

Restoration of the Salton Sea

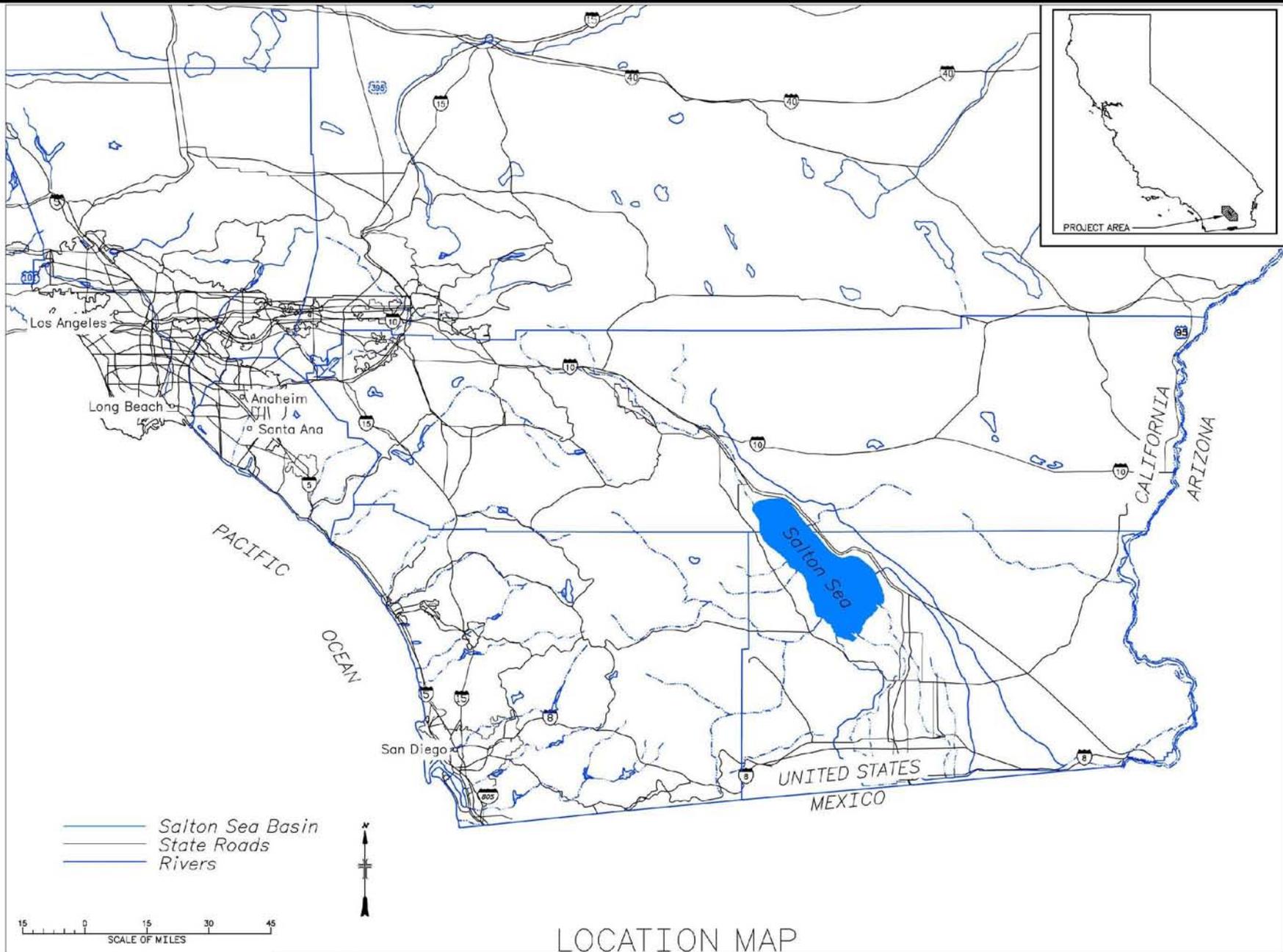
Volume 2: Embankment Designs and Optimization Study

Figures

**Prepared for:
U.S. Department of the Interior
Bureau of Reclamation
Lower Colorado Region
Boulder City, Nevada**

**Prepared by:
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Golden, CO 80401
Project No. 71100**

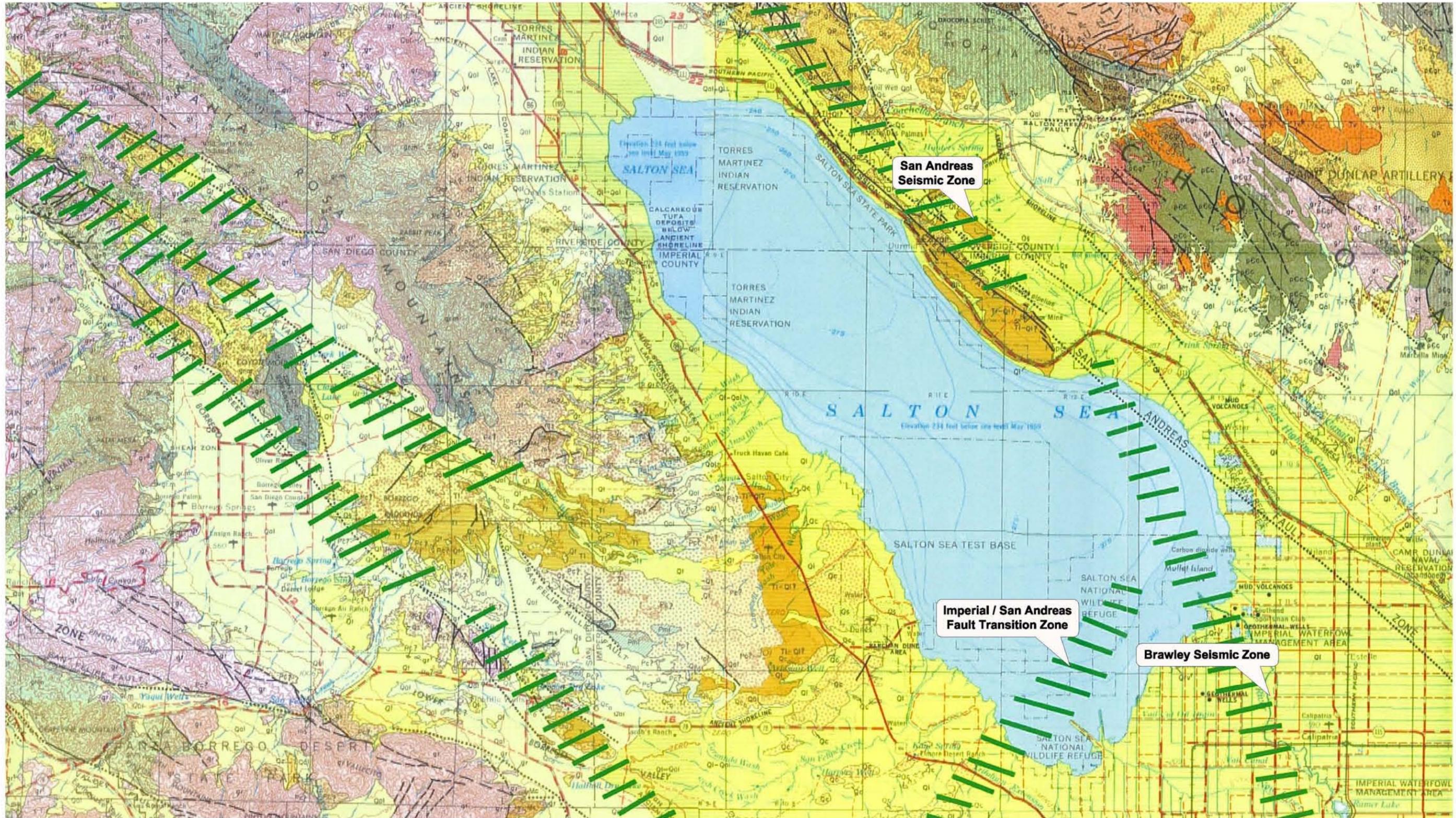
May 2007



LOCATION MAP

 <p>United States Department of the Interior Bureau of Reclamation</p>	<p>SALTON SEA RESTORATION PROJECT Embankment Designs and Optimization Study</p>		<p>PROJECT LOCATION MAP</p>
	<p>KLEINFELDER</p>	<p>Project: 71100</p>	<p>By: KAF/CL</p>

FIGURE 1.1



Source: URS, Figure 6, Dated: 1-29-04.




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SALTON SEA RESTORATION PROJECT
 Embankment Alternatives Optimization Study
 Project: 71100 By: KAF/CL Date: August 2006

Principal Geologic Features Surrounding the Salton Sea
FIGURE 1.2

Source: URS, Figure 7, Dated: 1-29-04.

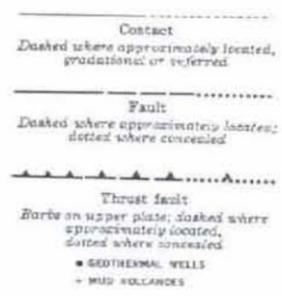
EXPLANATION

SEDIMENTARY AND METASEDIMENTARY ROCKS		IGNEOUS AND META-IGNEOUS ROCKS	
QUATERNARY	Qs	Dune sand	
	Qa	Alluvium	
	Qcc	Stream channel deposits	Qv Recent volcanic: Qv ¹ - rhyolite; Qv ² - andesite; Qv ³ - basalt; Qv ⁴ - pyroclastic rocks
	Qf	Fan deposits	
	Qt	Basin deposits	
	Qst	Salt deposits	
	Ql	Quaternary lake deposits	
	Qg	Glacial deposits	
	Qn	Quaternary nonmarine terrace deposits	
	Qm	Pleistocene marine and marine terrace deposits	Qm Pleistocene volcanic: Qm ¹ - rhyolite; Qm ² - andesite; Qm ³ - basalt; Qm ⁴ - pyroclastic rocks
	Qc	Pleistocene nonmarine	
	Qp	Piso-Pleistocene nonmarine	Quaternary and/or Pliocene cinder cones
	Qn	Undivided Pliocene nonmarine	
	Pac	Upper Pliocene nonmarine	
	Pa	Upper Pliocene marine	Pliocene volcanic: Pa ¹ - rhyolite; Pa ² - andesite; Pa ³ - basalt; Pa ⁴ - pyroclastic rocks
Pml	Middle and/or lower Pliocene nonmarine		
Pm	Middle and/or lower Pliocene marine		
TERTIARY	Micocene		
	Mu	Undivided Miocene nonmarine	
	Muc	Upper Miocene nonmarine	
	Mu	Upper Miocene marine	Miocene volcanic: M ¹ - rhyolite; M ² - andesite; M ³ - basalt; M ⁴ - pyroclastic rocks
	Mmc	Middle Miocene nonmarine	
	Mm	Middle Miocene marine	
	ML	Lower Miocene marine	
	Oligocene		
	Qc	Oligocene nonmarine	Oligocene volcanic: Qc ¹ - rhyolite; Qc ² - andesite; Qc ³ - basalt; Qc ⁴ - pyroclastic rocks
	Q	Oligocene marine	
Eocene			
Ec	Eocene nonmarine	Eocene volcanic: E ¹ - rhyolite; E ² - andesite; E ³ - basalt; E ⁴ - pyroclastic rocks	
E	Eocene marine		
Paleocene			
Epc	Paleocene nonmarine		
Ep	Paleocene marine		
Fault Segment Associated with Significant Linear Trend of Earthquake Epicenters			

EXPLANATION

SEDIMENTARY AND METASEDIMENTARY ROCKS		IGNEOUS AND META-IGNEOUS ROCKS	
Undivided	Qn	Cenozoic nonmarine	Qn Cenozoic volcanic: Qn ¹ - rhyolite; Qn ² - andesite; Qn ³ - basalt; Qn ⁴ - pyroclastic rocks
	Qc	Tertiary nonmarine	Qc Tertiary granitic rocks
	Ql	Tertiary lake deposits	Ql Tertiary intrusive (hypabyssal) rocks: Ql ¹ - rhyolite; Ql ² - andesite; Ql ³ - basalt
	Qm	Tertiary marine	Qm Tertiary volcanic: Qm ¹ - rhyolite; Qm ² - andesite; Qm ³ - basalt; Qm ⁴ - pyroclastic rocks
CRETACEOUS	K	Undivided Cretaceous marine	
	Ku	Upper Cretaceous marine	Ku Franciscan volcanic and metavolcanic rocks
	Kl	Lower Cretaceous marine	Kl Mesozoic granitic rocks: K ¹ - granite and adamellite; K ² - granodiorite; K ³ - tonalite and diorite
	Ka	Knoville Formation	Ka Mesozoic basic intrusive rocks
	Ju	Upper Jurassic marine	Ju Mesozoic ultrabasic intrusive rocks
	Jml	Middle and/or Lower Jurassic marine	Jml Jura-Triassic metavolcanic rocks
	J	Triassic marine	
	Pre-Cretaceous		
	Is	Pre-Cretaceous metamorphic rocks (Is = limestone or dolomite)	mv Pre-Cretaceous metavolcanic rocks
	ms	Pre-Cretaceous metasedimentary rocks	gm Pre-Cenozoic granitic and metamorphic rocks
P	Paleozoic marine (Is = limestone or dolomite)	pv Paleozoic metavolcanic rocks	
PERMIAN	P	Permian marine	P Permian metavolcanic rocks
	G	Undivided Carboniferous marine	G Carboniferous metavolcanic rocks
	CP	Pennsylvanian marine	
	CM	Mississippian marine	
	D	Devonian marine	D Devonian metavolcanic rocks
	S	Silurian marine	Dv Devonian and pre-Devonian? metavolcanic rocks
	ps	Pre-Silurian meta-sedimentary rocks	ps Pre-Silurian metamorphic rocks
	C	Ordovician marine	psr Pre-Silurian metavolcanic rocks
	C	Cambrian marine	
	CP	Cambrian - Precambrian marine	pc Precambrian igneous and metamorphic rock complex
CAMBRIAN ORDOVICIAN SILURIAN DEVONIAN CARBONIFEROUS	pc	Undivided Precambrian metamorphic rocks (G = gneiss, S = schist)	pcg Undivided Precambrian granitic rocks
	pc	Later Precambrian sedimentary and metamorphic rocks	pCan Precambrian anorthosite
	pc	Earlier Precambrian metamorphic rocks	

HEAD OF ORDER ON BOXES INDICATES UNITS THAT APPEAR ON THIS SHEET



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SALTON SEA RESTORATION PROJECT
 Embankment Designs and Optimization Study

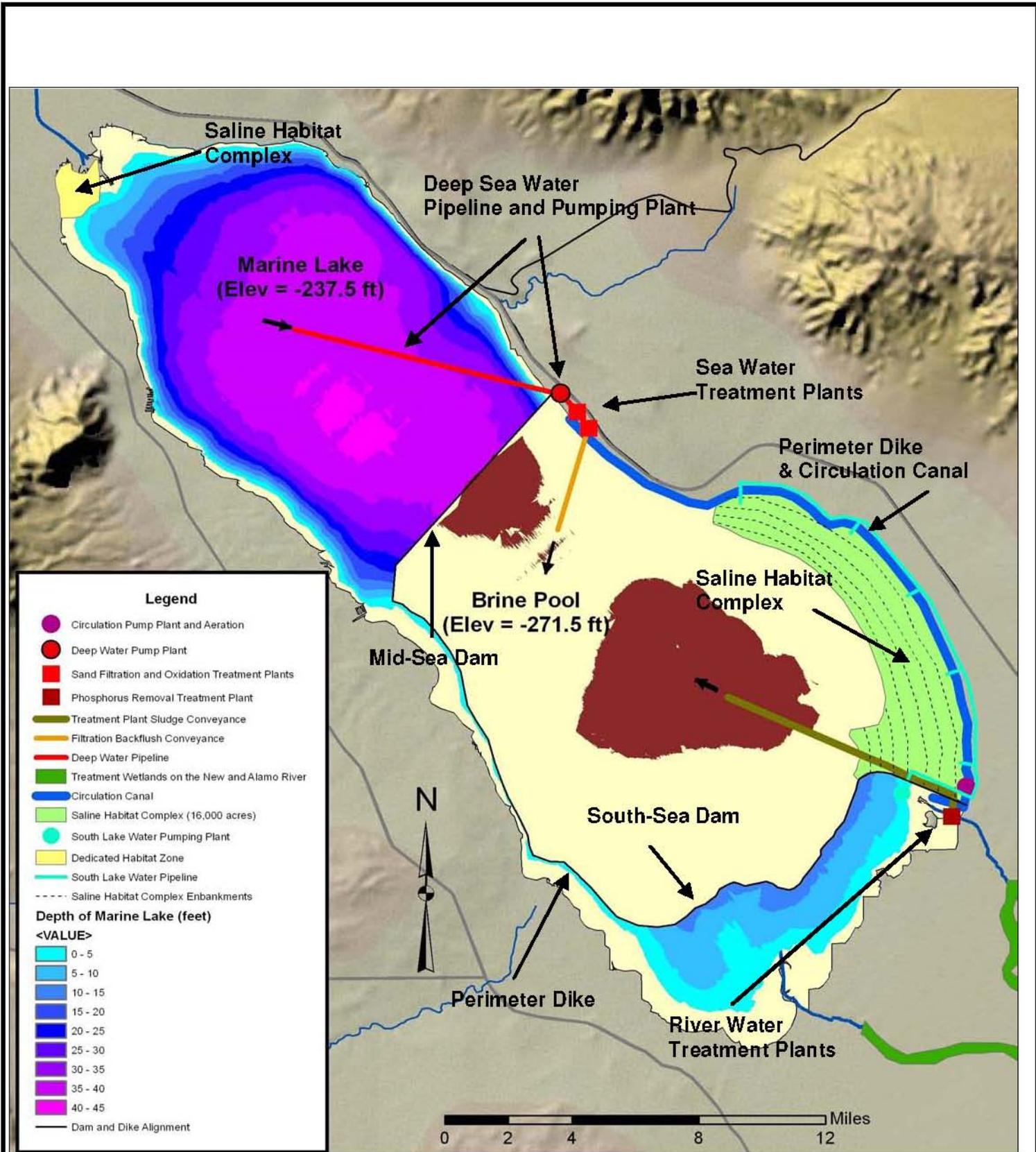
Geologic Features Legend

Project 71100

By: KAFCL

Date: August 2006

FIGURE 1.3



United States
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SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

Alternative No. 1
Mid-Sea-Dam / North Marine
Lake (Salton Sea Authority
Alternative)

