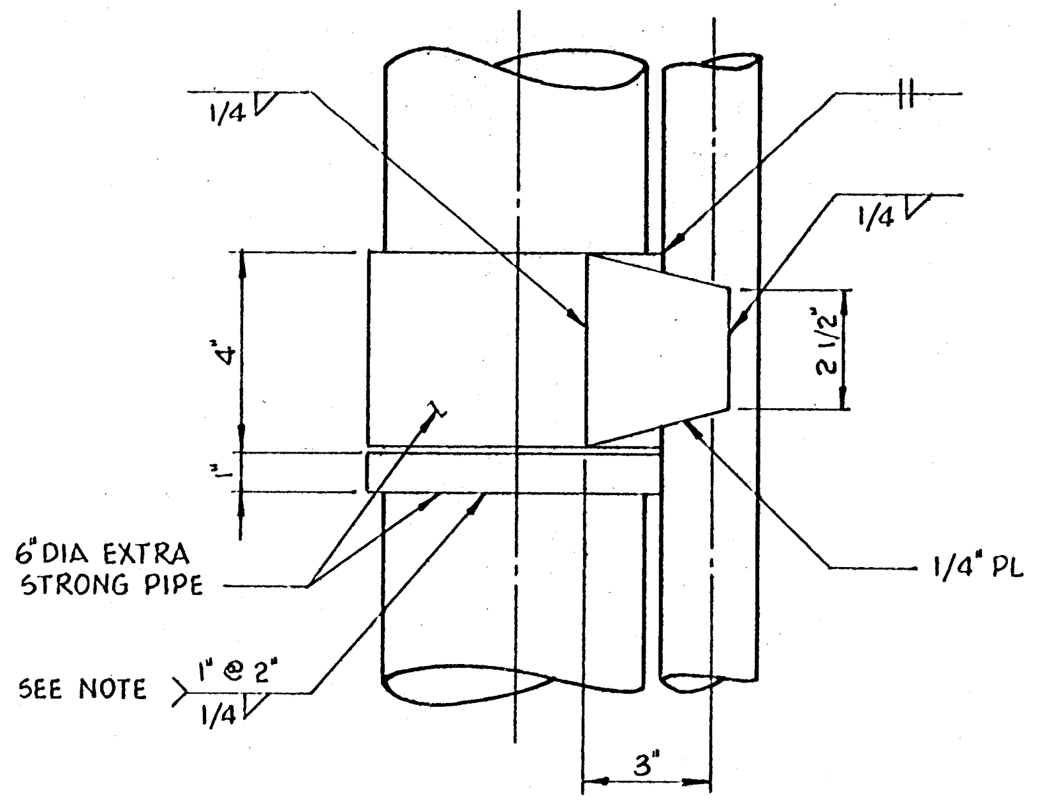
SECTION 1/24
1 1/2" = 1'-0"



DETAIL B/24
1 1/2" = 1'-0"

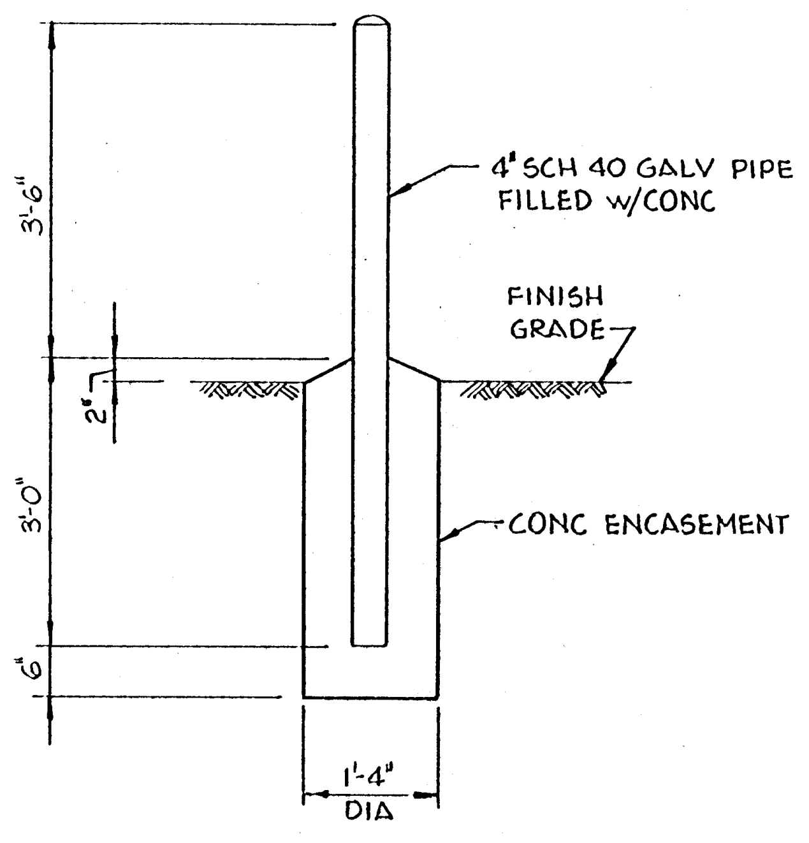


SECTION 2/24
1 1/2" = 1'-0"

