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June 12, 2019

Mr. Scott Glenn, Director
Office of Environmental Quality Control
Department of Health, State of Hawaii
235 S. Beretania Street, Room 702
Honolulu, Hawaii 96813
(by hand delivery)

Magazines for Long Ordnance West Loch Annex
Request for Publication
National Environmental Policy Act (NEPA) Draft Environmental Assessment
West Loch Annex, Ewa District, Oahu, Hawaii
TMK: (1) 9-1-001: 1 (por.), 31 (por.); (1) 9-1-010: 1 (por.), 10 (por.),
11 (por.), 12, 14 (por.), 15 (por.); Iroquois Road (por.)

Dear Director Glenn:

On behalf of the United States Department of the Navy, we request publication of the availability of the subject NEPA Draft Environmental Assessment (EA) in the June 23, 2019 edition of the Office of Environmental Quality Control (OEQC) Environmental Notice.

Enclosed is a completed OEQC Publication Form (for NEPA Action EA), a CD-ROM containing an Adobe Acrobat PDF file of the Draft EA, and an electronic copy of the publication form in MS Word.

If there are any questions or you need additional information, please contact the Navy's point of contact, Mr. Kyle Fujimoto, at (808) 472-1442 or by email at kyle.fujimoto@navy.mil.

Sincerely,

Thomas A. Fee AICP, LEED AP ND
President

Enclosures
1. Draft EA Magazines for Long Ordnance West Loch Annex (PDF format on CD-ROM)
2. NEPA Action EA/EIS Publication Form (Word format on CD-ROM)

c: ATTN: EV21KF, Naval Facilities Engineering Command, Pacific

19-388

NEPA Action EA/EIS
Publication Form

Project Name Magazines for Long Ordnance, JBPHH West Loch Annex -- Draft EA
Island: Oahu
District: Ewa
TMK: (1) 9-1-001: 1 (por.), 31 (por.); (1) 9-1-010: 1 (por.), 10 (por.), 11 (por.), 12, 14 (por.), 15 (por.); Iroquois Road (por.)
Permits: See document.

Applicant or Proposing Agency: Department of the Navy
Attn: EV21KF
Naval Facilities Engineering Command Pacific
258 Makalapa Drive, Suite 100
JBPHH, HI 96860-3134
Kyle Fujimoto, (808) 472-1442, NFPAC-Receive@navy.mil

Approving Agency: N/A

Consultant: HHF Planners, 733 Bishop Street, Suite 2590, Honolulu, HI 96813, Tom Fee (808) 457-3159

Status: 30-day comment period ends July 23, 2019. Send written comments by email to: NFPAC-Receive@navy.mil or by mail to: ATTN: Code EV21KF, Naval Facilities Engineering Command Pacific, 258 Makalapa Drive, Suite 100, JBPHH, HI 96860

Summary The United States Department of the Navy (the Navy) proposes construction of new magazines and secondary development at Joint Base Pearl Harbor-Hickam, West Loch Annex, Oahu, Hawaii. The proposed action is necessary for current ordnance storage requirements and safe ordnance operations. The Navy is the lead agency for the Proposed Action.

The Proposed Action includes construction of magazines; magazine access roads and concrete aprons; electrical, water, communication, and site drainage improvements; fire hydrants; construction staging areas; perimeter fence and associated patrol road; entry control point at Iroquois Road; gate at North Road and Iroquois Avenue; and closure of public access to West Loch Drive and portions of Iroquois Road and North Road for safety and security considerations. The Proposed Action includes a new bypass road that would replace the function of current public access along West Loch Drive to provide a new public connection extending from Iroquois Road to North Road.

Draft
Environmental Assessment
For

MAGAZINES FOR LONG ORDNANCE,
WEST LOCH ANNEX

At

JOINT BASE PEARL HARBOR-HICKAM, WEST LOCH ANNEX, HAWAII

JUNE 2019

DEPARTMENT OF THE NAVY
UNITED STATES OF AMERICA

Abstract

Designation:	Environmental Assessment
Title of Proposed Action:	Magazines for Long Ordnance, West Loch Annex
Project Location:	Joint Base Pearl Harbor-Hickam, West Loch Annex, Hawaii
Lead Agency for the EA:	Department of the Navy
Affected Region:	Honolulu, Hawaii
Action Proponent:	Joint Base Pearl Harbor-Hickam
Point of Contact:	Naval Facilities Engineering Command Pacific 258 Makalapa Drive, Suite 100 JBPHH, HI 96860 ATTN: EA Project Manager for Magazines for Long Ordnance West Loch Annex Email address: NFPAC-Receive@navy.mil
Date:	June 2019

Joint Base Pearl Harbor-Hickam, a Command of the U.S. Navy (hereinafter jointly referred to as the Navy) has prepared this Environmental Assessment (EA) in accordance with the National Environmental Policy Act (NEPA), as implemented by the Council on Environmental Quality Regulations and Navy regulations for implementing the National Environmental Policy Act as well as the Hawaii Environmental Policy Act (HEPA) codified as Chapter 343, Hawaii Revised Statutes (HRS) and Title 11, Chapter 200 of the Hawaii Administrative Rules (HAR). The Proposed Action would construct 24 box magazines and related improvements to provide sufficient storage space for Joint Base Pearl Harbor-Hickam to meet its current storage requirement. This Environmental Assessment evaluates the potential environmental impacts associated with the two action alternatives, Alternatives 1 and 2, and the No Action Alternative to the following resource areas: transportation, noise, air quality, land use, public health and safety, visual resources, biological resources, cultural resources, infrastructure, socioeconomics, environmental justice, water resources, geological resources, and hazardous materials and wastes.

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Executive Summary

ES.1 Proposed Action

The Proposed Action involves the construction of 24 new magazines for current ordnance storage requirements at Joint Base Pearl Harbor-Hickam, Oahu, Hawaii. The Proposed Action would also include secondary development necessary for safe ordnance operations such as magazine access roads/concrete aprons, utility and site drainage improvements, fire hydrants, construction staging area, a bypass road extending from Iroquois Road to North Road, perimeter fence and associated patrol road, entry control point at Iroquois Road, demolition of existing back gate near the corner of Iroquois Road and West Loch Drive, gate at North Road and Iroquois Avenue, as well as closing West Loch Drive and portions of Iroquois Road and North Road to public access due to safety and security considerations. The lead agency is the United States (U.S.) Navy. Joint Base Pearl Harbor-Hickam (JBPHH) is a command of the U.S. Navy that is responsible for endorsement of facilities at JBPHH West Loch Annex.

ES.2 Purpose of and Need for the Proposed Action

The purpose of the Proposed Action is to provide sufficient storage space for Joint Base Pearl Harbor-Hickam to meet its current storage requirement. The need for the Proposed Action is to meet the mission of Navy Munitions Command to receive, maintain, store and issue ammunition, weapons and technical ordnance material for the Navy, Air Force, Marine Corps and other activities and units as designated by the Chief of Naval Operations. In this regard, the Proposed Action furthers the Navy's execution of its congressionally mandated roles and responsibilities under 10 U.S.C. section 5062 (e.g., ready for prompt and sustained combat as it relates to operations at sea).

ES.3 Alternatives Considered

Alternatives were developed for analysis based upon the following reasonable alternative screening factors:

- Compatibility and availability of developable land in proximity to wharves;
- Minimize risk to public safety
- Minimize disturbance to natural, undeveloped areas; and
- Cost efficiency, constructability and ease of maintenance.

The Navy is considering two action alternatives that meet the purpose of and need for the Proposed Action and a No Action Alternative. Alternative 1 (Preferred Alternative) would involve the construction of 24 new box magazines clustered around the 10th Street and E Avenue intersections and related secondary improvements. Alternative 2 would involve the construction of 24 new box magazines located west of West Loch Drive and 6th Street with similar secondary improvements and addition of a new fire station to be located at 18th Street and G Avenue. The No Action Alternative would construct neither the 24 magazines nor any of the secondary improvements. The No Action Alternative does not meet the Purpose and Need for the Proposed Action, but as required by NEPA, it is carried forward for analysis in the EA and is analyzed as a benchmark by which to compare the impacts of the action alternatives.

ES.4 Summary of Environmental Resources Evaluated in the EA

Council on Environmental Quality regulations, National Environmental Policy Act, and Navy instructions for implementing the National Environmental Policy Act, specify that an Environmental Assessment (EA) should address those resource areas potentially subject to impacts. In addition, the level of analysis should be commensurate with the anticipated level of environmental impact.

The following resource areas have been addressed in this EA: transportation, noise, air quality, land use, public health and safety, visual resources, biological resources, cultural resources, infrastructure, socioeconomics, environmental justice, water resources, geological resources, and hazardous materials and waste. Because potential impacts were considered to be negligible or nonexistent, air space was not evaluated in this EA.

ES.5 Summary of Potential Environmental Consequences of the Action Alternatives and Major Mitigating Actions

Table ES-1 provides a tabular summary of potential impacts to the resources associated with each of the alternative actions analyzed.

ES.6 Public Involvement

This Draft EA is provided for public review and involvement.

Table ES-1 Summary of Potential Impacts to Resource Areas

Resource Area	***No Action Alternative***	***Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative)***	***Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive)***
Transportation	No impact.	The Preferred Alternative would have less than significant impacts to transportation. The construction and operation of the new magazines would have no impact on public transportation systems. West Loch Drive, on Navy land, currently provides public access from Iroquois Road to North Road near its intersection with Iroquois Avenue. The proposed bypass road would effectively replace the function of West Loch Drive, providing a new public connection between North Road and Iroquois Road through Navy property. It would be constructed and placed into service before closure of the existing West Loch Drive.	Alternative 2 is the same as Alternative 1 except for the location of the Alternative 2 magazines and a new fire station, which would not affect external transportation systems or traffic. Accordingly, Alternative 2 impacts would be the same as the Preferred Alternative (less than significant impact).
Noise	No impact.	The Preferred Alternative would have less than significant impacts to noise sensitive receptors such as residential uses. The construction and operation of the new magazines would have no offsite noise impacts due to the distance between the magazines and existing private residential uses. All construction and traffic noise activities would result in peak levels below 45 dBA at locations further than 300 feet from the bypass road. There are three residential areas adjacent to the bypass road. Residential uses adjacent to Kuanoo Street do not require noise abatement. At residences adjacent to Makalea and Hookaahea Streets, there is an existing 30-foot wide easement between the existing residential fenceline and Navy property. If traffic speeds are limited to 30 mph combined with the 30-foot wide easement, residences at Makalea-Hookaahea Streets would meet applicable noise standards. At the Hanaloa and Kauiki	Less than significant impacts (same as Preferred Alternative).

Table ES-1 Summary of Potential Impacts to Resource Areas

Resource Area	***No Action Alternative***	***Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative)***	***Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive)***
		Street residential segment, there is no existing 30-foot wide easement. Impacts to the Hanaloa-Kauiki Street properties can be avoided or minimized through several means: limiting traffic speeds to 30 mph, increasing the proposed horizontal separation of the roadway corridor and the subject residential property lines by 30 feet, constructing noise attenuation walls along the proposed bypass road corridor fronting the subject properties, reducing posted vehicle speeds and prohibiting heavy truck traffic and/or installing noise attenuation features in the impacted homes. With these measures or various combinations, off site noise impacts would be reduced to less than significant levels. It is recommended that the Navy conduct a noise analysis update to review sufficiency of abatement.	
Air Quality	No impact	The Preferred Alternative would result in less than significant air quality impacts. Short-term impacts on air quality may occur from the emission of fugitive dust during construction activities. A dust control plan is a standard best management practice of the Navy construction contract. The contractor for each phase of construction shall be responsible for dust control measures which meet applicable visible emissions and fugitive dust requirements. The proposed magazines would have no impact on air quality during the operational period. Emissions from vehicles traveling along the proposed security and bypass roadways have the potential to adversely impact air quality. Based on the analysis conducted, the	Less than significant impacts (same as Preferred Alternative).

Table ES-1 Summary of Potential Impacts to Resource Areas

Resource Area	***No Action Alternative***	***Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative)***	***Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive)***
		highest estimated concentrations of carbon monoxide (measured at the North Road and Iroquois Road intersections), would remain well within both state and national ambient air quality standards. Construction and operation of the Preferred Alternative would generate less than significant levels of greenhouse gases.	
Land Use	No impact	The Preferred Alternative would result in less than significant impacts to land use. Portions of the project on Navy land are categorized as Navy/Marine Corps *De Minimis* Activities Under the Coastal Zone Management Act (CZMA). Areas outside Navy land (Iroquois Road) would require an application for CZMA Consistency Determination submitted to the Hawaii Office of Planning.	Less than significant impacts (same as Preferred Alternative).
Public Health and Safety	No change to public health and safety. No impact. However, existing public vehicular usage of West Loch Drive and portions of Iroquois Road and North Road traverse immediately outside the existing West Loch Annex fence boundary which is a secure facility which stores military ordnance. Continued usage of West Loch	The Preferred Alternative would result in less than significant impacts to public health and safety. Proposed magazines would be constructed in accordance with current Department of Defense standards which includes Anti-Terrorism/Force Protection and physical security features. West Loch Annex would be secured by a proposed security fence and patrol road along its western boundary. Current public access through West Loch Annex would be relocated to the Annex perimeter along a re-aligned bypass road for safety and security reasons. In compliance with Executive Order 13045, *Protection of Children from Environmental Health Risks and Safety Risks*, there are no environmental health and safety risks associated with the Proposed Action that would disproportionately affect children.	Less than significant impacts (same as Preferred Alternative)

Table ES-1 Summary of Potential Impacts to Resource Areas

Resource Area	*No Action Alternative*	*Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative)*	*Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive)*
	Drive and portions of Iroquois Road and North Road is a safety concern which would continue under the No Action Alternative.		
Visual Resources	No impact	The Preferred Alternative would not significantly alter open space views from bordering roadways and adjacent areas. Previously approved PV improvements would result in some changes to existing landforms. Security fencing and patrol road would be visible from private homes and other properties along the southwestern boundary. Improvements are necessary for safety reasons. Should sound abatement measures or other roadway improvements be warranted within the bypass road right-of-way, view parameters may be affected, primarily from adjacent residences. However, the extent of the effect on views should be similar to existing and planned landforms, vegetation and structures such as the existing dirt/rock berm, the existing kiawe forest, and previously approved PV substations. Implementation of the Preferred Alternative would result in less than significant impacts.	Less than significant impacts (same as Preferred Alternative).
Biological Resources	No impact	With management measures designed to protect and benefit threatened and endangered species, the Preferred Alternative would result in less than significant impacts to biological resources. Approximately 310 acres of vegetation would be removed under the preferred alternative. This includes primarily common, introduced, or alien vegetation	Alternative 2 is the same as Alternative 1 except that approximately 273 acres of vegetation would be removed. With the implementation of applicable management measures, Alternative 2 would

Table ES-1 Summary of Potential Impacts to Resource Areas

Resource Area	***No Action Alternative***	***Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative)***	***Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive)***
		species. No federal- or state-listed threatened or endangered plants would be affected. There is no critical habitat within the various project sites. Management measures will be in place to minimize impacts to Migratory Bird Treaty Act (MBTA)-protected birds and waterbirds. Nest surveys will be conducted for the Hawaiian short-eared owl a maximum of seven days prior to construction. Removal of tall vegetation during the Hawaiian hoary bat pupping season will be avoided to reduce disturbance to young bats. The Navy has determined that the action may affect the Hawaiian hoary bat, but is not likely to adversely affect the species.	result in less than significant impacts to biological resources.
Cultural Resources	No impact	A previous APE was established through Section 106 consultation for the project. By letter dated 3 January 2019, the SHPO reviewed and concurred with the Navy's determination that the project will result in no adverse effect. Since that time, additional components of the project have been added to the undertaking. However, no historic properties are present in the revised APE of 310 acres. Upon reassessment, the appropriate finding of effect is no historic properties affected. The Preferred Alternative would result in less than significant impacts to cultural resources. Thirteen archaeological sites are known within the Alternative 1 proposed magazine areas. Three archaeological sites are adjacent to the proposed perimeter fence, patrol road, bypass road, new gate, and entry control point. None of the sites are eligible for listing on the National Register of Historic Places (NRHP). There are eight historic magazines within	There are no archaeological sites documented within the Alternative 2 magazine area, construction staging area, and fire station. Like Alternative 1, the known sites adjacent to the perimeter fence, patrol road, bypass road, new gate, and entry control point were subject to inventory-level documentation and no further actions were recommended. None of the sites are eligible for listing in the NRHP. Implementation of Alternative 2 would result in less than significant impacts to cultural resources.

Table ES-1 Summary of Potential Impacts to Resource Areas

Resource Area	***No Action Alternative***	***Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative)***	***Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive)***
		the vicinity of the proposed magazines; the proposed undertaking would not alter the historic setting of these magazines due to similarity in appearance of the new construction.	
Infrastructure	No impact	The Preferred Alternative would result in less than significant impacts to infrastructure systems. Minimal changes to potable water usage and wastewater generation would occur under the Preferred Alternative. Construction Best Management Practices would be implemented to address potential storm water soil erosion. Non-hazardous construction and demolition waste that cannot be recycled would be disposed off-site at an approved construction and demolition sanitary landfill. The operation of the Preferred Alternative would require minimal energy usage.	Less than significant impacts (same as Preferred Alternative)
Socioeconomics	No impact	The Preferred Alternative would result in less than significant impacts to socioeconomics of the local area or region. The Preferred Alternative would have a temporary beneficial impact on construction-related employment and spending.	Less than significant impacts. (same as the Preferred Alternative)
Environmental Justice	No impact.	The Preferred Alternative would have less than significant construction and operational period impacts. New magazines would be constructed in accordance with applicable DoD standards with safety buffers. A new public bypass road would be constructed, replacing the service currently provided by the Navy owned West Loch Drive.	Less than significant impacts (same as Preferred Alternative).
Water Resources	No impact	The Preferred Alternative would have less than significant impacts on the hydrology of the area. During construction and operational phases, BMPs would be	Less than significant impacts (same as the Preferred Alternative).

Table ES-1 Summary of Potential Impacts to Resource Areas

Resource Area	*No Action Alternative*	*Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative)*	*Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive)*
		implemented to capture and retain storm water on site and allow it to infiltrate into the soil or to be discharged at a rate that would not exceed the predevelopment hydrology to adjacent surface waters. The Navy has determined that the first phase of magazines does not require NPDES coverage under Section 11-55 HAR, Appendix C. For future phases, an NPDES permit would be obtained for the project to address discharges of storm water relating to construction activities and dewatering, as applicable. There are no known wetlands that would be affected.	
Geological Resources	No impact	The Preferred Alternative would have less than significant impact to topography and soils. Cut and fill quantities would be balanced on site to make use of excavated earth. BMPs would be followed. The Navy has determined that the first phase of magazines does not require NPDES coverage under Section 11-55 HAR, Appendix C. For future phases, an NPDES permit would be obtained as appropriate. Measures will be undertaken in an effort to prevent the spread of the invasive Coconut Rhinoceros Beetle (CRB) to other parts of Oahu. Green waste from the site clearing process would be brought to a JBPHH-approved green waste collection point.	Less than significant impacts (same as Preferred Alternative).
Hazardous Materials and Wastes	No impact	The Preferred Alternative would have a less than significant impact on existing hazardous materials and wastes sites. There would be no impact to the 4th Street Coral Pit, located approximately 1,500 feet from the closest Preferred Alternative construction activities. The West Loch Burn Pit and Electrical Components Disposal	Less than significant impacts (same as Preferred Alternative). There would be no impact to the 4th Street Coral Pit, located approximately 1,000 feet from the closest Alternative 2 construction

Table ES-1 Summary of Potential Impacts to Resource Areas

Resource Area	*No Action Alternative*	*Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative)*	*Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive)*
		Area are located at least 1,300 feet and 750 feet away respectively from Preferred Alternative construction activities. Investigative fieldwork for both the latter sites have not been completed. The Navy will oversee fieldwork to ensure that the Preferred Alternative would not impact either site.	activities The West Loch Burn Pit and Electrical Components Disposal Area are located at least 1,000 feet and 1,300 feet away respectively from Alternative 2 construction activities. Similar to the Preferred Alternative, the Navy will oversee fieldwork to ensure that Alternative 2 would not impact either site.

Magazines for Long Ordnance, West Loch Annex

Joint Base Pearl Harbor Hickam West Loch Annex Hawaii

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Abbreviations and Acronyms

Acronym	Definition
ABCD	Advance Base Construction Depot
ACHP	Advisory Council on Historic Preservation
ACM	Asbestos containing material
ALISH	Agricultural Lands of Importance to the State of Hawaii
APE	Area of Potential Effects
AT/FP	Anti-Terrorism/Force Protection
BMP	Best management practice
CAA	Clean Air Act
CAFE	Corporate average fuel economy
CCD	Coastal Consistency Determination
CDP	Census Designated Place
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CO	Carbon monoxide
CO2e	Carbon dioxide equivalent
COPC	Chemicals of Potential Concern
CRB	Coconut Rhinoceros Beetle
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DBEDT	Department of Business, Economic Development and Tourism
DLNR	Department of Land and Natural Resources
DoD	United States Department of Defense
DoH	State of Hawaii Department of Health
DoN	United States Department of the Navy
DP	Development Plan
EA	Environmental Assessment
EIS	Environmental Impact Statement
EO	Executive Order
ESA	Endangered Species Act
ESQD	Explosive Safety Quantity Distance
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
FONSI	Finding of No Significant Impact
FPPA	Farmland Protection Policy Act
FWS	U.S. Fish and Wildlife Service
GHG	Greenhouse Gas
HAPs	Hazardous Air Pollutants
HAR	Hawaii Administrative Rules
HCEI	Hawaii Clean Energy Initiative
HEPA	Hawaii Environmental Protection Act
HRS	Hawaii Revised Statutes
HCZMP	Hawaii Coastal Zone Management Program
ICRMP	Integrated Cultural Resources Management Plan
JBPHH	Joint Base Pearl Harbor-Hickam
LBP	Lead-based paint
LED	Light emitting diode
LOS	Level of service
LSB	Land Study Bureau
LUC	Land Use Commission

Acronym	Definition
LUO	Land Use Ordinance
MBTA	Migratory Bird Treaty Act
MC	Munitions constituents
MDAS	Material Documented as Safe
MEC	Munitions and explosives of concern
MMPA	Marine Mammal Protection Act
MOVES	Motor Vehicle Emission Simulator
MPPEH	Material Potentially Presenting an Explosive Hazard
MSATs	Mobile Source Air Toxics
MSL	Mean Sea Level
NAAQS	National Ambient Air Quality Standards
NAVFAC PAC	Naval Facilities Engineering Command, Pacific
NAVMAG	Naval Magazine
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOA	Notice of Availability
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NOSSA	Naval Ordnance Safety and Security Activity
NOx	Nitrogen oxides
NO_2	Nitrogen dioxide
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
OPNAV	Office of the Chief of Naval Operations
OPNAVINST	Office of the Chief of Naval Operations Instruction
Pb	Lead
PCB	Polychlorinated biphenyl
PHNHL	Pearl Harbor National Historic Landmark
PHNWR	Pearl Harbor National Wildlife Refuge
$PM_{2.5}$	Suspended particulate matter less than or equal to 2.5 microns in diameter
PM_{10}	Suspended particulate matter less than or equal to 10 microns in diameter
PSD	Prevention of Significant Deterioration
PV	Photovoltaic
RCRA	Resource Conservation and Recovery Act
RSIP	Regional Shore Infrastructure Planning
SHPO	State Historic Preservation Officer
SIP	State Implementation Plan
SMA	Special Management Area
SO_2	Sulfur dioxide
TCP	Traditional Cultural Property
TMDL	Total Maximum Daily Load
TPY	Tons per year
TSCA	Toxic Substances Control Act
U.S.C.	United States Code
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	Volatile Organic Compounds
WQLS	Water Quality-Limited Segments

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1 Purpose of and Need for the Proposed Action

1.1 Introduction

The Commander, Joint Base Pearl Harbor-Hickam (JBPHH), a Command of the United States (U.S.) Navy (hereinafter, referred to as the Navy) proposes to construct 24 new box magazines for storage of military ordnance at JBPHH, West Loch Annex on the island of Oahu, Hawaii. The Proposed Action would also include secondary development necessary for safe ordnance operations such as magazine access roads/concrete aprons, utility and site drainage improvements, fire hydrants, construction staging area, a bypass road extending from Iroquois Road to North Road, perimeter fence and associated patrol road, entry control point at Iroquois Road, gate at North Road and Iroquois Avenue, as well as closing West Loch Drive and portions of Iroquois Road and North Road to public access due to safety and security considerations. Construction site preparations for the Proposed Action would total an area of approximately 310 acres.

The Navy has prepared this Environmental Assessment (EA) in accordance with the National Environmental Policy Act (NEPA), as implemented by the Council on Environmental Quality Regulations and Navy regulations for implementing NEPA. In addition, a portion of Iroquois Road that is encumbered by the project is owned by the State of Hawaii, which triggers review under the Hawaii Environmental Policy Act (HEPA) codified as Chapter 343, Hawaii Revised Statutes (HRS) and Title 11, Chapter 200 of the Hawaii Administrative Rules (HAR).

The Navy is the lead agency for the NEPA Proposed Action, and JBPHH is the action proponent. Applicable compliance with HEPA would occur separately. The Hawaii Department of Transportation has concurred that it will be the accepting agency for HEPA purposes (Appendix A). However, this NEPA EA document discusses compliance with applicable HEPA provisions.

1.2 Background

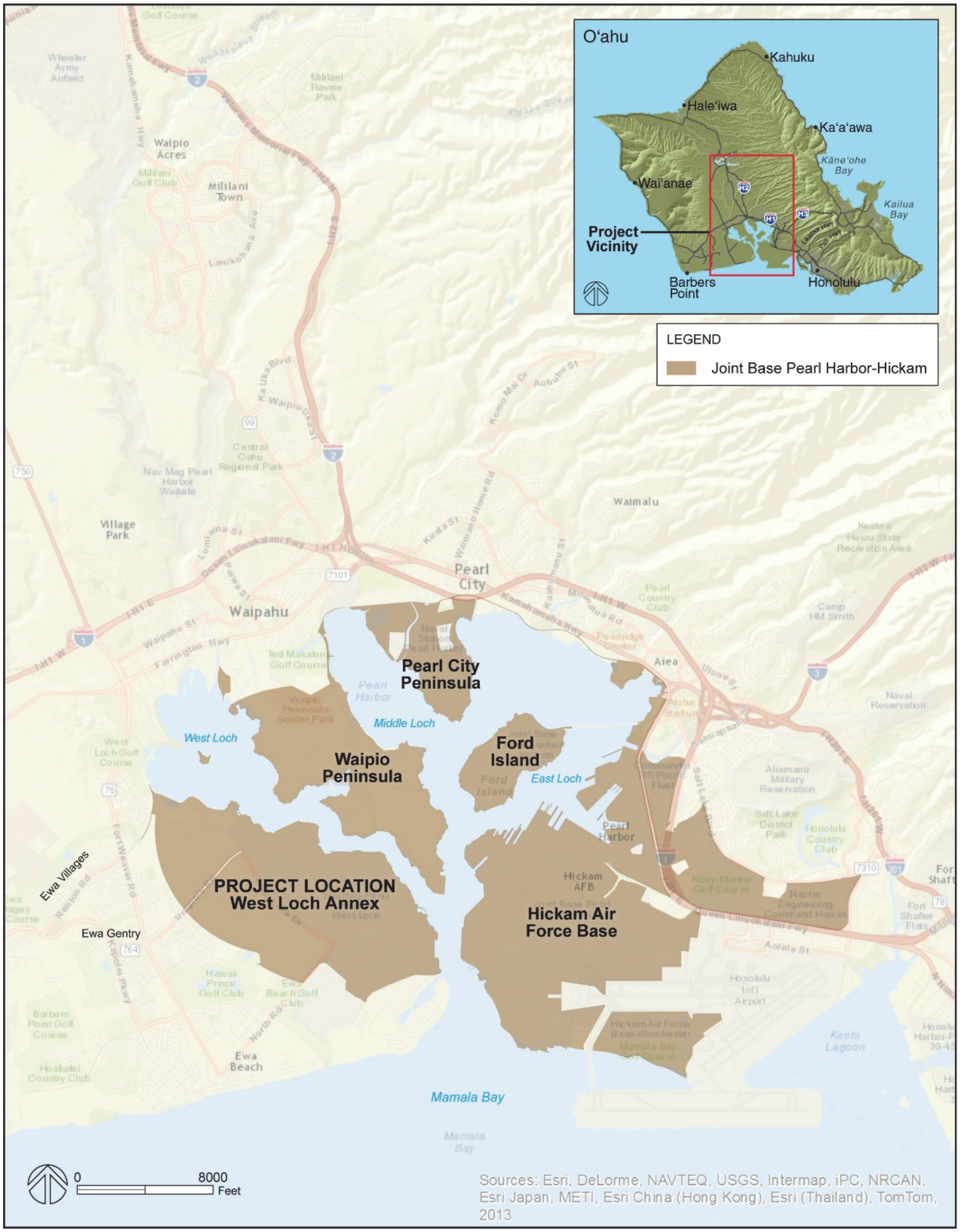
JBPHH serves as the home base for U.S. Air Force wings and Navy surface ship and submarine squadrons, and is a regional maintenance center for ships and submarines (Figure 1-1). It is a strategic base in the Central Pacific being located 2,400 miles west of California, 3,850 miles east of Japan and 3,600 miles east of Guam.

The ordnance mission in Hawaii is to receive, inspect, maintain, store, and issue ammunition, weapons and technical ordnance material for military services on Oahu. Ordnance movement at JBPHH primarily supports ship and submarine load-outs.

Since facilities at West Loch Annex are geographically closer to potential conflict areas in the western Pacific Ocean than facilities located in the continental United States, they provide significant potential to supplement the Navy's forward presence in the Pacific.

West Loch Annex is currently the main site used to support JBPHH for loading and unloading ordnance as well as storage. It is the only area available on JBPHH where transport of munitions over public roadways can be avoided.

Although West Loch Annex provides magazines for ordnance storage, only a portion of the existing magazines are suitable for long ordnance (i.e., projectile or self-propelled weapons) and these magazines are fully utilized. Other West Loch magazines are igloo design. These are either too small, or have narrow doors, narrow loading platforms, and/or many interior pillars. Over time, technological advances have changed the types and sizes of ordnance in use, resulting in some obsolete facilities at West Loch Annex. There simply is insufficient storage space for ordnance.



Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

Regional Location Map **Figure 1-1**

Magazines for Long Ordnance, West Loch Annex

Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii

1.3 Location

JBPHH encompasses approximately 28,000 acres of land and water, and includes significant land holdings at the main base, West Loch Annex, Pearl City Peninsula, Waipio Peninsula and other outlying areas. In 2010, Naval Station Pearl Harbor joined with Hickam Air Force Base to become JBPHH combining the two bases into a single joint installation to support both Air Force and Navy missions in the Pacific. The main base is host to Commander U.S. Pacific Fleet and Headquarters Pacific Air Forces. In addition, JBPHH hosts over 100 tenant commands that support the Navy, Air Force, and other missions in Hawaii and the Pacific.

The proposed project would be located at the West Loch Annex in the Ewa District of south-central Oahu. Vehicular access to West Loch Annex is via Fort Weaver Road, a divided four-lane State highway, and either Iroquois Road or North Road, two-lane non-federal roadways. To the west and southwest of West Loch Annex are several residential subdivisions that were built in the past 30 years as part of the Ewa by Gentry project, the Hawaii Prince Golf Club, older residential subdivisions built about 50 years ago (Leeward Estates) and the Ewa Beach Golf Club. Several apartment complexes are located southeast of North Road. James Campbell High School, Ilima Intermediate School, Pohakea Elementary School, Kaimiloa Elementary School, and Our Lady of Perpetual Help School are also located in this area.

The Kapilina residential community, formerly Iroquois Point Naval housing, includes nearly 1,500 housing units and is located south of West Loch Annex. Iroquois Point Elementary School is located within the community. Access to Kapilina is through Iroquois Avenue and North Road which connects with Fort Weaver Road, the main traffic artery serving this area of Ewa and West Loch Annex.

1.4 Purpose of and Need for the Proposed Action

The purpose of the Proposed Action is to provide sufficient storage space for Joint Base Pearl Harbor-Hickam to meet its current ordnance storage requirement.

The Proposed Action would provide needed ordnance storage at West Loch Annex which enhances combatant and ammunition ship accessibility. The Proposed Action enhances long-term Department of Defense (DoD) ordnance capability as well as supports military readiness in the Western Pacific.

The need for the Proposed Action is to meet the mission of Navy Munitions Command to receive, maintain, store and issue ammunition, weapons and technical ordnance material for the Navy, Air Force, Army and other activities and units as designated by the Chief of Naval Operations. In this regard, the Proposed Action furthers the Navy’s execution of its congressionally mandated roles and responsibilities under 10 U.S.C. section 5062.

> 10 U.S.C. section 5062: “The Navy shall be organized, trained, and equipped primarily for prompt and sustained combat incident to operations at sea. It is responsible for the preparation of naval forces necessary for the effective prosecution of war except as otherwise assigned and, in accordance with integrated joint mobilization plans, for the expansion of the peacetime components of the Navy to meet the needs of war.”

The Navy has considered explosive limits, spatial constraints, safe storage practices, and optimal storage techniques in its review of available storage capacity at West Loch Annex. Accordingly, the Navy has determined that an additional 24 Box Type “D” magazines are needed to accommodate an appropriate type and quantity of ordnance storage at West Loch Annex.

1.5 Scope of Environmental Analysis

This EA includes an analysis of potential environmental impacts associated with the action alternatives and the No Action Alternative. The environmental resource areas analyzed in this EA include: transportation, noise, air quality, land use, public health and safety, visual resources, biological resources, cultural resources, infrastructure, socioeconomics, environmental justice, water resources, geological resources, and hazardous materials and wastes. The study area for each resource analyzed may differ due to how the Proposed Action interacts with or impacts the resource.

1.6 Key Documents

Key documents are sources of information incorporated into this EA. Documents are considered to be key because of similar actions, analyses, or impacts that may apply to this Proposed Action. CEQ guidance encourages incorporating documents by reference. Documents incorporated by reference in part or in whole include:

- Installation Development Plan Training Practicum Report Volume I and II for Joint Base Pearl Harbor-Hickam, Honolulu, Hawaii, August 2013. This technical manual was formulated to guide development at JBPHH. The document includes plans for eleven planning districts: Eastside, Flightline Southside, Ford Island, Historic Downtown, Lualualei, Makalapa, Northside, Pearl City Peninsula, Southside, Wahiawa, and West Loch Annex.
- EA for Photovoltaic Systems, Joint Base Pearl Harbor-Hickam, Oahu, Hawaii, June 2015. This EA assessed the environmental impacts of leasing up to 380 acres of land at the West Loch Annex of JBPHH for the construction, operation, and decommissioning of an up to 50 megawatt photovoltaic system.
- EA for MCON P-181 Dredge Channel for T-AKE Naval Magazine Pearl Harbor West Loch Branch Oahu, Hawaii, December 2006. This EA assessed the environmental impacts of construction dredging to widen and deepen portions of West Loch Channel.

1.7 Relevant Laws and Regulations

The Navy has prepared this EA based upon federal and state laws, statutes, regulations, and policies that are pertinent to the implementation of the Proposed Action, including the following:

- National Environmental Policy Act (NEPA) (42 United States Code [U.S.C.] sections 4321-4370h), which requires an environmental analysis for major federal actions that have the potential to significantly impact the quality of the human environment
- Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 CFR parts 1500-1508)
- Navy regulations for implementing NEPA (32 CFR part 775), which provides Navy policy for implementing CEQ regulations and NEPA
- Clean Air Act (42 U.S.C. section 7401 et seq.)
- Clean Water Act (33 U.S.C. section 1251 et seq.)
- Coastal Zone Management Act (16 U.S.C. section 1451 et seq.)
- National Historic Preservation Act (54 U.S.C. section 306108 et seq.)
- Endangered Species Act (16 U.S.C. section 1531 et seq.)
- Migratory Bird Treaty Act (16 U.S.C. sections 703-712)
- Comprehensive Environmental Response and Liability Act (42 U.S.C. section 9601 et seq.)
- Emergency Planning and Community Right-to-Know Act (42 U.S.C. sections 11001-11050)

- Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. section 136 et seq.)
- Resource Conservation and Recovery Act (42 U.S.C. section 6901 et seq.)
- Toxic Substances Control Act (15 U.S.C. section 2601-2629)
- Farmland Protection Policy Act (7 U.S.C. 4201 et seq.)
- EO 11988, Floodplain Management
- EO 12088, Federal Compliance with Pollution Control Standards
- EO 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations
- EO 13045, Protection of Children from Environmental Health Risks and Safety Risks
- EO 13807, Establishing Discipline and Accountability in the Environmental Review and Permitting Process for Infrastructure Projects
- EO 13834, Efficient Federal Operations
- Chapter 343, Hawaii Revised Statutes (HRS)
- Title 11, Chapter 200 Hawaii Administrative Rules (HAR)

A description of the Proposed Action's consistency with the relevant laws, policies and regulations, as well as the names of regulatory agencies responsible for their implementation, is presented in Chapter 5 (Table 5-1).

1.8 Public and Agency Participation and Intergovernmental Coordination

Regulations from the Council on Environmental Quality (40 CFR section 1506.6) direct agencies to involve the public in preparing and implementing their NEPA procedures.

The Navy has prepared this Draft EA to inform the public of the Proposed Action and to allow the opportunity for public review and comment. Initial consultation has commenced with the State of Hawaii Department of Transportation as the non-federal owner of Iroquois Road. The Navy also has coordinated with the State Historic Preservation Officer on Section 106 of the National Historic Preservation Act. The 30-day Draft EA review period begins with notices published in the Honolulu Star Advertiser and the State's Office of Environmental Quality Control (OEQC) *Environmental Notice*, indicating the availability of the Draft EA on JBPHH and the OEQC websites.

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2 Proposed Action and Alternatives

2.1 Proposed Action

The Navy proposes to construct 24 new box magazines for storage of long ordnance at West Loch Annex on the island of Oahu, Hawaii. The Proposed Action would also include secondary development necessary for safe ordnance operations. The total acreage of the Proposed Action is approximately 310 non-contiguous acres (Figure 2-1).

Secondary development includes adjacent accessory roads and concrete pads, building electrical service and distribution, site drainage improvements, waterline and communication improvements, installation security features, and fire lines and hydrants. Construction staging areas, underground waterline and communication lines and a pole mounted transformer are located in proximity to the proposed magazines. Closure of certain roadway segments for public use within West Loch Annex (West Loch Drive, and portions of North Road and Iroquois Road) would apply due to safety reasons. A new two-lane two-way bypass road would be built adjacent to the western boundary of West Loch Annex extending from Iroquois Road to North Road, replacing the public access function of West Loch Drive. A security fence and associated patrol road, required for public safety purposes, would be constructed to the east of and adjacent to the bypass road. The security fence/patrol road also extends along North Road from its intersection with the bypass road to Iroquois Avenue. A security gate is proposed at the corner of North Road and Iroquois Avenue. The security fence/patrol road also extends to the northwest from Iroquois Road adjacent to the western boundary of West Loch Annex. The security fence/patrol road then extends adjacent to the boundary of the Pearl Harbor National Wildlife Refuge to a point near the shoreline. Alternatively, the security fence/patrol road may be located adjacent and parallel to Iroquois Road. A new entry control point (security checkpoint) would be constructed on and abutting Iroquois Road and then the existing back gate near the corner of Iroquois Road and West Loch Drive would be demolished. Electrical, communication and waterline connections would be installed from the entry control point to existing connections near the back gate. Overhead communication lines would be further extended along Iroquois Road and D Avenue to existing connections near Building 52.

2.2 Screening Factors

NEPA's implementing regulations provide guidance on the consideration of alternatives to a federally proposed action and require rigorous exploration and objective evaluation of reasonable alternatives. Only those alternatives determined to be reasonable and meet the purpose and need require detailed analysis.

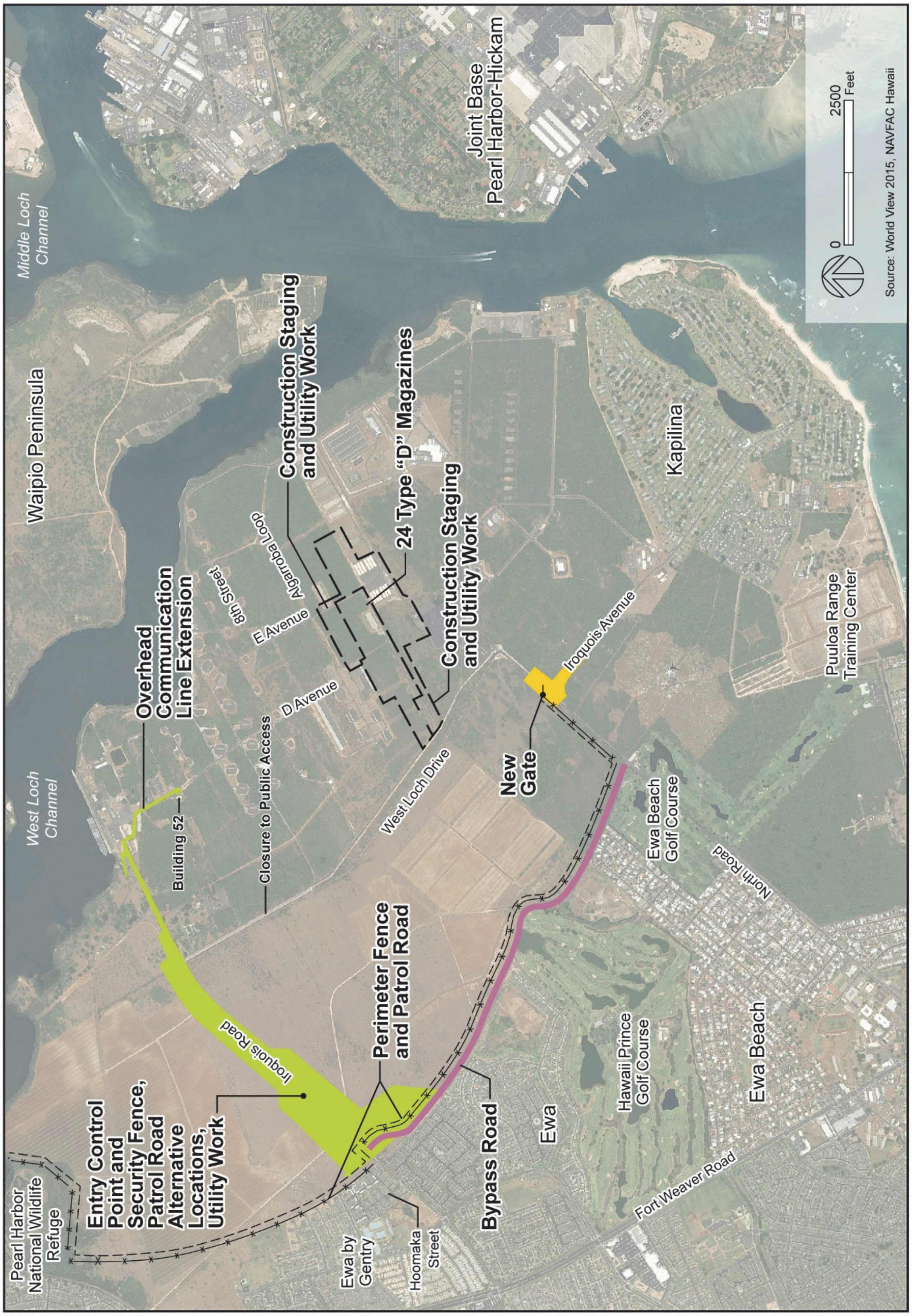
Potential alternatives that meet the purpose and need were evaluated against the following screening factors:

- Availability of developable land in close proximity to wharves
- Minimize risk to public safety
- Minimize disturbance to natural, undeveloped areas; and
- Cost efficiency, constructability and ease of maintenance

Various alternatives were evaluated against the screening factors. The alternatives considered included:

1. No Action
2. Construction of magazines at West Loch Annex (two alternatives)

3. Retrofit/alteration/modification of existing magazines at West Loch Annex
4. Construction of magazines at a different location at West Loch Annex
5. Construction of magazines at another location at JBPHH
6. Construction of new magazines outside of Oahu
7. Leasing of privately owned facilities at another location on Oahu
8. Alternative transportation options



Source: World View 2015, NAVFAC Hawaii

Figure 2-1

Project Location Map
Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii

2.3 Alternatives Carried Forward for Analysis

Based on the reasonable alternative screening factors and meeting the purpose and need for the Proposed Action, the no action alternative and two action alternatives were identified and would be analyzed within this EA.

2.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur. Under the No Action Alternative, there would continue to be a shortage of magazine storage for long ordnance and other ordnance when needs for storage are only expected to increase. The No Action Alternative would not meet the purpose and need for the Proposed Action; however, as required by NEPA, the No Action Alternative is carried forward for analysis in this EA. The No Action Alternative would be used to analyze the consequences of not undertaking the Proposed Action, not simply conclude no impact, and would serve to establish a comparative baseline for analysis.

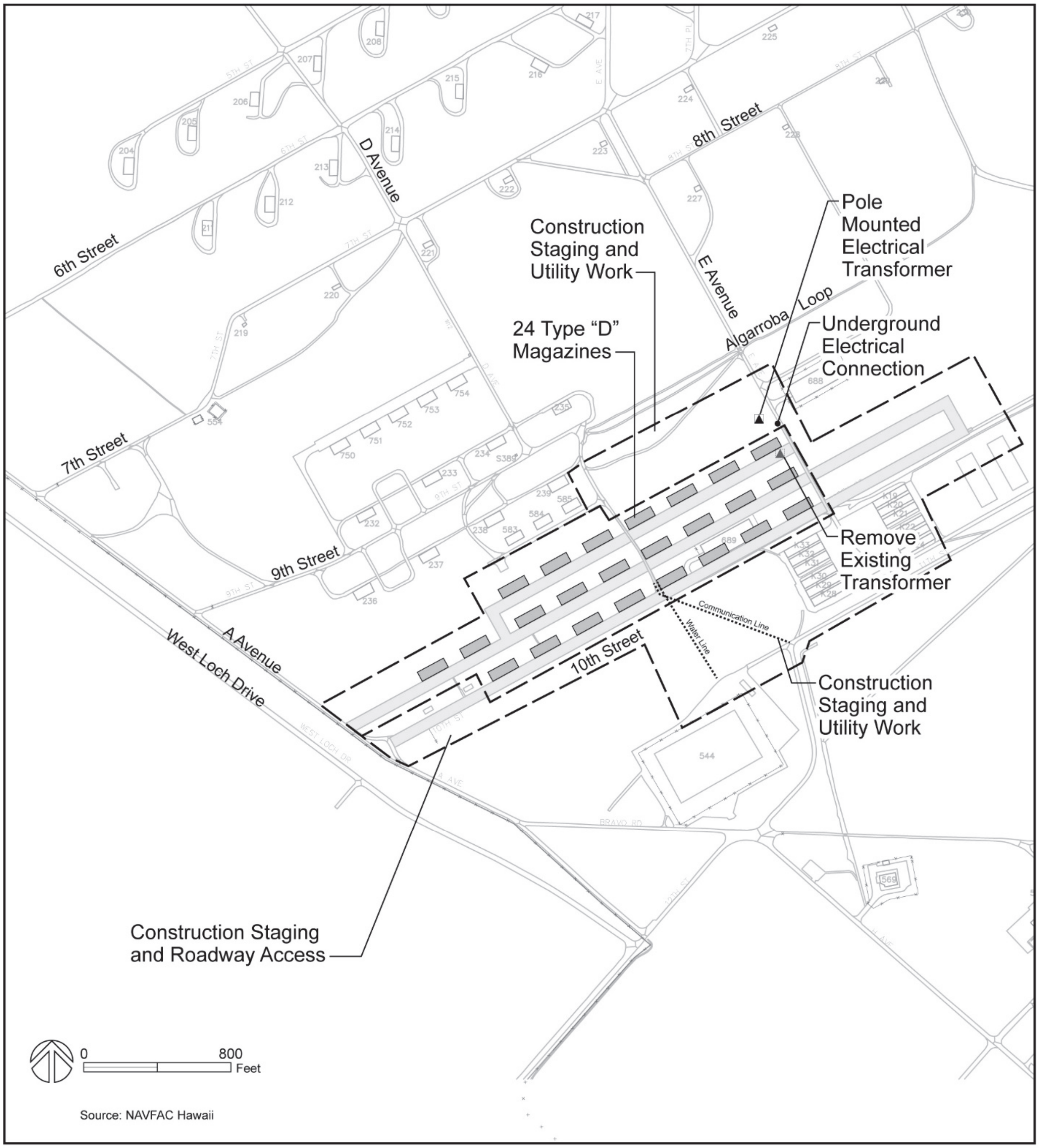
2.3.2 Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative)

2.3.2.1 Type "D" Magazines

Alternative 1 involves construction of 24 new box Type "D" magazines clustered around the 10th Street and E Avenue intersection (Figure 2-2). A construction staging area, access roadways and utility work would abut the 24 magazine site to the south of 10th Street and extends east of E Avenue. The construction staging area and related utility work also extends to the north of the 24 magazine site between D Avenue and E Avenue.

The new magazines would be standard Type "D" magazines (Figure 2-3). The individual magazine dimensions are approximately 160 feet wide by 50 feet long and 20 feet in height. The magazine structure is of reinforced concrete covered by a minimum of two feet of earth. The magazines would be constructed and spaced in accordance with applicable Navy standards to prevent sympathetic detonation (chain reactions). Each magazine would have five electronically operated doors at ground level and an intrusion detection system. Special foundation features would include concrete fill below the invert of the magazine foundation to the coral shelf. The project would include Anti-Terrorism/Force Protection (AT/FP) features and would comply with AT/FP regulations and physical security requirements in accordance with DoD Minimum Anti-Terrorism Standards for Buildings.

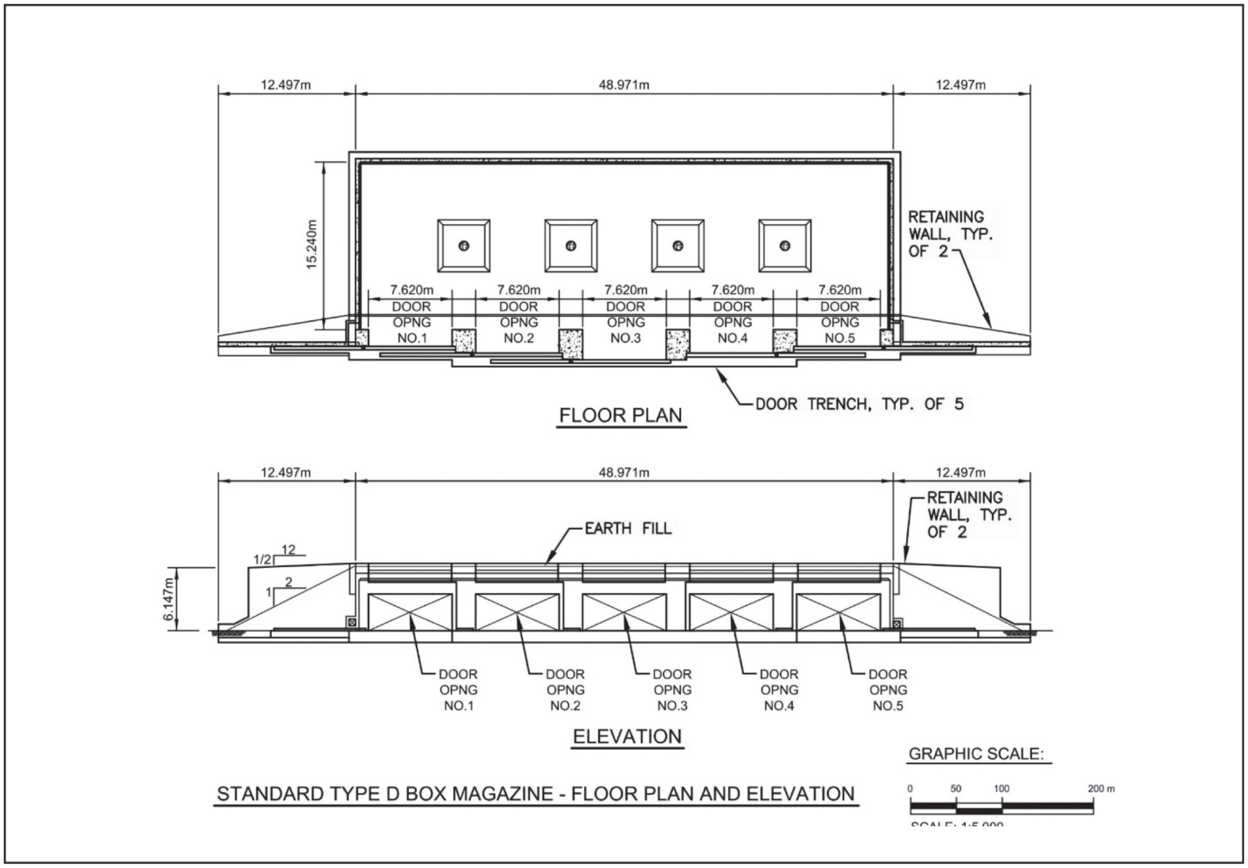
Project work would also include installing a 60-foot wide concrete apron and access road for the new magazine loading and unloading operations. Electrical and communication improvements would include applicable connections to existing systems. Fire hydrants and applicable waterline improvements would be installed adjacent to the magazines in case of brush fire. Landscaping would also be installed.



Source: NAVFAC Hawaii

Site Plan of Proposed Magazines (Alternative 1) **Figure 2-2**

Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii



Floor Plan and Elevation of Type "D" Magazines **Figure 2-3**

Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii

A percolation basin adjacent to each magazine would be installed to address stormwater runoff. Work on the 24 magazines, and appurtenant improvements would comprise approximately 39 acres.

Construction staging, access roadways, and utility work would comprise approximately 51 acres. This includes a buffer zone for equipment and potential laydown areas. Water, communication and electrical subsurface utility lines also would connect to a network of existing subsurface utilities located along E Avenue, 9th Street, 10th Street, and 11th Street. Water and communication utilities would extend between 10th and 11th Street and within a formally paved area between a series of Quonset huts constructed in 1943 and used for inert storage. A series of additional water, communication, and electric subsurface utilities would be installed along 10th Street. Additional area is included to provide flexibility during the construction phase.

The total land area for the magazines, appurtenant improvements, construction staging, access roadways and utility work is 90 acres.

Since existing igloo magazines are either too small or do not have optimum configurations for storage of modern ordnance, existing ordnance may be transferred from the igloo magazines to the new magazines, depending on overall storage needs. Igloo magazines may then be utilized for other needs such as inert storage. No construction or alteration to the existing igloo magazines is included as part of the Proposed Action.

2.3.2.2 Real Estate Actions

Public access would need to be terminated for safety and security reasons on Navy-owned West Loch Drive, as well as portions of Iroquois Road and North Road. Necessary and appropriate real estate rights will be obtained to accomplish road closure, or to mitigate the impact of road closure. This analysis considers acquisition of Navy real estate rights from any parties owning or controlling real estate related to construction of magazines, road closure or mitigation actions.

2.3.2.3 Bypass Road

A new public access bypass road would be constructed on Navy-owned land adjacent to and inside the western boundary of West Loch Annex between Iroquois Road and North Road, to avoid impacts resulting from the closure of West Loch Drive. Real estate rights may be necessary to align or interconnect the new bypass road with existing infrastructure and owners. The two-lane, two-way bypass road would be constructed within a 60-foot wide right-of-way across Navy property. The bypass road would extend approximately 8,700 lineal feet or 1.65 miles. The travel way would consist of two 18-foot wide lanes, each of which would comprise an approximately 12-foot wide vehicular travel lane and an approximately six-foot wide paved shoulder. Each side would be bounded by two-foot wide curb and gutter, and ten-foot wide unpaved shoulder. Two new T-intersections would be created, one at the state-owned Iroquois Road and the other at a non-federal-owned North Road. At its intersection with Iroquois Road, the bypass road would be located approximately 350 feet inside the western boundary of West Loch Annex. The bypass road would encompass approximately 24 acres (Figure 2-4).

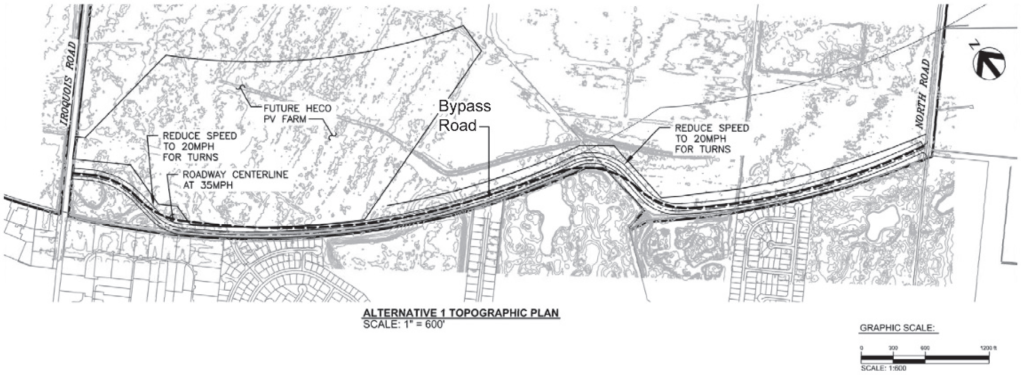
2.3.2.4 Perimeter Security and Entry Control Point

For security purposes, a ten-foot tall, wire strand, chain link fence is proposed on the eastern boundary of the 8,700-foot long bypass road right-of-way, within Navy property between Iroquois Road and North Road (Figure 2-1). An all-weather or aggregate surface security patrol road approximately 20 feet wide would be installed adjacent and to the east of the security fence (Figure 2-5). The perimeter fence and patrol road along this section would comprise approximately 19 acres.

The perimeter fence and patrol road would also extend approximately 5,500 feet along and inside the Annex boundary to the northwest of Iroquois Road. On the north end, the security fence and patrol road extends an additional 2,800 feet adjacent to the boundary of the Pearl Harbor National Wildlife Refuge to a point near the West Loch Annex shoreline (Figure 2-1). Along this northwest segment, the perimeter fence and patrol road comprise a total of approximately 19 acres. A perimeter fence and patrol road segment adjacent and parallel to Iroquois Road is included as part of the project as an alternative to the northwest segment. This alternative alignment covers approximately 10 acres.

At the connection with North Road, the perimeter fence and patrol road would continue on North Road to Iroquois Avenue, a distance of approximately 2,000 feet. Since West Loch Drive and portions of Iroquois Road and North Road would be closed to public access, a security gate would be installed on North Road at its Iroquois Avenue intersection. An additional area along Iroquois Avenue near the North Road intersection is included as part of the project to allow for minor intersection improvements. The perimeter fence and patrol road on North Road and the security gate would comprise approximately six acres. Public access would continue to be allowed on Iroquois Avenue and North Road connecting to the proposed bypass road and to Fort Weaver Road.

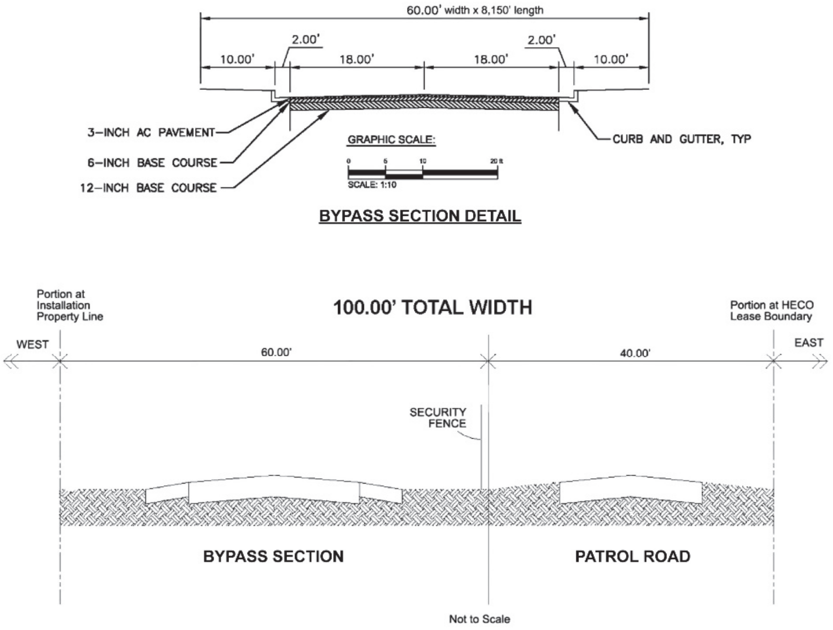
The security fence and patrol road would total approximately 54 acres.



Source: HDR

Plan View of Bypass Road **Figure 2-4**

Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii



Source: Julian Ng

Sections of Bypass Road and Patrol Road **Figure 2-5**

Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii

The existing front gate to West Loch Annex would remain at the corner of Iroquois Avenue and Barracks Road. The existing back gate is located at the intersection of Iroquois Road and West Loch Drive. The existing back gate would be demolished as it would no longer be required.

A new entry control point (ECP) would be constructed on Iroquois Road within the West Loch Annex boundary (Figure 2-1). The ECP may be located on either side of Iroquois Road. The ECP is comprised of a gate/sentry house, vehicle curbs and barriers, utility building and three parking stalls. A vehicle inspection, denial turnaround road, and inspection pull-out area would be installed as part of the ECP. The vehicle inspection area would be surrounded by an approximately ten-foot high earth berm or privacy walls. An approximately 40-foot high overwatch tower and a single story overwatch station would be located in proximity to the vehicle inspection area. Electrical power to the new ECP would be supplied by existing overhead electrical lines on Iroquois Road from the back gate to the site of the new facility. Fire hydrants would be installed and a new water line would be extended to the site. Subsurface water and electrical utilities would be within or adjacent to the existing Iroquois Road right-of-way. Communication utilities would extend from the primary power connection located at the existing back gate on 1st Street to the telephone exchange facility (Building 52) on D Avenue. These would be placed on existing power line poles. The land area encompassed by the ECP, appurtenant utility improvements and demolition of the existing back gate is approximately 142 acres. This area takes into consideration that the ECP may be located on either side of Iroquois Road.

Since the project provides additional ordnance storage within West Loch Annex (for ordnance loaded on and off ships berthed at West Loch wharves), the number of flatbed trucks and transport vehicles that would pass through the proposed Iroquois Road ECP should not change. No increase in personnel within the installation or for the ECP is anticipated.

Iroquois Road is currently owned by the State of Hawaii with a restricted easement granted to the Navy. Appropriate real estate interests would be obtained as needed for the bypass road intersection with Iroquois Road and the ECP which would be situated on or abut the state-owned portions of Iroquois Road.

The Proposed Action would incorporate Leadership in Energy and Environmental Design sustainable design elements, commonly referred to as LEED, and sustainable development concepts to achieve optimum resource efficiency, sustainability, and energy conservation. Low Impact Development techniques would be included in the design and construction of the Proposed Action as appropriate.

The total affected area for Alternative 1 would be approximately 310 acres.

Implementation of the Proposed Action would be in phases dependent on funding. Phase I would include the first four box magazines and adjacent site work (magazine access roads/concrete aprons, electrical, water, fire hydrants). Four subsequent construction phases are intended with the number of magazines included in each phase dependent on funding. Other improvements such as the perimeter fence, patrol road, entry control point on Iroquois Road, demolition of the existing back gate, the new gate on North Road at its intersection with Iroquois Avenue, and bypass road are intended to be constructed with the second phase of development depending on funding. West Loch Drive and portions of Iroquois Road and North Road would not be closed to public access until the bypass road is constructed and operational. Phase I is scheduled for construction in FY 2020 with subsequent phases planned in consecutive fiscal year budgets.

The summary of Alternative 1 project components are shown in Table 2-1.

Table 2-1 Summary of Alternative 1 Project Components

Project Component	***Alternative 1 (Preferred Alternative)***
24 Magazines, Adjacent Roads, Concrete Aprons, Electrical Service, Water, Fire Hydrants, Drainage, Communication, Staging Area, Access Roads	Approximately 90 acres (Twenty Four Magazines located adjacent to 10th Street. Construction staging and roadway access. Appurtenant improvements)
Bypass Road	Approximately 24 acres
Entry Control Point	Approximately 142 acres
Patrol Road, Security Fence, Gate on North Road	Approximately 54 acres
Total Acreage	Approximately 310 acres

2.3.3 Alternative 2 (24 New Box Type “D” Magazines Located West of West Loch Drive)

Alternative 2 is the same as Alternative 1 except that it involves the construction of 24 new box Type “D” magazines to the west of West Loch Drive and 6th Street. An adjacent area would be for construction staging (Figure 2-6). Alternative 2 also includes a new fire station.

The total area of the 24 magazines, and appurtenant roads, concrete pads, landscaping, and electrical, water, fire hydrant and drainage improvements would be approximately 39 acres. Construction staging would involve an additional 13 acres.

Because the location of the Alternative 2 magazines are in proximity to the existing Navy fire station, a new fire station is included in Alternative 2 for safety reasons. The new one-story fire station would be located on an approximately one-acre site at the corner of G Avenue and 18th Street (Figure 2-7), and would be a reinforced concrete and concrete masonry block structure with concrete footings and floor slab, steel roof joists with metal decking and built-up roofing. The fire station would include stalls for fire fighting vehicles, bathrooms, dormitory rooms, alarm room, combination day room and training area, dining area, exercise room, fire inspectors office, hose drying space, kitchen, medical supply storage area, shift supervisors office, work room, and storage space. In addition, a bedroom, office, shower and toilet facilities would be provided for the fire chief. The building would also include a fire protection system and air conditioning. Supporting facilities include sewer, water, electricity, site preparation, access road, parking area, emergency generator building, landscaping and fire hydrants. No increase in fire personnel is anticipated.

Reuse of the existing fire station would need to be compliant with DoD standards. No alterations are proposed for the existing fire station structure.

The total area of the 24 magazines, and appurtenant roads, pads, landscaping, and electrical, water, fire hydrant, drainage improvements and construction staging would be approximately 52 acres. The new fire station encompasses an additional area of approximately one-acre.

Alternative 2 includes the same bypass road improvements described under Alternative 1 (Section 2.3.2.3).

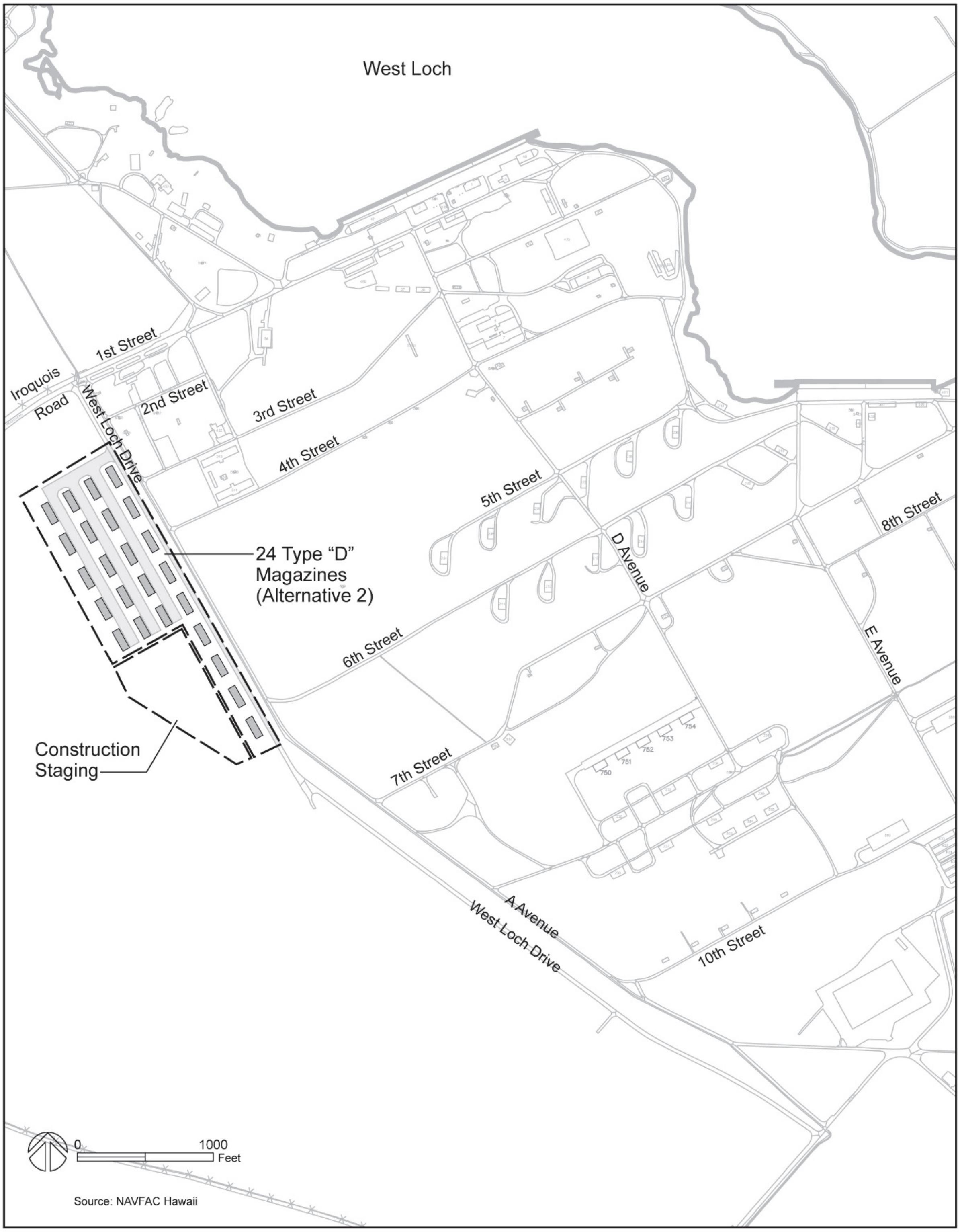
The total affected area for Alternative 2 would be approximately 273 acres.

This alternative meets the purpose and need for the action and was evaluated against the screening factors for alternatives. It was determined to be a reasonable alternative and is carried forward for analysis in this EA.

The summary of Alternative 2 project components are shown in Table 2-2.

Table 2-2 Summary of Alternative 2 Project Components

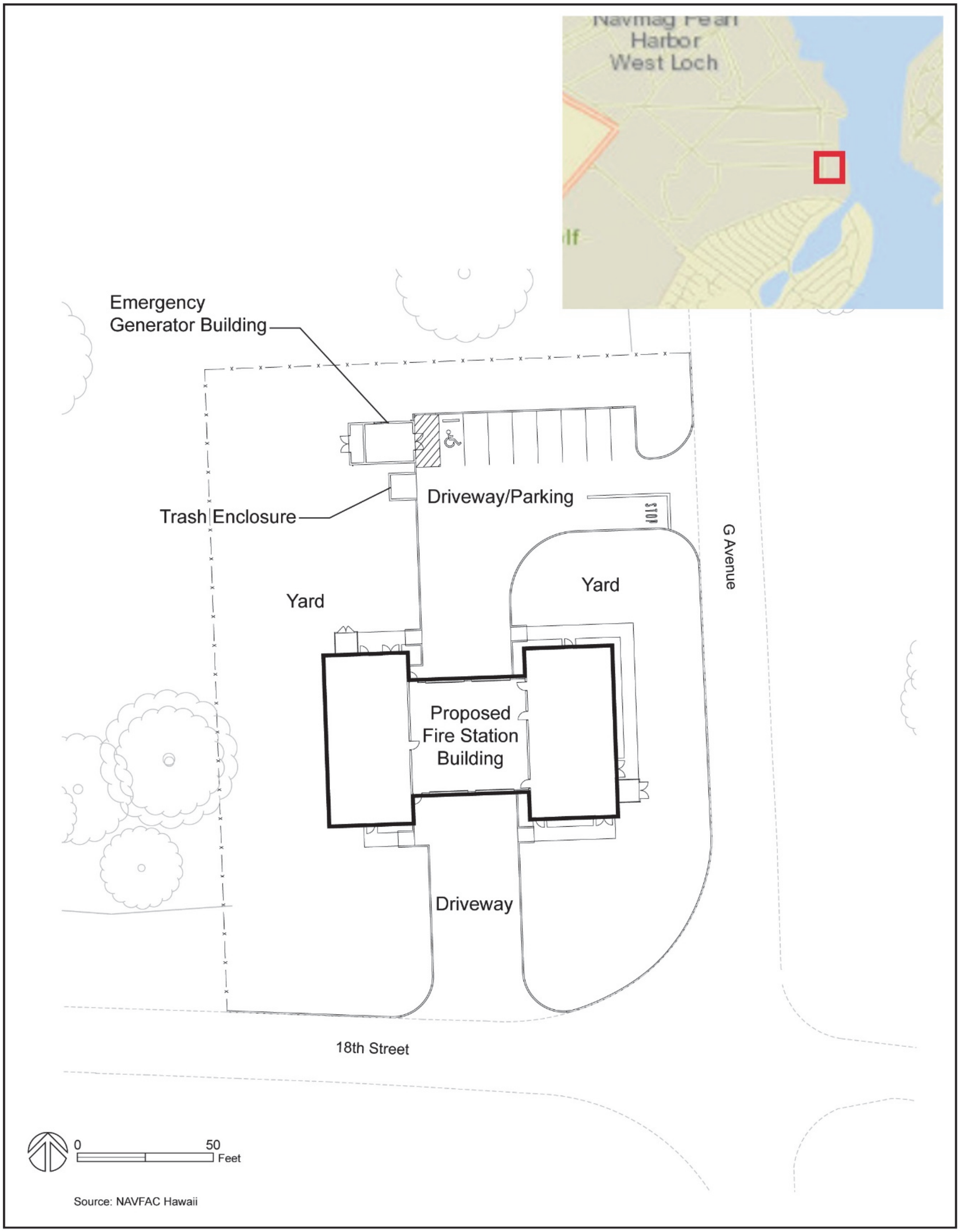
Project Component	*Alternative 2*
Magazines, Adjacent Roads, Concrete Aprons, Landscaping, Electrical Service, Water, Fire Hydrants, Drainage, Communication, Construction Staging	Approximately 52 acres (Twenty-four Magazines located to the west of West Loch Drive and 6th Street. Adjacent construction staging area. Appurtenant improvements)
Fire Station	Approximately one acre
Bypass Road	Approximately 24 acres (Same as Alternative 1)
Entry Control Point	Approximately 142 acres (Same as Alternative 1)
Patrol Road, Security Fence, Gate on North Road	Approximately 54 acres (Same as Alternative 1)
Total Acreage	Approximately 273 acres



Source: NAVFAC Hawaii

Alternative Layout with 24 Magazines (Alternative 2) **Figure 2-6**

Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii



Source: NAVFAC Hawaii

Proposed Fire Station **Figure 2-7**

Magazines for Long Ordnance, West Loch Annex

Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii

2.4 Alternatives Considered but not Carried Forward for Detailed Analysis

The following alternatives were considered, but not carried forward for detailed analysis in this EA as they did not meet the purpose and need for the project and satisfy the reasonable alternative screening factors presented in Section 2.2.