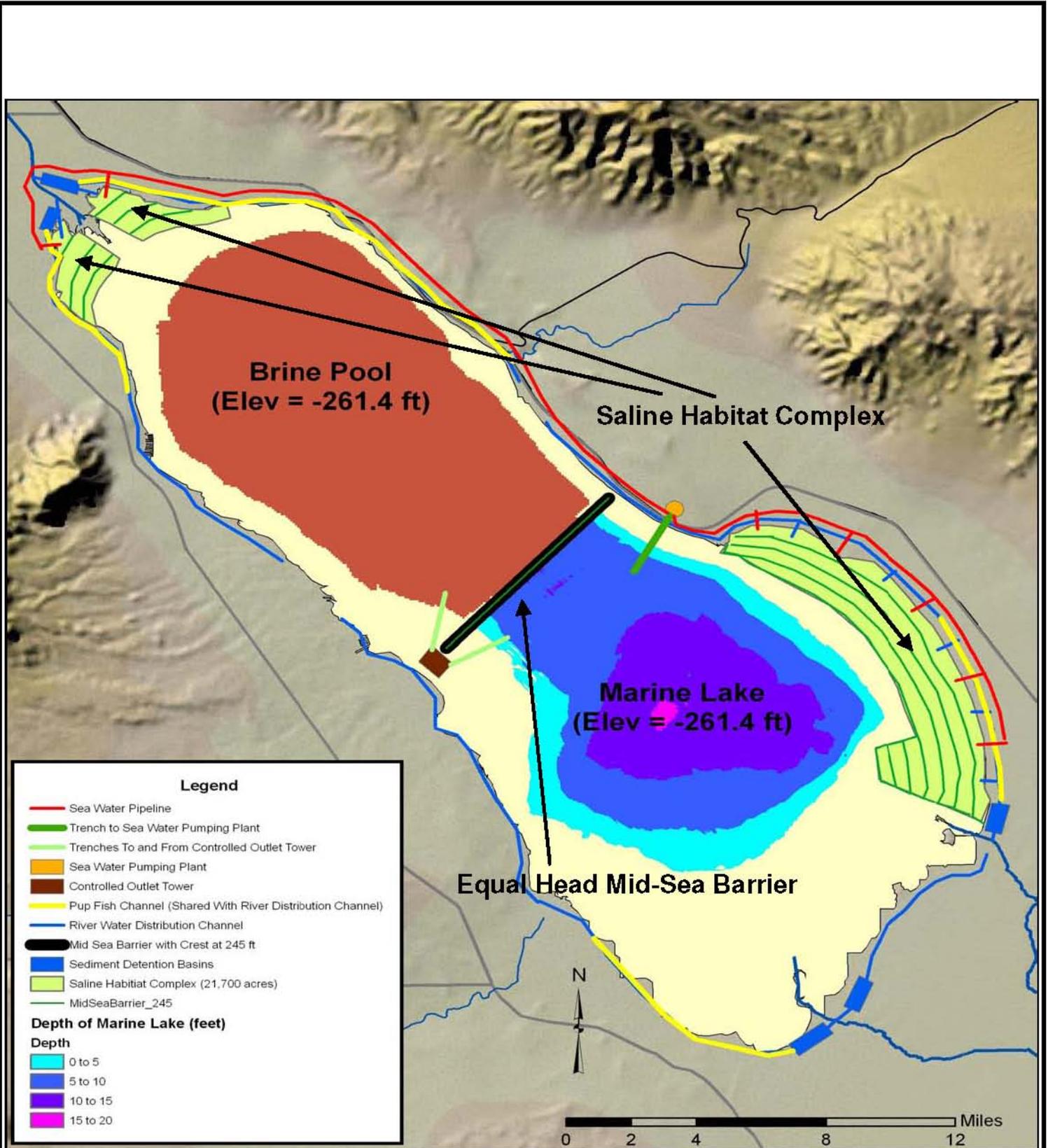
KLEINFELDER

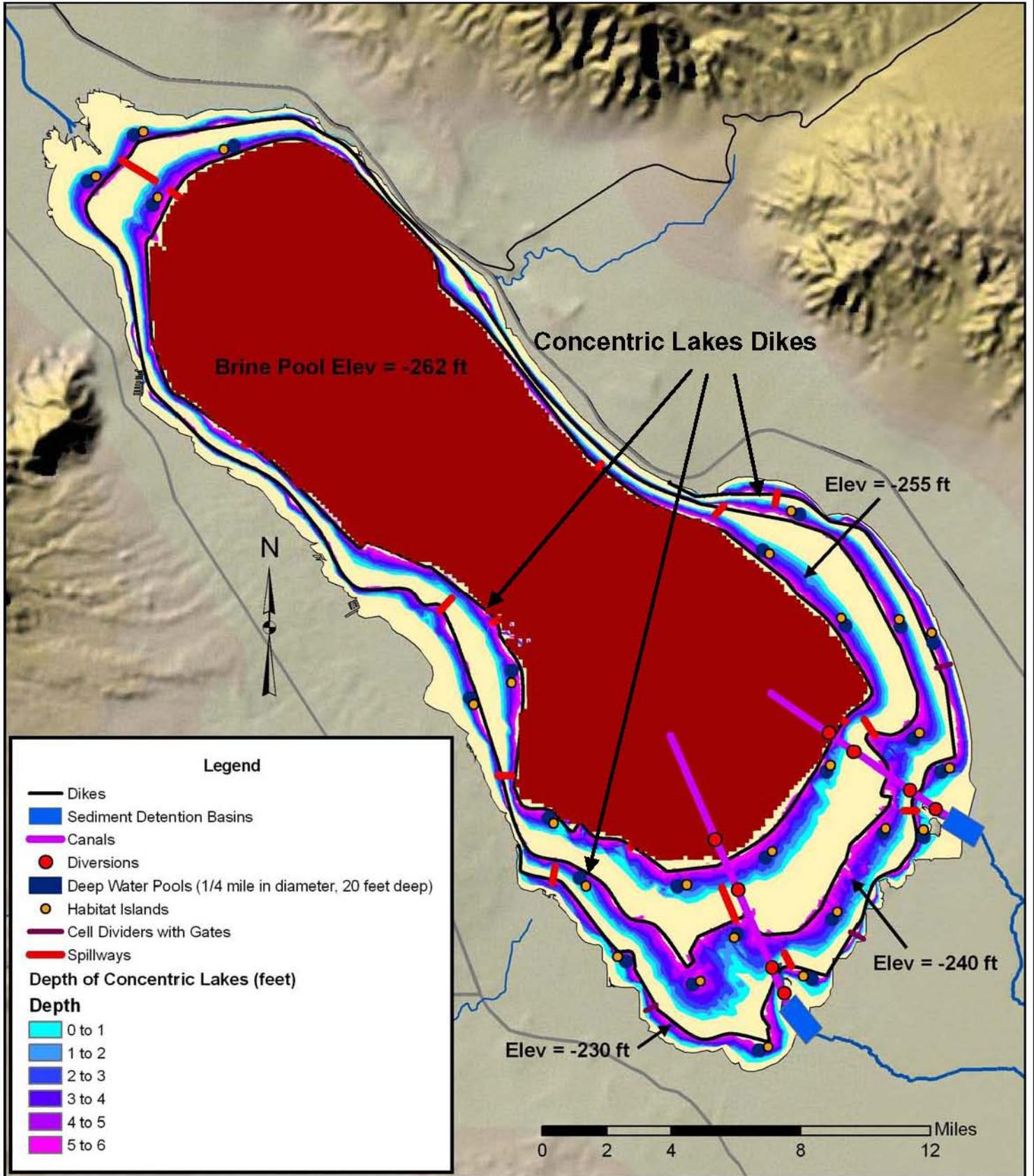
Project: 71100

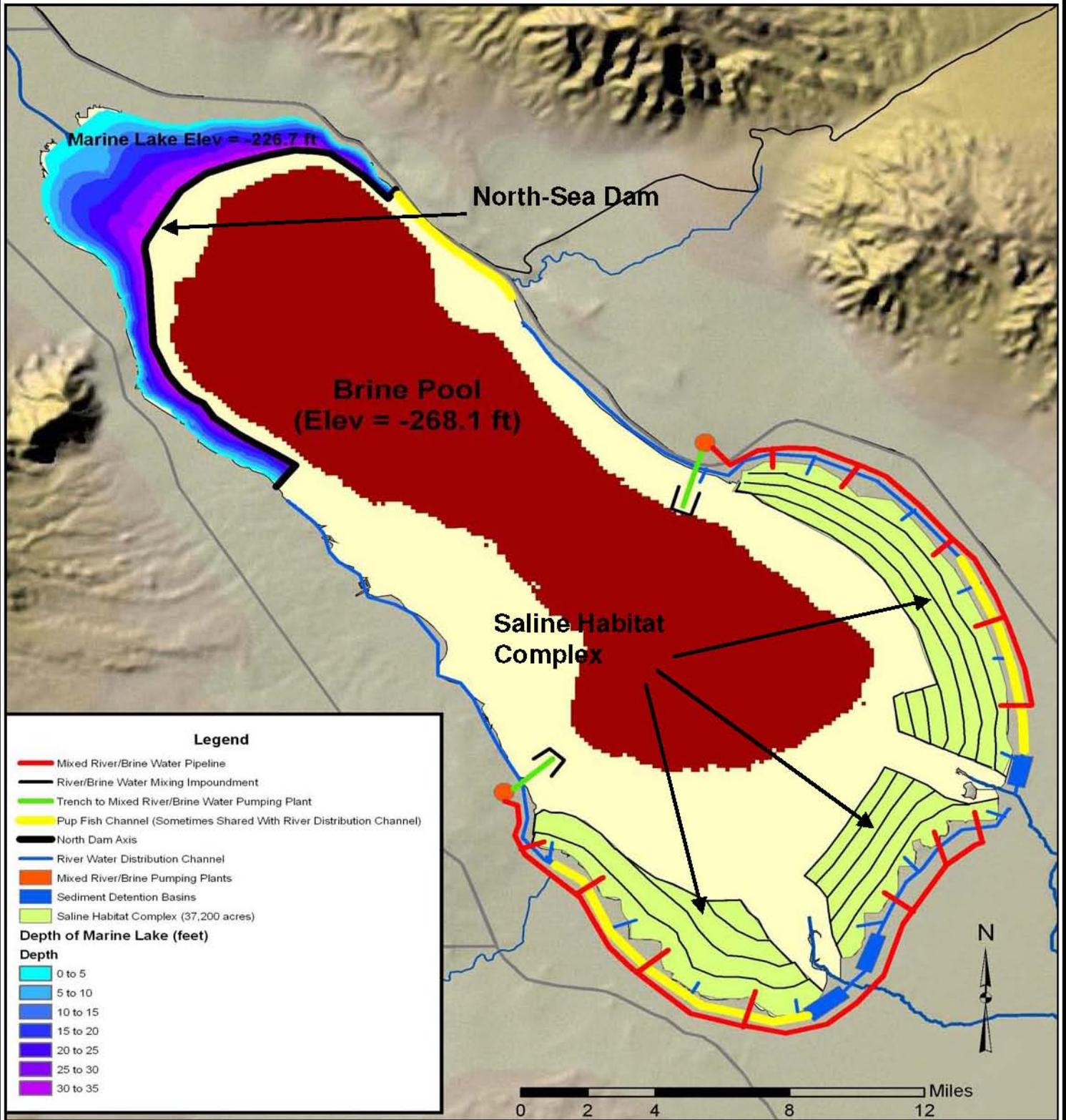
By: KAF/JCL

Date: April 2007

FIGURE 3.1







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SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

Alternative No. 4

North-Sea Dam / Marine Lake

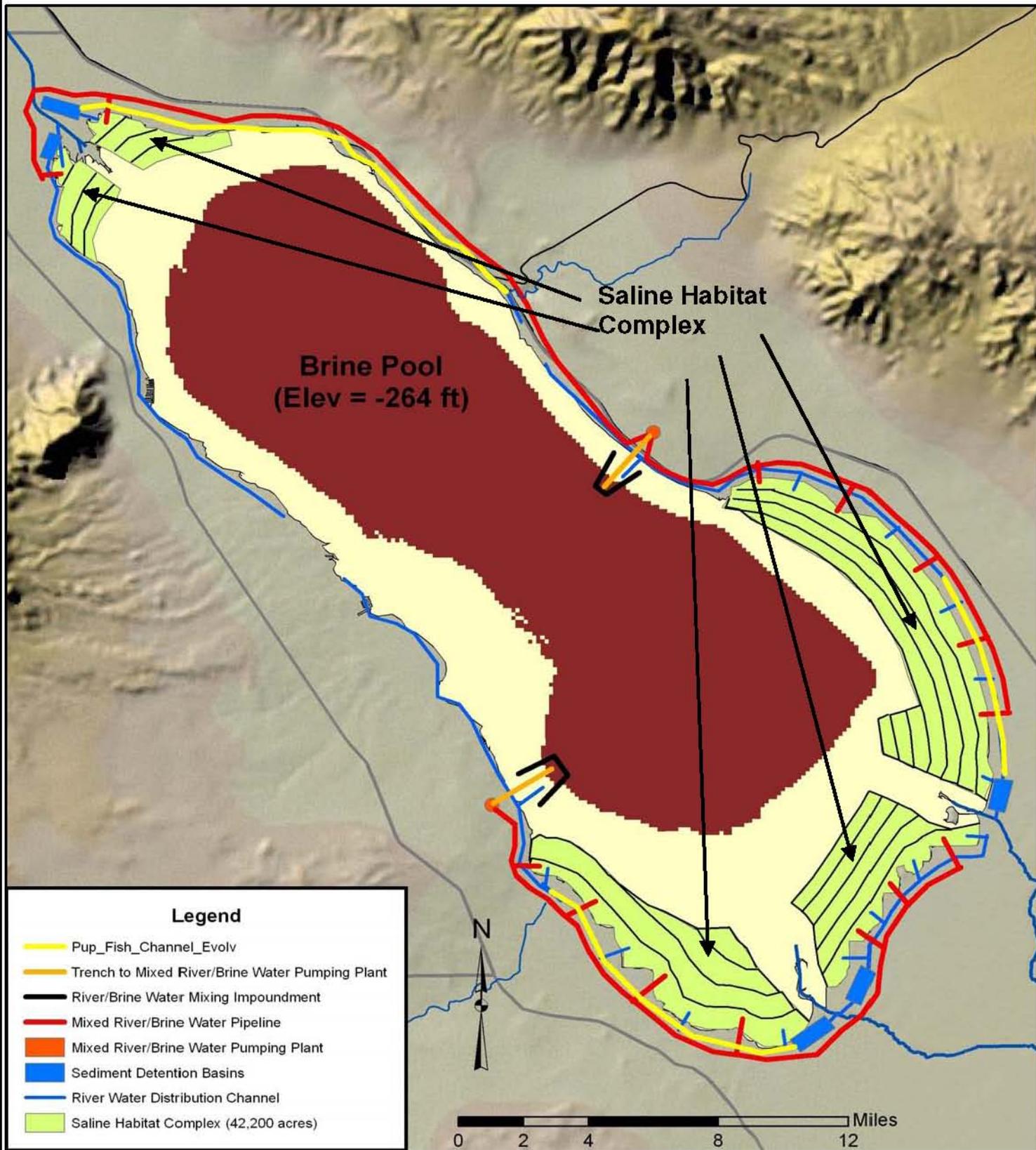
KLEINFELDER

Project: 71100

By: KAF/CL

Date: April 2007

FIGURE 3.4



Note: Base drawing taken from Reclamation's Statement of Work, dated April 11, 2006.

"Baseline" Mid-Sea Dam Characteristics and Assumptions :

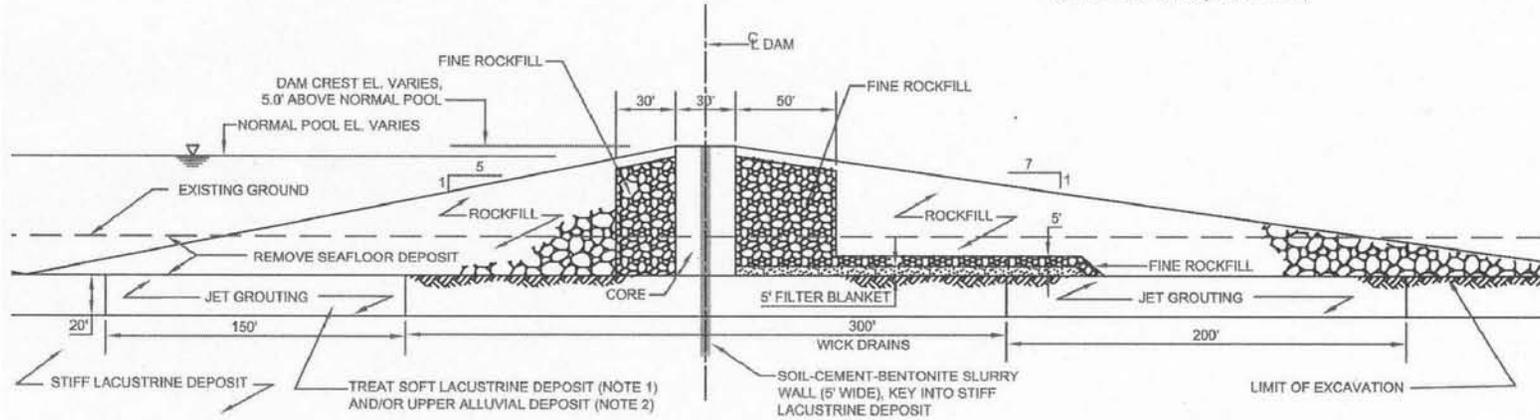
1. Dam crest at El -223 ft.
2. Pre-dredge mudline at El -268 ft.
3. Upstream pool at El -228 ft.
4. Downstream pool at El -268 ft.
5. Dredge exsiting Seafloor Deposits to El -280 ft.
6. Bottom of Soft Lacustrine Deposits at El -305 ft.

EMBANKMENT ZONES

ROCKFILL -	1' - 4' SOUND AND DURABLE QUARRY ROCK, DUMPED UNDERWATER.
FINE ROCKFILL -	3" - 12" SOUND AND DURABLE QUARRY ROCK, DUMPED UNDERWATER.
CORE -	CLEAN SAND AND GRAVEL, BUCKET PLACED IN LAYERS UNDERWATER.
FILTER BLANKET -	LAYER OF CLEAN SAND COVERED BY A LAYER OF GRAVEL, PLACED BY DUMPING IN WATER.

NOTES:

- 1) IN THE SOFT LACUSTRINE DEPOSIT, JET GROUT UPSTREAM AND DOWNSTREAM ZONES AND CONSOLIDATE MIDDLE ZONE WITH WICK DRAINS. (SEE DRAWING).
- 2) IN THE UPPER ALLUVIAL DEPOSIT, JET GROUT UPSTREAM AND DOWNSTREAM ZONES (SEE DRAWING).



ALTERNATIVE TYPICAL DAM
CROSS SECTION

0 50 100
Approximate Scale in Feet

SALTON SEA RESTORATION
PROJECT

FIGURE 1
ALTERNATE TYPICAL DAM
CROSS SECTION

CONSTRUCTABILITY REVIEW
8/4/2005



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SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

**Reclamation Preferred
Mid-Sea-Dam Configuration -
Appraisal Study**

Project: 71100

By: KAF/CL

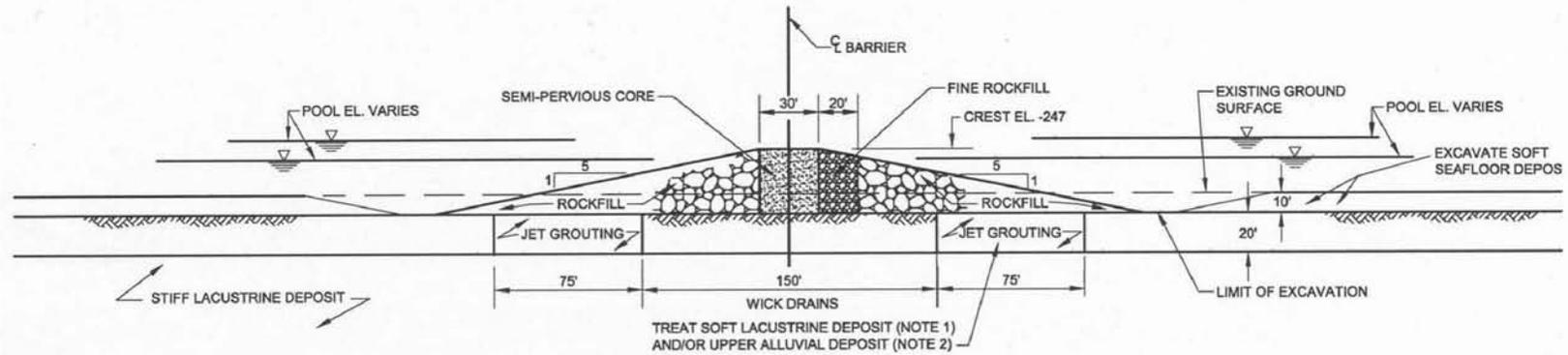
Date: August 2006

FIGURE 4.1

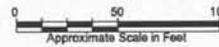
Note: Base drawing taken from Reclamation's Statement of Work, dated April 11, 2006.