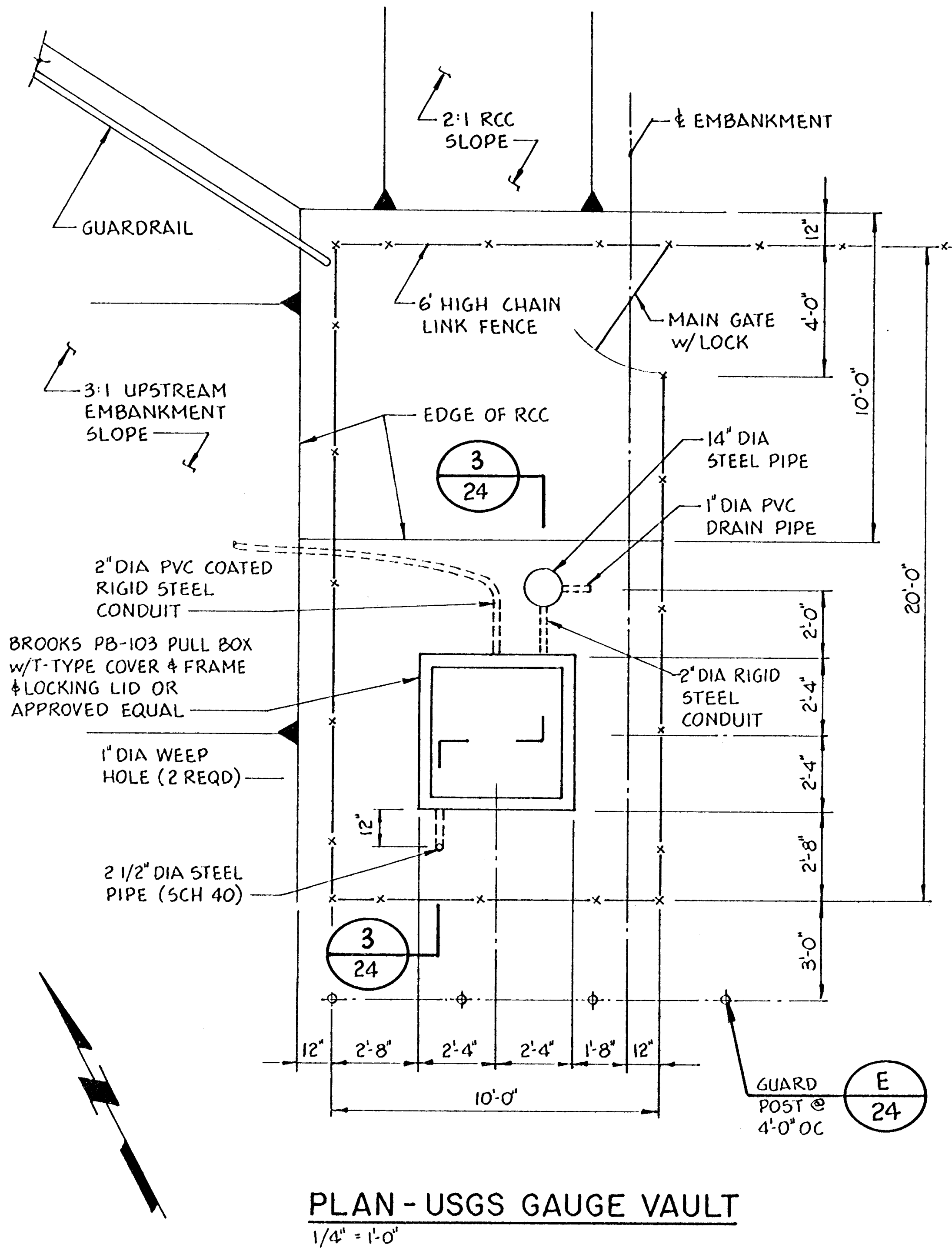


DETAIL C/24
3" = 1'-0"

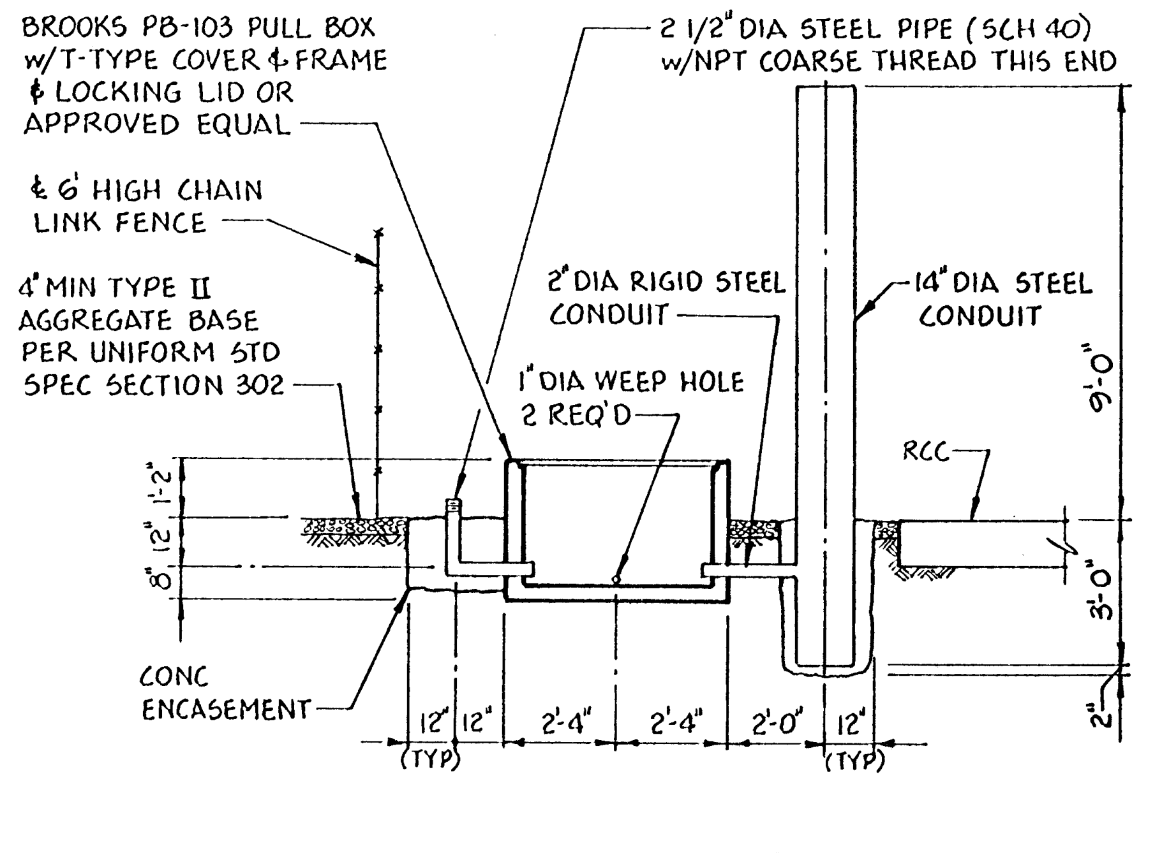
NOTES:
1. BOTTOM HINGE SUPPORT RING SHOP WELDED. TOP HINGE SUPPORT RING SHALL BE FIELD WELDED FOLLOWING GATE INSTALLATION.
2. SHOP APPLIED: 2 COATS RUST INHIBITIVE PRIMER: TNEMEC "77 CHEM-PRIME" OR ACCEPTABLE EQUAL. AFTER FIELD CONST, APPLY 2 COATS OF WHITE SEMI-GLOSS ALKYD ENAMEL: TNEMEC "SERIES 23 ENDURATONE" OR ACCEPTABLE EQUAL.



