REMEDIAL ALTERNATIVES ANALYSIS REPORT
For LEAD IMPACTED SOIL
AT
NANUE BRIDGE, NINOLE, HAWAII

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Table of Contents

TABLES

FIGURES

APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

ARARs	Applicable or Relevant and Appropriate Requirements
bgs	below ground surface
c-EHMP	Project-specific Construction Environmental Hazard Management Plan
CFR	Code of Federal Regulations
COC	Contaminant of Concern
COPC	Contaminants of Potential Concern
CSM	Conceptual site model
CY	Cubic yard(s)
DU	Decision Unit
EAL	Environmental Action Level
EHMP	Environmental Hazard Management Plan
EPA	United States Environmental Protection Agency
EQI	Enviroquest Inc.
HAR	Hawaii Administrative Rules
HDOH	State of Hawaii Department of Health
HDOH TGM	State of Hawaii Department of Health Technical Guidance Manual
HDOT	State of Hawaii Department of Transportation
HEER	Hazardous Evaluation and Emergency Response
Kd	Desorption coefficient (SPLP test results)
KPC	Kealamahi Pacific Consultants
LBP	Lead-Based Paint
mg/kg	Milligram per kilogram
NPS	National Parks Service
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyls
PPE	personal protective equipment
RAA	Remedial Alternatives Analysis

RCRA	Resource Conservation and Recovery Act
ROW	right-of-way
RSL	Regional Screening Levels
SAP	Sampling and Analysis Plan
SCP	State Contingency Plan
SPLP	Synthetic Precipitation Leaching Procedure
TBC	to be considered
TBD	to be determined
TCLP	Toxicity Characteristic Leaching Procedure
TMK	Tax Map Key
TSP	trisodium phosphate
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USDA NRCS	United States Department of Agriculture National Resource Conservation Service-
USEPA	United States Environmental Protection Agency

1 Introduction and Purpose

The site is located below Nanue Bridge, Ninole, Hawaii on the Hamakua Coast approximately 16 miles north of Hilo HI. The site is a right of way for the County of Hawaii Department of Transportation (Figure 1). The site includes the Hawaii County Tax Map Key (TMK) (3) 3-2-001 Parcel 008, and (3) 3-2-001:001 which is owned by the Hawaii Department of Transportation.

The ROW is located below Nanue Bridge. This steel girder and trestle bridge lie 250+ feet above the stream. The bridge was originally constructed in 1911, and lead-based paints were frequently applied to the structure throughout the 20th Century (Historic Hawaii 2014). Lead-based paint flaked off and may have spilled during application. The lead paint was removed from the bridge in 1997 (Hawaii Tribune-Herald 1997), but the area below the bridge now has lead-impacted soil.

1.1 Purpose

Lead-impacted soil has been documented at other nearby bridges (Hakalau and Kolekole), and it was suspected that Nanue Bridge would have comparable results. The bridge requires maintenance, and workers will need to be on site to repair and replace girders and trusses shore up footings and remove vegetation. Soil disturbance during foundation work and access requirements will potentially expose workers to contaminants of potential concern (COPC)-impacted soils. If soil is found to exceed the Hawaii Department of Health (HDOH) Tier 1 Environmental Action Levels (EALs) for unrestricted land use, a Construction Environmental Hazard Management Plan (C-EHMP) will be completed prior to site work. A site investigation was conducted in March 2023 to identify and delineate the extent of lead-impacted soil within Decision Units (DUs) at the site.

This report evaluates existing data and associated human health and/or environmental hazards and provides an analysis of potential remedial alternatives at the site.

2 Background

2.1 Site Description

The site is located in a steep gulch and is bisected by Nanue Stream which opens to the Pacific Ocean approximately 500 ft east of the bridge. The terrain is steep with a 78% grade (ControlPoint 2023). Some areas a vertical drops of appriximxately 20 ft. A set of old wooden stairs allow access to the first set of footing along the southern embankment.

The area under Nanue Bridge is rocky with tall grasses and non-native trees. Overhead utility lines run along the western side of the ROW and vegetation in the area is knocked back regularly, but grows rapidly. The Hamakua area receives heavy and often torrential rainfall. A scoured natural swale on the western edge of the ROW clearly funnels water to the footings at DU12 on the southern embankment during heavy rains. This swale has caused significant erosion along the western side of the ROW.

The site is not an identified critical habitat by the United States Fish and Wildlife Service (USFWS). The project is within the Special Management Area for the State of Hawaii (KPC 2023).

Soils in the northern embankment were finer silt than the southern embankment. DUs closest to the bridge decks (DU1, DU2 and DU8 and DU9) were in general drier than the lower elevation DUs and had less vegetation.

The embankments are challenging to access due to significant slope and dense shrubs/trees. The vegetation below and around the bridge consists of thick stands of fast growing introduced species including African tulip, Australian tree fern (*Cyathea C$*), Pohole/Fiddlehead fern (*Diplazium esculentum*), Strawberry guava (*Psidium cattleianum, Myrtaceae*), Maile pilau (*Paederia foetida*), California grass (*Urochloa mutica*), and Octopus Tree (*Schefflera actinophylla*) depending on the slope location.

2.2 Climate

The site is located on the Hamakua Coast of Hawaii Island on the windward side of the island. This area experiences higher than average rainfall than most of Hawaii. The average annual rainfall for the site is approximately 138 inches. March is the wettest month with over 15 inches of rainfall and June is the driest with approximately 8 inches (Giambelluca et al 2013). Temperatures have minimal variances with an average low of 65 to 70 degrees Fahrenheit and average highs of 79 to 84 degrees Fahrenheit (NOAA 2019).

2.3 Soils/Geology

The site is located to the north and south of Nanue Stream. Soils are identified by the United States Department of Agriculture National Resource Conservation Service (USDA NRCS) as Hilo Rock outcrop, with slopes of 35 to 100 percent. These are typical of gulches in lava flows and consist of hydrous silty clay loam over basalt (United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) 2023).

2.4 Surface Water

Nanue Stream bisects the site. This is a perennial freshwater stream that is approximately 10 miles long with a rocky channel. It is part of a 5.5 square mile watershed (USGS 2019). The stream is not channelized and has steep embankments, but it could scour upstream and back scour.

2.5 Groundwater

The site is located above the Underground Injection Line according to the HDOH Safe Drinking Water Branch (HDOH SDWB 2019) as the coastline serves as the demarcation in this part of Hamakua. It is unlikely that groundwater at the bridge is a source of drinking water due to the proximity of the shoreline.

2.6 Historic Land Use

The parcel targeted for remedial action alternatives are located below Hawaii Belt Road. This particular tax map key (TMK) was never identified as an agricultural site on historic maps. The steep terrain makes access to Nanue Stream challenging.

The bridge itself spans approximately 531-feet and is 286-feet tall at the deck (Historic Hawaii 2014). It is the tallest one in Hawaii (NPS 2009). The bridge was originally constructed in 1911/1912 for the Hilo Railroad Company to access the sugar plantations along the coast. The former sugarcane camp town of Honohina was located southwest of the bridge (1910s – 1960s), but today only the cemetery remains west of the bridge (Hakalau Home 2023). A former dump site associated with Honohina was identified during site inspection. Rubbish from the upper elevation was found in the swale along the southwest bank of Nanue Bridge. Nanue Bridge survived the 1946 tsunami, and the railroad was rebuilt in 1953 as a highway (NPS 2009).

In the early 1950s, lead-red and black bridge paint were applied to the Nanue Bridge and all over bridges along the Hamakua Coast (Honolulu Advertiser 1953). Lead paint was removed from the bridge in 1997.

2.7 Current/Future Land Use

The site is a Hawaii Department of Transportation right-of-way with no public access, no private easements, and no identified users besides bridge maintenance crews. The site is anticipated to remain a right-of-way for the near future.

3 Magnitude and Extent of Contamination

Previous site investigations on bridges along the Hamakua Coast identified that lead-based paint flakes could be a concern in the Hawaii Department of Transportation (HDOT) Highways right of way below the bridges.

Fifty-increment multi-increment (MI) soil samples were collected by hand on the north side of the bridge on March 5 and March 6th, 2023, following the Sampling and Analysis Plan (SAP) (EQI 2023). Samples on the southern side of the bridge were collected by hand on March 9 and 10th 2023. Samples were analyzed for Resource Conservation and Recovery Act (RCRA) 8 metals and PCBs. PCB analysis was requested by the HDOH Hazard Evaluation and Emergency Response (HEER) office, who were concerned that it may have been used in the bridge expansion joints. Lab tables and reports are found in Appendix A1 and Appendix A2.

Samples were analyzed using the following test methods.

RCRA 8 Methods

Arsenic	EPA* 6020B
Barium	EPA 6020B
Cadmium	EPA 6020B
Chromium	EPA 6020B
Lead	EPA 6020B
Mercury	EPA 7471A
Selenium	EPA 6020B
Silver	EPA 6020B

* *United States Environmental Protection Agency*

Polychlorinated Biphenyls (PCBs)

PCB-1016	EPA 8082A/3546
PCB-1221	EPA 8082A/3546
PCB-1232	EPA 8082A/3546
PCB-1242	EPA 8082A/3546
PCB-1248	EPA 8082A/3546
PCB-1254	EPA 8082A/3546
PCB-1260	EPA 8082A/3546

Decision Units (DUs) were established on the north and south embankments of the site at three depth profiles, 0 to 3 inches below ground surface (bgs), 3 to 6 inches bgs and 6 to 9 inches bgs.

Initial DUs were assigned based on the survey, ROW dimensions and anticipated work areas around the bridge footings. Two “side” DUs for each embankment (mauka and makai) were planned to capture the edge of the anticipated work area to the edge of the HDOT

ROW. Expanding the DUs from the footing work area to the wider ROW would not reflect the majority of the worker exposure.

On the northern side of the bridge, heading towards Honokaa, DU1, DU2, DU3, DU4 and DU5 were planned to represent each bridge footing area. Two side DUs (DU6 and DU7) were planned to extend from the bridge to the edge of the ROW (Figure 2). Belaying equipment was necessary to collect samples from DU3.

On the southern side of the bridge, heading towards Hilo, DU8, DU9, DU10, DU11 and DU12 were planned to represent each bridge footing area. Two side DUs (DU13 and DU14) were planned to extend from the bridge to the edge of the ROW (Figure 2). Ropes and belaying equipment were necessary to access DU11 and DU12 and is recommended for DU10.

Generally, DUs areas sampled in the upper DUs extended up to the edge of the bridge deck. In the lower DUs, sampled areas used the edge of the pier footings as the primary outer edge. The DUs stayed roughly below the bridge deck (Figures 2 – 4).

However, field conditions required adjustments to the DU due to the steepness of the incline, a bare rock substrate, and heavy vegetation that blocked access to soil. In the SAP (EQI 2023), some DUs were planned for sampling, but with the caveat that “samples will not be collected where the steepness of the slope makes it inaccessible or dangerous or where adequate soil is not present”. The entirety of the site was not accessible during the initial site inspection as belaying equipment would be required to safely review the length of the ROW. The sampled DUs used the outer edge of the bridge deck as the overhead reference and/or the pier footings to reflect the most likely work areas.

On the northern side of the stream embankment, DU4 and DU5 (the lowest elevation) were not sampled. DU4 consisted of a heavily vegetated 70-degree face with many African tulip trees (*Spathodea campanulate*) preventing ingress/egress on the sloped area. DU 5 was a completely vertical face with exposed bare rock and inadequate soil to sample. The physical characteristics of both DUs provide a low potential for exposure to human receptors. The primary current/future human receptor scenario would be construction workers. Climbing gear would be necessary to access and work in the site, reducing significant contact with lead-impacted soil.

The “edge” DUs; DU6 and DU7 on the northern side and DU13 and DU14 on the southern side were not sampled as they were inaccessible due to thick vegetation and steep slopes (50% to 80% slopes) (Figure 2). Additionally, fresh green waste cuttings from the DOT's periodic vegetation control activities occurred one day prior to the sampling event. There were many freshly cut large limbs and dangling branches suspended in the trees. The terrain is so steep that clearing of brush along this border area takes place from the bridge deck using an articulating man-lift that extends down into the valley below and worker cut brush from this platform using pole saws. There is currently no direct pathway for current/future occasional users/trespassers. The slope and dense vegetation acts as a physical boundary preventing direct exposure. Even ROW vegetation clearance occurs from the bridge deck using a vertical trimmer, reducing the exposure of regular landscape maintenance workers.

Based on previous soil investigations at other Hamakua bridges (Hakalau and Kolekole) it is likely that lead flakes from the bridge drifted in proximity to the bridge, and lead concentrations in these DUs are well above the HDOH Tier 1 EAL for unrestricted land use. Sampling these adjacent DUs seems unnecessary due to the heavy vegetation preventing physical access to receptors needed for potential exposure to occur. Due to the likelihood that concentrations of lead in these areas do exceed unrestricted land use EALs, and likely exceed construction/industrial EALs, remedial alternatives evaluated in this RAA consider addressing the entire DOT right-of-way.

3.1 Total Lead Results

Every DU in the HDOT ROW exceeded both the HDOH Tier 1 EAL for unrestricted land use (200 mg/kg). Only one DU profile (DU1 at 6 to 9 inches below ground surface), did not exceed the construction/trench worker safety of 800 mg/kg of total lead. Almost all of the DUs exceeded gross contamination of 1000 mg/kg. The southern embankment HDOT ROW (DU10 at 3 to 6 inches bgs) contained the highest lead concentration sample results (Table 3-1/Appendix A2).

Levels that exceed the construction trench worker EAL require a Construction EHMP while working on the site and may require additional personal protective equipment (PPE) and monitoring equipment.

3.1.1 Total Lead: Northern Embankment

On the north (Honokaa side) lead levels decreased with depth in DU1, but levels increased with depth in DU2 and DU3. All of the sample results ranged between 1100 to 1200 mg/kg for lead in the first three inches (Figure 3a).

In DU1, the highest elevation DU, there was a drop-off in the depth profiles. The mean decreased from 1133 at 0 to 3 inches bgs to 577 mg/kg in 6 to 9 inches bgs. DU1 at 6 to 9 inches was the only DU where the total lead results did not exceed Construction/Trench Worker EALs. The surface soil was most heavily impacted by lead and the surface contamination was consistent across DUs. The lead impacted soil had clearly run off onto the lower elevation DUs over time, building up the soil on the lower elevation DUs to match the surface levels.

Within DU2 the lead results were consistent – between 1000 to 1400 from 0 to 9 inches bgs at the three profiles. At DU3 (the lowest elevation DU that was sampled on the north side) the top six inches were 1200 mg/kg and the 6-to-9-inch profile had was at 1500 mg/kg (Figure 3b and Figure 3c).

3.1.2 Total Lead: Southern Embankment

On the South (Hilo side) lead contamination increased at the 3 to 6 inches profile when compared the to the upper 0 to 3 inches soil profile. These soils contained more total lead than the surface layer (0 to 3 inches) likely due to runoff and soil creep (a mass wasting process where soil particles move downhill due to hundreds to thousands, of wetting and drying cycles occurring over decades).

DU8, the highest elevation DU, had the lowest total lead concentration on that side of the bridge and had a noticeable falloff in total lead concentration from 4300 mg/kg in the 0-to-3-inch layer dropping to 2900 mg/kg in the 6-to-9-inch depth profile. This mirrors the results in DU1 in the northern embankment. However, the results at DU8 are all greatly elevated compared to DU1. DU8 has sheer exposed rocks and soil that differs from the lower elevation DUs.

DU9 included a mixture of sheer cliff and plateau areas. Vegetation cover varied from dense fern and California grass to bare weathered, nearly vertical, rock face. Results between the depth units were consistent varying from 6400 to 6000 mg/kg total lead with the lowest results at the 6-to-9-inch depth profile.

DU10 had the highest concentration of total at 3 to 6 inches bgs and a total lead result of 9700 mg/kg. This DU is steep, but heavily vegetated with grasses and had a greater amount of soil in the DU compared to some of the rockier DUs (DU9 and DU11). It is likely that this area had more soil build up, and somewhat less erosion.

