

PEN 1 & PEN 2

Seepage and Stability Analyses

Flood Levels Analyzed:

- USACE Authorized Design Water Elevation
- Reverse Analysis to Check Max Flood Height

Levee Seepage & Stability (Cornforth)

Freeboard (WEST)

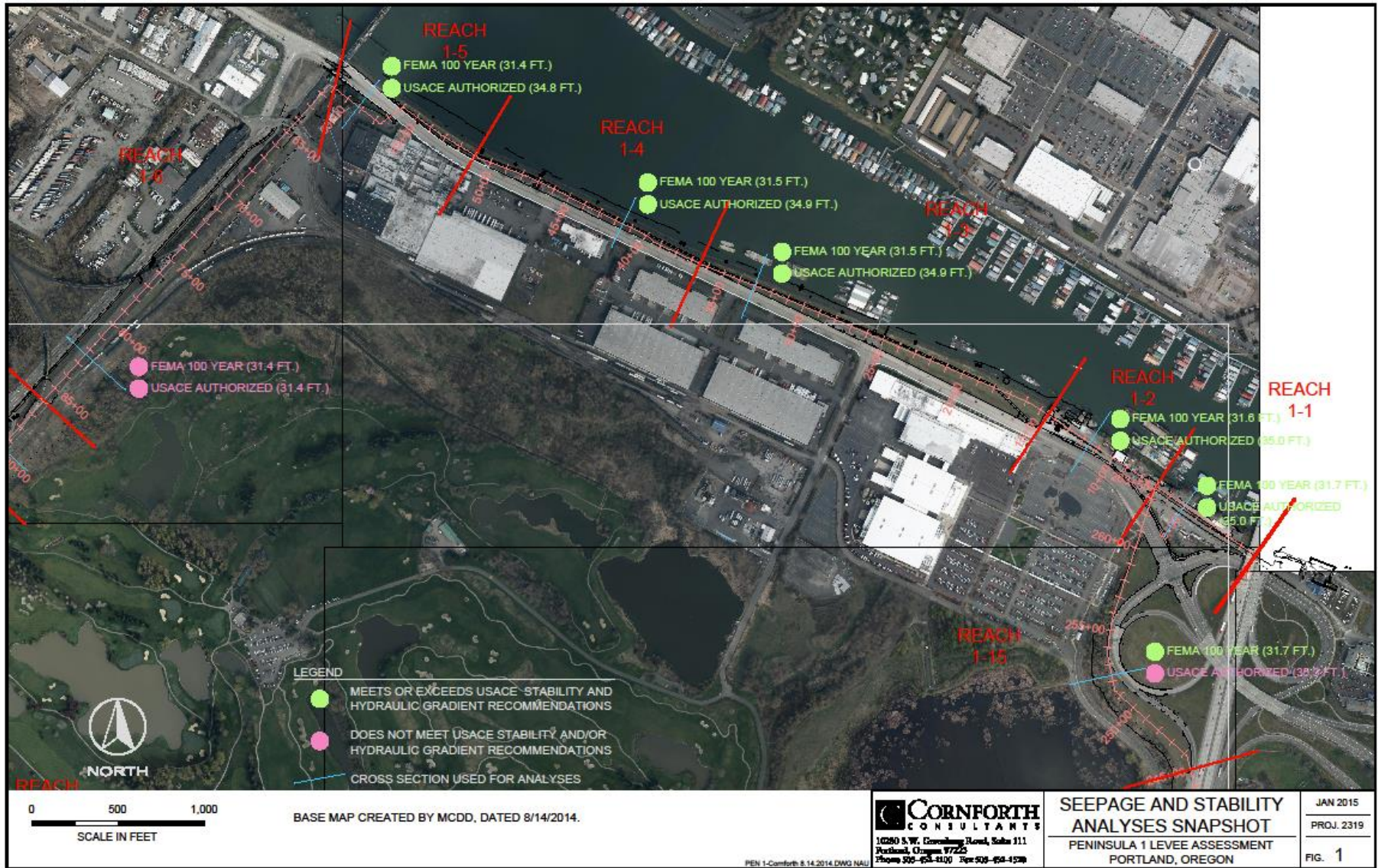
Peninsula Drainage Districts No. 1 and No. 2

Authorized by the 1936 Flood Control Act –
Columbia River flood of 1876

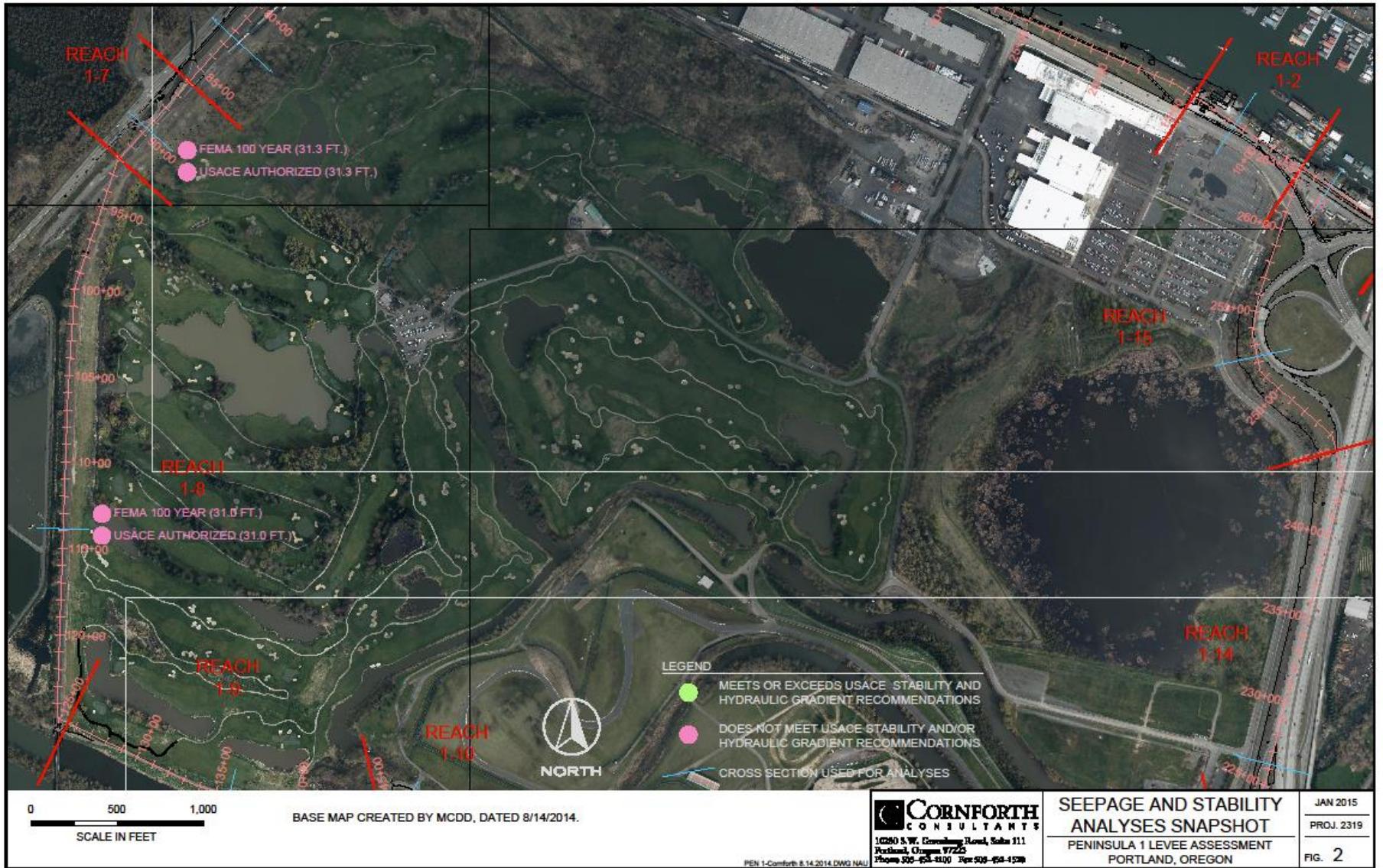
Summary Water Surface Elevations for PEN 1 & PEN 2 Levee System – NAVD88

River Mile	1%-annual-chance (100 yr.) - FEMA	0.2%-annual-chance (500 yr.) – FEMA	DWSE (470 yr.) - USACE
PEN 1 - 106.0	31.5 ft.	35.0 ft.	34.8 ft.
PEN 2 - 107.4	31.8 ft.	35.3 ft.	35.1 ft.

