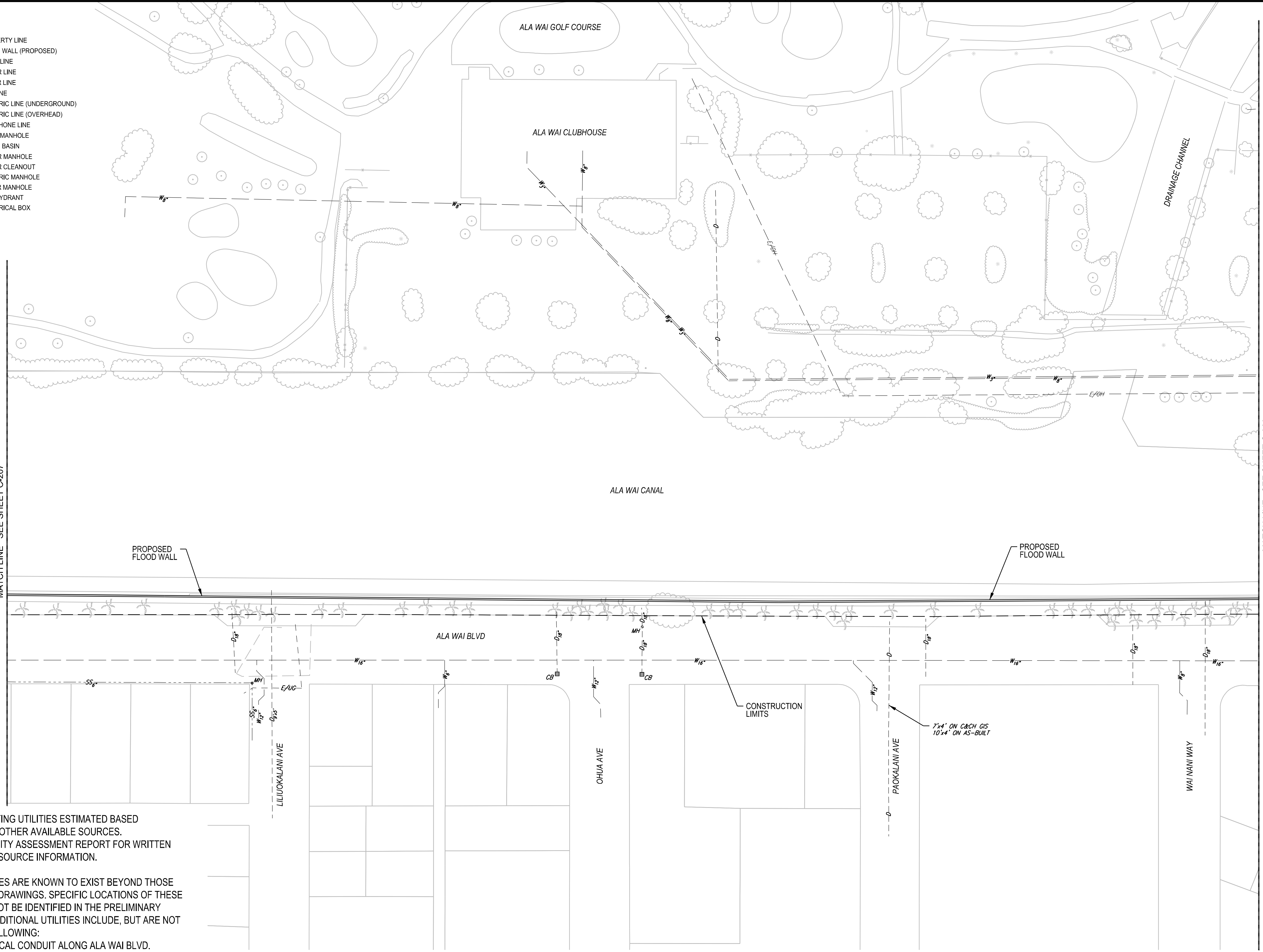
LEGEND:

- PROPERTY LINE
- FLOOD WALL (PROPOSED)
- DRAIN LINE
- SEWER LINE
- WATER LINE
- GAS LINE
- ELECTRIC LINE (UNDERGROUND)
- ELECTRIC LINE (OVERHEAD)
- TELEPHONE LINE
- DRAIN MANHOLE
- CATCH BASIN
- SEWER MANHOLE
- SEWER CLEANOUT
- ELECTRIC MANHOLE
- WATER MANHOLE
- FIRE HYDRANT
- ELECTRICAL BOX



NOTES:

1. LOCATION OF EXISTING UTILITIES ESTIMATED BASED ON AS-BUILTS AND OTHER AVAILABLE SOURCES. REFER TO THE UTILITY ASSESSMENT REPORT FOR WRITTEN DESCRIPTION AND SOURCE INFORMATION.
2. ADDITIONAL UTILITIES ARE KNOWN TO EXIST BEYOND THOSE SHOWN ON THESE DRAWINGS. SPECIFIC LOCATIONS OF THESE UTILITIES COULD NOT BE IDENTIFIED IN THE PRELIMINARY SEARCH. THESE ADDITIONAL UTILITIES INCLUDE, BUT ARE NOT LIMITED TO THE FOLLOWING:
   a. HECO ELECTRICAL CONDUIT ALONG ALA WAI BLVD.
   b. FIRE HYDRANT LATERALS
   c. IRRIGATION LINES ALONG ALA WAI BLVD.
   d. VARIOUS GAS DISTRIBUTION LINES WITHIN ALA WAI BLVD.
   e. STREET LIGHT CONDUITS ON BOTH SIDES OF ALA WAI CANAL
   f. TRAFFIC SIGNAL CONDUIT ALONG ALA WAI BLVD.

ALA WAI CANAL FLOOD WALLS - 8

1"=50'

0 50 100 150
Scale In Feet

PLOTDRIVER: $PLTDRV$$
PEN TABLE: $PENTBL$$
PRINTED BY: $USER$

FILE: $FILEL$
MODEL NAME: $MODELNAME$
DATE & TIME: $DATE$ $TIME$
LAST SAVED BY:

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR

MARK	DESCRIPTION	DATE	APPR

US ARMY CORPS OF ENGINEERS
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HONOLULU, HAWAII

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SUBMITTED BY: | LOCATION CODE
PLOT SCALE: AS SHOWN | PLOT DATE: $DATE$ | DRAWING NUMBER:
SIZE: ANSI D | FILE NAME: $FILE$$

ALA WAI WATERSHED PROJECT

EXISTING UTILITIES PLAN

SHEET IDENTIFICATION
C-208
SHEET 8 OF 19

LEGEND:

- PROPERTY LINE
- FLOOD WALL (PROPOSED)
- DRAIN LINE
- SEWER LINE
- WATER LINE
- GAS LINE
- ELECTRIC LINE (UNDERGROUND)
- ELECTRIC LINE (OVERHEAD)
- TELEPHONE LINE
- DRAIN MANHOLE
- CATCH BASIN
- SEWER MANHOLE
- SEWER CLEANOUT
- ELECTRIC MANHOLE
- WATER MANHOLE
- FIRE HYDRANT
- ELECTRICAL BOX

NOTES:

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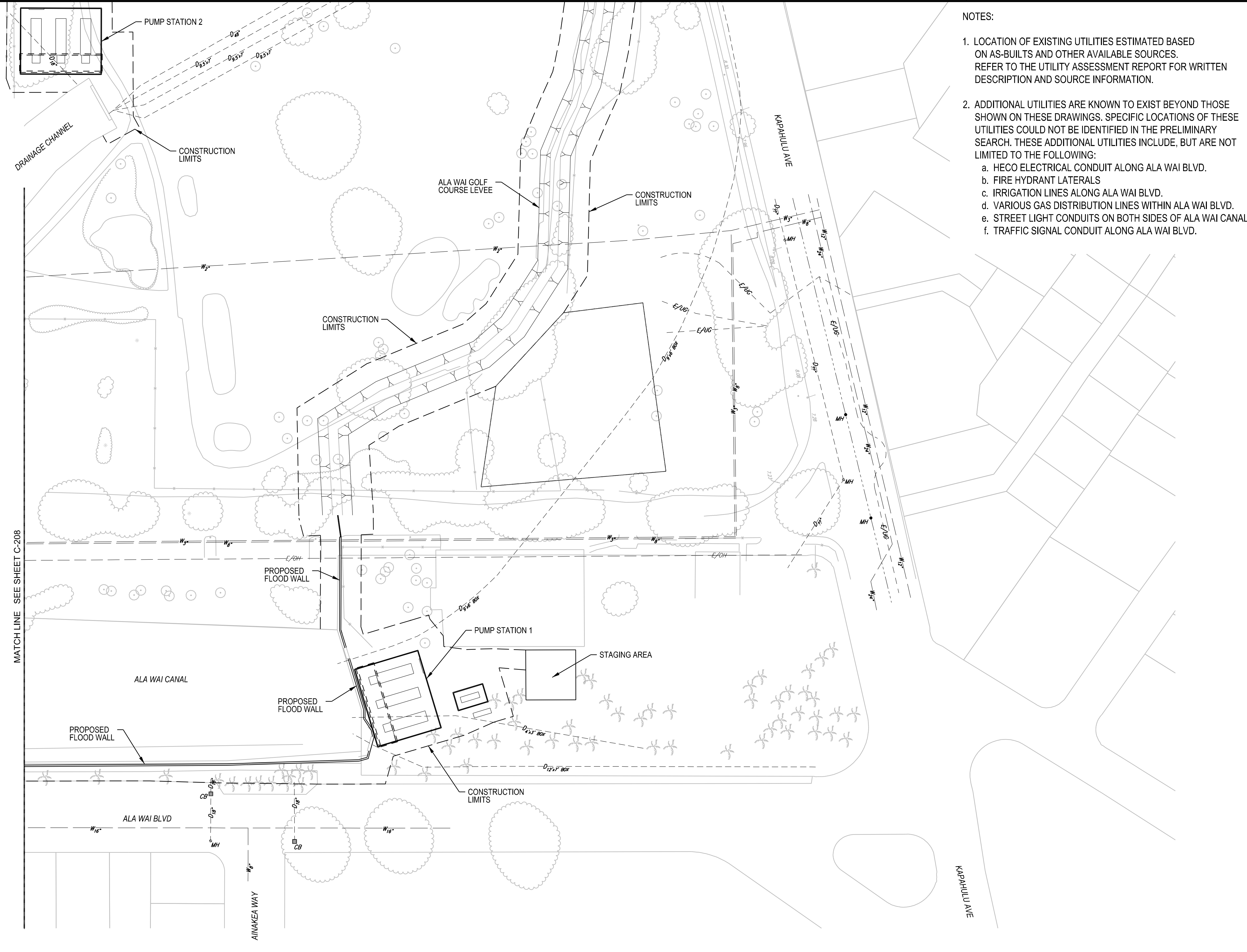
   a. HECO ELECTRICAL CONDUIT ALONG ALA WAI BLVD.
   b. FIRE HYDRANT LATERALS
   c. IRRIGATION LINES ALONG ALA WAI BLVD.
   d. VARIOUS GAS DISTRIBUTION LINES WITHIN ALA WAI BLVD.
   e. STREET LIGHT CONDUITS ON BOTH SIDES OF ALA WAI CANAL
   f. TRAFFIC SIGNAL CONDUIT ALONG ALA WAI BLVD.



ALA WAI CANAL FLOOD WALLS - 9

1"=50'

0 50 100 150
Scale In Feet

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR

MARK	DESCRIPTION	DATE	APPR

US ARMY CORPS OF ENGINEERS
HONOLULU DISTRICT
HONOLULU, HAWAII

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SUBMITTED BY: | LOCATION CODE
PLOT SCALE: AS SHOWN | PLOT DATE: $DATE$ | DRAWING NUMBER:
SIZE: ANSI D | FILE NAME: $FILE$

ALA WAI WATERSHED PROJECT

EXISTING UTILITIES PLAN

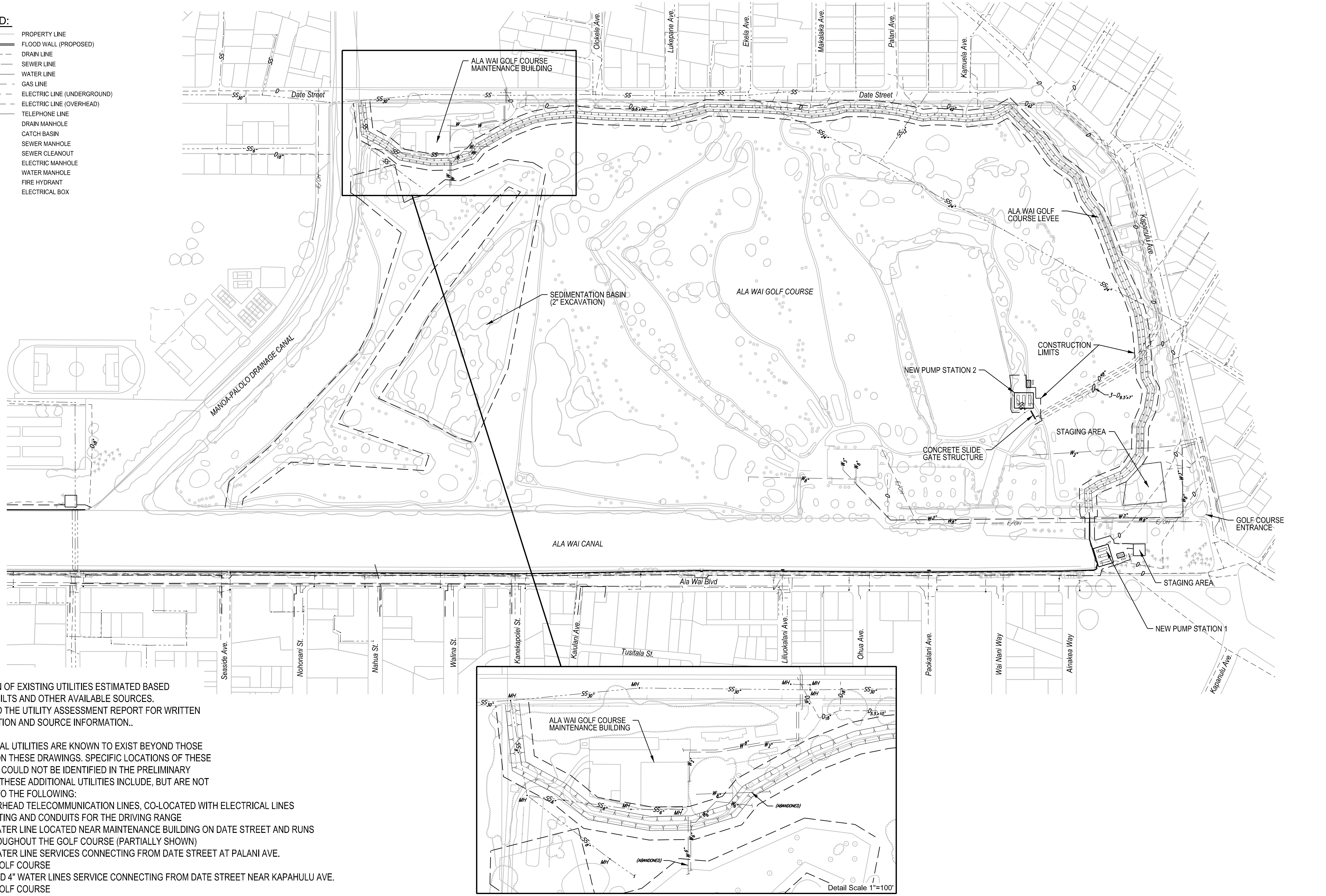
SHEET IDENTIFICATION
C-209
SHEET 9 OF 19

PLOTDRIVER: $PLTDRV$$
PEN TABLE: $PENTBL$$
PRINTED BY: $USER$

FILE: $FILEL$
MODEL NAME: $MODELNAME$
DATE & TIME: $DATE$ $TIME$
LAST SAVED BY:

LEGEND:

- PROPERTY LINE
- FLOOD WALL (PROPOSED)
- D — DRAIN LINE
- SS — SEWER LINE
- W — WATER LINE
- G — GAS LINE
- E/UG — ELECTRIC LINE (UNDERGROUND)
- E/OH — ELECTRIC LINE (OVERHEAD)
- T/UG — TELEPHONE LINE
- DRAIN MANHOLE
- CATCH BASIN
- SEWER MANHOLE
- SEWER CLEANOUT
- ELECTRIC MANHOLE
- WATER MANHOLE
- FIRE HYDRANT
- ELECTRICAL BOX



ALA WAI GOLF COURSE MULTI-PURPOSE DETENTION

1"=200'

0 200 400 600
Scale In Feet

NOTES:

1. LOCATION OF EXISTING UTILITIES ESTIMATED BASED ON AS-BUILTS AND OTHER AVAILABLE SOURCES. REFER TO THE UTILITY ASSESSMENT REPORT FOR WRITTEN DESCRIPTION AND SOURCE INFORMATION..
2. ADDITIONAL UTILITIES ARE KNOWN TO EXIST BEYOND THOSE SHOWN ON THESE DRAWINGS. SPECIFIC LOCATIONS OF THESE UTILITIES COULD NOT BE IDENTIFIED IN THE PRELIMINARY SEARCH. THESE ADDITIONAL UTILITIES INCLUDE, BUT ARE NOT LIMITED TO THE FOLLOWING:
   a. OVERHEAD TELECOMMUNICATION LINES, CO-LOCATED WITH ELECTRICAL LINES
   b. LIGHTING AND CONDUITS FOR THE DRIVING RANGE
   c. 6" WATER LINE LOCATED NEAR MAINTENANCE BUILDING ON DATE STREET AND RUNS THROUGHOUT THE GOLF COURSE (PARTIALLY SHOWN)
   d. 8" WATER LINE SERVICES CONNECTING FROM DATE STREET AT PALANI AVE. TO GOLF COURSE
   e. 8" AND 4" WATER LINES SERVICE CONNECTING FROM DATE STREET NEAR KAPAHULU AVE. TO GOLF COURSE
   f. 24" WATER LINE LOCATED NEAR EDGE OF GOLF COURSE PROPERTY ALONG KAPAHULU AVE.
   g. WATER LINES WITHIN DATE STREET ROADWAY
   h. VARIOUS GAS DISTRIBUTION LINES ALONG KAPAHULU AVE. WITHIN ROADWAY
   i. IRRIGATION AND PATHWAY LIGHTING ALONG PATHWAY PARALLEL TO MANOA-PALOLO DRAINAGE CANAL

FILE: $FILEL$
MODEL NAME: $MODELNAME$
DATE & TIME: $DATE$ $TIME$
LAST SAVED BY:

PLOTDRIVER: $PLTDRV$
PEN TABLE: $PENTBL$
PRINTED BY: $USER$

US Army Corps of Engineers

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DESIGNED BY: | DATE: | REVISION:
DRAWN BY: | CHECKED BY: | SOLICIT./ CONTRACT NO.:
SUBMITTED BY: | LOCATION CODE
PLOT SCALE: AS SHOWN | PLOT DATE: $DATE$ | DRAWING NUMBER:
SIZE: ANSI D | FILE NAME: $FILE$

US ARMY CORPS OF ENGINEERS
HONOLULU DISTRICT
HONOLULU, HAWAII

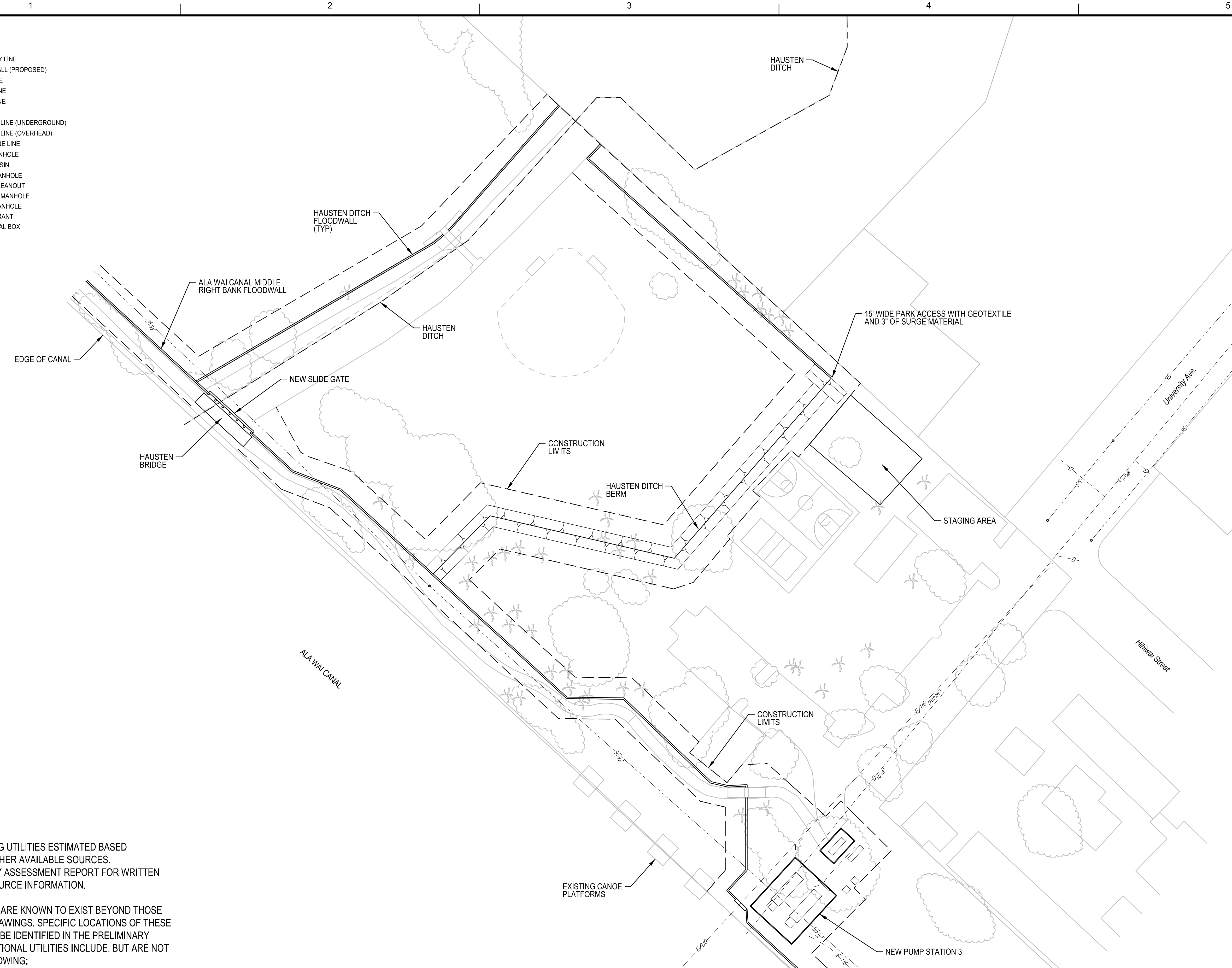
ALA WAI WATERSHED PROJECT

EXISTING UTILITIES PLAN

SHEET IDENTIFICATION
C-210
SHEET 10 OF 19

LEGEND:

- PROPERTY LINE
- FLOOD WALL (PROPOSED)
- DRAIN LINE
- SEWER LINE
- WATER LINE
- GAS LINE
- ELECTRIC LINE (UNDERGROUND)
- ELECTRIC LINE (OVERHEAD)
- TELEPHONE LINE
- DRAIN MANHOLE
- CATCH BASIN
- SEWER MANHOLE
- SEWER CLEANOUT
- ELECTRIC MANHOLE
- WATER MANHOLE
- FIRE HYDRANT
- ELECTRICAL BOX



NOTES:

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   a. 8" WATER LINE WITHIN UNIVERSITY AVE. AND HIHIWAI ST.
   b. LIGHTING AND CONDUITS ALONG WALKWAY WITHIN THE PARK AND AT SPORT COURTS.
   c. IRRIGATION LINES THROUGHOUT THE PARK AND THE BACKFLOW PREVENTER JUST WEST OF THE SPORTS COURTS.