DU11 was steep enough to require belaying equipment. It also had more exposed rocks, and a sheer drop at the end of the DU. Total lead surface results varied from 4300 to 6400 mg/kg. Results were lower than the 0-to-3-inch profile indicating that soil likely runs off.

DU12 was the stream level channel, and it is primarily level and slightly elevated from the stream. This area had higher results than DU11 varying from 6300 mg/kg of total lead at 0 to 3 inches bgs, 7900 mg/kg at 3 to 6 inches bgs, and 6500 at 6 to 9 bgs. Water from the swale is funneled to this DU on the western corner and it is obvious that the area is eroding during heavy rains.

3.2 Total Arsenic Results

Arsenic was the only other COPC that exceeded the HDOH Tier 1 EALs in the site investigation. However, only six DUs were at or above the HDOH Tier I EALs of 24 mg/kg. While the residential direct exposure is set to 23 mg/kg, this site is not now, nor will be become residential in the foreseeable future due to slope and land use. The highest exceedance was 32 mg/kg in DU8 at 6 to 9 inches bgs (Figure 4).

The highest exceedances were at the highest elevation DUs, in the areas that were drier and protected from runoff due to the proximity to the bridge deck. The DUs with arsenic exceedances also had wooden access ladders onsite. The DUs may have had arsenic pesticides applied which remained in the soil and did not runoff to lower DUs due to better rain coverage from the bridge.

Due to the low total results, bioaccessible arsenic was not analyzed as the results were primarily at the EAL for unrestricted land use.

All results were well below the construction/trench worker EAL of 95 mg/kg and are not identified as a site-specific contaminant of concern (COC) for the EHMP. ‘

3.2.1 Total Arsenic: Northern Embankment

DU1 was the only DU with arsenic exceedances. Total arsenic results were 26 mg/kg at 0 to 3 inches bgs. No other DUs were above 24 mg/kg.

3.2.2 Total Arsenic: Southern Embankment

At DU8 total arsenic in the surface soil (0 to 6 inches bgs) was 20 mg/kg. However, at 6 to 9 inches bgs total arsenic results were 32 mg/kg. This was the highest sample result.

At DU9 all three depth profiles were at 24 to 25 mg/kg. No other DUs downslope had any exceedances for arsenic greater than 24 mg/kg.

Table 3-1: Nanue Bridge Total Lead Summary Table

Yellow	Lead results above HDOH Tier 1 EAL Unrestricted Land Use (200 mg/kg), but below Construction/Trench Worker Scenario (800 mg/kg) (HDOH 2012)
Red	Lead results above HDOH Tier 1 EAL above Construction/Trench Worker Scenario (800 mg/kg), but below gross contamination (1,000 mg/kg)
Dark red	Lead results above gross contamination (1,000 mg/kg)

DU ID	Depth (in)	Lead Results (mg/kg)	Sq. Ft	CY	Description
DU1	0-3	1133	1722	16	Northern Embankment highest elevation
	3-6	930	1722	16	
	6-9	577	1722	16	
DU2	0-3	1200	1985	18.4	Northern Embankment Mid elevation
	3-6	1000	1985	18.4	
	6-9	1400	1985	18.4	
DU3	0-3	1200	4413	41	Northern Embankment Lowest DU on north, very steep.
	3-6	1200	4413	41	
	6-9	1500	4413	41	
DU8	0-3	4300	2161	20	Southern Embankment Highest elevation
	3-6	3100	2161	20	
	6-9	2900	2161	20	
DU9	0-3	6400	2843	26	Southern Embankment Second Highest elevation
	3-6	6200	2843	26	
	6-9	6000	2843	26	
DU10	0-3	8500	3848	37	Southern Embankment Steep slope, heavily vegetated
	3-6	9700	3848	37	
	6-9	8100	3848	37	
DU11	0-3	4300	3498	32	Southern Embankment Steepest slope
	3-6	6400	3498	32	
	6-9	6000	3498	32	
DU12	0-3	6300	7185	67	Southern Embankment Lowest elevation – at stream. Relatively flat
	3-6	7900	7185	67	
	6-9	6500	7185	67	

**DU1 results are the mean of the primary sample, duplicate, and triplicate.*

3.3 Contaminant Fate and Transport

It was anticipated that lead impacted soil would have run off from the upper elevation DUs to the lower elevation DUs and this was confirmed by the sampling. Erosion from upper elevation to the stream channel was obvious during sampling.

The data suggests that in some of the DU areas (DU2, DU3, DU10, DU11, and DU12) the higher concentrations at depth are possibly due to the slope being steep enough that soil from higher up area may have sloughed downslope. The earlier and deeper layers of soil were more heavily impacted by the 20th century lead paint application versus the more recent topsoil layers.

Visible paint flakes were seen in multiple DUs in soil 6-9 inches below the subsurface indicating that the soil higher on the valley wall had mobilized via sheet flow or soil creep (horizontal and vertical action from repeated wetting and drying cycles). The conditions are fair for this process since there is a developed soil horizon up to two feet thick over a weathered saprolite rock with slopes under the bridge up to 88 percent slope commonly over 70 percent in most of the DUs (Table 3-3). During cyclic wetting and drying the soil particles move out as they expand during the wetting cycle and are then pulled downward by gravity and drying out only to have this process repeat itself again during the next wetting cycle. Any rainwater sheet flowing on this surface causes soil to cover the soil below it.

Table 3-3: Nanue Bridge DU Slope Estimates

	Top Elevation	Bottom Elevation	Rise	Run	Slope
N. ROW	Feet	Feet	Feet	Feet	%
DU1	201	180	20	41	49%
DU2	180	148	32	40	80%
DU3	148	90	58	73	79%
S. ROW					
DU8	212	170	42	48	88%
DU9	170	130	40	50	80%
DU10	130	85	45	56	80%
DU11	85	48	37	53	70%
DU12	48	0	48	67	72%

Source: Survey ControlPoint Surveying 2023

3.4 PCB Results

Additionally, HDOH requested that EnviroQuest analyze some of the samples for PCBs, particularly in samples with the highest lead hits. PCBs have a shorter hold time (14 days from the sampling date) and due to transportation and sample analysis time, it was not possible to have all the total lead results in time to meet the hold time. Therefore, DUs with the highest lead levels were estimated.

In DU10 and DU11 orange paint flakes (anticipated to be lead-based or lead containing) was visible at the site in the 3-6 inches interval. These DUs were chosen for PCB analysis. The upper 0-3 inch layer at DU10 was also analyzed for PCBs to verify if the orange paint flakes correlated with higher lead levels.

The PCB congener PCB-1254 was present in all three samples at concentrations ranging from 0.037 mg/kg to 0.20 mg/kg, which are well below the HDOH Tier 1 EAL for unrestricted land use (Appendix A1). PCBs were not identified as a COPC at the site.

4 Environmental Hazard Evaluations

4.1 Chemicals of Potential Concern

Lead paint was used for decades on the Nanue Bridge until removed in 1997. Other bridges in the Hamakua Coast (Hakalau and Kolekole) have also been identified as sources of lead-based paint which have flaked off and been deposited below the structure on the valley floor.

Studies at other Hamakua bridges identified lead as the COC. Nanue Bridge is no different, as all the DUs were found to be above the HDOH Tier 1 EALs for unrestricted land use (200 mg/kg) and all but one DU was above the construction trench worker EAL (800 mg/kg) for lead.

Lead is persistent in the environment and accumulates in soils and sediments through deposition. Once absorbed into the body, lead may be stored for prolonged periods in mineralizing tissue (e.g., teeth, bones, etc.). The stored lead may be released again into the bloodstream, especially in times of calcium stress (e.g., pregnancy, lactation, osteoporosis, etc.) or calcium deficiency.

Depending on the level of exposure, lead can adversely affect the nervous system, kidney function, immune system, reproduction and developmental systems, and the cardiovascular system. Lead exposure also affects the oxygen-carrying capacity of the blood.

The most encountered lead impacts in current populations are neurological in children and cardiovascular effects (e.g., high blood pressure, heart disease, etc.) in adults. Infants and young children are especially sensitive to even low levels of lead, which may contribute to behavioral problems, learning deficits, and lowered IQ. No children access this site.

Ecosystems near point sources of lead demonstrate a wide range of adverse effects including losses in biodiversity, changes in community composition, decreased growth and reproductive rates in plants and animals, and neurological effects in vertebrates.

4.2 Exposure Setting

Nanue Bridge is a Hawaii Department of Transportation bridge and right of way. The entirety of the site is located within the HDOT tax parcel.

4.2.1 Potentially Complete Exposure Pathways

Potentially complete pathways to user trespasser/construction workers (trench and maintenance exposure scenario) and terrestrial and aquatic ecological receptors exist via direct exposure to soil and potentially fugitive dust if the grass cover was not maintained or a construction excavation project was conducted under the bridge and dust controls were not implemented correctly. This potential exposure route could be controlled using proper PPE and BMPs for construction/stormwater runoff and could limit this exposure pathway.

Currently, there is no complete pathway to any receptors via surface water runoff, but again, future construction activities could potentially complete this pathway if not conducted with care. Additionally, if there were a natural disaster such as a tsunami that could scour away the current stream bank and redistribute lead-impacted soils to the stream mouth and runoff could be a completed exposure pathway.

4.3 Conceptual Site Model

A conceptual site model (CSM) provides a framework regarding potential sources of contamination, types of contaminants, contaminated media, exposure and migration pathways, and receptors. The CSM (Table 4-1) was used in the preparation of the Remedial Alternatives Analysis (RAA). Based on the results of the document review, the following are identified as potential human receptors:

- On-site construction workers – including personnel involved in repair or construction/ trenching during future site activities; and
- On-site landscapers/site workers – personnel who may maintain landscaped areas and may trim/clear trees and brush from the ground or remove plants from the bridge supports and may mow, weed whack, and perform general site maintenance (stair access to lower footings).
- Trespassers– Including individuals of all ages, who may camp, recreate, or otherwise trespass on the site and may potentially dig, touch, drive, lie, or be exposed to lead-impacted soil or dust. There was no evidence of encampments under the bridge.
- Ecological Receptors – There was clear evidence that the site was used by pigs including wallows and trails crossing the ROW. Native and non-native birds may also nest, loaf, hunt, or transit across the site (AECOS, 2019).

4.4 Exposure Pathway Analysis

Direct exposure to lead-impacted soil is a potential exposure pathway to human receptors at the site via the following pathways:

- Direct Contact: Incidental ingestion or dermal contact with soil;
- Air: Inhalation of fugitive dust;
- Surface Runoff and Sediment Exposure: Contaminants bourn by water or revealed by erosion; and
- Groundwater Exposure: Contaminants leaching from soil or impacting flowing groundwater.

4.4.1 Direct Contact Pathways

Direct contact with soil may result in incidental oral ingestion and/or dermal absorption of lead. Dermal absorption is not considered a pathway at the site, as lead at the site is not organic. Direct contact exposure may occur for the following groups:

- *Construction/Trench Workers and Landscaping/Site Workers:* may experience direct contact with lead-impacted soils during trenching, construction, and landscaping activities.

  The HDOH construction/trench worker exposure scenarios are set equal to assumptions used in the United States Environmental Protection Agency (USEPA) Regional Screening Levels (RSLs) for consistency with screening levels for occupational exposure assumptions. The exposure rate reflects projects that may require the same workers returning frequently to the same site (construction workers in utility trenches). The HDOH Technical Guidance Manual (TGM) uses a total exposure duration of seven years for both carcinogens and noncarcinogens. An exposure frequency of 20 days (4 weeks) per year for 7 years yields a total of 140 days total exposure. Construction workers may receive 140 days (roughly 6 months) of exposure in a single year and never visit the site again. The United States Environmental Protection Agency (EPA) evaluates lead exposure by using blood-lead modeling, such as the Integrated Exposure-Uptake Biokinetic Model which recommends that soil lead levels less than 400 mg/kg are generally safe for residential use (HDOH 2017). Residual dirt on hands after digging may contribute to lead exposure through accidental ingestion of soil particles. Direct contact with lead-impacted soil is a concern as 20% to 70% of ingested lead is absorbed.
- *Trespassers:* It is unlikely that trespassers will be onsite long enough to be impacted by a brief time transvering the site to hunt or fish.
- *Ecological Receptors:* Ecological receptors including birds, mammals, and aquatic species may come into contact with the impacted soil through walking, loafing, digging, or directly in sediments.

4.4.2 Air Exposure Pathways

Inhalation of lead dust is another route of exposure, and almost all inhaled lead is absorbed into the body (ATSDR 2005). Lead particles can be absorbed from fugitive dust particles. The generation of fugitive dust may occur through disturbance of affected soil; such as wind or construction activities. Dust particles may be inhaled, may settle on human skin, and be ingested (hand to mouth), and/or may settle on vegetation ingested by humans.

- *Construction/Trench Workers and Landscaping/Site Workers:* may inhale fugitive dust during normal construction, landscaping, or maintenance activities. Total lead results in the HDOT ROW exceed 1,000 mg/kg for lead. This level is above the construction/trench worker scenario of 800 mg/kg and only trained personnel familiar with risks associated with exposure to lead should be allowed to conduct activities such as trenching, grading, and drilling operations. If the soil in these areas is disturbed, site workers would potentially require respirators based on air monitoring results.
- *Ecological receptors:* Ecological receptors including birds, mammals, and aquatic species may come into contact with the dust through walking, loafing, nesting, or digging.

4.4.3 Surface Runoff and Sediment Exposure Pathway

Surface runoff is part of the current conceptual exposure site model. Upstream and ROW DUs had exceedances of the gross contamination EAL of 1,000 mg/kg.

The exposed shoreline area did not have enough soil to sample.

The stream bank on DU12 could shift or be flooded from the western swale during storms. If extensive flooding, scouring, or high waves (tsunami or hurricane) causes extensive erosion of surface soil from the impacted DUs they may migrate to Nanue Stream. Sediment may accumulate in the adjacent marine environment and be available for contact with various receptors. The area is not an identified or accessible recreation site, but it is possible that sediments could migrate, and users of the marine environment (swimmers, surfers, fishermen) could come into direct contact with sediment and be exposed through oral ingestion and/or dermal absorption. However, given the remoteness and difficult terrain, it is unlikely to be accessed with any frequency by recreational user/trespassers. Ecological receptors may live directly in the impacted sediment and may be exposed to COC through feeding within the sediment. As a secondary transport mechanism, lead may bioaccumulate in ecological receptors (i.e., fish, shellfish), then ingested by human receptors.

4.4.4 Groundwater Exposure Pathway

To assess the potential environmental/groundwater leaching pathway, the Synthetic Precipitation Leaching Procedure (SPLP) analysis was conducted on a soil sample collected from DU1 at 0 to 3 inches bgs, DU3 at 6 to 9 inches bgs, DU8 at 0 to 3 inches bgs, DU10 at 3 to 6 inches bgs, DU11 at 3 to 6 inches bgs and DU12 at 3 to 6 inches bgs. Total lead results varied from 1133 mg/kg at DU1 to the highest total lead result of 9700 mg/kg at DU10. The SPLP value varied from 0.08 mg/L to 8 mg/L respectively (Appendix B1). The limit of quantification is 0.030 mg/L.

The SPLP assists in the determination of the mobility of both organic and inorganic analytes present in liquids, solids, and wastes. The results of the SPLP test are used to determine the Desorption Partitioning Coefficient (Kd), which is important to understanding how mobile the lead in the soil is and whether it poses a potential risk to ecological receptors in the vicinity of the stream (e.g., vertebrate and invertebrate organisms). EPA Method 1312 SPLP West extraction procedure was used on the Nanue soil samples identified in Appendix B1. West refers to the pH of the extraction fluid that is made by adding 60/40 weight percent of sulfuric and nitric acids to reagent water until the pH is 5.00 +/- 0.05 used to determine the leachability of a site that is west of the Mississippi River. This method’s pH is higher than the EPA methods extraction fluid for sites east of the Mississippi River (4.20 +/- 0.05) (KPC 2023).