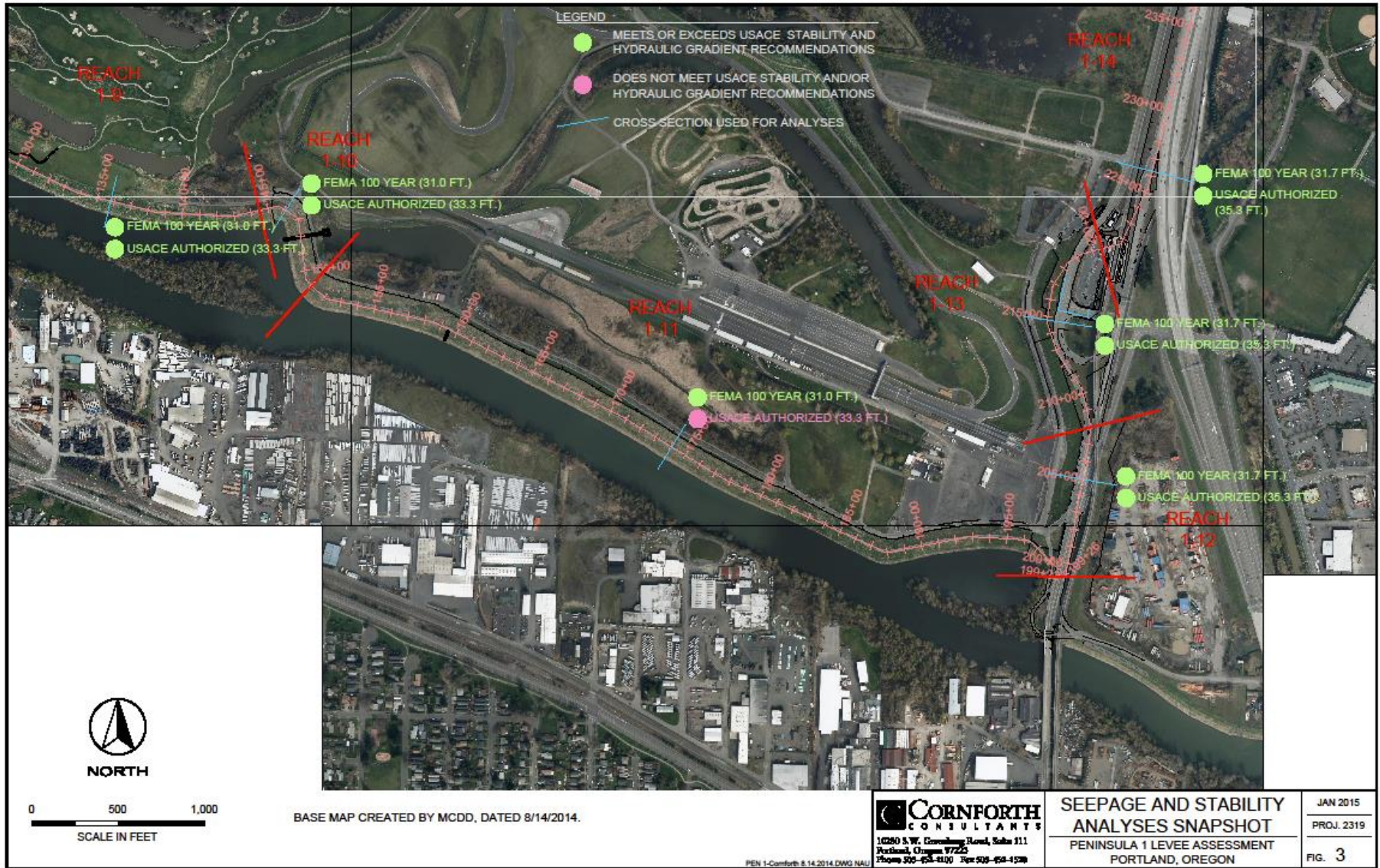
PEN 1 – NW Corner



PEN 1 – SW Corner



PEN 1 – SE Corner



PEN 1 – N Marine Drive Levee - 100 Year Analysis

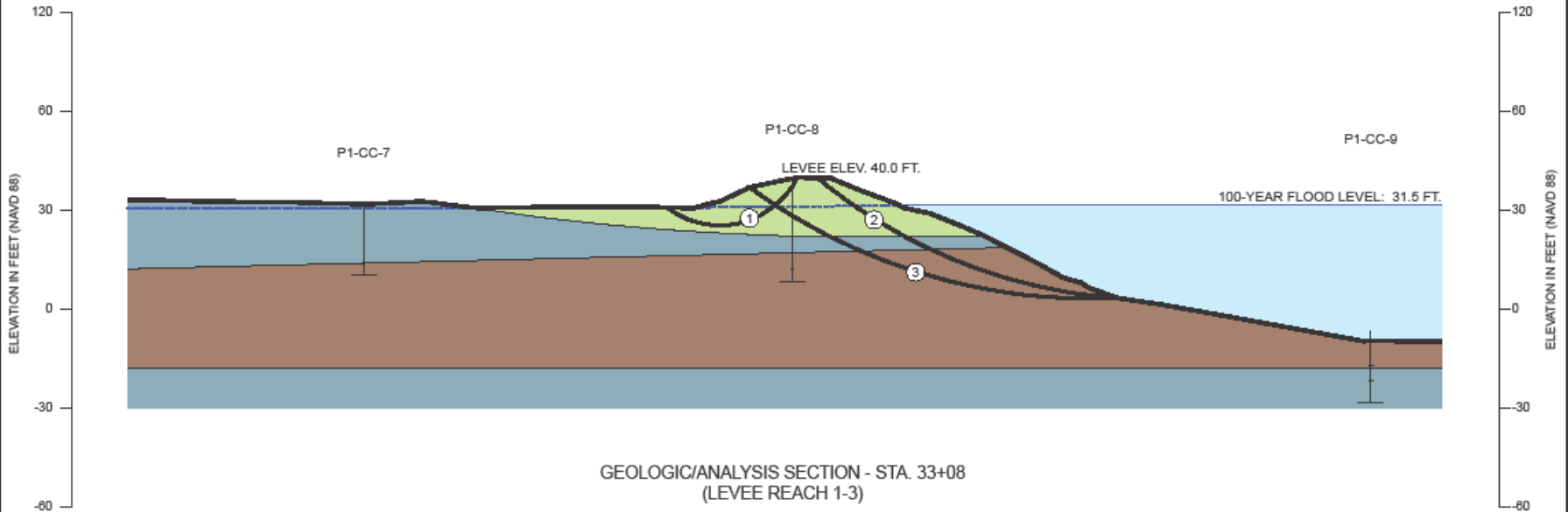
- Railroad Embankment Mixed sand and silt with timber remnants
- Fill Soft, slightly clayey to clayey SILT
- Fill Loose, silty SAND to sandy SILT
- Foundation Soft, clayey SILT (Alluvium)
- Foundation Loose, silty SAND (Alluvium)

SLIP SURFACE	CALCULATED FS	MEETS REQUIRED FS*
1	2.13	YES
2	1.55	YES
3	1.91	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.1**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913



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100 YEAR FLOOD LEVEL
 PENINSULA 1 LEVEE ASSESSMENT
 PORTLAND, OREGON