"Baseline" Mid-Sea Barrier Characteristics and Assumptions :

1. Embankment crest at El -247 ft.
2. Pre-dredge mudline at El -268 ft.
3. Upstream pool at El -252 ft.
4. Downstream pool at El -257 ft.
5. Dredge exsiting Seafloor Deposits to El -280 ft.
6. Bottom of Soft Lacustrine Deposits at El -305 ft.
7. No post-dredging ground improvement (contrary to what is shown on this illustration).



**ALTERNATE BARRIER
TYPICAL CROSS SECTION**



LEGEND

- ROCKFILL - 1' - 4' HARD DURABLE QUARRY ROCK, DUMPED UNDERWATER.
- FINE ROCKFILL 3' - 12" HARD DURABLE QUARRY ROCK, DUMPED UNDERWATER.
- SEMI-PERVIOUS CORE - SAND AND GRAVEL, BUCKET PLACED IN LAYERS UNDERWATER.

NOTES:

- 1) IN THE SOFT LACUSTRINE DEPOSIT, JET GROUT UPSTREAM AND DOWNSTREAM ZONES AND CONSOLIDATE MIDDLE ZONE WITH WICK DRAINS. (SEE DRAWING).
- 2) IN THE UPPER ALLUVIAL DEPOSIT, JET GROUT UPSTREAM AND DOWNSTREAM ZONES (SEE DRAWING).

**SALTON SEA RESTORATION
PROJECT**

**FIGURE 2
ALTERNATE BARRIER
TYPICAL CROSS SECTION**

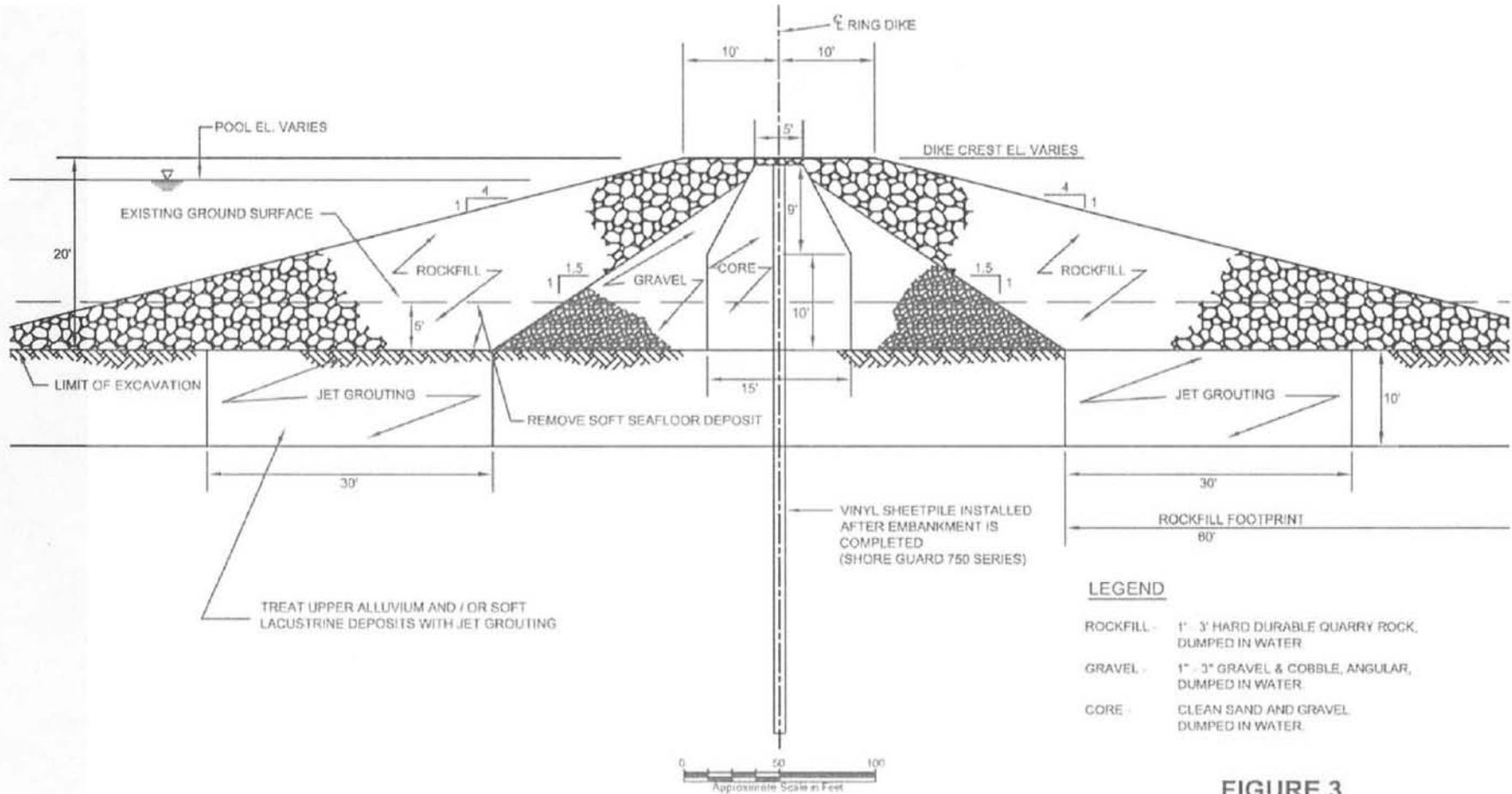
CONSTRUCTABILITY REVIEW
8/4/2005

 <p>United States Department of the Interior Bureau of Reclamation</p>	<p>SALTON SEA RESTORATION PROJECT Embankment Designs and Optimization Study</p>			<p>Reclamation Preferred Mid-Sea Barrier Configuration - Appraisal Study</p>	
	<p>KLEINFELDER</p>		<p>Project: 71100</p>		<p>By: KAF/CL</p>

Note: Base drawing taken from Reclamation's Statement of Work, dated April 11, 2006.

"Baseline" Ring / Perimeter Dike Characteristics and Assumptions :

1. Embankment crest at El -240 ft.
2. Pre-dredge mudline at El -260 ft.
3. Upstream pool at El -240.5 ft (0.5 ft freeboard).
4. Downstream pool at El -255 ft.
5. Dredge exsiting Seafloor Deposits to El -265 ft (west side) or to El -270 ft (east side).
6. Bottom of Soft Lacustrine Deposits at El -280 ft (east side).
7. Bottom of Upper Alluvium at El -275 ft (west side).



**SALTON SEA RESTORATION
PROJECT**

**FIGURE 3
ALTERNATE TYPICAL RING DIKE
CROSS SECTION**


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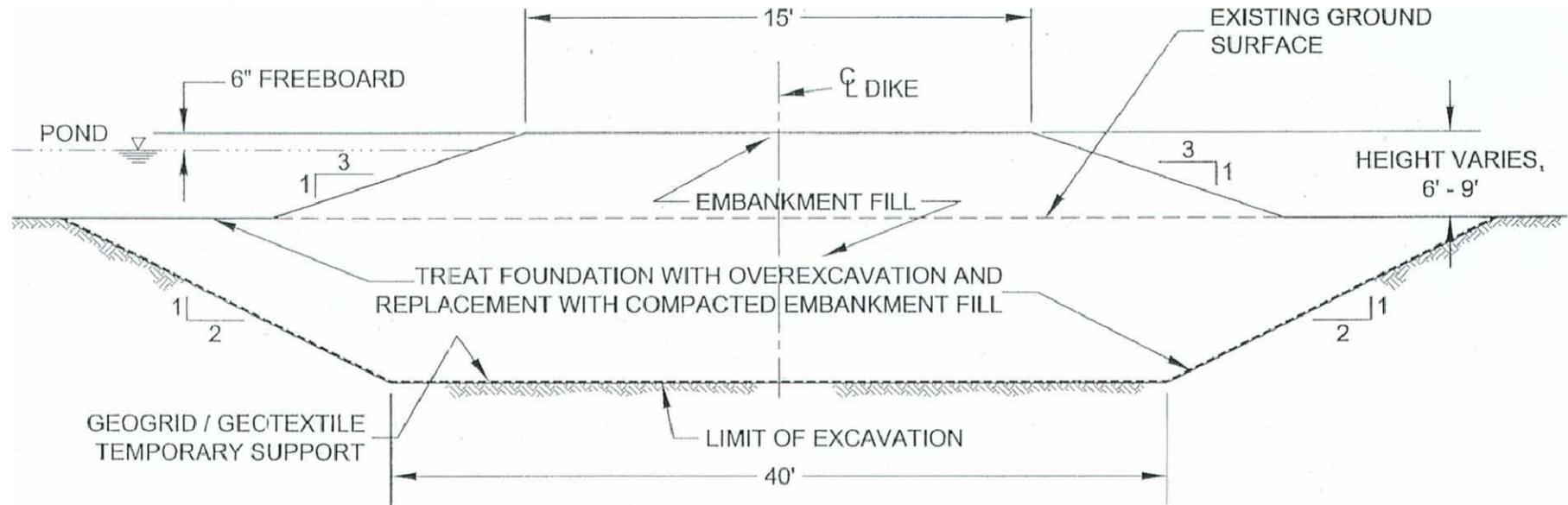
SALTON SEA RESTORATION PROJECT
 Embankment Alternatives Optimization Study
 Project: 71100 By: KAF/CL Date: August 2006

**Reclamation Preferred Ring
Dike Configuration - Appraisal
Study**
FIGURE 4.3

Note: Base drawing taken from Reclamation's Statement of Work, dated April 11, 2006.

"Baseline" Habitat Pond Earthfill Embankment Characteristics and Assumptions :

1. Embankment crest at EI -241 ft.
2. Pre-dredge mudline at EI -250 ft.
3. Upstream pool at EI -241.5 ft.
4. Downstream pool at EI -250 ft.
5. Dredge exsiting Seafloor Deposits to EI -260 ft.
6. Embankment founded on 5 ft of Upper Alluvium, underlain by 5 ft of Stiff Lacustrine, underlain by additional Upper Alluvium.



**TYPICAL EARTHFILL EMBANKMENT
FOR HABITAT PONDS**

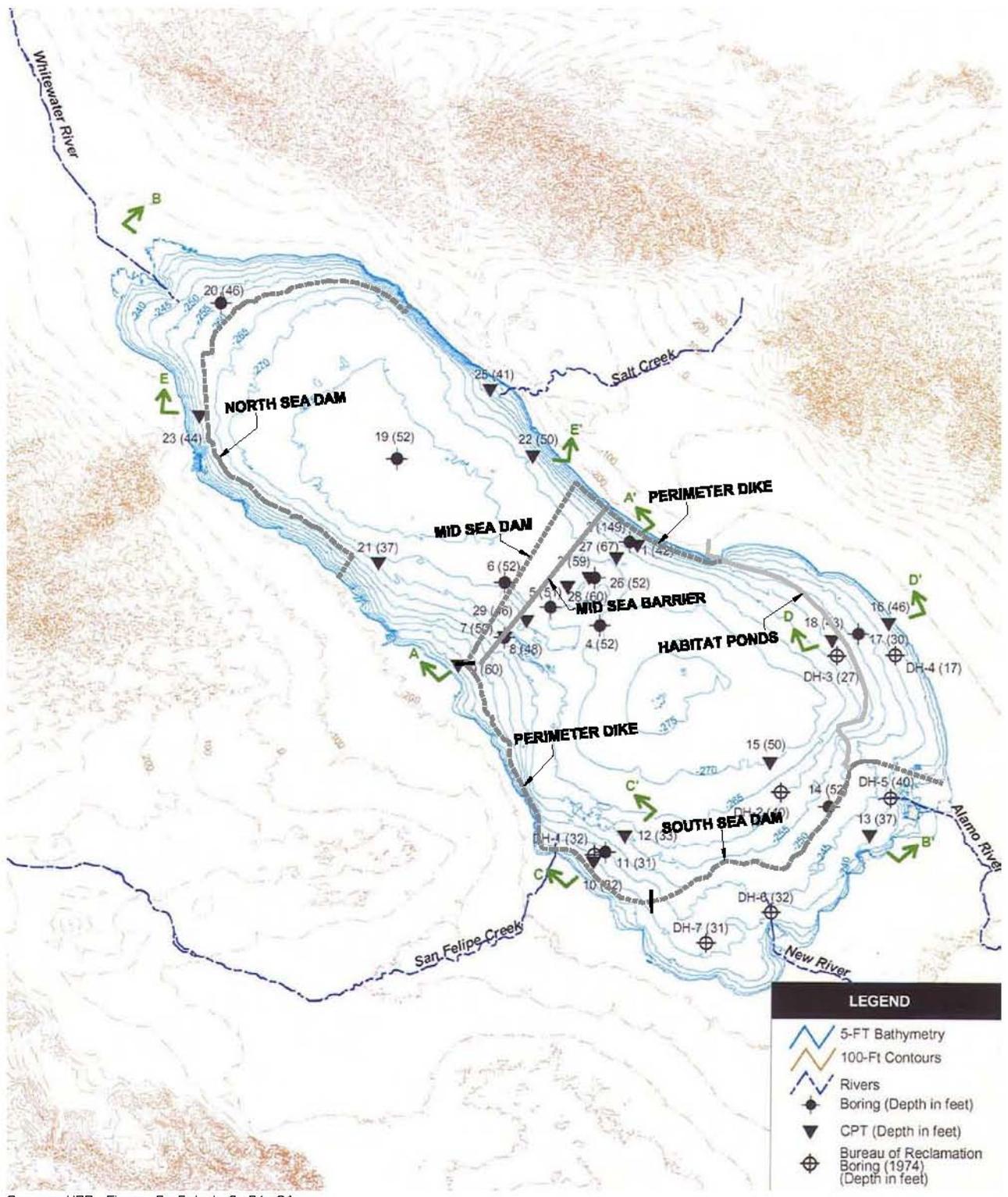
(NOT TO SCALE)

LEGEND

EMBANKMENT FILL - COMPACTED (IN THE DRY) EARTHFILL (CLAY, SILT)

 <p>United States Department of the Interior Bureau of Reclamation</p>	<p>SALTON SEA RESTORATION PROJECT Embankment Alternatives Optimization Study</p>		<p>Reclamation Preferred Habitat Pond Embankment Configuration - Appraisal Study</p>
	<p>KLEINFELDER</p>	<p>Project: 71100</p>	<p>By: KAF/CL</p>

FIGURE 4.4



Source: URS, Figure 2, Dated: 2-24-04.



United States
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SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

**Location of 2004 Explorations
Relative to Alternatives 1, 2
and 4 Embankments**

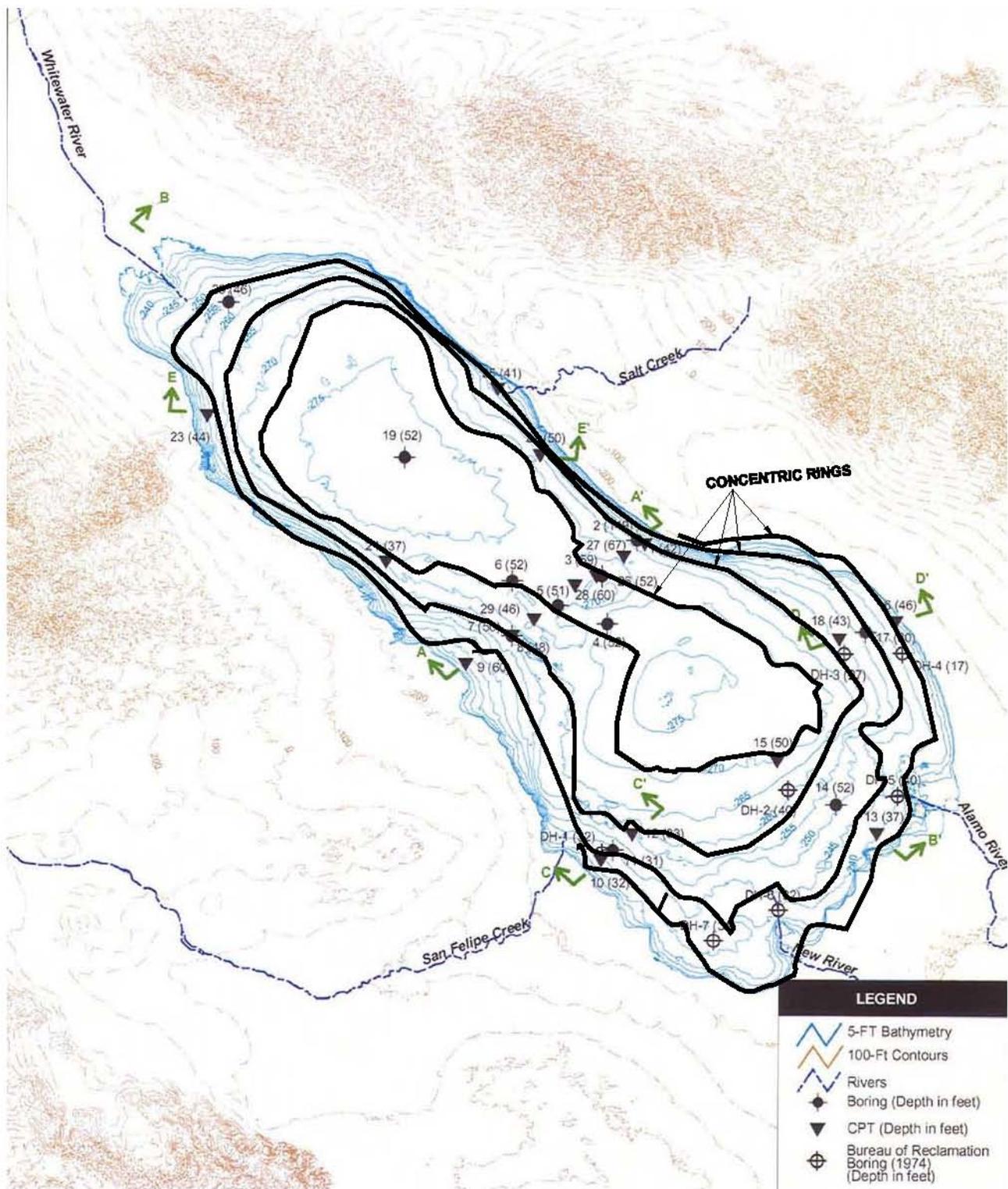
KLEINFELDER

Project: 71100

By: KAF/CL

Date: August 2006

FIGURE 4.5



Source: URS, Figure 2, Dated: 2-24-04.