HAUSTEN DITCH DETENTION

1"=50'

0 50 100 150
Scale In Feet

US Army Corps of Engineers®

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MARK	DESCRIPTION	DATE	APPR

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DRAWN BY: | CHECKED BY: | SOLICIT./ CONTRACT NO.:
SUBMITTED BY: | LOCATION CODE
PLOT SCALE: AS SHOWN | PLOT DATE: $DATE$ | DRAWING NUMBER:
SIZE: ANSI D | FILE NAME: $FILE$

US ARMY CORPS OF ENGINEERS
HONOLULU DISTRICT
HONOLULU, HAWAII

ALA WAI WATERSHED PROJECT

EXISTING UTILITIES PLAN

SHEET IDENTIFICATION
C-211
SHEET 11 OF 19

PLOTDRIVER: $PLTDRV$$
PEN TABLE: $PENTBL$$
PRINTED BY: $USER$

FILE: $FILEL$
MODEL NAME: $MODELNAME$
DATE & TIME: $DATE$ $TIME$
LAST SAVED BY:

LEGEND:

- PROPERTY LINE
- FLOOD WALL (PROPOSED)
- DRAIN LINE
- SEWER LINE
- WATER LINE
- GAS LINE
- ELECTRIC LINE (UNDERGROUND)
- ELECTRIC LINE (OVERHEAD)
- TELEPHONE LINE
- DRAIN MANHOLE
- CATCH BASIN
- SEWER MANHOLE
- SEWER CLEANOUT
- ELECTRIC MANHOLE
- WATER MANHOLE
- FIRE HYDRANT
- ELECTRICAL BOX

NOTES:

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   a. OVERHEAD ELECTRICAL AND TELECOMMUNICATION LINES CO-LOCATED RUNNING ALONG DOLE STREET, CROSSING BETWEEN MAUKA AND MAKAI SIDES OF ROAD
   b. ELECTRICAL LINES FOR PARK LIGHTING
   c. BACKFLOW PREVENTER VALVE AND OTHER MISC. IRRIGATION FEATURES THROUGHOUT THE PARK
   d. POSSIBLE UTILITY ROOM LOCATED UNDER TENNIS COURTS AT FIELD ELEVATION

N

KANEWAI FIELD MULTI-PURPOSE DETENTION BASIN

1"=50'

0 50 100 150
Scale In Feet

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR

MARK	DESCRIPTION	DATE	APPR

US ARMY CORPS OF ENGINEERS
HONOLULU DISTRICT
HONOLULU, HAWAII

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SUBMITTED BY: | LOCATION CODE
PLOT SCALE: AS SHOWN | PLOT DATE: $DATE$ | DRAWING NUMBER:
SIZE: ANSI D | FILE NAME: $FILE$

ALA WAI WATERSHED PROJECT

EXISTING UTILITIES PLAN

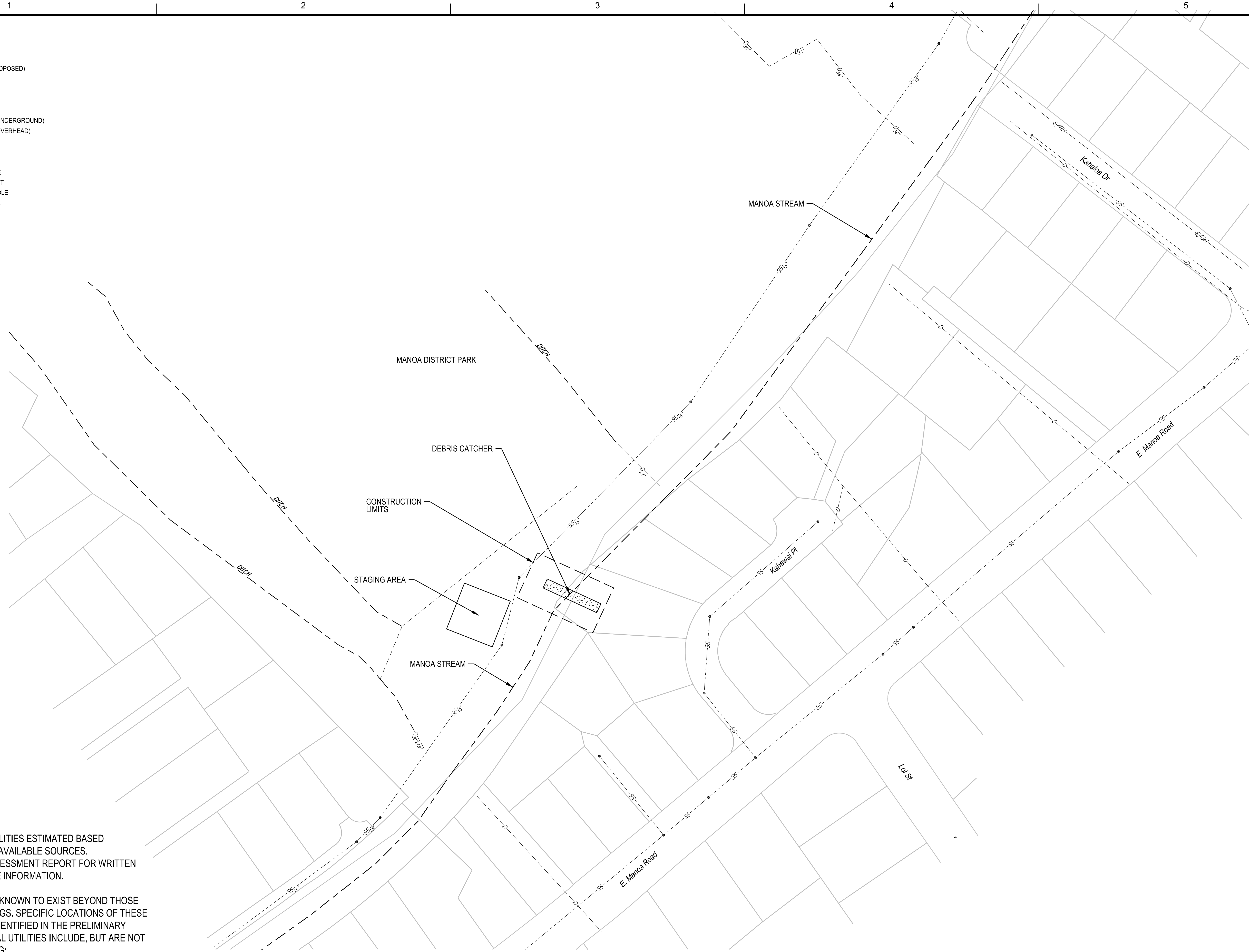
SHEET IDENTIFICATION
C-212
SHEET 12 OF 19

PLOTDRIVER: $PLTDRV$
PEN TABLE: $PENTBL$
PRINTED BY: $USER$

FILE: $FILE$
MODEL NAME: $MODELNAME$
DATE & TIME: $DATE$ $TIME$
LAST SAVED BY:

LEGEND:

——	PROPERTY LINE
═══	FLOOD WALL (PROPOSED)
— — D — —	DRAIN LINE
- - - SS - - -	SEWER LINE
—— W ——	WATER LINE
—— G ——	GAS LINE
— — E/UG — —	ELECTRIC LINE (UNDERGROUND)
— — E/OH — —	ELECTRIC LINE (OVERHEAD)
—— T/UG ——	TELEPHONE LINE
	DRAIN MANHOLE
	CATCH BASIN
	SEWER MANHOLE
	SEWER CLEANOUT
	ELECTRIC MANHOLE
	WATER MANHOLE
	FIRE HYDRANT
	ELECTRICAL BOX



NOTES:

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   a. OVERHEAD TELECOMMUNICATION LINES CO-LOCATED WITH OVERHEAD ELECTRICAL LINES.
   b. ELECTRICAL LINES FOR STREET LIGHTING LOCATED ALONG MAKAI SIDE OF KAHALOA DR. AT ENTRANCE TO PARK.

N

MANOA IN-STREAM DEBRIS CATCHMENT

1"=50'

0 50 100 150
Scale In Feet

PLOTDRIVER: $PLTDRV$$
PEN TABLE: $PENTBL$$
PRINTED BY: $USER$

FILE: $FILE$
MODEL NAME: $MODELNAME$
DATE & TIME: $DATE$ $TIME$
LAST SAVED BY:

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR

MARK	DESCRIPTION	DATE	APPR

US ARMY CORPS OF ENGINEERS
HONOLULU DISTRICT
HONOLULU, HAWAII

DESIGNED BY:	DATE:	REVISION:	
DRAWN BY:	CHECKED BY:	SOLICIT./ CONTRACT NO.:	
SUBMITTED BY:		LOCATION CODE	
PLOT SCALE: AS SHOWN	PLOT DATE: $DATE$	DRAWING NUMBER:	
SIZE: ANSI D	FILE NAME: $FILE$$		

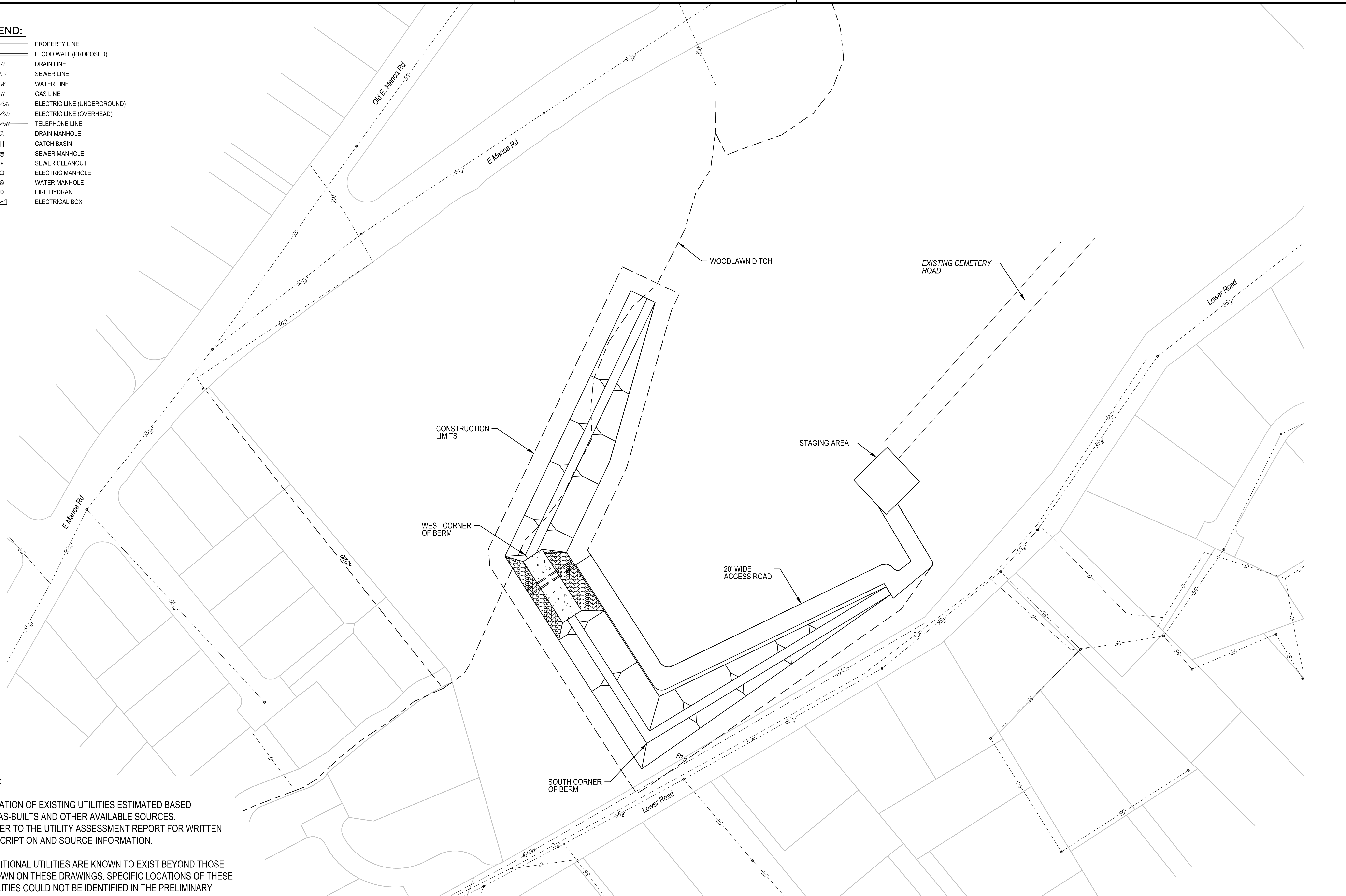
ALA WAI WATERSHED PROJECT

EXISTING UTILITIES PLAN

SHEET IDENTIFICATION
C-213
SHEET 13 OF 19

LEGEND:

	PROPERTY LINE
	FLOOD WALL (PROPOSED)
— — D — —	DRAIN LINE
- - SS - -	SEWER LINE
— W —	WATER LINE
— G —	GAS LINE
— E/UG —	ELECTRIC LINE (UNDERGROUND)
— E/OH —	ELECTRIC LINE (OVERHEAD)
— T/UG —	TELEPHONE LINE
	DRAIN MANHOLE
	CATCH BASIN
	SEWER MANHOLE
	SEWER CLEANOUT
	ELECTRIC MANHOLE
	WATER MANHOLE
	FIRE HYDRANT
	ELECTRICAL BOX



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   a. OVERHEAD TELECOMMUNICATION LINES CO-LOCATED WITH OVERHEAD ELECTRICAL LINES
   b. WATER LINES WITHIN ROADWAYS

N

WOODLAWN DITCH DETENTION

1"=50'

0 50 100 150
Scale In Feet

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MARK	DESCRIPTION	DATE	APPR

DESIGNED BY: | DATE: | REVISION:
DRAWN BY: | CHECKED BY: | SOLICIT./ CONTRACT NO.:
SUBMITTED BY: | LOCATION CODE
PLOT SCALE: AS SHOWN | PLOT DATE: $DATE$ | DRAWING NUMBER:
SIZE: ANSI D | FILE NAME: $FILE$

US ARMY CORPS OF ENGINEERS
HONOLULU DISTRICT
HONOLULU, HAWAII

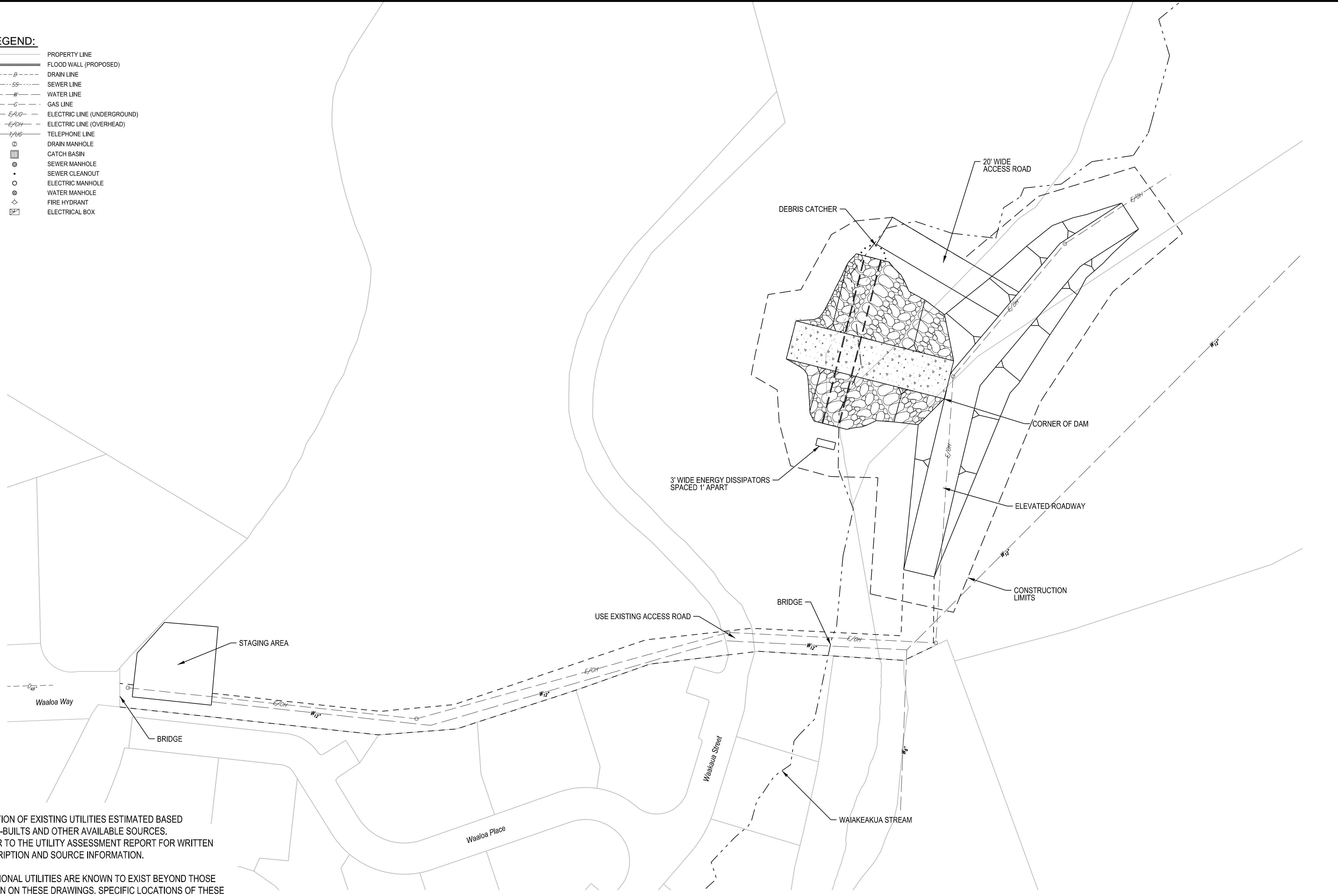
ALA WAI WATERSHED PROJECT

EXISTING UTILITIES PLAN

SHEET IDENTIFICATION
C-214
SHEET 14 OF 19

PLOTDRIVER: $PLTDRV$
PEN TABLE: $PENTBL$
PRINTED BY: $USER$

FILE: $FILE$
MODEL NAME: $MODELNAME$
DATE & TIME: $DATE$ $TIME$
LAST SAVED BY:



LEGEND:

	PROPERTY LINE
	FLOOD WALL (PROPOSED)
D	DRAIN LINE
SS	SEWER LINE
W	WATER LINE
G	GAS LINE
E/UG	ELECTRIC LINE (UNDERGROUND)
E/OH	ELECTRIC LINE (OVERHEAD)
T/UG	TELEPHONE LINE
	DRAIN MANHOLE
	CATCH BASIN
	SEWER MANHOLE
	SEWER CLEANOUT
	ELECTRIC MANHOLE
	WATER MANHOLE
	FIRE HYDRANT
	ELECTRICAL BOX

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   a. OVERHEAD TELECOMMUNICATION LINES CO-LOCATED WITH OVERHEAD ELECTRICAL LINES.

N

WAIAKEAKUA DEBRIS AND DETENTION BASIN PLAN

1"=30'

0 30 60 120
Scale In Feet

PLOTDRIVER: $PLTDRV$$
PEN TABLE: $PENTBL$$
PRINTED BY: $USER$

FILE: $FILEL$
MODEL NAME: $MODELNAME$
DATE & TIME: $DATE$ $TIME$
LAST SAVED BY:

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of Engineers®

MARK	DESCRIPTION	DATE	APPR

MARK	DESCRIPTION	DATE	APPR

DESIGNED BY: | DATE: | REVISION:
DRAWN BY: | CHECKED BY: | SOLICIT./CONTRACT NO.:
SUBMITTED BY: | LOCATION CODE
PLOT SCALE: AS SHOWN | PLOT DATE: $DATE$ | DRAWING NUMBER:
SIZE: ANSI D | FILE NAME: $FILE$$

US ARMY CORPS OF ENGINEERS
HONOLULU DISTRICT
HONOLULU, HAWAII

ALA WAI WATERSHED PROJECT

EXISTING UTILITIES
PLAN

SHEET
IDENTIFICATION
C-215
SHEET 15 OF 19

LEGEND:

- PROPERTY LINE
- FLOOD WALL (PROPOSED)
- DRAIN LINE
- SEWER LINE
- WATER LINE
- GAS LINE
- ELECTRIC LINE (UNDERGROUND)
- ELECTRIC LINE (OVERHEAD)
- TELEPHONE LINE
- DRAIN MANHOLE
- CATCH BASIN
- SEWER MANHOLE
- SEWER CLEANOUT
- ELECTRIC MANHOLE
- WATER MANHOLE
- FIRE HYDRANT
- ELECTRICAL BOX

NOTES:

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   a. OVERHEAD TELECOMMUNICATIONS LINES CO-LOCATED WITH OVERHEAD ELECTRICAL LINES.

MAKIKI DEBRIS AND DETENTION BASIN

1"=50'

0 50 100 150
Scale In Feet

PLOTDRIVER: $PLTDRVS$
PEN TABLE: $PENTBLS$
PRINTED BY: $USER$

FILE: $FILEL$
MODEL NAME: $MODELNAME$
DATE & TIME: $DATE$ $TIME$
LAST SAVED BY:

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR

MARK	DESCRIPTION	DATE	APPR

US ARMY CORPS OF ENGINEERS
HONOLULU DISTRICT
HONOLULU, HAWAII

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DRAWN BY: | CHECKED BY: | SOLICIT./ CONTRACT NO.:
SUBMITTED BY: | LOCATION CODE
PLOT SCALE: AS SHOWN | PLOT DATE: $DATE$ | DRAWING NUMBER:
SIZE: ANSI D | FILE NAME: $FILES$

ALA WAI WATERSHED PROJECT

EXISTING UTILITIES
PLAN

SHEET IDENTIFICATION
C-216
SHEET 16 OF 19

NOTES:

1. LOCATION OF EXISTING UTILITIES ESTIMATED BASED ON AS-BUILTS AND OTHER AVAILABLE SOURCES. REFER TO THE UTILITY ASSESSMENT REPORT FOR WRITTEN DESCRIPTION AND SOURCE INFORMATION.

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   a. OVERHEAD TELECOMMUNICATION LINES CO-LOCATED WITH OVERHEAD ELECTRICAL LINES.
   b. STREET LIGHTING CO-LOCATED WITH ELECTRICAL POLES.

PUKELE DEBRIS AND DETENTION BASIN

1"=50'

0 50 100 150
Scale In Feet

FILE: $FILEL$
MODEL NAME: $MODELNAME$
DATE & TIME: $DATE$ $TIME$
LAST SAVED BY:
PLOTDRIVER: $PLTDRV$$
PEN TABLE: $PENTBL$$
PRINTED BY: $USER$

US Army Corps of Engineers®

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MARK	DESCRIPTION	DATE	APPR

DESIGNED BY: | DATE: | REVISION:
DRAWN BY: | CHECKED BY: | SOLICIT./ CONTRACT NO.:
SUBMITTED BY: | LOCATION CODE
PLOT SCALE: AS SHOWN | PLOT DATE: $DATE$ | DRAWING NUMBER:
SIZE: ANSI D | FILE NAME: $FILES$

US ARMY CORPS OF ENGINEERS
HONOLULU DISTRICT
HONOLULU, HAWAII

ALA WAI WATERSHED PROJECT
MITIGATION MEASURES

EXISTING UTILITIES
PLAN

SHEET IDENTIFICATION
C-217
SHEET 17 OF 19

LEGEND:

- PROPERTY LINE
- FLOOD WALL (PROPOSED)
- D — DRAIN LINE
- SS — SEWER LINE
- W — WATER LINE
- G — GAS LINE
- E/UG — ELECTRIC LINE (UNDERGROUND)
- E/OH — ELECTRIC LINE (OVERHEAD)
- T/UG — TELEPHONE LINE
- DRAIN MANHOLE
- CATCH BASIN
- SEWER MANHOLE
- SEWER CLEANOUT
- ELECTRIC MANHOLE
- WATER MANHOLE
- FIRE HYDRANT
- ELECTRICAL BOX

NOTES:

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   a. OVERHEAD TELECOMMUNICATION LINES CO-LOCATED WITH OVERHEAD ELECTRICAL LINES ALONG WEST SIDE OF WAIOMAO ROAD.
   b. STREET LIGHTING CO-LOCATED WITH OVERHEAD ELECTRICAL LINES ALONG WEST SIDE OF WAIOMAO ROAD.

WAIOMAO DEBRIS AND DETENTION BASIN

1"=50'

0 50 100 150
Scale In Feet

FILE: $FILEL$
MODEL NAME: $MODELNAME$
DATE & TIME: $DATE$ $TIME$
LAST SAVED BY:
PLOTDRIVER: $PLTDRV$$
PEN TABLE: $PENTBL$$
PRINTED BY: $USER$

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR

MARK	DESCRIPTION	DATE	APPR

US ARMY CORPS OF ENGINEERS
HONOLULU DISTRICT
HONOLULU, HAWAII

DESIGNED BY: | DATE: | REVISION:
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SUBMITTED BY: | LOCATION CODE
PLOT SCALE: AS SHOWN | PLOT DATE: $DATE$ | DRAWING NUMBER:
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ALA WAI WATERSHED PROJECT

EXISTING UTILITIES PLAN

SHEET IDENTIFICATION
C-218
SHEET 18 OF 19

NOTES:

1. LOCATION OF EXISTING UTILITIES ESTIMATED BASED ON AS-BUILTS AND OTHER AVAILABLE SOURCES. REFER TO THE UTILITY ASSESSMENT REPORT FOR WRITTEN DESCRIPTION AND SOURCE INFORMATION.

2. ADDITIONAL UTILITIES ARE KNOWN TO EXIST BEYOND THOSE SHOWN ON THESE DRAWINGS. SPECIFIC LOCATIONS OF THESE UTILITIES COULD NOT BE IDENTIFIED IN THE PRELIMINARY SEARCH. THESE ADDITIONAL UTILITIES INCLUDE, BUT ARE NOT LIMITED TO THE FOLLOWING:
   a. OVERHEAD TELECOMMUNICATION LINES CO-LOCATED WITH OVERHEAD ELECTRICAL LINES ON SIDE OF PAWAINA STREET.