JAN 2015
 PROJ. 2319
 FIG. 3-1

2319\Flood Levels\Sec-33+07.88 AI NAU

PEN 1 – N Marine Drive Levee - USACE authorized design water elevation analysis

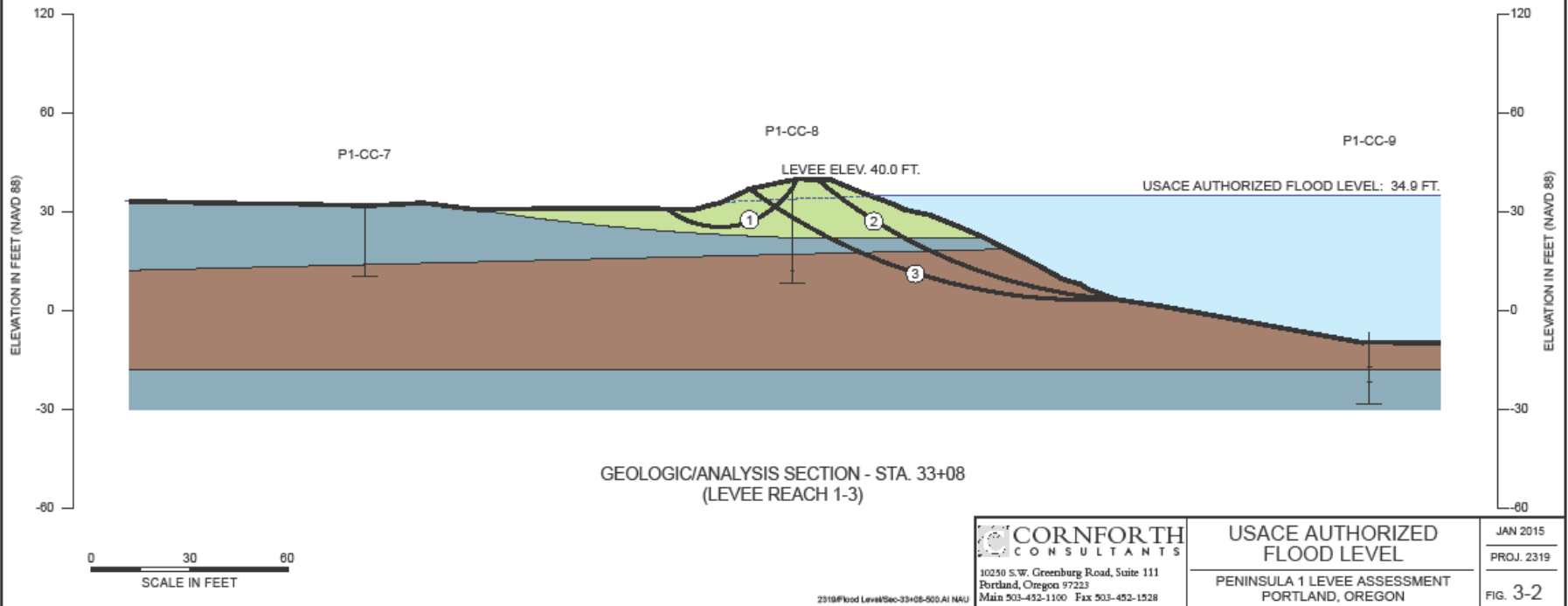
- Railroad Embankment Mixed sand and silt with timber remnants
- Fill Soft, slightly clayey to clayey SILT
- Fill Loose, silty SAND to sandy SILT
- Foundation Soft, clayey SILT (Alluvium)
- Foundation Loose, silty SAND (Alluvium)

SLIP SURFACE	CALCULATED FS	MEETS REQUIRED FS*
1	1.89	YES
2	1.87	YES
3	2.01	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.41**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913



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 FIG. 3-2

2319\Flood Level\Sec-33+08-900.AI.NAU

PEN 1 – N Marine Drive Levee - Reverse Analysis

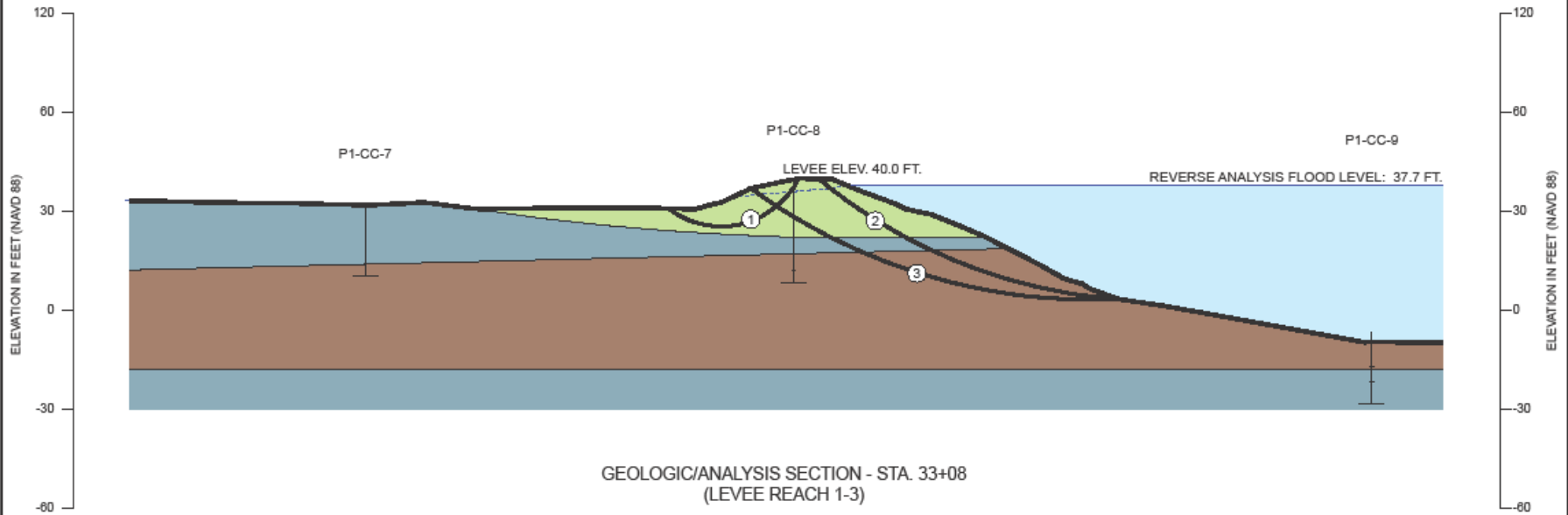
- Railroad Embankment Mixed sand and silt with timber remnants
- Fill Soft, slightly clayey to clayey SILT
- Fill Loose, silty SAND to sandy SILT
- Foundation Soft, clayey SILT (Alluvium)
- Foundation Loose, silty SAND (Alluvium)

SLIP SURFACE	CALCULATED FS	MEETS REQUIRED FS*
1	1.39	YES
2	1.79	YES
3	2.22	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.56**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913



GEOLOGIC/ANALYSIS SECTION - STA. 33+08
(LEVEE REACH 1-3)

0 30 60
SCALE IN FEET

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REVERSE ANALYSIS FLOOD LEVEL
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 PROJ. 2319
 FIG. 3-3

2319\Flood Level\Sec-33+08-1.4.AI.NAU

PEN 1 – N Marine Drive Floodwall - USACE authorized design water elevation analysis

- Railroad Embankment Mixed sand and silt with timber remnants
- Fill Soft, slightly clayey to clayey SILT
- Fill Loose, silty SAND to sandy SILT
- Foundation Soft, clayey SILT (Alluvium)
- Foundation Loose, silty SAND (Alluvium)

