CONFIDENTIAL – For Official Use Only

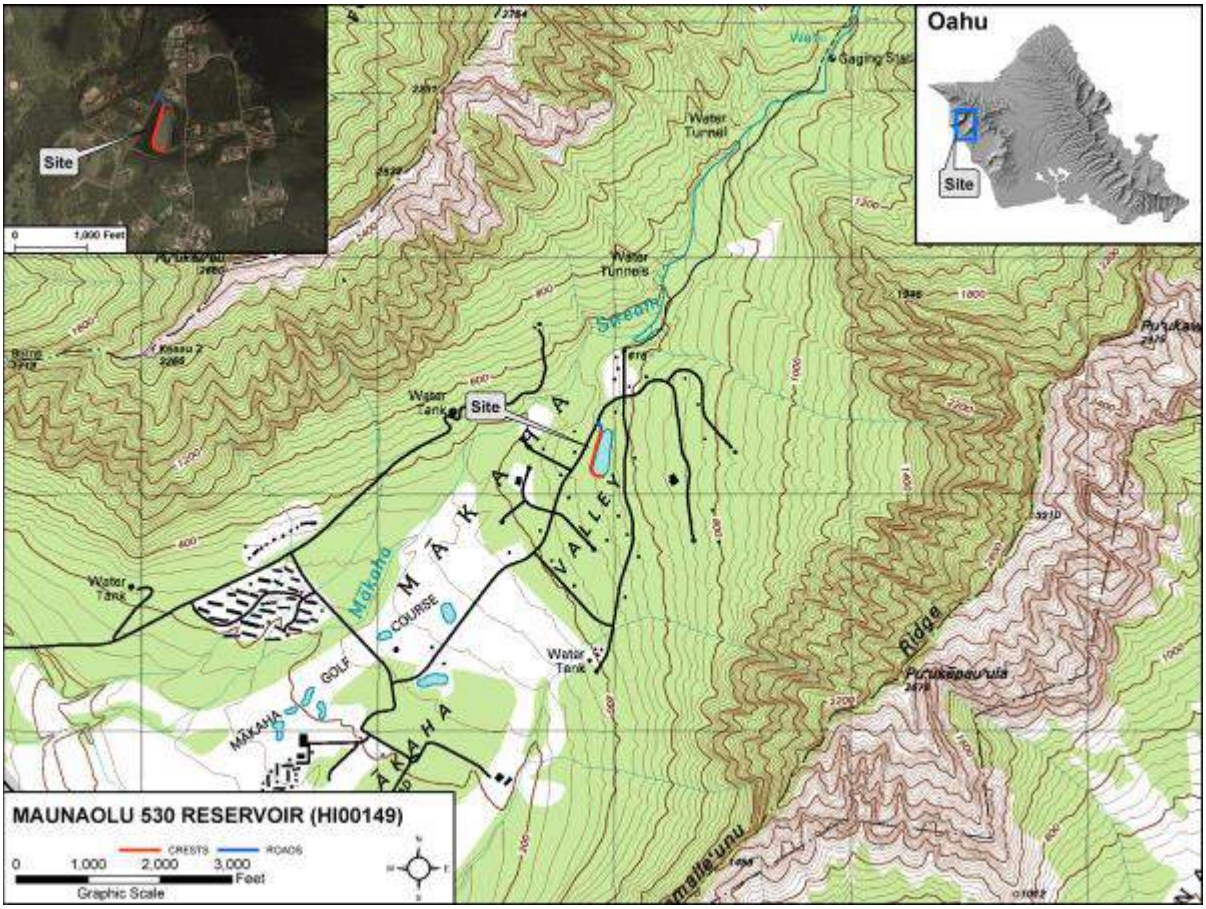
Emergency Action Plan (EAP)

for

MAUNAOLU RESERVOIR

State ID # OA-0149

Makaha, Oahu, Honolulu



Submitted By:

_____

Michael Matsuo, P.E., Land Administrator

Copy _____ of _____

(OA-0149) EAP for MAUNAOLU RESERVOIR

Instructions for use in preparing hard copy EAP binders

1. Obtain ½”~1” white view binder.
2. Print one copy of EAP for each report set.
3. Sign both copies of cover sheet and fill in copy number
4. Cut out binder spine and insert into binder spin.
5. Insert one copy of coversheet in binder cover view.
6. Collate EAP tabs and EAP report together.
7. Insert into binder and distribute.

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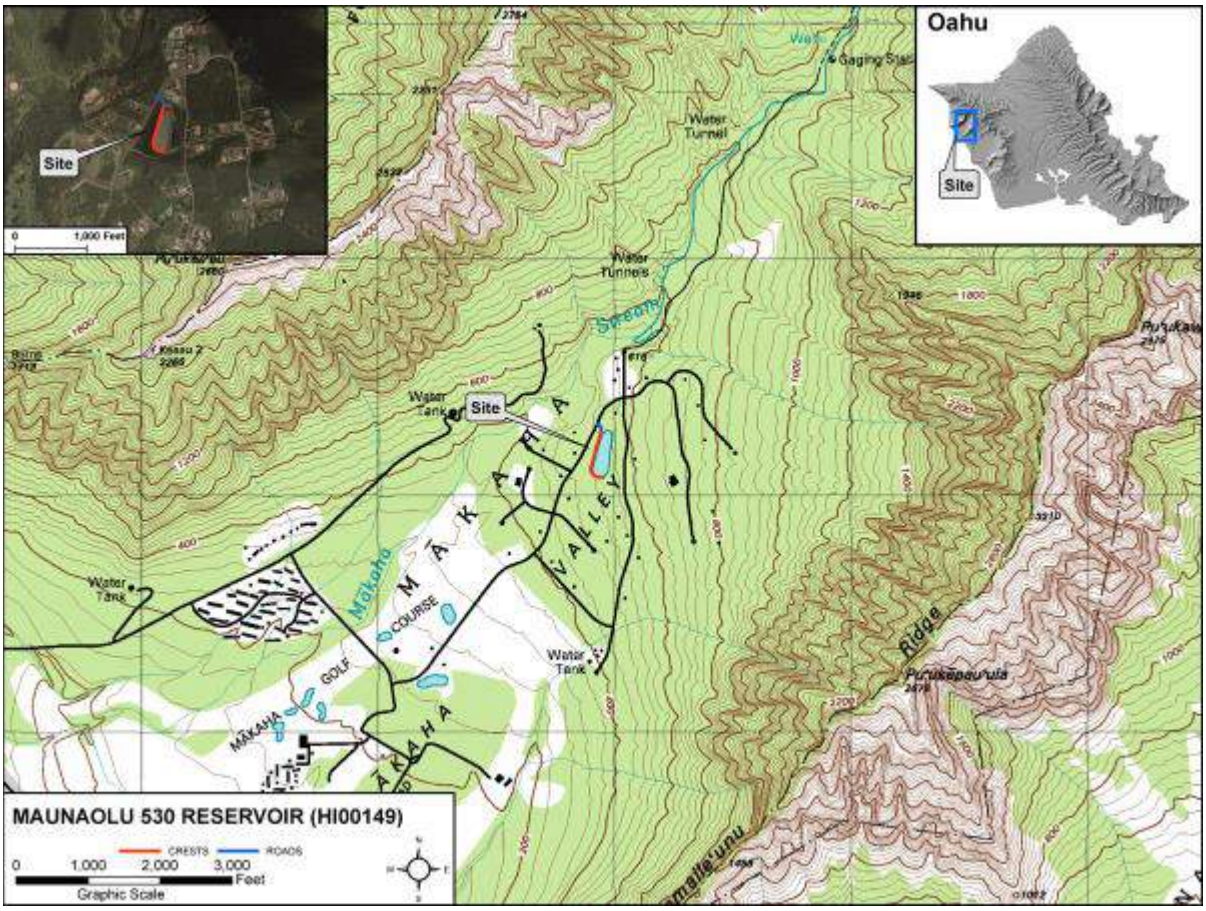

Submitted By:

_____

Michael Matsuo, P.E., Land Administrator

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Table of Contents

I. Introduction

Purpose

This EAP outlines procedures to minimize risks to life and property when the integrity of the subject dam facility may be in jeopardy. This EAP considers unusual and emergency situations, both natural and manmade, and identifies appropriate responses and details roles and responsibilities before, during and following an emergency event. This EAP was specifically developed for the named facility only, and is not intended for use with any other facility.

Categories of unusual and emergency situations that may trigger activation of this EAP include (but are not limited to):

- Earthquake
- Sudden Reservoir Level Rise
- Flow through Spillway
- Embankment Overtopping
- Seepage
- Sinkholes
- Piping
- Damage of Spillway or Outlet Works
- Embankment Cracks
- Embankment Movement
- Abnormal Instrumentation Readings
- Security Threat
- Sabotage or Vandalism
- Hurricane or Heavy Rain Storm Event

Roles and Responsibilities

The following roles and responsibilities have been assigned for implementation of this EAP:

Person or Agency	Responsibility
Dam Owner / Dam Owner's Representative	Inspect, monitor and operate dam. Detect unusual/emergency situation. Determine Notification Level for situation. Notify appropriate agencies by activating EAP. Monitor/Remediate situation. Provide status updates to other agencies. Develop EAP. Initiate and coordinate update and testing of EAP. Provide technical advice for the owner.
911 Dispatch / State Warning Point	Notify emergency responders of notifications received from owner or other sources. Participate in update and testing of EAP.
Police Department	Open communication with Department of Emergency Management/Civil Defense Agency, and other agencies pertinent to an emergency. Participate in update and testing of EAP.
Fire Department	Open communication with Department of Emergency Management/Civil Defense Agency, and other agencies pertinent to an emergency. Participate in update and testing of EAP.
Honolulu Department of Emergency Management, Kauai/Maui County Emergency Management Agency, County of Hawaii Civil Defense	Open communication with other agencies pertinent to an emergency. Terminate Level 2/3 (Emergency) event. Participate in update and testing of EAP.
Hawaii Emergency Management Agency (Hawaii State Civil Defense)	Operate State Warning Point. Assist local community as necessary. Participate in update and testing of EAP.
State Dam Safety Program	Assist agencies as necessary. Assess restrictions or other actions when deemed appropriate. Terminate Level 1 (Non-Emergency) event. Participate in update and testing of EAP.

Level 1 Notifications
NON-EMERGENCY
Unusual Event; Slowly Developing

Dam Owner's Representative
Ernest Y.W. Lau, P.E., Manager and Chief Engineer
Board of Water Supply

Primary Contact	Secondary Contact
Michael Matsuo, Land Administrator	Raelynn Nakabayashi, Dept.
(808) 748-5951	Emergency Coordinator (BWS)
(808) 291-7327	(808) 748-5177
mmatsuo@hbws.org	(808) 347-5386
	rnakabayashi@hbws.org

(1)

State Dam Safety Program
DLNR-Engineering Division

Primary Contact	Secondary Contact
Edwin Matsuda	Denise Manuel
(808) 587-0268	(808) 587-0246
(808) 729-7177	(808) 551-1413
Edwin.Y.Matsuda@hawaii.gov	Denise.M.Manuel@hawaii.gov

(Advice, No action required)

Honolulu Department of Emergency Management
City & County of Honolulu

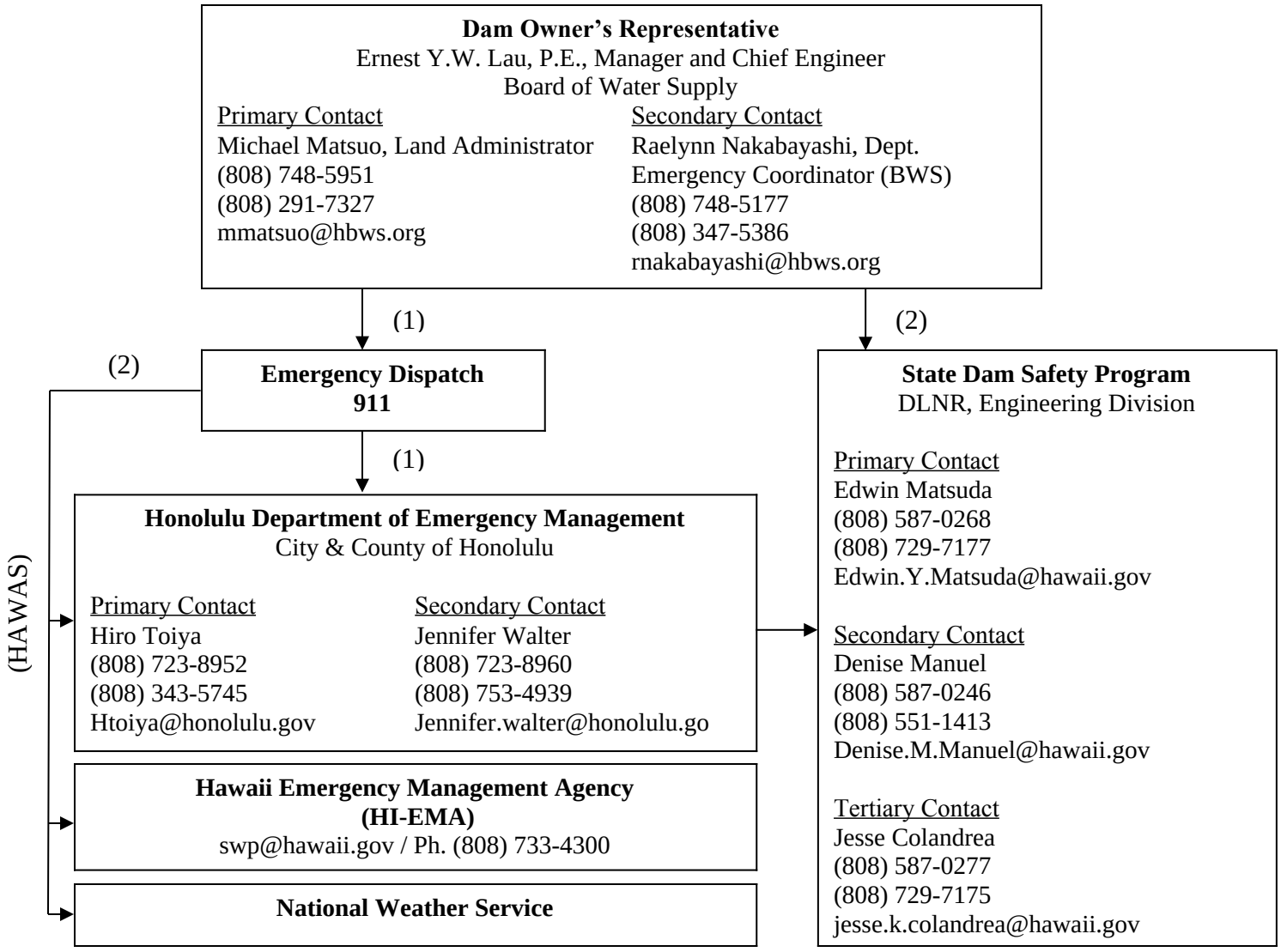
Primary Contact	Secondary Contact
Hiro Toiya	Jennifer Walter
(808) 723-8952	(808) 723-8960
(808) 343-5745	(808) 753-4939
Htoiya@honolulu.gov	Jennifer.walter@honolulu.gov

Hawaii Emergency Management Agency
(HI-EMA)
swp@hawaii.gov / Ph. (808) 733-4300

Suggested Pre-Scripted Statement – Level 1 - Dam Owner to State Dam Safety Program:

- This is [Name of Caller] from [Company you represent].
- We have a **LEVEL 1 Non-Emergency, Non-Failure situation** at **[MAUNAOLU RESERVOIR, OA-0149]**
- The type of unusual event is [describe unusual situation, i.e. maintenance work, change of outlet].
- The dam is located in [description of location, town neighborhood, address].
- The unusual event is expected to last [provide how long, i.e. week, month] and we will advise you of any changes to the status and when we are completed.
- My name is [Name of Caller] and I may be reached at [phone number] or alternate phone number [phone number].