MANOA STREAM FALLS 7 AND 8 REHABILITATION

1"=30'

0 30 60 120
Scale In Feet

PLOTDRIVER: $PLTDRV$$
PEN TABLE: $PENTBL$$
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MODEL NAME: $MODELNAME$
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US Army Corps of Engineers

MARK	DESCRIPTION	DATE	APPR

MARK	DESCRIPTION	DATE	APPR

US ARMY CORPS OF ENGINEERS
HONOLULU DISTRICT
HONOLULU, HAWAII

DESIGNED BY:	DATE:	REVISION:
DRAWN BY:	CHECKED BY:	SOLICIT./ CONTRACT NO.:
SUBMITTED BY:		LOCATION CODE
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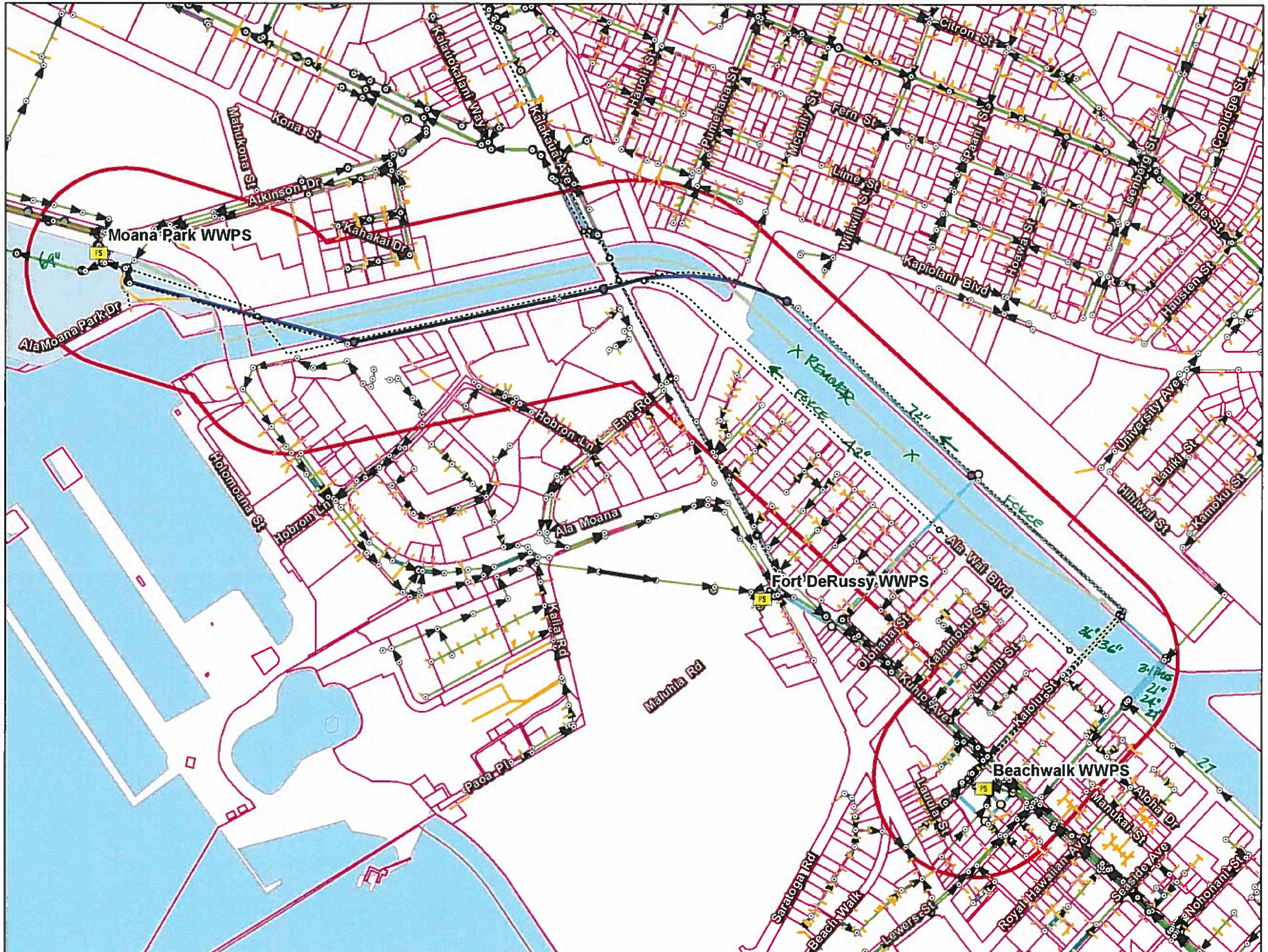
ALA WAI WATERSHED PROJECT
MITIGATION MEASURES

EXISTING UTILITIES
PLAN

SHEET IDENTIFICATION
C-219
SHEET 19 OF 19

Attachment 5

Waikiki Buffer Zone Map



WAIKIKI BUFFER ZONE

Note: Construction activity may cause damage to the Beachwalk WWPS force mains from ground vibrations or soil liquefaction. Prevention, mitigation, and/or monitoring measures may need to be taken. It is the responsibility of the owner/contractor to prevent any impacts or potential damage to the force main.

DASHED – FORCE MAINS

SOLID – GRAVITY

N

0 230 460 690 920

Feet

Prepared by: Dept. of Design & Construction
City & County of Honolulu
650 South King Street
Honolulu, Hawaii 96813

DRAFT TECHNICAL MEMORANDUM

Ala Wai Canal Project

Design Update for Ala Wai Canal Floodwalls

Contract No. W9128A-12-D-0009-0002, Task Order 002

PREPARED FOR:	U.S. Army Corps of Engineers, Honolulu District
PREPARED BY:	Erika Powell Mark Twede Jennifer Elwood
DATE:	June 16, 2016
REVIEWED BY:	Lisa Kettley Jaco Esterhuizen

The Ala Wai Canal Project is a flood risk management feasibility study being conducted by the U.S. Army Corps of Engineers, Honolulu District (USACE) under the authority of Section 209 of the Flood Control Act of 1962. The non-Federal sponsor is the State of Hawaii Department of Land and Natural Resources (DLNR) Engineering Division.

The project is currently in the feasibility phase of the USACE planning process, which consists of a study to investigate and determine the extent of Federal interest in a plan to reduce flood risk within the Ala Wai Canal watershed. Specifically, the study includes (1) an assessment of the risk of flooding, (2) analysis of a range of alternatives formulated to reduce flood risk, and (3) identification of a tentatively selected plan for implementation (with design drawings developed to a 35% level of design). The results of the feasibility study are presented with an integrated Environmental Impact Statement (EIS), as needed to comply with the National Environmental Policy Act (NEPA) and Hawaii Revised Statutes (HRS) Chapter 343.

The Draft Feasibility Report/EIS for the Ala Wai Canal Project was released for public review in the fall of 2015, and underwent concurrent public review, Agency Technical Review (ATR), USACE Headquarters Policy Review, and Independent External Peer Review (IEPR). The USACE is currently working to address comments received on the Draft Feasibility Report/EIS in preparation for the Final Feasibility Report/EIS. The Final Feasibility Report/EIS will be submitted to USACE Headquarters for review and approval; if approved, a Chief of Engineers Report would be sent to Congress recommending authorization of the Ala Wai Canal Project.

In support of this effort, CH2M HILL (CH2M) has been contracted to update the 35% design drawings for the left bank of the Ala Wai Canal floodwalls based on a review comment received on the Draft Feasibility Report/EIS. Specifically, CH2M's scope of work (SOW) states that the purpose of the task is to "*update the civil designs for…the left bank Ala Wai Canal floodwall to ensure a consistent level of detail with USACE designs on the right bank and address comments received from the Independent External Peer Review. The Contractor shall validate the current dimensions of the left bank foundation to ensure sufficient construction space and, if appropriate, designs shall be adjusted to accommodate space constraints (e.g. cantilevered wall).*"

This technical memorandum summarizes the approach and results of this task.

BACKGROUND

The Ala Wai Canal watershed is located on the southeastern side of the island of Oahu, and includes Makiki, Manoa, and Palolo streams, all of which drain to the Ala Wai Canal. The Canal is a 2-mile-long waterway constructed during the 1920s to drain extensive coastal wetlands, thus allowing development of the Waikiki District. A large portion of the watershed, including most of Waikiki, is highly susceptible to flooding.

The USACE's tentatively selected plan to address flood risk in the Ala Wai Canal watershed, as presented in the Draft Feasibility Report/EIS, consists of the following measures:

- Six in-stream debris and detention basins in the upper reaches of the watershed
- One standalone debris catchment feature
- Three multi-purpose detention basins in open-space areas within the developed watershed
- Floodwalls along the Ala Wai Canal (including three associated pump stations)
- Improvements to the flood warning system (non-structural)
- Compensatory mitigation features

Based on the 35% design drawings developed by the USACE, the Ala Wai Canal floodwalls would be constructed along approximately 1.7 miles of the left bank (from near Kapahulu Avenue to Ala Moana Bridge) and approximately 0.9 mile of the right bank (from the Manoa Palolo Drainage Canal to Ala Moana Bridge). The reinforced-concrete floodwalls would be an average of approximately 4 feet high, offset from the existing canal retaining walls; they would be as much as 6 feet high at the upstream end and would taper to the existing grade near Ala Moana Bridge. Three pump stations would be constructed to address storm flows associated with several large existing drainage features that flow into the canal, and gates would be installed for other smaller drainage pipes to prevent backflow from the Ala Wai Canal during a flood event. A copy of the relevant pages of the 35% design drawings are contained in Attachment 1.

Based on their review of the Draft Feasibility Report/EIS, the IEPR team provided the following comment regarding the Ala Wai Canal floodwalls:

> *The "L" shaped left bank floodwall includes a foundation equal to only 2/3 the wall height, with all foundation in the toe and no foundation heel. Therefore, the Panel is concerned that the "L" shaped left bank floodwall foundations may not have sufficient factor of safety to resist sliding and overturning.*
>
> *Ordinarily, this matter would be corrected during the Preconstruction Engineering & Design (PED) phase and increased incremental cost would be covered by the project contingency. However, the left bank site conditions may not provide adequate available space for construction of either the floodwall design indicated in Detail C of Sheet C-311 or any other cantilever design resulting from a reevaluation of foundation conditions. The already narrow available left bank work area is complicated by existing, possibly historic, canal wall stone work, existing utilities (street lighting and hydrants observed on Google Earth) and trees (indicated on plan drawings and artist renderings), and proximity of heavy vehicular and pedestrian traffic. If a left bank flood wall foundation designed with an adequate factor of safety against sliding and overturning cannot be constructed within the available site without impacts to site constraints, then a significant change in the TSP 35% design may be required. This change may be so major as to change the design concept and cause more environmental impacts to existing canal stone walls, utilities and trees, and traffic. Furthermore, the design is not aligned with the currently assessed level of risk assigned at this stage in the SMART Planning process.*

Recommendations:

1. Validate foundation design assumptions used for both left and right bank floodwalls.

2. Correlate left and right bank designs and adjust foundation dimensions accordingly.

3. Ensure that the dimension of correlated and adjusted left bank floodwall foundations allow sufficient construction space within existing left bank physical project constraints.

4. Revise the project constraints and impacts stated in the report if sufficient construction space within existing project constraints is not available, or consider revising design concepts away from a cantilever wall.

A copy of the complete IEPR comment is provided in Attachment 2.

APPROACH AND RESULTS

Consistent with the SOW requirements, the objective of the task is to update the left bank floodwall design pursuant to the relevant IEPR review comment. As such, the approach used for the design update mirrored the recommendations numbered in the IEPR comment. The specific methodology and results for these steps is presented below.

Floodwall Design Validation and Evaluation

In accordance with USACE design guidelines for stability analysis of gravity structures, floodwalls must meet minimum requirements for various loading conditions, including water levels for the design flood and to the top of the wall, earthquake loads, and temporary construction loads. Consistent with the IEPR recommendation, the stability of the existing canal floodwall design (as shown in Attachment 1) was checked for overturning, sliding, and bearing capacity failure modes in accordance with the USACE Engineer Manual (EM) 1110-2-2100 (USACE, 2005) and EM 1110-2-2502 (USACE, 1989), with clarifications provided in Engineering and Construction Bulletin (ECB) No. 2014-24 (USACE, 2014). Details of the methodology, design criteria, and results of the analysis are presented in Attachment 3.

Based on the results of the stability analysis, the following conclusions were reached for the right bank floodwall:

- The wall section as shown on the 35% design drawings (Sheet C-309, Attachment 1) is sufficient to retain the design flood.
- The width of the wall and the depth of its footing can be decreased and still meet minimum stability requirements. However, the cutoff should extend more than 1.5 feet below the footing, if the depth of the footing is decreased.

Based on the results of the stability analysis, the following conclusions were reached for the left bank floodwall:

- The wall as shown on the 35% design drawings (Sheet C-310, Attachment 1) is inadequate to retain the maximum design flood.
- Based on inspection, the left bank wall section could be similar to the right bank floodwall section, if the loading and foundation conditions are very similar.

In response to these findings, a wall section configuration similar to the right bank floodwall detail shown on Sheet C-309 was evaluated for the various loading requirements and wall heights. The required foundation size for the wall was adjusted to correspond to the specific wall heights for each reach of floodwall. The required floodwall dimensions for reaches along both the left and right banks are summarized in the tables on Sheet C-312 (Attachment 4).

Key design issues considered as part of this effort include the following:

- Based on preliminary utility information, it is estimated that the proposed left bank floodwall would cross over approximately 49 storm drains at varying depths. Approximately 30 culverts on the left bank and 1 on the right bank would penetrate the proposed wall key below the footing. The invert elevation of approximately 13 culverts is unknown. At least two culverts would intersect the floodwall footings on both the left and right banks, and require the footing to be raised such that it would bridge over the culvert. Special structural details will be required where the wall crosses over these features. Full development of structural details for these crossings are beyond the current scope, but general concepts for construction requirements at typical culvert crossings are shown in Details C and D on Sheet C-312A (Attachment 4). Encasement with lean concrete or controlled low-strength material would be required to both limit under-seepage along the culvert and to transfer wall loads around the existing culverts. A filter diaphragm, consisting of sand material, should be installed at the downgradient side of the floodwall to limit the risk of internal erosion and piping.
- Two box culverts located at the upstream end of the Ala Wai Canal are located at grade, and have little to no soil cover. It is understood that the proposed pump station would be designed to incorporate these culverts, such that the floodwall would not tie directly into these structures. However, in the event that the pump stations are removed from the design (or the floodwall is otherwise required to tie directly into these structures), the proposed floodwall foundation would not have sufficient embedment in these locations. In this case, it may be necessary to design a new headwall structure with a 7-foot extension above the culvert outlet, and tie the floodwall into the headwall structure. If needed, the design of these parapet wall-type special structural details (or other special details) will need to be performed during the PED phase.
- Existing information about the subsurface conditions beneath the proposed floodwalls is limited, consisting of descriptions of material types observed at various borings and test pits performed as part of a 1999 study of the existing canal retaining walls (Geolabs, 1999). The soil descriptions contain information useful for selecting preliminary soil properties, but should be refined through additional investigation as part of the PED phase. Specifically, a soil investigation must be performed to provide a high level of confidence in the foundation strength and permeability for final design of the Ala Wai Canal floodwalls, in accordance with EM 1110-2-2100, Section 3-4 (USACE, 2005).
- The existing Ala Wai Canal retaining walls vary in shape, size, and materials. They are at risk of becoming unstable in many locations, as concluded in the 1999 study. To limit impacts to the existing retaining walls from new loading imposed by the proposed floodwall and its construction, the floodwalls should be set back outside the influence zone of the existing retaining walls. For preliminary design purposes, it was assumed that the floodwall foundation should bear below an imaginary plane inclined at 45 degrees up from the base of the existing retaining walls. This assumption will need to be validated based on a detailed geotechnical investigation and analysis.

Construction Issues

The existing canal retaining walls are not watertight and the soil behind them appears to consist of loose sand fill materials with potentially high permeability. In the 1999 study of the existing canal retaining walls, the groundwater level was observed to be equal to the water level in the canal, which was as high as approximately 2 feet below the ground surface. High groundwater would likely cause caving of loose sand fill materials into the excavation for the floodwall key below the foundation during construction. In addition, with high groundwater, compaction of the foundation subgrade would be problematic.

Construction of the proposed floodwall section with a reinforced-concrete key below the wall foundation would require dewatering. To accomplish dewatering of any permeable fill materials, a positive groundwater cutoff system would likely be required in combination with wells or well points to maintain water levels below the required excavation, which has the potential to add significant additional costs during construction. The positive groundwater cutoff system may consist of deep temporary sheet pile walls on both sides of the excavation footprint. Pumping would be required between the cutoff system to remove water seeping through and beneath the cutoff system. A typical dewatering system that could be used to construct the wall with a concrete key beneath the footing is shown as Option 1 on Sheet C-313 (Attachment 4).

An option that could be used in lieu of the deep dewatering scheme would be to use permanent steel sheet piles in place of a concrete key beneath the footing. The installation of the sheet piles would reduce the uplift pressures, reduce the risk of piping beneath the foundation, and provide lateral resistance against sliding of the wall, similar to the reinforced concrete key. The preliminary required depth of the sheet piles is approximately 6 feet below the bottom of the floodwall foundation. The required construction dewatering for this option could be significantly simplified, consisting of pumping from sumps along the alignment to draw water down below the bottom of the relatively shallow wall foundation, as needed. This concept is shown as Option 2 on Sheet C-313A (Attachment 4).

One drawback of using the sheet piles in place of the concrete key is the potential for corrosion. Although not in direct contact with seawater, the sheet piles would be in contact with groundwater and would be subject to some level of corrosion. Corrosion can be mitigated by using a sheet pile with larger thickness than is structurally required. For example, an AZ-12 sheet pile would likely be sufficient for the proposed floodwall. Using an AZ-14 sheet pile instead would provide approximately 0.1 inch of sacrificial thickness to allow for corrosion over a finite design life for the floodwall.

It is estimated that sheet piles can be driven easily through the sand fill materials. However, a layer of cemented coral rubble was identified below the sand fill in the 1999 study of the existing retaining walls, which could cause difficulty in driving piles. If the depth of the coral rubble is found to be deeper than the 6-foot depth of the sheet piles in the PED geotechnical investigation, this would be a non-issue. Otherwise, the driveability of sheet piles should be evaluated during final design if sheet piles are proposed for either temporary dewatering or as a permanent cutoff below the floodwalls.

Space Availability and Utility Conflicts

Using the updated floodwall design, the team then considered whether there would be sufficient space for floodwall construction, given the limited space and potential utility conflicts along the left bank of the canal. As part of a separate task, CH2M assessed the existing and planned/future utilities within the construction limits for the proposed project. The utilities identified along the left bank of the canal and the approach to addressing those utilities as part of the proposed floodwall design are summarized below.

- Utilities running parallel to the canal within the existing sidewalk and greenspace include electrical distribution lines; power feeds and lines for lighting, street lights, and traffic signals; and water for irrigation. It is assumed that these would be protected in place or temporarily relocated during construction (and replaced within the existing sidewalk/greenspace corridor).
- Utilities running parallel to the canal within the Ala Wai Boulevard roadway include electrical and water distribution lines, as well as a 42-inch sewer force main and 72-inch sewer tunnel. It is assumed that the utilities located within the roadway can be avoided, but would need to be protected in place.
- Utilities running perpendicular to the canal include multiple storm drain pipes and culverts, as well as conduits for other utilities within the bridge alignments. It is assumed that these would need to be protected and incorporated into the floodwall design. In addition, the 42-inch sewer force main and a 72-inch sewer tunnel cross the canal in several locations, but in general, are expected to be deep enough such that the floodwall is not expected to directly conflict with this infrastructure (recognizing the need to consider loads imposed on the sewer lines and manhole access).

Based on these assumptions, the space availability for floodwall construction was assessed as follows. The required permanent width required for the floodwall is a maximum of approximately 11 feet, including the required setback and minimum wall foundation width. An additional 3 feet would be required for a temporary excavation slope, although this could be decreased through the use of vertical shoring. In general, the space available for the left floodwall on the Ala Wai Canal between the existing canal retaining wall and the edge of pavement alternates from approximately 17 feet (where there is parallel parking along Ala Wai Boulevard), to approximately 25 feet (where there is no parking). Based on a preliminary assessment of the available space and the average width needed for floodwall construction, there is approximately 6 feet of width remaining (in the narrow sections) for existing utilities running parallel to the canal between the existing canal retaining wall and Ala Wai Boulevard. It should be noted that the trees along Ala Wai Boulevard would most likely need to be removed to construct the wall, and with the limited space available for utilities, there may not be sufficient width for trees post-construction.

Field investigations to determine foundation conditions, along with a utilities survey during the PED phase will provide the information needed to verify the actual wall dimensions and utility locations. This information will be critical to confirm that the horizontal space for utilities along Ala Wai Boulevard is sufficient, and to mitigate and plan for any unanticipated encroachments. If it is determined that relocation of utilities cannot be accommodated within the available space, some of the utility relocations could be moved within the Ala Wai Boulevard roadway. A second option would be to modify the design concept for the floodwall to incorporate a deeper, narrower, foundation type (e.g. I-type wall, pilaster-supported wall panels, or narrow foundation supported by micro-piles or piers). Another option that would allow significantly more space for the existing utilities (and vegetation) on the left bank of Ala Wai Canal would be to reconstruct the existing left bank retaining wall, incorporating a cantilever wall stem above the canal bank retaining wall. This option would require a temporary cofferdam along the length of the project to allow construction in the dry. One benefit of this option would be that the failing portions of the existing wall would no longer be a concern.

It is understood that the USACE has identified a preliminary approach to transition the floodwall to the existing bridges; these transitions were not considered as part of this task. In any case, near the bridge approaches (particularly McCully Street bridge), the width of the corridor between Ala Wai Boulevard and the canal becomes very narrow. At McCully Street bridge, the space between the roadway and the canal is only as wide as the existing sidewalk. The proposed floodwall design shown on Sheet C-312A would not fit within these areas where the available corridor width diminishes near the bridges; instead, the floodwall design would need to incorporate a deep foundation in order to eliminate the footing. However, it is important to note that the addition of a floodwall setback from the existing retaining walls in these areas would displace the existing sidewalk. In these locations, it may be necessary to demolish the existing retaining walls and reconstruct a new combined retaining wall/floodwall. In addition to the space constraints described above, approximately 350 feet of the left bank on the downstream side of McCully Street bridge also extends over the water in the form of a deck that is supported on square concrete piles. As such, a floodwall structure with an embedded concrete foundation is not feasible at this location. It is understood that the USACE is currently planning for the floodwall to be supported using the existing piles/piers along this reach. Based on visual observation, there is concern that the existing piles/piers may not be adequate to support the proposed floodwall; a detailed analysis will be needed to verify this approach. Another concern is that flood water would pass directly beneath a pile-supported wall and create high uplift pressures on the existing deck or roadway. It is likely that a properly designed sheet pile wall that is embedded deep enough to withstand flood loading will be required in this area. These issues should be considered as part of the effort to design the transition of the floodwall to the bridges during the PED phase.

Issues related to storm drains and other utilities that intersect the alignment of the floodwall and either penetrate the key or encroach on the foundation were discussed in the preceding section. Where the utilities are below the concrete key, no change in the design may be necessary. Conceptual details of utility crossings that penetrate the concrete key are shown on Sheet C-312 (Attachment 4). For utilities that encroach on the floodwall's foundation base, additional details may be required; it is assumed that these will be developed in the PED phase, as necessary.

As also discussed previously, construction dewatering would be required at the utility crossing locations regardless of whether a concrete key or sheet pile cutoff is incorporated below the floodwall foundation. Multiple dewatering wells and/or well-points would likely be required because it would be difficult to install a positive groundwater cutoff at the crossing locations without leaving potential seepage windows.

In addition to the design and construction issues associated with the proposed floodwall design, it is also important to note specific conditions that require compliance in this area. In particular, the recently constructed Beachwalk Waste Water Pump Station (WWPS) resulted in the designation of the Waikiki Buffer Zone (Attachment 5). Any work within the Waikiki Buffer Zone would require mitigation and/or monitoring measures to avoid damage to the Beachwalk WWPS force mains caused by ground vibration or soil liquefaction. Additional information regarding the specific vibratory conditions that could result in impacts to the force mains (such as particle velocity and displacement magnitude), as well as a detailed geotechnical investigation is needed to clearly identify the construction risks due to vibrations or excavation within the buffer zone. However, at a minimum, it is expected that monitoring and mitigation (e.g., limits on the equipment and installation methods) will be required for project construction, particularly for any activities requiring installation of sheet piles.

SUMMARY AND CONCLUSIONS

In response to an IEPR comment on the 35% floodwall design presented in the Draft Feasibility Report/EIS, USACE tasked CH2M with updating the floodwall design pursuant to USACE design guidelines. The specific methodology, consistent with a 35% level of design, culminated from the professional judgement of CH2M staff, with discussion and input by USACE. The design update was based on information derived from site observations and photographs, the 1999 study of the Canal retaining walls, and relevant USACE engineering manuals (listed in the References section of this document). Recommendations for an updated design of the floodwall key are driven by space availability between the edge of the Ala Wai Boulevard roadway and the existing canal retaining walls, constructability issues, and perceived site conditions related to the groundwater. The following investigations and information gathering are recommended to validate the design of the floodwall and the applicable foundation, confirm site conditions, and support analyses necessary for development of the final floodwall and constructions details:

- Conduct a soil investigation to develop information regarding the foundation strength and permeability, as well as information necessary to analyze soil liquefaction and/or vibration within the Waikiki Buffer Zone.
- Conduct a detailed topographic survey (including utility identification) to further refine floodwall foundation design and utilities conflicts.
- Confirm setback criteria for floodwalls and available space based on detailed survey and geotechnical investigation.
- Perform finite element seepage analyses to verify the simplified uplift pressures used in accordance with the USACE design method.
- Perform detailed structural analysis or computations.

- Assess sheet pile penetration or driveability in cemented coral rubble.
- Develop details for utility encroachments.
- Develop details for transitioning the floodwalls into the existing bridges and incorporating the piles/piers adjacent to the McCully Street bridge.

REFERENCES

Geolabs Hawaii. 1999. Draft Evaluation of Seawalls. Ala Wai Canal Dredging Project, Honolulu, Oahu, Hawaii. August 2.

U.S. Army Corps of Engineers (USACE). 2015. Draft Integrated Feasibility Report and Environmental Impact Statement (EIS). Public Review Draft Report. August.

U.S. Army Corps of Engineers (USACE). 2014. Engineer and Construction Bulletin, No. 2014-24. Revision and Clarification of EM 1110-2-2100 and EM 1110-2-2502. 7 November.