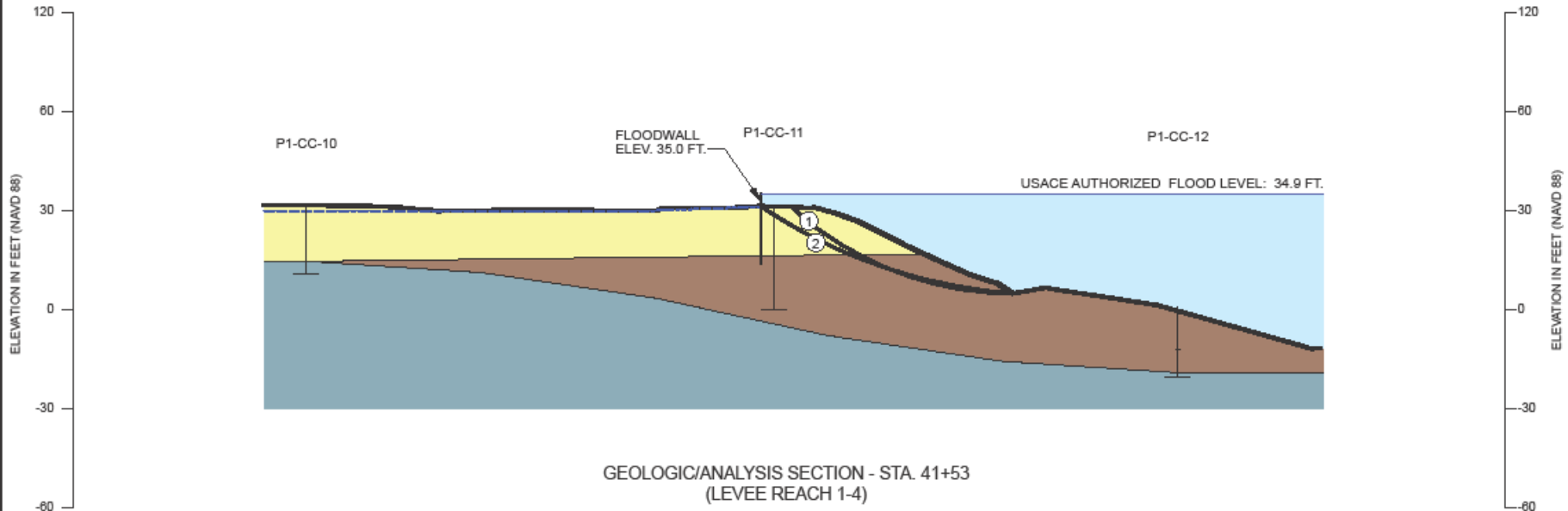
SLIP SURFACE	CALCULATED FS	MEETS REQUIRED FS*
1	1.73	YES
2	1.88	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.0**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913

NOTE: NO REVERSE ANALYSIS PERFORMED DUE TO FLOODWALL OVERTOPPING.



GEOLOGIC/ANALYSIS SECTION - STA. 41+53
(LEVEE REACH 1-4)



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USACE AUTHORIZED FLOOD LEVEL
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PORTLAND, OREGON

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PROJ. 2319
FIG. 4-2

2319\Flood Plan\Sec-41+53-500.AI.NAU

PEN 1 – Columbia Slough Levee near PIR - 100 Year Analysis

- Railroad Embankment Mixed sand and silt with timber remnants
- Fill Soft, slightly clayey to clayey SILT
- Fill Loose, silty SAND to sandy SILT
- Foundation Soft, clayey SILT (Alluvium)
- Foundation Loose, silty SAND (Alluvium)

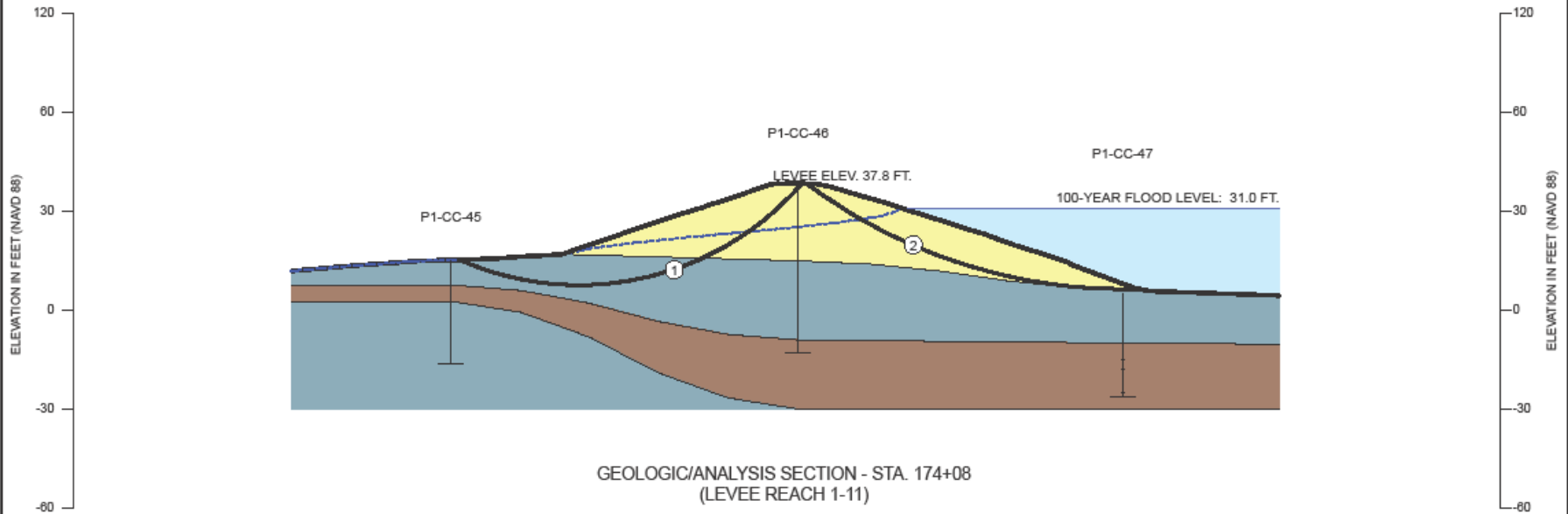
SLIP SURFACE	CALCULATED FS	MEETS REQUIRED FS*
1	1.40	YES
2	2.12	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.3**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913

NOTE: THIS ANALYSIS ALSO SERVES AS THE REVERSE ANALYSIS (SEE FS ABOVE).



GEOLOGIC/ANALYSIS SECTION - STA. 174+08
(LEVEE REACH 1-11)

0 30 60
SCALE IN FEET

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**100 YEAR
FLOOD LEVEL**
PENINSULA 1 LEVEE ASSESSMENT
PORTLAND, OREGON

JAN 2015
PROJ. 2319
FIG. 11-1

2319\Flood Levels\Sec-174+08.11.AI.NAU

PEN 1 – Columbia Slough Levee near PIR - USACE authorized design water elevation analysis

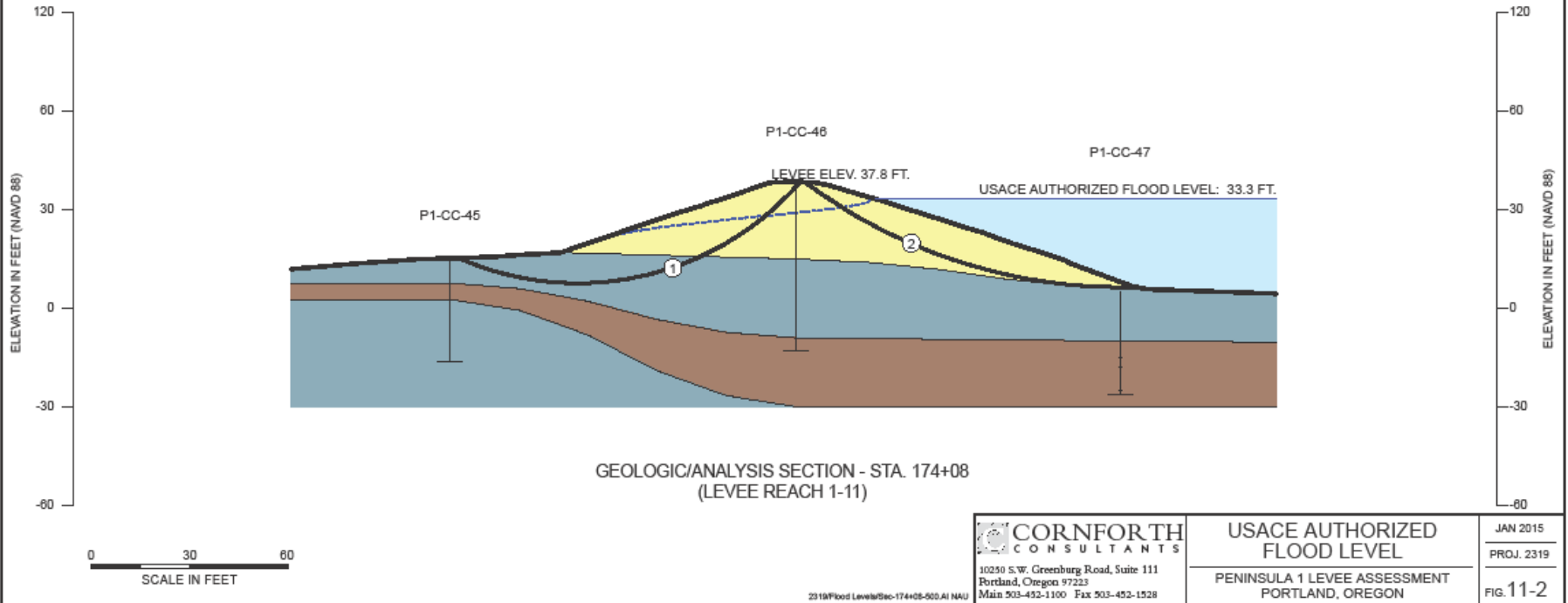
- Railroad Embankment Mixed sand and silt with timber remnants
- Fill Soft, slightly clayey to clayey SILT
- Fill Loose, silty SAND to sandy SILT
- Foundation Soft, clayey SILT (Alluvium)
- Foundation Loose, silty SAND (Alluvium)