United States
Department of the Interior
Bureau of Reclamation

SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

**Location of 2004 Explorations
Relative to Alternative 3
Embankments**

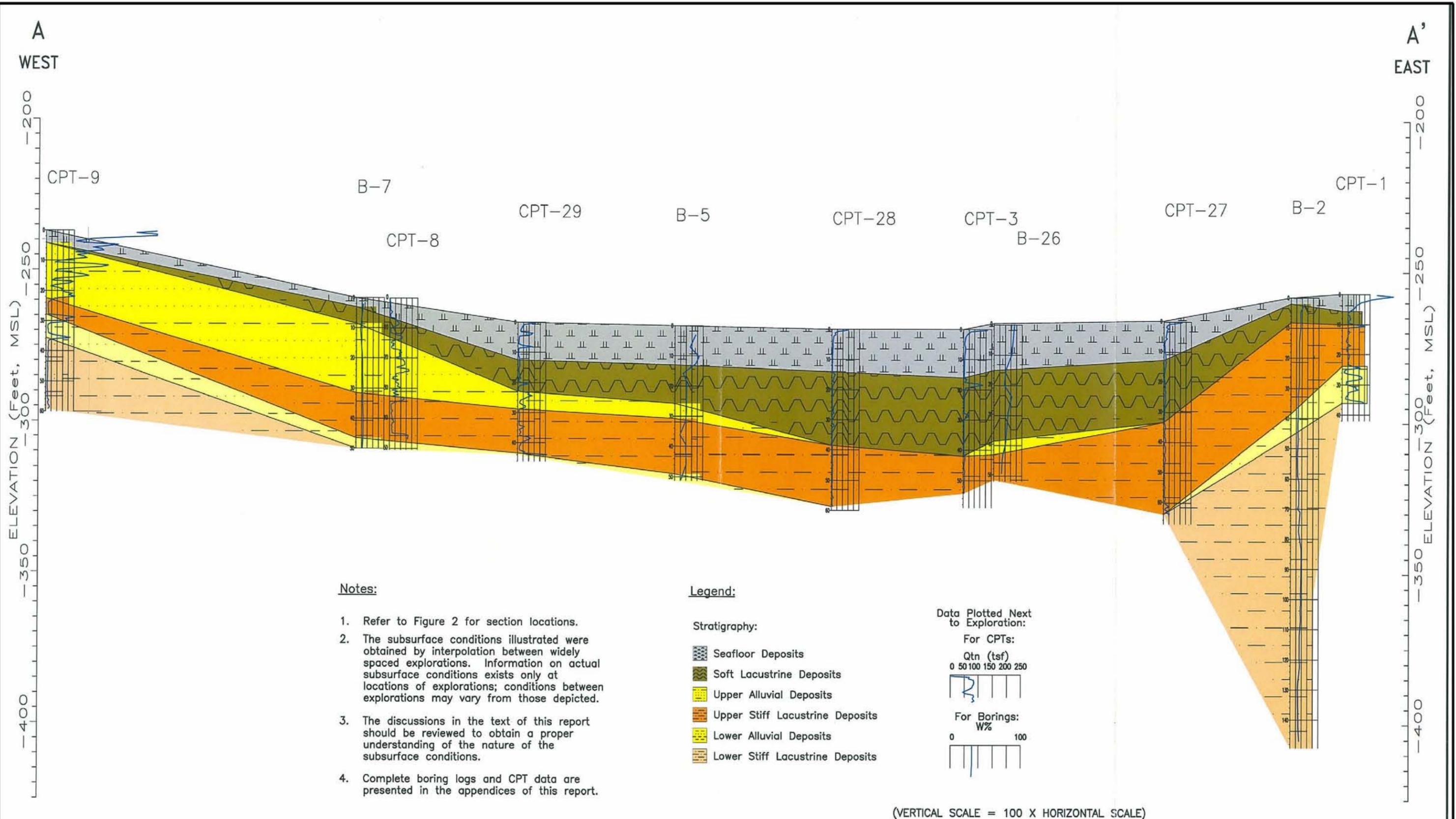
KLEINFELDER

Project: 71100

By: KAF/CL

Date: August 2006

FIGURE 4.6



Source: URS, Figure 9, Dated: 1-29-04.

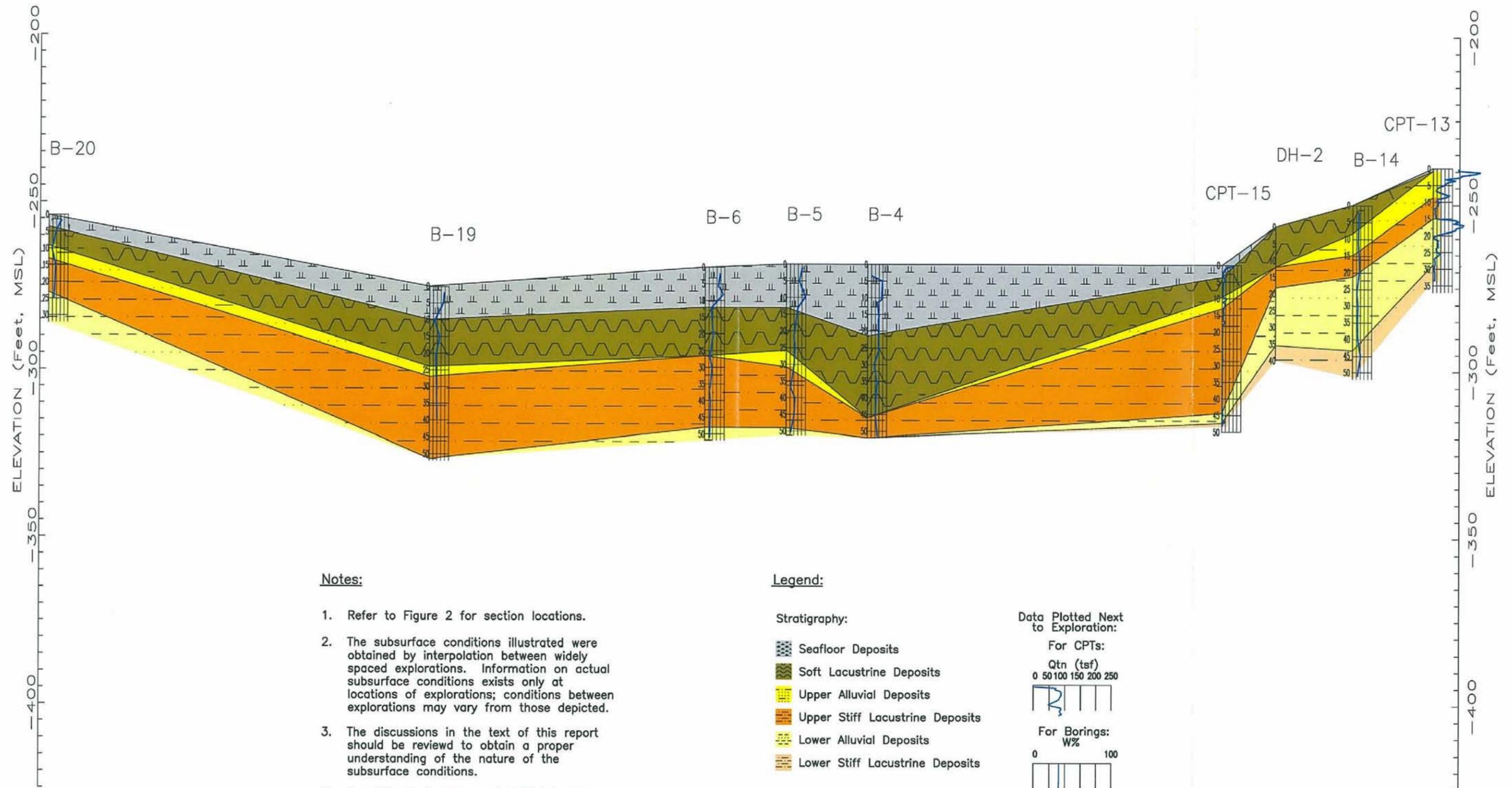


<p>United States Department of the Interior Bureau of Reclamation</p>	<p>SALTON SEA RESTORATION PROJECT Embankment Designs and Optimization Study</p>		<p>GEOLOGIC CROSS SECTION A-A'</p>
	<p>KLEINFELDER</p>	<p>Project: 71100</p>	

FIGURE 4.7a

B
NORTHWEST

B'
SOUTHEAST



Notes:

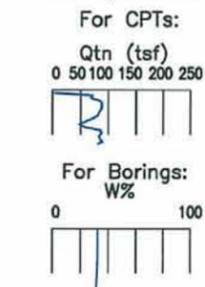
1. Refer to Figure 2 for section locations.
2. The subsurface conditions illustrated were obtained by interpolation between widely spaced explorations. Information on actual subsurface conditions exists only at locations of explorations; conditions between explorations may vary from those depicted.
3. The discussions in the text of this report should be reviewed to obtain a proper understanding of the nature of the subsurface conditions.
4. Complete boring logs and CPT data are presented in the appendices of this report.

Legend:

Stratigraphy:

- Seafloor Deposits
- Soft Lacustrine Deposits
- Upper Alluvial Deposits
- Upper Stiff Lacustrine Deposits
- Lower Alluvial Deposits
- Lower Stiff Lacustrine Deposits

Data Plotted Next to Exploration:



(VERTICAL SCALE = 400 X HORIZONTAL SCALE)

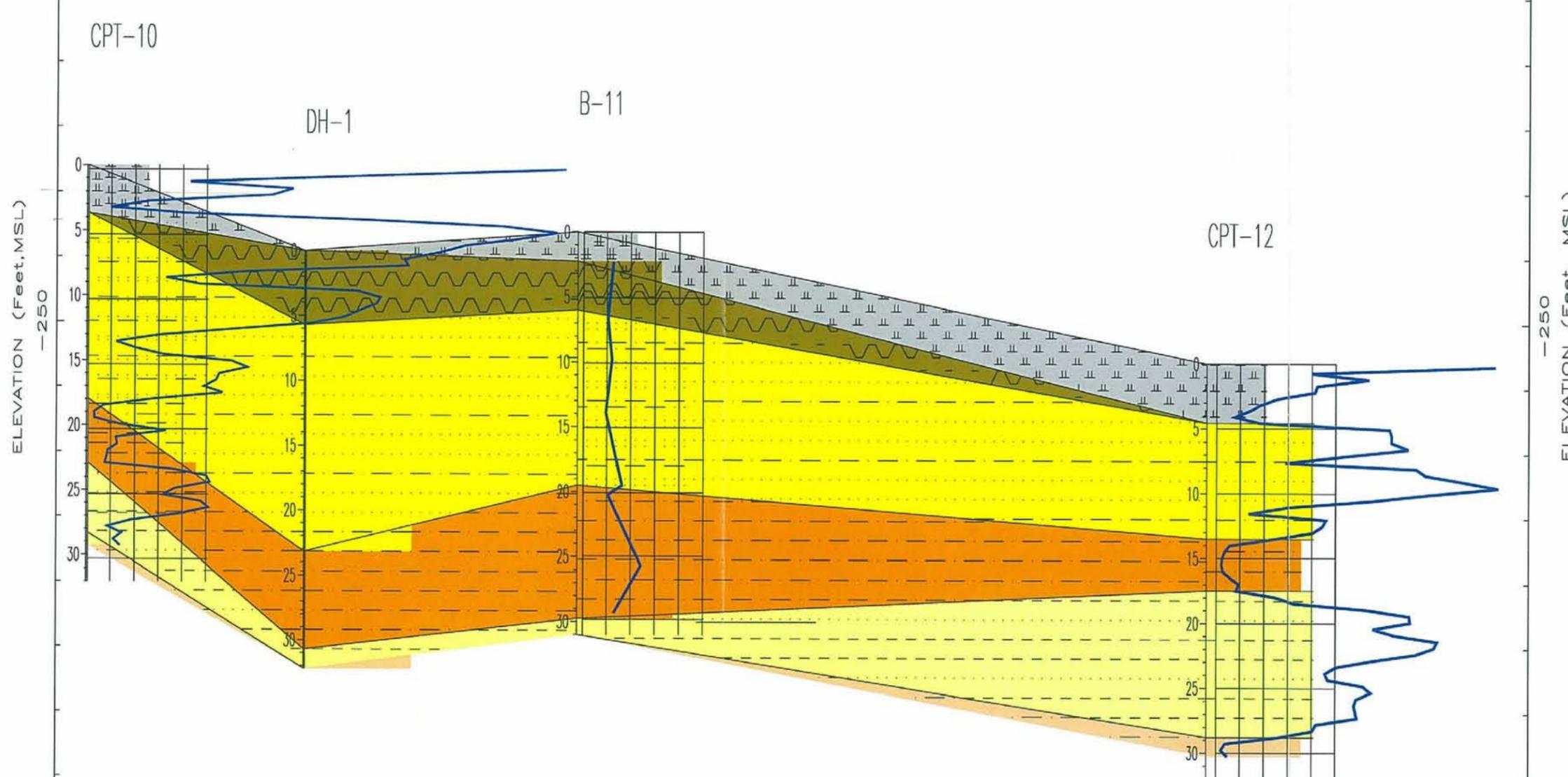
Source: URS, Figure 10, Dated: 12-10-03.



<p>United States Department of the Interior Bureau of Reclamation</p>	<p>SALTON SEA RESTORATION PROJECT Embankment Designs and Optimization Study</p>		<p>GEOLOGIC CROSS SECTION B-B'</p>
	<p>KLEINFELDER</p>	<p>Project: 71100</p>	<p>By: KAF/CL/MB</p>

FIGURE 4.7b

C WEST C' EAST

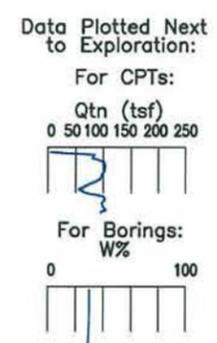


Notes:

1. Refer to Figure 2 for section locations.
2. The subsurface conditions illustrated were obtained by interpolation between widely spaced explorations. Information on actual subsurface conditions exists only at locations of explorations; conditions between explorations may vary from those depicted.
3. The discussions in the text of this report should be reviewed to obtain a proper understanding of the nature of the subsurface conditions.
4. Complete boring logs and CPT data are presented in the appendices of this report.

Legend:

- Stratigraphy:**
- Seafloor Deposits
 - Soft Lacustrine Deposits
 - Upper Alluvial Deposits
 - Upper Stiff Lacustrine Deposits
 - Lower Alluvial Deposits
 - Lower Stiff Lacustrine Deposits



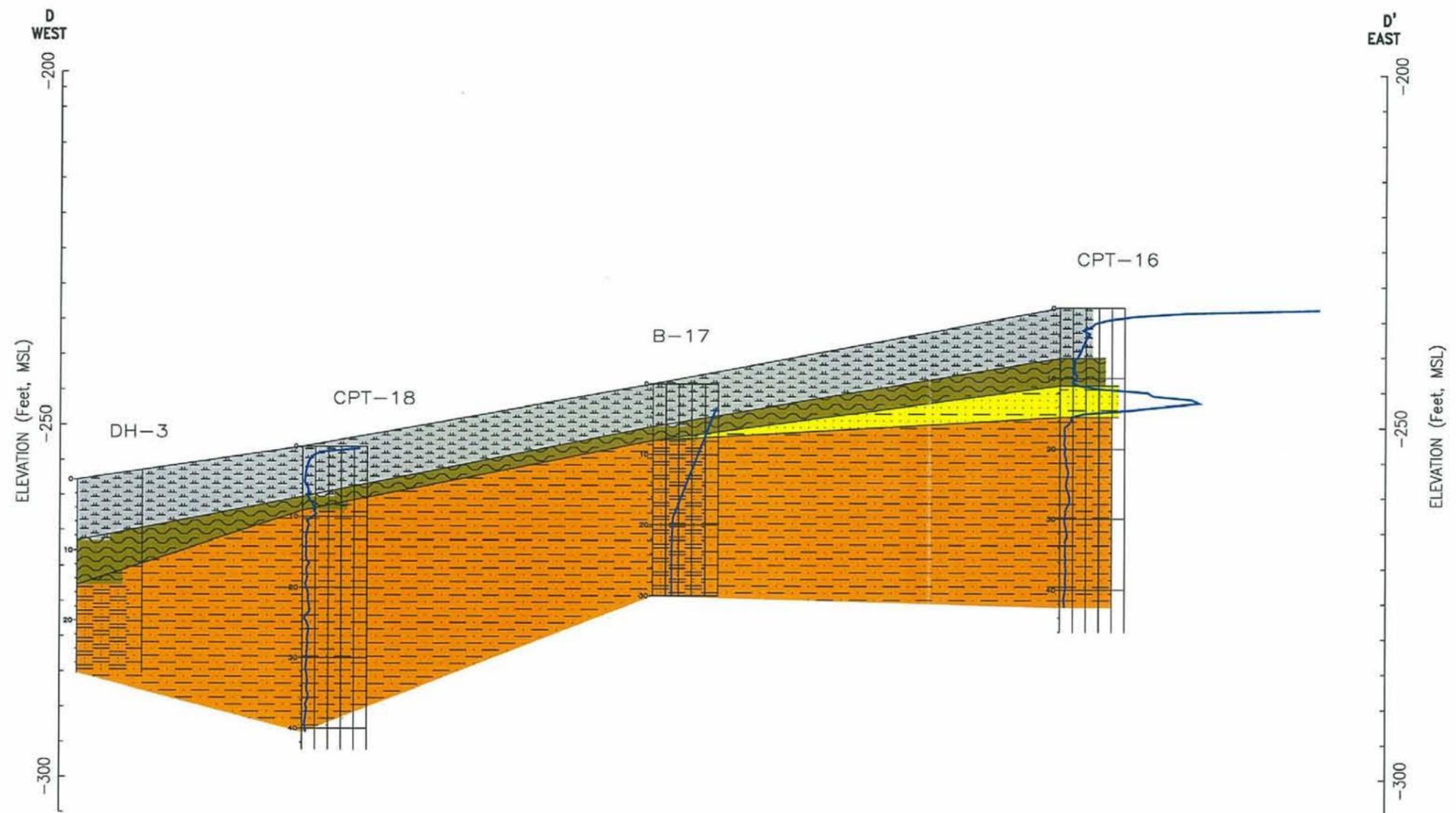
(VERTICAL SCALE = 100 X HORIZONTAL SCALE)

Source: URS, Figure 11, Dated: 1-29-04.



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	Project: 71100	By: KAF/CL/MB	Date: August 2006

FIGURE 4.7c



Legend:

Stratigraphy:

- Seafloor Deposits
- Soft Lacustrine Deposits
- Upper Alluvial Deposits
- Upper Stiff Lacustrine Deposits
- Lower Alluvial Deposits
- Lower Stiff Lacustrine Deposits

Data Plotted Next to Explorations:

For CPTs:

Qtn (tsf)

0 50 100 150 200 250



For Borings:

W%

0 100



Notes:

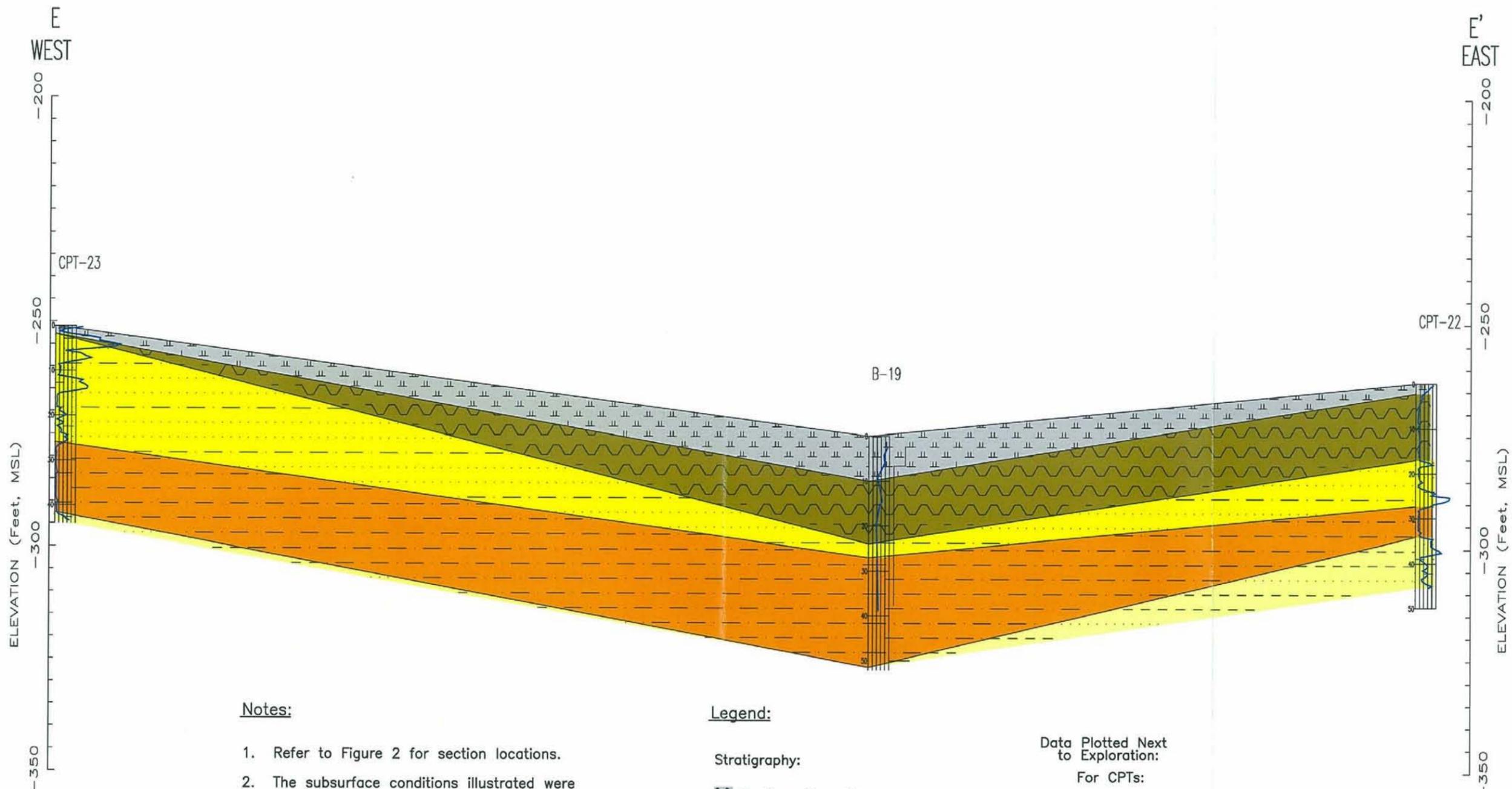
1. Refer to Figure 2 for section locations.
2. The subsurface conditions illustrated were obtained by interpolation between widely spaced explorations. Information on actual subsurface conditions exists only at locations of explorations; conditions between explorations may vary from those depicted.
3. The discussions in the text of this report should be reviewed to obtain a proper understanding of the nature of the subsurface conditions.
4. Complete boring logs and CPT data are presented in the appendices of this report.

