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October 21, 2010

Randall Wakumoto
City & County of Honolulu
Department of Environmental Services
1000 Uluohia Street, Suite 308
Kapolei, Hawaii 96707

Storm Drainage BMPs In the Vicinity of Kaelepulu Pond
Contract No. F-33975(D)
Task IV, Deliverable I – Conceptual Design Submittal

Dear Mr. Wakumoto:

AECOM has prepared the following letter to present the conceptual design plans, drainage report, and preliminary cost estimate for the project titled: Storm Drainage BMPs In the Vicinity of Kaelepulu Pond.

The purpose of this project is to design structural and non-structural BMP improvements for the City's existing storm drainage system in the Enchanted Lake area to reduce the amount of pollutants being discharged into Kaelepulu Pond. The scope is based on the recommendations presented in the preliminary planning study, titled "Storm Water Best Management Practices (BMP) Plan for Four Major Outlets at Kaelepulu Pond", November 2008. Based on the planning study, 4 types of BMPs are included with this conceptual design.

1. Bio Clean pre-manufactured catch basin filters for 37 existing curb inlets at specific locations throughout the project area (refer to sheet C-2 for locations)

2. Hydrothane High Density Polyethylene trash racks at 5 drainage channel locations (refer to sheet C-6 for locations)

3. 1 Bio Clean Nutrient Separating Baffle Box (NSBB) structural BMP in the Hele Channel, on the west side of the Keolu Drive culvert crossing.

4. Non-structural type erosion protection measures for two areas along Hele Channel and Kamahele Ditch.

AECOM's conceptual design conclusions, recommendations, and notable comments are presented below. Refer to the following attached documents for further details:

- Sheet C-2 (Site Plan 1 – Catch Basin Filters)
- Sheet C-3 (Typical Basket Installation Details for Standard Type "A" Catch Basins)
- Sheet C-4 (Typical Basket Installation Details for Standard Type "B" Catch Basins)
- Sheet C-5 (Typical Basket Installation Details for Standard Type "C" Catch Basins)
- Sheet C-6 (Site Plan 2 – Trash Rack Systems)

- Sheet C-7 (Installation Detail – Trash Rack System 1)
- Sheet C-8 (Installation Detail – Trash Rack System 2)
- Sheet C-9 (Installation Detail – Trash Rack System 3)
- Sheet C-10 (Installation Detail – Trash Rack System 4)
- Sheet C-11 (Installation Detail – Trash Rack System 5)
- Drainage Report
- Preliminary Engineer's Estimate
- Preliminary Construction Schedule
- KriStar Enterprises, Inc. Brochures

Bio Clean Catch Basin Filters:

1. Record plans and as-built drawings of all of the proposed catch basin filter locations were obtained from the City's archives. The record documents were used to compile catch basin information (i.e., type, invert elevations, pipe sizes). A field investigation was conducted to verify the information.

2. The manhole cover at Catch Basin (CB) #12 was covered with asphalt and could not be removed (Photo 1). We recommend restoring access to the manhole by adjusting the top to match existing surface grades as part of this project.

Photo 1 – CB #12 (Akaiki Street) – Manhole covered with asphalt.

3. Two type "A" catch basins (CB #13 and CB #14) exhibited structural damage and are in need of repair (Refer to Photo 2 below). We recommend replacing CB #13 with a Low Impact Design (LID) alternative such as a tree well (see attached KriStar brochure and product drawings). This LID alternative would reduce the amount of discharge by allowing ground water recharge through a permeable layer.

A tree well is not recommended at CB#14 since a large mango tree resides in the front yard of the adjacent property. Although not considered to be an LID alternative, we recommend installing a new catch basin containing a media filtration device, such as a Perk Filter (refer to attached product information and drawings from Kristar), at CB#14 in place of the existing catch basin. This could provide the same filtering benefits at one central location in place of several of the proposed Bio Clean locations upstream.

Photo 2 – CB #13 (Akahai Street) – Catch basin wall broken near wing. (Similar break in CB #14)

4. Seven of the proposed catch basin filter locations were either non-existent or existed as drain manholes rather than curb inlets.
    a. Three of these locations were moved to adjacent curb inlets.
    b. Four locations were removed from the project.

5. The contractor should be required to clean out all trash and debris from existing catch basins prior to installing the storm drain filters.

6. Geotech Solutions, Inc. assisted with the development of typical installation details for the Bio Clean catch basin filters (see attached plan sheets C-3, C-4, and C-5).

7. Geotech Solutions, Inc. and Kaikor Construction assisted with the preliminary cost estimate for the catch basin filters, installed complete.

Hydrothane Trash Racks:

1. Research was performed to locate subdivision record plans and as-built drawings for the existing drainage infrastructure at the proposed trash rack locations. Available record documents were used to develop the conceptual trash rack design drawings.

2. Hydrothane Systems, Inc. provided consultation advice during the development of the preliminary design drawings for the trash rack systems (see attached plan sheets C-7, C-8, C-9, C-10, and C-11).

3. Several federally protected endangered species of birds reside at the proposed trash rack locations, including the Hawaiian Moorhen (‘Alae ‘Ula), Hawaiian Coot (‘Alae Ke’oke’o), and Hawaiian duck (Koloa Maoli) (see Photo 3 below). Trash rack bar spacing should allow for safe passage of native fauna. Preliminary design recommendation is for 12” minimum bar spacing. We recommend consulting with the United States Fish and Wildlife Service for additional design considerations.

Photo 3 – Ducks seen wading in the Hele Channel, near the Keolu Drive bridge.

4. Preliminary hydraulic analyses were performed at each of the 5 proposed trash rack locations. Details are shown in the attached drainage report. The analyses concluded that the existing drainage infrastructures at the proposed trash rack locations may not meet flow capacities per the current drainage requirements.

Note that the Hele Channel will flood ABOVE Keolu Dr.

Bio Clean NSBB BMP:

1. Research was performed to obtain record design documents for the existing drainage infrastructure at the proposed NSBB location in the Hele Channel. Record documents and new survey data were used to develop a hydraulic computer model using HEC-RAS. Details of the hydraulic model are presented in the attached drainage report.

2. The hydraulic model indicated that the channel may experience overtopping at the upstream Keolu Drive culvert entrance in the event of a 20-year storm. Additionally, the freeboard of the channel at the proposed location of the NSBB (downstream of the culvert) was calculated to be less than desirable according to the current City drainage standards. These results imply that the existing channel will mostly likely not have adequate capacity for a 20-year storm condition, much less for a 100-year storm, as is the recommended recurrence interval for the drainage area,

No rationale offered for not doing the trash racks at the other locations which is greater than 100 acres. It can be assumed that installation of the NSBB at the proposed location would unfavorably affect existing channel hydraulics and is therefore not recommended.

Non-structural Erosion Control:

1. We recommend installing an anchored reinforced vegetation system on the side slopes of the Hele Channel and the Kamahele Ditch. This type of system consists of a heavy duty erosion mat secured to the ground using 4-ft deep mechanical earth anchors. Similar systems have been used to construct stabilized vegetated slopes at several locations here in Hawaii. Photo 4 shows before and after views of an anchored reinforced vegetation system.

Photo 4 – Before and after photos of an anchored reinforced vegetation system.

2. For the Kamahele Ditch, we recommend removing built-up sediments and restoring the ditch invert to the original design grade. The side slopes should be planted with shade tolerant vegetation that could grow beneath the existing trees.

3. For the Hele Channel, we recommend dressing the soil slopes prior to erosion mat installation. The anchored erosion mat should extend below the water line to the channel invert. Channel geometry should not be altered in order to avoid adverse affects to channel hydraulics.

4. Temporary BMP will be of high importance while working within the channel. The Contractor should employ turbidity barrier silt screens during construction.

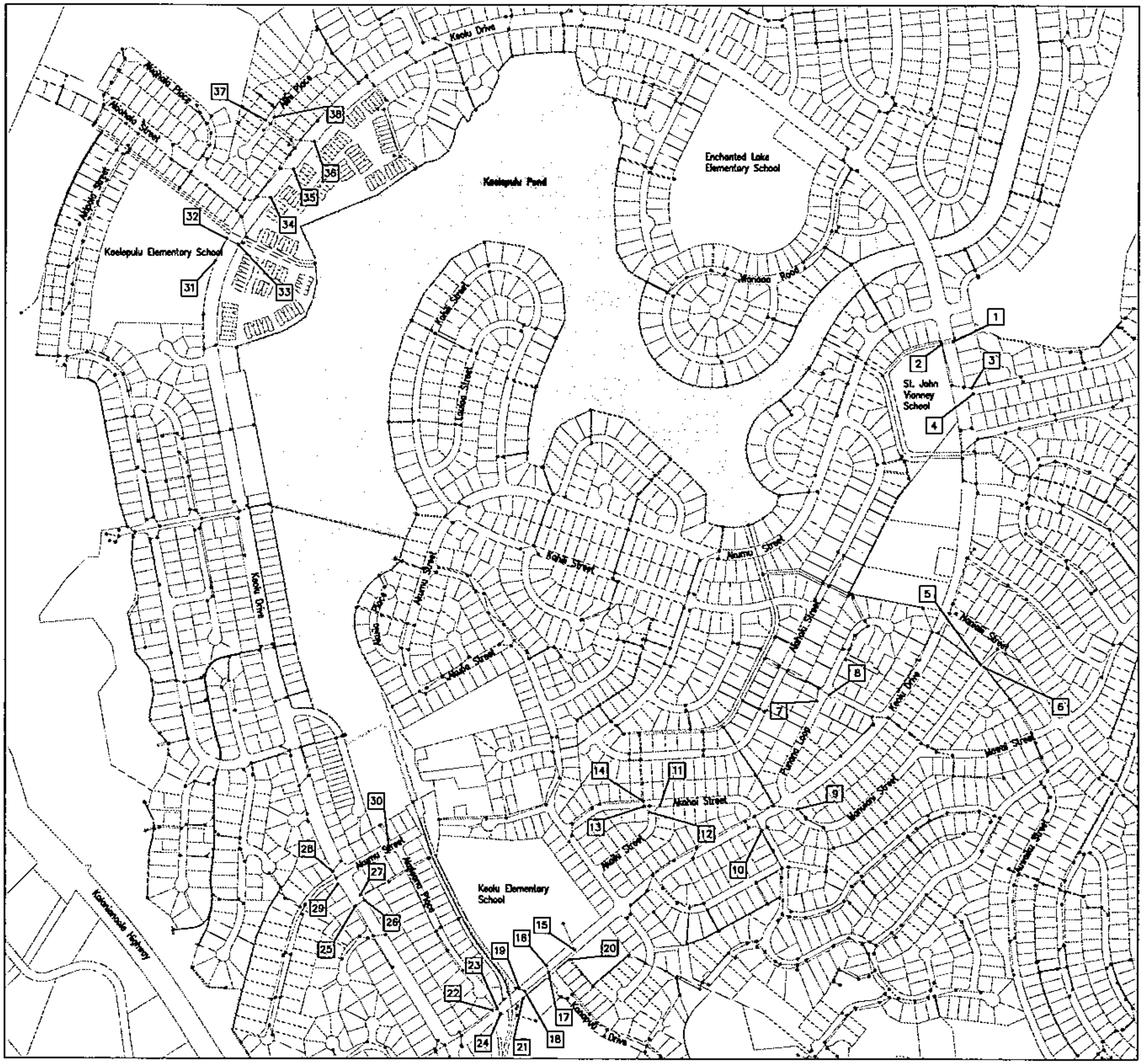
5. The design should be coordinated with the United States Army Corps of Engineers (USACE). USACE shall confirm if additional permits are required for the proposed improvements.

Construction:

1. Preliminary construction cost estimate is about $1.2 million. This cost includes replacing 2 catch basins, installing curb inlet filters, and installing anchored reinforced vegetation systems. See attached preliminary estimate for details.

2. The construction duration is estimated to be 3 months. See attached preliminary schedule for details.

Shows location of curb inlet basket BMPs of types A,B,C,&F



CB No.	CB Type	Discharge		Inflow				CB depth (invert to top curb/street)
		Invert	Pipe Size (in.)	Invert	Pipe Size (in.)	Invert	Pipe Size (in.)	
1	B	1.97	30					±5.00
2	A	1.78	30					±5.00
3	A	2.91	30	3.41	24	3.91	18	±5.31
4	A	3.97	18					±4.17
5	A	6.30	24					±4.50
6	A	6.50	24					±4.17
7	A	4.80	18					±4.58
8	A	2.88	24					±4.00
9	A	27.30	24					±5.83
10	A	25.00	36	25.50	36	26.00	18	±9.22
11	A	12.10	18					±7.50
12	B	14.00	18					±5.00
13	A	11.20	18					±8.02
14	A	10.90	24	11.20	18	12.50	18	±8.33
15	B	32.29	18					±5.58
16	A	31.60	18					±4.50
17	B	30.79	24	31.29	18	31.47	18	±4.42
18	F	28.58	36	29.20	24			±5.00
19	C	25.30	42	28.38	36			±9.33
~~20~~	~~DMH~~							-
~~21~~	~~DMH~~							-
22	A	30.55	18					±5.17
~~23~~	~~DMH~~	~~20.78~~	~~42~~	~~30.42~~	~~18~~			-
24	A	30.60	18					±5.17
25	B	21.80	30	22.29	24			±7.67
26	B	20.09	30	21.24	30			±9.00
~~27~~	~~DMH~~	~~19.70~~						-
28	A	23.47	18					±5.01
29	A	24.00	18					±4.17
~~30~~	~~DMH~~	~~6.80~~	~~60~~	~~7.10~~	~~24~~	~~3.10~~	~~18~~	-
31	B	7.11	24					±4.33
32	F	5.93	30	6.43	24	6.93	18	±5.50
33	A	5.74	30					±6.42
34	A	8.40	18					±5.00
35	A	9.40	18					±4.50
36	A	10.40	18					±4.50
37	A	9.40	30					±6.37
38	B	10.76	30					±5.17

NOTES:
1) SEE SHEET C-3 FOR TYPE "A" CATCH BASIN INLET BASKET DETAIL.
2) SEE SHEET C-4 FOR TYPE "B" AND TYPE "F" CATCH BASIN INLET BASKET DETAILS.
3) SEE SHEET C-5 FOR TYPE "C" CATCH BASIN INLET BASKET DETAIL.
5) LOCATIONS OF CATCH BASINS ARE APPROXIMATE AS THEY WERE ACQUIRED FROM THE CITY AND COUNTY OF HONOLULU'S GIS SERVER. CONTRACTOR SHALL FLAG SELECT CATCH BASINS FOR CITY APPROVAL PRIOR TO INSTALLING CURB INLET BASKETS.

SITE PLAN 1
SCALE: 1" = 300'-0"

GRAPHIC SCALE
300 0 300
SCALE: 1"=300'

REVISION	DATE	DESCRIPTION	MADE BY	APPROVED

DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

STORM DRAINAGE BMPS IN THE VICINITY OF KAELEPULU POND

SITE PLAN 1 - CATCH BASIN FILTERS

DESIGN:	APPROVED:		DWG. NO. C-2
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DATE: AUGUST 2010			
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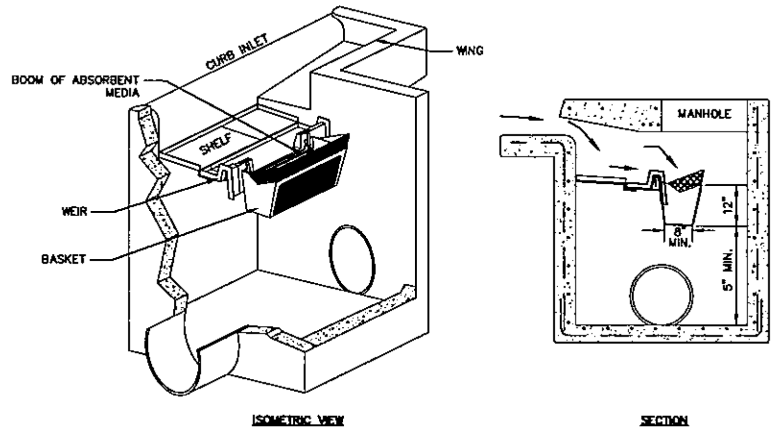

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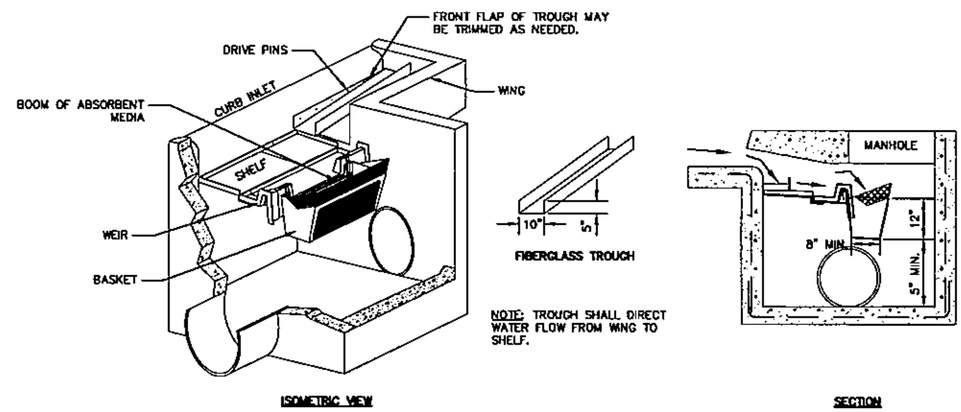

INSTALLATION FOR SHALLOW CATCH BASIN (WITH TROUGH)

NOTE:

1. TYPE "A" CATCH BASIN IS AS DEFINED IN STANDARD DETAILS FOR PUBLIC WORKS CONSTRUCTION, CITY AND COUNTY OF HONOLULU (SEPT 1984).
2. PIPE INVERTS AND LOCATIONS VARY WITH EACH CATCH BASIN AND ARE NOT DRAWN TO SCALE IN THE INSTALLATION DETAILS.
3. CONTRACTOR SHALL INSTALL CATCH BASIN BASKETS IN ACCORDANCE WITH MANUFACTURERS SPECIFICATIONS.
4. MINIMUM LONGITUDINAL SLOPE OF FIBERGLASS TROUGH SHALL BE 2%.
5. CATCH BASINS SHALL BE FIELD VERIFIED BY CONTRACTOR TO DETERMINE IF A STANDARD BASKET INSTALLATION OR A SHALLOW CATCH BASIN BASKET INSTALLATION IS REQUIRED.
6. IF BOTTOM OF BASKET IS TO BE BELOW THE CROWN OF AN INLET OR OUTLET PIPE, INSTALLATION FOR SHALLOW CATCH BASIN SHALL BE USED IN LIEU OF STANDARD INSTALLATION FOR TYPE "A" CATCH BASIN.

TYPE A CATCH BASIN BASKET INSTALLATION

NOT TO SCALE

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STORM DRAINAGE BMPS IN THE VICINITY OF KAELEPULU POND

TYPICAL BASKET INSTALLATION DETAILS FOR STANDARD TYPE A CATCH BASINS

DESIGN:	APPROVED:		DWG. NO. C-3
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DATE: AUGUST 2010			
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LICENSED PROFESSIONAL ENGINEER No. 6195-C HAWAII U.S.A.

4/30/12

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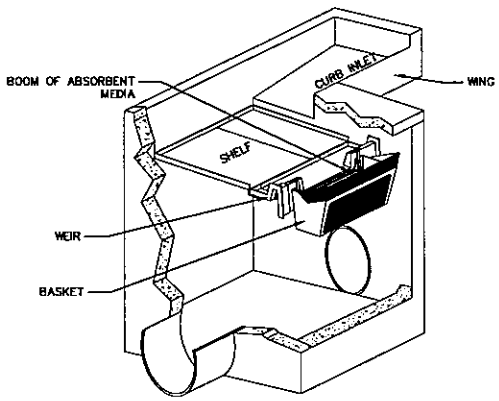
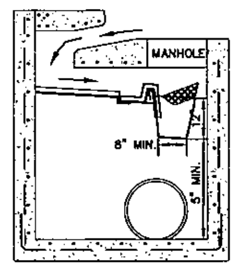
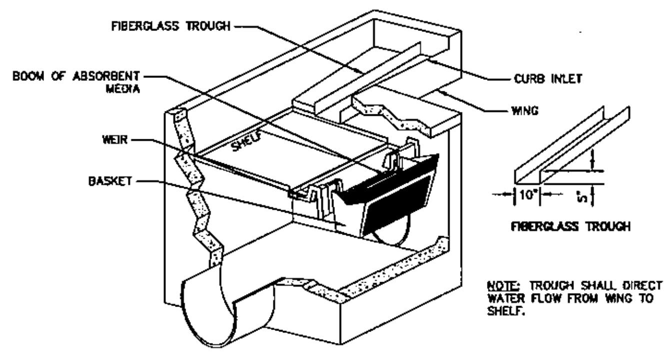
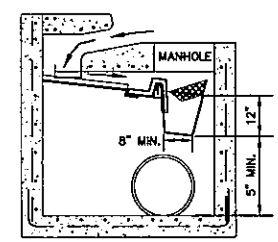




STANDARD INSTALLATION (WITHOUT TROUGH)





INSTALLATION FOR SHALLOW CATCH BASIN (WITH TROUGH)

NOTE:

1. TYPE "B" AND TYPE "F" CATCH BASINS ARE AS DEFINED IN STANDARD DETAILS FOR PUBLIC WORKS CONSTRUCTION, CITY AND COUNTY OF HONOLULU (SEPT 1984).
2. PIPE INVERTS AND LOCATIONS VARY WITH EACH CATCH BASIN AND ARE NOT DRAWN TO SCALE IN THE INSTALLATION DETAILS.
3. CONTRACTOR SHALL INSTALL CATCH BASIN BASKETS IN ACCORDANCE WITH MANUFACTURERS SPECIFICATIONS.
4. BASKET INSTALLATION DETAILS FOR THE STANDARD TYPE "B" CATCH BASIN SHALL BE USED FOR BASKET INSTALLATIONS OF STANDARD TYPE "F" CATCH BASINS.
5. BASKET INSTALLATION DETAILS FOR THE SHALLOW TYPE "B" CATCH BASIN SHALL BE USED FOR BASKET INSTALLATIONS OF SHALLOW TYPE "F" CATCH BASINS WITH FIBERGLASS TROUGH TO BE INSTALLED ALONG THE WING WALL BELOW THE CURB INLET.
6. MINIMUM LONGITUDINAL SLOPE OF FIBERGLASS TROUGH SHALL BE 2%.
7. CATCH BASINS SHALL BE FIELD VERIFIED BY CONTRACTOR TO DETERMINE IF A STANDARD BASKET INSTALLATION OR A SHALLOW CATCH BASIN BASKET INSTALLATION IS REQUIRED.
8. IF BOTTOM OF BASKET IS TO BE BELOW THE CROWN OF AN INLET OR OUTLET PIPE, INSTALLATION FOR SHALLOW CATCH BASIN SHALL BE USED IN LIEU OF STANDARD INSTALLATION FOR TYPE "B" AND TYPE "F" CATCH BASINS.

TYPE B CATCH BASIN BASKET INSTALLATION

NOT TO SCALE

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CITY AND COUNTY OF HONOLULU

STORM DRAINAGE BMPS IN THE VICINITY OF KAELEPULU POND

TYPICAL BASKET INSTALLATION DETAILS FOR STANDARD TYPE B CATCH BASINS

DESIGN:	APPROVED:	DWG. NO. C-4
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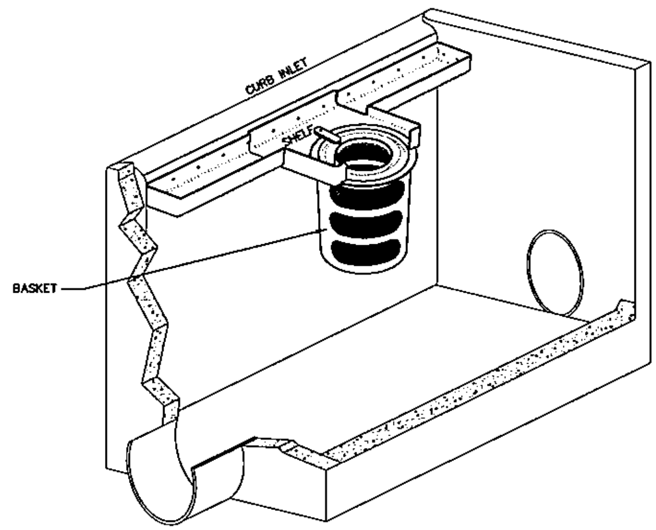
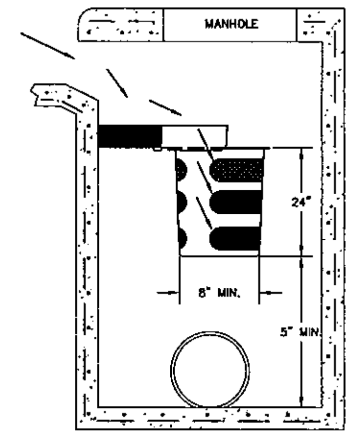


ISOMETRIC VIEW



SECTION

TYPE C CATCH BASIN BASKET INSTALLATION

NOT TO SCALE

NOTE:

1. TYPE "C" CATCH BASIN IS AS DEFINED IN STANDARD DETAILS FOR PUBLIC WORKS CONSTRUCTION, CITY AND COUNTY OF HONOLULU (SEPT 1984).
2. PIPE INVERTS AND LOCATIONS VARY WITH EACH CATCH BASIN AND ARE NOT DRAWN TO SCALE IN THE INSTALLATION DETAILS.
3. CONTRACTOR SHALL INSTALL CATCH BASIN BASKETS IN ACCORDANCE WITH MANUFACTURERS SPECIFICATIONS.

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STORM DRAINAGE BMPS IN THE VICINITY OF KAELEPULU POND

TYPICAL BASKET INSTALLATION DETAILS FOR STANDARD TYPE C CATCH BASINS

DESIGN:		APPROVED:	DWG. NO. C-5
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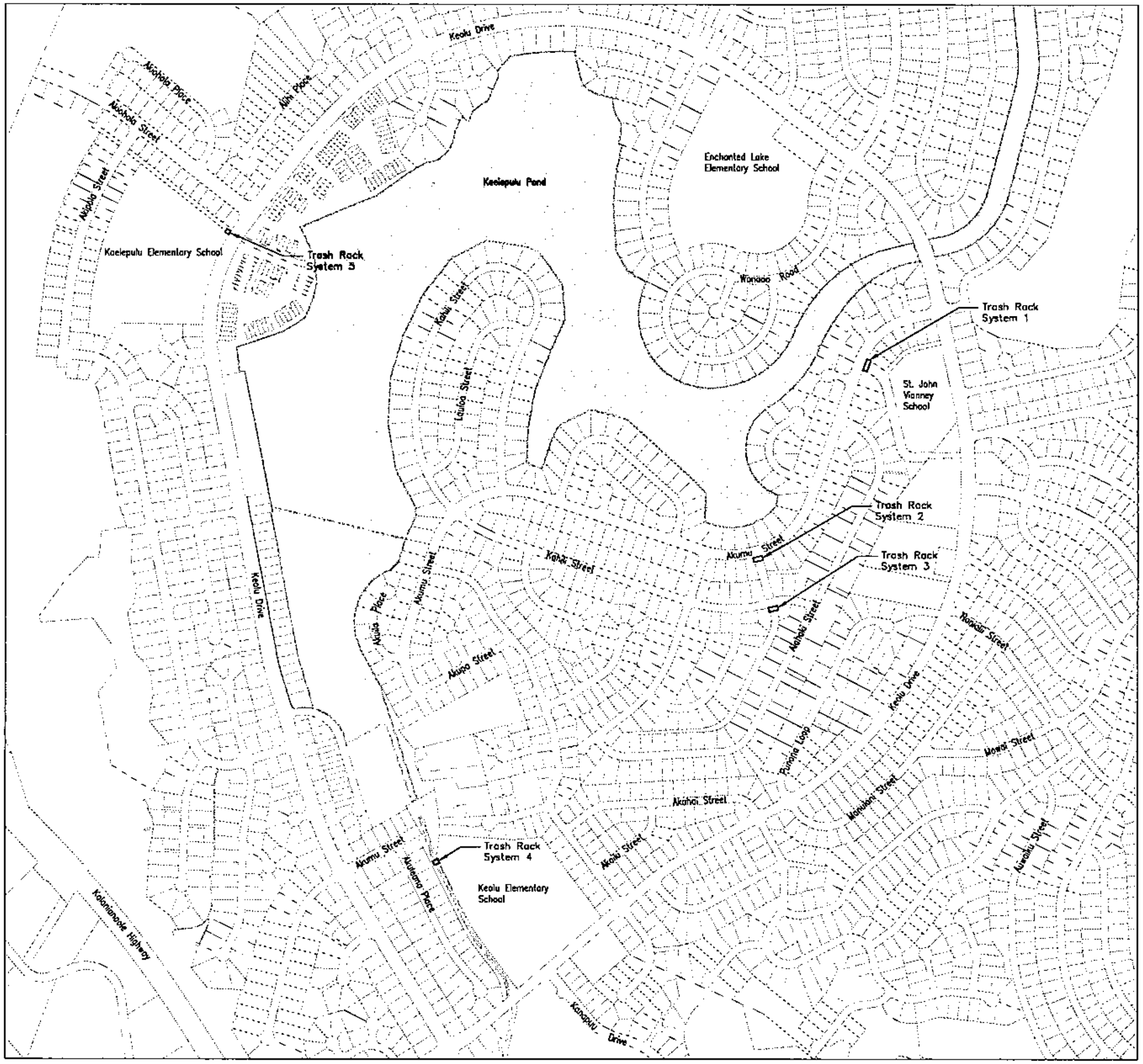

SITE PLAN 2
SCALE: 1" = 300'-0"

GRAPHIC SCALE
300 0 300 600
SCALE: 1"=300'

REVISION	DATE	DESCRIPTION	MADE BY	APPROVED

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION AND CONSTRUCTION OF THIS PROJECT WILL BE UNDER MY OBSERVATION.
ARDALAN R. NIKOU, LICENSED PROFESSIONAL ENGINEER, No. 8195-C, HAWAII, U.S.A.
4/30/12

AECOM

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CITY AND COUNTY OF HONOLULU

STORM DRAINAGE BMPS IN THE VICINITY OF KAELEPULU POND

SITE PLAN 2 - TRASH RACK SYSTEMS

DESIGN:	APPROVED:	DWG. NO. C-6
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DATE: AUGUST 2010		
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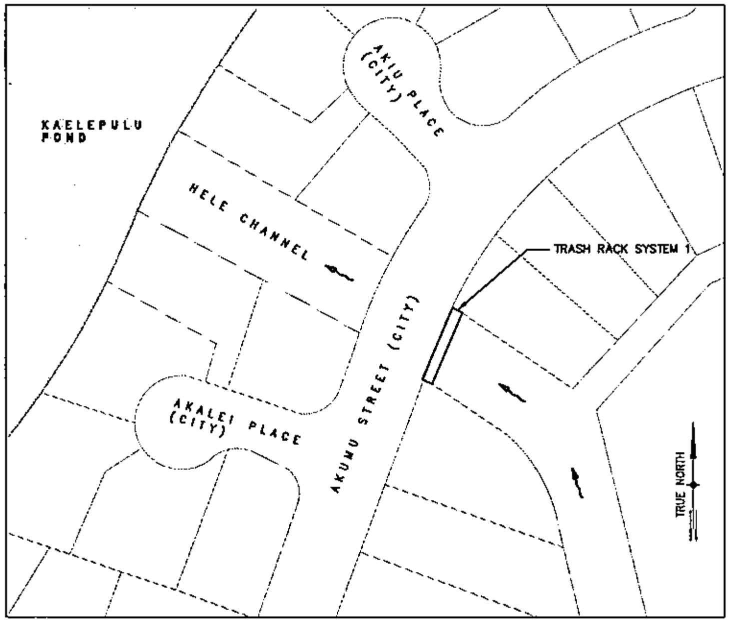

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GRAPHIC SCALE
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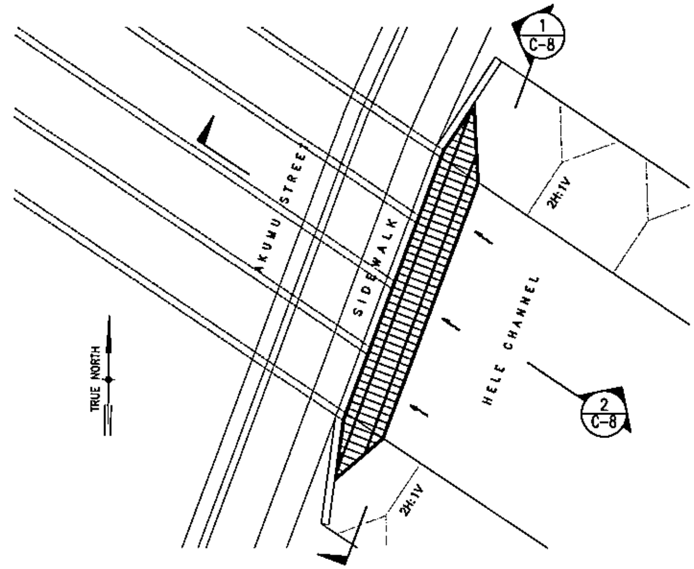
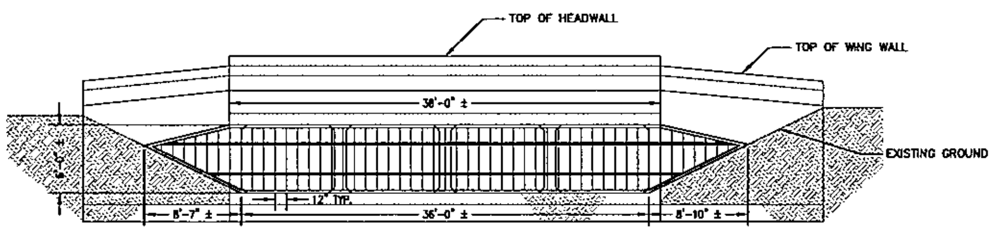


PLAN VIEW
SCALE: 1" = 8'-0"



1 (C-8) SECTION
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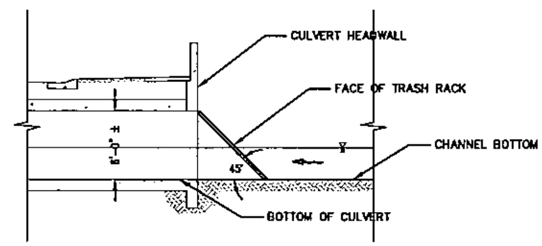

2 (C-8) LONGITUDINAL PROFILE
SCALE: 3/16" = 1'-0"

NOTE:
DIMENSIONS ARE APPROXIMATE AS THE SUBDIVISION PLANS WERE ACQUIRED FROM THE CITY AND COUNTY OF HONOLULU'S MICROFILM FILES. CONTRACTOR SHALL VERIFY ALL DIMENSIONS PRIOR TO INSTALLING THE TRASH RACK SYSTEMS.