SLIP SURFACE	CALCULATED FS	MEETS REQUIRED FS*
1	1.27	NO
2	2.27	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.48**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913



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 FIG. 11-2

2319\Flood Levels\Sec-174+08-500.AI.NAU

PEN 1 Summary

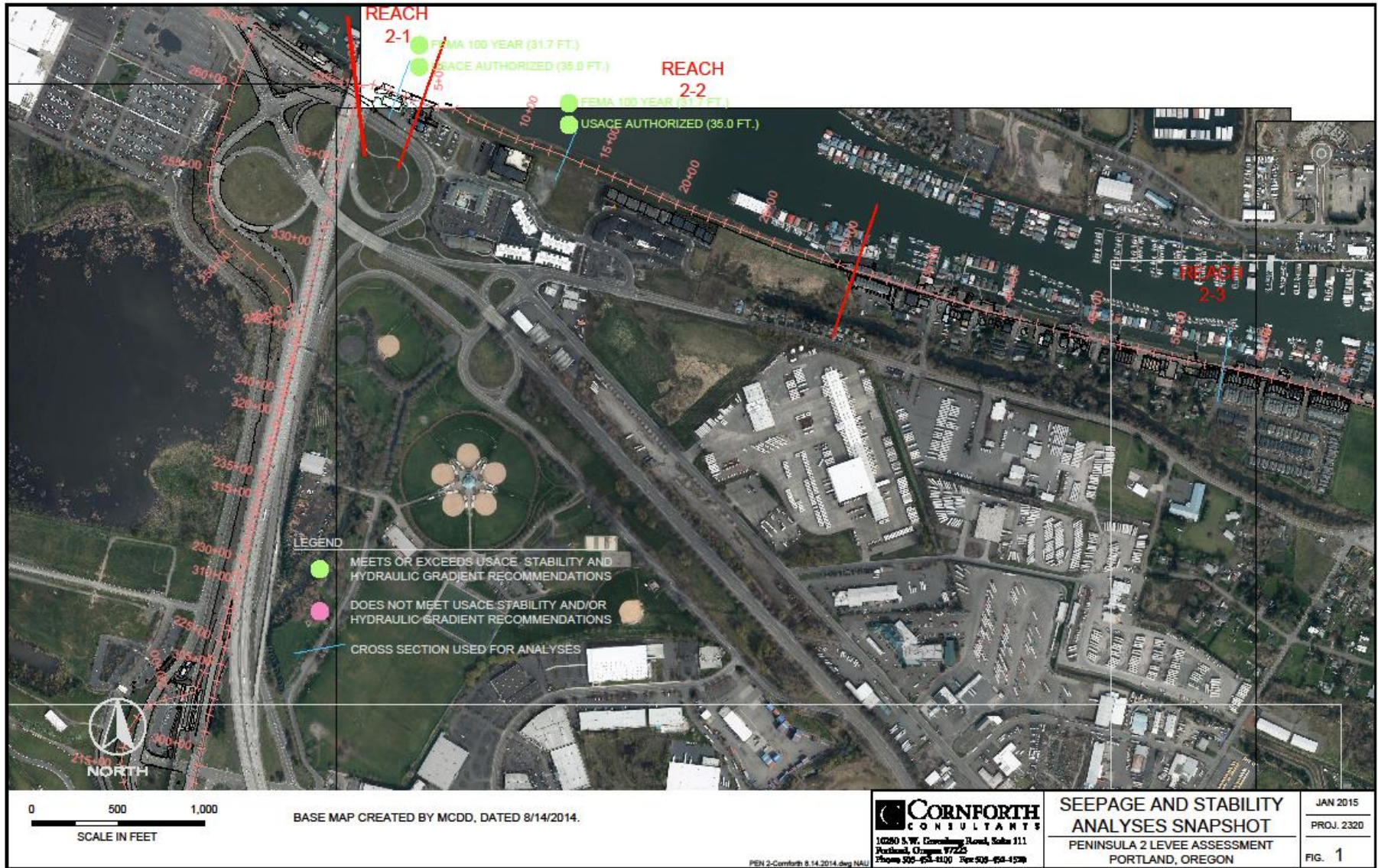
Problem areas focused on RR embankment & freeboard in Reach 1-15

Floodwalls meet USACE structural stability standards

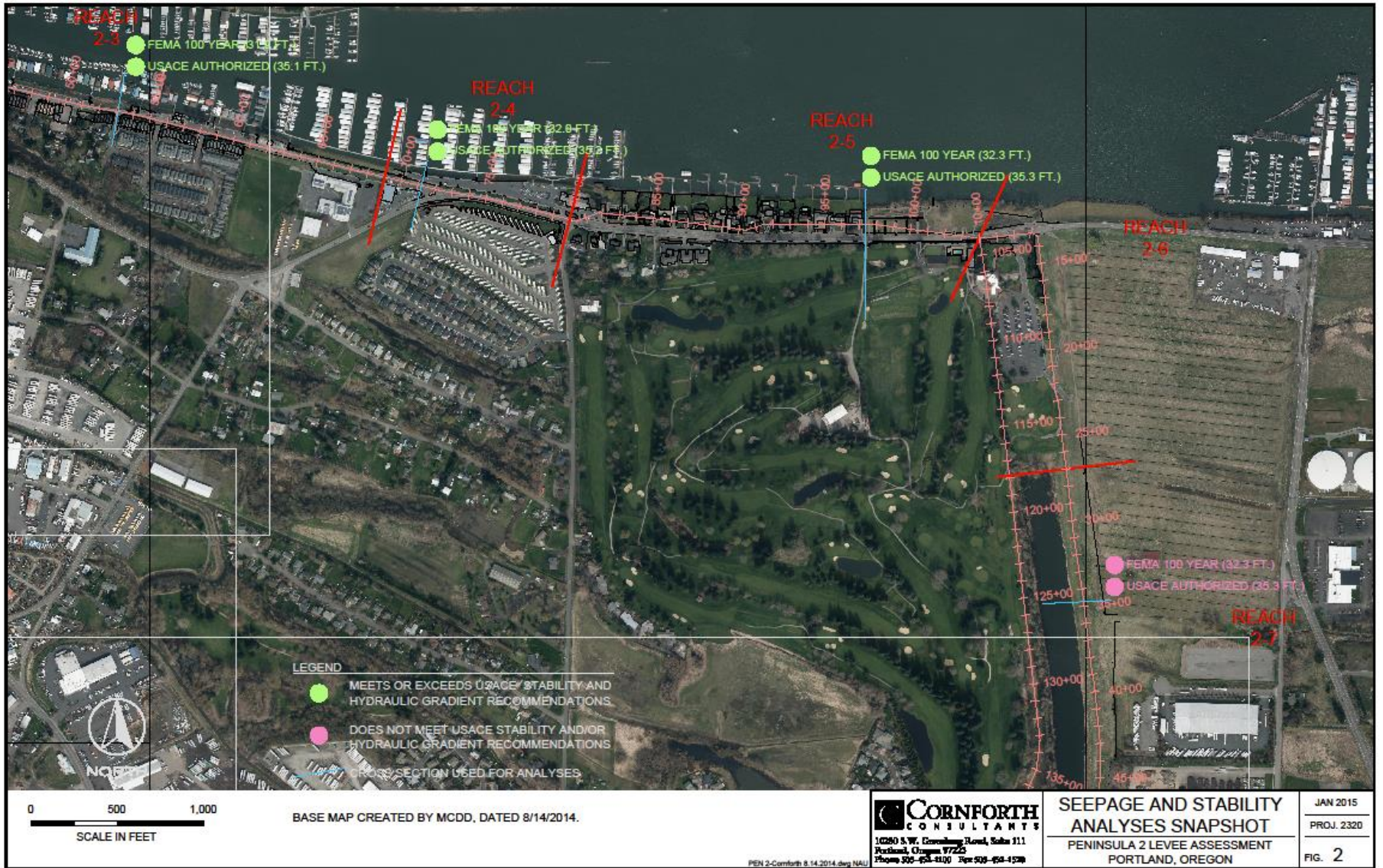
Reach 1-11 to be identified in O&M manual as “watch area” during flood events