(VERTICAL SCALE = 100 X HORIZONTAL SCALE)

Source: URS, Figure 12, Dated: 1-29-04.



 United States Department of the Interior Bureau of Reclamation	SALTON SEA RESTORATION PROJECT Embankment Designs and Optimization Study			GEOLOGIC CROSS SECTION D-D'
	KLEINFELDER	Project: 71100	By: KAF/CL/MB	Date: August 2006



Notes:

1. Refer to Figure 2 for section locations.
2. The subsurface conditions illustrated were obtained by interpolation between widely spaced explorations. Information on actual subsurface conditions exists only at locations of explorations; conditions between explorations may vary from those depicted.
3. The discussions in the text of this report should be reviewed to obtain a proper understanding of the nature of the subsurface conditions.
4. Complete boring logs and CPT data are presented in the appendices of this report.

Legend:

Stratigraphy:

- Seafloor Deposits
- Soft Lacustrine Deposits
- Upper Alluvial Deposits
- Upper Stiff Lacustrine Deposits
- Lower Alluvial Deposits
- Lower Stiff Lacustrine Deposits

Data Plotted Next to Exploration:

For CPTs:

Q_{tn} (tsf)
0 50 100 150 200 250



For Borings:

W%
0 100



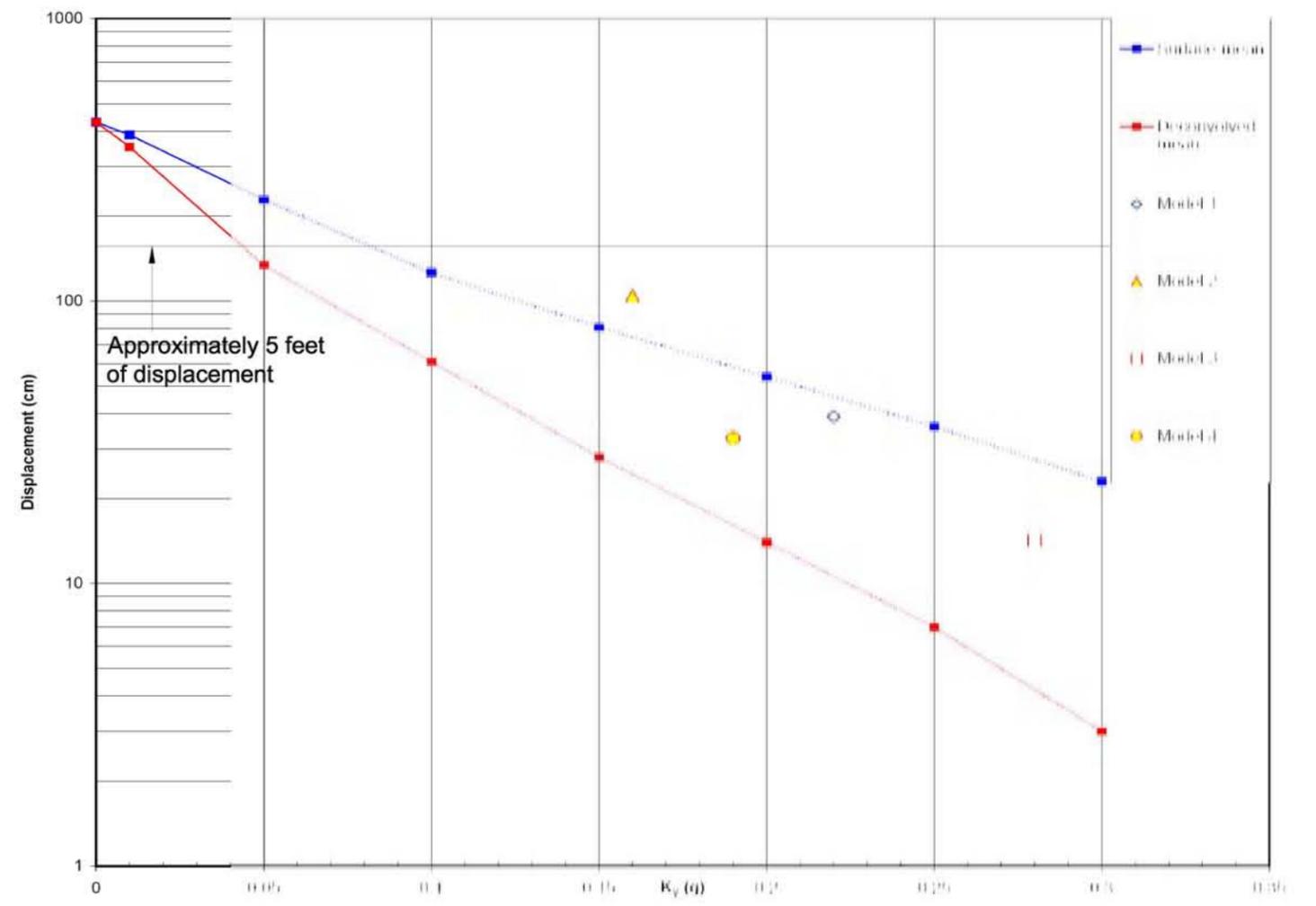
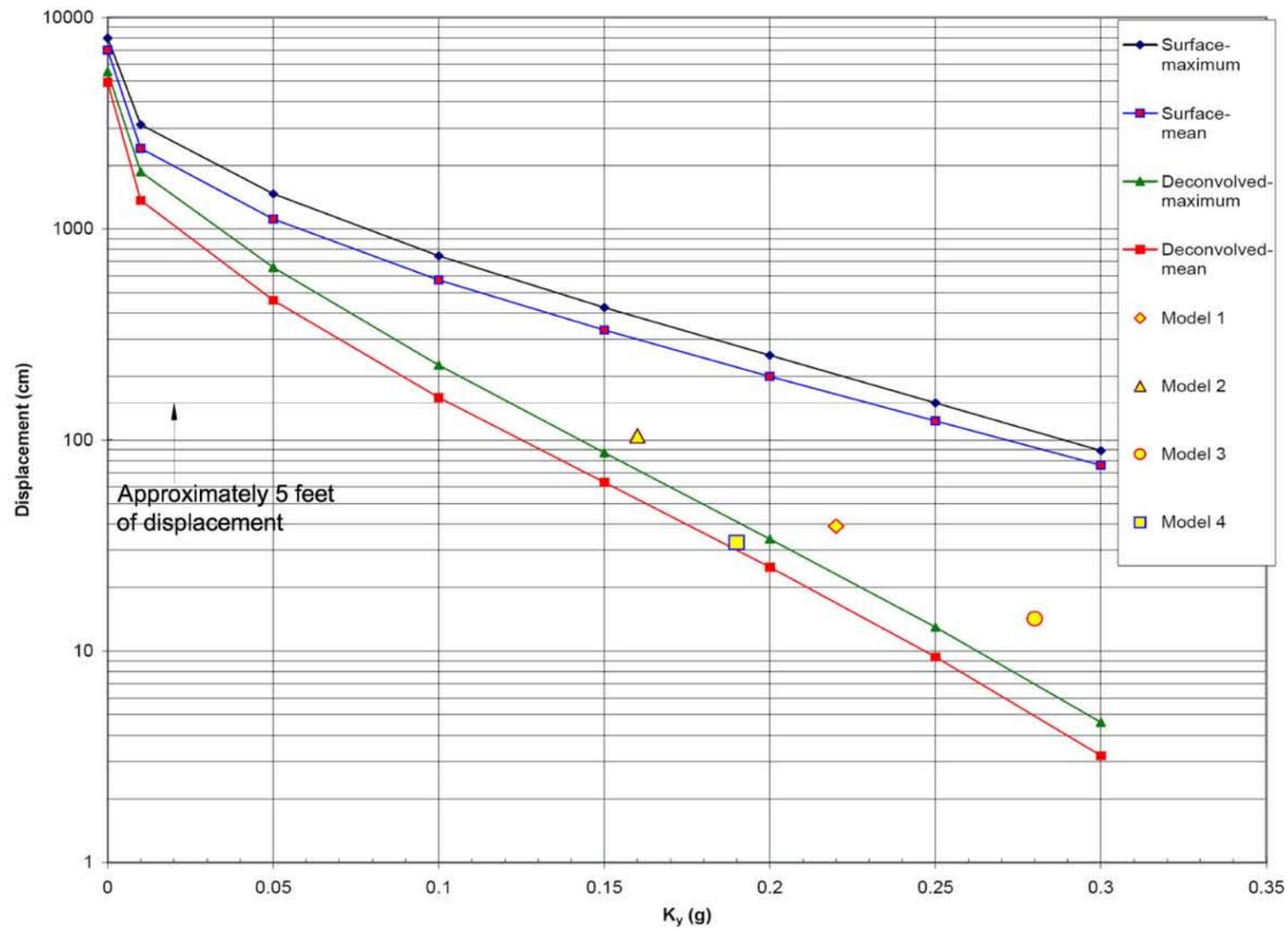
(VERTICAL SCALE = 200 X HORIZONTAL SCALE)

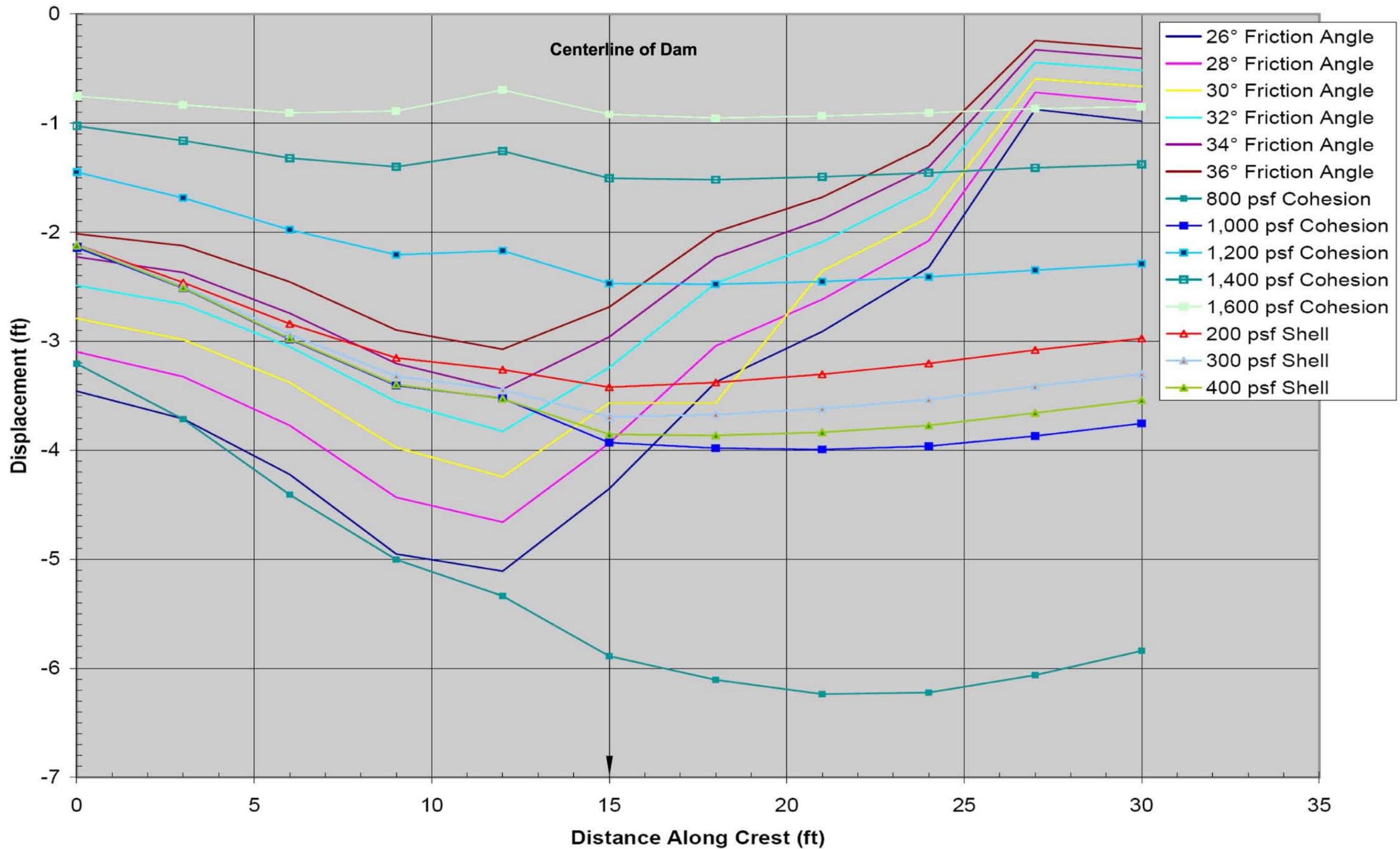
Source: URS, Figure 13, Dated: 1-29-04.



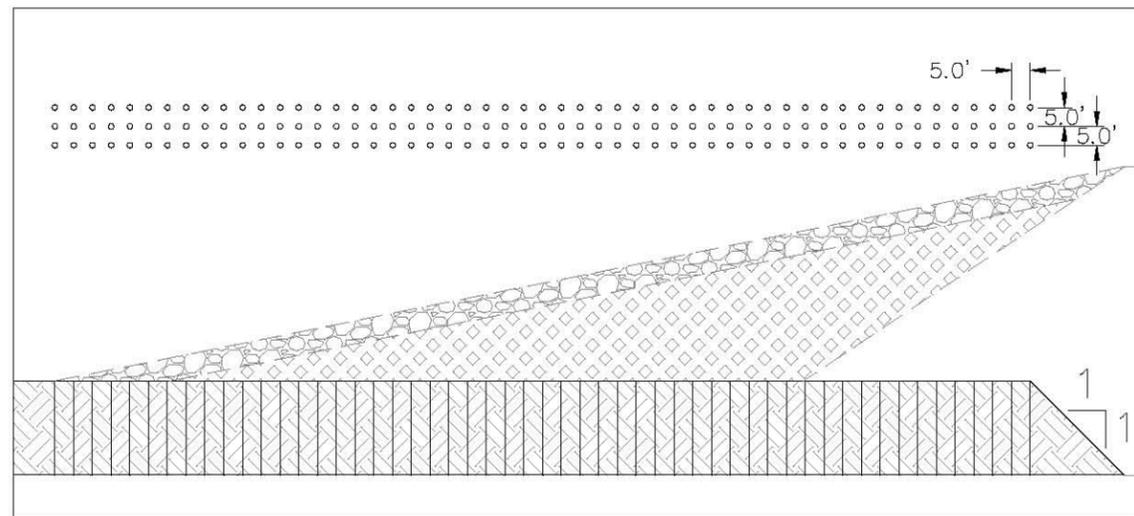
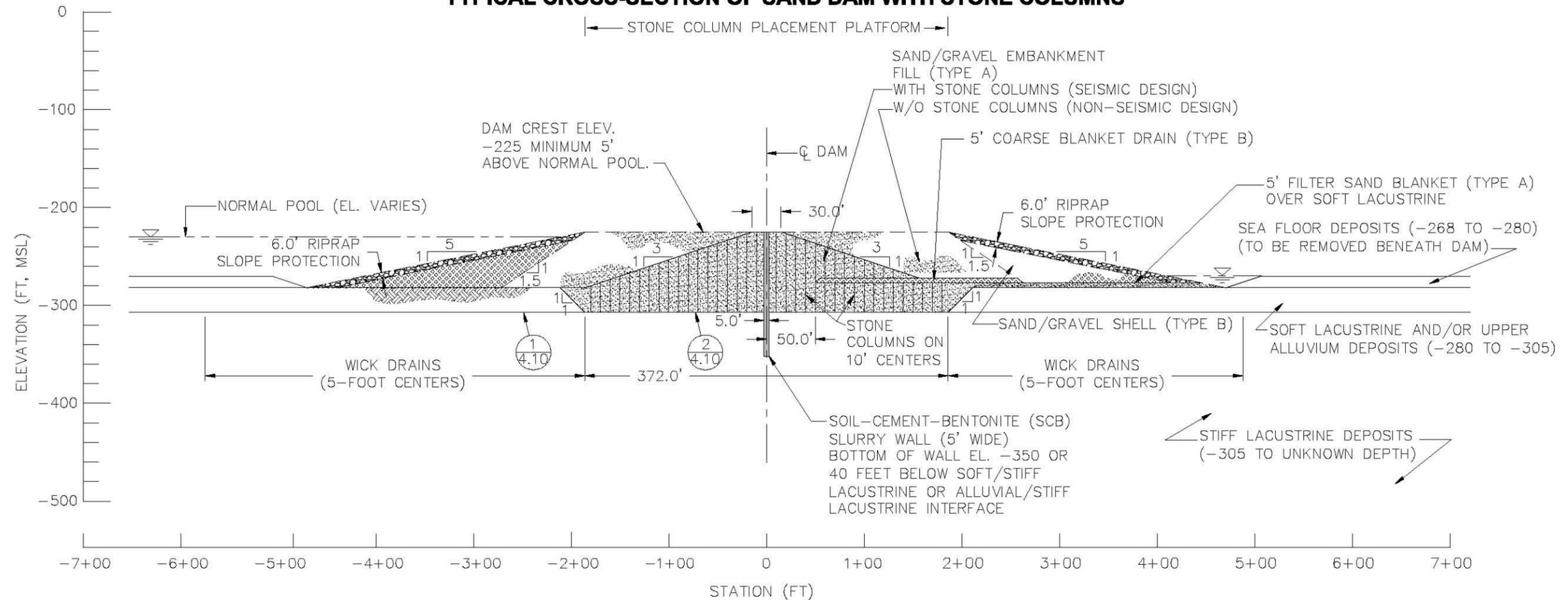
 United States Department of the Interior Bureau of Reclamation	SALTON SEA RESTORATION PROJECT Embankment Designs and Optimization Study		GEOLOGIC CROSS SECTION E-E'
	KLEINFELDER	Project: 71100	By: KAF/CL/MB