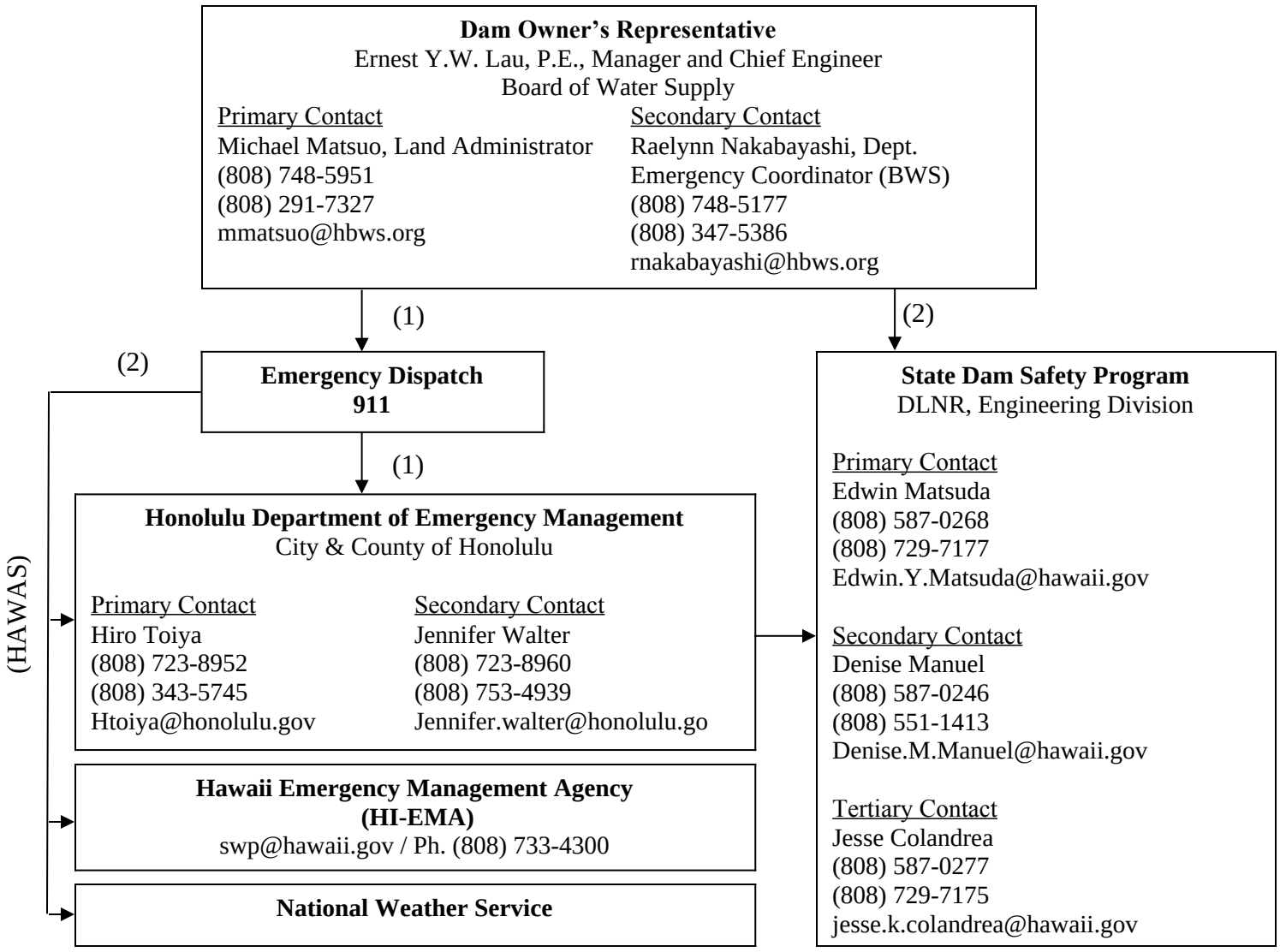
Level 2 Notifications
EMERGENCY EVENT
Potential Dam Failure Situation



Suggested Pre-Scripted Statement – Level 2 – Dam Owner to 911 Dispatch

- This is [Name of Caller] from [Company you represent].
- We have a **LEVEL 2 Emergency, Potential Dam Failure** at **[MAUNAOLU RESERVOIR, OA-0149]**
- The type of emergency concern is [describe failure mode – i.e. overtopping or seepage/embankment failure problem].
- The dam is located in [description of location, town neighborhood, address].
- The dam is being monitored by our staff [provide how often – continuously or hourly/every 2hours].
- My name is [Name of Caller] and I may be reached at [phone number] or alternate phone number [phone number].

Level 3 Notifications
URGENT EMERGENCY EVENT
Dam Failure is Imminent or In-Progress

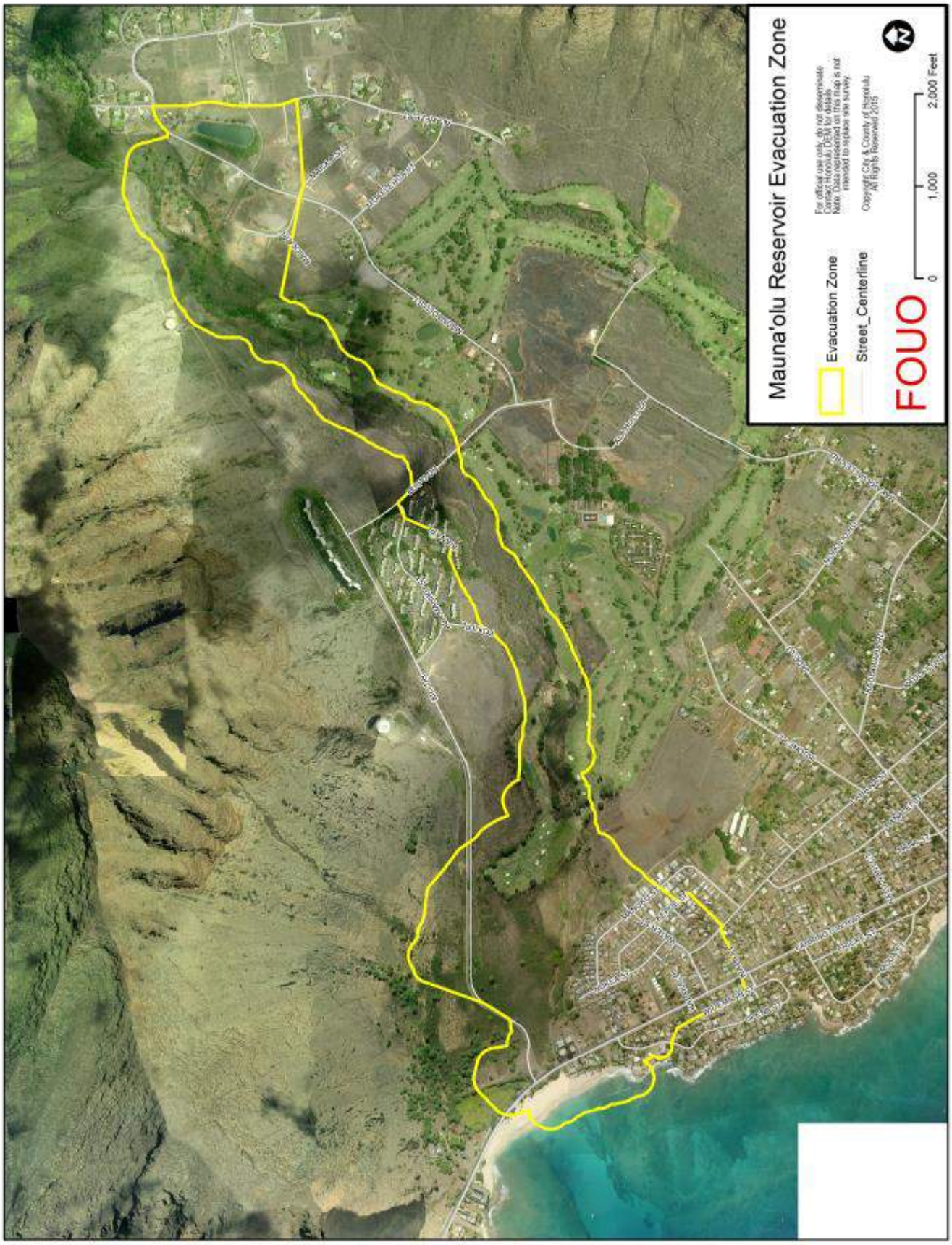


Suggested Pre-Scripted Statement – Level 3 – Dam Owner to 911 Dispatch

- This is [Name of Caller] from [Company you represent].
- We have a **LEVEL 3 Emergency, Imminent or In-Progress Dam Failure** at **[MAUNAOLU RESERVOIR, OA-0149]**
- The type of emergency concern is [describe failure mode – i.e. overtopping or seepage/embankment failure problem].
- The dam is located in [description of location, town neighborhood, address].
- The dam is being monitored by our staff [provide how often – continuously or hourly/every 2hours].
- My name is [Name of Caller] and I may be reached at [phone number] or alternate phone number [phone number].

V. Evacuation Map

a. Evacuation Map



b. Hazard Assessment Report

PACIFIC DISASTER CENTER

Individual Assessment Report

1 Identification

Name of Dam:	Maunaolu 530 Reservoir
National Id:	OA-149
Island:	Oahu
Nearest City/Town:	Makaha
Name of affected stream:	Makaha Stream
Current DLNR risk classification:	TBD
Owner:	Data Not Available

2 Background

Location (latitude/longitude):	21.486136N 158.189584W
Miles to nearest city:	2
Year completed:	Data Not Available
Purpose/use:	Data Not Available

3 Characteristics

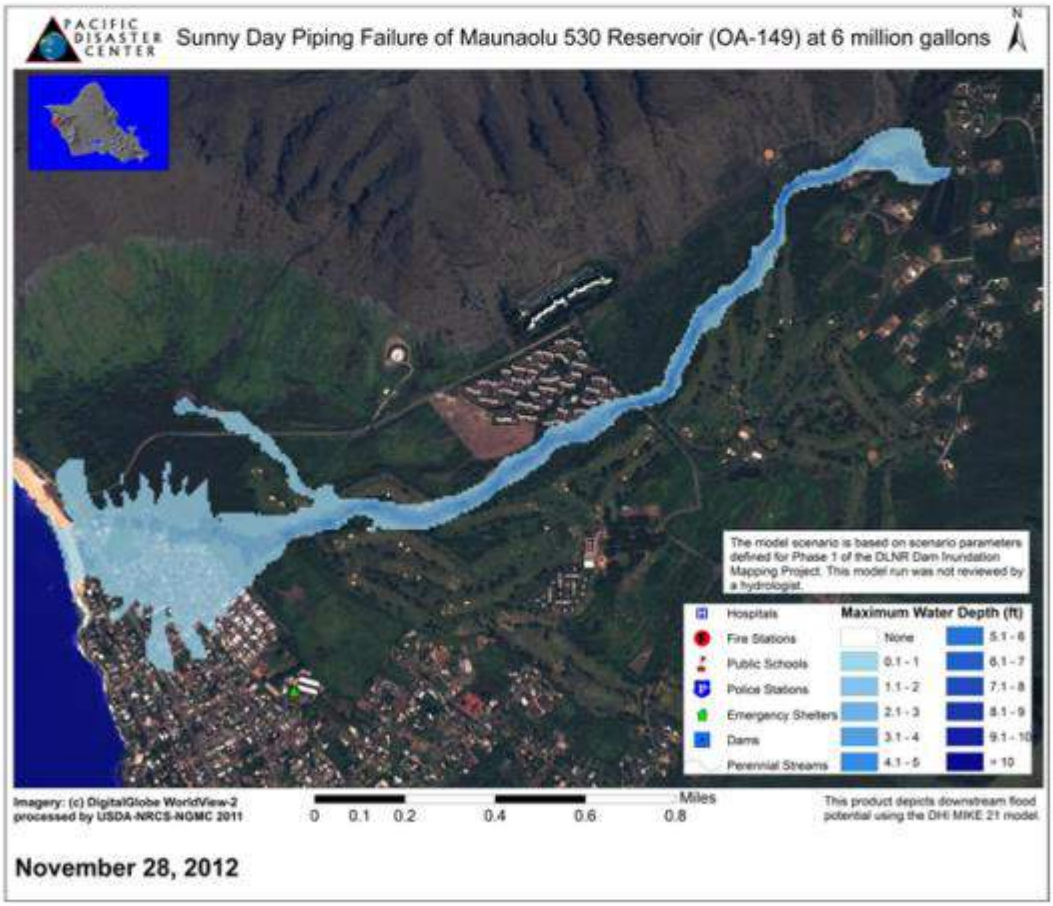
Dam type:	Earthen Dam
Max. storage capacity (acre feet):	18.41
Dam height (feet):	27
Dam length (feet):	156

4 Consequence Analysis

4.1 Scenario Parameters

Parameters	Value	Unit of Measure
Reservoir volume prior to breach:	18.41	acre-feet
Duration of breach:	7.17	minutes
Breach width:	31.4	feet
Distance from dam to ocean:	2.35	miles
Type of dam:	Earthen Dam	n/a
Type of breach:	Piping breach originating from spillway	n/a

4.2 MIKE 21 Model Results – Inundation Map*



*While the best available GIS data have been utilized as input to the model and in visualizing model output, due to variations in their currency and accuracy, final product results should be interpreted as "best available estimates" only and not definitive in establishing inundation boundaries.

4.3 Model Assumptions

It is assumed that each dam fails by piping while at maximum capacity. It is further assumed that 1) the piping failure originates halfway up the dam face, 2) the dam fails under sunny day conditions with dry conditions downstream of the reservoir, and 3) no water is discharged from the spillway. The outflow (discharge hydrograph) from the breached reservoir is modeled using the NWS' DAMBRK model (within the Danish Hydrological Institute's MIKE 11 model), and data from historical breaches is used to estimate parameters controlling breach development. The DHI MIKE 21 model is used to route the reservoir discharge down the valley into the ocean. MIKE 21 routes unsteady two dimensional flows using the full Saint-Venant equations. Topography is described by USGS standard 10 meter DEMs with a vertical accuracy of ±7 to 15 meters. The inundation maps produced by MIKE 21 represent the maximum water depth experienced at any given location. The inundation maps are not snapshots in time because different locations experience maximum flooding at different times. MIKE 21 also provides information on the time of flooding and water velocities.

5 Model Output Statistics

Inhabited Areas Or Landmarks	Distance from breach (miles)*	Time from beginning of breach to first inundation (minutes)	Time from beginning of breach to maximum water depth (minutes)	Maximum flood depth (feet)
Maunaolu rd	0.04	1.25	7.68	2.52
first residential structure	0.08	2.5	7.99	0.92
second residential structure	0.17	4	8.47	2.5
golf course	0.50	8.75	10.8	3.71
Huipu rd	0.98	13.75	14.46	3.57
golf course	1.49	18.75	19.4	2.32
Kili road	1.97	31.25	32.28	0.4
residential neighborhood	2.01	27.5	27.46	0.52

Farrington	2.28	35	35.45	0.37
ocean	2.35	37.5	39.91	0.65

* Distance determined by Euclidean method defined as the straight line distance between two points.

5.1 Impact on Bridges

Affected Bridges	Distance from breach (miles)*	Time from beginning of breach to first inundation (minutes)	Time from beginning of breach to maximum water depth (minutes)	Maximum flood depth (feet)
573	2.36	45	50.68	0.18
572	2.28	35	74.37	0.7

5.2 Hydrologist's Significant Observations and Comments

The model scenario is based on scenario parameters defined for Phase I of the DLNR Dam Inundation Mapping Project. This model run was not reviewed by a hydrologist.

6 Potential Scenario Consequences for OA-149 – Maunaolu 530 Reservoir

Dam Location: 21.486136N 158.189584W

Dam Owner: Data Not Available

The following table summarizes the estimated population and infrastructure potentially at risk as a result of the modeled dam break scenario, which assumes dam failure at maximum capacity.