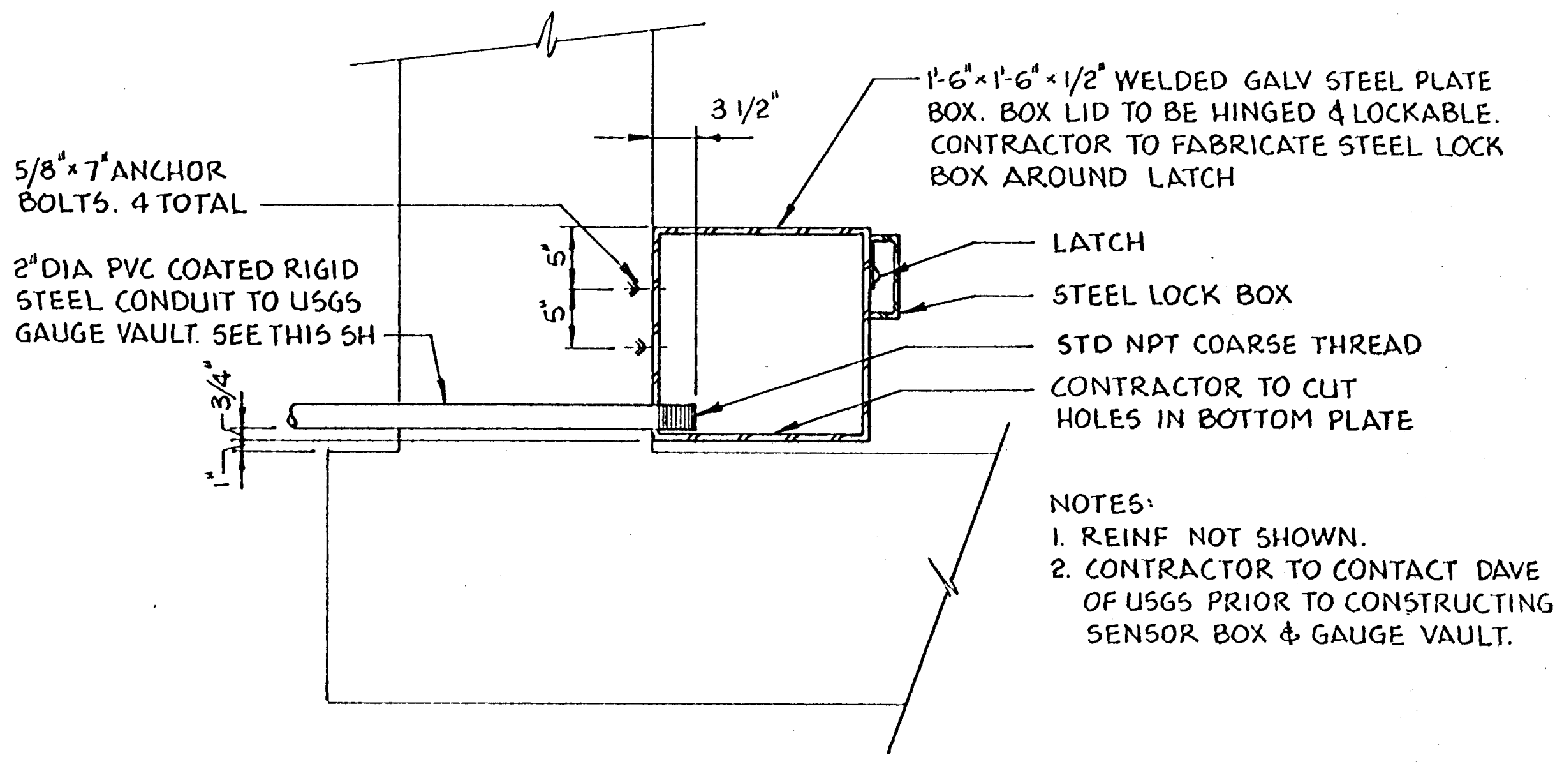
TYPICAL GUARD POST DETAIL E/24
1/2" = 1'-0"



PLAN - USGS GAUGE VAULT
1/4" = 1'-0"
SEE SH 18 FOR LOCATION

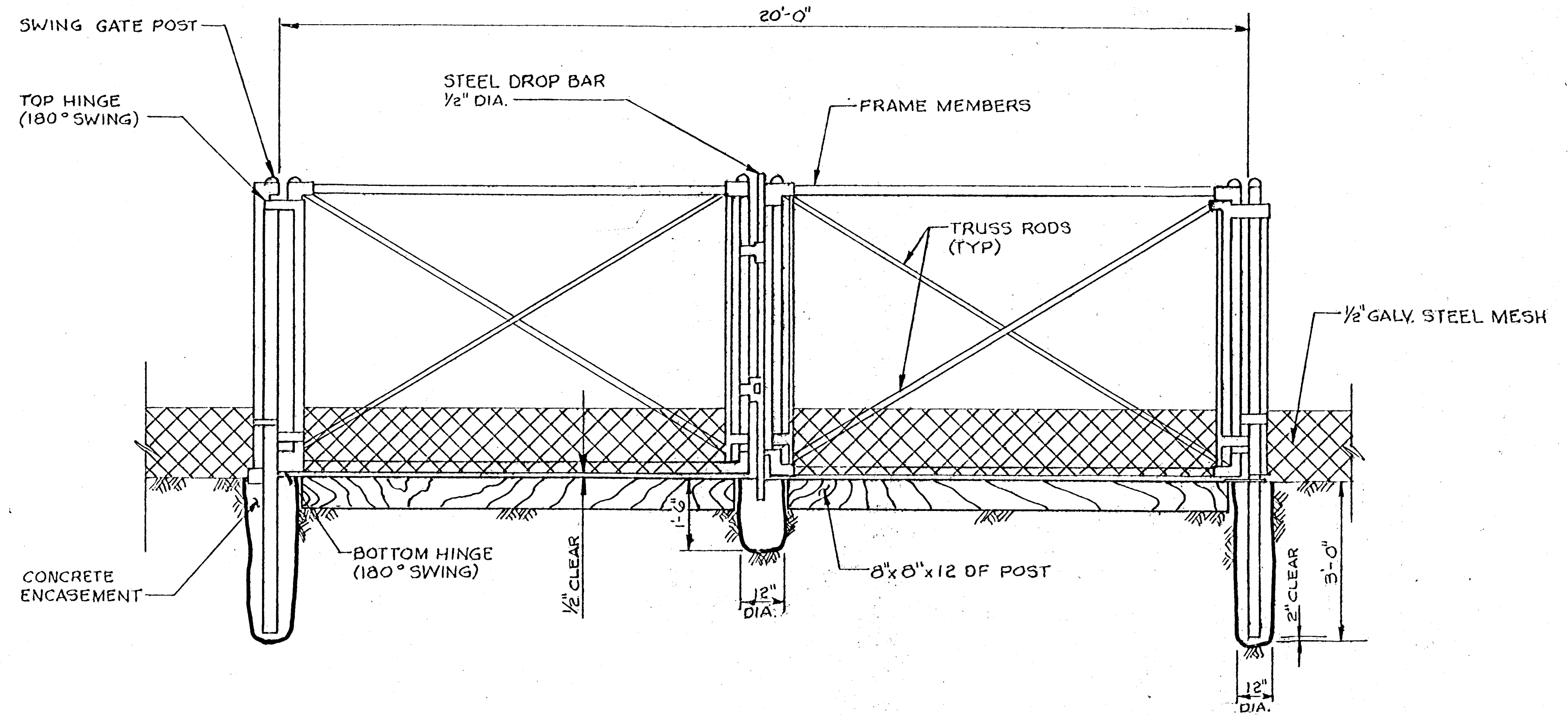


SECTION 3/24
1/4" = 1'-0"