The result of the SPLP was inputted in the Batch Test Leaching Model (HDOH, 2007 revised 2011), and used to determine the relative mobility of lead in the soil. Batch tests involve placing a small amount of the soil in buffered, de-ionized water, agitating the mixture for a set period and measuring the fraction of the contaminant that desorbs from the soil and goes into solution. The ratio of the mass of a contaminant that remains sorbed to the mass that goes into solution, adjusted to the test method, is referred to the contaminant's "desorption coefficient" or "Kd" value (HDOH 2007 revised 2011).

If the calculated desorption coefficient is greater than 20 (Kd>20), the contaminant is considered not significantly mobile and is unlikely to pose a leaching hazard to groundwater. If it is less than 20, then an estimated concentration in groundwater should be calculated and compared to the HDOH Tier 1 EAL. The Kd value uses micrograms/L and when calculated by this model for the soil samples Kd coefficient varied from 1193 to 14,143, all significantly greater than a Kd value of 20 (Appendix B-1).

This result demonstrates that the lead present in the soil is strongly bound to the soil and is considered immobile (soil is weathered volcanic alluvial sediments including gravel, sand, and clay). Thus, there is a low likelihood that the lead concentrations in the soil at pose a risk to ecological receptors (e.g., aquatic organisms) as a result of lead leaching from the soil into rainwater and sediments or impacting the groundwater below the site.

4.5 Environmental Hazard Evaluation Summary

The exposure pathway analysis described in the previous section identifies various exposure pathways (direct and indirect) where lead-impacted soil may pose a risk to human and ecological receptors. The conceptual site exposure model provides a graphical comparison of release mechanism, pathways, and exposure routes to potential current and future receptors at the Site (Table 4-1).

4.5.1 COPC Sources and Release Mechanisms

The primary source of the COPC at Nanue Bridge is lead-impacted surface and subsurface soil from lead released into the environment from lead-based paint used in historical bridge maintenance activities.

Lead-impacted soil present at the site has been shown to exist at concentrations above the HDOH Tier EALs for gross contamination (1000 mg/kg). Total concentrations vary across the site and include portions that are at or below HDOH Tier 1 EALs for unrestricted land use. The secondary release mechanism, besides direct contact with soil, includes dust, surface water runoff, and leaching.

4.5.2 Pathways and Exposure Routes

Lead poses a hazard to potential receptors through direct exposure to contaminated media through pathways including surface soil, subsurface soil, ambient air, surface water and sediments, and groundwater. These pathways potentially expose receptors to lead via inhalation, ingestion, or dermal adsorption.

4.5.3 Potential Receptors Current and Future Land Use

The main human exposure scenarios identified under current land use as a Hawaii Dept of Transportation right of way are construction/maintenance workers and ecological receptors. The site's land use and steep, inaccessible terrain limits trespassing. It is not open or appealing to the public. The land use is not likely to change as it serves as a primary highway for the Hamakua Coast, and future land use includes these same human exposure scenarios. This is also true for avian and aquatic receptors.

4.5.4 Complete Exposure Pathways

Complete exposure pathways exist for all receptor scenarios exposed to surface and subsurface soil at this site under current and future conditions. Exposure to dust is a complete pathway to on-site maintenance and construction workers when the current grass cover is disturbed and there is potential for inhalation of dust under dry windy conditions when activities such as land mowing and excavation occur.

4.5.5 Exposure to Lead Leaching

There has not been an identified complete pathway to current and future receptors via leaching in subsurface soil or groundwater. A batch test leachability model based on SPLP analyses from soil collected from DUs with total lead results between 1133 mg/kg at DU1 to total lead results of 9700 mg/kg at DU10 demonstrated that the absorption coefficient is high enough to prevent contaminant mobilization from the soil to groundwater (Appendix B1). The DUs end at a steep drop off on the northern embankment, and a rocky embankment on the south.

Table 4-1: Conceptual Site Exposure Model

Primary Sources	Primary Release Mechanism	Secondary Sources	Secondary Release Mechanism	Pathway	Exposure Route	Potential Receptors							
						Current Land Use				Future Land Use*			
						On-site Landscape or Construction Workers	User Trespassers	Terrestrial Ecological	Aquatic Ecological	On-site Landscape or Construction Workers	User trespassers	Terrestrial Ecological	Aquatic Ecological
Lead Impacted Soil	Lead-Based Paint from Bridge	Lead Impacted Soil	None	Surface Soil	Ingestion	X	X	X	O	X	X	X	O
					Dermal	X	X	X	O	X	X	X	O
			None	Sub-Surface Soil	Ingestion	X	X	X	O	X	X	X	O
					Dermal	X	X	X	O	X	X	X	O
			Dust	Ambient Air	Inhalation	X	O	O	O	X	O	O	O
			Surface Water Runoff	Surface Water and Sediments	Ingestion	O	O	O	O	O	O	O	O
					Dermal	O	O	O	O	O	O	O	O
			Leaching	Subsurface Soil	Ingestion	I	I	I	I	I	I	I	I
					Dermal	I	I	I	I	I	I	I	I
				Ground- water	Ingestion	I	I	I	I	I	I	I	I
					Dermal	I	I	I	I	I	I	I	I
					Inhalation	I	I	I	I	I	I	I	I

Notes: X - Complete exposure pathway O – Potentially Complete I - Incomplete
** - No significant change to the land use is planned in the near future*

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5 Establishing Alternatives

5.1 Introduction

Under amended Section 121(d) of CERCLA, remedial actions for hazardous substance cleanup must attain or waive federal environmental potentially applicable or relevant and appropriate requirements (ARARs), or more stringent state environmental ARARs, upon completion of the remedial action (EPA 2019).

ARARs include only federal and state environmental or facility-citing laws/regulations and do not include occupational safety or worker protection requirements. Compliance with Occupational Safety and Health Administration (OSHA) standards is required by 40 C.F.R. 300.150 and therefore the CERCLA requirement for compliance with or a waiver of ARARs does not apply to OSHA standards (EPA 2019). In addition to ARARs, non-promulgated criteria, advisories, guidance, or policies referred to as to-be-considered criteria (TBC) information may also apply to the conditions found at a site. Unlike ARARs, identification of and compliance with to be considered (TBC) information is not mandatory or legally binding; however, where TBC information is used as a cleanup level, its use for this purpose should be explained and justified.

See Appendix C for a table for ARARs and TBC criteria for remedial alternatives considered for Nanue Bridge. The alternatives evaluated to meet the ARARs, and compliance may require consultation with State and Federal Agencies.

5.2 Potential ARARs and TBC Criteria

5.2.1 Potential Chemical-Specific ARARs and TBCs

Chemical-specific ARARs include those environmental laws and regulations that regulate the release to the environment of materials with certain chemical or physical characteristics or that contain specified chemical compounds. These requirements generally set health- or risk-based concentration limits or discharge limits for specific hazardous substances by media. In this instance, the chemical of concern is lead. This contaminant is identified in the EPA RSLs, which identify industrial/non-residential soil screening levels at 800 ppm for soil. The RSLs are defined as TBCs as they are not promulgated.

5.2.2 Potential Location-Specific ARARs and TBCs

Location-specific ARARs govern activities in certain environmentally sensitive areas. The specific location and the proposed activity at the site trigger these requirements. The site is solely a right of way under a highway bridge with no public access, residential or commercial activities. The terrain is challenging due to its steepness and thick vegetation and limits trespassing. Wild pigs transverse the site. The primary site users would be bridge repair workers and maintenance/landscapers. The HDOH EALs for construction/trench workers have set a standard of 800 mg/kg for lead, the same as the lead RSL for industrial/non-residential use. The EALs are not promulgated.

Portions of the site are less than 150 meters from the water and within the Coastal Zone Management Special Management Area. It is above the Hawaii-designated underground injection control line but is not likely an area that will be developed as a source of drinking water. It is not located in a designated critical habitat or a designated wetland.

5.2.3 Potential Action-Specific ARARs and TBCs

Action-specific ARARs generally set performance, design, or other similar action-specified controls or restrictions on particular kinds of response activities. For example, action-specific ARARs may include restrictions that define acceptable treatment and disposal procedures for hazardous substances under 40 Code of Federal Regulations (CFR) Part 261 and 262. The EPA regulatory limit for lead is 5 mg/L. DUs at the site have been identified as exceeding this limit and would be classified as hazardous waste.

DUs were analyzed for Toxicity Characteristic Leaching Procedures (TCLP) using method 6010D for RCRA8 metals, and lead was the only analyte that failed TCLP (Table 5-1/Appendix B2). DUs were chosen to represent a range of total lead results. During the Hakalau Bridge TCLP assessment, “soil with total lead concentrations somewhere between 1410 mg/kg and 5080+ mg/kg (approximate range of total lead concentration 1500 - 5000 mg/kg) may likely have TCLP lead results greater than 5 mg/L.” Soils from Hakalau at had total lead results above 5000 mg/kg failed TCLP (KPC 2023). It was anticipated that Nanue would have comparable results.

Three DU samples failed TCLP at Nanue; they were all at a depth of 3 to 6 inches and included DU10, DU11, and DU12. DU9 and DU11 had identical total lead results, but DU11 failed TCLP and DU9 did not (Table 5-1/Appendix B2). Lead release is influenced by the soil’s natural pH, organic matter presence, soil cation exchange capacity, particle size, buffering capacity, and soil mineralogy (Pinto and Al-Abed 2017). DU8 and DU9 included a rocky cliff face with limited organic matter and drier conditions, whereas topsoil layers were thicker with dense vegetation in DU10, DU11, and DU12. Soils appeared siltier on the northern embankment and had limited vegetation in DU1 and DU2. There are no approved waste disposal sites in Hawaii authorized to accept this waste, it will need to be shipped out of state.

Table 5-1: TCLP Summary Results Nanue Bridge

	DU ID	**Total Lead**	**TCLP**
Northern Embankment		*mg/kg*	*mg/L*
	DU1_0-3_B	1200	0.6
	DU2_6-9	1400	0.69
	DU3_6-9	1200	1.1
Southern Embankment	DU8_0-3	4300	3.7
	DU9_0-3	6400	2.8
	DU10_3-6	9700	17
	DU11_3-6	6400	12
	DU12_3-6	7900	23

5.3 Remedial Action Objectives

The Remedial Action Objectives for Nanue Bridge as identified by the site owners and as recommended by the state guidance is to remove the direct contact pathway to human receptors (site workers) and ecological receptors to lead-impacted soil which exceeds concentrations of 800 mg/kg.

5.4 General Response Actions

Actions may include restricting access, fencing, administrative/institutional controls, reducing contact with lead-impacted soil through physical barriers, or removing the source of contamination.

6 Detailed Analysis of Alternatives

There are seven general categories of remedial alternatives to be considered in the State of Hawaii Department of Health Hazard Evaluation and Emergency Response Technical Guidance Manual. (HDOH TGM Section 16.2.2.2 and Hawaii Administrative Rules (HAR) 11-451-8(c)). The top five grayed-out ones were rejected due to not being feasible due to the site conditions and type of contaminant.

1. No Action
2. Recycle or reuse
3. Destruction or detoxification
4. Separation, concentration, or volume reduction
5. Immobilization of hazardous substances
6. On-site or off-site disposal, isolation, or containment_ Three options were considered
7. Institutional controls, fencing and long-term monitoring: Two options were considered.

6.1 Alternative 1: No Action

Under the no-action, no remediation activities will be performed. The site will remain as-is. Workers will still be exposed to lead-impacted soil that exceeds construction trench worker EALs during site work, and no EHMP will be completed. Trespassers and ecological receptors could still be exposed to lead contaminated soil, but trespassers are limited due to the terrain. Maintenance workers would continue to have a direct pathway to highly contaminated soil media. Lead is persistent in the environment and will not decay in the soil over time.

6.2 Alternative 2: Recycle or Reuse

The contaminant of concern is dispersed lead-paint flakes. The lead paint material is not dense enough to be separated from the soil to be recycled or reused. This alternative is not suitable to remove the contaminant from the site or reduce potential exposure pathways.

6.3 Alternative 3: Destruction or Detoxification

The lead at the site is also not organic, corrosive, or explosive and is relatively immobile. This alternative is not suitable to remove the contaminant from the site or reduce potential exposure pathways.

6.4 Alternative 4: Separation, concentration, or volume reduction

Under this alternative, contaminated material may be completely or partially separated from material that is not contaminated, or contamination may be reduced in a large volume of material by concentrating the contaminant in a smaller volume. Soil particle size separation is conducted to reduce contaminated soil volume. Soils at Nanue Bridge and lead paint flakes are not suitable for volume reduction in this form and contamination would not be reduced significantly.

6.5 Alternative 5: Immobilization of Hazardous Substances

Portions of the site exceed gross contamination and fail TCLP for lead (Appendix B2). The TCLP regulatory limit for lead is 5 mg/L. DUs which failed TCLP include DU 10, DU11 and DU12 at 3 to 6 inches bgs (and could include other depth profiles). TCLP results varied from 12 to 23 mg/L for lead.

The soil in DU10, DU11 and DU12 (approximately 14,535 sq. ft and 136 to 400 cubic yards (CY) of soil) would be classified as hazardous waste if removed for disposal. This soil cannot be disposed of in Hawaii as there are no facilities that are permitted to accept hazardous waste. In a previous project reducing bioavailability by stabilizing the lead with a strong buffering agent application was tested by HDOT to reduce the concentration which could allow for disposal in the state (e.g., through the application of triple superphosphate (TSP) as an amendment to the soil) (Kealamahi Pacific Consultants 2023). This would be in implemented in conjunction with soil excavation and removal and would not be used for in-situ stabilization (Fabian 2008). Treated soil would be hauled to RCRA subpart D permitted landfill (e.g., West Hawaii Sanitary Landfill). This would require extensive soil removal, handling, and processing and offer limited value due to the cost of excavation and handling. Successfully permitting a temporary hazardous waste treatment facility would be unlikely and may take years of effort before a decision for approval or non-approval could be made making this a poor remedial alternative.

6.6 Alternative 6: On-site or off-site disposal, isolation, or containment

This method offers a good option to prevent the site workers from coming into direct contact with lead-impacted soils.

There are three scenarios evaluated in the RAA that are considered effective presumptive remedies for addressing lead-impacted sites by the USEPA. Generally, if lead-impacted soil remains on-site it will be encapsulated, limiting exposure to site maintenance workers/construction worker. An Environmental Hazard Management Plan (EHMP) will need to be maintained and updated when future work activities are planned in areas where encapsulated contaminated soil is present. A project-specific construction EHMP (C-EHMP) will need to be prepared for each future repair and construction activity to manage lead-impacted soil and be protective of all potentially exposed receptors for the duration of the project. This alternative presents the remedial alternatives that reduce or remove contamination from direct contact with receptors at the site.

Swale/Drainage Channel Note

On the southwest portion of the DOT easement, an erosional channel has formed. This starts where runoff leaves the roadbed and then flows down the side of the valley forming is large gully adjacent to the bridge and has caused severe scour which has begun to undermine the last concrete bent on the southwest side of the bridge right before entering the stream. The soil containment and removal alternatives (6a, 6b, 6c) could address that erosion by incorporating flow velocity reduction measures into a concrete channel (rip rap). Design and construction costs associated with these design considerations are not included in the current remedial alternatives presented in this document.

6.6.1 Alternative 6a: On-site isolation and containment through a Tecco Mesh System

This method uses a combination of wire and HDPE plastic mesh and matting to control and define the lead impacted soil and prevent erosion. Tecco mesh allows for vegetation and has been used successfully on Kapue Bridge on the Hamakua Coast among other locations. This alternative is classified as an HDOH and EPA-acceptable soil encapsulation. The site would first be grubbed of all vegetation with chain saws and green waste would be removed. The bare soil would be covered with coconut matting or other geotextile. The Tecco wire mesh would be pinned in place up to the limits of the DOT easement. Spike plates and anchors may be used on bare rock (Table 6-1/Figure 5). An archaeological consultation and monitoring would be required during the excavation.