Potential Scenario Consequences**	Value
1. Total inundation area (acres)	141.2
2. Total Population at risk	1345
3. Number of affected Properties:	
a. Total Parcels affected	314
b. Total Land Value	$105,931,100
c. Total Building Value	$100,997,000
4. Number of Critical Facilities affected:	
a. Total number affected	0
b. School total	0
c. Hospital total	0

Potential Scenario Consequences**	Value
d. Fire Station total	0
e. Police total	0
f. Government total	0
g. Airports and Seaports total	0
5. Emergency Operation Centers affected (total number):	0
6. Shelters affected (total number):	0
7. Infrastructure Affected:	
a. Number of Bridges	2
b. Length of Roads (miles)	1.52

**Refer to Final Report for methodology used to derive values.

7 References

Data Sheet – Maunaolu Reservoir (UMA-2014 – Dam Inventory System vr. 1.204 – Dec 16, 2008

Hawaii Dasymetric Population Data (PDC), Jan 01, 2010

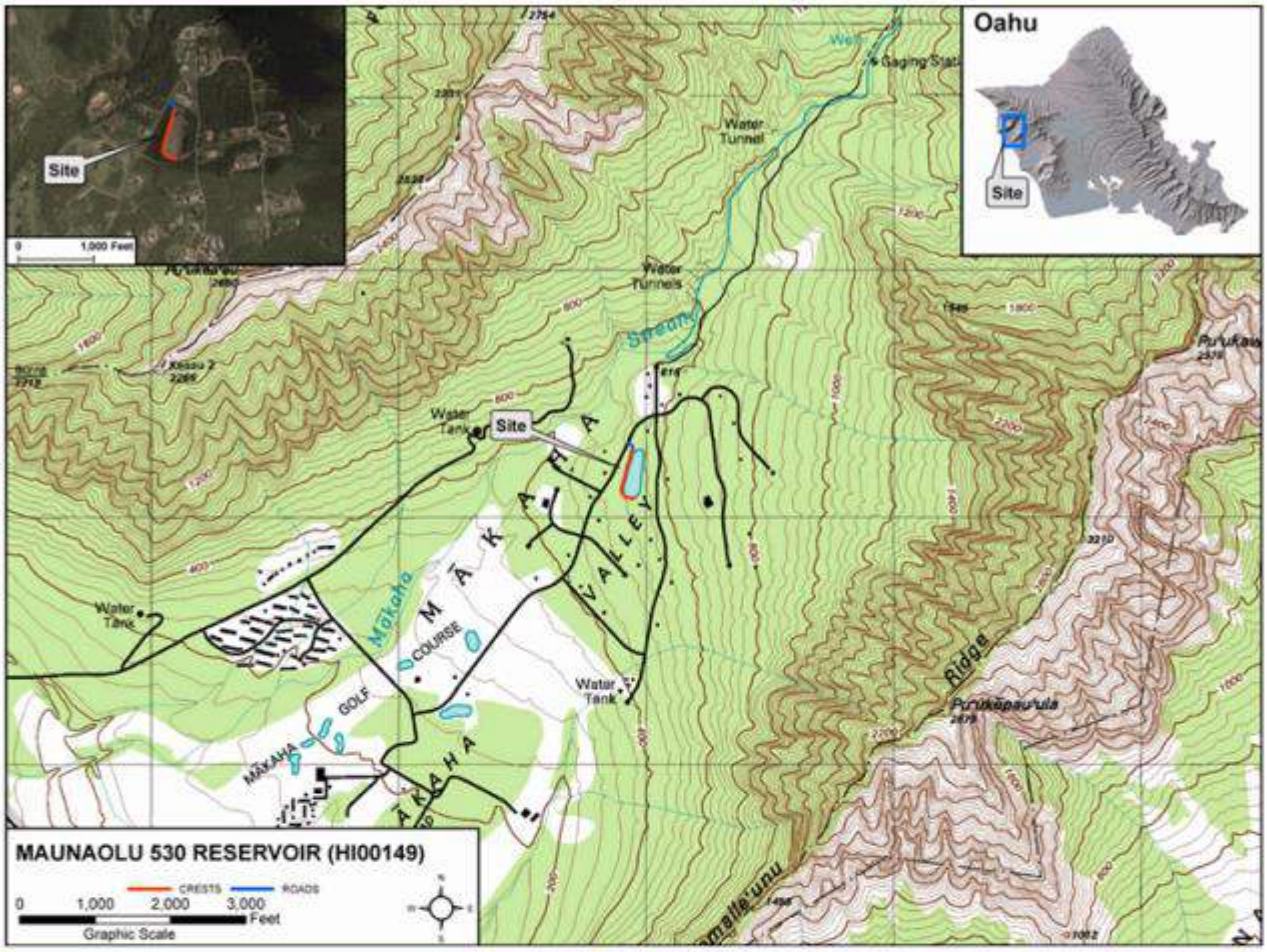
Oahu, Hawaii Tax Assessor Parcel Data, June 01, 2004

Disclaimer

VI. Facility Information

a. 2-page Facility Data Sheet

MAUNAOLU RESERVOIR | OA-0149 | Oahu



1. General Information	
a. State Dam ID	OA-0149
b. National ID	HI00149
c. Dam Name	MAUNAOLU RESERVOIR
d. Other Name(s)	
e. Longitude / Latitude	-158.1899 / 21.4862
f. County / Island	Honolulu / Oahu
g. Type of Dam	Earthen
h. Purpose	Irrigation
i. Completed / Last Modified	1966 / 2014
j. Nearest City / Town	Makaha
k. Water Body Type	State Regulated Dam
l. Dam Height	27 ft
m. Dam Length	800 ft
n. Drainage Area	/
o. Size Classification	Small

2. Owner Information	
a. Name of Owner	Honolulu Board of Water Supply
b. TMK(s)	(1) 8-4-029:135

3. Hazard Potential Classification	
a. Hazard Classification	High
b. Emergency Action Plan	11/29/2012

Date Printed: 08/05/2020 OA-0149 MAUNAOLU RESERVOIR - 2 Page Dam Data Sheet Page 1 of 2

MAUNAOLU RESERVOIR | OA-0149 | Oahu

Aerial Photo (05/06/2008)

4. Reservoir	
a. Normal Storage	18 ac-ft / 6 MG
b. Maximum Storage	23 ac-ft / 7 MG
c. Surface Area	2.3 acres

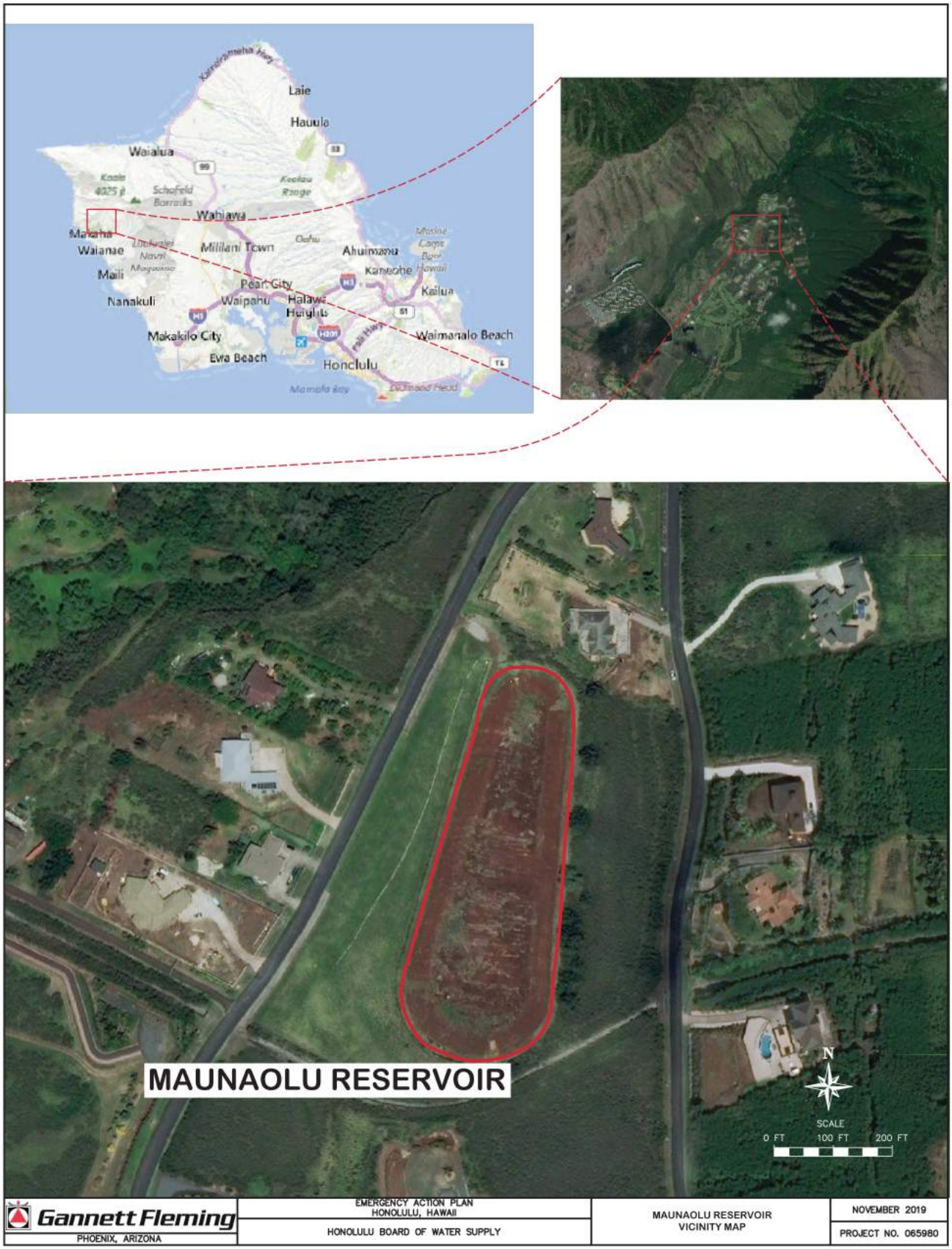
5. Primary Spillway	
a. Minimum Width	
b. Length	
c. Type	Pipe
d. Protection	Concrete
e. Maximum Discharge	

6. Primary Outlet Works	
a. Works Type	Downstream Control
b. Maximum Discharge	
c. Size	Unknown
d. Control Description	Valve

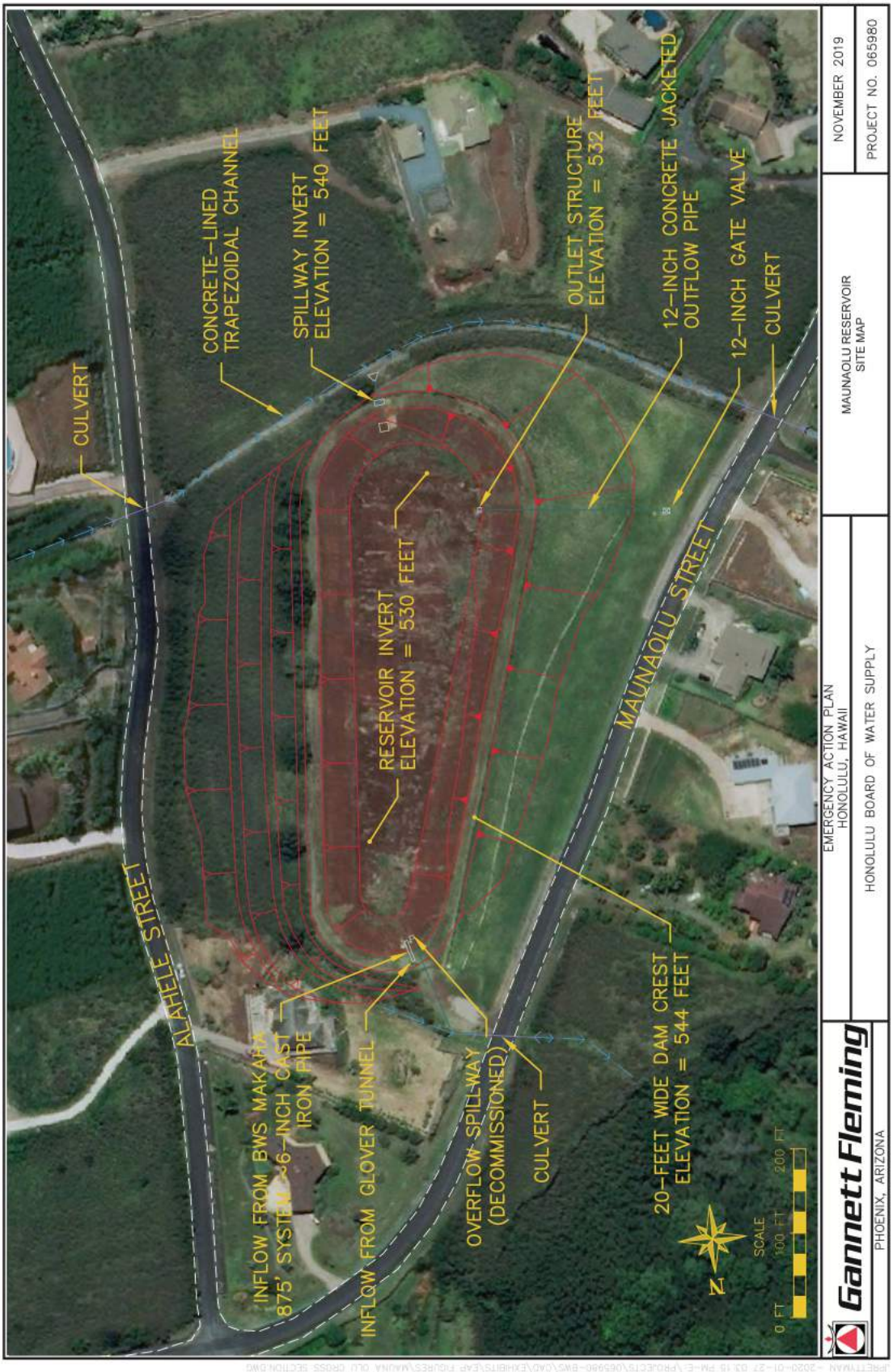
7. Embankment	
a. Type of Dam	Earthen
b. Minimum Crest Width	21 ft
c. Upstream Slope Grade	18° / 3.1:1
d. Upstream Slope Protection	Fabric Liner
e. Downstream Slope Grade	22.5° / 2.4:1
f. Downstream Slope Protection	Vegetation
g. Dam Height	27 ft
h. Dam Length	800 ft