NOTES:
1. REINF NOT SHOWN.
2. CONTRACTOR TO CONTACT DAVE BLACKSTUN OF USGS PRIOR TO CONSTRUCTING USGS SENSOR BOX & GAUGE VAULT.

USGS SENSOR BOX DETAIL D/24
3/4" = 1'-0"



TORTOISE PROOF SWING GATE
3/8" = 1'-0"

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10-26-93	AS BUILT		PT	SDC	

DESIGNED SDC, PJR
DETAILED HLR
CHECKED DIH
APPROVED
DATE 5-28-91

Black & Veatch
Engineers-Architects
Las Vegas, Nevada

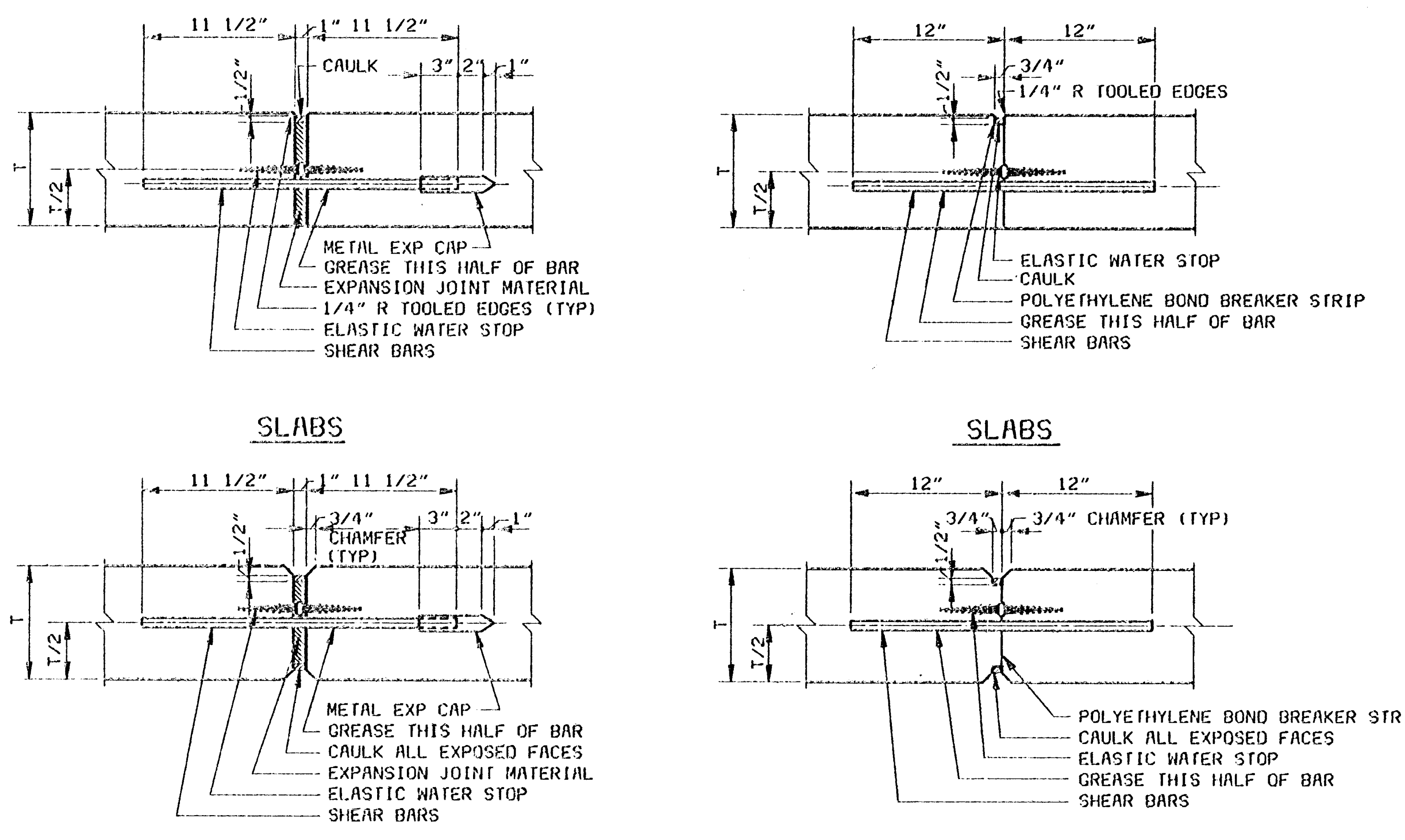
PROJECT NO.
17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH
DETENTION BASIN
MISCELLANEOUS SECTIONS & DETAILS