2.4.1 Retrofit/Alteration/Modification/Renovation of Existing Facilities at West Loch Annex

This alternative involves possible retrofit/alteration/modification/renovation of existing facilities at West Loch Annex. This alternative is not an option since there are not enough existing facilities at West Loch Annex to meet present and future planning requirements. All existing magazines at West Loch Annex are fully utilized. Moreover, some existing magazines at West Loch Annex would require major structural modifications/demolition to satisfy long ordnance storage requirements. There are also no other federal facilities on the island which could support this requirement. Retrofit/alteration/modification/ renovation is not a practical and viable alternative and is not being carried forward for further analysis.

2.4.2 Construction of New Magazine Area Outside of Current Alternative Sites but Within West Loch Annex

Regarding other areas within West Loch Annex, safety constraints involve taking into consideration the location of the magazines as well as the future movement of ordnance between the wharves and the respective magazines. New magazines should be a generous distance away from existing residential uses. Safety of Navy personnel working in the area is also of paramount concern. Thus, safe distances from residential use and Navy personnel (except those directly involved with ordnance transport and maintenance) must be factored into the location of the magazines. This limits flexibility of placement of new magazines. In addition, West Loch Annex is part of the Pearl Harbor National Historic Landmark. The Navy has identified historic and cultural resources within West Loch Annex. For these reasons, certain areas within West Loch Annex are discounted at the present time due to factors such as safety and cultural resource considerations and is not being carried forward for further analysis.

2.4.3 Development of New Magazine Area Outside of West Loch Annex but Within JBPHH

This alternative involves consideration of possible alternative locations within JBPHH but outside of the Alternative 1 and 2 sites. Since loading/unloading of ordnance occurs at West Loch Annex, other areas of JBPHH such as Hickam Air Force Base, Ford Island, Pearl City Peninsula, Waipio Peninsula, and Lualualei Annex would necessarily involve travel over public roadways. This adds transportation costs as well as increases security and accident risks. These areas also have insufficient space for new magazine storage and safety clearances and are in proximity to residential or other public facilities. Thus, use of the foregoing areas for new magazine storage represents an unacceptable risk and is not being carried forward for further analysis.

2.4.4 Construction of New Magazines Outside of Oahu

This alternative involves constructing new magazines at a US Navy site outside of Oahu. This would not meet the basic purpose of the action to provide sufficient storage space for JBPHH to meet its current ordnance storage requirement. In effect, this would be similar to the no action alternative.

2.4.5 Leasing of Privately Owned Facilities

This alternative involves leasing of privately owned facilities for ordnance storage. This alternative was considered but is not being carried forward for detailed analysis in the EA because of inherent public safety risks of storing ordnance outside of a secured military installation. Use of a private off-site facility for ordnance storage would require additional security and operational costs already provided by West Loch Annex. Transporting of ordnance to and from West Loch wharves from a private off-site facility would also entail security risks. Leasing of privately owned facilities represents an unacceptable risk and is not being carried forward for further analysis.

2.4.6 Development of Transportation Sub-alternatives

Since West Loch Drive and portions of Iroquois Road and North Road would be closed to public access, several transportation sub-alternatives were reviewed and considered. For various reasons discussed below, these alternatives are not being carried forward for further analysis. Additional detail on these alternatives are included in Appendix B.

2.4.6.1 Development of New Public Roadway as Extension of Iroquois Avenue

This sub-alternative involves consideration of a new bypass road as an extension of Iroquois Avenue which would be adjacent or abutting the eastern boundary of the planned Hawaiian Electric Company (HECO) solar PV farm. This would extend from Iroquois Avenue to Iroquois Drive and generally bisects Navy property between West Loch Drive and the West Loch Annex boundary. From a traffic standpoint, this bypass road alignment would replace the existing West Loch Drive alignment. Thus, any difference in traffic impact resulting from the project upon roadways on the vicinity should be minimal. Moreover, the bypass road alignment would be in excess of 900 feet away from existing residential uses. Thus, any additional traffic impact resulting from the project should be negligible.

However, existing residential uses have been required to comply with applicable safety buffer distances as evidenced by the limits of development along the western boundary of West Loch Annex. These lands have been procured by the federal government as a safety buffer. A new bypass roadway as an extension of Iroquois Avenue would lead to a reduction of possible options in the use of Navy alternatives to utilize West Loch Annex lands. Possible future Navy facility needs at West Loch Annex may require additional lands which may be precluded due to the location of the bypass road as an extension of Iroquois Avenue. Alternatively, this may trigger a relocation of the bypass road as extension of Iroquois Avenue. This preclusion of options is short-sighted and would not result in optimal use of federal resources. From a standpoint of a lack of a focus on long term planning and a lack of practicality, this alternative is not being carried forward for further analysis.

2.4.6.2 Development of New Public Roadway Between Kapilina and End of Fort Weaver Road

This sub-alternative involves consideration of a possible public roadway between Kapilina and the end of Fort Weaver Road, assuming closure of West Loch Drive and portions of Iroquois Road and North Road to public access. Consideration of this public roadway would preclude the public bypass along the western boundary of the project between Iroquois Road and North Road. Other portions of the preferred alternative were not considered for revision.

Some traffic currently using West Loch Drive could still be expected to travel via Iroquois Avenue, North Road and Hanakahi Street, since this route would be shorter in both travel distance and non-peak travel times.

The overall Level of Service for the intersection of Fort Weaver Road and Hanakahi Street/Keoneula Boulevard during the AM peak hour with the closure of West Loch Drive and without a new bypass road is Level of Service (LOS) E (LOS is a term defined in the Transportation Research Board's Highway Capacity Manual and based on the average delay per vehicle - with LOS A described as very little or no delay and LOS F described as very long traffic delays; see expanded explanation provided in Section 3.1 and Appendix B). Improved LOS could be achieved by converting the existing curb parking and right turn only lane into a third northbound lane on Fort Weaver Road. A similar practice occurs in many areas of high traffic volumes on Oahu, where a curb lane normally available for parallel parking is converted to a through traffic lane (with Tow-Away Zone or No Parking restrictions) during peak periods. In order to do this, however, widening of the existing shoulder (along with narrowing the existing wide sidewalk and reconstructing the existing curb, gutter, and drain structures) for a short distance north of the intersection would be necessary to provide adequate width for the third lane. With the third lane, overall conditions based on average peak hour delay would be LOS D. However, a number of individual intersection movements were identified as LOS E and F.

Extending the third northbound lane on Fort Weaver Road, between Hanakahi Street and Iroquois Road to meet an existing third lane may involve, at a minimum, strengthening the shoulder, replacing an existing multi-use path, and modifying traffic channelization at Keaunui Drive intersection. Based on the results of the traffic analyses for the Fort Weaver Road and Aikanaka Road intersection, the need for the third northbound lane is anticipated to begin north of the Papipi Road intersection. The use of a third northbound lane would only be necessary during the morning peak period.

Traffic on Hanakahi Street, however, would likely be similar to a no bypass road scenario. With West Loch Drive closed, the most direct route would include North Road between Iroquois Avenue and Hanakahi Street, Hanakahi Street between North Road and Fort Weaver Road, and Fort Weaver Road between Hanakahi Street and Iroquois Road. If a large portion of this traffic were added to Hanakahi Street, traffic volume could be twice (or more) the existing traffic volume if not for the physical limitations of the street.

Realistically, however, the increase in traffic on Hanakahi Street would be limited. Physical constraints to the capacity of Hanakahi Street or of turn lanes at the Hanakahi-Fort Weaver Road intersection would limit the increases in traffic on Hanakahi Street during peak periods when these intersections are already near capacity, and this would result in increased traffic volumes on other streets. In addition to Hanakahi Street, other existing alternative routes which would be impacted are North Road between Hanakahi Street and Fort Weaver Road and Kilaha Street between North Road and Fort Weaver Road.

Because of the overall deterioration of operating conditions, even with the bypass road between Kapilina and Fort Weaver Road, this alternative is not being carried forward for further analysis.

2.4.6.3 Use of Existing Roads Only (no bypass road)

If neither a bypass road nor a connection to the end of Fort Weaver Road is provided, this alternative would route traffic through existing residential neighborhood streets. Since much of the traffic would connect to Fort Weaver Road through either North Road directly or from Kuhina Street or Hanakahi Street via North Road, the additional northbound lane on Fort Weaver Road (between North Road and Iroquois Road) in the morning peak period as discussed in Section 2.4.6.2 would also be needed in order to accommodate the higher volume of traffic using Fort Weaver Road through that segment.

Poor LOS at the intersection of North Road and Hanakahi Street could be addressed by providing separate turn lanes on North Road. This would require widening of the roadway and extending the center lane to provide a refuge lane for left turns from Hanakahi Street. This would allow drivers desiring to turn left out of Hanakahi Street to take advantage of gaps in each direction on North Road rather than wait for a simultaneous gap in both directions.

However, while possible design treatments could result in acceptable conditions at the North Road and Hanakahi Street intersection, residents of affected streets in the neighborhood would have increased traffic congestion on streets already at, near or over capacity. In addition to Hanakahi Street, other existing alternative routes which would be impacted are North Road between Hanakahi Street and Fort Weaver Road and Kilaha Street between North Road and Fort Weaver Road. Thus, this alternative would result in further deterioration of traffic conditions, greater environmental impact and is not being carried forward for further analysis.

2.4.7 Best Management Practices

This section presents an overview of the best management practices (BMPs) that are incorporated into the Proposed Action in this document. BMPs are existing policies, practices, and measures that the Navy would adopt to reduce the environmental impacts of designated activities, functions, or processes. Although BMPs mitigate potential impacts by avoiding, minimizing or reducing/eliminating impacts, BMPs are distinguished from potential mitigation measures because BMPs are (1) existing requirements for the Proposed Action, (2) ongoing, regularly occurring practices, or (3) not unique to this Proposed Action. In other words, the BMPs identified in this document are inherently part of the Proposed Action and are not potential mitigation measures proposed as a function of the NEPA environmental review process for the Proposed Action. Table 2-3 includes a list of BMPs.

Table 2-3 Best Management Practices

BMP	*Description*	*Impacts Reduced/Avoided*
Implement appropriate construction noise abatement measures	A contractor-prepared Construction Noise Mitigation and Management Plan is recommended as a local best practice, because of the proximity of private residential uses to the proposed bypass and security road corridors.	Minimize construction noise impact upon adjacent uses
Implement construction dust control plan	Example BMPs include watering of active work areas, using wind screens, keeping adjacent paved roads clean, covering of open-bodied trucks, limiting the area that is disturbed at any given time and/or mulching or chemically stabilizing inactive areas that have been worked. Other potential BMPs include paving and landscaping of project areas early in the construction schedule and moving construction equipment and workers to and from the project site during off-peak traffic hours.	Prevents or minimizes fugitive particulate emissions from being transported away from the project area

BMP	***Description***	***Impacts Reduced/Avoided***
Erosion control	Compliance with National Pollutant Discharge Elimination System provisions including Storm Water Pollution Prevention Plans; erosion and sediment control measures, such as protection of erodible soils; control of storm water runoff from the construction site; use of sediment basins; use of vegetation and mulch on soil exposed by grading; use of silt fencing and barriers around excavated and cleared areas; and fugitive dust control measures.	Prevents or minimizes water quality impacts on receiving waters
Management of Historic Properties	In the event that there are inadvertent discoveries of cultural resources during the project, work must cease to allow the find to be assessed by DoN archaeologists. If the resource is determined to be significant, the DoN will initiate Section 106 consultation.	Protection of historic properties
Tree removal	No cutting of trees 15 feet or higher would occur during bat pupping season (June 1 to September 15).	To prevent disturbance to Hawaiian hoary bats
Pre-construction nest surveys of protected bird species	Conduct nest surveys for protected bird species before construction. Active nests would be left in place and undisturbed until chicks have fledged. A qualified biologist would monitor active nests during construction activities to reduce the chances of nest abandonment by temporarily shutting down construction activities that disrupt the normal daily patterns of the birds.	To prevent adverse impacts to protected avian species.
Shielded lighting	Use of shielded and Migratory Bird Treaty Act-compliant outdoor lights	To prevent disorientation, disturbance, and/or injury to protected avian species
Management of biological resources	Implement habitat management measures outlined in the JBPHH Integrated Natural Resources Management Plan	Protect and benefit threatened and endangered species on JBPHH -controlled lands
Hazardous Waste Management	Handle, transport, dispose of and/or remediate hazardous materials or waste encountered during construction in accordance with applicable federal and state regulations.	Protection of construction workers/community members from any hazardous material encountered during construction.

3 Affected Environment and Environmental Consequences

This chapter presents a description of the environmental resources and baseline conditions that could be affected from implementing any of the alternatives and an analysis of the potential direct and indirect effects of each alternative.

All potentially relevant environmental resource areas were initially considered for analysis in this Environmental Assessment (EA). In compliance with the National Environmental Policy Act (NEPA), the Council on Environmental Quality (CEQ), and Department of Navy guidelines; the discussion of the affected environment (i.e., existing conditions) focuses only on those resource areas potentially subject to impacts. Additionally, the level of detail used in describing a resource is commensurate with the anticipated level of potential environmental impact.

"Significantly," as used in NEPA, requires considerations of both context and intensity. Context means that the significance of an action must be analyzed in several contexts such as society as a whole (e.g., human, national), the affected region, the affected interests, and the locality. Significance varies with the setting of a proposed action. For instance, in the case of a site-specific action, significance would usually depend on the effects in the locale rather than in the world as a whole. Both short- and long-term effects are relevant. Intensity refers to the severity or extent of the potential environmental impact, which can be thought of in terms of the potential amount of the likely change. In general, the more sensitive the context, the less intense a potential impact needs to be in order to be considered significant. Likewise, the less sensitive the context, the more intense a potential impact would be expected to be significant.

This section includes transportation, noise, air quality, land use, public health and safety, visual resources, biological resources, cultural resources, infrastructure, socioeconomics, environmental justice water resources, geological resources, and hazardous materials and wastes.

The potential impacts to the following resource areas are considered to be negligible or non-existent so they were not analyzed in detail in this EA:

Airspace: Construction and operation of the Proposed Action does not involve impacts to military or civilian airspace. The proposed magazines and related improvements are low rise and constructed to applicable safety standards.

3.1 Transportation

This discussion of transportation includes all of the air, land, and sea routes with the means of moving passengers and goods. A transportation system can consist of any or all of the following: roadways, bus routes, railways, subways, bikeways, trails, waterways, airports, and taxis, and can be looked at on a local or regional scale.

Traffic is commonly measured through average daily traffic and design capacity. These two measures are used to assign a roadway with a corresponding level of service (LOS). The LOS designation is a professional industry standard used to describe the operating conditions of a roadway segment or intersection. The LOS is defined on a scale of A to F that describes the range of operating conditions on a particular type of roadway facility. LOS A through LOS B indicates free flow travel. LOS C indicates stable traffic flow. LOS D indicates the beginning of traffic congestion. LOS E indicates the nearing of traffic breakdown conditions. LOS F indicates stop-and-go traffic conditions and represents unacceptable congestion and delay.

3.1.1 Regulatory Setting

Executive Order (EO) 13834 Efficient Federal Operations affirms "that agencies shall meet such statutory requirements in a manner that increases efficiency, optimizes performance, eliminates unnecessary use of resources, and protects the environment."

The *Highway Capacity Manual* is a publication by the Transportation Research Board, a division of the National Academies of Sciences, Engineering, and Medicine that provides research-based solutions to improve transportation. The *Highway Capacity Manual* is a nationally-accepted reference for concepts, performance measures, and analysis techniques for evaluating the multimodal operation of streets, highways, freeways, and off-street pathways. It provides an integrated multimodal approach to the analysis and evaluation of urban streets from the points of view of automobile drivers, transit passengers, bicyclists, and pedestrians. It includes a methodology for evaluating the capacity and quality of service provided to road users traveling through signalized intersections.

3.1.2 Affected Environment

Uses adjacent to West Loch Annex include the Ewa by Gentry residential community, the Hawaii Prince Golf Club, older residential subdivisions built about 50 years ago (Leeward Estates) and the Ewa Beach Golf Club (Figure 3-1). The older subdivisions include approximately 580 single-family lots served by streets built in the 1960's (when the street standard included rolled curbs and unpaved sidewalks) along Kuhina Street and the Hawaii Prince Golf Club. Approximately 750 lots southeast of Kuhina Street were built on streets meeting more recent standards, which include barrier curbs and concrete sidewalks. Several apartment complexes are located southeast of North Road. James Campbell High School, Ilima Intermediate School, Pohakea Elementary School, Kaimiloa Elementary School, and Our Lady of Perpetual Help School are also located in this area.

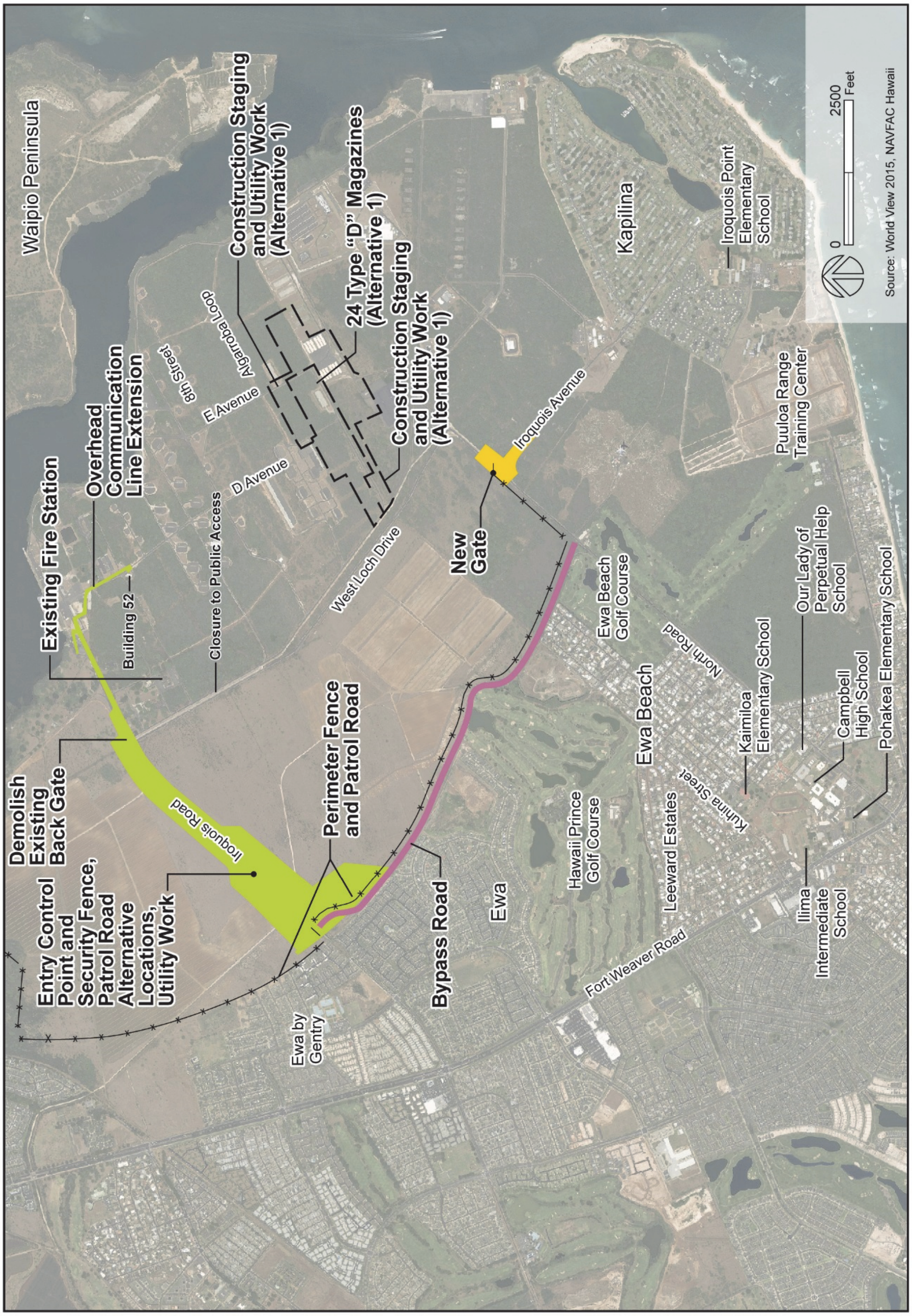
The Kapilina residential community, formerly Iroquois Point Naval housing, includes nearly 1,500 housing units and is located south of West Loch Annex. Iroquois Point Elementary School is located within the community. Access to Kapilina is through Iroquois Avenue and North Road which connects with Fort Weaver Road, the main traffic artery serving this area of Ewa and West Loch Annex.

Kapilina residents use both North Road directly to Fort Weaver Road (through Navy property) and West Loch Drive via Iroquois Road to Fort Weaver Road. The latter route bypasses about 1.5 miles of typically congested Fort Weaver Road.

Table 3-1 is excerpted from Appendix B and describes the delays associated with each Level of Service. Level of Service F describes conditions when traffic volume exceeds capacity.

Figure 3-2 presents an aerial view of the referenced intersections as well as existing morning, mid-day (school pickup hours) and evening traffic movements and peak hour counts. Table 3-2 shows the existing conditions at Iroquois Road and West Loch Drive.

Figure 3-3 shows an aerial view of the intersection as well as existing traffic counts. Table 3-3 shows the existing conditions at North Road and Iroquois Avenue.



Source: World View 2015, NAVFAC Hawaii

Figure 3-1

Uses Adjacent to West Loch Annex

Magazines for Long Ordnance, West Loch Annex

Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii

Table 3-1 Level of Service Categories

Average Delay (seconds per vehicle)	*General Description of Delay*	*Level of Service (LOS)*
≤ 10	Little or no delay	A
> 10 and ≤ 25	Short traffic delays	B
> 25 and ≤ 35	Average traffic delays	C
> 35 and ≤ 55	Long traffic delays	D
> 55 and ≤ 80	Very long traffic delays	E
> 80	Very long traffic delays	F

Source: *Highway Capacity Manual*, 2010 in Julian Ng Inc., 2018 (Appendix B)

3.1.3 Environmental Consequences

Transportation Potential Impacts:

- Impacts resulting from closure of West Loch Drive.

Impacts to ground traffic and transportation are analyzed by considering the possible changes to existing traffic conditions and the capacity of area roadways from proposed increases in commuter and construction traffic.

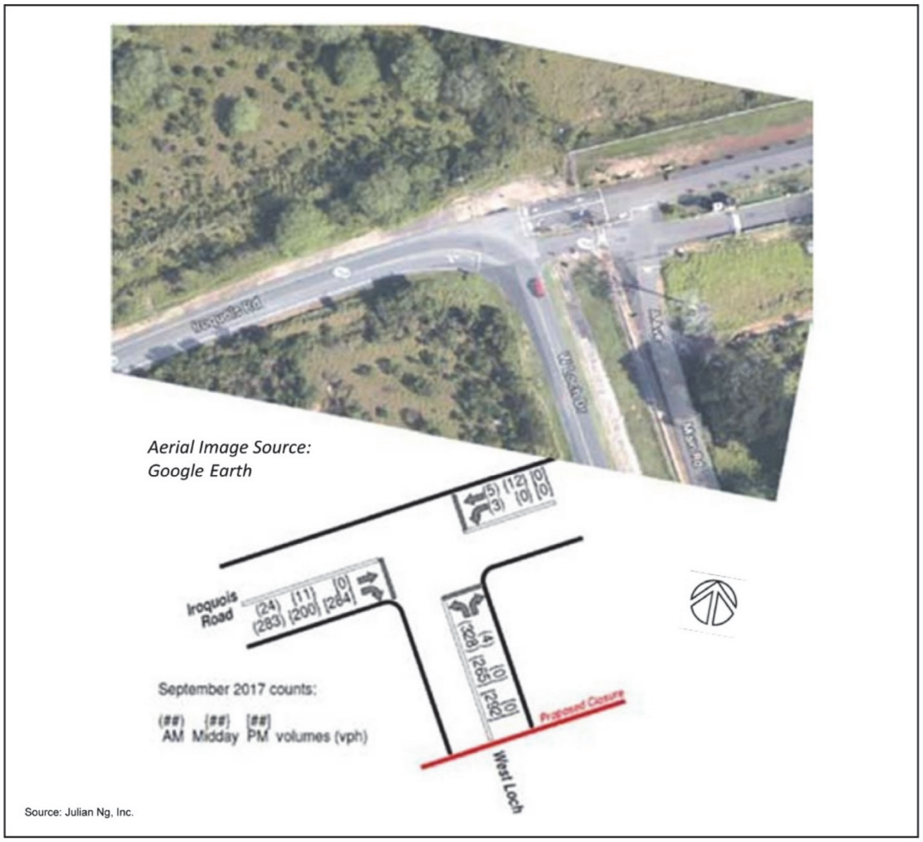
Due to safety considerations, portions of North Road, West Loch Drive and Iroquois Road, located within the JBPHH West Loch Annex installation, need to be closed to public access.

A traffic study was conducted to evaluate the potential effects to vehicular traffic conditions resulting from closure of West Loch Drive to public traffic. See Appendix B. Closure of West Loch Drive would divert approximately 6,525 vehicles per day onto other streets during a typical workday. Several transportation alternatives were considered to avoid or minimize the impact.

The Navy has selected a new bypass road along the inside of the installation boundary between Iroquois Road and North Road as part of the Proposed Action for both action alternatives. Other transportation alternatives were discussed in Section 2.4.6, Development of Transportation Sub-alternatives. Additional detail pertaining to these alternatives are included in the traffic study in Appendix B.

At the proposed intersection with the bypass road and Iroquois Road, the reassigned volumes would be similar to the existing volume at the Iroquois Road-West Loch Drive intersection. Assuming similar stop controls as the existing controls at the Iroquois Road-West Loch Drive intersection, delays and level of service at the bypass road-Iroquois Road intersection would be the same as the Iroquois Road-West Loch Drive intersection. LOS is primarily “A” or “B” for the various turning movements.

At the bypass road-North Road intersection, traffic volumes would be similar to existing volumes at the Iroquois Avenue-North Road intersection. With the closure of West Loch Drive, left turns now being made from North Road to Iroquois Avenue would become left turns from the bypass road to North Road. Similarly, right turns now being made from Iroquois Avenue to North Road would become right turns from North Road to the bypass road.



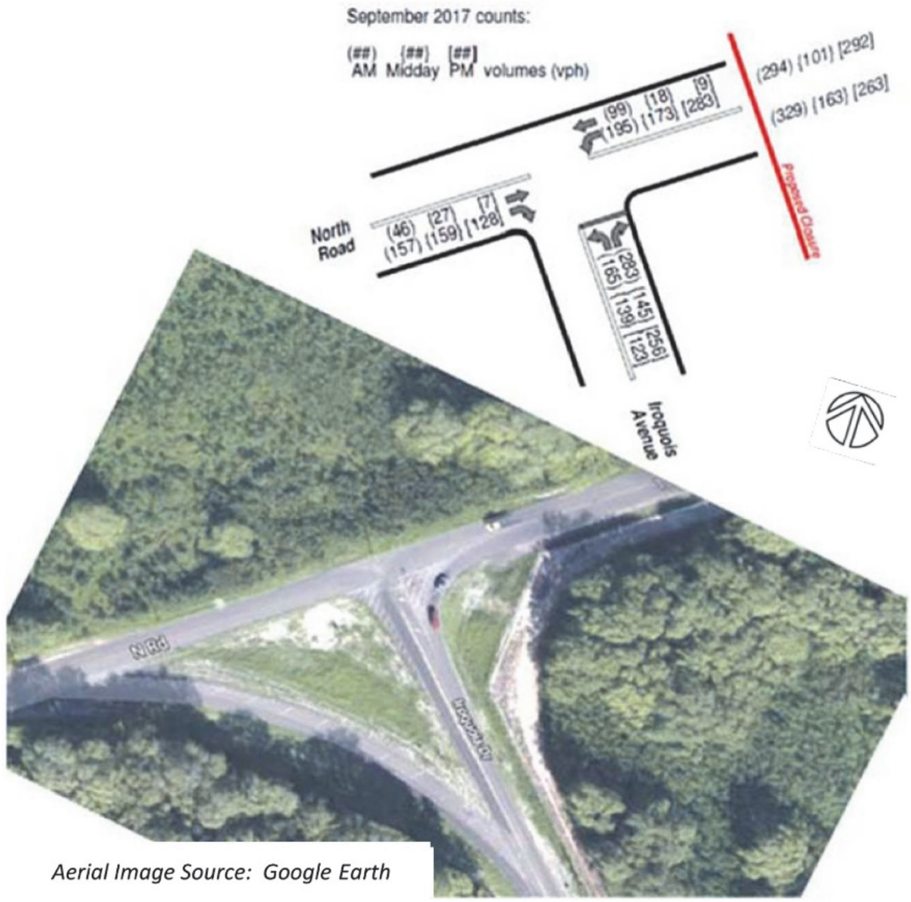
Source: Julian Ng, Inc.

Aerial View and Traffic Counts at Iroquois Road and West Loch Drive Intersection **Figure 3-2**
Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii

Table 3-2 Existing Traffic Conditions at Iroquois Road and West Loch Drive

Lane/Turn	*AM Peak Hour (0700-0800)*			*MM Peak Hour (Midday 1415-1515)*			*PM Peak Hour(1600-1700)*		
	X	*Delay*	*LOS*	*X*	*Delay*	*LOS*	*X*	*Delay*	*LOS*
Northbound Approach	0.38	10.8	B	0.31	10.2	B	0.33	10.3	B
Eastbound Approach	0.31	9.7	A	0.22	9.2	A	0.31	9.8	A
Westbound Left Turn Lane	0.01	11.8	B	---	---	---	0.00	---	---
Westbound Through Lane	0.01	9.0	A	0.02	9.1	A	0.00	---	---

X = Utilization (volume/capacity ratio)
Delay = Average Delay per vehicle, expressed in seconds
LOS = Level of Service
Note: Delay and LOS not shown where volume = 0



Aerial Image Source: Google Earth

Source: Julian Ng, Inc.

Aerial View and Traffic Counts at North Road and Iroquois Avenue **Figure 3-3**
Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii

Table 3-3 Existing Traffic Conditions at North Road and Iroquois Avenue

Lane/Turn	*AM Peak Hour (0700-0800)*			*MM Peak Hour (Midday 1345-1445)*			*PM Peak Hour(1600-1700)*		
	X	*Delay*	*LOS*	*X*	*Delay*	*LOS*	*X*	*Delay*	*LOS*
Northbound Left Turn	0.49	22.6	C	0.41	18.0	C	0.43	22.8	C
Northbound Right Turn	0.33	10.2	B	0.19	9.3	A	0.29	9.7	A
Westbound Left Turns	0.17	8.2	A	0.18	8.3	A	0.24	8.3	A

X = Utilization (volume/capacity ratio)
Delay = Average Delay per vehicle, expressed in seconds
LOS = Level of Service

Table 3-4 shows the results of the unsignalized intersection analyses. This documents that LOS "B" or better conditions could be achieved if separate left and right turn lanes are provided on the bypass road approach to North Road. If a separate left turn lane is provided, LOS "D" or better conditions could be achieved.

Table 3-4 Intersection Analyses at Bypass Road and North Road

Lane/Turn	*AM Peak Hour (0700-0800)*			*MM Peak Hour (Midday 1345-1445)*			*PM Peak Hour (1600-1700)*		
	X	*Delay*	*LOS*	*X*	*Delay*	*LOS*	*X*	*Delay*	*LOS*
Southbound									
• If Shared Lane	0.77	35.3	E	0.57	23.3	C	0.71	27.6	D
• If Separate Left Turn Lane	0.60	27.7	D	0.54	22.8	C	0.69	26.9	D
• If Separate Right and Left Turn Lanes	0.17	11.3	B	0.03	9.9	A	0.01	10.0	A
Eastbound Left Turn	0.05	8.6	A	0.03	8.1	A	0.01	8.3	A

X = Utilization (volume/capacity ratio)
Delay = Average Delay per vehicle, expressed in seconds
LOS = Level of Service

Estimated travel time between the Iroquois Avenue/North Road intersection and the Iroquois Road/Fort Weaver Road intersection is estimated to be 6 minutes using West Loch Drive. Travel time on the bypass road between the same two points is not expected to increase.

3.1.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to existing transportation routes. Therefore, no impacts to transportation would occur with implementation of the No Action Alternative.

3.1.3.2 Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative) Potential Impacts

The study area for the analysis of effects to transportation associated with the Preferred Alternative includes areas which would be altered by:

- the proposed 24 box magazines clustered around the 10th Street and E Avenue intersections;
- adjacent construction staging and roadway access;
- adjacent roadways and concrete pads, utility improvements, landscaping, and drainage improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

The bypass road would extend near the western boundary of West Loch Annex and would create two new T-intersections: a northern intersection with Iroquois Road and a southern intersection with North Road.

The bypass road would reconnect Iroquois Road and North Road and would maintain existing traffic conditions on Fort Weaver Road and within the community. The two new intersections created by the bypass road, one at Iroquois Road and the other at North Road, were found to provide adequate levels of service with typical stop controls at the intersections. LOS "B" or better conditions could be achieved if separate right and left turn lanes are provided on the bypass road approach to North Road. LOS "D" or better conditions could be achieved if a separate left turn lane is provided on the bypass road approach to North Road.

The bypass roadway would avoid the traffic effects attributable to the closure of West Loch Drive since the bypass road would be completed and opened for use prior to the closing of West Loch Drive.

The bypass road is essentially a replacement of the West Loch Drive route. The replacement of the two-way two-lane vehicular route does not affect bus routes or rail. A 10- foot-wide shoulder is being provided on both sides of the bypass road. Bicycles and pedestrians may utilize the shoulder of the bypass road.

Therefore, implementation of the Preferred Alternative would result in less than significant impacts to transportation.

3.1.3.3 Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive) Potential Impacts

The study area for the analysis of effects to transportation associated with this alternative includes:

- 24 box magazines west of West Loch Drive and 6th Street;
- adjacent construction staging;
- fire station;
- adjacent roadways and concrete pads, utility improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

Alternative 2 would also include the same improvements with the same specifications as the Preferred Alternative, with the exception of the location of the 24 magazines, construction staging and appurtenant improvements and new fire station. The Alternative 2 magazines would be located outside of the internal existing West Loch Drive fence line - that would become obsolete with the construction of the proposed new perimeter security fence line. Thus, in order to provide necessary base security as well as full intended use of Alternative 2 magazines, closure of the existing alternative route of North Road, West Loch Drive and Iroquois Road is recommended to occur prior to completion of the Alternative 2 magazines. Should applicable security measures not be completed prior to completion of the Alternative 2 magazines, this would limit its use.

With the foregoing management measure, implementation of Alternative 2 would result in less than significant impacts to transportation.

3.2 Noise

This discussion of noise includes the types or sources of noise and the associated sensitive receptors in the human environment.

Sound is a physical phenomenon consisting of minute vibrations that travel through a medium, such as air or water, and are sensed by the human ear. Sound is all around us. The perception and evaluation of sound involves three basic physical characteristics:

- Intensity – the acoustic energy, which is expressed in terms of sound pressure, in decibels (dB)
- Frequency – the number of cycles per second the air vibrates, in Hertz (Hz)
- Duration – the length of time the sound can be detected

Noise is defined as unwanted or annoying sound that interferes with or disrupts normal human activities. Although continuous and extended exposure to high noise levels (e.g., through occupational exposure) can cause hearing loss, the principal human response to noise is annoyance. The response of different individuals to similar noise events is diverse and is influenced by the type of noise, perceived importance of the noise, its appropriateness in the setting, time of day, type of activity during which the noise occurs, and sensitivity of the individual.

3.2.1 Basics of Sound and A-Weighted Sound Level

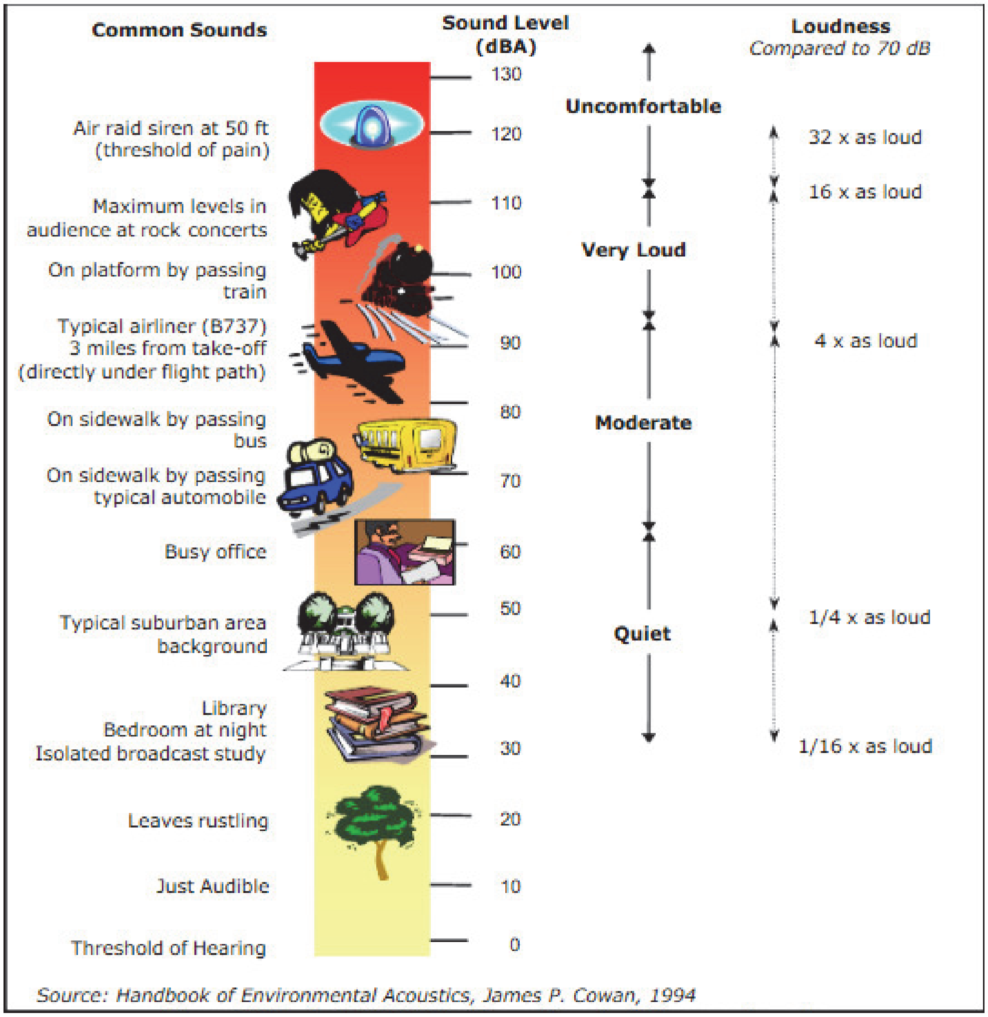
The loudest sounds that can be detected comfortably by the human ear have intensities that are a trillion times higher than those of sounds that can barely be detected. This vast range means that using a linear scale to represent sound intensity is not feasible. The dB is a logarithmic unit used to represent the intensity of a sound, also referred to as the sound level. All sounds have a spectral content, which means their magnitude or level changes with frequency, where frequency is measured in cycles per second or Hz. To mimic the human ear's non-linear sensitivity and perception of different frequencies of sound, the spectral content is weighted. For example, environmental noise measurements are usually on an "A-weighted" scale that filters out very low and very high frequencies in order to replicate human sensitivity. It is common to add the "A" to the measurement unit in order to identify that the measurement has been made with this filtering process (dBA). In this document, the dB unit refers to A-weighted sound levels. Table 3-5 provides a comparison of how the human ear perceives changes in loudness on the logarithmic scale.

Table 3-5 Subjective Responses to Changes in A-Weighted Decibels

Change	*Change in Perceived Loudness*
3 dB	Barely perceptible
5 dB	Quite noticeable
10 dB	Dramatic – twice or half as loud
20 dB	Striking – fourfold change

Figure 3-4 (Cowan, 1994) provides a chart of A-weighted sound levels from typical noise sources. Some noise sources (e.g., air conditioner, vacuum cleaner) are continuous sounds that maintain a constant sound level for some period of time. Other sources (e.g., automobile, heavy truck) are the maximum sound produced during an event like a vehicle pass-by. Other sounds (e.g., urban daytime, urban nighttime) are averages taken over extended periods of time.

Figure 3-4 A-Weighted Sound Levels from Typical Sources



Source: *Handbook of Environmental Acoustics, James P. Cowan, 1994*

3.2.2 Regulatory Setting

Under the Noise Control Act of 1972, the Occupational Safety and Health Administration established workplace standards for noise. The minimum requirement states that constant noise exposure must not exceed 90 A-weighted decibels (dBA) over an 8-hour period. The highest allowable sound level to which workers can be constantly exposed is 115 dBA and exposure to this level must not exceed 15 minutes within an 8-hour period. The standards limit instantaneous exposure, such as impact noise, to 140 dBA. If noise levels exceed these standards, employers are required to provide hearing protection equipment that will reduce sound levels to acceptable limits.

The Federal Highway Administration's (FHWA) *Highway Traffic Noise* Regulation*: Analysis and Abatement* Guidance Section 23 CFR Part 772 provides procedures for noise studies and noise abatement measures associated with federal highway projects to help protect the public health, welfare and livability, to supply noise abatement criteria, and to establish requirements for information to be given to local officials for use in the planning and design of highways. The provisions apply to a federal or federal-aid highway project that involves construction of a highway in a new location.

The State of Hawaii regulates noise pollution through Chapter 342F Hawaii Revised Statutes, Noise Pollution, and Chapter 11-46 Hawaii Administrative Rules (HAR), Community Noise Control, administered by the Hawaii Department of Health. The rules define maximum permissible sound levels and provide for the prevention and control and abatement of noise pollution in the State of Hawaii from construction activities and other sources of noise. The Navy considers these rules as local best management practices.

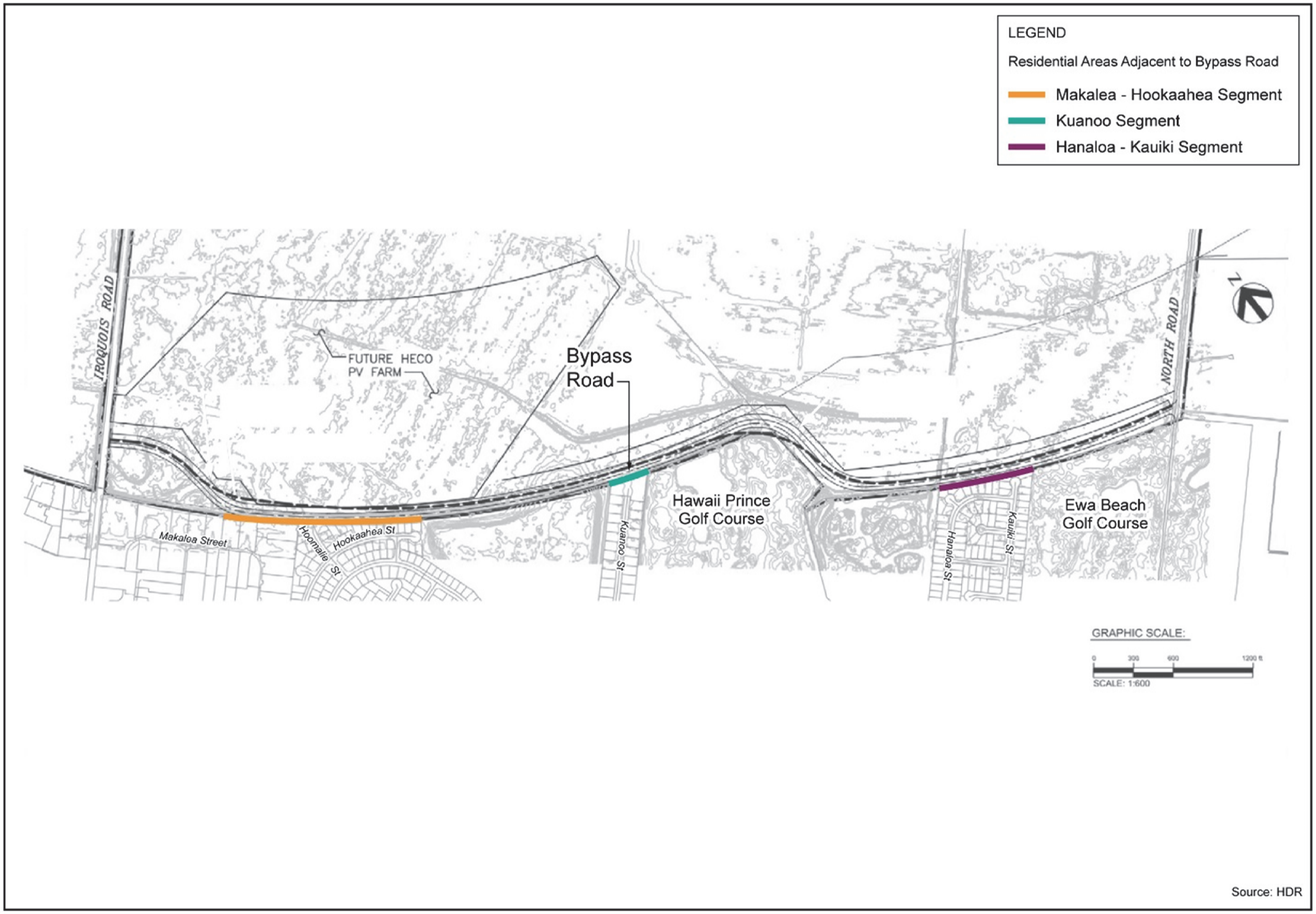
3.2.3 Affected Environment

Many components may generate noise and warrant analysis as contributors to the total noise impact. Existing noise in the vicinity of the project site is primarily attributable to vehicles along adjacent roadways, farm equipment, golf course sprinklers and lawnmowers or aircraft transiting the area. The site is adjacent to the main approach to Daniel K. Inouye International Airport approximately 0.5 and 2.0 miles north of the approach to Runway 26L, outside of the 55 DNL contour.

The federal government supports conditions free from noise that threaten human health and welfare and the environment. Response to noise varies, depending on the type and characteristics of the noise, distance between the noise source and whoever hears it (the receptor), receptor sensitivity, and time of day. A noise sensitive receptor is defined as a land use where people involved in indoor or outdoor activities may be subject to stress or considerable interference from noise. Such locations or facilities often include residential dwellings, hospitals, nursing homes, educational facilities, and libraries. Sensitive receptors may also include noise-sensitive cultural practices, some domestic animals, or certain wildlife species.

The Proposed Action includes a new entry control point along Iroquois Road which would be located more than 350 feet away from existing residential use (Figure 3-5). At its intersection with Iroquois Road, the bypass road and perimeter fence/patrol road would be approximately 350 feet away from existing residential use. The 100-foot wide right-of-way for the bypass road and perimeter fence/patrol road extends in a southeasterly direction adjacent to three existing areas of residential use, vacant property, and two golf courses.

The bypass road corridor would be adjacent to approximately 1,400 lineal feet of residential use (24 residential structures) near Makalea Street and Hookaahea Street (Figure 3-6). A shorter segment of approximately 300 lineal feet (two residential structures) is also adjacent to residential use near the Kuanoo Street terminus and next to the Hawaii Prince Golf Course. There is an approximately 750 lineal-foot segment (nine residential structures) adjacent to residential use at Hanaloa Street and Kauiki Street and next to the Ewa Beach Golf Course.



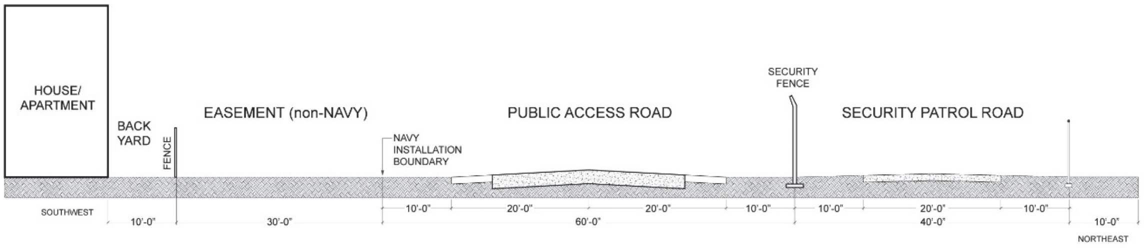
Source: HDR

Residential Areas Adjacent to Bypass Road **Figure 3-5**

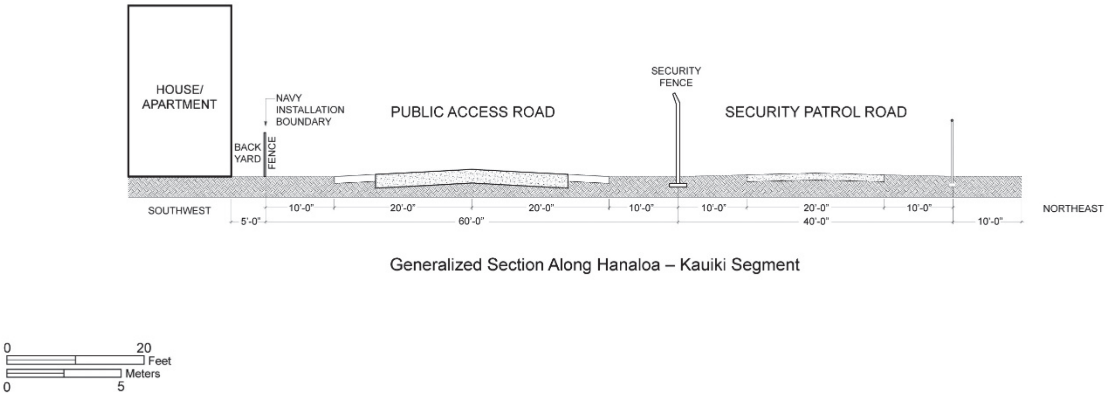
Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii

The nearest sensitive receptors would be the residential use located adjacent to three portions of the bypass road. Generally, the construction noise analysis reviewed possible impacts which are nearest these residential areas.

Along the approximately 1,400 lineal-foot Makalea-Hookaahea segment and the smaller 300 lineal-foot Kuanoo segment, there is a minimum of ten feet between the residential structure wall and an existing residential boundary fence. Between the fence and Navy property is an approximately 30-foot wide easement not under the control of the Navy which contains the HECO 46 kilovolt overhead electrical transmission line. Along the 750 lineal-foot Hanaloa-Kauiki segment, there is a five-foot wide required setback between residential dwellings and the property line. There is no abutting HECO easement along this segment (Figure 3-6).



Generalized Section Along Makaloa – Hookaahea and Kuanoo Segment



Generalized Section Along Hanaloa – Kauiki Segment

Residential Sections Adjacent to Bypass Road **Figure 3-6**
Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii

The perimeter fence/patrol road segment corridor northwest of Iroquois Road would extend approximately 1,900 feet adjacent to residential use. Holomua Elementary School is located to the west of the perimeter fence/patrol road, approximately 700 feet away. The proposed fire station (Alternative 2) is located approximately 550 feet from the Kapilina residential development. Alternative 1 magazine construction, is located approximately 3,400 feet from the closest residential use. Alternative 2 magazine construction would be located slightly farther, at least 3,500 feet away from the closest residential use.

3.2.4 Environmental Consequences

Noise Potential Impacts:

- Temporary impacts during the construction period
- Higher than projected increase in noise levels.

Analysis of potential noise impacts includes estimating likely noise levels from the Proposed Action and determining potential effects to sensitive receptor sites.

A noise analysis was conducted for the project (Appendix C).

On-site long-term acoustical measurements were conducted at two locations from Saturday September 22, 2018 to Wednesday September 26, 2018. One sound meter was located at 1032 Hoomalie Street within the Makalea-Hookaahea segment and a second sound level meter was located at the Hawaii Prince Golf Course close to the Kuanoo Street terminus.

The most frequent noise source observed at both locations was overhead air traffic. The golf course had additional localized noise sources such as sprinklers and lawn mowers. The results are shown in Table 3-6. The metrics include the average day noise level (Ld), the average night level (Ln), and the Day-night level (Ldn). The Ldn is a 24-hour average noise level, however the noise between 10:00 pm and 7:00 am is artificially increased by 10 dB.

Table 3-6 Summary of On-Site Noise Monitoring

Measurement Location	*Average Daytime Level (Ld)*	*Average Nighttime Level (Ln)*	*Average Day-Night Level (Ldn)*
1032 Hoomalie Street	53 dBA	40 dBA	52 dBA
Hawaii Prince Golf Course	56 dBA	46 dBA	56 dBA

The acoustical analysis methods and assumptions are noted as follows:

1. The study used CadnaA modeling software to predict construction and traffic noise propagation. Residential buildings within 300 feet of the bypass road were included in the model. The building shapes and heights were approximated based on Google Earth and Google Street Views. All structures located further than 300 feet from the bypass road were not analyzed. Based on CadnaA modeling results, all construction and traffic noise activities would result in peak levels below 45 dBA at locations further than 300 feet from the bypass road.
2. The local site topography is assumed to be flat.
3. The bypass road is assumed to be smooth asphalt.
4. The center of the bypass road is assumed to be located 60 feet from the residential property lines along the Makalea-Hookaahea segment and the Kuanoo Segment. The center of the bypass road is assumed to be located 30 feet from the residential property lines along the Hanaloa-Kauiki segment.
5. Traffic data used to predict traffic noise levels came from the West Loch Annex Traffic Study prepared by Julian Ng, Inc., dated August 2018 (Appendix B). The hourly Leq was calculated by using the traffic counts from the hour of 0700 – 0800, which was the busiest hour recorded. The

north bound traffic was 286 vehicles and southbound was 332 vehicles for a total of 618 vehicles.

6. The hourly Leq calculation was conducted in accordance with the FTA Transit Noise and Vibration Impact Assessment manual as required by the FHWA. Correction factors for 40 mph traffic speeds were applied in accordance with Table 10-1 of the FTA Assessment Manual.
7. The number of heavy vehicles was assumed to be 15 percent of total vehicles.
8. The analysis does not assess the noise impacts of any predicted increase in future traffic volumes.
9. The construction noise analysis modeled noise transmission from three different noise sources. Each source had a unique octave band sound power data set. The octave bands ranged from 63 Hz to 8000 Hz.

Construction Noise Sources

Measured octave band sound data published by the United Kingdom's Department for Environment and Rural Affairs (DEFRA) was used for both frequency content and overall noise levels. The advantages in using this dataset is that it is both expansive in equipment types and sizes and also includes octave band data rather than simply overall sound pressure or overall sound power levels. The three loudest pieces of construction equipment would be bulldozers, vibratory rollers, and dump trucks. The overall sound levels for equipment used in the sound analysis is shown in Table 3-7.

Table 3-7 Noise Sources Used in Analysis

Source	*Overall Level at 32 Feet*
Bulldozer (238 kW)	80 dBA
Vibratory Roller (20 kW)	73 dBA
Dump Truck (306 kW)	87 dBA

Summary of Construction Noise Impact Guidance

The Hawaii Department of Health (DoH) regulates excessive noise sources, including stationary noise sources and equipment related to agricultural, construction, and industrial activities under Chapter 342F, HRS (Noise Pollution) and HAR 11-46 (Community Noise Control). As a federal agency, the Navy considers DoH construction noise provisions as local best practices and will exert best efforts to comply with applicable State construction noise regulations.

DoH regulations specify that maximum permissible noise levels for Class A zoning districts which includes residences, are 55 dBA for daytime hours (7:00 am to 10:00 pm) and 45 dBA for nighttime (10:00 pm to 7:00 am). Pursuant to Section 11-46-7, HAR, a permit may be issued by the Hawaii DoH if it is found to be in the public interest and which may be subject to reasonable conditions. Notable factors which may be considered include the use of best available control technology and whether the services or activities for the permit is sought are temporary and cannot be delayed, postponed, or rescheduled to a time period in which such services are permitted.

There are specific permit restrictions for construction activities.

1. No permit can allow any construction activities in excess of maximum permissible noise levels for the hours before 7:00 am and after 6:00 pm of the same day, Monday through Friday.
2. No permit can allow any construction activities in excess of maximum permissible noise levels for the hours before 9:00 am and after 6:00 pm on Saturday.
3. No permit can allow any construction activities which emit noise in excess of the maximum permissible sound levels on Sundays and on holidays.

The Hawaii Department of Health may also consider a variance to operate an excessive noise source which emits or may emit noise levels in excess of the maximum noise levels and which use or operation does not conform to the requirements of Section 11-46-7 HAR. The variance must be in the public interest, does not substantially endanger human health or safety, and compliance with applicable provisions would produce serious hardship without equal or greater benefits to the public (Hawaii DoH, 1996).

Calculated construction peak noise levels at all three residential segments without any abatement measures are shown in Table 3-8. The predicted peak levels from construction noise is preliminary. It is also noted that construction noise which would result from the patrol road segment to the northwest of Iroquois Road would likely have construction noise levels above the permissible noise levels for Class A zoning districts but at lower levels than the three residential segments. The bypass road does not extend northwest of Iroquois Road.

A detailed noise impact analysis should be included in the Construction Noise Mitigation and Management Plan required as part of the project construction documents. The effect and design of temporary noise barriers, exhaust mufflers, reverse alarms, and project scheduling should be included in such an analysis. At this juncture, it is recommended that construction activities should be limited to Monday to Friday, between 7:00 am and 6:00 pm. The recommended limitation on construction activities includes Saturdays, Sundays and holidays.

Table 3-8 Calculated Maximum Construction Noise Levels at Residential Segments

Source	*Makalea–Hookaahea*	*Kuanoo*	*Hanaloa–Kauiki*
Bulldozer (238 kW)	72 dBA	64 dBA	78 dBA
Vibratory Roller (20 kW)	65 dBA	58 dBA	72 dBA
Dump Truck (306 kW)	80 dBA	72 dBA	86 dBA

Traffic Noise Modeling

All structures located further than 300 feet within acoustical shadows of nearfield structures from the bypass road were not included in the noise analyses. Based on CadnaA modeling results, all construction and traffic noise activities would result in peak levels below 45 dBA at such locations. Thus, operational analysis focuses on the bypass road.

Since the bypass road would be constructed by a federal agency with federal funds but may be eventually owned by a non-federal agency, the appropriate noise standard would be the Federal Highway Administration's (FHWA) *Highway Traffic Noise* Regulation*: Analysis and Abatement* Guidance Section 23 CFR Part 772. The foregoing provisions apply to a federal or federal-aid highway project that involves construction of a highway in a new location. The applicable criteria as it applies to residential uses are listed in Table 3-9. Leq(h) is defined as the equivalent steady-state sound level which in a stated period of time contains the same acoustic energy as the time-varying sound level during the same time period, with Leq(h) being the hourly value of Leq. L10(h) is defined as the sound level that is exceeded 10 percent of the time (the 90th percentile) for the period under consideration, with L10(h) being the hourly value of L10. Either Leq(h) or L10(h) may be used, but both may not be used for the same project.

Table 3-9 FHWA's Noise Abatement Criteria (applicable to traffic noise)

Zoning District	*Leq(h)*	*L10(h)*
Category B (Residential)	67 dBA	70 dBA

Additionally, Section 772.11(f) defines substantial noise increase between 5 dBA to 15 dBA over existing noise levels. This substantial noise increase criterion is considered independent of the absolute noise level.

Section 772.13(a) notes that when traffic noise impacts are identified, noise abatement shall be considered for feasibility and reasonableness. Feasibility would include factors such as 1) achievement of at least a 5 dBA highway traffic noise reduction at impacted receptors and 2) determination that it is possible to design and construct the noise abatement measure. Reasonableness includes 1) consideration of the viewpoints of the property owners and residents of the benefited receptors, 2) cost effectiveness of the highway traffic noise abatement measures and 3) noise reduction goals for highway traffic noise abatement measures. The design goal for noise reduction shall be at least 7 dBA but not more than 10 dBA (FHWA, 2011).

For the bypass road, the peak hourly Leq is calculated to be 65 dBA at a distance of 50 feet from the center of the bypass road. This assumes a traffic speed of 40 mph and 15 percent of all traffic is heavy diesel vehicles. Calculated average traffic noise levels at the three residential segments are listed in Table 3-10. All peak hourly average noise levels at all residential segments are less than the FHWA abatement threshold criteria of 67 dBA.

Table 3-10 Calculated Traffic Noise Levels at Residential Segments Without Abatement Measures

Metric	*Makalea-Hookaahea*	*Kuanoo*	*Hanaloa-Kauiki*
Peak Hour Average Noise Level (Leq)	61 dBA	56 dBA	66 dBA

The calculated noise levels results in peak hourly averages which range from 56 – 66 dBA. Existing average noise levels as taken from Hoomalie Street are at 52 dBA and the Hawaii Prince Golf Course (R2) are at 56 dBA. Thus, using 52 dBA as the base existing noise level, areas adjacent to the Kuanoo segment could potentially trigger an increase of up to 4 dBA (from 52 dBA to 56 dBA), and would not require noise abatement pursuant to FHWA standards at the present time. Areas around the Makalea-Hookaahea segment would require a reduction of approximately 5 dB (from 61 dBA to 56 dBA) to at least equal sound levels at R2. Sound levels at the Hanaloa-Kauiki segment should be reduced between 5 to 7 dB (from 66 dBA to 59-61 dBA) to comply with applicable FHWA standards.

3.2.4.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to baseline noise levels. Therefore, no impact to noise would occur with implementation of the No Action Alternative.

3.2.4.2 Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative) Potential Impacts

The study area for the analysis of effects to noise associated with the Preferred Alternative includes areas which would be altered by:

- the proposed 24 box magazines clustered around the 10th Street and E Avenue intersections;
- adjacent construction staging and roadway access;
- adjacent roadways and concrete pads, utility improvements, landscaping, and drainage improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

Under the Proposed Action, site preparation and construction activities would be expected to create short-term impacts.

As noted in the noise modeling results, all construction and traffic noise activities would result in peak noise levels below 45 dBA at locations further than 300 feet from the bypass road.

Besides construction noise from the bypass road, possible noise from the construction of the security fence/patrol road to the northwest of Iroquois Road should be considered. Construction activities would be adjacent to approximately 20 residential structures. Holomua Elementary School is located approximately 700 feet from the closest point of the security fence/patrol road, well beyond the 300-foot acoustical impact zone. There are several rows of single family homes between the school and the closest portion of the project site. Given the distance from the project site and the noise buffer that the residential uses provide, it is not expected that Holomua Elementary School would likely experience short-term noise impacts during the construction process.

A contractor-prepared Construction Noise Mitigation and Management Plan is recommended as a local best practice, because of the proximity of private residential uses to the proposed bypass and security road corridors. Construction activities are recommended to be limited to Monday to Friday, between 7:00 am and 6:00 pm. The limitation on construction activities is also recommended to include Saturdays, Sundays and holidays.

Long-term noise impacts relating to traffic focus on the bypass road. The patrol road would be used only by Navy personnel and as such, usage of the road would be occasional. Long-term noise impacts relating to the operation of the magazines would be negligible (e.g., occasional movement of ordnance).

FHWA noise abatement criteria were utilized since federal funding would be utilized to construct the bypass road and the bypass road would eventually be owned or transferred to a State or local entity. The peak hourly Leq is calculated to be 65 dBA at a distance of 50 feet from the center of the bypass road. The calculations also assume a traffic speed of 40 mph and that 15 percent of all traffic is heavy diesel vehicles. All peak hourly average noise levels at the three residential segments meet the FHWA criteria of 67 dBA.

Areas adjacent to the Kuanoo segment would not require noise abatement pursuant to FHWA standards at the present time. However, since projected noise levels would increase more than 5 dBA over existing noise levels at the Makalea-Hookaahea and Hanaloa-Kauiki segments, noise abatement which would reduce projected noise levels by between 5-7 dBA would be needed to comply with FHWA standards.

The noise analyses predicts that any property within 30-40 feet of the center of the bypass road would produce noise levels at least 5 dBA above the existing background level with traffic traveling at 40 mph. However, if traffic speeds are limited to 30 mph and the bypass road centerline is located at least 60 feet from the existing residential fenceline, the noise analyses indicate that this would not result in an increase of 5 dBA or greater at Makalea-Hookaahea segment. There is an existing approximately 30-foot wide easement between the existing residential fenceline and Navy property at the Makalea-Hookaahea as well as the Kuanoo segments. With the easement, the distance from the bypass road centerline to existing residential fenceline would be approximately 60 feet.

The traffic source noise calculations use methods outlined in the FTA Transit Noise and Vibration Impact Assessment Manual. The calculation assumes that 15 percent of the total traffic count during peak hours are heavy diesel vehicles. Should heavy vehicles be prohibited from using the bypass road, this would reduce sound levels by an additional 2 dBA.

With the 30 mph speed limit and heavy vehicle limitation, projected noise levels at the Makalea-Hookaahea segment would comply with FHWA standards.

Along the 750-foot Hanaloa-Kauiki segment (nine residential structures), the noise analyses show a noise increase greater than 5-7 dBA where the centerline of the bypass road is approximately 30 feet from the residential property line, even with reduction of traffic speeds to 30 mph and prohibition of heavy vehicles. Other options may be considered:

1. Setting back the roadway centerline an additional 30-feet from the residential property lines.
2. Construction of sound barrier walls along the 750-foot residential frontage with the Navy-owned bypass road corridor. The height of the barrier would vary depending on the height of the structures (ten feet for two-story and less for one-story structures).
3. Noise insulation of the second story of private residences may also be considered with a shorter sound barrier wall.

There may be several possible future changes in circumstances which should be considered prior to initial construction. For instance, inputs such as average daily trips may increase over time and percentages of truck traffic as part of the total traffic may also change over time. This may alter eventual noise measurements.

It is recommended that the Navy conduct a noise analysis update to review sufficiency of abatement.

Therefore, with the implementation of appropriate design measures, the Preferred Alternative would result in less than significant impacts to the noise environment.

3.2.4.3 Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive) Potential Impacts

The study area for the analysis of effects to noise associated with this alternative includes:

- 24 box magazines west of West Loch Drive and 6th Street;
- adjacent construction staging;
- fire station;
- adjacent roadways and concrete pads, utility improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

Alternative 2 would involve generally the same improvements as the Preferred Alternative. The main differences are the location of the magazines and a fire station. Both are significant distances away from existing residential uses. The same noise abatement measures as the Preferred Alternative would be implemented, as appropriate.

Therefore, with the implementation of appropriate design measures, Alternative 2 would result in less than significant impacts to the noise environment.

3.3 Air Quality

This discussion of air quality includes criteria pollutants, standards, sources, permitting, and greenhouse gases. Air quality in a given location is defined by the concentration of various pollutants in the atmosphere. A region's air quality is influenced by many factors, including the type and amount of pollutants emitted into the atmosphere, the size and topography of the air basin, and the prevailing meteorological conditions.

Most air pollutants originate from human-made sources, including mobile sources (e.g., cars, trucks, and buses), stationary sources (e.g., factories, refineries, power plants), non-point stationary sources (e.g. quarries) as well as indoor sources (e.g., some building materials and cleaning solvents). Air pollutants are also released from natural sources such as volcanic eruptions and forest fires.

3.3.1 Regulatory Setting

3.3.1.1 Criteria Pollutants and Ambient Air Quality Standards

The principal pollutants defining the air quality, called "criteria pollutants," include carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone, suspended particulate matter less than or equal to 10 microns in diameter (PM_{10}), fine particulate matter less than or equal to 2.5 microns in diameter ($PM_{2.5}$), and lead (Pb). CO, SO_2, NO_2, Pb, and some particulates are emitted directly into the atmosphere from emissions sources. Ozone, NO_2, and some particulates are formed through atmospheric chemical reactions that are influenced by weather, ultraviolet light, and other atmospheric processes.

Under the Clean Air Act (CAA), the U.S. Environmental Protection Agency (USEPA) has established National Ambient Air Quality Standards (NAAQS) (40 CFR part 50) for these pollutants. NAAQS are classified as primary or secondary. Primary standards protect against adverse health effects; secondary standards protect against welfare effects, such as damage to farm crops and vegetation and damage to buildings. Some pollutants have long-term and short-term standards. Short-term standards are designed to protect against acute, or short-term, health effects, while long-term standards were established to protect against chronic health effects.

Areas that are and have historically been in compliance with the NAAQS are designated as attainment areas. Areas that violate a federal air quality standard are designated as nonattainment areas. Areas that have transitioned from nonattainment to attainment are designated as maintenance areas and are required to adhere to maintenance plans to ensure continued attainment.

The CAA requires states to develop a general plan to attain and maintain the NAAQS in all areas of the country and a specific plan to attain the standards for each area designated nonattainment for a NAAQS. These plans, known as State Implementation Plans (SIPs), are developed by state and local air quality management agencies and submitted to USEPA for approval. If a state fails to submit a SIP, USEPA is required to develop a Federal Implementation Plan (FIP). Hawaii has a USEPA-approved SIP.

In addition to the NAAQS for criteria pollutants, national standards exist for hazardous air pollutants (HAPs), which are regulated under Section 112(b) of the 1990 CAA Amendments. The *National Emission Standards for Hazardous Air Pollutants (NESHAP)* regulate HAP emissions from stationary sources (40 CFR part 61). NESHAP involves emission standards, not health standards.

The State of Hawaii regulates ambient air quality standards (AAQS) defined in Chapter 11-59 of the Hawaii Administrative Rules. State standards have been established for particulate matter, SO_2, NO_2, CO, ozone and Pb. The state has also set a standard for hydrogen sulfide. The Hawaii AAQS are given in terms of a single standard that is designed “to protect the public health and welfare and to prevent the significant deterioration of air quality”.

Each of the regulated air pollutants has the potential to create or exacerbate some form of adverse health effect or to produce environmental degradation when present in sufficiently high concentration for prolonged periods of time. The AAQS specify a maximum allowable concentration for a given air pollutant for one or more averaging times to prevent harmful effects. Averaging times vary from one hour to one year depending on the pollutant and type of exposure necessary to cause adverse effects. In the case of the short-term (i.e., 1- to 24-hour) AAQS, both national and state standards allow a specified number of exceedances each year.

The Hawaii AAQS are in some cases considerably more stringent than the comparable national AAQS. In particular, the Hawaii 1-hour AAQS for carbon monoxide is four times more stringent than the comparable national limit.

The NAAQS are reviewed periodically, and multiple revisions have occurred over the past 30 years. The latest revisions include the NO_2 and SO_2 in 2010, the particulate matter standards in 2012 and the ozone standard in 2015. In general, the NAAQS have become more stringent with the passage of time and as more information and evidence become available concerning the detrimental effects of air pollution. Changes to the Hawaii AAQS over the past several years have tended to follow revisions to the national AAQS, making several of the Hawaii AAQS the same as the national AAQS.

The State of Hawaii regulates visible emissions in Section 11-60.1-32, HAR. Visible emissions pertain to stationary sources which commenced construction, modification, or relocation after March 20, 1972. Emissions of visible air pollutants cannot exceed a density equal to or darker than 20 percent opacity, except during start-up shutdown, or when breakdown of equipment occurs. In these instances, discharge into the atmosphere may not exceed a density of 60 percent opacity for greater than six minutes in any 60 minute period.

Section 11-60.1-33, HAR regulates fugitive dust. The rules note that no person shall cause or permit fugitive dust to become airborne without taking reasonable precautions. Examples of reasonable precautions are:

- Use of water or suitable chemical for control of fugitive dust in the demolition of existing buildings or structures, construction operations, the grading of roads, or the clearing of land;
- Application of asphalt, water, or suitable chemicals on roads, material stockpiles, and other surfaces which may result in fugitive dust;
- Installation and use of hoods, fans, and fabric filters to enclose and vent the handling of dusty materials.
- Covering all moving, open-bodied trucks transporting material which may result in fugitive dust;
- Maintenance of roadways in a clean manner;
- Prompt removal of earth and other material from paved streets which have been transported there by trucking, earth-moving equipment, erosion, or other means.

3.3.1.2 Mobile Sources

HAPs emitted from mobile sources are called Mobile Source Air Toxics (MSAT). MSAT are compounds emitted from motor vehicles that are known or suspected to cause cancer or other serious health and environmental effects. In 2001, USEPA issued its first MSAT Rule, which identified 201 compounds as being HAPs that require regulation. A subset of six of the MSAT compounds was identified as having the greatest influence on health and included benzene, butadiene, formaldehyde, acrolein, acetaldehyde, and diesel particulate matter. More recently, USEPA issued a second MSAT Rule in February 2007, which generally supported the findings in the first rule and provided additional recommendations of compounds having the greatest impact on health. The rule also identified several engine emission certification standards that must be implemented (40 CFR parts 59, 80, 85, and 86; Federal Register Volume 72, No. 37, pp. 8427–8570, 2007). Unlike the criteria pollutants, there are no NAAQS for benzene and other HAPs. The primary control methodologies for these pollutants for mobile sources involves reducing their content in fuel and altering the engine operating characteristics to reduce the volume of pollutant generated during combustion.

3.3.1.3 General Conformity

The USEPA General Conformity Rule applies to federal actions occurring in nonattainment or maintenance areas when the total direct and indirect emissions of nonattainment pollutants (or their precursors) exceed specified thresholds. This rule is not applicable for this project as there are no nonattainment or maintenance areas in Hawaii.

3.3.1.4 Permitting

<u>New Source Review (Preconstruction Permit)</u>

New major stationary sources and major modifications at existing major stationary sources are required by the CAA to obtain an air pollution permit before commencing construction. This permitting process for major stationary sources is called New Source Review and is required whether the major stationary source or major modification is planned for nonattainment areas or attainment and unclassifiable areas. In general, permits for sources in attainment areas and for other pollutants regulated under the major source program are referred to as Prevention of Significant Deterioration (PSD) permits, while permits for major stationary sources emitting nonattainment pollutants and located in nonattainment areas are referred to as nonattainment new source review permits. In addition, a proposed project may have to meet the requirements of nonattainment new source review for the pollutants for which the area is designated as nonattainment and PSD for the pollutants for which the area is attainment. Additional PSD permitting thresholds apply to increases in stationary source greenhouse gas (GHG) emissions. PSD permitting can also apply to a new major stationary source (or any net emissions increase associated with a modification to an existing major stationary source) that is constructed within 6.2 miles of a Class I area, and which would increase the 24-hour average concentration of any regulated pollutant in the Class I area by 1 microgram per cubic meter ($\mu g/m^3$) or more. Navy installations shall comply with applicable permit requirements under the PSD program per 40 CFR section 51.166. There are no Class I areas on Oahu.

Applicable State permit requirements for the project are specified in the USEPA-approved SIP for Hawaii which addresses each NAAQS promulgated by the USEPA. Title 11 Chapter 59, HAR discusses ambient air quality standards and Title 11 Chapter 60.1, HAR details air pollution control requirements for the State of Hawaii.