8. Inflow Works			
Type	Name	Controlled	Size
Pipe		Yes	6"
Pipe		Yes	8"
Pipe		Yes	8"

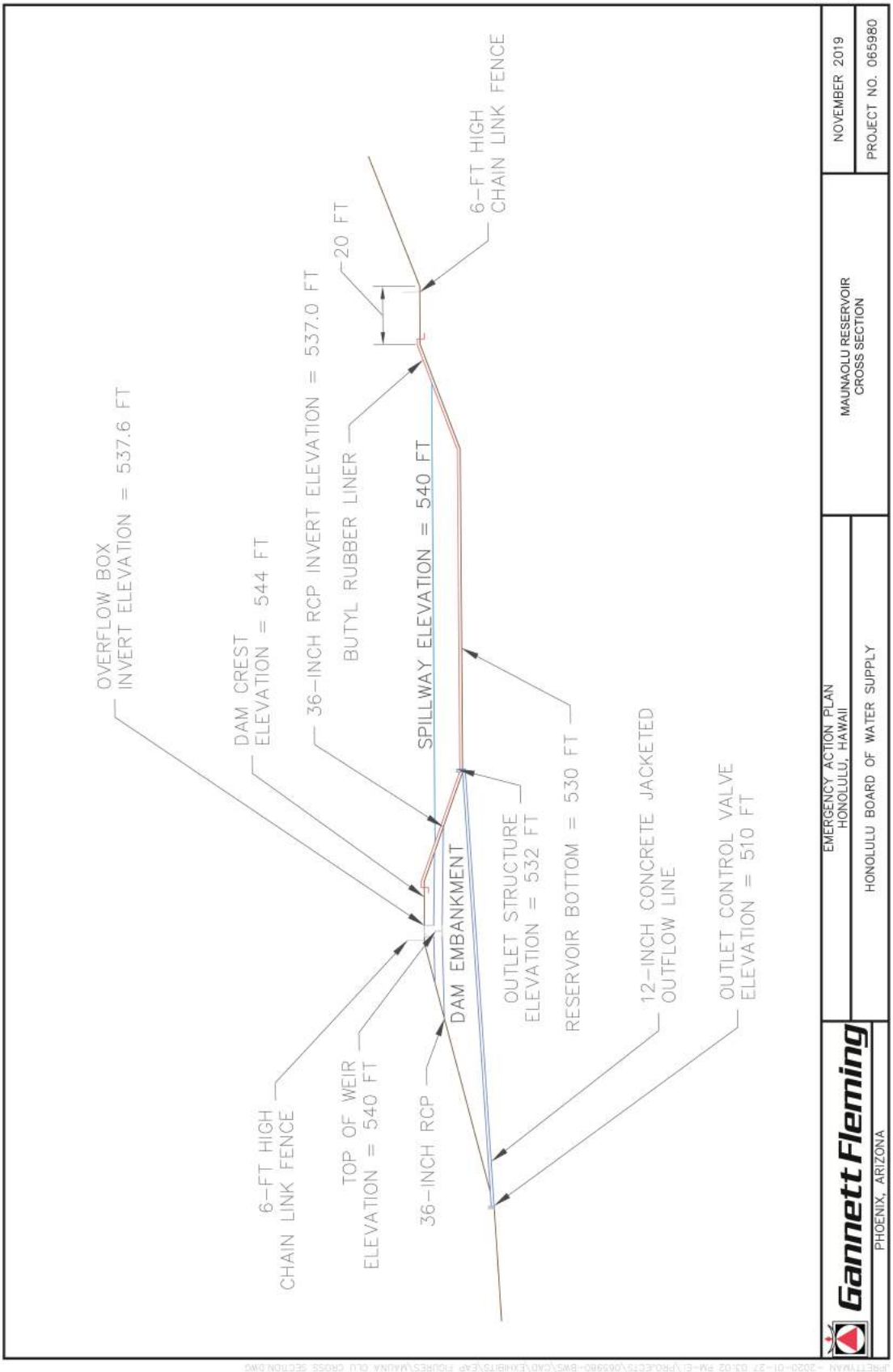
b. Vicinity Map



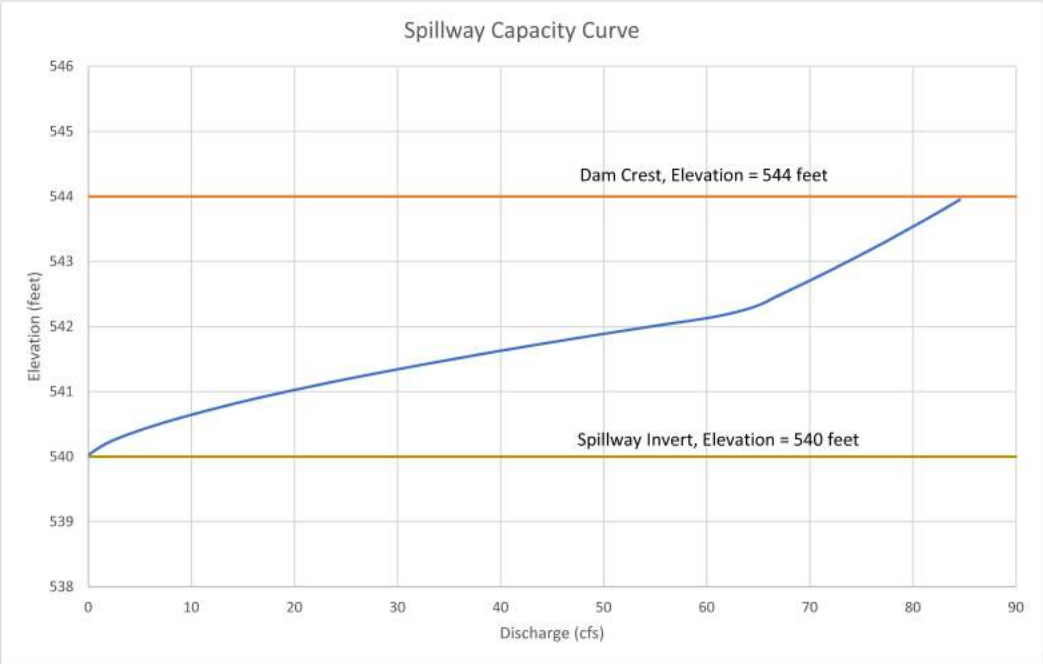
c. Site Plan or Drawing



d Cross Section or Drawing



e. Spillway Capacity Curve



Elevation (feet)	Discharge (cfs)
540.0	0.00
540.5	6.81
541.0	19.29
541.5	35.41
542.0	54.48
542.5	67.26
543.0	73.68
543.5	79.59
544.0	85.09

Values from Bills Engineering Inc, *Drainange Study for Maunaolu 530 Non-potable Reservoir Drainage Improvements* , 2014.

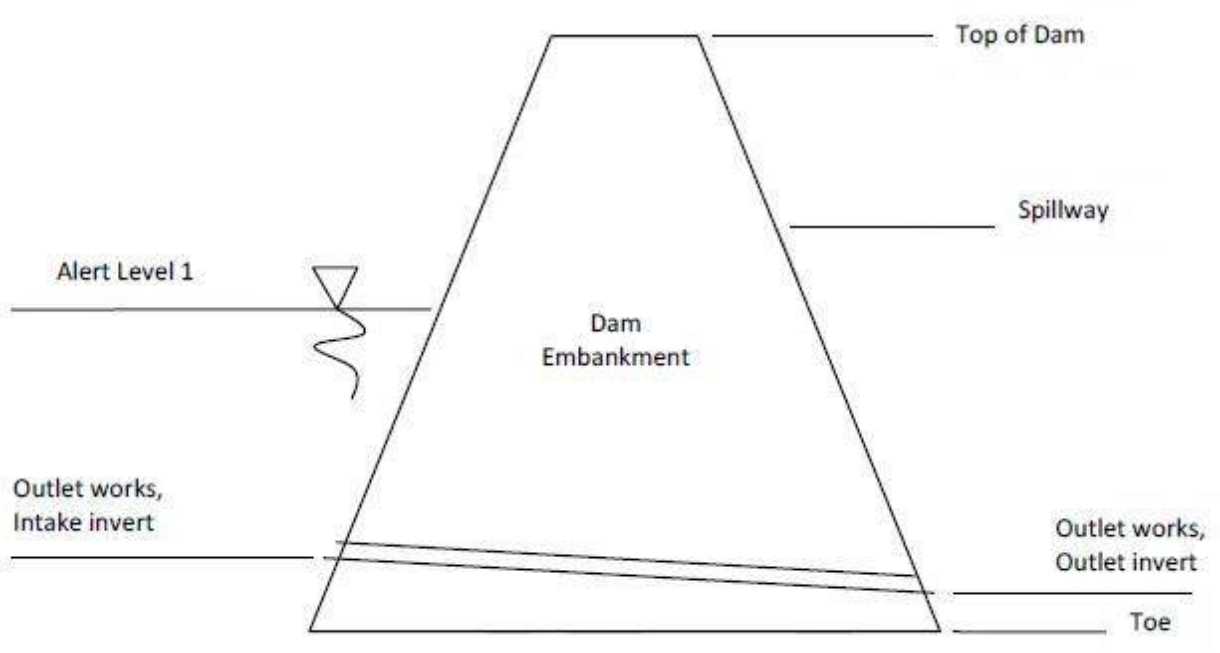
f. Outlet Capacity Curve

NOT AVAILABLE

g. Reservoir Drainage Chart

NOT AVAILABLE

h. Key Elevations



	Fill in Elevations for:	**Elevation**	**Staff Gage**
1	Top of Dam	544	14
2	Invert of Overflow Box	537.6	7.6
3	Overflow Box Weir Crest	540	10
4	Reservoir Bottom	530	0
5	Outlet works, Intake invert	532	2
6	Outlet works, Outlet invert	510	-
7	Toe	517	-
8	*PMF level (See other dam info on next page)	544.6	-
9	EAP Alert Level 3 (See Section VIII)	544	14
10	EAP Alert Level 2 (See Section VIII)	543	13
11	EAP Alert Level 1		

i. Other Dam Info/Operation

*Updated Probable Maximum Flood (PMF) analysis was completed by Gannett Fleming in November 2019. This analysis indicated that during a large flood event, such as the PMF, the drainage systems intended to divert water from the adjacent hillside will be overwhelmed and may spill into Maunaolu Reservoir. During the PMF, the analysis shows that the dam crest will be overtopped by about 0.6 feet due to these additional inflows.

VII. Directions to Site

a. Directions to Dam Facility Site

From Honolulu, take Interstate H-1 Highway west, then H1-93 (Farrington Highway) north. From Farrington Highway, turn right onto Makaha Valley Road. From Makaha Valley Road turn left onto Ala Holo Loop. From Ala Holo Loop turn left onto Huipu Drive. From Huipu Drive turn right onto Maunaolu Street. Proceed along Maunaolu Street for approximately 0.90 miles. Mauna Olu 530 Reservoir is on the right. Entry to the reservoir site is via a cable gate secured by a combination lock. To obtain the combination to the cable lock, call the Board of Water Supply (BWS) Security Center at (808) 748-5911. Visitors to the reservoir site must also pass through the security check-point for the Mauna Olu Estates subdivision. Prior to entry to the reservoir site, authorization is required from the BWS Land Administrator by calling (808) 748-5951.

b. Street Map

Directions:
From Makaha
Head East on Makaha Valley Rd
Continue onto Ala Holo Loop/Huipu Dr
Turn Right onto Maunauolu St
Continue approximately 0.9 mile
Mauna Olu Reservoir will be on right

Gannett Fleming PHOENIX, ARIZONA	EMERGENCY ACTION PLAN HONOLULU, HAWAII HONOLULU BOARD OF WATER SUPPLY	MAUNA OLU RESERVOIR STREET MAP	DECEMBER 2019 PROJECT NO. 065980

VIII. Emergency Detection

Guidance for Determining the Event Level at MAUNAOLU RESERVOIR

Note: This is a site-specific guide developed for use at the named facility only!

Level 1: Non-Emergency, Unusual Event, Slowly Developing
Level 2: Emergency, Potential Dam Failure Situation
Level 3: Urgent Emergency; Imminent or In-progress Dam Failure

Event	Situation	Event Level		
Earthquake	Earthquake resulting in uncontrolled release of water from the dam			3
Earthquake	Earthquake resulting in visible damage to the dam or appurtenances that could result in an uncontrolled release of water from the dam		2	
Earthquake	An earthquake has been felt or is reported to have occurred in the area with Richter Magnitude (M) of 4.0M or greater within a 30-mile distance of the epicenter, 5.0M or greater within 60 miles, or 6.0M or greater within a 120 mile radius of the site. Look up magnitude here: https://earthquake.usgs.gov/earthquakes/map/	1		
Embankment Cracking / Movement	Sudden or rapidly proceeding slides of the embankment slopes resulting in an uncontrolled release of water			3
Embankment Cracking / Movement	Sudden or rapidly proceeding slides of the embankment slopes that do not result in an uncontrolled release of water but could if movement continues		2	
Embankment Cracking / Movement	New cracks in the embankment with seepage flowing through the crack (see section on "Seepage")		2	
Embankment Cracking / Movement	Visible evidence of movement/slippage of the embankment slope	1		
Embankment Cracking / Movement	New cracks in the embankment greater than 1-inch wide without seepage	1		
Sabotage / Vandalism / Security Threat	Sabotage/damage to dam or appurtenances that has resulted in uncontrolled water release			3
Sabotage / Vandalism / Security Threat	Sabotage/damage to dam or appurtenances that may result in uncontrolled water release		2	
Sabotage / Vandalism / Security Threat	Modification to the dam or appurtenances that could adversely impact the functioning of the dam	1		
Seepage / Low Water Level	Uncontrollable, erratic, or rapidly increasing flow from seepage area with transport of sediment			3
Seepage / Low Water Level	Reservoir water level is falling without apparent cause		2	
Seepage / Low Water Level	Observation of boils or seepage areas with cloudy discharge possibly transporting sediment		2	
Sinkholes or Whirlpools	Rapidly enlarging sinkhole on dam or abutments to extent that failure appears imminent			3
Sinkholes or Whirlpools	Whirlpool or other evidence indicating that reservoir is draining rapidly through dam or foundation			3
Sinkholes or Whirlpools	Observation of new sinkhole in reservoir area or on embankment		2	
Spillway Flow / Overtopping	Water from the reservoir is flowing over the top (crest) of the dam			3
Spillway Flow / Overtopping	Significant flow from adjacent drainage channels is spilling into the reservoir, overwhelming the spillway and causing the reservoir level to rise			3

Event	Situation	Event Level		
Spillway Flow / Overtopping	Spillway is flowing with high rate of rise of reservoir water surface elevation (concern that spillway may be inadequate for incoming flood flows)		2	
Spillway Flow / Overtopping	The spillway is clogged/obstructed with debris during a period of heavy or sustained precipitation, resulting in an elevated/increasing reservoir level		2	
Spillway Flow / Overtopping	Spillway flow could result in flooding of downstream roadways and/or inhabited structures if reservoir level continues to rise		2	

IX. Local Resources

Local Resources Available at MAUNAOLU RESERVOIR

Note: This is a site-specific list developed for use at the named facility only!

The following owner/operator resources are available in the event of an emergency:

Quantity	Equipment/Resources	Contact Name/Telephone No.(s)
1	Sump Pump 8 Inch 3240 GPM	Board of Water Supply (BWS)
2	Sump Pump 4 Inch 1200 GPM	BWS
2	Sump Pump 6 Inch 1400 GPM	BWS

Other locally available resources include:

Resources	Suppliers	Telephone No.(s)
Heavy Equipment Service and Rental	C&R Enterprise Inc.	(808) 239-9248
Sand and Gravel Supply	Ameron Hawaii Kapaa Quarry	(808) 266-2660
Ready-Mix Concrete Supply	West Hawaii Concrete Administration	(808) 329-3561
Sand Bags	Honolulu Bag Supply	(808) 841-8333
Pumps	Engineered Systems Inc.	(808) 263-2232
Driving Contractor	Advanced Towing and Recovery	(808) 456-8697
Lighting	Board of Water Supply, FO Division	(808) 748-5000
Generator	Board of Water Supply, FO Division	(808) 748-5000
Piping	Board of Water Supply, FO Division	(808) 748-5000

X. Contacts

Contact Names and Numbers for MAUNAOLU RESERVOIR

Role & Responsibility	Primary Contact	Office Phone No.	Alternate Phone No.	Agency or Organization	Address
Dam Owner's Representatives:					
Primary EAP Contact	Michael Matsuo, Land Administrator	(808) 748-5951	(808) 291-7327	Board of Water Supply	630 South Beretania Street Honolulu, HI 96843
Secondary EAP Contact	Raelynn Nakabayashi, Dept. Emergency Coordinator (BWS)	(808) 748-5177	(808) 347-5386	Board of Water Supply	630 South Beretania Street Honolulu, HI 96843
Dam Owner	Ernest Y.W. Lau, P.E., Manager and Chief Engineer	(808) 748-5061		Board of Water Supply	630 South Beretania Street Honolulu, HI 96843
Dam Owner	Ellen Kitamura, Deputy Manager and Chief Engineer	(808) 748-5066		Board of Water Supply	630 South Beretania Street Honolulu, HI 96843
Dam Lessee					
Dam Operator	Kevin Ihu, Program Administrator, Water Systems Operations Division	(808) 748-5800	(808) 225-8446	Board of Water Supply	630 South Beretania Street Honolulu, HI 96843
Dam Technical Representative	Nancy Matsumoto, Chief Hydro-Geologist (BWS)	(808) 748-5938		Board of Water Supply	630 South Beretania Street Honolulu, HI 96843
State Dam Safety Program:					
State Dam Safety Program	Edwin Matsuda	(808) 587-0268	(808) 729-7177	State DLNR	1151 Punchbowl St. Room 221 Honolulu, HI 96813
State Dam Safety Program	Denise Manuel	(808) 587-0246	(808) 551-1413	State DLNR	1151 Punchbowl St. Room 221 Honolulu, HI 96813
State Dam Safety Program	Jesse Colandrea	(808) 587-0277	(808) 729-7175	State of Hawaii DLNR	1151 Punchbowl Street, rm 221 Honolulu, HI 96813
Honolulu Department of Emergency Management– City & County of Honolulu:					
Honolulu Department of Emergency Management	Hiro Toiya	(808) 723-8952	(808) 343-5745	Honolulu Department of Emergency Management	650 South King Street Honolulu, HI 96813
Honolulu Department of Emergency Management	Jennifer Walter	(808) 723-8960	(808) 753-4939	Honolulu Department of Emergency Management	650 South King Street Honolulu, HI 96813
Hawaii Emergency Management Agency (Hawaii State Civil Defense):					
Hawaii Emergency Management Agency	Luke P. Meyers	(808) 733-4300		Hawaii Emergency Management Agency	3949 Diamond Head Road Honolulu, HI 96816
County Emergency Responders:					
Police Department	Dispatch	911		Honolulu Police Department	801 South Beretania Street Honolulu, HI 96813
Police Department	Susan Ballard, Chief of Police	(808) 723-8782		Honolulu Police Department	801 South Beretania Street Honolulu, HI 96813
Fire Department	Manuel P. Neves, Fire Chief	(808) 723-7101		Honolulu Fire Department	636 South Street Honolulu, HI 96813