REVISION	DATE	DESCRIPTION	MADE BY	APPROVED

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CITY AND COUNTY OF HONOLULU

STORM DRAINAGE BMPS IN THE VICINITY OF KAELEPULU POND

INSTALLATION DETAIL - TRASH RACK SYSTEM 1

ABDALLAH R. NIMOU — LICENSED PROFESSIONAL ENGINEER — HAWAII U.S.A.

4/30/12

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DESIGN:
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CHECKED:
DATE: AUGUST 2010
APPROVED:
DWG. NO. C-7
SHEET 8 OF XX SHEETS
PROJECT NO. XX-XX
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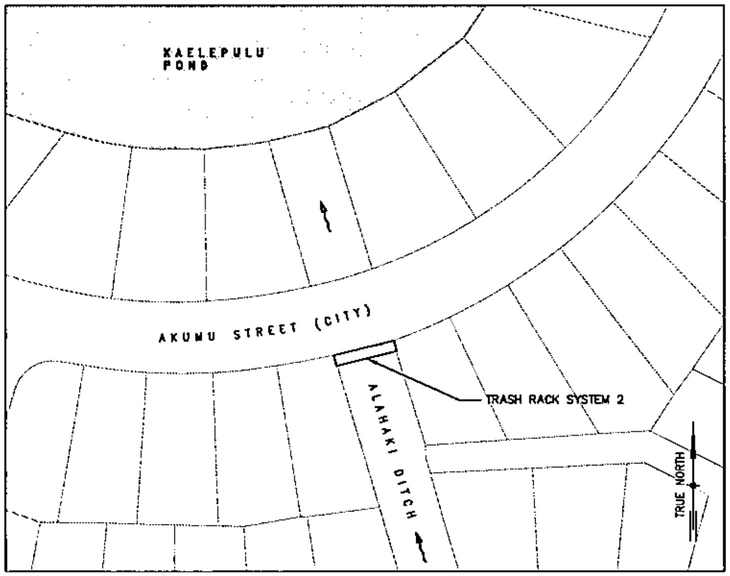

LOCATION
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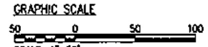
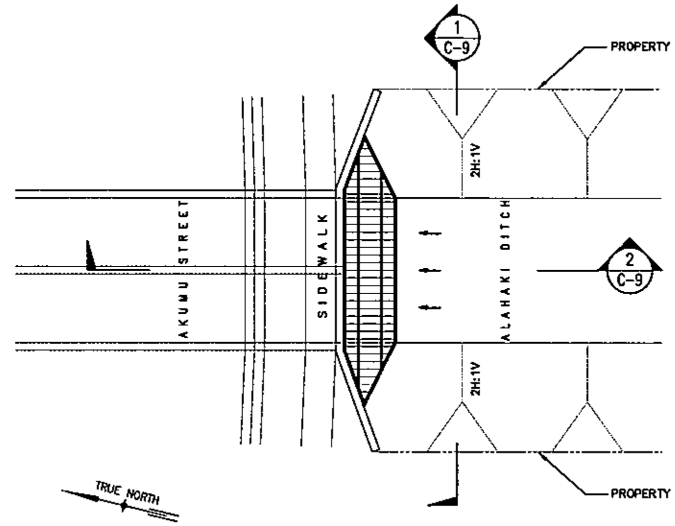
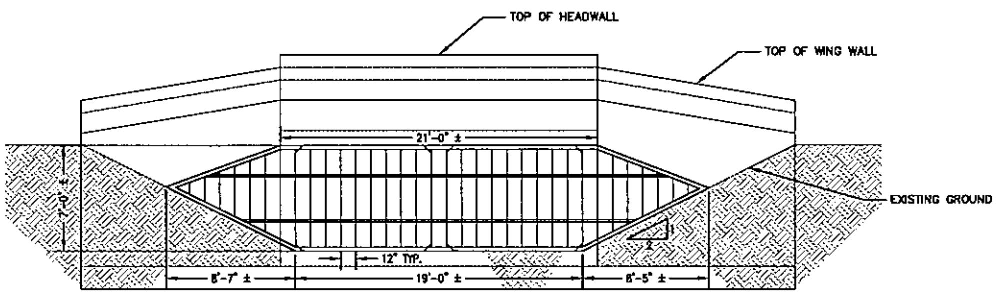
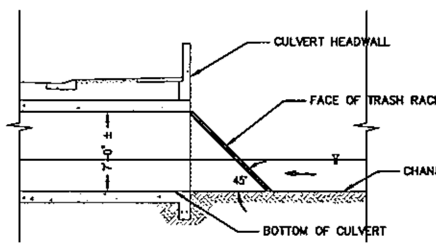




PLAN VIEW
SCALE: 1" = 8'-0"



1 C-9 SECTION
SCALE: 1/4" = 1'-0"



2 C-9 LONGITUDINAL PROFILE
SCALE: 3/16" = 1'-0"

NOTE:
DIMENSIONS ARE APPROXIMATE AS THE SUBDIVISION PLANS WERE ACQUIRED FROM THE CITY AND COUNTY OF HONOLULU'S MICROFILM FILES. CONTRACTOR SHALL VERIFY ALL DIMENSIONS PRIOR TO INSTALLING THE TRASH RACK SYSTEMS.

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STORM DRAINAGE BMPS IN THE VICINITY OF KAELEPULU POND

INSTALLATION DETAIL - TRASH RACK SYSTEM 2

AECOM

DESIGN:	APPROVED:		DWG. NO. C-8
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DATE: AUGUST 2010			
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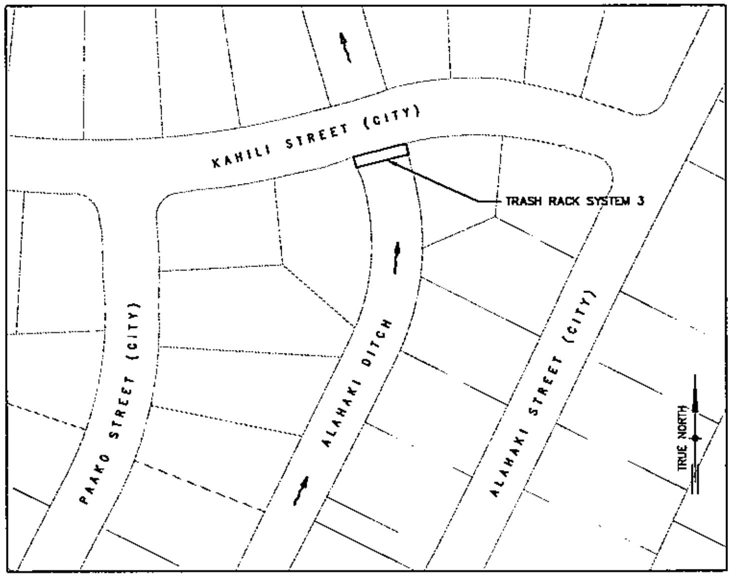

LOCATION
SCALE: 1" = 50'-0"

GRAPHIC SCALE
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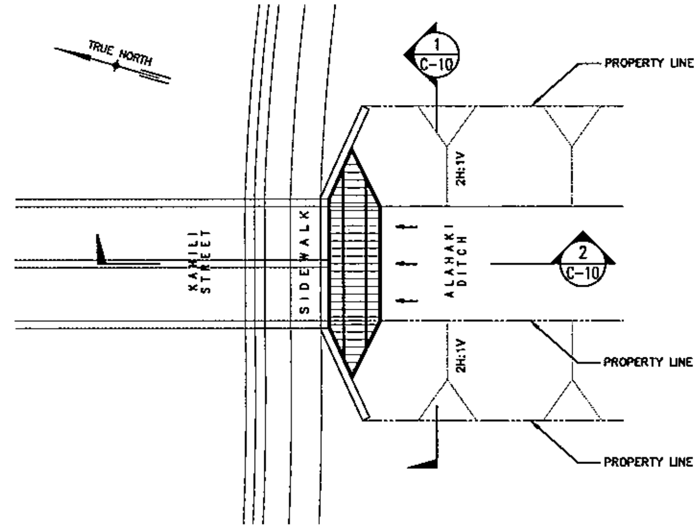
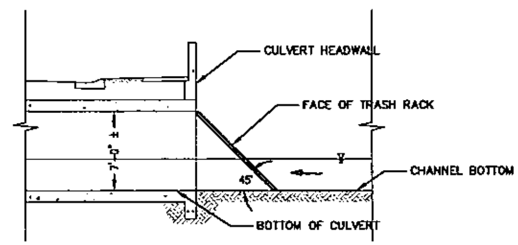
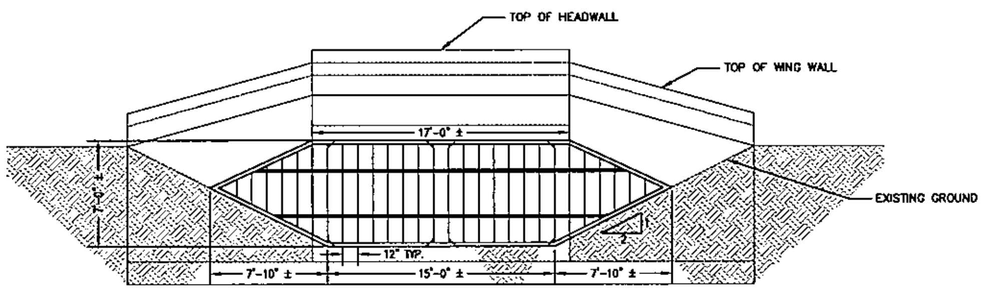
SCALE: 1"=50'



PLAN VIEW
SCALE: 1" = 8'-0"



2 C-10 LONGITUDINAL PROFILE
SCALE: 3/16" = 1'-0"



1 C-10 SECTION
SCALE: 1/4" = 1'-0"

NOTE:
DIMENSIONS ARE APPROXIMATE AS THE SUBDIVISION PLANS WERE ACQUIRED FROM THE CITY AND COUNTY OF HONOLULU'S MICROFILM FILES. CONTRACTOR SHALL VERIFY ALL DIMENSIONS PRIOR TO INSTALLING THE TRASH RACK SYSTEMS.

REVISION	DATE	DESCRIPTION	MADE BY	APPROVED

DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

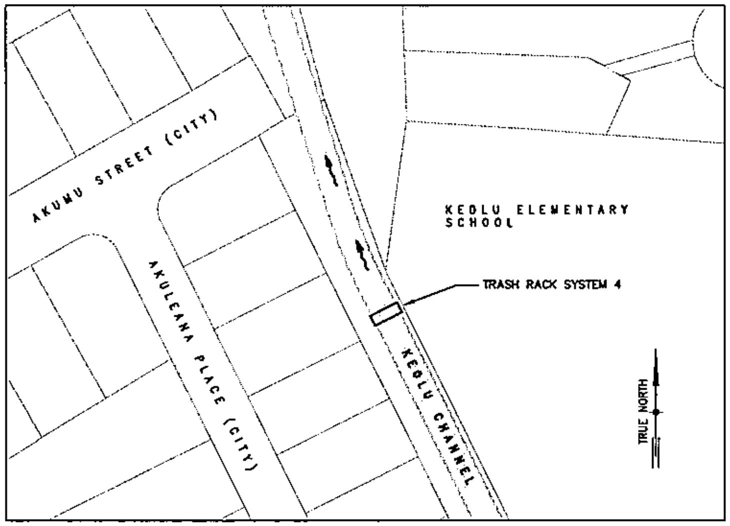
STORM DRAINAGE BMPS IN THE VICINITY OF KAELEPULU POND

INSTALLATION DETAIL - TRASH RACK SYSTEM 3

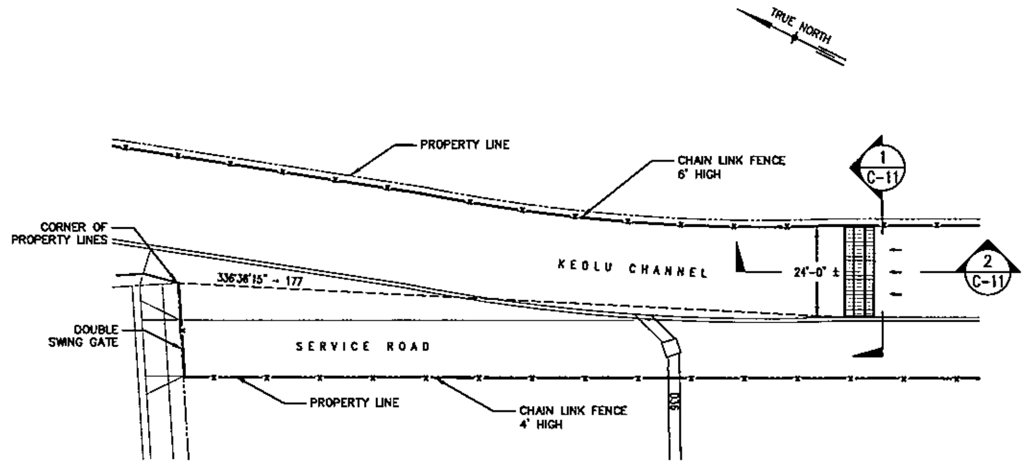
DESIGN:	APPROVED:	DWG. NO. C-9
DRAWN: MM		
CHECKED:		SHEET 10 OF XX SHEETS
DATE: AUGUST 2010		
PROJECT NO. XX-XX	FILE — DRAW — FOLDER — NUMBER —	

ABDALLAH R. MAHOU
LICENSED PROFESSIONAL ENGINEER
No. 9188-C
HAWAII, U.S.A.
4/30/12

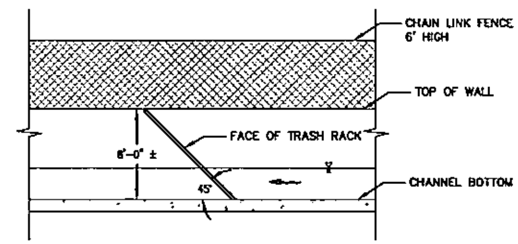
AECOM



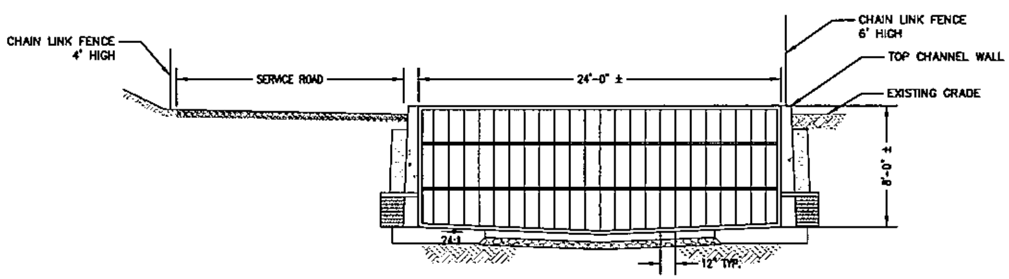
LOCATION
SCALE: 1" = 50'-0"



PLAN VIEW
SCALE: 1/16" = 1'-0"



2 / C-11 LONGITUDINAL PROFILE
SCALE: 3/16" = 1'-0"



1 / C-11 SECTION
SCALE: 1/4" = 1'-0"

NOTE:
DIMENSIONS ARE APPROXIMATE AS THE SUBDIVISION PLANS WERE ACQUIRED FROM THE CITY AND COUNTY OF HONOLULU'S MICROFILM FILES. CONTRACTOR SHALL VERIFY ALL DIMENSIONS PRIOR TO INSTALLING THE TRASH RACK SYSTEMS.

REVISION	DATE	DESCRIPTION	MADE BY	APPROVED

DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

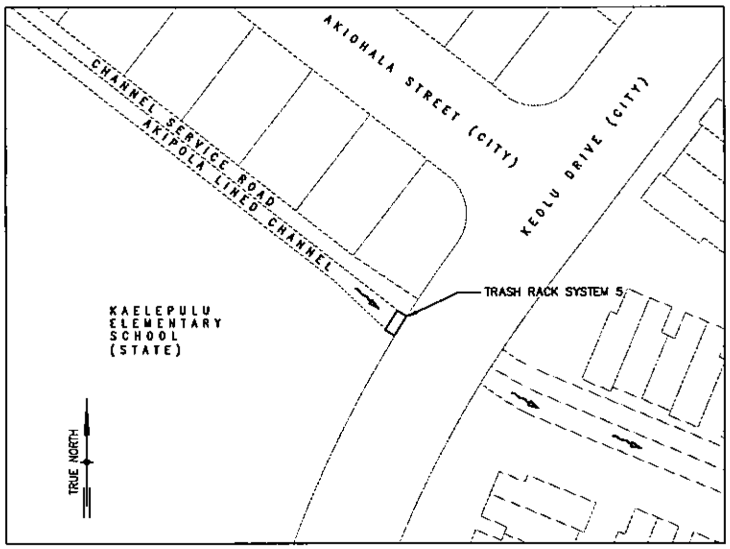
STORM DRAINAGE BMPS IN THE VICINITY OF KAELEPULU POND

INSTALLATION DETAIL - TRASH RACK SYSTEM 4

AECOM

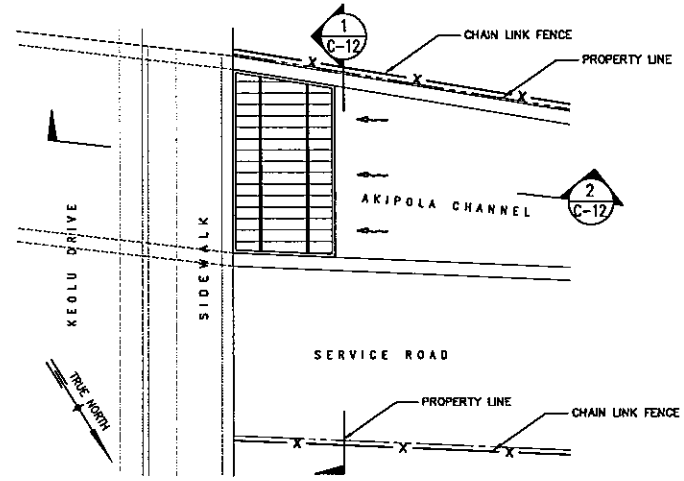
4/30/12

DESIGN:	APPROVED:	DWG. NO. C-10
DRAWN: MN		SHEET 11
CHECKED:		OF XX SHEETS
DATE: AUGUST 2010		
PROJECT NO. XX-XX	FILE __ DRAW __ FOLDER __ NUMBER __	

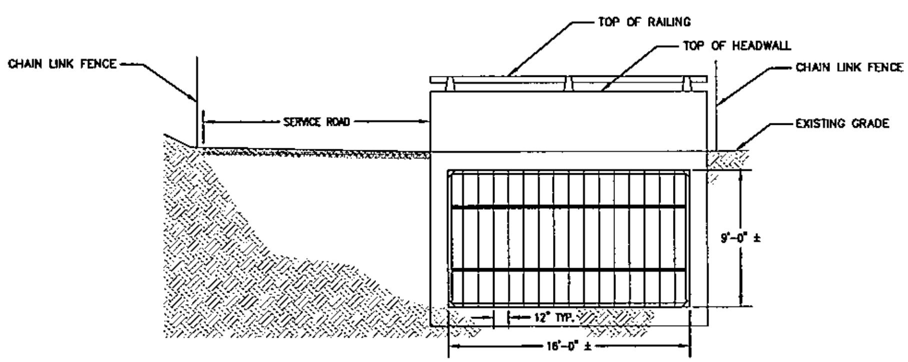


LOCATION
SCALE: 1" = 50'-0"

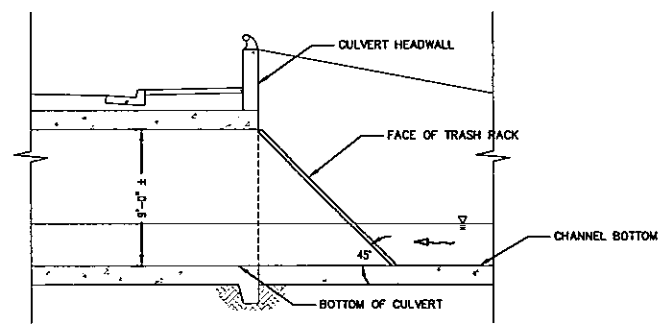
GRAPHIC SCALE
50 0 50 100
SCALE: 1"=50'



PLAN VIEW
SCALE: 3/16" = 1'-0"



1 C-12 SECTION
SCALE: 1/4" = 1'-0"



2 C-12 LONGITUDINAL PROFILE
SCALE: 1/4" = 1'-0"

NOTE:
DIMENSIONS ARE APPROXIMATE AS THE SUBDIVISION PLANS WERE ACQUIRED FROM THE CITY AND COUNTY OF HONOLULU'S MICROFILM FILES. CONTRACTOR SHALL VERIFY ALL DIMENSIONS PRIOR TO INSTALLING THE TRASH RACK SYSTEMS.

REVISION	DATE	DESCRIPTION	MADE BY	APPROVED

DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU

STORM DRAINAGE BMPS IN THE VICINITY OF KAELEPULU POND

INSTALLATION DETAIL - TRASH RACK SYSTEM 5

DESIGN:	APPROVED:	DWG. NO. C-11
DRAWN: NN		SHEET 12
CHECKED:		OF XX SHEETS
DATE: AUGUST 2010		
PROJECT NO. XX-XX	FILE — DRAW — FOLDER — NUMBER —	

4/30/12

AECOM

ENGINEER'S PRELIMINARY ESTIMATE

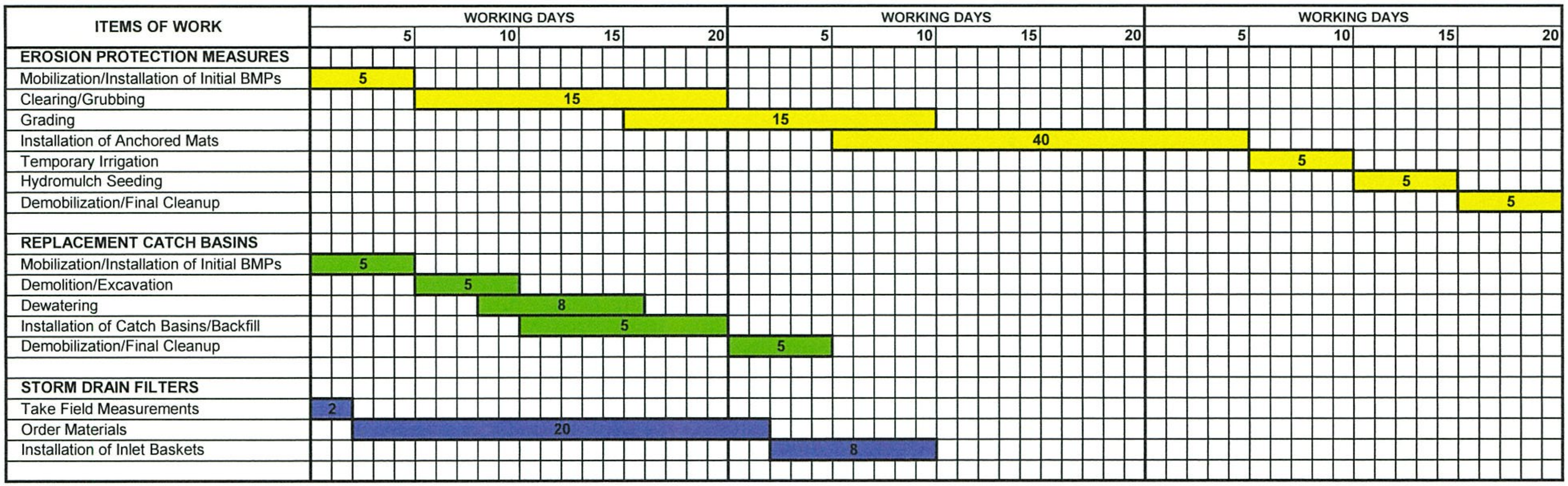
STORM DRAINAGE BMPS IN THE VICINITY OF KAELEPULU POND

ITEM NO.	ITEM	APPROXIMATE QUANTITY	UNIT	UNIT PRICE	AMOUNT
1	Mobilization and Demobilization (10%)	1	LS	$95,000.00	$95,000.00
2	Construction Barricades and Traffic Control	1	LS	$7,500.00	$7,500.00
3	Construction BMPs (Installation, Maintenance, Monitoring, and Removal)	1	LS	$60,000.00	$60,000.00
4	Clearing and Grubbing				
	i. Hele Channel	20,100	SF	$2.00	$40,200.00
	ii. Kamahele Ditch	10,500	SF	$2.00	$21,000.00
5	Anchored Erosion Control Mat				
	i. Hele Channel	20,100	SF	$18.00	$361,800.00
	ii. Kamahele Ditch	10,500	SF	$18.00	$189,000.00
6	Hydromulch Seeding				
	i. Hele Channel	20,100	SF	$2.60	$52,260.00
	ii. Kamahele Ditch	10,500	SF	$2.60	$27,300.00
7	Demolish and Reconstruct Existing Damaged Catch Basins				
	i. Demolition	15	CY	$300.00	$4,500.00
	ii. Dewatering	8	days	$3,000.00	$24,000.00
	iii. Excavation/Backfill	30	CY	$200.00	$6,000.00
	iv. LID Replacement Catch Basin	2	LS	$35,000.00	$70,000.00
8	Manhole Cover Restoration/Asphalt Removal	1	LS	$600.00	$600.00
9	Bio Clean Curb Inlet Baskets				
	i. Type "A" Catch Basins	20	EA	$2,700.00	$54,000.00
	ii. Type "B" Catch Basins	8	EA	$2,700.00	$21,600.00
	iii. Type "C" Catch Basins	1	EA	$3,200.00	$3,200.00
	iv. Type "F" Catch Basins	2	EA	$2,700.00	$5,400.00
	Sub-Total				$1,043,360.00
	Contingencies (@ 15%)				$156,504.00
	Total Construction Cost				$1,199,864.00
				Rounded	**$1,200,000.00**

CONSTRUCTION TIME CALCULATIONS

PROJECT: STORM DRAINAGE BMPS IN THE VICINITY OF KAELEPULU POND

PROJECT NO.:



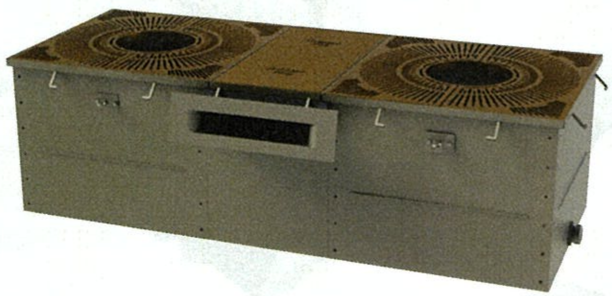
TREEPOD® Biofilter

Cost Saving Design

The TREEPOD® offers flexible and economical designs that simplify the design and construction of your storm drain system. One piece construction of durable precast concrete assures ease of installation and a long service life. The unique TREEPOD® pre-filtration chamber extends maintenance intervals and helps assure peak filter performance.