This option leaves the lead-impacted soil on site (including areas of Gross Contamination) and an EHMP would still be needed. Batch Test Leachability analysis demonstrated that lead is immobile and unlikely to affect groundwater and surface water. Although the need for future maintenance measures below the hard cap is unlikely, workers within the DOT ROW would need respirators when performing maintenance tasks where they are digging/trenching in soil below the mesh system.

Table 6-1: Alternative 6a: No Removal, Cap Only on ROW

Site	Sq. Ft
HDOT ROW (North) 800+ mg/kg	27,428
HDOT ROW (South) 800+ mg/kg	33,254
Total	**60,682**

**Minimum, the paved surface would likely require additional coverage.*

The Tecco system can fail during landslides or extreme weather that causes extensive erosion and rockfall. During landslides/erosional events there is a potential that impacted soil would flow directly to the stream despite the mesh. An annual inspection of this cap will be required per the EHMP and will be documented and submitted to HDOH. Annual operation and maintenance costs would need to reflect the potential for erosion due to the heavy rains and steep slopes.

6.6.2 Alternative 6b: On-site isolation and containment through a hard cap: shotcrete

This is an HDOH and EPA-acceptable mitigation measure to encapsulate the soil using a hard cap of wired meds and shotcrete. All but one of the DUs exceed HDOH construction/trench worker's EALs (800 mg/kg) (HDOH 2012) for total lead) and would be encapsulated along with the remaining HDOT ROW, not solely the known and sampled DUs. The site would first be grubbed of all vegetation with chain saws and green waste would be removed. A welded fabric with wire reinforcement would be installed up to the limits of the DOT easement. Shotcrete would be sprayed to form a hard cap over the site and minimize the potential for erosion. This is the same area as Alternative 6a (Table 6-2/Figure 5). An archaeological consultation and monitoring would be required during the excavation.

This option, like Alternative 6a, leaves the lead-impacted soil on site and requires an EHMP. The lead impacted soil has been demonstrated to be immobile under current environmental conditions and is unlikely to affect groundwater and surface water. General maintenance crews would be protected from lead-impacted soil, but any work which penetrates the cap would require respirators.

Table 6-2: Alternative 6b: No Removal, Shotcrete Cap Only on ROW

Site	Sq. Ft
HDOT ROW (North) 800+ mg/kg	27,428
HDOT ROW (South) 800+ mg/kg	33,254
Total	**60,682**

**Minimum, the paved surface would likely require additional coverage.*

Due to the steepness of the slope some areas may not be feasible to cap, however these are surface rock and would not require shotcrete.

The hard cap option may be undermined during large storms. Impacted soil could runoff despite the cap if water infiltrated from below. An annual inspection of this cap will be required per the EHMP and will be documented and submitted to HDOH. Annual operation and maintenance costs would need to reflect the potential for erosion due to the heavy rains and steep slopes. The EHMP would need to be updated four times over 30 years to reflect bridge maintenance changes.

6.6.3 Alternative 6c: Removal of all soil that exceeds 800 mg/kg for lead. Lead-impacted soil (greater than 800 mg/kg) which passes TCLP will be disposed of at West Hawaii Sanitary Landfill. Lead impacted soil which fails TCLP will be shipped off-island for disposal.

All but one of the DUs exceeded 800 mg/kg for lead and will require removal under this scenario. If the entirety of the ROW were to be tested and exceed 800 mg/kg, this would result in over 2200 CY of soil removal (Table 6-3). If DUs were below 800 mg/kg they would stay on site to minimize soil removal costs. Cleaning the site to unrestricted land use EALs of 200 mg/kg for total lead is not an identified priority as the site is only used by site workers/maintenance crews who can have access to EHMP information and PPE. Unlike Hakalau and Kolekole, the area is and is not a public site, accessible, or attractive for the public.

If only the DUs which were sampled were excavated and removed to a depth of 9 inches this would be 756.2 CY (Table 6-4). However, this would not address all of the areas that workers will be in and would be an incomplete alternative. It is presented here to identify and quantify the known risks in comparison to the total volume and give an idea of the percent of required removal volume.

Table 6-3: Estimated Soil Removal Area – Entire ROW

	Approx. Area	**Removal Depth**	**Cubic Yards**
	Sq. Ft.	*inches*	
North ROW	27,428	12	1016
South ROW	33,254	12	1232
Total ROW	**60,682**		**2,248**

Table 6-4: Known Soil Removal Area – Sampled DUs

	Approx. Area	**Removal Depth**	**Cubic Yards**
	Sq. Ft.	*inches*	
DU1	1722	6	32
DU2	1985	9	55.2
DU3	4413	9	123
Total Known North DUs	**8120**		**210.2**
DU8	2161	9	60
DU9	2843	9	78
DU10	3848	9	111
DU11	3498	9	96
DU12	7185	9	201
Total Known South DUs	**19,535**		**546**
Total Combined DUs	**27,655**		**756.2**

Soil would be hauled to different disposal sites depending on TCLP analysis. DUs which pass TCLP will be excavated (Figure 6) and hauled to West Hawaii Sanitary Landfill. DUs which fail TCLP will be shipped out of state. Not all depth profiles were analyzed for TCLP initially – an assessment was run to determine if total lead results had a relationship to TCLP. If this alternative is chosen, additional TCLP analysis will be necessary for other DUs to determine if some of the DUs can be scraped and disposed of at West Hawaii Landfill.

Costs would be high as soil which is classified as hazardous waste could not be disposed of at facilities in Hawaii. DU10, DU11 and DU12 failed TCLP at the 3 to 6-inch depth profile. Approximately 14,531 sq. ft. of the site failed TCLP, representing 136 cubic yards (Table 6-5). Not all DUs were analyzed, and it is possible that additional depth profiles would also fail TCLP in the known impacted areas or could be so difficult to remove in three-inch lifts that the entirety of the DU would end up being removed as it cannot be easily segregated on the steep slopes. This would increase the volume of out of state soil disposal to 400 cubic yards (Table 6-5 and Table 6-6).

Table 6-5: DUs which Failed TCLP and Require Mainland Disposal

DU	sq. ft	Depth* (inches)	CY	Total Lead mg/kg	TCLP
DU10_3-6	3848	3 to 6	37	9700	17
DU11_3-6	3498	3 to 6	32	6400	12
DU12_3-6	7185	3 to 6	67	7900	23
Total Identified	**14,531**	**3 inches**	**136**		

Soil removal would require hand digging in areas of the steepest slopes and removal to the bridge deck via lifts and hoists. Backhoes and excavation equipment would not be feasible or would require additional grading/temporary leveling in some of the DUs due to the slope. This activity would expose workers to lead soil and lead dust during excavation and removal.

Confirmation sampling will be conducted to ensure that all targeted soil is removed from each DU. All DUs would be excavated until reaching 1-foot depth or confirmation samples indicated that soil concentrations were below the HDOH EAL construction worker safety (800 mg/kg). This would impact the entire HDOT ROW: 60,682 sq. ft to various depths. The sampling depth went to 9 inches bgs, but it would potentially require 12” excavation or until rock is encountered. For this alternative, an estimated depth of 12 inches is possible, but the depth will likely be less on a site-wide average as surface rock is present in several DUs.

Typically, clean fill would then be brought in and overlaid across the impacted site at a depth of 18-24 inches to re-level the site for use and allow for revegetation, drainage, and grading. However, due to the steep slopes, this would not be an acceptable method to try to restore the site. Final stabilization for this alternative could include no cover, cover area with jute mats to encourage vegetation and minimize water scour that would be nailed down to the slope with soil nails. The current cost for this alternative does not include any finish other than no cover. Slope stability analysis would need to be considered further in a remedial design if this alternative were selected.

An archaeological consultation and monitoring would be required during the excavation. The lead-impacted soil would be left on site therefore an EHMP will be needed.

Depending on the confirmation sample results, an EHMP for the remaining lead-impacted soil on site would still be needed. The primary maintenance item would be addressing any erosional issues to the finished grade which would vary based on the selected alternative and could include matting installation and hydroseeding. Annual inspections would be needed to check slope stabilization. The EHMP would need to be updated periodically to reflect bridge maintenance changes.

Table 6-6: Alternative 6c, Soil Removal 800+ mg/kg, Summary Table: Known and Potential Disposal Sites

CY	Disposal Site
16	Left onsite: Meets Construction/Trench Worker EALs (below 800 mg/kg Total Lead)
136	TCLP Fail: Removal Out of State
272	Potential TCLP Fail: Removal Out of State
121.4	TCLP Passed: West Hawaii
226.8	Potential West Hawaii Landfill

DU ID	Depth (in)	Lead Results (mg/kg)	Sq. Ft	CY	Disposal Site
DU1	0-3	1133	1722	16	Passed TCLP: West Hawaii Landfill
	3-6	930	1722	16	Unknown: Likely West Hawaii Landfill
	6-9	577	1722	16	Can be left onsite
DU2	0-3	1200	1985	18.4	Unknown: Likely West Hawaii Landfill
	3-6	1000	1985	18.4	Unknown: Likely West Hawaii Landfill
	6-9	1400	1985	18.4	West Hawaii Landfill
DU3	0-3	1200	4413	41	Unknown: Likely West Hawaii Landfill
	3-6	1200	4413	41	Unknown: Likely West Hawaii Landfill
	6-9	1500	4413	41	Passed TCLP: West Hawaii Landfill
DU8	0-3	4300	2161	20	Passed TCLP: West Hawaii Landfill
	3-6	3100	2161	20	Unknown: Likely West Hawaii Landfill
	6-9	2900	2161	20	Unknown: Likely West Hawaii Landfill
DU9	0-3	6400	2843	26	Passed TCLP: West Hawaii Landfill
	3-6	6200	2843	26	Unknown: Likely West Hawaii Landfill
	6-9	6000	2843	26	Unknown: Likely West Hawaii Landfill
DU10	0-3	8500	3848	37	Unknown: Potential out of state
	3-6	9700	3848	37	TCLP Fail: Out of State
	6-9	8100	3848	37	Unknown: Potential out of state
DU11	0-3	4300	3498	32	Unknown: Potential out of state*
	3-6	6400	3498	32	TCLP Fail: Out of State

DU ID	Depth (in)	Lead Results (mg/kg)	Sq. Ft	CY	Disposal Site
	6-9	6000	3498	32	Unknown: Potential out of state
DU12	0-3	6300	7185	67	Unknown: Potential out of state
	3-6	7900	7185	67	TCLP Fail: Out of State
	6-9	6500	7185	67	Unknown: Potential out of state

**This DU may pass TCLP based on total lead results, but logistical difficulties in scraping only the 0 to 3 inches of surface soil on the steep slope may require it to be removed along with the 3-to-6-inch depth profile.*

6.7 Alternative 7 Institutional Controls, and Institutional Controls/ Fencing and Long-Term Monitoring

These options identify the risks but do not remove or reduce the lead-impacted soil. Workers are prevented from coming into direct contact with the soil using an EHMP, PPE, and decontamination methods.

There are two options available under these alternatives:

- Alternative 7a: A site-specific Environmental Hazard Management Plan (EHMP) would be prepared that would outline the areas where various lead concentrations are on the site to facilitate awareness about the risks to current and future workers. The EHMP would need to be updated periodically and the effectiveness of this alternative would be reviewed every 5 years. This alternative assumes two updates per 30-year period to accommodate bridge maintenance changes. Appropriate PPE would be identified and used to perform work on-site. Decontamination sites would be established and used by workers.

- Alternative 7b: This alternative would include the site-specific EHMP and PPE identified in Alternative 7a, and in addition, fencing and signage would be installed but no remediation activities will be performed. Signage and fencing would be installed to prevent access to the ROW and to warn workers and trespassers of the hazards (Figure 7).

  Periodic inspections of the fencing and signage would be required under Alternative 7b and will need to be documented in annual reports. Site workers may be required to wear respirators due to the high levels of lead in some areas.

  This alternative would include clearing all the vegetation along the perimeter of the DOT easement and installing a fence down a very steep slope from the top of the embankment down to the stream floor. Gates would need to be incorporated in the fence design to allow future maintenance workers to access the enclosed area.

  The fence would eventually be covered in vines and brush so periodic maintenance would need to be performed.

These alternatives meet the needs of the Hawaii Department of Transportation needs and costs. The site is highly challenging, steep, and is not used by the public. No outside users are anticipated on the site.

7 Comparative Analysis of Remedial Alternatives

7.1 Overall Protectiveness

The first four identified alternatives do not meet the overall protectiveness requirements as these alternatives would not remove, limit, or reduce the potential lead exposure pathways for receptors. Alternative 4 could potentially be used in conjunction with other remedial actions to reduce disposal costs.

- Alternative 1: No action, including no EHMP, would not protect the workers who must perform repairs at the bridge. Soil results exceed construction/trench worker EALs.
- Alternative 2: The lead paint material is not dense enough to be separated from the soil in order to be recycled or reused.
- Alternative 3: The lead at the site is also not organic, corrosive, or explosive and is relatively immobile.
- Alternative 4: Soils at Nanue and lead paint flakes are not suitable for volume reduction in this form and lead would not be reduced significantly.
- Alternative 5: Previous assessments at Hakalau Bridge using the Bench Test Treatability study had demonstrated that immobilization via treatment with trisodium phosphate (TSP) to reduce the mobility of lead is potentially feasible but would require extensive excavation and soil removal from the challenging terrain, which would expose many more workers to lead-impacted soil. This alternative would reduce the quantity of lead-impacted soil that would need to be disposed of at mainland US facilities but would require a permit to treat hazardous waste at the designated treatment location. This alternative also has additional costs associated with treatment (industrial machinery for mixing TSP or Portland Cement into the lead-impacted soil, grading, managing stormwater controls on site). The application of this alternative would be in conjunction with soil excavation and removal and would not be used for in-situ stabilization. However, regulatory approval for a temporary hazardous waste treatment facility would be unlikely for this location.

Alternatives 6a, 6b, 6c and 7a and 7b presented in Table 7-1 and summarized below vary in protectiveness. The following assumptions are made.

- The public obeys signage and restricted areas.
- Regular site workers (Landscapers) have infrequent exposure to surface soil as tree trimming is conducted from the bridge deck. Brush trimmers onsite primarily handle vegetation and do not excavate below the surface (0 to 3 inches).
- Construction/Trench Workers dig below surface soil (6+ inches bgs) and handle soil.
- Ecological receptors primarily wallow, nest, dig, loaf, or lie on the surface of the soil.
- The site remains primarily vegetated, as consistent rainfall in the area typically ensures vegetation growth.

Table 7-1: Alternatives Analysis - Protectiveness

	6a. On-site isolation and containment. Tecco Mesh cap on areas of 800 mg/kg Lead exceedances	6b. On-site isolation and containment. Shotcrete hard cap on areas of 800 mg/kg Lead exceedances	**6c.** Removal and disposal of all soil which exceeds 800 mg/kg for lead	**7a.** Institutional and Engineering Controls: PPE/EHMP – No Fencing	**7b.** Institutional and Engineering Controls: Fencing to Limit Access
Is Lead-Impacted Soil Still Present?	Yes	Yes	Reduced: above 200 mg/kg but below 800 mg/kg	Yes	Yes
	Direct Contact Does the site have a complete exposure pathway for the following users under the scenario?				
Public	No: but only trespassers present	No: but only trespassers present	Potential: Unlikely - only trespassers	Potential: Unlikely - only trespassers	No: but only trespassers present
Construction/ Bridge Workers	Potential if mesh is breached	Potential if cap is breached	No	Potential: Mitigated by EHMP and PPE	Potential: Mitigated by EHMP and PPE
Site Workers (Landscapers)	No	No	No	Potential: Mitigated by EHMP and PPE	Potential: Mitigated by EHMP and PPE
Ecological Receptors	No	No	Potential: Unlikely	Yes	Yes
	Air Exposure Does the site have a complete exposure pathway for the following users under the scenario?				
Public	No: but only trespassers present	No: but only trespassers present	No: but only trespassers present	No: but only trespassers present	No: but only trespassers present
Construction/ Trench Workers	Potential	Potential	Potential: If deeper than 12"	Potential: Mitigated by EHMP and PPE	Potential: Mitigated by EHMP and PPE
Site Workers (Landscapers)	No	No	No	Potential: Mitigated by EHMP and PPE	Potential: Mitigated by EHMP and PPE
Ecological Receptors	No	No	No	Yes	Yes
	Surface Water Runoff (Sediment) in River Does the site have a complete exposure pathway for the following users under the scenario?				
Public	No	No	No	Potential: Trespassers only	Potential: Trespassers only
Construction/ Trench Workers	No	No	No	Potential: Mitigated by EHMP and PPE	Potential: Mitigated by EHMP and PPE
Site Workers (Landscapers)	No	No	No	Potential: Mitigated by EHMP and PPE	Potential: Mitigated by EHMP and PPE
Ecological Receptors	No	No	No	Potential	Potential

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7.2 Compliance with ARARs

All the alternatives shall meet the requirements of the ARARs (Appendix C) and will use TBC as guidance (EPA RSLs, HDOH EALs). The actions are compatible with standard excavation and/or earth-moving activities and waste disposal in Hawaii. Depending on the chosen alternative, the site work plan will identify methods to prevent, mitigate, and respond to the conservation of cultural and ecological resources ARARs. ARARs evaluation is presented in Appendix C.