Other	Ross S. Sasamura, Director and Chief Engineer	(808) 768-3345		Department of Facility Maintenance, City and County of Honolulu	1000 Uluohia Street, Suite 215 Kapolei, HI 96707
Other	Wes Frysztacki, Director	(808) 768-8303		Dept. of Transportation Services, City & County of Honolulu	650 South King Street, 3rd Floor Honolulu, HI 96813
Other	James D. Howe, Jr., Director	(808) 723-7800		Department of Emergency Services, City and County of Honolulu	3375 Koapaka Street, Suite H450 Honolulu, HI 96819
Other	Wes Frysztacki, Director	(808) 768-8303		Dept. of Transportation Services, City & County of Honolulu	650 South King Street, 3rd Floor Honolulu, HI 96813
Other	James D. Howe, Jr., Director	(808) 723-7800		Department of Emergency Services, City and County of Honolulu	3375 Koapaka Street, Suite H450 Honolulu, HI 96819
Other	Ross S. Sasamura, Director and Chief Engineer	(808) 768-3345		Department of Facility Maintenance, City and County of Honolulu	1000 Uluohia Street, Suite 215 Kapolei, HI 96707

XI. EAP Holders

Official EAP Holders

Copy #	Organization	Person receiving copy	Concurrence Form Received
1 Primary EAP Contact	Board of Water Supply 630 South Beretania Street Honolulu, HI 96843	Michael Matsuo, Land Administrator	
2 Secondary EAP Contact	Board of Water Supply 630 South Beretania Street Honolulu, HI 96843	Raelynn Nakabayashi, Dept. Emergency Coordinator (BWS)	
3 Dam Owner	Board of Water Supply 630 South Beretania Street Honolulu, HI 96843	Ernest Y.W. Lau, P.E., Manager and Chief Engineer	
4 Dam Operator	Board of Water Supply 630 South Beretania Street Honolulu, HI 96843	Kevin Ihu, Program Administrator, Water Systems Operations Division	
5 Dam Technical Representative	Board of Water Supply 630 South Beretania Street Honolulu, HI 96843	Nancy Matsumoto, Chief Hydro-Geologist (BWS)	
6 Dam Owner	Board of Water Supply 630 South Beretania Street Honolulu, HI 96843	Ellen Kitamura, Deputy Manager and Chief Engineer	
7 Police Department	Honolulu Police Department 801 South Beretania Street Honolulu, HI 96813	Dispatch	
8 Fire Department	Honolulu Fire Department 636 South Street Honolulu, HI 96813	Manuel P. Neves, Fire Chief	
9 Police Department	Honolulu Police Department 801 South Beretania Street Honolulu, HI 96813	Susan Ballard, Chief of Police	
10 State Dam Safety Program	State DLNR 1151 Punchbowl St. Room 221 Honolulu, HI 96813	Edwin Matsuda	

11 Honolulu Department of Emergency Management	Honolulu Department of Emergency Management 650 South King Street Honolulu, HI 96813	Hiro Toiya	
12 Hawaii Emergency Management Agency	Hawaii Emergency Management Agency 3949 Diamond Head Road Honolulu, HI 96816	Luke P. Meyers	

XII. Appendix A – Testing and Updating

a. Testing

Test Date	Test Type	Comments

b. Updating

Revision #	Date Published	Comments
2	10/31/2019	

1. Training of Dam Owner's Representative(s)

The people involved in the implementation of the EAP should receive training to ensure that they are thoroughly familiar with all elements of the plan, the available equipment, and their responsibilities and duties under the plan.

Technically qualified personnel should be trained in the incident management process, including detection, evaluation, notification, and appropriate response actions during all emergency level determinations. A sufficient number of people should be trained to ensure adequate coverage at all times.

2. Testing the EAP

Dam owners should exercise the Emergency Action Plan (EAP) in coordination with State, local and tribal emergency management authorities. Exercises promote prevention, preparedness, and response to incidents and emergencies and may also be extended to include recovery operations. Exercising also demonstrates the EAP's effectiveness in an actual situation and demonstrates the readiness levels of key personnel. Periodic exercises result in an improved EAP as lessons learned are incorporated into the updated EAP document.

Dam owners should include State, local and tribal emergency authorities in exercise activities. This includes, but is not limited to, entities listed on the Notification Flowchart. To facilitate the participation of emergency management authorities, dam safety exercises also can be coordinated with, or integrated into, other event exercise scenarios for earthquakes, floods, hurricanes, and other hazards.

Exercise Type	Brief Description	Frequency
Seminar	Review EAP with staff and local emergency responders	Annual
Drill	Review EAP with principle staff and O&M personnel • Review of Contact List & Phone Numbers • Review of Critical deficiencies and notify plan holders if Level 1 exists • Review EAP Guidance for Determination levels	Annual
Table Top	Drill several different scenarios, in a classroom type setting All plan holders should participate	Every 3-4 years
Functional		As required
Other	Review Hazard Assessment Classification Downstream Public Awareness Campaign	Every 5 years As required

Summary of Exercises

There are various types of exercises to test the plans, discussion-based exercises and operations-based exercises. Discussion-based exercises familiarize participants with current plans, policies, agreements, and procedures, or may be used to develop new plans, policies, agreements, and procedures. Operations-based exercises validate plans, policies, agreements and procedures; clarify roles and responsibilities; and identify resource gaps in an operational

environment. The seminar, drill, tabletop exercise, and functional exercise should receive the most emphasis in an EAP exercise program.

- **Seminar.** A seminar is an informal discussion designed to orient participants to new or updated plans, policies, or procedures (e.g., a seminar to review a new Evacuation Standard Operating Procedure). Seminars should include internal discussions as well as coordination with emergency management authorities and other organizations with a role in EAP implementation.
- **Drill.** A drill is a coordinated, supervised activity usually employed to test a single operation or function within a single entity, such as testing sirens and warning systems, calling suppliers, checking material on hand, and conducting a call-down drill of those listed on the Notification Flowchart.
- **Tabletop Exercise.** A tabletop exercise involves key personnel discussing simulated scenarios in an informal setting. Tabletop exercises can be used to assess plans, policies, and procedures.
- **Functional Exercise.** A functional exercise examines and/or validates the coordination, command, and control between various multi-agency coordination centers, such as Emergency Operation Centers (EOCs) and Joint Field Offices. A functional exercise does not involve any "boots on the ground" such as first responders or emergency officials responding to an incident in real time.

Functional exercises are a comprehensive exercise that provides the necessary verification, training, and practice to improve the EAP and the operational readiness and coordination efforts of all parties responsible for responding to emergencies at a dam.

Evaluation of Exercises

Emergency exercises and equipment tests should be evaluated orally and in writing. Any outdated telephone numbers on the Notification Flowchart, inundation maps with inaccurate information, and problems with procedures, priorities, assigned responsibilities, materials and equipment, and staff levels shall be corrected, the plan be updated and disseminated.

EAP Emergency Incident Log

Dam Name/State ID:			
Name:		**Job Title:**	
Incident Start Date		**Incident Start Time**	
Incident Description			
Initial Incident Water Level			
Incident Detection			
When did you detect or learn about the incident?			
How did you detect or learn about the incident?			

LOG ALL NOTIFICATION AND ACTIVITY IN THE TABLE BELOW

DATE	TIME	ACTION/INCIDENT PROGRESSION	ACTION TAKEN BY

EAP Inspection Checklist

EAP Inspection Checklist		PAGE 1 of 2
Dam Name:		Inspected By:
		Date:
Weather Condition:		Event Triggering Inspection:
Reservoir Water Level:		
Inspection Item:		Deficiencies/Comments:
NOTE ANY PRE-EXISTING CONDITIONS (AGE, LOCATION) AND CHANGES OBSERVED:		
SPILLWAY:		
	General Condition	
	Cracks?	
	Leaning?	
	Seepage?	
	Overtopping?	
	Erosion?	
	Other Comments?	
GATES/STOPLOG BAYS:		
	General Condition	
	Cracks?	
EMBANKMENT CREST:		
	Visual Settlement?	
	Misalignment?	
	Cracking?	
EMBANKMENT UPSTREAM SLOPE:		
	Erosion? Condition of Ground Cover?	
	Settlement, depressions, bulges?	
	Longitudinal/Vertical Cracks?	

EAP Inspection Checklist		PAGE 2 of 2
Dam Name:		Inspected By:
		Date:
EMBANKMENT DOWNSTREAM SLOPE:		
	Erosion? Condition of Ground Cover?	
	Settlement, depressions, bulges?	
	Longitudinal/Vertical Cracks?	
	Soft spots or boggy areas?	
	Movement at or beyond toe?	
	Boils at toe?	
SEEPAGE:		
	Location	
	Does seepage contain fine soil particles?	
	Approximate flow rate (garden hose, full blast = approx. 5 gal/min)	
RESERVOIR:		
	Observed vortex?	
	Sinkhole?	
ABUTMENT CONTACTS:		
	General Condition	
	Cracks?	
	Leaning?	
OTHER OBSERVATIONS OR COMMENTS:		

EAP Emergency Termination Log

Dam Name/State ID:	**County:**
Dam Location:	**Stream/River:**

Date/Time:	
Weather Conditions:	
General Description of Emergency Situation:	
Area(s) of Dam Affected:	
Extent of Damage to Dam and Possible Causes:	
Effect on Dam Operation:	
Initial Reservoir Elevation/Time:	
Maximum Reservoir Elevation/Time:	
Final Reservoir Elevation/Time:	
Description of Area Flooded Downstream / Damage / Loss of Life:	
Justification for Termination of Dam Safety Emergency:	
Other Data and Comments:	
Report Prepared by: (Printed Name and Signature)	
Date:	

EAP CONCURRENCE FORM

I have received the latest copy of the Emergency Action Plan (EAP) for the State Regulated Dam listed below, and concur with the tasks and responsibilities assigned herein for this agency in the event of an emergency and during testing of the EAP.

Dam Name: _____

State Dam ID: _____

EAP Revision Date: _____

Signed: _____ **Date:** _____

Representing _____

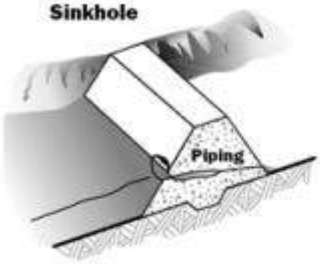
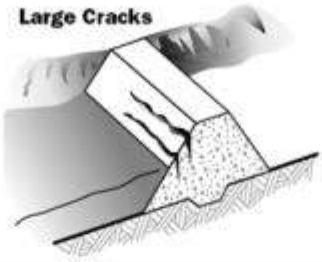
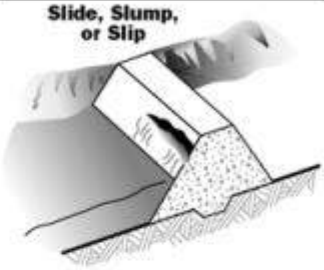
(Title, Agency Name)

Please return completed form to the owner at their address.

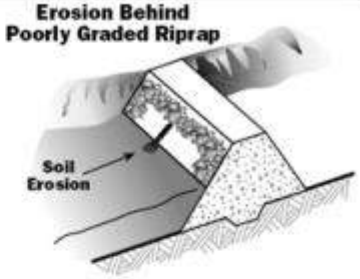
XIV. Appendix C – Mitigative and Preparedness Actions

1. Inspection Guidelines & Remedial Actions

Inspection Guidelines – Upstream Slope

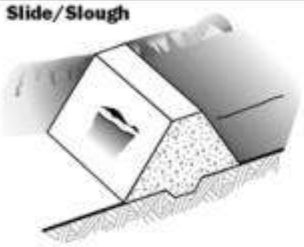
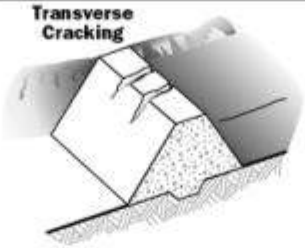
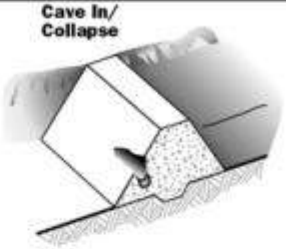
Problem	Probable Cause and Possible Consequences	Recommended Actions
Sinkhole 	**Large Cracks** 	**Slide, Slump, or Slip** 
Sinkhole	Piping or internal erosion of embankment materials or foundation causes a sinkhole. The cave-in of an eroded cavern can result in a sinkhole. A small hole in the wall of an outlet pipe can develop into a sinkhole. Dirty water at the exit indicates erosion of the dam. Piping can empty a reservoir through a small hole in the wall or can lead to failure of a dam as soil pipes erode through the foundation or a pervious part of the dam. Dispersive soils are particularly susceptible to sinkholes.	Inspect other parts of the dam for seepage or more sinkholes. Check seepage and leakage outflows for dirty water. A qualified engineer should inspect the conditions, identify the exact cause of sinkholes, and recommend further actions. Depending on the location in the embankment, the reservoir may need to be drawn down. DLNR NOTIFICATION REQUIRED
Large Cracks	A portion of the embankment has moved because of loss of strength, or the foundation may have moved, causing embankment movement. Indicates onset of massive slide or settlement caused by foundation failure.	Depending on embankment involved, draw reservoir level down. A qualified engineer should inspect the condition and recommend further actions. DLNR NOTIFICATION REQUIRED
Slide, Slump, or Slip	Earth or rocks move down the slope along a slippage surface because of too steep aslope, or the foundation moves. Also, look for slide movements in reservoir basin. A series of slides can lead to obstruction of the inlet or failure of the dam.	Evaluate extent of the slide. Monitor slide. Draw the reservoir level down if safety of dam is threatened. A qualified engineer should inspect the conditions and recommend further actions. DLNR NOTIFICATION REQUIRED

Inspection Guidelines - Upstream Slope

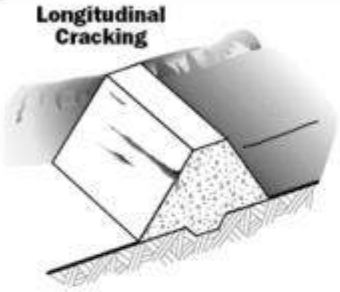
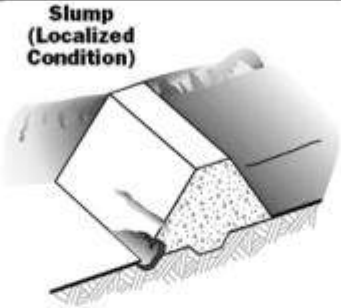
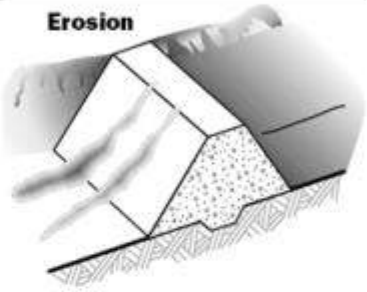
Problem	Probable Cause and Possible Consequences	Recommended Actions
		
Scarps, Benches Oversteep Areas	Wave action or local settlement cause soil and rock to erode and slide to the lower part of the slope, forming a bench. Erosion lessens the width and possible height of the embankment and could lead to seepage or overtopping of the dam.	Determine exact cause of scarps. Do necessary earthwork, restore embankment to original slope, and supply adequate protection (bedding and riprap).
Broken Down Missing Riprap	Poor-quality riprap has deteriorated. Wave action has displaced riprap. Round and similar-sized rocks have rolled downhill. Wave action against these unprotected areas decreases embankment width.	Reestablish normal slope. Place bedding and competent riprap.
Erosion Behind Poorly Graded Riprap	Similar-sized rocks allow waves to pass between them and erode small gravel particles and soil. Soil is eroded away from behind the riprap. This allows riprap to settle, offering less protection and decreased embankment width.	Reestablish effective slope protection. Place bedding material. DLNR NOTIFICATION REQUIRED for design – for graduation and size for rock for bedding and riprap. A qualified engineer should inspect the conditions and recommend further actions.