DANA V. REEL
CIVIL
No. 1139

SHEET
24 OF 25

B&V-C-2436-D



WALLS

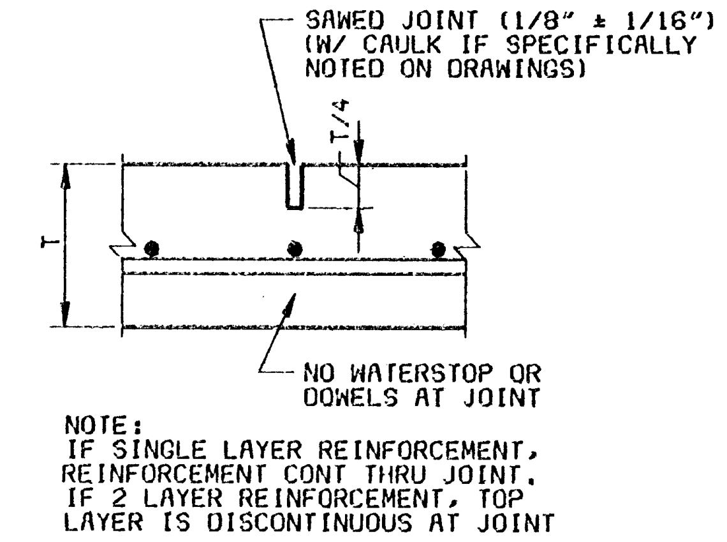
WALLS

EXPANSION JOINTS

NOTE:
TYPE A - WITH ELASTIC WATER STOP
TYPE B - WITHOUT ELASTIC WATER STOP

CONTRACTION JOINTS

NOTE:
TYPE C - WITH ELASTIC WATER STOP
TYPE D - WITHOUT ELASTIC WATER STOP



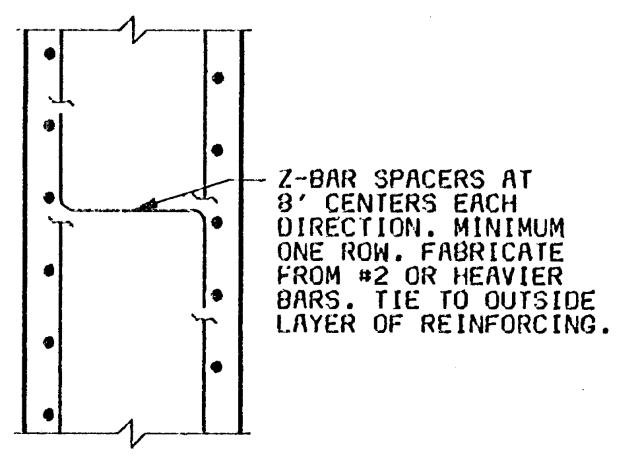
NOTE:
IF SINGLE LAYER REINFORCEMENT, REINFORCEMENT CONT THRU JOINT. IF 2 LAYER REINFORCEMENT, TOP LAYER IS DISCONTINUOUS AT JOINT

INTERIOR SLAB ON GRADE
TYPE E

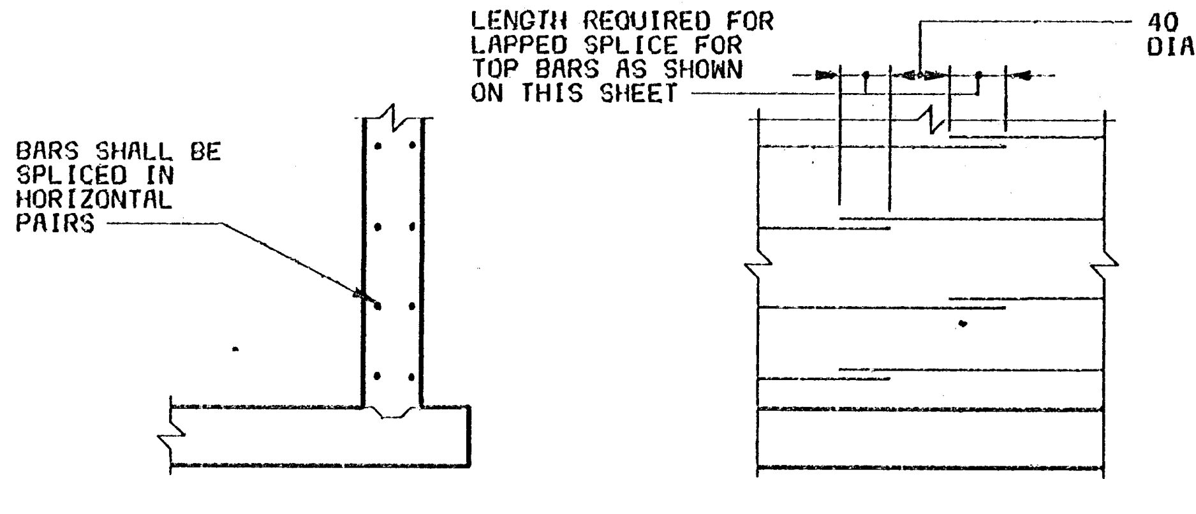
(TYPICAL CONTROL JOINT NOTES 1 THRU 3 NOT APPLICABLE)

TYPICAL CONTROL JOINTS

NOTES:
1. PROVIDE 3/4" SHEAR BARS @ 18" CTRS ACROSS JOINT
2. REINFORCING STEEL SHALL NOT BE EXTENDED ACROSS JOINT
3. SHEAR BARS SHALL BE SMOOTH, FREE FROM RUST OR SCALE, AND GREASED TO PREVENT BOND (ONE HALF OF BAR ONLY)
4. DESIGNATED TYPE _ CONTROL JT ON PLANS