U.S. Army Corps of Engineers (USACE). 2005. Engineering Manual 1110-2-2100. ENGINEERING AND DESIGN. Stability Analysis of Concrete Structures. 1 December.

U.S. Army Corps of Engineers (USACE). 1994. Engineering Manual 1110-2-1601. ENGINEERING AND DESIGN. Hydraulic Design of Flood Control Channels. 30 June.

U.S. Army Corps of Engineers (USACE). 1999. Engineering Manual 1110-2-1150. ENGINEERING AND DESIGN. Engineering and Design for Civil Works Projects. 31 August.

U.S. Army Corps of Engineers (USACE). 1989. Engineering Manual 1110-2-2502. ENGINEERING AND DESIGN. Retaining and Flood Walls. 29 September.

ATTACHMENTS

1 USACE 35% Design Drawings (Excerpts)

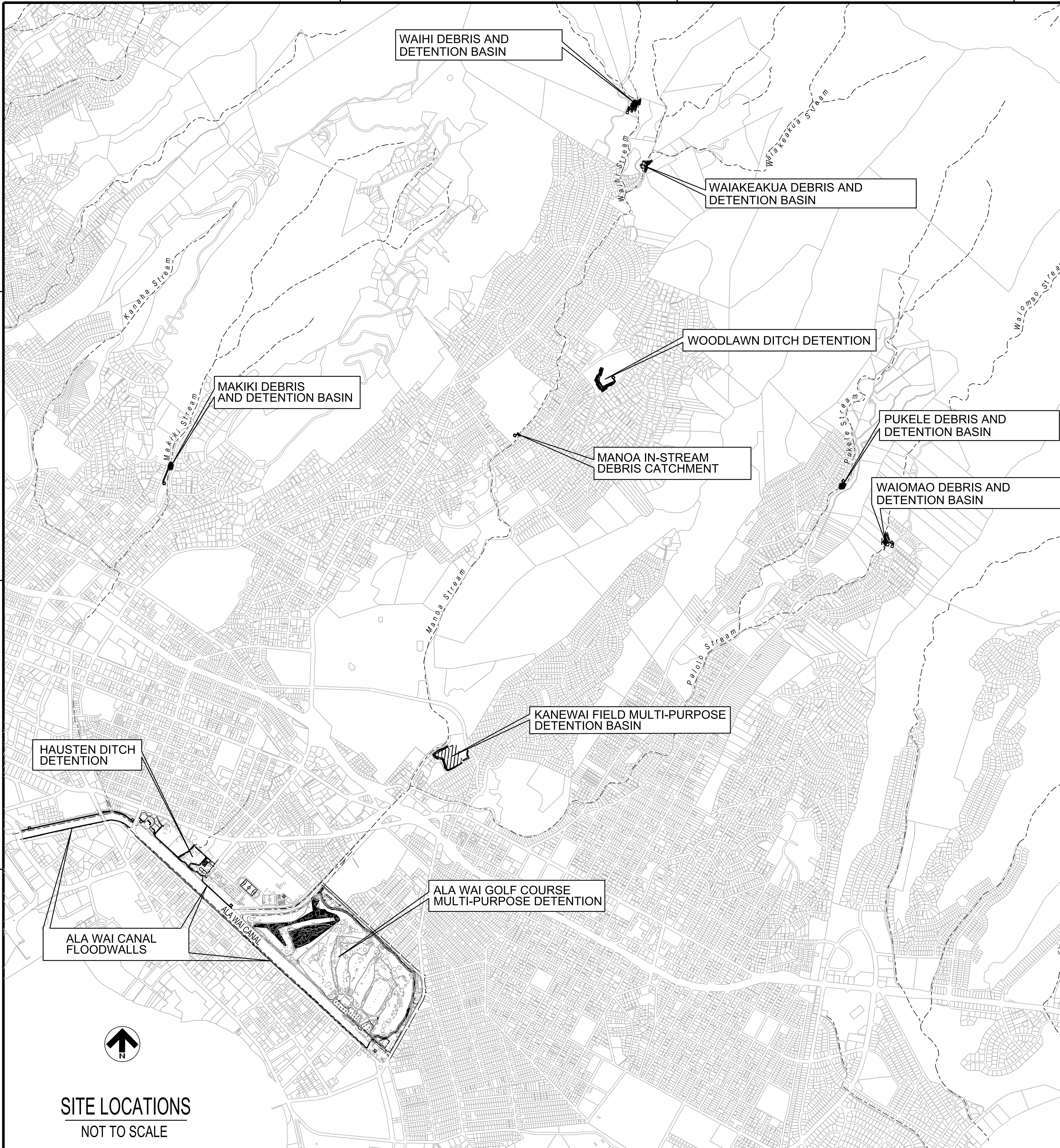
2 Independent External Peer Review Comment #4

3 Stability Evaluation of Proposed Ala Wai Canal Floodwalls

4 Details for Updated Ala Wai Canal Floodwalls

Attachment 1

USACE 35% Design Drawings
(Sheets C-101 through C-107, and C-309 through C-311)



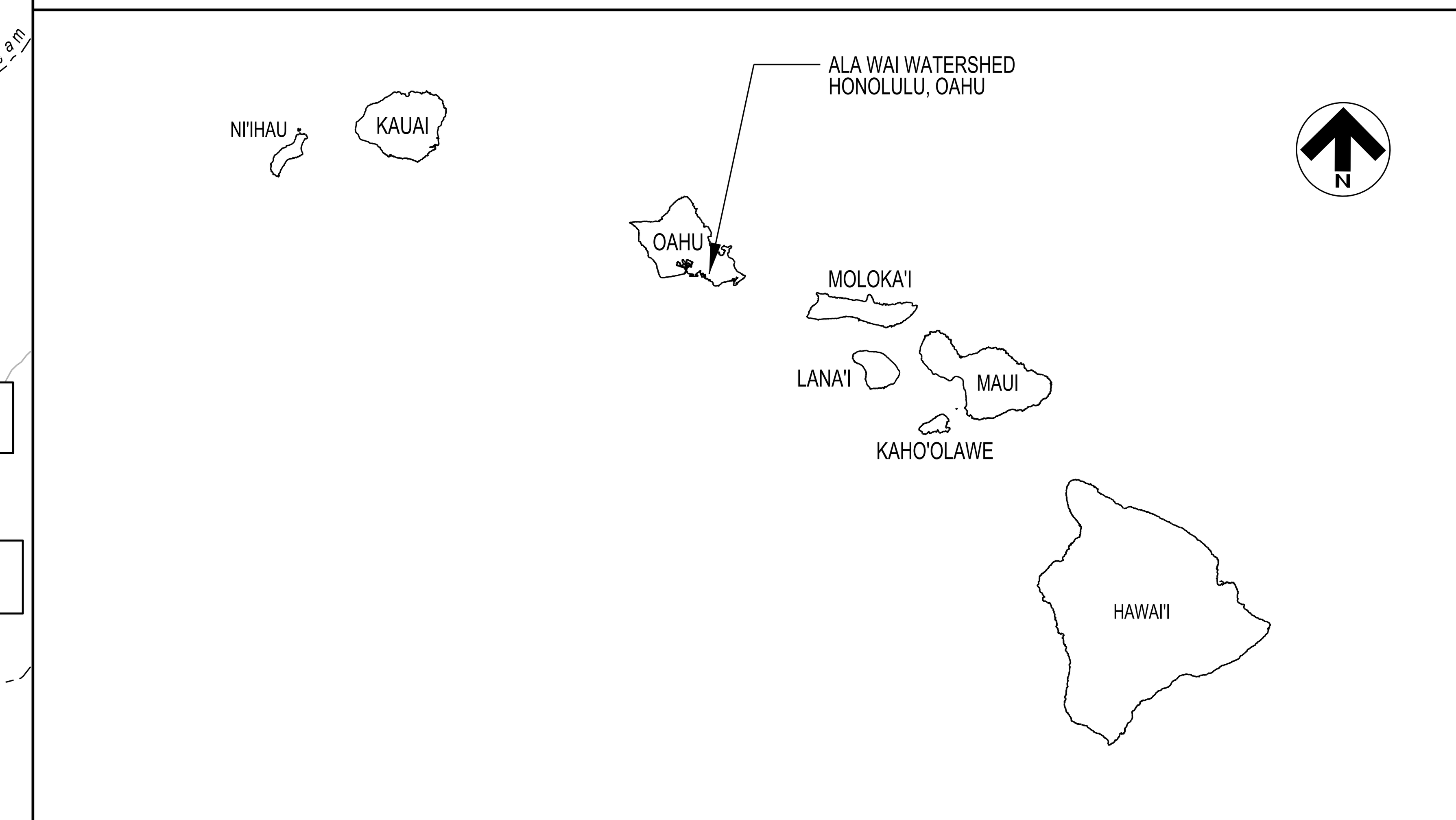
SITE LOCATIONS

NOT TO SCALE

ALA WAI WATERSHED PROJECT

HONOLULU, OAHU, HI

PROJECT TITLE



VICINITY MAP

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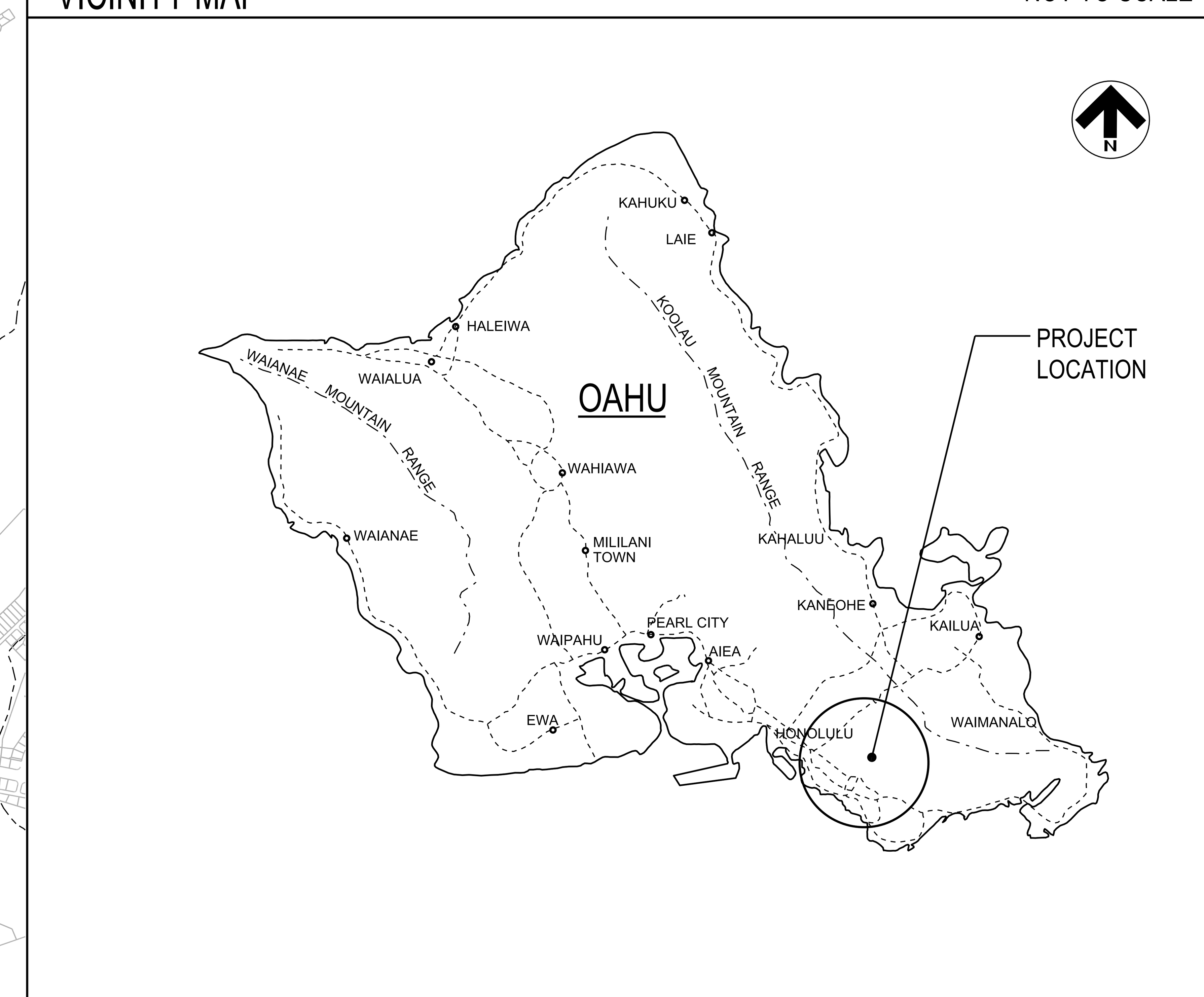

PROJECT LOCATION

NOT TO SCALE

US Army Corps
of Engineers®
Honolulu District

MARK	DESCRIPTION	DATE	APPR	MARK	DESCRIPTION	DATE	APPR

35% DESIGN

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DRAWN BY:	SUBMITTED BY:	LOCATION CODE	REVISION:
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US ARMY CORPS OF ENGINEERS
HONOLULU DISTRICT
HONOLULU, HAWAII

ALA WAI WATERSHED PROJECT

SITE LOCATIONS
PROJECT LOCATION & VICINITY MAP

SHEET
IDENTIFICATION
G-001
SHEET 1 OF 31

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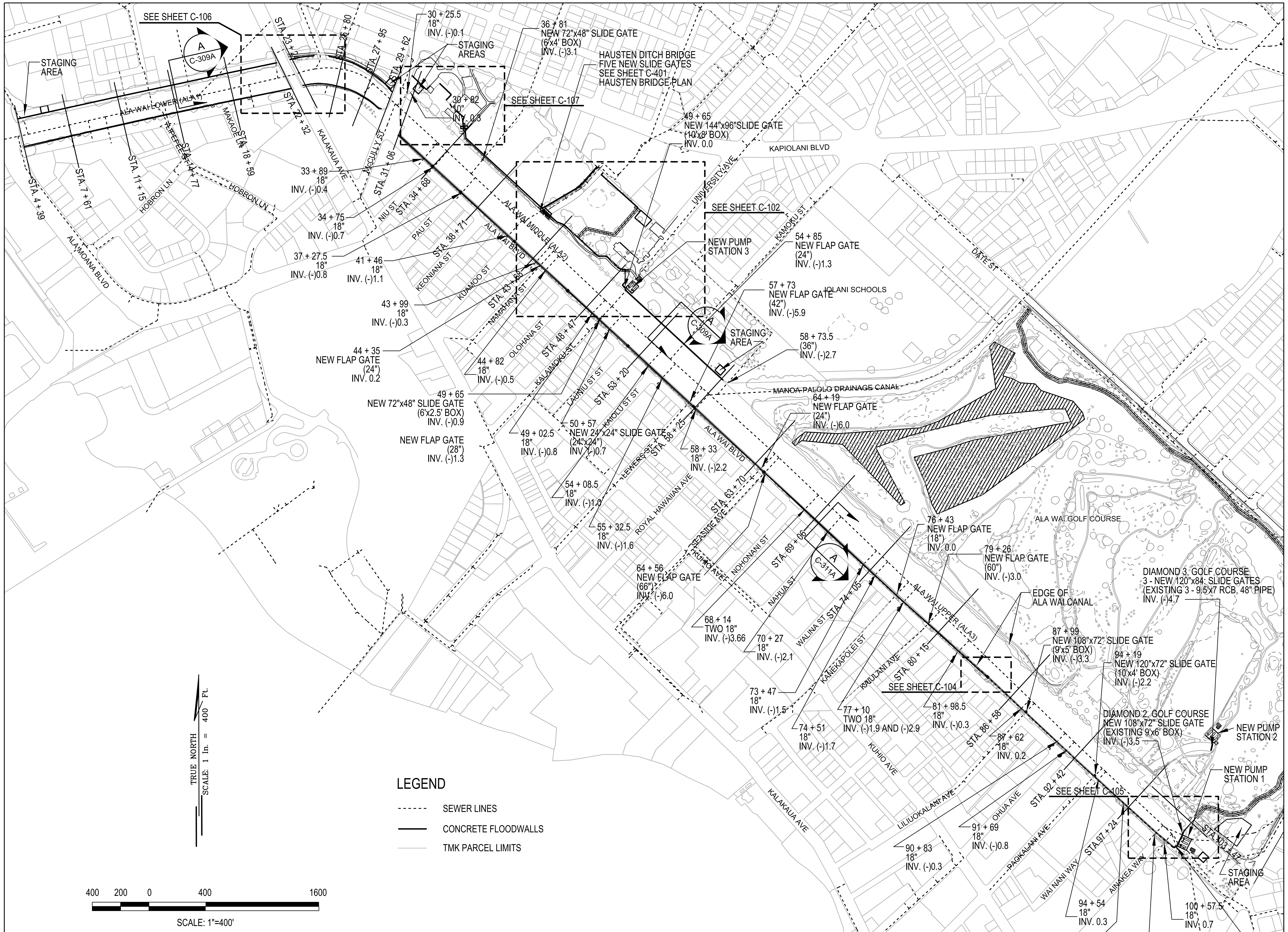

96 +80
18"
INV. (-)0.3

99 + 72.5
18"
INV. 0.6

DIAMOND 1, ALA WAI BLVD
NEW 144"x96" SLIDE GATES
(EXISTING 12'x7' BOX)
INV. (-)4.1

SITE PLAN
ALA WAI CANAL FLOODWALLS

ALA WAI CANAL INTERIOR DRAINAGE TABLE

CULVERT NAME	STATION	SIZE & TYPE	NOTES
DIAMOND 2, GOLF COURSE	102+45.5	108"x72" SLIDE GATE	PUMP STATION 1
DIAMOND 1, ALA WAI BLVD	101+75	144"x96" SLIDE GATES	
DIAMOND 3, GOLF COURSE	96+67	3 - 120"x84" SLIDE GATES	PUMP STATION 2
100+57.5	100+57.5	18" FLAP GATE	INV. 0.7
99+72.5	99+72.5	18" FLAP GATE	INV. 0.6
96+80	96+80	18" FLAP GATE	INV. (-)0.3
94+54	94+54	18" FLAP GATE	INV. 0.3
94+19	94+19	120"x72" SLIDE GATE	INV. (-)2.2
91+69	91+69	18" FLAP GATE	INV. (-)0.8
90+83	90+83	18" FLAP GATE	INV. (-)0.3
87+99	87+99	108"x72" SLIDE GATE	INV. (-)3.3
87+62	87+62	18" FLAP GATE	INV. 0.2
81+98.5	81+98.5	18" FLAP GATE	INV. (-)0.3
79+26	79+26	60" FLAP GATE	INV. (-)3.0
77+10	77+10	TWO 18" FLAP GATES	INV. (-)1.9 AND (-)2.9
76+43	76+43	18" FLAP GATE	INV. 0.0
74+51	74+51	18" FLAP GATE	INV. (-)1.7
73+47	73+47	18" FLAP GATE	INV. (-)1.5
70+27	70+27	18" FLAP GATE	INV. (-)2.1
68+14	68+14	TWO 18" FLAP GATES	INV. (-)3.7
64+56	64+56	66" FLAP GATE	INV. (-)6.0
64+19	64+19	24" FLAP GATE	INV. (-)6.0
58+73.5, RB	58+73.5	36" FLAP GATE	INV. (-)2.7
58+33	58+33	18" FLAP GATE	INV. (-)2.2
57+73	57+73	42" FLAP GATE	INV. (-)5.9
55+32.5	55+32.5	18" FLAP GATE	INV. (-)5.6
54+08.5	54+08.5	18" FLAP GATE	INV. (-)1.0
54+85, RB	54+85	24" FLAP GATE	INV. (-)1.3
50+57	50+57	24"x24" SLIDE GATE	INV. (-)0.7
49+65, RB	49+65	144"x96" SLIDE GATE	INV. 0.0, PUMP STATION 3
49+65	49+65	72"x48" SLIDE GATE & 28" FLAP GATE	INV. (-)1.3 & (-)0.9
49+02.5	49+02.5	18" FLAP GATE	INV. (-)0.8
44+82	44+82	18" FLAP GATE	INV. (-)0.5
44+35	44+35	24" FLAP GATE	INV. 0.2
43+99	43+99	18" FLAP GATE	INV. (-)0.3
HAUSTEN DITCH BRIDGE	42+10	4 - SLIDE GATES	SEE SHEET C-401
41+46	41+46	18" FLAP GATE	INV. (-)1.1
37+27.5	37+27.5	18" FLAP GATE	INV. (-)0.8
36+81, RB	36+81	72"x48" SLIDE GATE	INV. (-)3.1
34+75	34+75	18" FLAP GATE	INV. (-)0.7
33+89	33+89	18" FLAP GATE	INV. (-)0.4
30+82, RB	30+82	10" FLAP GATE	INV. 0.3
30+25.5, RB	30+25.5	18" FLAP GATE	INV. (-)0.1

NOTES:

1. SEE SHEET C-309 FOR THE RIGHT BANK (MOUNTAIN SIDE) PROFILE OF ALA WAI MIDDLE (ALA2) AND ALA WAI LOWER (ALA1).
2. SEE SHEET C-310 FOR THE LEFT BANK (OCEAN SIDE) PROFILE OF ALA WAI MIDDLE (ALA2) AND ALA WAI LOWER (ALA1).
3. SEE SHEET C-311 FOR THE LEFT BANK (OCEAN SIDE) PROFILE OF ALA WAI UPPER (ALA3).
4. SEE SHEET C-103 FOR ALA WAI GOLF COURSE MULTI-PURPOSE DETENTION PLAN.

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SUBMITTED BY: | LOCATION CODE
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SIZE: ANSI D | FILE NAME: Ala_Wai_C-101xxx.dgn

ALA WAI WATERSHED PROJECT
ALA WAI LOWER, MIDDLE & UPPER FLOODWALLS
SITE PLAN

SHEET IDENTIFICATION
C-101
SHEET 3 OF 31

FILE: \\POH-AP09FTS\ProjectWise_DCS_Share\2324\143718_12\Ala_Wai_C-101xxx.dgn
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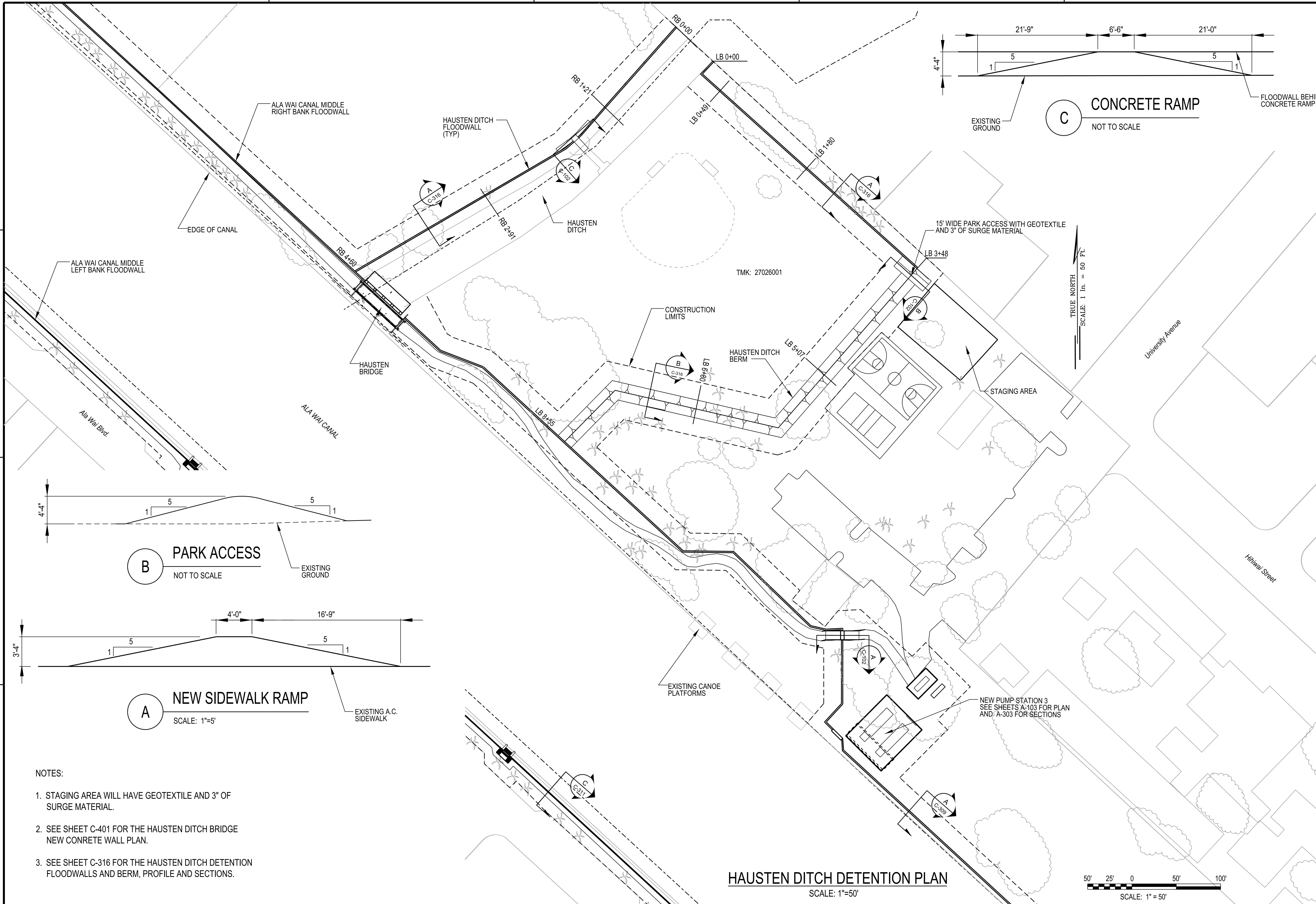

NOTES:

1. STAGING AREA WILL HAVE GEOTEXTILE AND 3" OF SURGE MATERIAL.
2. SEE SHEET C-401 FOR THE HAUSTEN DITCH BRIDGE NEW CONRETE WALL PLAN.
3. SEE SHEET C-316 FOR THE HAUSTEN DITCH DETENTION FLOODWALLS AND BERM, PROFILE AND SECTIONS.