Minor New Source Review (NSR) is for pollutants from stationary sources that do not require PSD or nonattainment NSR permits. The purpose of minor NSR permits is to prevent the construction of sources that would interfere with attainment or maintenance of NAAQS or violate the control strategy on nonattainment areas. Also, minor NSR permits often contain permit conditions to limit the sources emissions to avoid PSD or nonattainment NSR.

States are able to customize the requirements of the minor NSR program as long as their program meets minimum requirements. The permit agency’s minor NSR programs is part of the SIP.

Title V (Operating Permit)

The Title V Operating Permit Program consolidates all CAA requirements applicable to the operation of a source, including requirements from the SIP, preconstruction permits, and the air toxics program. It applies to stationary sources of air pollution that exceed the major source emission thresholds, as well as other non-major sources specified in a particular regulation. The program includes a requirement for payment of permit fees to finance the operating permit program whether implemented by USEPA or a state or local regulator. Navy installations subject to Title V permitting shall comply with the requirements of the Title V Operating Permit Program, which are detailed in 40 CFR Part 70 and all specific requirements contained in their individual permits.

State of Hawaii Fugitive Dust Control

Section 11-60.1-33(b) HAR prohibits visible emissions of fugitive dust from construction activities at the property line. Thus, an effective dust control plan for the project construction phase is essential.

3.3.1.5 Greenhouse Gases

GHGs are gas emissions that trap heat in the atmosphere. These emissions occur from natural processes and human activities. Scientific evidence indicates a trend of increasing global temperature over the past century due to an increase in GHG emissions from human activities. The climate change associated with this global warming is predicted to produce negative economic and social consequences across the globe.

USEPA issued the Final Mandatory Reporting of Greenhouse Gases Rule on September 22, 2009. GHGs covered under the Final Mandatory Reporting of Greenhouse Gases Rule are carbon dioxide (CO_2), methane, nitrogen oxide (NO_x), hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and other fluorinated gases including nitrogen trifluoride and hydrofluorinated ethers. Each GHG is assigned a global warming potential. The global warming potential is the ability of a gas or aerosol to trap heat in the atmosphere. The global warming potential rating system is standardized to CO_2, which has a value of one. The equivalent CO_2 rate is calculated by multiplying the emissions of each GHG by its global warming potential and adding the results together to produce a single, combined emissions rate representing all GHGs. Under the rule, suppliers of fossil fuels or industrial GHGs, manufacturers of mobile sources and engines, and facilities that emit 25,000 metric tons or more per year of GHG emissions as CO_{2e} are required to submit annual reports to USEPA.

In an effort to reduce energy consumption, reduce GHGs, reduce dependence on petroleum, and increase the use of renewable energy resources the Navy has implemented a number of renewable energy projects. The Navy has established Fiscal Year 2020 GHG emissions reduction targets of 34 percent from a FY 2008 baseline for direct GHG emissions and 13.5 percent for indirect emissions. Examples of Navy-wide GHG reduction projects include energy efficient construction, thermal and photovoltaic solar systems, geothermal power plants, and the generation of electricity with wind energy. The Navy continues to promote and install new renewable energy projects.

3.3.2 Affected Environment

The USEPA characterizes air quality by comparing concentrations of criteria pollutants to established NAAQS. A summary of state and federal ambient air quality standards and air quality monitoring data for the Kapolei monitoring station is presented in Table 3-11 for the year 2015. The State of Hawaii Kapolei air quality monitoring station is the closest station to West Loch Annex.

Table 3-11 Comparison of State and Federal Air Quality Standards with Design Values for State of Hawaii Kapolei Monitoring Station for Year 2015

Air Pollutant	*Averaging Time*	*Standards*			*Design Values for Kapolei Monitoring Station (2015)*
		Hawaii State Standard	*Federal Primary Standard*[a]	*Federal Secondary Standard*[b]	
Carbon Monoxide (CO)	1-hour	9 ppm	35 ppm	None	2.400 ppm
	8-hour	4.4 ppm	9 ppm		1.700 ppm
Nitrogen Dioxide (NO2)	1-hour	---	0.100 ppm	---	0.031 ppm
	Annual	0.04 ppm	0.053 ppm	0.053 ppm	0.004 ppm
PM10	24-hour	150 µg/m3	150 µg/m3	---	32 µg/m3
	Annual	50 µg/m3	---	---	16 µg/m3
PM2.5	24-hour	---	35 µg/m3	35 µg/m3	17 µg/m3
	Annual		12 µg/m3	15 µg/m3	4 µg/m3
Ozone (O3)	8-hour	0.080 ppm	0.070 ppm	0.070 ppm	0.052 ppm

Air Pollutant	*Averaging Time*	*Standards*			*Design Values for Kapolei Monitoring Station (2015)*
		Hawaii State Standard	*Federal Primary Standard*[a]	*Federal Secondary Standard*[b]	
Sulfur Dioxide (SO2)	1-hour	---	0.075 ppm	---	0.026 ppm
	3-hour	0.500 ppm	---	0.500 ppm	0.015 ppm
	24-hour	0.140 ppm	---	---	0.004 ppm
	Annual	0.030 ppm	---	---	0.001 ppm
Lead (Pb)	Rolling 3-month	1.5 µg/m3 [d]	0.15 µg/m3	0.15 µg/m3	0.003 µg/m3
Hydrogen Sulfide	1-hour	0.025 ppm	None	None	0.004 ppm

[a] **Primary Standards** set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children and the elderly.

[b] **Secondary Standards** set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

[C] Due to a lack of evidence linking health problems to long-term exposure to coarse particle pollution, EPA revoked the annual PM10 standard effective December 17, 2006. However, the state still has an annual standard.

[d] The state standard is based on calendar quarter.

Source: DoH, 2016

The most recent emissions inventory for Honolulu County is shown in Table 3-12. Volatile organic compound (VOC) and nitrogen oxides (NO$_x$) emissions are used to represent ozone generation because they are precursors of ozone.

Table 3-12 Honolulu County Air Emissions Inventory (2014)

Location	*NOx (tpy)*	*VOC (tpy)*	*CO (tpy)*	*SO2 (tpy)*	*PM10 (tpy)*	*PM2.5 (tpy)*
Fire	65	306	938	5	119	93
Mobile	12,242	9,307	97,268	418	4,136	886
Stationary	17,031	13,677	10,061	14,355	12,430	3,670
Totals	29,337	23,289	108,267	14,778	16,685	4,649

Source: USEPA, 2014
Key: tpy = tons per year.

JBPHH operates under four Title V permits issued by the Hawaii Department of Health for several types of air emissions units:

- Permit 0209-01-C: fuel loading facilities
- Permit 0105a-01-C: shipbuilding and ship repair operations
- Permit 0105b-01-C: shipbuilding and ship repair operations
- Permit 0105e-01-C: combustion turbines, industrial waste treatment complex

Recent annual criteria pollutants emissions for JBPHH as reported by the DoN are shown in Table 3-13.

Table 3-13 JBPHH Air Emissions Inventory

Year	*NOx (tpy)*	*VOC (tpy)*	*CO (tpy)*	*SO_2 (tpy)*	*PM_{10} (tpy)*	*$PM_{2.5}$ (tpy)*	*HAP (tpy)*	*H_2S (tpy)*
2017	0.4	12.4	0.0	0.2	0.0	0.0	11.3	0.0
2016	0.9	14.3	0.0	0.3	0.1	0.1	12.9	0.0
2015	0.8	17.2	0.0	0.3	0.1	0.1	16.1	0.0

Source: DoN Annual Air Fee Reporting and Payment for Covered and Noncovered Sources for CY 2015, CY 2016, CY 2017 for CNRH Title V Permit Nos. 0209-01-C, 0105a-01-C, 0105b-01-C, and 0105e-01-C. Reported to nearest 1/10 of a ton. Various dates.

Key: tpy = tons per year.

DoH operates a network of air quality monitoring stations at various locations on Oahu. Each station, however, typically does not monitor the full complement of air quality parameters. During the 2011-2015 period, sulfur dioxide, particulate and carbon monoxide were monitored by DoH at an air quality station located in downtown Honolulu. Nitrogen dioxide was monitored at Kapolei and ozone was monitored at Sand Island. The concentrations reported were consistently low compared to the standards for all parameters except for ozone. Maximum 8-hour ozone concentrations reached up to about 75% of the standard. Ozone concentrations tend to be high in Hawaii due to the abundant sunshine and the island setting.

Much of the particulate emissions on Oahu originate from area sources, such as the mineral products industry and agriculture. Sulfur oxides are emitted almost exclusively by point sources, such as power plants, refineries and other industrial sources. Nitrogen oxides emissions emanate predominantly from industrial point sources, although area sources (mostly motor vehicle traffic) also contribute a substantial share. The majority of carbon monoxide emissions occur from area sources (motor vehicle traffic), while hydrocarbons are emitted mainly from point sources.

Natural sources of air pollution emissions that could affect the primary and secondary project areas at times but cannot be quantified very accurately include plants (aero-allergens), wind-blown dust, and to a lesser extent, volcanoes on the island of Hawaii. Manmade sources in the project area region include construction related to the future rapid transit guideway and stations, homeported and transient ships at JBPHH, and aircraft operating at Daniel K. Inouye International Airport and JBPHH.

Federal air pollution control regulations require that new motor vehicles be equipped with emission control devices that reduce emissions significantly compared to even a few years ago. Federal actions over the past several decades have significantly increased vehicle mileage through the corporate average fuel economy (CAFE) standards, originally passed by the U.S. Congress in 1975 to improve the average fuel economy of cars and light trucks. In 1990, President George H.W. Bush signed into law the Clean Air Act Amendments of 1990. This legislation required further emission reductions, which were phased in since 1994. Additional restrictions were signed into law during the Clinton administration, and began to take effect during the following decade. The increase in mileage and restrictions on emissions from new motor vehicles have helped to lower average emissions even as an increasing number of vehicles are on the roadways. CAFE standards issued in 2012 under the Obama Administration addressed fuel economy standards for new cars and light trucks model years 2017-2025, which would nearly double the fuel efficiency of new cars and light trucks over that of similar vehicles that were currently on the road. In August 2018, the Trump Administration proposed a pause in the rate of emissions reductions established by the CAFE program. The Trump Administration's proposal would freeze the fuel economy standards at 2020 levels, rather than continuing the increase in vehicle fuel economy through model year 2025. Even if the Trump Administration proposal were implemented, the reductions in pollutant emissions required under prior provisions would result in substantial improvements (i.e., declines) in vehicle pollutant emissions.

Actions by the State of Hawaii are also focused on reducing vehicle emissions. The Hawaii Clean Energy Initiative (HCEI), established by the Hawaii legislature in 2015, sets a 100 percent clean energy goal by 2045, making Hawaii the first state in the nation to set a legally required deadline for obtaining 100 percent of its electricity from sustainable renewable resources (USEIA, 2017). Another major goal of the HCEI is to displace 70 percent of petroleum-based ground transportation fuels by 2030 (ibid). Hawaii has instituted incentives for electric vehicles, including discounted electricity rates, and is second in the nation in the number of electric vehicles per capita. Other HCEI goals include reducing the use of petroleum based fuels in the transportation sector and reducing electricity consumption by 4,300 gigawatt-hours by 2030 (HCEI, 2017).

3.3.2.1 Quantitative Emissions and Dispersion Modeling

An air quality study (B.D. Neal & Associates, 2019) was conducted to analyze existing conditions, projected future conditions, and the effects associated with the Proposed Action (Appendix D-1).

To evaluate the potential long-term ambient air quality impact of motor vehicle traffic using the proposed new roadway facilities, computerized emission and atmospheric dispersion models can be used to estimate ambient carbon monoxide concentrations along roadways within the project area. Carbon monoxide is selected for modeling because it is both the most stable and the most abundant of the pollutants generated by motor vehicles.

For this project, two scenarios were evaluated for the carbon monoxide modeling study: year 2017 with present conditions and year 2017 with the project. To begin the modeling study of the two scenarios, critical receptor areas in the vicinity of the project were identified for analysis. Generally, roadway intersections are the primary concern because of traffic congestion and the increase in vehicular emissions associated with traffic queuing. Four key intersections were selected for the air quality analysis. (Refer to Figure 2-1 and Figure 2-4). These included:

- West Loch Drive at Iroquois Road
- North Road at Iroquois Avenue
- Bypass Road at Iroquois Road
- Bypass Road at North Road

The West Loch Drive at Iroquois Road intersection would only exist for the present scenario, while the two Bypass Road intersections would only exist with the Proposed Action.

At the bypass road-Iroquois Road intersection, the reassigned volumes would be similar to the existing volume at the Iroquois Road-West Loch Drive intersection. Assuming similar stop controls as the existing controls at the Iroquois Road-West Loch Drive intersection, delays and level of service at the bypass road-Iroquois Road intersection would be the same as the Iroquois Road-West Loch Drive intersection. LOS is primarily "A" or "B" for the various turning movements. Figure 3-2 in the Transportation section shows an aerial view of the intersection as well as existing traffic counts. Table 3-2 shows the existing conditions at Iroquois Road and West Loch Drive.

At the bypass road-North Road intersection, traffic volumes would be similar to existing volumes at the Iroquois Avenue-North Road intersection. Figure 3-3 shows an aerial view of the intersection as well as existing traffic counts. Table 3-3 shows the existing conditions at North Road and Iroquois Avenue. Table 3-4 shows the results of the unsignalized intersection analyses. LOS "B" or better conditions could be achieved if separate left and right turn lanes are provided on the bypass road approach to North Road. If a separate left turn lane is provided, LOS "D" or better conditions could be achieved.

The main objective of the modeling study was to estimate maximum 1-hour average carbon monoxide concentrations for each of the two scenarios studied. To evaluate the significance of the estimated concentrations, a comparison of the predicted values for each scenario was made. Comparison of the estimated values to the national and state AAQS was also used to provide another measure of significance.

Maximum carbon monoxide concentrations typically coincide with peak traffic periods. The traffic impact assessment report evaluated both morning and afternoon peak traffic periods. Typically, afternoon peak hour volumes are higher, but atmospheric dispersion conditions are generally worse during the morning. Thus, the air quality study evaluated both morning and afternoon peak traffic periods.

Vehicular carbon monoxide emissions for each year studied were calculated using EPA's Motor Vehicle Emission Simulator (MOVES) computer model. Federal Corporate Fuel Economy (CAFE) standards as well as other federal emission regulations are factored into MOVES.

MOVES was configured for a project-level analysis specifically for Hawaii. Assumptions included an urban, unrestricted road type, default fuel supply and fuel formulation, default vehicle age distribution and morning and afternoon ambient temperatures of 70 degrees Fahrenheit and 90 degrees Fahrenheit, respectively. MOVES emission factors were generated both for idling and for moving traffic.

After computing vehicular carbon monoxide emissions through the use of MOVES, these data were then inputted to an atmospheric dispersion model. EPA air quality modeling guidelines currently recommend that the computer model CAL3QHC be used to assess carbon monoxide concentrations at roadway intersections, or in areas where its use has previously been established, CALINE4 may be used. Until a few years ago, CALINE4 was used extensively in Hawaii to assess air quality impacts at intersections. In December 1997, the California Department of Transportation recommended that CALINE4 no longer be used because it may tend to over-predict maximum concentrations in some situations. Therefore, CAL3QHC was used for the subject analysis.

CAL3QHC was developed for the USEPA to simulate vehicular movement, vehicle queuing and atmospheric dispersion of vehicular emissions near roadway intersections. It is designed to predict 1-hour average pollutant concentrations near roadway intersections based on input traffic and emission data, roadway/receptor geometry and meteorological conditions.

Peak-hour traffic data included vehicle approach volumes, saturation capacity estimates, intersection laneage and signal timings. All emission factors that were inputted to CAL3QHC for free-flow traffic on roadways were obtained from MOVES based on assumed free-flow vehicle speeds corresponding to the posted or design speed limits.

Model roadways were set up to reflect roadway geometry, physical dimensions and operating characteristics. Concentrations predicted by air quality models generally are not considered valid within the roadway-mixing zone. The roadway-mixing zone is usually taken to include 9.84 feet (three meters) on either side of the travelled portion of the roadway. Model receptor sites were thus located at the edges of the mixing zones near all intersections that were studied for the two scenarios. This acknowledges that pedestrian sidewalks already exist or may exist in the future in these locations. All receptor heights were placed at 5.9 feet (1.8 meters) above ground to simulate levels within the normal human breathing zone.

Input meteorological conditions for this study were defined to provide “worst case” or highest estimated results. One of the key meteorological inputs is atmospheric stability category. For these analyses, atmospheric stability category 5 was assumed for the morning cases, atmospheric stability category 4 was assumed for the afternoon cases. These are the most conservative stability categories that are generally used for estimating worst case pollutant dispersion within urban areas for these periods. A surface roughness length of 39.4 inches (100 centimeters) and a mixing height of 3,281 feet (1000 meters) were used in all cases. Worst case wind conditions were defined as a wind speed of one meter per second (2.2 miles per hour) with a wind direction resulting in the highest predicted concentration. Concentration estimates were calculated at wind directions of every five degrees.

3.3.3 Environmental Consequences

Effects on air quality are based on estimated direct and indirect emissions associated with the action alternatives. The study area for assessing air quality impacts is the air basin in which the project is located, the project area in West Loch Annex as well as roadway intersections which may be affected by changes to traffic patterns resulting from the Proposed Action (i.e., West Loch Drive-Iroquois Road, North Road-Iroquois Avenue, Bypass Road-Iroquois Road, and Bypass Road-North Road intersections).

Air Quality Potential Impacts:

- Possible construction dust and traffic related impacts.

Estimated emissions from a proposed federal action are typically compared with the relevant national and state standards to assess the potential for increases in pollutant concentrations.

3.3.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to baseline air quality. Therefore, no impact to air quality or air resources would occur with implementation of the No Action Alternative.

3.3.3.2 Alternative 1 (24 New Box Type “D” Magazines Adjacent to 10th Street) (Preferred Alternative) Potential Impacts

The study area for the analysis of effects to air quality associated with the Preferred Alternative includes areas which would be altered by:

- the proposed 24 box magazines clustered around the 10th Street and E Avenue intersections;
- adjacent construction staging and roadway access;
- adjacent roadways and concrete pads, utility improvements, landscaping, and drainage improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

In the Preferred Alternative, it is likely that all state and federal ambient air quality standards are currently being met in the project area.

Construction Period

Project-related short-term impacts on air quality may occur from the emission of fugitive dust during construction phases. To control dust, the project construction contractor should prepare a dust control plan that will ensure that state regulations related to fugitive dust will be met. Typical dust control measures include:

- Watering of active work areas and any temporary unpaved work roads at least twice daily on days without rainfall.
- Use of wind screens around the project perimeter and/or limiting the area that is disturbed at any given time.
- Mulching or use of chemical soil stabilizers to control wind erosion of inactive areas of the site that have been disturbed.
- Covering of dirt-hauling trucks when traveling on roadways to prevent windage.
- Implementing a routine road cleaning and/or tire washing program to reduce fugitive dust emissions that may occur as a result of trucks tracking dirt onto paved roadways in the project area.
- Establishment of landscaping early in the construction schedule.

The specific dust control measures will depend, in part, on the amount and nature of earthwork that is needed, soil type, wind and precipitation conditions, and the proximity of neighbors.

During construction phases, emissions from engine exhausts (primarily consisting of carbon monoxide and nitrogen oxides) will also occur both from on-site construction equipment and from vehicles used by construction workers and from trucks traveling to and from the project. Increased vehicular emissions due to disruption of traffic by construction equipment and/or commuting construction workers can be alleviated by moving equipment and personnel to the site during off-peak traffic hours.

A dust control plan is a standard requirement of the Navy construction contract. The contractor for each phase of construction shall be responsible for dust control measures which meet applicable visible emissions and fugitive dust requirements.

Operational Period

Existing background concentrations of carbon monoxide are believed to be at reasonably low levels. Department of Health monitoring stations for locations on Oahu report average carbon monoxide concentrations of less than one part per million (ppm). Background concentrations of carbon monoxide from sources or roadways not directly considered in the analysis were conservatively accounted for by adding a background concentration on one ppm to all predicted concentrations for 2017.

Maximum eight-hour carbon monoxide concentrations were estimated by multiplying the maximum-modeled one-hour values by a persistence factor of 0.5. This accounts for two factors: (1) traffic volumes averaged over eight hours are lower than peak one-hour values, and (2) meteorological conditions are more variable (and hence more favorable for dispersion) over an eight-hour period than they are for a single hour. Based on monitoring data, one-hour to eight-hour persistence factors for most locations generally vary from 0.4 to 0.8 with 0.6 being the most typical. EPA guidelines recommend using a value of 0.7 unless a locally derived persistence factor is available. Recent monitoring data for locations on Oahu reported by the Department of Health suggest that this factor may range between about 0.2 and

0.6 depending on location and traffic variability. Considering the location of the project and the traffic pattern for the area, one-hour to eight-hour persistence factor of 0.5 will likely yield reasonable estimates of worst-case eight-hour concentrations.

The final results of the modeling study in the form of the highest estimated one-hour morning and afternoon ambient carbon monoxide concentrations are shown in Table 3-14. Highest estimated carbon monoxide concentrations are presented for two scenarios: year 2017 with existing traffic and year 2017 with the project. The locations of these highest estimated one-hour concentrations all occurred at or very near the indicated intersections.

Table 3-14 Highest Estimated One-Hour Carbon Monoxide Concentrations Along Roadways Near West Loch Drive Closure Project (parts per million)

Roadway Intersection	*Year/Scenario*			
	2017/ Present		*2017/ With Project*	
	AM	*PM*	*AM*	*PM*
West Loch Drive at Iroquois Road	1.4	1.4	-	-
North Road at Iroquois Avenue	1.3	1.4	-	-
Bypass Road at Iroquois Road	-	-	1.4	1.4
Bypass Road at North Road	-	-	1.3	1.5

Note: The Hawaii State AAQS is 9 ppm. The National AAQS is 35 ppm.

The highest estimated one-hour concentration at the two intersections studied for the present (2017) case was 1.4 ppm. This was projected to occur during the afternoon at both locations. This is well within both the national AAQS of 35 ppm (4% of threshold) and the state standard of 9 ppm (16% of threshold).

With the proposed project, the highest estimated one-hour carbon monoxide concentration in the project area was predicted to reach 1.5 ppm. This was predicted to occur during the afternoon peak traffic hour at the intersection of the new Bypass Road and North Road. Peak-hour concentrations at the other end of the new Bypass Road (Bypass Road at Iroquois Road) would be slightly lower in the afternoon. Compared to the existing case, predicted concentrations for the 2017 with the project increased slightly or remained unchanged. Forecast highest estimated concentrations remained well within the state and federal standards.

The resulting highest estimated eight-hour concentrations are indicated in Table 3-15.

Table 3-15 Highest Estimated Eight-Hour Carbon Monoxide Concentrations Along Roadways Near West Loch Drive Closure Project (parts per million)

Roadway Intersection	*Year/Scenario*	
	2017/ Present	*2017/ With Project*
West Loch Drive at Iroquois Road	0.7	-
North Road at Iroquois Avenue	0.6	-
Bypass Road at Iroquois Road	-	0.7
Bypass Road at North Road	-	0.8

Note: The Hawaii State AAQS is 4.4 ppm. The National AAQS is 9 ppm.

For the 2017/present scenario, the highest estimated eight-hour carbon monoxide concentrations for the two locations studied ranged from 0.6 to 0.7 ppm. The highest estimated concentrations for the existing case were well within both the state standard of 4.4 ppm (20% of threshold) and the national limit of 9 ppm (9% of threshold).

For the year 2017 with project scenario, predicted highest estimated concentrations at the two intersections studied ranged from 0.7 to 0.8 ppm, similar to the existing scenario, and the predicted concentrations were well within both state and national ambient air quality standards.

Highest estimated concentrations of carbon monoxide should remain well within both state and national ambient air quality standards.

General Conformity

Mobile Source Air Toxics

The closure of West Loch Drive necessitated by safety and security concerns is proposed to be replaced by a new bypass road extending from Iroquois Road to North Road. Three portions of the bypass road would be located adjacent to residential uses. The project has been determined to generate minimal air quality impacts for Clean Air Act criteria pollutants. The State of Hawaii is not a nonattainment or maintenance area. General Conformity rules do not apply. Hence, MSAT analysis should not be necessary.

Residential areas adjacent to the bypass road would generally be free flowing which would generate lower emissions than queued vehicles idling at an intersection. The closest residential use along the bypass road to its intersections is 900 feet away, approximately 45 car lengths. Figure 3-5 shows the location of residential use in relation to bypass road intersections. Bypass road intersections would be stop-controlled with possible separate turn lanes at the North Road intersection to attain acceptable levels of service. The design speed of the bypass road is 30 miles per hour and is anticipated to carry approximately the same amount of traffic as West Loch Drive. Queueing would be anticipated to be less than substantial.

Moreover, Environmental Protection Agency (EPA) regulations for vehicle engines and fuels will cause MSAT emissions to decline significantly over the next several decades. Based on regulations now in effect, an analysis of national trends with EPA's MOVES2014 model forecasts a combined reduction of over 90 percent in the total emissions rate for the priority MSAT from 2010 to 2050 while vehicle-miles of travel are projected to increase by over 45 percent (Updated Interim Guidance on Mobile Source Air Toxics Analysis in NEPA Documents, Federal Highway Administration, October 12, 2016). This will both reduce the background level of MSAT as well as the possibility of even minor MSAT emissions from this project.

Greenhouse Gases

Implementation of Preferred Alternative would contribute directly to emissions of GHGs from the combustion of fossil fuels. A rough estimate of GHG generated during the construction period was derived using the Green Footstep calculator (URL: www.greenfootstep.org; Rocky Mountain Institute, 2009) assuming 24 magazines covering 192,000 square feet constructed on 29 acres on Oahu, with a total building lifetime of 75 years. The calculation indicated GHG emissions of 20,600 tons of CO2e over a 10-year construction period – an annual average of 2,060 tons (1,869 metric tons) of CO2e per year from demolition, construction, and clearing activities (see Appendix D-2). After the facility is operational, routine activities would generate approximately 1,276 tons (1,158 metric tons) of CO2e each year. These estimated annual GHG emissions fall below the 25,000 metric tons of CO2e at or above which USEPA requires suppliers of fossil fuels or industrial GHGs, manufacturers of mobile sources and engines, and other facilities emitting GHGs to provide annual reporting. This limited amount of emissions would not likely contribute to global warming to any discernible extent. The project is not an affected facility of the EPA's Final Mandatory Reporting Rule.

Should fuel-burning power generation equipment be needed, the Navy will coordinate with the State Department of Health regarding applicable requirements.

Therefore, the Preferred Alternative would result in less than significant impacts to air quality.

3.3.3.3 Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive) Potential Impacts

The study area for the analysis of effects to air quality associated with this alternative includes:

- 24 box magazines west of West Loch Drive and 6th Street;
- adjacent construction staging;
- fire station;
- adjacent roadways and concrete pads, utility improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

Alternative 2 is very similar to Alternative 1 except that the proposed 24 magazines and staging area are located west of West Loch Drive in the vicinity of 6th Street. Since the proposed magazines would be located in proximity to the existing fire station, a new fire station is being built further away from the magazine area at the corner of G Avenue and 18th Street. An emergency generator building is included as part of the fire station. It is anticipated that the generators would provide emergency power, with operation to occur only a few hours per year during power outages and scheduled testing. The Navy must notify SOH of any changes in emissions sources in compliance with its Title V permits, such as adding emergency generators. However, emergency generators would be considered "insignificant activities" under Hawaii Administrative Rules (HAR) 11-60.1-83(f)(5) and generally exempted from the Title V permit system.

Other aspects of Alternative 2 would be the same as Alternative 1. The same construction period best management practices would be implemented and bypass road construction and operational measures would be the same. Therefore, Alternative 2 would result in less than significant impacts to air quality.

3.4 Land Use

This discussion of land use includes current and planned uses and the regulations, policies, or zoning that may control the proposed land use. The term land use refers to real property classifications that indicate either natural conditions or the types of human activity occurring on a parcel. Two main objectives of land use planning are to ensure orderly growth and compatible uses among adjacent property parcels or areas. However, there is no nationally recognized convention or uniform terminology for describing land use categories. As a result, the meanings of various land use descriptions, labels, and definitions vary among jurisdictions. Natural conditions of property can be described or categorized as unimproved, undeveloped, conservation or preservation area, and natural or scenic area. There is a wide variety of land use categories resulting from human activity. Descriptive terms often used include residential, commercial, industrial, agricultural, institutional, and recreational.

Visual resources are discussed in Section 3.6, Visual Resources.

3.4.1 Regulatory Setting

In many cases, land use descriptions are codified in installation master planning and local zoning laws. Office of the Chief of Naval Operations Instruction (OPNAVINST) 11010.40 establishes an encroachment management program to ensure operational sustainment that has direct bearing on land use planning on installations. Additionally, the joint instruction OPNAVINST 11010.36C and Marine Corps Order 11010.16 provides guidance administering the Air Installation Compatible Use Zone (AICUZ) program, which recommends land uses that are compatible with noise levels, accident potential, and obstruction clearance criteria for military airfield operations. OPNAVINST 3550.1A and Marine Corps Order 3550.11 provide guidance for a similar program, Range AICUZ (RAICUZ). This program includes range safety and noise analyses, and provides land use recommendations which will be compatible with Range Compatibility Zones and noise levels associated with military range operations.

Through the Coastal Zone Management Act of 1972 (CZMA), Congress established national policy to preserve, protect, develop, restore, or enhance resources in the coastal zone. This Act encourages coastal states to properly manage use of their coasts and coastal resources, prepare and implement coastal management programs, and provide for public and governmental participation in decisions affecting the coastal zone. To this end, CZMA imparts an obligation upon federal agencies whose actions or activities affect any land or water use or natural resource of the coastal zone to be carried out in a manner consistent to the maximum extent practicable with the enforceable policies of federally approved state coastal management programs. However, federal lands, which are “lands the use of which is by law subject solely to the discretion of the Federal Government, its officers, or agents,” are statutorily excluded from the State’s “coastal uses or resources.” If, however, the proposed federal activity affects coastal uses or resources beyond the boundaries of the federal property (i.e., has spillover effects), the CZMA Section 307 federal consistency requirement applies. As a federal agency, the Navy is required to determine whether its proposed activities would affect the coastal zone. This takes the form of a consistency determination, a *De Minimus* determination, or a determination that no further action is necessary.

The Farmland Protection Policy Act (FPPA) is intended to minimize the impact federal programs have on the unnecessary and irreversible conversion of farmland to nonagricultural uses. For the purpose of FPPA, farmland includes prime farmland, unique farmland, and land of statewide or local importance. Farmland subject to FPPA requirements does not have to be currently used for cropland. It can be forest land, pastureland, cropland, or other land, but not water or urban built-up land.

3.4.2 Affected Environment

The following discussions provide a description of the existing conditions under land use resources at West Loch Annex.

3.4.2.1 Land Use Compatibility

The Proposed Action is located within the approximately 2,640-acre JBPHH West Loch Annex. The primary land use within West Loch Annex is regional long ordnance storage. A safety arc has been established as evidenced by the various arcs at the southwest border of West Loch Annex. Navy administrative uses are located near the southeast corner of West Loch Annex.

Public use of West Loch Drive, and portions of North Road and Iroquois Road has been permitted within West Loch Annex. Public access has been allowed through a waiver.

Approximately 825 acres of land within West Loch Annex between West Loch Drive and the edge of the safety arc is currently leased under JBPHH's agricultural outlease program. These areas have been leased through the year 2023. Lands included in the agricultural outlease are currently operating under a waiver. Any extension of the agricultural outlease beyond 2023 would be considered in accord with regulations and policy applicable at that time.

An Environmental Assessment/Finding of No Significant Impact (EA/FONSI) was approved for a PV farm in June 2015 for up to 380 acres for lands located west of West Loch Drive (Figure 3-7). The lease for the first phase of the PV system, approximately 200 acres, has been executed and were formerly included in the agricultural outlease. With the execution of the first phase lease, the current remaining lands in the West Loch Annex agricultural outlease total approximately 825 acres. Phase II of the solar farm would encumber up to 180 additional acres of the agricultural outlease. While current and future phases of the PV farm would displace portions of land included as part of the agricultural outlease, the approved purpose of the PV farm is to reduce energy costs and fuel oil dependency, and increase the energy security, operational capability, strategic flexibility and resource availability of Navy installations in general.

The surrounding communities of Kapilina, Ewa Gentry, Ewa Villages, and Ewa Beach are characterized mainly by single family residential areas. Commercial areas serving these communities are focused along Fort Weaver Road, approximately one-mile southwest of the project area. There are several schools located in the region including James Campbell High School, Ilima Intermediate School, Ewa Beach Elementary School, Pohakea Elementary School, Keoneula Elementary School, Ewa Makai Middle School, and Holomua Elementary School. The closest of the schools, Holomua Elementary, is located approximately 700 feet away from the southwest border of West Loch Annex near Iroquois Road. Golf courses represent the other major land use in the area. The Hawaii Prince Golf Club and the Ewa Beach Golf Club are both located directly southwest of the project site.

Photovoltaic Arrays **Figure 3-7**
Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii

3.4.2.2 Federal, State, and County Land Use Plans, Policies, and Controls

Federal

JBPHH Installation Development Plan

The JBPHH Installation Development Plan (IDP) (The Urban Collaborative, LLC, 2013) is a planning document intended to guide and shape development across the entire JBPHH installation (including West Loch Annex). It illustrates planning actions that guide development at the installation and establishes a strategy for executing the planning vision and describes the implementation of planning principles at 11 planning districts within the installation. The IDP comprises installation-wide network plans and more specific Area Development Plans (ADP) for each of the JBPHH's planning districts. The planning vision for West Loch is to create a multi-purpose site made up of a regional munitions storage area and a mixed-use cantonment campus that preserves the natural and cultural qualities.

Farmland Protection Policy Act

Federal actions that affect prime or unique farmlands are subject to the federal Farmland Protection Policy Act (FPPA, subtitle I of Title XV, Section 1539-1549) administered by the NRCS, if they may irreversibly convert farmland (directly or indirectly). For the purpose of FPPA, important farmland includes lands which are considered prime, unique or locally important. The Alternative 1 magazines, the gate at the corner of North Road and Iroquois Avenue, and the fire station are located on lands which are Unclassified. Portions of the bypass road, security fencing, patrol road, and entry control point are located on lands which are considered Prime. However, most of these lands are designated as Other Lands Important for Agriculture. Agricultural Lands of Importance to the State of Hawaii (ALISH) in relation to the project area are mapped in Section 3.13.2.3 Soils, Figure 3-21.

Coastal Zone Management Act

The National Coastal Zone Management Act (CZMA) of 1972, as amended, authorizes a national program for the management, beneficial use, protection and development of the natural resources in the nation's coastal zone. However, lands owned, leased, held in trust, or whose use is otherwise subject solely to the discretion of the federal government, its officers, or agents are excluded from the coastal zone area. While this area is excluded from the State's CZM area, the CZMA Section 307 federal consistency provision requires federal agency activities and development projects affecting any coastal use or resource to be undertaken in a manner consistent to the maximum extent practicable with the state's CZM program. The State of Hawaii Department of Business, Economic Development and Tourism Office of Planning (DBEDT/OP) is the lead agency for coastal management and is responsible for enforcing the State's federally approved coastal management plan.

State of Hawaii

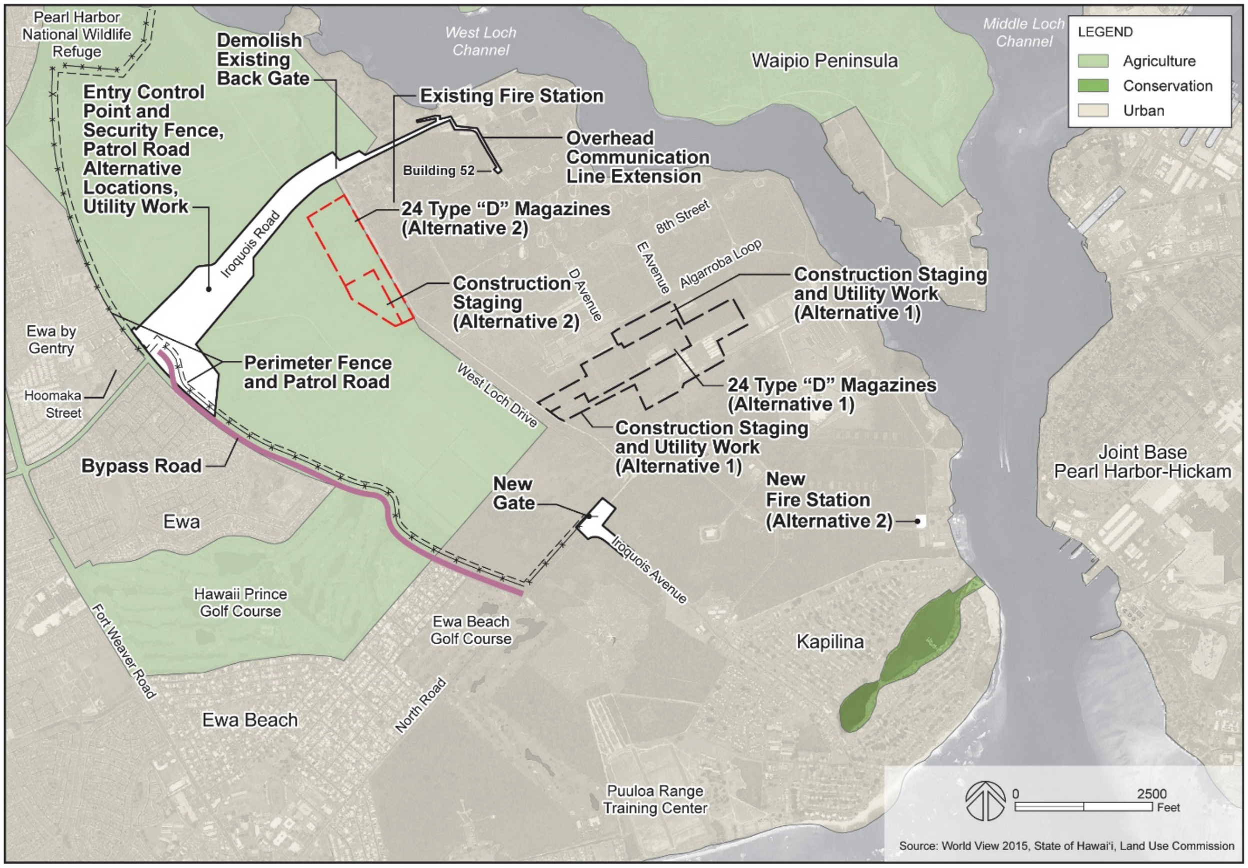
Hawaii State Plan

The Hawaii State Plan, codified under Chapter 226, HRS, serves as a guide for the future long-range development of the State. The State Plan provides a basis for determining priorities, allocating limited resources, and improving coordination of State and County plans, policies, programs, projects, and regulatory activities. The plan is divided into three parts: Part I identifies the State's theme, goals, objectives, and policies; Part II establishes a statewide planning system which guides the coordination and implementation of the Plan; and Part III establishes priority guidelines to address areas of statewide concern.

State Land Use Districts

The State Land Use Law, Chapter 205, HRS, establishes a statewide zoning framework for land use management by classifying all lands in the State into four land use districts: Urban, Agricultural, Conservation, and Rural. This law was developed in response to a lack of adequate controls which resulted in widespread development of Hawaii's limited and valuable land. The State Land Use Commission (LUC), the governing body who administers this statewide zoning law, is responsible for preserving and protecting the lands in the State, and encouraging those uses to which lands are best suited. The project area is located in the State Urban and Agricultural Districts, as shown in the State Land Use Districts Map (Figure 3-8).

Areas of the Proposed Action which are within the State Agricultural District include portions of the security fencing and patrol road, entry control point, and bypass road. These portions total approximately 178 acres. Other portions of Alternative 1 such as the magazines, portions of the bypass road, security fence and patrol road and utility improvements, and demolition of the back gate are in the Urban District. The Alternative 2 magazines would affect an additional 52 acres in the State Agricultural District.



Source: World View 2015, State of Hawai'i, Land Use Commission

State Land Use District **Figure 3-8**

Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii

City and County of Honolulu

General Plan

The General Plan for the City and County of Honolulu, adopted in 1977 and last amended in 2002, identifies long term objectives and policies along with the strategies and actions to achieve them. The Plan is a statement of the long-range social, economic, environmental, and design objectives for the general welfare and prosperity of the people of Oahu. The identified objectives contain statements of desirable conditions to be achieved in the long run, within an approximate 20-year timeframe. The broad policies are intended to facilitate the attainment of the objectives of the Plan. The Plan includes eleven subject areas which provide a framework of the City's expression of public policy concerning the needs of the people and the functions of government. The eleven areas of concern include: population; economic activity; the natural environment; housing; transportation and utilities; energy; physical development and urban design; public safety; health and education; cultural and recreation; and government operations and fiscal management.

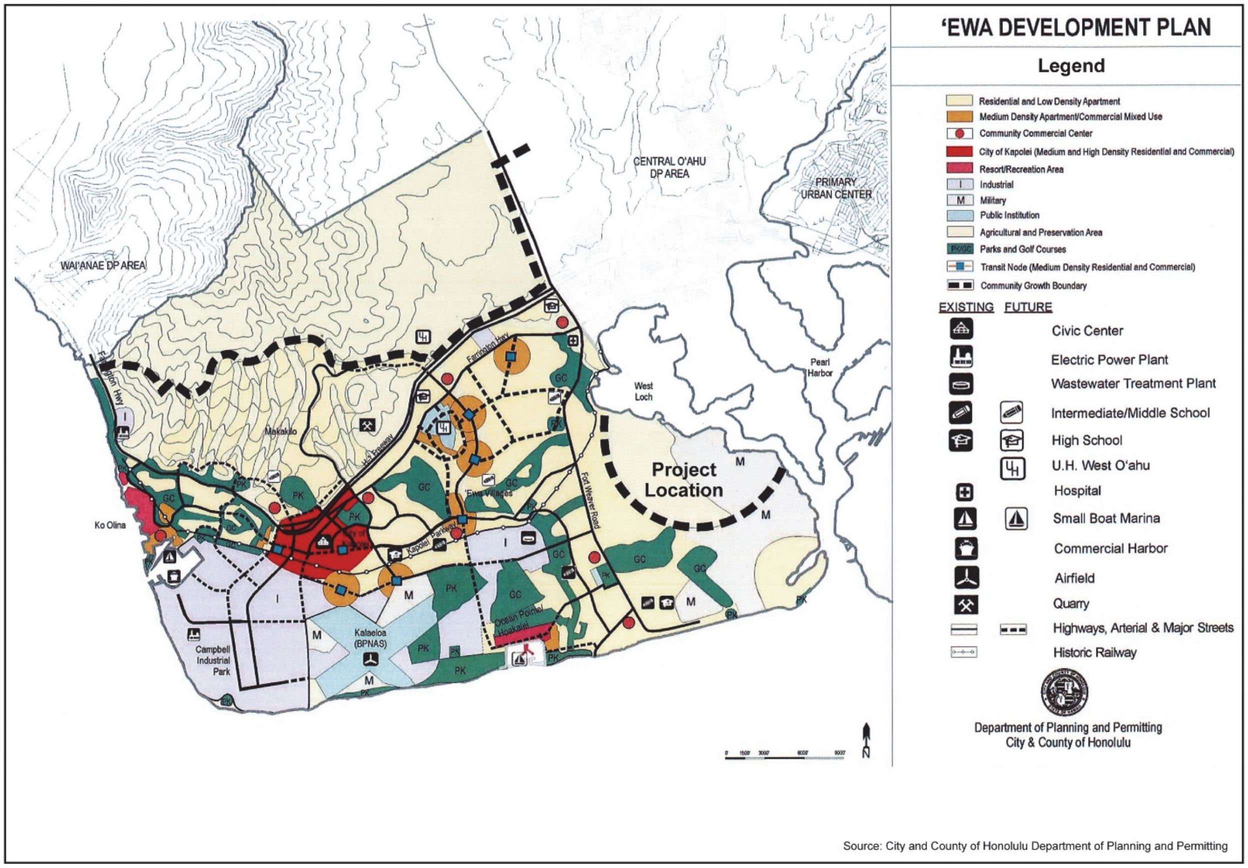
The General Plan is currently being updated and will focus on critical issues such as growth, development, economic health, tourism, affordable housing, agriculture, and sustainability. In support of the update, five trend reports, three economic discussions with key stakeholders, and a summary paper on the key planning issues have been completed. Key focus groups for agriculture, affordable housing, and tourism were created and involved participation from the public.

Ewa Development Plan

The City and County of Honolulu provides a conceptual framework for implementing the objectives and policies of the General Plan though its Development Plan (DP) program. There are eight geographical DP areas established on Oahu, which each have community-oriented plans intended to guide public policy and decision-making through 2025.

Major growth in population and economic activity will be directed into two of the eight planning areas, the Primary Urban Center (PUC) and Ewa, and are guided under their respective Development Plans. The remaining six planning regions are considered Sustainable Communities Plans, and are envisioned to remain relatively stable.

The project area is located within the Ewa DP area. The Ewa Development Plan (DP), revised in 2013, establishes policy to shape the growth and development of the Ewa region through 2035. The Ewa region is designated as the secondary urban center for Oahu and contains an increasing number of residential, commercial, industrial and institutional uses. According to the Ewa Development Plan Urban Land Use Map, there are two land use designations within the project area: (1) Military and (2) Agricultural and Preservation Area (Figure 3-9). One of the elements of the Plan is to promote diversified agriculture on prime agricultural lands along Kunia Road and surrounding the West Loch Naval Magazine.



Source: City and County of Honolulu Department of Planning and Permitting

Ewa Development Plan Urban Land Use Map **Figure 3-9**
Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii

City and County of Honolulu Land Use Ordinance

The Land Use Ordinance (LUO) of the City and County of Honolulu regulates land use in accordance with adopted land use polices from the General Plan and Development Plans. The provisions of the LUO are intended to provide reasonable development and design standards. Under current LUO zoning, most of the project site is designated F-1 Military and Federal Preservation District with slivers of the project site along the shoreline designated P-1 Restricted Preservation District. Small portions of the proposed security fence and patrol road are located in the AG-1 Restricted Agricultural District, AG-2 General Agricultural District and R-5 Residential District near North Road (Figure 3-10).

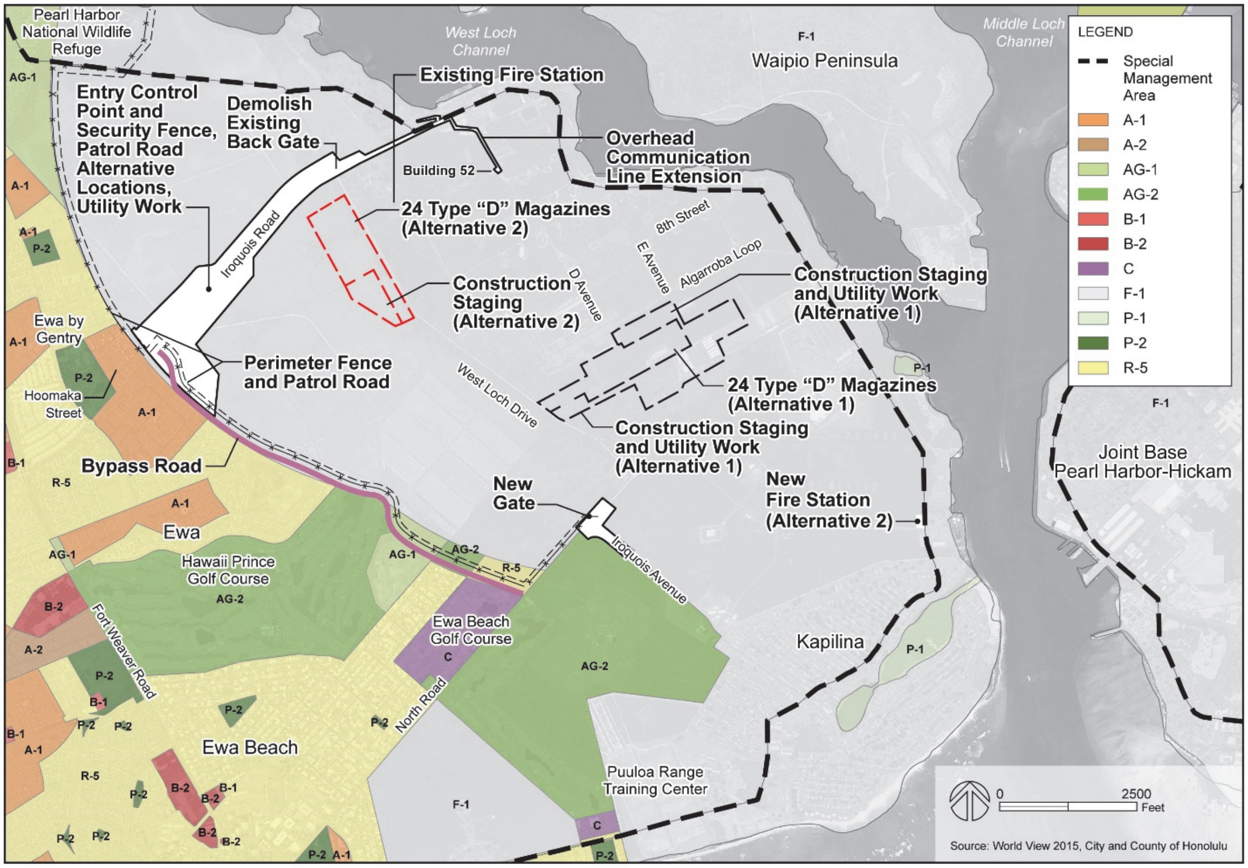
City and County of Honolulu Special Management Area and Shoreline Setback

Established in 1975 with the enactment of Act 176, the special management area (SMA) permit is also known as the Shoreline Protection Act. The SMA, conferred by HRS Chapter 205A, is designed to preserve, protect, and restore the natural resources of Hawaii’s coastal zone. Along the shoreline, special controls on development are necessary in order to avoid the permanent loss of valuable resources and insure adequate access to beaches, recreation areas, and natural reserves. Permissible land uses, allowed by various land use policies such as county general plans, are regulated through the SMA permit. The SMA permit ensures that uses, activities, or operations on land, in water, or under water within the SMA comply with SMA guidelines, as well as the CZM objectives and policies.

Chapter 205A, HRS, also established shoreline setbacks. The City and County of Honolulu administers shoreline setback provisions through establishment of Chapter 23, Revised Ordinances of Honolulu. The policy of the City to protect and preserve the natural shoreline, especially sandy beaches; to protect and preserve pedestrian access laterally along the shoreline and to the sea; and to protect and preserve open space along the shoreline. Generally, the shoreline setback line is established 40 feet inland from the certified shoreline.

Hawaii Coastal Zone Management Program

The National Coastal Zone Management Program was created through passage of the Coastal Zone Management Act of 1972. Hawaii’s CZM Program, adopted as Chapter 205A, HRS, provides a basis for protecting, restoring and responsibly developing coastal communities and resources. The objectives and policies of the Hawaii CZM Program encompass broad concerns such as impact on recreational resources, historic and archaeological resources, coastal scenic resources and open space, coastal ecosystems, coastal hazards, and the management of development.



Source: World View 2015, City and County of Honolulu

City and County of Honolulu Zoning Districts and Special Management Area **Figure 3-10**

Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii

3.4.3 Environmental Consequences

The location and extent of a proposed action needs to be evaluated for its potential effects on a project site and adjacent land uses. Factors affecting a proposed action in terms of land use include its compatibility with on-site and adjacent land uses, restrictions on public access to land, or change in an existing land use that is valued by the community. Other considerations are given to proximity to a proposed action, the duration of a proposed activity, and its permanence.

3.4.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to land use. Therefore, no impact to land use would occur with implementation of the No Action Alternative.

3.4.3.2 Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative) Potential Impacts

The study area for the analysis of effects to land use associated with the Preferred Alternative includes areas which would be altered by:

- the proposed 24 box magazines clustered around the 10th Street and E Avenue intersections;
- adjacent construction staging and roadway access;

- adjacent roadways and concrete pads, utility improvements, landscaping, and drainage improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

The site proposed for the Preferred Alternative and adjacent lands define the study area for land use analyses.

The project area is part of JBPHH and the land at West Loch Annex has long been set aside for national defense purposes. Safety arcs have been established up to the southwest border of West Loch Annex and the agricultural outlease is being permitted under a temporary waiver. Thus, the provisions of the FPPA do not apply to this project. It is emphasized that safety and security measures as part of the Proposed Action are necessary and essential.

Public access on West Loch Drive and applicable portions of North Road and Iroquois Road would cease for safety reasons and to provide additional site security. The new entry control point on Iroquois Road, the gate on North Road at its intersection with Iroquois Avenue, and the patrol road and security fence along the southwest border of West Loch Annex provide additional security.

The Hawaii CZM Program reviewed and concurred that New Construction activities, when within Navy/Marine Corps controlled areas that is similar to present use and when completed, the use or operation of which complies with existing regulatory requirements, is expected to have insignificant direct or indirect (cumulative and secondary) coastal effects and should not be subject to further review by the Hawaii CZM Program on the basis and condition that the activities are subject to and bound by the full compliance to project mitigation/general conditions 1, 3, 6, 8, 9, 10, 11, 13, 14, and 16:

1. Navy/Marine Corps controlled property refers to land areas, rights of way, easements, roads, safety zones, danger zones, ocean and naval defensive sea areas under active Navy/Marine Corps control.

3. Turbidity and siltation from project related work shall be minimized and contained to within the vicinity of the site through appropriate use of effective silt containment devices and the curtailment of work during adverse tidal and weather conditions.

6. No project-related materials (fill, revetment rock, pipe, etc.) should be stockpiled in the water (intertidal zones, reef flats, stream channels, wetlands, etc.).

8. No contamination (trash or debris disposal, alien species introductions, etc.) of adjacent marine/aquatic environments (reef flats, channels, open ocean, stream channels, wetlands, etc.) shall result from project-related activities.

9. Fueling of project-related vehicles and equipment should take place away from the water and a contingency plan to control petroleum products accidentally spilled during the project shall be developed. Absorbent pads and containment booms shall be stored on-site, if appropriate, to facilitate clean-up of accidental petroleum releases.

10. Any under-layer fills used in the project shall be protected from erosion with stones (or core-loc units) as soon after placement as practicable.

11. Any soil exposed near water as part of the project shall be protected from erosion (with plastic sheeting, filter fabric, etc.) after exposure and stabilized as soon as practicable (with vegetation matting, hydroseeding, etc.).
13. Navy/Marine Corps shall evaluate the possible impact of the action on species and habitats protected under the Endangered Species Act (ESA).
14. The National Environmental Policy Act (NEPA) review process will be completed.
16. Navy or Marine Corps staff shall notify State CZM of de minimus usage for projects which require an Environmental Assessment (EA). Notification can be sent via email to: Jnakagaw@dbedt.hawaii.gov.

The area of the Preferred Alternative not on existing Navy property (Iroquois Road) would be subject to a CZMA Consistency Determination (CCD) to ensure that the Proposed Action would be consistent with the enforceable policies of the Hawaii Coastal Zone Management Program, to the maximum extent practicable.

The following objective of the Hawaii State Plan is relevant to the Proposed Action.

Section 226-9 economy – federal expenditures

(b)(3) Promote the development of the federally supported activities in Hawaii that respect statewide economic concerns, are sensitive to community needs, and minimize adverse impacts on Hawaii's environment.

The Proposed Action would provide sufficient storage for JBPHH to meet its current ordnance storage requirement. The magazine storage would address an appropriate type and quantity of ordnance storage which supports military readiness in the Western Pacific and Hawaiʻi's role in national defense. The Proposed Action would be implemented in phases which provides economic benefit to Hawaii's economy over a multi-year period. The Proposed Action provides efficient storage in magazines close to loading and unloading docks with necessary buffers to address public safety concerns. Numerous avoidance and minimization measures noted in the EA would be implemented to minimize impacts on Hawaii's environment.

Agricultural District lands affected by Alternative 1 (178 acres) represent 0.14 percent of lands in the State Agricultural District on Oahu (approximately 128,000 acres) (DBEDT, 2016). As of 2014, approximately 12,000 acres (27 percent) of the 44,400 acres of high quality farmland on Oahu was being farmed (City and County of Honolulu, 2014). Thus the proposed Action would represent a less than significant impact to the amount of available farmland on the island of Oahu.

The following objective of the City and County of Honolulu General Plan is relevant to the Proposed Action.

A: To promote employment opportunities that will enable the people of Oahu to attain a decent standard of living.

The Proposed Action would provide employment opportunities during the construction phase of the project to aid the local economy. The project would create a more efficient and safe ordnance storage operation which helps to ensure the continuation of a significant level of federal employment on Oahu.

The Ewa Community Plan acknowledges that significant acreages of highly productive agricultural lands within the region have been converted to urban use over the years with the demise of sugar. The Plan also acknowledges that agricultural operations at West Loch Annex are limited by military safety restrictions and the brackish water supply.

The Proposed Action's safety and security improvements are within an established safety arc and necessary to protect public safety and encourage growth and development in the Ewa region in accord with established Plan provisions.

Under the LUO, the F-1 Military and Federal Preservation District permits all military and federal uses and structures. The bypass road, security fence and patrol road would be proposed near the boundary of federal property and preserves needed contiguous lands for military and federal uses and structures within West Loch Annex. The fence and patrol road are not inconsistent with the AG-1, AG-2 and R-5 District provisions. There are no portions of the project proposed within the P-1 Restricted Preservation District.

Most of the proposed project is not located within the SMA. However, portions of the perimeter road/patrol road near its northern terminus are located in the SMA and would be located within the shoreline setback (Figure 3-10). As a federal agency, the Navy considers City and County of Honolulu special management area and shoreline setback provisions as local best practices. The Navy will exert best efforts to comply with applicable City and County of Honolulu special management area and shoreline setback provisions.

The project is consistent with the objectives of the Hawaii CZM program.

Objective: Provide coastal recreational opportunities accessible to the public.

> The Proposed Action would not impact coastal recreational resources or opportunities accessible to the public.

Objective: Protect, preserve and, where desirable, restore those natural and manmade historic and prehistoric resources in the coastal zone management area that are significant in Hawaiian and American history and culture.

> For Alternative 1 and Alternative 2, the majority of the known sites are concrete foundations or utility infrastructure from the initial development of the U.S. Naval Ammunition Depot West Loch Branch (beginning in 1931) and the Advance Base Construction Depot Annex (ABCD Annex) (1943-1951). The exception is a plantation road network that pre-dates military development in the area. These sites were subject to inventory-level documentation and no further actions were recommended (Filimoehala et al., 2015; Jensen and Head, 1997; Rieth, 2011). None of the sites are eligible for listing in the NRHP.

Objective: Protect, preserve, and, where desirable, restore or improve the quality of coastal scenic and open space resources.

> The Proposed Action would not adversely affect scenic and open space resources in shoreline or other areas. Many areas of West Loch Annex are overgrown primarily with kiawe trees, haole koa and other non-native vegetation. Proposed developments are low rise and generally would not exceed the height of surrounding vegetation. Security fencing and a patrol road would be necessary along the western boundary of the project for safety purposes.

Objective: Protect valuable coastal ecosystems, including reefs, from disruption and minimize adverse impacts on all coastal ecosystems.

The project would not degrade coastal ecosystems or surface waters that flow into marine waters. During construction, BMPs would be implemented to avoid or minimize sediment flows into coastal waters. The project would obtain a National Pollutant Discharge Elimination System (NPDES) permit for temporary discharge of stormwater and an NPDES permit for dewatering, as applicable. Permit conditions would minimize or eliminate impact to coastal ecosystems.

Objective: Provide public or private facilities and improvements important to the State's economy in suitable locations.

The Proposed Action involves the provision of needed ordnance storage for the Navy. Although ordnance storage is not coastal dependent per se, it enhances efficiency and public safety to be in close proximity to West Loch Annex. The proposed project is important to the State's economy and is in a suitable location.

Objective: Reduce hazard to life and property from tsunami, storm waves, stream flooding, erosion, subsidence, and pollution.

The proposed project is located within Zone D (i.e., areas with possible but undetermined flood hazards) (FEMA, 2011). There are no streams or surface water features in or near the Proposed Action and alternatives that could cause potential flood hazards.

Objective: Improve the development review process, communication, and public participation in the management of coastal resource and hazards.

Objective: Stimulate public awareness, education, and participation in coastal management.

The Proposed Action represents a consolidation of ordnance storage in an area currently used for such purposes. Relevant federal, state and county agencies would be notified at an early stage. Coordination among the Navy and the various permitting agencies would be ongoing. Public review would be conducted as part of the NEPA EA process.

Objective: Protect beaches for public use and recreation.

The Proposed Action does not involve any improvements on any public beach. The proposed improvements are adjacent to the established shoreline of West Loch and are necessary for safety and security purposes. Since this is a secure area, the project would have no effect on public use of beaches and recreation.

Objective: Promote the protection, use, and development of marine and coastal resources to assure their sustainability.

The Proposed Action would not involve the use or development of marine or coastal resources.

Alternative 1 would result in less than significant impacts to land use.

3.4.3.3 Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive) Potential Impacts

The study area for the analysis of effects to land use associated with this alternative includes:

- 24 box magazines west of West Loch Drive and 6th Street;
- adjacent construction staging;
- fire station;
- adjacent roadways and concrete pads, utility improvements;

- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

Alternative 2 is the same as Alternative 1 except that the magazines are in different areas and a new fire station is included. The Alternative 2 magazines would affect an additional 52 acres of State Agricultural District land. The total acreage of additional Agricultural District lands affected in Alternative 2 is 230 acres or 0.18 percent of lands in the State Agricultural District on Oahu. While Alternative 2 requires slightly greater acreages of agricultural-designated lands, it is also within established safety arcs and necessary to protect public safety. Regarding tsunami evacuation parameters, the project site is located within a Safe Zone with the exception of the proposed fire station site. This is located in an Extreme Tsunami Evacuation Zone in which an evacuation is recommended in the unlikely case of an “Extreme Tsunami Warning” caused by a very large (Magnitude 9+) earthquake and tsunami.

Alternative 2 would result in less than significant impacts to land use.

3.5 Public Health and Safety

This discussion of public health and safety includes consideration for any activities, occurrences, or operations that have the potential to affect the safety, well-being, or health of members of the public. A safe environment is one in which there is no, or optimally reduced, potential for death, serious bodily injury or illness, or property damage. The primary goal is to identify and prevent potential accidents or impacts on the general public. Public health and safety within this EA discusses information pertaining to community emergency services, construction activities, operations, and environmental health and safety risks to children.

Community emergency services are organizations which ensure public safety and health by addressing different emergencies. The three main emergency service functions include police, fire and rescue service, and emergency medical service.

Public health and safety during construction, demolition, and renovation activities is generally associated with construction traffic, as well as the safety of personnel within or adjacent to the construction zones.

Operational safety may refer to the actual use of the facility or built-out proposed project, or training or testing activities and potential risks to inhabitants or users of adjacent or nearby land and water parcels. Safety measures are often implemented through designated safety zones, warning areas, or other types of designations.

Environmental health and safety risks to children are defined as those that are attributable to products or substances a child is likely to come into contact with or ingest, such as air, food, water, soil, and products that children use or to which they are exposed.

3.5.1 Regulatory Setting

Executive Order 13045, *Protection of Children from Environmental Health Risks and Safety Risks*, requires federal agencies to “make it a high priority to identify and assess environmental health and safety risks that may disproportionately affect children and shall ensure that its policies, programs, activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks.”

3.5.2 Affected Environment

The project area is located in Sector 3 of Honolulu Police Department's District 8 – Kapolei/Waianae. The Kapolei Police Station is located at 1100 Kamokila Boulevard approximately 8 miles from the project site. The existing Navy fire station is located within the north-central portion of West Loch Annex. Due to safety issues involving the location of storage of ordnance with Alternative 2, a new fire station facility would be built further away from the existing and proposed magazines near the southeast corner of West Loch Annex. The new fire station is included with Alternative 2. With Alternative 1, no changes are proposed to the existing fire station. The City and County of Honolulu Fire Department is also available to provide assistance as appropriate. Ewa Beach Fire Station 24, located at 91-995 Kaileolea Drive, is approximately 3 miles from the project site. The City and County of Honolulu has emergency medical services (EMS) advance life support ambulance units located throughout the community. The closest units are located in Ewa Beach and Makakilo.

3.5.3 Environmental Consequences

The safety and environmental health analysis contained in the respective sections addresses issues related to the health and well-being of military personnel and civilians living on or in the vicinity of the project area. Specifically, this section provides information on hazards associated with construction and operation of the proposed project. Additionally, this section addresses the environmental health and safety risks to children.

3.5.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to public health and safety. Therefore, no impacts to public health and safety would occur with implementation of the No Action Alternative. However, existing public vehicular usage of West Loch Drive and portions of Iroquois Road and North Road traverse immediately outside the existing West Loch Annex fence boundary which is a secure facility which stores military ordnance. Continued usage of West Loch Drive and portions of Iroquois Road and North Road is a safety concern which would continue under the No Action Alternative.

3.5.3.2 Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative) Potential Impacts

The study area for the analysis of effects to public health and safety associated with the Preferred Alternative includes areas which would be altered by:

- the proposed 24 box magazines clustered around the 10th Street and E Avenue intersections;
- adjacent construction staging and roadway access;
- adjacent roadways and concrete pads, utility improvements, landscaping, and drainage improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

The Navy has determined that the proposed 24 Type "D" magazines would address an appropriate type and quantity of needed ordnance storage at West Loch Annex. Ordnance storage which would be provided in these facilities would preclude corresponding ordnance transport on public highways. This would enhance public safety and security for those who live, work and traverse along and adjacent to these public transit routes.

Contractors will be required to implement appropriate construction BMPs to prevent potential storm water soil erosion from unexpected storm events. Any potential runoff would be intercepted, collected, and either absorbed on site, or filtered or treated, as appropriate, consistent with federal and state regulations.

The proposed magazines are Type “D” magazines which would be constructed at West Loch Annex in accord with DoD standards. Each magazine would have five electronically operated doors and an intrusion detection system. The project also includes Anti-Terrorism/Force Protection (AT/FP) features and comply with AT/FP regulation and physical security mitigation. West Loch Annex would be secured by the security fence and patrol road along its western boundary. The entry control point on Iroquois Road would prohibit public access into West Loch Annex. A security gate is also being installed at the corner of North Road and Iroquois Avenue. The existing West Loch Annex front gate would continue to provide security at the corner of Iroquois Avenue and Barracks Road.

Public access within West Loch Annex would not be allowed for safety and security reasons. The Navy has determined that there are no environmental health and safety risks associated with the Proposed Action that would disproportionately affect children.

Therefore, implementation of the Preferred Alternative would result in less than significant impacts to public health and safety.

3.5.3.3 Alternative 2 (24 New Box Type “D” Magazines Located West of West Loch Drive) Potential Impacts

The study area for the analysis of effects to public health and safety associated with this alternative includes:

- 24 box magazines west of West Loch Drive and 6th Street;
- adjacent construction staging;
- fire station;
- adjacent roadways and concrete pads, utility improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

The magazines for Alternative 2 are the same Type “D” magazines as the Preferred Alternative except that the location is west of West Loch Drive and 6th Street. The magazines would be built to the same applicable DoD standards and would involve generally the same improvements as the Preferred Alternative. Because the location of the magazines are in proximity to the existing fire station, a new fire station would be built at the corner of G Avenue and 18th Street in the southeast portion of West Loch Annex. Safety and security precautions would otherwise be the same as the Preferred Alternative. The Navy has determined that there are no environmental health and safety risks associated with Alternative 2 that would disproportionately affect children.

Therefore, implementation of Alternative 2 would result in less than significant impacts to public health and safety.

3.6 Visual Resources

This discussion of visual resources includes the natural and built features of the landscape visible from public views that contribute to an area's visual quality. Visual perception is an important component of environmental quality that can be impacted through changes created by various projects. Visual impacts occur as a result of the relationship between people and the physical environment.

3.6.1 Regulatory Setting

The City and County of Honolulu's Ewa DP has identified that utilizing open space to protect scenic views is a general policy for the Ewa community. It has specified several views which are considered particularly significant views and vistas which should be preserved including, "Distant vistas of the shoreline from the H-1 Freeway above the Ewa Plain (Ewa DP, 2013)." The project site lies between the H-1 Freeway and the Ewa shoreline approximately 3.25 miles south of the H-1 Freeway at the Fort Weaver Interchange. The elevation of the freeway is approximately 174 feet MSL, while the elevation at the mauka boundary of West Loch Annex is about 40 feet MSL. The landform of the intervening area is characterized by gently sloping terrain, vacant land, cultivated fields, and residential and golf course development.

3.6.2 Affected Environment

The project site lies in the relatively flat Ewa Plain. Except for a portion of Iroquois Road presently owned by the State of Hawaii, the project site is located on Navy property. Public access on segments of North Road, West Loch Drive and Iroquois Road through West Loch Annex is currently allowed. The proposed project would discontinue public access (and consequently public views) on these roadways.

The waters of West Loch, Waipio Peninsula, and Hickam Air Force Base are located to the east of the project site. The Kapilina residential development is located to the south of the development. Single family residences and two private golf courses are located to the southwest of the project site. To the north of the project site are portions of West Loch with the Kunia and Waipahu areas further distances away.

The proposed magazines would be approximately 20 feet in height and would be covered by a minimum of 2 feet of earth. Areas to the east of West Loch Drive are heavily vegetated. The predominant vegetation is kiawe (*Prosopis pallida*) forest with an understory of grasses, typically buffel grass (*Cenchrus ciliaris*) or Guinea grass (*Urochloa maxima*). Areas to the west of West Loch Drive have been farmed more recently and vegetation is typically lower in height. Existing vegetation would screen much of the proposed magazine development.

The bypass road would extend along the southwestern boundary of West Loch Annex, between Iroquois Road and North Road a distance of approximately 8,700 lineal feet. The two-lane two-way roadway would be within a 60-foot wide right-of-way. At its intersection with Iroquois Road, it is approximately 350 feet away from the southwestern boundary of West Loch Annex. The alignment then proceeds adjacent to the southwestern boundary of West Loch Annex toward North Road. There are residential uses, vacant land and two golf courses abutting the southwestern boundary of West Loch Annex. For approximately 5,300 lineal feet extending southeast from Iroquois Road, there is also an approximately 30-foot wide easement, not under the control of the Navy which contains a HECO 46 kilovolt overhead electrical transmission line. On Navy property near the southwestern boundary, there are also existing dirt/rock berms which were likely built by agricultural tenants as well as berms formed during previous military construction. The berms or applicable portions may be retained if not needed for construction of the bypass road and security fence/patrol road.

The entry control point would be located on Iroquois Road on the installation side of the bypass road intersection with Iroquois Road more than 350 feet from the southwestern boundary of West Loch Annex. A gate/sentry house, vehicle curbs and barriers, utility building and three parking stalls, vehicle inspection and vehicle turnaround area would be installed as part of the entry control point. The vehicle inspection and turnaround area would be surrounded by an approximately ten-foot high earth berm or privacy walls. An approximately 40-foot high overwatch tower and a single story overwatch station would be located in proximity to the vehicle inspection area.

A ten-foot high wire strand chain link security fence and patrol road within a 40-foot right-of-way would be built along the eastern boundary of the bypass road right of way extending from Iroquois Road to North Road (Figure 2-5). Although the bypass road does not extend northwest of Iroquois Road, the security fence and patrol road would extend approximately 8,300 lineal feet along the installation boundary, then extend adjacent to the Pearl Harbor National Wildlife Refuge – Honouliuli Unit boundary to an area close to the shoreline. At the bypass road and North Road intersection, the security fence and patrol road would extend northeast along North Road approximately 2,000 feet to its intersection with Iroquois Avenue.

HECO is in the process of constructing a PV array project along the West Loch Annex western boundary extending from Iroquois Road to North Road. Among the structures previously approved, the substations would include medium voltage switchgear and transformers, as well as a two-story warehouse-type building. A microwave communications tower, not to exceed 75 feet in height, would be located adjacent to the building. The solar arrays are approximately 4 feet above ground level.

3.6.3 Environmental Consequences

The evaluation of visual resources in the context of environmental analysis typically addresses the contrast between visible landscape elements. Collectively, these elements comprise the aesthetic environment, or landscape character. The landscape character is compared to the Proposed Action's visual qualities to determine the compatibility or contrast resulting from the buildout and demolition activities associated with the Proposed Action.

Visual Resources:

- Compatibility with significant regional views and vistas.

3.6.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to visual resources. Therefore, no impact to visual resources would occur with implementation of the No Action Alternative.

3.6.3.2 Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative) Potential Impacts

The study area for the analysis of effects to visual resources associated with the Preferred Alternative includes areas which would be altered by:

- the proposed 24 box magazines clustered around the 10th Street and E Avenue intersections;
- adjacent construction staging and roadway access;

- adjacent roadways and concrete pads, utility improvements, landscaping, and drainage improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

The site proposed for the Preferred Alternative and adjacent lands define the study area for visual resources analyses. The following components of the Preferred Alternative are being addressed in terms of possible visual impact.

Box Magazines

The proposed 24 box magazines are located in the vicinity of 10th Street and E Avenue. The proposed magazines would be more than 3,300 feet from the West Loch Annex western boundary. The magazines would be 20 feet in height and would be covered by a minimum of two feet of earth. The magazines would be obscured by unmaintained vegetation, primarily kiawe (*Prosopis pallida*) forest. The view impact of the proposed magazines would be negligible.

Bypass Road

The bypass road would be located adjacent to the West Loch Annex southwestern boundary. This includes three non-contiguous residential areas which abut the bypass road alignment. From north to south, the alignment abuts 24 residential structures, two residential structures, and nine residential structures, respectively (Figure 2-4). Along the two northern residential segments, an existing approximately six-foot high boundary fence is located at the residential rear property line. Along the two northern residential segments, there is also a 30-foot wide easement between the residential boundary fence and Navy property. This easement contains overhead electrical transmission lines. Along Navy property, there are existing dirt/rock berms which range from 10-15 feet above grade. Along the most southern residential segment, there is no easement and the area is obscured by unmaintained vegetation, primarily kiawe.

The bypass road would be located within a 60-foot wide right-of-way. The two-way two-lane roadway would consist of two 12-foot wide travel lanes with six-foot wide paved shoulders, curb, gutter and ten-foot wide unpaved shoulders on each side. Overgrown vegetation and dirt/rock berms along the bypass road, security fence and patrol road alignment would be removed, as necessary.

The bypass road would be visible from adjacent property. However, the road would be at-grade or low-rise. Should sound abatement measures or other roadway improvements be warranted within the bypass road right-of-way, view parameters may be affected, primarily from adjacent residences. However, the extent of the effect on views should be similar to existing and planned landforms, vegetation and structures such as the existing dirt/rock berm, the existing kiawe forest, and previously approved PV substations.

Entry Control Point

The entry control point along Iroquois Road and new gate on North Road would be visible to motorists traveling on Iroquois Road and North Road in the vicinity of the proposed improvements. The improvements would generally be low rise in nature. The tallest structure at the entry control point is an overwatch tower approximately 40 feet in height set back at least 1,200 feet from the closest residence.