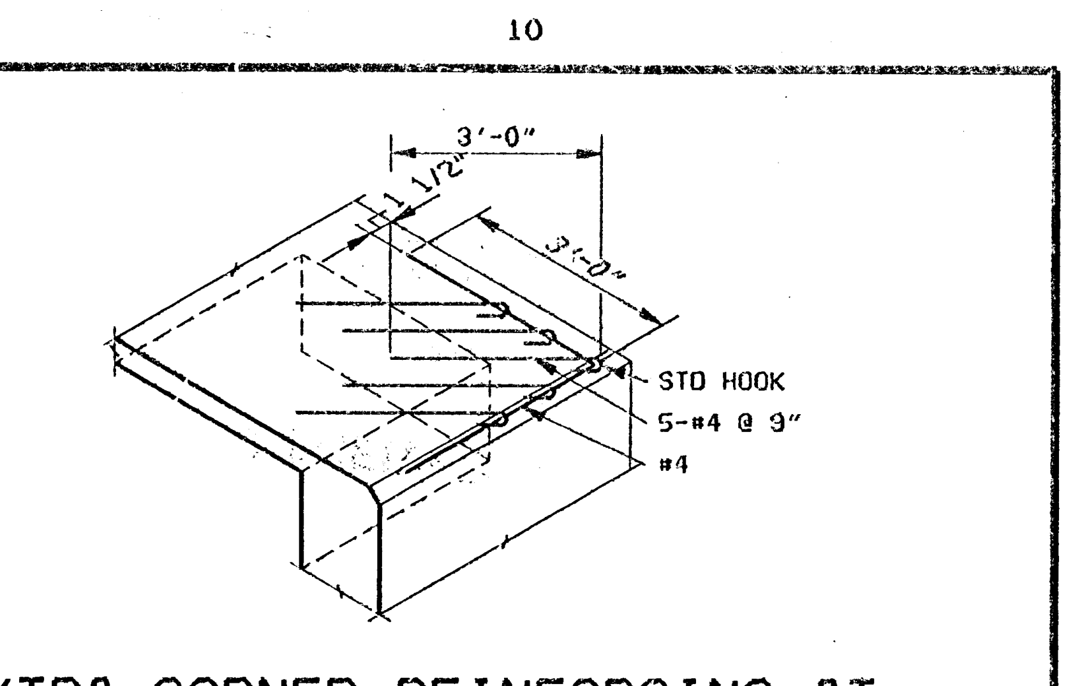
SPACERS FOR WALL REINFORCEMENT



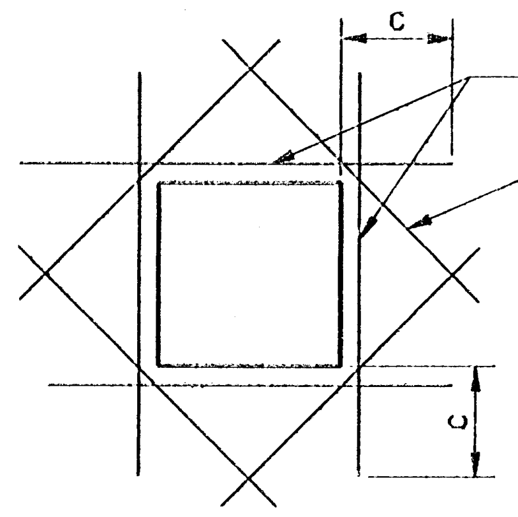
WALL SECTION

WALL ELEVATION

TYPICAL RING WALL REINFORCING SPLICE DETAIL



EXTRA CORNER REINFORCING AT TOP OF WALLS WITH SLABS WHICH ARE TO SUPPORT MASONRY



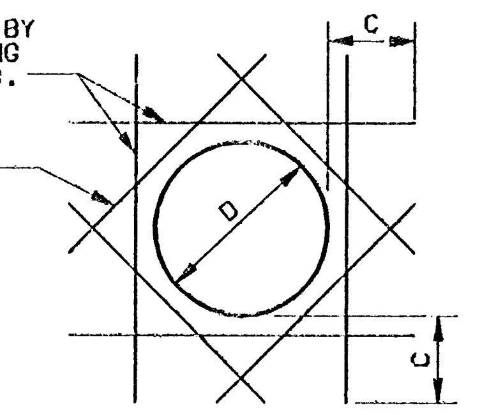
EXTRA BARS EQUAL IN TOTAL AREA TO REGULAR REINFORCING CUT BY OPENING. PLACE ONE HALF TOTAL AREA TO EACH SIDE OF OPENING AND IN THE SAME TRANSVERSE POSITION AS REGULAR REINFORCING.

ONE EXTRA BAR EACH CORNER PER LAYER OF REGULAR REINFORCING (SEE TABLE BELOW). PLACE IN SAME TRANSVERSE POSITION AS REGULAR REINFORCING.

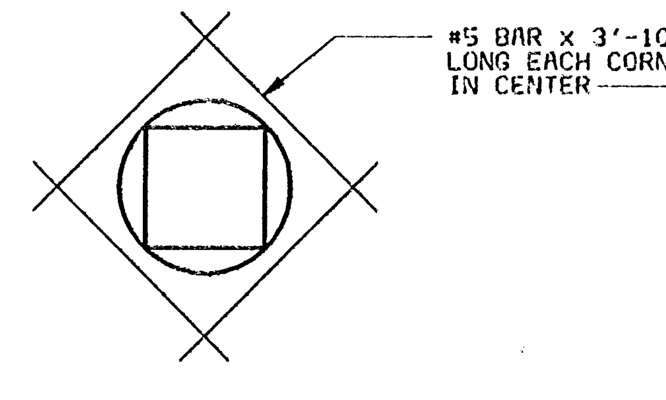
THICKNESS OF CONCRETE	BAR SIZE	BAR LENGTH RECT OPG	BAR LENGTH CIRC OPG
<12"	4	3'-0"	D+12"
12" TO 18"	5	3'-0"	D+12"
>18"	6	3'-8"	D+12"

C=THE REQUIRED LENGTH FOR LAPPED SPLICE FOR TOP BARS AS SHOWN ON THIS SHEET

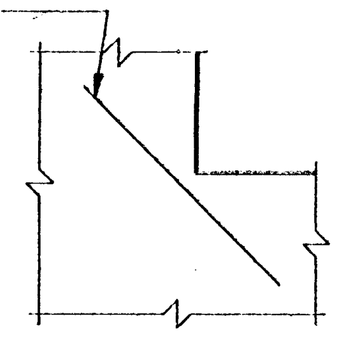
FOR RECTANGULAR OPENINGS LARGER THAN 21" DIAGONAL



FOR CIRCULAR OPENINGS LARGER THAN 21" DIAMETER



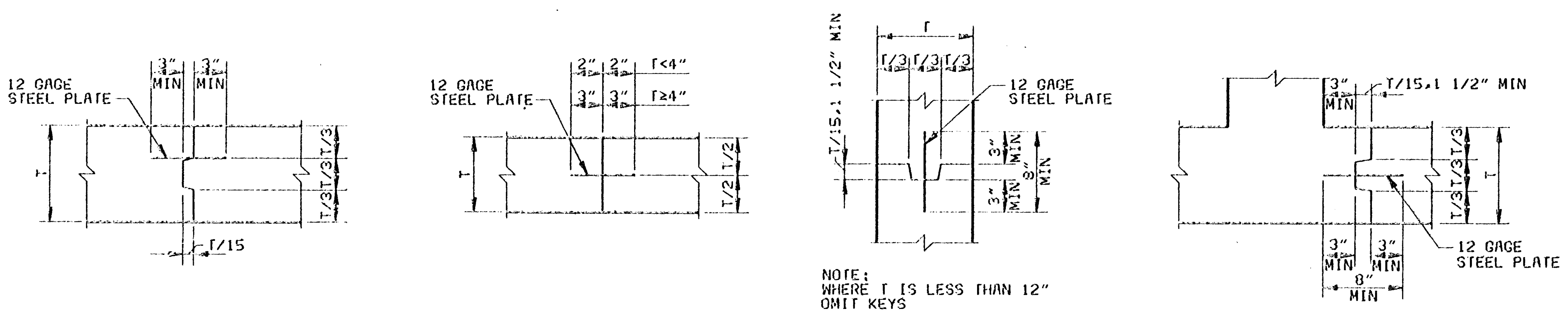
FOR OPENINGS 21" AND SMALLER IN DIAMETER OR DIAGONAL



ISOLATED RE-ENTRANT CORNERS

TYPICAL EXTRA REINFORCING AT OPENINGS

(TYPICAL REQUIRED UNLESS ADDITIONAL REINFORCEMENT SPECIFICALLY INDICATED AT OPENINGS ON DRAWINGS)



SECTION T≥12"