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PLOT DATE: 10/9/2014
SIZE: ANSI D
FILE NAME: Ala_Wai_C-102xxx.dgn
DATE:
REVISION:
SOLICIT / CONTRACT NO.:
LOCATION CODE
DRAWING NUMBER:

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ALA WAI WATERSHED PROJECT

HAUSTEN DITCH DETENTION PLAN

SHEET IDENTIFICATION
C-102
SHEET 4 OF 31

FILE: \\POH-AP09FTS\ProjectWise_DCS_Share\2506\143718_1\Ala_Wai_C-102xxx.dgn
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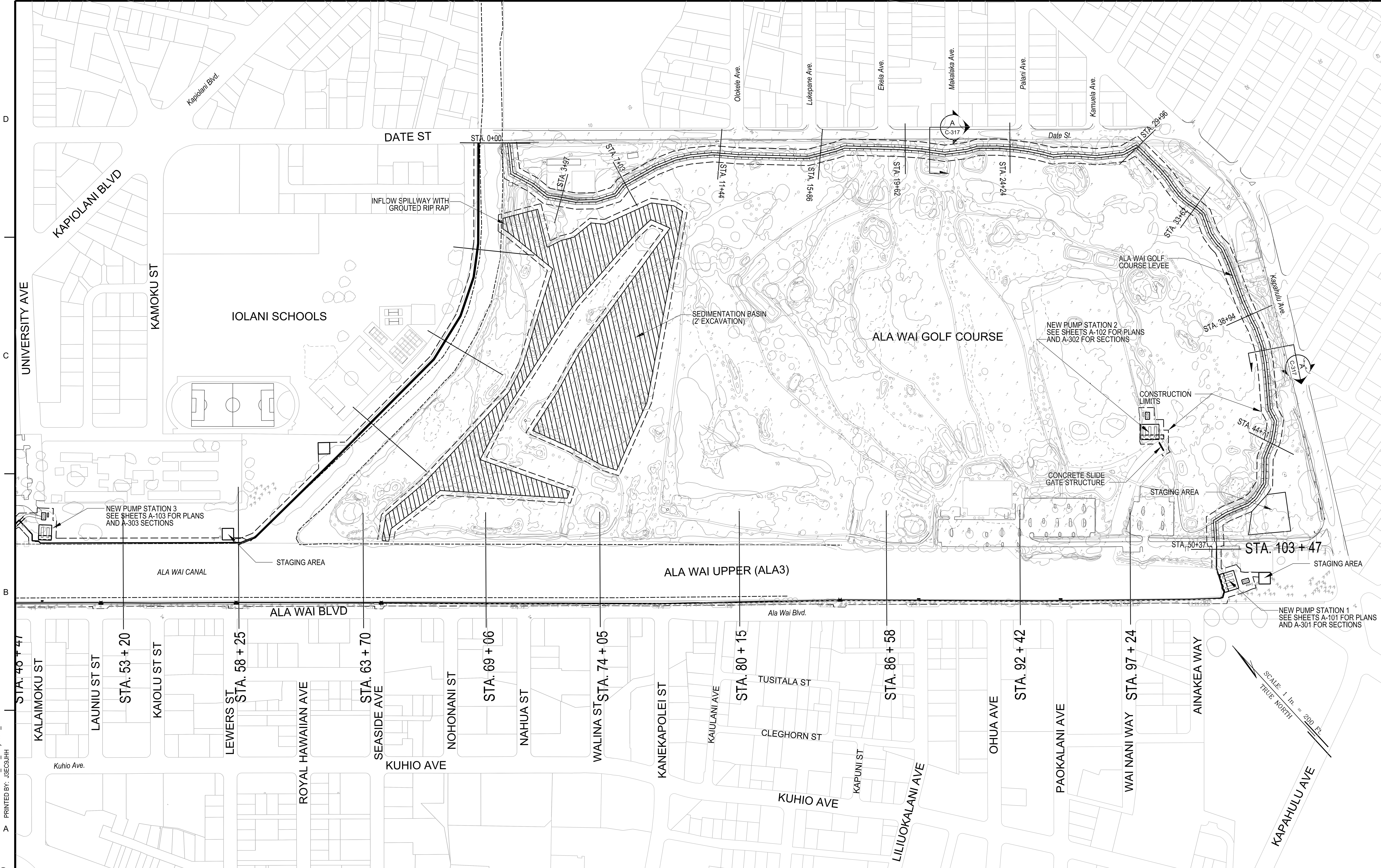

NOTES:

1. STAGING AREA WILL HAVE GEOTEXTILE AND 3" OF SURGE MATERIAL.
2. SEE SHEET C-317 FOR THE ALA WAI GOLF COURSE MULTI-PURPOSE DETENTION, PROFILE AND SECTION.

ALA WAI GOLF COURSE MULTI-PURPOSE DETENTION PLAN

SCALE: 1"=200'

200' 100' 0 200' 300'

SCALE: 1" = 200'

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SUBMITTED BY: | LOCATION CODE
PLOT SCALE: AS SHOWN | PLOT DATE: 10/14/2014 | DRAWING NUMBER:
SIZE: ANSI D | FILE NAME: ALA WAI GOLF COURSE MULTI-PURPOSE DETENTION

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ALA WAI WATERSHED PROJECT

ALA WAI GOLF COURSE MULTI-PURPOSE DETENTION
PLAN

SHEET IDENTIFICATION
C-103
SHEET 5 OF 31

FILE: c:\pw-work\poh-1\j3ec9jhh\d0143718\Ala_Wai_C-103xxx.dgn
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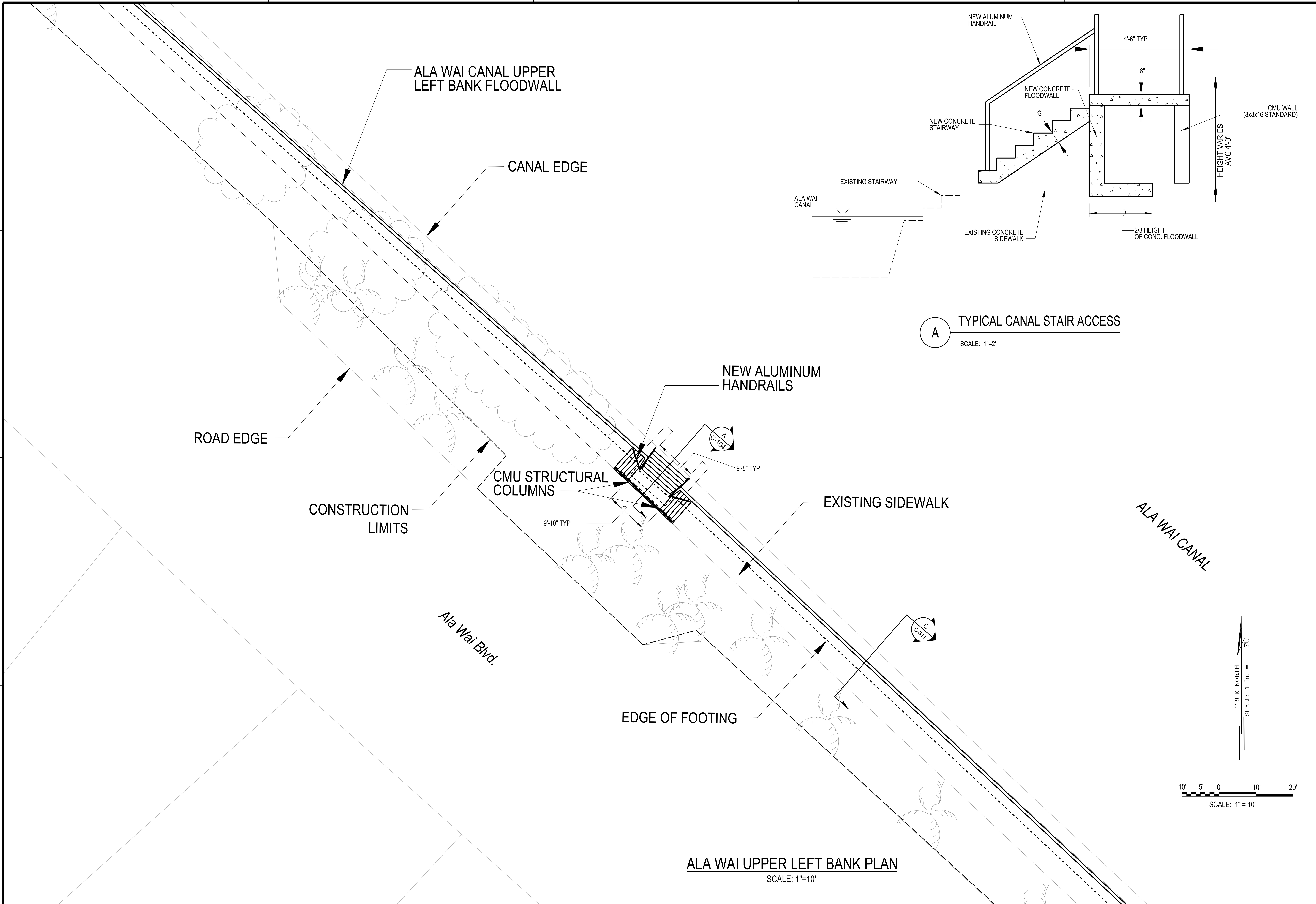

A TYPICAL CANAL STAIR ACCESS

SCALE: 1"=2'

ALA WAI UPPER LEFT BANK PLAN

SCALE: 1"=10'

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PLOT DATE: 10/9/2014
SIZE: ANSI D
FILE NAME: ALA WAI UPPER LEFT BANK PLAN
DATE:
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LOCATION CODE
DRAWING NUMBER:

ALA WAI WATERSHED PROJECT

ALA WAI UPPER LEFT BANK PLAN

SHEET IDENTIFICATION
C-104
SHEET 6 OF 31

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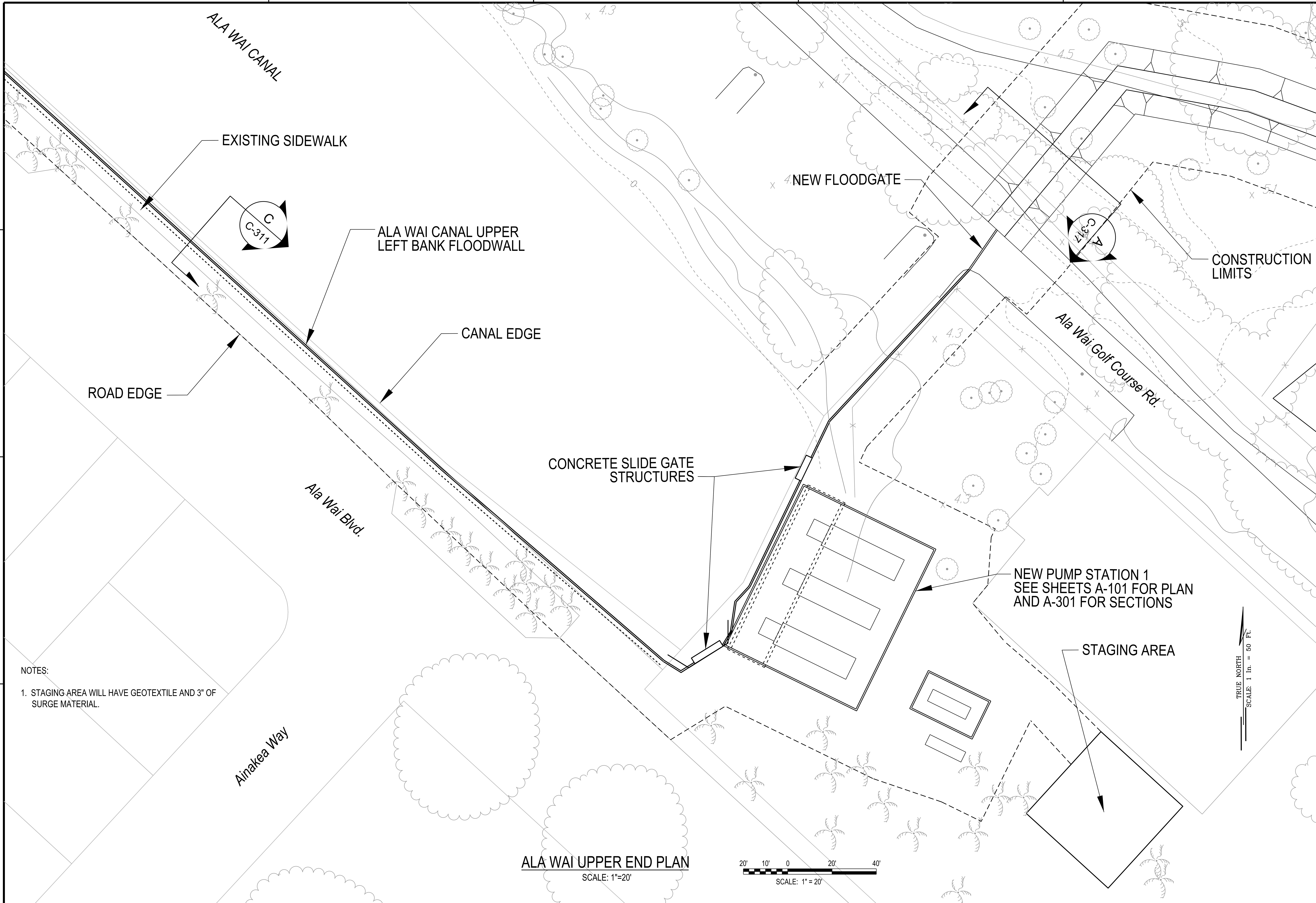
PRINTED BY: J3EC9JHH



NOTES:

1. STAGING AREA WILL HAVE GEOTEXTILE AND 3" OF SURGE MATERIAL.

ALA WAI UPPER END PLAN

SCALE: 1"=20'

FILE: \\POH-AP09FTS\ProjectWise_DCS_Share\2506\143718_19\Ala_Wai_C-105xxx.dgn
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PLOT DATE: 10/9/2014
SIZE: ANSI D
FILE NAME: Ala_Wai_C-105xxx.dgn
DATE:
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SOLICIT / CONTRACT NO.:
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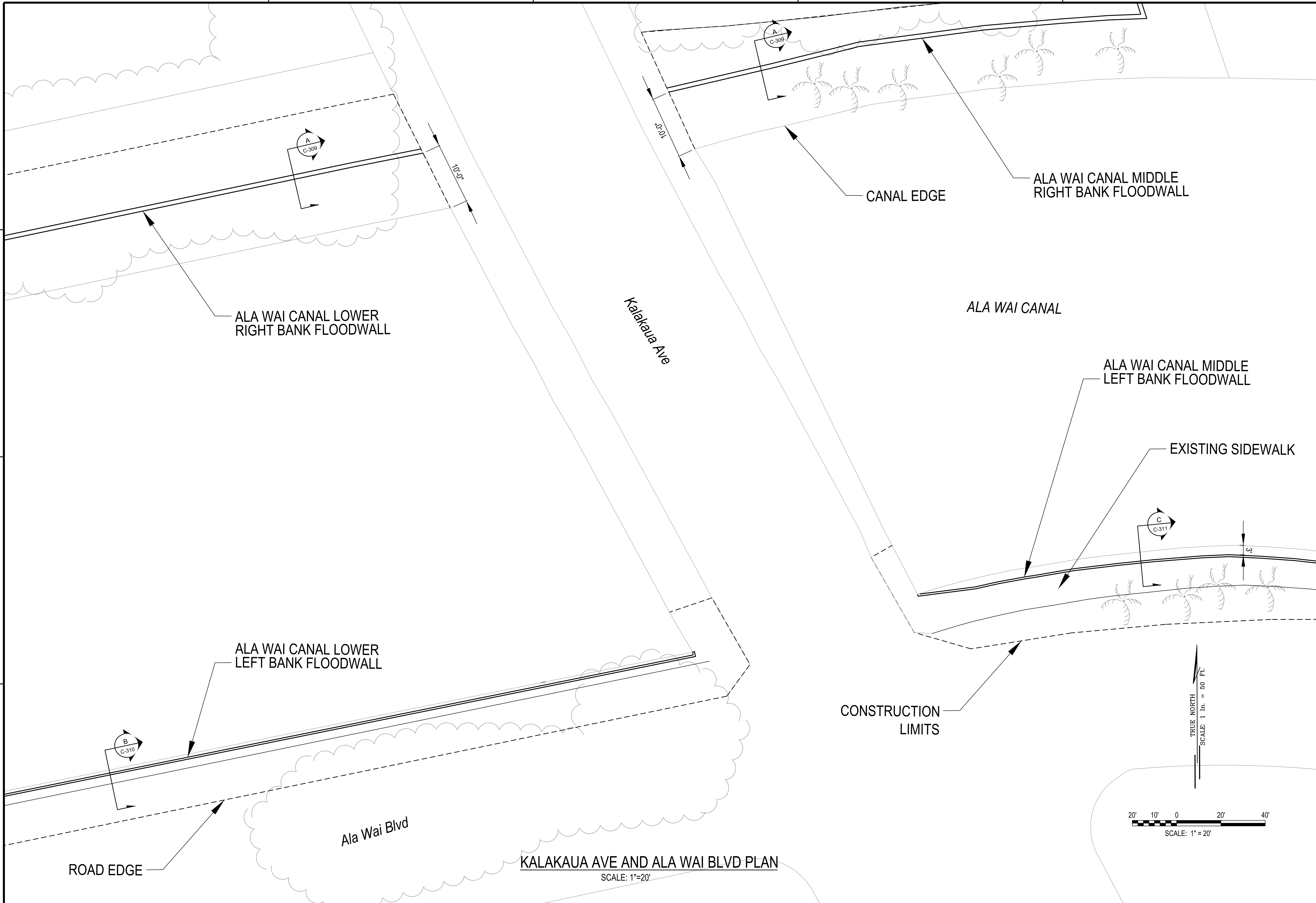
DRAWING NUMBER:

ALA WAI WATERSHED PROJECT

ALA WAI UPPER END PLAN

SHEET IDENTIFICATION
C-105
SHEET 7 OF 31



KALAKAUA AVE AND ALA WAI BLVD PLAN

SCALE: 1"=20'

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PLOT SCALE: AS SHOWN	PLOT DATE: 10/9/2014	DRAWING NUMBER:
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ALA WAI WATERSHED PROJECT

KALAKAUA AVE AND ALA WAI BLVD PLAN

SHEET IDENTIFICATION
C-106
SHEET 8 OF 31

FILE: \\POH-AP09FTS\ProjectWise_DCS_Share\2506\143718_20\Ala_Wai_C-106xxx.dgn
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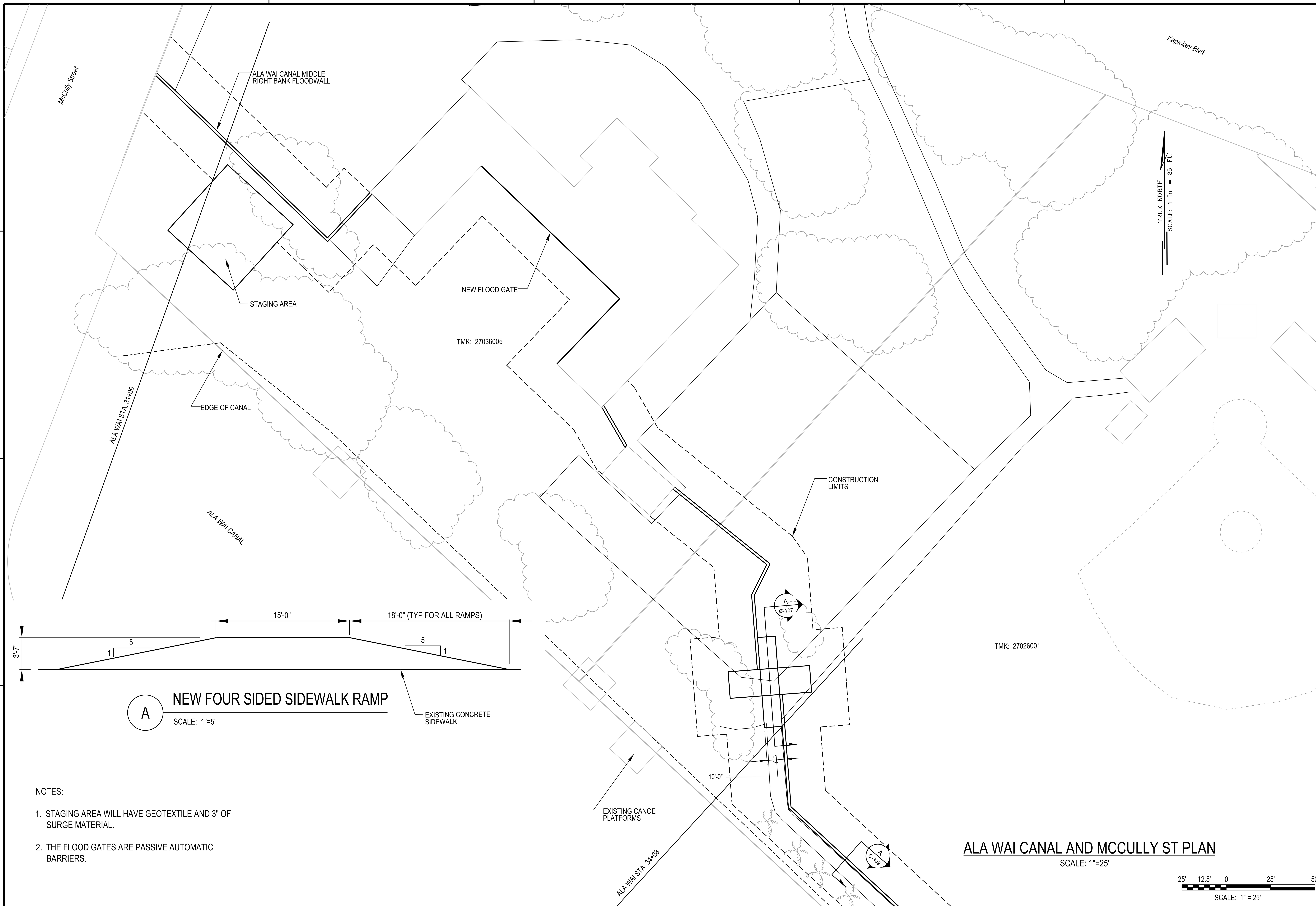

NOTES:

1. STAGING AREA WILL HAVE GEOTEXTILE AND 3" OF SURGE MATERIAL.
2. THE FLOOD GATES ARE PASSIVE AUTOMATIC BARRIERS.

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SIZE: ANSI D	FILE NAME: Ala_Wai_C-107xxx.dgn		