Security Fence/Patrol Road

A security fence/patrol road includes a ten-foot tall wire strand chain link fence and an all-weather or aggregate surface security patrol road with unpaved shoulders within a 40-foot wide right-of-way. On the eastern boundary of the bypass road, there is a ten-foot tall wire strand chain link perimeter fence.

An all-weather or aggregate surface security patrol road approximately 20 feet wide would be installed adjacent and to the east of the security fence. Planned and previously approved Phase I and Phase II of the photovoltaic arrays would also extend to within 100 feet away from the West Loch Annex western boundary. The ground-mounted solar arrays would be low-rise, no more than four feet above existing grade. The existing overhead 46 kV powerlines extending along most of the western Annex boundary would remain in place. Substations for Phase I and Phase II and microwave towers have also been previously approved as part of the solar array project.

The Proposed Action would not significantly alter open space views from bordering roadways and adjacent areas. A portion of Iroquois Road, West Loch Drive and a portion of North Road would be closed to public access once the proposed bypass road is operational. At the entrance to the entry control point, the security fence would be visible to adjacent residential use, but is a necessary component for safety reasons. The entry control point consists primarily of low-rise structures and earth berms located more than 350 feet away from the southwestern boundary of West Loch Annex. An approximately 40-foot high overwatch tower would likely be located further away from the West Loch Annex western boundary to keep watch of vehicles entering West Loch Annex. Visual impacts on neighboring property would be minimal.

The wire strand chain link security fence for the project would be similar to the existing security fence on West Loch Drive which allows views through the fence. The fence is a necessary security measure, is similar to what already exists in other parts of the secure facility, and would result in a minimal visual impact.

Previously approved PV improvements would result in some changes to existing landforms.

The Proposed Action would result in a relatively low profile and significant distance from elevated public viewpoints. The project would not significantly impact regional views from the surrounding community.

Therefore, implementation of Alternative 1 would result in less than significant impacts to visual resources.

3.6.3.3 Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive) Potential Impacts

The study area for the analysis of effects to visual resources associated with this alternative includes:

- 24 box magazines west of West Loch Drive and 6th Street;
- adjacent construction staging;
- fire station;
- adjacent roadways and concrete pads, utility improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

The site proposed for Alternative 2 and adjacent lands define the study area for visual resources analyses.

Alternative 2 would involve generally the same improvements as the Preferred Alternative. The main difference is the location of the magazines. Alternative 2 includes 24 box magazines located to the west of West Loch Drive and 6th Street. The magazines would be located approximately 3,000 feet from the southwestern boundary of West Loch Annex. The height of the box magazines are the same as the Preferred Alternative. The differences in visual impacts from the Preferred Alternative are slight. Alternative 2 would not significantly impact regional views from the surrounding community.

Alternative 2 also would include a new fire station. This is a low-rise structure located near the southeast corner of West Loch Annex approximately 550 feet away from the Kapilina residential development.

Therefore, implementation of Alternative 2 would result in less than significant impacts to visual resources.

3.7 Biological Resources

Biological resources include living, native, or naturalized plant and animal species and the habitats within which they occur. Plant associations are referred to generally as vegetation, and animal species are referred to generally as wildlife. Habitat can be defined as the resources and conditions present in an area that support a plant or animal.

Within this EA, biological resources are discussed in the following categories: (1) terrestrial vegetation and (2) terrestrial wildlife. Threatened, endangered, and other special status species are discussed in their respective categories.

3.7.1 Regulatory Setting

Special-status species, for the purposes of this assessment, are those species listed as threatened or endangered under the Endangered Species Act (ESA) and species afforded federal protection under the Migratory Bird Treaty Act (MBTA).

The purpose of the ESA is to conserve the ecosystems upon which threatened and endangered species depend and to conserve and recover listed species. Section 7 of the ESA requires action proponents to consult with the U.S. Fish and Wildlife Service (USFWS) or National Oceanic and Atmospheric Administration (NOAA) Fisheries to ensure that their actions are not likely to jeopardize the continued existence of federally listed threatened and endangered species, or result in the destruction or adverse modification of designated critical habitat. Critical habitat cannot be designated on any areas owned, controlled, or designated for use by the DoD where an Integrated Natural Resources Management Plan has been developed that, as determined by the Department of Interior or Department of Commerce Secretary, provides a benefit to the species subject to critical habitat designation.

Birds, both migratory and most native-resident bird species, are protected under the MBTA, and their conservation by federal agencies is mandated by EO 13186 (Migratory Bird Conservation). Under the MBTA it is unlawful by any means or in any manner, to pursue, hunt, take, capture, kill, attempt to take, capture, or kill, [or] possess migratory birds or their nests or eggs at any time, unless permitted by regulation. The 2003 National Defense Authorization Act gave the Secretary of the Interior authority to prescribe regulations to exempt the Armed Forces from the incidental taking of migratory birds during authorized military readiness activities. The final rule authorizing the DoD to take migratory birds in such cases includes a requirement that the Armed Forces must confer with the USFWS to develop and implement appropriate conservation measures to minimize or mitigate adverse effects of the Proposed Action if the action will have a significant negative effect on the sustainability of a population of a migratory bird species.

See Section 3.4.2.2 for the discussion regarding the CZMA.

3.7.2 Affected Environment

The following discussion provides a description of the existing conditions for each of the categories under biological resources at the West Loch Annex.

The biological resources study area (study area) is the West Loch Annex located on the western side of Pearl Harbor (NAVFAC PAC, 2011). Land within West Loch Annex has been heavily disturbed for more than a century, from sugar plantations to U.S. Navy uses (AECOS, 2016). West Loch Annex now contains operations and maintenance buildings, community and personnel support facilities, magazines, wharves, and a considerable amount of open land within established safety arcs (NAVFAC PAC, 2011). Undeveloped areas include coastal wetlands, agricultural lands, and natural areas frequented by protected bird species (NAVFAC PAC, 2011).

Outside of the current perimeter fence to the west is leased agricultural land that is also included in the study area of West Loch Annex. An Environmental Assessment/Finding of No Significant Impact (EA/FONSI) was approved for a PV farm in June 2015 for up to 380 acres for lands located west of West Loch Drive. The lease for the first phase of the PV system, approximately 200 acres, has been executed. With the execution of the first phase lease, the current remaining lands in the West Loch Annex agricultural outlease total approximately 825 acres. Up to 180 additional acres of the future phase of the PV farm would affect the remaining acreage of the agricultural outlease. The existing lease expires in 2023.

The Honouliuli Pearl Harbor National Wildlife Refuge (PHNWR) is located to the northwest of the study area and is maintained by the USFWS.

3.7.2.1 Terrestrial Vegetation

Vegetation includes terrestrial plant as well as freshwater aquatic communities and constituent plant species.

The inland vegetation at West Loch Annex is vegetated with non-native dryland vegetation, primarily kiawe (*Prosopis pallida*) that range in size but with a maximum height of 20 feet. Koa haole (*Leucaena leucocephala*) and opiuma (*Pithecellobium dulce*) is interspersed within and at the edges of the forest. Buffel grass (*Cenchrus ciliaris*) is the only vegetation below the kiawe trees creating an open understory. Buffel grass also fills in the forest edges. There are also open fields of koa haole and buffel grass that surrounds the kiawe forest.

Both actively tilled and fallow cropland occur within the leased agricultural land (AECOS, 2016). Most of the plant diversity within developed areas or former residential areas is a result of landscape plantings (AECOS, 2016). Mangrove (*Rhizophora mangle*) trees are scattered along the eastern coastline of West Loch Annex, occupying steep shores, fishponds, and mudflats (AECOS, 2016). In areas where mangrove trees have been removed, pickleweed (*Batis maritima*) has become established (AECOS, 2016). Most plants recorded in and around the study area can be found in similar habitats throughout Hawaii.

3.7.2.2 Terrestrial Wildlife

Wildlife includes all animal species (i.e. insects and other invertebrates, freshwater fish, amphibians, reptiles, birds, and mammals) focusing on the species and habitat features of greatest importance or interest.

Birds

In all, seven species observed at the study area had no federal or state protection, while 12 of the observed species are protected under the MBTA (SWCA 2015, NAVFAC 2019) (Table 3-16).

Table 3-16 Birds Observed at West Loch Annex

Species	*Common Name*	*Status*
Amandava amandava	Strawberry finch	Non-native
Cettia diphone	Japanese bush warbler	Non-native
Acridotheres tristis	Common mynah	Non-native
Paroaria coronata	Red-crested cardinal	Non-native
Columba livia	Rock dove	Non-native
Copsychus malabaricus	White-rumped shama	Non-native
Geopelia striata	Zebra dove	Non-native
Bubulcus ibis	Cattle egret	Non-native, MBTA
Arenaria interpres	Ruddy turnstone	MBTA
Pluvialis fulva	Pacific golden plover	MBTA
Tringa incana	Wandering tattler	MBTA
Spatula clypeata	Northern shoveler	MBTA
Aythya affinis	Lesser scaup	MBTA
Anas wyvilliana-Anas platyrhynchos	Koloa-mallard hybrid duck	MBTA
Nycticorax nycticorax	Black-crowned night heron	MBTA
Mareca americana	American widgeon	MBTA
Anas acuta	Northern pintail	MBTA
Aythya collaris	Ring-necked duck	MBTA
Pandion haliaetus	Osprey	MBTA

Source: SWCA 2015, NAVFAC Hawaii 2019.

Non-Native Mammals and Reptiles

Though mammal and reptile surveys were not conducted in the West Loch Annex study area, a survey was conducted on the Waipio Peninsula in 2006 by NAVFAC PAC (NAVFAC PAC, 2006). Vegetation on the Waipio Peninsula is similar to the vegetation in the study area, so mammals and reptiles occurring in Waipio could also occur in the study area. The Waipio Peninsula survey documented three mammal species: feral cat (*Felis catus*), mongoose (*Herpestes auropunctatus*), and rat (*Rattus rattus*). Two reptiles were also reported, the house gecko (*Hemidactylus frenatus*) and mourning gecko (*Lepidodactylus* *lugubrus*). None of these species are indigenous to Hawaii or are threatened or endangered. All can be found throughout urbanized areas of Oahu.

Special-Status Species

There are federally listed and state-listed species known to occur or potentially occur in the study area (described below in Table 3-17), but no critical habitat has been designated for these species in the study area (NAVFAC PAC, 2011).

Table 3-17 Threatened and Endangered Species Known to Occur or Potentially Occur in the Study Area and Critical Habitat Present in the Study Area

Common Name	*Scientific Name*	*Federal Listing Status*	*State Listing Status*	*Critical Habitat Present?*
Hawaiian owl	*Asio flammeus*		SE	No
Hawaiian hoary bat	*Lasiurus cinereus*	FE	SE	No
Hawaiian stilt	*Himantopus mexicanus knudseni*	FE	SE	No
Hawaiian coot	*Fulica americana alai*	FE	SE	No

Notes: FE = federal endangered, SE = state endangered.

Hawaiian Short-Eared Owl

Hawaiian short-eared owls are active during the day and occur in a variety of habitats, including wet and dry forests, grasslands, and shrublands (Mitchell et al., 2005). Owls could forage and nest within the study area's grasslands or open-canopy kiawe forests with grassy understories. The owl's diet consists of small mammals and birds (Holt and Leasure, 2006).

This species is listed by the state as endangered on Oahu, and can be found throughout the main Hawaiian Islands from sea level to 8,000 feet. Little is known about the breeding biology of the Hawaiian short-eared owl, but nesting occurs throughout the year (USFWS, 2013). Nests are made on the ground and are lined with grasses and feathers.

Hawaiian Stilt

Hawaiian stilt abundance varied between 1,100 and 1,783 individuals between 1997 and 2007, and the statewide population has been increasing over the past 30 years (Reed et al. 2011; USFWS 2011). Hawaiian stilts use a variety of aquatic habitats, but they prefer to loaf in open mudflats, sparsely vegetated pickleweed mats, and open pasturelands. Specific water depths of 5 inches (12.7 centimeters [cm]) are required for optimal foraging. Nest sites are frequently separated from feeding sites, and they are adjacent to or on low islands within bodies of fresh, brackish, or salt water.

Hawaiian Coot

The Hawaiian coot occurs on all the main Hawaiian Islands except Kahoʻolawe, with an estimated population of 1,000 to 2,000 individuals. This species is associated with emergent freshwater and brackish water marsh habitat in lowland valleys, reservoirs, and occasionally in high-elevation plunge pools (USFWS 2011). Hawaiian coots forage in mud, sand, on the water surface; can dive in water up to

4 feet (1.21 m) deep; and may graze at grassy sites adjacent to wetlands (USFWS 2011). Nests are typically built on floating aquatic vegetation or in clumps or wetland vegetation, although nests have been documented on shorelines and rocky islets (USFWS 2011).

Hawaiian Hoary Bat

The Hawaiian hoary bat (*Lasiurus cinereus semotus*) is the only ESA-listed species that may be present within the project area. The Hawaiian hoary bat is a solitary species that has been recorded on the islands of Kauai, Oahu, Maui and Hawaii, with the largest populations thought to be on Kauai and Hawaii Island (USFWS, 1998). Accurate estimates of the population are not available, but estimates for all islands have ranged from hundreds to a few thousand (USFWS, 1998).

The Hawaiian hoary bat uses a wide variety of habitats including native, non-native, and agricultural areas. Vegetation cover and structure appear to be more important than a particular vegetation species. Transition area or forest breaks are generally considered good Hawaiian hoary bat habitats (Koob, 2012).

Seasonal elevation movements have been documented in Hawaiian hoary bats on Hawaii Island and Kauai (Gorresen et al., 2013, Bonaccorso and Pinzari, 2011). On Hawaii, bats move to higher elevations from January through April. It is believed that bats move to cooler temperatures in higher elevations to achieve a lower metabolic rate while roosting (Pacific Rim, 2013).

The United States Geological Survey (USGS) conducted bat detection surveys on Navy installations on Oahu at Wahiawa Gulch, Wahiawa Housing, Pearl Harbor National Wildlife Refuge, Waiawa Watershed, Ford Island, and Hickam near Ahua Reef from February to July of 2012. Bats were detected at only two sites, Wahiawa Gulch and Wahiawa Housing area on the slopes of the Koolau Mountains (Bonaccorso et al., 2012). More recent USGS data resulted in detections at six sites: Wahiawa Gulch, Wahiawa Housing, Ford Island, Ahua Wetland at Hickam, Kolekole Pass, and Red Hill (USGS, 2015).

Bats have been detected in the northern Koolau mountains from studies associated with the Kahuku wind turbines (Gorresen et al., 2015). Peak detections of bats were from March through September. Although seasonal elevation movement has been documented on Kauai and Hawaii, detections at the Kahuku study did not show a strong seasonal movement pattern. Elevation range on Oahu is restricted as compared to other islands and therefore seasonal movement may be more limited (Gorresen et al., 2015). The study did find bat occupancy is driven by local conditions that vary with wind exposure and prey availability. Bats favored leeward ridges that were wind sheltered and high elevation sites with flat ridge tops (Gorresen et al., 2015).

Because accurate population estimates of Hawaiian hoary bats are limited and historical distribution information is lacking, the decline of the species has been largely inferred (USFWS, 1998). Observations and species records suggest that bats are absent from historically occupied ranges (USFWS, 1998). The primary factors associated with Hawaiian hoary bat declines are thought to be habitat loss, collision with structures, and possibly pesticide use (USFWS, 2010). Effects of pesticides have not been fully investigated as to whether it effects bats directly, or indirectly through limiting prey (USFWS, 1998). Therefore, pesticides have not been evaluated as part of this assessment.

Roost disturbance is a common threat for all bats worldwide (Koob, 2012). For the Hawaiian hoary bat, this could be clearing or pruning trees where bats roost. The availability of roosting sites and suitable roosting habitat are important to pregnant lactating females and fledging bats (USFWS, 2010). Disturbing roosting sites when juvenile bats are fledging (July to September) has the highest potential for mortality as young bats are not able to evade disturbance. Bat numbers are thought to have decreased significantly perhaps due to deforestation that occurred in the early nineteenth century (USFWS, 1998). Mortality of breeding adults and females may also limit the recovery of the species. Current loss of forests and land conversions from agriculture contribute to habitat loss. (USFWS, 2010).

More observations of bats interacting with man-made structures in the natural environment have been documented. Specifically, windfarms and barbed wire fences have caused mortality of migratory tree-roosting bats in Australia (Koob, 2012). Fences placed between wind breaks and vegetation gaps are hazards to transiting bats. When flying and feeding, bats are unable to detect these structures and collide with them often leading to death. The National Park Service reported that hog wire fences with top stands of barbed wire killed at least 12 Hawaiian hoary bats at two locations in Haleakala National Park from 1986-2004 (USFWS, 2010). The Nature Conservancy recorded three dead bats at their Kona Hema Preserve on the top barbed wire strand along their hog wire fence from August to October 2008 (USFWS, 2010).

3.7.3 Environmental Consequences

This analysis focuses on wildlife or vegetation types that are important to the function of the ecosystem or are protected under federal or state law or statute.

Biological Resource Potential Impacts:

- Vegetation removal
- Wildlife displacement
- Loss of foraging and breeding habitat

3.7.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to biological resources. Therefore, no impact to biological resources would occur with implementation of the No Action Alternative.

3.7.3.2 Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative) Potential Impacts

The study area for the analysis of effects to biological resources associated with the Preferred Alternative includes areas which would be altered by:

- the proposed 24 box magazines clustered around the 10th Street and E Avenue intersections;
- adjacent construction staging and roadway access;
- adjacent roadways and concrete pads, utility improvements, landscaping, and drainage improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

<u>**Vegetation**</u>

Alternative 1 would remove more vegetation than would the No Action Alternative. However, Alternative 1 is not expected to have a substantial, adverse effect on vegetation. Construction of Alternative 1 would remove most vegetation within the project footprint (approximately 310 acres), but the study area consists primarily of common, introduced, and alien vegetation species (as described in Section 3.7.2.1). The primary vegetation types that would be removed are non-native kiawe trees, non-native koa haole trees and non-native grasses.

Using off-island equipment or introducing landscaping vegetation could introduce invasive species to the study area. To minimize the potential for invasive species introduction, all construction equipment, vehicles, and materials that have been sourced off-island would be inspected and decontaminated of any excessive debris or plant material. Inspection and cleaning activities would be conducted at a designated location. If portions of the project footprint are landscaped as a result of the project, native Hawaiian plants would be employed for landscaping around the study area to the maximum extent possible. If native plants do not meet landscaping objectives, plants with a low risk of becoming invasive would be substituted.

Terrestrial Wildlife

Most of the habitat removed by Alternative 1 would be kiawe forest and koa haole scrub forest. This would primarily impact forest-dwelling species. Construction of the new perimeter fence and patrol road would increase fragmentation of the existing habitat, especially for wide-ranging terrestrial species. A portion of the new perimeter fence and patrol road would be located in proximity to the PHNWR. A minimum 20-foot wide clear area would be provided outside of the wildlife boundary area. The security fence and patrol road would be installed in the area separating the former agricultural lands located at West Loch Annex from residential communities and a wetland area within the PHNWR. Ground disturbing activities will be located in previously disturbed agricultural lands located east of the wetlands. The proposed security fence would be located approximately 200 feet away from the PHNWR predator proof fence and 180 feet from the wetland boundary fence.

In the short term, the noise and human activity associated with construction of Alternative 1 would displace wildlife from an area greater than the project footprint. In the long term, wildlife would return to the habitat remaining in the study area but would be permanently displaced from the project footprint. However, the observed species are expected to use suitable nearby habitats for temporary relocation and foraging. Displacement of these individuals from the project footprint would not be expected to affect the survival of individuals or populations.

MBTA-Protected Birds

MBTA-protected birds would be impacted if active nests are disturbed or damaged during vegetation removal. Construction at the study area may potentially displace some MBTA species temporarily, and tree-nesting and forest-dwelling species could permanently lose nesting and foraging habitat. The temporary displacement of these individuals is not expected to affect individuals' survival or the overall species' populations.

To minimize impacts to MBTA-protected birds, nest surveys would be conducted a maximum of 7 days before construction and reported to the JBPHH Natural Resources Manager. Active nests would be left in place and undisturbed until chicks have fledged. A qualified biologist would monitor active nests during construction activities to reduce the chances of nest abandonment by temporarily shutting down construction activities that disrupt the normal daily patterns of the birds.

To minimize effects on nocturnal seabirds, Navy policy is to avoid all night lighting not needed for Anti-Terrorism/Force Protection (AT/FP) or personnel safety. For all new construction, whenever possible exterior lights should be LED lights with full cut-off fixtures for compliance with MBTA. Lights that are International Dark Sky Association certified, are preferred but not required.

Threatened and Endangered Species

No federal- or state-threatened or endangered plants occur in the study area.

Federal- and state-listed species of birds were observed, but no critical habitat has been designated within the study area (NAVFAC PAC, 2011). Temporary impacts to threatened and endangered terrestrial species could occur from noise or habitat disturbances associated with construction activities. However, threatened and endangered species in the study area are already habituated to high levels of noise associated with military use, harbor and air traffic, and urban development. Increases in noise levels from construction activities to the ambient noise environment would be negligible and temporary.

Permanent loss of non-native kiawe forest and grasslands would occur under the Preferred Alternative. Construction activities would not threaten the existence of any protected species or critical or sensitive habitats. Additionally, installation personnel would continue to manage habitats according to the INRMP, which is designed to protect and benefit threatened and endangered species.

Waterbirds

The Hawaiian coot and Hawaiian stilt constitute the waterbird group because these species share similar habitat needs and biological characteristics. Individual birds or pairs of birds may be discouraged from nesting or foraging in the project area because of the human noise and activity during construction. This temporary displacement of waterbirds would reduce the amount of nest, roost, and/or forage habitats available. This displacement could alter an individual’s typical nesting, foraging, and roosting patterns. However, this impact would be insignificant because the displacement would only occur for a short period of time while construction activities last and adjacent foraging and nesting habitat is available for displaced waterbirds to use.

Short-term direct impacts to waterbirds could occur if human activity, noise, and removal of vegetation disrupt nesting adults, causing temporary or permanent abandonment of nest, ducklings, and/or chicks, which could in turn increase the likelihood of nest failure, predation, exposure, or trauma. Disturbance to duckling- and/or chick-rearing areas can result in separation of young from adults, which often results in duckling/chick mortality due to predation, exposure, and/or trauma. Permanent removal of foraging and nesting habitat would constitute a long-term direct impact.

In areas where vegetated streambanks would be disturbed, waterbird nest searches will be conducted by a qualified biologist before any work is conducted and after any subsequent delay in work of 3 or more days (during which birds may attempt nesting). The results of the pre-construction survey will be submitted to the JBPHH Natural Resources Manager. If a waterbird nest with eggs or chicks/ducklings is discovered in the construction limits, work will not begin until the chicks/ducklings have fledged. Waterbird nests, chicks, or broods found in the survey area before or during construction will be reported to JBPHH Natural Resources Manager within 48 hours. A biological monitor will be present on the project site during all construction activities to ensure that Hawaiian waterbirds and nests are not adversely impacted.

Hawaiian Short-Eared Owl

In the short term, the human noise and disturbance associated with construction activities could temporarily displace owls from roosting or foraging habitats. This displacement could alter an individual’s typical foraging and roosting patterns, forcing it to expend energy to search for new foraging and roosting locations.

The permanent removal of roosting and foraging habitat would constitute a long-term indirect impact. Hawaiian short-eared owls create nests on the ground, and a direct impact would occur if young owls that are unable to fly are disturbed. Chicks may fledge from the nest before being able to fly and are dependent on their parents for approximately two months (Mitchell et al., 2005; USFWS, 2013).

Approximately 310 acres of potential roosting, foraging, and nesting habitat would be removed under the Preferred Alternative; however, there is available roosting and nesting habitat with similar vegetation nearby.

To minimize impacts to the Hawaiian short-eared owl, nest surveys would be conducted by JBPHH Natural Resources staff a maximum of seven days prior to construction. Regular on-site staff would be trained to identify this species and know the appropriate measures to be taken if the species are present. If a Hawaiian short-eared owl is observed in the area during construction activities, all activities within 100 feet of the species would cease, and work would not continue until the species leaves the area on its own accord. If a Hawaiian short-eared owl nest is discovered, all activities within 100 feet of the nest would cease and the JBPHH Natural Resources Manager would be contacted. Work would not resume until directed by the JBPHH Natural Resources Manager.

Hawaiian Hoary Bat

Vegetation structure within the West Loch Annex area could provide habitat for bats including trees to roost and forest edges to forage. However, the presence of bats have not been verified by survey results. Surveys on Oahu have detected bats at installations on the slopes of the Koolau mountains, but not in the lowlands of Oahu.

Clearing vegetation would have the greatest impact to hoary bats from loss of habitat and harming pups that are unable to fly. The project area has some non-native trees greater than 15 feet tall, potentially providing suitable habitat for bats to roost. Tree removal may take away bat roosting sites, but it is assumed adult bats could find other roosting locations nearby. However, young bats (pups and/or fledglings) would not be able to escape if disturbed. Conservation measures will be implemented to clear taller vegetation (greater than 15 feet) outside of the bat pupping season (June 1 through September 15). This measure will avoid pupping bats that cannot escape if vegetation is cleared. Once vegetation clearing is finished, bats would be able to occupy surrounding vegetation within West Loch Annex. Considering the action, biology of the bats, and this avoidance conservation measure, the Navy has determined that vegetation clearing associated with this action may affect the Hawaiian hoary bat from disturbance and vegetation loss, but is not likely to adversely affect the species.

A barbed wire security fence, with three strands of barbed wire, could be a flight obstacle that may cause injury or mortality to Hawaiian hoary bats. USGS has calculated a mortality rate for bats colliding with barbed wire fencing. They estimate 0.013 bats killed per mile of wire per year (USFWS, 2014). In the case of the project, each of the three strands would act independently. Thus, 0.013 (mortality rate) x 3.3 miles (length of fence) x three separate strands = 0.1287 bat mortalities per year. The Navy views this as a high estimate based on the fact that collision with barbed wire fences have been documented mostly on low four-foot tall agricultural fences and not on chain link fences with barbed wire along the top, associated with urban landscapes. The low profile fences may be less detectable when bats are feeding than chain link fences. Additionally, occupancy of bats is estimated to be very low in the project area based on nearby installation surveys. Therefore, the Navy has determined that barbed wire fencing associated with this action may affect the Hawaiian hoary bat, but is not likely to adversely affect the species.

The Navy examined the potential impacts from tree clearing and installation of barbed wire fencing on the Hawaiian hoary bat. Conservation measures have been proposed for inclusion in the proposed action to avoid or reduce impacts to the species. Fledging bats may be harmed because they are unable to escape during tree clearing. To address this possibility, trees greater than 15 feet in height will not be removed during the bat pupping period, from June 1 through September 15.

With the implementation of the foregoing management measures designed to protect and benefit threatened and endangered species, implementation of Alternative 1 would result in less than significant impacts to biological resources.

3.7.3.3 Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive) Potential Impacts

The study area for the analysis of effects to biological resources associated with this alternative includes:

- 24 box magazines west of West Loch Drive and 6th Street;
- adjacent construction staging;
- fire station;
- adjacent roadways and concrete pads, utility improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

The project footprint for Alternative 2 is slightly less (approximately 273 acres) than Alternative 1. Impacts likely to occur as a result of Alternative 2 are similar to those described for the Preferred Alternative except as described in the following three sections for vegetation, terrestrial wildlife, and threatened and endangered species.

Vegetation

Alternative 2 is not expected to have a substantial, adverse effect on vegetation. Construction of Alternative 2 would remove all vegetation within the project footprint (approximately 273 acres), but the study area consists primarily of common, introduced, and alien vegetation species (as described in section 3.7.2.1).

Alternative 2 would remove less vegetation than Alternative 1 and more than the No Action Alternative.

Terrestrial Wildlife

In the short term, the noise and human activity associated with construction of Alternative 2 would displace wildlife from an area greater than the project footprint. In the long term, wildlife would return to the habitat remaining in the study area but would be permanently displaced from the project footprint. Most observed species in the study area are common throughout urban Oahu, and would be able to use suitable nearby habitats for temporary relocation and foraging. Displacement of terrestrial species individuals from the project footprint would not be expected to affect the survival of individuals or populations.

Threatened and Endangered Species

Temporary impacts to threatened and endangered terrestrial and marine species from Alternative 2 would be the same as those from the Preferred Alternative and would result from noise and habitat disturbances associated with construction activities. To minimize impacts on MBTA-protected birds and waterbirds, nest surveys would be conducted before construction. A biological monitor will be present on the project site during all construction activities to ensure that MBTA-protected birds and waterbirds and nests are not adversely impacted. Permanent impacts would include loss of foraging or nesting habitat for the Hawaiian short-eared owl. However, foraging and nesting habitat for the Hawaiian short-eared owl is available nearby and nest surveys would be conducted a maximum of seven days prior to construction. Like the Preferred Alternative, conservation measures have been proposed to avoid or reduce impacts to the Hawaiian hoary bat. To address the possibility that fledging Hawaiian hoary bats may be unable to escape during tree clearing, trees greater than 15 feet in height will not be removed during the bat pupping period from June 1 through September 15. With these foregoing measures, Alternative 2 may affect the Hawaiian hoary bat, but is not likely to adversely affect the species.

With the implementation of the management measures noted in Alternative 1 designed to protect and benefit threatened and endangered species, implementation of these measures as part of Alternative 2 would also result in less than significant impacts to biological resources.

3.8 Cultural Resources

The term cultural resources have been defined as a tangible entity or a cultural practice that is valued by or significantly representative of a culture or that contained significant information about a culture. Cultural resources may include archaeological and historic sites and artifacts; traditional religious, ceremonial, and social sites, funerary and other sacred objects; and buildings, structures, or material remains resulting from, or associated with, human cultural activity. Cultural resources can be divided into four major categories:

- Archaeological resources are any material remains of past human life or activities which are at least 50 years of age that are of archaeological interest.
- Architectural resources include buildings and structures, and other built-environment resources of historic or aesthetic significance, but not including roads, railroads, and landscapes.
- Historic properties are historically important cultural resources that are included, or potentially eligible for inclusion, in the National Register because they possess integrity and meet one or more of the four National Register criterion, pursuant to 36 CFR Sec. 60.4.
- Traditional Cultural Properties (TCPs) are historic properties that are included, or eligible for inclusion in the National Register because they possess integrity and meet one or more of the four National Register criterion, pursuant to 36 CFR Sec. 60.4. A historic property is considered a TCP when it is a place that a living community regards as important for its association with cultural practices, beliefs, traditions, lifeways, arts, crafts, or social institutions. TCPs are rooted in a community’s history and are important in maintaining the continuing cultural identity of the community.

Cultural resources listed in the National Register of Historic Places (NRHP) or eligible for listing in the NRHP are “historic properties” as defined by the NHPA. The list was established under the NHPA and is administered by the National Park Service on behalf of the Secretary of the Interior. The NRHP includes properties on public and private land. Properties can be determined eligible for listing in the NRHP by the Secretary of the Interior or by a federal agency official with concurrence from the applicable State Historic Preservation Office (SHPO). A NRHP-eligible property has the same protections as a property listed in the NRHP. The historical properties include archaeological and architectural resources and TCPs.

3.8.1 Regulatory Setting

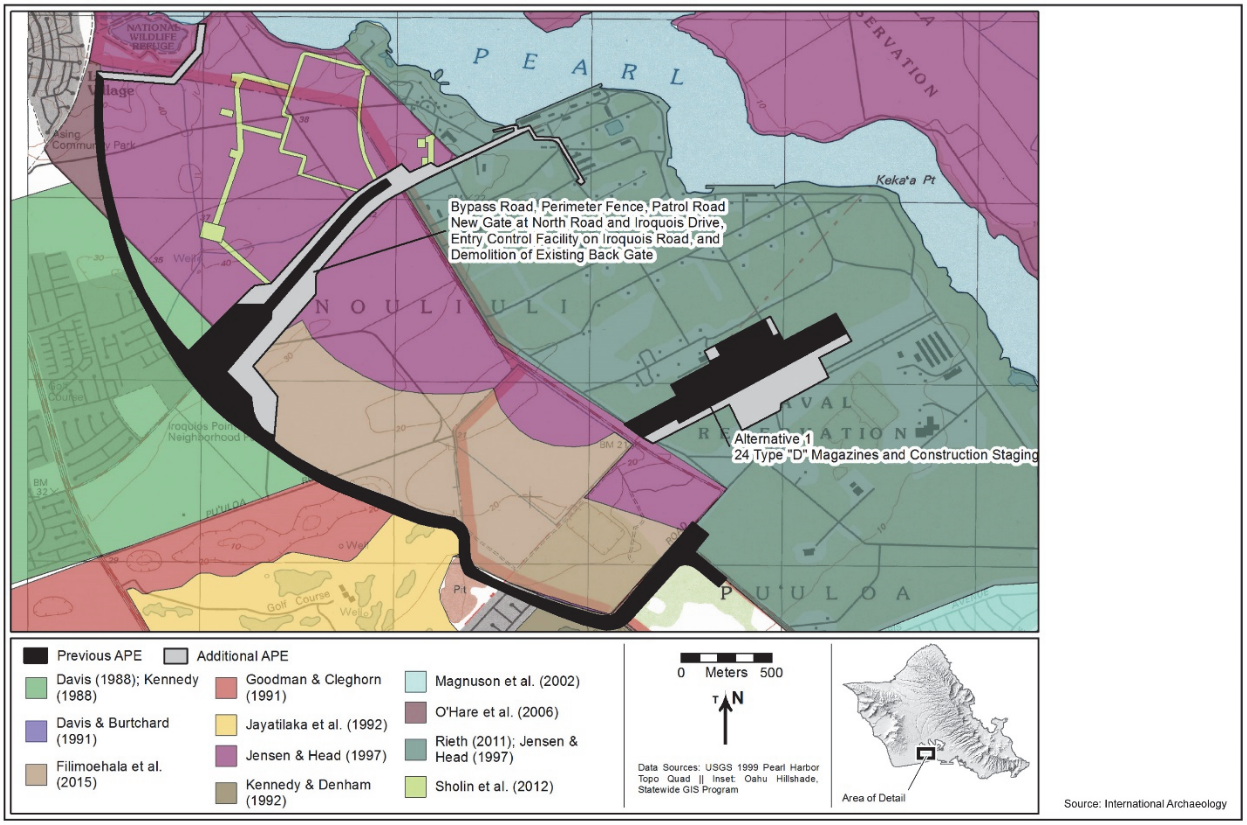
There are a variety of laws that protect certain types of cultural resources: the National Historic Preservation Act (NHPA) of 1966 as amended in 2006 (currently codified in 54 U.S.C. 306108), the Archaeological and Historic Preservation Act of 1974, the Archaeological Resources Protection Act of 1979, the American Indian Religious Freedom Act of 1978, and the Native American Graves Protection and Repatriation Act (NAGPRA) of 1990. The Advisory Council on Historic Preservation (ACHP) further guides treatment of archaeological and architectural resources through the regulations detailed in protection of historic properties (36 C.F.R. part 800). The category of “historic properties” is a subset of cultural resources that is defined in the NHPA (54 U.S.C. 306108) as any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the National Register of Historic Places (NRHP), including artifacts, records, and material remains related to such a property or resource.

Under Section 106 of NHPA, federal agencies must review the effects of an undertaking within the area of potential effects, defined as the geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist. The identification of cultural resources in a given Area of Potential Effect (APE) is generally the first step in the review of effects. Once an APE has been defined, a reasonable and good faith effort is made to identify historic properties (listed or eligible for listing in the National Register) within the APE. Cultural Resources that are not included in the National Register, such as sites listed in the State Inventory of Historic Properties (SIHP) are reviewed, but not considered in the identification process. However, the agency official may either treat a cultural resource as an historic property, or, the agency official may determine whether the resource meets any of the National Register criteria and if SHPO concurs, the resource may be considered eligible for the National Register for Section 106 purposes of a given undertaking. To assist in identification of historic properties and the effects determination regarding the proposed actions, the regulations implementing Section 106 (36 CFR Part 800) specify a consultation process with the appropriate State Historic Preservation Officers, the ACHP, Native Hawaiian organizations, the public, state and federal agencies. For the area being considered in the Proposed Action, all cultural resources have been identified during previous investigations of the area as detailed in the following paragraphs.

Cultural resources information relevant to this Environmental Assessment was derived from a variety of sources, including previous environmental documents, management plans related to cultural resources, the NRHP Information System, information repositories associated with State Historic Preservation Offices, online maps and data, and published sources, as cited. Environmental documents used include the Integrated Cultural Resources Management Plan (ICRMP) for Commander Navy Region Hawaii (HHF, 2008) and the reports from various archaeological surveys, historic building inventories and traditional cultural property assessments (Davis, 1988; Davis and Burtchard, 1991; Goodman and Cleghorn, 1991; Jayatilaka et al., 1992; Kennedy, 1988; Kennedy and Denham, 1992; Jensen and Head, 1997; Magnuson et al, 2002; O’Hare et al., 2006; Rieth, 2011; Sholin et al., 2012; Tuggle and Tomonari-Tuggle, 2004; Filimoehala et al., 2015; Vernon et al., 2016).

3.8.2 Affected Environment

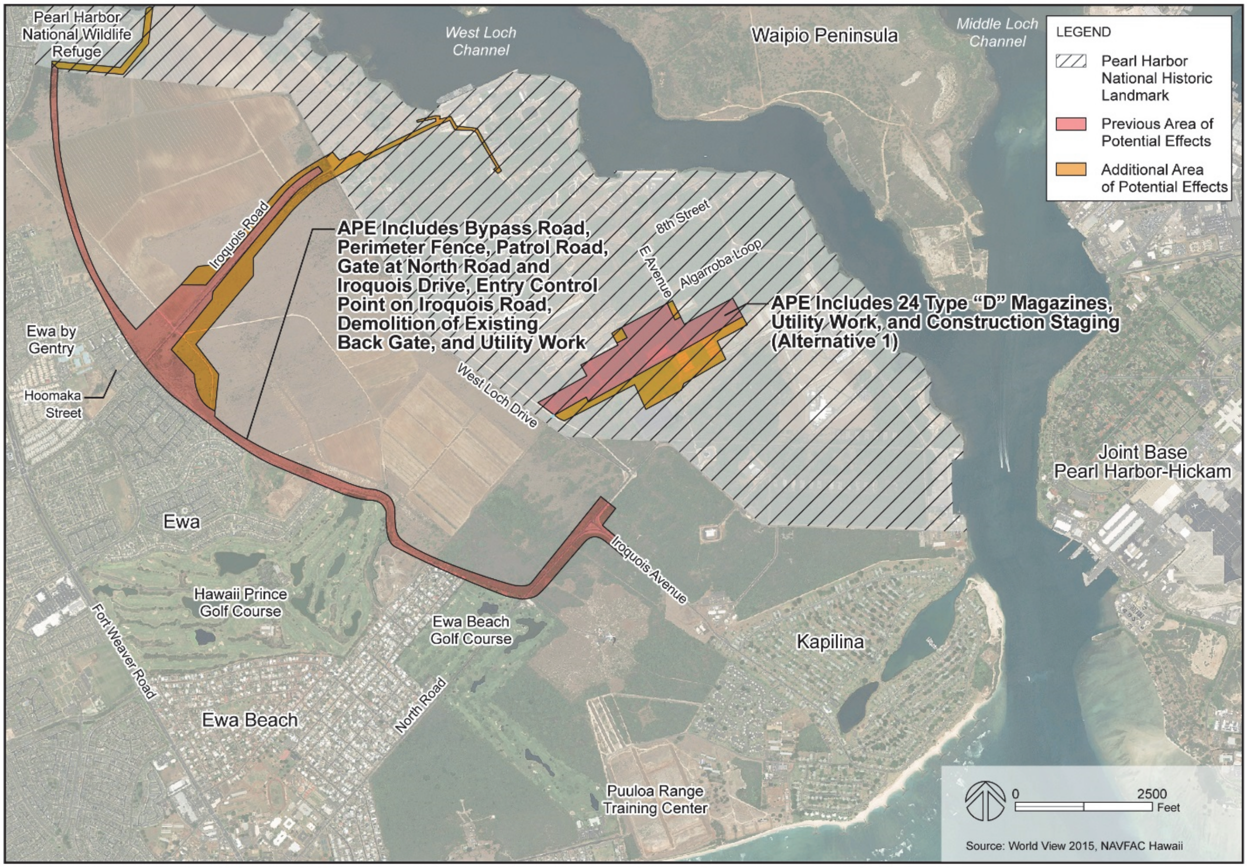
The Navy has conducted inventories of cultural resources at West Loch Annex to identify historical properties that are listed or potentially eligible for listing in the NRHP (Jensen and Head, 1997; Rieth, 2011; Filimoehala et al., 2015) (Figure 3-11). This includes the previous APE and additional APE as explained below.



Inventories of Cultural Resources **Figure 3-11**
Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii

The APE for historic properties is the geographic area or areas within which an undertaking (project, activity, program or practice) may cause changes in the character or use of any historic properties present. The APE is influenced by the scale and nature of the undertaking and may be different for various kinds of effects caused by the undertaking. For this Proposed Action, the Navy's proposed APE comprises approximately 310 acres (Figure 3-12). The area of the proposed magazines, staging, access roads and utility work is approximately 90 acres. All other related improvements of the project including security fencing, patrol road, ECP, utility work, gate at North Road and Iroquois Avenue, and bypass road are approximately 220 acres.

The current APE has been developed through two Section 106 consultations. The previous APE was established by letter dated January 3, 2019. The SHPO reviewed and concurred with the Navy's determination that the proposed project will result in no adverse effect (Log No. 2018.02711/2018.02899; Doc. No. 1901SH04). Since that time, additional components of the project have been added to the undertaking. The previously approved APE and additional APE are shown in Figure 3-11 and Figure 3-12. The additional area includes security fencing and paved perimeter road extending from the northern terminus of the previously proposed security fence and patrol road to the coastal margin east of the Pearl Harbor Wildlife Refuge. Ground disturbing activities will be located in disturbed agricultural lands located east of the PHNWR. The APE in the area of the ECP has been widened at the location of the vehicle inspection area. The additional APE provides flexibility in the site design for a patrol route gate, utility building, gate/sentry house, overwatch tower, overwatch station, access road, denial road, and inspection pullout area. Water and electrical subsurface utilities would be installed along Iroquois Road from the ECP to existing connections near the existing back gate. The existing back gate near the corner of West Loch Drive and Iroquois Road would be demolished as it would no longer be required. Communication utilities would extend from the back gate on existing power poles on 1st Street and D Avenue to Building 52. In the area of the proposed magazines, the APE has been enlarged to include additional utilities as well as to serve as a large buffer zone for equipment and potential laydown areas. Water, communication, and electrical subsurface utilities lines have also been added to the scope.



Area of Potential Effects **Figure 3-12**

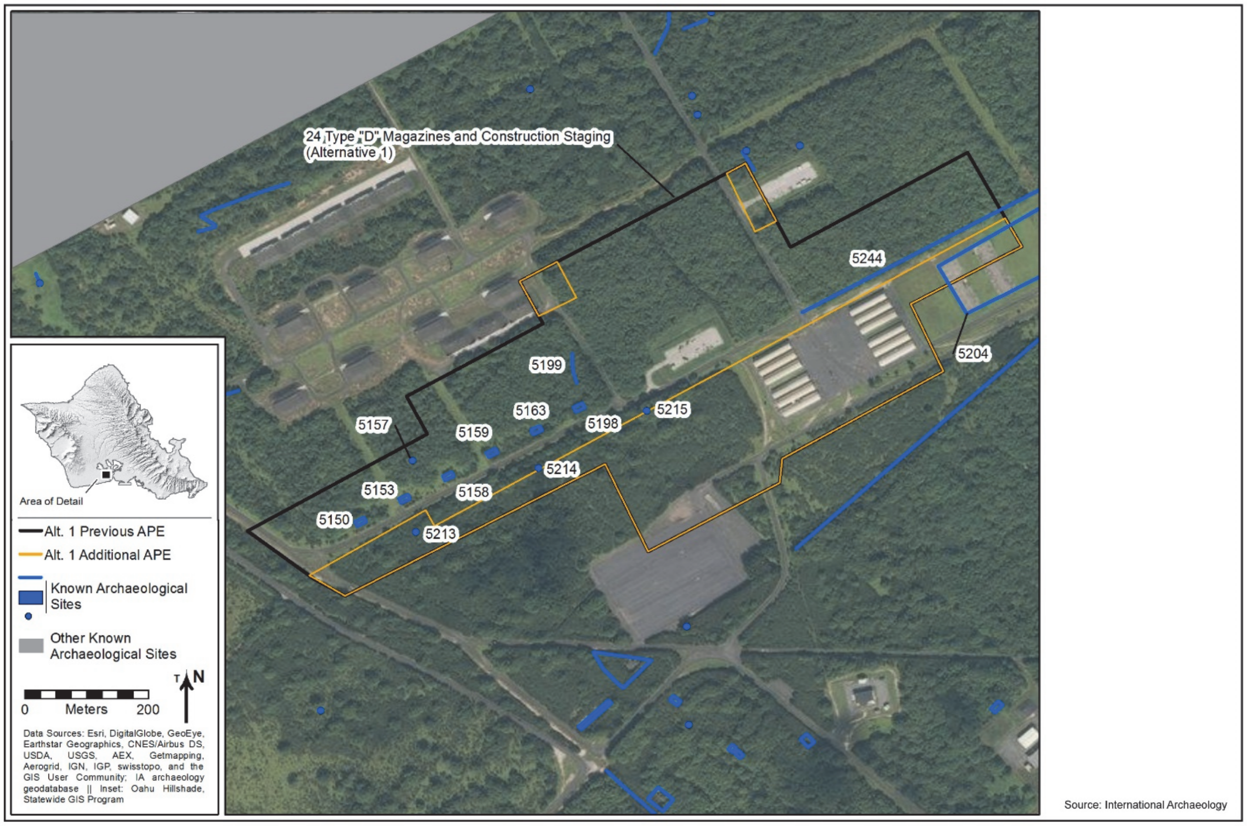
Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii

By letter dated April 29, 2019, the Navy has reinitiated consultation under Section 106 of the NHPA for the previous APE and additional APE which comprises 310 acres. For reference, portions of the Pearl Harbor National Historic Landmark (PHNHL) within the general project vicinity are marked by parallel solid lines on Figure 3-12. The January 3, 2019 Section 106 letter reviewing and concurring on the previous APE and the April 29, 2019 letter reinitiating Section 106 consultation are included in Appendix E.

3.8.2.1 Archaeological Resources

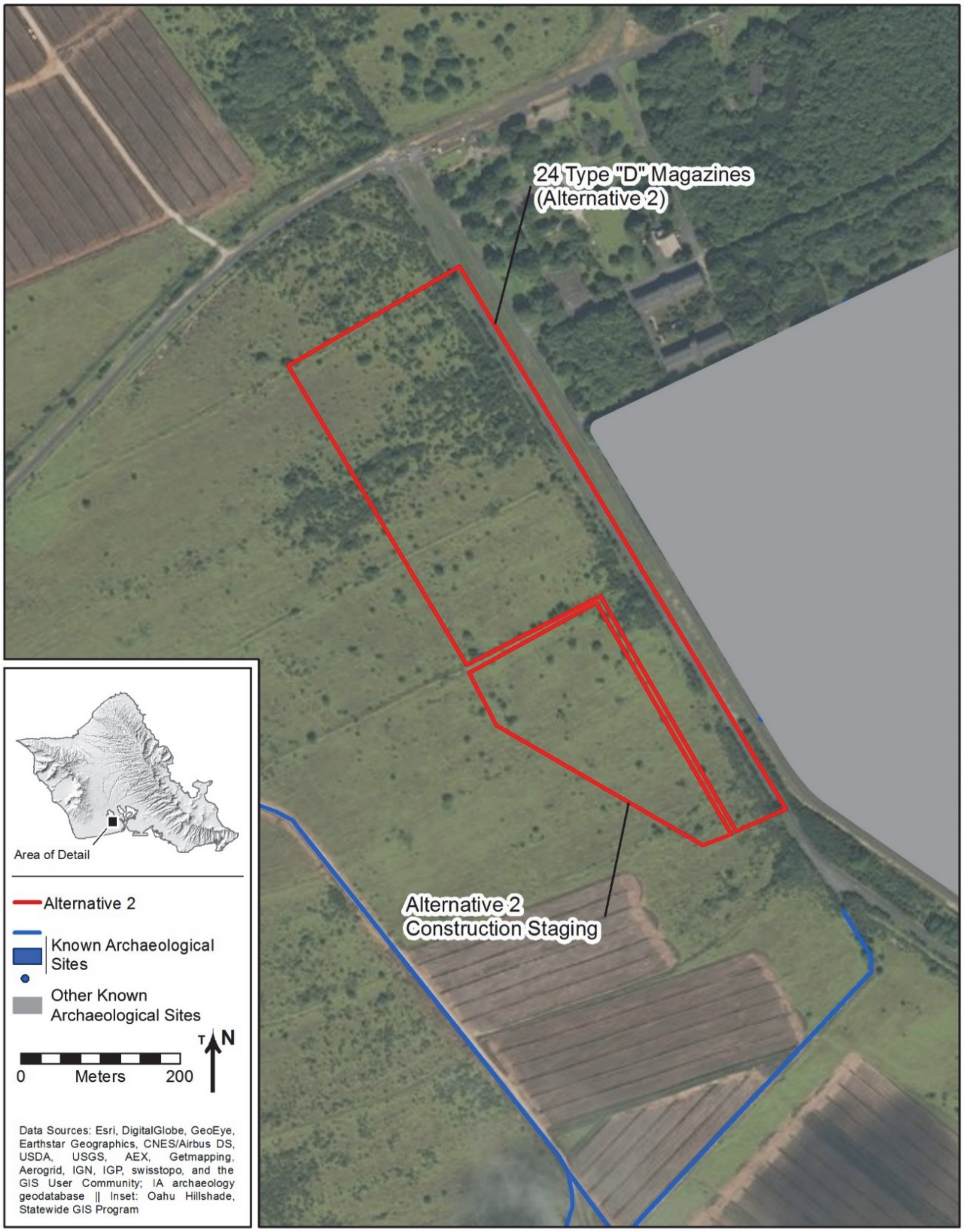
Thirteen archaeological sites are known within the Alternative 1 proposed magazine construction areas (Figure 3-13). The Alternative 1 magazine area falls within the Pearl Harbor National Historic Landmark.

There are no known sites within the Alternative 2 magazine area (Figure 3-14). Three archaeological sites are adjacent to the perimeter fence, patrol road, bypass road, new gate, and entry control point (Figure 3-15). None of these sites are eligible for listing on the NRHP.



Source: International Archaeology

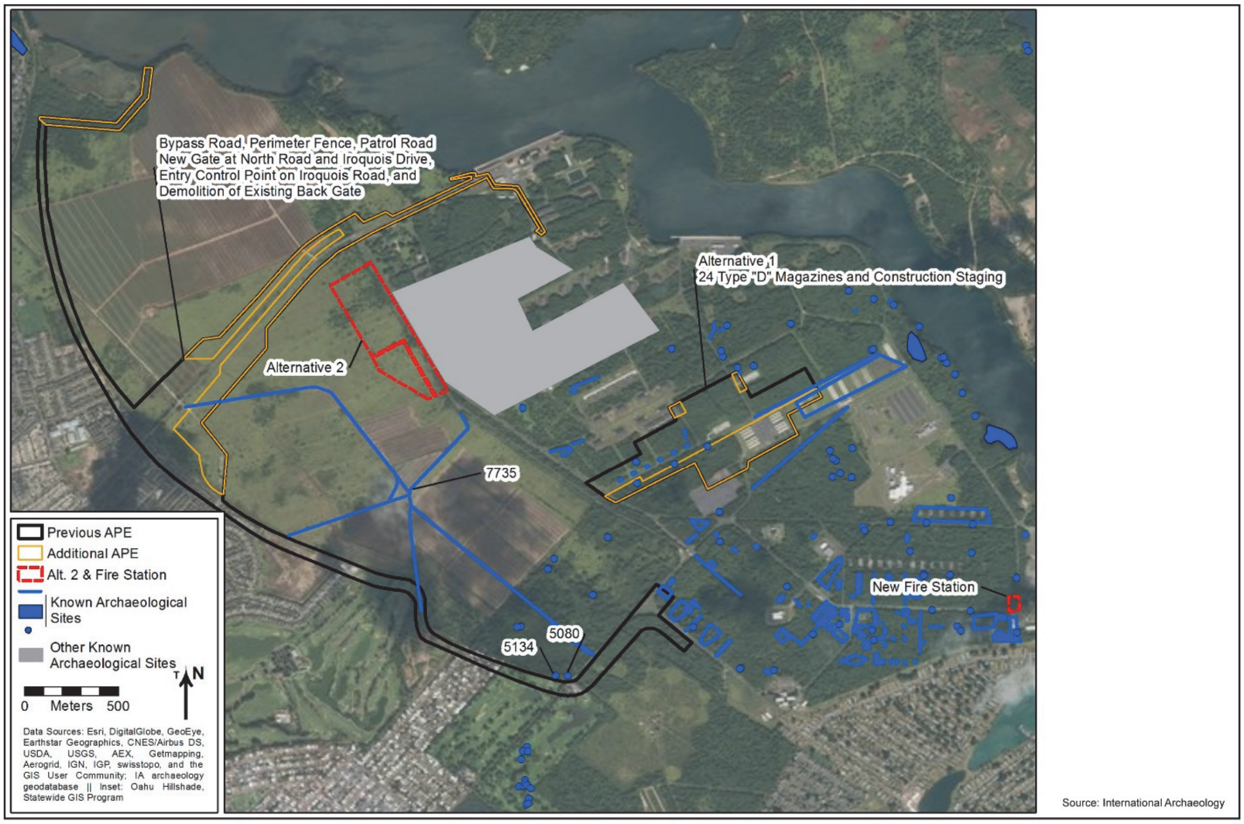
Location of Archaeological Sites – Alternative 1 Magazine Area **Figure 3-13**
Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii



Source: International Archaeology

Location of Archaeological Sites – Alternative 2 Magazine Area **Figure 3-14**

Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii



Data Sources: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community; IA archaeology geodatabase || Inset: Oahu Hillshade, Statewide GIS Program

Source: International Archaeology

Location of Archaeological Sites - Perimeter Fence and Patrol Road Corridor, Bypass Road, Entry Control Point, New Gate, Demolition of Existing Back Gate, and New Fire Station **Figure 3-15**
Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii

Table 3-18 summarizes the site characteristics, NRHP significance evaluations, and source references for Alternative 1 including the perimeter fence, patrol road, bypass road, demolition of the existing back gate, new gate, and entry control point.

Table 3-18 Previously Recorded Archaeological Sites Within or Adjacent to Alternative 1 Including the Perimeter Fence, Patrol Road, Bypass Road, Demolition of Back Gate, New Gate, and Entry Control Point

Site 50-80-13-	*Type*	*Function & Affiliation*	*Description*	*NRHP Eligibility*	*References*
5080	Concrete slab	Foundation Historic/ Military	The concrete slab has clearly delineated edges and a level surface flush with the surrounding grade. Graded gravel or decaying asphalt is on the surrounding surface. The southeast end of the feature abuts an approximately 5 feet high	Not eligible	Filimoehala et al., (92015); Jensen and Head, (1997)

Site 50-80-13-	*Type*	*Function & Affiliation*	*Description*	*NRHP Eligibility*	*References*
			push pile with modern materials and the frame of a rusted car. The site is interpreted as a building foundation constructed by the military between 1943-1951 as part of the ABCD Annex, although a specific building function or designation is unknown.		
5081	Concrete slab	Foundation Historic/ Military	This is a truncated pyramidal concrete slab interpreted as the base for a street light.	Not eligible	Jensen and Head, (1997)
5133	Metal tank	Utilities/ infrastructure Historic/ Military	Site 5133 consists of a concrete foundation supporting a metal(?) tank. It is interpreted as a water pump or pressure tank.	Not eligible	Jensen and Head, (1997)
5134	Concrete foundation	Foundation Historic/ Military	Site 5134 consists of two features: a concrete stemwall foundation (Fea. 1) and a concrete slab foundation (Fea. 2). The stemwall foundation is 25.9 feet long, 22 feet wide, and 1.3 feet tall. The stemwall is 0.5 feet wide by 1.3 feet tall. It has ventilation openings in all sides. A short L-shaped concrete stemwall segment is outside of the southern corner of the foundation and likely originally supported a porch or entrance. The interior area is unpaved and two square concrete pedestals (0.9 feet wide and long by 1.3 feet tall) are present towards the center. The feature is in good condition. Thirteen feet to the north of the stemwall foundation is a	Not eligible	Filimoehala et al., (92015); Jensen and Head, (1997)

Site 50-80-13-	*Type*	*Function & Affiliation*	*Description*	*NRHP Eligibility*	*References*
			small concrete pad (5.9 feet square and 2-6 inches high). A 3 inch diameter pipe is at the center of the pad. The southern and eastern edges of the feature are broken off. The surrounding area is covered in graded basalt gravel or degraded asphalt. The feature is in fair condition. Site 5134 is interpreted as the foundations for a building and associated structure constructed as part of the ABCD Annex between 1943-1951, although a specific building function or designation is unknown.		
5150	Concrete slab	Foundations Historic/ Military	Jensen and Head, (1997) recorded a concrete paving as a historical military site. The concrete slab was constructed as a monolithic pour with no internal features or divisions. The feature is oriented parallel to 10th Street and is 51 feet in length and 25.9 feet in width. Sites -5150, -5153, -5158, -5159, -5163, and -5198 are identical features that are evenly spaced along the northwest side of 10th Street. These features appear on the 1951 West Loch Branch map as Buildings 247-252, inert storehouses.	Not eligible	Jensen and Head, (1997:B-66 - B-67); Rieth, (2011:109, 214)
5153	Concrete slab	Foundations Historic/ Military	Jensen and Head, (1997) recorded a concrete paving as a historical military site. The concrete slab was constructed as a monolithic pour with no internal features or divisions. The feature is oriented	Not eligible	Jensen and Head, (1997:B-68); Rieth, (2011:111, 214)

Site 50-80-13-	*Type*	*Function & Affiliation*	*Description*	*NRHP Eligibility*	*References*
			parallel to 10th Street and is 51 feet in length and 25.9 feet in width. Sites -5150, -5153, -5158, -5159, -5163, and -5198 are identical features that are evenly spaced along the northwest side of 10th Street. These features appear on the 1951 West Loch Branch map as Buildings 247-252, inert storehouses.		
5157	Wooden Fence	Military boundary Historic/ Military	The fence includes wooden posts connected by strands of wire. Most of the posts have fallen. The fence is at least 236 feet in length and is in poor condition.	Not eligible	Jensen and Head, (1997:B-70); Rieth, (2011:112, 214)
5158	Concrete slab	Foundations Historic/ Military	Jensen and Head, (1997) recorded a concrete paving as a historical military site. The concrete slab was constructed as a monolithic pour with no internal features or divisions. The feature is oriented parallel to 10th Street and is 51 feet in length and 25.9 feet in width. Sites -5150, -5153, -5158, -5159, -5163, and -5198 are identical features that are evenly spaced along the northwest side of 10th Street. These features appear on the 1951 West Loch Branch map as Buildings 247-252, inert storehouses.	Not eligible	Jensen and Head, (1997:B-70); Rieth, (2011:112, 214)
5159	Concrete slab	Foundations Historic/ Military	Jensen and Head, (1997) recorded a concrete paving as a historical military site. The concrete slab was constructed as a monolithic pour with no internal features or divisions. The feature is oriented parallel to 10th Street and is 51 feet in length and 25.9 feet	Not eligible	Jensen and Head, (1997:B-70); Rieth, (2011:113, 214)

Site 50-80-13-	***Type***	***Function & Affiliation***	***Description***	***NRHP Eligibility***	***References***
			in width. Sites -5150, -5153, -5158, -5159, -5163, and -5198 are identical features that are evenly spaced along the northwest side of 10th Street. These features appear on the 1951 West Loch Branch map as Buildings 247-252, inert storehouses.		
5163	Concrete slab	Foundations Historic/ Military	Jensen and Head, (1997) recorded a concrete paving as a historical military site. The concrete slab was constructed as a monolithic pour with no internal features or divisions. The feature is oriented parallel to 10th Street and is 51 feet in length and 25.9 feet in width. Sites -5150, -5153, -5158, -5159, -5163, and -5198 are identical features that are evenly spaced along the northwest side of 10th Street. These features appear on the 1951 West Loch Branch map as Buildings 247-252, inert storehouses. These features are the foundations for military structures.	Not eligible	Jensen and Head, (1997:B-72); Rieth, (2011:114, 214)
5198	Concrete slab	Foundations Historic/ Military	Jensen and Head, (1997) recorded a concrete paving as a historical military site. The concrete slab was constructed as a monolithic pour with no internal features or divisions. The feature is oriented parallel to 10th Street and is 51 feet in length and 25.9 feet in width. Sites -5150, -5153, -5158, -5159, -5163, and -5198 are identical features that are evenly spaced along the northwest side of 10th Street. These features appear on the	Not eligible	Jensen and Head, (1997:B-88); Rieth, (2011:122, 214)

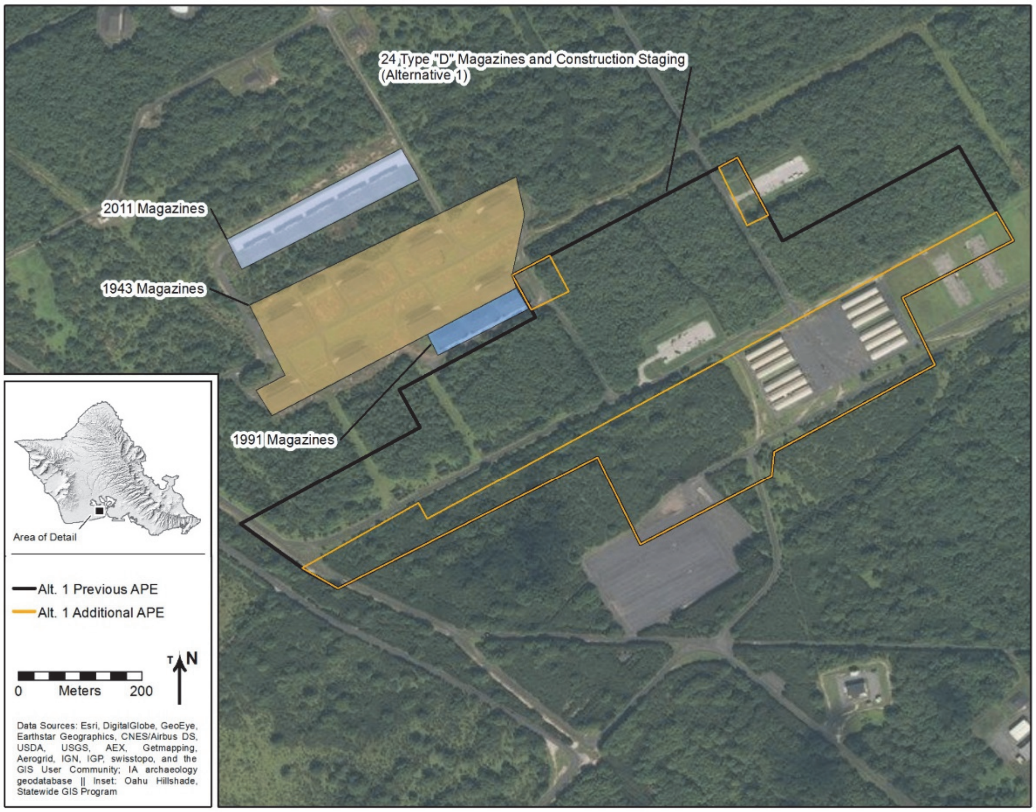
Site 50-80-13-	***Type***	***Function & Affiliation***	***Description***	***NRHP Eligibility***	***References***
			1951 West Loch Branch map as Buildings 247-252, inert storehouses. These features are the foundations for military structures.		
5199	Ditch	Irrigation/ water control Historical/ Military or Plantation	Jensen and Head, (1997) recorded this ditch as a historical military site. The feature may be an earlier historical irrigation feature, although a military age and function is possible. The ditch is constructed with straight sides and a level bottom. Up to six courses of dry stacked limestone slabs reinforce the ditch sidewalls. The feature is oriented north-south and is 156.5 feet long, 3 feet wide, and 1.3 feet deep. The north and south ends of the ditch are truncated by berms. The site is in good condition. Site -5199 is either a historical irrigation ditch or military water control feature.	Not eligible	Jensen and Head, (1997:B-88); Rieth, (2011:122-123, 214)
5204	Concrete slabs, asphalt paving	Infrastructure Historic/ Military	Jensen and Head, (1997) recorded six large, rectangular concrete slabs and one area of asphalt paving as a historical military site.	Not eligible	Jensen and Head, (1997:B-90 to B-91); Rieth, (2011:124, 214)
5213	Fire hydrant	Infrastructure Historic/ Military	Jensen and Head, (1997) recorded this fire hydrant as a historical military site.	Not eligible	Jensen and Head, (1997:B-94); Rieth, (2011:128, 214)
5214	Fire hydrant	Infrastructure Historic/ Military	Jensen and Head, (1997) recorded this fire hydrant as a historical military site.	Not eligible	Jensen and Head, (1997:B-95); Rieth,

Site 50-80-13-	*Type*	*Function & Affiliation*	*Description*	*NRHP Eligibility*	*References*
					(2011:128, 214)
5215	Fire hydrant	Infrastructure Historic/ Military	Jensen and Head, (1997) recorded this fire hydrant as a historical military site.	Not eligible	Jensen and Head, (1997:B-95); Rieth, (2011:129, 214)
5224	Road	Transportation/ security	Jensen and Head, (1997) recorded this asphalt road as a historical military site. It is labeled as a "patrol road" on the 1951 West Loch Branch map. The road is 692 m long and approximately 4 m wide; it is an extension of 10th Street. It is in fair to good condition.	Not eligible	Jensen and Head, (1997:B-99); Rieth, (2011:130, 214)
7735	Road	Transportation Historic/ Military	Site 7735 includes four features: three road segments dating to three periods during the 20th century (Feas. 1-3) and one barbed wire fence (Fea. 4). At its maximum limits, the features of Site 7735 extend across an 8,028 feet by 4,724 feet area, with a total combined length of 16,833 feet. The roads were constructed over several decades during the mid-20th century. The oldest right-of-way is the Puʻuloa Road segment (Feature 1), which had been graded for the Puʻuloa rail line in 1900; the rails were removed by 1947 when the route was converted to a roadway. Another road (Feature 2) intersects Puʻuloa Road and other roads before extending further north and then west. This road is depicted on a	Not eligible	Filimoehala et al., (2015)

Site 50-80-13-	*Type*	*Function & Affiliation*	*Description*	*NRHP Eligibility*	*References*
			1939 Ewa Plantation map, thus providing a terminus ante quem estimate for its construction. A third series of interconnected roadways (Feature 3) extend from North Road and intersecting with West Loch Road at two locations. These segments are represented on an undated map of the ABCD Annex, indicating they were likely constructed in conjunction with the facility. A portion of a barbed-wire fence (Feature 4) is intact along a part of this road. Portions of these roads are still in use as farm roads. The site is in fair condition.		

3.8.2.2 Architectural Resources

There are eight historic magazines within the vicinity of the proposed Type D magazines in Alternative 1 that are covered under an ACHP program comment. These magazines are a group of similar, widely-spaced ammunition storage facilities (Facility Nos. 232-239) and an associated observation tower (Facility No. S389). These buildings are small arms magazine storage facilities that were built in 1943. Each magazine is surrounded by a small, maintained cleared open area bounded by dense scrubby trees. The magazine buildings are eligible for listing on the NRHP and are contributing elements to the PHNHL. The observation tower is eligible for the NRHP; however, it is not a contributing resource of the PHNHL. A group of three magazines was constructed south of the historic magazines in 1991 and another group of five magazines to the north in 2011 (Figure 3-16).



Source: International Archaeology

Historic and Modern Magazines Located Adjacent to the Area of the Proposed 24 Type "D" Magazines at West Loch **Figure 3-16**
Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii

The proposed undertaking would not alter the historic setting of adjacent historic magazines due to the similarity in appearance (i.e., earth-covered structure with berm-like appearance) of the new construction and screening provided by unmaintained vegetation between magazine areas.

While the proposed magazines are larger in scale than the historic magazines (proposed magazines are 60 feet longer than the historic magazines), the construction materials, signage, and color scheme would all be similar to that of the existing magazines.

3.8.2.3 Traditional Cultural Properties

There are no known TCPs in the APE. Two studies were conducted by the Navy to identify potential TCPs on Pearl Harbor (Tuggle and Tomonari-Tuggle, 2004; Vernon et al., 2016). The studies identified places that were mentioned in *moolelo,* traditional legends or stories; historic documents such as maps and newspaper articles; and interviews with members of the community. Three places associated with *moolelo*—Kumomoku, Kaupea, and Kanehili—and described by Emerson (1915), Fornander (1916), and Kamakau (1964 [1869-1870]) are thought to be in the general vicinity of the APE, however, precise locations are unknown (Table 3-19).

Table 3-19 Place Names Referenced in the General Vicinity of the APE (from Tuggle and Tomonari-Tuggle 2004:63 and A-8)

Place Name	*Description/Location*	*Text Source*	*Translation*
Kumomoku	Point? Entrance to salt works?	Fornander, (1916:390)	
Kaupea	Plain; portion of the Ewa Plain	Kamakau, (1964:47 [1869-1870]) Emerson, (1915:167-168) Kapaahulani, in Fornander, (1916:390) Keonaona and Desha et al., (1927)	*Crisscross, interwoven bat's perch* (possible reference to the southern cross ?)
Kanehili	Plain; portion of the Ewa Plain, may be part of Kaupea; may also be the name of a trail	Emerson, (1915:167) Kapaahulani in Fornander, (1916:390) Keonaona and Desha et al., (1927)	

Kumomoku (or Kumumoku) is at or near the mouth of the drainage into the former Puuloa salt production area. It is a traditional name that occurs in Kapaahulani's chant for Kualii, Moolelo o Kualii (Fornander, 1916:390); it is one of many names in the Puuloa area that are mentioned in the chant. Fornander's presentation of the chant includes a footnote (possibly by C.J. Lyons) that says Kumomoku (and another place called Leleiwi, location unknown) was "near Puuloa, Ewa, where the land breezes were said to be peculiarly cold." Kumomoku appears on the Metcalf 1850 map, as well as on maps dating from the turn of the century.

The plain of Kaupea is one of many named "plains" of the Ewa region (others include the plains of Puuloa, Puuokapolei, Kanehili, Pee-kaua, and Kaiona) (see Emerson, 1915:167; Keonaona and Desha Sr. et al., 1927, February 22, in Maly 1992, 1997, and 1998; also see summary in Tuggle, 1997). However, the locations of these plains are generally undefined, and it is unclear if they are distinct areas, or whether some are alternative names for the same locality. For more detail regarding Kaupea and Kanehili see Tuggle and Tomonari-Tuggle, (2004).

Guidance for identifying TCPs is provided in NRHP Bulletin 38, Guidelines for Evaluating and Documenting Traditional Cultural Properties (Parker and King 1998). Bulletin 38 defines a TCP as a historic property such as a site, district, building, structure, or object that possesses integrity, meets criteria for the NRHP and is associated with the cultural practices and beliefs of a living community that (a) are rooted in that community's history, and (b) are important in maintaining the continuing cultural identity of that community. None of the places named in the aforementioned references and studies meet the criteria for a TCP.

3.8.3 Environmental Consequences

While the NHPA considers the impacts to historic properties, NEPA considers the impacts to cultural resources in general. Analysis of potential impacts to cultural resources considers both direct and indirect impacts. Direct impacts may be the result of physically altering, damaging, or destroying all or part of a resource, altering characteristics of the surrounding environment that contribute to the importance of the resource, introducing visual, atmospheric, or audible elements that are out of character for the period the resource represents (thereby altering the setting), or neglecting the resource to the extent that it deteriorates or is destroyed.

Cultural Resources Potential Impacts:

- Potential undiscovered eligible cultural resources

3.8.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to cultural resources. Therefore, no impact to cultural resources would occur with implementation of the No Action Alternative.

3.8.3.2 Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative) Potential Impacts

The study area for the analysis of effects to cultural resources associated with the Preferred Alternative includes areas which would be altered by:

- the proposed 24 box magazines clustered around the 10th Street and E Avenue intersections;
- adjacent construction staging and roadway access;
- adjacent roadways and concrete pads, utility improvements, landscaping, and drainage improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

In preparation of the 2008 ICRMP, the Navy consulted with the SHPO on the eligibility of sites within West Loch Annex. Sites in areas with no and/or low potential for archaeological sites were determined to not be eligible for inclusion in the NRHP. The current APE is within said area. For Alternative 1, the majority of the known sites are concrete foundations or utility infrastructure from the initial development of the U.S. Naval Ammunition Depot West Loch Branch (beginning in 1931) and the Advance Base Construction Depot Annex (ABCD Annex) (1943-1951). The exception is a plantation road network that pre-dates military development in the area. These sites were subject to inventory-level documentation and no further actions were recommended (Filimoehala et al., 2015; Jensen and Head, 1997; Rieth, 2011). None of the sites are eligible for listing in the NRHP.

The 1943 magazine buildings are eligible for listing on the NRHP and are contributing elements to the PHNHL. The observation tower is eligible for the NRHP; however, it is not a contributing resource of the PHNHL. Newer magazines have previously been constructed on either side of the historic magazines. Moreover, the proposed magazines would not alter the historic setting of adjacent historic magazines due to the similarity of appearance (i.e., earth-covered structure with berm-like appearance) of the new construction and screening provided by unmaintained dense vegetation between magazine areas. Pursuant to NHPA Section 106 review on the previous APE, the Navy has determined, with concurrence from SHPO that the Preferred Alternative will result in no adverse effect to historic properties and would not significantly impact other cultural resources.

Since the Navy is reinitiating Section 106 consultation, the Navy is requesting concurrence with the SHPO on the revised APE pursuant to Stipulation VI. of the 2012 PA. The Navy's Section 106 consultation dated November 13, 2018, the SHPO concurrence letter dated January 3, 2019, and the Navy's reinitiation of Section 106 consultation dated April 29, 2019 are included in Appendix E.

Several previous archaeological and historic architectural studies at West Loch Annex were done (see Figure 3-11). While there are a few sites listed on the State Inventory of Historic Places within the APE, these are not eligible for listing in the NRHP and no historic properties are present in the revised APE of 310 acres. Additionally, a site visit of the proposed project area was conducted on December 27, 2018 with NHOs and a member of OHA. The locations of the proposed magazines and the perimeter fence and patrol road were viewed. At that time, it was agreed that there were no cultural resources concerns within the proposed APE and that the proposed undertaking will not affect historic properties within West Loch Annex.