SECTION T<12"

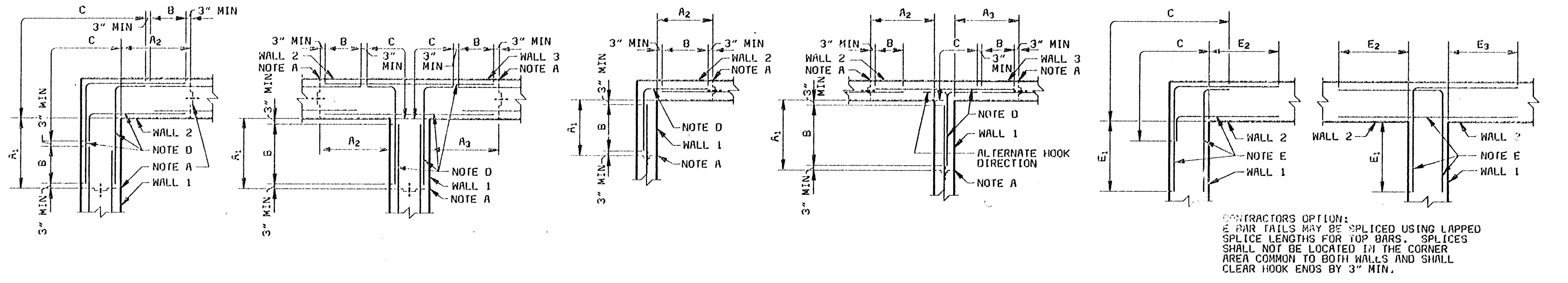
T≥12"

T≥12"

SLABS

WALLS

CORNERS



CONTRACTORS OPTION:
E BAR TAILS MAY BE SPLICED USING LAPPED SPLICE LENGTHS FOR TOP BARS. SPLICES SHALL NOT BE LOCATED IN THE CORNER AREA COMMON TO BOTH WALLS AND SHALL CLEAR HOOK ENDS BY 3" MIN.

MAIN REINFORCEMENT FOR ALL STRUCTURES

ADDITIONAL REINFORCEMENT FOR LIQUID CONTAINMENT STRUCTURES AND DRY PIT WALLS EXPOSED TO GROUND WATER

A = VERTICAL CONSTRUCTION JOINT NEAREST TO WALL CORNER.

A_X = DISTANCE FROM INSIDE C ER FACE TO NEAREST VERTICAL CONSTRUCTION JOINT IN SIMILARLY NUMBERED WALL. A_X SHALL NOT BE LESS THAN DIMENSIONS INDICATED BY THESE DETAILS, NOR GREATER THAN INDICATED ON PLAN DRAWINGS; BUT IN ANY CASE SHALL NOT EXCEED 30 FEET IN LIQUID CONTAINMENT STRUCTURES AND DRY PIT WALLS EXPOSED TO GROUND WATER OR 40 FEET IN OTHER STRUCTURES.

B = OPTIONAL SPLICE LOCATION UNLESS SPECIFICALLY NOTED ON PLAN DRAWINGS. SPLICE LENGTH SHALL NOT BE LESS THAN THAT REQUIRED FOR TOP BARS AS SHOWN IN TABLE ON THIS SHEET.

C = LENGTH REQUIRED FOR DEVELOPMENT OF TOP BARS AS SHOWN IN TABLE ON THIS SHEET; TERMINATING WITH NO LESS THAN A STANDARD HOOK.

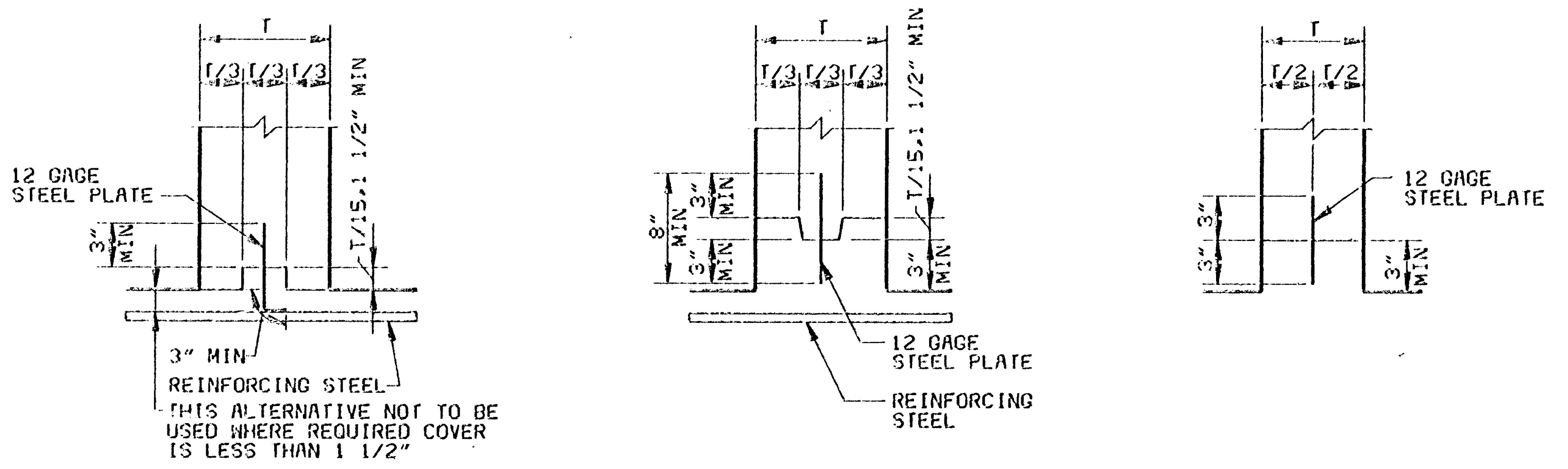
D = TYPICAL CORNER REINFORCEMENT. SIZE SHALL MATCH LARGEST ADJACENT WALL HORIZONTAL REINFORCEMENT; SPACING SHALL MATCH MINIMUM ADJACENT WALL HORIZONTAL REINFORCEMENT SPACING.

E = ADDITIONAL CORNER REINFORCEMENT REQUIRED IN BOTH FACES OF LIQUID CONTAINMENT STRUCTURES AND ON BACKFILL FACE ONLY OF DRY PIT WALLS EXPOSED TO GROUND WATER. ADDITIONAL CORNER REINFORCEMENT SHALL BE OF THE SAME SIZE AND SPACING AS THE MAIN CORNER REINFORCEMENT. PLACE ADDITIONAL REINFORCEMENT ALTERNATELY WITH, AND EQUAL DISTANCE BETWEEN, MAIN CORNER REINFORCEMENT.