7.3 Reduction of Toxicity, Mobility, and Volume through Treatment

The degree to which the remedial alternative reduces toxicity, mobility, and reduction of volume is achieved, including how the treatment is used to address the COC at the site is presented below (Table 7-2). Factors considered, as appropriate, include the following:

- The number of hazardous substances, pollutants, or contaminants that will be destroyed, treated, or recycled;
- The degree of the expected reduction in toxicity, mobility, or volume of the waste due to treatment; and
- The degree to which the treatment is irreversible.

Alternative 6a - On-site isolation and containment would not remove the volume of contamination, but it would reduce the mobility through a robust mesh cap and vegetation. This cap is potentially vulnerable to landslides and rockfall. The toxicity would not be reduced but the potential for landscapers/site workers to encounter it would be reduced as long as the mesh system is in place. Treatment under this alternative may not protect against future seismic or climatic events (e.g., tsunami, flooding, or sea-level rise) Table 7-2).

Alternative 6b - On-site isolation and containment would not remove the volume of contamination, but it would reduce the mobility through a hard cap. This cap is potentially vulnerable to scouring from flooding and sloughing if water gets under the cap. The toxicity would not be reduced but the potential for landscapers/site workers to encounter it would be reduced as long as the cap is not penetrated. Treatment under this alternative may not protect against future seismic or climatic events (e.g., tsunami, flooding, or sea-level rise) Table 7-2).

Alternative 6c – Removal and disposal of all soil which exceeds the HDOH Tier 1 EAL for commercial/industrial land use for lead (800 mg/kg), offers a reduction in toxicity. Mobility will be reduced as the source is removed. The overall volume of lead-impacted soil would be reduced by over 2000 CY.

Alternative 7a: Use of an EHMP and PPE and identifying risks with appropriate decontamination areas for workers on the site will limit direct exposure for site workers. Lead-impacted soil could still runoff to the stream and Pacific Ocean. There is no reduction of contaminant volume under this option. (Table 7- 2). Signage would be installed but fencing would not be installed.

Alternative 7b: Use of an EHMP and PPE and identifying risks with appropriate decontamination areas for workers on the site will limit direct exposure for site workers. Fencing and signage will warn trespassers and will reduce opportunities for pigs, but not birds to be exposed. Lead-impacted soil could still runoff to the stream and Pacific Ocean. There is no reduction of contaminant volume under this option. (Table 7- 2).

Table 7-2: Reduction of Toxicity, Mobility, and Volume through Treatment Comparison

6a. On-site isolation and containment. Tecco Wire Mesh System on areas of soil at 800 mg/kg for lead	**6b.** On-site isolation and containment. Shotcrete Hard Cap on areas of soil at 800 mg/kg exceedances.	**6c.** Removal and disposal of all soil which exceeds 800 mg/kg for lead	**7a.** Institutional Controls: EHMP and PPE used for site workers. Signage, no fencing.	**7b.** Institutional and Engineering Controls: EHMP and PPE used for site workers, Entire ROW fenced, signage installed.
Toxicity: No change under cap - contaminants are still present for construction/site workers if work under the mesh system is needed. Impacts are reduced for maintenance crews, trespassers, and ecological receptors. **Mobility:** Lead impacted soil is limited from reaching the stream/ocean as long as system is present. **Volume:** No reduction in volume of contaminant.	Toxicity: No change under cap - contaminants are still present for construction/ site workers if work under the cap is needed. Impacts are reduced for maintenance crews, trespassers, and ecological receptors. **Mobility:** Lead impacted soil is limited from reaching the stream/ocean as long as the cap is present. **Volume:** No reduction in volume of contaminant.	**Toxicity:** Reduced. **Mobility:** Reduced but lead impacted soil below 800 mg/kg potentially mobile during extensive erosion due to scouring. **Volume:** Reduced – all soil above 800 mg/kg for lead removed	**Toxicity:** No Change - contaminants are still present for ecological receptors, maintenance crews and any potential construction/site workers. **Mobility:** No change - contaminant is potentially mobile through erosion and surface runoff. **Volume:** No reduction in volume of contaminant	**Toxicity:** No Change - contaminants are still present for ecological receptors. PPE is used for maintenance crews and any potential construction/site workers. Public/Trespassers are informed. Some ecological receptors may be limited by fencing. **Mobility:** No change - contaminant is potentially mobile through erosion and surface runoff. **Volume:** No reduction in volume of contaminant

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7.4 Long-Term and Short-Term Effectiveness

Alternative 6a: Offers short-term and long-term effectiveness. Sitework is still needed in terms of grubbing, applying matting and the Tecco stabilizing wire mesh system. Contaminant mobility will be reduced. The mesh will form a barrier to protect ecological receptors and limit runoff to the stream and Pacific Ocean. It will need to be inspected and maintained especially after significant storms and associated flooding. Landscapers and work crews who need to work below the system will need to wear appropriate PPE and follow the site specific EHMP.

Alternative 6b: Offers short-term and long-term effectiveness and potentially more stability than 6a, but can also crack and slough. Sitework is still needed in terms of grubbing, wire mesh base and shotcrete. Contaminant mobility will be reduced further than Alternative 6a. The hard cap will form a barrier to protect ecological receptors and limit runoff to the stream and Pacific Ocean. Like Alternative 6a, the hard cap will need to be maintained to ensure that it is not scoured or breached during torrential rains and associated flooding. Landscapers and work crews who need to work below the cap will need to wear appropriate PPE and follow the site specific EHMP

Alternative 6c: Repairs to the site will take longer and be more complicated due to the logistics of removing is much volume from the base of bridge footings. This alternative has long-term effectiveness. Sitework will include scraping soil and disposing of soil (off-island). There is an option for mirafi /jute matting and hydroseeding.

Site work will take longer than alternative 6a and 6b. Soil disposal costs and soil disposal work will remain high. An EHMP will also be required as lead-impacted soil (less than 800 mg/kg and greater than 200 mg/kg) will remain on-site. The removal of soils with total lead greater than 800 mg/kg will mean that construction/trench workers will not require additional PPE while working on the site. Lead-impacted soil may be present in the upper steep gulch slopes and could migrate to the stream below. However, the site is not used by the public and this alternative is by far the costliest scenario.

Institutional controls Alternative 7a and 7b offer short-term and effectiveness. The lead impacted soil would remain, but this could be managed with an EHMP and PPE for site and construction/trench workers. Ecological receptors will still access the site and be exposed. The site will need to be protected from erosion and washouts. Surface soil may wash into Nanue Stream and the Pacific Ocean. Site work will need to refer to recommendations in the EHMP.

Under Alternative 7b, the site would also be more restricted and warn potential trespassers and the fencing would limit the number of pigs that may cross the site (as long as the fence is maintained). This could offer a longer-term effectiveness than Alternative 7a.

7.5 Implementability

Alternative 6a is implementable using equipment and supplies from Hawaii County or shipped to Hawaii County. This alternative will require excavators, work crews, Tecco wire mesh system, and EHMP document production.

Alternative 6b is implementable using equipment and supplies from Hawaii County or shipped to Hawaii County. This alternative will require excavators, work crews, shotcrete/concrete (from Hawaii County), and EHMP document production.

Alternative 6c is implementable using equipment and supplies from Hawaii County or shipped to Hawaii County. However, this alternative requires at least 136 CY of off-island soil disposal and shipping. This alternative will require excavators, work crews and an EHMP. The steepness of the site will offer logistical challenges and expose workers to lead contaminated dust potentially in excess of normal site work.

Alternatives 7a and 7b will be the easiest and most affordable to implement. This alternative requires an EHMP document, and Alterative 7b adds fencing installation and signage. These alternatives will require the State of Hawaii to maintain an EHMP and conduct periodic inspections. The fencing will need to be maintained in Alternative 7b.

7.6 Estimated Cost

A complete cost table of the alternatives is found in Appendix D. A cost summary is found in Table 7-3. All alternatives are assumed to have the same costs for the planning component including project management, permitting, and public meeting support. This cost is estimated at $103,333 and is included in all alternative costs.

Table 7-3: Cost Comparison

Project Management, Permitting, Public Meeting Support	6a.Soil cover. Install Tecco Mesh System over entire area.	6b. Soil cover. Use wire mesh, soil nails and apply shotcrete slope armor.	6c. Soil Excavation and Off-Site Disposal for lead impacted soil greater than 800 mg/kg for total lead. If lead-impacted soil passes TCLP send to WHSL. If Lead impacted soil > 800 mg/kg fails TCLP, dispose of CONUS.	7a. Institutional Controls: No Action - Institutional Controls. Signage warning of Lead Risk.	7b. Institutional and Engineering Controls- Prepare EHMP and updated every 5 years. Install a fence around all areas under HDOT Right of Way. Fence to include gates. Signage warning of Lead Risk.
Assume all alternatives have a similar amount of planning effort. This cost would be in addition to each of the alternatives evaluated.	EHMP needed. Annual inspections of system. Assume four EHMP updates over 30 years. Clear and Grub and install BMPs. Cover contaminated areas over entire HDOT Right of Way with Tecco system. Coconut matting, soil anchors, and Tecco mesh (aluminum and HDPE mesh fabric). Archeological Consultation and Monitoring (5 weeks)	EHMP needed. Annual inspections of cap. Assume four EHMP updates over 30 years. Clear and Grub and install BMPs. Install soil nails, welded fabric and wire reinforcing tie downs. Cover with shotcrete. Archeological Consultation and Monitoring (5 weeks)	EHMP needed based on confirmation sampling. Annual inspections of stabilization. Assume four EHMP updates over 30 years to accommodate bridge maintenance changes Assume mirafi/geotextile/ jute matting placed over post excavation surface. No replacement fill. Matting will be nailed down with wood stakes. Archeological Consultation and Monitoring (5 weeks)	EHMP Needed. Land Use Controls and perform 5-year inspections. Assume four EHMP updates over 30 years to accommodate maintenance changes (Pre-construction EHMPs).	EHMP needed Assume LUC inspections every year, with brush removal along fence and periodic maintenance. Two weeks of clearing using a four-man crew. Assume four EHMP updates over 30 years to accommodate bridge maintenance changes (Pre-construction EHMPs).
$103,333	$7,328,238	$10,759,994	$7,956,089	$172,441	$666,983

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8 Preferred Alternative

The four remedial alternatives are compared to the nine evaluation criteria previously in Section 7 presented qualitatively in a summary comparison in Table 8-1.

Table 8-1: Evaluation of Cleanup Alternatives: Nanue Bridge RAA

	6a. On-site isolation and containment. Tecco Mesh	6b. On-site isolation and containment. Shotcrete	6c. Removal of all soil that exceeds 800 mg/kg.	7a. Institutional and Engineering Controls: EHMP, no fencing	7b. Institutional and Engineering Controls: EHMP, fencing
1. Overall protection of human health and the environment.	H	H	H	L	L
2. Compliance with applicable or relevant and appropriate requirements.	M	M	H	M	M
3. Long-term effectiveness and permanence	M	M	H	M	M
4. Reduction of toxicity, mobility, or volume through treatment.	M	M	H	L	L
5. Short-term effectiveness	H	H	L	H	H
6. Implementability	M	M	L	H	H
7. Cost.	L	L	L	H	H
8. State regulator acceptance.	H	H	H	H	H
9. Community acceptance.	H	H	H	M	M
L satisfies the criteria to a low degree or does not satisfy in a timely manner					
M satisfies the criteria to a moderate degree in a timely manner					
H satisfies the criteria to high degree in a timely manner					

Alternative 6a and 6b fully satisfies 4 out of 9 of the evaluation criteria to a high degree.

Alternatives 6c fully satisfies 6 of 9 evaluation criteria to a high degree, however the challenges and cost to implement would results in a much longer time to execute this plan and would also expose additional site remediation workers to lead-impacted dirt during site work. Concerns about slope stability are not completely addressed and would require further analysis.

Alternative 7a and 7b, Institutional and Engineering controls with an EHMP would be effective in the short term, straightforward to implement and affordable. Alternative 7a and 7b fully satisfies 4 out of 9 of the evaluation criteria to a high degree.

The site is not used by the public, only site workers, occasional trespassers, and some ecological receptors (pigs primarily). The plan would receive state and community acceptance, but it does not address overall protection to the environment, long-term effectiveness and permanence, or the reduction of toxicity, mobility, or volume through treatment.

Alternative 6c has a potentially prohibitive price point and would expose site workers to additional lead impacted soil while performing remediation work, potentially in excess of normal maintenance and work. Soil removal would require hand digging. This is ranked lower relative to alternative 6a and 6b at satisfying the other evaluation criteria.

Alternatives 7a and 7b are by far the most cost-effective and expedient to implement. Bridge repair workers that would potentially be exposed to lead impacted soil on-site during repairs would have appropriate PPE and site-specific training due to the EHMP. Alternative 7a and 7b would not remove the source of lead-impacted soil but leaving it place would minimize disturbance to the soil reducing the potential of any further exposure or release to the environment.

Alternative 7a: administrative controls; EHMP; and signage; has been selected as the preferred remedial alternative for addressing the risks posed by the lead-impacted below Nanue Bridge.