FIGURE 4.7e

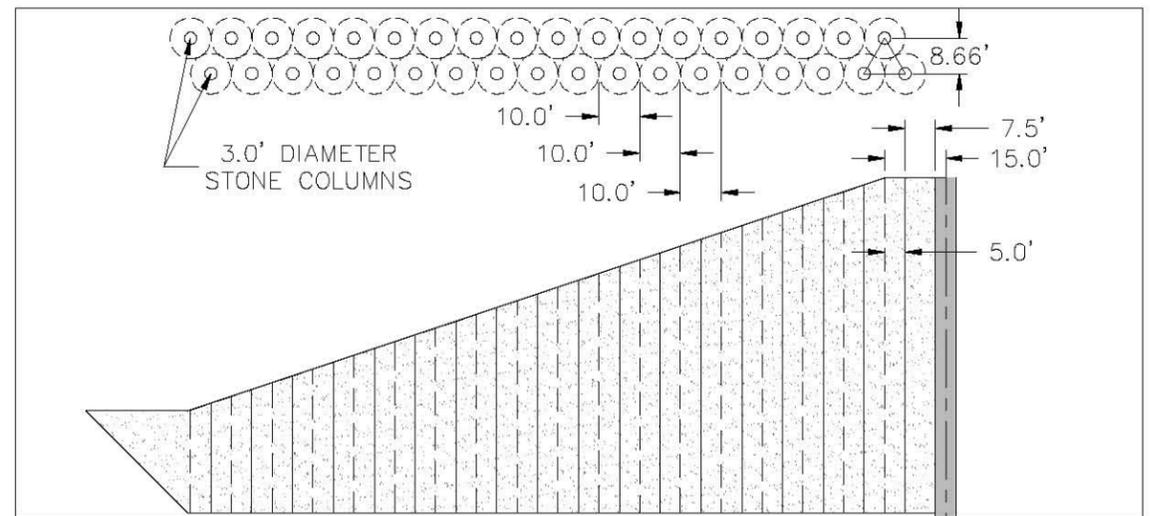




TYPICAL CROSS-SECTION OF SAND DAM WITH STONE COLUMNS



WICK DRAIN LAYOUT SCHEMATIC



TYPICAL STONE COLUMNS LAYOUT SCHEMATIC

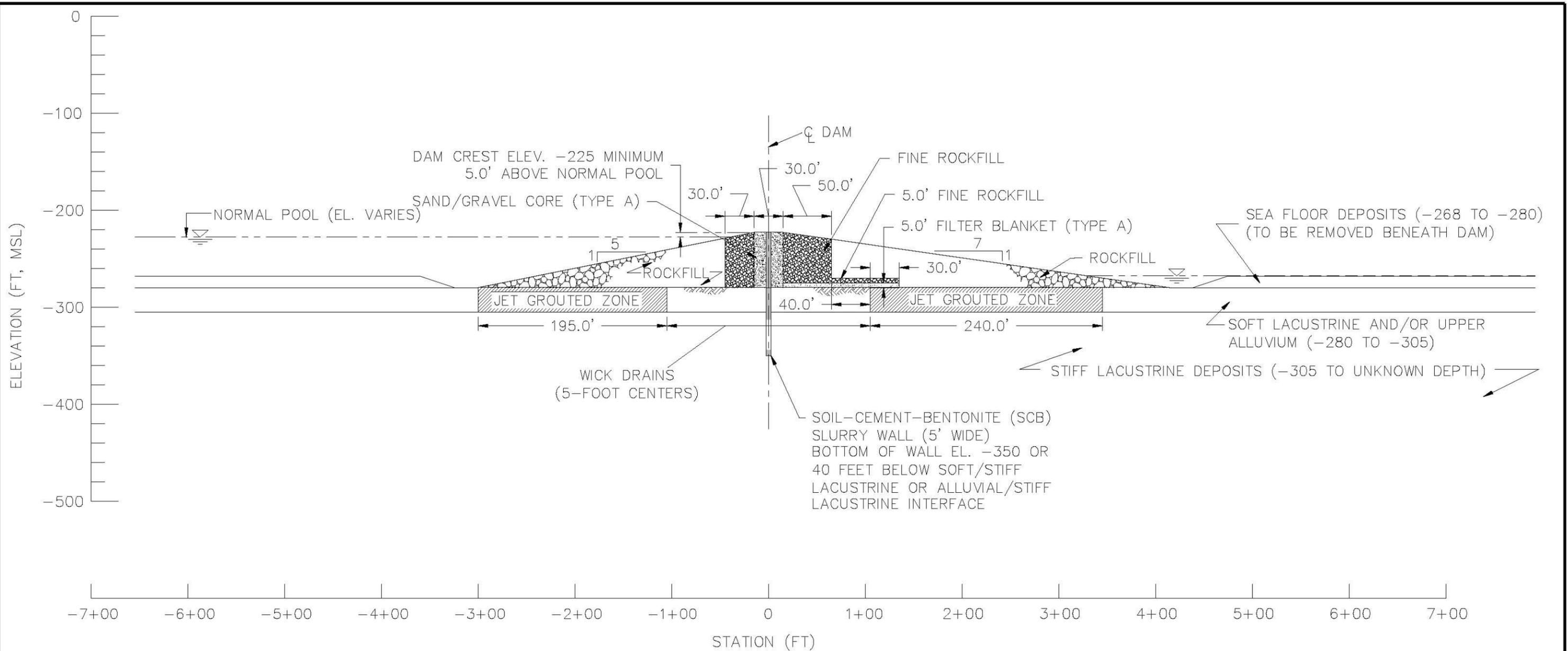
LEGEND

- SAND/GRAVEL EMBANKMENT FILL (TYPE A): FINE TO COARSE SAND AND GRAVEL, MIX WITH MAXIMUM 3/4-INCH GRAVEL SIZE AND MAXIMUM 10% FINES SUITABLE FOR COMPACTION WITH STONE COLUMNS
- SAND/GRAVEL SHELL (TYPE B): FINE TO COARSE SAND AND GRAVEL WITH VARIABLE FINES NOT INTENDED FOR COMPACTION WITH STONE COLUMNS
- TYPE A WITH STONE COLUMNS: 3' DIA. STONE COLUMNS, 10' ON CENTERS, INSTALLED IN TYPE A SAND/GRAVEL (TRIANGULAR PATTERN).
- RIP RAP SLOPE PROTECTION: 1'-4' DIAMETER SOUND AND DURABLE QUARRY ROCK DUMPED UNDER WATER



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FIGURE 4.10



TYPICAL CROSS-SECTION OF ROCKFILL DAM WITH JET GROUDED FOUNDATION

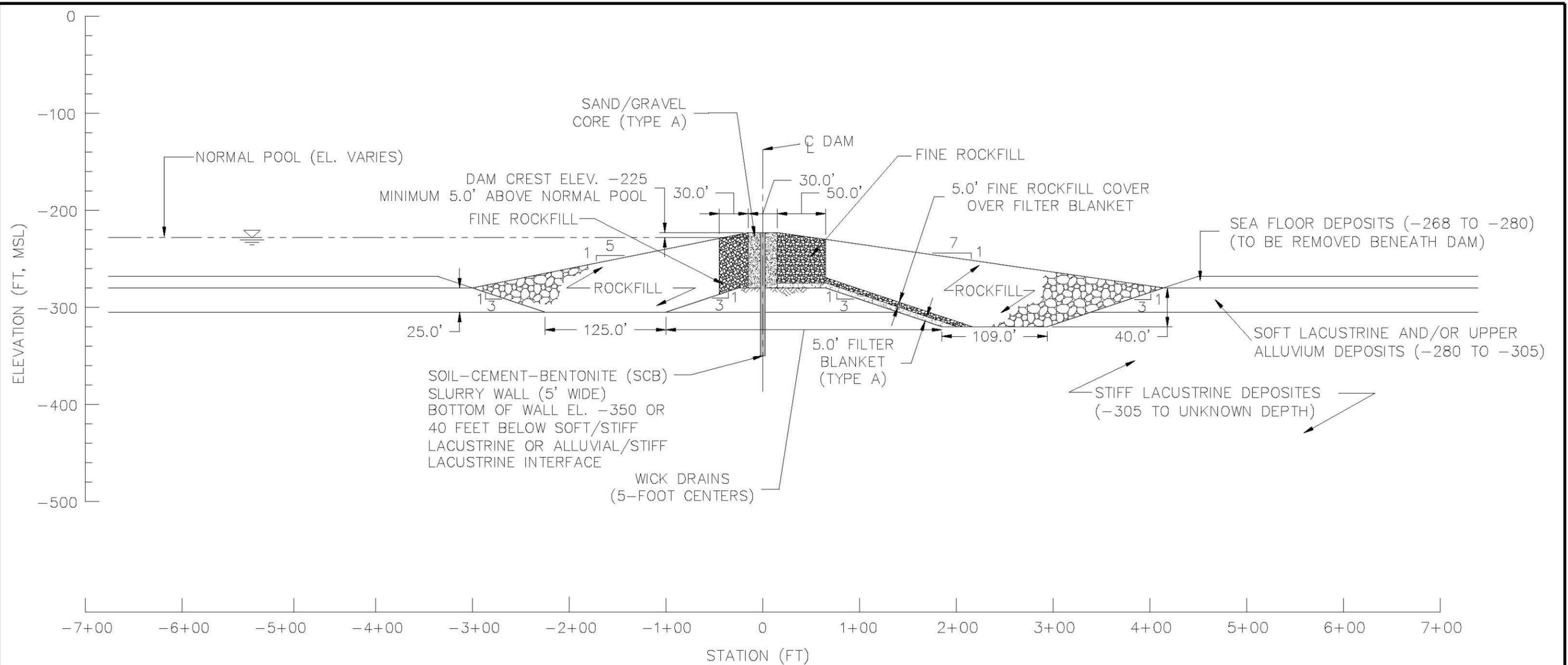


LEGEND

-  **ROCKFILL:** 1'-4' SOUND AND DURABLE QUARRY ROCK DUMPED UNDERWATER
-  **FINE ROCKFILL:** 3"-12" SOUND AND DURABLE QUARRY ROCK DUMPED UNDERWATER
-  **TYPE A SAND/GRAVEL CORE:** CLEAN SAND AND GRAVEL, BUCKET PLACED IN LAYERS UNDERWATER
-  **FILTER BLANKET:** LAYER OF TYPE A SAND/GRAVEL COVERED BY A LAYER OF FINE ROCKFILL, PLACED BY DUMPING UNDERWATER

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Project: 71100	By: KAF/CL/MB	Date: August 2006	FIGURE 4.11



TYPICAL CROSS-SECTION OF MODIFIED ROCK NOTCHES WITH MINIMUM FILTERS



LEGEND

- ROCKFILL:** 1'-4' SOUND AND DURABLE QUARRY ROCK DUMPED UNDERWATER
- FINE ROCKFILL:** 3"-12" SOUND AND DURABLE QUARRY ROCK DUMPED UNDERWATER
- TYPE A SAND/GRAVEL CORE:** CLEAN SAND AND GRAVEL, BUCKET PLACED IN LAYERS UNDERWATER
- FILTER BLANKET:** LAYER OF TYPE A SAND/GRAVEL COVERED BY A LAYER OF FINE ROCKFILL, PLACED BY DUMPING UNDERWATER

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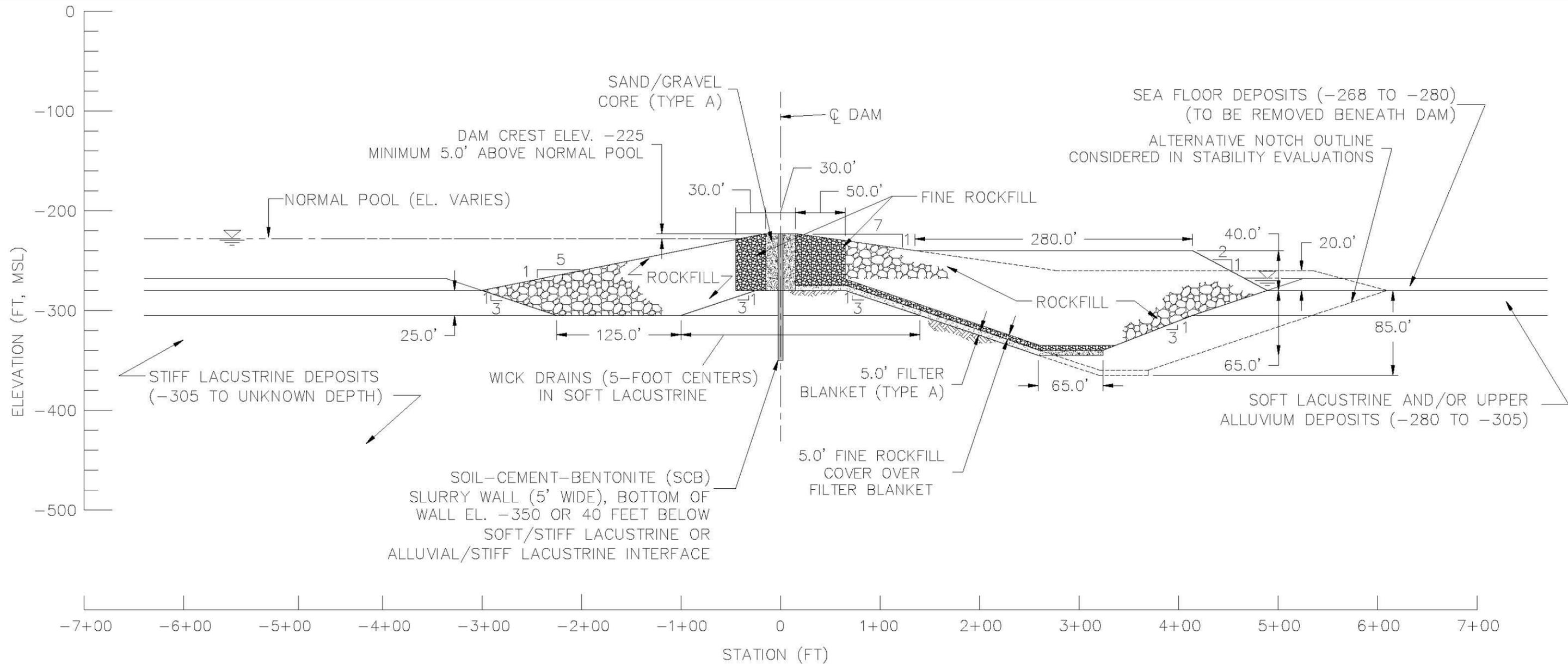
OPTION C
MODIFIED ROCK NOTCHES
DAM WITH MINIMUM FILTERS

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FIGURE 4.12



TYPICAL CROSS-SECTION OF MODIFIED ROCK NOTCHES WITH MAXIMUM SEISMIC FILTERS



LEGEND

- ROCKFILL:** 1'-4' SOUND AND DURABLE QUARRY ROCK DUMPED UNDERWATER
- FINE ROCKFILL:** 3"-12" SOUND AND DURABLE QUARRY ROCK DUMPED UNDERWATER
- TYPE A SAND/GRAVEL CORE:** CLEAN SAND AND GRAVEL, BUCKET PLACED IN LAYERS UNDERWATER
- FILTER BLANKET:** LAYER OF TYPE A SAND/GRAVEL COVERED BY A LAYER OF FINE ROCKFILL, PLACED BY DUMPING UNDERWATER

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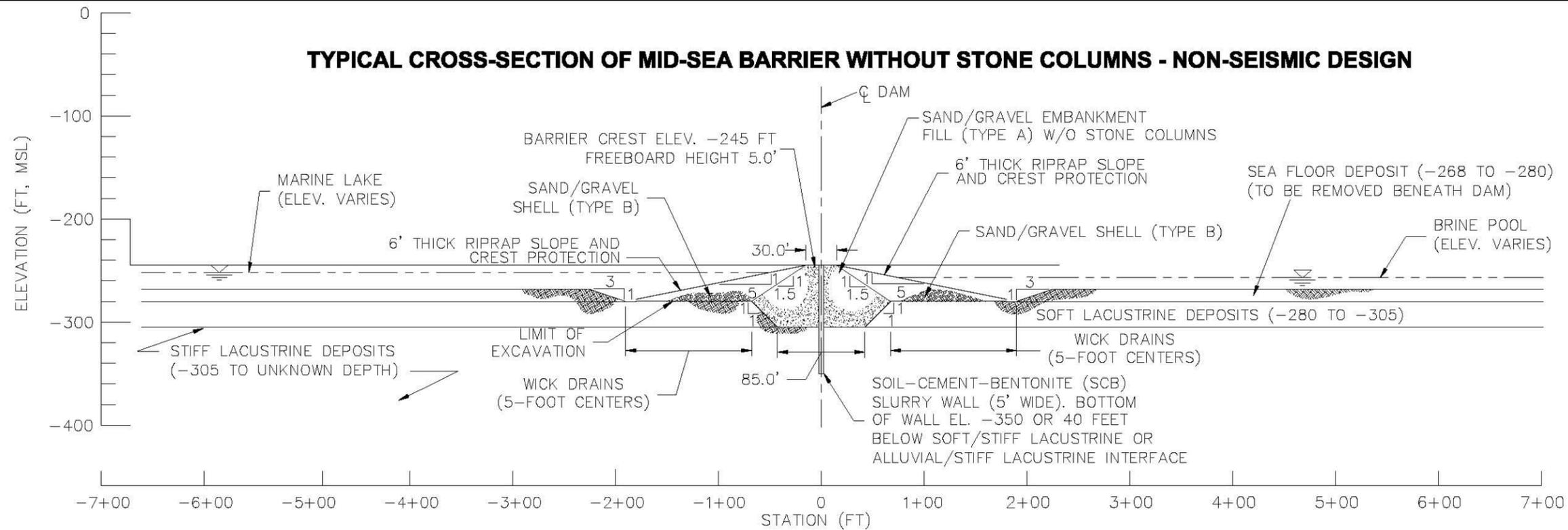
By: KAF/CL/MB