The Navy's November 13, 2018 Section 106 consultation letter (5750 Ser N4/0659) stated that the undertaking would result in "no adverse effect" on historic properties. However, reassessing the foregoing information on the identification of historic properties, there are no historic properties within the APE and the appropriate finding of effect pursuant to 36 CFR Sec 800.4(d)(1) is "no historic properties affected". In the event that NAGPRA cultural items are discovered, all work in the vicinity will stop and the remains will be stabilized and protected. Treatment will proceed under the authority of NAGPRA.

Pursuant to IX.B.1 of the 2012 PA, the Navy is requesting concurrence with the expanded APE and the finding of effect.

Implementation of the Preferred Alternative would result in less than significant impacts to cultural resources.

3.8.3.3 Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive) Potential Impacts

The study area for the analysis of effects to cultural resources associated with this alternative includes:

- 24 box magazines west of West Loch Drive and 6th Street;
- adjacent construction staging;
- fire station;
- adjacent roadways and concrete pads, utility improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

There have been no sites documented within the Alternative 2 magazine area, construction staging area, and fire station. As noted for Alternative 1, the known sites adjacent to the perimeter fence and patrol road corridor, bypass road, and entry facility relate to the ABCD Annex and earlier plantation agriculture. These sites were subject to inventory-level documentation and no further actions were recommended (Filimoehala et al., 2015; Jensen and Head, 1997). None of the sites are eligible for listing in the NRHP.

Implementation of Alternative 2 would result in less than significant impacts to cultural resources.

3.9 Infrastructure

This section discusses infrastructure such as utilities (including drinking water production, storage, and distribution; wastewater collection treatment and disposal; storm water management, solid waste management, energy production, transmission, and distribution; and communications), and facilities (including airfields, buildings, ranges, training and testing areas, wharves, piers, housing, etc.) Transportation systems and traffic are addressed separately in Section 3.1.

3.9.1 Regulatory Setting

EO 13834 Efficient Federal Operations affirms “that agencies shall meet such statutory requirements in a manner that increases efficiency, optimizes performance, eliminates unnecessary use of resources, and protects the environment.”

Chief of Naval Operation Instruction 4100.5E outlines the Secretary of the Navy’s vision for shore energy management. The focus of this instruction is establishing the energy goals and implementing strategy to achieve energy efficiency.

Antiterrorism Force Protection Standards have been adopted by the Department of Defense (DoD) through Instruction number 2000.16 of October 2006. The standards require all DoD Components to adopt and adhere to common criteria and minimum construction standards to mitigate antiterrorism vulnerabilities and terrorist threats.

3.9.2 Affected Environment

The following discussions provide a description of the existing conditions for each of the categories under infrastructure at West Loch Annex.

3.9.2.1 Utilities

This section describes utility systems that may be impacted by the Proposed Action during construction or operation. West Loch Annex includes DoD-owned utilities that provide service on base.

Potable Water

The existing water system at JBPHH is comprised of off-site potable groundwater sources and pumping stations, two 6-million gallon storage tanks, and a network of transmission and distribution mains which service Camp Smith, Red Hill Coast Guard Housing, and Aliamanu Army Housing distribution systems. A network of Navy waterlines distribute water through various parts of West Loch Annex. There are no groundwater wells within West Loch Annex.

Wastewater

The existing West Loch Annex wastewater network consists of a system of gravity sewers, sewer force mains and sewage pump stations. The primary component of wastewater flows is domestic sewage.

Stormwater

The relatively flat topography of the area, combined with the highly permeable soil and rock, allow storm water runoff to easily infiltrate the ground surface and collect in man-made detention basins, dry wells, natural sinkholes, or pits in the subsurface. During extreme precipitation events however, storm water typically overflows and sheet-flows into the nearest drainage or collects in low-lying areas.

Solid Waste Management

Solid waste is collected by private refuse collection companies for disposal at the City and County of Honolulu Waimanalo Landfill. Construction waste is diverted to a private construction and demolition landfill. Recycling is handled by the JBPHH Recycling Program.

Energy and Communication

The proposed magazines and entry control point will require electrical connection for operational purposes. However, increases in levels of electricity use should be minimal. Under Alternative 2, electricity usage at the new fire station should be approximately the same as the existing facility. Through a previously approved project, the Navy is proceeding with Hawaiian Electric Company on implementing PV arrays at West Loch Annex which would incrementally reduce Oahu's overall energy costs and fuel oil dependency. New communication lines would be connected to the existing system within West Loch Annex.

3.9.3 Environmental Consequences

This section analyzes the magnitude of anticipated increases or decreases in public works infrastructure demands considering historic levels, existing management practices, and storage capacity, and evaluates potential impacts to public works infrastructure associated with implementation of the alternatives. Impacts are evaluated by whether they would result in the use of a substantial proportion of the remaining system capacity, reach or exceed the current capacity of the system, or require development of facilities and sources beyond those existing or currently planned.

Infrastructure Potential Impacts:

- Storm water soil erosion from unexpected storm events

3.9.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to the existing infrastructure of West Loch Annex. Therefore, no impact to infrastructure would occur with implementation of the No Action Alternative.

3.9.3.2 Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative) Potential Impacts

The study area for the analysis of effects to infrastructure associated with the Preferred Alternative includes areas which would be altered by:

- the proposed 24 box magazines clustered around the 10th Street and E Avenue intersections;
- adjacent construction staging and roadway access;
- adjacent roadways and concrete pads, utility improvements, landscaping, and drainage improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

Water and wastewater service are not required for the magazines. Waterline improvements and fire hydrants in proximity to the magazines would be provided in case of brush fires. The entry control point replaces the existing back entrance gate so water usage and wastewater generation is anticipated to be minimal and comparable to the existing situation. Water, wastewater, electrical, and communication connections would be made to existing West Loch Annex systems.

For all construction activities with a potential for storm water runoff from the various project construction sites, contractors will be required to implement appropriate construction BMPs to prevent potential storm water soil erosion from unexpected storm events. Any potential runoff would be intercepted, collected, and either absorbed on site, or filtered or treated, as appropriate, consistent with federal and state regulations.

Non-hazardous construction and demolition waste that cannot be recycled would be disposed off-site at an approved construction and demolition sanitary landfill under both alternatives. Contractors should strive to divert a significant percentage of construction waste from disposal. Recycling and reuse measures, including salvaging of building elements for future use, would be encouraged to divert solid waste from the landfill and minimize waste generated by the project.

The project would result in minimal impacts on required energy usage.

Therefore, implementation of the Preferred Alternative would result in less than significant impacts to infrastructure.

3.9.3.3 Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive) Potential Impacts

The study area for the analysis of effects to infrastructure associated with this alternative includes:

- 24 box magazines west of West Loch Drive and 6th Street;
- adjacent construction staging;
- fire station;
- adjacent roadways and concrete pads, utility improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

Alternative 2 would involve generally the same improvements as the Preferred Alternative. The main difference is the location of the magazines and a new fire station. Alternative 2 includes 24 magazines located to the west of West Loch Drive. The proposed fire station is anticipated to have approximately the same number of staff so potable water usage as well as wastewater generation should be approximately the same as the existing situation. The existing fire station may be repurposed but it would not include any living accommodations. Infrastructure impacts which would result from Alternative 2 would be approximately the same as the Preferred Alternative.

Therefore, implementation of Alternative 2 would result in less than significant impacts to infrastructure.

3.10 Socioeconomics

This section discusses population demographics, education, housing, and related data providing key insights into the socioeconomic conditions that might be affected by a proposed action.

3.10.1 Regulatory Setting

Socioeconomic data shown in this section are presented at the U.S. Census Designated Place, county and state levels to characterize baseline socioeconomic conditions. Data have been collected from previously published documents issued by federal, state, and local agencies and from state and national databases.

3.10.2 Affected Environment

Table 3-20 presents socioeconomic data for several census-designated places (CDP) adjacent to West Loch Annex, the island of Oahu, and the State of Hawaii for the year 2010 Census and 2012-2016 American Community Survey 5-Year Estimates. Data are presented for the West Loch Estate, Ewa Villages, Ewa Gentry, Ocean Pointe, Ewa Beach and Iroquois Point CDPs as well as the island of Oahu and State of Hawaii (Figure 3-17).

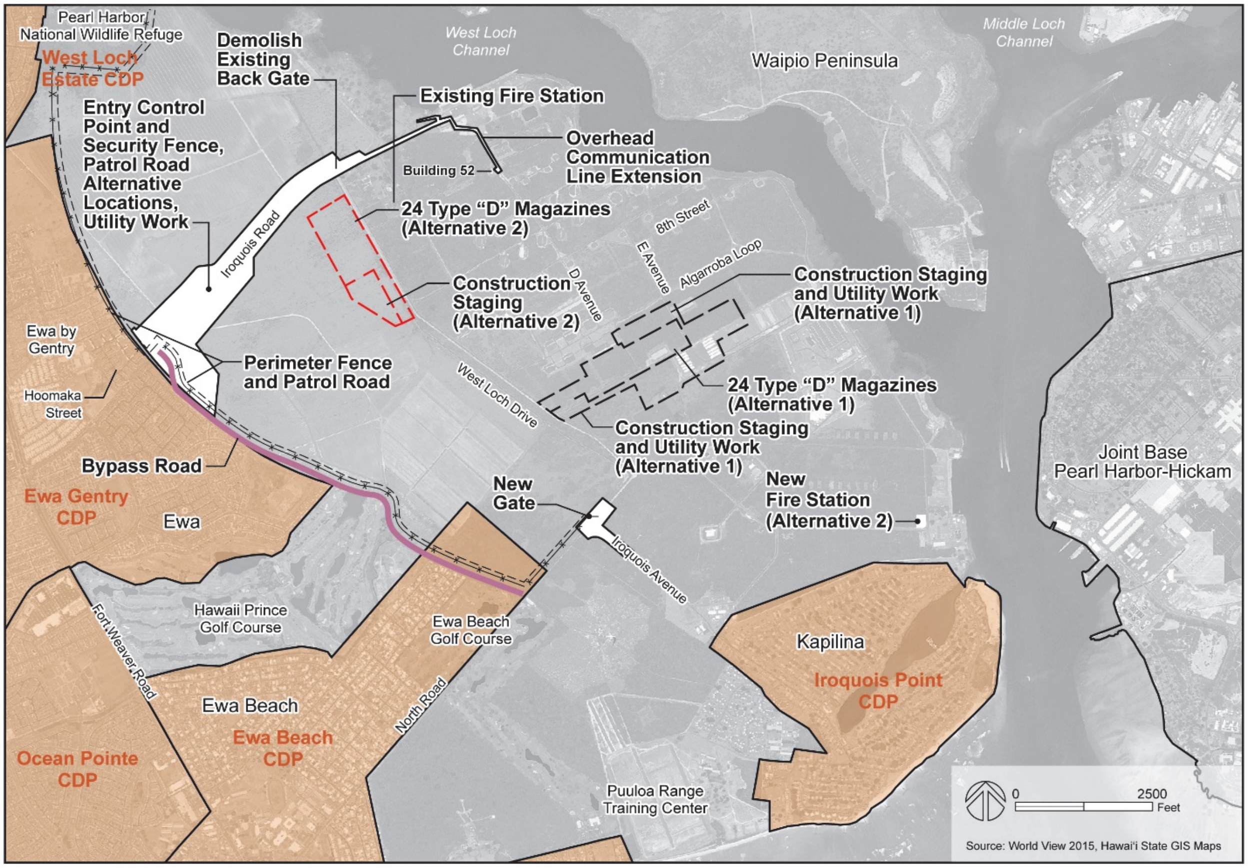
Table 3-20 Selected Socioeconomic Data for CDPs Adjacent to West Loch Annex, Island of Oahu and State of Hawaii

	Ewa Beach CDP	*Ewa Gentry CDP*	*Ocean Pointe CDP*	*West Loch Estates CDP*	*Iroquois Point CDP*	*Island of Oahu*	*State of Hawaii*
Population, Census, April 1, 2010	14,955	22,690	8,361	5,485	3,374	953,207	1,360,301
Persons Under 5 Years, percent, April 1, 2010	6.6%	8.7%	10.4%	6.3%	11.4%	6.4%	6.4%
Persons Under 18 Years, percent, April 1, 2010	26.3%	30.2%	30.2%	24.5%	34.5%	22.1%	22.3%
Persons 65 years and over, percent, April 1, 2010	14.7%	5.5%	4.8%	11.9%	3.2%	14.5%	14.3%
Female persons, percent, April 1, 2010	50.5%	50.2%	50.7%	51.0%	49.3%	49.9%	49.8%
Housing Units, April 1, 2010	3,490	7,243	2,928	1,634	1,119	336,899	519,508
Owner-occupied Housing Unit Rate, 2012-2016	70.1%	72.4%	75.5%	77.5%	0.1%	55.0%	57.5%
Persons per household, 2012-2016	4.85	3.30	3.35	3.46	3.17	3.07	3.03
High school graduate or higher, percent of persons	84.3%	94.3%	95.7%	92.8%	95.5%	91.1%	91.3%

	Ewa Beach CDP	***Ewa Gentry CDP***	***Ocean Pointe CDP***	***West Loch Estates CDP***	***Iroquois Point CDP***	***Island of Oahu***	***State of Hawaii***
age 25 years+, 2012-2016							
Bachelor's degree or higher, percent of persons age 25 years+, 2012-2016	13.3%	29.3%	37.5%	24.5%	22.4%	33.4%	31.4%

Source: U.S. Census Bureau

The data show that CDPs adjacent to West Loch Annex in the Ewa area have a relatively higher percentage of persons 18 years and younger compared to the Island of Oahu and State of Hawaii. Newer developments such as Iroquois Point, Ewa Gentry and Ocean Pointe have a lower percentage of persons 65 and older than the Island of Oahu and State of Hawaii. The percentage of owner-occupied housing units in CDPs adjacent to West Loch Annex is significantly higher than the Island of Oahu and the State of Hawaii. The exception is Iroquois Point which is a rental housing development. However, the number of persons per household in CDPs adjacent to West Loch Annex is higher than Oahu and the State of Hawaii. Percentages of high school graduates in CDPs adjacent to West Loch Annex are generally comparable with the island of Oahu and the State of Hawaii although the Ewa Beach CDP has lower percentages in both categories. Percentages of those with Bachelor's degree or higher are generally lower than Oahu and the State of Hawaii although the Ocean Pointe CDP has a higher percentage of those with Bachelor's degrees or higher.



Ewa Region Census Designated Places **Figure 3-17**
Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii

3.10.3 Environmental Consequences

Analysis of impacts to socioeconomics focuses on the effects of the alternatives on population, income, tax revenue, and housing.

Socioeconomic Potential Impacts:

- Beneficial impact relating to construction spending and ongoing operational spending.

3.10.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to the socioeconomics of the local area or region. Therefore, no impact to socioeconomics would occur with implementation of the No Action Alternative.

3.10.3.2 Alternative 1 (24 New Box Type “D” Magazines Adjacent to 10th Street) (Preferred Alternative) Potential Impacts

The study area for the analysis of effects to socioeconomics associated with the Preferred Alternative includes areas which would be altered by:

- the proposed 24 box magazines clustered around the 10th Street and E Avenue intersections;
- adjacent construction staging and roadway access;

- adjacent roadways and concrete pads, utility improvements, landscaping, and drainage improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

The Preferred Alternative would not substantially alter population and demographic characteristics nor would it result in inconsistent population growth or have any disproportionate impacts upon housing and employment markets. Construction-related employment would have a positive impact on the local economy due to spending by those employed in construction jobs and businesses providing goods and services to the construction industry. Construction-related spending would also benefit businesses in other commercial sectors (e.g., stores, restaurants), while construction-related tax revenues would benefit the local economy. After completion of construction, there would be ongoing purchase of goods and services needed for operation and maintenance.

Therefore, implementation of the Preferred Alternative would result in less than significant impacts to the socioeconomics of the local area or region. Construction-related employment and spending would, however, benefit the local economy.

3.10.3.3 Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive) Potential Impacts

The study area for the analysis of effects to socioeconomics associated with this alternative includes:

- 24 box magazines west of West Loch Drive and 6th Street;
- adjacent construction staging;
- fire station;
- adjacent roadways and concrete pads, utility improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

Alternative 2 also would not result in any substantial change to socioeconomic parameters in the Ewa area and region. Construction-related employment and spending are anticipated to be very similar to the Preferred Alternative.

Therefore, implementation of Alternative 2 would result in less than significant impacts to the socioeconomics of the local area or region.

3.11 Environmental Justice

USEPA defines Environmental Justice as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies (USEPA, 2014).

3.11.1 Regulatory Setting

Consistent with EO 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (February 11, 1994), the Navy's policy is to identify and address any disproportionately high and adverse human health or environmental effects of its actions on minority and low-income populations.

3.11.2 Affected Environment

Table 3-21 presents data on race for several CDPs adjacent to West Loch Annex, the island of Oahu, and the State of Hawaii. The data show that Whites are generally underrepresented in the Ewa Beach, Ewa Gentry and West Loch Estate CDPs, but the Ocean Pointe and Iroquois Point CDPs have a higher representation of Whites. Blacks or African Americans and American Indians or Alaska Natives are present in relatively small numbers across the board but Blacks or African Americans have the higher percentages in the Ocean Pointe and Iroquois Point CDPs. Asians have the highest percentages in the West Loch Estate and Ewa Beach CDPs, with the lowest percentages occurring in the Iroquois Point CDP. Native Hawaiian and Other Pacific Islanders are present in the adjacent CDPs in generally lower percentages than the Island of Oahu and the State of Hawaii, although the Ewa Beach and Iroquois Point CDPs have a higher percentage than Oahu and the State as a whole. People of two or more races are generally consistent across the adjacent CDPs and the Island of Oahu and State of Hawaii.

Table 3-21 Data on Race for CDPs Adjacent to West Loch Annex, Island of Oahu and State of Hawaii

	Ewa Beach CDP	*Ewa Gentry CDP*	*Ocean Pointe CDP*	*West Loch Estates CDP*	*Iroquois Point CDP*	*Island of Oahu*	*State of Hawaii*
White	8.4%	16.2%	34.6%	13.7%	42.4%	20.8%	24.7%
Black or African American	0.7%	3.6%	7.4%	1.7%	6.5%	2.0%	1.6%
American Indian and Alaska Native	0.1%	0.2%	0.6%	0.2%	0.5%	0.3%	0.3%
Asian	50.6%	44.3%	30.5%	55.0%	11.4%	43.9%	38.6%
Native Hawaiian and Other Pacific Islander	12.9%	7.0%	4.1%	5.8%	11.7%	9.5%	10.0%
Two or More Races	26.6%	27.1%	21.3%	22.3%	24.9%	22.3%	23.6%

Source: U.S. Census Bureau

Table 3-22 presents income and poverty data for several CDPs adjacent to West Loch Annex, the island of Oahu, and the State of Hawaii. The data show that median household income for adjacent Ewa area CDPs are generally higher than for the cumulative data for Oahu and the State of Hawaii. Per capita income is generally the same between the Ewa area CDPs, Oahu and the State of Hawaii. However, the Ewa Beach and Iroquois Point CDPs have a lower per capita income. The percentages of persons in poverty in the Ewa Gentry, Ocean Pointe, West Loch Estates, and Iroquois Point CDPs are lower than the Island of Oahu and the State of Hawaii as a whole. However, the Ewa Beach CDP has a higher percentage of persons in poverty than both Oahu and the State.

Table 3-22 Income and Poverty Data for CDPs Adjacent to West Loch Annex, Island of Oahu and State of Hawaii

	Ewa Beach CDP	*Ewa Gentry CDP*	*Ocean Pointe CDP*	*West Loch Estates CDP*	*Iroquois Point CDP*	*Island of Oahu*	*State of Hawaii*
Median Household Income (in 2016 dollars), 2012-2016	$86,424	$91,872	$111,729	$98,293	$90,843	$77,161	$71,977
Per Capita Income in Past 12 months (in 2016 dollars), 2012-2016	$24,716	$32,545	$37,402	$31,515	$26,282	$32,194	$30,970
Persons in Poverty, percent	10.0%	3.3%	3.7%	4.4%	7.9%	8.5%	9.3%

Source: U.S. Census Bureau

3.11.3 Environmental Consequences

This analysis focuses on the potential for a disproportionate and adverse exposure of specific off-base population groups to the projected adverse consequences discussed in the previous sections of this chapter.

3.11.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to environmental justice parameters. Therefore, no impact to environmental justice would occur with implementation of the No Action Alternative.

3.11.3.2 Alternative 1 (24 New Box Type “D” Magazines Adjacent to 10th Street) (Preferred Alternative) Potential Impacts

The study area for the analysis of effects to environmental justice associated with the Preferred Alternative includes areas which would be altered by:

- the proposed 24 box magazines clustered around the 10th Street and E Avenue intersections;
- adjacent construction staging and roadway access;
- adjacent roadways and concrete pads, utility improvements, landscaping, and drainage improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

The Preferred Alternative would involve the construction of magazines at West Loch Annex to address a shortage of needed storage space. The Proposed Action provides needed storage space for ordnance at

West Loch Annex in magazines that are being built to current DoD standards with the needed buffer space for safety and security reasons. Data from the census designated places in close proximity to West Loch Annex are relatively mixed in terms of race and national origin. Household median incomes are higher in the CDPs adjacent to West Loch Annex compared to Oahu and the State of Hawaii as a whole. Four of the five neighboring CDPs have lower poverty rates than the island of Oahu and the State as a whole. Public access would also be prohibited through West Loch Annex. However, a new bypass road would be built linking Iroquois Road and North Road which would provide a replacement roadway of similar capacity.

Implementation of the Preferred Alternative would not cause disproportionately high and adverse human health or environmental effects on minority or low-income populations resulting in less than significant construction and operational period impacts.

3.11.3.3 Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive) Potential Impacts

The study area for the analysis of effects to environmental justice associated with this alternative includes:

- 24 box magazines west of West Loch Drive and 6th Street;
- adjacent construction staging;
- fire station;
- adjacent roadways and concrete pads, utility improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

Alternative 2 would also involve construction of needed magazine space which would also be built to the applicable DoD standards with adequate buffer space, prohibition of public access through West Loch Annex for safety and security reasons, and construction of a new public bypass road.

Implementation of Alternative 2 would not cause disproportionately high and adverse human health or environmental effects on any minority or low-income populations resulting in less than significant construction and operational period impacts.

3.12 Water Resources

This discussion of water resources includes groundwater, surface water, marine waters, wetlands, floodplains, and shorelines. This section also discusses the physical characteristics of marine waters, wetlands, etc.; wildlife and vegetation are addressed in Section 3.7, Biological Resources.

Groundwater is water that flows or seeps downward and saturates soil or rock, supplying springs and wells. Groundwater is used for water consumption, agricultural irrigation, and industrial applications. Groundwater properties are often described in terms of depth to aquifer, aquifer or well capacity, water quality, and surrounding geologic composition. Sole source aquifer designation provides limited protection of groundwater resources which serve as drinking water supplies.

Surface water resources generally consist of wetlands, lakes, rivers, and streams. Surface water is important for its contributions to the economic, ecological, recreational, and human health of a community or locale. A Total Maximum Daily Load (TMDL) is the maximum amount of a substance that can be assimilated by a water body without causing impairment. A water body can be deemed impaired if water quality analyses conclude that exceedances of water quality standards occur.

Marine waters would typically include estuaries, waters seaward of the historic height of tidal influence, and offshore high salinity waters. Marine water quality would be described as the chemical and physical composition of the water as affected by natural conditions and human activities. Additionally, marine waters may include an area within a National Marine Sanctuary requiring an action proponent to avoid adverse water quality impacts in order to prevent damage to resources within the sanctuary.

Wetlands are jointly defined by USEPA and USACE as "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." Wetlands generally include "swamps, marshes, bogs and similar areas."

Floodplains are areas of low-level ground present along rivers, stream channels, large wetlands, or coastal waters. Floodplain ecosystem functions include natural moderation of floods, flood storage and conveyance, groundwater recharge, and nutrient cycling. Floodplains also help to maintain water quality and are often home to a diverse array of plants and animals. In their natural vegetated state, floodplains slow the rate at which the incoming overland flow reaches the main water body. Floodplain boundaries are most often defined in terms of frequency of inundation, that is, the 100-year and 500-year flood. Floodplain delineation maps are produced by the Federal Emergency Management Agency and provide a basis for comparing the locale of the Proposed Action to the floodplains.

Shorelines can be located along marine (oceans), brackish (estuaries), or fresh (lakes) bodies of water. Physical dynamics of shorelines include tidal influences, channel movement and hydrological systems, flooding or storm surge areas, erosion and sedimentation, water quality and temperature, presence of nutrients and pathogens, and sites with potential for protection or restoration. Shoreline ecosystems are vital habitat for multiple life states of many fish, birds, reptiles, amphibians, and invertebrates. Different shore zones provide different kinds and levels of habitat, and when aggregated, can significantly influence life. Organic matter that is washed onto the shore, or "wrack," is an important component of shoreline ecosystems, providing habitat for invertebrates, soil and organic matter, and nutrients to both the upland terrestrial communities and aquatic ecosystems.

3.12.1 Regulatory Setting

The Safe Drinking Water Act is the federal law that protects public drinking water supplies throughout the nation. Under the Safe Drinking Water Act, the USEPA sets standards for drinking water quality. Groundwater quality and quantity are regulated under several statutes and regulations, including the Safe Drinking Water Act.

The CWA establishes federal limits, through the NPDES program, on the amounts of specific pollutants that can be discharged into surface waters to restore and maintain the chemical, physical, and biological integrity of the water. The NPDES program regulates the discharge of point (i.e., end of pipe) and nonpoint sources (i.e., stormwater) of water pollution.

The State of Hawaii NPDES stormwater program requires construction site operators engaged in clearing, grading, and excavating activities that disturb one acre or more to obtain coverage under an NPDES Construction General Permit for stormwater discharges. However, the site must discharge stormwater in order to be regulated by Section 11-55 HAR, Appendix C. Construction or demolition that necessitates an individual permit also requires preparation of a Notice of Intent to discharge stormwater and a Stormwater Pollution Prevention Plan that is implemented during construction. As part of the 2010 Final Rule for the CWA, titled Effluent Limitations Guidelines and Standards for the Construction and Development Point Source Category, activities covered by this permit must implement non-numeric erosion and sediment controls and pollution prevention measures.

Wetlands are currently regulated by the USACE under Section 404 of the CWA as a subset of all "Waters of the United States." Waters of the United States are defined as (1) traditional navigable waters, (2) wetlands adjacent to navigable waters, (3) nonnavigable tributaries of traditional navigable waters that are relatively permanent where the tributaries typically flow perennially or have continuous flow at least seasonally (e.g., typically 3 months), and (4) wetlands that directly abut such tributaries under Section 404 of the CWA, as amended, and are regulated by USEPA and the USACE. The CWA requires that the State of Hawaii establish a Section 303(d) list to identify impaired waters and establish TMDLs for the sources causing the impairment.

Section 404 of the CWA authorizes the Secretary of the Army, acting through the Chief of Engineers, to issue permits for the discharge of dredge or fill into wetlands and other Waters of the United States. Any discharge of dredge or fill into Waters of the United States requires a permit from the USACE.

Section 438 of the Energy Independence and Security Act establishes storm water design requirements for development and redevelopment projects. Under these requirements, federal facility projects larger than 5,000 square feet must "maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of flow."

Section 10 of the Rivers and Harbors Act provides for USACE permit requirements for any in-water construction. USACE and some states require a permit for any in-water construction. Permits are required for construction of piers, wharfs, bulkheads, pilings, marinas, docks, ramps, floats, moorings, and like structures; construction of wires and cables over the water, and pipes, cables, or tunnels under the water; dredging and excavation; any obstruction or alteration of navigable waters; depositing fill and dredged material; filling of wetlands adjacent or contiguous to waters of the U.S.; construction of riprap, revetments, groins, breakwaters, and levees; and transportation of dredged material for dumping into ocean waters.

The National Wild and Scenic Rivers System was created by Congress in 1968 to preserve certain rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations. The Act is notable for safeguarding the special character of these rivers, while also recognizing the potential for their appropriate use and development. It encourages river management that crosses political boundaries and promotes public participation in developing goals for river protection.

The Coastal Zone Management Act of 1972 (CZMA) provides assistance to states, in cooperation with federal and local agencies, for developing land and water use programs in coastal zones. Actions occurring within the coastal zone commonly have several resource areas that may be relevant to the CZMA. The CZMA regulatory setting discussion is discussed in Section 3.4.1.

Executive Order 11990, Protection of Wetlands, requires that federal agencies adopt a policy to avoid, to the extent possible, long- and short-term adverse impacts associated with destruction and modification of wetlands and to avoid the direct and indirect support of new construction in wetlands whenever there is a practicable alternative.

Executive Order 11988, Floodplain Management, requires federal agencies to avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development unless it is the only practicable alternative. Flood potential of a site is usually determined by the 100-year floodplain, which is defined as the area that has a one percent chance of inundation by a flood event in a given year.

Executive Order 13807, Establishing Discipline and Accountability in the Environmental Review and Permitting Process for Infrastructure Projects, is geared toward obtaining more efficient and effective federal infrastructure decisions and to change the way the federal government processes environmental reviews and authorization decisions.

3.12.2 Affected Environment

The following discussions provide a description of the existing conditions for each of the categories under water quality resources at the West Loch Annex.

3.12.2.1 Groundwater

The Proposed Action is located within the Pearl Harbor Aquifer Sector. The area is underlain by both deep and shallow aquifers. The deep aquifers are basal, confined flank aquifers in the underlying basalt. The shallow aquifers overlie the deep aquifers and are basal, unconfined, sedimentary caprock aquifers (Mink and Lau, 1990). There are no potable water aquifers or perennial streams crossing potential areas of disturbance in the vicinity of the project.

Groundwater seeps (surface leakage from the shallow groundwater aquifer) are present along the coastline of the Ewa coast. The mingling of groundwater and surface water at the coast is important in the sustainment of the Ewa Plain coastal ecosystems (Mr. Mike Lee, 2010). This interaction replenishes and nurtures coastal limu.

3.12.2.2 Surface Water

The Proposed Action would affect various locations extending from areas adjacent to the shoreline to as much as 9,500 feet from the shoreline. The relatively flat topography of the area, combined with the highly permeable soil and rock, allow storm water runoff to easily infiltrate the ground surface and collect in man-made detention basins, dry wells, natural sinkholes, or pits in the subsurface. During extreme precipitation events however, storm water typically overflows and sheet-flows into the nearest drainage or collects in low-lying areas.

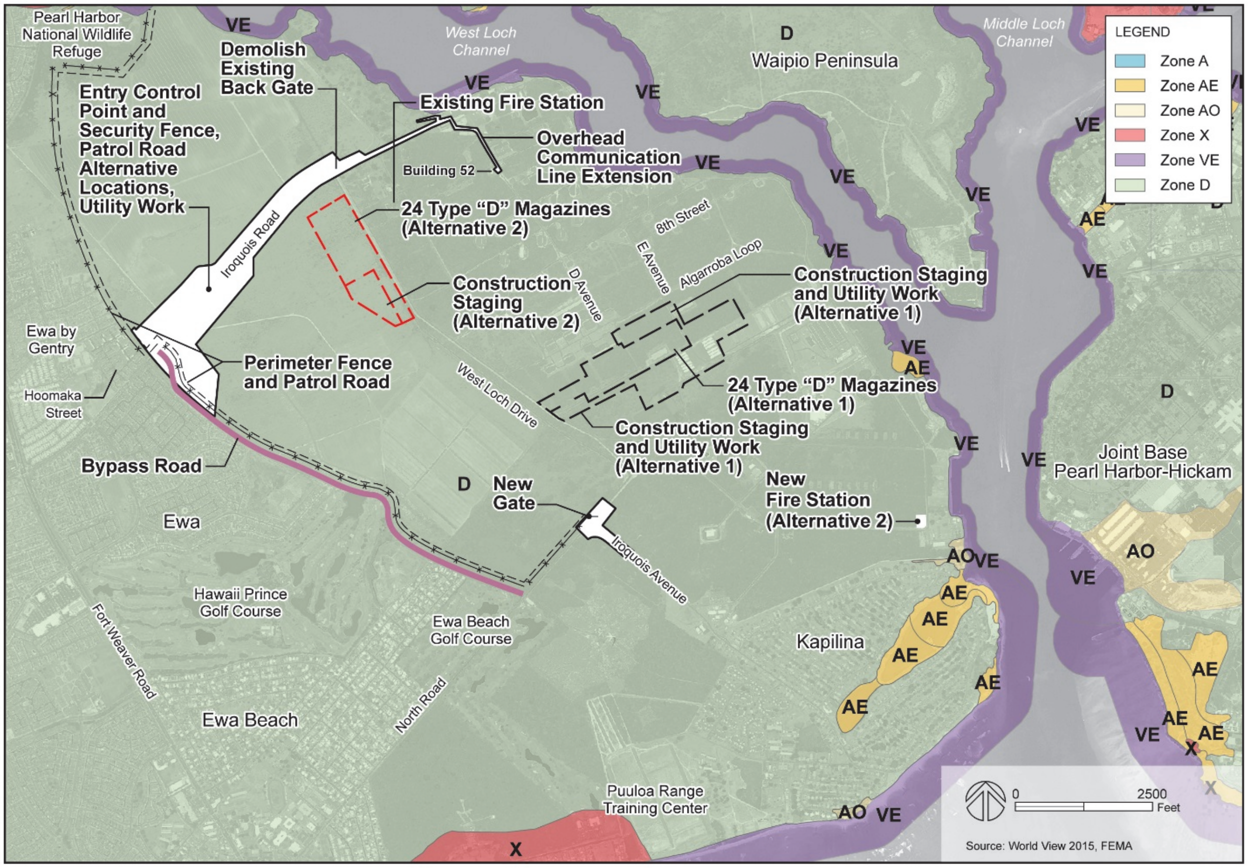
The Proposed Action is located within the Pearl Harbor watershed, a 110-square mile watershed subdivided into nine subwatersheds. These subwatersheds contain the headwaters of nine streams that drain into Pearl Harbor (CNRH, 2011). The State of Hawaii Department of Health (DoH) classifies the waters of Pearl Harbor as an inland estuary, Class 2 (Title 11, Chapter 54, Water Quality Standards, HAR). The objective of Class 2 waters is to protect their use for recreational purposes, propagation of fish and other aquatic life, agricultural and industrial water supplies, shipping, and navigation. Discharges into Class 2 waters must receive the best degree of treatment or control compatible with the criteria established for this class (Section 11-54-03(b)(2) HAR).

3.12.2.3 Wetlands

The area of the Proposed Action does not include known jurisdictional wetlands. The Final Integrated Natural Resource Management Plan for JBPHH does not indicate wetland areas within lands affected by the project (CNRH, 2011). The U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory also does not indicate the presence of wetlands on lands affected by the project. The PHNWR, located north of the project site, is classified as a Freshwater Emergent Wetland. A Freshwater Pond is also identified to the northwest of the PHNWR. Abutting the West Loch Annex shoreline are various estuarine and marine wetland areas. The waters of West Loch are classified as an estuarine and marine deepwater. None of these wetland designated areas would involve land altered or affected by the project. The security fence and patrol road in this vicinity would be located on disturbed agricultural lands east of the wetlands.

3.12.2.4 Floodplains

The Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) for the land encompassed by the Proposed Action indicates that the area is within Zone D (i.e., areas with possible but undetermined flood hazards) (FEMA, 2011) (Figure 3-18). There are no streams or surface water features in or near the Proposed Action that could cause potential flood hazards.



Flood Zones **Figure 3-18**

Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii

Regarding tsunami evacuation parameters, the Proposed Action is located within a Safe Zone with the exception of the proposed fire station site. This is located in an Extreme Tsunami Evacuation Zone in which an evacuation is recommended in the unlikely case of an "Extreme Tsunami Warning" caused by a very large (Magnitude 9+) earthquake and tsunami. (City and County of Honolulu, 2015).

3.12.2.5 Marine Resources

The project does not involve work within the shoreline area or within the nearshore marine environment.

3.12.3 Environmental Consequences

Water Resources Potential Impacts:

- Lack of or incorrect implementation of BMPs
- Possible leakage of fluids from vehicles and equipment

In this EA, the analysis of water resources looks at the potential impacts on groundwater, surface water, wetlands and floodplains. Groundwater analysis focuses on the potential for impacts to the quality, quantity, and accessibility of the water. The analysis of surface water quality considers the potential for impacts that may change the water quality, including both improvements and degradation of current water quality. The impact assessment of wetlands considers the potential for impacts that may change the local hydrology, soils, or vegetation that support a wetland. The analysis of floodplains considers if any new construction is proposed within a floodplain or may impede the functions of floodplains in conveying floodwaters.

3.12.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to baseline water resources. Therefore, no impact to water resources would occur with implementation of the No Action Alternative.

3.12.3.2 Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative) Potential Impacts

The study area for the analysis of effects to water resources associated with the Preferred Alternative includes areas which would be altered by:

- the proposed 24 box magazines clustered around the 10th Street and E Avenue intersections;
- adjacent construction staging and roadway access;
- adjacent roadways and concrete pads, utility improvements, landscaping, and drainage improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

In the Preferred Alternative, the effects upon the predevelopment hydrology of the area will be less than significant.

The project site is predominantly covered with vegetation. Construction of the proposed magazines and appurtenant concrete pads and roadways, paved portions of the bypass road, and portions of the entry control point would increase the amount of impervious surface. The security fence would have a very minimal effect on the predevelopment hydrology since the fence post foundations are minimal. The patrol road may be an all-weather impermeable surface or it could be permeable aggregate. In terms of the overall size of the West Loch Annex site (approximately 2,640 acres), the increase in runoff would be minor as the increase in impervious surface would be limited and estimated at approximately 91 acres or 3.4 percent of the total site area (assuming an impervious patrol road surface). If a pervious patrol road surface is implemented, the increase in impervious surface is estimated at approximately 77 acres or 2.9 percent of the total site area. Impervious surfaces associated with the magazines, roadways, and concrete aprons are approximately 39 acres. Impervious surfaces for the bypass road are approximately ten acres while the entry control point impervious surfaces are estimated at 28 acres. The patrol roadway surface is approximately 14 acres. The project would implement BMPs to capture and retain storm water on site and allow it to infiltrate into the soil or to be discharged at a rate that would not exceed the predevelopment hydrology to adjacent surface waters. Percolation basins would be installed adjacent to the magazines, as appropriate. The Navy has determined that the first phase of magazines does not require coverage under Section 11-55 HAR, Appendix C. For future phases, an NPDES permit would be obtained for the project to address temporary discharges of storm water relating to construction activities, as applicable. An NPDES permit for dewatering would be obtained, as applicable.

Section 438 of the Energy Independence and Security Act of 2007 established strict storm water runoff requirements for federal development and redevelopment projects. The provision requires that "The sponsor of any development or redevelopment project involving federal facility with a footprint that exceeds 5,000 square feet shall use site planning, design, construction, and maintenance strategies for the property to maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of flow." These requirements would be followed for the proposed project.

During construction, water would be dispensed by water trucks or temporary irrigation systems to control fugitive dust and wet down any exposed ground. During the operational period, the components of the project would not require significant water use nor would it significantly affect ground water withdrawals or infiltration. Minimal landscaping near the magazines are planned.

The proposed project would not impact ground water resources as it would have a negligible effect on groundwater recharge. The West Loch Annex site is located over the Ewa caprock aquifer which is insulated from the underlying Pearl Harbor aquifer, Oahu's major source of potable water. During construction, BMPs such as proper storage of hazardous materials and immediate cleanup of any leaks or spills will be implemented to prevent contamination of groundwater resources. After construction, there are a number of safety and precautionary measures in place in order to minimize and prevent any inadvertent detonation of ordnance. Only qualified Navy ordnance trained specialists will handle the ordnance. The magazines will be secured and an intrusion detection system would be installed on each magazine. Unauthorized personnel will not be allowed within this secured area.

The Preferred Alternative would not result in the destruction, modification of, or new construction in any known wetlands. The Preferred Alternative would not involve the discharge of dredge or fill into any known wetlands or other Waters of the United States. The Navy will confirm the likelihood and/or presence or absence of jurisdictional wetlands located within the project area prior to construction. If any jurisdictional wetlands are identified within the project area, the Navy will coordinate with the U.S. Army Corps of Engineers (USACE) to avoid, minimize and/or mitigate impacts resulting from the Proposed Action.

The Preferred Alternative would not involve the placement of any permanent above ground structures within the floodplain or floodway and would not result in a modification to the floodplain or floodway. Design plans are being or would be reviewed by pertinent state and city agencies for approval.

Implementation of the Preferred Alternative would result in less than significant impacts to water resources.

3.12.3.3 Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive) Potential Impacts

The study area for the analysis of effects to water resources associated with this alternative includes:

- 24 box magazines west of West Loch Drive and 6th Street;
- adjacent construction staging;
- fire station;
- adjacent roadways and concrete pads, utility improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive) would have similar less than significant impacts to water resources as the Preferred Alternative. During construction, Alternative 2 will involve alteration of approximately 92 acres or 3.5 percent of the total site area (assuming an impervious surface for the patrol road). If a pervious patrol road surface is implemented, the increase in impervious surface is estimated at approximately 78 acres or 3.0 percent of the total site area. This is approximately the same as Alternative 1. Impervious surfaces associated with the magazines, roadways, and concrete pads are approximately 39 acres. Impervious surfaces for the bypass road are approximately ten acres while the entry control point impervious surfaces are estimated at 28 acres. The patrol roadway surface is approximately 14 acres. Impervious surfaces on the fire station site would be approximately 0.5 acre.

BMPs would be implemented to capture and retain stormwater on site and allow it to infiltrate into the soil or to be discharged at a rate that would not exceed the predevelopment hydrology to adjacent surface waters. Percolation basins would be installed adjacent to the magazines, as appropriate. The Navy has determined that the first phase of magazines does not require NPDES coverage under Section 11-55 HAR, Appendix C. For future phases, NPDES permit(s) would be obtained, as applicable. Compliance with Section 438 of the Energy Independence and Security Act of 2007 would also be enforced.

Staff from the existing fire station would transfer to the new fire station so water usage generally transfers to the new facility. Reuse of the existing fire station structure would need to comply with applicable DoD safety standards. However, any future use of the existing fire station structure would not involve habitation.

Like Alternative 1, water would be dispensed by water trucks or temporary irrigation systems to control fugitive dust and wet down any exposed ground during the construction period. During the operational period, the components of the project would not require significant water use nor would it significantly affect ground water withdrawals or infiltration.

Alternative 2 would not impact ground water resources as it would have a negligible effect on groundwater recharge.

Alternative 2 would not result in the destruction or modification of or new construction in any known wetlands. The Navy will confirm the likelihood and/or presence or absence of jurisdictional wetlands located within the project area prior to construction. If any jurisdictional wetlands are identified within the project area, the Navy will coordinate with the U.S. Army Corps of Engineers (USACE) to avoid, minimize and/or mitigate impacts resulting from the Proposed Action.

Alternative 2 would not involve the placement of any permanent above ground structures within the floodplain or floodway and would not result in a modification to the floodplain or floodway.

Implementation of Alternative 2 would result in less than significant impacts to water resources.

3.13 Geological Resources

This discussion of geological resources includes topography, geology, and soils of a given area. Topography is typically described with respect to the elevation, slope, and surface features found within a given area. The geology of an area may include bedrock materials, mineral deposits, and fossil remains. The principal geological factors influencing the stability of structures are soil stability and seismic properties. Soil refers to unconsolidated earthen materials overlying bedrock or other parent material. Soil structure, elasticity, strength, shrink-swell potential, and erodibility determine the ability for the ground to support structures and facilities. Soils are typically described in terms of their type, slope, physical characteristics, and relative compatibility or limitations with regard to particular construction activities and types of land use.

3.13.1 Regulatory Setting

Consideration of geologic resources extends to prime or unique farmlands. The Farmland Protection Policy Act (FPPA) was enacted in 1981 in order to minimize the loss of prime farmland and unique farmlands as a result of federal actions. The implementing procedures of the FPPA require federal agencies to evaluate the adverse effects of their activities on farmland, which includes prime and unique farmland and farmland of statewide and local importance, and to consider alternative actions that could avoid adverse effects.

3.13.2 Affected Environment

The following discussions provide a description of the existing conditions for the categories under geological resources at the West Loch Annex.

3.13.2.1 Topography

The topography of the area of the Proposed Action is generally flat and low lying. Elevations range from sea level to approximately 10 feet above sea level near West Loch Drive. Further west, elevations rise gradually to 20 feet above sea level. Portions of the site reach 40 feet above sea level near the northwest corner of the site (INRMP JBPHH, 2011).

3.13.2.2 Geology

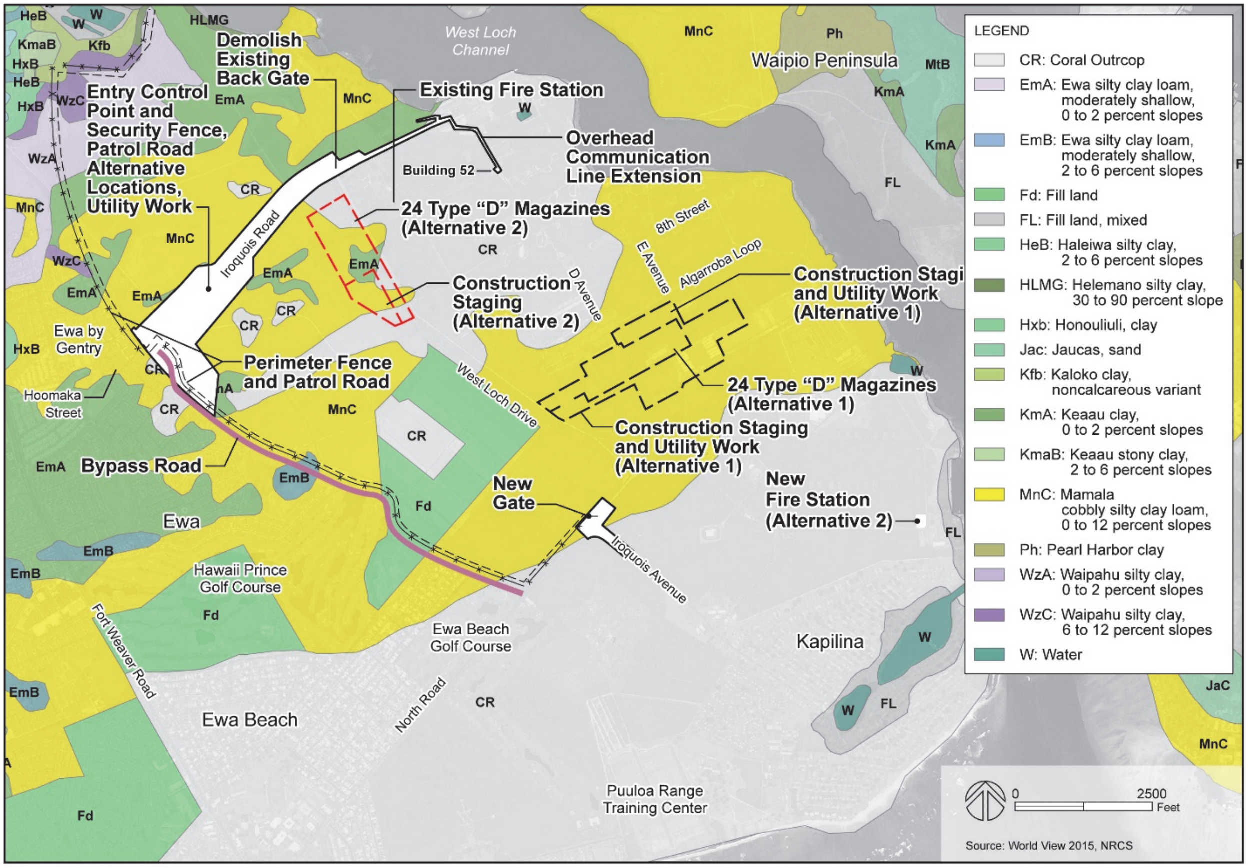
The site of the Proposed Action is within the Pearl Harbor area which is within the coastal plain on the southwestern coast of Oahu. The majority of rocks on Oahu originate from the Waianae and Koolau shield volcanoes. The west side of Pearl Harbor is composed mostly of limestone reef material and known as the Ewa Plain (CNRH, 2001).

The ancient reef that comprises the Ewa Plain grew when sea level was up to 100 feet higher than the present day. The consolidated limestone increases in thickness from 120 feet at the northwest corner of West Loch Annex to 200 feet near Iroquois Point. The fossil reef is highly permeable and serves as an aquifer and filter. Below the reef, caprock, consisting of a complicated sequence of terrestrial and marine sediments, extends to the top of the Koolau basalt (INRMP JBPHH, 2011).

3.13.2.3 Soils

The general soil association found in the JBPHH area is the Lualualei-Fill Land-Ewa association. This soil association makes up about 14 percent of the Island of Oahu, and is described as deep, nearly level to moderately sloping, well-drained soils that have fine-textured or moderately fine textured subsoil or underlying material and areas of fill land on coastal plains (DoN, 2013).

The U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) classifies the soils in the project area by several different soil types (Figure 3-19).



Source: World View 2015, NRCS

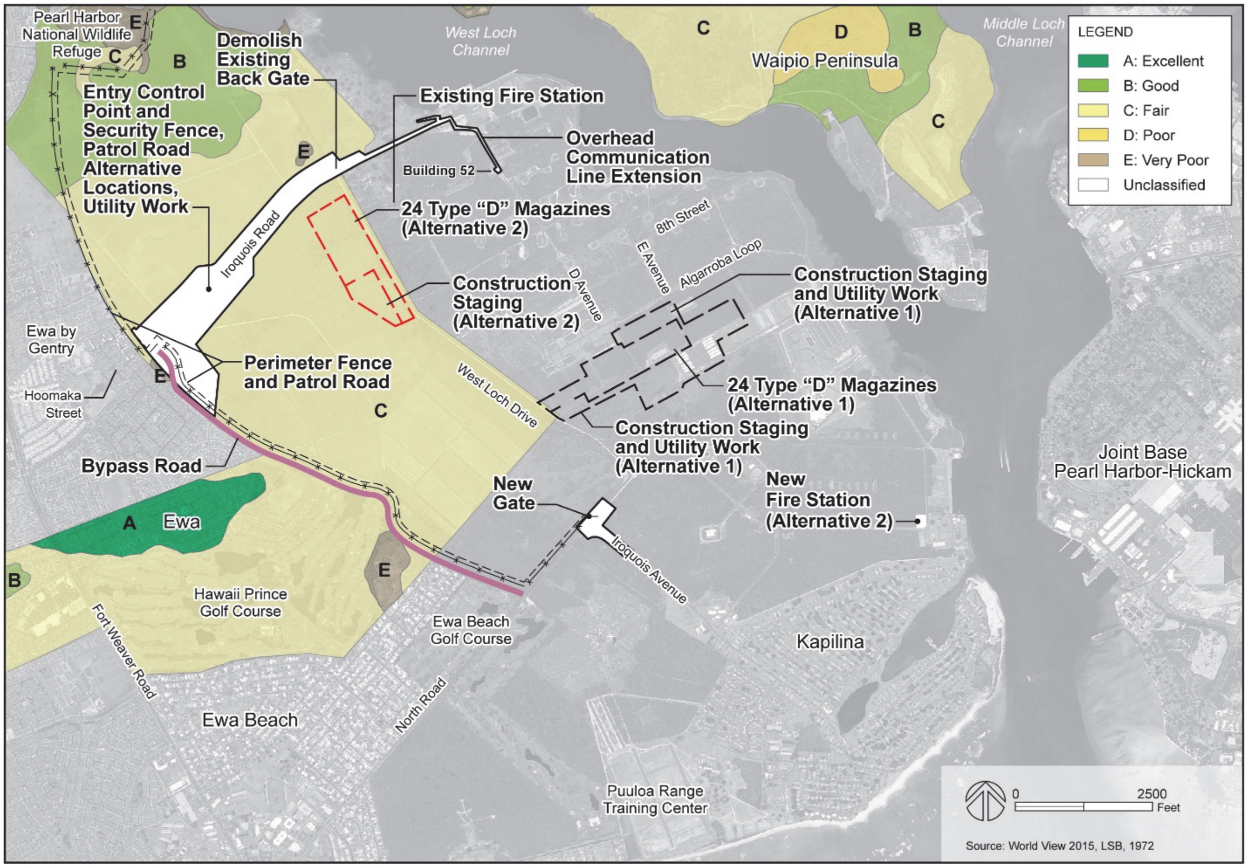
NRCS Soil Classifications **Figure 3-19**
Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii

The area which would be occupied by the proposed magazine locations in the Preferred Alternative, appurtenant roads, concrete pads, landscaping, utility improvements and construction staging is Mamala cobbly silty clay loam, 0 to 12 percent slopes (MnC). Alternative 2 is underlain by MnC, Coral Outcrop (CR), and Ewa silty clay loam, moderately shallow, 0 to 2 percent slopes (EmA) soils. The entry control point, demolition of the back gate and overhead communication line extension would be located on CR, MnC, and EmA soils. The bypass road is located on CR, MnC, EmA, Ewa silty clay loam, moderately shallow, 2 to 6 percent slopes (EmB), and Fill land (Fd). The fence and patrol road are located on CR, MnC, EmA, EmB, Fd, Waipahu silty clay, 0 to 2 percent slopes (WzA), Waipahu silty clay, 6 to 12 percent slopes (WzC) Kaloko clay, noncalcareous variant (Kfb), and Helemano silty clay, 30 to 90 percent slopes (HLMG). The gate at the corner of North Road and Iroquois Avenue is located on MnC and CR soils. The fire station is located in CR soils. The soils are described in Table 3-23.

Table 3-23 NRCS Soil Classifications in the Project Area

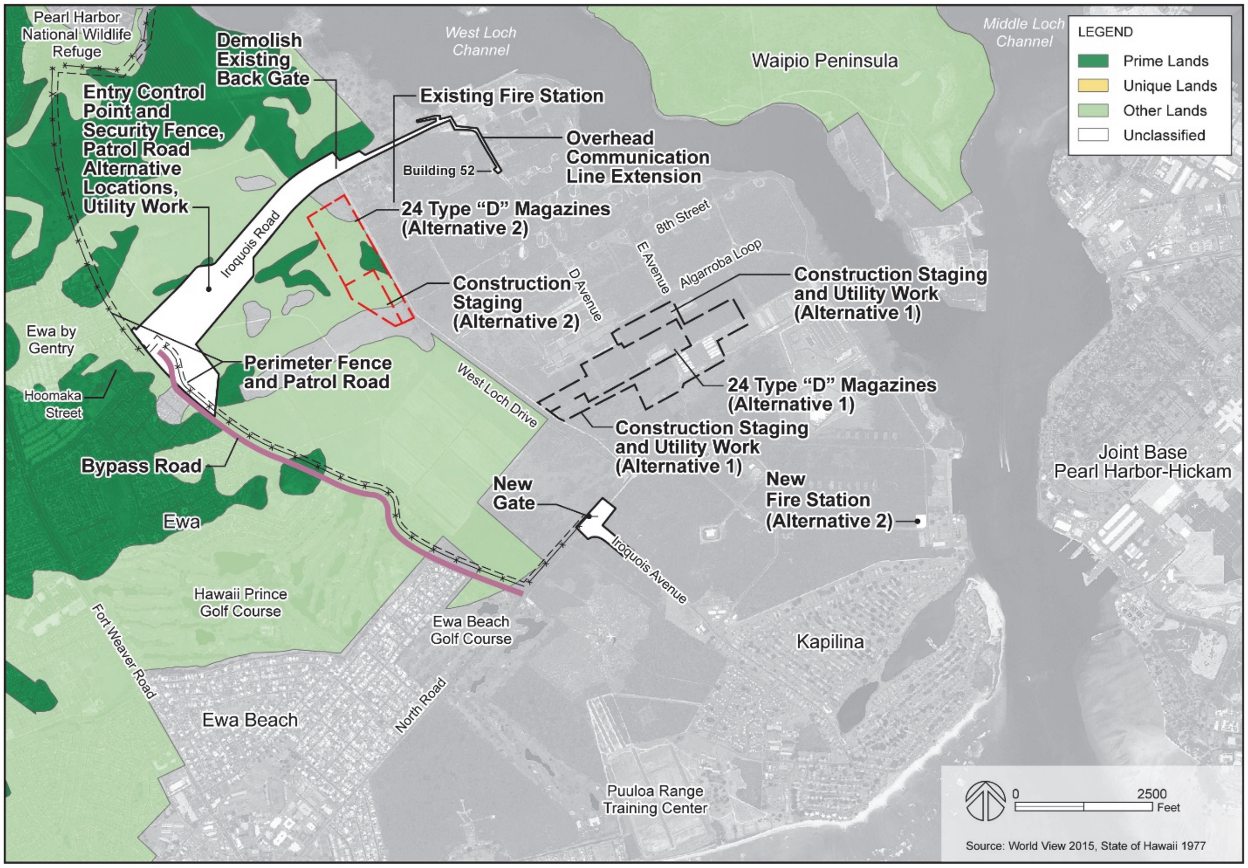
Map Unit Symbol	***Map Unit Name***	***Description***
CR	Coral Outcrop	Excessively drained soils with low runoff found on reefs.
EmA	Ewa silty clay loam, moderately shallow, 0 to 2 percent slopes	Well drained soils with low runoff found on footslopes with slopes of 0 to 2 percent.
EmB	Ewa silty clay loam, moderately shallow, 2 to 6 percent slopes	Well drained soils with low runoff found on footslopes with slopes of 2 to 6 percent.
Fd	Fill land, mixed	Well drained soils with low runoff found on flats.
HLMG	Helemano silty clay, 30 to 90 percent slopes	Silty clay and paragravelly silty clay typically found in gulches
Kfb	Kaloko clay, noncalcareous variant	Clay soils with negligible runoff and slopes of 0 to 2 percent.
MnC	Mamala cobbly silty clay loam, 0 to 12 percent slopes	Well drained soils with medium runoff found on coastal plains.
WzA	Waipahu silty clay, 0 to 2 percent slopes	Well drained soils with low runoff found on terraces with slopes of 0 to 2 percent.
WzC	Waipahu silty clay, 6 to 12 percent slopes	Well drained soils with medium runoff found on terraces with slopes of 6 to 12 percent.
NRCS Web Soil Survey National Cooperative Soil Survey (accessed October 2017)		

The Land Study Bureau (LSB) of the University of Hawaii prepared an inventory and evaluation of the State’s land resources in 1973. The LSB evaluated the quality or productive capacity of certain lands for selected crops and overall suitability for agricultural use. A five-class productivity rating system was established with “A” representing the class of highest productivity and “E” the lowest. Areas of West Loch Annex east of West Loch Drive as well as areas adjacent to North Road have not been classified by the LSB. Areas adjacent to Iroquois Road and west of West Loch Drive have been classified as “C” lands with small portions classified as “E”. Areas to the northwest of Iroquois Road are classified as “B” and “C” with small portions being classified “E” (Figure 3-20).



Land Study Bureau Soil Ratings **Figure 3-20**
Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii

The Agricultural Lands of Importance to the State of Hawaii (ALISH) system was developed and compiled by the State of Hawaii Department of Agriculture. The classification system identified three classes of agriculturally important land. These are Prime, Unique, and Other. Prime Agricultural Land are lands which have the soil quality, growing season, and moisture supply needed to produce sustained high yields of crops economically when treated and managed according to modern farming methods. Unique Agricultural Lands have a special combination of soil quality, location, growing season, moisture supply, and is used to produce sustained high yields of crops economically when treated and managed according to modern farming methods. Other Important Agricultural Lands are lands other than Prime or Unique Agricultural Land that is also of statewide or local importance to agricultural use. Most of the West Loch Annex land to the east of West Loch Drive is Unclassified. Most of the West Loch Annex lands located to the west of West Loch Drive as well as northwest of Iroquois Road are classified as Prime and Other Important Agricultural lands with smaller portions of Unclassified lands (Figure 3-21). The City and County of Honolulu has identified what it refers to as important agricultural lands in response to a State mandate. Federal lands were excluded from the survey.



Agricultural Lands of Importance to the State of Hawaii Classifications **Figure 3-21**
Magazines for Long Ordnance, West Loch Annex
Joint Base Pearl Harbor Hickam, West Loch Annex, Hawaii

3.13.2.4 Bathymetry and Marine Sediment

The Proposed Action does not involve work in the waters of Pearl Harbor and would have negligible to no effect on bathymetry or marine sediment parameters.

3.13.3 Environmental Consequences

Geological resources are analyzed in terms of drainage, erosion, prime farmland, land subsidence, beach stability and erosion, and seismic activity. The analysis of topography and soils focuses on the area of soils that would be disturbed, the potential for erosion of soils from construction areas, and the potential for eroded soils to become pollutants in downstream surface water during storm events. The analysis also examines potential impacts related to seismic events. Best Management Practices (BMPs) are identified to minimize soil impacts and prevent or control pollutant releases into stormwater. The potentially affected environment for geological resources is limited to lands that would be disturbed by any proposed facility development or demolition.

Geological Resources Potential Impacts:

- Loss of agricultural land

3.13.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to baseline geology, topography, or soils. Therefore, no impact to geological resources would occur with implementation of the No Action Alternative.

3.13.3.2 Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative) Potential Impacts

The study area for the analysis of effects to geological resources associated with the Preferred Alternative includes areas which would be altered by:

- the proposed 24 box magazines clustered around the 10th Street and E Avenue intersections;
- adjacent construction staging and roadway access;
- adjacent roadways and concrete pads, utility improvements, landscaping, and drainage improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

The study area encompasses the proposed construction and ground disturbance areas related to the Preferred Alternative. No significant impacts to topography and soils would occur at the various project sites. Site preparation for the proposed magazines would involve excavation of the existing sub-grade to the coral formation and concrete fill below the invert of the magazine foundation to the coral foundation. Roadways and concrete pads for the magazines, bypass road, patrol road and fire station site work would involve selective grading, grubbing and vegetation removal. Other earthwork relating to fence posts and underground electrical lines are expected to be minimal.

Cut and fill quantities would be balanced on-site to make use of excavated earth although not all of this material may be suitable for structural fill. As necessary, the Contractor may need to import appropriate fill material (e.g., gravel, rock, sand) to create a strong and stable foundation for components of the project. The proposed project is not expected to have an adverse impact on land subsidence.

Ground-altering construction activities will comply with all applicable regulatory requirements. The Navy has determined that the first phase of magazines does not require NPDES coverage under Section 11-55 HAR, Appendix C. For future phases, an NPDES Permit would be obtained from the Hawaii Department of Health for the discharge of stormwater associated with construction activities such as grubbing and grading, as applicable. An NPDES permit for dewatering would be obtained, as applicable. To the extent possible, earthwork will be balanced to maintain existing drainage patterns and bare ground shall be hydromulched or planted with ground cover to minimize erosion and runoff. If necessary, water trucks or temporary irrigation systems would be utilized to facilitate plant growth. The Contractor will be responsible for implementing BMPs to control soil erosion and sedimentation during construction activities.

Existing dirt/rock berms along the West Loch Annex western boundary may need to be displaced by the bypass road or patrol road. The berms may have been built by the agricultural tenants or may have been formed during previous military construction. Prior to any alteration of the berms, the Navy would check for any contamination or public health issues, and work with the appropriate agencies concerning any applicable avoidance or minimization measures.

Green waste from the site clearing process would be brought to a designated green waste collection point throughout JBPHH. Measures will be undertaken in an effort to prevent the spread of the invasive Coconut Rhinoceros Beetle (CRB) to other parts of Oahu. If the CRB is suspected in the green waste, material shall not be further disturbed or transferred. Instead, the Pest Hotline shall be contacted for further instructions. If deciduous and evergreen material is two-inch diameter or greater, it shall be cut in five- to six-foot lengths. If it is less than two inches in diameter, the material shall be chipped. Palmaceous material of two inches in diameter or greater shall be cut in three-foot lengths. If it is less than two inches in diameter, it shall be left whole. Palm material shall not be chipped and palm fronds shall be delivered whole. All green waste will be completely enclosed or covered with tarp to prevent possible spread of the CRB during transport. Green waste will be processed in the in-vessel/biosolid composting system or Air Curtain Burner sites for disposal.

JBPHH owns/operates the composting system. The U.S. Department of Agriculture purchased the air curtain burner but will be operated by personnel from NAVFAC at JBPHH. The air curtain burner is an efficient incinerator that significantly reduces the amount of ash and other particulates from being released into the environment. All applicable air permitting requirements have been complied with.

During the operational period, the project is not expected to have an adverse impact upon topography and soils.

No adverse impacts are anticipated during the construction process. Dust from the implementation of improvements, and emissions from vehicles and equipment used to perform this work will be temporary in duration. BMPs will be implemented during construction to control soil erosion, sedimentation, and stormwater runoff.

Discussion on the Farmland Protection Policy Act is located in Section 3.4, Land Use.

The proposed project will be constructed in accordance with the appropriate seismic design category. This is a classification assigned to a structure based on its occupancy or use and on the level of expected soil modified seismic ground motion. Thus, potential seismic impacts are expected to be addressed through design.

Therefore, with the implementation of management measures, the Preferred Alternative would result in less than significant impacts to geological resources.

3.13.3.3 Alternative 2 (24 New Box Type “D” Magazines Located West of West Loch Drive) Potential Impacts

The study area for the analysis of effects to geological resources associated with this alternative includes:

- 24 box magazines west of West Loch Drive and 6th Street;
- adjacent construction staging;
- fire station;
- adjacent roadways and concrete pads, utility improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

Proposed construction and ground disturbance areas related to Alternative 2 are at nearby and partially overlapping sites compared to Alternative 1. This alternative would have similar insignificant impacts to geological resources as the Preferred Alternative. Like Alternative 1, no significant impacts to topography and soils would occur at the various project sites either during the construction phase or operational phase.

The proposed magazines are located within an area of the existing outlease. Thus, Alternative 2 would affect an additional approximately 52 acres compared to Alternative 1. Other than the location of the magazines, Alternative 2 improvements are the same as the Preferred Alternative. The magazines, bypass road, security fencing, patrol road and entry control point are necessary for national defense purposes and the area has long been set aside as a buffer for the safety of the general public. FPPA is discussed in Section 3.4, Land Use.

Like Alternative 1, the proposed project would continue to implement measures to prevent the spread of the CRB to other areas of Oahu. The project also will be constructed in accordance with the appropriate seismic design category. Thus, potential seismic impacts are expected to be addressed through design.

Therefore, with the implementation of management measures, Alternative 2 would result in less than significant impacts to geological resources.

3.14 Hazardous Materials and Wastes

This section discusses hazardous materials, hazardous waste, toxic substances, and contaminated sites.

3.14.1 Regulatory Setting

Hazardous materials are defined by 49 CFR section 171.8 as "hazardous substances, hazardous wastes, marine pollutants, elevated temperature materials, materials designated as hazardous in the Hazardous Materials Table, and materials that meet the defining criteria for hazard classes and divisions in 49 CFR part 173." Transportation of hazardous materials is regulated by the U.S. Department of Transportation regulations.

Hazardous wastes are defined by the Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments, as: "a solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may (A) cause, or significantly contribute to, an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or (B) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed." Certain types of hazardous wastes are subject to special management provisions intended to ease the management burden and facilitate the recycling of such materials. These are called universal wastes and their associated regulatory requirements are specified in 40 CFR part 273. Four types of waste are currently covered under the universal wastes regulations: hazardous waste batteries, hazardous waste pesticides that are either recalled or collected in waste pesticide collection programs, hazardous waste thermostats, and hazardous waste lamps, such as fluorescent light bulbs.

Special hazards are those substances that might pose a risk to human health and are addressed separately from other hazardous substances. Special hazards include asbestos-containing material (ACM), polychlorinated biphenyls (PCBs), and lead-based paint (LBP). USEPA is given authority to regulate special hazard substances by the Toxic Substances Control Act (TSCA). Asbestos is also regulated by USEPA under the Clean Air Act, and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

3.14.2 Affected Environment

The Navy has implemented a strict Hazardous Material Control and Management Program and a Hazardous Waste Minimization Program for all activities. These programs are governed Navy-wide by applicable OPNAV instructions and at the installation by specific instructions issued by the Base Commander. The Navy continuously monitors its operations to find ways to minimize the use of hazardous materials and to reduce the generation of hazardous wastes.

3.14.2.1 Hazardous Materials and Hazardous Waste

Within West Loch Annex, near this project location, there are three sites located on the National Priorities List regulated under CERCLA.

The 4th Street Coral Pit is a former disposal area located between 3rd Street and 4th Street and is approximately 1,000 feet long by 250 feet wide. The Alternative 1 magazines are located approximately 4,000 feet from the Coral Pit. The closest improvements in Alternative 1 would be improvements to Iroquois Road near the existing back gate which would be located approximately 1,500 feet away from the 4th Street Coral Pit. All other Alternative 1 or Alternative 2 improvements are located farther away from the Coral Pit. Starting from the 1930’s, the site was excavated as a source of coral for use as road construction materials. During World War II, the Coral Pit was used as a waste disposal site. In the mid-1970’s, the site was partially backfilled to preclude further disposal at the site although scrap metal disposal and other unauthorized disposal occurred.

The types of waste found at the Coral Pit consisted predominantly of scrap metal, construction debris, and other inert or non-hazardous waste. A remedial investigation (RI) found arsenic detected above residential and industrial screening levels within surface soil across the site. Arsenic was thus identified as the primary chemical of concern (DoN, September 2014).

The West Loch Burn Pit (UXO 7) is located on approximately 1.2 acres on the south side of 7th Street. The actual burning pit is a surface depression approximately 150 feet long by 100 feet wide. The West Loch Burn Pit is located at least 1,300 feet away from the Alternative 1 magazines and other project components. The Burn Pit is located at least 1,000 feet away from the Alternative 2 magazines and other project components. The site was used in the early 1970’s for material disposal and burning. No information was available confirming the types of material disposed of or burned in the pit during its use. The Navy conducted a preliminary assessment, a site inspection, and Phase I of the RI.

A conclusion from the RI noted that identified chemicals of potential concern (COPC) are not considered munitions constituents (MC)-related, but are associated with burning activities and materials. However, lateral delineation of COPCs in soil is not considered complete. Thus, further evaluation is necessary for soil at the site. Data also shows that shallow groundwater of the site has not been impacted by COPCs. (Naval Facilities Engineering Command Pacific, October 2016).

The Electrical Components Disposal Area site (UXO 18) is also located adjacent and to the east of the West Loch Burn Pit. It is located at least 750 feet from the Alternative 1 magazines and other project components. UXO 18 is located at least 1,300 feet from the Alternative 2 magazines and other project components. A preliminary assessment and site inspection were done for UXO 18. The site inspection data showed evidence of munitions and explosives of concern (MEC). Munitions debris items were also recovered. All items that were identified during the investigation were inspected by a UXO technician and qualified as Material Documented as Safe (MDAS). There are still items that were left in place since the previous investigation consisted only of identifying the extent of the area with Material Potentially Presenting an Explosive Hazard (MPPEH) items. (NMC EAD DET PH, October 2010).

Alternative 1 would require the removal of an existing pad mounted transformer located in the area of the proposed magazines. This may be replaced by a pole mounted transformer.

3.14.3 Environmental Consequences

The hazardous materials and wastes analysis contained in the respective sections addresses issues related to the use and management of hazardous materials and wastes as well as the presence and management of specific cleanup sites at West Loch Annex.

Hazardous Material and Waste Potential Impacts:

- Unauthorized excavation, uncontrolled soil removal without proper handling and disposal.
- Unauthorized human contact with, or ingestion of contaminated soil
- Inadequate notice of presence of contaminated soil to users, workers, and any potential landowners.

3.14.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change associated with hazardous materials and wastes. Therefore, no impact to hazardous materials and wastes would occur with implementation of the No Action Alternative.

3.14.3.2 Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative) Potential Impacts

The study area for the analysis of effects to hazardous materials and hazardous wastes associated with the Preferred Alternative includes areas which would be altered by:

- the proposed 24 box magazines clustered around the 10th Street and E Avenue intersections;
- adjacent construction staging and roadway access;
- adjacent roadways and concrete pads, utility improvements, landscaping, and drainage improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

The 4th Street Coral Pit site is located within the portion of West Loch Annex east of the existing back gate on Iroquois Road. Thus, public access is currently prohibited. Moreover, the site is secured by a fence and locked gates. The 4th Street Coral Pit also would not be within areas proposed to be altered by project construction. The Alternative 1 magazines are located approximately 4,000 feet away. Utility work near the existing back gate relating to the entry control point would be approximately 1,500 feet away. Other portions of the project are located further distances away.

A Record of Decision for the 4th Street Coral Pit concluded that Land Use Controls (LUCs) is the final remedy for the site. The selected remedy is intended to prevent the disturbance of the source material (solid waste) and, as required, ensure that risks to human and ecological receptors remain within acceptable levels. (Department of the Navy, 2014)

The West Loch Burn Pit is located at least 1,300 feet away from the Alternative 1 magazines and other project components. The Electrical Components Disposal Area is located at least 750 feet away from the Alternative 1 magazines and other project components. However, investigative work for these two areas has not been completed. Although a Phase I RI has been done for the West Loch Burn Pit, the investigation for Phase 2 of the RI has not been completed. Similarly, the Electrical Components Disposal Area is recommended for further action/munitions response under the Munitions Response Program based on historical data and SI survey results. An RI is recommended in order to determine character and extent of MEC and MC remaining at the site.

The Navy will oversee fieldwork on the project to ensure that the project would not impact either site.

Construction Period

Due to potential presence of past construction and dredged material debris at the project site, hazardous wastes and materials may be encountered during site preparation and project construction. The existing pad mounted transformer within the magazine site may contain Polychlorinated Biphenyls (PCBs). Demolition of the existing back gate may also involve removal of asbestos. If hazardous materials or waste are encountered during the construction period, they would be handled, transported, disposed of and/or remediated in accordance with applicable federal and state regulations.

Operational Period

Limited quantities of hazardous materials and wastes typical of operating the proposed facilities would be stored, used, and or generated during the operational period. All hazardous materials, wastes, special hazards would be transported, stored, handled, and disposed of in accordance with federal and state regulations.

Implementation of the Preferred Alternative would result in less than significant impacts to hazardous materials and wastes.

3.14.3.3 Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive) Potential Impacts

The study area for the analysis of effects to hazardous materials and hazardous wastes associated with this alternative includes:

- 24 box magazines west of West Loch Drive and 6th Street;
- adjacent construction staging;
- fire station;
- adjacent roadways and concrete pads, utility improvements;
- security fence, patrol road, entry control point on Iroquois Road, demolition of existing back gate and new gate on North Road;
- closure of West Loch Drive and portions of Iroquois Road and North Road to public access; and
- bypass road.

Alternative 2 also would not involve any change to prohibition of access to the 4th Street Coral Pit and would comply with the prior Record of Decision. There would be no construction within the 4th Street Coral Pit area for Alternative 2. The closest construction in Alternative 2 is the magazine cluster along West Loch Drive and 6th Street which is located approximately 1,000 feet to the southwest of the 4th Street Coral Pit. Utility work near the existing back gate relating to the entry control point would be approximately 1,500 feet away. Other portions of Alternative 2 are located further distances away.