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FIGURES

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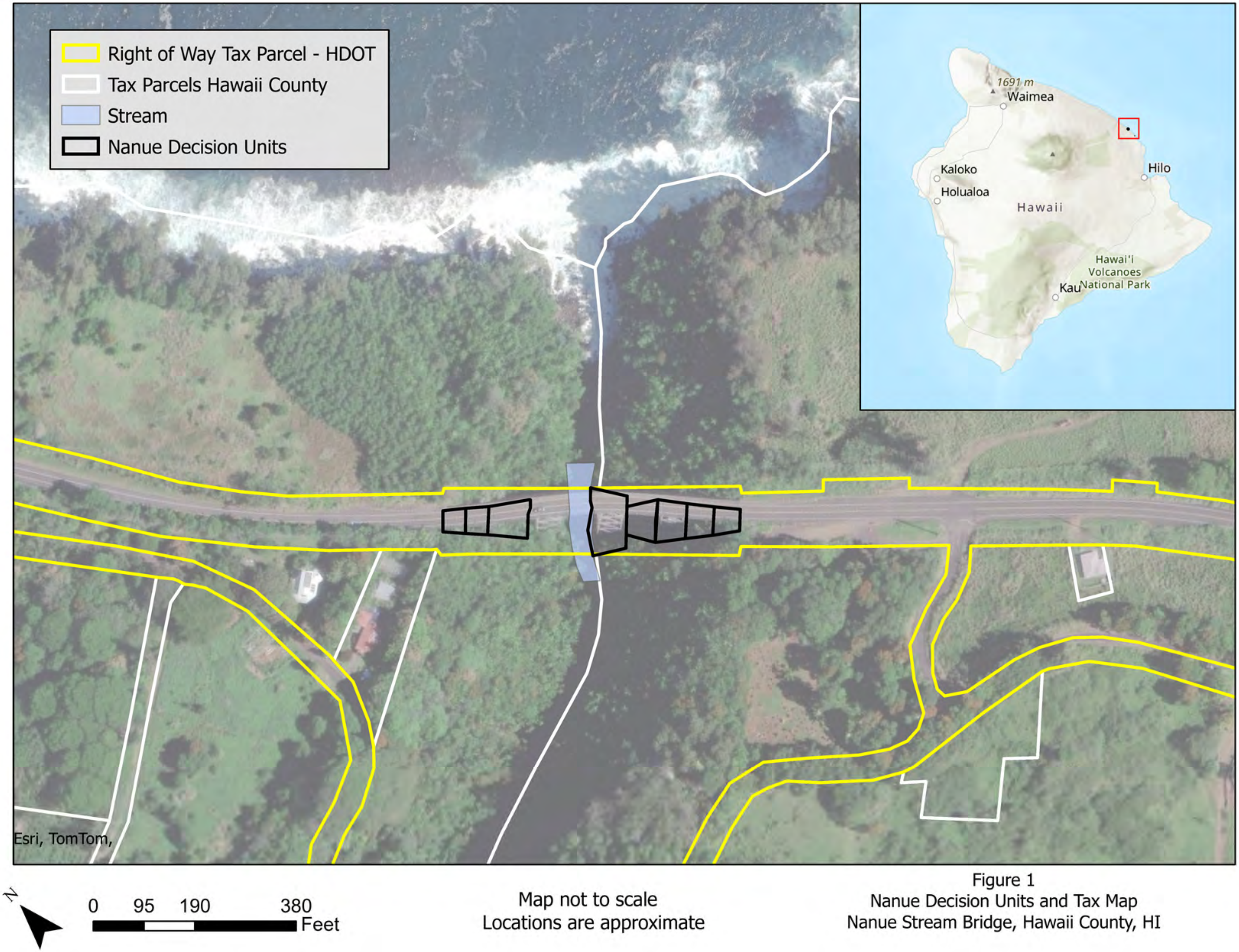
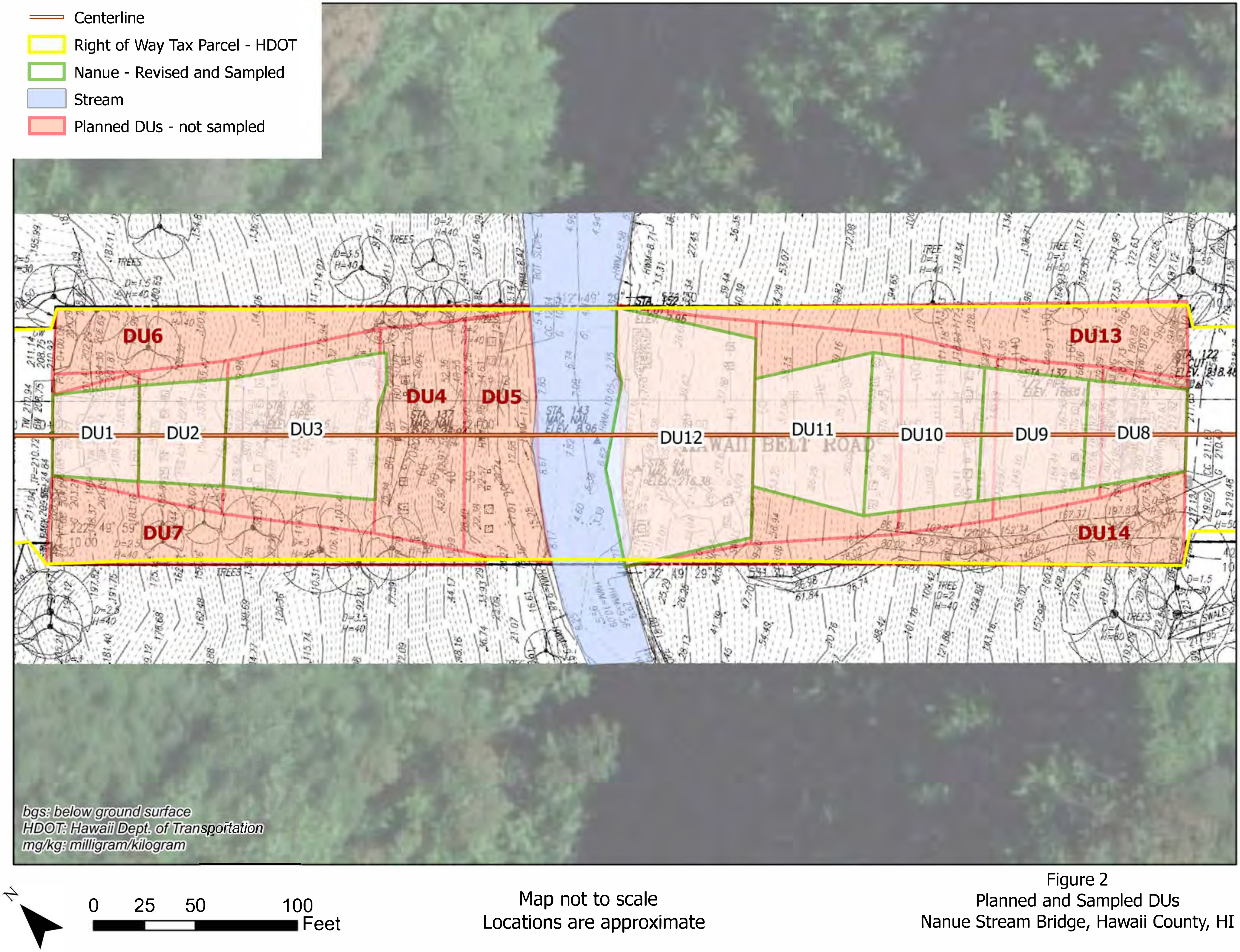


Map not to scale
Locations are approximate

Figure 1
Nanue Decision Units and Tax Map
Nanue Stream Bridge, Hawaii County, HI



Map not to scale
Locations are approximate

Figure 2
Planned and Sampled DUs
Nanue Stream Bridge, Hawaii County, HI

Map not to scale
Locations are approximate

Figure 3a
Total Lead Results 0 - 3 Inches bgs
Nanue Stream Bridge, Hawaii County, HI

Map not to scale
Locations are approximate

Figure 3b
Total Lead Results 3 - 6 Inches bgs
Nanue Stream Bridge, Hawaii County, HI

Map not to scale
Locations are approximate

Figure 3c
Total Lead Results 6 - 9 inches bgs
Nanue Stream Bridge, Hawaii County, HI

	DU1
inches bgs	Total As mg/kg
0 to 3	26
3 to 6	23
6 to 9	17

	DU9
inches bgs	Total As mg/kg
0 to 3	24
3 to 6	25
6 to 9	24

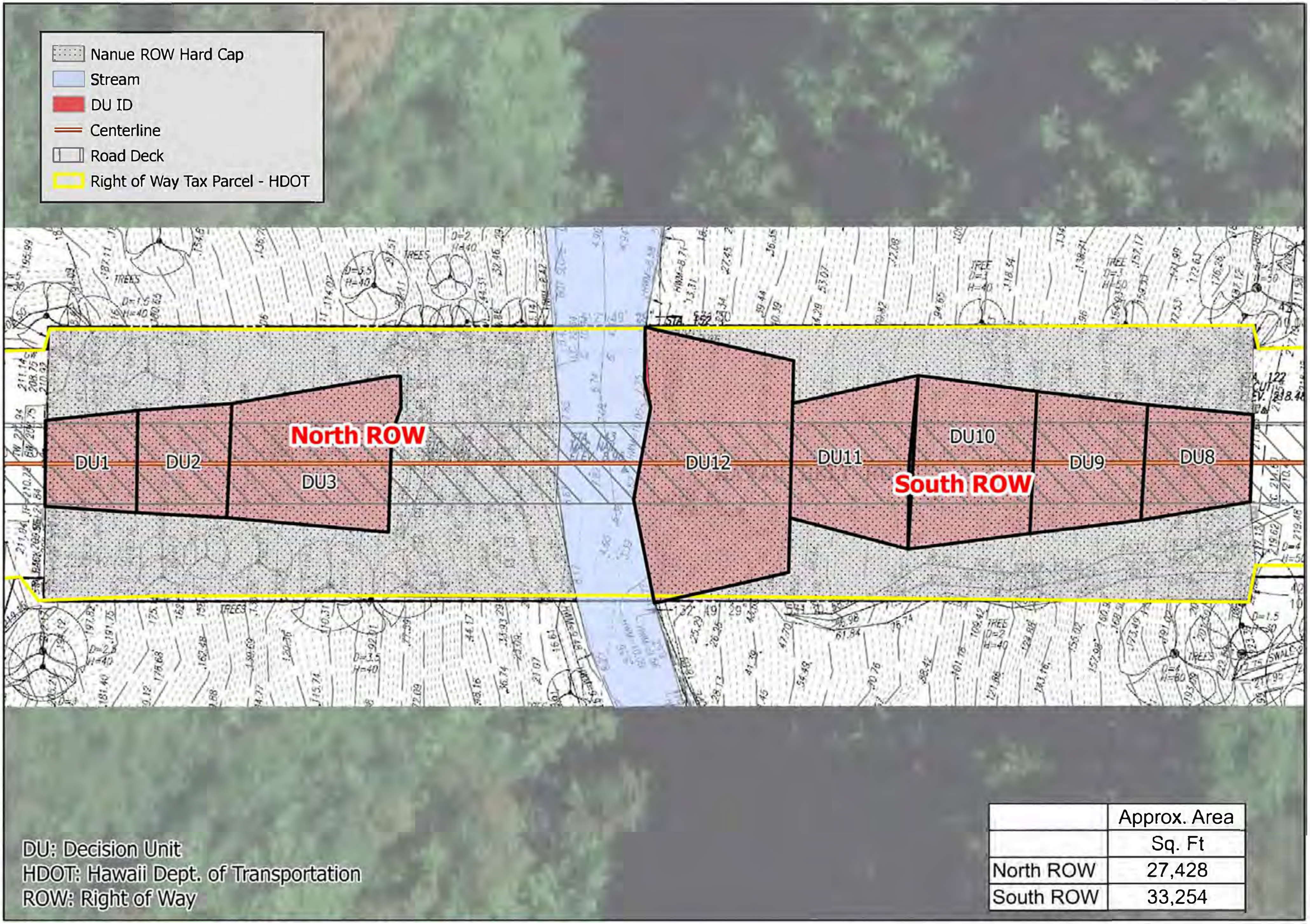
	DU8
inches bgs	Total As mg/kg
0 to 3	20
3 to 6	20
6 to 9	32

N

0 25 50 100 Feet

Map not to scale
Locations are approximate

Figure 4
Total Arsenic Results 0 to 9 inches bgs
Nanue Stream Bridge, Hawaii County, HI

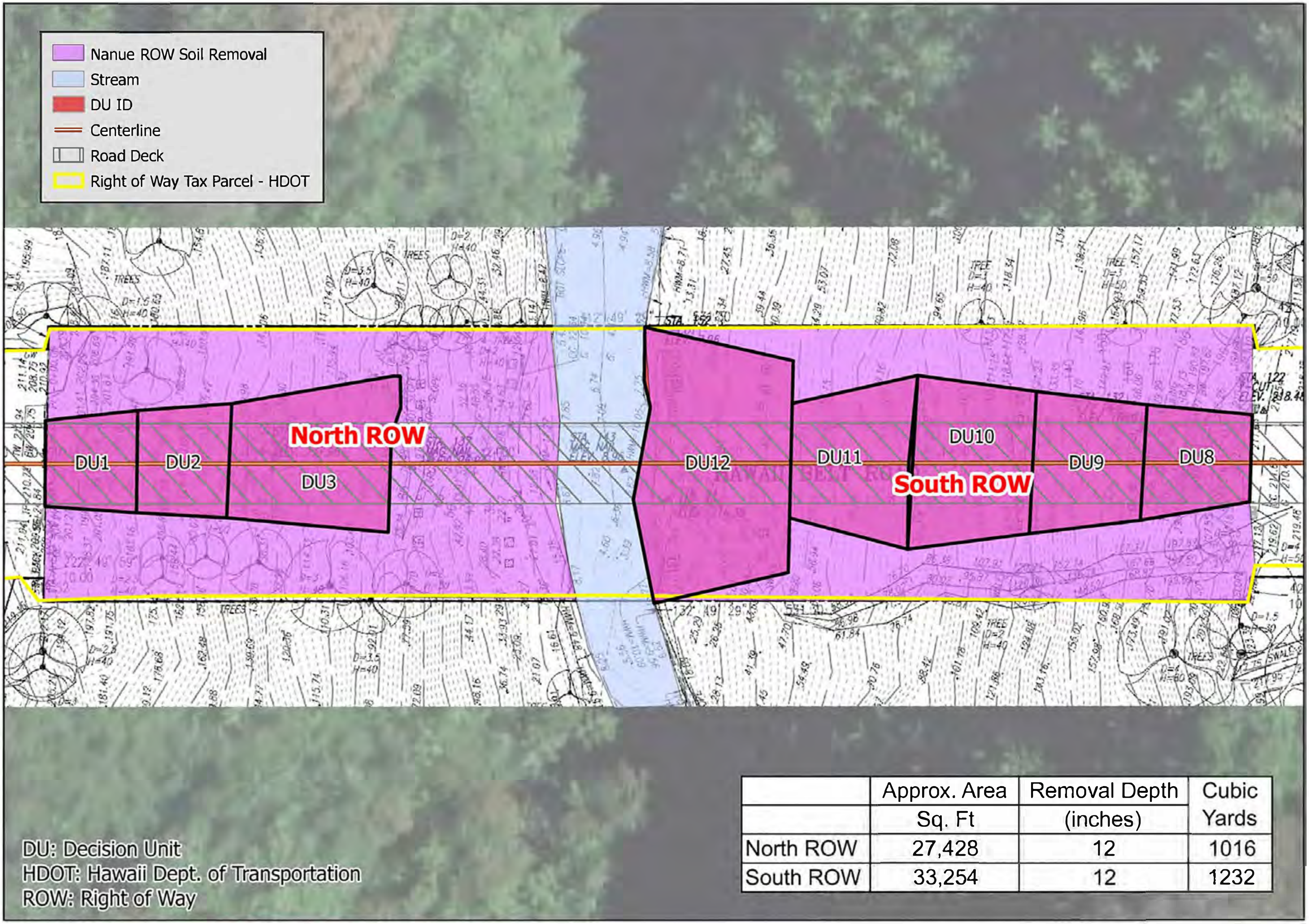


N

0 25 50 100 Feet

Map not to scale
Locations are approximate

Figure 5
ROW Hard Cap Remedial Action
Nanue Stream Bridge, Hawaii County, HI



	Approx. Area Sq. Ft	Removal Depth (inches)	Cubic Yards
North ROW	27,428	12	1016
South ROW	33,254	12	1232

N

0 25 50 100 Feet

Map not to scale
Locations are approximate

Figure 6
ROW Soil Removal Remedial Action
Nanue Stream Bridge, Hawaii County, HI

	Approx. Area	Perimeter
	Sq. Ft	Feet
North ROW	27,428	704
South ROW	33,254	783

Map not to scale
Locations are approximate

Figure 7
ROW Fencing
Nanue Stream Bridge, Hawaii County, HI

APPENDIX A-1:

2024 SAMPLING RESULTS SUMMARY TABLES

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Table A-1a: Analytical Soil Profiling Results - Total RCRA Regulated Metals - Nanue Bridge (page 1 of 3)