Date: August 2006

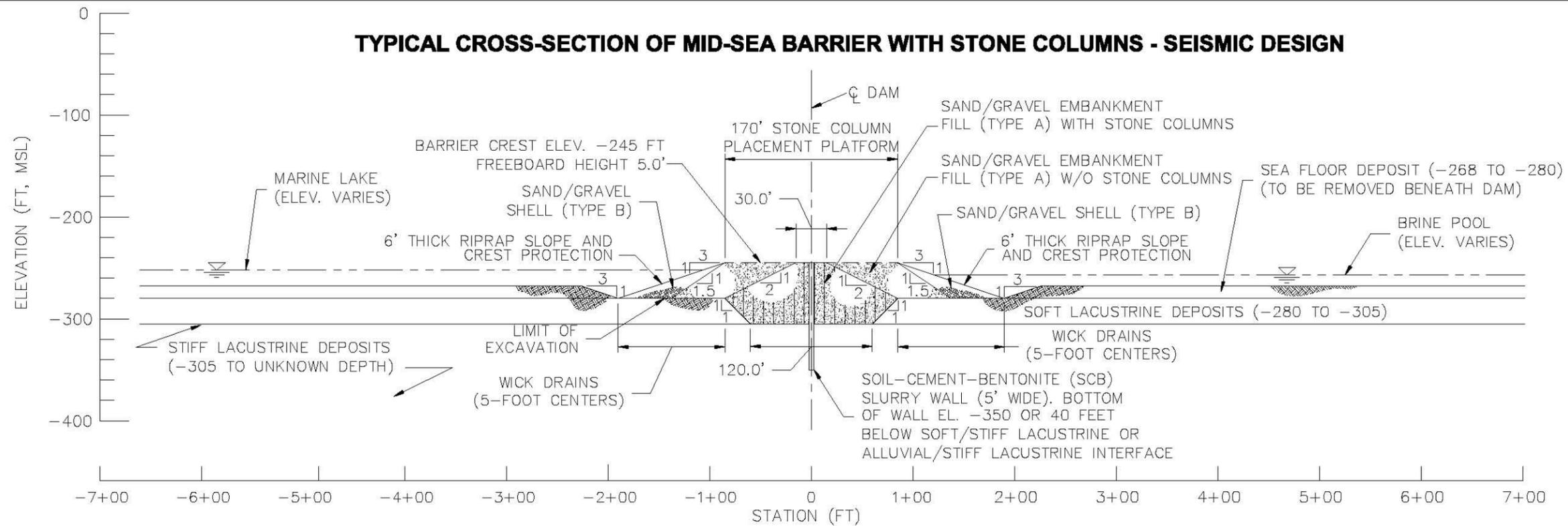
OPTION D
MODIFIED ROCK NOTCHES
DAM WITH MAXIMUM SEISMIC
FILTERS

FIGURE 4.13

TYPICAL CROSS-SECTION OF MID-SEA BARRIER WITHOUT STONE COLUMNS - NON-SEISMIC DESIGN



TYPICAL CROSS-SECTION OF MID-SEA BARRIER WITH STONE COLUMNS - SEISMIC DESIGN



LEGEND

- SAND/GRAVEL EMBANKMENT FILL (TYPE A): FINE TO COARSE SAND AND GRAVEL, MIX WITH MAXIMUM 3/4-INCH GRAVEL SIZE AND MAXIMUM 10% FINES SUITABLE FOR COMPACTION WITH STONE COLUMNS
- SAND/GRAVEL SHELL (TYPE B): FINE TO COARSE SAND AND GRAVEL WITH VARIABLE FINES NOT INTENDED FOR COMPACTION WITH STONE COLUMNS
- STONE COLUMNS: 3' DIA. STONE COLUMNS, 10' ON CENTERS, INSTALLED IN TYPE A SAND/GRAVEL (TRIANGULAR PATTERN).
- RIPRAP SLOPE PROTECTION: 1'-4' DIAMETER SOUND AND DURABLE QUARRY ROCK DUMPED UNDERWATER



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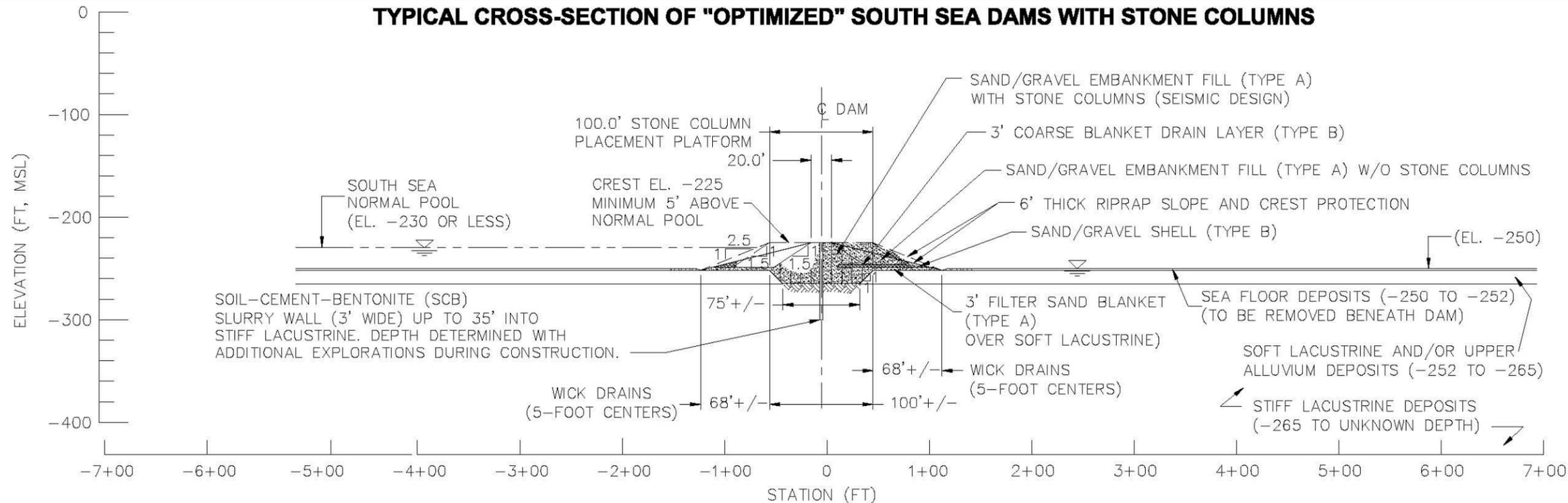
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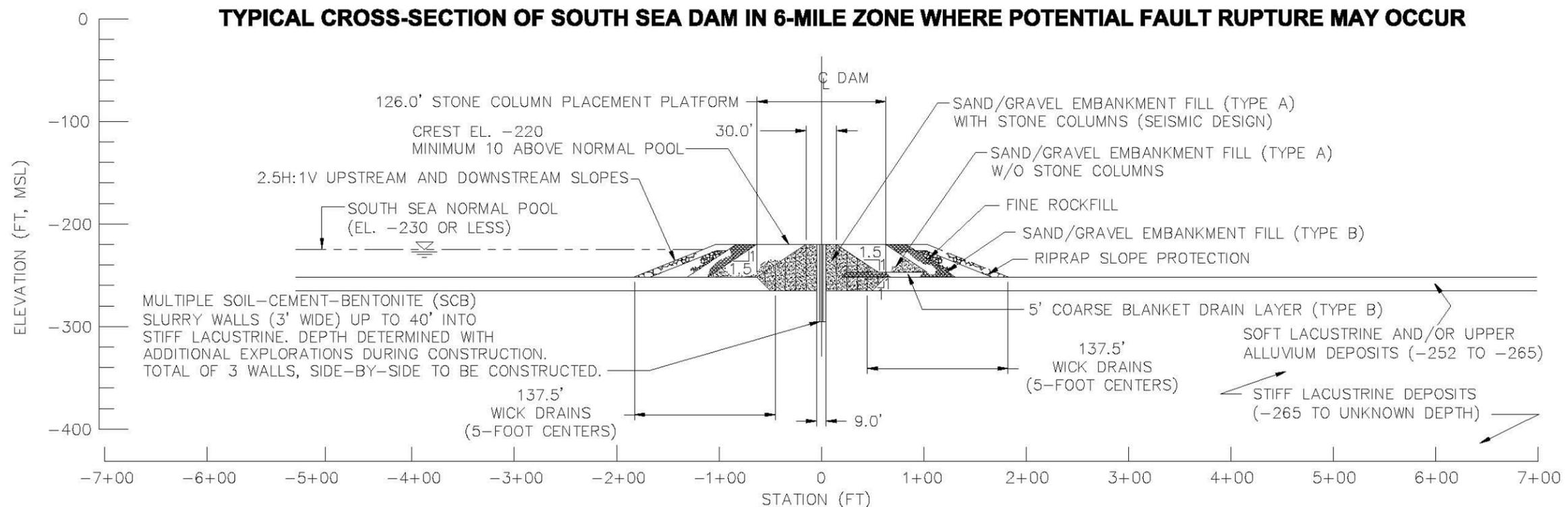
"OPTIMIZED" MID-SEA BARRIER WITH AND WITHOUT STONE COLUMNS

FIGURE 4.14

TYPICAL CROSS-SECTION OF "OPTIMIZED" SOUTH SEA DAMS WITH STONE COLUMNS



TYPICAL CROSS-SECTION OF SOUTH SEA DAM IN 6-MILE ZONE WHERE POTENTIAL FAULT RUPTURE MAY OCCUR



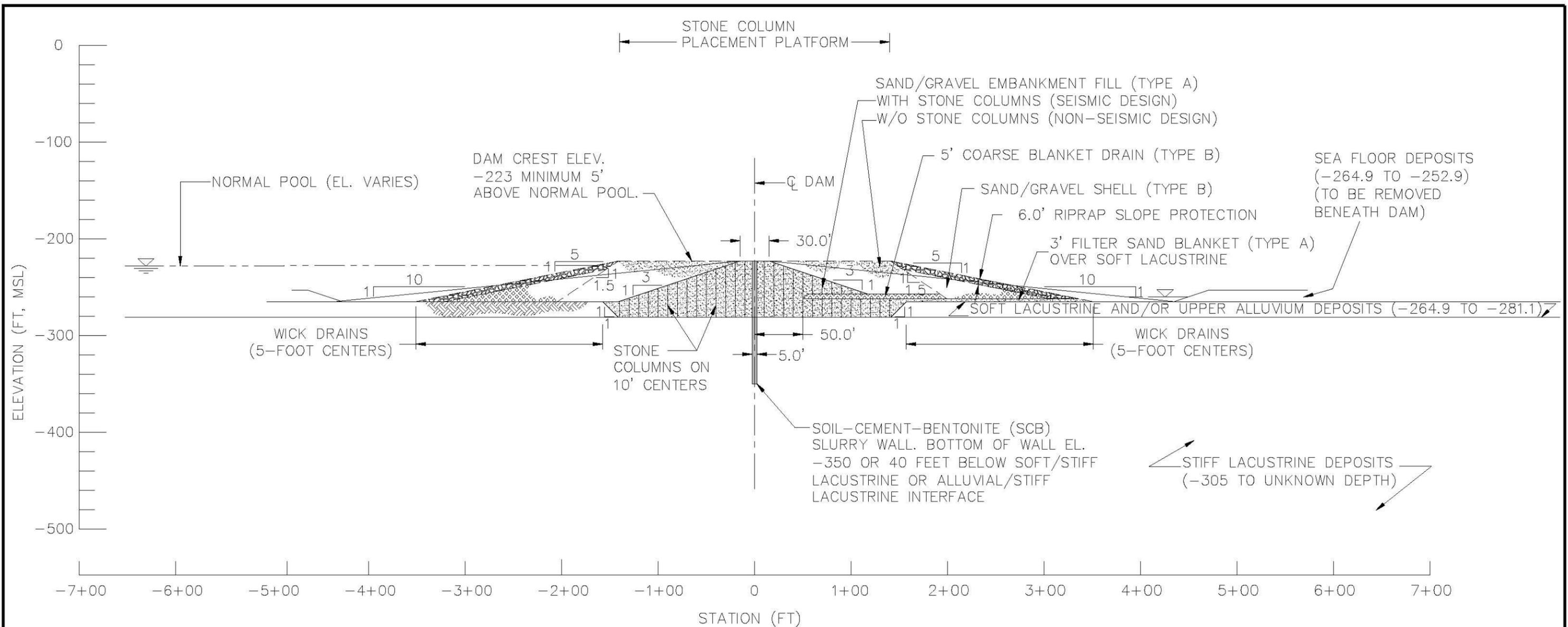
LEGEND

- SAND/GRAVEL EMBANKMENT FILL (TYPE A): FINE TO COARSE SAND AND GRAVEL, MIX WITH MAXIMUM 3/4-INCH GRAVEL SIZE AND MAXIMUM 10% FINES SUITABLE FOR COMPACTION WITH STONE COLUMNS
- SAND/GRAVEL SHELL (TYPE B): FINE TO COARSE SAND AND GRAVEL WITH VARIABLE FINES NOT INTENDED FOR COMPACTION WITH STONE COLUMNS
- STONE COLUMNS: 3' DIA. STONE COLUMNS, 10' ON CENTERS, INSTALLED IN TYPE A SAND/GRAVEL (TRIANGULAR PATTERN).
- RIPRAP SLOPE PROTECTION: 1'-4' DIAMETER SOUND AND DURABLE QUARRY ROCK DUMPED UNDERWATER
- FINE ROCKFILL: 1"-6" SAND AND GRAVEL



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FIGURE 5.1



TYPICAL CROSS-SECTION OF NORTH SEA SAND DAM WITH STONE COLUMNS

NOTES

SOLID LINES SHOW THE IDEALIZED SECTION USED IN STABILITY AND SEEPAGE ANALYSES. DASHED LINES SHOW THE SECTION FOR CONSTRUCTION USING CONVEYOR PLACEMENT METHODS.



LEGEND

- SAND/GRAVEL EMBANKMENT FILL (TYPE A): FINE TO COARSE SAND AND GRAVEL, MIX WITH MAXIMUM 3/4-INCH GRAVEL SIZE AND MAXIMUM 10% FINES SUITABLE FOR COMPACTION WITH STONE COLUMNS
- SAND/GRAVEL SHELL (TYPE B): FINE TO COARSE SAND AND GRAVEL WITH VARIABLE FINES NOT INTENDED FOR COMPACTION WITH STONE COLUMNS
- TYPE A WITH STONE COLUMNS: 3' DIA. STONE COLUMNS, 10' ON CENTER, INSTALLED IN TYPE A SAND/GRAVEL (TRIANGULAR PATTERN).
- RIP RAP SLOPE PROTECTION: 1'-4' DIAMETER SOUND AND DURABLE QUARRY ROCK DUMPED UNDERWATER

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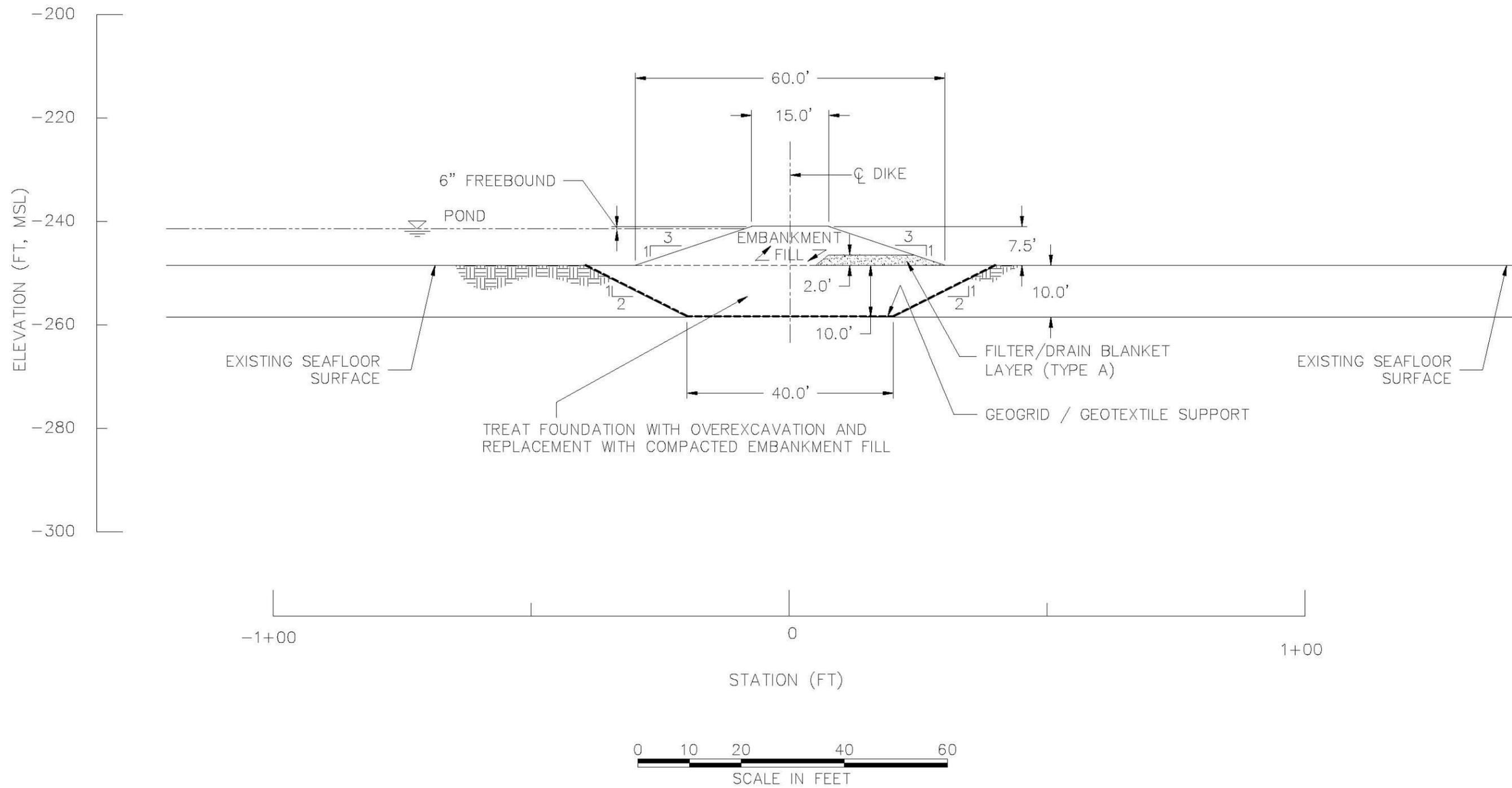
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"OPTIMIZED" NORTH-SEA DAM WITH STONE COLUMNS

FIGURE 5.2



LEGEND

FILTER/DRAIN BLANKET (TYPE A): FINE TO COARSE SAND AND GRAVEL, MIX WITH MAXIMUM 3/4-INCH GRAVEL SIZE AND MAXIMUM 10% FINES.