Inspection Guidelines - Upstream Slope

Inspection Guidelines – Downstream Slope

Problem	Probable Cause and Possible Consequences	Recommended Actions
Slide/Slough 	**Transverse Cracking** 	**Cave In/ Collapse** 
Slide or Slough	Lack loss of strength of embankment material. Loss of strength can be attributed to infiltration of water into the embankment or loss of support by the foundation. Massive slide cuts through crest or upstream slope reducing freeboard and cross-section. Structural collapse or overtopping can result	1. Measure extent and displacement of slide. If continued movement is seen, begin lowering water level until movement stops. 2. Have a qualified engineer inspect the condition and recommend further action. DLNR NOTIFICATION REQUIRED
Transverse Cracking	1. Uneven movement between adjacent segments of the embankment. 2. Deformation caused by structural stressor instability. 1. Can provide a path for seepage through the embankment cross-section. 2. Provides local area of low strength within embankment. Future structural movement, deformation or failure could begin. 3.. Provides entrance point for surface runoff to enter embankment	1. Inspect crack and carefully record crack location, length, depth, width and other pertinent physical features. Stake out limits of cracking. Engineer should determine cause of cracking and supervise all steps necessary to reduce danger to dam and correct condition. 2. Excavate slope along crack to a point below the bottom of the crack. Then, backfill excavation using competent material and correct construction techniques. This will seal the crack against seepage and surface runoff. This should be supervised by engineer. Continue to monitor crest routinely for evidence of future cracking. DLNR NOTIFICATION REQUIRED

Inspection Guidelines - Downstream Slope

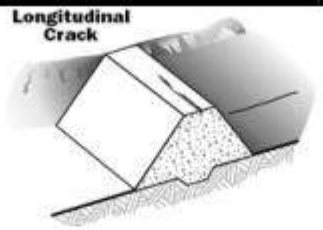
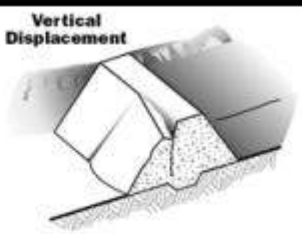
Problem	Probable Cause and Possible Consequences	Recommended Actions
Cave-in or Collapse	1. Lack of adequate compaction. 2. Piping through embankment or foundation. 3. Presence of dispersive soils. Indicates possible washout of embankment.	1. Have a qualified engineer inspect the condition and recommend further action. DLNR NOTIFICATION REQUIRED
Longitudinal Cracking 	**Slump (Localized Condition)** 	**Erosion** 
Longitudinal Cracking	1. Drying and shrinkage of surface material. 2. Downstream movement or settlement of embankment. 1. Can be an early warning of a potential slide. 2. Shrinkage cracks allow water to enter the embankment and freezing will further crack the embankment. 3. Settlement or slide, showing loss of strength in embankment that can lead to failure.	1. If cracks are from drying, dress area with well-compacted material to keep surface water out and natural moisture in. 2. If cracks are extensive, a qualified engineer should inspect the condition and recommend further actions. DLNR NOTIFICATION REQUIRED
Slump (*localized condition*)	Preceded by erosion undercutting a portion of the slope. Can also be found on steep slopes. Can expose impervious zone to erosion and lead to additional slumps.	1. Inspect area for seepage. 2. Monitor for progressive failure. 3. Have a qualified engineer inspect the condition and recommend further action. DLNR NOTIFICATION REQUIRED

Inspection Guidelines - Downstream Slope

Problem	Probable Cause and Possible Consequences	Recommended Actions
Erosion	Water from intense rainstorms or snowmelt carries surface material down the slope, resulting in continuous troughs. Can be hazardous if allowed to continue. Erosion can lead to eventual deterioration of the downstream slope and failure of the structure.	1. The preferred method to protect eroded areas is rock or riprap. 2. Reestablishing protective grasses can be adequate if the problem is detected early.
	Trees/ Obscuring Brush 	**Livestock/ Cattle Traffic** 
Trees, Obscuring Brush	Natural vegetation in area. Large tree roots can create seepage paths. Large trees can blow over during storms and damage dam or cause breach. Bushes can obscure visual inspection.	1. Remove all brush and trees less than 4" in diameter. Larger trees may be allowed to stay until they die. At that time, the tree, with its root system, should be removed and the void properly filled with compacted soil. 2. Control vegetation on the embankment that obscures visual inspection.
Livestock (*such as cattle*) Traffic	Excessive travel by livestock especially harmful to slope when wet. Creates areas bare of erosion protection and causes erosion channels. Allows water to stand. Area susceptible to drying cracks.	1. Fence livestock outside embankment area. 2. Repair erosion protection, i.e. riprap, grass.

Inspection Guidelines - Downstream Slope

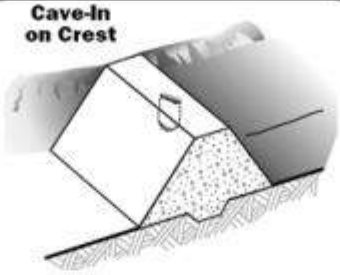
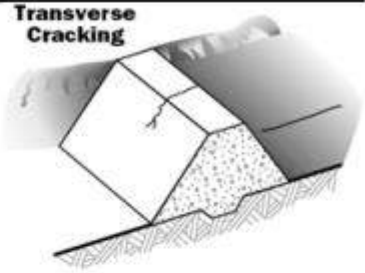
Inspection Guidelines – Crest

Problem	Probable Cause and Possible Consequences	Recommended Actions
		
Longitudinal Crack	1. Uneven settlement between adjacent sections or zones within the embankment. 2. Foundation failure causing loss of support to embankment. 3. Initial stages of embankment slide. 1. Creates local area of low strength within an embankment. Could be the point of initiation of future structural movement, deformation or failure. 2. Provides entrance point for surface runoff into embankment, allowing saturation of adjacent embankment area and possible lubrication which could lead to localized failure.	1. Inspect crack and carefully record location, length, depth, width, alignment, and other pertinent physical features. Immediately stake out limits of cracking. Monitor frequently. 2. Engineer should determine cause of cracking and supervise steps necessary to reduce danger to dam and correct condition. 3. Effectively seal the cracks at the crest surface to prevent infiltration by surface water. 4. Continue to routinely monitor crest for evidence of further cracking. DLNR NOTIFICATION REQUIRED

Inspection Guidelines - Crest

Problem	Probable Cause and Possible Consequences	Recommended Actions
Vertical Displacement	1. Vertical movement between adjacent sections of the embankment. 2. Structural deformation or failure caused by structure stress or instability, or by failure of the foundation. 1. Creates local area of low strength within embankment which could cause future movement. 2. Leads to structural instability or failure. 3. Creates entrance point for surface water that could further lubricate failure plane. 4. Reduces available embankment cross-section.	1. Carefully inspect displacement and record its location, vertical and horizontal displacement, length and other physical features. Immediately stake out limits of cracking. 2. Engineer should determine cause of displacement and supervise all steps necessary to reduce danger to dam and correct condition. 3. Excavate area to the bottom of the displacement. Backfill excavation using competent material and correct construction techniques, under supervision of engineer. 4. Continue to monitor areas routinely for evidence of cracking or movement. DLNR NOTIFICATION REQUIRED

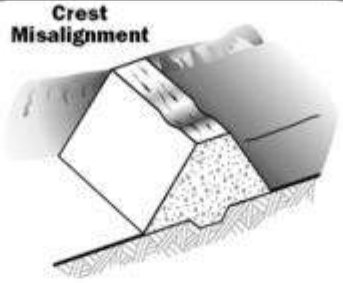
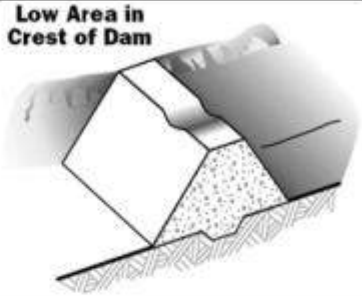
Inspection Guidelines - Crest

Problem	Probable Cause and Possible Consequences	Recommended Actions
	Cave-in on Crest 	**Transverse Cracking** 
Cave-in On Crest	1. Hole in outlet conduit is causing erosion of embankment material. 2. Internal erosion or piping of embankment material by seepage. 3. Breakdown of dispersive clays within embankment by seepage waters. 1. Void within dam could cause localized caving, sloughing, instability or reduced embankment cross-section. 2. Entrance point for surface water.	1. Carefully inspect and record location and physical characteristics (depth, width, length) of cave-in. 2. Engineer should determine cause of cave-in and supervise all steps necessary to reduce threat to dam and correct condition. 3. Excavate cave-in, slope sides of excavation and backfill hole with competent material using proper construction techniques. This should be supervised by engineer. DLNR NOTIFICATION REQUIRED

Inspection Guidelines - Crest

Problem	Probable Cause and Possible Consequences	Recommended Actions
Transverse Cracking	1. Uneven movement between adjacent segments of the embankment. 2. Deformation caused by structural stressor instability. 1. Can provide a path for seepage through the embankment cross-section. 2 Provides local area of low strength within embankment. Future structural movement, deformation or failure could begin. 3. Provides entrance point for surface runoff to enter embankment.	1. Inspect crack and carefully record crack location, length, depth, width and other pertinent physical features. Stake out limits of cracking. 2. Engineer should determine cause of cracking and supervise all steps necessary to reduce danger to dam and correct condition. 3. Excavate crest along crack to a point below the bottom of the crack. Then backfilling excavation using competent material and correct construction techniques. This will seal the crack against seepage and surface runoff. This should be supervised by engineer. 4. Continue to monitor crest routinely for evidence of future cracking. DLNR NOTIFICATION REQUIRED

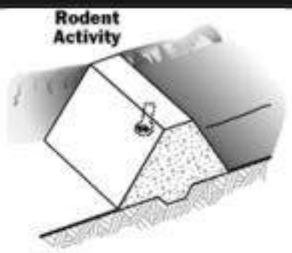
Inspection Guidelines - Crest

Problem	Probable Cause and Possible Consequences	Recommended Actions
	Crest Misalignment 	**Low Area in Crest of Dam** 
Crest Misalignment	1. Movement between adjacent parts of the structure. 2. Uneven deflection of dam under loading by reservoir. 3. Structural deformation or failure near area of misalignment. 1. Area of misalignment is usually accompanied by low area in crest which reduces freeboard. 2. Can produce local areas of low embankment strength which may lead to failure.	1. Establish monuments across crest to determine exact amount, location, and extent of misalignment. 2. Engineer should determine cause of misalignment and supervise all steps necessary to reduce threat to dam and correct condition. 3. Following remedial action, monitor crest monuments according to a schedule to detect any movement. DLNR NOTIFICATION REQUIRED

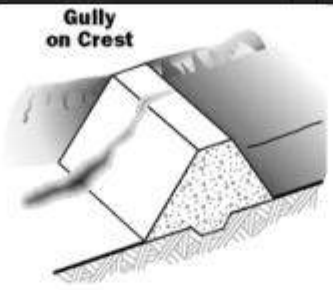
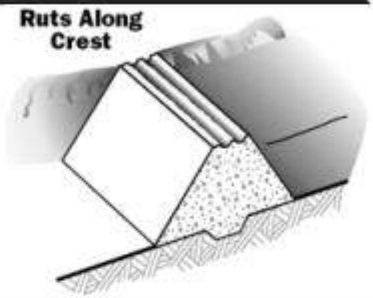
Inspection Guidelines - Crest

Problem	Probable Cause and Possible Consequences	Recommended Actions
Low Area in Crest	1. Excessive settlement in the embankment or foundation directly beneath the low area in the crest. 2. Internal erosion of embankment material. 3. Foundation spreading to upstream and/or downstream direction. 4. Prolonged wind erosion of crest area. 5. Improper final grading following construction. Reduces freeboard available to pass flood flows safely through spillway.	1. Establish monuments along length of crest to determine exact amount, location, and extent of settlement in crest. 2. Engineer should determine cause of low area and supervise all steps necessary to reduce possible threat to the dam and correct condition. 3. Reestablish uniform crest elevation over crest length by filling in low area using proper construction techniques. This should be supervised by engineer. 4. Reestablish monuments across crest of dam and routinely monitor monuments to detect any settlement.

Inspection Guidelines - Crest

Problem	Probable Cause and Possible Consequences	Recommended Actions
		
Obscuring Vegetation	Neglect of dam and lack of proper maintenance procedures. 1. Obscures large parts of the dam, preventing adequate, accurate visual inspection of all parts of the dam. Problems which threaten the integrity of the dam can develop and remain undetected until they progress to a point that threatens the dam's safety. 2. Associated root systems develop and penetrate into the dam's cross section. When the vegetation dies, the decaying root systems can provide paths for seepage. This reduces the effective seepage path through the embankment and could lead to possible piping situations. 3. Prevents easy access to all parts of the dam for operation, maintenance and inspection. 4. Large trees can blow over during storms, resulting in damage and possible breach of the dam.	1. Remove all damaging growth from the dam. This would include removal of trees (4-inches or less in diameter), bushes, brush, conifers and growth other than grass. Grass should be encouraged on all segments of the dam to prevent erosion by surface runoff. Root systems should also be removed to the maximum practical extent. The void which results from removing the root system should backfilled with well-competent, well-compacted material. 2. Future undesirable growth should be removed by cutting or spraying, as part of an annual maintenance program. 3. All cutting or debris resulting from the vegetative removal should be immediately taken from the dam and properly disposed of outside the reservoir basin. An engineer should be involved if the tree removal process poses a threat to the dam.

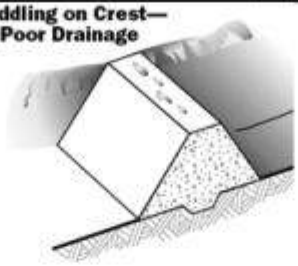
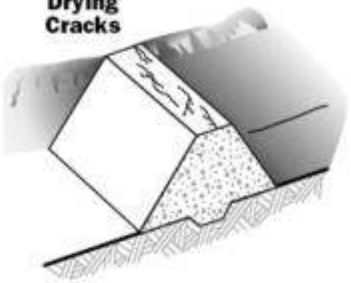
Inspection Guidelines - Crest

Problem	Probable Cause and Possible Consequences	Recommended Actions
		
Gully on Crest	1. Poor grading and improper drainage of crest. Improper drainage causes surface runoff to collect and drain off crest at low point in upstream or downstream shoulder. 2. Inadequate spillway capacity which has caused dam to overtop. 1. Can reduce available freeboard. 2. Reduces cross-sectional area of dam. 3. Inhibits access to all parts of the crest and dam. 4. Can result in a hazardous condition if due to overtopping. Heavy vehicle traffic without adequate or proper maintenance or proper crest surfacing	1. Restore freeboard to dam by adding fill material to low area, using proper construction techniques. 2. Regrading crest to provide proper drainage of surface runoff. 3. If gully was caused by overtopping, create adequate spillway that meets current design standards. This should be done by engineer. 4. Reestablish protective cover.

Inspection Guidelines - Crest

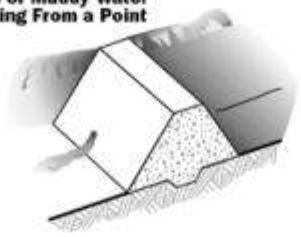
Problem	Probable Cause and Possible Consequences	Recommended Actions
Ruts Along Crest	1. Inhibits easy access to all parts of crest. 2. Allows continued development of rutting. 3. Allows standing water to collect and saturate crest of dam. 4. Operating and maintenance vehicles can get stuck.	1 Drain standing water from ruts. 2. Regrade and recompact crest to restore integrity and provide proper drainage to upstream slope. 3. Provide gravel or road base material to accommodate traffic. 4. Periodically maintain and regrade to prevent ruts reforming.