							Sample Identifier	NAN_DU1_0-3			NAN_DU1_3-6			NAN_DU1_6-9			NAN_DU2_0-3		
							Sample Date	5-Mar-2024			5-Mar-2024			5-Mar-2024			6-Mar-2024		
							Sample Depth (inches bgs)	0-3			3-6			6-9			0-3		
Analyte	Analytical Method	Units	**20 x Regulatory Limits for TCLP Metals+**	**HDOH Tier 1 EALs* (Unrestricted Use)**	**HDOH Tier 1 EALs (Residential Direct-Exposure)1**	**HDOH Tier 1 EALs (Commercial / Industrial Direct-Exposure)2**	**HDOH Tier 1 EALs (Construction Worker Direct-Exposure)3**	**Results**	Q	RL	**Results**	Q	RL	**Results**	Q	RL	**Results**	Q	RL
Resource Conservation and Recovery Act (RCRA) Regulated Metals																			
Arsenic	EPA 6020B	mg/kg	**100**	**24**	**23**	**95**	**110**	**26**		0.47	**23**		0.49	**17**		0.48	**14**		0.47
Barium	EPA 6020B	mg/kg	**2000**	**1,000**	**3,100**	**4,300**	**4,300**	**263**		0.95	**287**		0.98	**307**		0.96	**200**		0.95
Cadmium	EPA 6020B	mg/kg	**20**	**14**	**14**	**72**	**72**	0.39	J	0.76	0.39	J	0.78	0.34	J	0.77	0.41	J	0.76
Chromium	EPA 6020B	mg/kg	**100**	**1,100**	**NS**	**NS**	**NS**	**190**		0.95	**190**		0.98	**187**		0.96	**180**		0.95
Lead	EPA 6020B	mg/kg	**100**	**200**	**200**	**800**	**800**	**1,133**		0.47	**840**		0.49	**577**		0.48	**1,200**		0.47
Mercury	EPA 7471A	mg/kg	**4**	**4.7**	**4.7**	**61**	**130**	**0.14**		0.020	**0.15**		0.021	**0.14**		0.021	**0.15**		0.022
Selenium	EPA 6020B	mg/kg	**20**	**78**	**78**	**1,000**	**2,200**	**7.7**		1.4	**8.9**		1.5	**9.4**		1.4	**8.3**		1.4
Silver	EPA 6020B	mg/kg	**100**	**78**	**78**	**1,000**	**2,200**	0.059	J	0.19	0.053	J	0.20	0.044	J	0.19	0.077	J	0.19

							Sample Identifier	NAN_DU2_3-6			NAN_DU2_6-9			NAN_DU3_0-3			NAN_DU3_3-6		
							Sample Date	6-Mar-2024			6-Mar-2024			6-Mar-2024			6-Mar-2024		
							Sample Depth (feet bgs)	3-6			6-9			0-3			3-6		
Analyte	Analytical Method	Units	**20 x Regulatory Limits for TCLP Metals+**	**HDOH Tier 1 EALs* (Unrestricted Use)**	**HDOH Tier 1 EALs (Residential Direct-Exposure)1**	**HDOH Tier 1 EALs (Commercial / Industrial Direct-Exposure)2**	**HDOH Tier 1 EALs (Construction Worker Direct-Exposure)3**	**Results**	Q	RL	**Results**	Q	RL	**Results**	Q	RL	**Results**	Q	RL
Resource Conservation and Recovery Act (RCRA) Regulated Metals																			
Arsenic	EPA 6020B	mg/kg	**100**	**24**	**23**	**95**	**110**	**12**		0.48	**14**		0.47	**13**		0.46	**15**		0.47
Barium	EPA 6020B	mg/kg	**2000**	**1,000**	**3,100**	**4,300**	**4,300**	**190**		0.95	**210**		0.95	**130**	J1	0.92	**140**		0.95
Cadmium	EPA 6020B	mg/kg	**20**	**14**	**14**	**72**	**72**	0.37	J	0.76	0.40	J	0.76	0.30	J	0.74	0.33	J	0.76
Chromium	EPA 6020B	mg/kg	**100**	**1,100**	**NS**	**NS**	**NS**	**170**		0.95	**190**		0.95	**130**	J1	0.92	**140**		0.95
Lead	EPA 6020B	mg/kg	**100**	**200**	**200**	**800**	**800**	**1,000**		0.48	**1,400**		0.47	**1,200**	J1	0.46	**1,200**		0.47
Mercury	EPA 7471A	mg/kg	**4**	**4.7**	**4.7**	**61**	**130**	**0.15**		0.021	**0.18**		0.020	**0.15**		0.024	**0.16**		0.022
Selenium	EPA 6020B	mg/kg	**20**	**78**	**78**	**1,000**	**2,200**	**7.8**		1.4	**9.2**		1.4	**6.6**		1.4	**6.8**		1.4
Silver	EPA 6020B	mg/kg	**100**	**78**	**78**	**1,000**	**2,200**	0.060	J	0.19	0.054	J	0.19	0.047	J	0.18	0.048	J	0.19

Notes:

+ If the total concentration of a RCRA metal exceeds 20 times the RCRA regulated toxicity characteristic concentrations then TCLP analysis is required for acceptance at a RCRA regulated waste disposal facility.

** This value represents the result of the Relative Percent Difference replicate comparison result (see Table 2-1a).

1 State of Hawaii Department of Health Tier I EALs, Residential Land-Use Scenario presented in Table I-1 of the Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater (Fall 2017 Edition).

2 State of Hawaii Department of Health Tier I EALs, Commercial / Industrial Land-Use Scenario presented in Table I-2 of the Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater (Fall 2017 Edition).

3 State of Hawaii Department of Health Tier I EALs, Construction/Trench Worker Exposure Scenario presented in Table I-3 of the Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater (Fall 2017 Edition).

bgs = below ground surface

mg/kg = milligram(s) per kilogram

RL = reporting limit

Q = qualifier

J = The analyte was positively identified; the quantitation is an estimation

J1 = The quantitation is an estimation due to discrepancies in meeting certain analyte-specific quality control criteria

Table A-1a: Analytical Soil Profiling Results - Total RCRA Regulated Metals - Nanue Bridge (page 2 of 3)

							Sample Identifier	NAN_DU3_6-9			NAN_DU8_0-3			NAN_DU8_3-6			NAN_DU8_6-9		
							Sample Date	6-Mar-2024			3-Mar-2024			3-Mar-2024			3-Mar-2024		
							Sample Depth (inches bgs)	6-9			0-3			3-6			6-9		
Analyte	Analytical Method	Units	**20 x Regulatory Limits for TCLP Metals+**	**HDOH Tier 1 EALs* (Unrestricted Use)**	**HDOH Tier 1 EALs (Residential Direct-Exposure)1**	**HDOH Tier 1 EALs (Commercial / Industrial Direct-Exposure)2**	**HDOH Tier 1 EALs (Construction Worker Direct-Exposure)3**	**Results**	Q	RL	**Results**	Q	RL	**Results**	Q	RL	**Results**	Q	RL
Resource Conservation and Recovery Act (RCRA) Regulated Metals																			
Arsenic	EPA 6020B	mg/kg	**100**	**24**	**23**	**95**	**110**	**14**		0.48	**20**		0.47	**20**		0.48	**32**		0.47
Barium	EPA 6020B	mg/kg	**2000**	**1,000**	**3,100**	**4,300**	**4,300**	**140**		0.96	**150**		0.95	**200**		0.95	**180**		0.95
Cadmium	EPA 6020B	mg/kg	**20**	**14**	**14**	**72**	**72**	0.28	J	0.77	0.56	J	0.76	0.62	J	0.76	0.66	J	0.76
Chromium	EPA 6020B	mg/kg	**100**	**1,100**	**NS**	**NS**	**NS**	**130**		0.96	**170**		0.95	**180**		0.95	**180**		0.95
Lead	EPA 6020B	mg/kg	**100**	**200**	**200**	**800**	**800**	**1,500**		0.48	**4,300**		0.47	**3,100**		0.48	**2,900**		0.47
Mercury	EPA 7471A	mg/kg	**4**	**4.7**	**4.7**	**61**	**130**	**0.16**		0.022	**0.31**		0.022	**0.30**		0.021	**0.34**		0.020
Selenium	EPA 6020B	mg/kg	**20**	**78**	**78**	**1,000**	**2,200**	**7.3**		1.4	**5.8**		1.4	**6.8**		1.4	**7.1**		1.4
Silver	EPA 6020B	mg/kg	**100**	**78**	**78**	**1,000**	**2,200**	0.053	J	0.19	0.088	J	0.19	0.072	J	0.19	0.073	J	0.19

							Sample Identifier	NAN_DU9_0-3			NAN_DU9_3-6			NAN_DU9_6-9			NAN_DU10_0-3		
							Sample Date	9-Mar-2024			9-Mar-2024			9-Mar-2024			9-Mar-2024		
							Sample Depth (feet bgs)	0-3			3-6			6-9			0-3		
Analyte	Analytical Method	Units	**20 x Regulatory Limits for TCLP Metals+**	**HDOH Tier 1 EALs* (Unrestricted Use)**	**HDOH Tier 1 EALs (Residential Direct-Exposure)1**	**HDOH Tier 1 EALs (Commercial / Industrial Direct-Exposure)2**	**HDOH Tier 1 EALs (Construction Worker Direct-Exposure)3**	**Results**	Q	RL	**Results**	Q	RL	**Results**	Q	RL	**Results**	Q	RL
Resource Conservation and Recovery Act (RCRA) Regulated Metals																			
Arsenic	EPA 6020B	mg/kg	**100**	**24**	**23**	**95**	**110**	**24**		0.48	**25**		0.48	**24**		0.48	**9.6**		0.46
Barium	EPA 6020B	mg/kg	**2000**	**1,000**	**3,100**	**4,300**	**4,300**	**100**		0.96	**110**		0.96	**110**		0.95	**120**	J1	0.92
Cadmium	EPA 6020B	mg/kg	**20**	**14**	**14**	**72**	**72**	0.67	J	0.77	0.67	J	0.77	0.59	J	0.76	0.4	J	0.74
Chromium	EPA 6020B	mg/kg	**100**	**1,100**	**NS**	**NS**	**NS**	**160**		0.96	**190**		0.96	**180**		0.95	**150**	J1	0.92
Lead	EPA 6020B	mg/kg	**100**	**200**	**200**	**800**	**800**	**6,400**		48	**6,200**		48	**6,000**		48	**8,500**	J1	46
Mercury	EPA 7471A	mg/kg	**4**	**4.7**	**4.7**	**61**	**130**	**0.28**		0.024	**0.26**		0.027	**0.26**		0.026	**0.12**		0.023
Selenium	EPA 6020B	mg/kg	**20**	**78**	**78**	**1,000**	**2,200**	**4.9**		1.4	**5.1**		1.4	**6.7**		1.4	**5.8**		1.4
Silver	EPA 6020B	mg/kg	**100**	**78**	**78**	**1,000**	**2,200**	0.085	J	0.19	0.089	J	0.19	0.095	J	0.19	0.088	J	0.18

Notes:

+ If the total concentration of a RCRA metal exceeds 20 times the RCRA regulated toxicity characteristic concentrations then TCLP analysis is required for acceptance at a RCRA regulated waste disposal facility.

** This value represents the result of the Relative Percent Difference replicate comparison result (see Table 2-1a).

1 State of Hawaii Department of Health Tier I EALs, Residential Land-Use Scenario presented in Table I-1 of the Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater (Fall 2017 Edition).

2 State of Hawaii Department of Health Tier I EALs, Commercial / Industrial Land-Use Scenario presented in Table I-2 of the Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater (Fall 2017 Edition).

3 State of Hawaii Department of Health Tier I EALs, Construction/Trench Worker Exposure Scenario presented in Table I-3 of the Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater (Fall 2017 Edition).

bgs = below ground surface

mg/kg = milligram(s) per kilogram

RL = reporting limit

Q = qualifier

J = The analyte was positively identified; the quantitation is an estimation

J1 = The quantitation is an estimation due to discrepancies in meeting certain analyte-specific quality control criteria

Table A-1a: Analytical Soil Profiling Results - Total RCRA Regulated Metals - Nanue Bridge (page 3 of 3)

							Sample Identifier	NAN_DU10_3-6			NAN_DU10_6-9			NAN_DU11_0-3			NAN_DU11_3-6		
							Sample Date	9-Mar-2024			9-Mar-2024			10-Mar-2024			10-Mar-2024		
							Sample Depth (inches bgs)	3-6			6-9			0-3			3-6		
Analyte	Analytical Method	Units	20 x Regulatory Limits for TCLP Metals+	HDOH Tier 1 EALs* (Unrestricted Use)	HDOH Tier 1 EALs (Residential Direct-Exposure)1	HDOH Tier 1 EALs (Commercial / Industrial Direct-Exposure)2	HDOH Tier 1 EALs (Construction Worker Direct-Exposure)3	Results	Q	RL	Results	Q	RL	Results	Q	RL	Results	Q	RL
Resource Conservation and Recovery Act (RCRA) Regulated Metals																			
Arsenic	EPA 6020B	mg/kg	100	24	23	95	110	8.7		0.47	7.9		0.47	11		0.47	10.0		0.48
Barium	EPA 6020B	mg/kg	2000	1,000	3,100	4,300	4,300	130		0.95	160		0.94	110		0.95	100		0.95
Cadmium	EPA 6020B	mg/kg	20	14	14	72	72	0.39	J	0.76	0.35	J	0.76	0.37	J	0.76	0.40	J	0.76
Chromium	EPA 6020B	mg/kg	100	1,100	NS	NS	NS	160		0.95	170		0.94	130		0.95	150		0.95
Lead	EPA 6020B	mg/kg	100	200	200	800	800	9,700		47	8,100		47	4,300		47	6,400		48
Mercury	EPA 7471A	mg/kg	4	4.7	4.7	61	130	0.16		0.007	0.13		0.024	0.10		0.025	0.12		0.027
Selenium	EPA 6020B	mg/kg	20	78	78	1,000	2,200	6.9		1.4	7.8		1.4	4.8		1.4	6.2		1.4
Silver	EPA 6020B	mg/kg	100	78	78	1,000	2,200	0.10	J	0.19	0.078	J	0.19	0.081	J	0.19	0.086	J	0.19

							Sample Identifier	NAN_DU11_6-9			NAN_DU12_0-3			NAN_DU12_3-6			NAN_DU12_6-9		
							Sample Date	10-Mar-2024			10-Mar-2024			10-Mar-2024			10-Mar-2024		
							Sample Depth (feet bgs)	6-9			0-3			3-6			6-9		
Analyte	Analytical Method	Units	20 x Regulatory Limits for TCLP Metals+	HDOH Tier 1 EALs* (Unrestricted Use)	HDOH Tier 1 EALs (Residential Direct-Exposure)1	HDOH Tier 1 EALs (Commercial / Industrial Direct-Exposure)2	HDOH Tier 1 EALs (Construction Worker Direct-Exposure)3	Results	Q	RL	Results	Q	RL	Results	Q	RL	Results	Q	RL
Resource Conservation and Recovery Act (RCRA) Regulated Metals																			
Arsenic	EPA 6020B	mg/kg	100	24	23	95	110	8.7		0.46	16		0.46	11		0.46	10		0.47
Barium	EPA 6020B	mg/kg	2000	1,000	3,100	4,300	4,300	110		0.92	79		0.92	50		0.92	69		0.94
Cadmium	EPA 6020B	mg/kg	20	14	14	72	72	0.39	J	0.74	0.4	J	0.74	0.29	J	0.74	0.30	J	0.75
Chromium	EPA 6020B	mg/kg	100	1,100	NS	NS	NS	150		0.92	130		0.92	87		0.92	90		0.94
Lead	EPA 6020B	mg/kg	100	200	200	800	800	6,000		0.46	6,300		0.46	7,900		0.46	6,500		0.47
Mercury	EPA 7471A	mg/kg	4	4.7	4.7	61	130	0.16		0.025	0.09		0.023	0.12		0.022	0.12		0.023
Selenium	EPA 6020B	mg/kg	20	78	78	1,000	2,200	6.3		1.4	2.8		1.4	3.4		1.4	3.6		1.4
Silver	EPA 6020B	mg/kg	100	78	78	1,000	2,200	0.083	J	0.18	0.088	J	0.18	0.086	J	0.18	0.068		0.19

Notes:

+ If the total concentration of a RCRA metal exceeds 20 times the RCRA regulated toxicity characteristic concentrations then TCLP analysis is required for acceptance at a RCRA regulated waste disposal facility.