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ALA WAI WATERSHED PROJECT

ALA WAI CANAL AND MCCULLY ST PLAN

SHEET IDENTIFICATION
C-107
SHEET 9 OF 31

FILE: \\POH-AP09FTS\ProjectWise_DCS_Share\2506\143718_29\Ala_Wai_C-107xxx.dgn
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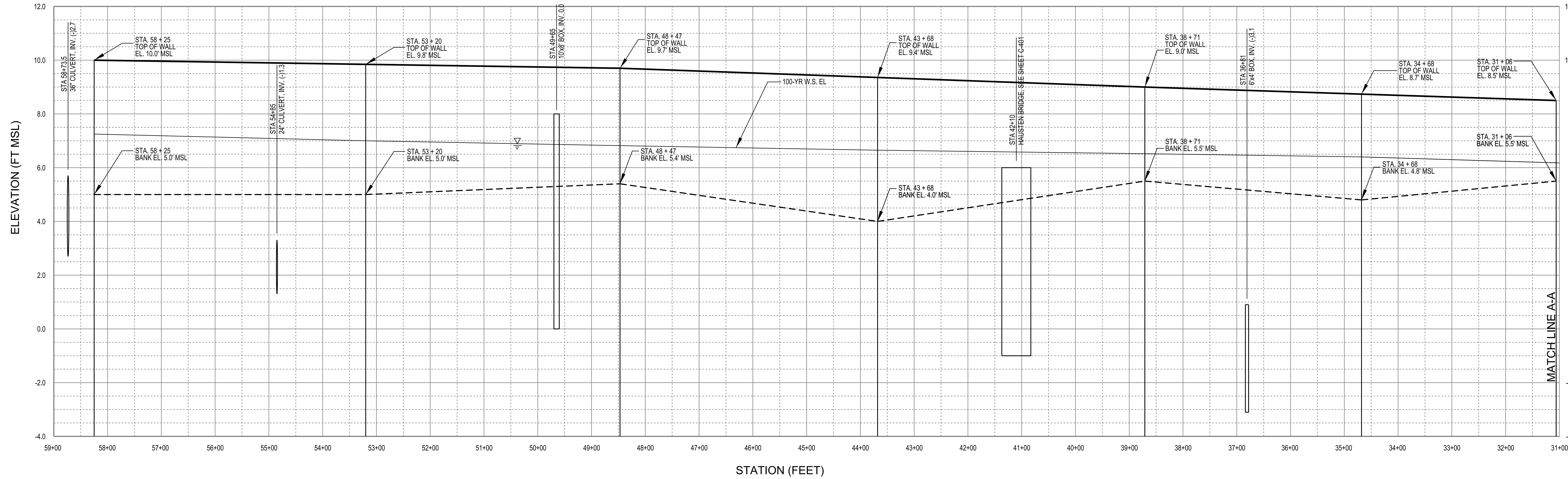
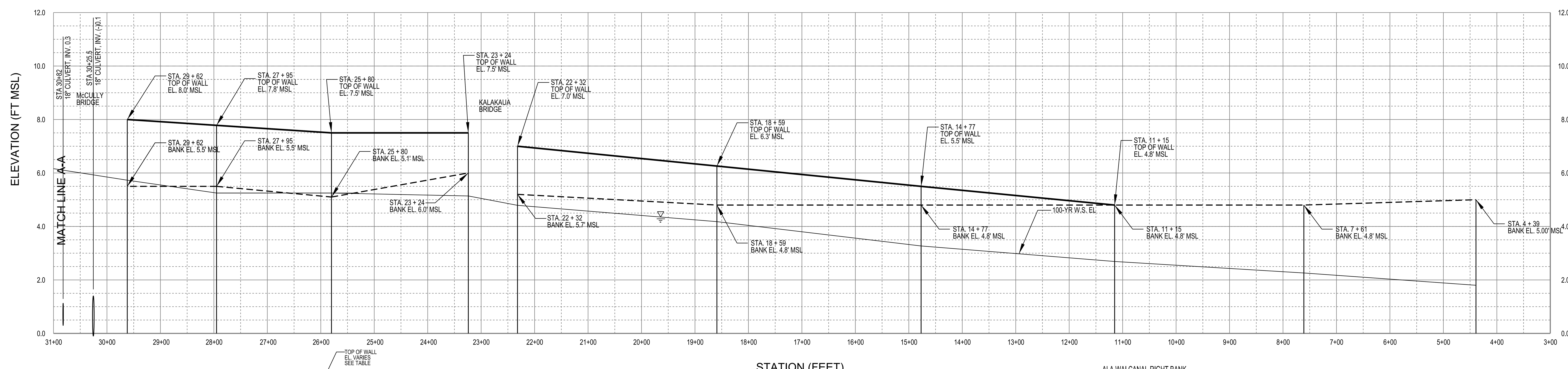
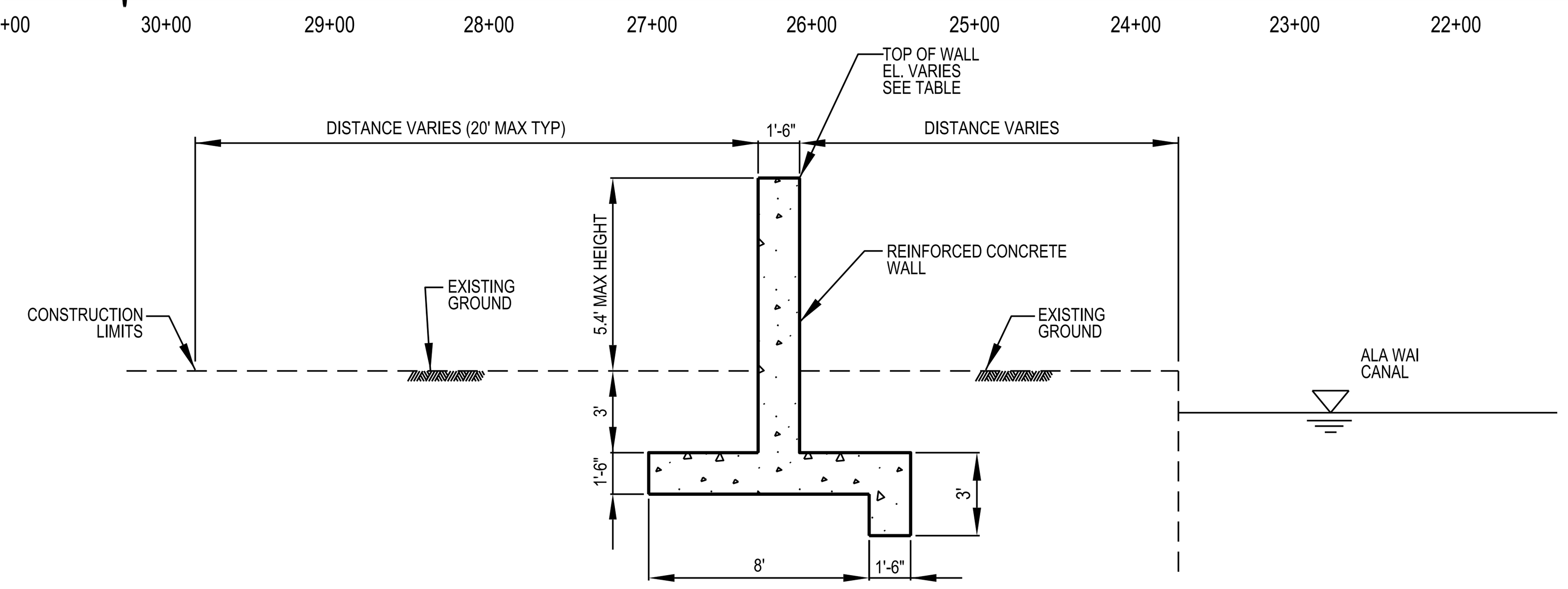




PROFILE
ALA WAI MIDDLE (ALA2) AND LOWER (ALA1) RIGHT BANK FLOODWALLS

SCALE:
HORIZONTAL: 1" = 100'
VERTICAL: 1" = 2'



A TYPICAL RIGHT BANK REINFORCED CONCRETE FLOODWALL SECTION
NOT TO SCALE

ALA WAI CANAL RIGHT BANK
STA 58 + 25 TO 25+80

STATION	WALL HEIGHT (FT)	FINISHED WALL ELEVATION (FT MSL)
58 + 25	5.0	10.0
53 + 20	4.8	9.8
48 + 47	4.3	9.7
43 + 68	5.4	9.4
38 + 71	3.5	9.0
34 + 68	3.9	8.7
31 + 06	3.0	8.5
MCCLULLY BRIDGE		
29 + 62	2.5	8.0
27 + 95	2.3	7.8
25 + 80	2.4	7.5

ALA WAI CANAL RIGHT BANK
STA 23 + 24 TO 11 + 15

STATION	WALL HEIGHT (FT)	FINISHED WALL ELEVATION (FT MSL)
23 + 24	1.5	7.5
22 + 32	1.3	7.0
18 + 59	1.5	6.3
14 + 77	0.7	5.5
11 + 15	0.0	4.8

FILE: \\POH-AP09FTS\ProjectWise_DCS_Share\2506\143718_18\Ala_Wai_C-309xxx.dgn
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DATE & TIME: 10/9/2014 3:16:45 PM
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PLOTDRIVER: C:\Program Files (x86)\Common Files\InterPlot\IPLOT\bin\iplotdrvm.plt
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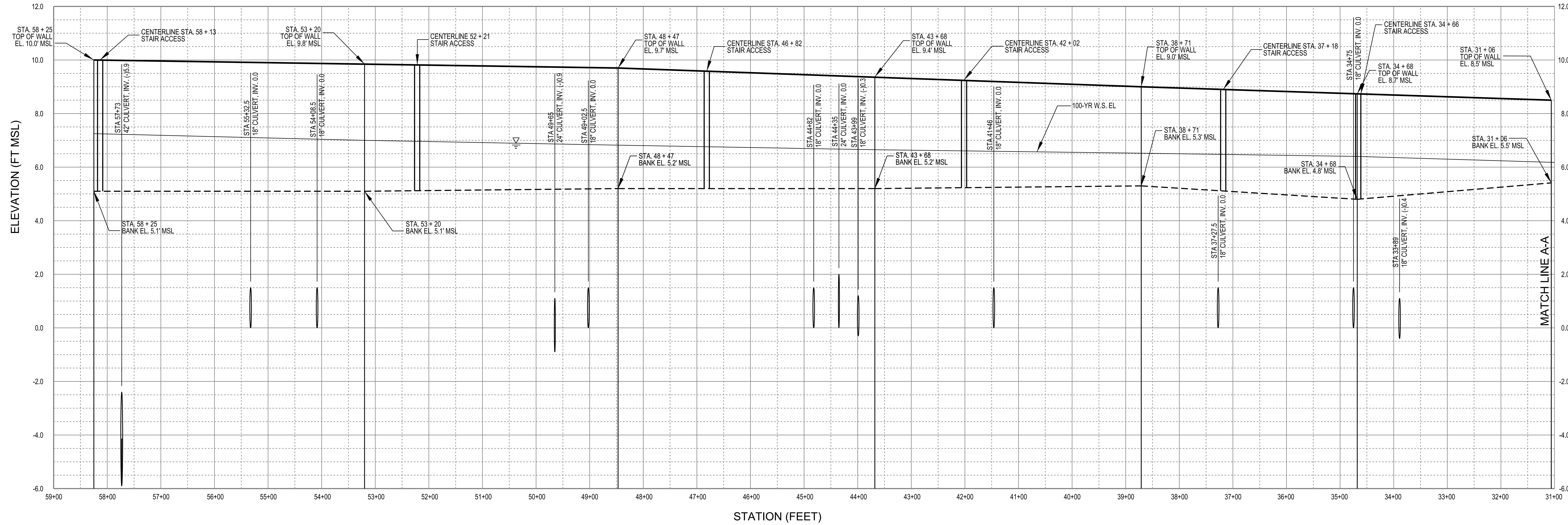
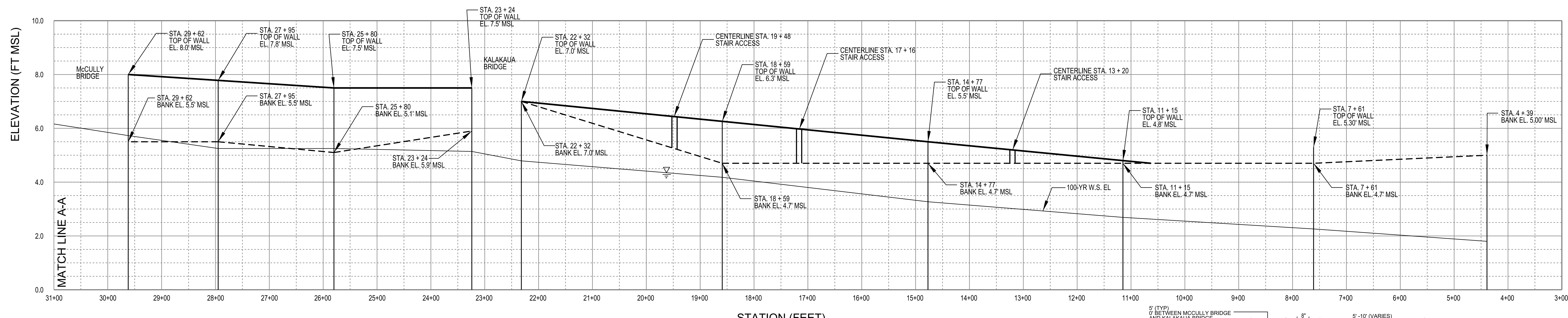
SIZE: ANSI D
FILE NAME: Ala_Wai_C-309xxx.dgn

ALA WAI WATERSHED PROJECT

ALA WAI MIDDLE & LOWER RIGHT BANK FLOODWALLS
PROFILE AND SECTION

SHEET IDENTIFICATION
C-309
SHEET 15 OF 31





ALA WAI CANAL LEFT BANK
STA TO 58 + 25 TO 25+80

STATION	WALL HEIGHT (FT)	FINISHED WALL ELEVATION (FT MSL)
58 + 25	4.9	10.0
53 + 20	4.7	9.8
48 + 47	4.5	9.7
43 + 68	4.2	9.4
38 + 71	3.7	9.0
34 + 68	3.9	8.7
31 + 06	3.0	8.5
MCCLULLY BRIDGE		
29 + 62	2.5	8.0
27 + 95	2.3	7.8
25 + 80	2.4	7.5

ALA WAI CANAL LEFT BANK
STA TO 23 + 24 TO 4 + 39

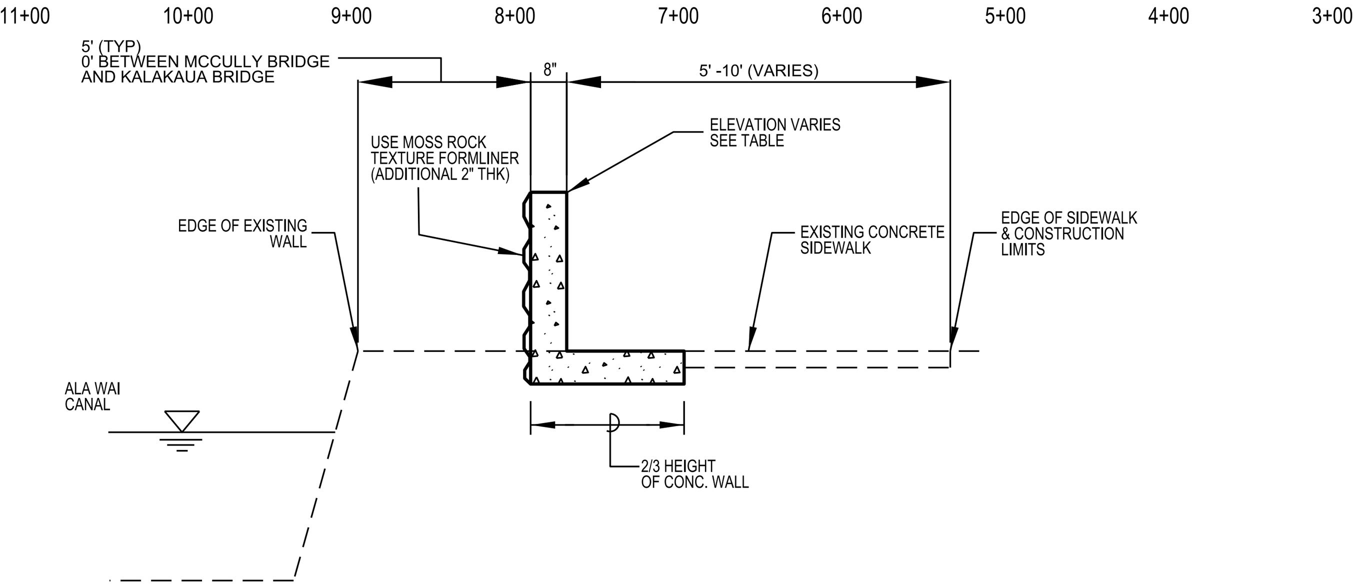
STATION	WALL HEIGHT (FT)	FINISHED WALL ELEVATION (FT MSL)
23 + 24	1.6	7.5
KALAKAUA BRIDGE		
22 + 32	0.0	7.0
18 + 59	1.6	6.3
14 + 77	0.8	5.5
11 + 15	0.1	4.8

PROFILE
ALA WAI CANAL MIDDLE (ALA2) AND LOWER (ALA1) LEFT BANK FLOODWALLS

SCALE:
HORIZONTAL: 1" = 100'
VERTICAL: 1" = 2'

NOTES:

1. SEE DETAIL "C" ON SHEET C-311 FOR ALA WAI CANAL MIDDLE (ALA2) TYPICAL LEFT BANK CONCRETE FLOODWALL SECTION.
2. ALA WAI CANAL LOWER (ALA1) IS FROM STATION 23+24 TO STATION 4+39.



B TYPICAL ALA WAI LOWER (ALA1) LEFT BANK CONCRETE FLOODWALL SECTION

NOT TO SCALE

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SIZE: ANSI D | FILE NAME: Ala_Wai_C-310xxx.dgn

ALA WAI WATERSHED PROJECT

ALA WAI MIDDLE & LOWER LEFT BANK FLOODWALLS
PROFILE AND SECTION

SHEET IDENTIFICATION
C-310
SHEET 16 OF 31

FILE: \\POH-AP09FTS\ProjectWise_DCS_Share\2506\143718_22\Ala_Wai_C-310xxx.dgn
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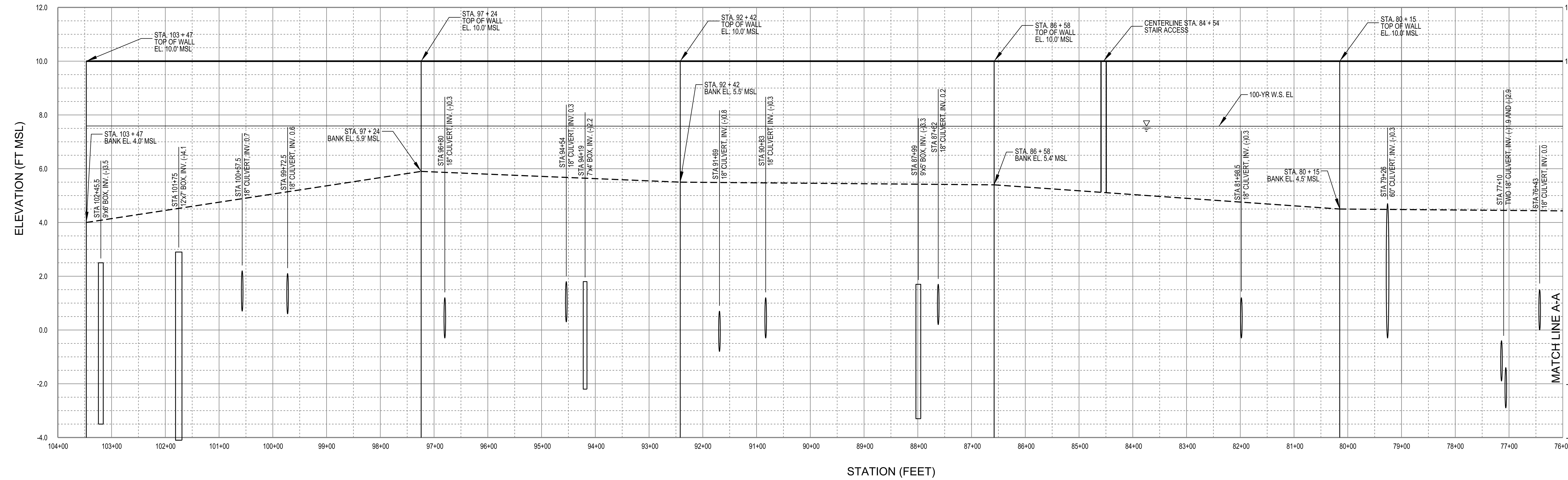

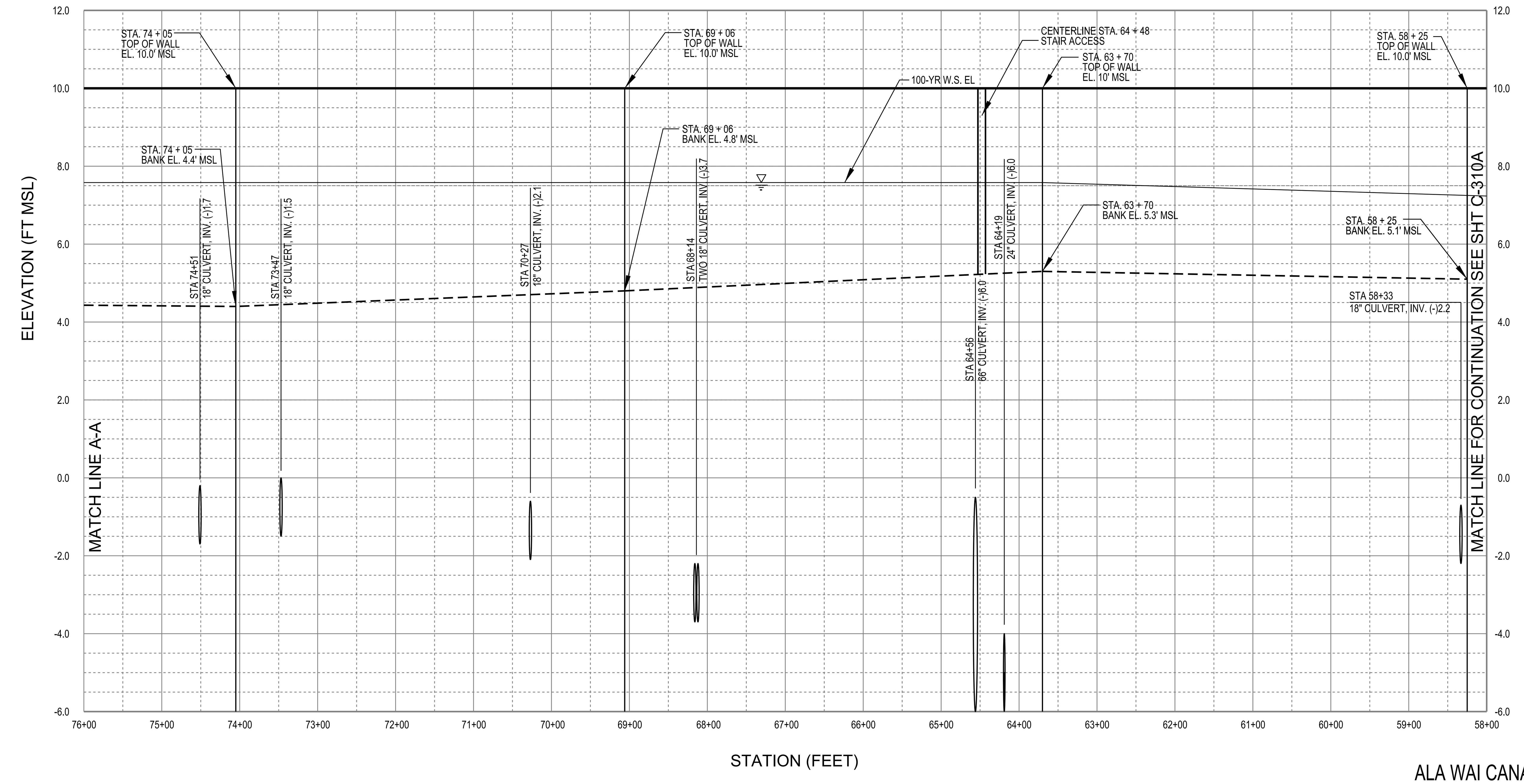

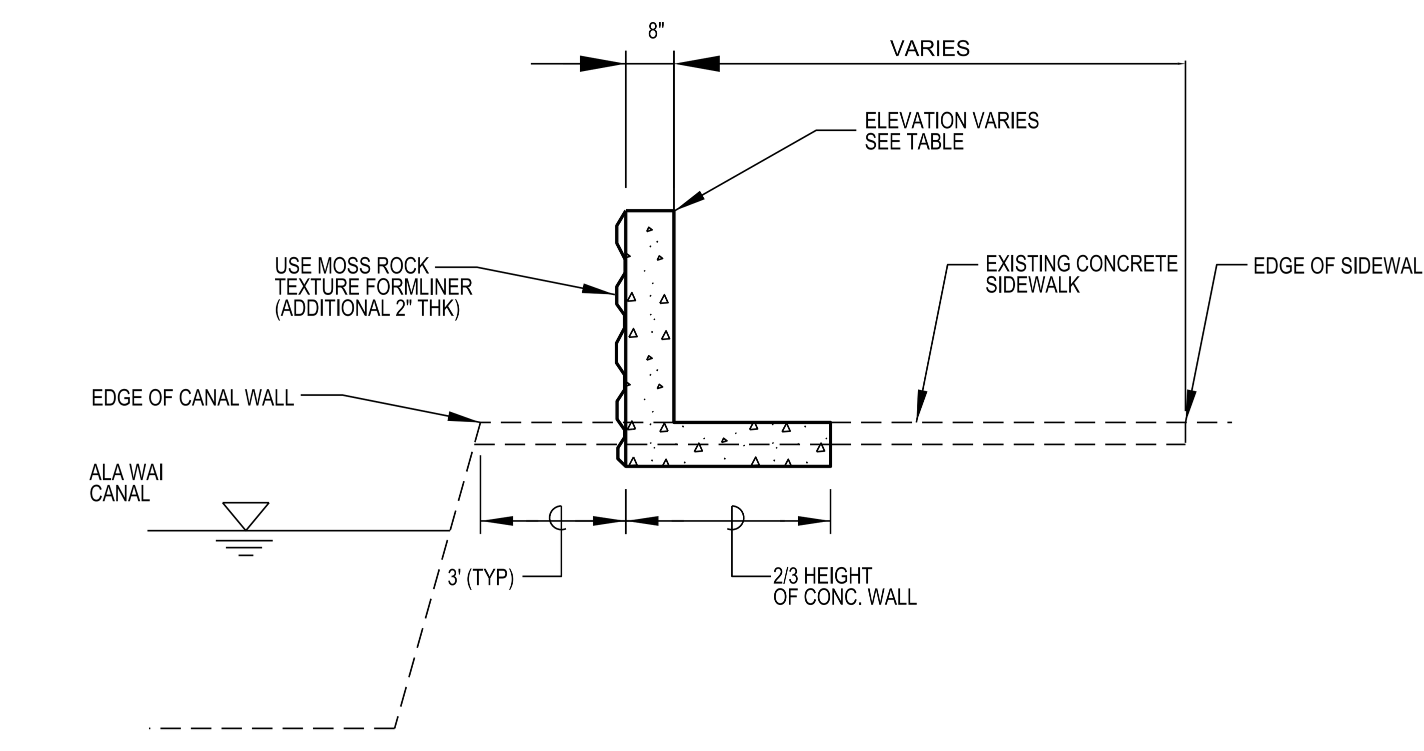

C TYPICAL LEFT BANK CONCRETE FLOODWALL SECTION

NOT TO SCALE

ALA WAI CANAL LEFT BANK
STA 101 + 24 TO 58 + 25

STATION	WALL HEIGHT (FT)	FINISHED WALL ELEVATION (FT MSL)
103 + 47	6.0	10.0
97 +24	4.1	10.0
92 + 42	4.5	10.0
86 + 58	4.6	10.0
80 + 15	5.5	10.0
74 + 05	5.6	10.0
69 + 06	5.2	10.0
63 + 70	4.7	10.0
58 + 25	4.9	10.0

PROFILE
ALA WAI CANAL UPPER (ALA3) LEFT BANK FLOODWALLS

SCALE:
HORIZONTAL: 1" = 100'
VERTICAL: 1" = 2'

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FILE NAME: Ala_Wai_C-311xxx.dgn
SIZE: ANSI D

ALA WAI WATERSHED PROJECT

ALA WAI UPPER LEFT BANK FLOODWALLS
PROFILE AND SECTION

SHEET IDENTIFICATION
C-311
SHEET 17 OF 31

FILE: \\POH-AP09FTS\ProjectWise_DCS_Share\2506\143718_14\Ala_Wai_C-311xxx.dgn
MODEL NAME: C-311A
DATE & TIME: 10/9/2014 3:14:08 PM
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PLOTDRIVER: C:\Program Files (x86)\Common Files\InterPlot\IPLOT\bin\iplotdrvm.plt
PEN TABLE: GrayScale_TLW_Pen.tbl
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Attachment 2

Independent External Peer Review Comment #4

Final Panel Comment 4

Site conditions for the Ala Wai Canal left bank floodwall may not have sufficient space to design an adequate factor of safety against sliding and overturning.