Materials Options for the TREEPOD® Biofilter

To further enhance the ease of handling and installation, TREEPOD® is also available in metal and fiberglass designs.



Contact us today to learn more about this exciting system.

1-800-579-8819

Visit our web site at: www.kristar.com

KriStar Enterprises, Inc.
360 Sutton Place
Santa Rosa, CA 95407
PH: 800-579-8819
FAX: 707-524-8186
www.kristar.com

TREEPOD® Biofilter

Sustainable Low Impact Design (LID) For Stormwater Management

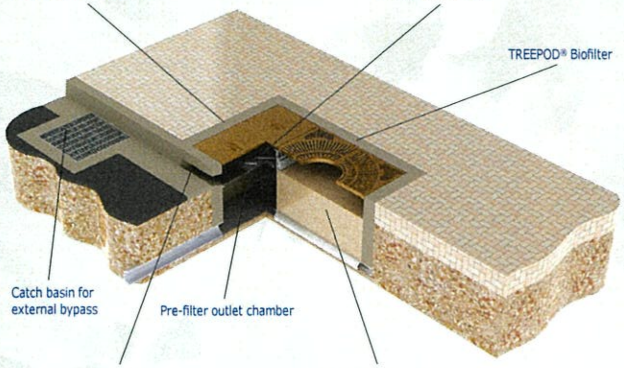
• Bioretention With Pre-filtration •
• Enhanced Filtration (Ultra-fine Sediment, Dissolved Pollutants) •
• LEED Points •

Bioretention
The TREEPOD® Biofilter uses conventional tree box filter design criteria that has proven to be effective at the removal of ultra-fine and dissolved pollutants normally found in storm water runoff.

Pre-Filtration Chamber
Pre-filtration chamber separates and retains gross pollutants such as trash, debris and coarse sediments – pollutants known to reduce efficiency and increase maintenance frequency of typical tree box filters. Collected gross pollutants are removed from the pre-filtration chamber through the maintenance access cover, without disturbing the bioretention area.

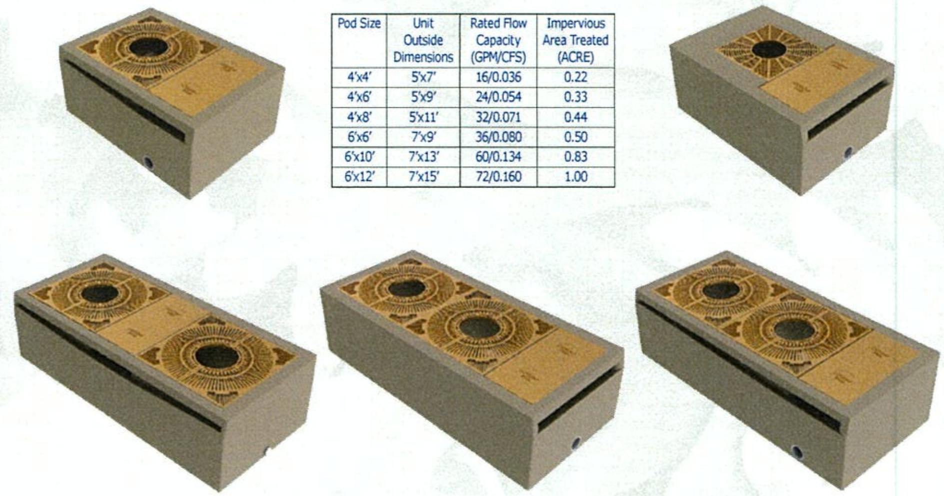
High Flow Bypass
The TREEPOD® system is designed to be used in conjunction with a standard drainage inlet to accommodate peak flow or may be specified with an optional internal high flow bypass, eliminating the need for a separate bypass structure.

Adds LEED® to Enhance Your Project/Design
Earn LEED for:
Sustainable Sites (6.1, 6.2)
Water Efficiency (1.1, 1.2, 3.1, 3.2)
Materials and Resourses (4.1, 4.2; 5.1, 5.2 in AZ, CA, NV, UT)



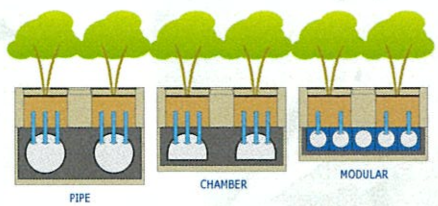
TREEPOD® Biofilter Size and Capacity
TREEPOD® is available in standard sizes and shapes to meet most site requirements. Contact your local Kristar representative for custom sizing.

Pod Size	Unit Outside Dimensions	Rated Flow Capacity (GPM/CFS)	Impervious Area Treated (ACRE)
4'x4'	5'x7'	16/0.036	0.22
4'x6'	5'x9'	24/0.054	0.33
4'x8'	5'x11'	32/0.071	0.44
6'x6'	7'x9'	36/0.080	0.50
6'x10'	7'x13'	60/0.134	0.83
6'x12'	7'x15'	72/0.160	1.00



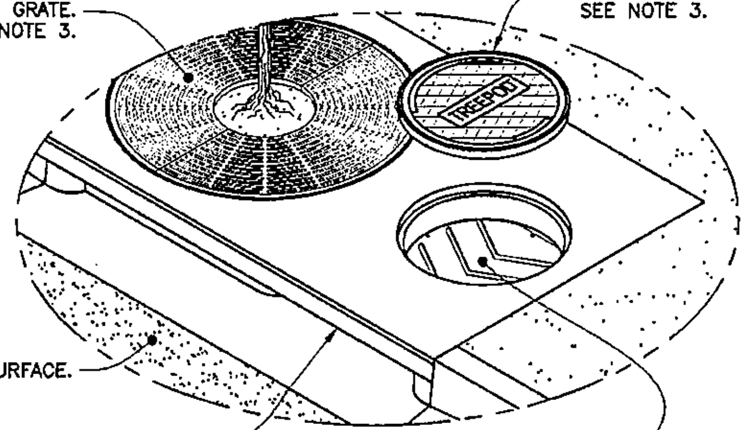
Hydromodification
The TREEPOD® Biofilter system may be used in conjunction with all storm water storage systems (pipe, chamber or modular) to address site hydromodification and water quality. Treated flows may be collected, stored or infiltrated to help meet the most challenging design criteria.

Collected flows may be utilized to supplement irrigation of the TREEPOD® or surrounding vegetated areas through active or passive means, reducing demands on local water supplies.

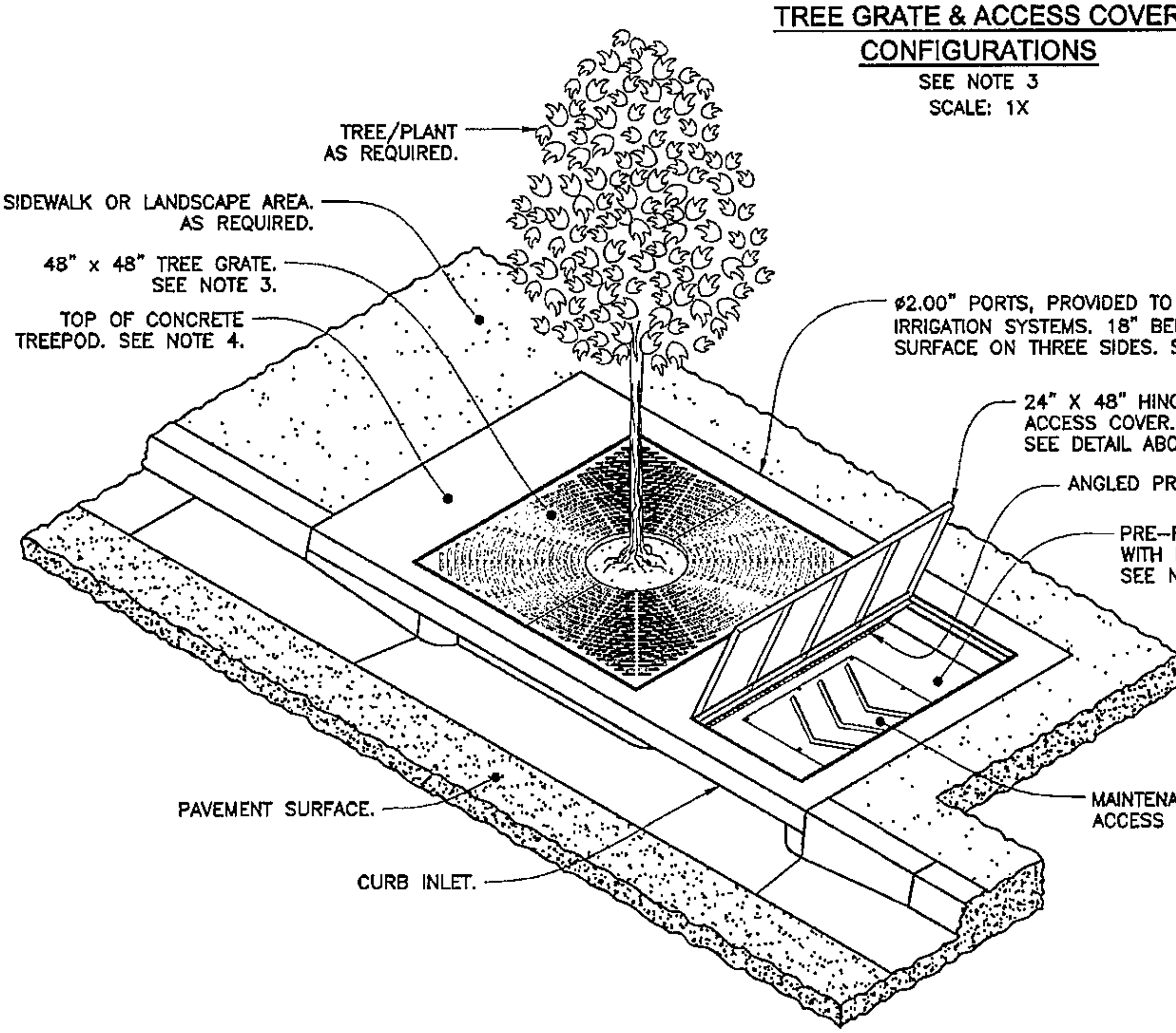


TREEPOD® Biofilter

TPB-IB-0002



ALTERNATE
TREE GRATE & ACCESS COVER
CONFIGURATIONS
SEE NOTE 3
SCALE: 1X



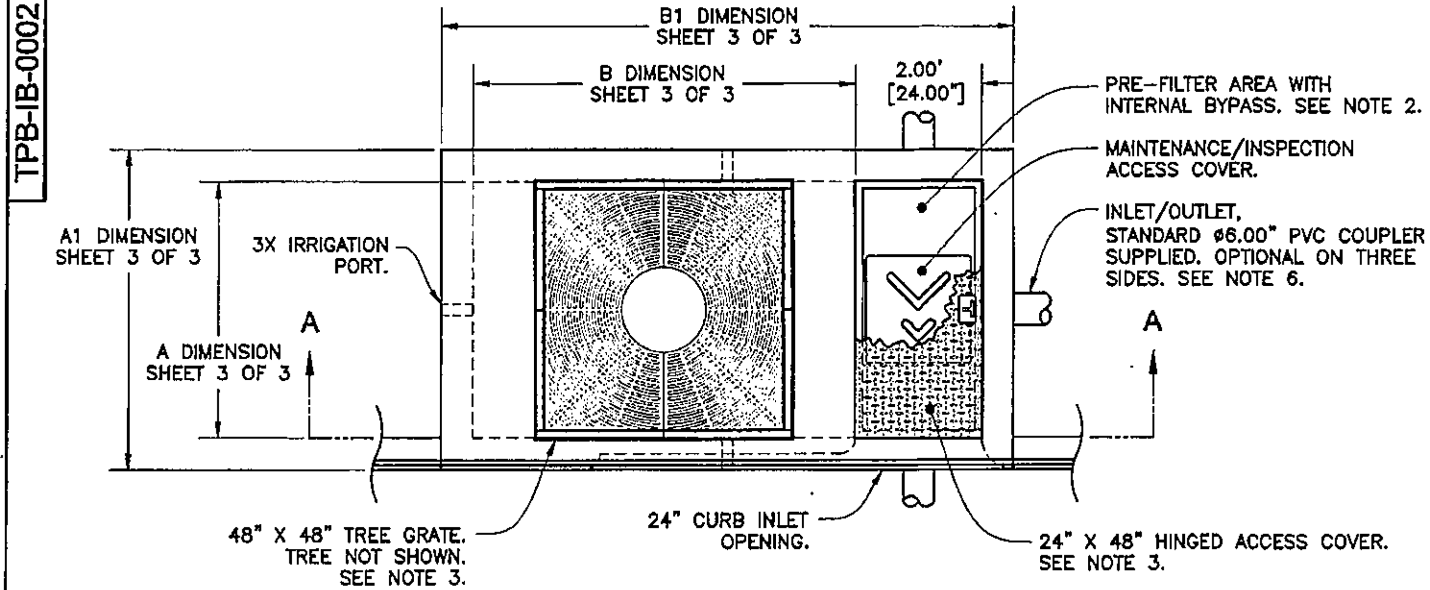
SEE SHEET 3 OF 3 FOR NOTES, SPECIFICATIONS & CAPACITIES.

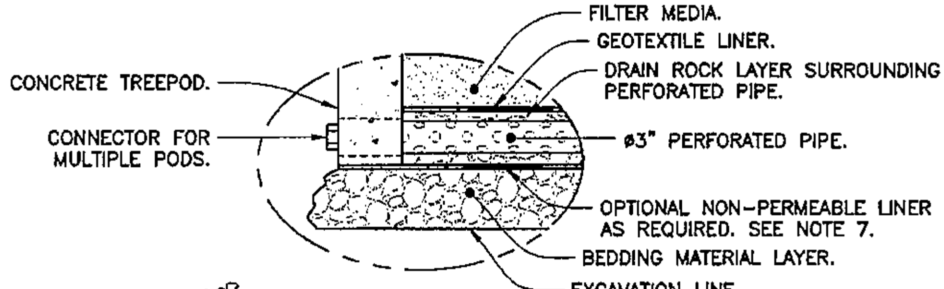
TREEPOD™ Biofilter
with Internal Bypass
(Side Inlet Version)

US PATENT

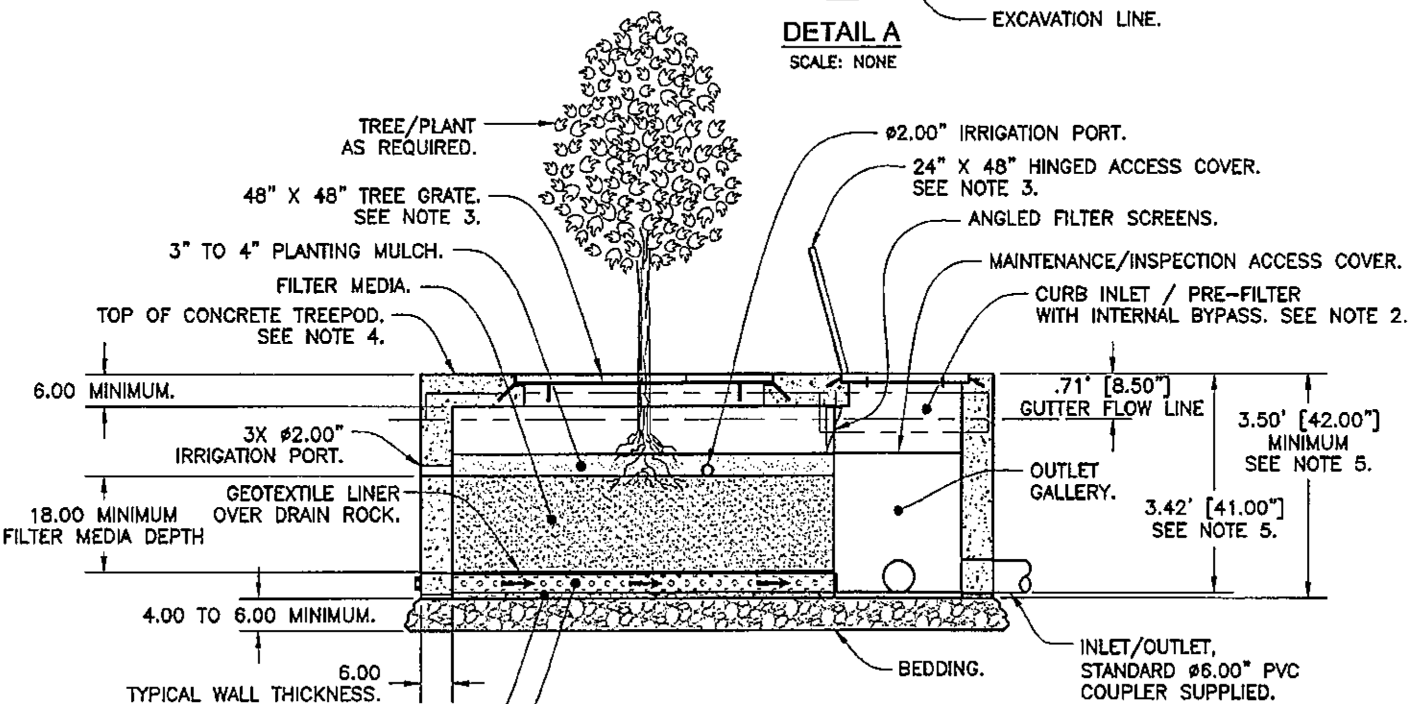
KriStar Enterprises, Inc.
360 Sutton Place, Santa Rosa, CA 95407
Ph: 800.579.8819, Fax: 707.524.8186, www.kristar.com

DRAWING NO.	REV	ECO	DATE	
TPB-IB-0002	B	ECO-0069 JPR 7/26/10	JPR 3/13/09	SHEET 1 OF 3





DETAIL A
SCALE: NONE



SECTION A-A
SCALE: 1X

SEE SHEET 3 OF 3 FOR NOTES, SPECIFICATIONS & CAPACITIES.

US PATENT

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DRAWING NO.	REV	ECO	DATE	
TPB-IB-0002	B	ECO-0069 JPR 7/26/10	JPR 3/13/09	SHEET 2 OF 3

TABULATION									
POD SIZE		FOOT PRINT (OD)		TREE / GRATE QUANTITY SEE NOTE X	RATED FLOW CAPACITY (GPM / CFS)	MAX. DRAINAGE AREA TREATED [1] (ACRE)	MAX. DRAINAGE AREA TREATED [2] (ACRE)	MAX. DRAINAGE AREA TREATED [3] (ACRE)	MAX. DRAINAGE AREA TREATED [4] (ACRE)
A DIM	B DIM	A1 DIM	B1 DIM						
4'	4'	5'	7'	1 EA	16 / 0.036	0.18	0.22	0.30	0.44
4'	5'	5'	8'	1 EA	20 / 0.045	0.23	0.28	0.38	0.56
4'	6'	5'	9'	1 EA	24 / 0.054	0.27	0.33	0.44	0.67
4'	7'	5'	10'	1 EA	28 / 0.062	0.31	0.39	0.52	0.78
4'	8'	5'	11'	1 EA	32 / 0.071	0.36	0.44	0.59	0.89
4'	9'	5'	12'	1 EA	36 / 0.080	0.40	0.50	0.67	1.00
4'	10'	5'	13'	1 EA	40 / 0.089	0.45	0.56	0.74	1.11
4'	11'	5'	14'	2 (MAX)	44 / 0.098	0.49	0.61	0.82	1.23
4'	12'	5'	15'	2 (MAX)	48 / 0.11	0.55	0.69	0.92	1.38
5'	4'	6'	7'	1 EA	20 / 0.045	0.23	0.28	0.38	0.56
5'	5'	6'	8'	1 EA	25 / 0.056	0.28	0.35	0.47	0.70
5'	6'	6'	9'	1 EA	30 / 0.067	0.34	0.42	0.56	0.84
5'	7'	6'	10'	1 EA	35 / 0.078	0.39	0.49	0.65	0.98
5'	8'	6'	11'	1 EA	40 / 0.089	0.49	0.61	0.82	1.23
5'	9'	6'	12'	1 EA	45 / 0.10	0.50	0.63	0.83	1.25
5'	10'	6'	13'	1 EA	50 / 0.111	0.55	0.70	0.93	1.39
5'	11'	6'	14'	2 (MAX)	55 / 0.123	0.62	0.77	1.03	1.54
5'	12'	6'	15'	2 (MAX)	60 / 0.133	0.67	0.83	1.11	1.66
6'	4'	7'	7'	1 EA	24 / 0.054	0.27	0.33	0.44	0.67
6'	5'	7'	8'	1 EA	30 / 0.067	0.34	0.42	0.56	0.84
6'	6'	7'	9'	1 EA	36 / 0.080	0.40	0.50	0.67	1.00
6'	7'	7'	10'	1 EA	42 / 0.094	0.47	0.59	0.78	1.18
6'	8'	7'	11'	1 EA	48 / 0.11	0.55	0.69	0.92	1.38
6'	9'	7'	12'	1 EA	54 / 0.12	0.60	0.75	1.00	1.50
6'	10'	7'	13'	1 EA	60 / 0.134	0.67	0.83	1.11	1.67
6'	11'	7'	14'	2 (MAX)	66 / 0.147	0.74	0.92	1.23	1.84
6'	12'	7'	15'	2 (MAX)	72 / 0.160	0.80	1.00	1.33	2.00

[1] C = 1.00, I = 0.20 inch / hour
[2] Commercial Development where; C = 0.80, I = 0.20 inch / hour
[3] Detached Multi-Unit Residential where; C = 0.60, I = 0.20 inch / hour
[4] Suburban Residential where; C = 0.40, I = 0.20 inch / hour

C - values from San Diego County Hydrology Manual (2002)
I - values reflect Uniform Intensity Approach targeting 85%-ile storm (CASQA).

NOTES:

1. PRECAST CONCRETE TREEPOD VAULT CONFORMS TO ASTM C857 & C858.
2. FOR BYPASS FLOW RATES CONTACT KRISTAR ENTERPRISES, INC.
3. OPTIONAL ACCESS COVER & TREE GRATE CONFIGURATIONS TO MEET LOCAL AGENCY STANDARDS ARE AVAILABLE UPON REQUEST.
4. RECESSED DECKING FOR VEGETATED LANDSCAPE AREAS OR ALTERNATE FINISHED SURFACES (e.g. PAVERS, ETC.) CAN BE PROVIDED AS REQUIRED UPON REQUEST.
5. STANDARD MINIMUM STRUCTURE DEPTH IS 3.5' [42.00"], OUTLET INVERT IS SLIGHTLY LESS TO ACCOMMODATE PIPE SIZE & TYPE. FOR DEPTHS LESS THAN THE STATED MINIMUM CONTACT KRISTAR ENTERPRISES, INC. FOR ENGINEERING ASSISTANCE.
6. BOTH INLET & OUTLET PIPES CAN BE ACCOMMODATED ON THREE SIDES UNDER THE PREFILTER AREA ALLOWING JUNCTION CONNECTIONS TO BE MADE. STANDARD UNITS ARE SUPPLIED WITH ø6.00" PVC COUPLERS CAST MONOLITHIC, HOWEVER PIPE SIZES UP TO ø18" RCP CAN BE ACCOMMODATED UPON REQUEST. FOR SIZES OVER ø18.00" RCP CONTACT KRISTAR ENTERPRISES, INC. FOR ENGINEERING ASSISTANCE.
7. FOR APPLICATIONS THAT DO NOT REQUIRE INFILTRATION, A NON-PERMEABLE LINER CAN BE PLACED BETWEEN THE UNIT & BEDDING MATERIAL.

US PATENT

TREEPOD™ Biofilter

TREEPOD™ Biofilter

with Internal Bypass
(Side Inlet Version)

US PATENT

KRISTAR

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DRAWING NO.	REV	ECO	DATE	
TPB-IB-0002	B	ECO-0069 JPR 7/26/10	JPR 3/13/09	SHEET 3 OF 3

Innovative stormwater management products

FloGard®

PERK FILTER

Media Filtration Device

KRISTAR

The Perk Filter is a stormwater filtration device used to reduce pollutant loading in runoff from urban developments.

Impervious surfaces and other urban and suburban landscapes generate a variety of contaminants that can enter stormwater, polluting downstream receiving waters. The Perk Filter captures and retains sediment, oils, metals and other target constituents close to the source and reduces the total discharge load.

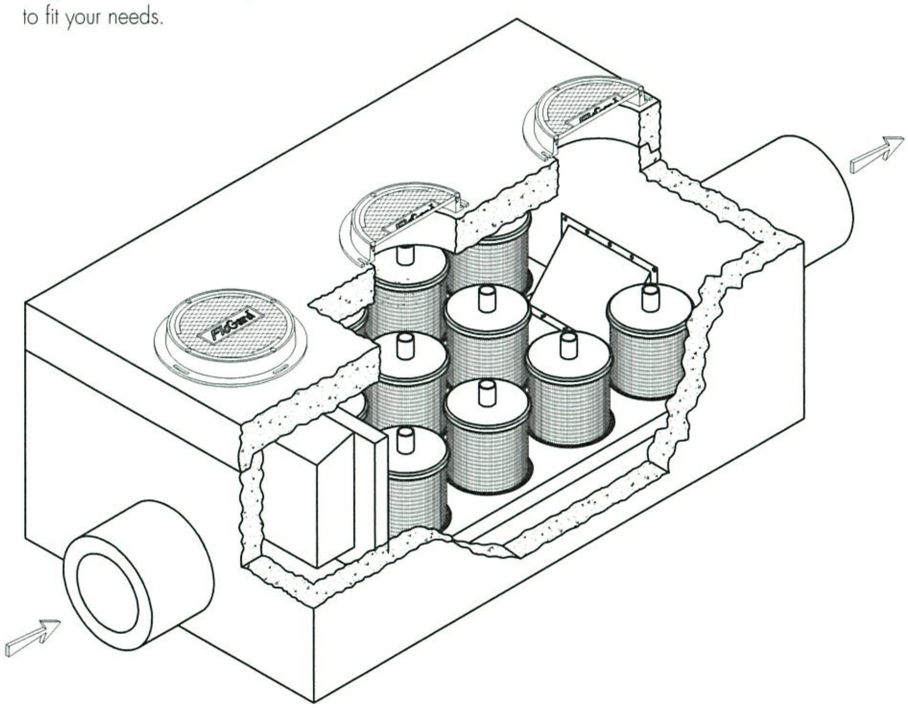
The Perk Filter cartridge is manufactured from durable polymeric components with a polymer-coated steel support screen and stainless steel hardware. Its base construction allows use with a wide variety of media chosen to address site-specific pollutants of concern.

Perk Filters may be installed as a retrofit to suitable existing catch basins, or supplied as an integral part of a coated steel- or concrete-housed system. Modular system design provides flexibility of use, ease of maintenance and economy.

Flexibility and adaptability in design makes the FloGard® PERK FILTER the right choice for any application ... small or large.

Typical Concrete Vault Configuration

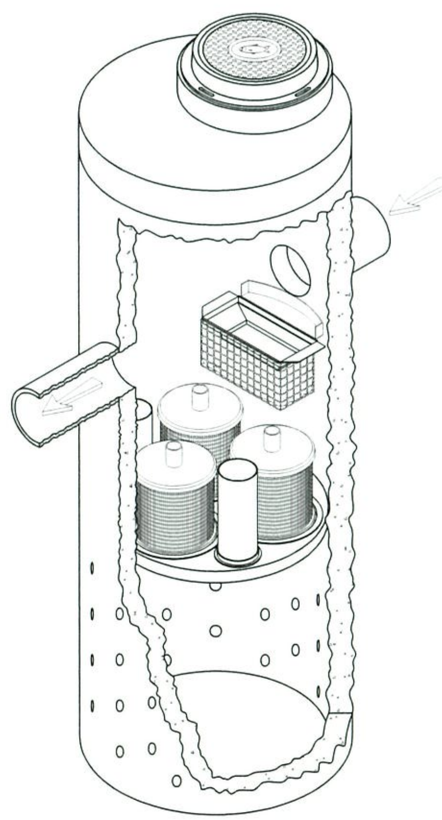
A vault configuration is applicable to installations where greater flow rates are encountered as in large drainage areas. Where depth allows FloGard® PERK FILTER cartridges may be stacked, increasing capacity without increasing the system-footprint. Other vault configurations are available to fit your needs.



Typical Manhole-Style Dry Well Pre-Filter Configuration

FloGard® PERK FILTER is the right solution for capturing pollutants that may find their way into a dry well during stormwater runoff periods. When used in conjunction with a FloGard®+PLUS pre-filter for capturing debris, a treatment train is established.

As in other applications using the FloGard® PERK FILTER, stacking is an option, increasing the flow rate capacity within the same footprint.



A shallow concrete vault configuration of three FloGard® PERK FILTER cartridges.

Typical Concrete Catch Basin Configurations

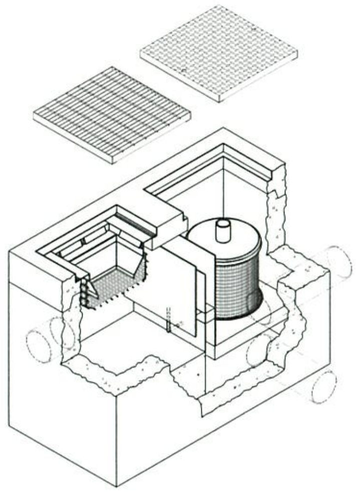
The FloGard® PERK FILTER, when placed in a catch basin, will handle small to medium filtering applications with ease. It is also possible with each configuration to double-stack the filter for increased performance capability, within the same footprint. For sites with restricted area this can be a critical feature. Plus, a smaller footprint is a less expensive installation.

Illustrated are only some of the typical FloGard® PERK FILTER configuration, with available pre-cast concrete catch basin structures. Single, double, triple and quad cartridge designs feature either end grate or bilateral configurations. Note that the grated inlet houses a FloGard®+PLUS pre-filter for capturing debris prior to entering the FloGard® PERK FILTER.

Each basin housing a FloGard® PERK FILTER is grated with a traffic-rated checker plate cover for easy access.