Inspection Guidelines - Crest

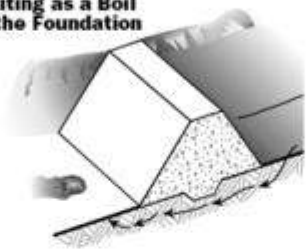
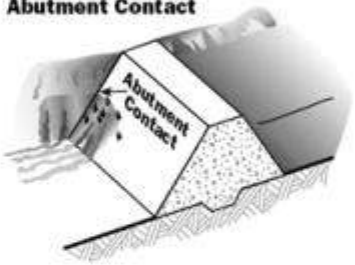
Problem	Probable Cause and Possible Consequences	Recommended Actions
	Puddling on Crest—Poor Drainage 	**Drying Cracks** 
Puddling on Crest – Poor Drainage	1. Poor grading and improper drainage of crest. 2. Localized consolidation or settlement on crest allows puddles to develop. 1. Causes localized saturation of the crest. 2. Inhibits access to all parts of the dam and crest. 3. Becomes progressively worse if not corrected.	1. Drain standing water from puddles. 2. Regrade and recompact crest to restore integrity and provide proper drainage to upstream slope. 3. Provide gravel or road base material to accommodate traffic. 4. Periodically maintain and regrade to prevent low areas reforming.
Drying Cracks	Material on the crest of dam expands and contracts with alternate wetting and drying of weather cycles. Drying cracks are usually short, shallow, narrow, and numerous. Point of entry for surface runoff and surface moisture, causing saturation of adjacent embankment areas. This saturation, and later drying of the dam, could cause further cracking.	1. Seal surface cracks with a tight, impervious material. 2. Routinely grade crest to proper drainage and fill cracks. 3. Cover crest with non-plastic material (not clay) to prevent large variations in moisture content.

Inspection Guidelines - Crest

Inspection Guidelines – Embankment Seepage Areas

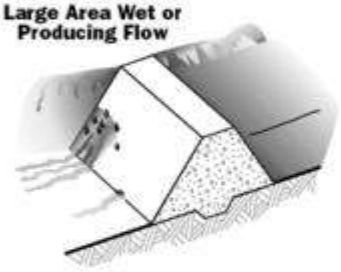
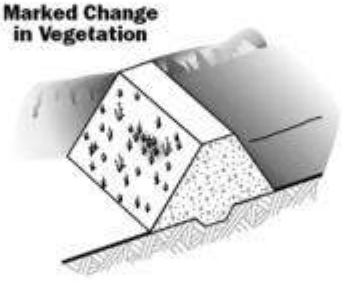
Problem	Probable Cause and Possible Consequences	Recommended Actions
	Excessive Quantity and/or Muddy Water Exiting From a Point 	**Stream of Water Exiting Through Cracks Near the Crest** 
Excessive Quantity and/or Muddy Water Exiting From a Point	1 Water has created an open pathway, channel or pipe through the dam. The water is eroding and carrying embankment material. 2. Large amounts of water have accumulated in the downstream slope. Water and embankment materials are exiting at one point. Surface agitation may be causing the muddy water. 3. Poor construction has allowed water to create an open pathway or pipe through the embankment. 1. Continued flows can saturate parts of the embankment and lead to slides in the area. 2. Continued flows can further erode embankment materials and lead to failure of the dam.	1. Begin measuring outflow quantity and establishing whether water is getting muddier, staying the same or clearing up. 2. If quantity of flow is increasing, water level in reservoir should be lowered until flow stabilizes or stops. 3. Search for opening on upstream side and plug if possible. 4. A qualified engineer should inspect the condition and recommend further actions to be taken. DLNR NOTIFICATION REQUIRED

Inspection Guidelines - Embankment Seepage Areas

Problem	Probable Cause and Possible Consequences	Recommended Actions
Stream of Water Exiting Through Cracks Near the Crest	1. Severe drying has caused shrinkage of embankment material. 2. Settlement in the embankment or foundation is causing the transverse cracks. Flow through the crack can cause failure of the dam.	1. Plug upstream side of crack to stop flow. 2. Lower water level in the reservoir should be lowered until below level of cracks. 3. A qualified engineer should inspect the condition and recommend further actions. DLNR NOTIFICATION REQUIRED
	Seepage Water Exiting as a Boil in the Foundation 	**Seepage Exiting at Abutment Contact** 
Seepage Water Exiting as a Boil in the Foundation	Some part of the foundation material is supplying a flow path. This could be caused by a sand or gravel layer in the foundation. Increased flows can lead to erosion of the foundation and failure of the dam.	1. Examine the boil for transportation of foundation materials. 2. If soil particles are moving downstream, sandbags or earth should be used to create a dike around the boil. The pressures created by the water level with the dike may control flow velocities and temporarily prevent further erosion. 3. If erosion is becoming greater, the reservoir level should be lowered. 4. A qualified engineer should inspect the condition and recommend further actions. DLNR NOTIFICATION REQUIRED

Inspection Guidelines - Embankment Seepage Areas

Problem	Probable Cause and Possible Consequences	Recommended Actions
Seepage Exiting at Abutment Contact	1. Water flowing through pathways in the abutment. 2. Water flowing through the embankment. Can lead to erosion of embankment materials and failure of the dam.	1. Study leakage area to determine quantity of flow and extent of saturation. 2. Inspect daily for developing slides. 3. Water level in reservoir may need to be lowered to assure the safety of the embankment. 4. A qualified engineer should inspect the condition and recommend further actions. DLNR NOTIFICATION REQUIRED

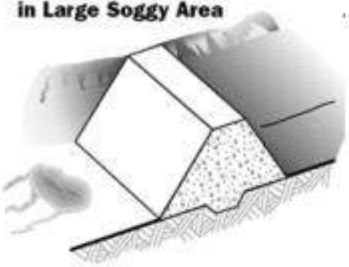
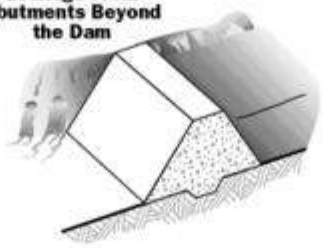
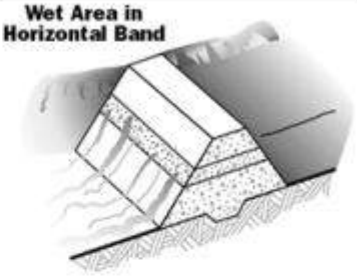
Large Area Wet or Producing Flow	Marked Change in Vegetation	Bulge in Large Wet Area
		

Large Area Wet or Producing Flow	A seepage path has developed through the abutment or embankment materials and failure of the dam can occur. 1. Increased flows could lead to erosion of embankment material and failure of the dam. 2. Saturation of the embankment can lead to local slides which could cause failure of the dam.	1. Stake out the saturated area and monitor for growth or shrinking. 2. Measure any outflows as accurately as possible. 3. Reservoir level may need to be lowered if saturated areas grow at a fixed storage level or if flow increases. 4. A qualified engineer should inspect the condition and recommend further actions. DLNR NOTIFICATION REQUIRED

Inspection Guidelines - Embankment Seepage Areas

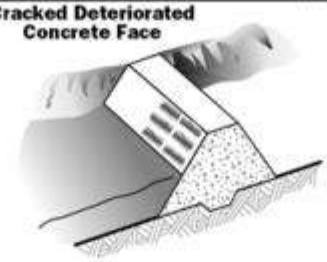
Problem	Probable Cause and Possible Consequences	Recommended Actions
Marked Change in Vegetation	1. Embankment materials are supplying flow paths. 2. Natural seeding by wind. 3. Change in seed type during early post-construction seeding. Can show a saturated area.	1. Use probe and shovel to establish if the materials in this area are wetter than surrounding areas. 2. If area shows wetness, when surrounding areas are dry or drier, a qualified engineer should inspect the condition and recommend further actions. DLNR NOTIFICATION REQUIRED
Bulge in Large Wet Area	Downstream embankment materials have begun to move. Failure of the embankment resulting from massive sliding can follow these early movements.	1. Compare embankment cross-section to the end of construction condition to see if observed condition may reflect end of construction. 2. Stake out affected area and accurately measure outflow. 3. A qualified engineer should inspect the condition and recommend further actions. DLNR NOTIFICATION REQUIRED

Inspection Guidelines - Embankment Seepage Areas

Problem	Probable Cause and Possible Consequences	Recommended Actions
Trampoline Effect in Large Soggy Area 	**Leakage From Abutments Beyond the Dam** 	**Wet Area in Horizontal Band** 
Trampoline Effect (*bouncy when jumped on*) in Large Soggy Area	Water moving rapidly through the embankment or foundation is being controlled or contained by a well-established turf root system. Condition shows excessive seepage in the area. If control layer of turf is destroyed, rapid erosion of foundation materials could result in failure of the dam.	1. Carefully inspect the area for outflow quantity and any transported material. 2. A qualified engineer should inspect the condition and recommend further actions. DLNR NOTIFICATION REQUIRED
Leakage From Abutments Beyond the Dam	Water moving through cracks and fissures in the abutment materials. Can lead to rapid erosion of abutment and evacuation of the reservoir. Can lead to massive slides near or downstream from the dam.	1. Carefully inspect the area to determine quantity of flow and amount of transported material. 2. A qualified engineer or geologist should inspect the condition and recommend further actions. DLNR NOTIFICATION REQUIRED
Wet Area in Horizontal Band	Frost layer or layer of sandy material in original construction. 1. Wetting of areas below the area of excessive seepage can lead to localized instability of the embankment, resulting in slides. 2. Excessive flows can lead to accelerated erosion of embankment materials and failure of the dam.	1. Determine as closely as possible the flow being produced. 2. If flow increases, reservoir level should be reduced until flow stabilizes or stops. 3. Stake out the exact area involved. 4. Using hand tools, try to identify the material allowing the flow. 5. A qualified engineer should inspect the condition and recommend further actions. DLNR NOTIFICATION REQUIRED

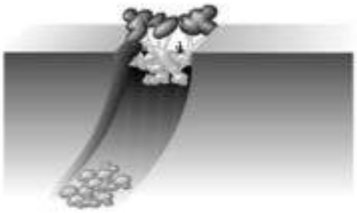
Inspection Guidelines - Embankment Seepage Areas

Inspection Guidelines – Concrete Upstream Slope

Problem	Probable Cause and Possible Consequences	Recommended Actions
Large Increase in Flow or Sediment in Drain Outfall 	**Cracked Deteriorated Concrete Face** 	**Cracks Due to Drying** 
Large Increase in Flow or Sediment in Drain Outfall	Shortened seepage path or increased storage levels. 1. Higher velocity flows can cause erosion of drain, then embankment materials. 2. Can lead to piping failure.	1. Accurately measure outflow quantity and determine amount of increase over previous flow. 2. Collect jar samples to compare turbidity. 3. If either quantity or turbidity has increased by 25%, a qualified engineer should evaluate the condition and recommend further actions. DLNR NOTIFICATION REQUIRED
Cracked Deteriorated Concrete Face	Concrete deteriorated from weathering. Joint filler deteriorated or displaced. Soil is eroded behind the face and caverns can be formed. Unsupported sections of concrete crack. Ice action may displace concrete.	1. Determine cause. Either patch with grout or contact engineer for permanent repair method. 2. If damage is extensive, a qualified engineer should inspect the condition and recommend further actions. DLNR NOTIFICATION REQUIRED
Cracks Due to Drying	Soil loses its moisture and shrinks, causing cracks. *Note:* Usually limited to crest and downstream slope. Heavy rains can fill cracks and cause small parts of embankment to move along internal slip surface.	1. Monitor cracks for increases in width, depth , or length. 2. A qualified engineer should inspect condition and recommend further actions. DLNR NOTIFICATION REQUIRED

Inspection Guidelines - Concrete Upstream Slope

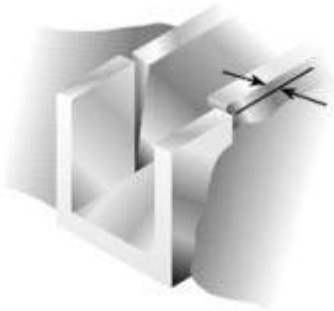
Inspection Guidelines – Spillways

Problem	Probable Cause and Possible Consequences	Recommended Actions
Excessive Vegetation or Debris in Channel 	**Erosion Channels** 	**Excessive Erosion in Earth-Slide Causes Concentrated Flows** 
Excessive Vegetation or Debris in Channel	Accumulation of slide materials, dead trees, excessive vegetative growth, etc., in spillway channel. Reduced discharge capacity; overflow of spillway, overcropping of dam. Prolonged overtopping can cause failure of the dam.	Clean out debris periodically; control vegetative growth in spillway channel. Install log boom in front of spillway entrance to intercept debris.
Erosion Channels	Surface runoff from intense rainstorms or flow from spillway carries surface material down the slope, resulting in continuous troughs. Livestock traffic creates gullies where flow concentrates varies. Unabated erosion can lead to slides, slumps or slips which can result in reduced spillway capacity. Inadequate spillway capacity can lead to embankment overtopping and result in dam failure.	Photograph condition. Repair damaged areas by replacing eroded material with compacted fill. Protect areas against future erosion by installing suitable rock riprap. Re-vegetate area if appropriate. Bring condition to the attention of the engineer during next inspection.

Inspection Guidelines - Spillways

Problem	Probable Cause and Possible Consequences	Recommended Actions
Excessive Erosion in Earth-Slide Causes Concentrated Flows	Discharge velocity too high; bottom and slope material loose or deteriorated; channel and bank slopes too steep; bare soil unprotected; poor construction protective surface failed. Disturbed flow pattern; loss of material, increased sediment load downstream, collapse of banks; failure of spillway; can lead to rapid evacuation of the reservoir through the severely eroded spillway.	Minimize flow velocity by proper design. Use sound material. Keep channel and bank slopes mild. Encourage growth of grass on soil surface. Construct smooth and well-compacted surfaces. Protect surface with riprap, asphalt or concrete. Repair eroded portion using sound construction practices.

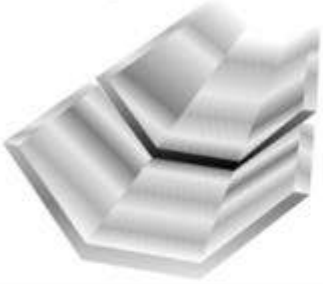
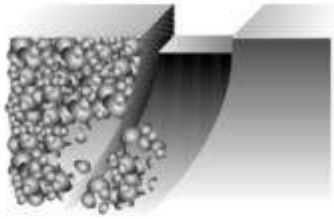
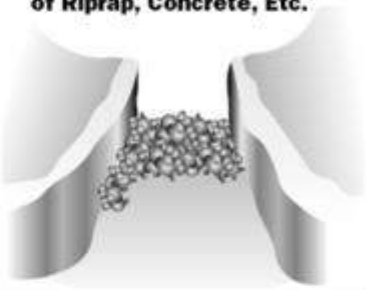
Inspection Guidelines - Spillways

Problem	Probable Cause and Possible Consequences	Recommended Actions
End of Spillway Chute Undercut 	Poor configuration of stilling basin area. Highly erodible materials. Absence of cut-off wall at end of chute. Structural damage to spillway structure; collapse of slab and wall lead to costly repair.	Dewater affected area; clean out eroded area and properly backfill. Improve stream channel below chute; provide properly sized riprap in stilling basin area. Install cutoff wall.
Wall Displacement 	Poor workmanship; uneven settlement of foundation; excessive earth and water pressure; insufficient steel bar reinforcement of concrete. Minor displacement will create eddies and turbulence in the flow, causing erosion of the soil behind the wall. Major displacement will cause severe cracks and eventual failure of the structure.	Reconstruction should be done according to sound engineering practices. Foundation should be carefully prepared. Adequate weep holes should be installed to relieve water pressure behind wall. Use enough reinforcement in the concrete. Anchor walls to present further displacement. Install struts between spillway walls. Clean out and back flush drains to assure proper operations. Consult an engineer before actions are taken. DLNR NOTIFICATION REQUIRED
Large Cracks 		

Inspection Guidelines - Spillways

Problem	Probable Cause and Possible Consequences	Recommended Actions
Large Cracks	Construction defect; local concentrate distress; local material deterioration; foundation failure, excessive backfill pressure. Disturbance in flow patterns; erosion of foundation and backfill; eventual collapse of structure.	Large cracks without large displacement should be repaired by patching. Surrounding areas should be cleaned or cut out before patching material is applied. Installation of weep holes or other actions may be needed.