E_X = DISTANCE FROM INSIDE CORNER FACE TO TERM[illegible]TION OF ADDITIONAL CORNER REINFORCEMENT IN SIMILARLY NUMBERED WALL. E_X SHALL NOT BE LESS THAN 0.20 THE CLEAR SPAN DISTANCE MEASURED HORIZONTALLY BETWEEN THIS CORNER AND THE NEXT OR 0.40 THE CLEAR SPAN DISTANCE OR CANTILEVERED DISTANCE MEASURED VERTICALLY, WHICHEVER IS SMALLER, BUT NOT LESS THAN 3'-0".

TYPICAL HORIZONTAL CORNER REINFORCING DETAILS

NOTES:
1. VERTICAL REINFORCING NOT SHOWN
2. THESE DETAILS SHALL BE APPLICABLE TO ALL WALL CORNERS UNLESS NOTED OTHERWISE ON THE DRAWINGS.



THIS ALTERNATIVE NOT TO BE USED WHERE REQUIRED COVER IS LESS THAN 1 1/2"

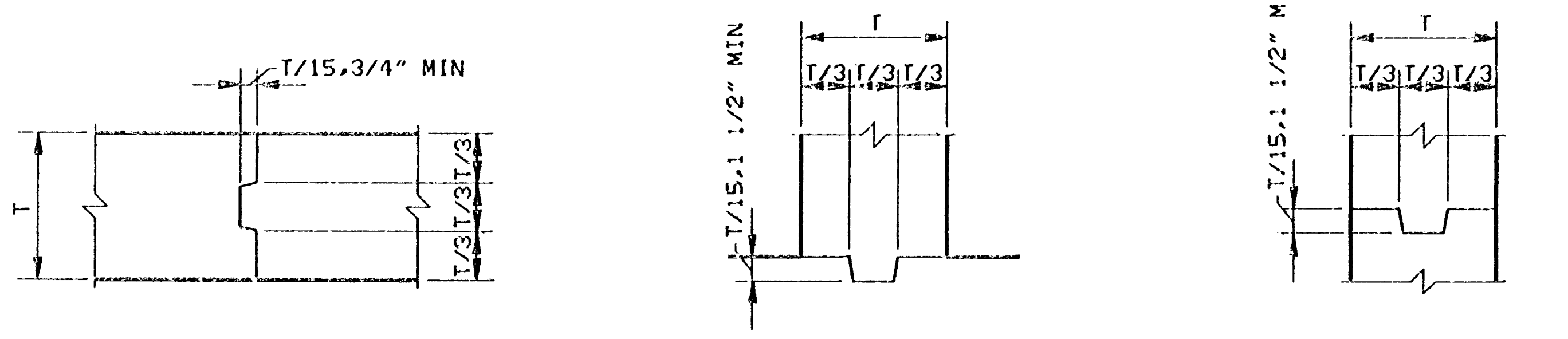
ALTERNATIVE T≥12"

ALTERNATIVE T≥12"

T<12"

BASE OF WALLS

JOINTS WITH WATER STOPS



SLABS

BASE OF WALLS

WALLS

JOINTS WITHOUT WATER STOPS

TYPICAL CONSTRUCTION JOINTS

NOTE: REINFORCING STEEL IS CONTINUOUS THROUGH ALL CONSTRUCTION JOINTS

CONCRETE COVER FOR REINFORCEMENT

LOCATION	MINIMUM COVER
UNFORMED SURFACES ADJACENT TO EXCAVATION	3"
FORMED OR TOP SURFACES EXPOSED TO WEATHER OR SATURATED AIR, SUBMERGED OR IN CONTACT WITH EARTH	
#6 OR LARGER BARS	2"
#5 OR SMALLER BARS	1 1/2"
OTHER LOCATIONS	
BARS IN BEAMS OR GIRDERS, INCLUDING STIRRUPS AND COLUMN SPIRALS OR TIES	1 1/2"
SLABS, WALLS AND JOISTS	
#14 AND #18	1 1/2"
#11 AND SMALLER	3/4"

TOLERANCES FOR CONCRETE COVER AND THE FABRICATION AND PLACING OF REINFORCEMENT SHALL CONFORM TO SECTION 6.0 OF ACI 117.

SPLICE & DEVELOPMENT LENGTHS

BAR SIZE	LENGTH OF LAPPED SPLICES FOR REINF (INCHES)		LENGTH OF DEVELOPMENT FOR END ANCHORAGE OF REINFORCEMENT (INCHES)		
	*TOP BARS	OTHERS	*TOP BARS	OTHERS	HOOKED BARS
3	20	20	12	12	6
4	22	20	14	12	8
5	29	20	17	12	10
6	37	26	22	15	12
7	50	36	29	21	14
8	66	47	39	28	16
9	83	60	49	35	18
10	106	76	62	45	20
11	130	93	77	55	22
14	---	---	104	74	38
18	---	---	135	96	50

* TOP BARS ARE HORIZONTAL BARS SO PLACED THAT MORE THAN 12" OF CONCRETE IS CAST IN THE MEMBER BELOW THE BAR. HORIZONTAL BARS IN WALLS ARE TO BE PROVIDED WITH LAP LENGTHS AS REQUIRED FOR TOP BARS.

STRAIGHT BARS SPACED LESS THAN 6 INCHES ON C[illegible] SHALL HAVE A DEVELOPMENT LENGTH OF 1.25 TIMES THE LENGTH SHOWN.

LAPPED SPLICES SHALL NOT BE MADE AT POINTS OF MAXIMUM STRESS AS DETERMINED BY THE ENGINEER. IF SPLICES ARE STAGGERED SO THAT NO MORE THAN 1/2 ARE SPLICED IN A LAP SPLICE LENGTH, THE SPLICE LENGTH CAN BE REDUCED TO 75% [illegible] THE LENGTHS TABULATED ABOVE.

GENERAL NOTE:
DETAILS ON THIS SHEET APPLY TO ALL DRAWINGS UNLESS OTHERWISE NOTED

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
10-26-93	AS BUILT		PT	SDC	ACR

DESIGNED ALK
DETAILED HLR
CHECKED CJM
APPROVED AC Roberts
DATE 5-28-91

Black & Veatch

PROJECT NO.
17149

CITY OF NORTH LAS VEGAS
UPPER LAS VEGAS WASH
DETENTION BASIN

STANDARD CONCRETE DETAILS

DANA V. AZEL
CIVIL
No. 7138
1-10-95

SHEET
25 OF 25

CCG. DWG. NO: 17149-350 208-C028

Data CD

Technical Appendices and Reference Material