Freeboard issues in Reach 1-15 need to be addressed

PEN 2 – NW Corner



PEN 2 – NE Corner



PEN 2 – SE Corner



PEN 2 – SW Corner



PEN 2 – Bridgeton Road Levee - 100 Year Analysis

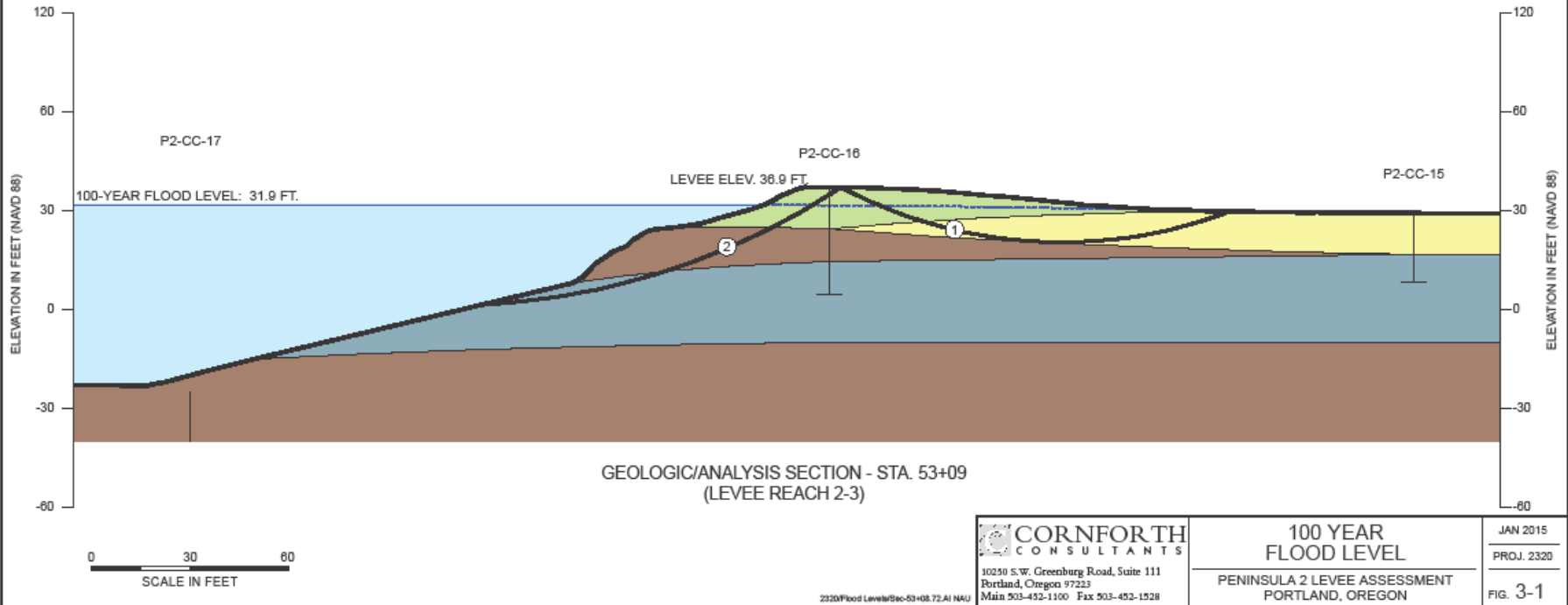
- Embankment Soft, slightly clayey to clayey SILT
- Embankment Loose, silty SAND to sandy SILT
- Foundation Loose, silty SAND and sandy SILT (Alluvium)
- Foundation Soft, clayey SILT to silty CLAY (Alluvium)

SLIP SURFACE	CALCULATED FS	MEETS REQUIRED FS*
1	5.39	YES
2	1.79	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.0**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913



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100 YEAR FLOOD LEVEL
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 PROJ. 2320
 FIG. 3-1

2320\Flood Levels\Sec-53+08.72.A1.NAU

PEN 2 – Bridgeton Road Levee - USACE authorized design water elevation analysis

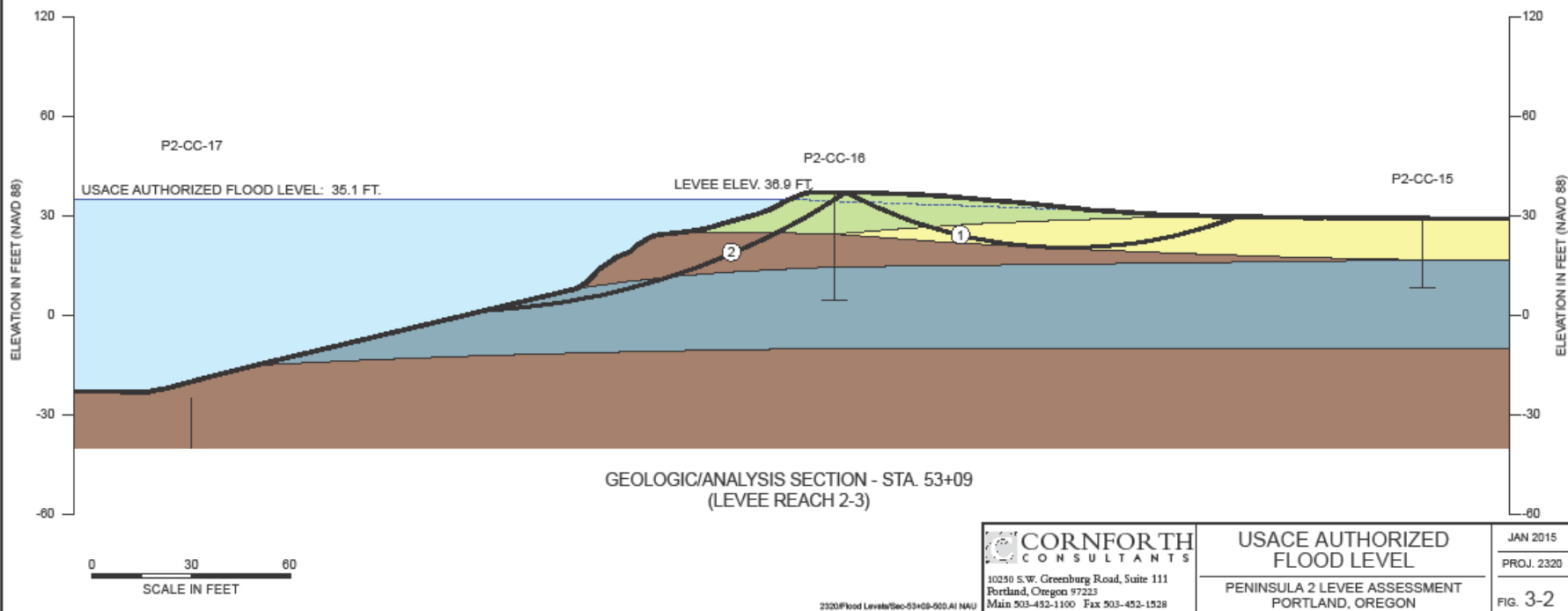
- Embankment Soft, slightly clayey to clayey SILT
- Embankment Loose, silty SAND to sandy SILT
- Foundation Loose, silty SAND and sandy SILT (Alluvium)
- Foundation Soft, clayey SILT to silty CLAY (Alluvium)