Basis for Comment

Ala Wai Canal FS/EIS Draft Report Appendix A2, Plate 11, TSP 35% Design sheets C-103, C-309 and C-316 indicate construction of “inverted T” shaped floodwalls for Hausten Ditch Detention Basin and the right bank (mountain side) Ala Wai Canal with foundations 3 feet below grade and 9.5 feet wide, with a key to resist sliding an additional 3 feet deep. Report Appendix A2, Plate 11, TSP 35% Design sheets C-310 and C-311 indicate construction of “L” shaped floodwalls for the left bank (ocean side) of the Ala Wai Canal with no foundation heel, no key, and the toe foundation 1 foot below grade.

The report does not include specific geotechnical data or floodwall design calculations. The Panel expects that geotechnical data and design loading for floodwalls on both sides of the canal would be similar; thus, the floodwall foundations would also be similar. However, as indicated above, the foundations are very dissimilar.

USACE Engineer Manual (EM) 110-2-2502 Retaining and Flood Walls does not provide guidance for the use of “L” shaped floodwalls, though the same general design process for “inverted T” shaped walls can be applied to “L” shaped walls. While EM 110-2-2502 addresses only specific design methodologies, conservative rule-of-thumb professional judgment would begin with a floodwall foundation width equal to wall height, with the foundation heel equal to approximately 2/3 the foundation width and the foundation toe equal to approximately 1/3 the foundation width (Federal Emergency Management Agency [FEMA] Engineering Principles and Practice Chapter 5F). The “L” shaped left bank floodwall includes a foundation equal to only 2/3 the wall height, with all foundation in the toe and no foundation heel. Therefore, the Panel is concerned that the “L” shaped left bank floodwall foundations may not have sufficient factor of safety to resist sliding and overturning.

Ordinarily, this matter would be corrected during the Preconstruction Engineering & Design (PED) phase and increased incremental cost would be covered by the project contingency. However, the left bank site conditions may not provide adequate available space for construction of either the floodwall design indicated in Detail C of Sheet C-311 or any other cantilever design resulting from a re-evaluation of foundation conditions. The already narrow available left bank work area is complicated by existing, possibly historic, canal wall stone work, existing utilities (street lighting and hydrants observed on Google Earth) and trees (indicated on plan drawings and artist renderings), and proximity of heavy vehicular and pedestrian traffic. If a left bank flood wall foundation designed with an adequate factor of safety against sliding and overturning cannot be constructed within the available site without impacts to site constraints, then a significant change in the TSP 35% design may be required. This change may be so major as to change the design concept and cause more environmental impacts to existing canal stone walls, utilities and trees, and traffic. Furthermore, the design is not aligned with the currently assessed level of risk assigned at this stage in the SMART Planning process.

Significance – Medium

Final Panel Comment 4

A significant design change may be required during PED to construct the floodwalls, which is not aligned with the currently assessed level of risk assigned at this stage in the SMART Planning process.

Recommendation for Resolution

1. Validate foundation design assumptions used for both left and right bank floodwalls.
2. Correlate left and right bank designs and adjust foundation dimensions accordingly.
3. Ensure that the dimension of correlated and adjusted left bank floodwall foundations allow sufficient construction space within existing left bank physical project constraints.
4. Revise the project constraints and impacts stated in the report if sufficient construction space within existing project constraints is not available, or consider revising design concepts away from a cantilever wall.

PDT Final Evaluator Response (FPC#4):

Non-Concur. The Team will re-visit the floodwall typical shown on the drawings during the Design Phase of the study. As presented on the drawings, the wall sizes are variable and will depend on the final height and location for the thickness and wall footing requirements. Risk-informed contingency estimates are intended to address cost uncertainties with the Feasibility-level design. The cost estimates that were used for the various floodwall heights in the optimization analysis assumed contingency costs to address uncertainties related to the height and footing requirements. The contingency would cover the utility site constraints you have mentioned. Thus, no significant changes in cost would occur with the more refined detail recommended. You are correct in that these details would be determined during the Preconstruction Engineering & Design (PED) phase as this was the Team's plan. There is a low risk that the left bank floodwall foundation designed with an adequate factor of safety against sliding and overturning cannot be constructed within the available site constraints. It was included in the construction cost estimate that trees will be removed, existing sidewalk will be reconstructed, and light pole utilities will be realigned. More than likely the footing will be merged with the new sidewalk in some fashion to provide resiliency in case of overtopping.

Recommendation #1: Not adopt

Explanation: The team further develop the typical sections and provide new typical sections on the drawings during the Design Phase of the study.

Recommendation #2: Not adopt

Explanation: Correlation between the left and right bank floodwalls and development of new typical sections on the drawings will occur during the Design Phase of the study.

Recommendation #3: Adopt

Explanation: The team will re-look at the space constraints of the left bank floodwall. It is not expected that these constraints will prohibit the floodwall construction.

Recommendation #4: Adopt

Final Panel Comment 4

Explanation: The team will revise if needed based on the concerns expressed in this comment.

Panel Final BackCheck Response (FPC#4):

Non-concur. The Panel agrees that floodwall designs will be refined during PED. However, the Panel remains concerned that a cantilever floodwall will not fit into the available left bank footprint. If this lack of space bears out, then this matter becomes not one of design refinement that is captured in the cost and schedule contingency, but of needing a new floodwall concept.

The PDT response to Recommendation #3 to ‘re-look at the space constraints of the left bank floodwall’ is not in accordance with the actual recommendations that were to revisit those space constraints only after correlating the footing dimensions of the right and left bank typical floodwalls. The Panel is concerned that in re-looking at left bank space constraints without first correlating left and right bank design gross foundation dimensions could lead to checking the space constraints for the wrong sized foundation. The differences as shown in the 35% drawing for these two designs are significant enough (9.5 foot footing vs. 3.5 foot footings) to potentially overwhelm the allowed contingency. The potential historic nature of the existing Ala Wai Canal stonework should also be considered as a left bank floodwall space constraint.

Attachment 3

Stability Evaluation of Proposed Ala Wai Canal Floodwalls

Stability Evaluation of Proposed Ala Wai Canal Floodwalls

PREPARED FOR:	File
COPY TO:	Jaco Esterhuizen/CVO
PREPARED BY:	Mark Twede/RDD
DATE:	May 24, 2016
PROJECT NUMBER:	461555.06.02.01

1.0 Purpose and Background

The purpose of this technical memorandum is to summarize stability analyses of proposed floodwalls along the Ala Wai Canal in Honolulu, Hawaii. The preliminary floodwalls were designed by the U.S. Army Corps of Engineers (USACE) to a designated 35 percent design level. The design is presented on drawings dated October 9, 2014; these include the proposed concrete shape and dimensions for the floodwalls.

To assist with addressing a comment received from the Independent External Peer Review (IEPR), USACE contracted CH2M HILL (CH2M) to conduct the following tasks:

- Validate foundation design assumptions used for both left and right bank floodwalls. The left and Right banks are referenced looking downstream.
- Correlate left and right bank designs and adjust foundation dimensions accordingly.
- Ensure that the dimensions of correlated and adjusted left bank floodwall foundations allow sufficient construction space, given the existing left bank space constraints.

This technical memo documents the methodology, design criteria, and results of the stability analysis conducted in support of these tasks.

2.0 Description of Proposed Floodwalls

Reinforced-concrete cantilevered floodwalls are proposed for both the left and right flood defenses along the Ala Wai Canal. The left wall extends from the head of the canal near Kapahulu Avenue to near the ocean outflow at the Ala Moana Boulevard bridge crossing. The right wall begins at the confluence of the Manoa Palolo Drainage Canal and the Ala Wai Canal, and ends near the bridge crossing at Ala Moana Boulevard. The floodwalls are tallest at the upstream end, and decrease in height moving downstream to a height of zero near the Ala Moana Boulevard bridge crossing. Table 1 summarizes the proposed wall height above existing grade and the associated freeboard above the 100-year flood for various reaches of the floodwall.

TABLE 1
Floodwall Height and Freeboard

Station	Left Bank Floodwall Height Above Existing Grade (feet)	Freeboard Above 100-year Flood (feet)	Right Bank Floodwall Height Above Existing Grade (feet)	Freeboard Above 100-year Flood (feet)
10+50 (downstream end)	0	2	0	2
18+59	1.6	2	1.5	2
23+24 (Kalakaua Bridge)	1.6	2.3	1.8	2.2
31+06 (McCully Bridge)	3	2.3	3	2.3
43+68	4.2	2.7	5.4 (maximum)	2.5
58+25 (end right wall)	4.9	2.8	5	2.8
74+05	5.6	2.4		
101+75 (left wall corner)	5.5	2.4		
103+47 (end left wall)	6.0 (maximum)	2.4		

Gravity retaining walls of various shapes and sizes were previously constructed along most of the canal. The floodwalls will be set back from the existing structures to prevent loading on the existing retaining walls. Numerous pipe and culverts cross the proposed floodwall alignment; crossings will require structural details for the floodwalls to bridge over the existing pipes or culverts.

Penetrations (conduits) through floodwall foundations represent a risk of uncontrolled seepage, internal erosion, and piping. Defects or joints in the conduits can facilitate seepage into the conduit, transporting soil particles with the leakage. Even if the conduit is intact, water may flow along the contact between the conduit and surrounding soil and erode this soil. Where the soil is highly erodible, such as is the case for low-plasticity silt and fine sands, this internal erosion can lead to piping and eventually a breaching type failure. Filter diaphragms are typically used as a standard defensive design measure to mitigate the potential for seepage and internal erosion in the foundation soils surrounding a conduit. The Natural Resources Conservation Service (NRCS) defined a filter diaphragm as “a designed zone of filter material (usually well-graded, clean sand) constructed around a conduit” (NRCS, 2007).

Structural and filter diaphragm details will need to be designed as part of the Preconstruction Engineering & Design (PED) phase, and are not considered as part of this stability analysis.

3.0 Method of Stability Analysis

The stability of the floodwall design was checked for overturning, sliding, and bearing capacity failure modes in accordance with USACE guidance documents. Many of the applicable sections for inland floodwalls in Engineer Manual (EM) 1110-2-2502, Retaining and Flood Walls (USACE, 1989) have been superseded by parts of EM 1110-2-2100, Stability Analysis of Concrete Structures (USACE, 2005). Further guidance is provided in USACE Engineering and Construction Bulletin (ECB) No. 2014-24 (USACE, 2014), which contains some revisions and clarifications regarding the relationship between EM 1110-2-2100 and EM 1110-2-2502. In accordance with these guidance documents, evaluation of wall stability is required for four different scenarios, as follows:

- Case I1, Infrequent Flood, or design flood loading corresponding to 100-year flood. The water level is at the design flood level (top of wall less freeboard) on the unprotected side; uplift is acting.

- Case I2, Maximum Design Flood, or water to top of wall corresponding to a return period greater than 750 years. This is the same as Case I1 except the water level is at the top of the unprotected side of the wall. Lower factors of safety are allowed for this condition.
- Case I3A and I3B, Earthquake Loading. The water is at the coincident level, or temporal average; uplift, if applicable, is acting; earthquake-induced lateral and vertical loads from the operational basis (Case I3a) and maximum credible earthquakes (Case I3b) are evaluated.
- Case I4, Construction Short-Duration Loading. The floodwall is in place with the loads added, which are possible during the construction period, but are of short duration such as from strong winds (paragraph 3-25) and construction equipment surcharges. Case I4 does not apply to the freestanding floodwall, and will not be evaluated.

The required design criteria for each case of inland floodwalls is dependent upon the following:

- The structure classification – either a normal or critical structure
- The loading condition - usual, unusual, or extreme
- The amount of soil characterization available and certainty in soil design parameters – limited, ordinary, or well-defined

The proposed floodwall is considered a critical structure during a flood stage (Case I1 or I2) because failure of the wall would cause loss of life. The floodwall is considered a normal structure for earthquake loading (Case I3) because failure would be unlikely to cause loss of life.

The loading condition for the 100-year flood loading is unusual. The loading condition for water to the top of the floodwall is extreme because the return period is greater than 750 years (Table 1, USACE ECB 2014-24). Because hydrological data was only available up to a return period of 500 years, the data was extrapolated to a return period of 750 years using both a straight-line trend and a logarithmic trend (Figure 1) to show that the top of the wall is just above the 750-year return period water level. The load condition for the operational basis earthquake is unusual, but the maximum credible earthquake is extreme.

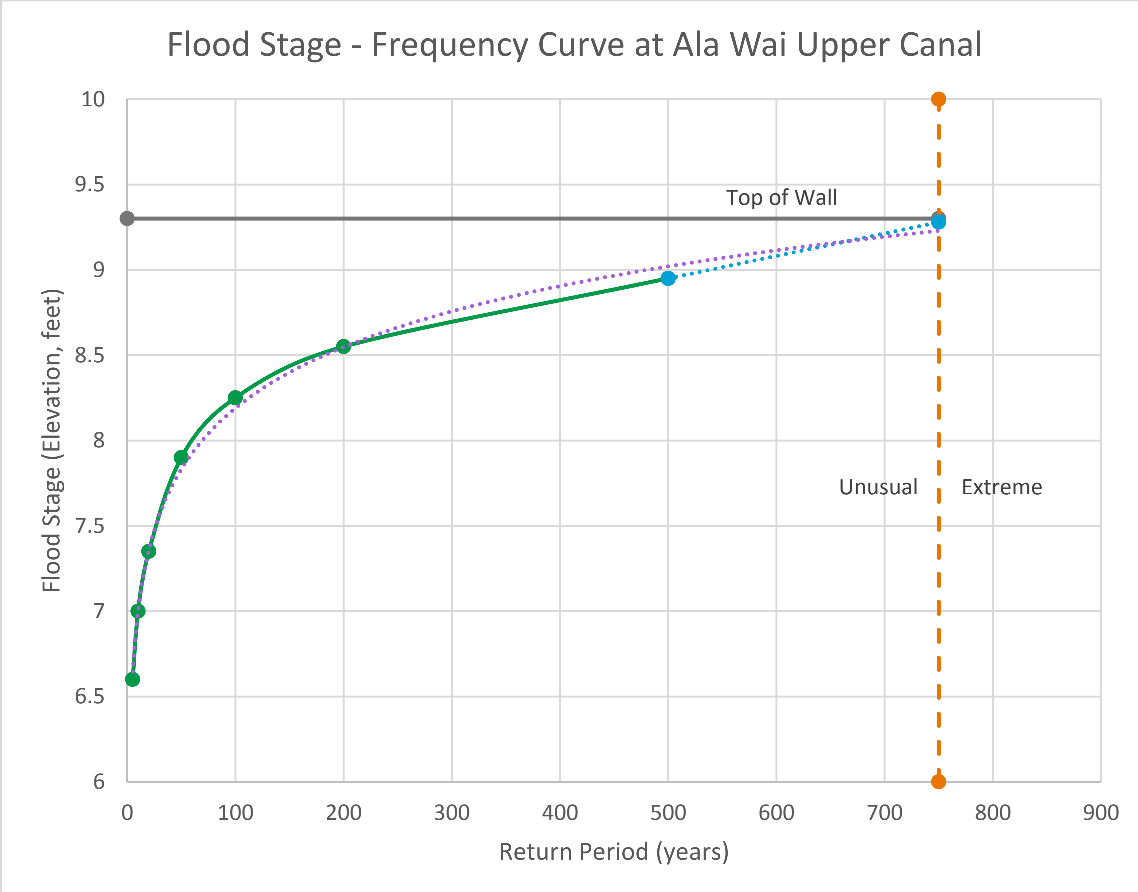


Figure 1. Flood Stage Frequency Curve for the Upper Ala Wai Canal, Extrapolated to 750-year Return Period

The information regarding soil characterization is currently limited, and final design of critical structures is not allowed with only limited soil data. Therefore, the stability evaluations of the proposed floodwall were made assuming ordinary soil characterization; validation of this information will be required before final design.

Based on these descriptions, the analysis assumes the following:

- Case I1 is an unusual loading on a critical structure with ordinary soil characterization.
- Case I2 is an extreme loading on a critical structure with ordinary soil characterization.
- Case I3A is an unusual loading on a normal structure with ordinary soil characterization.
- Case I3B is an extreme loading on a normal structure with ordinary soil characterization.

Table 2 summarizes the required minimum factors of safety for each load case as set forth in EM 1110-2-2100 (USACE, 2005). The floodwall design stability criteria in Table 2 are taken from Table 2 of ECB 2014-24 (USACE, 2014) and Tables 3-2, 3-3, and 3-5 of EM 1110-2-2100 (USACE, 2005).

TABLE 2
Floodwall Stability Criteria

Case No.	Loading Condition	Sliding Factor of Safety	Overturning Criteria, Minimum Base Area in Compression	Bearing Capacity Factor of Safety
I1	Design Flood	1.5	75 percent	3.0
I2	Water to Top of Wall	1.1	Resultant within base	2.0
I3A	Earthquake (OBE)	1.3	75 percent	2.0
I3B	Earthquake (MCE)	1.1	Resultant within base	>1.0

The analysis methods specified in EM 1110-2-2100 (USACE, 2005), EM 1110-2-2502 (USACE, 1989), and ECB 2014-24 (USACE, 2014) were incorporated into an Excel spreadsheet so that multiple analyses of different wall heights and foundation sizes could be evaluated. The Excel spreadsheet was validated using Example 3 in Appendix N of EM 1110-2-2502.

The forces on the wall include soil loads, water loads, uplift loads caused by seepage pressures, and the weight of the wall itself. Force and moment limit equilibrium methods were used to evaluate the factors of safety for the different failure modes. The wall heights and freeboards listed in Table 1 were evaluated for stability to determine the required width and depth of footing, and the depth of the keyway beneath the wall.

A cantilevered floodwall was considered for these analyses. Different types of walls may also be considered, depending on the constraints from adjacent utilities that may limit the amount of space available for floodwall construction. A pilaster wall (with pier-supported pilasters and wall panels between), or a sheet pile wall may provide an alternative type of wall where less footprint is necessary.

Detailed utility constraints were not yet available at the time of writing. Special design details to accommodate utility crossings were qualitatively considered, as presented herein. The structural requirements of these special details must be further evaluated in the PED phase.

The following assumptions were considered in evaluating stability of the floodwall:

- A crack between the soil and the canal side of the floodwall was assumed, in accordance with USACE guidelines. This results in the full water head in uplift at the base of the key. There is no soil pressure on the canal side of the wall, only water pressure.
- The uplift pressures beneath the wall were estimated using the simplified line of seepage method.
- Passive soil pressure at the toe of the wall in sliding analyses was estimated as 1/2 of the ultimate passive pressure, calculated using the buoyant weight.
- The buoyant weight was equal to the saturated soil unit weight minus the pore pressures that were estimated using the line-of-creep method.
- Sliding stability was evaluated for both a horizontal-sliding plane and a plane inclined from the bottom of the key to the toe of the wall.
- The interface friction between the concrete and the soil was equal to 2/3 of the internal friction angle of the soil.
- Water level is at normal level during an earthquake.

4.0 Soil Material Properties

The soil material properties along the floodwall have not yet been investigated as part of this project. Investigation of the foundation materials was performed as part of an evaluation of the stability of the existing canal retaining walls in 1999. According to the report by Geoloabs-Hawaii, the soil beneath the foundation of the proposed floodwalls generally consists of loose to medium dense silty sand fill materials. Zones of soft to stiff clayey silt and clay, of unknown plasticity, were also observed. The fill thickness varies up to approximately 6 feet, and is generally underlain by cemented coral rubble, which provides the foundation for the existing canal bank retaining walls. Laboratory testing was not performed on the soil materials.

According to the material type descriptions, an internal friction angle of 28 degrees and zero cohesion for the foundation soil beneath the proposed floodwalls was assumed for these analyses. A moist unit weight of 115 pounds per cubic foot (pcf) and a saturated unit weight of 130 pcf were assumed. The friction coefficient between the bottom of the concrete floodwall and the fill materials was estimated as 0.36 based on an assumed friction angle of 2/3 of the soil internal friction angle.

These assumed soil properties must be verified through field sampling and laboratory testing as part of the PED phase. Specifically, a soil investigation must be performed to provide a high level of confidence in the foundation strength and loading conditions for final design of the Ala Wai Canal floodwalls, in accordance with EM 1110-2-2100, Section 3-4 (USACE, 2005).

The analyses performed assume effective stress (drained) conditions based on the soil being mostly silty sand material. If significant amount of clay is present, undrained analysis should be performed to evaluate the stability under loading from a rapid rise in the water level.

5.0 Results of Analyses

5.1 Cantilever Floodwall

Figure 2 shows a general floodwall shape and key to the variable dimensions of a cantilever floodwall. The required wall dimensions are summarized in Tables 3 and 4 for the different wall heights and freeboard requirements listed in Table 1.

An attempt was made to limit the depth of the key to no more than 5 feet below grade for ease of construction. The same level of stability can be achieved by inversely adjusting the wall width and key depth for a given floodwall height. In other words, if the key is deepened, the wall footing width may be decreased to avoid adjacent utilities, or if the wall width is increased, the key depth can be decreased to avoid utilities passing below the wall.

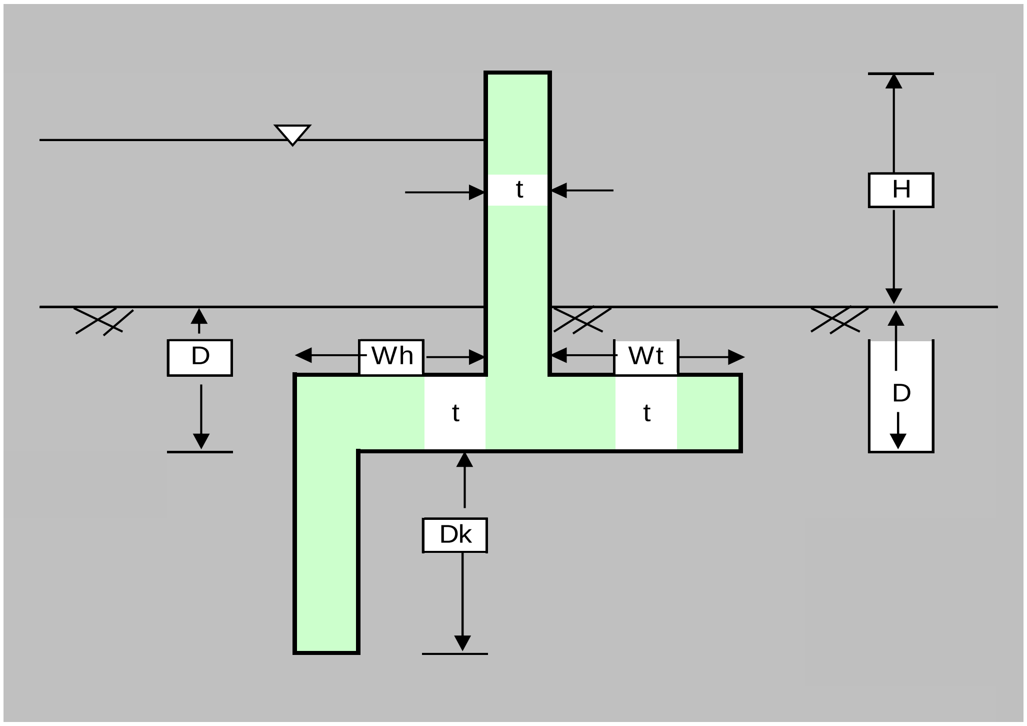


Figure 2. Floodwall Typical Diagram

TABLE 3

Wall Dimension Requirements –Right Bank Floodwall

Start Station	End Station	Wall Height, H (feet)	Depth of Footing, D (feet)	Wall Thickness, t (feet)	Width of Toe, Wt (feet)	Width of Heel, Wh (feet)	Depth of Key, Dk (feet)
11+15	30+00 (McCully Bridge)	0 to 2.5	1.5	1.5	1	1	1
30+00	40+00	3 to 4	2	1.5	1	2.5	2
40+00	59+00	4 to 5.4	2	1.5	2	4	3

TABLE 4

Wall Dimension Requirements –Left Bank Floodwall

Location	End Station	Wall Height, H (feet)	Depth of Footing, D (feet)	Wall Thickness, t (feet)	Width of Toe, Wt (feet)	Width of Heel, Wh (feet)	Depth of Key, Dk (feet)
10+50	30+00 (McCully Bridge)	0 to 2.5	1.5	1.5	1	1	1
30+00	42+00	3 to 4	2	1.5	1	2.5	2
42+00	67+00	4 to 5	2	1.5	1.5	3.5	3
67+00	84+00	5 to 5.6	2	1.5	2	4	3
84+00	100+00	4 to 5	2	1.5	1.5	3.5	3
100+00	103+47	5 to 6	2	1.5	2.5	4.5	3

The sidewalk can be integrated into the structure, but should be reinforced to not have differential settlement or cracking between the wall footing and sidewalk that would result in a tripping hazard.