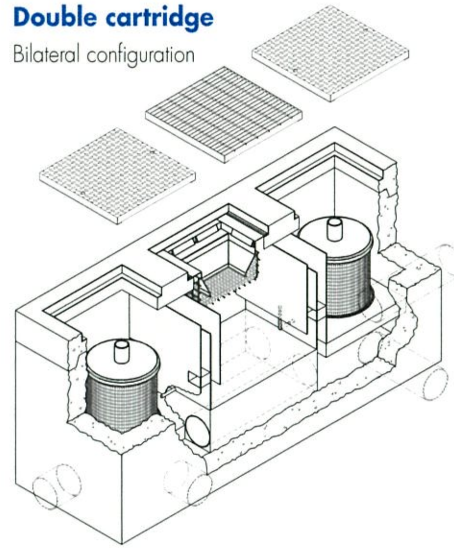
A close-up view of a single cartridge FloGard® PERK FILTER catch basin installation.

Single cartridge



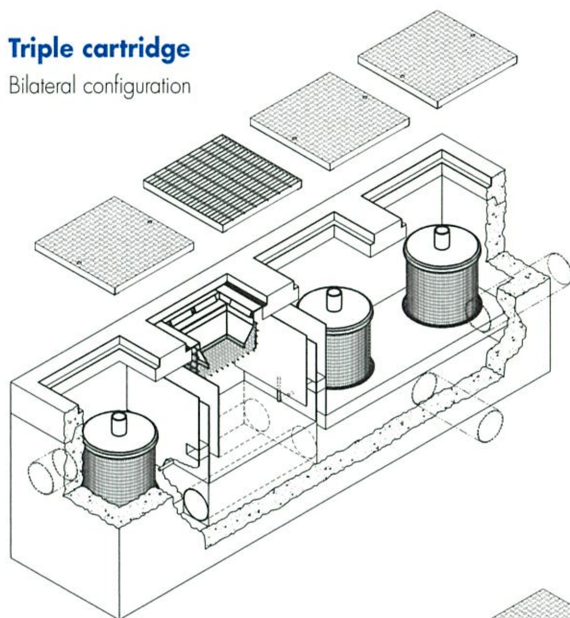
Double cartridge

Bilateral configuration



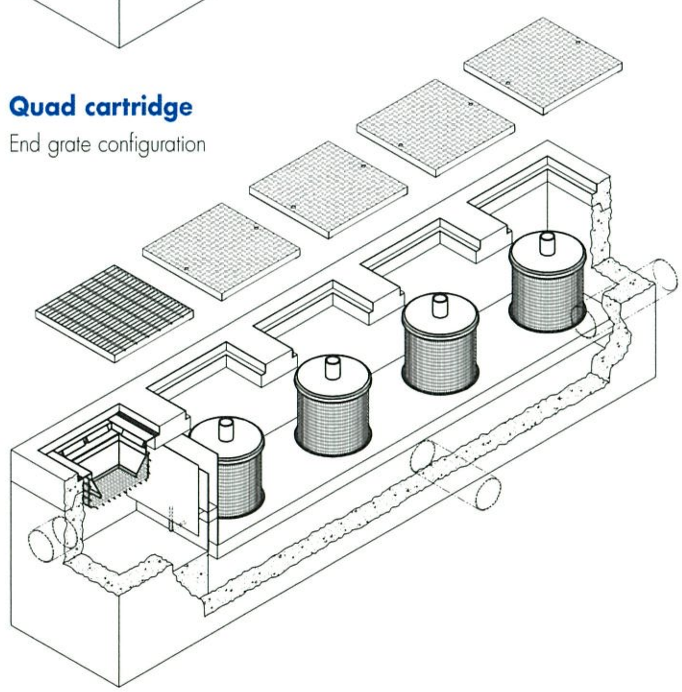
Triple cartridge

Bilateral configuration



Quad cartridge

End grate configuration



Innovative stormwater management products

FloGard® PERK FILTER

Media Filtration Device

Applications

Perk Filters can be installed in existing drop inlets of adequate depth, installed as a catch basin system at individual inlets or as a centralized modular treatment system installed either on-line or off-line. Typical installation locations include:

- Retrofits in curb, combination or flat-grated inlets
- New drop inlets in commercial, residential or industrial developments
- Pretreatment to first-flush retention/detention systems
- As a component in a treatment train

Advantages and features

- Modular, scalable design
- Widely variable media selection
- Addresses wide array of pollutants
- Highly effective media filter performance
- Easy, low cost installation and maintenance
- Various sizes available

Sizes and Properties

Cartridge Type	Diameter	Height	Dry Weight	Targeted Pollutants	Treatment Flow Capacity per Cartridge[1]
PF1812	18 in.	12 in.	30 lb.	Sediment/Oils/Metals/Others	12 gpm/0.026 cfs
PF1818	18 in.	18 in.	45 lb.	Sediment/Oils/Metals/Others	18 gpm/0.040 cfs

System Type	Steel Structure Footprint	Steel Structure Min. Height	Concrete Structure Footprint[2]	Concrete Structure Min. Height	Maximum number of Cartridge Stacks[3]
Catch Basin – Single	58.50 in. x 28.25 in.	36 in.	72 in. x 36 in.	42 in.	1
Catch Basin – Double	88.75 in. x 28.25 in.	36 in.	108 in. x 36 in.	42 in.	2
Catch Basin – Triple	117.00 in. x 28.25 in.	36 in.	144 in. x 36 in.	42 in..	3
Catch Basin – Quad	145.25 in. x 28.25 in.	36 in.	180 in. x 36 in.	42 in.	4
Vault – Type A	NA	NA	96-144 in. x 60 in.	54 in	7
Vault – Type B	NA	NA	96-144 in. x 84 in.	54 in.	11
Vault – Type C	NA	NA	96-228 in. x 108 in.	54 in.	27

Custom vault sizes and arrays may be designed to accommodate treatment flows larger than the capacity of 27-cartridge stacks

1. Design flow capacity may vary to comply with local guidelines.
2. Outside dimensions; smaller footprints may be available for lower range of cartridge stack quantity.
3. Cartridges may be double stacked to accommodate higher flow rates within each respective footprint.

Stackable cartridge for higher media volume over system surface area.

Materials

Coated steel structures are asphalt-dipped with HS-25 load-rated grates. Concrete structures are steel reinforced precast with H-20 load rated-grates. Cartridge manufactured of HDPE, PVC and stainless steel components with stainless steel hardware. Various filter media and adsorbents available for removal of specific pollutants.

Installation

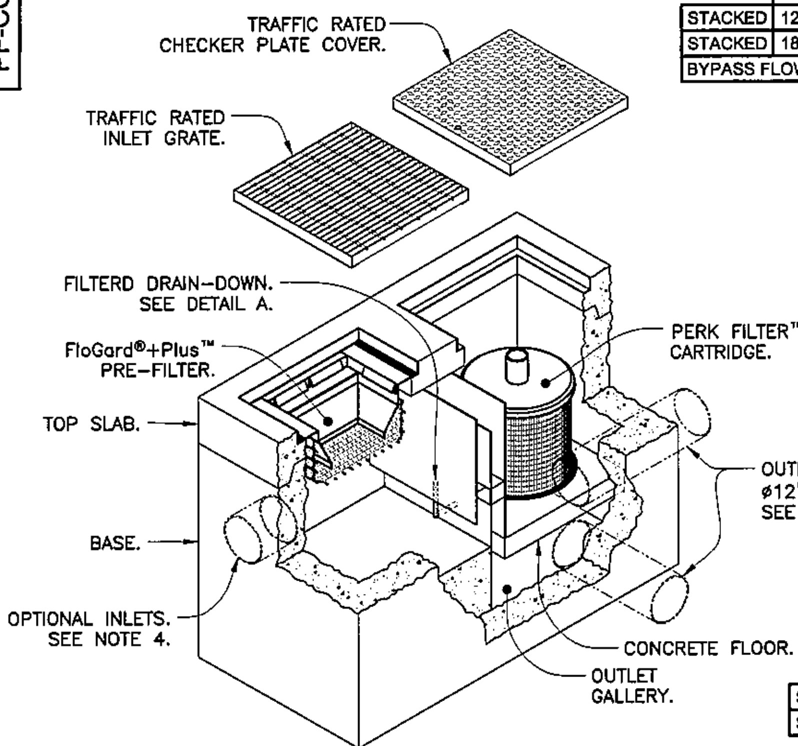
See Kristar General Installation Guidelines for more details.

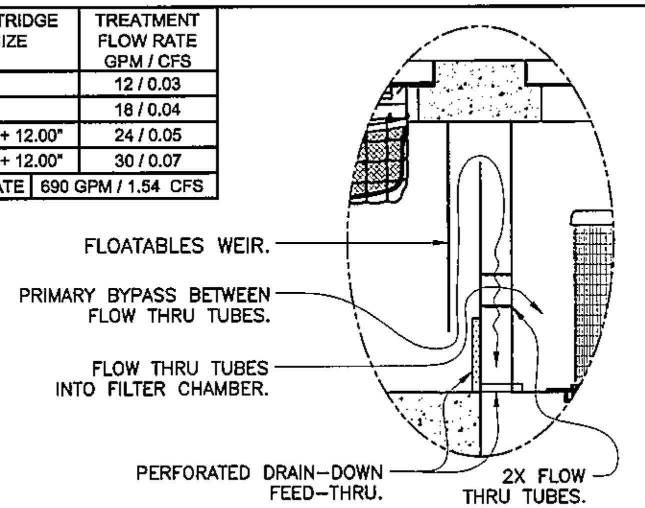
Maintenance

- Periodically remove sediment and floatables collected around cartridge and dispose of it in accordance with local agency requirements.
- Replace filter media periodically in accordance with Kristar General Maintenance Guidelines.

DISTRIBUTED BY:
KriStar Enterprises, Inc. • P.O. Box 6419 • Santa Rosa, CA 95406-1419
PH: 800-579-8819 • FAX: 707-524-8186 • **www.kristar.com**

	CARTRIDGE SIZE	TREATMENT FLOW RATE GPM / CFS
	12.00"	12 / 0.03
	18.00"	18 / 0.04
STACKED	12.00" + 12.00"	24 / 0.05
STACKED	18.00" + 12.00"	30 / 0.07
BYPASS FLOW RATE		690 GPM / 1.54 CFS





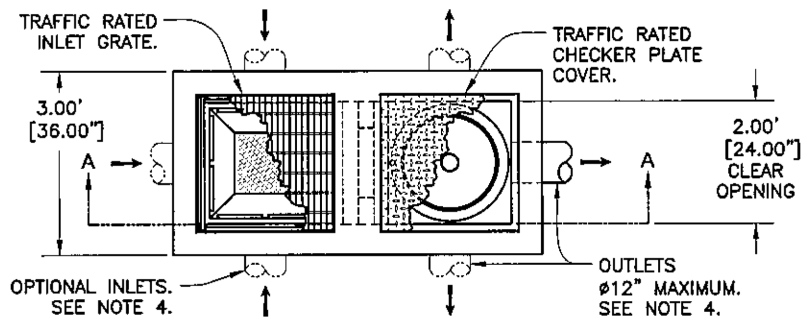
DETAIL A
INLET / BYPASS ASSEMBLY & DRAIN–DOWN SCALE: 2X

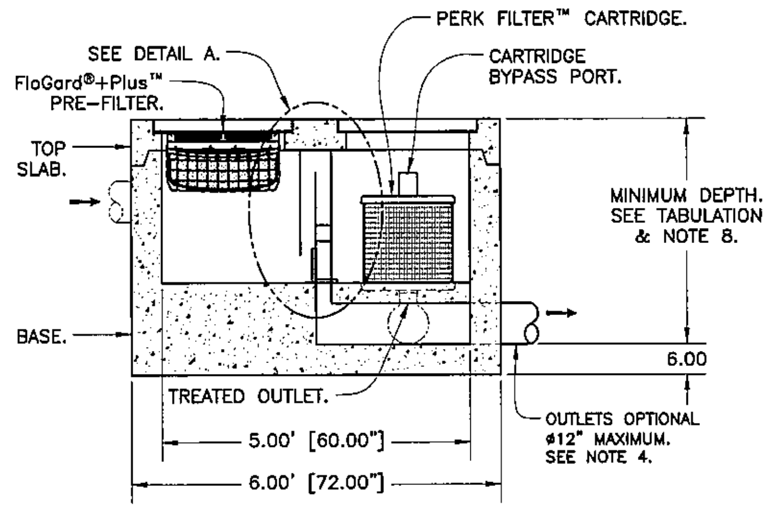
MINIMUM DEPTHS (SEE NOTE 8)

	CARTRIDGE SIZE	Ø 6.0" OUTLET PIPE (IN INCHES)	Ø 8.0" OUTLET PIPE (IN INCHES)	Ø 10.0" OUTLET PIPE (IN INCHES)	Ø 12.0" OUTLET PIPE (IN INCHES)
	12.00"	31	33	35	37
	18.00"	38	40	42	44
STACKED	12.00" + 12.00"	46	48	50	52
STACKED	18.00" + 12.00"	53	55	57	59

Notes:

1. Structure shall be pre-cast concrete (3,000 psi min), reinforced with welded wire mesh (4x4-6-6). Special reinforcing may be specified.
2. Catch basin/filter system shall be supplied with traffic rated (H20) bicycle-proof grates and checker plate cover. Cast iron grates and/or covers are available upon request.
3. All exposed steel components shall have a hot dipped galvanized finish in accordance with ASTM A-123.
4. Inlet & outlet pipe(s) (Ø 12" maximum) may enter device on all three sides of the inlet & outlet chambers respectively. For pipe sizes greater than Ø 12", contact Kristar Enterprises for engineering assistance.
5. Inlet chamber shall be supplied with drain down device, designed to remove standing water between storm events.
6. Perk-Filter catch basin/filter device shall be supplied with FloGard PLUS pre-filter device. FloGard PLUS and Perk-Filter cartridge shall be maintained in accordance with manufacturer recommendations.
7. Perk-Filter catch basin/filter assembly may be supplied with individual or multiple 18" or 12" high Perk-Filter cartridge. Filter cartridge may be stacked to accommodate higher flow rates.
8. For depths less than specified minumum contact Kristar Enterprises for engineering assistance.





SECTION A-A
SINGLE CARTRIDGE CONCRETE CATCH BASIN

TITLE
FloGard® Perk Filter™
CONCRETE CATCH BASIN
- SINGLE CARTRIDGE -

KriStar Enterprises, Inc.
360 Sutton Place, Santa Rosa, CA 95407
Ph: 800.579.8819, Fax: 707.524.8186, www.kristar.com

DRAWING NO.	REV	ECO	DATE	
PF-CCB-0001	C	0060 JPR 1/28/09	JPR 6/4/08	SHEET 1 OF 1

City and County of Honolulu
Department of Environmental Services

Drainage Report

Storm Drainage BMPs
In the Vicinity of Kaelepulu Pond

Kailua, Oahu, Hawaii

Contract No. F-33975(D)

Prepared by:

AECOM
1001 Bishop Street, Suite 1600
Honolulu, Hawaii 96813

October 2010

TABLE OF CONTENTS

APPENDICES

1.0 INTRODUCTION

The project is located in the Enchanted Lakes community in Kailua, Oahu, Hawaii. The intent of this project is to reduce the amount of pollutants currently being discharged into Kaelepulu Pond through the City & County of Honolulu's storm drainage system. The scope of work involves the design of structural and non-structural BMP improvements for the City's storm drainage system. The proposed BMPs were based on the recommendations presented in the preliminary planning study titled, "Storm Water Best Management Practices (BMP) Plan for Four Major Outlets at Kaelepulu Pond", November 2008. A brief summary of the proposed BMP measures are outlined below:

- Bio Clean Nutrient Separating Baffle Box (NSBB) for the Hele Channel
- Hydrothane High Density Polyethylene trash racks at 5 drainage channel locations
- Bio Clean pre-manufactured catch basin filters at various curb inlets
- Non-structural erosion control measures for the Kamahele Ditch and Hele Channel

Hydraulic analyses are essential in determining whether or not the existing drainage system will have adequate capacity to support the proposed changes. The following drainage report describes the hydraulic analysis that was performed at the proposed location of the NSBB device in the Hele Channel. Additionally, preliminary hydraulic analyses were performed at each of the 5 trash rack locations, and are also detailed in this report. However, no hydraulic calculations were performed at the locations of the catch basin filters or the erosion control mats.

2.0 BIO CLEAN NUTRIENT SEPARATING BAFFLE BOX

2.1 EXISTING CONDITIONS

The proposed location for the NSBB device is in the Hele Channel just downstream of the Keolu Street culvert crossing. The existing Hele Channel has a concrete-lined bottom and concrete rubble masonry (CRM) walls. The channel dimensions vary from about 17 ft to 22 ft in width and the channel invert has an average slope of about 0.5%. Channel walls range in height from about 4'-8" to about 5'-8". The contributing drainage area at the proposed BMP location is approximately 280 acres.

Storm water is conveyed along the Hele Channel under Keolu Drive through two side-by-side box culverts measuring 13 ft wide and 10 ft wide. Photo 2-1 shows the downstream end of the Keolu Street culverts, at the location of the proposed BMP.

Photo 2-1 – Downstream of the Keolu Street Hele Channel culverts; proposed BMP location.

A topographic survey was performed at the proposed location of the Hele Channel BMP (see Appendix A for details). The survey extended from about 230 ft downstream of Keolu Street, and about 100 ft upstream. Supplemental field measurements were taken to about 400 ft upstream of the culvert opening. Additional information was obtained through research of the City's record design documents and with assistance from the Department of Design and Construction, Civil Division, Drainage Section (see Figure 2-1 and Appendix A).

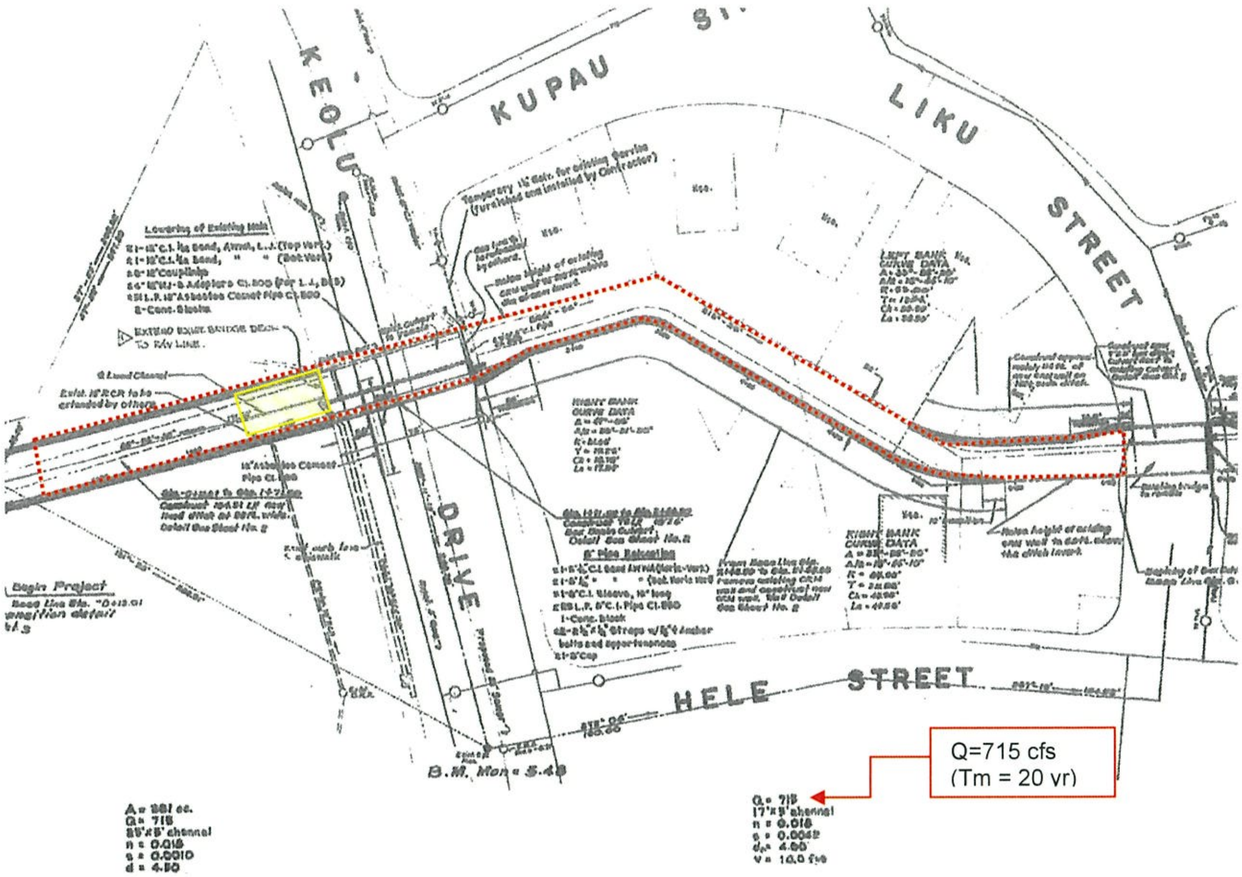


Figure 2-1 – Hele Channel Record Drawing; Proposed BMP location highlighted yellow

2.2 APPROACH

Hydrological data used for the model was obtained from record design documents. The documents showed that the existing channel was designed for a flow of 715 cfs, 20 year storm event (t_m) (see Figure 2-1 and Appendix A).

Hydraulic modeling was performed using HEC-RAS 4.1, a hydraulic modeling software program. HEC-RAS was developed by the United States Army Corps of Engineers and is designed to perform one-dimensional hydraulic calculations for natural and constructed open channels. The limits of the model extended from about 400 ft upstream of the proposed BMP location to about 200 ft downstream (see Figure 2-2). Spatial data was selected from the available record documents, topographic survey map, and field measurements. The storm flow used for the model was 715 cfs (20-year storm event). The effects of tidal influx were neglected for this model.

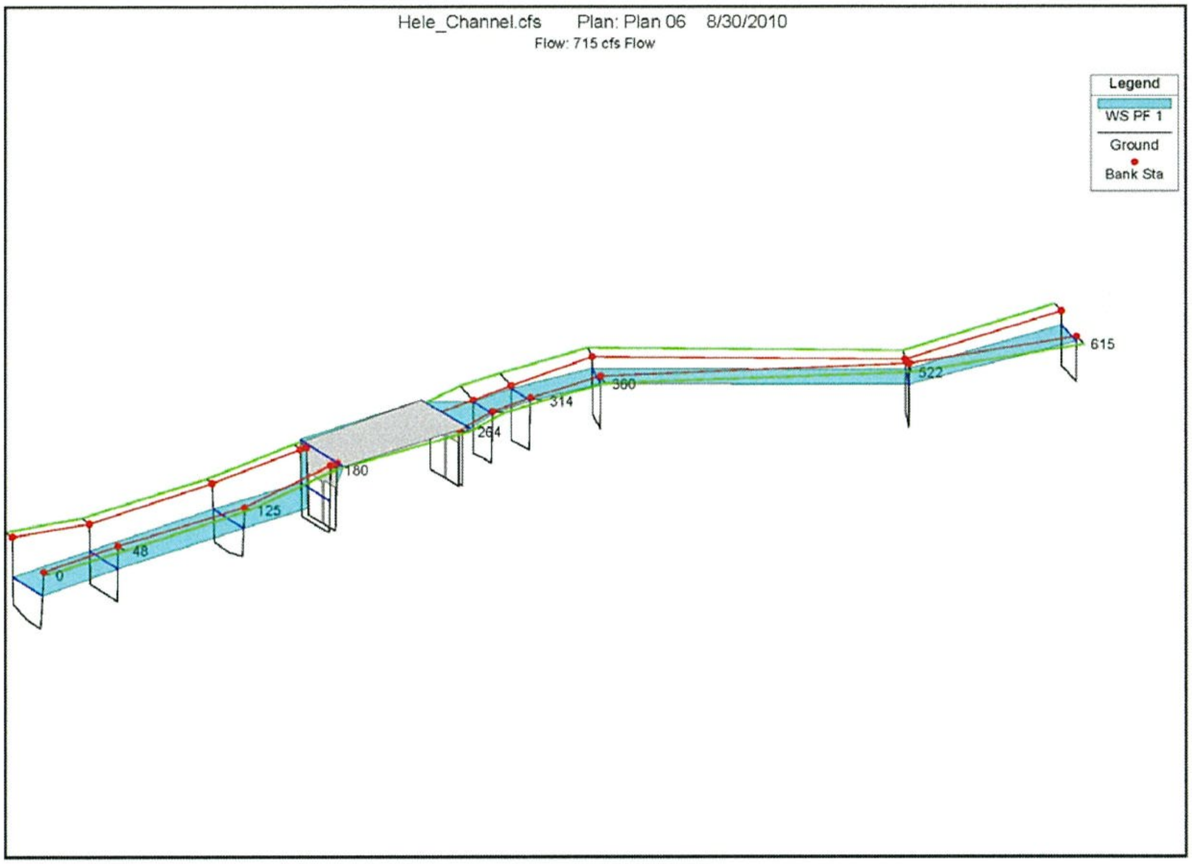


Figure 2-2 – Hydraulic computer model; normal water surface is shown in blue.

The minimum freeboard was calculated according to the City & County Rules Relating to Storm Drainage Standards, 2000.

$$F = 2.0 + 0.025 \times V \times D^{1/3}$$

Where: F = Minimum Freeboard (ft)

V = Velocity (ft/s)

D = Normal Depth (ft)

2.3 Results

The results of the hydraulic analysis at the proposed BMP location are presented in the following table. Results at other locations within the limits of the HEC-RAS model can be found in Appendix A.

Table 2-1

	HEC-RAS Model	*Design Information*
Flow (Q)	715 cfs	715 cfs
Normal Depth (D)	2.94 ft	4.50 ft
Total Channel Depth	4.84 ft ±	
Velocity (V)	9.37 ft/s	6.48 ft/s
Available Freeboard	1.9 ft	
Minimum Freeboard (per C&C Std.)	2.33 ft	

The minimum freeboard at the proposed BMP location was calculated as follows:

$$F = 2.0 + 0.025 \times 9.37 \times 2.94^{1/3} = \underline{2.33\ \text{ft}}$$

The computer model also revealed overtopping conditions near the culvert entrance upstream of the proposed BMP location. This condition was illustrated in Figure 2-2 and in the detailed cross section presented in Appendix A (see River Station, RS = 264).

During the historic March 2006 storm event, it was reported that storm water overtopped the channel sides at the culvert structure and flooded the adjacent 76 Gas Station to a depth of about 1 ft (report titled "*Water Quality in Kaelepulu Pond*", 2006). This account confirms the probability of overtopping at this location in the event of heavy rain.

2.4 Conclusion

The following conclusions were made based on the hydraulic analysis of the Hele Channel:

- The existing channel was designed for a 20-year recurrence interval. The current design standards require a 100-year recurrence interval for areas greater than 100 acres. Hence, the channel was under-designed per the current drainage standards.
- The minimum required freeboard per the current City standard was calculated to be 2.33 ft. The available freeboard at the proposed BMP location was only 1.9 ft (for Q=715 cfs, t_m = 20

yr). Therefore, the channel does not have adequate freeboard for a 20-year storm event per the current drainage standards.

- The HEC-RAS computer model displayed overtopping at the Keolu Street culverts. Eye-witness accounts also reported the channel being overtopped during the historic March 2006 storm event.
- The proposed Bio Clean NSBB BMP could affect the channel hydraulics by reducing the freeboard and potentially worsen existing overtopping conditions at the culverts.
- Based on this report, the proposed Bio Clean NSBB BMP is not recommended at the proposed location.

3.0 TRASH RACKS

3.1 Existing Conditions

Trash racks were proposed at 5 locations, as shown by the site plan in Appendix B. The proposed location for Trash Rack No. 1 was in the Hele Channel at the Akumu Street culvert crossing. The proposed locations for Trash Racks No. 2 and No. 3 were in the Alahaki Ditch at the Akumu Street and Kahili Street culvert crossings, respectively. The proposed location for Trash Rack No. 4 was in the Keolu Lined Channel near Akumu Street. The proposed location for Trash Rack No. 5 was in the Akipola Lined Channel at the Keolu Street culvert crossing.

3.2 Approach

Hydrological data was obtained from record design documents for each of the 5 proposed trash rack locations.

Hydraulic calculations were performed using Bentley's FlowMaster and CulvertMaster, computer software programs used for modeling one-dimensional flow. Details of the channel and culvert sections such as slope, width, Manning's "n", and flow were entered into the program. The program calculated the normal depths and velocities at each location from the given information.

The minimum freeboard was calculated according to the City & County Rules Relating to Storm Drainage Standards, 2000.

$$F = 2.0 + 0.025 \times V \times D^{1/3}$$

3.3 Results

Record design documents of the existing drainage infrastructure at each of the proposed trash rack locations were obtained from the City's archives (see Appendix B). The record documents confirmed that the calculated discharge quantities were out-dated and understated per the current drainage standards. New discharge quantities were estimated for each location based on the current storm interval requirement (see Appendix B for details). Table 3-1 shows a summary of the record discharge values versus the new discharge values.

Table 3-1

Trash Rack No.	*Area (A)*	*Record Design Data*		*New Design Data*	
		Interval (T_m)	*Flow (Q)*	*Interval (T_m)*	*Flow (Q)*
1	289 ac	20 yr	837 cfs	100 yr	1288 cfs
2	87 ac	20 yr	381 cfs	50 yr	440 cfs
3	49 ac	20 yr	287 cfs	50 yr	331 cfs
4	>100 ac	50 yr	2865 cfs	100 yr	3820 cfs
5	116 ac	50 yr	1200 cfs	100 yr	1600 cfs

Hydraulic calculations were performed with Bentley's FlowMaster and CulvertMaster, using the existing channel and culvert geometries and the new discharge quantities. The results of the hydraulic analyses at each of the 5 proposed trash rack locations are presented in Table 3-2. Calculations and descriptive details are presented in Appendix B.