SLIP SURFACE	CALCULATED FS	MEETS REQUIRED FS*
1	4.87	YES
2	1.90	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.1**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913



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USACE AUTHORIZED
FLOOD LEVEL
PENINSULA 2 LEVEE ASSESSMENT
PORTLAND, OREGON

JAN 2015
PROJ. 2320
FIG. 3-2

PEN 2 – Bridgeton Road Levee - Reverse Analysis

- Embankment Soft, slightly clayey to clayey SILT
- Embankment Loose, silty SAND to sandy SILT
- Foundation Loose, silty SAND and sandy SILT (Alluvium)
- Foundation Soft, clayey SILT to silty CLAY (Alluvium)

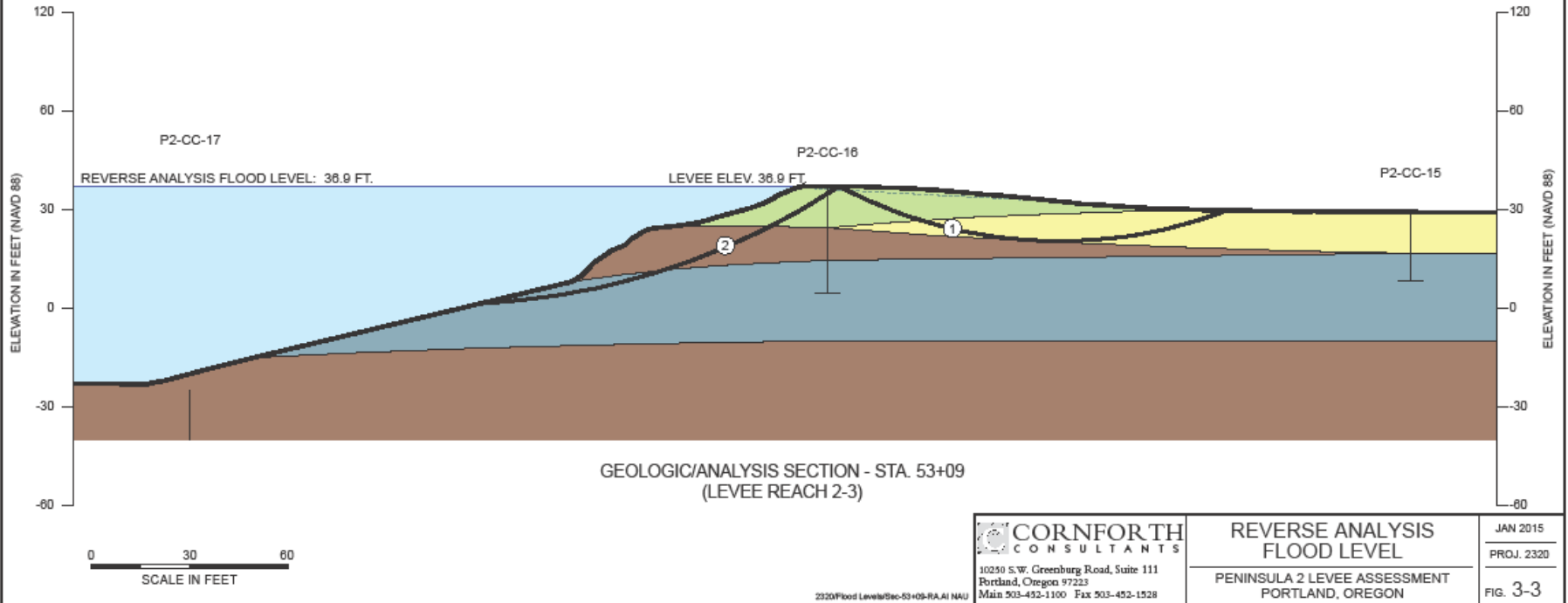
SLIP SURFACE	CALCULATED FS	MEETS REQUIRED FS*
1	4.27	YES
2	1.97	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.1**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913

NOTE: RAISING FLOOD ELEVATION ABOVE 36.9 FT. OVERTOPS THE LEVEE.



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**REVERSE ANALYSIS
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FIG. 3-3

2320\Flood Levels\Sec-53+09-RA.A1.NAU

PEN 2 – Peninsula Drainage Canal - 100 Year Analysis

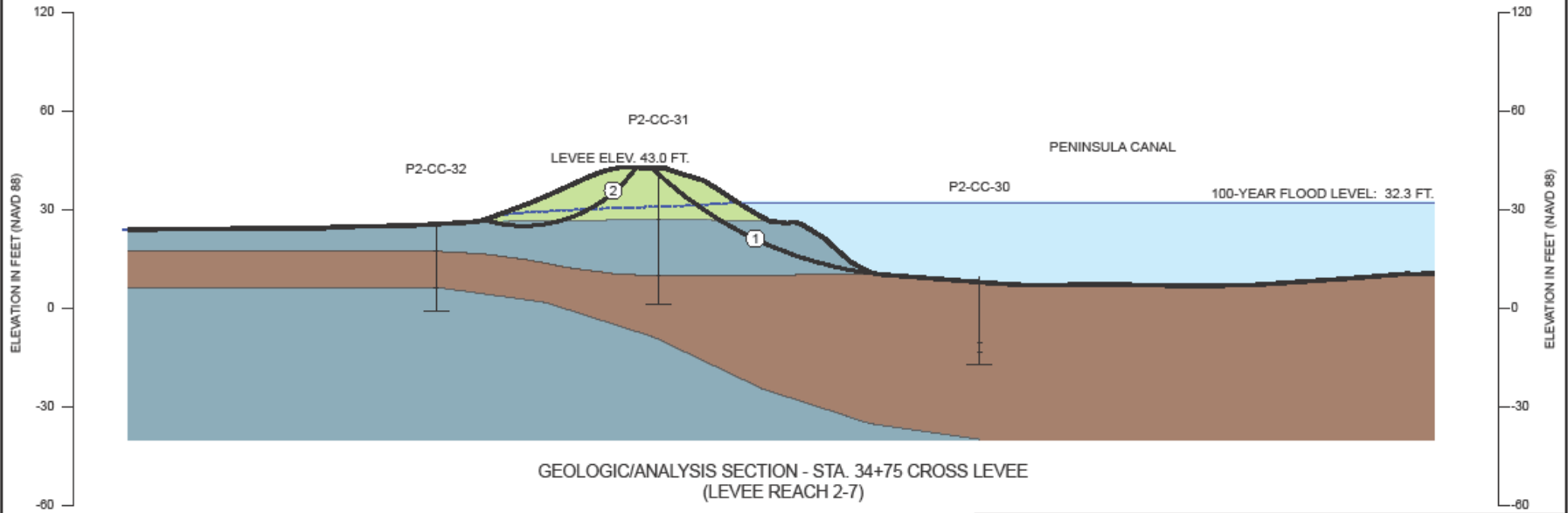
- Embankment Soft, slightly clayey to clayey SILT
- Embankment Loose, silty SAND to sandy SILT
- Foundation Loose, silty SAND and sandy SILT (Alluvium)
- Foundation Soft, clayey SILT to silty CLAY (Alluvium)

SLIP SURFACE	CALCULATED FS	MEETS REQUIRED FS*
1	1.34	NO
2	1.87	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.1**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913



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100 YEAR FLOOD
ALTERNATE ANALYSIS
PENINSULA 2 LEVEE ASSESSMENT
PORTLAND, OREGON

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PROJ. 2320
FIG. 6-4

2320\Flood Levels\Sec-125\39_6-4.AI\NAU

PEN 2 – Peninsula Drainage Canal - USACE authorized design water elevation analysis