The West Loch Burn Pit is located at least 1,000 feet away from the Alternative 2 magazines and other project components. The Electrical Components Disposal Area is located at least 1,300 feet away from the Alternative 2 magazines and other project components. Like Alternative 1, investigative work for these two areas has not been completed.

The Navy will oversee fieldwork on the project to ensure that the project would not impact either site.

If hazardous materials or waste are encountered during the construction or operational period, they would be handled, transported, disposed of and/or remediated in accordance with applicable federal and state regulations.

Implementation of the Preferred Alternative would result in less than significant impacts to hazardous materials and wastes.

3.15 Summary of Potential Impacts to Resources and Impact Avoidance and Minimization

A summary of the potential impacts associated with each of the action alternatives and the No Action Alternative and impact avoidance and minimization measures are presented in Tables 3-24 and 3-25, respectively. Table 3-25 provides a comprehensive list of all avoidance and minimization requirements associated with the Proposed Action.

Table 3-24 Summary of Potential Impacts to Resource Areas

Resource Area	*No Action Alternative*	*Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative)*	*Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive)*
Transportation	No impact	The Preferred Alternative would have less than significant impacts to transportation. The construction and operation of the new magazines would have no impact on public transportation systems. West Loch Drive, on Navy land, currently provides public access from Iroquois Road to North Road near its intersection with Iroquois Avenue. The proposed bypass road would effectively replace the function of West Loch Drive, providing a new public connection between North Road and Iroquois Road through Navy property. It would be constructed and placed into service before closure of the existing West Loch Drive.	Alternative 2 is the same as Alternative 1 except for the location of the Alternative 2 magazines and a new fire station, which would not affect external transportation systems or traffic. Accordingly, Alternative 2 impacts would be the same as the Preferred Alternative (less than significant impact).
Noise	No impact	The Preferred Alternative would have less than significant impacts to noise sensitive receptors such as residential uses. The construction and operation of the new magazines would have no offsite noise impacts due to the distance between the magazines and existing private residential uses. All construction and traffic noise activities would result in peak levels below 45 dBA at locations further than 300 feet from the bypass road. There are three residential areas adjacent to the bypass road. Residential uses adjacent to Kuanoo Street do not require noise abatement. At residences adjacent to Makalea and Hookaahea Streets, there is an existing 30-foot wide easement between the existing residential fenceline and Navy property. If traffic speeds are limited to 30 mph combined with the 30-foot wide easement, residences at Makalea-Hookaahea Streets would meet applicable noise	Less than significant impacts (same as Preferred Alternative).

Table 3-24 Summary of Potential Impacts to Resource Areas

Resource Area	*No Action Alternative*	*Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative)*	*Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive)*
		standards. At the Hanaloa and Kauiki Street residential segment, there is no existing 30-foot wide easement. Impacts to the Hanaloa-Kauiki Street properties can be avoided or minimized through several means: limiting traffic speeds to 30 mph, increasing the proposed horizontal separation of the roadway corridor and the subject residential property lines by 30 feet, constructing noise attenuation walls along the proposed bypass road corridor fronting the subject properties, reducing posted vehicle speeds and prohibiting heavy truck traffic and/or installing noise attenuation features in the impacted homes. With these measures or various combinations, off site noise impacts would be reduced to less than significant levels. It is recommended that the Navy conduct a noise analysis update to review sufficiency of abatement.	
Air Quality	No impact	The Preferred Alternative would result in less than significant air quality impacts. Short-term impacts on air quality may occur from the emission of fugitive dust during construction activities. A dust control plan is a standard best management practice of the Navy construction contract. The contractor for each phase of construction shall be responsible for dust control measures which meet applicable visible emissions and fugitive dust requirements. The proposed magazines would have no impact on air quality during the operational period. Emissions from vehicles traveling along the proposed security and bypass roadways have the potential to adversely	Less than significant impacts (same as Preferred Alternative).

Table 3-24 Summary of Potential Impacts to Resource Areas

Resource Area	***No Action Alternative***	***Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative)***	***Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive)***
		impact air quality. Based on the analysis conducted, the highest estimated concentrations of carbon monoxide (measured at the North Road and Iroquois Road intersections), would remain well within both state and national ambient air quality standards. Construction and operation of the Preferred Alternative would generate less than significant levels of greenhouse gases.	
Land Use	No impact.	The Preferred Alternative would result in less than significant impacts to land use. Portions of the project on Navy land are categorized as Navy/Marine Corps *De Minimis* Activities Under the Coastal Zone Management Act (CZMA). Areas outside Navy land (Iroquois Road) would require an application for CZMA Consistency Determination submitted to the Hawaii Office of Planning.	Less than significant impacts (same as Preferred Alternative).
Public Health and Safety	No change to public health and safety. However, existing public vehicular usage of West Loch Drive and portions of Iroquois Road and North Road traverse immediately outside the existing West Loch Annex fence boundary which is a secure facility which stores military ordnance. Continued	The Preferred Alternative would result in less than significant impacts to public health and safety. Proposed magazines would be constructed in accordance with current Department of Defense standards which includes Anti-Terrorism/Force Protection and physical security features. West Loch Annex would be secured by a proposed security fence and patrol road along its western boundary. Current public access through West Loch Annex would be relocated to the Annex perimeter along a re-aligned bypass road for safety and security reasons. In compliance with Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks, there are no environmental health and safety	Less than significant impacts (same as Preferred Alternative).

Table 3-24 Summary of Potential Impacts to Resource Areas

Resource Area	*No Action Alternative*	*Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative)*	*Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive)*
	usage of West Loch Drive and portions of Iroquois Road and North Road is a safety concern which would continue under the No Action Alternative.	risks associated with the Proposed Action that would disproportionately affect children.	
Visual Resources	No impact	Preferred Alternative would not significantly alter open space views from bordering roadways and adjacent areas. Previously approved PV improvements would result in some changes to existing landforms. Security fencing and patrol road would be visible from private homes and other properties along the southwestern boundary. Improvements are necessary for safety reasons. Should sound abatement measures or other roadway improvements be warranted within the bypass road right-of-way, view parameters may be affected, primarily from adjacent residences. However, the extent of the effect on views should be similar to existing and planned landforms, vegetation and structures such as the existing dirt/rock berm, the existing kiawe forest, and previously approved PV substations. Implementation of the Preferred Alternative would result in less than significant impacts.	Less than significant impacts. (same as Preferred Alternative).
Biological Resources	No impact	With management measures designed to protect and benefit threatened and endangered species, the Preferred Alternative would result in less than significant impacts to biological resources. Approximately 310 acres of vegetation would be	Alternative 2 is the same as Alternative 1 except that approximately 273 acres of vegetation would be removed. With the implementation of

Table 3-24 Summary of Potential Impacts to Resource Areas

Resource Area	***No Action Alternative***	***Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative)***	***Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive)***
		removed under the Preferred Alternative. This includes primarily common, introduced, or alien vegetation species. No federal- or state-listed threatened or endangered plants would be affected. There is no critical habitat within the various project sites. Management measures will be in place to minimize impacts to Migratory Bird Treaty Act (MBTA)-protected birds and waterbirds. Nest surveys will be conducted for the Hawaiian short-eared owl a maximum of seven days prior to construction. Removal of tall vegetation during the Hawaiian hoary bat pupping season will be avoided to reduce disturbance to young bats. The Navy has determined that the action may affect the Hawaiian hoary bat, but is not likely to adversely affect the species.	applicable management measures, Alternative 2 would result in less than significant impacts to biological resources.
Cultural Resources	No impact	A previous APE was established through Section 106 consultation for the project. By letter dated 3 January 2019, the SHPO reviewed and concurred with the Navy's determination that the project will result in no adverse effect. Since that time, additional components of the project have been added to the undertaking. However, no historic properties are present in the revised APE of 310 acres. Upon reassessment, the appropriate finding of effect is no historic properties affected. The Preferred Alternative would result in less than significant impacts to cultural resources. Thirteen archaeological sites are known within the Alternative 1 proposed magazine areas. Three archaeological sites are adjacent to the	Less than significant impacts to cultural resources. There are no archaeological sites documented within the Alternative 2 magazine area, construction staging area, and fire station. Like Alternative 1, the known sites adjacent to the perimeter fence and patrol road corridor, bypass road, and entry control point were subject to inventory-level documentation and no further actions were recommended. None of the sites

Table 3-24 Summary of Potential Impacts to Resource Areas

Resource Area	*No Action Alternative*	*Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative)*	*Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive)*
		perimeter fence, patrol road, bypass road, new gate, and entry control point. None of the sites are eligible for listing on the NRHP. There are eight historic magazines within the vicinity of the proposed magazines; the proposed undertaking would not alter the historic setting of adjacent historic magazines due to similarity in appearance of the new construction.	are eligible for listing in the NRHP.
Infrastructure	No impact	The Preferred Alternative would result in less than significant impacts to infrastructure. Minimal changes to potable water usage and wastewater generation would occur under the Preferred Alternative. Construction BMPs would be implemented to address potential storm water soil erosion. Non-hazardous construction and demolition waste that cannot be recycled would be disposed off-site at an approved construction and demolition sanitary landfill. The operation of the Preferred Alternative would result in minimal energy usage.	Less than significant impacts (same as Preferred Alternative).
Socioeconomics	No impact	The Preferred Alternative would have a less than significant impact to socioeconomics of the local area or region. The Preferred Alternative would have a temporary beneficial impact on construction-related employment and spending.	Less than significant impacts (same as the Preferred Alternative).
Environmental Justice	No impact.	The Preferred Alternative would have less than significant construction and operational period impacts. New magazines would be constructed in accordance with applicable DoD standards with safety buffers. A new public bypass road would be constructed, replacing the service currently provided by the Navy owned West Loch Drive.	Less than significant impacts (same as Preferred Alternative).

Table 3-24 Summary of Potential Impacts to Resource Areas

Resource Area	*No Action Alternative*	*Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative)*	*Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive)*
Water Resources	No impact	The Preferred Alternative would have less than significant effects on the hydrology of the area. During construction and operational phases, BMPs would be implemented to capture and retain storm water on site and allow it to infiltrate into the soil or to be discharged at a rate that would not exceed the predevelopment hydrology to adjacent surface waters. The Navy has determined that the first phase of magazines does not require NPDES coverage under Section 11-55 HAR, Appendix C. For future phases, an NPDES permit would be obtained for the project to address discharges of storm water relating to construction activities and dewatering, as applicable. There are no known wetlands that would be affected.	Less than significant impacts (same as Preferred Alternative).
Geological Resources	No impact	The Preferred Alternative would have less than significant impact to topography and soils. Cut and fill quantities would be balanced on site to make use of excavated earth. BMPs would be followed. The Navy has determined that the first phase of magazines does not require NPDES coverage under Section 11-55 HAR, Appendix C. For future phases, an NPDES permit would be obtained as appropriate. Measures will be undertaken in an effort to prevent the spread of the invasive Coconut Rhinoceros Beetle (CRB) to other parts of Oahu. Green waste from the site clearing process would be brought to a JBPHH-approved green waste collection point.	With the implementation of management measures, less than significant impacts (same as Preferred Alternative).
Hazardous Materials and Wastes	No impact	The 4th Street Coral Pit would be located approximately 1,500 feet from the closest Alternative	The 4th Street Coral Pit would be located approximately 1,000 feet

Table 3-24 Summary of Potential Impacts to Resource Areas

Resource Area	*No Action Alternative*	*Alternative 1 (24 New Box Type "D" Magazines Adjacent to 10th Street) (Preferred Alternative)*	*Alternative 2 (24 New Box Type "D" Magazines Located West of West Loch Drive)*
		1 project construction. No impact to 4th Street Coral Pit. West Loch Burn Pit and Electrical Components Disposal Area are located at least 1,300 feet and 750 feet away respectively from Alternative 1 magazines and other project components. Investigative fieldwork for both sites have not been completed. The Navy will oversee fieldwork to ensure that the project would not impact either site. Implementation of the Preferred Alternative would result in less than significant hazardous materials and wastes impacts.	from the closest Alternative 2 construction. No impact to 4th Street Coral Pit. West Loch Burn Pit and Electrical Components Disposal Area are located at least 1,000 feet and 1,300 feet away respectively from Alternative 2 magazines and other project components. The Navy will oversee fieldwork to ensure that the project would not impact either site. Less than significant hazardous materials and wastes impacts.

Table 3-25 Impact Avoidance And Minimization Measures

Avoidance/Minimization Measure	***Anticipated Benefit / Evaluating Effectiveness***	***Resource Areas Affected***	***Preferred Alternative***	***Alternative 2***
Bypass road extending from Iroquois Road to North Road	With closure of West Loch Drive to public access, the bypass road provides a replacement roadway which would maintain existing traffic conditions on Fort Weaver Road and within the community.	Transportation	x	x
As a federal agency, the Navy considers DoH construction noise provisions as local best practices and will exert best efforts to comply with applicable State construction noise regulations.	Minimize construction noise impact	Noise	x	x
Avoidance or minimization measures along certain adjacent residential properties addressed through several possible means: limiting traffic speeds to 30 mph, increasing horizontal separation of roadway corridor and subject residential property, constructing noise attenuation walls, prohibiting heavy truck traffic, noise attenuation features in the impacted homes.	Minimize noise impact upon adjacent uses	Noise	x	x
Implement construction period air emissions BMPs, including HAR 11-60.1-33 (Fugitive Dust)	Reduce fugitive dust and other particulate emissions	Air Quality	x	x
Off-island construction equipment, vehicles and material which are sourced off-island would be inspected and decontaminated of any excessive plant debris and material	Minimize potential for invasive species introduction	Biological Resources	x	x
Use of native Hawaiian plants for landscaping or plants with a low risk of becoming invasive	Minimize spread of invasive plants	Biological Resources	x	x
Conduct nest surveys of MBTA protected birds a maximum of 7 days before construction. Active	Qualified biologist would monitor effective nests during construction	Biological Resources	x	x

Table 3-25 Impact Avoidance And Minimization Measures

Avoidance/Minimization Measure	***Anticipated Benefit / Evaluating Effectiveness***	***Resource Areas Affected***	***Preferred Alternative***	***Alternative 2***
nests would be left in place and undisturbed until chicks have fledged.	activities to reduce chances of nest abandonment.			
Conduct nest surveys for Hawaiian short-eared owl a maximum of 7 days prior to construction. Regular on-site staff would be trained to identify this species and know the appropriate measures to be taken if the species are present. If a Hawaiian short-eared owl is observed in the area during construction activities, all activities within 100 feet of the species would cease, and work would not continue until the species leaves the area on its own accord.	If a Hawaiian short-eared owl nest is discovered, all activities within 100 feet of the nest would cease and the NAVFAC Hawaii natural resources staff would be contacted. Work would not resume until directed by NAVFAC Hawaii.	Biological Resources	x	x
No trees taller than 15 feet would be trimmed or removed as a result of this project between June 1 and September 15, when juvenile bats that are not yet capable of flying may be roosting in the trees.	Minimize or avoid impacts to Hawaiian hoary bat	Biological Resources	x	x
Site recording by Rieth (2011) recommended that no further documentation is needed.	Fulfill intent of Criterion D	Cultural Resources	x	x
Implement construction period stormwater quality BMPs and applicable NPDES permit conditions	Avoid and minimize storm water transport of sediments and pollutants to receiving waters	Water Resources	x	x
All green waste will be delivered to the in-vessel/bio-solid composting system or Air Curtain Burner sites for disposal. All applicable air permitting requirements are being complied with.	Helps to prevent the spread of the Coconut Rhinoceros Beetle to other parts of Oahu.	Geological Resources	x	x

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4 Cumulative Impacts

This section (1) defines cumulative impacts, (2) describes past, present, and reasonably foreseeable future actions relevant to cumulative impacts, (3) analyzes the incremental interaction the proposed action may have with other actions, and (4) evaluates cumulative impacts potentially resulting from these interactions.

4.1 Definition of Cumulative Impacts

The approach taken in the analysis of cumulative impacts follows the objectives of the National Environmental Policy Act (NEPA), Council on Environmental Quality (CEQ) regulations, and CEQ guidance. Cumulative impacts are defined in 40 CFR section 1508.7 as "the impact on the environment that results from the incremental impact of the action when added to the other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time."

To determine the scope of environmental impact analyses, agencies shall consider cumulative actions, which when viewed with other proposed actions have cumulatively significant impacts and should therefore be discussed in the same impact analysis document.

In addition, CEQ and USEPA have published guidance addressing implementation of cumulative impact analyses—Guidance on the Consideration of Past Actions in Cumulative Effects Analysis (CEQ, 2005) and Consideration of Cumulative Impacts in EPA Review of NEPA Documents (USEPA, 1999). CEQ guidance entitled Considering Cumulative Impacts Under NEPA (1997) states that cumulative impact analyses should

"…determine the magnitude and significance of the environmental consequences of the proposed action in the context of the cumulative impacts of other past, present, and future actions...identify significant cumulative impacts…[and]…focus on truly meaningful impacts."

Cumulative impacts are most likely to arise when a relationship or synergism exists between a proposed action and other actions expected to occur in a similar location or during a similar time period. Actions overlapping with or in close proximity to the proposed action would be expected to have more potential for a relationship than those more geographically separated. Similarly, relatively concurrent actions would tend to offer a higher potential for cumulative impacts. To identify cumulative impacts, the analysis needs to address the following three fundamental questions.

- Does a relationship exist such that affected resource areas of the proposed action might interact with the affected resource areas of past, present, or reasonably foreseeable actions?
- If one or more of the affected resource areas of the proposed action and another action could be expected to interact, would the proposed action affect or be affected by impacts of the other action?
- If such a relationship exists, then does an assessment reveal any potentially significant impacts not identified when the proposed action is considered alone?

4.2 Scope of Cumulative Impacts Analysis

The scope of the cumulative impacts analysis involves both the geographic extent of the effects and the time frame in which the effects could be expected to occur. For this EA, the study area delimits the geographic extent of the cumulative impacts analysis. In general, the study area will include those areas previously identified in Chapter 3 for the respective resource areas. The time frame for cumulative impacts centers on the timing of the proposed action.

Another factor influencing the scope of cumulative impacts analysis involves identifying other actions to consider. Beyond determining that the geographic scope and time frame for the actions interrelate to the proposed action, the analysis employs the measure of "reasonably foreseeable" to include or exclude other actions. For the purposes of this analysis, public documents prepared by federal, state, and local government agencies form the primary sources of information regarding reasonably foreseeable actions. Documents used to identify other actions include notices of intent for EISs and EAs, management plans, land use plans, and other planning related studies.

4.3 Past, Present, and Reasonably Foreseeable Actions

This section will focus on past, present, and reasonably foreseeable future projects at and near the Proposed Action locale. In determining which projects to include in the cumulative impacts analysis, a preliminary determination was made regarding the past, present, or reasonably foreseeable action. Specifically, using the first fundamental question included in Section 4.1, it was determined if a relationship exists such that the affected resource areas of the Proposed Action (included in this EA) might interact with the affected resource area of a past, present, or reasonably foreseeable action. If no such potential relationship exists, the project was not carried forward into the cumulative impacts analysis. In accordance with CEQ guidance (CEQ, 2005), these actions considered but excluded from further cumulative effects analysis are not catalogued here as the intent is to focus the analysis on the meaningful actions relevant to informed decision-making. Projects included in this cumulative impacts analysis are listed in Table 4-1 and briefly described in the following subsections.

Table 4-1 Cumulative Action Evaluation

Action	*Level of NEPA Analysis Completed*
Past Actions	
Environmental Assessment for Photovoltaic Systems JBPHH, Oahu, Hawaii	NEPA EA/FONSI
Environmental Assessment MCON P-181 Dredge Channel for T-AKE Naval	NEPA EA/FONSI
B559, B559A, B559B – Upgrade fuel station	Categorical Exclusion
Building 489 – Re-roof	Categorical Exclusion
Building 547 – Construct shelter for EOD	Categorical Exclusion
Building 603 - Construction of disability ramp and parking stalls	Categorical Exclusion
Group 24 W 2-5 Magazines roof repair	Categorical Exclusion
W 1-5 Minor shops - Locate and paint bents	Categorical Exclusion
Building 440 – Replace chillers	Categorical Exclusion
Building 562, 563 – Duct Cleaning	Categorical Exclusion

Action	*Level of NEPA Analysis Completed*
Present and Reasonably Foreseeable Actions	
Incremental increase in magazines to meet increased storage needs	To be determined
Various buildings West Loch Annex – Roof replacement	Categorical Exclusion
Building 440 – Repair roof, paint, repair walls	To be determined
Bathroom renovation (B1, B4, B399) at pier	Categorical Exclusion
Building B 204- B13 – Install Chain Link Fence	To be determined
RM17-0006 Pier Repair	To be determined
MK46/MK48 Torpedo Shop	To be determined
Building 543 – Replace ACCU	To be determined
Building 440 – Replace fire alarm panel	To be determined
Building 547 – Replace septic tank	To be determined
Building 563 – Lighting and climate control improvements	To be determined
Buildings 562, 580, 563, 603, 600 – Generator improvements	To be determined
Honouliuli/Waipahu/Pearl City Wastewater Conveyance Facilities	To be determined

4.3.1 Past Actions

JBPHH has plans to lease up to 380 acres of Navy land at West Loch Annex to Hawaiian Electric Company, for the construction, operation and decommissioning of a photovoltaic system with up to 50 megawatt capacity (Commander Navy Region Hawaii, 2015). The project implements the following executive order and statutes:

- Executive Order (EO) 13834, Efficient Federal Operations affirms "that agencies shall meet such statutory requirements in a manner that increases efficiency, optimizes performance, eliminates unnecessary use of resources, and protects the environment."
- Energy Policy Act of 2005 (42 U.S.C. 15852): Section 203 of the Act requires that the federal government consume not less than 7.5 percent of its electricity from renewable sources in FY 2013 and each fiscal year thereafter.
- Title 10 U.S.C. 2911(e). This statute requires the submission of an energy performance master plan and performance goals, including the goal to produce or procure 25 percent of the total quantity of energy consumed within its facilities from renewable sources by 2025 and each fiscal year thereafter.

The photovoltaic system is proposed on lands which were previously part of an agricultural outlease. The land underlying the PV site would be leased to HECO for up to 37 years after which time the lease may be renewed or the facility could be decommissioned. Phase I of the project covers approximately 200 acres of land. Phase II is under negotiation.

The Navy also performed construction dredging and widening of portions of the West Loch Channel (Commander Navy Region Hawaii, 2006). The purpose is to provide berthing facilities for the Advanced Auxiliary Dry Cargo Ships (T-AKE). The previous depth and width of West Loch Channel had been inadequate for T-AKE vessels to navigate to Wharves 1-3. The T-AKE is a relatively new Combat Logistics Force Underway Replenishment Naval vessel which is larger than previous ships used to transport ordnance and ammunition. Thus, portions of West Loch Channel were dredged and widened in order to supplement and facilitate ordnance re-supply in support of Navy mission requirements.

The remaining projects noted under Past Actions are generally maintenance improvements throughout West Loch Annex. These involved repair or replacement of existing equipment or improvements. The improvements do not increase capacity or existing functions to a substantial degree. Affected resource areas of the Proposed Action have a negligible interaction with the affected resource areas of past or present actions.

4.3.2 Reasonably Foreseeable Actions

The Navy has determined a current need of 24 Type “D” magazines within West Loch Annex to meet its storage needs for long ordnance. Explosive limits, spatial constraints, safe storage practices, and optimal storage techniques have been considered in the Navy’s review of available storage capacity at West Loch Annex. However, incremental increases in the number of magazines may be needed to meet storage needs in the foreseeable future. The need for these magazines is currently unknown, but could be associated with future changes such as homebasing/homeporting requirements. Possible areas considered for location of magazines may be portions of construction staging areas which abut the magazine areas in Alternative 1. The construction staging area is noted in Figure 2-1. The construction staging area abuts the south, east and north portions of the Alternative 1 magazines. The construction staging area is approximately 51 acres. Similarly, should Alternative 2 be pursued and should there be future incremental increased need for ordnance storage, the 13-acre construction staging area for Alternative 2 may also be considered. Should the Alternative 1 or Alternative 2 construction staging areas be considered for additional magazines, a separate analysis would be required.

Remaining reasonably foreseeable actions pertain to ongoing replacement or upgrade of existing equipment and/or buildings within West Loch Annex. These projects are in various stages of design, awaiting funding, in conceptual planning, induction or scoping. As details of each individual project become known, applicable environmental requirements will be complied with.

The City and County of Honolulu has published a Chapter 343, HRS, Environmental Impact Statement Preparation Notice (EISPN) for the Honouliuli/Waipahu/Pearl City Wastewater Conveyance Facilities. The EISPN was published for public review by the State Office of Environmental Quality Control on May 8, 2019. The project proposes the improvement, rehabilitation and/or upgrade of the existing East Interceptor Wastewater Collection System, which includes the system of sewer lines, pump stations, and force mains conveying flows from Halawa, Waimalu, Pearl City and Waipahu to the Honouliuli Wastewater Treatment Plant.

Portions of the project involve Navy property at West Loch Annex. There are existing Waipahu Wastewater Pump Station (WWPS) dual force mains which extend from the Waipio Peninsula across West Loch to West Loch Annex. The City force mains extend to 1st Street and connect to the existing Honouliuli Interceptor Sewer Line within the Iroquois Road right of way. The City and County of Honolulu proposes the rehabilitation of the Waipahu WWPS dual force mains. A new Waipahu WWPS third force main would follow a similar alignment as the dual force mains and discharge into the Honouliuli Interceptor Sewer Line. Since the construction would be located on Navy property, compliance with NEPA and other federal agency provisions including Navy permits and approvals would be required.

A portion of Iroquois Road which is included in the Navy's Magazines for Long Ordnance project is owned by the State of Hawaii. Since the Navy project would close Iroquois Road to public access, necessary and appropriate real estate rights will be obtained by the Navy. Appropriate disposition of the Honouliuli Interceptor Sewer Line within the Iroquois Road right of way would be arranged with the City and County of Honolulu.

4.4 Cumulative Impact Analysis

The following analysis of cumulative impacts is organized by resource area in the same order presented in Chapter 3. Only the resource areas that have the potential to have cumulative impacts resulting from the Proposed Action are addressed. Where feasible, the cumulative impacts were assessed using quantifiable data; however, for many of the resources included for analysis, quantifiable data is not available and a qualitative analysis was undertaken. In addition, where an analysis of potential environmental effects for future actions has not been completed, assumptions were made regarding cumulative impacts related to this EA where possible. The analytical methodology presented in Chapter 3, which was used to determine potential impacts to the various resources analyzed in this document, was also used to determine cumulative impacts. The analyses show that, when considered with relevant past, present and reasonably foreseeable projects, the incremental effects of the Preferred Alternative and Alternative 2 would not contribute to cumulative impacts on pertinent resource areas. Because it would not contribute any incremental effects, the No Action Alternative would not result in cumulative impacts on the relevant resource areas during the construction or operational period.

4.4.1 Transportation

4.4.1.1 Description of Geographic Study Area

The study area for transportation includes the area transportation network within West Loch Annex, and areas bounded by Fort Weaver Road, from its terminus to Iroquois Road.

4.4.1.2 Relevant Past, Present, and Future Actions

To the west and southwest of JBPHH are several residential subdivisions that were built in the past 30 years as part of the Ewa by Gentry project, the Hawaii Prince Golf Club, older residential subdivisions built about 50 years ago (Leeward Estates) and the Ewa Beach Golf Club. Several apartment complexes are located southeast of North Road. James Campbell High School, Ilima Intermediate School, Pohakea Elementary School, Kaimiloa Elementary School, and our Lady of Perpetual Help School are also located in this area.

The Kapilina residential community, formerly Iroquois Point Naval Housing, and the Iroquois Point Elementary School are located south of West Loch Annex. Access to this area is through Iroquois Avenue and North Road which connects with Fort Weaver Road, the main traffic artery serving this area of Ewa and West Loch Annex.

However, at the northern terminus of Iroquois Avenue, North Road heading east, West Loch Drive heading north, and Iroquois Road heading west has provided an alternative access route to Fort Weaver Road. This has allowed traffic to bypass congestion occurring on North Road near the Fort Weaver Road intersection. However, due to safety considerations, these portions of North Road, West Loch Drive and Iroquois Road, located within the JBPHH West Loch Annex installation, need to be closed to public access.

The Navy has selected a new bypass road along the West Loch Annex installation boundary as part of the Proposed Action. Two new intersections would be created, one at Iroquois Road and the other at North Road. At the Iroquois Road intersection, the reassigned volumes would be similar to the existing volume at the Iroquois Road-West Loch Drive intersection. At the North Road intersection, traffic volumes would be similar to existing volumes at the Iroquois Avenue-North Road intersection, except that left turns now being made from North Road to Iroquois Avenue would become left turns from the new road to North Road, with the complementary right turns also being changed. The new bypass road would thus basically replace West Loch Drive. The results of the unsignalized intersection analyses documents that LOS “B” of better conditions could be achieved if separate left and right turn lanes are provided on the bypass road approach to North Road. LOS “D” or better conditions could be achieved if a separate left turn lane is provided on the bypass road approach to North Road (See Table 3-4 in Section 3.1 Transportation). Estimated travel time between the Iroquois Avenue/North Road intersection and the Iroquois Road/Fort Weaver Road intersection is estimated to be six minutes using West Loch Drive. Travel time on the bypass road between the same two points is not expected to increase.

Other past, present or reasonably foreseeable projects such as expansion of the photovoltaic system, incremental increases in magazines, replacement or upgrade of existing equipment and/or buildings, and City wastewater conveyance facilities within West Loch Annex are unlikely to result in any sizable increase in traffic. General increase in development in the Ewa area would likely result in some increase in traffic on roadways in the general vicinity depending on the intensity and specific location of the development. However, the bypass road is intended as a general replacement of an existing public transit route.

4.4.1.3 Cumulative Impact Analysis

Cumulative transportation impacts from past, present, and future actions within the study area would be less than significant. The LOS levels of the new bypass road remains within acceptable levels and it does not worsen the travel time between the Iroquois Avenue/North Road intersection and the Iroquois Road/Fort Weaver Road intersection. A portion of the City’s dual force main construction would occur within 1st Street where new communication lines are proposed on existing utility poles. The City’s existing Honouliuli Interceptor Sewer is located below grade within the Iroquois Road right of way. Entry control point improvements would be located on portions of Iroquois Road. Construction and operational coordination between applicable parties would be necessary to ensure a seamless transition. Therefore, implementation of the Proposed Action combined with the past, present, and reasonably foreseeable future projects, would result in less than significant impacts within the study area.

4.4.2 Noise

4.4.2.1 Description of Geographic Study Area

The geographic study area includes the Ewa neighborhood in which West Loch Annex is situated.

4.4.2.2 Relevant Past, Present and Future Actions

Existing noise in the vicinity of the project site is primarily attributable to vehicles along adjacent roadways, farm equipment, golf course sprinklers and lawnmowers or aircraft transiting the area. The site is in general proximity to Daniel K. Inouye International Airport. Most of the project site is outside of the 55 DNL contour.

Existing uses adjacent to the project site include the Ewa by Gentry project, the Hawaii Prince Golf Club, older residential subdivisions built about 50 years ago (Leeward Estates) and the Ewa Beach Golf Club. Schools in the vicinity include James Campbell High School, Ilima Intermediate School, Pohakea Elementary School, Kaimiloa Elementary School, and Our Lady of Perpetual Help School.

Possible noise issues from the project would primarily be from the bypass road. This replaces the traffic which formerly utilized West Loch Drive. Construction activities are recommended to be limited to Monday to Friday, between 7:00 am and 6:00 pm. The limitation on construction is also recommended to include Saturdays, Sundays and holidays.

Operationally, there are three residential areas which are adjacent to the bypass road. Abatement which would reduce projected noise levels by between 5-7 dB would be needed to comply with FHWA standards.

The bypass road would not result in desired noise abatement at one of the residential areas. With a 30 mph speed limit and a heavy vehicle limitation on the road, projected sound levels meet applicable standards at the second residential area. At the remaining residential area, other options may be considered:

1. An additional 30 feet increase of distance to 60 feet from the centerline of the bypass road to the residential property lines is an option which would result in similar noise levels as the first two residential areas.
2. Structural mitigation along the 700-foot residential frontage. The height of the barrier would vary depending on the height of the structures (10 feet for two story and less for one story).
3. Noise insulation of private residences may also be considered.

It is recommended that the Navy conduct a noise analysis update to review sufficiency of abatement. With the implementation of appropriate abatement measures, operational noise impacts would be less than significant.

Other past, present or reasonably foreseeable projects are unlikely to result in any significant increase in noise levels. The effect of past dredging of West Loch was negligible in terms of effect on noise given the absence of noise sensitive receptors. Construction of the PV arrays in West Loch Annex would comply with DoH noise standards. Operationally, noise concerns due to the PV project should be minimal. Because of safety concerns, any future incremental increases in magazines are likely to be placed substantial distances from sensitive noise receptors. City wastewater conveyance work also would take place at substantial distances from sensitive noise receptors. Short-term and long-term impacts would likely be negligible. Other past, present or reasonably foreseeable projects are generally repair and maintenance. These have been and are unlikely to result in any substantial increase in noise.

4.4.2.3 Cumulative Impact Analysis

Cumulative noise impacts from past, present, and future actions within the study area would not add a significant amount of noise to existing or projected levels resulting from the project. Therefore, implementation of the Proposed Action combined with the past, present, and reasonably foreseeable future projects, would result in less than significant impacts within the study area.

4.4.3 Air Quality

4.4.3.1 Description of Geographic Study Area

The study area for assessing air quality impacts is the State of Hawaii. Air quality in the State is generally good, with criteria air pollutant levels well within federal and state standards. Due to the improvements in vehicle fuel efficiency over many years, as well as federal and state initiatives requiring reduced pollutant emissions and a transition to clean energy sources, vehicle-related pollutant levels are predicted to decline even as development within the state and project vicinity has occurred over time.

4.4.3.2 Relevant Past, Present, and Future Actions

The proposed project would replace West Loch Drive with a new bypass road located near the western boundary of West Loch Annex. Two new intersections would be created with the bypass road, one at Iroquois Road and the other at North Road. To evaluate the potential long-term ambient air quality impact of motor vehicle traffic on the bypass road, computerized emission and atmospheric dispersion models were used to estimate ambient carbon monoxide concentrations at intersections within the project area. Carbon monoxide was selected for modeling because it is both the most stable and the most abundant of the pollutants generated by motor vehicles.

Two scenarios were evaluated for the carbon monoxide modeling study: year 2017 with existing conditions and year 2017 with the project. In general, roadway intersections are the primary concern because of traffic congestion and the increase in vehicular emissions associated with traffic queuing.

The highest estimated one-hour concentration at the two intersections studied for the present (2017) case was 1.4 ppm. This was projected to occur during the afternoon at both locations. This is well within both the national AAQS of 35 ppm and the state standard of 9 ppm.

With the proposed project, the highest estimated one-hour carbon monoxide concentration in the project area was predicted to reach 1.5 ppm. This was predicted to occur during the afternoon peak traffic hour at the intersection of the new Bypass Road and North Road. Peak-hour concentrations at the other end of the new Bypass Road (Bypass Road at Iroquois Road) would be slightly lower in the afternoon. Compared to the existing case, predicted concentrations for the 2017 with the project increased slightly or remained unchanged. Forecast highest estimated concentrations remained well within the state and federal standards.

For the 2017/present scenario, the highest estimated eight-hour carbon monoxide concentrations for the two locations studied ranged from 0.6 to 0.7 ppm. The highest estimated concentrations for the existing case were well within both the state standard of 4.4 ppm and the national limit of 9 ppm.

For the year 2017 with project scenario, predicted highest estimated eight-hour concentrations at the two intersections studied ranged from 0.7 to 0.8 ppm, similar to the existing scenario, and the predicted concentrations were within the standards (see Tables 3-14 and 3-15 in Section 3.3 Air Quality).

Possible future actions which could generally affect air quality are a general increase in traffic due to increased development in the Ewa region.

The project has been determined to generate minimal air quality impacts for Clean Air Act criteria pollutants. The State of Hawaii is not a nonattainment or maintenance area. General Conformity rules do not apply. Hence, MSAT analysis should not be necessary.

The project would likely generate a limited amount of greenhouse gas emissions which would not likely contribute to global warming to any discernible extent. The project is not an affected facility of the EPA's Final Mandatory Reporting Rule.

4.4.3.3 Cumulative Impact Analysis

Cumulative air quality impacts from past, present, and future actions within the study area would be less than significant. Construction period air quality impacts from the Proposed Action and any other relevant projects would be temporary. In the long term, air pollution concentrations from vehicle emissions with the project are estimated to continue to be well within federal and state standards. The project has been determined to generate minimal air quality impacts for Clean Air Act criteria pollutants. Although numbers of vehicles may increase in the future, federal and state initiatives requiring reduced pollutant emissions and a transition to clean energy sources would likely lead to a decline in vehicle emissions. Therefore, implementation of the Proposed Action combined with the past, present, and reasonably foreseeable future projects, would result in less than significant impacts within the study area.

4.4.4 Visual Resources

4.4.4.1 Description of Geographic Study Area

The project site lies in the relatively flat Ewa Plain. Except for a portion of Iroquois Road presently owned by the State of Hawaii, the project site is located on Navy property. Public access on segments of North Road, West Loch Drive and Iroquois Road through West Loch Annex is currently allowed. The proposed project would discontinue public access (and consequently public views) on these roadways.

The waters of West Loch, Waipio Peninsula, and Hickam Air Force Base are located to the east of the project site. The Kapilina residential development is located to the south of the development. Single family residential subdivisions and two private golf courses are located to the southwest of the project site. To the north of the project are portions of West Loch Annex with the Kunia and Waipahu areas further distances away.

4.4.4.2 Relevant Past, Present and Future Actions

The proposed project is generally low-rise. The proposed magazines would be approximately 20 feet in height and would be covered by a minimum of 2 feet of earth. Areas to the east of West Loch Drive are heavily vegetated. The predominant vegetation is kiawe (*Prosopis pallida*) forest with an understory of grasses, typically buffel grass (*Cenchrus ciliaris*) or Guinea grass (*Urochloa maxima*). Areas to the west of West Loch Drive have been farmed more recently and vegetation is typically lower in height. Existing vegetation would screen much of the proposed magazine development.

The bypass road would extend along the southwestern boundary of West Loch Annex, between Iroquois Road and North Road a distance of approximately 8,700 lineal feet. The two-lane two-way roadway would be within a 60-foot wide right-of-way. At its intersection with Iroquois Road, it is approximately 350 feet away from the southwestern boundary of West Loch Annex. The alignment then proceeds adjacent to the southwestern boundary of West Loch Annex toward North Road. There are residential uses, vacant land and two golf courses abutting the western boundary of West Loch Annex. For approximately 5,300 lineal feet extending southeast from Iroquois Road, there is also an approximately 30-foot wide easement, not under the control of the Navy, which contains a HECO 46 kilovolt overhead electrical transmission line. On Navy property near the southwestern boundary, there are also existing dirt/rock berms which were likely built by agricultural tenants as well as berms formed during previous military construction. The berms or applicable portions may be retained if not needed for construction of the bypass road and security fence/patrol road.

Should sound abatement measures or other roadway improvements be warranted within the bypass road right-of-way, view parameters may be affected, primarily from adjacent residences. However, the extent of the effect on views should be similar to existing and planned landforms, vegetation and structures such as the existing dirt/rock berm, the existing kiawe forest, and previously approved PV substations.

The entry control point would be located on Iroquois Road on the installation side of the bypass road intersection with Iroquois Road more than 350 feet from the southwestern boundary of West Loch Annex. A gate/sentry house, vehicle curbs and barriers, utility building and three parking stalls, vehicle inspection and vehicle turnaround area would be installed as part of the entry control point. The vehicle inspection and turnaround area would be surrounded by an approximately 10-foot high earth berm. An approximately 40-foot high overwatch tower and a single story overwatch station would be located in proximity to the vehicle inspection area.

A ten-foot high wire strand chain link security fence and patrol road within a 40-foot right-of-way would be built along the eastern boundary of the bypass road right of way extending from Iroquois Road to North Road (Figure 2-5). Although the bypass road does not extend northwest of Iroquois Road, the security fence and patrol road would extend approximately 8,300 lineal feet along the installation boundary, then extend adjacent to the Pearl Harbor National Wildlife Refuge – Honouliuli Unit boundary to an area close to the shoreline. At the bypass road and North Road intersection, the security fence and patrol road would extend northeast along North Road approximately 2,000 feet to its intersection with Iroquois Avenue.

Past approvals include the HECO PV array project along the West Loch Annex southwestern boundary extending from Iroquois Road to North Road. Among the structures previously approved, the substations would include medium voltage switchgear and transformers, as well as a two-story warehouse-type building. A microwave communications tower, not to exceed 75 feet in height, would be located adjacent to the building. The solar arrays are approximately 4 feet above ground level.

Future incremental increases in magazines are likely to be placed significant distances from public transit routes and other areas of public access. Other past, present or reasonably foreseeable projects are generally general repair and maintenance which would not alter building profiles to any significant extent. The City wastewater conveyance facilities project improvements would be below grade within West Loch Annex.

4.4.4.3 Cumulative Impact Analysis

Implementation of the Proposed Action combined with the past, present, and reasonably foreseeable future projects, would result in less than significant view resource impacts within the study area.

4.4.5 Biological Resources

4.4.5.1 Description of Geographic Study Area

The study area for biological resources cumulative impacts for the Proposed Action is the West Loch Annex comprising the approximately 2,640 acres on the western side of Pearl Harbor and the waters of West Loch.

4.4.5.2 Relevant Past, Present, and Future Actions

Land within West Loch Annex has been heavily disturbed for more than a century, from sugar plantations to U.S. Navy uses. There are currently operations and maintenance buildings, community and personnel support facilities, magazines, wharves for the loading and unloading of military ordnance, and a considerable amount of open land which provides safety buffers to surrounding uses. There is an existing agricultural outlease of approximately 825 acres to the west of West Loch Drive. A lease of 200 acres for a PV system has been executed for Phase I of the system on lands formerly part of the agricultural outlease. Phase 2 on approximately 180 acres, also to the west of West Loch Drive, is still to be negotiated, and would affect lands within the existing agricultural outlease. In addition to grading and grubbing which occurred within West Loch Annex, the dredging of West Loch involved short-term construction impacts to terrestrial and marine biological resources. BMPs were employed to minimize construction impacts such as siltation and sediment loading. Areas were recolonized and stabilized after completion of construction. The City's rehabilitation of dual force mains and new third force main involve work across West Loch as well as portions within West Loch Annex.

4.4.5.3 Cumulative Impact Analysis

Cumulative biological resource impacts from past, present, and future actions within the study area would be less than significant. Vegetation within the study area consists primarily of common, introduced and alien species. No federal- or state-listed threatened or endangered plants are located within the study area. No critical habitat has been designated within the study area. Management measures will be in place to minimize impacts to MBTA-protected birds. Nest surveys will be conducted for the Hawaiian short-eared owl a maximum of seven days prior to construction. Removal of tall vegetation during the Hawaiian hoary bat pupping season will be avoided to reduce disturbance to young bats. Removal of tall vegetation during the Hawaiian hoary bat pupping season will be avoided to reduce disturbance to young bats. The Navy has determined that the action may affect the Hawaiian hoary bat, but is not likely to adversely affect the species.

No additional work relating to the project would be taking place in the waters of West Loch. The City wastewater conveyance project will require coordination with the Navy to ensure compliance with applicable regulations. The Proposed Action would include BMPs and erosion control measures to address possible water quality issues.

Therefore, implementation of the Proposed Action combined with the past, present, and reasonably foreseeable future projects, would result in less than significant impacts within the study area.

4.4.6 Cultural Resources

4.4.6.1 Description of Geographic Study Area

The study area for cultural resources cumulative impacts for the Proposed Action is equivalent to the undertaking's APE described in Section 3.8, the project area of the PV system, the waters of West Loch, and other past, present and future projects within West Loch Annex.

4.4.6.2 Relevant Past, Present, and Future Actions

The project area of the PV system is located in an area formerly utilized for sugar cane cultivation. It is presently part of the agricultural outlease area. The Navy determined that there would be "no historic properties affected" by the PV project. The dredging of the West Loch Channel was determined to not adversely affect the characteristics of the Pearl Harbor National Historic Landmark or individual historic properties that qualify for the NRHP. Under Alternative 1 of the proposed project, the majority of known sites are concrete foundations or utility infrastructure from the initial development of the U.S. Naval Ammunition Depot West Loch Branch (beginning in 1931) and the Advance Base Construction Depot Annex (ABCD Annex) (1943-1951). The exception is a plantation road network that pre-dates military development in the area. These sites were subject to inventory-level documentation and no further actions were recommended. None of the sites are eligible for listing in the NRHP. No sites have been documented as part of the Alternative 2 magazines, construction staging and fire station.

Relevant past actions have received necessary cultural resource clearances. Present and future actions involve generally maintenance-type improvements to existing facilities and City wastewater conveyance facility work. Applicable present and future actions would be required to undergo cultural resource review as timing and project details are clarified for these individual projects.

4.4.6.3 Cumulative Impact Analysis

A previous APE was established through Section 106 consultation for the project. By letter dated January 3, 2019, the SHPO reviewed and concurred with the Navy's determination that the project will result in no adverse effect. Since that time, additional components of the project have been added to the undertaking. However, no historic properties are present in the revised APE of 310 acres. Upon reassessment, the appropriate finding of effect is no historic properties affected. Cumulative impacts to cultural resources resulting from the Proposed Action would be less than significant because none of the sites affected by the project are eligible for listing in the NRHP. There are no other known cumulative impacts relating to cultural resources.

4.4.7 Water Resources

4.4.7.1 Description of Geographic Study Area

The study area for assessing water resources are West Loch Annex and the waters of West Loch.

4.4.7.2 Relevant Past, Present, and Future Actions

The study area is part of the larger JBPHH area which houses Pearl Harbor and the Hickam Air Field. West Loch Annex is an expansive area of approximately 2,640 acres which is currently used for ordnance loading and unloading as well as storage. There are currently operations and maintenance buildings, community and personnel support facilities, magazines, and wharves for the loading and unloading of military ordnance. There is a considerable amount of open land which provides safety buffers to surrounding uses along the western boundary of West Loch Annex. Approximately 825 acres in this area is currently outleased for agricultural use. The lease for the first phase of the PV system, approximately 200 acres, has been executed and were formerly included in the agricultural outlease. Phase II of the PV system is under negotiation and may affect up to 180 acres of lands currently part of the agricultural outlease.

The 24 magazines included in the Preferred Alternative are located to the east of West Loch Drive.

4.4.7.3 Cumulative Impact Analysis

Cumulative water resources impacts from past, present, and future actions within the study area would be less than significant because the Proposed Action does not involve work in the shoreline area or within the nearshore marine environment. Although not part of the Proposed Action, pier repair is one of the reasonably foreseeable projects within West Loch Annex. The City's Wastewater Conveyance project involves work within West Loch and West Loch Annex. It is not clear at this juncture to what extent work would take place in the water or affect water resources. However, as details of these projects become known, applicable water quality permit provisions would be reviewed and complied with.

Proposed work for the Proposed Action would comply with applicable permit conditions. BMPs and conditions of the project's NPDES permits would capture and retain storm water on site and allow it to infiltrate into the soil or to be discharged at a rate that would not exceed the predevelopment hydrology to adjacent surface waters. The project area, with the exception of a portion of Iroquois Road, is expected to have insignificant direct or indirect (cumulative and secondary) coastal effects and the project would comply with *de minimus* project mitigation/general conditions for new construction on Navy property. Iroquois Road would be subject to a CCD to ensure that the Proposed Action would be consistent with the enforceable policies of the Hawaii Coastal Zone Management Program, to the maximum extent practicable. The project would also comply with Section 438 of the Energy Independence and Security Act of 2007 which established strict storm water runoff requirements for federal development and redevelopment projects.

West Loch Harbor improvements have complied with necessary permits relating to water quality and/or discharge. Water quality monitoring was also conducted during dredging and shoreline stabilization activities. Silt curtains and other appropriate BMPs were used to contain sediment re-suspended by dredging activities.

Except for West Loch Harbor improvements, the possible pier repair project, and City wastewater conveyance project, the remaining past and reasonably foreseeable projects and the Proposed Action are located in an upland, dry area. Excluding the West Loch Harbor improvements, possible pier repair project, and City wastewater conveyance project, there are no wetlands identified by the U.S. Fish and Wildlife Service National Wetlands Inventory within the remaining past and reasonably foreseeable projects and Proposed Action sites.

Therefore, implementation of the Proposed Action combined with the past, present, and reasonably foreseeable future projects, would result in less than significant impacts within the study area.

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5 Other Considerations Required by NEPA

5.1 Consistency with Other Federal, State, and Local Laws, Plans, Policies, and Regulations

In accordance with 40 Code of Federal Regulations (CFR) section 1502.16(c), analysis of environmental consequences shall include discussion of possible conflicts between the Proposed Action and the objectives of federal, regional, state and local land use plans, policies, and controls. Table 5-1 identifies the principal federal and state laws and regulations that are applicable to the Proposed Action, and describes briefly how compliance with these laws and regulations would be accomplished.

Table 5-1 Principal Federal, State and Local Laws Applicable to the Proposed Action

Federal, State, Local, and Regional Land Use Plans, Policies, and Controls	***Status of Compliance***
National Environmental Policy Act; CEQ NEPA implementing regulations; Navy procedures for Implementing NEPA	EA in progress
Clean Air Act	Proposed project in attainment area
Clean Water Act	NPDES permit to be obtained for temporary discharge of stormwater during construction. NPDES permit for dewatering to be obtained, as applicable
Coastal Zone Management Act	No further action required for new construction on Navy-controlled areas of project with full compliance of project mitigation general conditions. Area of project not on existing Navy property subject to CCD.
National Historic Preservation Act	SHPO concurrence with Navy determination on previous APE that the project will result in no adverse effect. Since that time, additional components of the project have been added to the undertaking. No historic properties are present in the revised APE. Upon reassessment, the appropriate finding of effect is no historic properties affected.
Endangered Species Act	No federal- or state-listed threatened or endangered plants would be affected. There is no critical habitat in the project area. To minimize impacts on waterbirds and the short-eared owl, nest surveys would be conducted before construction. Removal of tall vegetation during the Hawaiian hoary bat pupping season will be avoided to reduce disturbance to young bats. The Navy has determined that the action may affect the Hawaiian hoary bat, but is not likely to adversely affect the species.
Migratory Bird Treaty Act	Nest surveys of MBTA-protected birds would be conducted a maximum of seven days before construction. Night lighting avoided where not needed.
Comprehensive Environmental Response and Liability Act	No impact to 4th Street Coral Pit. Regarding the West Loch Burn Pit and Electrical Components Disposal Area, Navy will work with NOSSA, Hazardous Material Control

Table 5-1 Principal Federal, State and Local Laws Applicable to the Proposed Action

Federal, State, Local, and Regional Land Use Plans, Policies, and Controls	***Status of Compliance***
	and Management Program and Hazardous Waste Minimization Program.
Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-income Populations	No high and adverse human health or environmental effects on minority and low-income populations.
Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks	No environmental health and safety risks associated with the Proposed Action that would disproportionately affect children.
Chapter 6E, Hawaii Revised Statutes	State DOT to consult and obtain concurrence.
Chapter 195D, Hawaii Revised Statutes	State DOT to coordinate with State DLNR to ensure compliance.
Chapter 343, Hawaii Revised Statutes	State DOT to prepare appropriate compliance document.

5.1.1 Chapter 6E, Hawaii Revised Statutes

Before any agency or officer of the state or its political subdivisions commences any project which may affect historic property, aviation artifact, or a burial site, the agency or officer shall advise the SHPO and allow the SHPO an opportunity for review of the effect of the proposed project on historic properties, aviation artifacts, or burial sites, consistent with section 6E-43 (relating to protocol on prehistoric and historic burial sites), especially those listed on the Hawaii register of historic places. The proposed project shall not be commenced, or in the event it has already begun, continued, until the department shall have given its written concurrence.

The SHPO is to provide written concurrence or non-concurrence within ninety days after the filing of a request with the SHPO. The agency or officer seeking to proceed with the project, or any person, may appeal the department's concurrence or non-concurrence to the Hawaii historic places review board.

The SHPO has concurred with the Navy's finding of no adverse effect to historic properties and no significant impact to other cultural resources as part of the NHPA Section 106 review. Additional consultation is needed for portions of the project not considered under the original Section 106 review. The State DOT would be responsible for compliance with Chapter 6E, HRS.

5.1.2 Chapter 195D, Hawaii Revised Statutes

Any species of aquatic life, wildlife, or land plant that has been determined to be an endangered species pursuant to the Endangered Species Act shall be deemed an endangered species under Chapter 195D, HRS. Any indigenous species of aquatic life, wildlife, or land plant that has been determined to be a threatened species pursuant to the Endangered Species Act is deemed to be a threatened species under this chapter.

In addition to the species that have been determined to be endangered or threatened pursuant to the Endangered Species Act, the Department of Land and Natural Resources (DLNR) may determine, by rule, any indigenous species of aquatic life, wildlife, or land plant to be an endangered species or threatened species because of any of the following factors:

1. The present or threatened destruction, modification, or curtailment of its habitat or range;
2. Overutilization for commercial, sporting, scientific, educational, or other purposes;
3. Disease or predation;
4. The inadequacy of existing regulatory mechanisms; or
5. Other natural or artificial factors affecting its continued existence within Hawaii.

With management measures designed to protect and benefit threatened and endangered species, the Preferred Alternative would result in less than significant impacts to biological resources. Approximately 310 acres of vegetation would be removed under the Preferred Alternative. This includes primarily common, introduced, or alien vegetation species. No federal- or state-listed threatened or endangered plants would be affected. There is no critical habitat within the various project sites. Management measures will be in place to minimize impacts to Migratory Bird Treaty Act (MBTA)-protected birds. Removal of tall vegetation during the Hawaiian hoary bat pupping season will be avoided to reduce disturbance to young bats. Site inspections for the Hawaiian short-eared owl will be conducted a maximum of seven days prior to site clearing.

5.1.3 Chapter 343, Hawaii Revised Statutes

Environmental review under Chapter 343, HRS is required for any program or project that proposes one or more of eight land uses or administrative acts, including use of State or County lands or funds other than for feasibility studies or the purchase of raw land. As described in Section 1.1, because a portion of Iroquois Road is owned by the State of Hawaii and is encumbered by the project, it is subject to review under Chapter 343, HRS. The State DOT would be the responsible entity for compliance to applicable requirements under Chapter 343, HRS.

Based on the analysis under NEPA, the Navy has reviewed the significance criteria set forth in Chapter 200, Title 11, HAR. The Navy believes that the Proposed Action would have a less than significant effect on the environment. The reasons supporting the conclusion are discussed below pursuant to the significance criteria noted in Section 11-200-12, HAR.

1. Involves an irrevocable commitment to loss or destruction of any natural or cultural resource;

Development of the proposed project would require an irrevocable commitment of energy, labor, capital, and materials for construction. Land will be used for the proposed project improvements and would be used for those purposes for an indefinite period of time.

No state-listed or federally-listed threatened, endangered, or candidate plant species or rare native Hawaiian plant species have been reported in West Loch Annex in recent decades. To minimize the potential of invasive species introduction, construction equipment which is sourced off-island would be inspected and decontaminated.

The endangered Hawaiian Hoary bat may be present in West Loch Annex. The State-listed short- eared owl could forage and nest within the study area’s grasslands, or open-canopy kiawe forests with grassy understories. Critical habitat for endangered species has not been designated within West Loch Annex. Fledging bats may be harmed because they are unable to escape during tree clearing. To address this possibility, trees greater than 15 feet in height will not be removed during the bat pupping period, from June 1 through September 15. To minimize impacts on MBTA-protected birds and Hawaiian short-eared owls, nest surveys would be conducted a maximum of 7 days before construction. If nests are found, the JBPHH Natural Resources Manager will be notified.

In preparation of the 2008 ICRMP, the Navy consulted with the SHPO on the eligibility of sites within West Loch Annex. Sites in areas with no and/or low potential for archaeological sites were determined to not be eligible for inclusion in the NRHP. The current APE is within said area. For both Alternative 1 and 2, the majority of the known sites are concrete foundations or utility infrastructure from the initial development of the U.S. Naval Ammunition Depot West Loch Branch (beginning in 1931) and the Advance Base Construction Depot Annex (ABCD Annex) (1943-1951). The exception is a plantation road network that pre-dates military development in the area. These sites were subject to inventory-level documentation and no further actions were recommended (Filimoehala et al., 2015; Jensen and Head, 1997; Rieth, 2011). None of the sites are eligible for listing in the NRHP. The Navy is requesting concurrence with the expanded APE and the finding of effect of no historic properties affected.

Implementation of Alternative 1 and 2 would result in less than significant impacts to cultural resources.

The Proposed Action would not involve an irrevocable commitment to loss or destruction of any natural or cultural resource.

2. Curtails the range of beneficial uses of the environment;

The intention of the proposed project is to commit the project site to the proposed use over the long-term. The Proposed Action addresses the need to provide storage space for ordnance. This provides operational convenience for Navy specialists and enhances public safety by limiting the areas over which ordnance is transported and stored. Moreover, areas within West Loch Annex would be secured with public access being prohibited on West Loch Drive and portions of Iroquois Road and North Road for safety reasons. Additional improvements such as the bypass road, security fencing, patrol road and entry control point are also essential in addressing safety and security parameters. Alternative 1 improvements would affect approximately 178 acres of land within the State Agricultural District. The Alternative 2 magazines are located within the State Agricultural District and would affect an additional approximately 52 acres of land compared to Alternative 1. The proposed bypass road would be within federal property and would not require land acquisition of private residential properties along the Annex's southwest border. The project improvements are essential from a public safety standpoint and do not curtail the range of beneficial uses of the environment.

3. Conflicts with the State's long-term environmental policies or goals and guidelines as expressed in Chapter 344, HRS, and any revisions thereof and amendment thereto, court decisions, or executive orders;

The proposed project does not conflict with long-term environmental policies, goals, and guidelines of the State of Hawaii. Potential impacts related to short-term construction activities would be avoided or minimized through applicable best management practices and erosion control measures. Through various management measures, biological and cultural resource concerns would be addressed.

4. Substantially affects the economic, social welfare, or cultural practices of the community or State;

In the short-term, the project would confer positive benefits to the local economy. Direct economic benefits would result from construction expenditures both through the purchase of material from local suppliers and through the employment of local labor, thereby stimulating that sector of the economy. Indirect economic benefits would include benefits to local retailing and service businesses resulting from construction activities.

There are no significant adverse long-term socioeconomic impacts anticipated with the proposed project. The proposed project is not expected to induce population growth in the area or region. A new public bypass road is proposed adjacent to the western boundary of West Loch Annex in order to address closure of West Loch Drive and portions of Iroquois Road and North Road within the project area due to safety reasons. Because the State of Hawaii is in attainment of the NAAQS, the proposed project is not subject to the Clean Air Act's General Conformity Rule. The proposed project would not involve new stationary air emissions sources or major modifications to existing stationary sources. The project would formulate a Construction Noise Mitigation and Management Plan for the bypass road prior to construction. With appropriate abatement, the project would not result in substantial long term noise impacts. There would be less than significant effect upon the social welfare of the community resulting from the Proposed Action.

The project site is part of the larger Pearl Harbor Hickam area which has been in active military use since prior to World War II. There are no known traditional cultural places within the project area. The proposed project is anticipated to have a less than significant impact on TCP or practices, gathering rights, or access.

5. Substantially affects public health;

The proposed project involves construction of magazines in order to meet an ordnance storage requirement. In the short-term, possible construction-related impacts would be mitigated through implementation of applicable best management practices and erosion control measures. In the long-term, the Proposed Action provides a secure area for ordnance storage which would be constructed in accord with the latest DoD standards for safety. Only authorized technical personnel would be allowed in these areas.

6. Involves substantial secondary impacts, such as population changes or effects on public facilities;

No secondary effects are anticipated with the construction and operation of the proposed project. The proposed project is not anticipated to induce growth beyond that which is anticipated for the region and should have a negligible influence on future population and land use patterns in Ewa. Effects on public facilities like highways, schools, and public infrastructure systems resulting from the project should be minimal.

7. Involves a substantial degradation of environmental quality;

The proposed project is not anticipated to involve a substantial degradation of environmental quality.

There are potential short-term construction-related impacts to noise, and air quality in the immediate project vicinity. The project would formulate a Construction Noise Mitigation and Management Plan. With appropriate abatement, the project would not result in substantial long term noise impacts. Because the State of Hawaii is in attainment of the NAAQS, the proposed project is not subject to the Clean Air Act's General Conformity Rule. The proposed project would not involve new stationary air emissions sources or major modifications to existing stationary sources. Applicable best management practices and erosion control measures would be implemented to address potential soil erosion and sedimentation issues. To the extent possible, earthwork would be balanced to maintain existing drainage patterns and bare ground shall be hydromulched or planted with ground cover to minimize erosion and runoff. In the operational period, environmental impacts should be minimal.

8. Is individually limited but cumulatively has a considerable effect upon the environment or involves a commitment for larger actions;

No significant cumulative effects are anticipated. There is no commitment for larger actions.

9. Substantially affects a rare, threatened or endangered species, or its habitat;

The project site consists of primarily xeric vegetation which can be found in similar habitats throughout Hawaii. There are no known mammal and reptiles within the West Loch Annex which are indigenous to Hawaii or are threatened or endangered. No state-listed or federally-listed threatened, endangered, or candidate plant species or rare native Hawaiian plant species have been reported in West Loch Annex in recent decades. There are federally listed and state-listed bird species in Pearl Harbor, but no critical habitat has been declared for these species in the harbor. Management measures would be implemented to benefit and protect possible threatened and endangered species individuals or populations. The project is not anticipated to adversely affect any rare, threatened or endangered species, or its habitat.

10. Detrimentally affects air and water quality or ambient noise levels;

Because the State of Hawaii is in attainment of the NAAQS, the proposed project is not subject to the Clean Air Act's General Conformity Rule. The proposed project would not involve new stationary air emissions sources or major modifications to existing stationary sources.

Project-related short-term impacts on air quality may occur from the emission of fugitive dust during construction phases. To control dust, the project construction contractor should prepare a dust control plan that will ensure that state regulations related to fugitive dust will be met.

Operation of construction equipment may temporarily elevate ambient noise and concentrations of exhaust emissions in the immediate vicinity of the project site. Construction on the project is recommended to be limited to weekday daylight hours. Dust would be addressed through watering of unpaved areas of exposed soil and planting of landscaping as soon as possible on completed areas.

The project would implement BMPs to capture and retain storm water on site and allow it to infiltrate into the soil or to be discharged at a rate that would not exceed the predevelopment hydrology to adjacent surface waters.

The project would formulate a Construction Noise Mitigation and Management Plan. With appropriate abatement, the project would result in less than significant long term noise impacts. The project would not result in detrimental effects to air and water quality or ambient noise levels.

11. Affects or is likely to suffer damage by being located in an environmentally sensitive area such as a flood plain, tsunami zone, beach, erosion-prone area, geologically hazardous land, estuary, fresh water, or coastal waters;

According to the FIRM prepared by FEMA, the project site is located within Zone "D" which is an area with possible but undetermined flood hazards (FEMA, 2011). No streams or surface water features are located within or near the Proposed Action. Regarding tsunami evacuation parameters, the Proposed Action is located within a Safe Zone with the exception of the proposed fire station site. This is located in an Extreme Tsunami Evacuation Zone in which an evacuation is recommended in the unlikely case of an "Extreme Tsunami Warning" caused by a very large (Magnitude 9+) earthquake and tsunami. (City and County of Honolulu 2015).

12. Substantially affects scenic vistas and viewplanes identified in county or state plans or studies;

Most of the proposed project involves scattered low rise development over a large expanse of land already heavily vegetated. Most of the project such as the magazines, adjacent roadways and concrete pads, electrical and fire hydrant improvements, and fire station would be obscured by existing vegetation. The bypass road, security fence and patrol road would be located along the western boundary of the project and would be visible from adjacent properties. The tallest structure in the Proposed Action is an overwatch tower adjacent to the entry control point of approximately 40 feet.

The City and County of Honolulu's Ewa Development Plan has identified distant vistas of the shoreline from the H-1 Freeway above the Ewa Plain as a significant view and vista which should be preserved. Because of the gently sloping terrain of the Ewa plain, the abundant existing vegetation on the project site and the low rise nature of the proposed development, the project does not substantially affect scenic vistas and viewplanes identified in the Ewa Development Plan.

There are no specific scenic vistas identified in state plans relating to West Loch Annex.

13. Requires substantial energy consumption.

Construction and operation of the proposed project will not require substantial increases in energy consumption. The project involves primarily storage use.

5.2 Irreversible or Irretrievable Commitments of Resources

Resources that are irreversibly or irretrievably committed to a project are those that are used on a long-term or permanent basis. This includes the use of non-renewable resources such as metal and fuel, and natural or cultural resources. These resources are irretrievable in that they would be used for this project when they could have been used for other purposes. Human labor is also considered an irretrievable resource. Another impact that falls under this category is the unavoidable destruction of natural resources that could limit the range of potential uses of that particular environment.

Implementation of the Proposed Action would involve human labor; the consumption of fuel, oil, and lubricants for construction vehicles. Existing vegetation would be removed in the area of project construction. However, the vegetation in the West Loch Annex area is primarily common, introduced, and alien vegetation species. Moreover, the Proposed Action would not alter remaining substantial acreages of West Loch Annex. Management measures would be implemented to protect and benefit MBTA-protected birds, waterbirds, the Hawaiian short-eared owl, and the Hawaiian hoary bat.

Implementing the Proposed Action would not result in significant irreversible or irretrievable commitment of resources.

5.3 Relationship between Short-Term Use of the Environment and Long-Term Productivity

NEPA requires an analysis of the relationship between a project's short-term impacts on the environment and the effects that these impacts may have on the maintenance and enhancement of the long-term productivity of the affected environment. Impacts that narrow the range of beneficial uses of the environment are of particular concern. This refers to the possibility that choosing one development site reduces future flexibility in pursuing other options, or that using a parcel of land or other resources often eliminates the possibility of other uses at that site.

In the short-term, effects to the human environment with implementation of the Proposed Action would primarily relate to the construction activity itself. Traffic, air quality and noise would be impacted in the short-term. In the long-term, public access through West Loch Annex would be prohibited due to safety and security reasons. Alternative public access accommodations would include a new bypass road along the western boundary of West Loch Annex. Clearing resulting from the project would result in loss of primarily xeric vegetation. However, no critical or sensitive habitats would be threatened. Management measures would also be implemented to protect and benefit threatened and endangered species. The construction of the facility and operation would not significantly impact the long-term natural resource productivity of the area. The Proposed Action would not result in any impacts that would significantly reduce environmental productivity or permanently narrow the range of beneficial uses of the environment.

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7 List of Preparers

This EA was prepared collaboratively between the Navy and contractor preparers.

U.S. Department of the Navy
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Responsible for: Contracting Officers Representative (COR)

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Responsible for: Principal in charge; Overall quality assurance/quality control

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Years of Experience: 5 years
Responsible for: Noise Study

Appendices

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Appendix A

State Department of Transportation Consultation

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DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE NAVY
COMMANDER
NAVY REGION HAWAII
850 TICONDEROGA ST STE 110
JBPHH, HAWAII 96860-5101

5090
Ser N45/0401
January 11, 2019

CERTIFIED NO: 7016 0910 0001 0892 1410

Office of Environmental Quality Control
235 South Beretania Street, Room 702
Honolulu, HI 96813

CERTIFIED NO: 7016 0910 0001 0892 1427

Department of Transportation
Attn: Ken Tatsuguchi
869 Punchbowl Street, Room 301
Aliiaimoku Hale
Honolulu, HI 96813

Dear Sirs/Madam:

SUBJECT: NAVAL MAGAZINES FOR LONG ORDNANCE ENVIRONMENTAL ASSESSMENT PRE-ASSESSMENT CONSULTATION, JOINT BASE PEARL HARBOR HICKAM WEST LOCH ANNEX, OAHU HAWAII

The U.S. Navy proposes to construct 24 Type D box magazines for the safe storage of Naval long ordnance at Joint Base Pearl Harbor Hickam (JBPHH) West Loch Annex. To comply with safety standards, the project would require the permanent closure of currently unrestricted vehicular access on a portion of Iroquois Road and on West Loch Drive. To accomplish this, the project would acquire the portion of Iroquois Road that would be closed and a bypass road replacing West Loch Drive along the installation perimeter (exterior to a security fence and interior security patrol road) would be constructed to mitigate the traffic impacts. After construction of the bypass road, the Navy would excess it to the custody of an appropriate State or Local agency for ownership and maintenance. Additional related improvements include an entry control point and related utility connections. A project summary is provided as enclosure (1) and project area is provided in enclosure (2).

The U.S. Navy is preparing an Environmental Assessment (EA) for the proposed project in compliance with the National Environmental Policy Act (NEPA).

Due to the closure and acquisition of a portion of Iroquois Road that is state property, the EA would also be prepared to satisfy the applicable requirements of Hawaii Revised Statutes (HRS) Chapter 343. As advised in discussions between Navy, State of Hawaii Department of Transportation, and State of Hawaii Office of Environmental Quality Control staff, the Navy is requesting State of Hawaii Department of Transportation concurrence that it would be considered the approving agency for the action per HRS Chapter 343.

Thank you for taking the time to review the enclosed project information. If you have specific questions about the forthcoming EA or would like to be removed from the list of parties to receive the EA, please contact Mr. James Furuhashi at (808) 471-9702 or by email to james.furuhashi@navy.mil.

Sincerely,

AARON Y. POENTIS
Director
Regional Environmental Department
By direction of the
Commander

Enclosures: 1. Project Summary
2. Regional Location Map

Copy to:
COMMANDER, JOINT BASE PEARL HARBOR HICKAM, JB4
COMMANDER NAVFAC PACIFIC, EV2

PROJECT SUMMARY

Applicant:	U.S. Navy
EA Preparer:	NAVFAC Pacific 258 Makalapa Drive, Suite 100 JBPHH, HI 96860 Phone: (808) 472-1442 POC: Kyle Fujimoto
Chapter 343, Hawaii Revised Statutes "EA Trigger:"	Use of State- and County-owned lands
Proposed Action:	Construction of Naval Magazines for Long Ordnance, bypass road, perimeter security and related improvements.
Project Location:	JBPHH West Loch Annex, Oahu, Hawaii
Tax Map Key Parcel:	9-1-010-015; 9-1-010-016; 9-1-010-011; 9-1-001-031; 9-1-001-001; State DOT Rights of Way for portion of Iroquois Road
Project Area:	Approximately 190 acres
Existing Uses:	Department of the Navy lands; State roadways
Landowners:	USA; State of Hawaii
State Land Use District:	Urban; Agricultural
Ewa Development Plan Urban Land Use Map:	Military; Agricultural and Preservation Area
City and County of Honolulu Zoning District:	F-1 Military and Federal Preservation; AG-1 Restricted Agricultural, AG-2 General Agricultural, R-5 Residential
State and County Permits and Approvals:	**State of Hawaii** Department of Transportation • Acquisition of portion of Iroquois road Department of Health • National Pollutant Discharge Elimination System permit
Federal Permits and Approvals	USFWS endangered species act consultation

ENCLOSURE(1)

Enclosure (2)

REGIONAL LOCATION MAP

1. COMPONENT
NAVY

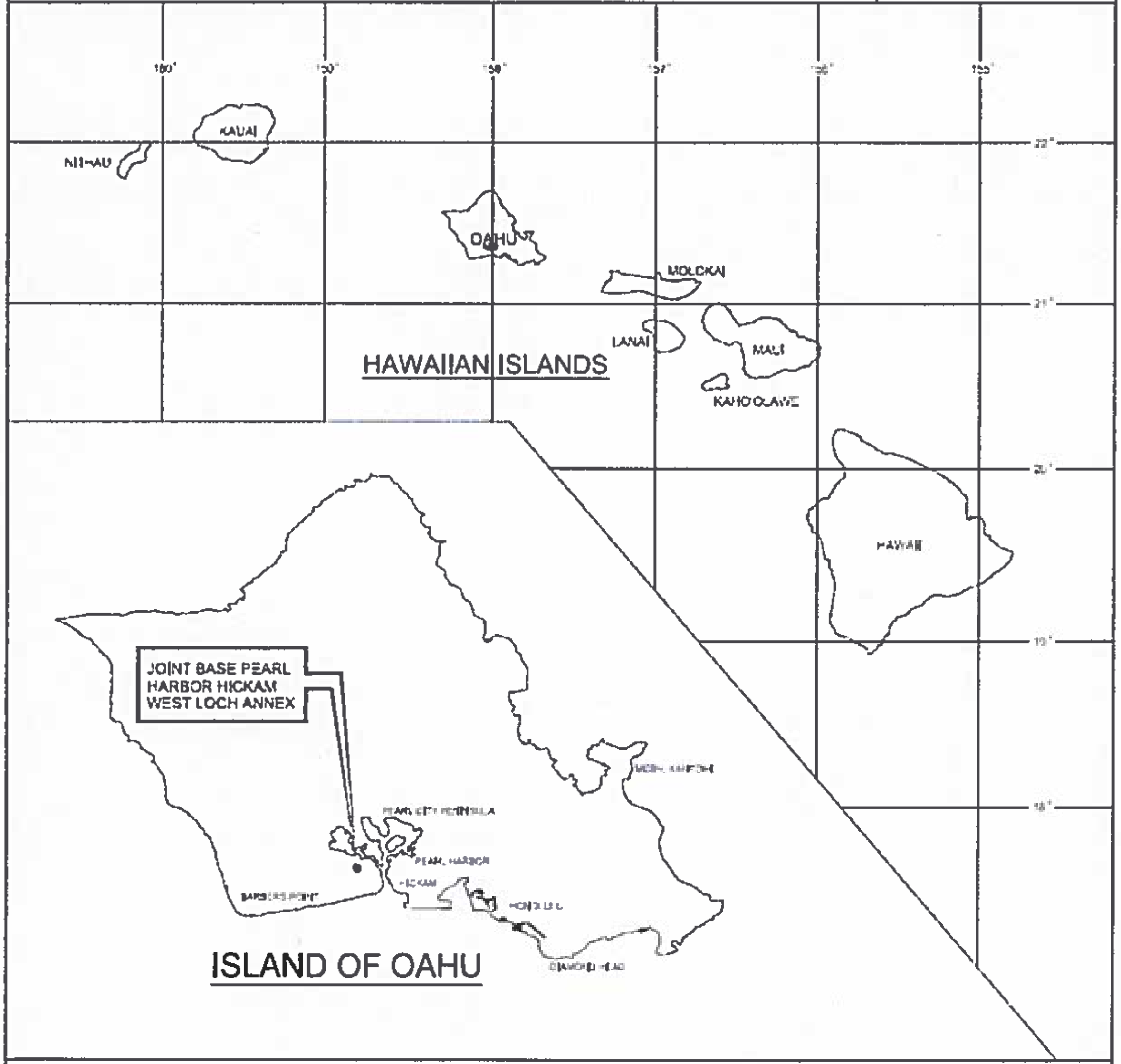
FY 20__ PROJECT DATA

2. DATE
JUN 2018

3. INSTALLATION AND LOCATION
JOINT BASE PEARL HARBOR HICKAM
WEST LOCH ANNEX, HAWAII

4. PROJECT TITLE
MAGAZINES FOR LONG ORDNANCE, WEST LOCH

5. PROJECT NUMBER
P-033



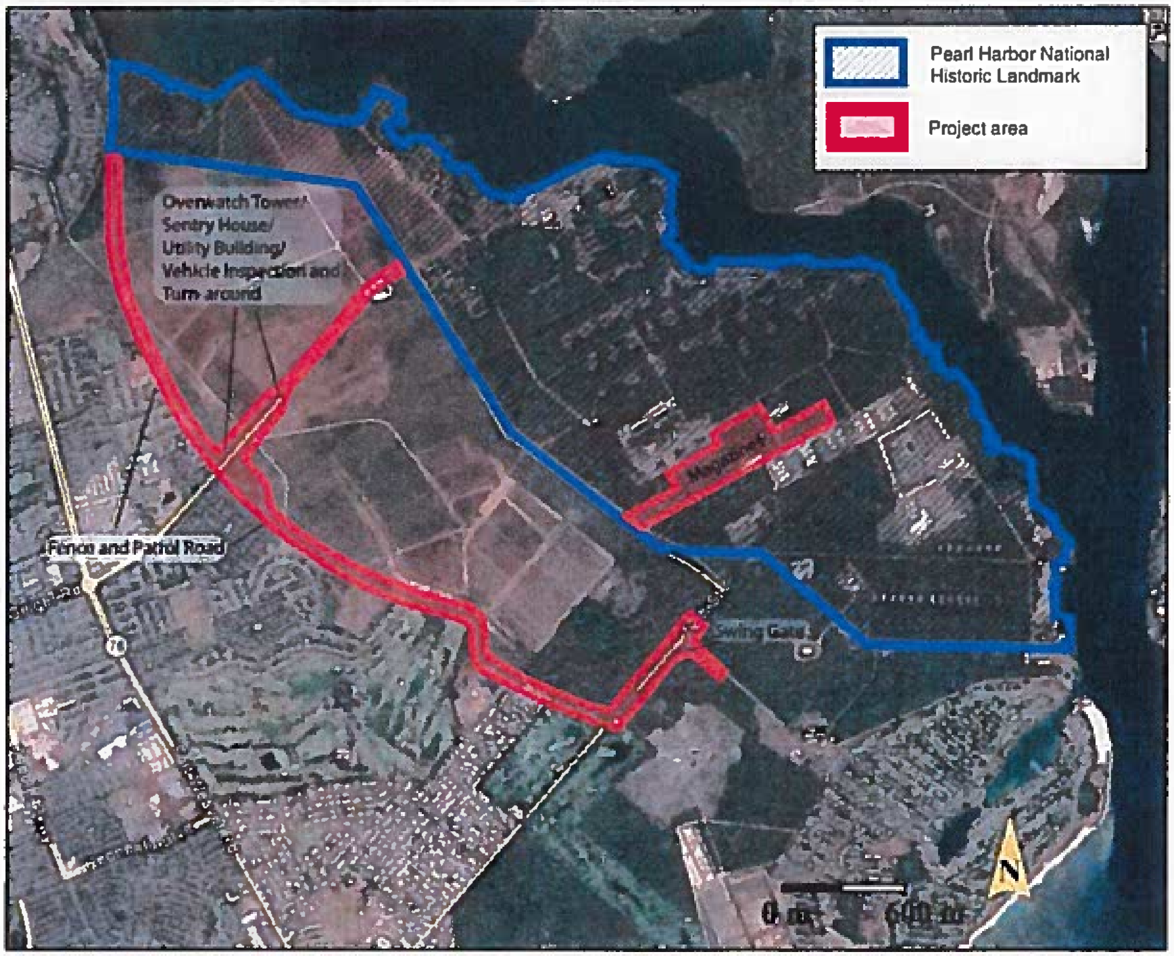
HAWAIIAN ISLANDS
SCALE: NOT TO SCALE

ENCLOSURE(2)

Enclosure (2)

PROJECT LOCATION MAP

Project Area:



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STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

IN REPLY REFER TO:
HWY-PS 2.9482

March 7, 2019

Mr. Aaron Y. Poentis
Director
Regional Environmental Department
Department of the Navy
Commander, Naval Region Hawaii
850 Ticoneroga Street, Suite 110
JBPHH, Hawaii 96860-5101

Dear Mr. Poentis:

Subject: Naval Magazines for Long Ordnance
Pre-Assessment Consultation for Hawaii Revised Statues (HRS) 343,
Accepting Agency
Joint Base Pearl Harbor Hickam, West Loch Annex

In letter 5090 Ser N45/0401, dated January 11, 2019, the U.S. Navy (Navy) proposes to construct 24 Type D box magazines for Naval ordnance at the West Loch Annex. A safety zone needs to be extended beyond the existing perimeter fence which would require that changes be made to existing roadways.