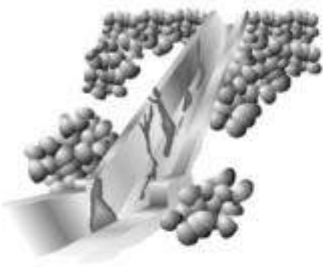
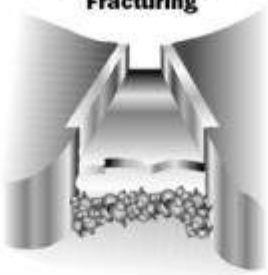
Inspection Guidelines - Spillways

Problem	Probable Cause and Possible Consequences	Recommended Actions
Open or Displaced Joints 	**Breakdown and Loss of Riprap** 	**Material Deterioration—Spalling and Disintegration of Riprap, Concrete, Etc.** 
Open or Displaced Joints	Excessive and uneven settlement of foundation; sliding of concrete slab; construction joint too wide and left unsealed. Sealant deteriorated and washed away. Erosion of foundation material may weaken support and cause further cracks; pressure induced by water flowing over displaced joints may wash away wall or slab, or cause extensive undermining.	Construction joint should be no wider than 1/2". All joints should be sealed with asphalt or other flexible materials. Water stops should be used where feasible. Clean the joint, replace eroded materials, and seal the joint. Foundations should be properly drained and prepared. Underside of chute slabs should have ribs of enough depth to prevent sliding. Avoid steep chute slope. DLNR NOTIFICATION REQUIRED
Breakdown and Loss of Riprap	Slope too steep; material poorly graded; failure of subgrade; flow velocity too high; improper placement of material; bedding material or foundation washed away. Erosion of channel bottom and banks; failure of spillway.	Design a stable slope for channel bottom and banks. Riprap material should be well-graded (the material should contain small, medium and large particles). Subgrade should be properly prepared before placement of riprap. Install filter fabric if necessary. Control flow velocity in the spillway by proper design. Riprap should be placed according to specification. DLNR NOTIFICATION REQUIRED

Inspection Guidelines - Spillways

Problem	Probable Cause and Possible Consequences	Recommended Actions
Material Deterioration – Spalling and Disintegration of Riprap, Concrete, Etc.	Use of unsound or defective materials; structures subject to freeze-thaw cycles; improper maintenance practices; harmful chemicals. Structure life will be shortened; premature failure.	Avoid using shale or sandstone for riprap. Add air-entraining agent when mixing concrete. Use only clean, good quality aggregates in the concrete. Steel bars should have at least 1" of concrete cover. Concrete should be kept damp and protected from freezing during curing.

Inspection Guidelines - Spillways

Problem	Probable Cause and Possible Consequences	Recommended Actions
Poor Surface Drainage 	**Concrete Erosion, Abrasion, and Fracturing** 	**Leakage in or Around Spillway** 
Poor Surface Drainage	No weep holes; no drainage facility; plugged drains. Wet foundation has lower supporting capacity; uplift pressure resulting from seepage water may damage spillway chute; accumulation of water may also increase total pressure on spillway walls and cause damage.	Install weep holes on spillway walls. Inner end of hole should be surrounded and packed with graded filtering material. Install drain system under spillway near downstream end. Clean out existing weep holes. Back flush and rehabilitate drain system under the supervision of an engineer. DLNR NOTIFICATION REQUIRED
Concrete Erosion, Abrasion, and Fracturing	Flow velocity too high (usually occurs at lower end of chute in high dams); rolling of gravel and rocks down the chutes; cavity behind or below concrete slab. Pockmarks and spalling of concrete surface may progressively worsen; small hole may cause undermining of foundation, leading to failure of structure.	Remove rocks and gravels from spillway chute before flood season. Raise water level in stilling basin. Use good quality concrete. Assure concrete surface is smooth. DLNR NOTIFICATION REQUIRED

Inspection Guidelines - Spillways

Problem	Probable Cause and Possible Consequences	Recommended Actions
Leakage in or Around Spillway	1. Cracks and joints in geologic formation at spillway are permitting seepage. 2. Gravel or sand layers at spillway are permitting seepage. 1. Could lead to excessive loss of stored water. 2. Could lead to a progressive failure if velocities are high enough to cause erosion of natural materials.	1. Examine exit area to see if type of material can explain leakage. 2. Measure flow quantity and check for erosion of natural materials. 3. If flow rate or amount of eroded materials increases rapidly, reservoir level should be lowered until flow stabilizes or stops. 4. A qualified engineer should inspect the condition and recommend further actions. DLNR NOTIFICATION REQUIRED

Inspection Guidelines - Spillways

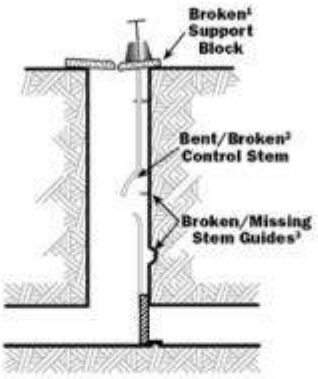
Problem	Probable Cause and Possible Consequences	Recommended Actions
	Too Much Leakage From Spillway Under Drains 	**Seepage From a Construction Joint or Crack in Concrete Structure** 
Too Much Leakage From Spillway Under Drains	Drain or cutoff may have failed. 1. Excessive flows under the spillway could lead to erosion of foundation material and collapse of parts of the spillway. 2. Uncontrolled flows could lead to loss of stored water.	1. Examine exit area to see if type of material can explain leakage. 2. Measure flow and check for erosion of natural materials. 3. If flow rate or amount of eroded materials increases rapidly, reservoir level should be lowered until flow stabilizes or stops. 4. A qualified engineer should inspect the condition and recommend further actions. DLNR NOTIFICATION REQUIRED
Seepage From a Construction Joint or Crack in Concrete Structure	Water is collecting behind structure because of insufficient drainage or clogged weep holes. 1. Can cause walls to tip in and over. Flows through concrete can lead to rapid deterioration from weathering. 2. If spillway is located within embankment, rapid erosion can lead to failure of the dam.	1. Check area behind wall for puddling of surface water. 2. Check and clean as needed; drain outfalls, flush lines and weep holes. 3. If condition persists, a qualified engineer should inspect the condition and recommend further actions. DLNR NOTIFICATION REQUIRED

Inspection Guidelines - Spillways

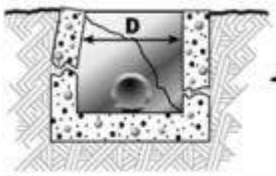
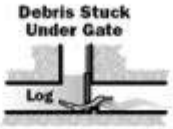
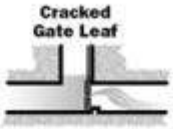
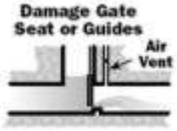
Inspection Guidelines – Inlets, Outlets, and Drains

Problem	Probable Cause and Possible Consequences	Recommended Actions
Outlet Pipe Damage		
Crack 	**Hole** 	**Joint Offset** 
Outlet Pipe Damage: Crack	Settlement; impact. Excessive seepage, possible internal erosion.	Check for evidence of water either entering or exiting pipe at crack, hole, etc.
Outlet Pipe Damage: Hole	Rust (steel pipe); erosion (concrete pipe); cavitation.	Tap pipe in vicinity of damaged area, listening for hollow sound which indicates a void has formed along the outside of the conduit.
Outlet Pipe Damage: Joint Offset	Settlement or poor construction practice. Provides passageway for water or exit or enter pipe, resulting in erosion of internal materials of the dam.	If a progressive failure is suspected, request engineering advice.

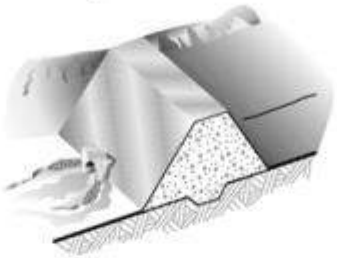
Inspection Guidelines - Inlets, Outlets, and Drains

Problem	Probable Cause and Possible Consequences	Recommended Actions
	Control Works  	
Damage to Control Works	1. BROKEN SUPPORT BLOCK Concrete deterioration. Excessive force exerted on control stem by trying to open gate when it was jammed. Causes control support block to tile; control stem may bind. Control head works may settle. Gate may not open all the way. Support block may fail completely, leaving outlet inoperable. 2. BENT/BROKEN CONTROL STEM Rust. Excess force used to open or close gate. Inadequate or broken stem guides. Outlet is inoperable. 3. BROKEN/MISSING STEM GUIDES Rust. Inadequate lubrication. Excess force used to open or close gate when jammed. Loss of support for control stem. Stem may buckle and break under normal use (as in this example).	Any of these conditions can mean the control is either inoperable or, at best, partly operable. Use of the system should be minimized or discontinued. If the outlet system has a second control valve, consider using it to regulate releases until repairs can be made. Engineering help is recommended.

Inspection Guidelines - Inlets, Outlets, and Drains

Problem	Probable Cause and Possible Consequences	Recommended Actions
Failure of Concrete Outfall Structure 	Excessive side pressures on non reinforced concrete structure. Poor concrete quality. Loss of outfall structure exposes embankment to erosion by outlet releases.	1. Check for progressive failure by monitoring typical dimension, such as "D" shown in figure. 2. Repair by patching cracks and supplying drainage around concrete structure. Outfall structure may need total replacement.
Outlet Releases Eroding Toe of Dam 	Outlet pipe too short. Lack of energy-dissipating pool or structure at down stream end of conduit. Erosion of toe over steepens downstream slope, causing progressive sloughing.	1. Extend pipe beyond toe (use pipe of same size and material, and form watertight connection to existing conduit). 2. Protect embankment with riprap over suitable bedding.
Valve Leakage: Debris Stuck Under Gate **Valve Leakage** 	Trashrack missing or damaged. Gate will not close. Gate or stem may be damaged in effort to close gate.	Raise and lower gate slowly until debris is loosened and floats past valve. When reservoir is lowered, repair or replace trashrack.
Valve Leakage: Cracked Gate Leaf 	Rust, affect vibration, or stress resulting from forcing gate closed when it is jammed. Gate-leaf main fail completely, evacuating reservoir.	Use valve only in fully open or closed position. Minimize use of valve until leaf can be repaired or replaced.
Valve Leakage: Damaged Gate Seat or Guides 	Rust, erosion, cavitation, vibration or wear. Leakage and loss of support for gate leaf. Gate may bind in guides and become inoperable.	Minimize use of valve until guides or seats can be repaired. If cavitation is the cause, check to see if air vent pipe exists, and is unobstructed.

Inspection Guidelines - Inlets, Outlets, and Drains

Problem	Probable Cause and Possible Consequences	Recommended Actions
	Seepage Water Exiting From a Point Adjacent to the Outlet 	
Seepage Water Exiting From a Point Adjacent to the Outlet	1. A break in the outlet pipe. 2. A path for flow has developed along the outside of the outlet pipe. Continued flows can lead to erosion of the embankment materials and failure of the dam.	1. Thoroughly investigate the area by probing and/or shoveling to try to determine cause. 2. Determine if leakage water is carrying soil particles. 3. Determine quantity of flow. 4. If flow increases or is carrying embankment materials, reservoir level should be lowered until leakage stops. 5. A qualified engineer should inspect the condition and recommend further actions. DLNR NOTIFICATION REQUIRED

Inspection Guidelines - Inlets, Outlets, and Drains

2. Hyperlink to Internet Quicklinks (DOC)

http://dlnreng.hawaii.gov/dam/forms/emergency-action-plan/

February 2016 – Links to Information for the Hawaiian Islands

Weather – NOAA Satellites (6 Hour Loops)

http://www.ssd.noaa.gov/goes/west/hi/flash-rb.html (Hawaiian Islands)

http://www.ssd.noaa.gov/goes/west/tpac/flash-rb.html (Tropical Pacific)

http://www.ssd.noaa.gov/goes/west/nepac/flash-rb.html (Northeast Pacific)

http://weather.hawaii.edu/satellite/satanim.cgi?res=4km&chnl=ir&domain=hus&size=large&period=2880&incr=30&rr=900&satplat=goeswest&overlay=off&animtype=flash (Northeast Pacific – 48 Hours)

TV Weather

http://khon2.com/weather/radar/

http://www.kitv.com/weather

http://www.hawaiinewsnow.com/category/202017/weather

Central Pacific Hurricane Center

http://www.prh.noaa.gov/hnl/cphc/?gtwo

Hawaii Flash Flood Response Tool

http://hawaiipacioosapplication-1672159924.us-east-1.elb.amazonaws.com/

USGS Data for Hawaii

http://waterdata.usgs.gov/hi/nwis/current/?type=lake&group_key=county_cd (Reservoir Levels)

http://waterdata.usgs.gov/hi/nwis/current/?type=all&group_key=county_cd (All Real Time Gages)

http://hvo.wr.usgs.gov/seismic/volcweb/earthquakes/ (Earthquakes)

http://waterwatch.usgs.gov/?m=real&r=hi&w=map (Stream Flow & Reservoir Level Data Map)

State of Hawaii Dam Inventory User Login

http://132.160.239.52/daminventory/login.aspx

Pacific Disaster Center Home Page

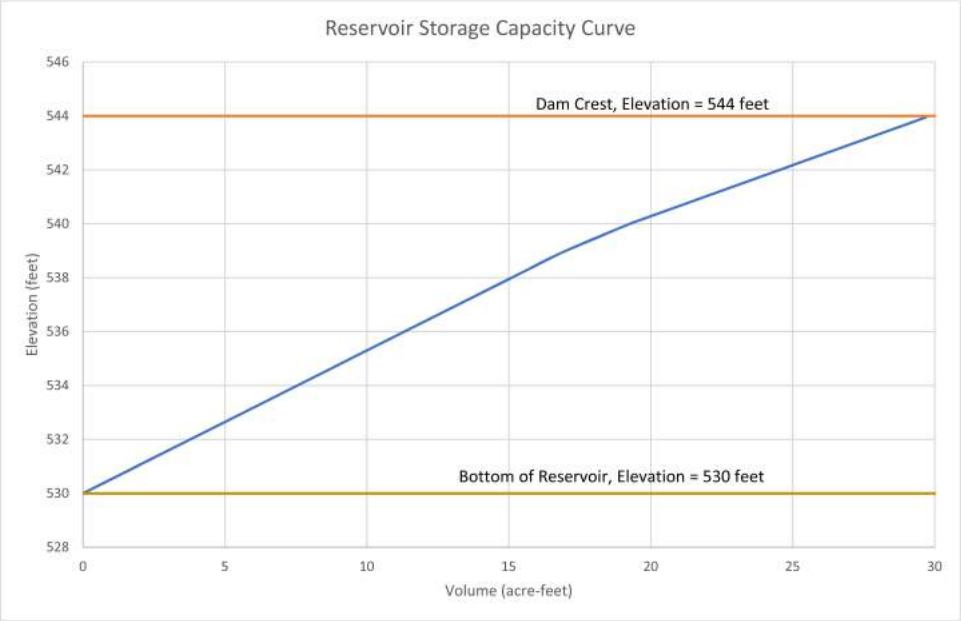
http://www.pdc.org/

Hawaii State Civil Defense (Hawaii Emergency Management Agency) Home Page

http://www.scd.hawaii.gov/

XV. Appendix D – Dam Owner Additional Information

1. Maunaolu Storage Capacity Curve



Elevation (feet)	Volume (acre feet)
530.0	0.00
532.0	3.77
534.0	7.55
536.0	11.32
538.0	15.09
540.0	19.26
542.0	24.54
544.0	29.82

Values from Gannett Fleming, *Drainage Study Technical Memorandum Maunaolu Reservoir Mākaha, Oahu, Hawaii*, 2019.

XVI. Appendix E - Terms & Conditions

Disclaimers:

The Department of Land and Natural Resources, Engineering Division (DLNR) has developed this DLNR Emergency Action Plan (EAP) template based on guidance from FEMA Publication 64. These guidelines help dam owners and emergency management agencies effectively develop, prepare and implement emergency actions should there be an incident at a dam facility. The use of this DLNR EAP template is highly recommended, however not mandatory.

Dam Owners are responsible for the Production, Distribution, Updating/Maintenance, and Testing of their facility EAPs, per HAR 13-190.1. Each owner shall ensure that content entered into the plan is specific for each facility. The successful use of this plan relies on the inspection and notification event triggers in the plan.

There are many factors and scenarios for a dam failure, and several assumptions were made in order to run the models. DLNR assisted with development of dam break modeling and potential inundation mapping using a sunny day dam break scenario. Dam failure evacuation maps were then developed by the Counties. Dam Owner's may provide alternative dam break models to the County Emergency Management / Civil Defense Agencies to update the dam failure evacuation maps. Upon developing revisions or modifications to the evacuation maps, dam owners shall submit a digital copy to DLNR for inclusion on this EAP site.

The use of this template is provided as a guidance to initiate an EAP. DLNR is not responsible for errors, deficiency or omissions within the plan. Any use, disclosure, or distribution by unintended recipients is prohibited. Should an error be found, please notify DLNR as soon as possible for a change to be posted.