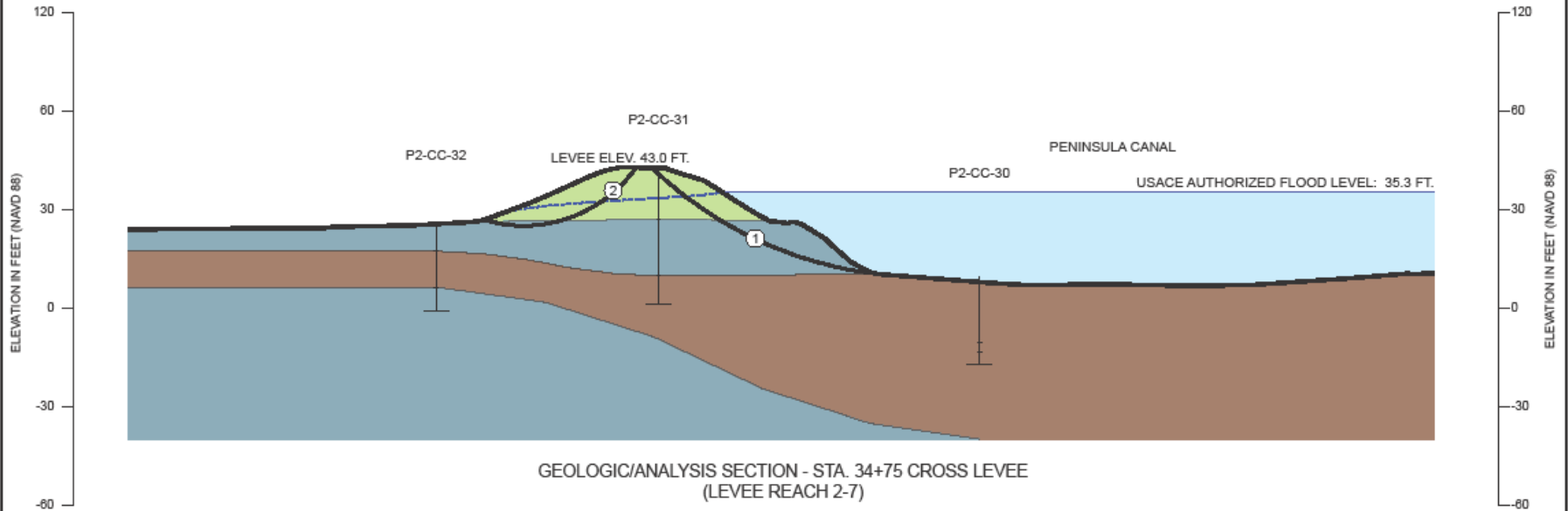
- Embankment Soft, slightly clayey to clayey SILT
- Embankment Loose, silty SAND to sandy SILT
- Foundation Loose, silty SAND and sandy SILT (Alluvium)
- Foundation Soft, clayey SILT to silty CLAY (Alluvium)

SLIP SURFACE	CALCULATED FS	MEETS REQUIRED FS*
1	1.43	YES
2	1.50	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.3**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913



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USACE AUTHORIZED
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PENINSULA 2 LEVEE ASSESSMENT
PORTLAND, OREGON

JAN 2015
PROJ. 2320
FIG. 6-5

2320\Flood Levels\Sec-125\39_6-5.AI NAU

PEN 2 – Peninsula Drainage Canal - Reverse Analysis

- Embankment Soft, slightly clayey to clayey SILT
- Embankment Loose, silty SAND to sandy SILT
- Foundation Loose, silty SAND and sandy SILT (Alluvium)
- Foundation Soft, clayey SILT to silty CLAY (Alluvium)

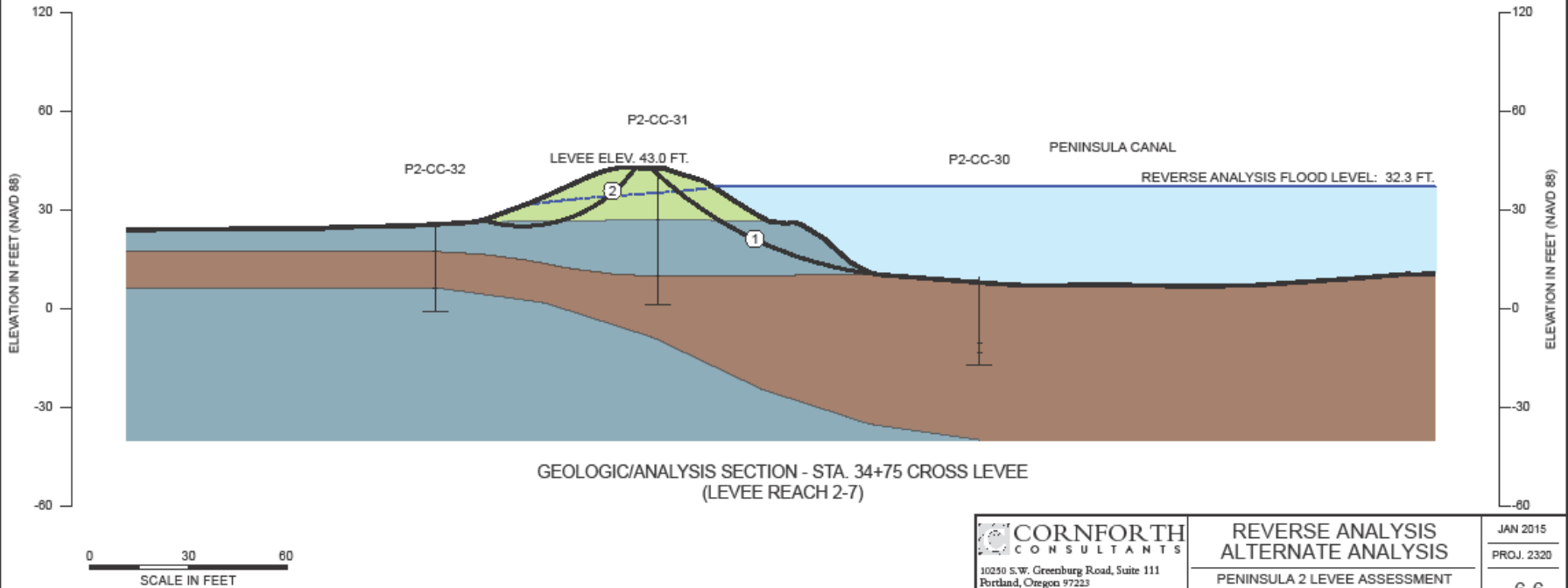
SLIP SURFACE	CALCULATED FS	MEETS REQUIRED FS*
1	1.50	YES
2	1.40	YES

*MINIMUM ALLOWABLE FS=1.4, USACE, EM 1110-2-1913

CALCULATED EXIT GRADIENT AT TOE OF LANDWARD SLOPE = 0.3**

**RECOMMENDED MAXIMUM EXIT GRADIENT = 0.5, USACE, EM 1110-2-1913

NOTE: REVERSE ANALYSIS OF LEVEE REACH UNDER NON-FLOOD CONDITIONS



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**REVERSE ANALYSIS
ALTERNATE ANALYSIS**
PENINSULA 2 LEVEE ASSESSMENT
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FIG. 6-6

2320Flood LevelsSec-125+39_6.6.AI.NAU

PEN 2 Summary

Problem areas focused on Peninsula Drainage Canal & freeboard in Reach 2-5

Seepage & stability issues along Peninsula Drainage Canal could likely be addressed with modifications to existing levee

Freeboard issues in Reach 2-5 need to be addressed

General Conclusions

Results are positive - majority of systems perform to much higher standard

No problems under USACE authorized design water elevation that did not exist under FEMA 100 year flood

Deficiencies identified in the October 2014 Levee Engineering Assessments still need to be addressed

Analyses will be helpful to address encroachments & inform the Districts' O&M and Emergency Plans

Analyses are valuable for FEMA accreditation

PEN 1

Design Flood = 1876 Flood *
Required Freeboard = 2 Feet
* BNSF RR = 1% Annual-Chance Flood

PEN 2

Design Flood = 1876 Flood
Required Freeboard = 3 Feet

PEN 1

PEN 2



Legend

Freeboard @ Auth. Elev.
Does Not Meet
Meets



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community