The Navy proposes to acquire a portion of Iroquois Road, State Route 7141, which currently extends to the existing security gate of the Annex, as part of the safety zone extension to the vicinity of a new security gate that the Navy will construct. In addition, it will close West Loch Drive and construct a replacement roadway beyond the extended safety zone, outside of the new perimeter fencing, on Federal land, to mitigate effects of closure of West Loch Drive, which would then be excessed to the City and County of Honolulu for ownership and maintenance.

The Navy will comply with HRS Chapter 343 due to the use of State lands. The Navy, in consultation with the Hawaii Department of Transportation (HDOT) and Office of Environmental Quality Control, requests the concurrence of HDOT that HDOT would be the accepting agency for HRS 343.

The HDOT concurs that it will be the accepting agency for HRS 343 purposes.

If there are any questions, please contact Ken Tatsuguchi, Engineering Program Manager, Highways Planning Branch at (808) 587-1830. Please reference file review number 2018-140.

Sincerely,

JADE T. BUTAY
Director of Transportation

c: Kyle Fujimoto, Naval Facilities Engineering Command, Pacific

Appendix B

Traffic Study

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West Loch Annex Traffic Study
Joint Base Pearl Harbor-Hickam West Loch Annex

FINAL

August 2018

Prepared for:

NAVFAC Hawaii
Navy Contract N62742-16-D-0200, Revised Amendment No. 8

Prepared by:

Helber Hastert & Fee, Planners
Julian Ng Incorporated

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Acronyms and Abbreviations

A.M.	Morning
JBPHH	Joint Base Pearl Harbor-Hickam
LOS	Level of Service
M.M.	Midday
P.M.	Afternoon
PV	Photovoltaic
vpd	vehicles per day
X	Utilization (volume/capacity ratio)

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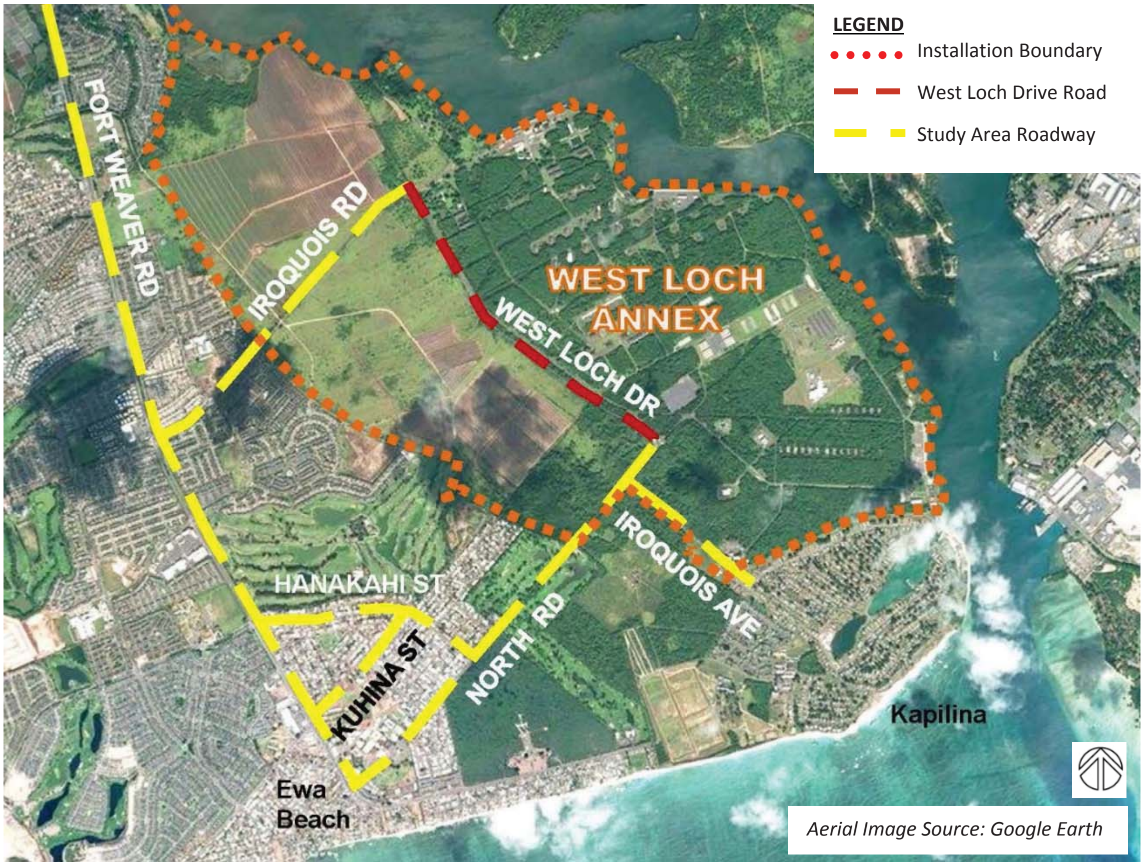
Executive Summary

A traffic study was conducted to evaluate the potential effects to vehicular traffic conditions resulting from closure of West Loch Drive to public traffic. Public use of this two-lane roadway, located within the Joint Base Pearl Harbor-Hickam West Loch Annex installation, is currently allowed, and traffic counts on West Loch Drive show an average daily volume of 6,500 vehicles. Closure of the roadway is proposed due to existing safety concerns and future planned development at West Loch Annex.

Most of the traffic currently using West Loch Drive travels between Iroquois Avenue (which serves the West Loch Annex front gate and provides the only existing public access into the Kapilina community, formerly Iroquois Point Naval Housing) and the intersection of Iroquois Road and Fort Weaver Road. With closure of West Loch Drive, traffic would need to find new paths to complete travel between these points. These paths would include two-lane local residential streets designed to carry between 2,000 and 5,000 vehicles per day. Several of these streets already carry traffic volumes that exceed their original design intent, so they would likely be unable to carry additional traffic. For example, Hanakahi Street would be expected to be a desirable alternative to West Loch Drive, but near Fort Weaver Road, the estimated daily traffic volume in 2015 was 5,500 vehicles per day (State transportation agency estimate), and in the fall of 2017, the City transportation agency implemented “traffic calming” on Hanakahi Street. For this traffic study, capacity analyses of peak hour traffic volumes confirmed that this alternative routing would not be able to accommodate the traffic displaced by closure of West Loch Drive.



Aerial Image Source: Google Earth

Study Area

Three mitigation alternatives were identified and analyzed. Alternative 1 would “replace” West Loch Drive with a similar two-lane roadway (“bypass”) and minimize the rerouting of affected traffic onto existing residential streets. Alternative 2 would provide a roadway to reconnect the Kapilina community with the end of Fort Weaver Road. Alternative 3 would allow the diverted traffic through the existing residential communities in ‘Ewa Beach and implement intersection improvements at key locations to better serve the increased traffic. The second and third alternatives were found to also require an additional (third) northbound lane of Fort Weaver Road from the vicinity of Papipi Road to the existing widened portion near Iroquois Road. Concepts for all three mitigation alternatives were limited to Navy/federal lands and/or public rights-of-way.

The three alternatives were compared based on traffic service, ease of implementation, and the possible effects in the study area. In conclusion, Alternative 1—construction of a bypass roadway—would minimize the effects of additional traffic within existing communities. Construction of a new bypass roadway would be needed prior to closing West Loch Drive to the public to minimize traffic effects due to the closure of West Loch Drive.

1 Introduction

This traffic study was prepared to evaluate the potential effects to vehicular traffic conditions resulting from closure of West Loch Drive to public traffic. The two-lane roadway is located within the Joint Base Pearl Harbor-Hickam West Loch Annex installation, but public access is currently neither restricted nor prevented by a fence line. However, West Loch Annex is an active military ordnance storage area, and the closure of the road is proposed due to existing safety concerns that would be compounded by future development at West Loch Annex. The study includes traffic counts at key locations and analyses of the effects of the road closure. Several alternatives to mitigate these effects were developed, evaluated, and refined to determine how effects could be minimized. Figure 1 shows the affected roadways in the vicinity of West Loch Annex.

Aerial Image Source: Google Earth

Figure 1 – Study Area

West Loch Drive is currently one of the vehicular routes taken to travel between the Fort Weaver Road-Iroquois Road intersection and the North Road-Iroquois Avenue intersection. Much of this traffic is generated by the Kapilina residential community (formerly Iroquois Point Naval housing), which has been provided with legal access (Land Court Orders) via Iroquois Avenue and North Road. Traffic between Kapilina and the ʻEwa Beach area likely uses this route to link with Fort Weaver Road; however, any traffic between Kapilina and areas north of Iroquois Road likely uses West Loch Drive. Other users of West Loch Drive include drivers entering or leaving West Loch Annex front gate or drivers bypassing existing congestion along Fort Weaver Road south of Iroquois Road. Unless a replacement is provided, closure of West Loch Drive would divert this traffic to other existing streets, such as Hanakahi Street and North Road.

1.1 Levels of Service

The intersection analysis procedures from the *Highway Capacity Manual* (2010) were used for this study. Results include utilization (volume/capacity ratio), average delay, and Level of Service. Levels of Service (LOS) [1] are based on the average delay per vehicle using the criteria shown in Table 1.

Table 1
Levels of Service Definitions

Average Delay (seconds per vehicle)		**General Description of Delay**	**Level of Service (LOS)**
Signalized Intersection	**Unsignalized Intersection**		
≤ 10	≤ 10	Little or no delay	A
> 10 and ≤ 20	> 10 and ≤ 15	Short traffic delays	B
> 20 and ≤ 35	> 15 and ≤ 25	Average traffic delays	C
> 35 and ≤ 55	> 25 and ≤ 35	Long traffic delays	D
> 55 and ≤ 80	> 35 and ≤ 50	Very long traffic delays	E
> 80	> 50	Very long traffic delays	F

Source: *Highway Capacity Manual* (2010).

Level of Service F also describes conditions when traffic volume exceeds capacity. At signalized intersections, overall average delay is considered.

In the study area, existing peak hours were determined from daytime (13-hour) turning movement (manual) counts taken during a single day in September 2017 at seven intersections (see traffic count summaries in Appendix A). The samples were selected to be representative of existing conditions of a typical weekday. Counts at two locations were also taken for an entire 24-hour period.

1.2 Study Organization

Chapter 2 of this study provides the results of analyzing existing peak hour traffic conditions at seven intersections where the proposed roadway closure is expected to change traffic volumes. Summaries of these analyses are included in Appendix B.

---

[1] While traffic engineers have traditionally considered Level of Service D or better conditions to be “acceptable” during peak hours, current practice often downplays vehicular levels of service. At unsignalized intersections, acceptable conditions would only require that capacities be adequate.

Chapter 3 discusses the probable effects of closing West Loch Drive if no mitigation measures were implemented. Since West Loch Drive road closure would result in drivers using other existing roadways, the study included an iterative process to reassign traffic volumes on alternate routes, seeking to balance utilization and possible travel delays. Analyses were done for both existing and future conditions, and summaries of these analyses are included in Appendix C.

Chapter 4 presents the results of analyzing mitigation Alternative 1 and its variations. Alternative 1 comprises a replacement roadway that would bypass the otherwise affected ‘Ewa Beach community, linking Iroquois Road and North Road. Summaries of the analyses are included in Appendix D.

Chapter 5 presents the findings of analyzing mitigation Alternative 2, which would provide access into the Kapilina community from the southeastern end of Fort Weaver Road. Summaries of these analyses are included in Appendix E.

Chapter 6 describes the findings of analyzing Alternative 3, which identifies several mitigation measures that would be needed to provide sufficient capacity to serve traffic diverted from West Loch Drive if neither Alternative 1 nor Alternative 2 were implemented. Summaries of these analyses are included in Appendix F.

Chapter 7 provides conclusions and recommendations.

Traffic mitigation concept plans for all three alternatives are included in Appendix G.

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2 Existing Conditions

Joint Base Pearl Harbor-Hickam (JBPHH) West Loch Annex is located south of the West Loch estuary of Pearl Harbor and west of the Pearl Harbor entrance channel. To the west and southwest, West Loch Annex is bounded by several residential subdivisions that were built in the past 30 years as part of the Ewa by Gentry project, the Hawaii Prince Golf Club, older residential subdivisions built about 50 years ago (Leeward Estates), and the Ewa Beach Golf Club. The older subdivisions include approximately 580 single-family lots served by streets built in the 1960s (when the street standard included rolled curbs and unpaved sidewalks) along Kuhina Street and between Kuhina Street and the Hawaii Prince Golf Club. Approximately 750 lots southeast of Kuhina Street were built on streets meeting more recent standards, which include barrier curbs and concrete sidewalks. Several apartment complexes are located southeast of North Road. James Campbell High School, Ilima Intermediate School, Pohakea Elementary School, Ka'imiloa Elementary School, and the Our Lady of Perpetual Help School are also located in this area.

The Kapilina residential community, formerly Iroquois Point Naval housing, includes nearly 1,500 housing units and is located south of West Loch Annex. Vehicular access to Kapilina is through a guard gate on Iroquois Avenue approximately 800 feet south of (beyond) the front gate to West Loch Annex (Barracks Road). Iroquois Point Elementary School is located within the community.

In addition to the areas already described—which are generally bounded by Fort Weaver Road, Iroquois Road, the west loch of Pearl Harbor, and the Pearl Harbor entrance channel—Fort Weaver Road also serves as the primary major access road to and from properties located on the south or west side of Fort Weaver Road, including residences, a shopping center, and Ewa Beach Elementary School. Keoneula Boulevard, a major roadway serving the growing Hoakalei residential development, is the fourth (west) leg of the intersection where Hanakahi Street meets Fort Weaver Road.

Intersection turning movement counts were taken at seven intersections (Figure 2) during September 2017. These intersections were selected to obtain traffic data for analyzing the potential effects of closing West Loch Drive. A single day's sample was taken at each intersection: vehicular turning movements were recorded in 15-minute increments between 0600 and 1900 hours. In addition, nighttime counts were conducted at the West Loch Drive-Iroquois Road intersection and the North Road-Iroquois Avenue intersection in order to obtain 24-hour totals. Count summaries are tabulated in Appendix A.

The turning movement counts were taken on weekdays with public schools in normal mid-term session with no known special activities that may have affected traffic volumes. While the data are from single-day samples, the volumes are considered to be typical, as no unusual traffic activity was observed. The turning movement counts collected for this study were supplemented by peak period counts[2] taken in September 2016 at several intersections near Campbell High School.

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[2] Julian Ng, Inc., *Classroom Addition at James Campbell High School Traffic Impact Analysis Report, April 2017.*

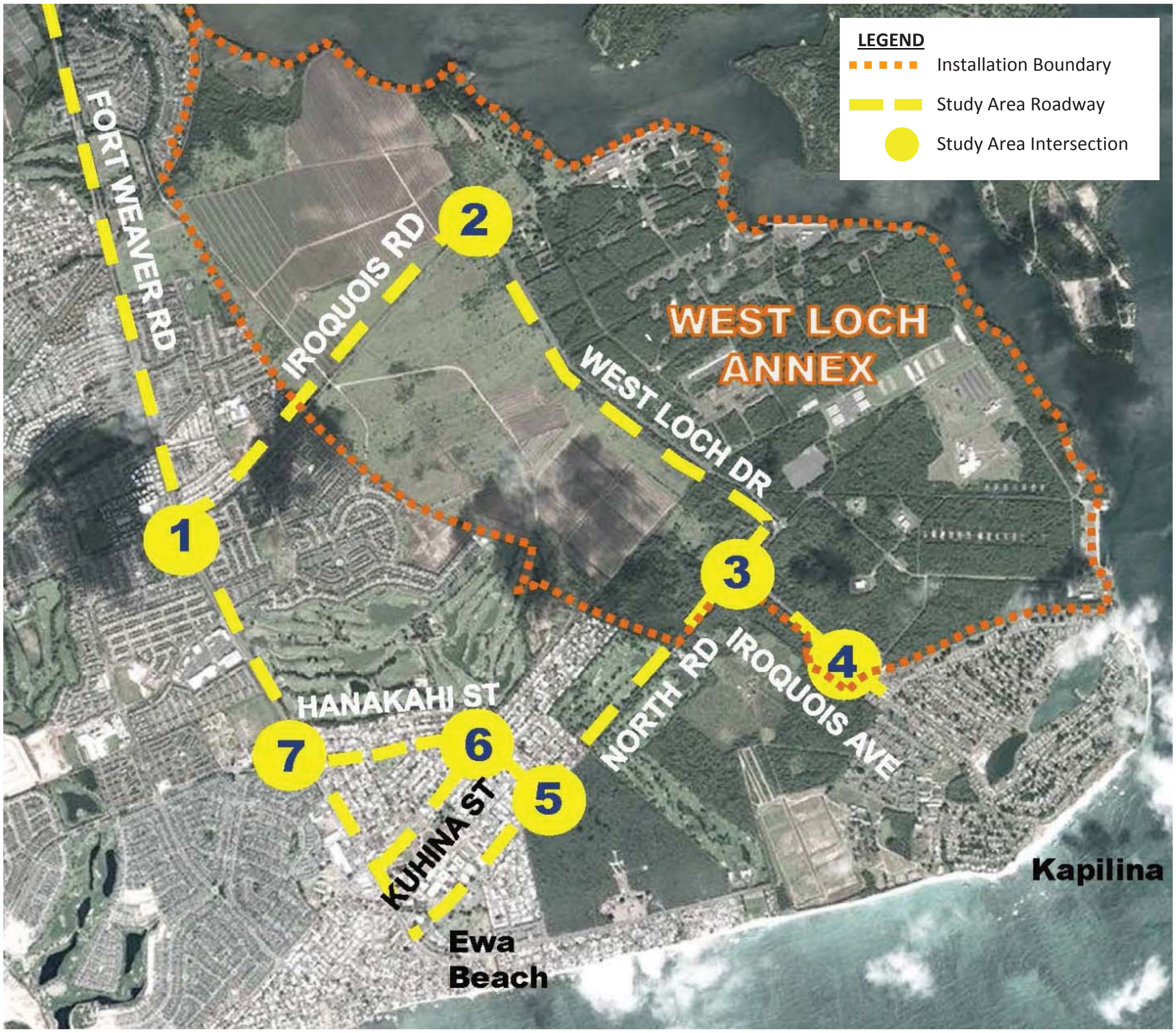


Figure 2 – Traffic Count Locations

2.1 Intersection 1: Fort Weaver Road and Iroquois Road

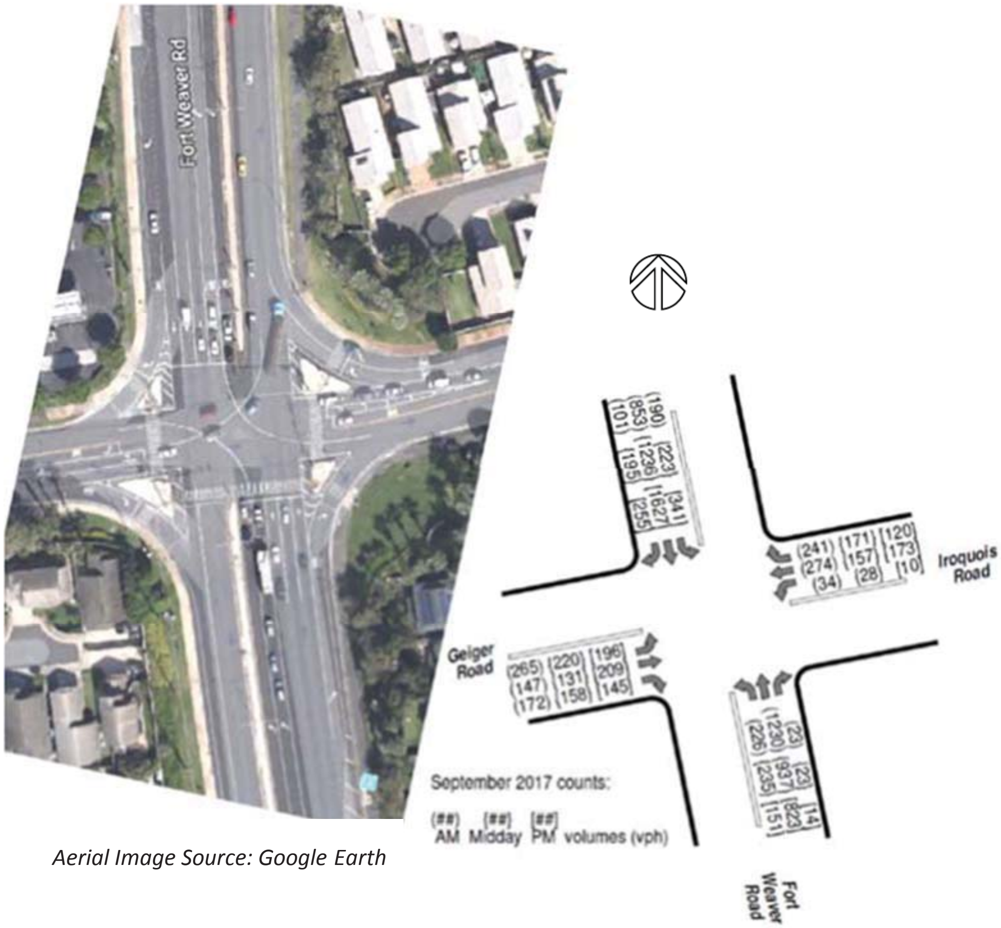
The Fort Weaver Road approaches to this intersection each consists of two left turn lanes, three through lanes, and a separate right turn lane. The westbound Iroquois Road approach includes a single lane for left turns, a single lane for through movements, and two lanes for right turns. The opposite approach (Geiger Road) has three eastbound lanes: a left turn only lane, an option lane for left turns and through movements, and an option lane for through movements and right turns.

Paved sidewalks or roadway shoulders are provided for pedestrian use on both sides of the roadways near the intersection. Crosswalks are striped across the west, south, and east legs of the intersection and between the roadside sidewalks and channelization islands.

Bus turnouts are located off of both the northbound and southbound lanes Fort Weaver Road approximately 350 feet before the intersection prior to the separate right turn lanes. These stops are served by the City's TheBus Routes E and 42, each route being served by 2 buses per hour during the day on weekdays, with reduced service in the evenings and on weekends. Supplemental service is also provided by Route 91 during peak hours (about 3 additional buses per hour in the peak direction: northbound between 0420 and 0710 hours and southbound between 1615 and 1905 hours). Bus service at these stops is available between 0400 and 0100 hours northbound and 0515 and 0245 hours southbound (all times approximate).

The intersection is controlled by a traffic signal system that operates in six phases. The Geiger Road eastbound approach and the Iroquois Road westbound approach each have green lights on separate phases, followed by protected (i.e., unopposed) left turn phases for the Fort Weaver Road approaches. Through traffic phases on Fort Weaver Road are displayed after the end of the opposing left turn phases. Pedestrian phases coincide with the through phases in the adjacent parallel lanes. The left turn and minor street phases occur after detection of vehicles in the lanes or pedestrian actuation of call buttons.

Figure 3 shows existing laneage in an aerial image of the intersection, and the accompanying intersection diagram shows peak hour volumes from manual counts collected on Tuesday, September 26, 2017. Three peak hours were identified: A.M. (0700-0800 hours), M.M. (Midday, 1400-1500 hours), and P.M. (1600-1700 hours). The results of the intersection analyses are shown in Table 2.



Aerial Image Source: Google Earth

Figure 3 – Intersection 1, Fort Weaver Road and Iroquois Road / Geiger Road

Table 2 – Intersection 1
Existing Conditions, Fort Weaver Road and Iroquois Road / Geiger Road

Lane/Turn	A.M. Peak Hour			M.M. Peak Hour			P.M. Peak Hour		
	X	Delay	LOS	X	Delay	LOS	X	Delay	LOS
Southbound Left Turn	0.76	77.7	E	0.85	87.0	F	0.95	94.2	F
Southbound Through Lanes	0.53	36.8	D	0.73	41.8	D	0.72	32.2	C
Northbound Left Turn	0.68	66.2	E	0.67	65.9	E	0.84	98.0	F
Northbound Through Lanes	0.80	41.6	D	0.58	34.9	C	0.50	33.1	C
Eastbound Approach	0.75	60.2	E	0.63	55.2	E	0.64	56.1	E
Westbound Left Turn	0.10	52.7	D	0.08	52.4	D	0.04	56.3	E
Westbound Through	0.66	63.7	E	0.36	56.3	E	0.51	64.3	E
Westbound Right Turn	0.41	35.8	D	0.28	33.2	C	0.19	28.5	C
Overall Intersection	**0.71**	**48.1**	**D**	**0.61**	**47.1**	**D**	**0.64**	**46.6**	**D**

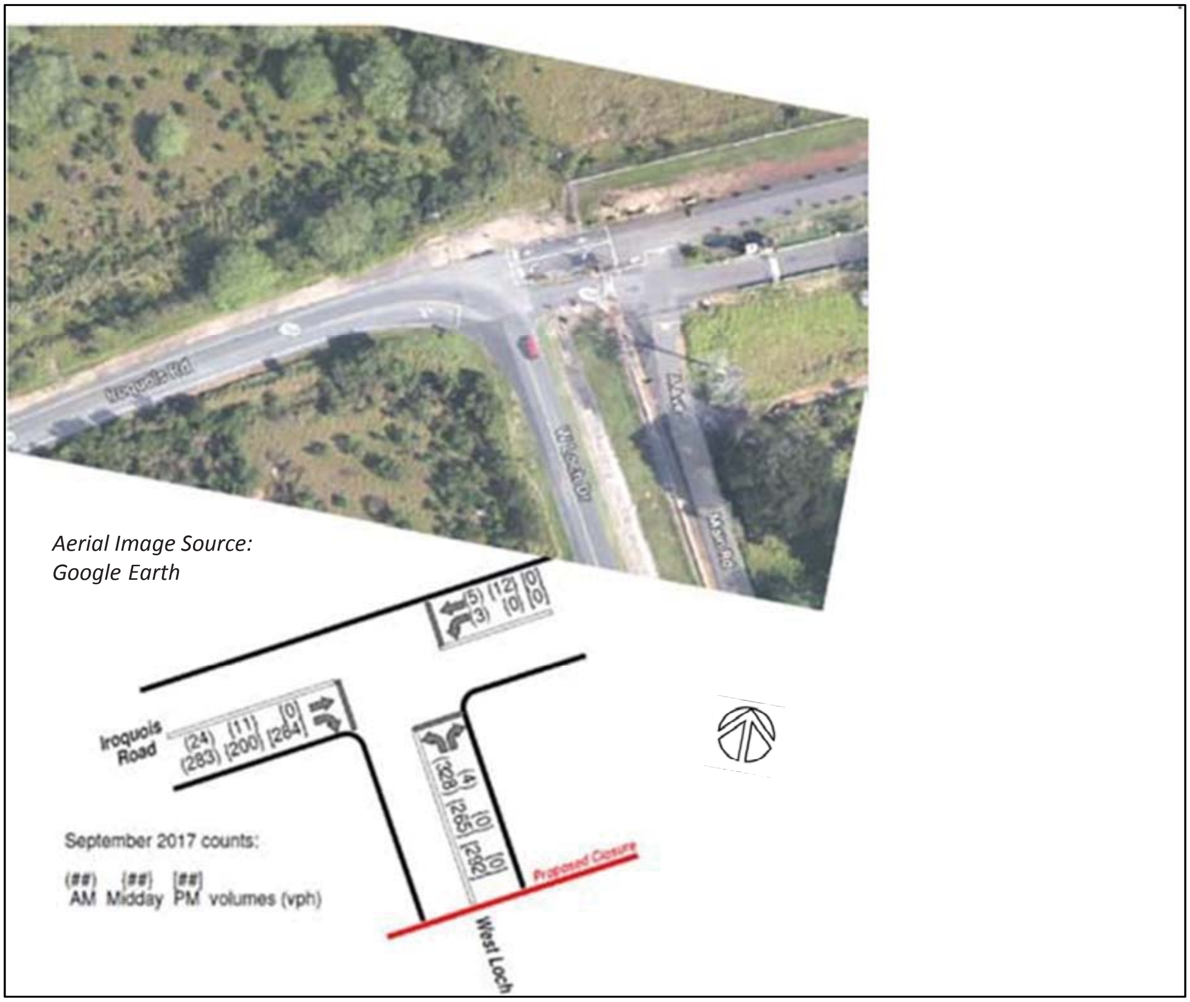
X = Utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

2.2 Intersection 2: Iroquois Road and West Loch Drive

This T-intersection has three legs: a west, a south, and an east leg. The eastbound approach and the northbound approach both have single lanes controlled by a stop sign. The westbound approach, which is also stopped, is the exit from the back gate of West Loch Annex. It consists of two lanes, one for through traffic and one for left turn traffic.

No designated bicycle or pedestrian facilities are located at this intersection, and no scheduled bus service passes through the intersection.

Figure 4 includes an aerial image of the intersection, and an intersection diagram shows peak hour volumes from manual counts collected on Tuesday, September 12, 2017. Three peak hours were identified: A.M. (0700-0800 hours), M.M. (Midday 1415-1515 hours), and P.M. (1600-1700 hours). As indicated in the figure, if the road closure had been in place when the counts were taken, 618 vehicles in the A.M. peak hour and 576 vehicles in the P.M. peak hour would have used other roadways. The results of the intersection analyses are shown in Table 3.



Aerial Image Source:
Google Earth

Figure 4 – Intersection 2, Iroquois Road and West Loch Drive

Table 3 – Intersection 2
Existing Conditions, Iroquois Road and West Loch Drive

Lane/Turn	A.M. Peak Hour			M.M. Peak Hour			P.M. Peak Hour		
	X	Delay	LOS	X	Delay	LOS	X	Delay	LOS
Northbound Approach	0.38	10.8	B	0.31	10.2	B	0.33	10.3	B
Eastbound Approach	0.31	9.7	A	0.22	9.2	A	0.31	9.8	A
Westbound Left Turn Lane	0.01	11.8	B	---	---	---	0.00	---	---
Westbound Through Lane	0.01	9.0	A	0.02	9.1	A	0.00	---	---

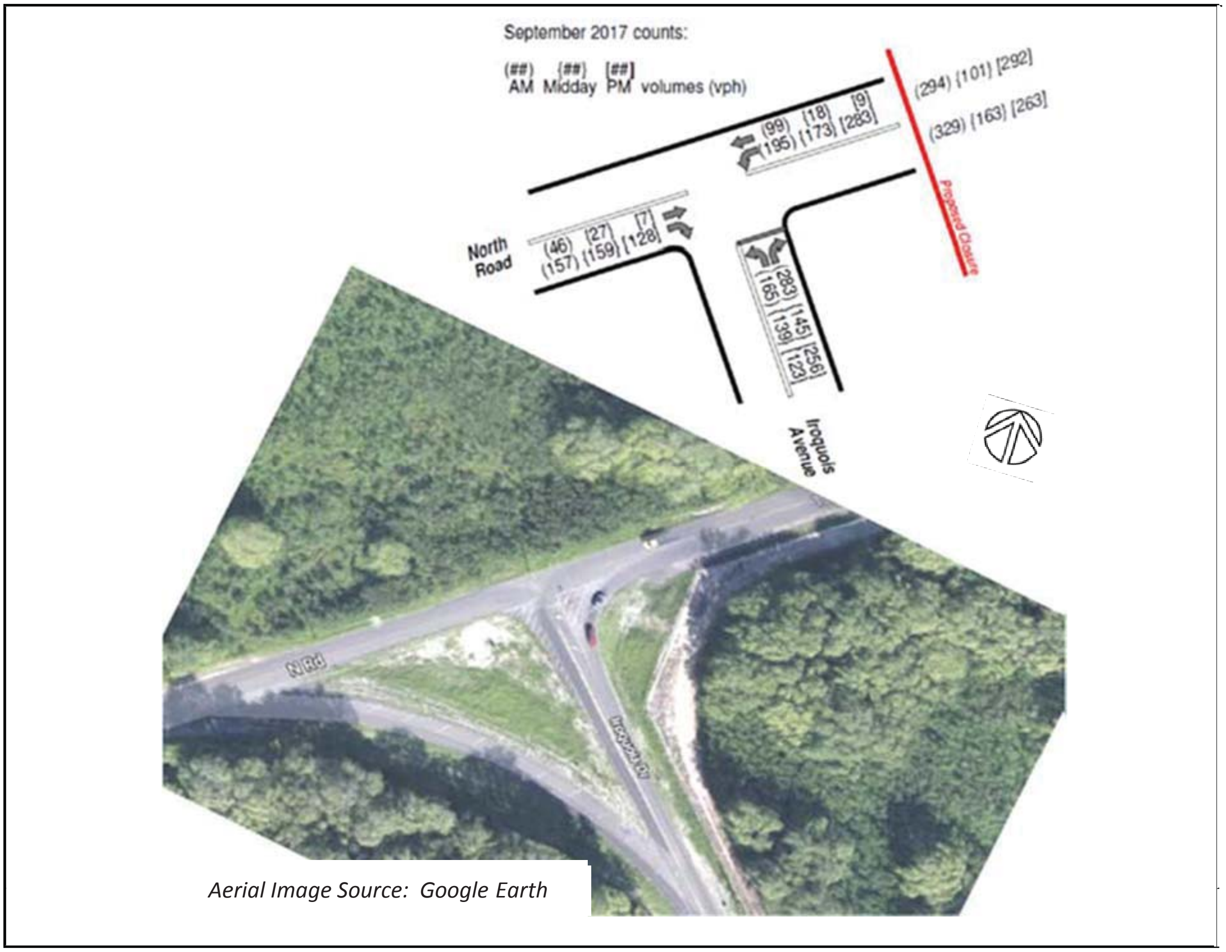
X = Utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service
Note: Delay and LOS not shown where volume = 0

2.3 Intersection 3: North Road and Iroquois Avenue

This T-intersection has three legs: a west, a south, and an east leg. The northbound approach on Iroquois Avenue has separate lanes for left and right turns and is controlled by a stop sign. Eastbound right turns from North Road are channelized, and North Road across the intersection consists of single lanes in each direction, with westbound left turns yielding to any eastbound through traffic.

No designated pedestrian facilities are located at this intersection. No scheduled bus service passes through the intersection.

Figure 5 includes an aerial image of the intersection, and an intersection diagram shows peak hour volumes from manual counts collected on Thursday, September 7, 2017. Three peak hours were identified: A.M. (0700-0800 hours), M.M. (Midday 1345-1445 hours), and P.M. (1600-1700 hours). As indicated in the figure, if the road closure had been in place when the counts were taken, 623 vehicles in the A.M. peak hour and 555 vehicles in the P.M. peak hour would have used other roadways. The results of the intersection analyses are shown in Table 4.



Aerial Image Source: Google Earth

Figure 5 – Intersection 3, North Road and Iroquois Avenue

Table 4 – Intersection 3
Existing Conditions, North Road and Iroquois Avenue

Lane/Turn	A.M. Peak Hour			M.M. Peak Hour			P.M. Peak Hour		
	X	Delay	LOS	X	Delay	LOS	X	Delay	LOS
Northbound Left Turn	0.49	22.6	C	0.41	18.0	C	0.43	22.8	C
Northbound Right Turn	0.33	10.2	B	0.19	9.3	A	0.29	9.7	A
Westbound Left Turns	0.17	8.2	A	0.18	8.3	A	0.24	8.3	A

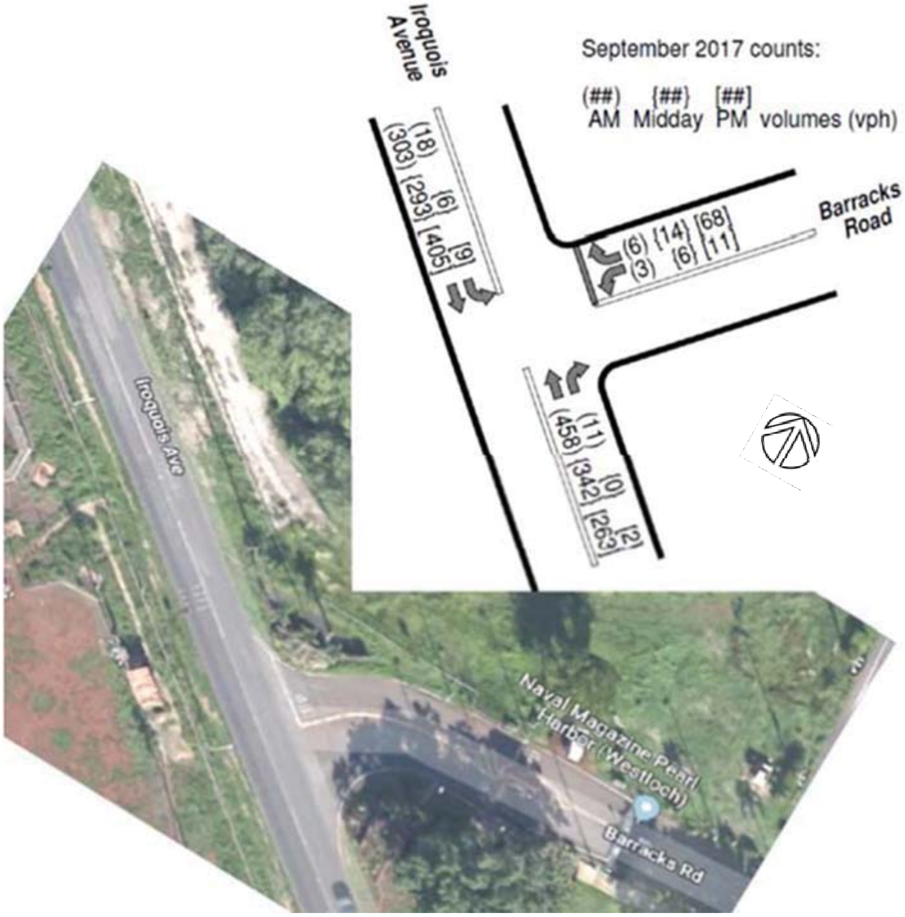
X = Utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

2.4 Intersection 4: Iroquois Avenue and Barracks Road

This T-intersection has three legs: a north, an east, and a south leg. The single-lane westbound approach on Barracks Road is the exit from the West Loch Annex front gate, and traffic is controlled by a stop sign. North-south Iroquois Avenue consists of a single lane in each direction, with southbound left turns yielding to any northbound through traffic.

No designated bicycle or pedestrian facilities are located at this intersection. No scheduled bus service passes through the intersection.

Figure 6 includes an aerial image of the intersection, and an intersection diagram shows peak hour volumes from manual counts collected on Tuesday, September 26, 2017. Three peak hours were identified: A.M. (0700-0800 hours), M.M. (Midday 1400-1500 hours), and P.M. (1600-1700 hours). The results of the intersection analyses are shown in Table 5.



Aerial Image Source: Google Earth

Figure 6 – Intersection 4, Iroquois Avenue and Barracks Road

Table 5 – Intersection 4
Existing Conditions, Iroquois Avenue and Barracks Road

Lane/Turn	A.M. Peak Hour			M.M. Peak Hour			P.M. Peak Hour		
	X	Delay	LOS	X	Delay	LOS	X	Delay	LOS
Westbound Approach	0.03	14.6	B	0.04	12.2	B	0.14	11.5	B
Southbound Left Turns	0.02	8.6	A	0.01	8.1	A	0.01	7.8	A

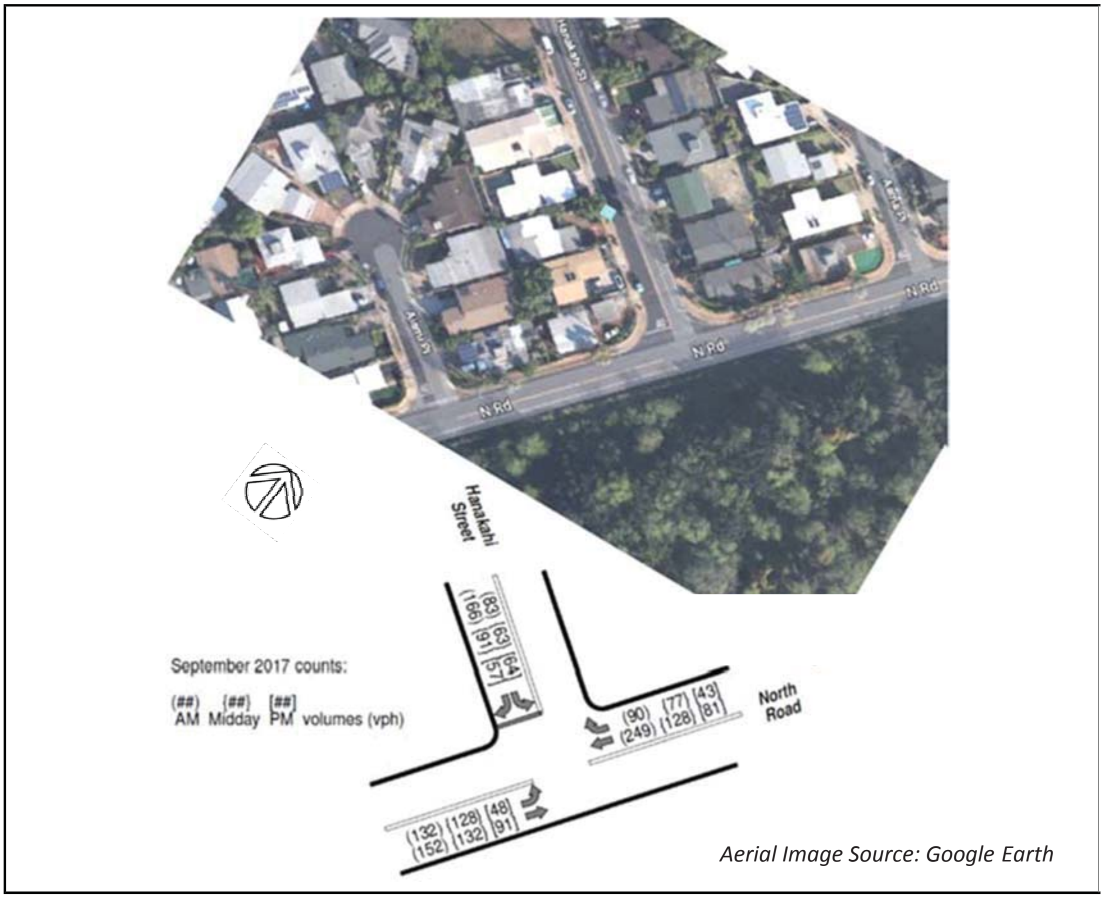
X = Utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

2.5 Intersection 5: North Road and Hanakahi Street

This T-intersection has three legs: a west, a north, and an east leg. The southbound approach on Hanakahi Street is controlled by a stop sign. While it has sufficient width so that right turns should not be impeded by vehicles waiting to make left turns, a car parked near the stop sign would preclude consideration of the approach as having two lanes. East-west North Road consists of single lanes in each direction, with eastbound left turns yielding to any westbound traffic.

Sidewalks are provided along the north side of North Road and on both sides of Hanakahi Street. None of the pedestrian crossings at the intersection are marked crosswalks, and there are no curb ramps. No designated bicycle facilities are located at this intersection. A bus stop is located approximately 150 feet north of the intersection on Hanakahi Street for buses that travel southbound before making a right turn onto North Road. This bus stop is served by the City's TheBus Routes E and 42, each route having 2 buses per hour during the day on weekdays, with reduced service in the evenings and on weekends. Supplemental service is also provided by Route 91 during peak hours (about 3 additional buses per hour in the peak direction between 0420 and 0710 hours and between 1615 and 1905 hours). Bus service at this stop is available between 0500 and 0100 hours (all times approximate).

Figure 7 includes an aerial image of the intersection, and an intersection diagram shows peak hour volumes from manual counts collected on Tuesday, September 12, 2017. Three peak hours were identified: A.M. (0700-0800 hours), M.M. (Midday 1400-1500 hours), and P.M. (1600-1700 hours). The results of the intersection analyses are shown in Table 6.



Aerial Image Source: Google Earth

Figure 7 – Intersection 5, North Road and Hanakahi Street

Table 6 – Intersection 5
Existing Conditions, North Road and Hanakahi Street

Lane/Turn	A.M. Peak Hour			M.M. Peak Hour			P.M. Peak Hour		
	X	Delay	LOS	X	Delay	LOS	X	Delay	LOS
Southbound Approach	0.59	22.7	C	0.44	18.1	C	0.18	10.9	B
Eastbound Left Turns	0.13	8.5	A	0.14	8.3	A	0.04	7.6	A

X = Utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

2.6 Intersection 6: Hanakahi Street and Kuhina Street

This is a cross- or X-intersection. The northbound and southbound approaches on Hanakahi Street are controlled by stop signs. Kuhina Street consists of single lanes in each direction, with any left turns yielding to opposing through traffic.

Paved sidewalk exists only on the southwest corner and the west side of the north approach of Hanakahi Street; pedestrian crossings are unmarked. No designated bicycle facilities are located at this intersection. A bus stop is located on Hanakahi Street approximately 130 feet south of the intersection for buses turning right from eastbound Kuhina Street and traveling in the southbound direction. This bus stop is served by the City's TheBus Routes E and 42, each route having 2 buses per hour during the day on weekdays, with reduced service in the evenings and on weekends. Supplemental service is also provided by Route 91 during peak hours (about 3 additional buses per hour in the peak direction between 0420 and 0710 hours and between 1615 and 1905 hours). Bus service at this stop is available between 0500 and 0100 hours (all times approximate).

Figure 8 includes an aerial image of the intersection and an intersection diagram that shows peak hour volumes from manual counts collected on Tuesday, September 19, 2017. Three peak hours were identified: A.M. (0700-0800 hours), M.M. (Midday 1415-1515 hours), and P.M. (1600-1700 hours). The results of the intersection analyses are shown in Table 7.

Aerial Image Source: Google Earth

Figure 8 – Intersection 6, Hanakahi Street and Kuhina Street

Table 7 – Intersection 6
Existing Conditions, Hanakahi Street and Kuhina Street

Lane	A.M. Peak Hour			M.M. Peak Hour			P.M. Peak Hour		
	X	Delay	LOS	X	Delay	LOS	X	Delay	LOS
Southbound Approach	0.51	15.2	C	0.44	13.8	B	0.46	13.9	B
Northbound Approach	0.86	35.9	E	0.60	17.8	C	0.48	14.8	B

X = utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

2.7 Intersection 7: Fort Weaver Road and Hanakahi Street

Each approach to this intersection on Fort Weaver Road consists of a single left turn lane, two through lanes, and a separate right turn lane. The westbound Hanakahi Street approach is a single lane with a short right turn lane, but due to low volumes of left turns and through movements, queued vehicles waiting for the traffic signal did not block right turns from proceeding when eastbound or northbound traffic is stopped. The eastbound approach (Keoneula Boulevard) has three lanes: a left turn only lane, an option lane for left turns and through movements, and a right turn only lane.

Paved sidewalks or roadway shoulders are provided for pedestrian use on both sides of the roadways near the intersection. Crosswalks are striped across the west, south, and east legs of the intersection.

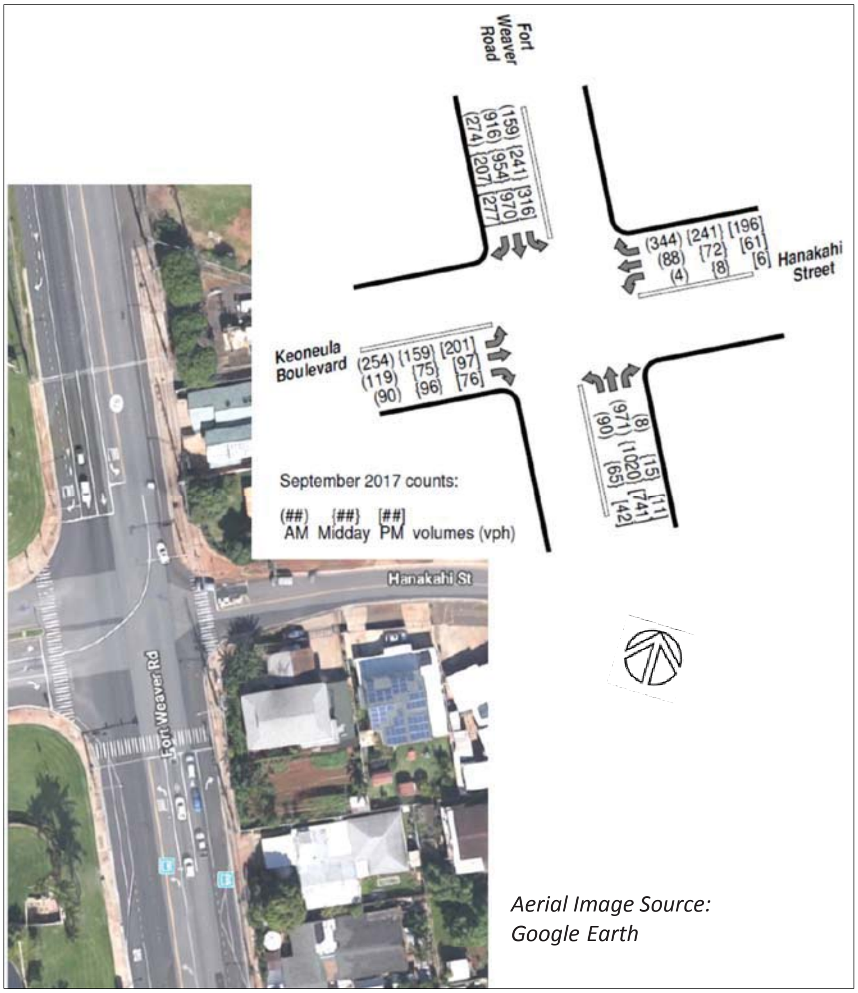
The shoulders on Fort Weaver Road serve as bicycle lanes; bicyclists traveling in both directions were observed in the shoulder and sidewalk areas along Fort Weaver Road.

Bus turnouts are located off of both the northbound and southbound lanes Fort Weaver Road and approximately 200 feet south of the intersection. These stops are served by the City's TheBus Routes E and 42, each route having 2 buses per hour during the day on weekdays, with reduced service in the evenings and on weekends. Supplemental service is also provided by Route 91 during peak hours (about 3 additional buses per hour in the peak directions: northbound between 0420 and 0710 hours and southbound between 1615 and 1905 hours). Bus service at these stops is available between 0400 and 0100 hours northbound and 0515 and 0245 hours southbound (all times approximate).

The intersection is controlled by a traffic signal that operates in six phases. The Keoneula Boulevard eastbound approach and the Hanakahi Street westbound approach each have a green light on separate phases, followed by protected (i.e., unopposed) left turn phases for the Fort Weaver Road approaches. Through traffic phases on Fort Weaver Road are displayed after the end of the opposing left turn phases. Southbound left turns are also permitted during the northbound through phase during any gaps in the opposing traffic. Pedestrian phases coincide with the through phases in the adjacent parallel lanes. The left turn and minor street phases occur after detection of vehicles in the lanes or pedestrian actuation of call buttons.

Figure 9 includes an aerial image of the intersection, and an intersection diagram shows peak hour volumes from manual counts collected on Tuesday, September 19, 2017. Three peak hours were identified: A.M. (0700-0800 hours), M.M. (Midday 1400-1500 hours), and P.M. (1530-1630 hours). The results of the intersection analyses are shown in Table 8.

The intersection analysis of existing volumes shows that the intersection is already operating very near capacity in the A.M. peak hour, with the southbound left turn lane, northbound through lanes, the eastbound left and through lanes, and the westbound right turns at 96 percent (or higher) of capacity. Long delays also occur for many movements during the other peak hours, despite lower utilization, due to the long cycle lengths needed to serve traffic volumes through this intersection. (The wide intersection, including long pedestrian crossings and setbacks for left turn lanes, as well as the high traffic demand, contribute to the need for long signal cycles.)



Aerial Image Source: Google Earth

Figure 9 – Intersection 7, Fort Weaver Road and Hanakahi Street / Keoneula Boulevard

Table 8 – Intersection 7 Existing Conditions, Fort Weaver Road and Hanakahi Street / Keoneula Boulevard									
Lane/Turn	**A.M. Peak Hour**			**M.M. Peak Hour**			**P.M. Peak Hour**		
	X	Delay	LOS	X	Delay	LOS	X	Delay	LOS
Southbound Left Turn	0.62	77.6	E	0.96	109.6	F	0.75	61.8	E
Southbound Through Lanes	0.53	34.5	C	0.58	35.3	D	0.57	33.3	C
Northbound Left Turn	0.74	110.0	F	0.46	78.3	E	0.40	77.7	E
Northbound Through Lanes	0.85	58.1	E	0.90	58.8	E	0.97	81.5	F
Eastbound Left & Through	0.63	74.8	E	0.34	55.1	E	0.39	51.1	D
Eastbound Right Turn	0.32	64.8	E	0.29	54.2	E	0.21	47.5	D
Westbound Left & Through	0.44	76.8	E	0.41	70.4	E	0.31	62.2	E
Westbound Right Turn	0.69	57.3	E	0.50	46.8	D	0.29	28.5	C
Overall Intersection	**0.74**	**54.2**	**D**	**0.68**	**53.0**	**D**	**0.62**	**51.1**	**D**

X = Utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

3 Effects of Closing West Loch Drive (No Mitigation)

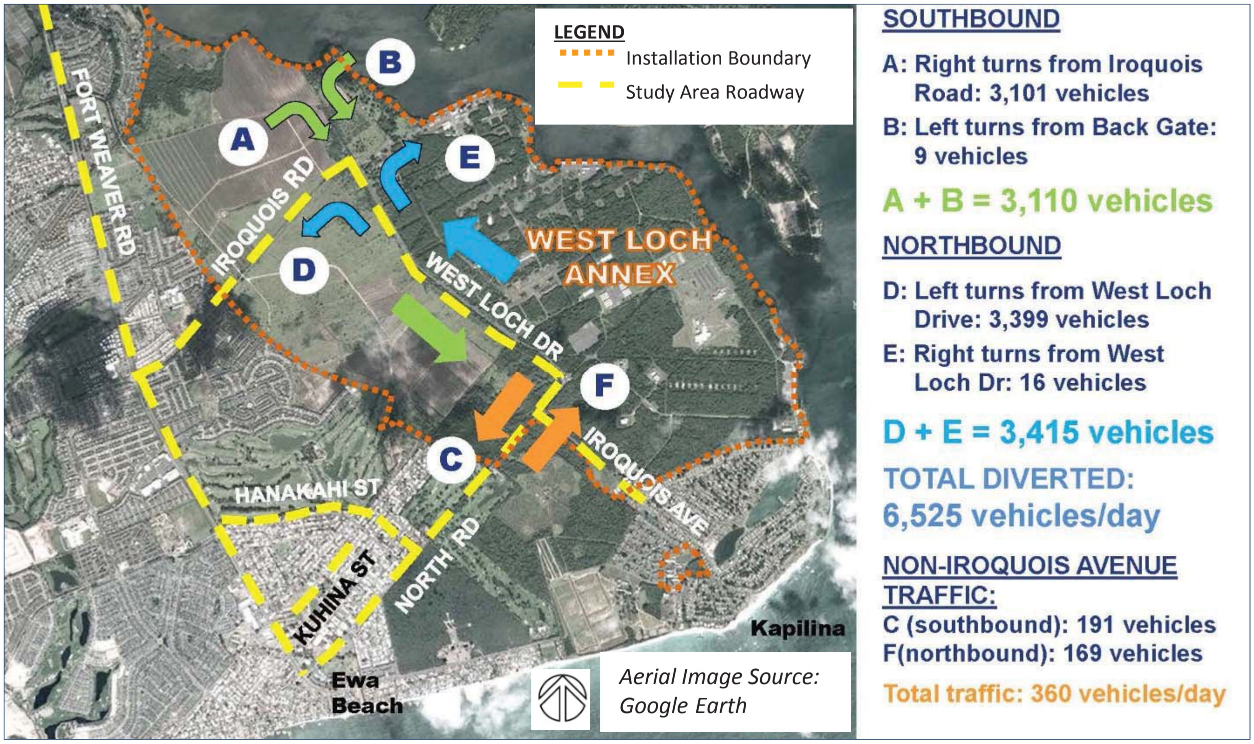
The closure of West Loch Drive, assuming no mitigation measures are taken, would result in traffic diversion onto parallel roadways. The diverted traffic would include not only traffic originating from or destined to the West Loch Annex front gate and Kapilina but also traffic traveling between Iroquois Road and North Road. In Table 9, Columns A + B and D + E show the traffic volumes that would be diverted; columns C and F show the counts of vehicles that would not use Iroquois Avenue (i.e., would not go to or come from West Loch Annex front gate or Kapilina).

Table 9 – Traffic on West Loch Drive

Time Period/Movement	Southbound Vehicles				Northbound Vehicles			
	A*	B*	A + B	C*	D*	E*	D + E	F*
0000 – 0100 hours	26	0	26	0	6	0	6	0
0100 – 0200 hours	16	0	16	0	12	0	12	0
0200 – 0300 hours	10	0	10	0	9	0	9	1
0300 – 0400 hours	7	0	7	0	16	0	16	1
0400 – 0500 hours	65	0	65	1	175	0	175	0
0500 – 0600 hours	90	0	90	1	325	0	325	6
0600 – 0700 hours	110	0	110	3	302	3	305	15
0700 – 0800 hours	283	3	286	99	328	4	332	46
0800 – 0900 hours	112	0	112	14	229	0	229	11
0900 – 1000 hours	76	1	77	3	171	5	176	3
1000 – 1100 hours	92	1	93	6	138	2	140	4
1100 – 1200 hours	96	0	96	5	148	0	148	2
1200 – 1300 hours	120	1	121	0	116	0	116	1
1300 – 1400 hours	167	1	168	5	119	2	121	5
1400 – 1500 hours	180	0	180	21	263	0	263	28
1500 – 1600 hours	223	2	225	6	189	0	189	10
1600 – 1700 hours	284	0	284	9	292	0	292	7
1700 – 1800 hours	306	0	306	3	152	0	152	7
1800 – 1900 hours	256	0	256	3	144	0	144	8
1900 – 2000 hours	220	0	220	2	83	0	83	4
2000 – 2100 hours	121	0	121	2	77	0	77	4
2100 – 2200 hours	117	0	117	4	48	0	48	1
2200 – 2300 hours	75	0	75	1	32	0	32	2
2300 – 2400 hours	49	0	49	3	25	0	25	3
24-hour Total	**3,101**	**9**	**3,110**	**191**	**3,399**	**16**	**3,415**	**169**

*Note: From manual counts: Movements A, B, D, & E taken 12 September 2017, C & F taken 6 & 7 September 2017

A = Right turns from Iroquois Road to West Loch Drive
B = Left turns from West Loch Annex back gate to West Loch Drive
C = Though movements southwest direction on North Road across Iroquois Avenue
D =Left turns from West Loch Drive to Iroquois Road
E = Right turns from West Loch Drive to West Loch Annex back gate
F = Through movements northeast direction on North Road across Iroquois Avenue



SOUTHBOUND

A: Right turns from Iroquois Road: 3,101 vehicles

B: Left turns from Back Gate: 9 vehicles

A + B = 3,110 vehicles

NORTHBOUND

D: Left turns from West Loch Drive: 3,399 vehicles

E: Right turns from West Loch Dr: 16 vehicles

D + E = 3,415 vehicles

TOTAL DIVERTED: 6,525 vehicles/day

NON-IROQUOIS AVENUE TRAFFIC:

C (southbound): 191 vehicles

F(northbound): 169 vehicles

Total traffic: 360 vehicles/day

Aerial Image Source: Google Earth

Figure 10 – West Loch Drive Traffic Volume

Closure of West Loch Drive would divert 6,525 vehicles per day (vpd) onto other streets during a typical weekday (Figure 10). Of this volume, 360 vpd are using West Loch Drive but did not originate from or were not destined to West Loch Annex front gate or Kapilina and are apparently already avoiding other routes.

3.1 Alternative Routes for Diverted Traffic

With West Loch Drive closed, the most direct alternative route would include North Road between Iroquois Avenue and Hanakahi Street, Hanakahi Street between North Road and Fort Weaver Road, and Fort Weaver Road between Hanakahi Street and Iroquois Road. The increase in traffic volume on this segment of Fort Weaver Road would be nearly 19 percent of its estimated daily volume[3] in 2015.

If a large portion of this traffic were added to Hanakahi Street, traffic volume could be twice (or more) the existing traffic volume if not for the physical limitations of the street. In 2015, the State Highways Division estimated an annual daily traffic of 5,700 vpd[4] on Hanakahi Street north of its intersection with Kuhina Street based on two days of machine counts taken in December 2015 (data from the Traffic Survey reports show an average of two days of data volume of 6,313 vpd). The relative increase in traffic on Hanakahi Street would be greater near North Road, where the average daily volume was estimated to be 2,600 vpd[5] in 2015.

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[3] State of Hawaii Department of Transportation, Highways Division. *Traffic Survey Data 2015.* Report for Station B72007600258 shows an average annual daily traffic of 34,700 vpd, based on counts taken in September 2015, which averaged 36,820 vpd.

[4] State of Hawaii Department of Transportation, Highways Division. *Traffic Survey Data 2015.* Report for Station B72714400059.

[5] State of Hawaii Department of Transportation, Highways Division. *Traffic Survey Data 2015.* Report for Station B72714400088.

Realistically, however, the increase in traffic on Hanakahi Street would be limited. Physical constraints to the capacity of Hanakahi Street or of turn lanes at the Hanakahi Street-Fort Weaver Road intersection would limit the increases in traffic on Hanakahi Street during peak periods when these intersections are already near capacity, and this would result in increased traffic volumes on other streets.

Other existing alternative routes would be North Road between Hanakahi Street and Fort Weaver Road and Kilaha Street between North Road and Fort Weaver Road. Any increases in traffic on these streets would also be noticeable. Daily traffic volume on North Road between Kilaha Street and Kulana Place (fronting Campbell High School and the ʻEwa Community Park) was estimated to be 4,600 vpd[6] in 2015. Daily traffic volume on Fort Weaver Road near Kilaha Street was estimated to be 5,900 vpd[7] in 2015.

3.2 Potential Peak Hour Effects of Diverting Traffic

If West Loch Drive were closed, traffic currently using West Loch Drive would be diverted at the Fort Weaver Road Geiger Road / Iroquois Road intersection from the east leg to the south leg. For this study, an iterative process was used at other locations to reassign peak hour volumes of traffic currently using West Loch Drive onto alternative routes on existing roadways. Existing roadway geometry was maintained (i.e., no mitigation measures were taken), but road users were expected to adhere to existing on-street parking restrictions. While various reassignments would be expected to produce different results, one set of results is shown below to illustrate the potential effects of closing West Loch Drive without mitigation.

3.3 Intersection of Fort Weaver Road and Iroquois Road (Table 10)

The diversion of traffic at this intersection from the east leg (Iroquois Road) to the south leg (Fort Weaver Road) would affect turning movements. An increased number of left turns from northbound Fort Weaver Road to westbound Geiger Road and—the opposite move—the right turn from eastbound Geiger Road to southbound Fort Weaver Road would offset reductions in through movements between Iroquois Road and Geiger Road. Increased through movements on Fort Weaver Road would result from the reduction of turns to and from Iroquois Road. No changes, however, would be expected in the total volumes on either the west leg (Geiger Road) or the north leg of Fort Weaver Road.

Traffic volumes on Iroquois Road would be reduced, as access to the West Loch Annex front gate and to Kapilina would no longer be possible via Iroquois Road; this traffic would be added to the south leg of Fort Weaver Road. The existing West Loch Drive traffic that does not turn onto or from Iroquois Avenue (see columns C and F in Table 9) was assumed to be traveling between the Iroquois Road-Hoʻomaka Street intersection and the North Road-Hanakahi Street intersection; these flows were reassigned to a route along Iroquois Road, Fort Weaver Road, and Hanakahi Street.

While no changes were assumed in the physical layout of the intersection, adjustments to the signal timing were made to accommodate the changed traffic patterns and the peak hours were reanalyzed. Table 10 shows the results of the analyses.

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[6] State of Hawaii Department of Transportation, Highways Division. *Traffic Survey Data 2015.* Report for Station B72714500008.

[7] State of Hawaii Department of Transportation, Highways Division. *Traffic Survey Data 2015.* Report for Station B72007600099.

Table 10
Fort Weaver Road and Iroquois Road / Geiger Road (West Loch Drive Closed)

Lane/Turn	A.M. Peak Hour			M.M. Peak Hour			P.M. Peak Hour		
	X	Delay	LOS	X	Delay	LOS	X	Delay	LOS
Southbound Left Turn	0.48	70.9	E	0.65	79.4	E	0.46	59.0	E
Southbound Through Lanes	0.66	43.1	D	0.80	44.2	D	0.90	44.6	D
Northbound Left Turn	0.90	78.9	E	0.87	81.2	F	0.99	108.0	F
Northbound Through Lanes	0.81	39.0	D	0.58	31.7	C	0.56	34.4	C
Eastbound Approach	0.86	64.7	E	0.71	57.1	E	0.78	59.9	E
Westbound Left Turn	0.40	57.6	E	0.13	53.1	D	0.07	56.7	E
Westbound Through	0.29	55.3	E	0.20	53.9	D	0.07	56.5	E
Westbound Right Turn	0.22	38.9	D	0.18	38.4	D	0.02	26.1	C
Overall Intersection	**0.66**	**49.4**	**D**	**0.65**	**47.2**	**D**	**0.72**	**50.9**	**D**
(Compare with existing)	*0.71*	*48.1*	*D*	*0.61*	*47.1*	*D*	*0.64*	*46.6*	*D*

X = Utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

3.4 Eliminated or Unaffected Intersections

Two intersections would be eliminated with the closure of West Loch Drive. The public would no longer have access to the Iroquois Road and West Loch Drive intersection, and the stop controls would no longer be needed and could be removed (the reduction in speed limit on traffic approaching the gate, however, should remain in place). At the intersection of North Road and Iroquois Avenue, conflicting traffic on North Road would no longer affect traffic northbound traffic on Iroquois Avenue, and control of that intersection would no longer be needed.

Closure of West Loch Drive would not affect traffic volumes at the intersection of Iroquois Avenue and Barracks Drive, assuming existing front gate users do not alter their entry and exit to the back gate.

3.5 Intersection of North Road and Hanakahi Street (Table 11)

Increases in traffic volumes at this intersection during the peak hours coinciding with area school start and end times would make left turns from Hanakahi Street to North Road very difficult. During the midday (M.M.) peak hour, this intersection would constrain the potential increase in southbound volume on Hanakahi Street.

Table 11
North Road and Hanakahi Street (West Loch Drive Closed)

Lane/Turn	A.M. Peak Hour			M.M. Peak Hour			P.M. Peak Hour		
	X	Delay	LOS	X	Delay	LOS	X	Delay	LOS
Southbound Left Turns	0.80	96.1	F	1.00	115.8	F	0.73	33.1	D
Southbound Right Turns	0.37	16.1	C	0.07	10.7	B	0.10	10.3	B
Eastbound Left Turns	0.21	9.6	A	0.20	9.1	A	0.05	8.3	A

X = Utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

3.6 Intersection of Hanakahi Street and Kuhina Street (Table 12)

The increases in traffic on Hanakahi Street during the A.M. peak hour would be constrained by long delays and limited capacity for right turns at the Fort Weaver Road intersection. While not modeled, there could be additional left turns from northbound Hanakahi Street to Kuhina Street, since the northbound approach would still be under capacity. In the M.M. peak hour, small increases in traffic volumes would increase delays slightly, but levels of service would be unchanged. In the P.M. peak hour, capacity at this intersection would constrain the volume of northbound traffic diverted by closure of West Loch Drive.

Table 12
Hanakahi Street and Kuhina Street (West Loch Drive Closed)

Lane/Turn	A.M. Peak Hour			M.M. Peak Hour			P.M. Peak Hour		
	X	Delay	LOS	X	Delay	LOS	X	Delay	LOS
Southbound Approach	0.52	15.4	C	0.46	14.2	B	0.83	29.5	D
Northbound Approach	0.88	38.1	E	0.75	23.7	C	1.00	63.6	F

X = Utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

3.7 Intersection of Fort Weaver Road and Hanakahi Street (Table 13)

Traffic diverted by closure of West Loch Drive would pass through this intersection, and traffic that now travels northbound would either be additional westbound right turns from Hanakahi Street or additional northbound through traffic on Fort Weaver Road. Both of these lane groups were found to have long delays or be near capacity in the analysis of existing conditions, and all iterations of traffic reassignment resulted in Level of Service E conditions at this intersection in the A.M. peak hour. The results of the analyses of one reassignment are shown in Table 13. Increased volumes in the M.M. and P.M. peak hours would increase average delay slightly, but overall delays at the intersection would remain at LOS D.

Table 13
Fort Weaver Road and Hanakahi Street / Keoneula Boulevard (West Loch Drive Closed)

Lane/Turn	**A.M. Peak Hour**			**M.M. Peak Hour**			**P.M. Peak Hour**		
	X	Delay	LOS	X	Delay	LOS	X	Delay	LOS
Southbound Left Turn	0.98	138.9	F	0.97	112.2	F	0.99	101.9	F
Southbound Through Lanes	0.70	39.5	D	0.62	31.5	D	0.62	31.5	C
Northbound Left Turn	0.74	110.0	F	0.69	105.4	E	0.43	84.7	F
Northbound Through Lanes	0.99	70.8	E	0.94	63.2	E	0.95	73.7	E
Eastbound Left & Through	0.63	74.8	E	0.34	55.1	E	0.41	56.9	E
Eastbound Right Turn	0.32	64.8	E	0.29	54.2	D	0.22	52.7	D
Westbound Left & Through	0.44	76.8	E	0.49	76.5	E	0.39	72.8	E
Westbound Right Turn	0.85	78.0	E	0.70	56.3	E	0.43	38.1	D
Overall Intersection	**0.87**	**63.3**	**E**	**0.72**	**53.8**	**D**	**0.73**	**54.5**	**D**
(Compare with existing)	*0.74*	*54.2*	*D*	*0.68*	*53.0*	*D*	*0.62*	*51.1*	*D*

X = Utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

3.8 Other Intersections Affected by Diverted Traffic (Tables 14-17)

The traffic assignment used for the results presented thus far included diverting some traffic through the intersections of North Road and Kilaha Street and Kilaha Street and Fort Weaver Road as well as increased volumes at the Fort Weaver Road intersections with North Road and with Aikanaka Road.