Table 3-2

	Trash Rack No. 1	*Trash Rack No. 2*	*Trash Rack No. 3*	*Trash Rack No. 4*	*Trash Rack No. 5*
Flow (Q)	1288 cfs	440 cfs	331 cfs	3820 cfs	1600 cfs
Velocity (V)	6.36 ft/s	2.84 ft/s	2.50 ft/s	27.1 ft/s	30.25 ft/s
Normal Depth (D_t)	8.94 ft	5.56 ft	5.22 ft	5.88 ft	6.61 ft
Channel Depth (H)	7.67 ft	7.25 ft	7.0 ft ±	8.0 ft	9.0 ft
Available Freeboard (F)	-1.27 ft	1.69 ft	1.78 ft	2.12 ft	2.39 ft
Minimum Freeboard (per C&C Std.) (F')	2.33 ft	2.13 ft	2.11 ft	3.22 ft	3.42 ft

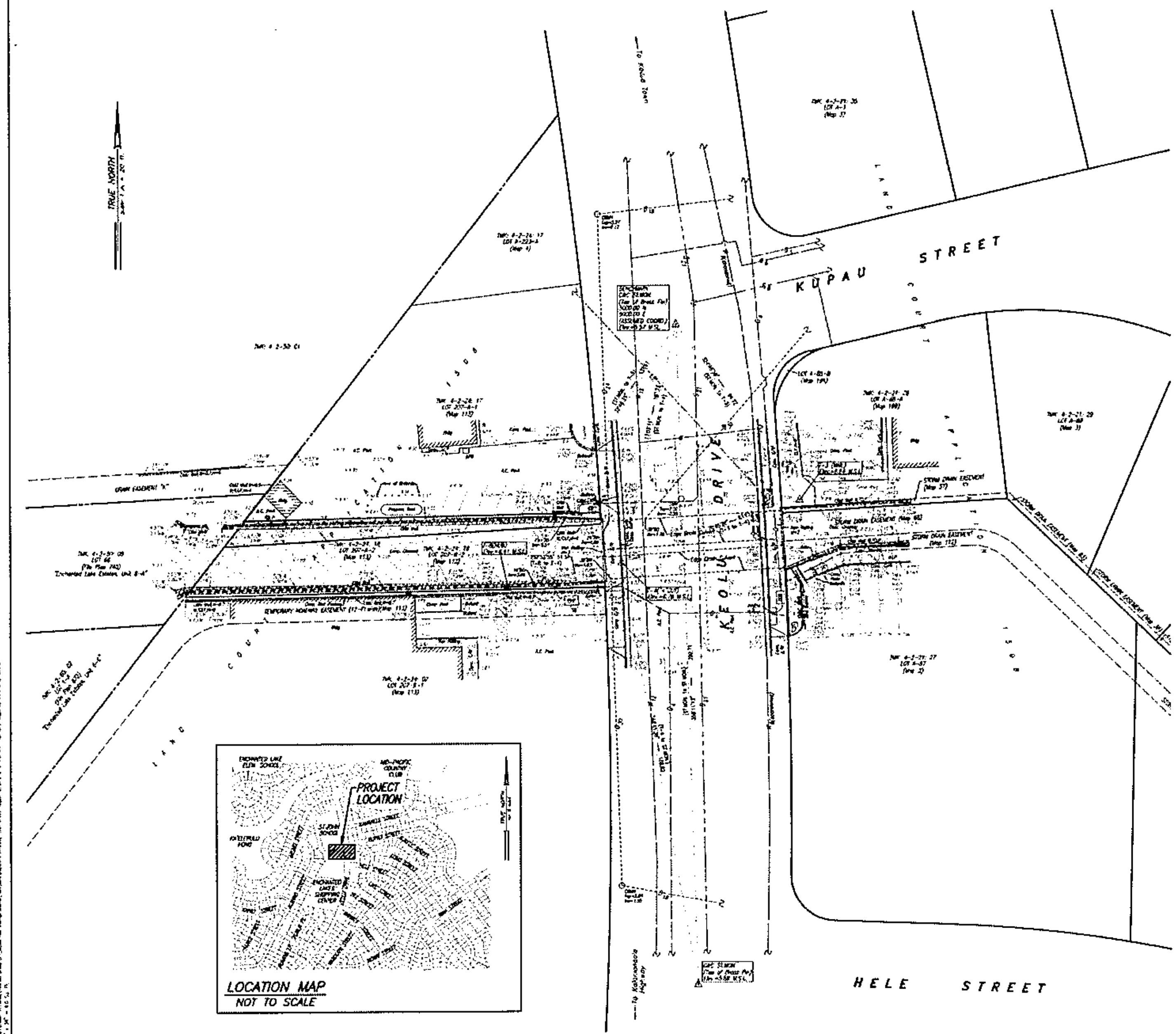
3.4 Conclusion

Preliminary hydraulic analyses of the existing drainage infrastructures concluded that the channels and culverts were under-designed per the current drainage standards for all 5 trash rack locations. It is anticipated that installing any type of trash rack screening would adversely alter existing channel hydraulics. Structural additions to the channels, such as trash rack installations, are not recommended at the locations analyzed.

4.0 REFERENCES

- *Rules Relating to Storm Drainage Standards*, Department of Planning and Permitting City & County of Honolulu, January 2000.
- *HEC-RAS River Analysis System Applications Guide*, Version 4.1, January 2010
- *Portion of Hele Drainage Channel,* Topographic Survey Map, AECOM, Inc., July 12, 2010
- *Water Quality in Kaelepulu Pond, Results and Summary of Sampling from Five Storms,* R.E. Bourke, June 2006
- *Storm Water Best Management Practices (BMP) Plan for Four Major Outlets at Kaelepulu Pond,* City & County of Honolulu Department of Environmental Services, November 2008.
- *Job No. 15-65 Keolu Hills Flood Control Unit III, Kailua, Koolaupoko, Oahu*, City & County of Honolulu Department of Public Works, 1963
- *Enchanted Lake Estates, Unit - Six A, Kaelepulu, Koolaupoko, Oahu,* Island Construction Company, 1960
- *Enchanted Lake Estates, Unit - Six B, Kaelepulu, Koolaupoko, Oahu,* Island Construction Company, 1961
- *Kaopa Subdivision Unit 1-B1, Kailua, Koolaupoko, Oahu,* Island Construction Company, 1972
- *Kaopa Subdivision Unit Two, Kailua, Koolaupoko, Oahu,* Island Construction Company, 1971

Appendix A
NSBB Calculations and Reference Documents



TOPOGRAPHIC SURVEY

PORTION HELE DRAINAGE CHANNEL
PORTION LAND COURT APPLICATION 1508
AND PORTION FILE PLAN 750
ENCHANTED LAKE ESTATES, UNIT 6-A

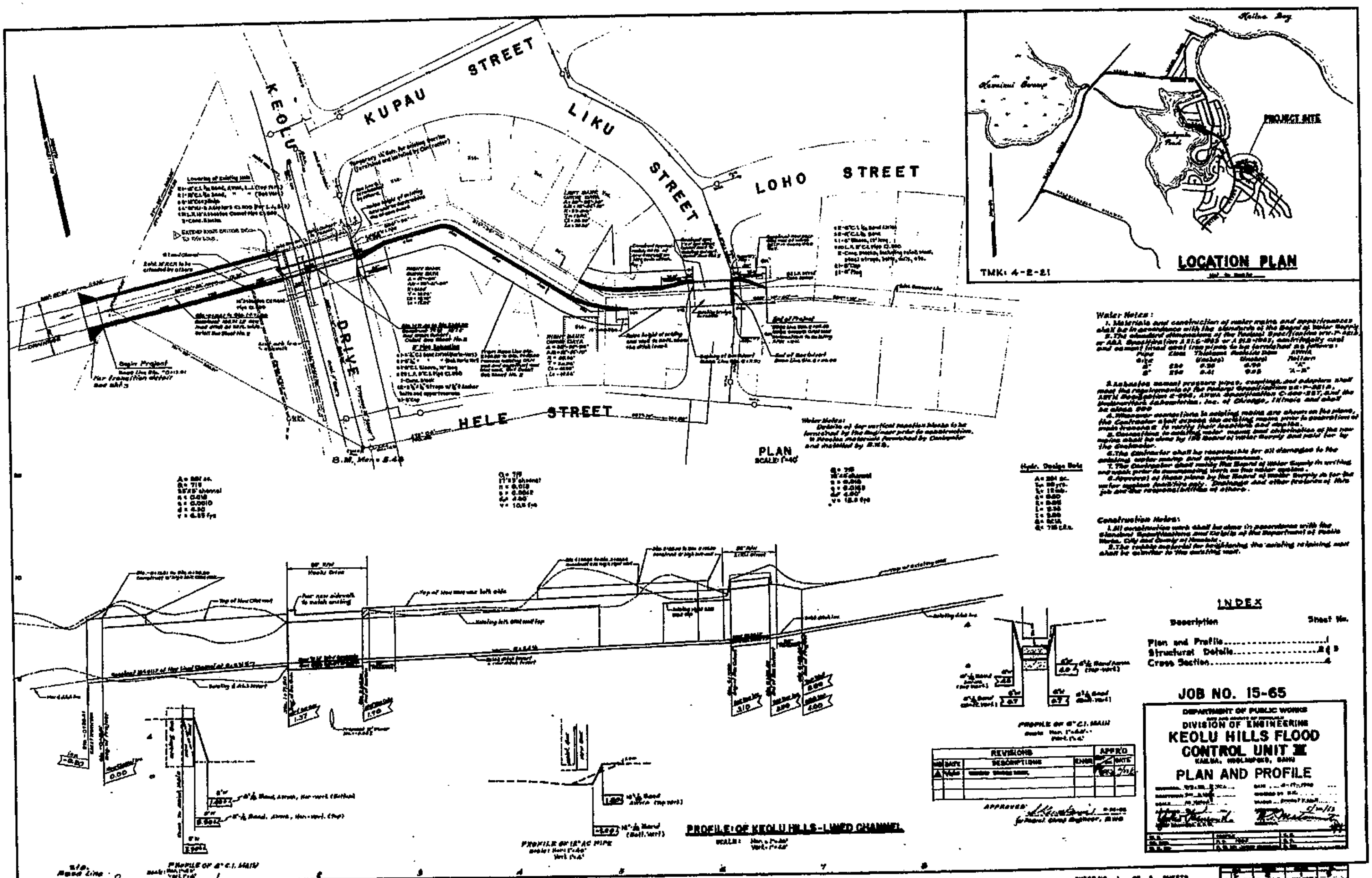
KAILUA, KOOLAUPOKO, OAHU, HAWAII
TAX MAP KEY: (1ST DIV.) 4-2-21: VARIOUS, 4-2-24: VARIOUS
& 4-2-50: VARIOUS

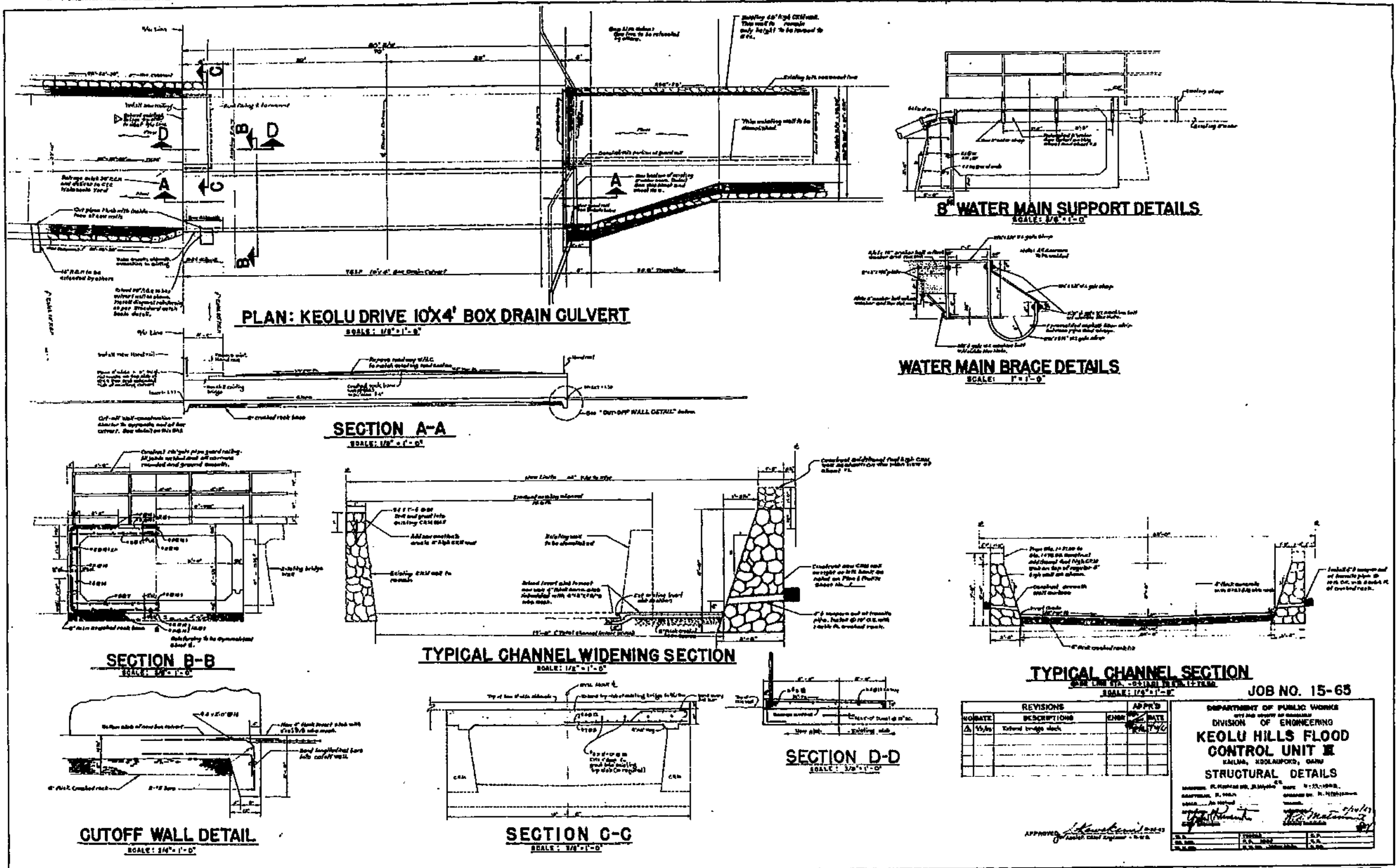
GRAPHIC SCALE IN FEET

AECOM
1001 Bishop Street
Honolulu, Hawaii
August 2, 2010

Licensed Professional Land Surveyor
Certificate No. 12575 Exp 4/30/12

AECOM
Engineers & Surveyors


KUPAU STREET
LIKU STREET
LOHO STREET
HELE STREET
KEOLU DRIVE
PLAN
LOCATION PLAN
PROJECT SITE
Kailua Bay
TMK: 4-2-21
INDEX
Description
Sheet No.
Plan and Profile
Structural Details
Cross Section
JOB NO. 15-65
DEPARTMENT OF PUBLIC WORKS
DIVISION OF ENGINEERING
KEOLU HILLS FLOOD
CONTROL UNIT III
PLAN AND PROFILE
REVISIONS
PROFILE OF KEOLU HILLS - LINED CHANNEL
Water Notes:
Construction Notes:



PLAN: KEOLU DRIVE 10'X4' BOX DRAIN CULVERT
SECTION A-A
8" WATER MAIN SUPPORT DETAILS
WATER MAIN BRACE DETAILS
SECTION B-B
TYPICAL CHANNEL WIDENING SECTION
TYPICAL CHANNEL SECTION
CUTOFF WALL DETAIL
SECTION C-C
SECTION D-D
JOB NO. 15-65
REVISIONS
DEPARTMENT OF PUBLIC WORKS
DIVISION OF ENGINEERING
KEOLU HILLS FLOOD
CONTROL UNIT III
KAILUA, KOOLAUPOKO, OAHU
STRUCTURAL DETAILS

HEC-RAS Version 4.1.0 Jan 2010
U.S. Army Corps of Engineers
Hydrologic Engineering Center
609 Second Street
Davis, California

```
X     X  XXXXXX    XXXX          XXXX       XX      XXXX
X     X  X        X    X         X   X     X  X    X
X     X  X        X              X   X    X    X   X
XXXXXXX  XXXX     X        XXX   XXXX     XXXXXX    XXXX
X     X  X        X              X  X     X    X        X
X     X  X        X    X         X   X    X    X        X
X     X  XXXXXX    XXXX          X    X   X    X   XXXXX
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PROJECT DATA
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Project File : Hele_Channel.prj
Run Date and Time: 9/1/2010 8:46:27 AM

Project in English units

PLAN DATA

Plan Title: Plan 06
Plan File : p:\SES\60135488-ENV Kaelepulu Pond\400 Technical\405 Hydrology\HEC-RAS model\Hele_Channel.p06

Geometry Title: Hele_EX_geom points_w/culverts
Geometry File : p:\SES\60135488-ENV Kaelepulu Pond\400 Technical\405 Hydrology\HEC-RAS model\Hele_Channel.g01

Flow Title : 715 cfs Flow
Flow File : p:\SES\60135488-ENV Kaelepulu Pond\400 Technical\405 Hydrology\HEC-RAS model\Hele_Channel.f02

Plan Summary Information:

Number of:	Cross Sections =	12	Multiple Openings	=	0
	Culverts =	1	Inline Structures	=	0
	Bridges =	0	Lateral Structures	=	0

Computational Information
    Water surface calculation tolerance = 0.01
    Critical depth calculation tolerance = 0.01
    Maximum number of iterations = 20
    Maximum difference tolerance = 0.3
    Flow tolerance factor = 0.001

Computation Options
    Critical depth computed only where necessary
    Conveyance Calculation Method: At breaks in n values only
    Friction Slope Method: Average Conveyance
    Computational Flow Regime: Subcritical Flow

FLOW DATA

Flow Title: 715 cfs Flow
Flow File : p:\SES\60135488-ENV Kaelepulu Pond\400 Technical\405 Hydrology\HEC-RAS model\Hele_Channel.f02

Flow Data (cfs)

River	Reach	RS	PF 1
Hele Channel	reach 1	615	715

Boundary Conditions

```
  River            Reach            Profile                        Upstream
    Downstream

  Hele Channel     reach 1          PF 1
      Critical
```

GEOMETRY DATA

Geometry Title: Hele_EX_geom points_w/culverts
Geometry File : p:\SES\60135488-ENV Kaelepulu Pond\400 Technical\405 Hydrology\HEC-RAS model\Hele_Channel.g01

CROSS SECTION

RIVER: Hele Channel
REACH: reach 1   RS: 615

INPUT
Description:

```
Station Elevation Data    num=       7
     Sta     Elev      Sta     Elev     Sta     Elev      Sta     Elev      Sta     Elev
       0     9.48       10     9.48    10.5     5.4820.50006     5.48    30.95     5.48
31.00005   10.3140.50001    10.31

Manning's n Values        num=       3
     Sta    n Val      Sta    n Val     Sta    n Val
       0     .069       10    .01631.00005    .069

Bank Sta: Left   Right    Lengths: Left Channel    Right      Coeff Contr.   Expan.
            1031.00005             46.5    46.5     46.5                .1       .3
```

CROSS SECTION OUTPUT Profile #PF 1

```
  E.G. Elev (ft)              10.49    Element                    Left OB     Channel
Right OB
  Vel Head (ft)                1.52    Wt. n-Val.                             0.016
  W.S. Elev (ft)               8.98    Reach Len. (ft)             46.50      46.50
  46.50
  Crit W.S. (ft)               8.82    Flow Area (sq ft)                      72.38
```

E.G. Slope (ft/ft)	0.003110	Area (sq ft)		72.38
Q Total (cfs)	715.00	Flow (cfs)		715.00
Top Width (ft)	20.92	Top Width (ft)		20.92
Vel Total (ft/s)	9.88	Avg. Vel. (ft/s)		9.88
Max Chl Dpth (ft)	3.50	Hydr. Depth (ft)		3.46
Conv. Total (cfs)	12821.7	Conv. (cfs)		12821.7
Length Wtd. (ft)	46.50	Wetted Per. (ft)		27.48
Min Ch El (ft)	5.48	Shear (lb/sq ft)		0.51
Alpha	1.00	Stream Power (lb/ft s)	40.50	0.00
0.00				
Frctn Loss (ft)	0.14	Cum Volume (acre-ft)	0.00	1.04
0.00				
C & E Loss (ft)	0.02	Cum SA (acres)	0.01	0.32
0.01				

CROSS SECTION

RIVER: Hele Channel
REACH: reach 1 RS: 568.5*

INPUT
Description:
Station Elevation Data num= 8

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	9.84	10.33	9.84	11.11	5.01	20.16	5.01	20.36	5.01
29.62	5.01	30.17	9.76	40.25	9.76				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.069	10.33	.016	30.17	.069

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
10.33	30.17	46.5	46.5	46.5	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	10.34	Element	Left OB	Channel
Right OB				
Vel Head (ft)	1.46	Wt. n-Val.		0.016
W.S. Elev (ft)	8.88	Reach Len. (ft)	46.50	46.50
46.50				
Crit W.S. (ft)		Flow Area (sq ft)		73.75
E.G. Slope (ft/ft)	0.002761	Area (sq ft)		73.75
Q Total (cfs)	715.00	Flow (cfs)		715.00
Top Width (ft)	19.58	Top Width (ft)		19.58
Vel Total (ft/s)	9.70	Avg. Vel. (ft/s)		9.70

```
Max Chl Dpth (ft)            3.87     Hydr. Depth (ft)                       3.77
Conv. Total (cfs)         13608.5     Conv. (cfs)                         13608.5
Length Wtd. (ft)            46.50     Wetted Per. (ft)                      26.33
Min Ch El (ft)               5.01     Shear (lb/sq ft)                       0.48
Alpha                        1.00     Stream Power (lb/ft s)      40.25      0.00
 0.00
Frctn Loss (ft)              0.15     Cum Volume (acre-ft)         0.00      0.96
 0.00
C & E Loss (ft)              0.04     Cum SA (acres)               0.01      0.29
 0.01
```

CROSS SECTION

```
RIVER: Hele Channel
REACH: reach 1          RS: 522

INPUT
Description:
Station Elevation Data     num=       7
     Sta     Elev     Sta     Elev     Sta     Elev     Sta     Elev     Sta     Elev
       0   10.2110.66686   10.2111.71086   4.5420.00032   4.5428.29085   4.54
29.33386   9.21 40.0017    9.21

Manning's n Values         num=       3
     Sta    n Val     Sta    n Val     Sta    n Val
       0   .06910.66686   .01629.33386   .069

Bank Sta: Left   Right     Lengths: Left Channel   Right     Coeff Contr.   Expan.
      10.6668629.33386                 82      82      82              .1       .3
```

CROSS SECTION OUTPUT Profile #PF 1

```
  E.G. Elev (ft)            10.17     Element                   Left OB    Channel
Right OB
  Vel Head (ft)              1.83     Wt. n-Val.                           0.016
  W.S. Elev (ft)             8.33     Reach Len. (ft)            82.00     82.00
  82.00
  Crit W.S. (ft)             8.33     Flow Area (sq ft)                    65.80
  E.G. Slope (ft/ft)     0.003632     Area (sq ft)                         65.80
  Q Total (cfs)            715.00     Flow (cfs)                          715.00
  Top Width (ft)            18.13     Top Width (ft)                       18.13
  Vel Total (ft/s)          10.87     Avg. Vel. (ft/s)                     10.87
  Max Chl Dpth (ft)          3.79     Hydr. Depth (ft)                      3.63
  Conv. Total (cfs)       11864.4     Conv. (cfs)                        11864.4
  Length Wtd. (ft)          82.00     Wetted Per. (ft)                     24.32
```

Min Ch El (ft)	4.54	Shear (lb/sq ft)		0.61
Alpha	1.00	Stream Power (lb/ft s)	40.00	0.00
0.00				
Frctn Loss (ft)	0.30	Cum Volume (acre-ft)	0.00	0.89
0.00				
C & E Loss (ft)	0.01	Cum SA (acres)	0.01	0.27
0.01				

Warning: The energy equation could not be balanced within the specified number of iterations. The program used critical depth
for the water surface and continued on with the calculations.
Warning: During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated
water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program
defaulted to critical depth.

CROSS SECTION

RIVER: Hele Channel
REACH: reach 1 RS: 440.*

INPUT
Description:
Station Elevation Data num= 7

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	8.94	10.48	8.88	11.48	3.72	20	3.72	28.52	3.72
29.52	8.56	40	8.6						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.069	10.48	.016	29.52	.069

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
10.48	29.52	80	80	80	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	9.25	Element	Left OB	Channel
Right OB				
Vel Head (ft)	1.81	Wt. n-Val.		0.016
W.S. Elev (ft)	7.45	Reach Len. (ft)	80.00	80.00
80.00				
Crit W.S. (ft)	7.45	Flow Area (sq ft)		66.29
E.G. Slope (ft/ft)	0.003606	Area (sq ft)		66.29
Q Total (cfs)	715.00	Flow (cfs)		715.00
Top Width (ft)	18.53	Top Width (ft)		18.53
Vel Total (ft/s)	10.79	Avg. Vel. (ft/s)		10.79
Max Chl Dpth (ft)	3.73	Hydr. Depth (ft)		3.58
Conv. Total (cfs)	11907.4	Conv. (cfs)		11907.4

```
  Length Wtd. (ft)              80.00   Wetted Per. (ft)                      24.64

  Min Ch El (ft)                 3.72   Shear (lb/sq ft)                       0.61

  Alpha                          1.00   Stream Power (lb/ft s)      40.00      0.00
   0.00
  Frctn Loss (ft)                0.25   Cum Volume (acre-ft)         0.00      0.76
   0.00
  C & E Loss (ft)                0.09   Cum SA (acres)               0.01      0.24
   0.01
```

Warning: The energy equation could not be balanced within the specified number of iterations. The program used critical depth
for the water surface and continued on with the calculations.
Warning: During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated
water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program
defaulted to critical depth.

CROSS SECTION

```
RIVER: Hele Channel
REACH: reach 1            RS: 360

INPUT
Description:
Station Elevation Data    num=        7
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0     7.710.30136     7.5911.25201     2.9220.00132     2.9228.75208     2.92
29.70133     7.92 40.0027        8

Manning's n Values        num=        3
     Sta    n Val      Sta    n Val      Sta    n Val
       0    .06910.30136    .01629.70133    .069

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
      10.3013629.70133                  46       46      46              .1       .3

CROSS SECTION OUTPUT  Profile #PF 1


  E.G. Elev (ft)                 8.40   Element                    Left OB    Channel
Right OB
  Vel Head (ft)                  1.49   Wt. n-Val.                            0.016

  W.S. Elev (ft)                 6.91   Reach Len. (ft)            46.00      46.00
  46.00
  Crit W.S. (ft)                 6.58   Flow Area (sq ft)                     72.90

  E.G. Slope (ft/ft)         0.002767   Area (sq ft)                          72.90

  Q Total (cfs)                715.00   Flow (cfs)                           715.00

  Top Width (ft)                19.07   Top Width (ft)                        19.07

  Vel Total (ft/s)               9.81   Avg. Vel. (ft/s)                       9.81

  Max Chl Dpth (ft)              3.99   Hydr. Depth (ft)                       3.82
```

```
  Conv. Total (cfs)          13593.1    Conv. (cfs)                          13593.1

  Length Wtd. (ft)             46.00    Wetted Per. (ft)                       25.63

  Min Ch El (ft)                2.92    Shear (lb/sq ft)                        0.49

  Alpha                         1.00    Stream Power (lb/ft s)     40.00        0.00
   0.00
  Frctn Loss (ft)               0.12    Cum Volume (acre-ft)        0.00        0.64
   0.00
  C & E Loss (ft)               0.05    Cum SA (acres)              0.01        0.20
   0.01


CROSS SECTION


RIVER: Hele Channel
REACH: reach 1            RS: 314

INPUT
Description:
Station Elevation Data    num=       6
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0     7.611.35091    7.1612.53165    2.5229.14915    2.3829.47276    7.14
40.00003     7.6

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0   .06911.35091    .01629.47276    .069

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
      11.3509129.47276                24      24      24             .1       .3

CROSS SECTION OUTPUT  Profile #PF 1


  E.G. Elev (ft)                8.24    Element                   Left OB    Channel
Right OB
  Vel Head (ft)                 1.33    Wt. n-Val.                             0.016

  W.S. Elev (ft)                6.90    Reach Len. (ft)            24.00       24.00
  24.00
  Crit W.S. (ft)                        Flow Area (sq ft)                      77.12

  E.G. Slope (ft/ft)        0.002299    Area (sq ft)                           77.12

  Q Total (cfs)               715.00    Flow (cfs)                            715.00

  Top Width (ft)               18.04    Top Width (ft)                         18.04

  Vel Total (ft/s)              9.27    Avg. Vel. (ft/s)                        9.27

  Max Chl Dpth (ft)             4.52    Hydr. Depth (ft)                        4.28

  Conv. Total (cfs)          14911.8    Conv. (cfs)                          14911.8

  Length Wtd. (ft)             24.00    Wetted Per. (ft)                       25.67

  Min Ch El (ft)                2.38    Shear (lb/sq ft)                        0.43

  Alpha                         1.00    Stream Power (lb/ft s)     40.00        0.00
```

```
 0.00
 Frctn Loss (ft)            0.06    Cum Volume (acre-ft)        0.00        0.56
 0.00
 C & E Loss (ft)            0.01    Cum SA (acres)              0.01        0.19
 0.01
```

CROSS SECTION

```
RIVER: Hele Channel
REACH: reach 1             RS: 290

INPUT
Description:
Station Elevation Data     num=        7
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0      7.510.45336     6.9911.63333     2.3820.00007     2.3828.07568     2.26
28.18823     6.9240.00004      7.5

Manning's n Values         num=        3
     Sta    n Val      Sta    n Val      Sta    n Val
       0     .06910.45336     .01628.18823     .069

Bank Sta: Left   Right     Lengths: Left Channel   Right      Coeff Contr.   Expan.
      10.4533628.18823               26       26      26                .1       .3

CROSS SECTION OUTPUT  Profile #PF 1


  E.G. Elev (ft)            8.17    Element                   Left OB     Channel
Right OB
  Vel Head (ft)             1.39    Wt. n-Val.                             0.016

  W.S. Elev (ft)            6.79    Reach Len. (ft)            26.00       26.00
  26.00
  Crit W.S. (ft)            6.18    Flow Area (sq ft)                      75.65