Waterstop details and structural evaluations for bridging across utilities will be analyzed as part of the PED phase.

The next step in the analysis is to evaluate the seepage beneath the wall and check the exit gradient at the toe of the wall to make sure that the gradient is low enough to limit the risk of piping beneath the wall. It is expected that this will be performed as part of the PED phase, unless otherwise directed.

6.0 References

Geolabs Hawaii. 1999. Draft Evaluation of Seawalls. Ala Wai Canal Dredging Project, Honolulu, Oahu, Hawaii. August 2.

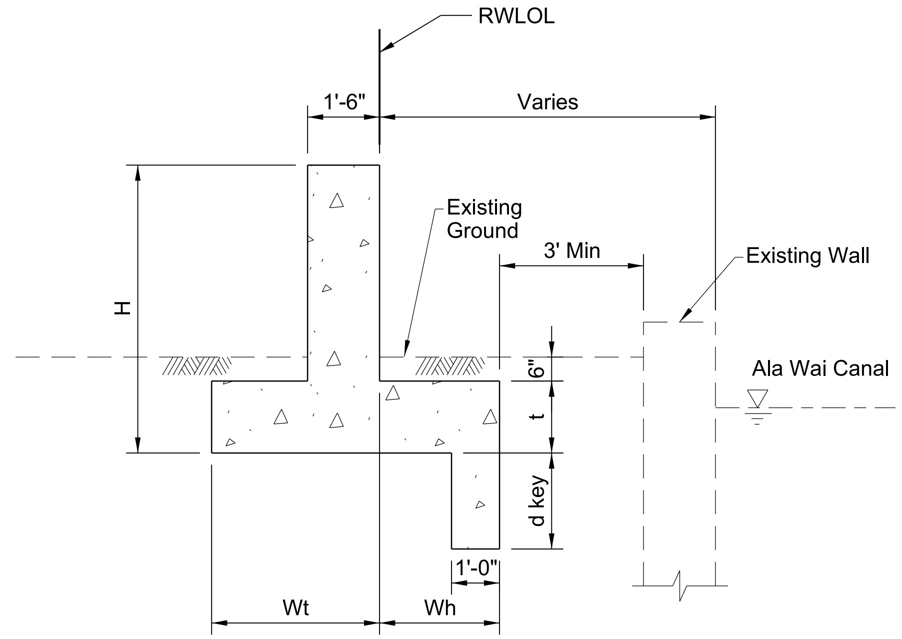
U.S. Army Corps of Engineers (USACE). 2014. Engineer and Construction Bulletin, No. 2014-24. Revision and Clarification of EM 1110-2-2100 and EM 1110-2-2502. 7 November.

U.S. Army Corps of Engineers (USACE). 2005. Engineering Manual 1110-2-2100. ENGINEERING AND DESIGN. Stability Analysis of Concrete Structures. 1 December.

U.S. Army Corps of Engineers (USACE). 1989. Engineering Manual 1110-2-2502. ENGINEERING AND DESIGN. Retaining and Flood Walls. 29 September.

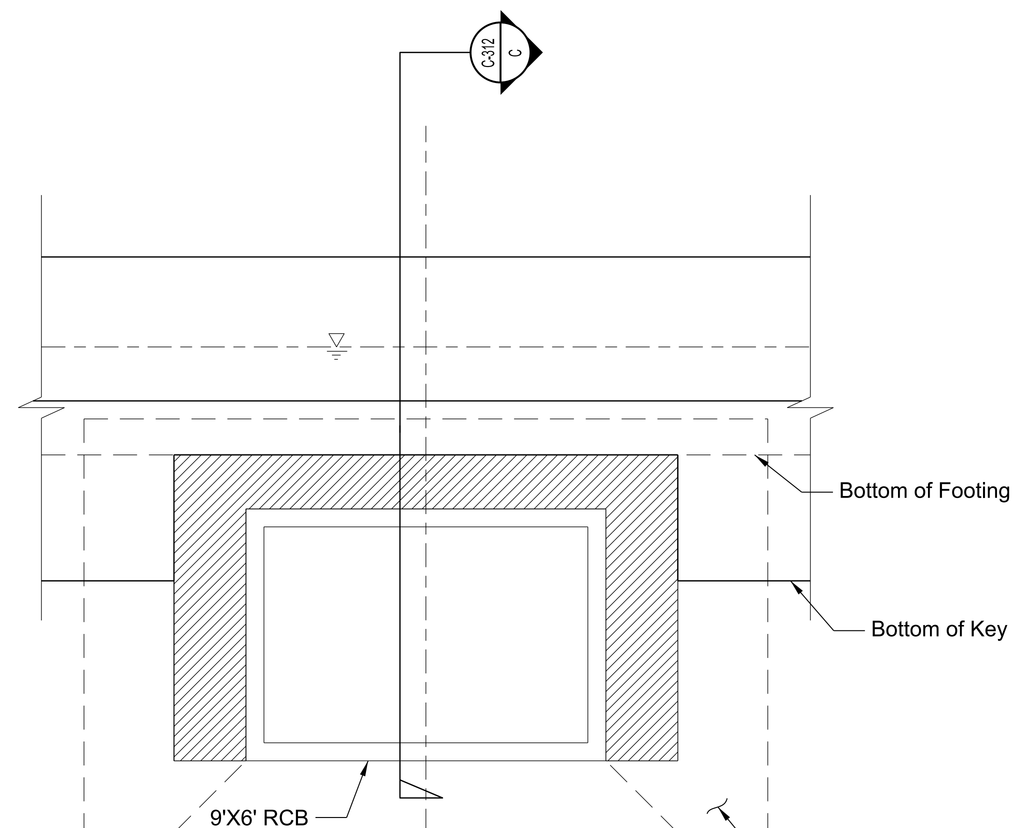
Attachment 4

Updated Ala Wai Canal Floodwalls Details

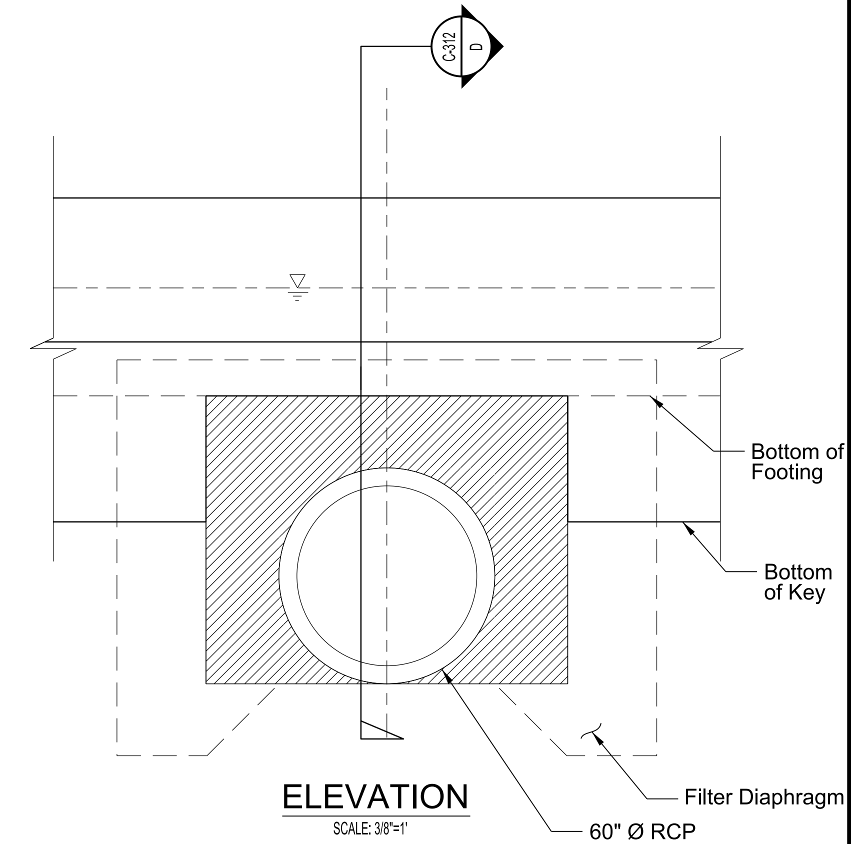


A RIGHT BANK FLOOD WALL
SCALE: 1/2"=1'

LOCATION	H max	d key	t	Wt	Wh
11+15 to 30+00 Right	4	1	1	2.5	1
30+00 to 40+00 Right	6	2	1.5	2.5	2.5
40+00 to 59+00 Right	7.4	3	1.5	3.5	4



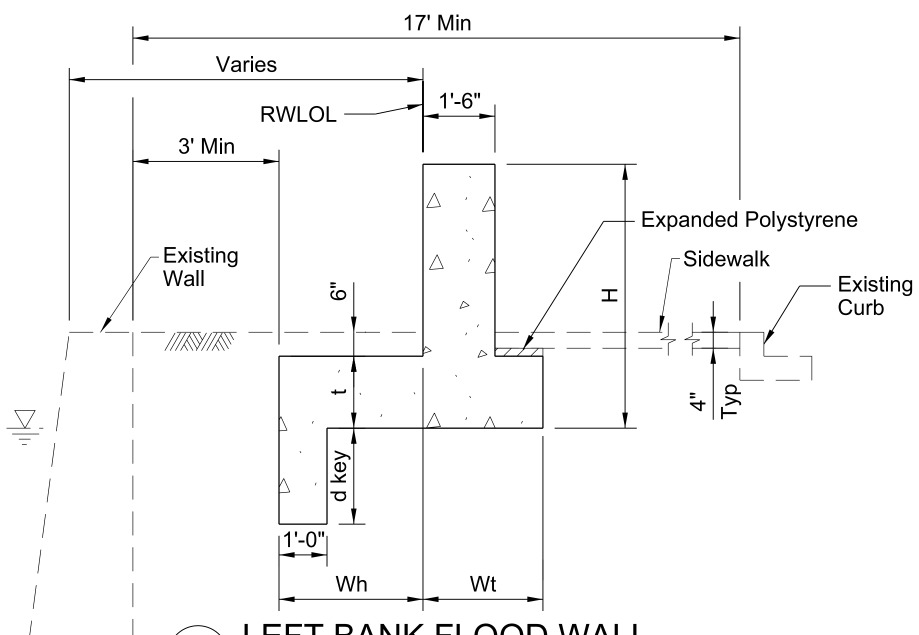
ELEVATION
SCALE: 3/8"=1'



ELEVATION
SCALE: 3/8"=1'

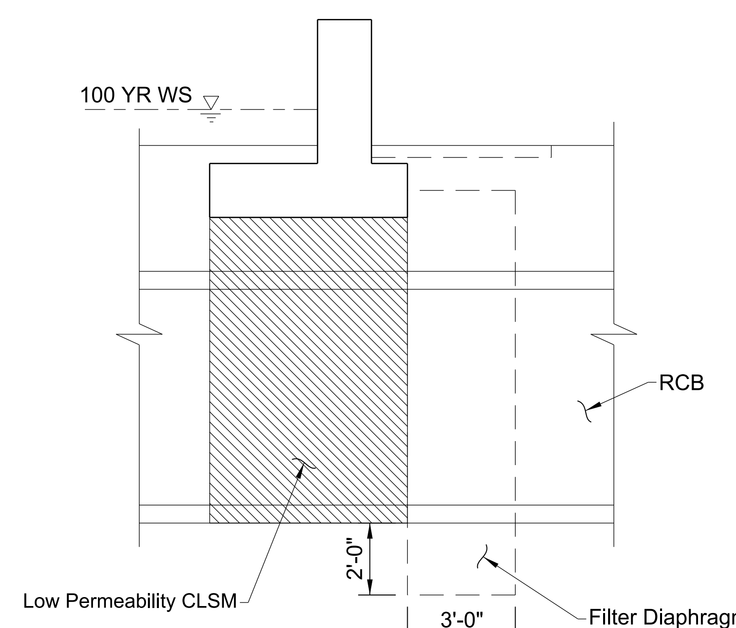
NOTE:

1. Filter diaphragm consists of trench with imported sand to prevent piping at utility penetrations.

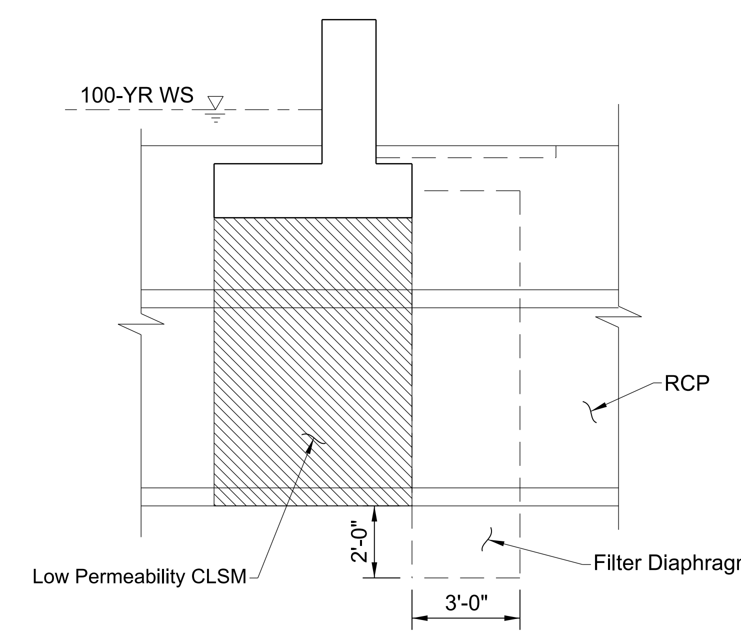


B LEFT BANK FLOOD WALL
SCALE: 1/2"=1'

LOCATION	H max	d key	t	Wt	Wh
10+50 to 30+00 Left	4	1	1	2.5	1
30+00 to 42+00 Left	6	2	1.5	2.5	2.5
42+00 to 67+00 Left	7	3	1.5	3	3.5
67+00 to 84+00 Left	7.6	3	1.5	3.5	4
84+00 to 101+40 Left	7	3	1.5	3	3.5
101+40 to 103+47 Left	8	3	1.5	4	4.5



C SECTION
SCALE: 3/8"=1'
FLOOD WALL OVER BOX CULVERT (TYP)



D SECTION
SCALE: 3/8"=1'
FLOOD WALL OVER PIPE CULVERT (TYP)

US Army Corps of Engineers®

MARK	DESCRIPTION	DATE	APPR

MARK	DESCRIPTION	DATE	APPR

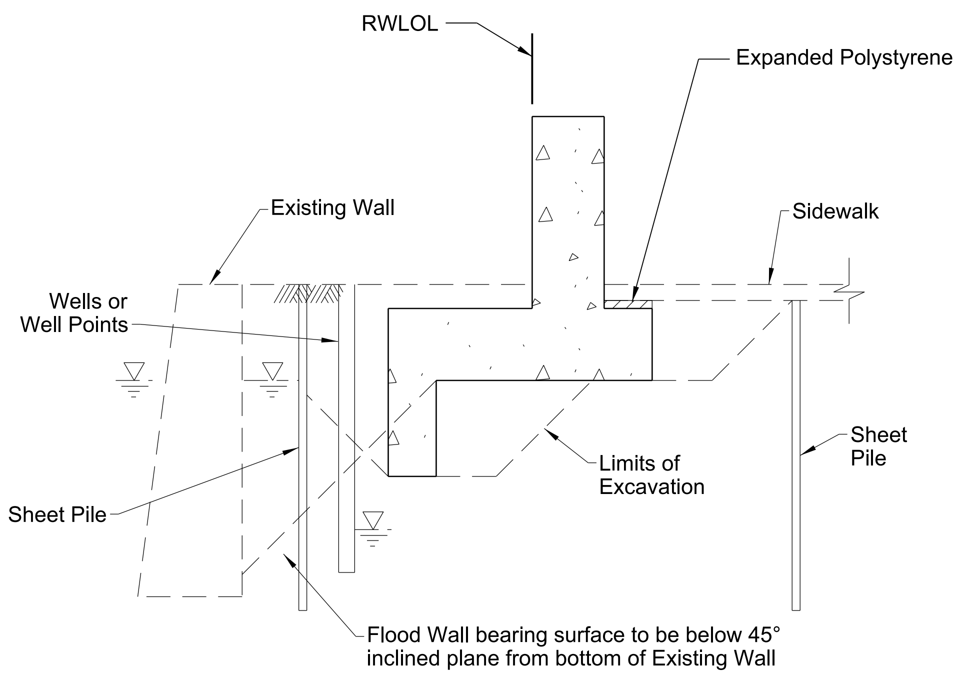
DESIGNED BY: J ELWOOD
DRAWN BY: P WALKER
CHECKED BY:
SUBMITTED BY:
DATE:
REVISION:
SOLICIT./ CONTRACT NO.:
LOCATION CODE
DRAWING NUMBER:
PLOT SCALE: AS SHOWN
PLOT DATE: $DATE$
SIZE: ANSI D
FILE NAME: $FILE$

ALA WAI WATERSHED PROJECT
FLOOD WALL DETAILS

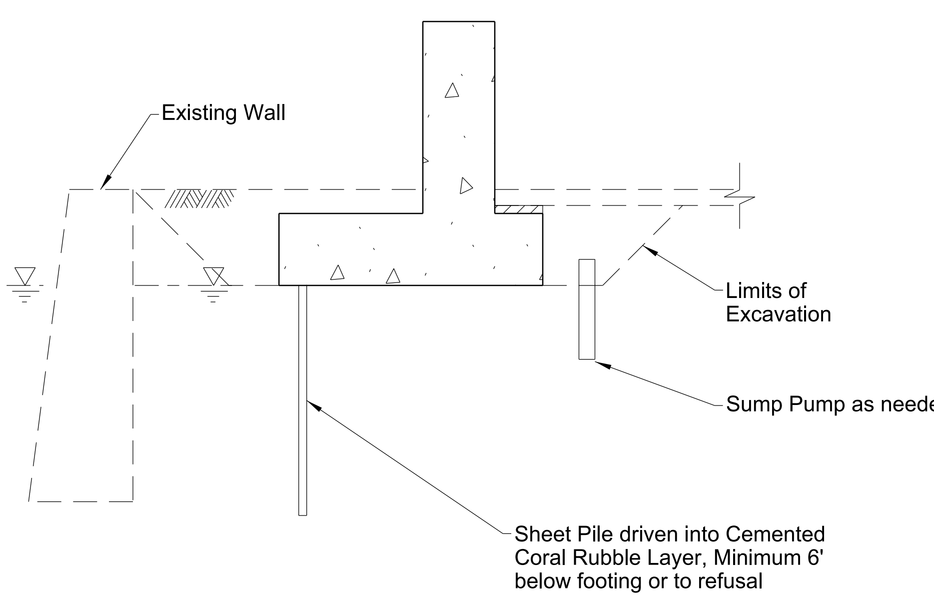
SHEET IDENTIFICATION
C-312

PLOTDRIVER: $PLTDRV$$
PEN TABLE: $PENTBL$$
PRINTED BY: $USER$$

FILE: $FILEL$
MODEL NAME: $MODELNAME$
DATE & TIME: $DATE$ $TIME$
LAST SAVED BY:



OPTION 1



OPTION 2

CONCEPTUAL DEWATERING REQUIREMENTS FOR LEFT BANK FLOOD WALL

SCALE: 1/2"=1'

NOTES:

1. Native soil is subject to caving, and groundwater table must be lowered below the excavation to allow dry construction.
2. Dewatering to construct a concrete key will likely require a positive groundwater cutoff system in addition to pumping from wells or well-points installed inside the positive groundwater cutoff limits.
3. At culvert penetrations, dewatering with more closely spaced deep well systems will be required, because sheet piles cannot be used.

US Army Corps of Engineers

MARK	DESCRIPTION	DATE	APPR

MARK	DESCRIPTION	DATE	APPR

DESIGNED BY: J ELWOOD | DRAWN BY: P WALKER | CHECKED BY: | SUBMITTED BY: | DATE: | SOLICIT./CONTRACT NO.: | LOCATION CODE | REVISION: | PLOT SCALE: AS SHOWN | PLOT DATE: $DATE$ | SIZE: ANSI D | FILE NAME: $FILES$ | DRAWING NUMBER:

ALA WAI WATERSHED PROJECT

FLOOD WALL DETAILS

SHEET IDENTIFICATION
C-312A

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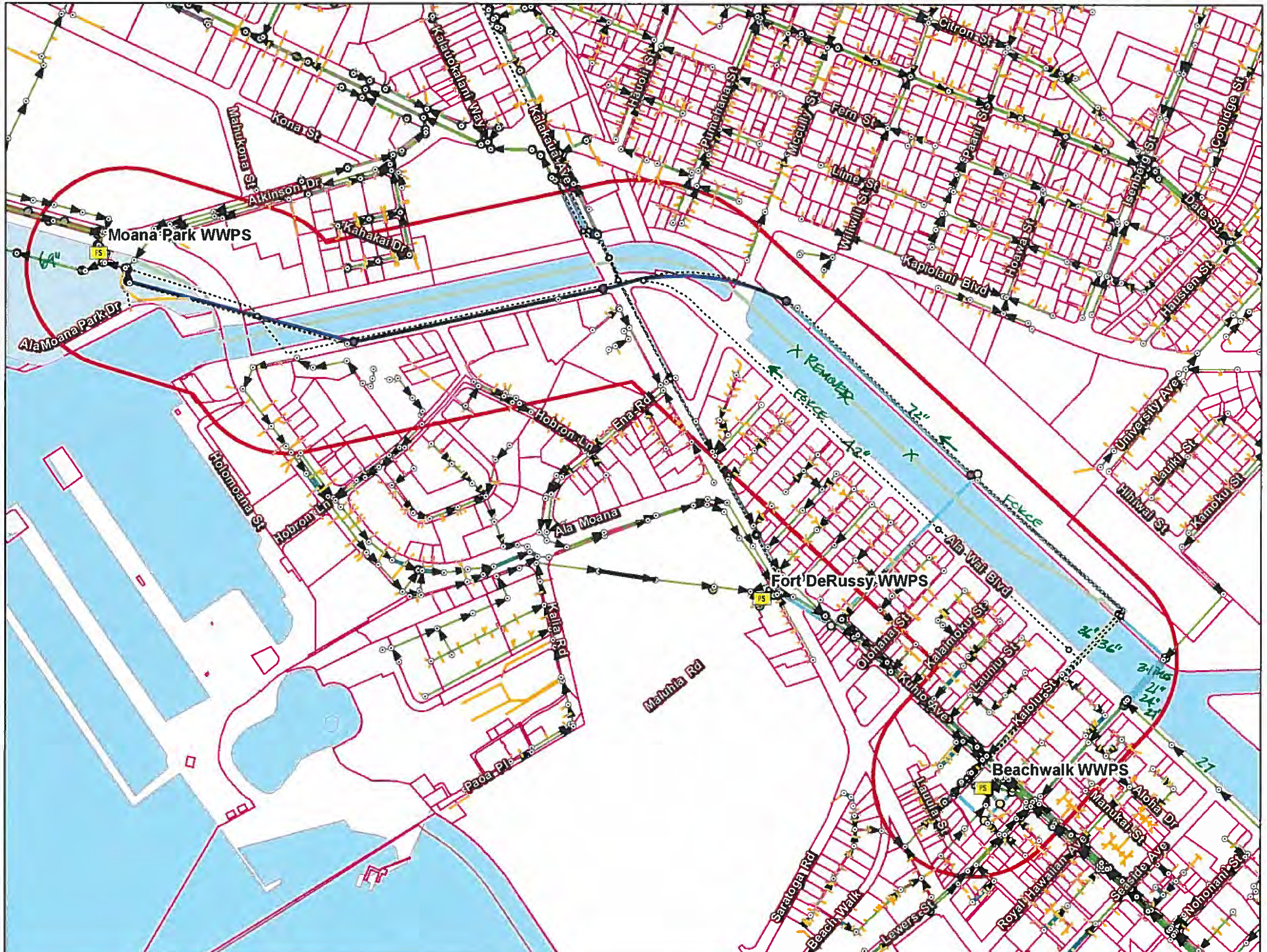
PEN TABLE: $PENTBL$$
PRINTED BY: $USER$
FILE: $FILEL$
MODEL NAME: $MODELNAME$
DATE & TIME: $DATE$ $TIME$
LAST SAVED BY:

Attachment 5

Waikiki Buffer Zone



WAIKIKI BUFFER ZONE

Note: Construction activity may cause damage to the Beachwalk WWPS force mains from ground vibrations or soil liquefaction. Prevention, mitigation, and/or monitoring measures may need to be taken. It is the responsibility of the owner/contractor to prevent any impacts or potential damage to the force main.

DASHED – FORCE MAINS

SOLID – GRAVITY

N

0 230 460 690 920

Feet

Prepared by: Dept. of Design & Construction
City & County of Honolulu
650 South King Street
Honolulu, Hawaii 96813