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"OPTIMIZED" HABITAT POND
 EMBANKMENT
 CONFIGURATION

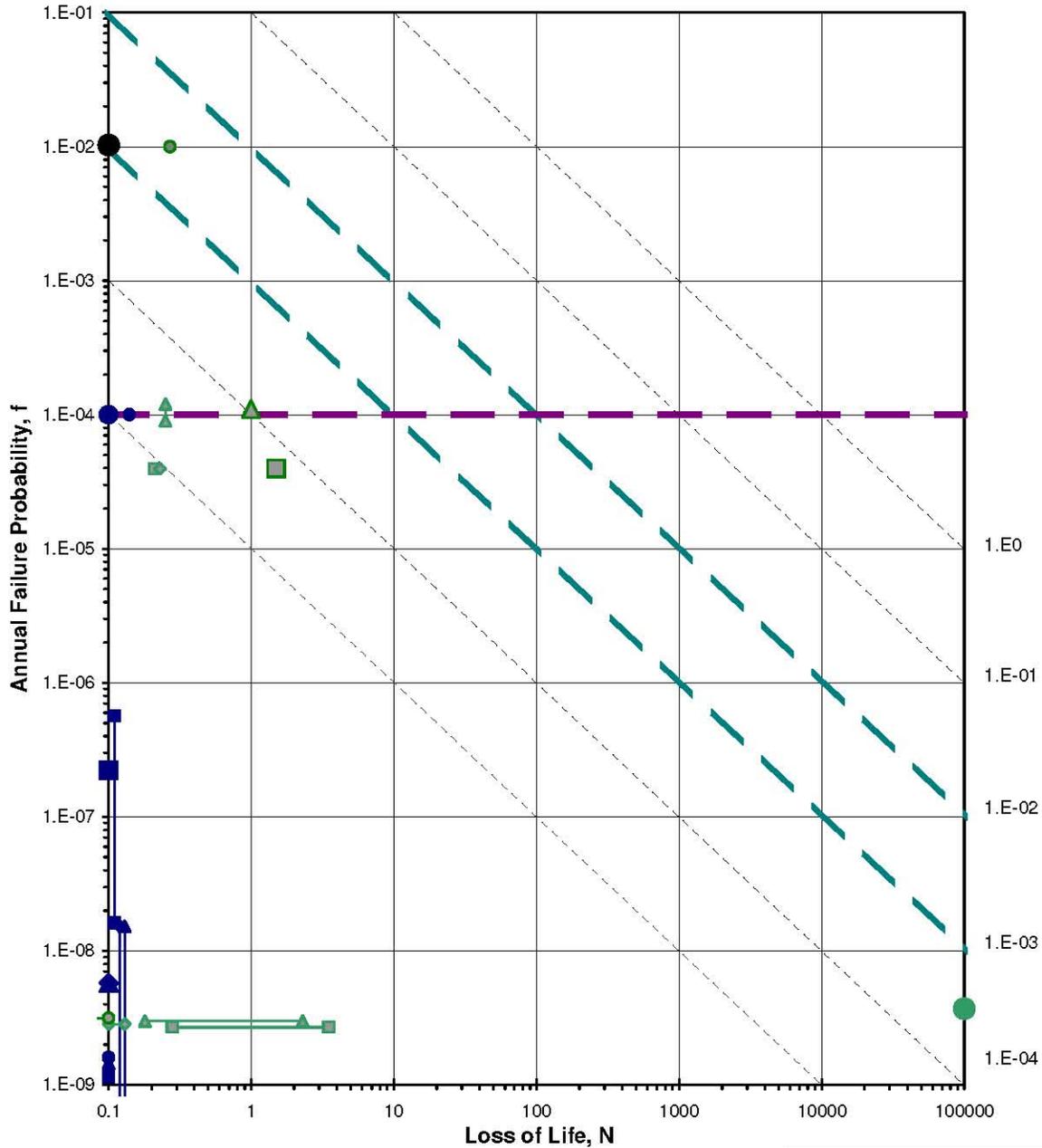
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Date: August 2006

FIGURE 5.4

Risk Estimates Alternative No 1



- Static-Mid-Sea-Dam, FM No 8
- ◆ Static-Perimeter Dike, Based on FM No 2
- ▲ Static-South-Sea Dam, Based on FM No 2
- Static-Habitat Ponds, Under Seepage
- Seismic-Mid-Sea-Dam, FM No 6
- ◆ Seismic-Perimeter Dike, Based on FM No 6
- ▲ Seismic-South-Sea Dam, Based on FM No 12 with mitigation design features
- Seismic-Habitat Ponds, Overtopping

Notes:
These values are estimated based on maximum APF for static and seismic FMs for each structure in the alternative



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Embankment Designs and Optimization Study

**f-N Diagram Portraying Risks
for Restoration Alternative
No. 1 - Mid-Sea-Dam/North
Marine Lake**

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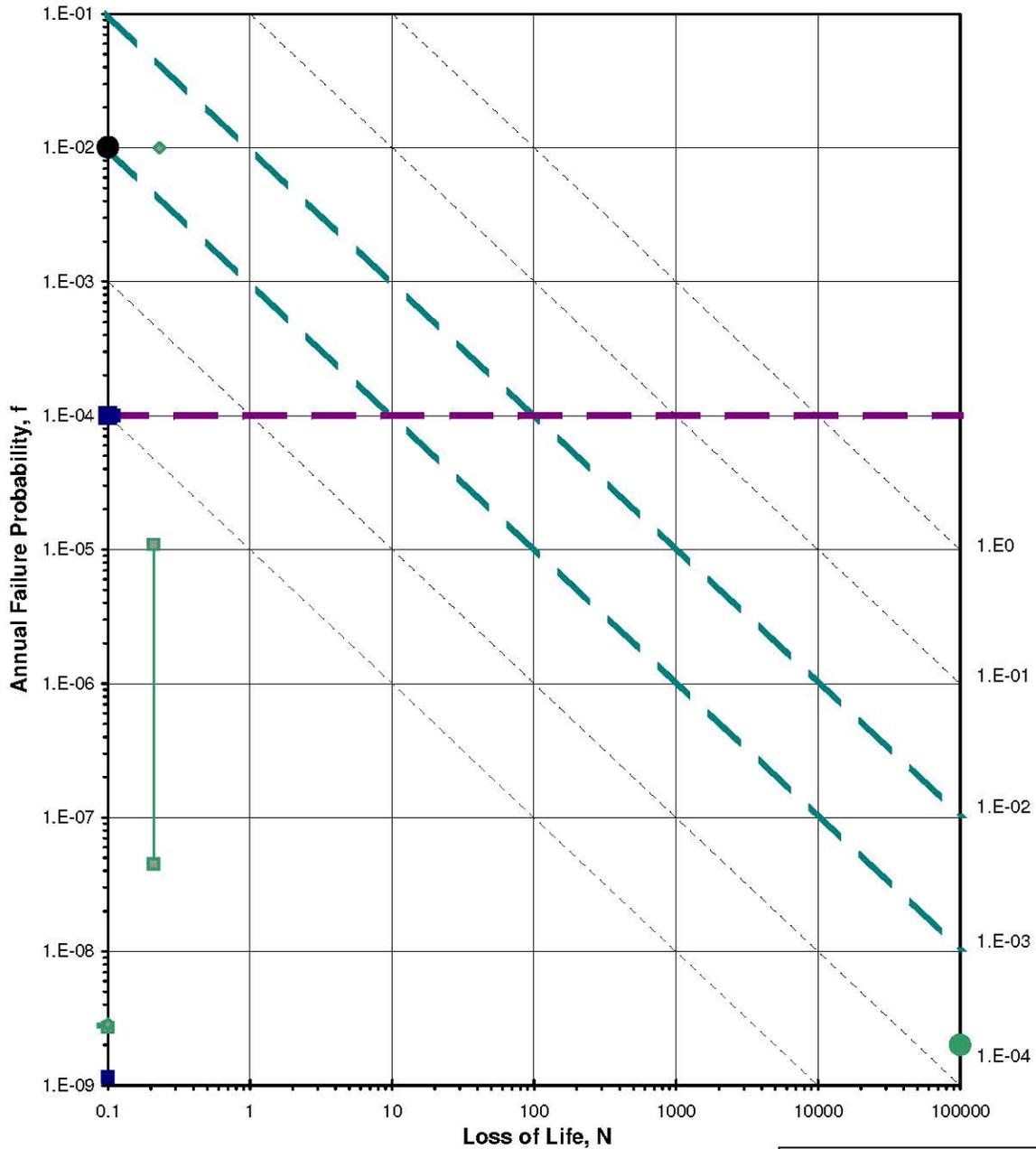
Project: 71100

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Date: August 2006

FIGURE 6.1

Risk Estimates Alternative No 2



- Static-Habitat Ponds, Under Seepage
- Seismic-Mid-Sea Barrier, Based on FM No 3 with stone columns
- ◆ Seismic-Habitat Ponds, Overtopping
- Total Static Risk Estimate
- Total Seismic Risk Estimate
- Total Probability of Failure - All Loadings

Notes:
 These values are estimated based on maximum APF for static and seismic FMs for each structure in the alternative

Mid-Sea Barrier without stone columns would have APF 1.0E-02 and ALL 0.0E-00



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**f-N Diagram Portraying Risks
 for Restoration Alternative
 No. 2 - Mid-Sea-Barrier/South
 Marine Lake**

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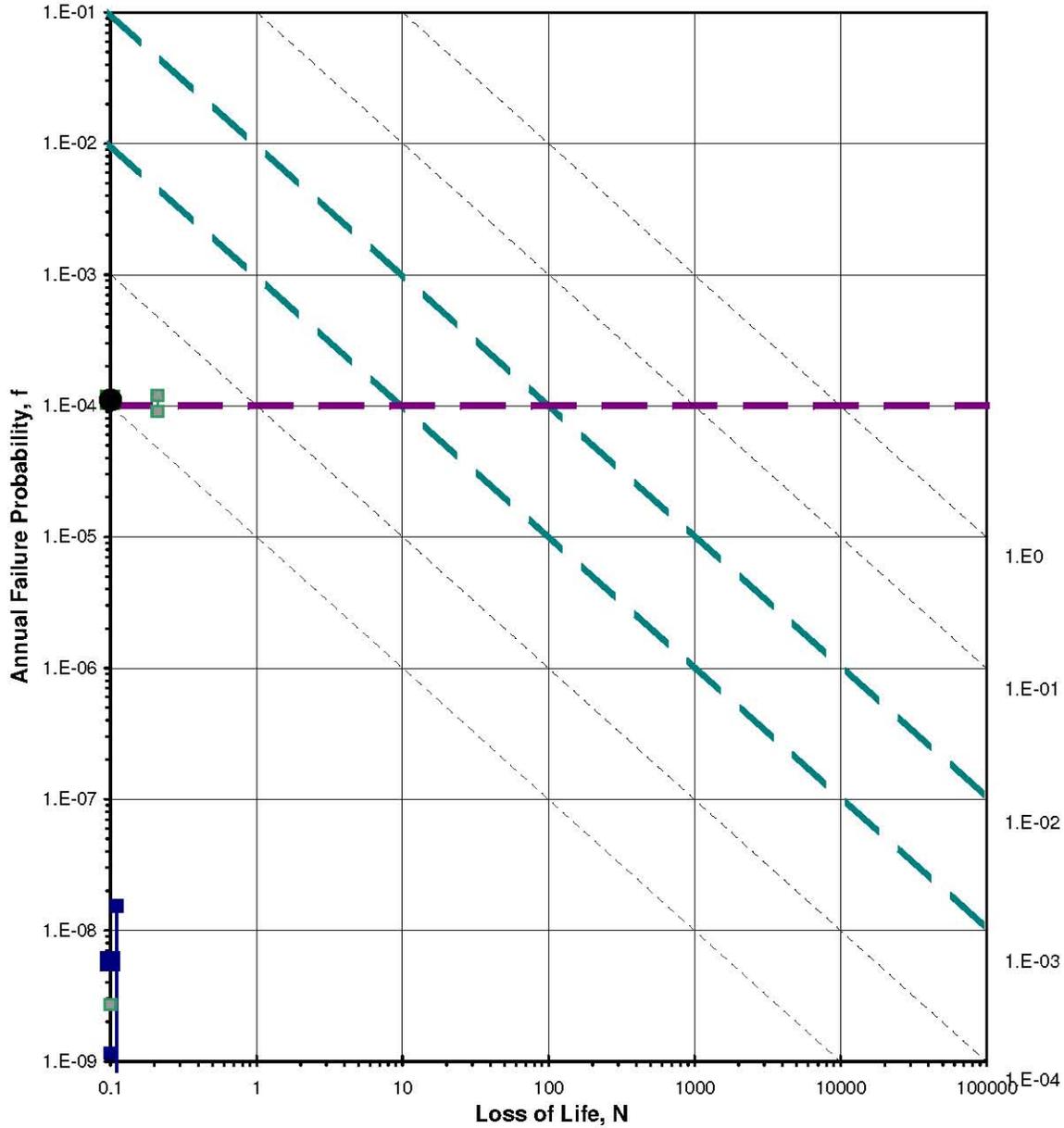
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Date: August 2006

FIGURE 6.2

Risk Estimates Alternative No 3



- Static-Concentric Ring Dikes (outer rings), Underseepage
- Seismic-Concentric Ring Dikes (outer rings) with mitigation design features, Translation
- Total Static Risk Estimate
- Total Seismic Risk Estimate
- Total Probability of Failure - All Loadings

Notes:
 These values are estimated based on maximum APF for static and seismic FMs for each structure in the alternative

Outer Concentric Ring Embankment without design features mitigating translation failure, would have APF of 1.0E-02 (failure by translation) and ALL of 0.0E-00

inner Concentric Rings not meeting seismic or seepage design criteria, would have APF 1.0E-02 (Overtopping) and ALL of 0.0E-000



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**f-N Diagram Portraying Risks
 for Restoration Alternative No.
 3 - Concentric Lakes Dikes**

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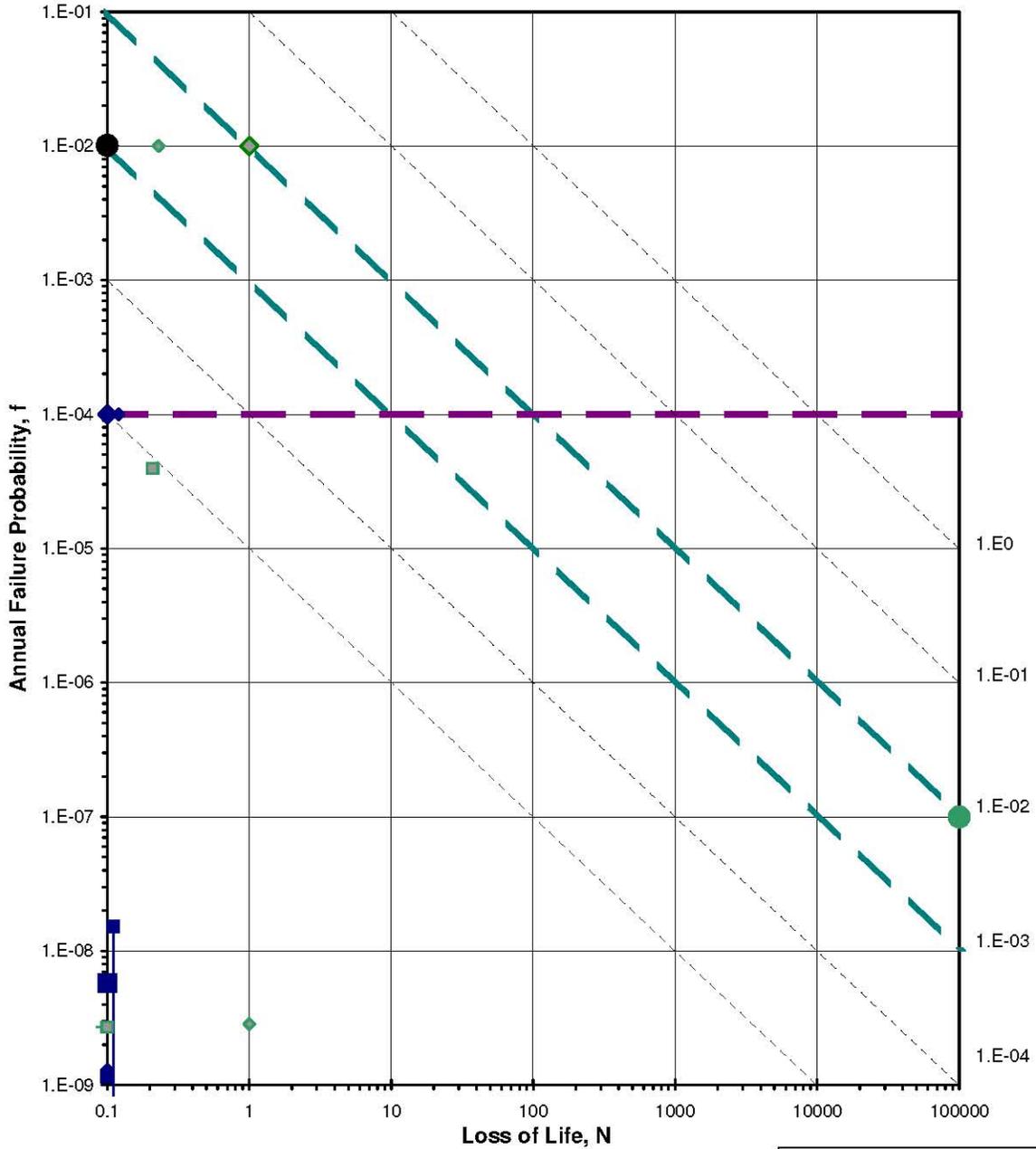
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FIGURE 6.3

Risk Estimates Alternative No 4



- Static-North-Sea Dam, Based on FM No 2
- ◆ Static-Habitat Ponds, Under Seepage
- Seismic-North-Sea Dam, Based on FM No 6
- ◆ Seismic-Habitat Ponds, Overtopping
- Total Static Risk Estimate
- Total Seismic Risk Estimate
- Total Probability of Failure - All Loadings

Notes:
These values are estimated based on maximum APF for static and seismic FMs for each structure in the alternative



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**f-N Diagram Portraying Risks
for Restoration Alternative
No. 4 - North-Sea Dam /
Marine Lake**

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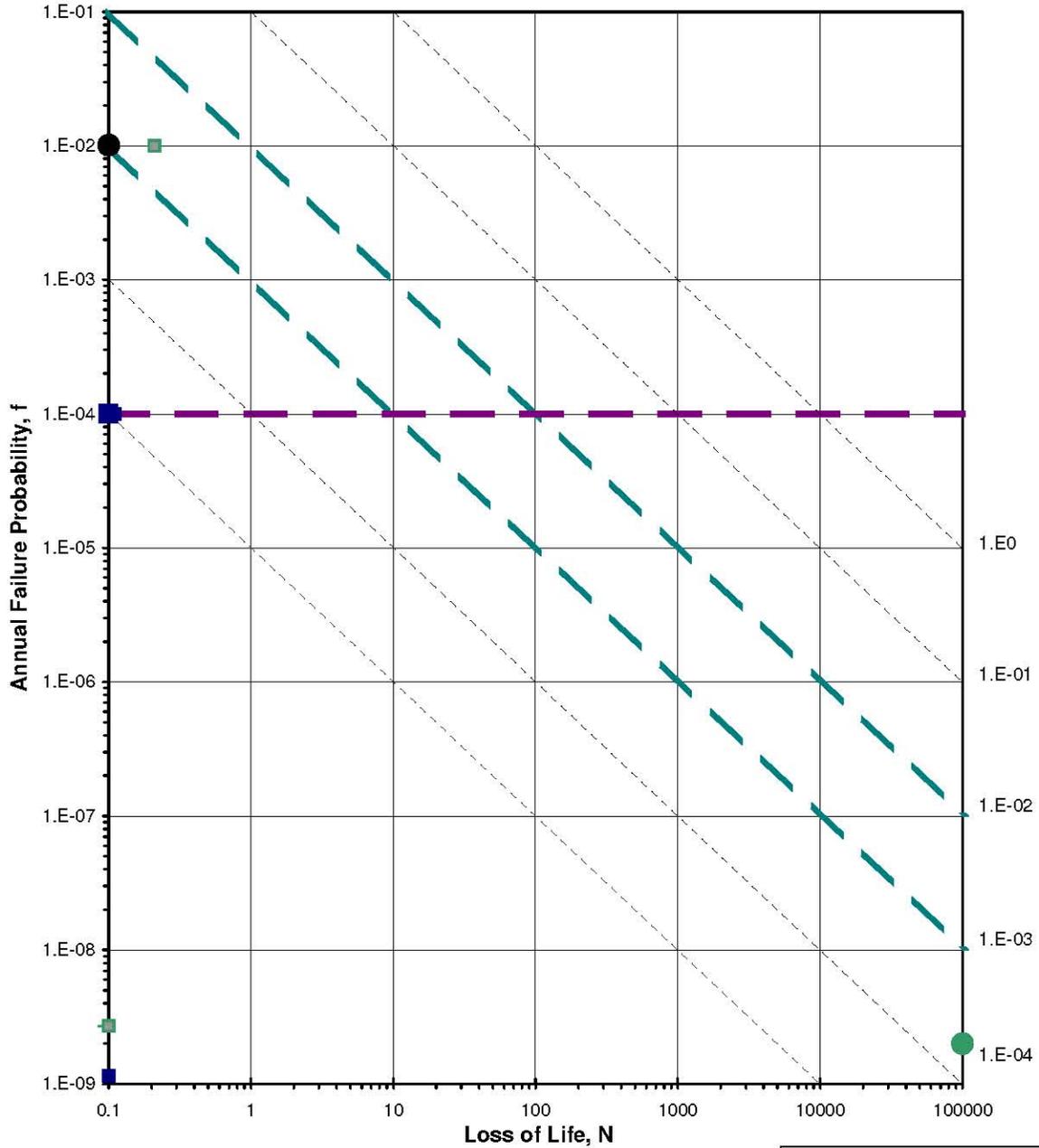
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FIGURE 6.4

Risk Estimates Alternative No 5



- Static-Habitat Ponds, Under Seepage
- Seismic-Habitat Ponds, Overtopping
- Total Static Risk Estimate
- Total Seismic Risk Estimate
- Total Probability of Failure - All Loadings

Notes:
These values are estimated based on maximum APF for static and seismic FMs for each structure in the alternative



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**f-N Diagram Portraying Risks
for Restoration Alternative No.
5 - Habitat Enhancement
without Marine Lake**

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FIGURE 6.5