  E.G. Slope (ft/ft)    0.002431    Area (sq ft)                           75.65

  Q Total (cfs)           715.00    Flow (cfs)                            715.00

  Top Width (ft)           17.68    Top Width (ft)                         17.68

  Vel Total (ft/s)          9.45    Avg. Vel. (ft/s)                        9.45

  Max Chl Dpth (ft)         4.53    Hydr. Depth (ft)                        4.28

  Conv. Total (cfs)      14500.1    Conv. (cfs)                          14500.1

  Length Wtd. (ft)         26.00    Wetted Per. (ft)                       25.52

  Min Ch El (ft)            2.26    Shear (lb/sq ft)                        0.45

  Alpha                     1.00    Stream Power (lb/ft s)     40.00        0.00
   0.00
  Frctn Loss (ft)           0.03    Cum Volume (acre-ft)        0.00        0.52
   0.00
  C & E Loss (ft)           0.29    Cum SA (acres)              0.01        0.18
   0.01
```

Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
This may indicate the need for additional cross sections.

CROSS SECTION

RIVER: Hele Channel
REACH: reach 1 RS: 264

INPUT
Description:
Station Elevation Data num= 7

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	7.2	6.89464	7.06	6.99	2.01	20.09033	2.07	32.16778	2.07
32.2906	6.77	40.24369	7.3						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.069	6.89464	.016	32.2906	.069

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
6.89464	32.2906	84	84	84	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	7.86	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.43	Wt. n-Val.	0.069	0.016	0.069
W.S. Elev (ft)	7.43	Reach Len. (ft)	84.00	84.00	84.00
Crit W.S. (ft)	4.97	Flow Area (sq ft)	2.08	136.02	3.15
E.G. Slope (ft/ft)	0.000521	Area (sq ft)	2.08	136.02	3.15
Q Total (cfs)	715.00	Flow (cfs)	0.45	713.73	0.83
Top Width (ft)	40.24	Top Width (ft)	6.89	25.40	7.95
Vel Total (ft/s)	5.06	Avg. Vel. (ft/s)	0.22	5.25	0.26
Max Chl Dpth (ft)	5.42	Hydr. Depth (ft)	0.30	5.36	0.40
Conv. Total (cfs)	31322.0	Conv. (cfs)	19.6	31266.3	36.1
Length Wtd. (ft)	84.00	Wetted Per. (ft)	7.13	34.93	8.10
Min Ch El (ft)	2.01	Shear (lb/sq ft)	0.01	0.13	0.01
Alpha	1.07	Stream Power (lb/ft s)	40.24	0.00	0.00
Frctn Loss (ft)		Cum Volume (acre-ft)		0.45	
C & E Loss (ft)		Cum SA (acres)	0.01	0.16	0.01

```
CULVERT


RIVER: Hele Channel
REACH: reach 1             RS: 224

INPUT
Description: culverts
Distance from Upstream XS =       2
Deck/Roadway Width        =      78
Weir Coefficient          =     2.6
Upstream  Deck/Roadway Coordinates
    num=       2
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
       0    7.64       1     100    7.64       1

Upstream Bridge Cross Section Data
Station Elevation Data     num=        7
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0      7.2 6.89464     7.06      6.99     2.0120.09033     2.0732.16778     2.07
 32.2906    6.7740.24369      7.3

Manning's n Values         num=        3
     Sta    n Val      Sta    n Val      Sta    n Val
       0     .069 6.89464     .016 32.2906     .069

Bank Sta: Left   Right    Coeff Contr.   Expan.
       6.89464 32.2906              .1       .3

Downstream  Deck/Roadway Coordinates
    num=       2
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
       0    7.64       1      40    7.64       1

Downstream Bridge Cross Section Data
Station Elevation Data     num=        7
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0     7.65.792333      7.6     6.99      1.620.00368     1.51     32.2      1.5
34.04792    7.2940.00817     7.39

Manning's n Values         num=        3
     Sta    n Val      Sta    n Val      Sta    n Val
       0     .0695.792333     .01634.04792     .069

Bank Sta: Left   Right    Coeff Contr.   Expan.
      5.79233334.04792              .1       .3

Upstream Embankment side slope                 =       0 horiz. to 1.0 vertical
Downstream Embankment side slope               =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =       .98
Elevation at which weir flow begins            =
Energy head used in spillway design            =
Spillway height used in design                 =
Weir crest shape                               = Broad Crested

Number of Culverts =  2

Culvert Name     Shape      Rise     Span
Culvert #2           Box    3.84       10
FHWA Chart # 10- 90 degree headwall; Chamfered or beveled inlet
FHWA Scale # 1 - Inlet edges chamfered 3/4 inch
Solution Criteria = Highest U.S. EG
Culvert Upstrm Dist  Length    Top n  Bottom n  Depth Blocked  Entrance Loss Coef
```

Exit Loss Coef
2 78 .016 .016 0 .7
1
Upstream Elevation = 2
Centerline Station = 12
Downstream Elevation = 1.51
Centerline Station = 12

Culvert Name	Shape	Rise	Span
Culvert #1	Box	3.67	12.25

FHWA Chart # 10- 90 degree headwall; Chamfered or beveled inlet
FHWA Scale # 1 - Inlet edges chamfered 3/4 inch
Solution Criteria = Highest U.S. EG

Culvert Upstrm Dist	Length	Top n	Bottom n	Depth Blocked	Entrance Loss Coef	Exit Loss Coef
2	78	.016	.016	0	.7	1

Upstream Elevation = 2.07
Centerline Station = 26.125
Downstream Elevation = 1.5
Centerline Station = 26.125

CULVERT OUTPUT Profile #PF 1 Culv Group: Culvert #2

Q Culv Group (cfs)	320.24	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	10.10
Q Barrel (cfs)	320.24	Culv Vel DS (ft/s)	10.95
E.G. US. (ft)	7.86	Culv Inv El Up (ft)	2.00
W.S. US. (ft)	7.43	Culv Inv El Dn (ft)	1.51
E.G. DS (ft)	5.83	Culv Frctn Ls (ft)	0.46
W.S. DS (ft)	4.42	Culv Exit Loss (ft)	0.46
Delta EG (ft)	2.03	Culv Entr Loss (ft)	1.11
Delta WS (ft)	3.01	Q Weir (cfs)	10.60
E.G. IC (ft)	7.64	Weir Sta Lft (ft)	0.00
E.G. OC (ft)	7.86	Weir Sta Rgt (ft)	40.24
Culvert Control	Outlet	Weir Submerg	0.00
Culv WS Inlet (ft)	5.17	Weir Max Depth (ft)	0.22
Culv WS Outlet (ft)	4.43	Weir Avg Depth (ft)	0.22
Culv Nml Depth (ft)	2.90	Weir Flow Area (sq ft)	8.74
Culv Crt Depth (ft)	3.17	Min El Weir Flow (ft)	7.65

Note: The flow in the culvert is entirely supercritical.

CULVERT OUTPUT Profile #PF 1 Culv Group: Culvert #1

Q Culv Group (cfs)	384.17	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	10.03
Q Barrel (cfs)	384.17	Culv Vel DS (ft/s)	11.55
E.G. US. (ft)	7.86	Culv Inv El Up (ft)	2.07
W.S. US. (ft)	7.43	Culv Inv El Dn (ft)	1.50
E.G. DS (ft)	5.83	Culv Frctn Ls (ft)	0.47
W.S. DS (ft)	4.42	Culv Exit Loss (ft)	0.46
Delta EG (ft)	2.03	Culv Entr Loss (ft)	1.09
Delta WS (ft)	3.01	Q Weir (cfs)	10.60
E.G. IC (ft)	7.71	Weir Sta Lft (ft)	0.00
E.G. OC (ft)	7.85	Weir Sta Rgt (ft)	40.24
Culvert Control	Outlet	Weir Submerg	0.00
Culv WS Inlet (ft)	5.20	Weir Max Depth (ft)	0.22
Culv WS Outlet (ft)	4.22	Weir Avg Depth (ft)	0.22
Culv Nml Depth (ft)	2.63	Weir Flow Area (sq ft)	8.74
Culv Crt Depth (ft)	3.13	Min El Weir Flow (ft)	7.65

Note: The flow in the culvert is entirely supercritical.

CROSS SECTION

RIVER: Hele Channel
REACH: reach 1 RS: 180

INPUT
Description:
Station Elevation Data num= 7

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	7.6	5.792333	7.6	6.99	1.62	20.00368	1.51	32.2	1.5
34.04792	7.29	40.00817	7.39						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.069	5.792333	.0163	34.04792	.069

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
5.792333	34.04792	55	55	55	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

I believe this is the section below the Keolu culverts where the trash racks are proposed

E.G. Elev (ft)	5.83	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.41	Wt. n-Val.		0.016	
W.S. Elev (ft)	4.42	Reach Len. (ft)	55.00	55.00	55.00
Crit W.S. (ft)	4.42	Flow Area (sq ft)		74.95	
E.G. Slope (ft/ft)	0.003273	Area (sq ft)		74.95	
Q Total (cfs)	715.00	Flow (cfs)		715.00	
Top Width (ft)	26.70	Top Width (ft)		26.70	
Vel Total (ft/s)	9.54	Avg. Vel. (ft/s)		9.54	
Max Chl Dpth (ft)	2.92	Hydr. Depth (ft)		2.81	
Conv. Total (cfs)	12498.3	Conv. (cfs)		12498.3	
Length Wtd. (ft)	55.00	Wetted Per. (ft)		31.15	
Min Ch El (ft)	1.50	Shear (lb/sq ft)		0.49	
Alpha	1.00	Stream Power (lb/ft s)	40.01	0.00	0.00
Frctn Loss (ft)	0.18	Cum Volume (acre-ft)		0.31	
C & E Loss (ft)	0.01	Cum SA (acres)		0.11	

Warning: The energy equation could not be balanced within the specified number of iterations. The program used critical depth for the water surface and continued on with the calculations.
Warning: During the standard step iterations, when the assumed water surface was set

equal to critical depth, the calculated
water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program
defaulted to critical depth.

CROSS SECTION

RIVER: Hele Channel
REACH: reach 1 RS: 125

INPUT
Description:
Station Elevation Data num= 7

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	6.2	4.743718	6.1	46.874851	1.69	19.04668	1.31	32.69107	1.4
34.86891	6.42	39.99997	6.5						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.069	4.743718	.016	34.86891	.069

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
4.743718	34.86891	77	77	77	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	5.61	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.36	Wt. n-Val.		0.016	
W.S. Elev (ft)	4.25	Reach Len. (ft)	77.00	77.00	77.00
Crit W.S. (ft)	4.25	Flow Area (sq ft)		76.30	
E.G. Slope (ft/ft)	0.003166	Area (sq ft)		76.30	
Q Total (cfs)	715.00	Flow (cfs)		715.00	
Top Width (ft)	28.28	Top Width (ft)		28.28	
Vel Total (ft/s)	9.37	Avg. Vel. (ft/s)		9.37	
Max Chl Dpth (ft)	2.94	Hydr. Depth (ft)		2.70	
Conv. Total (cfs)	12708.2	Conv. (cfs)		12708.2	
Length Wtd. (ft)	77.00	Wetted Per. (ft)		31.77	
Min Ch El (ft)	1.31	Shear (lb/sq ft)		0.47	
Alpha	1.00	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.25	Cum Volume (acre-ft)		0.22	
C & E Loss (ft)	0.01	Cum SA (acres)		0.08	

Warning: The energy equation could not be balanced within the specified number of iterations. The program used critical depth

for the water surface and continued on with the calculations.
Warning: During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated
water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program
defaulted to critical depth.

CROSS SECTION

RIVER: Hele Channel
REACH: reach 1 RS: 48

INPUT
Description:
Station Elevation Data num= 7

```
     Sta    Elev     Sta    Elev     Sta     Elev     Sta     Elev     Sta     Elev
       0    5.76  6.4027    5.766.871451      .8619.99998      .8832.31243      .86
 32.9575    6.1139.99997     6.2
```

Manning's n Values num= 3

```
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .069  6.4027    .016 32.9575    .069
```