** This value represents the result of the Relative Percent Difference replicate comparison result (see Table 2-1a).

1 State of Hawaii Department of Health Tier I EALs, Residential Land-Use Scenario presented in Table I-1 of the Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater (Fall 2017 Edition).

2 State of Hawaii Department of Health Tier I EALs, Commercial / Industrial Land-Use Scenario presented in Table I-2 of the Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater (Fall 2017 Edition).

3 State of Hawaii Department of Health Tier I EALs, Construction/Trench Worker Exposure Scenario presented in Table I-3 of the Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater (Fall 2017 Edition).

bgs = below ground surface

mg/kg = milligram(s) per kilogram

RL = reporting limit

Q = qualifier

J = The analyte was positively identified; the quantitation is an estimation

J1 = The quantitation is an estimation due to discrepancies in meeting certain analyte-specific quality control criteria

Table A-1b: Replicate Sample Results Comparison - Total RCRA Regulated Metals - Nanue Bridge (page 1 of 3)

Analyte	EPA Method	Sample Identification	Sample Type	Result (mg/kg)	Relative Percent Difference		Mean	Standard Deviation*	Relative Standard Deviation	Comment
					Primary and Duplicate	Primary and Triplicate				
Arsenic	EPA 6020B	NAN_DU1_0-3_A	Primary	28	0%	24%	26.0	3.5	13%	RSD is less than 50% so the mean concentration is used as the reported concentration. The result is less than 20 x regulatory limits for TCLP metals, but above HDOH Tier 1 EAL.
		NAN_DU1_0-3_B	Duplicate	28						
		NAN_DU1_0-3_C	Triplicate	22						
Barium	EPA 6020B	NAN_DU1_0-3_A	Primary	260	4%	7%	263.3	15.3	6%	RSD is less than 50% so the mean concentration is used as the reported concentration.The mean concentration is below HDOH Tier 1 EAL and less than 20x regulatory limits for TCLP metals.
		NAN_DU1_0-3_B	Duplicate	250						
		NAN_DU1_0-3_C	Triplicate	280						
Cadmium	EPA 6020B	NAN_DU1_0-3_A	Primary	0.37	13%	3%	0.390	0.026	7%	RSD is less than 50% so the mean concentration is used as the reported concentration.The mean concentration is below HDOH Tier 1 EAL and less than 20x regulatory limits for TCLP metals.
		NAN_DU1_0-3_B	Duplicate	0.42						
		NAN_DU1_0-3_C	Triplicate	0.38						
Chromium	EPA 6020B	NAN_DU1_0-3_A	Primary	180	5%	11%	190	10.0	5%	RSD is less than 50% so the mean concentration is used as the reported concentration. The result is above 20 x regulatory limits for TCLP metals. Mean concentration is below HDOH Tier 1 EAL.
		NAN_DU1_0-3_B	Duplicate	190						
		NAN_DU1_0-3_C	Triplicate	200						
Lead	EPA 6020B	NAN_DU1_0-3_A	Primary	1100	9%	0%	1,133	57.7	5%	RSD is less than 50% so the mean concentration is used as the reported concentration. The result is above 20 x regulatory limits for TCLP metal and above HDOH Tier 1 EAL.
		NAN_DU1_0-3_B	Duplicate	1200						
		NAN_DU1_0-3_C	Triplicate	1100						
Mercury	EPA 7471A	NAN_DU1_0-3_A	Primary	0.15	14%	0%	0.143	0.012	8%	RSD is less than 50% so the mean concentration is used as the reported concentration.The mean concentration is below HDOH Tier 1 EAL and less than 20x regulatory limits for TCLP metals.
		NAN_DU1_0-3_B	Duplicate	0.13						
		NAN_DU1_0-3_C	Triplicate	0.15						
Selenium	EPA 6020B	NAN_DU1_0-3_A	Primary	8.1	8%	9%	7.67	0.38	5%	RSD is less than 50% so the mean concentration is used as the reported concentration.The mean concentration is below HDOH Tier 1 EAL and less than 20x regulatory limits for TCLP metals.
		NAN_DU1_0-3_B	Duplicate	7.5						
		NAN_DU1_0-3_C	Triplicate	7.4						
Silver	EPA 6020B	NAN_DU1_0-3_A	Primary	0.064	17%	10%	0.0587	0.0050	9%	RSD is less than 50% so the mean concentration is used as the reported concentration.The mean concentration is below HDOH Tier 1 EAL and less than 20x regulatory limits for TCLP metals.
		NAN_DU1_0-3_B	Duplicate	0.054						
		NAN_DU1_0-3_C	Triplicate	0.058						

Notes:
* Standard Deviation: If < 50% use the arithmatic mean, if < 50% then use the max of the replicate group.

Green: Result below HDOH Tier 1 EAL

Red: Result above 20 x Regulatory Limits for TCLP Metals

Table A-1b: Replicate Sample Results Comparison - Total RCRA Regulated Metals - Nanue Bridge (page 2 of 3)

Analyte	EPA Method	Sample Identification	Sample Type	Result (mg/kg)	Relative Percent Difference		Mean	Standard Deviation*	Relative Standard Deviation	Comment
					Primary and Duplicate	Primary and Triplicate				
Arsenic	EPA 6020B	NAN_DU1_3-6_A	Primary	24	4%	9%	23.0	1.0	4%	RSD is less than 50% so the mean concentration is used as the reported concentration. The result is less than 20 x regulatory limits for TCLP, but above HDOH Tier 1 EAL.
		NAN_DU1_3-6_B	Duplicate	23						
		NAN_DU1_3-6_C	Triplicate	22						
Barium	EPA 6020B	NAN_DU1_3-6_A	Primary	270	11%	7%	286.7	15.3	5%	RSD is less than 50% so the mean concentration is used as the reported concentration.The mean concentration is below HDOH Tier 1 EAL and less than 20x regulatory limits for TCLP metals.
		NAN_DU1_3-6_B	Duplicate	300						
		NAN_DU1_3-6_C	Triplicate	290						
Cadmium	EPA 6020B	NAN_DU1_3-6_A	Primary	0.42	13%	13%	0.387	0.029	7%	RSD is less than 50% so the mean concentration is used as the reported concentration.The mean concentration is below HDOH Tier 1 EAL and less than 20x regulatory limits for TCLP metals.
		NAN_DU1_3-6_B	Duplicate	0.37						
		NAN_DU1_3-6_C	Triplicate	0.37						
Chromium	EPA 6020B	NAN_DU1_3-6_A	Primary	190	0%	0%	190	0.0	0%	RSD is less than 50% so the mean concentration is used as the reported concentration. The result is above 20 x regulatory limits for TCLP metals. Mean concentration is below HDOH Tier 1 EAL.
		NAN_DU1_3-6_B	Duplicate	190						
		NAN_DU1_3-6_C	Triplicate	190						
Lead	EPA 6020B	NAN_DU1_3-6_A	Primary	980	2%	14%	930	70.0	8%	RSD is less than 50% so the mean concentration is used as the reported concentration. The result is above 20 x regulatory limits for TCLP metal and above HDOH Tier 1 EAL.
		NAN_DU1_3-6_B	Duplicate	960						
		NAN_DU1_3-6_C	Triplicate	850						
Mercury	EPA 7471A	NAN_DU1_3-6_A	Primary	0.16	0%	21%	0.150	0.017	12%	RSD is less than 50% so the mean concentration is used as the reported concentration.The mean concentration is below HDOH Tier 1 EAL and less than 20x regulatory limits for TCLP metals.
		NAN_DU1_3-6_B	Duplicate	0.16						
		NAN_DU1_3-6_C	Triplicate	0.13						
Selenium	EPA 6020B	NAN_DU1_3-6_A	Primary	9.6	11%	12%	8.90	0.61	7%	RSD is less than 50% so the mean concentration is used as the reported concentration.The mean concentration is below HDOH Tier 1 EAL and less than 20x regulatory limits for TCLP metals.
		NAN_DU1_3-6_B	Duplicate	8.6						
		NAN_DU1_3-6_C	Triplicate	8.5						
Silver	EPA 6020B	NAN_DU1_3-6_A	Primary	0.057	19%	4%	0.0530	0.0053	10%	RSD is less than 50% so the mean concentration is used as the reported concentration.The mean concentration is below HDOH Tier 1 EAL and less than 20x regulatory limits for TCLP metals.
		NAN_DU1_3-6_B	Duplicate	0.047						
		NAN_DU1_3-6_C	Triplicate	0.055						

Notes:
* Standard Deviation: If < 50% use the arithmatic mean, if < 50% then use the max of the replicate group.

(green) Result below HDOH Tier 1 EAL

(red) Result above 20 x Regulatory Limits for TCLP Metals

Table A-1b: Replicate Sample Results Comparison - Total RCRA Regulated Metals - Nanue Bridge (page 3 of 3)

Analyte	EPA Method	Sample Identification	Sample Type	Result (mg/kg)	Relative Percent Difference		Mean	Standard Deviation*	Relative Standard Deviation	Comment
					Primary and Duplicate	Primary and Triplicate				
Arsenic	EPA 6020B	NAN_DU1_6-9_A	Primary	17	0%	6%	17.3	0.6	3%	RSD is less than 50% so the mean concentration is used as the reported concentration.The mean concentration is below HDOH Tier 1 EAL and less than 20x regulatory limits for TCLP metals.
		NAN_DU1_6-9_B	Duplicate	17						
		NAN_DU1_6-9_C	Triplicate	18						
Barium	EPA 6020B	NAN_DU1_6-9_A	Primary	340	3%	31%	306.7	49.3	16%	RSD is less than 50% so the mean concentration is used as the reported concentration.The mean concentration is below HDOH Tier 1 EAL and less than 20x regulatory limits for TCLP metals.
		NAN_DU1_6-9_B	Duplicate	330						
		NAN_DU1_6-9_C	Triplicate	250						
Cadmium	EPA 6020B	NAN_DU1_6-9_A	Primary	0.32	14%	0%	0.337	0.029	9%	RSD is less than 50% so the mean concentration is used as the reported concentration.The mean concentration is below HDOH Tier 1 EAL and less than 20x regulatory limits for TCLP metals.
		NAN_DU1_6-9_B	Duplicate	0.37						
		NAN_DU1_6-9_C	Triplicate	0.32						
Chromium	EPA 6020B	NAN_DU1_6-9_A	Primary	190	5%	11%	186.7	15.3	8%	RSD is less than 50% so the mean concentration is used as the reported concentration. The result is above 20 x regulatory limits for TCLP metals. Mean concentration is below HDOH Tier 1 EAL.
		NAN_DU1_6-9_B	Duplicate	200						
		NAN_DU1_6-9_C	Triplicate	170						
Lead	EPA 6020B	NAN_DU1_6-9_A	Primary	640	3%	31%	576.7	92.9	16%	RSD is less than 50% so the mean concentration is used as the reported concentration. The result is above 20 x regulatory limits for TCLP metal and above HDOH Tier 1 EAL.
		NAN_DU1_6-9_B	Duplicate	620						
		NAN_DU1_6-9_C	Triplicate	470						
Mercury	EPA 7471A	NAN_DU1_6-9_A	Primary	0.15	6%	22%	0.143	0.021	15%	RSD is less than 50% so the mean concentration is used as the reported concentration.The mean concentration is below HDOH Tier 1 EAL and less than 20x regulatory limits for TCLP metals.
		NAN_DU1_6-9_B	Duplicate	0.16						
		NAN_DU1_6-9_C	Triplicate	0.12						
Selenium	EPA 6020B	NAN_DU1_6-9_A	Primary	10.0	3%	16%	9.40	0.79	8%	RSD is less than 50% so the mean concentration is used as the reported concentration.The mean concentration is below HDOH Tier 1 EAL and less than 20x regulatory limits for TCLP metals.
		NAN_DU1_6-9_B	Duplicate	9.7						
		NAN_DU1_6-9_C	Triplicate	8.5						
Silver	EPA 6020B	NAN_DU1_6-9_A	Primary	0.043	13%	5%	0.0443	0.0042	9%	RSD is less than 50% so the mean concentration is used as the reported concentration.The mean concentration is below HDOH Tier 1 EAL and less than 20x regulatory limits for TCLP metals.
		NAN_DU1_6-9_B	Duplicate	0.049						
		NAN_DU1_6-9_C	Triplicate	0.041						

Notes:
* Standard Deviation: If < 50% use the arithmatic mean, if < 50% then use the max of the replicate group.

Green: Result below HDOH Tier 1 EAL

Red: Result above 20 x Regulatory Limits for TCLP Metals

Table A-1c: Analytical Soil Profiling Results - Polychlorinated Biphenyls - Nanue Bridge (page 1 of 1)

						Sample Identifier	NAN_DU10_0-3			NAN_DU10_3-6			NAN_DU11_3-6		
						Sample Date	9-Mar-2024			9-Mar-2024			10-Mar-2024		
						Sample Depth (inches bgs)	0-3			3-6			3-6		
Analyte	Analytical Method	Units	**HDOH Tier 1 EALs* (Unrestricted Use)**	**HDOH Tier 1 EALs (Residential Direct-Exposure)1**	**HDOH Tier 1 EALs (Commercial/Industrial Direct-Exposure)2**	**HDOH Tier 1 EALs (Construction Worker Direct-Exposure)3**	**Results**	Q	RL	**Results**	Q	RL	**Results**	Q	RL
Polychlorinated Biphenyls (PCBs)															
PCB-1016	EPA 8082A/3546	mg/kg	**1.2**	**1.2**	**8.6**	**25**	ND	M	0.019	ND		0.019	0.017	M	0.019
PCB-1221	EPA 8082A/3546	mg/kg	**1.2**	**1.2**	**8.6**	**25**	ND		0.019	ND		0.019	0.017		0.019
PCB-1232	EPA 8082A/3546	mg/kg	**1.2**	**1.2**	**8.6**	**25**	ND		0.019	ND		0.019	0.017		0.019
PCB-1242	EPA 8082A/3546	mg/kg	**1.2**	**1.2**	**8.6**	**25**	ND	M	0.019	ND		0.019	0.017	M	0.019
PCB-1248	EPA 8082A/3546	mg/kg	**1.2**	**1.2**	**8.6**	**25**	ND	M	0.019	ND		0.019	0.017	M	0.019
PCB-1254	EPA 8082A/3546	mg/kg	**1.2**	**1.2**	**8.6**	**25**	**0.055**	M	0.019	**0.037**	J1 M	0.019	**0.20**	M	0.019
PCB-1260	EPA 8082A/3546	mg/kg	**1.2**	**1.2**	**8.6**	**25**	ND	J1 M	0.019	ND	M	0.019	0.017	M	0.019

Notes:

* State of Hawaii Department of Health Tier I Environmental Action Levels (EALs), Groundwater is a Current or Potential Source of Drinking Water (<150 meter to surface water body) presented in Table A of the Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater (Fall 2017 Edition).

1 State of Hawaii Department of Health Tier I EALs, Residential Land-Use Scenario presented in Table I-1 of the Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater (Fall 2017 Edition).

2 State of Hawaii Department of Health Tier I EALs, Commercial / Industrial Land-Use Scenario presented in Table I-2 of the Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater (Fall 2017 Edition).

3 State of Hawaii Department of Health Tier I EALs, Construction/Trench Worker Exposure Scenario presented in Table I-3 of the Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater (Fall 2017 Edition).

M = Manual integrated compound.

mg/kg = milligram(s) per kilogram

ND = not detected in concentrations above the laboratories method reporting limit

RL = reporting limit

Q = qualifier

J1 = The quantitation is an estimation due to discrepancies in meeting certain analyte-specific quality control criteria

bgs = below ground surface

APPENDIX A-2:

2024 LABORATORY ANALYTICAL REPORTS

J137730-1: RCRA8 Metals and PCBs

J137730-1: Revision 1 TCLP and SPLP

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