```
Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        6.4027 32.9575               48      48      48                .1       .3
```

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	5.19	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.44	Wt. n-Val.		0.016	
W.S. Elev (ft)	3.75	Reach Len. (ft)	48.00	48.00	48.00
Crit W.S. (ft)	3.75	Flow Area (sq ft)		74.28	
E.G. Slope (ft/ft)	0.003388	Area (sq ft)		74.28	
Q Total (cfs)	715.00	Flow (cfs)		715.00	
Top Width (ft)	26.07	Top Width (ft)		26.07	
Vel Total (ft/s)	9.63	Avg. Vel. (ft/s)		9.63	
Max Chl Dpth (ft)	2.89	Hydr. Depth (ft)		2.85	
Conv. Total (cfs)	12283.1	Conv. (cfs)		12283.1	
Length Wtd. (ft)	48.00	Wetted Per. (ft)		31.26	
Min Ch El (ft)	0.86	Shear (lb/sq ft)		0.50	
Alpha	1.00	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)	0.16	Cum Volume (acre-ft)		0.08	
C & E Loss (ft)	0.02	Cum SA (acres)		0.03	

Warning: The energy equation could not be balanced within the specified number of iterations. The program used critical depth
for the water surface and continued on with the calculations.
Warning: During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated
water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program
defaulted to critical depth.

CROSS SECTION

RIVER: Hele Channel
REACH: reach 1 RS: 0

INPUT
Description:
Station Elevation Data num= 7

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5.6	4.148653	5.55	7.212788	.36	19.99998	.43	2.78688	1
33.70868	6.86	39.99997	6.9						

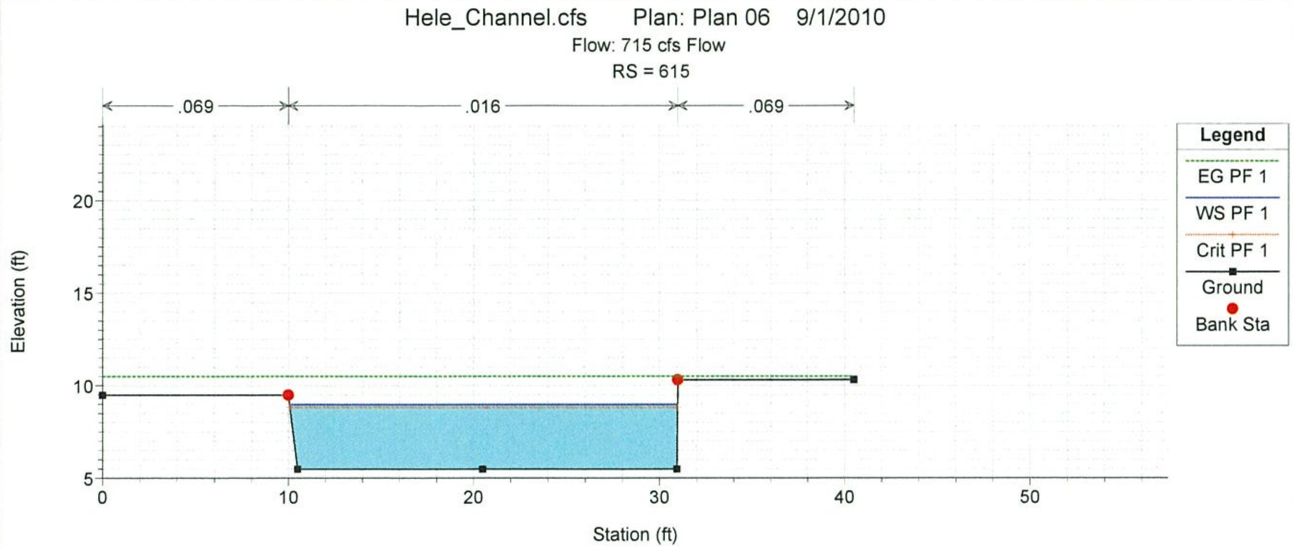
Manning's n Values num= 3

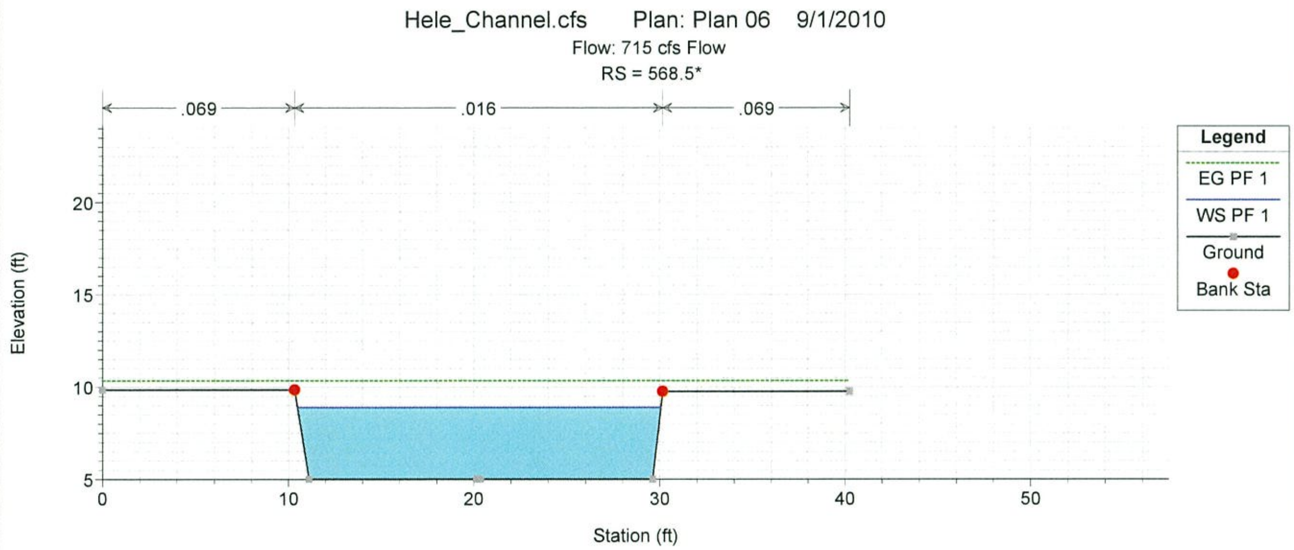
Sta	n Val	Sta	n Val	Sta	n Val
0	.069	4.148653	.016	33.70868	.069

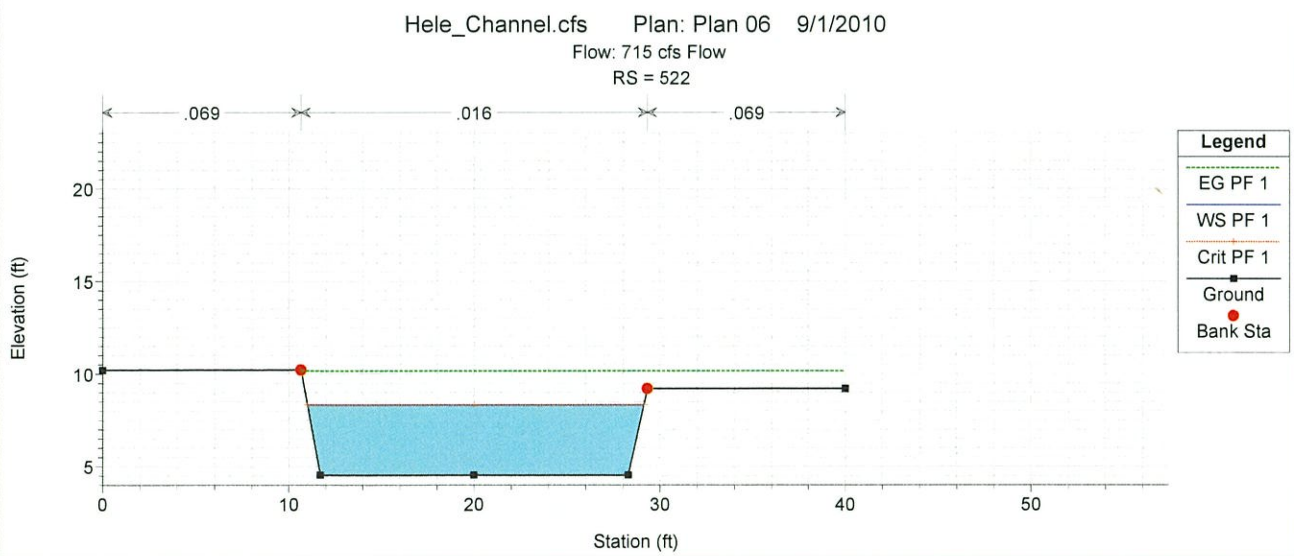
Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
4.148653	33.70868	0	0	0	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	4.76				
Vel Head (ft)	1.38	Wt. n-Val.		0.016	
W.S. Elev (ft)	3.38	Reach Len. (ft)			
Crit W.S. (ft)	3.38	Flow Area (sq ft)		75.75	
E.G. Slope (ft/ft)	0.003206	Area (sq ft)		75.75	
Q Total (cfs)	715.00	Flow (cfs)		715.00	
Top Width (ft)	27.73	Top Width (ft)		27.73	
Vel Total (ft/s)	9.44	Avg. Vel. (ft/s)		9.44	
Max Chl Dpth (ft)	3.02	Hydr. Depth (ft)		2.73	
Conv. Total (cfs)	12627.0	Conv. (cfs)		12627.0	
Length Wtd. (ft)		Wetted Per. (ft)		31.50	
Min Ch El (ft)	0.36	Shear (lb/sq ft)		0.48	
Alpha	1.00	Stream Power (lb/ft s)	40.00	0.00	0.00
Frctn Loss (ft)		Cum Volume (acre-ft)			
C & E Loss (ft)		Cum SA (acres)			

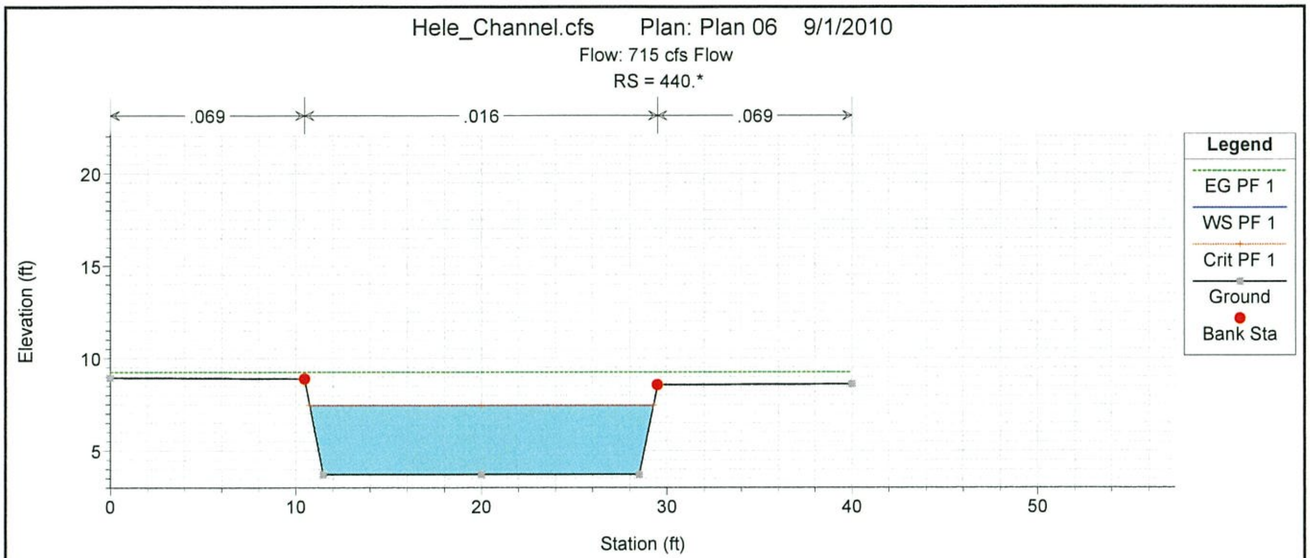


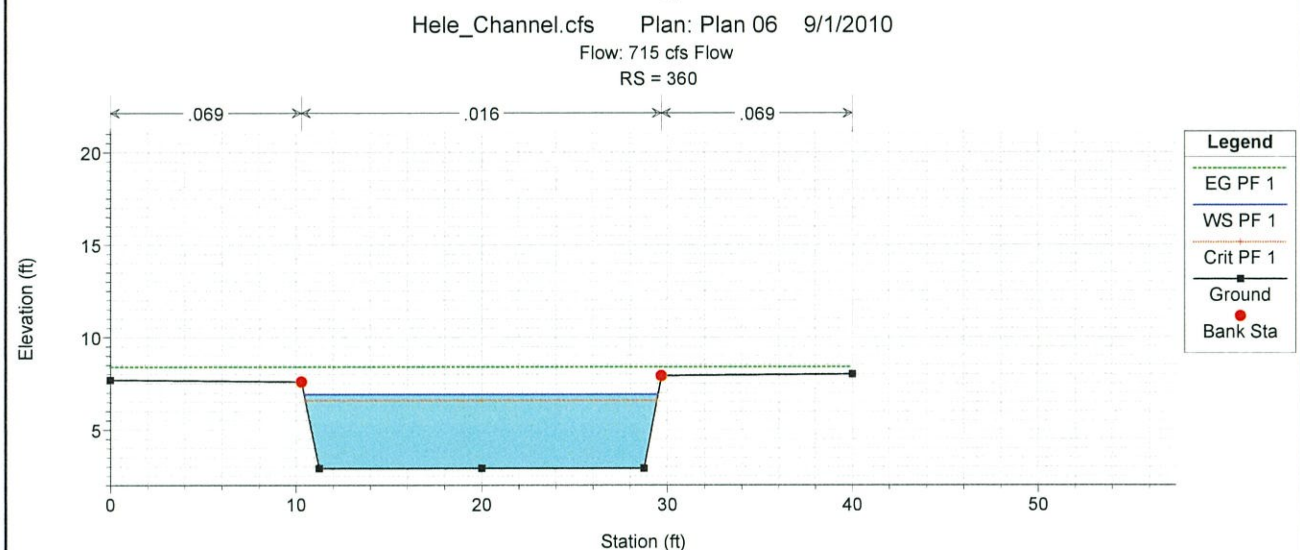


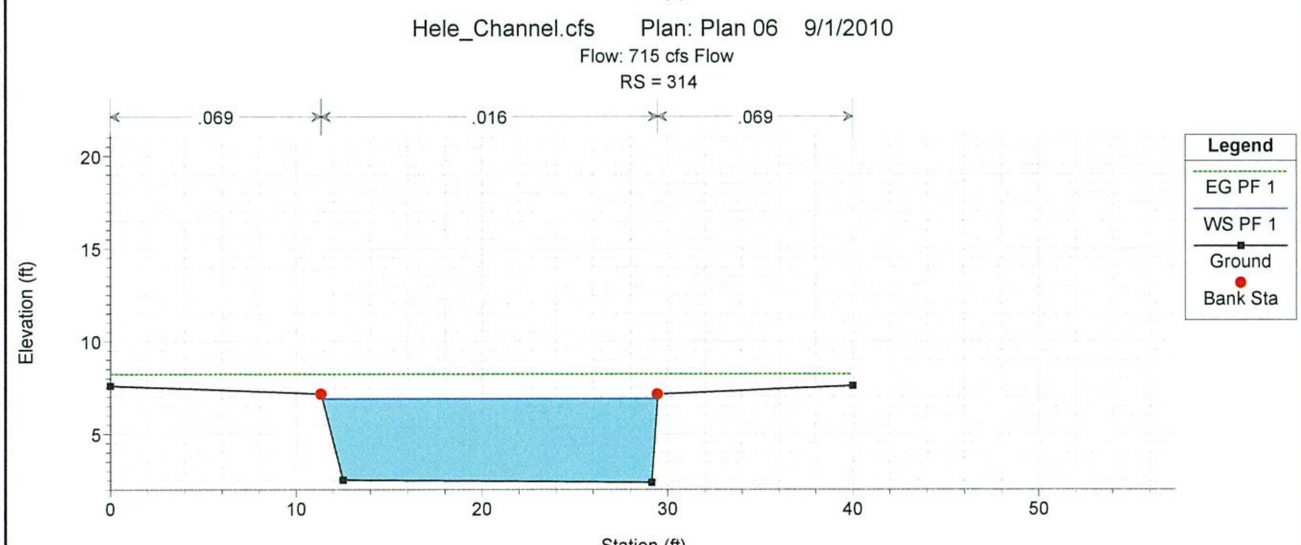


1 in Horiz. = 10 ft 1 in Vert. = 10 ft

Note: RS = River Station

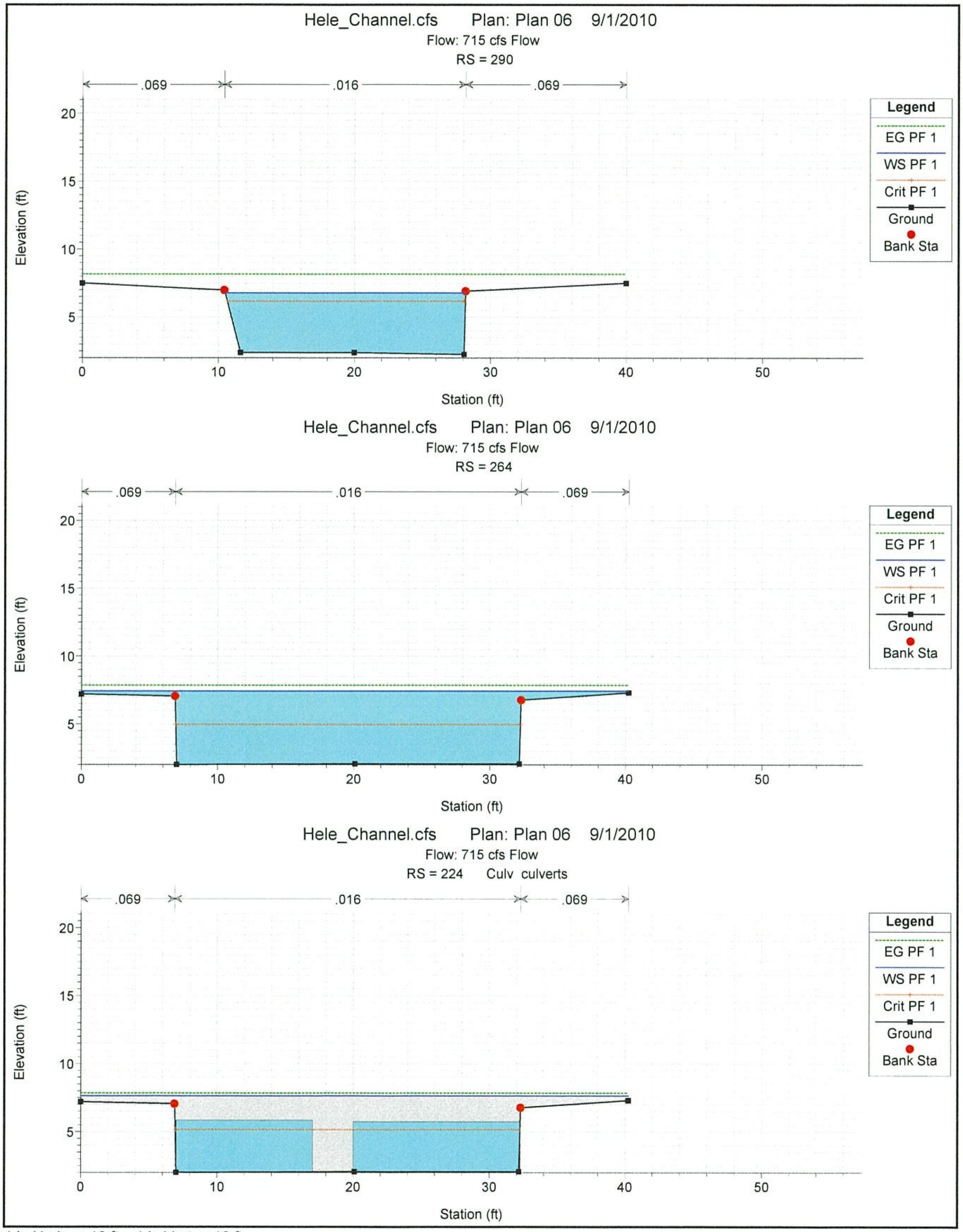






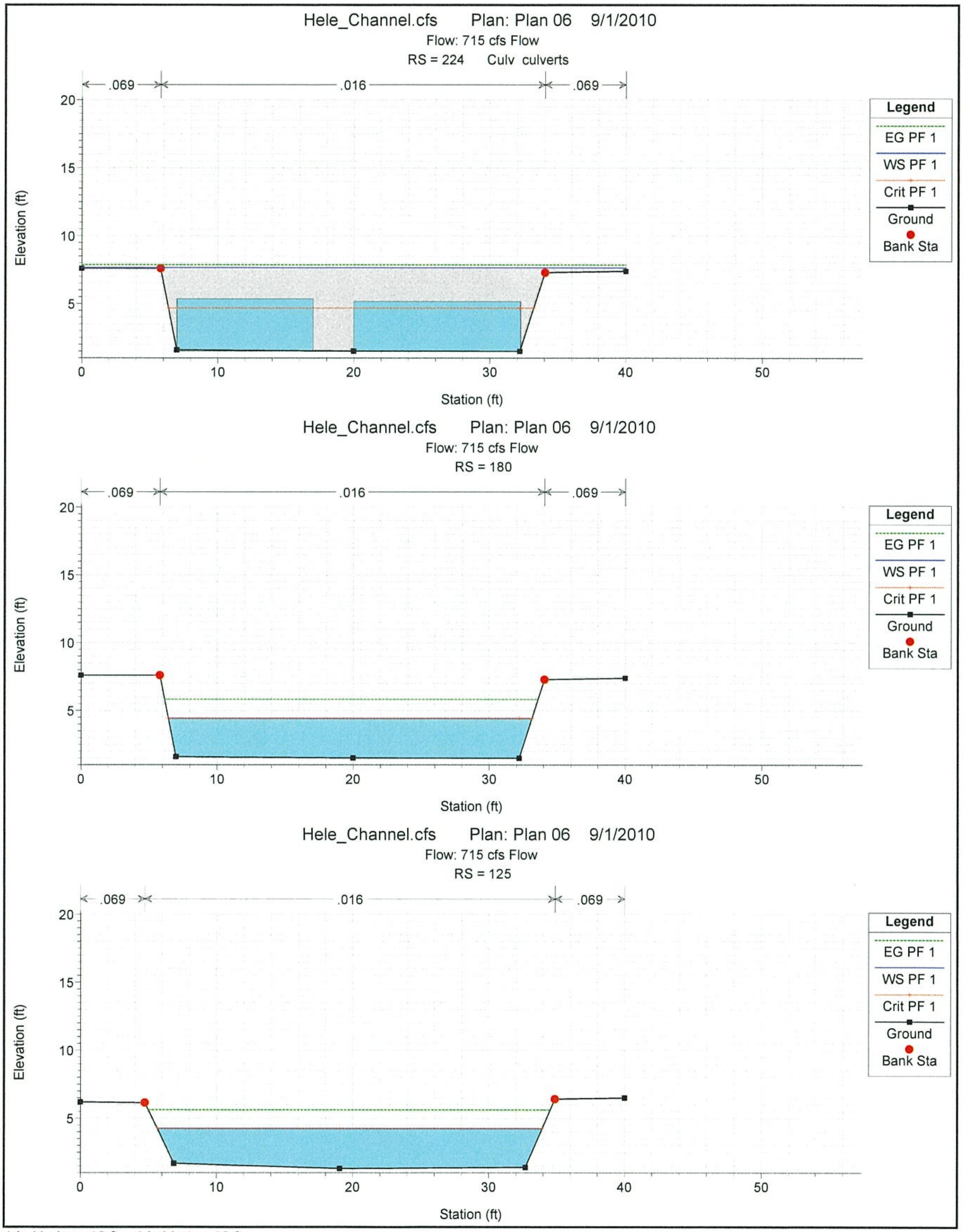
1 in Horiz. = 10 ft 1 in Vert. = 10 ft

Note: RS = River Station



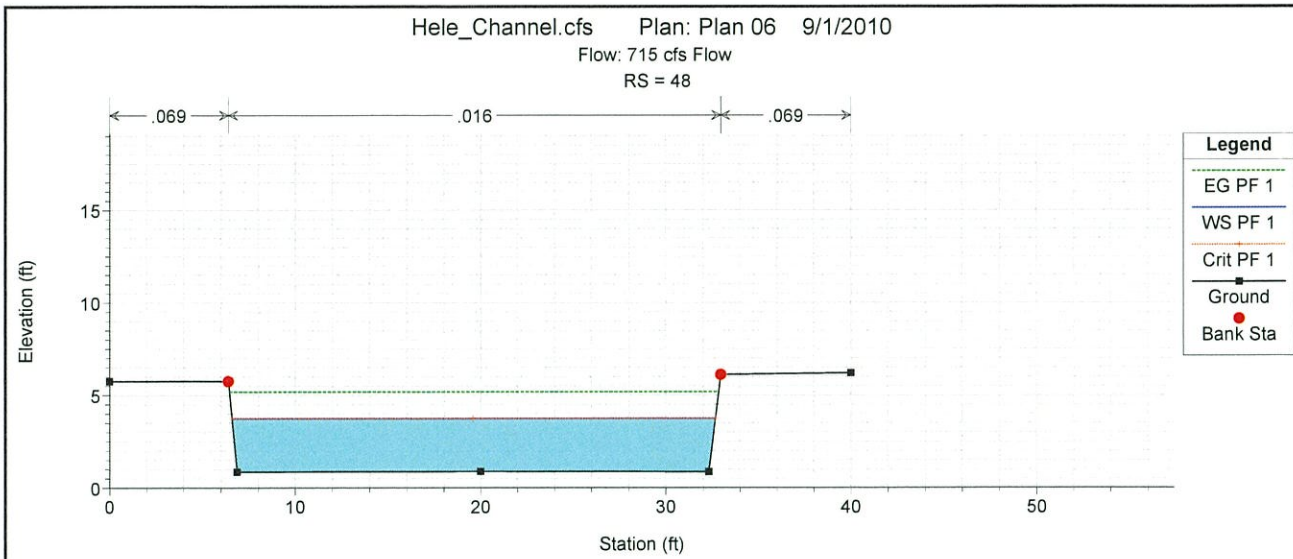
1 in Horiz. = 10 ft 1 in Vert. = 10 ft

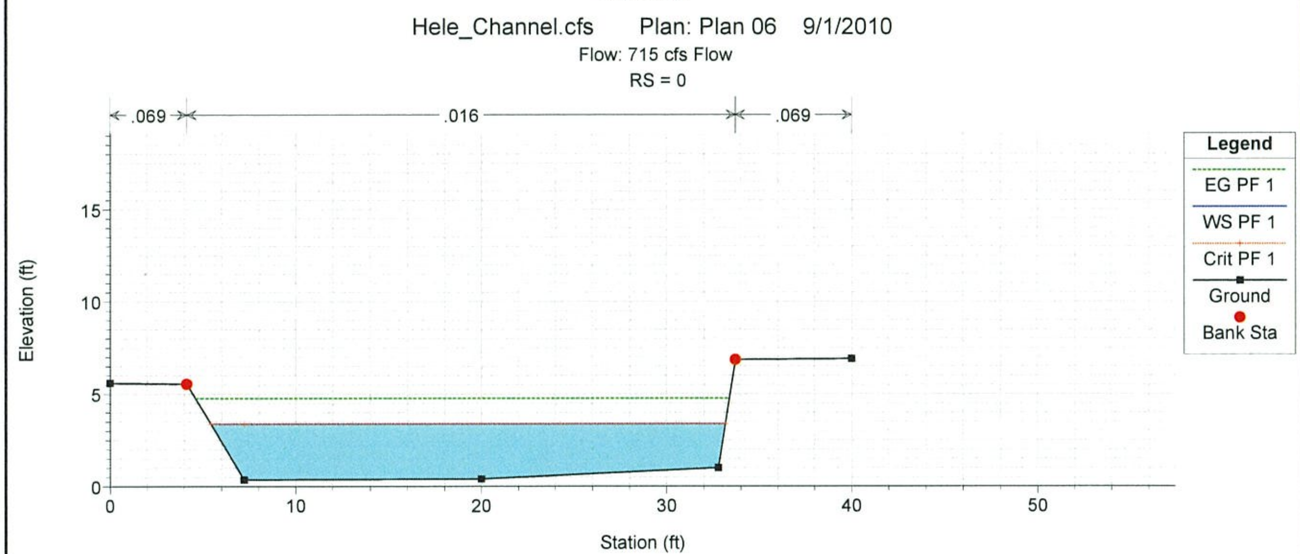
Note: RS = River Station



1 in Horiz. = 10 ft 1 in Vert. = 10 ft

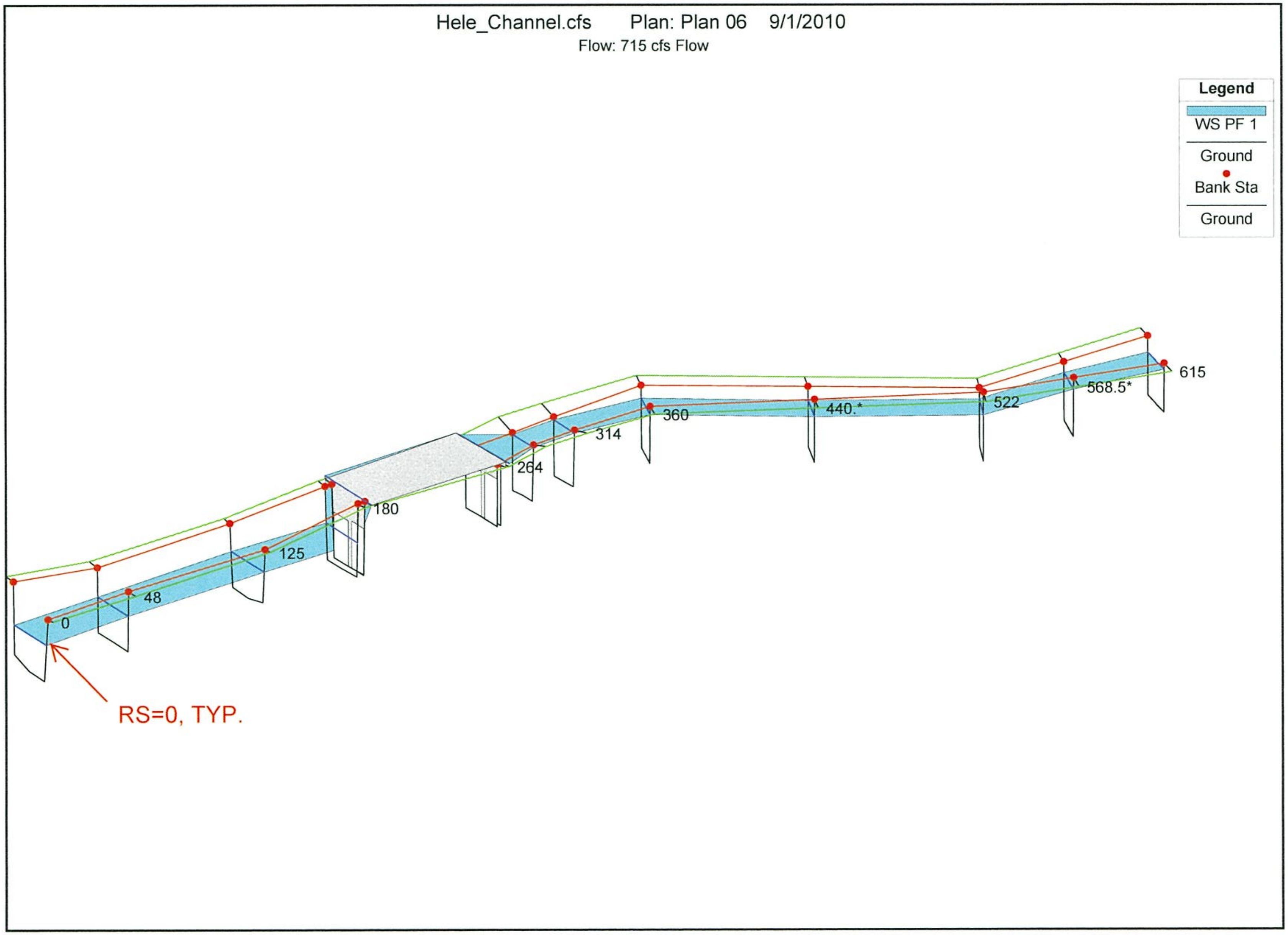
Note: RS = River Station





1 in Horiz. = 10 ft 1 in Vert. = 10 ft

Note: RS = River Station


Hele_Channel.cfs Plan: Plan 06 9/1/2010
Flow: 715 cfs Flow
Legend
WS PF 1
Ground
Bank Sta
Ground
0
48
125
180
264
314
360
440.*
522
568.5*
615
RS=0, TYP.

Appendix B

Trash Rack Calculations

and Reference Documents

Trash Rack Calculations

Trash Rack 1:

Step 1, find Q:

According to the record documents, the channel and the culvert were designed base on the following design values:

T_m = 20 yr
i_{20} = 2.6 in/hr
A = 289 ac
Q_{20} = $C\ I_{20}\ A\ R$ = 837 cfs

According the current design standards, areas over 100 acres should be designed for a 100 reoccurrence interval, therefore:

Tm = 100 yr
i_{100} = 4.0 in/hr

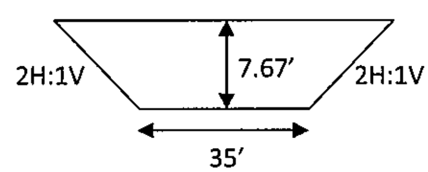
Q_{100} = $C\ I_{100}\ A\ R$, therefore

Q_{100} = $Q_{20}\ i_{100} / i_{20}$
= (837)(4.0)/(2.6) = 1288 cfs

Step 2, find normal depth and velocity at the proposed trash rack location:

Using the new storm flow data, the normal depth and the velocity were calculated using computer software.

D_n = 8.94 ft (Headwater depth at culvert entrance)
v = 6.36 fps (Velocity within the trapezoidal channel upstream of the culvert)



Step 3, find freeboard:

According to the current Storm Drainage Standards, the minimum required freeboard can be calculated as follows:

Minimum Freeboard $= 2.0 + 0.025\ v\ (d)^{1/3}$
$= 2 + 0.025(6.36)(8.94)^{1/3}$
= 2.33 ft

Available Freeboard = Total Channel Depth - D_n
= 7.67 – 8.94 = –1.27 ft

Trash Rack 2:

Step 1, find Q:

According to the record documents, the channel and the culvert were designed base on the following design values:

T_m = 20 yr
i_{20} = 2.6 in/hr
A = 87 ac
Q_{20} = C I_{20} A R = 381 cfs

According the current design standards, roadway culverts and tailwater conditions shall be designed for a 50 year reoccurrence interval, therefore:

T_m = 50 yr
i_{50} = 3.0 in/hr

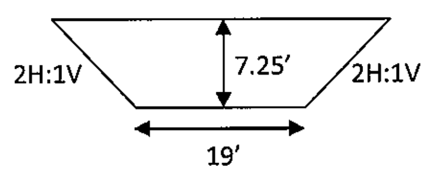
Q_{50} = C I_{50} A R, therefore

Q_{50} = Q_{20} i_{50} / i_{20}
= (381)(3.0)/(2.6) = 440 cfs

Step 2, find normal depth and velocity at the proposed trash rack location:

Using the new storm flow data, the normal depth and the velocity were calculated using computer software.

D_n = 5.56 ft (Headwater depth at culvert entrance)
v = 2.84 fps (Velocity within the trapezoidal channel upstream of the culvert)



Step 3, find freeboard:

According to the current Storm Drainage Standards, the minimum required freeboard can be calculated as follows:

Desirable Freeboard $= 2.0 + 0.025\, v\, (d)^{1/3}$
$= 2 + 0.025(5.56)(2.84)^{1/3}$
$= 2.13$ ft

Available Freeboard = Total Channel Depth - D_n
= 7.25 – 5.56 = 1.69 ft

Trash Rack 3:

Step 1, find Q:

According to the record documents, the channel and the culvert were designed base on the following design values:

T_m	= 20 yr
i_{20}	= 2.6 in/hr
A	= 49 ac
Q_{20}	= C I_{20} A R = 287 cfs

According the current design standards, roadway culverts and tailwater conditions shall be designed for a 50 year reoccurrence interval, therefore:

T_m	= 50 yr
i_{50}	= 3.0 in/hr

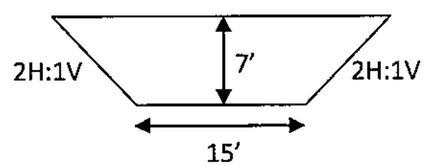
Q_{50} = C I_{50} A R, therefore

$Q_{50} = Q_{20}\, i_{50} / i_{20}$
$= (287)(3.0)/(2.6) = \underline{331\text{ cfs}}$

Step 2, find normal depth and velocity at the proposed trash rack location:

Using the new storm flow data, the normal depth and the velocity were calculated using computer software.

D_n	= 5.22 ft	(Headwater depth at culvert entrance)
v	= 2.50 fps	(Velocity within the trapezoidal channel upstream of the culvert)



Step 3, find freeboard:

According to the current Storm Drainage Standards, the minimum required freeboard can be calculated as follows:

Storm Drainage Standards Calculations:

Desirable Freeboard $= 2.0 + 0.025\, v\, (d)^{1/3}$
$= 2 + 0.025(5.22)(2.50)^{1/3}$
$= \underline{2.11\text{ ft}}$

Available Freeboard = Total Channel Depth - D_n
$= 7.00 - 5.22 = \underline{1.78\text{ ft}}$

Trash Rack 4

Step 1, find Q:

According to the record documents, the concrete lined channel was designed base on the following design values:

T_m = 50 yr
i_{50} = 3 in/hr (assumed)
A = over 100 ac (assumed)
Q_{50} = C I_{50} A R = 2865 cfs

According the current design standards, areas over 100 acres should be designed for a 100 reoccurrence interval, therefore:

T_m = 100 yr
I_{100} = 4.0 in/hr

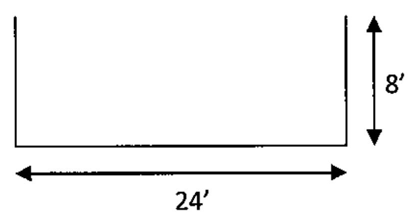
Q_{100} = C I_{100} A R, therefore

Q_{100} = Q_{50} i_{100} / i_{50}
= (2865)(4.0)/(3.0) = 3820 cfs

Step 2, find normal depth and velocity at the proposed trash rack location:

Using the new storm flow data, the normal depth and the velocity were calculated using computer software.

D_n = 5.88 ft (Normal depth within the channel at the trash rack location)
v = 27.1 fps (Velocity within the channel at the trash rack location)



Step 3, find freeboard:

According to the current Storm Drainage Standards, the minimum required freeboard can be calculated as follows:

Storm Drainage Standards Calculations:

$$\text{Desirable Freeboard} = 2.0 + 0.025\,v\,(d)^{1/3} = 2 + 0.025(27.1)(5.88)^{1/3} = 3.22\text{ ft}$$

Available Freeboard = Total Channel Depth - D_n
= 8.00 – 5.88 = 2.12 ft

Trash Rack 5

Step 1, find Q:

According to the record documents, the concrete lined channel was designed base on the following design values:

T_m = 50 yr
i_{50} = 3 in/hr (assumed)
A = 116 ac (assumed)
Q_{50} = C I_{50} A R = 1200 cfs

According the current design standards, areas over 100 acres should be designed for a 100 reoccurrence interval, therefore:

T_m = 100 yr
i_{100} = 4.0 in/hr

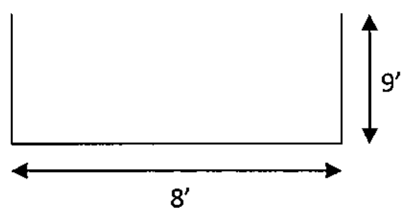
Q_{100} = C I_{100} A R, therefore

$Q_{100} = Q_{50}\, i_{100} / i_{50}$
= (1200)(4.0)/(3.0) = 1600 cfs

Step 2, find normal depth and velocity at the proposed trash rack location:

Using the new storm flow data, the normal depth and the velocity were calculated using computer software.

D_n = 6.61 ft (Normal depth within trapezoidal channel at the trash rack location)
v = 30.25 fps (Velocity within the trapezoidal channel at the trash rack location)



Step 3, find freeboard:

According to the current Storm Drainage Standards, the minimum required freeboard can be calculated as follows:

Storm Drainage Standards Calculations:

Desirable Freeboard = $2.0 + 0.025\, v\, (d)^{1/3}$
$= 2 + 0.025(6.61)(30.25)^{1/3}$
= 3.42 ft

Available Freeboard = Total Channel Depth - D_n
= 9.00 – 6.61 = 2.39 ft

Worksheet for Trash Rack No. 1 - Channel (downstream)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00060	ft/ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Bottom Width	35.00	ft
Discharge	1288.00	ft³/s

Results

Normal Depth	7.76	ft
Flow Area	391.74	ft²
Wetted Perimeter	69.68	ft
Top Width	66.02	ft
Critical Depth	3.26	ft
Critical Slope	0.01318	ft/ft
Velocity	3.29	ft/s
Velocity Head	0.17	ft
Specific Energy	7.92	ft
Froude Number	0.24	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	7.76	ft
Critical Depth	3.26	ft
Channel Slope	0.00060	ft/ft
Critical Slope	0.01318	ft/ft

Culvert Calculator Report
Trash Rack No. 1 - Culvert

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	0.00 ft	Headwater Depth/Height	1.49
Computed Headwater Eleva	8.94 ft	Discharge	1,288.00 cfs
Inlet Control HW Elev.	7.76 ft	Tailwater Elevation	7.76 ft
Outlet Control HW Elev.	8.94 ft	Control Type	Outlet Control

Grades

Upstream Invert	0.00 ft	Downstream Invert	0.00 ft
Length	60.00 ft	Constructed Slope	0.000000 ft/ft

Hydraulic Profile

Profile	PressureProfile	Depth, Downstream	7.76 ft
Slope Type	N/A	Normal Depth	N/A ft
Flow Regime	N/A	Critical Depth	3.69 ft
Velocity Downstream	6.71 ft/s	Critical Slope	0.005073 ft/ft

Section

Section Shape	Box	Mannings Coefficient	0.015
Section Material	Concrete	Span	8.00 ft
Section Size	8 x 6 ft	Rise	6.00 ft
Number Sections	4		

Outlet Control Properties

Outlet Control HW Elev.	8.94 ft	Upstream Velocity Head	0.70 ft
Ke	0.50	Entrance Loss	0.35 ft

Inlet Control Properties

Inlet Control HW Elev.	7.76 ft	Flow Control	N/A
Inlet Type	90 and 15° wingwall flares	Area Full	192.0 ft²
K	0.06100	HDS 5 Chart	8
M	0.75000	HDS 5 Scale	2
C	0.04000	Equation Form	1
Y	0.80000		

Worksheet for Trash Rack No. 1 - Channel (upstream)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00400	ft/ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Bottom Width	35.00	ft
Discharge	1288.00	ft^3/s

Results

Normal Depth	4.58	ft
Flow Area	202.43	ft^2
Wetted Perimeter	55.50	ft
Top Width	53.33	ft
Critical Depth	3.26	ft
Critical Slope	0.01318	ft/ft
Velocity	6.36	ft/s
Velocity Head	0.63	ft
Specific Energy	5.21	ft
Froude Number	0.58	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	4.58	ft
Critical Depth	3.26	ft
Channel Slope	0.00400	ft/ft
Critical Slope	0.01318	ft/ft

Worksheet for Trash Rack No. 2 - Channel (downstream)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00100	ft/ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Bottom Width	19.00	ft
Discharge	440.00	ft³/s

Results

Normal Depth	4.95	ft
Flow Area	142.86	ft²
Wetted Perimeter	41.11	ft
Top Width	38.78	ft
Critical Depth	2.34	ft
Critical Slope	0.01502	ft/ft
Velocity	3.08	ft/s
Velocity Head	0.15	ft
Specific Energy	5.09	ft
Froude Number	0.28	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	4.95	ft
Critical Depth	2.34	ft
Channel Slope	0.00100	ft/ft
Critical Slope	0.01502	ft/ft

Culvert Calculator Report
Trash Rack No. 2 - Culvert

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	0.00 ft	Headwater Depth/Height	0.79
Computed Headwater Eleva	5.56 ft	Discharge	440.00 cfs
Inlet Control HW Elev.	4.95 ft	Tailwater Elevation	4.95 ft
Outlet Control HW Elev.	5.56 ft	Control Type	Outlet Control

Grades

Upstream Invert	0.00 ft	Downstream Invert	0.00 ft
Length	60.00 ft	Constructed Slope	0.000000 ft/ft

Hydraulic Profile

Profile	H2	Depth, Downstream	4.95 ft
Slope Type	Horizontal	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	2.65 ft
Velocity Downstream	4.94 ft/s	Critical Slope	0.004392 ft/ft

Section

Section Shape	Box	Mannings Coefficient	0.015
Section Material	Concrete (wood forms)	Span	9.00 ft
Section Size	9 x 7 ft	Rise	7.00 ft
Number Sections	2		

Outlet Control Properties

Outlet Control HW Elev.	5.56 ft	Upstream Velocity Head	0.37 ft
Ke	0.50	Entrance Loss	0.19 ft

Inlet Control Properties

Inlet Control HW Elev.	4.95 ft	Flow Control	N/A
Inlet Type	90 and 15° wingwall flares	Area Full	126.0 ft²
K	0.06100	HDS 5 Chart	8
M	0.75000	HDS 5 Scale	2
C	0.04000	Equation Form	1
Y	0.80000		

Worksheet for Trash Rack No. 2 - Channel (upstream)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00080	ft/ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Bottom Width	19.00	ft
Discharge	440.00	ft³/s

Results

Normal Depth	5.25	ft
Flow Area	154.74	ft²
Wetted Perimeter	42.46	ft
Top Width	39.99	ft
Critical Depth	2.34	ft
Critical Slope	0.01502	ft/ft
Velocity	2.84	ft/s
Velocity Head	0.13	ft
Specific Energy	5.37	ft
Froude Number	0.25	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	5.25	ft
Critical Depth	2.34	ft
Channel Slope	0.00080	ft/ft
Critical Slope	0.01502	ft/ft

Worksheet for Trash Rack No. 3 - Channel (downstream)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00080	ft/ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Bottom Width	19.00	ft
Discharge	331.00	ft^3/s

Results

Normal Depth	4.51	ft
Flow Area	126.28	ft^2
Wetted Perimeter	39.16	ft
Top Width	37.03	ft
Critical Depth	1.96	ft
Critical Slope	0.01572	ft/ft
Velocity	2.62	ft/s
Velocity Head	0.11	ft
Specific Energy	4.61	ft
Froude Number	0.25	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	4.51	ft
Critical Depth	1.96	ft
Channel Slope	0.00080	ft/ft
Critical Slope	0.01572	ft/ft

Culvert Calculator Report
Trash Rack No. 3 - Culvert

Solve For: Headwater Elevation

Culvert Summary

Allowable HW Elevation	0.00 ft	Headwater Depth/Height	0.74
Computed Headwater Elev:	5.20 ft	Discharge	331.00 cfs
Inlet Control HW Elev.	4.51 ft	Tailwater Elevation	4.51 ft
Outlet Control HW Elev.	5.20 ft	Control Type	Outlet Control

Grades

Upstream Invert	0.00 ft	Downstream Invert	0.00 ft
Length	50.00 ft	Constructed Slope	0.000000 ft/ft

Hydraulic Profile

Profile	H2	Depth, Downstream	4.51 ft
Slope Type	Horizontal	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	2.59 ft
Velocity Downstream	5.24 ft/s	Critical Slope	0.004996 ft/ft

Section

Section Shape	Box	Mannings Coefficient	0.015
Section Material	Concrete	Span	7.00 ft
Section Size	7 x 7 ft	Rise	7.00 ft
Number Sections	2		

Outlet Control Properties

Outlet Control HW Elev.	5.20 ft	Upstream Velocity Head	0.41 ft
Ke	0.50	Entrance Loss	0.21 ft

Inlet Control Properties

Inlet Control HW Elev.	4.51 ft	Flow Control	N/A
Inlet Type	90 and 15° wingwall flares	Area Full	98.0 ft^2
K	0.06100	HDS 5 Chart	8
M	0.75000	HDS 5 Scale	2
C	0.04000	Equation Form	1
Y	0.80000		

Worksheet for Trash Rack No. 3 - Channel (upstream)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.00066	ft/ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Bottom Width	15.00	ft
Discharge	331.00	ft³/s

Results

Normal Depth	5.22	ft
Flow Area	132.64	ft²
Wetted Perimeter	38.32	ft
Top Width	35.86	ft
Critical Depth	2.23	ft
Critical Slope	0.01551	ft/ft
Velocity	2.50	ft/s
Velocity Head	0.10	ft
Specific Energy	5.31	ft
Froude Number	0.23	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	5.22	ft
Critical Depth	2.23	ft
Channel Slope	0.00066	ft/ft
Critical Slope	0.01551	ft/ft

Worksheet for Trash Rack No. 4 - Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.015	
Channel Slope	0.01200	ft/ft
Bottom Width	24.00	ft
Discharge	3820.00	ft³/s

Results

Normal Depth	5.88	ft
Flow Area	141.01	ft²
Wetted Perimeter	35.75	ft
Hydraulic Radius	3.94	ft
Top Width	24.00	ft
Critical Depth	9.23	ft
Critical Slope	0.00334	ft/ft
Velocity	27.09	ft/s
Velocity Head	11.41	ft
Specific Energy	17.28	ft
Froude Number	1.97	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	5.88	ft
Critical Depth	9.23	ft
Channel Slope	0.01200	ft/ft
Critical Slope	0.00334	ft/ft

Worksheet for Trash Rack No. 5 - Channel (upstream)

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.015	
Channel Slope	0.02760	ft/ft
Bottom Width	8.00	ft
Discharge	1600.00	ft³/s

Results

Normal Depth	6.61	ft
Flow Area	52.89	ft²
Wetted Perimeter	21.22	ft
Hydraulic Radius	2.49	ft
Top Width	8.00	ft
Critical Depth	10.75	ft
Critical Slope	0.00846	ft/ft
Velocity	30.25	ft/s
Velocity Head	14.22	ft
Specific Energy	20.83	ft
Froude Number	2.07	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	6.61	ft
Critical Depth	10.75	ft
Channel Slope	0.02760	ft/ft
Critical Slope	0.00846	ft/ft

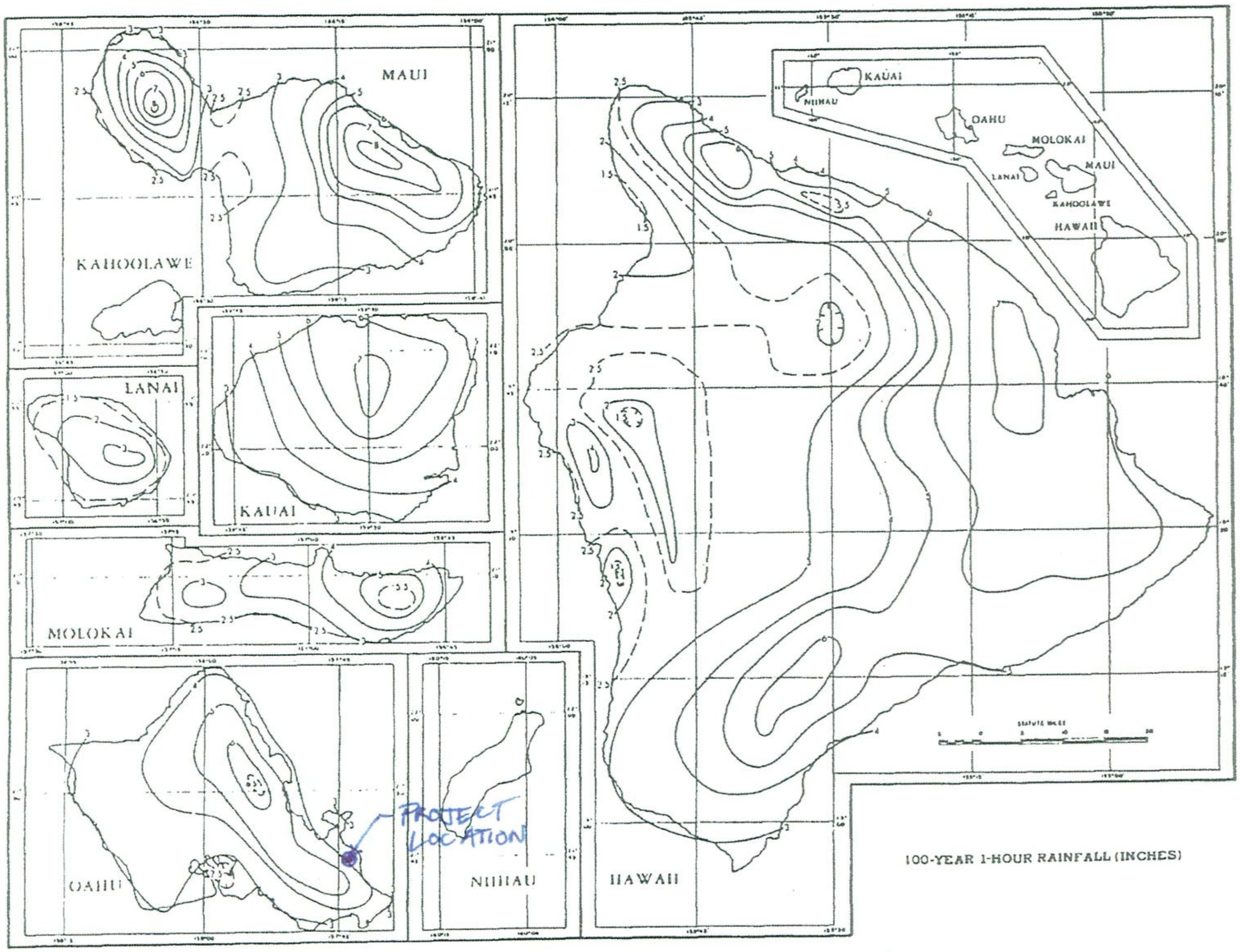


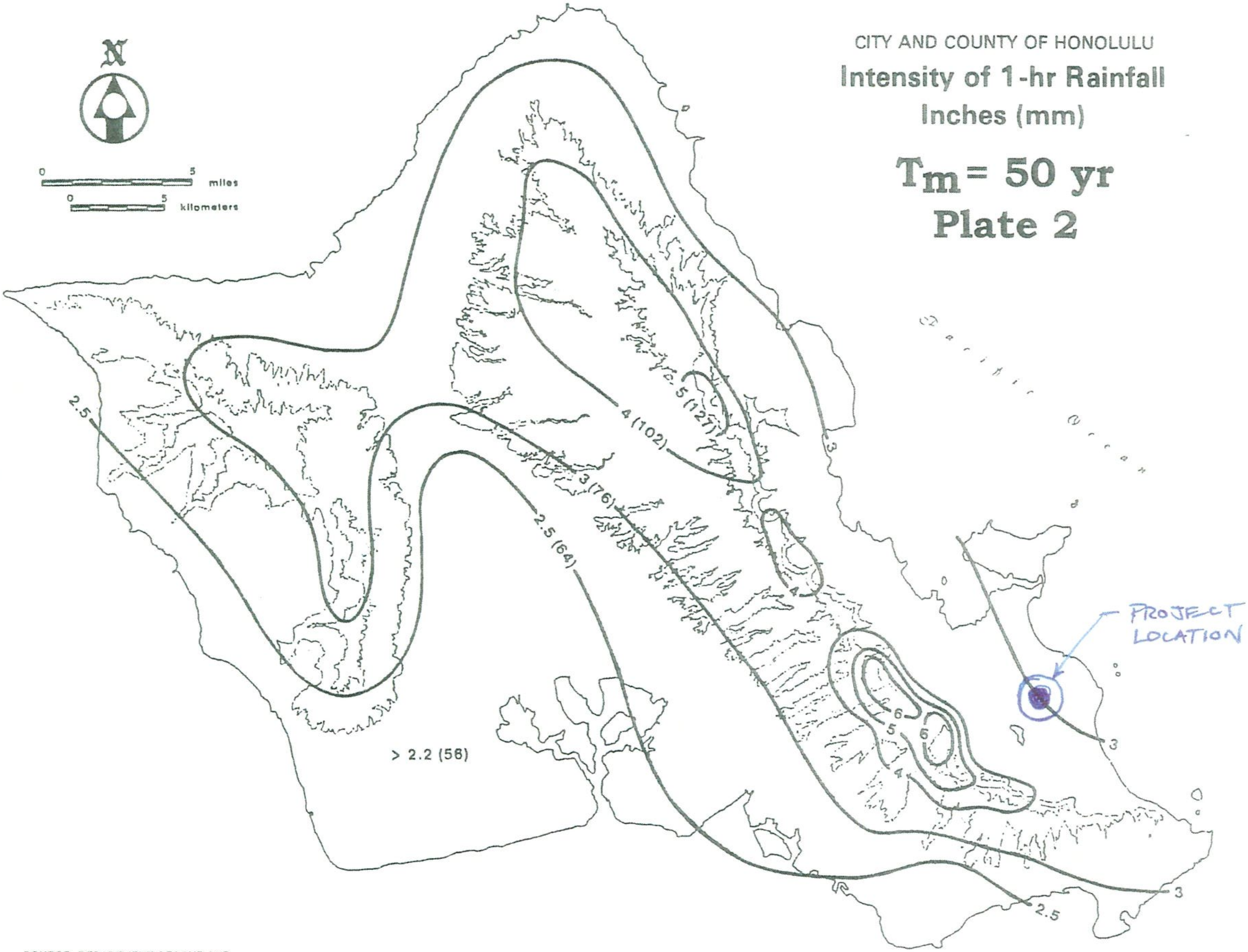
FIGURE 21.—100-yr. 1-hr. rainfall (in.)

CITY AND COUNTY OF HONOLULU

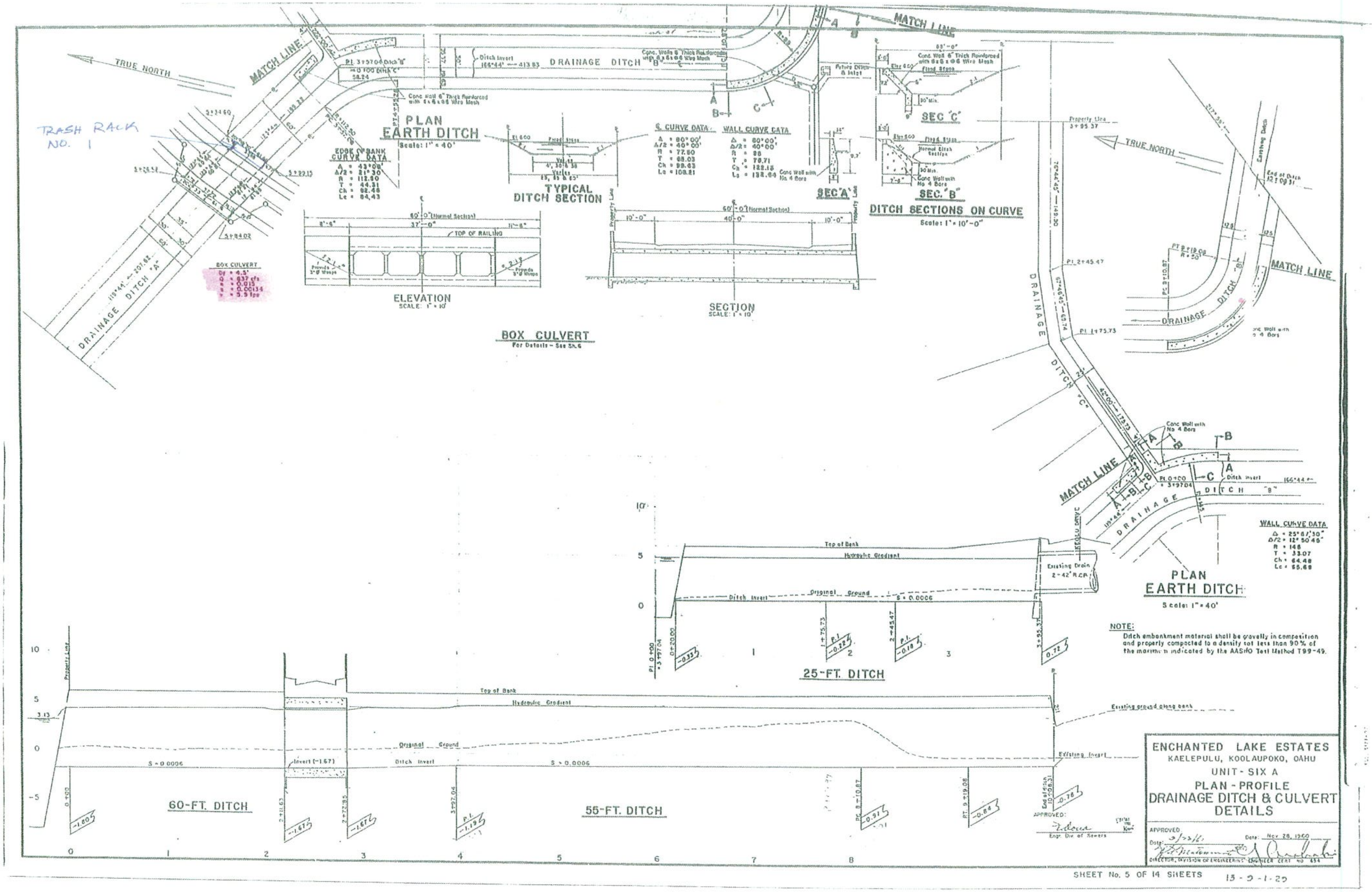
Intensity of 1-hr Rainfall

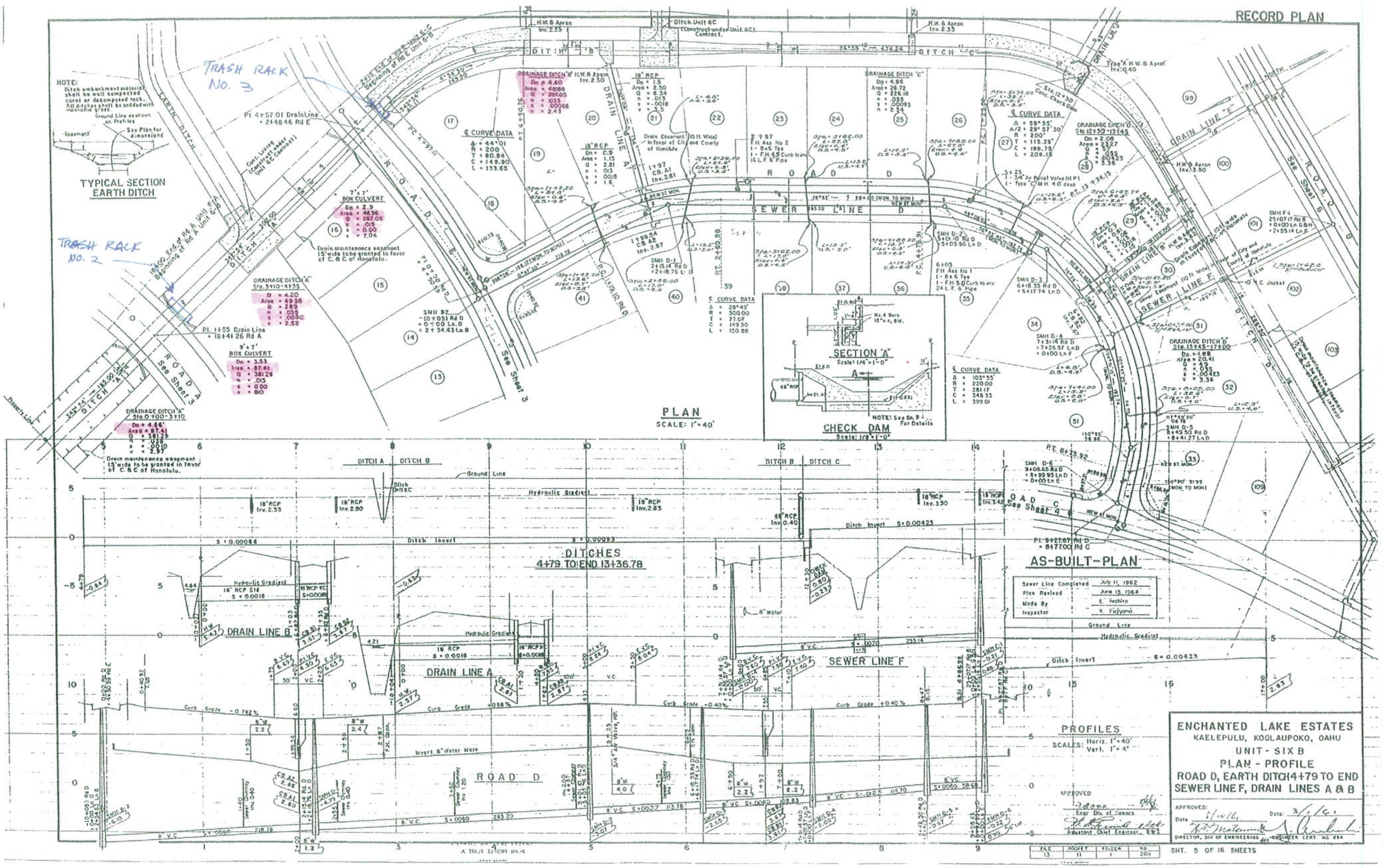
Inches (mm)

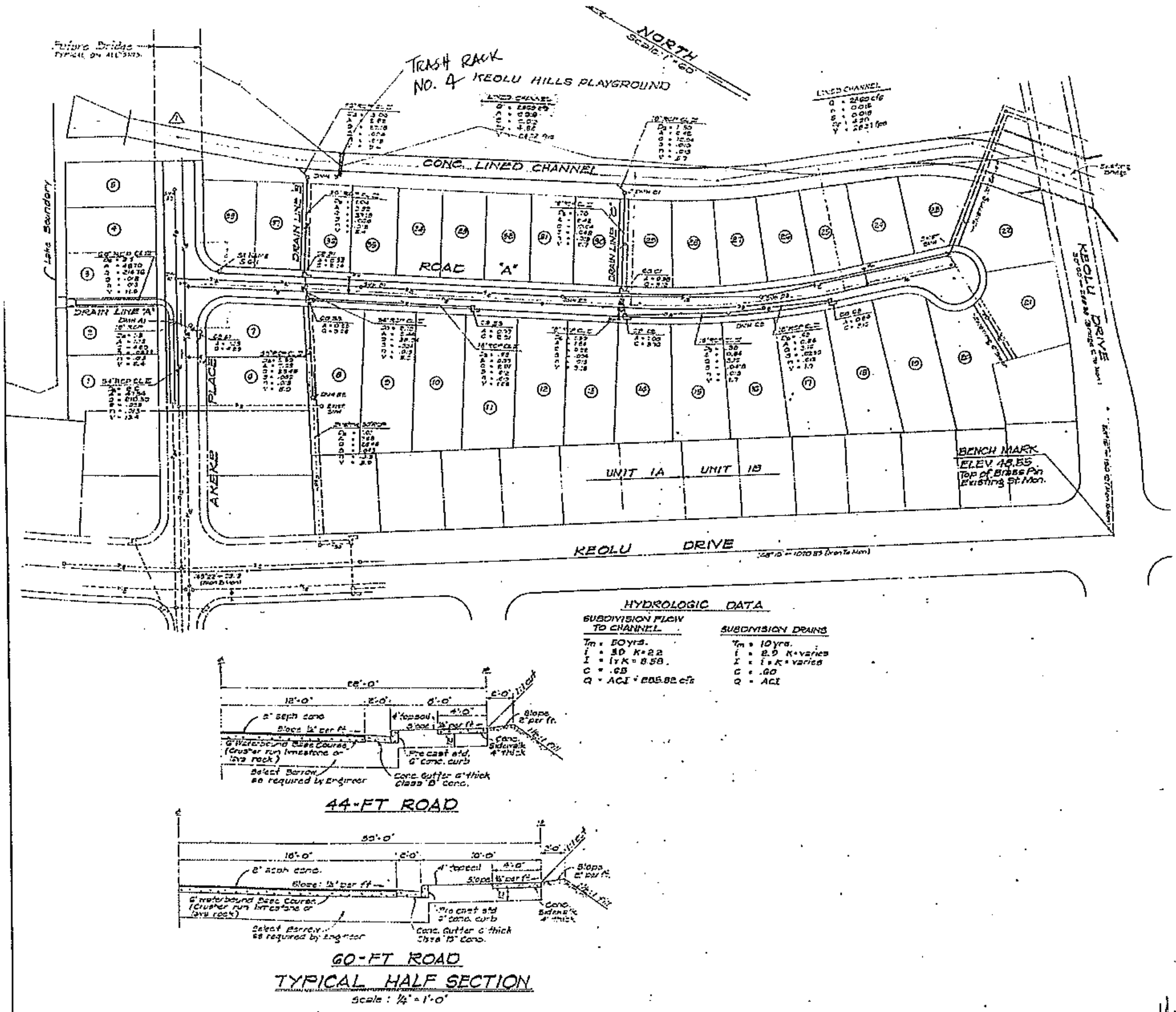
Tm= 50 yr
Plate 2



SOURCE: DEPARTMENT OF LAND AND NATURAL RESOURCES STATE OF HAWAII


ENCHANTED LAKE ESTATES
KAELEPULU, KOOLAUPOKO, OAHU
UNIT - SIX A
PLAN - PROFILE
DRAINAGE DITCH & CULVERT DETAILS
APPROVED
Date: Nov 28, 1960
DIRECTOR, DIVISION OF ENGINEERING
ENGINEER CERT. NO. 634
Engr. Div. of Sewers
SHEET No. 5 OF 14 SHEETS
13 - 9 - 1 - 29
PLAN
EARTH DITCH
Scale: 1" = 40'
TYPICAL
DITCH SECTION
DITCH SECTIONS ON CURVE
Scale: 1" = 10'-0"
SEC. "A"
SEC. "B"
SEC. "C"
BOX CULVERT
For Details - See Sh. 6
ELEVATION
SCALE: 1" = 10'
SECTION
SCALE: 1" = 10'
TOP OF RAILING
BOX CULVERT
MATCH LINE
TRUE NORTH
DRAINAGE DITCH "A"
DRAINAGE DITCH "B"
DRAINAGE DITCH "C"
TRASH RACK NO. 1
EDGE OF BANK CURVE DATA
Δ = 43°08'
Δ/2 = 21°30'
R = 112.50
T = 44.31
Ch = 82.46
Lc = 84.43
℄ CURVE DATA
Δ = 80°00'
Δ/2 = 40°00'
R = 77.50
T = 65.03
Ch = 99.63
Lc = 108.21
WALL CURVE DATA
Δ = 80°00'
Δ/2 = 40°00'
R = 95
T = 79.71
Ch = 122.13
Lc = 132.64
WALL CURVE DATA
Δ = 25°41'30"
Δ/2 = 12°50'45"
R = 146
T = 33.07
Ch = 64.48
Lc = 65.09
Conc. Wall 6" Thick Reinforced with 6x6 #6 Wire Mesh
Conc. Wall with No. 4 Bars
Existing Drain 2-42" R.C.P.
Existing Ditch
Future Ditch & Inlet
NOTE:
Ditch embankment material shall be gravelly in composition and properly compacted to a density not less than 90% of the maximum indicated by the AASHO Test Method T99-49.
Top of Bank
Hydraulic Gradient
Original Ground
Ditch Invert
Existing Invert
Existing ground along bank
S = 0.0006
Property Line
25-FT. DITCH
55-FT. DITCH
60-FT. DITCH


RECORD PLAN
TRASH RACK NO. 3
TRASH RACK NO. 2
TYPICAL SECTION EARTH DITCH
PLAN
SCALE: 1"=40'
SECTION "A"
CHECK DAM
DITCHES 4+79 TO END 13+36.78
AS-BUILT-PLAN
Sewer Line Completed July 11, 1962
Plan Revised June 15, 1964
DRAIN LINE B
DRAIN LINE A
SEWER LINE F
ROAD D
PROFILES
SCALES: Horiz. 1"=40' Vert. 1"=4'
ENCHANTED LAKE ESTATES
KAELEPULU, KOOLAUPOKO, OAHU
UNIT - SIX B
PLAN - PROFILE
ROAD D, EARTH DITCH 4+79 TO END
SEWER LINE F, DRAIN LINES A & B
SHT. 5 OF 16 SHEETS



GENERAL NOTES:

Contractor shall perform construction work all in accordance with STANDARD DETAILS, July 1958 of the DEPARTMENT OF PUBLIC WORKS, and the STANDARD SPECIFICATIONS, November 1958 of the DEPARTMENT OF PUBLIC WORKS of the CITY AND COUNTY OF HONOLULU.

All sewer construction shall be performed in accordance with City and County STANDARD SPECIFICATIONS approved by the CHIEF ENGINEER on November 1956, and the Department of Public Works Standard Details, July 1958 and the revised Ordinances of Honolulu, September 1961.

In the event that any changes in alignment or grade for the proposed sewers are required due to unforeseen conflict with other underground utilities, the subdivision Engineer or maker of the plans shall be responsible for the required changes which are to be presented to the DIVISION OF SEWERS for approval.

Unless otherwise shown on the plans sewer laterals shall be located 5.00 feet from the property corners except where a transformer pad is located at the property corner, the lateral shall then be located at a minimum distance of 11.50 ft from the property corner. All sewer laterals shall be provided with a 6"x4" C.I. Reducer with V.C. caps and redwood markers. Minimum slope of all laterals shall be 1.00%.

Crushed rock cradle will be permitted where the soil is stable. In areas of unstable soil, the maker of the plans and the Construction Engineer will discuss and determine the pipe support required.

The Contractor shall notify the Division of Sewer 2 days prior to the commencement of sewer work.

Bench Marks shall be established on new Street Monuments and data submitted to the Division of Engineering.

Street signs shall be installed by Contractor in accordance with Standards of the Department of Traffic. The exact location shall be determined by the Traffic Engineer. In lieu of the Standard embossed signs, reflectorized street name signs with sign brackets identical to that presently used by the Department of Traffic may be used.

The Developer and/or Contractor shall be responsible for the cleaning and removal of all silt and debris generated by any grading work and deposited and accumulated within downstream waterways, ditches and drain pipes, and on public roadways. The Developer and/or Contractor agrees to reimburse the City and County of Honolulu for all costs expended in the performance of the above work if required for public health and safety or made necessary by non-performance of the Developer and/or Contractor.

The Contractor at his expense shall keep the Project Site and surrounding areas free from dust nuisance. The City may require supplementary measures as necessary.

Street Lights shall be installed in accordance with Ordinance No.1929 as amended by Ordinances Nos. 1770, 2875, 3225 and 2957. Utilities shall be installed in conformance to Ordinances Nos. 2973 and 2957 (Underground Utilities).

The Contractor shall acquire a park-use permit for construction for work to be done in the parks property.

The Contractor and/or Developer shall be responsible for conformance to Chapter 37 & 37A of Public Health Regulations, Department of Health, State of Hawaii.

WATER NOTES:

1. Unless otherwise specified, all materials and construction of water system facilities and appurtenances shall be in accordance with the Honolulu Board of Water Supply's "Water Systems Standards" dated July 1960, and all subsequent amendments and additions.
2. All plans approved by the Board of Water Supply are based solely on the adequacy of the Water Supply. All other features of the water system such as lines, grades, fittings, etc. shall be the responsibility of the Engineer who prepared the plans. Drainage and other features of the improvements shall not be the responsibility of Board of Water Supply.
3. All meter boxes shall be type "X" and will be furnished by the Board of Water Supply at the Board's Kalihi Corporation Yard at no cost to the project. The Contractor shall pick up, haul to the job site and install the type "X" meter boxes in place complete at his own expense. The Contractor shall notify the Board of Water Supply 30 days prior to the time when meter boxes are required for the project.
4. Copper service laterals shall be 1½" with Type C-1 copper connection unless otherwise noted. See BWS Standards.
5. Prior to excavating for new drain, sewer and other utility lines, the Contractor shall verify in the field the location of existing water mains and appurtenances. Where the installation of new drain, sewer or other utility lines are to cross over or under existing water mains, the Contractor shall expose the existing water mains prior to trenching. Excavation around water mains shall be done by hand.
6. Pressure regulators shall be installed for all lots in this subdivision.
7. The Contractor shall notify the Board of Water Supply in writing one week prior to commencing work on the main.
8. In the event that asbestos cement is to be used, the plans shall be resubmitted for approval.

APPROVED:

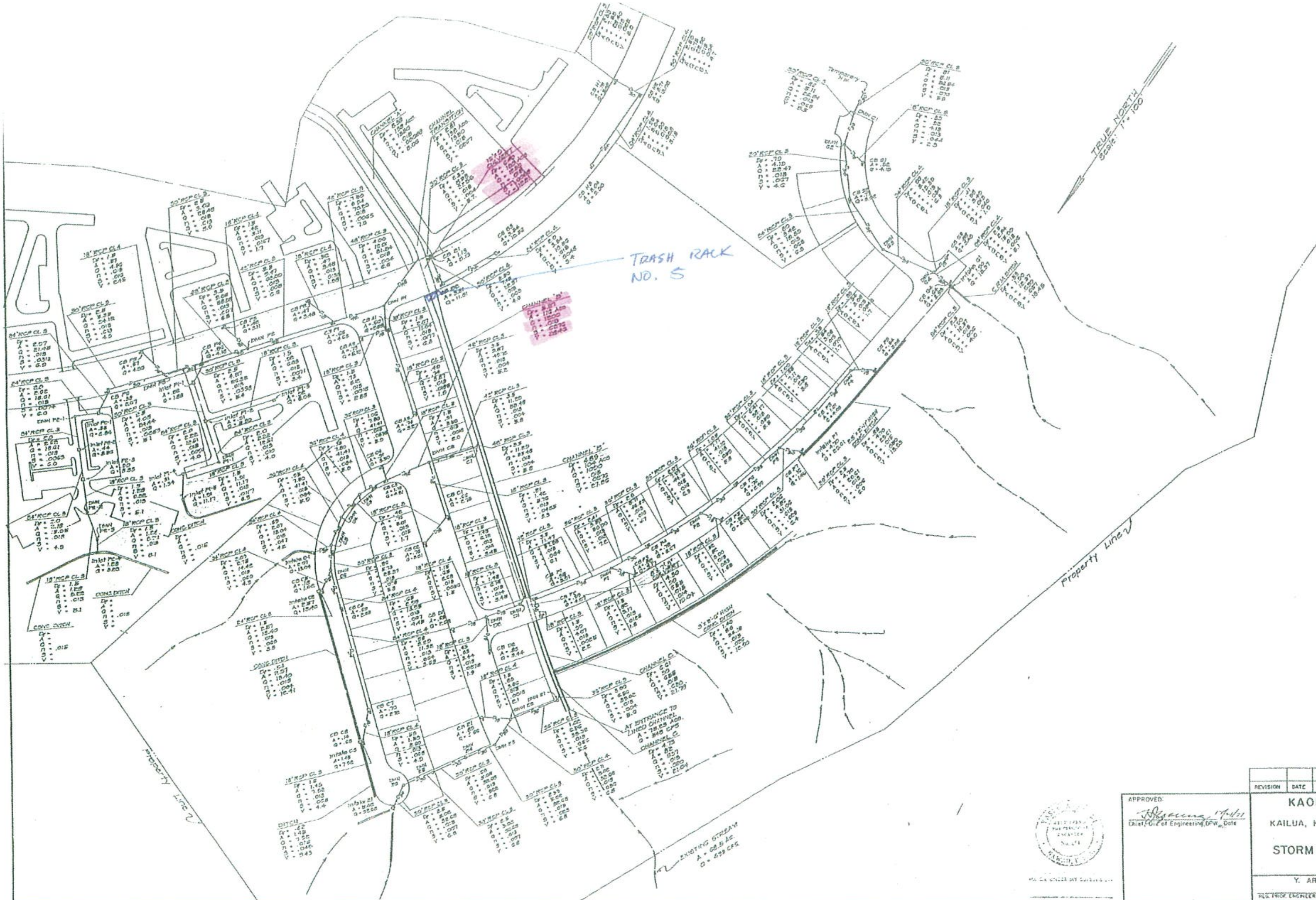
KAOPA SUBDIVISION
UNIT I-B1
KAILUA, KOOLAUPOKO, OAHU, HAWAII

GENERAL PLAN

Y. ARAKAKI - Consulting Engineer

"AS-BUILT"

SHT. NO 2 OF 14 SHEETS



REVISION	DATE	BRIEF	BY	APPROVED

APPROVED:
Chief, Div. of Engineering, DPW Date

KAOPA SUBDIVISION
UNIT TWO
KAILUA, KOOLAUPOKO, OAHU, HAWAII

STORM DRAINAGE DESIGN DATA

Y. ARAKAKI - Consulting Engineer
REG. PROF. ENGINEER NO. 654 DATE: SEP 20 1971

"AS-BUILT" SHT. NO. 3 OF 19 SHEETS 19-1-2-3