Conditions at these intersections were checked to verify whether they would be able to handle the added traffic. While traffic counts were not conducted at these intersections, manual counts taken in September 2016 at two of the intersections were used to develop peak hour traffic estimates. The results of the analyses shown in Tables 14, 15, 16, and 17 indicate that conditions at these intersections would have adequate capacity for peak hour traffic.

Left turns and through movements, which were assumed to share a lane on the stop-controlled northbound approach of Kilaha Street at North Road, were found to have over 50 seconds of delay (threshold between LOS E and LOS F at an unsignalized intersection) in the A.M. peak traffic hour. These findings are not unusual for this type of movement; observed driver behavior in these situations often result in less delay when drivers of vehicles with the right-of-way yield to those waiting at the stop sign.

Table 14
North Road and Kilaha Street (West Loch Drive Closed)

Lane/Turn	**A.M. Peak Hour**			**M.M. Peak Hour**			**P.M. Peak Hour**		
	X	Delay	LOS	X	Delay	LOS	X	Delay	LOS
Westbound Left Turns	0.04	8.6	A	0.16	8.7	A	0.05	8.0	A
Northbound Left Turns/Through	0.57	80.9	F	0.11	24.2	C	0.06	15.1	C
Northbound Right Turns	0.29	12.8	B	0.12	11.2	A	0.09	10.2	B

X = Utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

Table 15
Fort Weaver Road and Kilaha Street (West Loch Drive Closed)

Lane/Turn	A.M. Peak Hour			M.M. Peak Hour			P.M. Peak Hour		
	X	Delay	LOS	X	Delay	LOS	X	Delay	LOS
Westbound Left Turns	0.15	8.4	A	0.06	7.7	A	0.09	7.8	A
Southbound Approach	0.39	12.1	B	0.07	9.4	A	0.09	9.6	A
Northbound Approach	0.07	20.6	C	0.02	12.4	B	0.04	14.5	B

X = Utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

Table 16
Fort Weaver Road and North Road / Kimopelekane Street (West Loch Drive Closed)

Lane/Turn	A.M. Peak Hour			M.M. Peak Hour			P.M. Peak Hour		
	X	Delay	LOS	X	Delay	LOS	X	Delay	LOS
Southbound Left Turn	0.98	62.7	E	0.75	35.5	D	0.54	28.1	C
Southbound Through Lanes	0.11	11.2	B	0.13	11.3	B	0.13	11.4	B
Northbound Left Turn	0.02	50.8	D	0.01	50.5	D	0.00	50.4	D
Northbound Through Lanes	0.53	42.0	D	0.24	37.8	D	0.22	37.6	D
Eastbound Approach	0.24	37.2	D	0.09	34.9	C	0.07	34.6	C
Westbound Left & Through	0.07	34.8	C	0.14	35.8	D	0.06	34.6	C
Westbound Right Turn	0.74	14.2	B	0.45	8.0	A	0.29	6.4	A
Overall Intersection	**0.70**	**34.6**	**C**	**0.47**	**23.0**	**C**	**0.35**	**20.5**	**C**

X = Utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

Table 17
Fort Weaver Road and Aikanaka Road (West Loch Drive Closed)

Lane/Turn	A.M. Peak Hour			M.M. Peak Hour			P.M. Peak Hour		
	X	Delay	LOS	X	Delay	LOS	X	Delay	LOS
Southbound Left Turn	0.78	60.7	E	0.37	43.8	D	0.27	41.7	D
Southbound Through Lanes	0.47	20.4	C	0.43	19.7	B	0.30	18.1	B
Northbound Left Turn	0.06	51.5	D	0.11	52.5	D	0.02	50.8	D
Northbound Through Lanes	0.86	41.0	D	0.54	30.7	C	0.33	27.4	C
Eastbound Approach	0.36	32.2	C	0.06	27.4	C	0.02	26.9	C
Westbound Approach	0.70	42.4	D	0.63	39.6	D	0.29	30.9	C
Overall Intersection	**0.82**	**35.4**	**D**	**0.56**	**28.4**	**C**	**0.32**	**24.5**	**C**

X = Utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

For comparison purposes, analyses[8] of the Fort Weaver Road and North Road / Kimopelekane Street intersection without closure of West Loch Drive had average overall delays of 24.2 seconds in the A.M. peak hour, 20.1 seconds in the M.M. peak hour, and 19.9 seconds in the P.M. peak hour, and the analyses of the Fort Weaver Road and Aikanaka Road intersection without closure of West Loch Drive had average overall delays of 32.7 seconds in the A.M. peak hour, 28.3 seconds in the M.M. peak hour, and 24.4 seconds in the P.M. peak hour.

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[8] Tables 2 and 3 in the report *Classroom Addition at James Campbell High School Traffic Impact Analysis Report* (April 2017) showed slightly different results due to use of different software. Although results were slightly different, one of the premises of that traffic study was that the classroom project itself would not change traffic volumes and would not cause additional delay.

4 Alternative 1: Bypass Road

To mitigate the closure of West Loch Drive, Alternative 1 considers the effects of constructing a new access road for public use that would bypass the existing communities and, in effect, provide a replacement roadway in the same general vicinity. Several alignments may be possible while also considering safety issues associated with existing and future ordnance storage at West Loch Annex.

One potential alignment for the bypass road would be within a 100-foot-wide buffer area between the West Loch Annex western installation boundary and the lease boundary for a photovoltaic (PV) farm (see Alternative 1 concept plan in Appendix G). While the buffer was intended for a security fence and a security patrol road, there may sufficient space to also accommodate the bypass road. Figure 11 illustrates a potential typical cross-section.

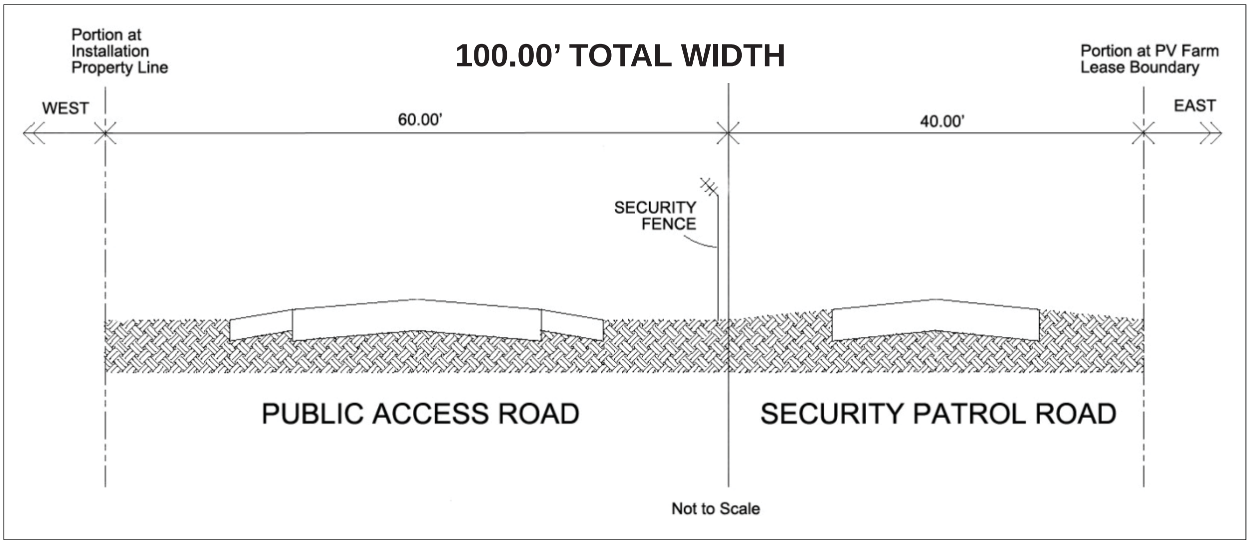


Figure 11 – Typical Section of Alternative 1 Bypass Road

The bypass road would create two new T-intersections: a northern intersection with Iroquois Road and a southern intersection with North Road. At the Iroquois Road intersection, the reassigned volumes would be similar to the existing volume at the Iroquois Road-West Loch Drive intersection. Assuming similar stop controls as the existing controls at the Iroquois Road-West Loch Drive intersection, delays and levels of service would be the same as existing (as shown in Table 3). At the North Road intersection, traffic volumes would be similar to existing volumes at the Iroquois Avenue-North Road intersection, except that the left turns now being made from North Road to Iroquois Avenue would become left turns from the new road to North Road, with the complementary right turns also being changed.

Depending on field conditions, a bypass road alignment further east of the installation boundary could result in a cross-intersection with North Road and Iroquois Avenue (Figure 12). In this case, traffic volumes at a modified unsignalized intersection of Iroquois Avenue and North Road would be slightly different from existing. Figure 13 illustrates the peak hour traffic volumes for these two intersection scenarios. It should be noted, however, that the eastern alignment could limit future development at West Loch Annex.

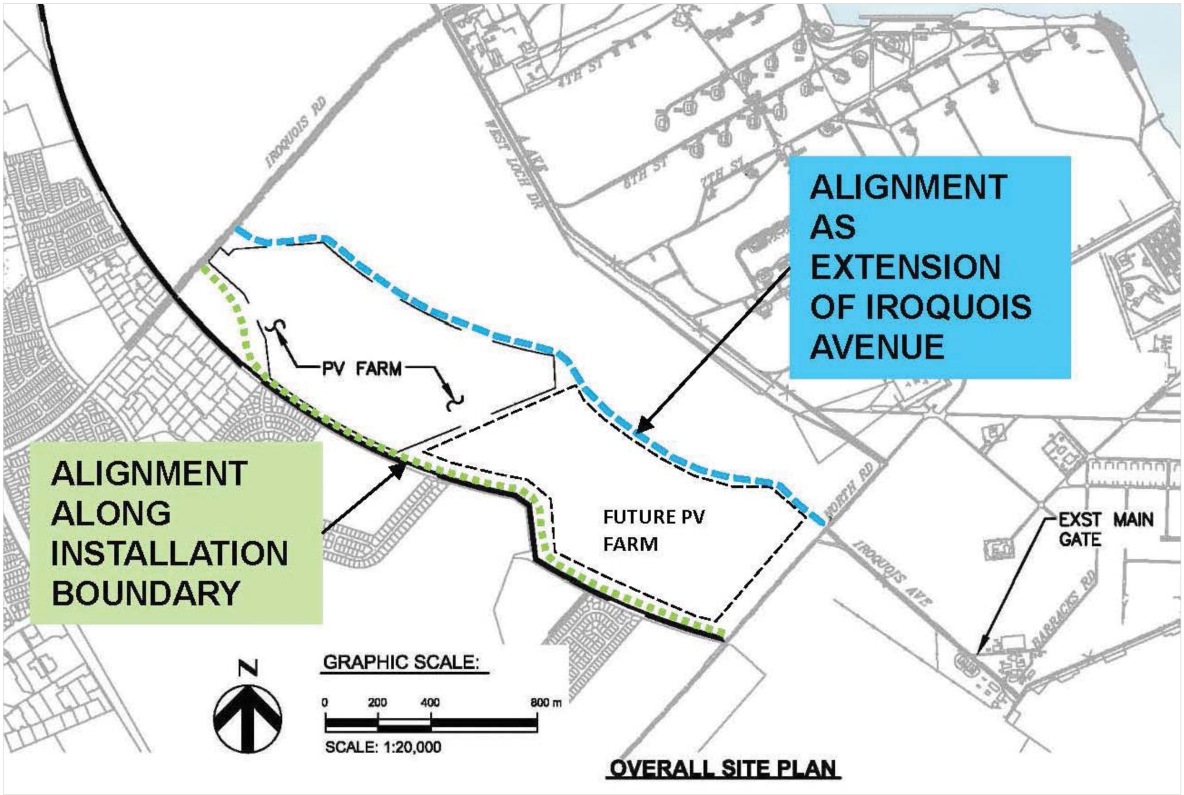
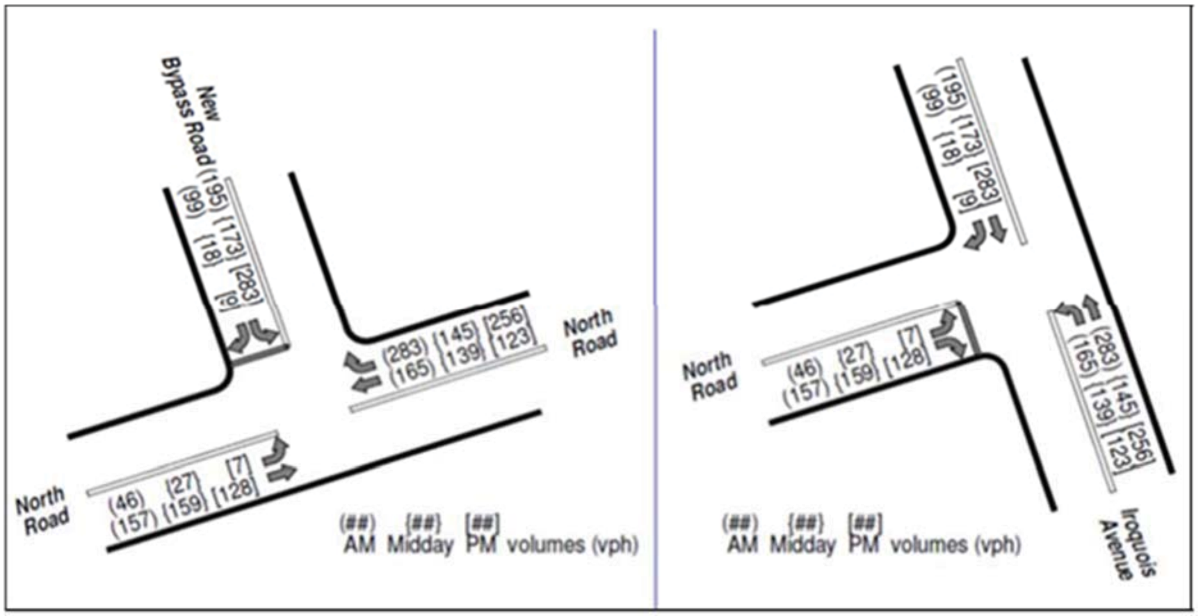


Figure 12 – Potential Alignments for Alternative 1 Bypass Road



Bypass Road along Installation Boundary

Bypass Road as Extension of Iroquois Avenue

Figure 13 – Traffic Assignments for Potential Bypass Road-North Road Intersections

Table 18 shows the results of the unsignalized intersection analyses and documents that sufficient capacities are available with either scenario, assuming a two-lane through roadway and side street traffic approaching on the stem of the T-intersection in a shared lane with stop control. In the case of a bypass road along the installation boundary, LOS D or better conditions could be achieved if separate turn lanes are provided on the bypass road approach to North Road.

Table 18
North Road and Iroquois Avenue, Alternative 1 Variations

Lane/Turn	A.M. Peak Hour			M.M. Peak Hour			P.M. Peak Hour		
	X	Delay	LOS	X	Delay	LOS	X	Delay	LOS
Bypass Road along Installation Boundary									
Southbound:									
• If Shared Lane	0.77	35.3	E	0.57	23.3	C	0.71	27.6	D
• If Separate Left Turn Lane	0.60	27.7	D	0.54	22.8	C	0.69	26.9	D
• If Separate Right and Left Turn Lanes	0.17	11.3	B	0.03	9.9	A	0.01	10.0	A
Eastbound Left Turn	0.05	8.6	A	0.03	8.1	A	0.01	8.3	A
Bypass Road as Extension of Iroquois Avenue									
Eastbound Shared Lane	0.49	19.4	C	0.39	14.2	B	0.26	12.7	B
Northbound Left Turn	0.16	8.5	A	0.14	8.2	A	0.12	8.4	A

X = Utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

The traffic volumes on a bypass roadway would be expected to be similar to traffic volumes counted on West Loch Drive as shown in Table 9 column A + B (southbound toward North Road) and column D + E (northbound toward Iroquois Road). Current travel time between the Iroquois Avenue/North Road intersection and the Iroquois Road/Fort Weaver Road intersection is estimated to be 6 minutes using West Loch Drive. Travel time on an Alternative 1 bypass road is not expected to increase.

Current travel time between these two intersections using Hanakahi Street is 7 minutes, with delays of up to 3 minutes during peak hours. If North Road (in the vicinity of Campbell High School) is used between these two intersections, current travel time is between 8 and 20 minutes. In the future, if traffic is diverted from West Loch Drive (due to road closure), these travel times are expected to increase during peak traffic periods.

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5 Alternative 2: Extend Fort Weaver Road to Kapilina

Alternative 2 considers the effects of constructing a roadway for public access between Kapilina and the southern end of Fort Weaver Road to serve traffic affected by closure of West Loch Drive (see Appendix G). For the purpose of evaluating any effects on Fort Weaver Road, the volumes shown in Table 9 (for West Loch Drive in columns A + B and D + E) would show the potential increase in traffic volumes; these increases would apply for the segment of Fort Weaver Road from Iroquois Road (Geiger Road) to the end.

Some traffic currently using West Loch Drive could still be expected to travel via Iroquois Avenue, North Road, and Hanakahi Street, since this route would be shorter in both travel distance and non-peak travel times.

During peak traffic hours, when Hanakahi Street or its intersections with Fort Weaver Road or North Road are already at or near capacity, estimated traffic volumes would be similar to those estimated for no mitigation (as discussed in Chapter 3), except that volumes on Kilaha Street, North Road southwest of Hanakahi Street, and Fort Weaver Road southeast of North Road would be different. With no changes to peak hour volumes on Fort Weaver Road north of Hanakahi Street and on Hanakahi Street, the results of the peak hour intersection analyses shown in Tables 10 through 13 and in Table 17 would be applicable to Alternative 2.

The results of the analyses previously shown in Tables 14 and 15 would be different for Alternative 2. At the intersection of North Road and Kilaha Street, volumes would not be any different from existing conditions. However, at the Fort Weaver Road intersections, increased volumes on Fort Weaver Road would affect conditions. Tables 19 and 20 show the applicable results for these intersections.

Table 19
Fort Weaver Road and Kilaha Street (Alternative 2)

	A.M. Peak Hour			**M.M. Peak Hour**			**P.M. Peak Hour**		
	X	Delay	LOS	X	Delay	LOS	X	Delay	LOS
Westbound Left Turns	0.08	9.1	A	0.06	8.1	A	0.07	8.6	A
Southbound Approach	0.20	12.8	B	0.08	10.2	B	0.07	12.1	B
Northbound Approach	0.07	21.2	C	0.03	16.4	C	0.08	23.1	C

X = Utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

Table 20 Fort Weaver Road and North Road / Kimopelekane Street (Alternative 2)									
	A.M. Peak Hour			M.M. Peak Hour			P.M. Peak Hour		
	X	Delay	LOS	X	Delay	LOS	X	Delay	LOS
Southbound Left Turn	0.66	31.9	C	0.54	28.1	C	0.48	26.6	C
Southbound Through Lanes	0.15	11.5	B	0.17	11.7	B	0.21	12.0	B
Northbound Left Turn	0.02	50.8	D	0.01	50.5	D	0.00	50.4	D
Northbound Through Lanes	0.64	44.1	D	0.31	38.6	D	0.43	40.4	D
Eastbound Approach	0.24	37.2	D	0.09	34.9	C	0.07	34.6	C
Westbound Left & Through	0.07	34.8	C	0.14	35.8	D	0.06	34.6	C
Westbound Right Turn	0.56	9.7	A	0.41	7.5	A	0.26	6.1	A
Overall Intersection	**0.57**	**26.5**	**C**	**0.39**	**20.8**	**C**	**0.37**	**22.4**	**C**

X = Utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

Mitigation of the overall Level of Service E condition at the intersection of Fort Weaver Road and Hanakahi Street/ Keoneula Boulevard (Table 13) during the A.M. peak hour could be achieved by converting the existing curb parking and right turn only lane into a third northbound lane on Fort Weaver Road. A similar practice occurs in many areas of high traffic volumes on O'ahu, where a curb lane normally available for parallel parking is converted to a through traffic lane (with Tow-Away Zone or No Parking restrictions). In order to do this, however, widening of the existing shoulder (along with narrowing the existing wide sidewalk and reconstructing the existing curb, gutter, and drain structures) for a short distance north of the intersection would be necessary to provide adequate width for the third lane. As shown in Table 21, the third northbound lane would provide sufficient capacity, and overall conditions based on average peak hour delay would be LOS D.

Table 21 Fort Weaver Road and Hanakahi Street / Keoneula Boulevard (Alternative 2, Mitigated)									
	A.M. Peak Hour			M.M. Peak Hour			P.M. Peak Hour		
	X	Delay	LOS	X	Delay	LOS	X	Delay	LOS
Southbound Left Turn	0.98	138.9	F	0.91	96.0	F	0.93	81.9	F
Southbound Through Lanes	0.70	39.5	D	0.69	38.4	D	0.70	36.8	D
Northbound Left Turn	0.74	110.0	F	0.46	78.3	E	0.40	77.7	E
Northbound Through Lanes	0.67	41.8	D	0.71	47.9	D	0.84	61.9	E
Eastbound Left & Through	0.63	74.8	E	0.34	55.1	E	0.39	51.1	D
Eastbound Right Turn	0.32	64.8	E	0.29	54.2	D	0.21	47.5	D
Westbound Left & Through	0.44	76.8	E	0.41	70.4	E	0.31	62.2	E
Westbound Right Turn	0.85	78.0	E	0.64	46.8	D	0.38	28.5	C
Overall Intersection	**0.72**	**53.7**	**D**	**0.60**	**49.2**	**D**	**0.64**	**49.9**	**D**

X = Utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

Extending the third northbound lane on Fort Weaver Road—between Hanakahi Street and Iroquois Road—to meet an existing third lane may involve, at a minimum, strengthening the shoulder, replacing an existing multi-use path, and modifying traffic channelization at the Keaunui Drive intersection. Based on the results of the analyses for the Fort Weaver Road and Aikanaka Street intersection, the need for the third northbound lane is anticipated to begin north of the Papipi Road intersection. The use of a third northbound lane would only be necessary during the morning peak period.

At the intersection of North Road and Hanakahi Street, the potential increases in traffic volumes on Hanakahi Street for Alternative 2 were assumed to be similar to the no mitigation scenario described in Chapter 3, and through volumes on North Road would not vary from existing, as any traffic that would not be able to use Hanakahi Street would be served by the new road to the end of Fort Weaver Road. Table 22 shows the results of the intersection analyses for single lanes on North Road and separate turn lanes from the stop on Hanakahi Street.

Table 22
North Road and Hanakahi Street (Alternative 2)

	A.M. Peak Hour			**M.M. Peak Hour**			**P.M. Peak Hour**		
	X	Delay	LOS	X	Delay	LOS	X	Delay	LOS
Southbound Left Turn	0.80	96.1	F	1.00	115.8	F	0.73	33.1	D
Southbound Right Turn	0.37	16.1	C	0.07	10.7	B	0.10	10.3	B
Eastbound Left Turn	0.21	9.6	A	0.20	9.1	A	0.05	8.3	A

X = Utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

Other factors related to this alternative not considered in the level of service analyses discussed above include the ability of the Fort Weaver Road extension to divert any traffic from the front gate of West Loch Annex, which would depend on whether this traffic would be allowed to drive through the Kapilina residential area. Also, if any portion of the Fort Weaver Road extension would need to be temporarily closed because of safety considerations associated with activities at the adjacent training facilities, Kapilina and West Loch Annex front gate traffic would need to be served by existing roads, similar to the no mitigation scenario described in Chapter 3.

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6 Alternative 3: Provide Capacity to Use Existing Roads Only

If neither a bypass road nor an extension of Fort Weaver Road is provided, traffic to and from Kapilina (and the West Loch Annex front gate) would travel through the existing subdivision streets, with peak hour traffic volume estimates as discussed in Chapter 3. Due to the inappropriateness of adding high volumes of traffic onto Hanakahi Street, a narrow local street, improvements to increase intersection capacities were not identified (since any improvements would also require additional improvements at other constrained locations). Rather, estimates of peak hour volumes were developed assuming use of existing roadways are maximized to determine loadings at other locations.

Since much of the traffic would connect to Fort Weaver Road south of the North Road intersection, the additional northbound lane on Fort Weaver Road in the morning peak period—as discussed in Chapter 5 for Alternative 2—would also be needed in order to accommodate the higher volume of traffic that would use Fort Weaver Road. Results previously shown in Tables 10, 12, and 14 through 17 and in Table 22 for Alternative 2 would also be applicable to Alternative 3.

Poor operating conditions, as identified by full utilization (X = 1.00) or poor levels of service (E or F), at the intersection of North Road and Hanakahi Street could be mitigated by providing separate turn lanes on North Road (Table 23), which would require that the roadway be widened. The prohibition of parking on the north side would provide space for a right turn only lane, but a left turn lane would require that the existing eastbound lane be shifted south into the existing shoulder, with the existing eastbound lane becoming the left turn lane in the center of North Road. Extending the center lane to provide a refuge lane for left turns from Hanakahi Street would allow drivers wishing to turn left out of Hanakahi Street to take advantage of gaps in each direction on North Road rather than wait for a simultaneous gap in both directions. Figure 14 illustrates these improvements (see also Appendix G concept plans for Alternative 3). With the separate turn lanes and a refuge lane, acceptable conditions at the intersection of North Road and Hanakahi Street can be expected.

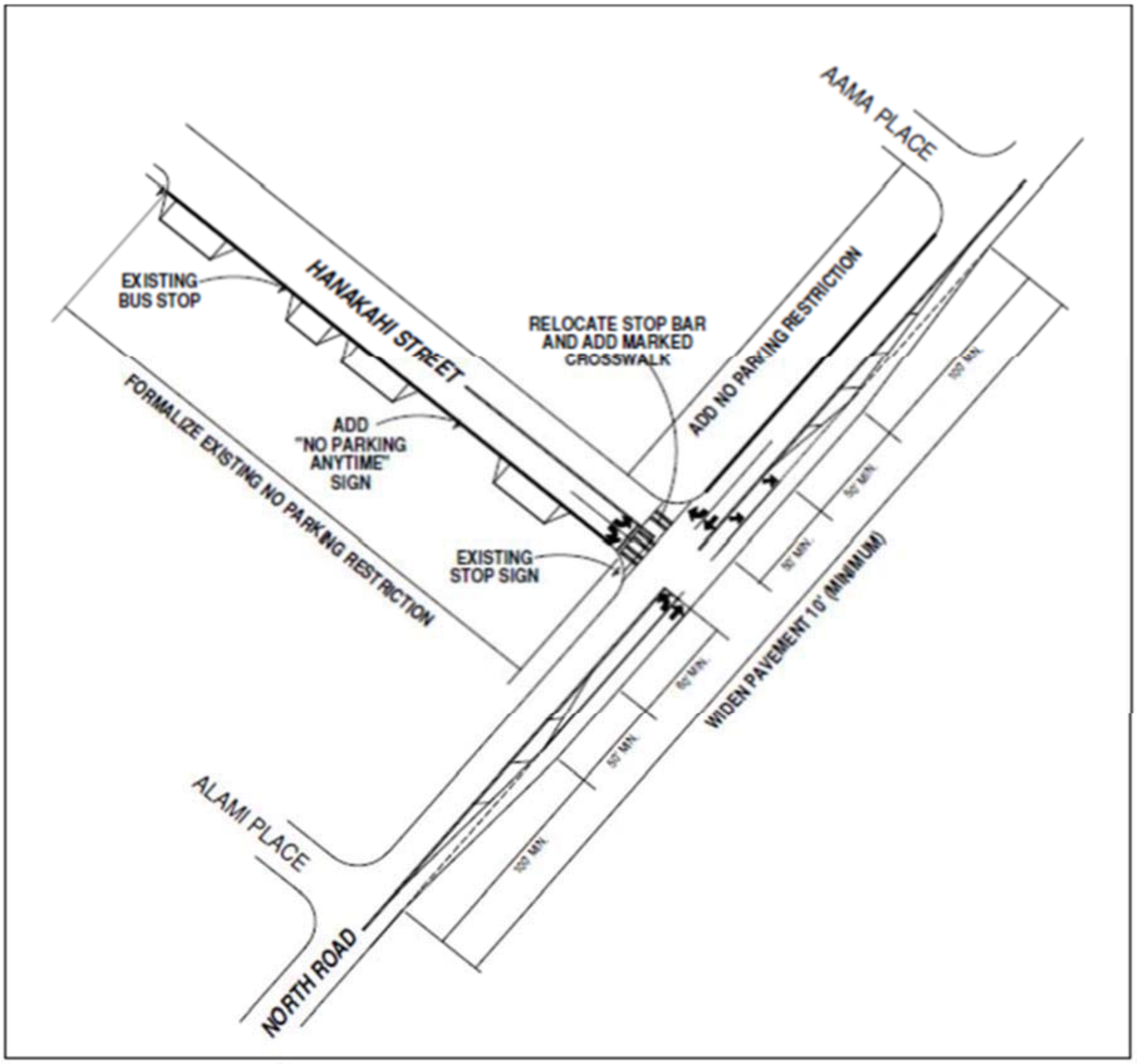

Figure 14 – Conceptual Layout of Intersection Improvements

Table 23
North Road and Hanakahi Street (Alternative 3)

	A.M. Peak Hour			**M.M. Peak Hour**			**P.M. Peak Hour**		
	X	Delay	LOS	X	Delay	LOS	X	Delay	LOS
Southbound Left Turn	0.24	30.1	D	0.37	28.4	D	0.39	24.3	C
Southbound Right Turn	0.36	15.8	C	0.06	10.0	B	0.08	9.4	A
Eastbound Left Turn	0.21	9.6	A	0.20	9.1	A	0.05	8.3	A

X = Utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

7 Conclusion and Recommendation

West Loch Drive connects Iroquois Road near the back gate of JBPHH West Loch Annex to North Road near its intersection with Iroquois Avenue. Closure of West Loch Drive, if not mitigated, would greatly affect Fort Weaver Road traffic conditions south of Iroquois Road and in the existing residential neighborhoods of the ‘Ewa Beach community. Traffic volumes on local streets would increase considerably throughout the day; during peak hours, overcapacity conditions would be expected at several locations. Closure of West Loch Drive, however, is not expected to have any effect on traffic volumes on Fort Weaver Road north of Iroquois Road.

Three alternatives were considered for mitigating the poor and overcapacity conditions. Concepts for all three mitigation alternatives were limited to Navy/federal lands and/or public rights-of-way. Alternative 1, a bypass roadway to reconnect Iroquois Road and North Road, would maintain existing traffic conditions on Fort Weaver Road and within the community. While the potential bypass road alignments shown in this study are conceptual, two possible intersection scenarios at North Road were found to be adequate with typical stop controls at the intersections.

Alternative 2, an extension of the southern end of Fort Weaver Road, was also analyzed. In addition to the roadway extension, a third northbound lane on Fort Weaver Road north of Papipi Street would also be required in order to accommodate traffic demands at acceptable levels of service during the A.M. peak hour.

Alternative 3 analyzed the effects of improving local streets, which also would require the addition of a third northbound lane on Fort Weaver Road in order to provide sufficient capacity for traffic that now uses West Loch Drive. Increased vehicular traffic volumes on North Road may also require improvements to the roadside to better accommodate pedestrian traffic. Even with these mitigation measures, residents along the affected streets would have large increases in traffic volumes on streets in front of their homes.

Of the three alternatives analyzed, only Alternative 1—the bypass road—could avoid the traffic effects that would be attributable to the closure of West Loch Drive, and only if the bypass road were completed and opened for use prior to closing West Loch Drive.

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Appendix A
Field Count Summaries

Manual Turning Movement Counts
taken September 2017

7 sheets follow:

① Geiger Road and Iroquois Road at Fort Weaver Road

②West Loch Drive and Iroquois Road (West Loch Annex Back Gate)

③Iroquois Avenue at North Road

④ JBPHH West Loch Annex Front Gate (Barracks Road) at Iroquois Avenue

⑤ Hanakahi Street at North Road

⑥ Kuhina Street and Hanakahi Street

⑦ Hanakahi Street (Keoneula Boulevard) and Fort Weaver Road

① Manual Traffic Count, Geiger Road and Iroquois Road at Fort Weaver Road

count taken: Tuesday, September 26, 2017	**Eastbound Geiger Road**			**Southbound Fort Weaver Rd.**			**Northbound Fort Weaver Rd.**			**Westbound Iroquois Road**		
	Left Turn	Through	Right Turn	Left Turn	Through	Right Turn	Left Turn	Through	Right Turn	Left Turn	Through	Right Turn
6:00 - 6:15	62	11	11	22	98	25	11	265	3	1	37	53
6:15 - 6:30	39	22	15	23	158	38	16	284	1	1	33	39
6:30 - 6:45	49	28	28	40	156	38	25	265	13	0	57	50
6:45 - 7:00	50	12	24	45	215	41	30	234	4	2	59	65
7:00 - 7:15	**54**	**32**	**42**	**50**	**233**	**24**	**29**	**245**	**9**	**6**	**57**	**50**
7:15 - 7:30	**59**	**27**	**57**	**48**	**268**	**18**	**66**	**368**	**7**	**11**	**69**	**66**
7:30 - 7:45	**83**	**61**	**49**	**54**	**206**	**33**	**72**	**327**	**5**	**9**	**73**	**68**
7:45 - 8:00	**69**	**27**	**24**	**38**	**146**	**26**	**59**	**290**	**2**	**8**	**75**	**57**
8:00 - 8:15	23	27	17	31	148	21	29	388	0	2	34	44
8:15 - 8:30	27	19	23	32	195	29	25	320	2	0	27	45
8:30 - 8:45	56	10	21	32	173	21	28	283	1	4	33	56
8:45 - 9:00	49	20	20	32	126	31	27	234	2	3	36	38
9:00 - 9:15	50	19	25	31	153	37	21	254	2	3	31	45
9:15 - 9:30	56	21	19	32	131	30	36	251	5	3	27	41
9:30 - 9:45	54	19	21	26	154	23	17	227	2	4	33	40
9:45 - 10:00	43	11	17	16	152	36	32	230	3	2	35	22
10:00 - 10:15	45	24	26	27	180	31	33	221	3	6	28	31
10:15 - 10:30	52	25	25	26	163	38	35	229	3	1	33	24
10:30 - 10:45	53	24	28	22	216	29	25	218	2	2	28	27
10:45 - 11:00	44	25	22	19	181	19	34	188	5	2	35	24
11:00 - 11:15	45	35	21	33	192	20	32	195	0	0	31	23
11:15 - 11:30	47	19	29	24	196	33	26	177	3	4	35	32
11:30 - 11:45	40	25	30	46	198	29	32	190	1	1	16	32
11:45 - 12:00	51	35	23	17	204	32	34	178	1	2	22	21
12:00 - 12:15	49	28	21	40	199	32	36	183	2	2	22	24
12:15 - 12:30	52	32	19	47	213	47	28	189	6	2	26	30
12:30 - 12:45	71	38	24	40	217	50	26	159	5	1	23	32
12:45 - 13:00	48	23	30	58	215	31	26	164	4	5	28	20
13:00 - 13:15	56	25	28	40	224	35	33	174	2	3	31	27
13:15 - 13:30	42	30	37	44	274	36	34	212	2	5	18	28
13:30 - 13:45	61	31	34	37	253	38	29	194	4	1	23	27
13:45 - 14:00	68	37	42	52	252	41	30	175	2	2	34	30
14:00 - 14:15	49	34	48	56	312	41	34	207	9	9	27	37
14:15 - 14:30	52	35	35	60	286	57	84	235	4	7	55	42
14:30 - 14:45	71	36	27	46	254	36	64	273	5	3	40	37
14:45 - 15:00	**48**	**26**	**48**	**61**	**384**	**61**	**53**	**222**	**5**	**9**	**35**	**55**
15:00 - 15:15	**56**	**38**	**34**	**84**	**429**	**69**	**40**	**196**	**5**	**5**	**29**	**29**
15:15 - 15:30	**42**	**42**	**29**	**88**	**438**	**72**	**51**	**233**	**5**	**3**	**42**	**28**
15:30 - 15:45	**61**	**62**	**41**	**101**	**406**	**65**	**42**	**257**	**3**	**7**	**45**	**25**
15:45 - 16:00	68	69	39	102	336	45	39	181	4	3	35	19
16:00 - 16:15	52	61	37	75	424	64	29	206	3	2	38	28
16:15 - 16:30	41	35	31	86	428	62	59	235	1	4	55	31
16:30 - 16:45	55	53	42	102	374	65	38	195	7	3	45	29
16:45 - 17:00	48	60	35	78	401	64	25	187	3	1	35	32
17:00 - 17:15	44	67	26	85	390	81	34	158	8	2	35	42
17:15 - 17:30	37	52	29	86	447	75	36	192	5	5	49	26
17:30 - 17:45	45	57	35	103	400	59	28	213	6	8	31	23
17:45 - 18:00	36	48	38	95	325	78	47	159	8	2	59	29
18:00 - 18:15	58	50	31	79	431	72	44	254	6	44	35	19
18:15 - 18:30	36	56	21	105	397	82	47	222	3	47	45	20
18:30 - 18:45	57	50	35	83	381	68	32	182	4	35	56	23
18:45 - 19:00	46	85	37	79	352	58	42	165	5	37	49	24

Count Total (T=2.8%)

6:00 - 19:00	**2649**	**1838**	**1550**	**2778**	**13684**	**2286**	**1884**	**11683**	**205**	**334**	**1989**	**1809**
approach total (42689)	**6037**			**18748**			**13772**			**4132**		
departures	***6159***			***16141***			***15568***			***4821***		

AM Peak Hour (T=2.7%, PH=0.88)

7:00 - 8:00	**265**	**147**	**172**	**190**	**853**	**101**	**226**	**1230**	**23**	**34**	**274**	**241**
approach total (3756)	**584**			**1144**			**1479**			**549**		
departures	***601***			***1736***			***1059***			***360***		

MM Peak Hour (T=2.8%, PH=0.92)

14:00 - 15:00	**220**	**131**	**158**	**223**	**1236**	**195**	**235**	**937**	**23**	**28**	**157**	**171**
approach total (3714)	**509**			**1654**			**1195**			**356**		
departures	***587***			***1328***			***1422***			***377***		

PM Peak Hour (T=1.1%, PH=0.95)

16:00 - 17:00	**196**	**209**	**145**	**341**	**1627**	**255**	**151**	**823**	**14**	**10**	**173**	**120**
approach total (4064)	**550**			**2223**			**988**			**303**		
departures	***579***			***1139***			***1782***			***564***		

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② Manual Traffic Count, West Loch Drive and Iroquois Road

count taken:	Eastbound Iroquois Road						Northbound West Loch Drive			Westbound Iroquois Road		
Tuesday, September 12, 2017	Left Turn	Through	Right Turn				Left Turn	Through	Right Turn	Left Turn	Through	Right Turn
6:00 - 6:15		10	20				77		0	0	1	
6:15 - 6:30		32	25				79		2	0	0	
6:30 - 6:45		26	27				69		1	0	0	
6:45 - 7:00		24	38				77		0	0	0	
7:00 - 7:15		9	58				69		0	0	1	
7:15 - 7:30		8	88				88		0	0	4	
7:30 - 7:45		2	99				74		1	1	0	
7:45 - 8:00		5	38				97		3	2	0	
8:00 - 8:15		1	35				71		0	0	3	
8:15 - 8:30		2	20				54		0	0	3	
8:30 - 8:45		1	28				60		0	0	2	
8:45 - 9:00		4	29				44		0	0	1	
9:00 - 9:15		1	28				41		0	0	3	
9:15 - 9:30		3	19				47		1	0	1	
9:30 - 9:45		1	18				44		3	1	1	
9:45 - 10:00		0	11				39		1	0	3	
10:00 - 10:15		3	10				45		0	1	1	
10:15 - 10:30		1	28				34		2	0	5	
10:30 - 10:45		1	30				29		0	0	3	
10:45 - 11:00		1	24				30		0	0	2	
11:00 - 11:15		0	27				29		0	0	3	
11:15 - 11:30		0	26				31		0	0	3	
11:30 - 11:45		3	24				36		0	0	6	
11:45 - 12:00		3	19				52		0	0	1	
12:00 - 12:15		5	22				38		0	0	3	
12:15 - 12:30		6	27				23		0	0	1	
12:30 - 12:45		8	31				31		0	1	1	
12:45 - 13:00		0	40				24		0	0	2	
13:00 - 13:15		2	38				35		0	0	2	
13:15 - 13:30		3	44				31		2	0	1	
13:30 - 13:45		2	49				32		0	0	1	
13:45 - 14:00		0	36				21		0	1	0	
14:00 - 14:15		0	37				41		0	0	4	
14:15 - 14:30		0	50				97		0	0	2	
14:30 - 14:45		3	40				80		0	0	1	
14:45 - 15:00		5	53				45		0	0	0	
15:00 - 15:15		3	57				43		0	0	9	
15:15 - 15:30		0	38				48		0	0	9	
15:30 - 15:45		0	78				55		0	2	32	
15:45 - 16:00		0	50				43		0	0	4	
16:00 - 16:15		0	67				91		0	0	0	
16:15 - 16:30		0	61				95		0	0	0	
16:30 - 16:45		0	84				59		0	0	0	
16:45 - 17:00		0	72				47		0	0	0	
17:00 - 17:15		0	86				48		0	0	0	
17:15 - 17:30		0	77				36		0	0	0	
17:30 - 17:45		0	77				41		0	0	0	
17:45 - 18:00		0	66				27		0	0	0	
18:00 - 18:15		0	77				47		0	0	0	
18:15 - 18:30		0	59				41		0	0	0	
18:30 - 18:45		0	59				29		0	0	0	
18:45 - 19:00		0	61				27		0	0	0	

Count Total (T=vpd counted)

6:00 - 19:00	0	178	2305	0	0	0	2591	0	16	9	119	0
approach total (5218)	2483			0			2607			128		
departures	*2710*			*0*			*2314*			*194*		

AM Peak Hour (T=2.9%, PHF=0.86)

7:00 - 8:00	0	24	283	0	0	0	328	0	4	3	5	0
approach total (647)	307			0			332			8		
departures	*333*			*0*			*286*			*28*		

MM Peak Hour (T=1.6%, PHF=0.82)

14:15 - 15:15	0	11	200	0	0	0	265	0	0	0	12	0
approach total (488)	211			0			265			12		
departures	*277*			*0*			*200*			*11*		

PM Peak Hour (T=0.7%, PHF=0.91)

16:00 - 17:00	0	0	284	0	0	0	292	0	0	0	0	0
approach total (576)	284			0			292			0		
departures	*292*			*0*			*284*			*0*		

③ Manual Traffic Count, Iroquois Avenue at North Road

count taken:	Eastbound North Road						Northbound Iroquois Avenue			Westbound North Road		
Thursday, September 07, 2017	Left Turn	Through	Right Turn				Left Turn	Through	Right Turn	Left Turn	Through	Right Turn
6:00 - 6:15		6	22				13		75	9	0	
6:15 - 6:30		3	24				18		61	30	0	
6:30 - 6:45		3	27				24		66	25	1	
6:45 - 7:00		3	35				17		71	31	2	
7:00 - 7:15		**3**	**35**				**28**		**67**	**44**	**11**	
7:15 - 7:30		**8**	**40**				**49**		**62**	**68**	**27**	
7:30 - 7:45		**18**	**48**				**46**		**69**	**52**	**46**	
7:45 - 8:00		**17**	**34**				**42**		**85**	**31**	**15**	
8:00 - 8:15		7	21				26		56	22	7	
8:15 - 8:30		2	21				16		63	33	4	
8:30 - 8:45		2	12				27		60	16	1	
8:45 - 9:00		0	15				15		49	26	2	
9:00 - 9:15		0	5				14		30	23	0	
9:15 - 9:30		0	11				10		45	16	1	
9:30 - 9:45		0	13				6		44	20	1	
9:45 - 10:00		3	7				17		46	26	1	
10:00 - 10:15		2	9				20		37	20	2	
10:15 - 10:30		1	11				10		37	21	0	
10:30 - 10:45		1	14				16		32	21	1	
10:45 - 11:00		0	17				14		31	23	3	
11:00 - 11:15		0	12				14		33	31	1	
11:15 - 11:30		0	15				18		32	26	1	
11:30 - 11:45		2	21				35		35	22	2	
11:45 - 12:00		0	23				18		42	35	1	
12:00 - 12:15		0	24				11		31	28	0	
12:15 - 12:30		0	24				21		15	28	0	
12:30 - 12:45		1	11				19		26	36	0	
12:45 - 13:00		0	23				16		31	30	0	
13:00 - 13:15		1	16				14		31	32	2	
13:15 - 13:30		0	18				17		40	35	1	
13:30 - 13:45		3	31				19		38	36	0	
13:45 - 14:00		1	44				17		21	48	2	
14:00 - 14:15		2	38				35		42	39	5	
14:15 - 14:30		11	40				64		56	43	8	
14:30 - 14:45		13	37				23		26	43	3	
14:45 - 15:00		2	21				26		31	40	5	
15:00 - 15:15		1	30				25		27	49	2	
15:15 - 15:30		3	32				28		35	57	2	
15:30 - 15:45		4	28				32		54	55	0	
15:45 - 16:00		2	25				29		37	70	2	
16:00 - 16:15		**2**	**29**				**38**		**91**	**86**	**1**	
16:15 - 16:30		**2**	**28**				**24**		**66**	**74**	**2**	
16:30 - 16:45		**1**	**40**				**32**		**58**	**59**	**5**	
16:45 - 17:00		**2**	**31**				**29**		**41**	**64**	**1**	
17:00 - 17:15		3	36				14		49	66	0	
17:15 - 17:30		1	30				15		56	76	0	
17:30 - 17:45		1	28				28		45	63	0	
17:45 - 18:00		2	24				33		30	62	3	
18:00 - 18:15		2	30				18		44	71	0	
18:15 - 18:30		3	27				22		36	49	1	
18:30 - 18:45		2	23				20		32	47	1	
18:45 - 19:00		1	33				23		32	63	1	

Count Total (T=2.1%)										*2496*		
6:00 - 19:00	**0**	**147**	**1293**	**0**	**0**	**0**	**1205**	**0**	**2349**	**2120**	**177**	**0**
approach total (7291)	**1440**			**0**			**3554**			**2297**		
departures	***1382***			***0***			***3413***			***2496***		

AM Peak Hour (T=1.9%, PHF=0.85)												
7:00 - 8:00	**0**	**46**	**157**	**0**	**0**	**0**	**165**	**0**	**283**	**195**	**99**	**0**
approach total (945)	**203**			**0**			**448**			**294**		
departures	***264***			***0***			***352***			***329***		

MM Peak Hour (T=2.1%, PHF=0.74)												
13:45 - 14:45	**0**	**27**	**159**	**0**	**0**	**0**	**139**	**0**	**145**	**173**	**18**	**0**
approach total (661)	**186**			**0**			**284**			**191**		
departures	***157***			***0***			***332***			***172***		

PM Peak Hour (T=1.1%, PHF=0.82)												
16:00 - 17:00	**0**	**7**	**128**	**0**	**0**	**0**	**123**	**0**	**256**	**283**	**9**	**0**
approach total (806)	**135**			**0**			**379**			**292**		
departures	***132***			***0***			***411***			***263***		

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④ Manual Traffic Count, JBPHH West Loch Annex Front Gate at Iroquois Avenue

count taken:				Southbound Iroquois Avenue			Northbound Iroquois Avenue			Westbound Barracks Road		
Tuesday, September 26, 2017				Left Turn	Through	Right Turn	Left Turn	Through	Right Turn	Left Turn	Through	Right Turn
6:00 - 6:15				9	16			98	2	0		1
6:15 - 6:30				18	26			95	1	0		3
6:30 - 6:45				23	27			92	1	0		0
6:45 - 7:00				25	44			92	3	0		1
7:00 - 7:15				**8**	**66**			**99**	**4**	**0**		**3**
7:15 - 7:30				**5**	**79**			**116**	**1**	**1**		**1**
7:30 - 7:45				**3**	**104**			**122**	**4**	**1**		**0**
7:45 - 8:00				**2**	**54**			**121**	**2**	**1**		**2**
8:00 - 8:15				8	58			53	4	1		0
8:15 - 8:30				8	47			72	0	1		2
8:30 - 8:45				0	35			72	2	1		1
8:45 - 9:00				4	38			60	2	0		1
9:00 - 9:15				4	23			62	1	1		4
9:15 - 9:30				3	28			49	0	0		2
9:30 - 9:45				2	25			47	0	0		5
9:45 - 10:00				2	20			56	0	0		5
10:00 - 10:15				0	31			62	0	2		2
10:15 - 10:30				2	38			37	0	1		2
10:30 - 10:45				3	23			47	1	0		3
10:45 - 11:00				2	30			45	0	1		4
11:00 - 11:15				3	59			41	2	0		5
11:15 - 11:30				3	48			42	0	2		9
11:30 - 11:45				8	44			59	2	2		16
11:45 - 12:00				8	45			46	0	0		1
12:00 - 12:15				5	57			52	0	0		2
12:15 - 12:30				9	48			43	2	1		6
12:30 - 12:45				4	56			48	3	0		5
12:45 - 13:00				6	51			44	1	1		3
13:00 - 13:15				4	55			46	0	0		7
13:15 - 13:30				2	47			42	0	1		0
13:30 - 13:45				1	60			47	0	2		2
13:45 - 14:00				4	82			43	0	2		2
14:00 - 14:15				2	70			93	0	2		6
14:15 - 14:30				0	59			119	0	1		4
14:30 - 14:45				3	95			71	0	3		3
14:45 - 15:00				1	69			59	0	0		1
15:00 - 15:15				2	87			48	1	0		6
15:15 - 15:30				3	82			52	0	0		5
15:30 - 15:45				2	107			54	1	3		23
15:45 - 16:00				2	103			43	2	1		15
16:00 - 16:15				**1**	**93**			**75**	**1**	**4**		**34**
16:15 - 16:30				**3**	**104**			**67**	**0**	**0**		**12**
16:30 - 16:45				**2**	**96**			**75**	**1**	**6**		**15**
16:45 - 17:00				**3**	**112**			**46**	**0**	**1**		**7**
17:00 - 17:15				0	101			72	0	1		29
17:15 - 17:30				2	90			56	0	0		3
17:30 - 17:45				3	106			48	0	1		8
17:45 - 18:00				4	106			52	1	2		10
18:00 - 18:15				1	94			47	0	1		13
18:15 - 18:30				1	79			48	0	1		7
18:30 - 18:45				2	93			51	1	1		8
18:45 - 19:00				3	104			43	0	0		1

Count Total (T=2.4%)

6:00 - 19:00	**0**	**0**	**0**	**228**	**3314**	**0**	**0**	**3269**	**46**	**50**	**0**	**310**
approach total (7217)	**0**			**3542**			**3315**			**360**		
departures	***0***			***3579***			***3364***			***274***		

AM Peak Hour (T=1.5%, PH=0.85)

7:00 - 8:00	**0**	**0**	**0**	**18**	**303**	**0**	**0**	**458**	**11**	**3**	**0**	**6**
approach total (799)	**0**			**321**			**469**			**9**		
departures	***0***			***464***			***306***			***29***		

MM Peak Hour (T=3.2%, PH=0.90)

14:00 - 15:00	**0**	**0**	**0**	**6**	**293**	**0**	**0**	**342**	**0**	**6**	**0**	**14**
approach total (661)	**0**			**299**			**342**			**20**		
departures	***0***			***356***			***299***			***6***		

PM Peak Hour (T=1.5%, PH=0.91)

16:00 - 17:00	**0**	**0**	**0**	**9**	**405**	**0**	**0**	**263**	**2**	**11**	**0**	**68**
approach total (758)	**0**			**414**			**265**			**79**		
departures	***0***			***331***			***416***			***11***		

Appendix A (page 5 of 8)

⑤ Manual Traffic Count, Hanakahi Street at North Road

count taken:	Eastbound North Road			Southbound Hanakahi Street						Westbound North Road		
Tuesday, September 12, 2017	Left Turn	Through	Right Turn	Left Turn	Through	Right Turn				Left Turn	Through	Right Turn
6:00 - 6:15	10	14		4		10					9	11
6:15 - 6:30	7	17		18		8					10	11
6:30 - 6:45	11	20		24		11					18	13
6:45 - 7:00	9	22		17		10					22	7
7:00 - 7:15	12	24		18		26					38	13
7:15 - 7:30	23	33		27		44					62	24
7:30 - 7:45	51	47		27		59					97	24
7:45 - 8:00	46	48		11		37					52	29
8:00 - 8:15	19	20		12		9					21	5
8:15 - 8:30	9	11		12		5					10	14
8:30 - 8:45	8	15		6		7					15	6
8:45 - 9:00	10	11		9		10					11	9
9:00 - 9:15	9	12		5		12					12	5
9:15 - 9:30	4	8		10		4					16	11
9:30 - 9:45	10	13		3		8					14	4
9:45 - 10:00	11	10		5		7					17	7
10:00 - 10:15	3	11		10		10					3	10
10:15 - 10:30	14	13		6		8					11	5
10:30 - 10:45	9	10		6		8					14	10
10:45 - 11:00	6	11		8		6					15	10
11:00 - 11:15	9	8		4		11					16	8
11:15 - 11:30	12	16		8		10					20	8
11:30 - 11:45	9	16		9		6					18	13
11:45 - 12:00	9	18		8		10					15	16
12:00 - 12:15	7	12		14		6					17	8
12:15 - 12:30	8	9		17		7					16	7
12:30 - 12:45	8	19		11		12					9	9
12:45 - 13:00	5	10		13		5					16	9
13:00 - 13:15	2	9		10		7					18	10
13:15 - 13:30	10	18		5		12					9	8
13:30 - 13:45	4	19		15		13					16	11
13:45 - 14:00	5	14		22		9					23	13
14:00 - 14:15	12	19		17		25					31	13
14:15 - 14:30	48	48		13		26					48	36
14:30 - 14:45	54	40		20		26					25	14
14:45 - 15:00	14	25		13		14					24	14
15:00 - 15:15	17	34		16		12					20	7
15:15 - 15:30	21	30		17		15					18	16
15:30 - 15:45	13	19		15		14					29	11
15:45 - 16:00	11	22		16		14					26	11
16:00 - 16:15	11	24		15		12					25	10
16:15 - 16:30	11	32		13		22					19	11
16:30 - 16:45	17	14		18		14					17	8
16:45 - 17:00	9	21		18		9					20	14
17:00 - 17:15	10	26		19		18					22	12
17:15 - 17:30	14	14		18		13					21	10
17:30 - 17:45	9	24		17		18					24	15
17:45 - 18:00	7	27		20		9					14	13
18:00 - 18:15	8	25		11		13					17	14
18:15 - 18:30	8	22		12		13					17	12
18:30 - 18:45	12	14		16		10					9	10
18:45 - 19:00	10	26		7		11					24	3

Count Total (T=4.6%)

6:00 - 19:00	**685**	**1044**	**0**	**685**	**0**	**715**	**0**	**0**	**0**	**0**	**1110**	**602**
approach total (4841)	**1729**			**1400**			**0**			**1712**		
departures	***1825***			***1287***			***0***			***1729***		

AM Peak Hour (T=3.1%, PHF=0.71)

7:00 - 8:00	**132**	**152**	**0**	**83**	**0**	**166**	**0**	**0**	**0**	**0**	**249**	**90**
approach total (872)	**284**			**249**			**0**			**339**		
departures	***415***			***222***			***0***			***235***		

MM Peak Hour (T=4.2%, PHF=0.71)

14:00 - 15:00	**128**	**132**	**0**	**63**	**0**	**91**	**0**	**0**	**0**	**0**	**128**	**77**
approach total (619)	**260**			**154**			**0**			**205**		
departures	***219***			***205***			***0***			***195***		

PM Peak Hour (T=2.6%, PHF=0.89)

16:00 - 17:00	**48**	**91**	**0**	**64**	**0**	**57**	**0**	**0**	**0**	**0**	**81**	**43**
approach total (384)	**139**			**121**			**0**			**124**		
departures	***138***			***91***			***0***			***155***		

Appendix A (page 6 of 8)

⑥ Manual Traffic Count, Kuhina Street and Hanakahi Street

count taken:	Eastbound Kuhina Street			Southbound Hanakahi Street			Northbound Hanakahi Street			Westbound Kuhina Street		
Tuesday, September 19, 2017	Left Turn	Through	Right Turn	Left Turn	Through	Right Turn	Left Turn	Through	Right Turn	Left Turn	Through	Right Turn
6:00 - 6:15	1	0	4	0	19	2	9	71	0	0	0	0
6:15 - 6:30	0	0	6	2	28	0	6	58	0	0	0	0
6:30 - 6:45	1	0	20	0	42	0	19	71	0	0	1	0
6:45 - 7:00	3	0	16	0	38	1	11	66	0	0	1	0
7:00 - 7:15	3	0	19	0	67	2	24	67	0	0	0	0
7:15 - 7:30	0	0	35	0	79	0	25	81	0	0	0	1
7:30 - 7:45	2	0	49	1	94	0	33	90	0	0	1	1
7:45 - 8:00	2	1	25	0	48	1	26	101	0	1	1	0
8:00 - 8:15	2	0	21	1	26	2	9	70	0	1	1	0
8:15 - 8:30	1	0	14	0	29	0	6	65	0	0	0	0
8:30 - 8:45	2	0	9	0	23	2	13	48	0	0	0	0
8:45 - 9:00	0	0	14	0	25	1	8	42	0	0	0	1
9:00 - 9:15	1	0	10	0	25	2	15	50	0	0	0	0
9:15 - 9:30	2	0	13	0	32	0	15	46	0	0	0	0
9:30 - 9:45	1	0	16	1	26	0	13	56	0	0	0	1
9:45 - 10:00	1	0	9	0	36	2	8	47	0	0	0	0
10:00 - 10:15	3	0	9	0	36	1	6	55	0	0	0	0
10:15 - 10:30	2	0	9	0	21	1	13	42	0	0	0	0
10:30 - 10:45	2	0	13	0	29	0	11	25	0	0	0	0
10:45 - 11:00	0	0	10	0	37	0	13	36	0	0	0	0
11:00 - 11:15	3	0	17	0	26	2	16	32	0	0	0	0
11:15 - 11:30	1	2	16	0	31	1	13	36	0	0	0	0
11:30 - 11:45	2	0	17	0	29	0	10	45	1	0	0	0
11:45 - 12:00	0	0	22	0	40	1	12	26	1	0	0	1
12:00 - 12:15	1	0	14	0	34	0	7	29	0	0	1	0
12:15 - 12:30	0	0	18	0	44	1	13	33	3	1	0	0
12:30 - 12:45	0	1	11	0	47	2	7	54	0	0	0	1
12:45 - 13:00	0	0	15	0	46	4	12	44	0	0	0	0
13:00 - 13:15	1	0	25	0	39	2	13	32	0	0	0	0
13:15 - 13:30	1	0	21	1	37	3	12	45	0	0	0	0
13:30 - 13:45	0	1	28	0	56	3	14	29	0	0	0	0
13:45 - 14:00	4	0	18	0	59	3	13	37	0	1	0	1
14:00 - 14:15	3	0	22	0	65	2	24	45	0	0	0	0
14:15 - 14:30	3	0	31	0	59	0	18	92	1	1	0	0
14:30 - 14:45	5	0	35	0	53	4	23	83	1	0	0	0
14:45 - 15:00	1	0	27	0	61	4	12	45	0	0	1	0
15:00 - 15:15	2	1	24	0	71	4	12	48	0	0	0	0
15:15 - 15:30	1	1	25	0	67	1	15	59	0	0	0	1
15:30 - 15:45	1	0	22	0	65	4	12	36	0	0	0	0
15:45 - 16:00	1	0	29	0	72	4	9	46	0	0	0	0
16:00 - 16:15	2	0	25	0	71	0	14	62	1	0	0	0
16:15 - 16:30	3	1	28	2	60	2	15	45	0	0	1	0
16:30 - 16:45	1	0	20	1	68	3	8	51	0	0	0	0
16:45 - 17:00	3	0	19	0	59	1	10	53	0	0	0	0
17:00 - 17:15	3	0	27	1	65	5	16	66	0	0	0	0
17:15 - 17:30	2	1	28	0	71	1	12	39	0	0	0	0
17:30 - 17:45	1	0	35	0	68	1	12	59	1	0	0	1
17:45 - 18:00	2	0	17	1	61	1	12	52	0	0	0	0
18:00 - 18:15	0	0	18	0	69	3	8	37	0	0	0	0
18:15 - 18:30	3	0	34	1	72	7	10	44	0	0	0	0
18:30 - 18:45	2	0	25	1	66	3	15	44	0	0	0	0
18:45 - 19:00	0	0	29	1	75	1	16	52	0	2	0	0

Count Total (T=3.2%)

6:00 - 19:00	**81**	**9**	**1063**	**14**	**2566**	**90**	**698**	**2687**	**9**	**7**	**8**	**9**

AM Peak Hour (T=3.8%, PH=0.81)

7:00 - 8:00	**7**	**1**	**128**	**1**	**288**	**3**	**108**	**339**	**0**	**1**	**2**	**2**
approach total (880)	**136**			**292**			**447**			**5**		
departures	***113***			***348***			***417***			***2***		

MM Peak Hour (T=3.9%, PH=0.88)

14:15 - 15:15	**11**	**1**	**117**	**0**	**244**	**12**	**65**	**268**	**2**	**1**	**1**	**0**
approach total (722)	**129**			**256**			**335**			**2**		
departures	***78***			***279***			***362***			***3***		

PM Peak Hour (T=2.1%, PH=0.90)

17:00 - 18:00	**8**	**1**	**107**	**2**	**265**	**8**	**52**	**216**	**1**	**0**	**0**	**1**
approach total (661)	**116**			**275**			**269**			**1**		
departures	***60***			***225***			***372***			***4***		

⑦ Manual Traffic Count, Hanakahi Street (Keoneula Boulevard) and Fort Weaver Road

count taken:	Eastbound Keoneula Boulevard			Southbound Fort Weaver Road			Northbound Fort Weaver Road			Westbound Hanakahi Street		
Tuesday, September 19, 2017	Left Turn	Through	Right Turn	Left Turn	Through	Right Turn	Left Turn	Through	Right Turn	Left Turn	Through	Right Turn
6:00 - 6:15	62	1	5	12	60	13	10	161	0	2	15	76
6:15 - 6:30	41	8	0	24	72	29	14	128	0	1	17	68
6:30 - 6:45	52	10	4	28	118	27	13	145	3	1	23	81
6:45 - 7:00	47	6	9	31	170	40	11	136	0	2	14	97
7:00 - 7:15	59	22	26	38	236	49	17	222	1	0	15	78
7:15 - 7:30	67	43	22	26	293	83	18	217	3	1	18	86
7:30 - 7:45	65	31	27	56	237	107	34	280	2	1	18	91
7:45 - 8:00	63	23	15	39	150	35	21	252	2	2	37	89
8:00 - 8:15	52	5	9	27	107	21	22	278	4	2	14	81
8:15 - 8:30	64	10	6	22	123	30	8	147	4	0	10	65
8:30 - 8:45	48	4	7	30	107	24	4	151	0	0	6	63
8:45 - 9:00	37	11	5	17	96	21	5	109	4	2	11	46
9:00 - 9:15	47	5	8	39	127	26	8	141	2	1	10	63
9:15 - 9:30	49	3	4	37	108	22	5	140	0	4	12	53
9:30 - 9:45	43	5	12	33	113	17	10	144	2	1	9	69
9:45 - 10:00	46	6	11	37	110	10	4	136	5	0	10	67
10:00 - 10:15	37	6	10	28	103	16	11	147	4	0	15	58
10:15 - 10:30	33	6	4	31	84	24	5	155	0	1	6	51
10:30 - 10:45	32	7	8	28	150	21	4	128	2	1	10	34
10:45 - 11:00	34	10	15	37	139	19	9	121	3	1	4	44
11:00 - 11:15	26	14	6	31	122	23	12	154	3	0	9	51
11:15 - 11:30	22	10	6	39	123	29	13	125	0	2	4	47
11:30 - 11:45	25	6	10	32	116	25	9	131	1	0	8	48
11:45 - 12:00	19	8	7	43	126	22	6	109	0	0	6	30
12:00 - 12:15	31	8	7	47	116	27	9	118	3	2	5	37
12:15 - 12:30	21	10	12	36	156	36	3	100	4	1	7	41
12:30 - 12:45	19	7	8	48	147	26	6	123	3	1	10	53
12:45 - 13:00	29	11	10	48	152	36	12	117	2	1	12	38
13:00 - 13:15	26	6	12	49	123	36	5	140	1	0	5	38
13:15 - 13:30	30	8	7	40	167	63	15	114	6	1	9	54
13:30 - 13:45	24	19	12	49	189	49	11	137	3	2	9	39
13:45 - 14:00	27	19	18	59	212	59	7	123	3	2	6	44
14:00 - 14:15	33	21	26	55	249	62	18	206	1	4	11	52
14:15 - 14:30	58	22	37	55	260	44	14	287	6	2	29	60
14:30 - 14:45	42	12	16	64	216	49	19	290	5	1	27	79
14:45 - 15:00	26	20	17	67	229	52	14	237	3	1	5	50
15:00 - 15:15	32	8	17	77	225	56	15	179	3	1	9	48
15:15 - 15:30	35	21	23	76	179	47	16	161	2	1	18	49
15:30 - 15:45	65	20	19	80	259	60	10	193	1	2	9	33
15:45 - 16:00	43	31	18	75	228	62	12	158	3	3	22	45
16:00 - 16:15	50	27	20	89	246	77	13	194	2	0	19	58
16:15 - 16:30	43	19	19	72	237	78	7	196	5	1	11	60
16:30 - 16:45	35	21	20	84	224	75	14	178	5	1	8	52
16:45 - 17:00	35	25	30	71	219	75	12	157	1	2	11	58
17:00 - 17:15	32	19	13	76	215	69	10	174	4	2	13	61
17:15 - 17:30	40	23	17	80	205	84	6	136	0	1	12	55
17:30 - 17:45	34	14	16	80	241	58	8	169	4	5	6	62
17:45 - 18:00	30	23	14	71	233	65	9	148	5	5	11	57
18:00 - 18:15	18	10	10	91	200	67	5	168	2	4	17	40
18:15 - 18:30	33	18	14	86	196	52	6	119	3	4	12	68
18:30 - 18:45	33	18	10	85	226	67	12	162	4	2	7	55
18:45 - 19:00	27	13	6	88	199	54	8	132	2	6	19	53

Count Total (T=3.0%)

6:00 - 19:00	**2021**	**733**	**684**	**2663**	**8938**	**2318**	**569**	**8473**	**131**	**83**	**640**	**2975**

AM Peak Hour (T=2.4%, PH=0.87)

7:00 - 8:00	**254**	**119**	**90**	**159**	**916**	**274**	**90**	**971**	**8**	**4**	**88**	**344**
approach total (3317)	**463**			**1349**			**1069**			**436**		
departures	***452***			***1569***			***1010***			***286***		

MM Peak Hour (T=2.7%, PH=0.90)

14:00 - 15:00	**159**	**75**	**96**	**241**	**954**	**207**	**65**	**1020**	**15**	**8**	**72**	**241**
approach total (3153)	**330**			**1402**			**1100**			**321**		
departures	***344***			***1420***			***1058***			***331***		

PM Peak Hour (T=1.9%, PH=0.94)

15:30 - 16:30	**201**	**97**	**76**	**316**	**970**	**277**	**42**	**741**	**11**	**6**	**61**	**196**
approach total (2994)	**374**			**1563**			**794**			**263**		
departures	***380***			***1138***			***1052***			***424***		

Appendix B
Intersection Analyses Worksheets
Existing Conditions

21 sheets follow

INPUT WORKSHEET

General Information

Analyst: Julian Ng
Agency or Company: JNI
Date Performed: February 15, 2018
Analysis Time Period: AM Peak Hour (Existing)

Site Information

Intersection: Fort Weaver Road & Geiger Road / Iroquois Road
Area Type: ☐ CBD ☒ Other
Jurisdiction: HDOT HWY
Analysis Year: - 2017 -

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	190	853	101	226	1230	23	265	147	172	34	274	241
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	15.0	50.0	30.0	20.0	55.0	55.0	30.0	30.0	30.0	20.0	20.0	35.0
Y + R (s) Cycle length, C = 140.0 s	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description: Fort Weaver Road & Geiger Road / Iroquois Road- 2017 - AM Peak Hour (Existing)

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	190	853	101	226	1,230	23	265	147	172	34	274	241
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Adjusted flow rate, v_p = V/PHF (veh/h)	216	969	115	257	1398	26	301	167	195	39	311	274
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	216	969	115	257	1398	26	428	235		39	311	274
Proportion[1] of LT or RT (P_{LT} or P_{RT})									0.830			
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	1900	1900	1900	1900	1900	1900	1900	1900		1900	1900	1900
Number of lanes, N	2	3	1	2	3	1	2	1		2	1	2
Approach width	12	36	12	12	24	12	12	12		12	36	12
Lane width, W	6	12	12	6	8	12	6	12		6	36	6
Lane width adjustment factor, f_w	0.800	1.000	1.000	0.800	0.867	1.000	0.800	1.000		0.800	1.800	0.800
Heavy-vehicle adjustment factor, f_{HV}	0.971	0.971	0.971	0.971	0.971	0.971	0.971	0.971		0.971	0.971	0.971
Grade adjustment factor, f_g	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000
Parking adjustment factor, f_p	0.950	1.000	0.900	0.950	1.000	0.900	0.950	1.000		0.950	1.000	0.950
Bus blockage adjustment factor, f_{bb}	1.000	0.993	1.000	1.000	0.993	1.000	1.000	1.000		1.000	1.000	1.000
Area type adj. factor, f_a (***0.90** CBD, **1.00** other)*	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000
Lane utilization adjustment factor, f_{LU}	0.950	0.933	1.000	0.950	0.933	1.000	0.950	1.000		0.950	1.000	0.950
Left-turn adjustment factor, f_{LT}	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000
Right-turn adjustment factor, f_{RT}	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.888		1.000	1.000	1.000
Left-turn ped/bike adjustment factor, f_{Lpb}	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000
Right-turn ped/bike adjustment factor, f_{Rpb}	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	2664	5131	1660	2664	4447	1660	2664	1638		2664	3320	2664

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: Fort Weaver Road & Geiger Road / Iroquois Road- 2017 - AM Peak Hour (Existing)

Capacity Analysis

Phase number	1	6	2	5	2	2	4	4		3	3	3
Phase type	P	P	P	P	P	P	P	P		P	P	P
Lane Group												
Adjusted flow rate, v (veh/h)	216	969	115	257	1398	26	428	235		39	311	274
Saturation flow rate, s (veh/h)	2664	5131	1660	2664	4447	1660	2664	1638		2664	3320	2664
Lost time, t_L (s), $t_L = I_1 + Y + e$	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0	5.0
Effective green time, g (s), $g = G + Y - t_L$	15.0	50.0	30.0	20.0	55.0	55.0	30.0	30.0		20.0	20.0	50.0
Green ratio, g/C	0.11	0.36	0.21	0.14	0.39	0.39	0.21	0.21		0.14	0.14	0.25
Lane group capacity,[1] c = s(g/C), (veh/h)	285	1,832	356	381	1,747	652	571	351		381	474	666
v/c ratio, X	0.757	0.529	0.323	0.675	0.800	0.040	0.750	0.670		0.102	0.656	0.411
Flow ratio, v/s	0.081	0.189	0.069	0.096	0.314	0.016	0.161	0.143		0.015	0.094	0.103
Critical lane group/phase (√)	√		√			√	√					√
Sum of flow ratios for critical lane groups, Y_c Yc = Σ (critical lane groups, v/s)	0.659											
Total lost time per cycle, L (s)	10											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.71**											

Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Adjusted flow rate,[2] v (veh/h)	216	969	115	257	1398	26	428	235		39	311	274
Lane Group Capacity,[2] c (veh/h)	285	1832	356	381	1747	652	571	351		381	474	666
v/c ratio[2], X = v/c	**0.76**	**0.53**	**0.32**	**0.68**	**0.80**	**0.04**	**0.75**	**0.67**		**0.10**	**0.66**	**0.41**
Total green ratio,[2] g/C	0.11	0.36	0.21	0.14	0.39	0.39	0.21	0.21		0.14	0.14	0.36
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	60.73	35.66	46.43	56.92	37.64	26.21	51.49	50.45		52.19	56.75	33.91
Incremental delay calibration,[3] k	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	16.99	1.10	2.40	9.26	3.96	0.11	8.77	9.75		0.53	6.94	1.87
Initial queue delay, d_3 (s/veh) (Appendix F)	0	0	0	0	0	0	0	0		0	0	0
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000
Delay = $d = d_1(PF) + d_2 + d_3$ (s/veh)	**77.7**	**36.8**	**48.8**	**66.2**	**41.6**	**26.3**	**60.3**	**60.2**		**52.7**	**63.7**	**35.8**
LOS by lane group (Exhibit 16-2)	E	D	D	E	D	C	E	E		D	E	D
Intersection delay, $d_1 = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	**48.1**											
Intersection Level of Service (Exhibit 16-2)	**D**											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information

Analyst: *Julian Ng*
Agency or Company: *JNI*
Date Performed: *February 15, 2018*
Analysis Time Period: *MM Peak Hour (Existing)*

Site Information

Intersection: *Fort Weaver Road & Geiger Road / Iroquois Road*
Area Type: ☐ CBD ☒ Other
Jurisdiction: *HDOT HWY*
Analysis Year: *- 2017 -*

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	223	1236	195	235	937	23	220	131	158	28	157	171
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	*15.0*	*50.0*	*30.0*	*20.0*	*55.0*	*55.0*	*30.0*	*30.0*	*30.0*	*20.0*	*20.0*	*35.0*
Y + R (s) Cycle length, C = 140.0 s	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description: *Fort Weaver Road & Geiger Road / Iroquois Road- 2017 - MM Peak Hour (Existing)*

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*223*	*1,236*	*195*	*235*	*937*	*23*	*220*	*131*	*158*	*28*	*157*	*171*
Peak-hour factor, PHF	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*
Adjusted flow rate, v_p = V/PHF (veh/h)	*242*	*1343*	*212*	*255*	*1018*	*25*	*239*	*142*	*172*	*30*	*171*	*186*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*242*	*1343*	*212*	*255*	*1018*	*25*	*360*	*193*		*30*	*171*	*186*
Proportion[1] of LT or RT (P_{LT} or P_{RT})									*0.891*			
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*		*1900*	*1900*	*1900*
Number of lanes, N	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*1*		*2*	*1*	*2*
Approach width	*12*	*36*	*12*	*12*	*24*	*12*	*12*	*12*		*12*	*36*	*12*
Lane width, W	*6*	*12*	*12*	*6*	*8*	*12*	*6*	*12*		*6*	*36*	*6*
Lane width adjustment factor, f_w	*0.800*	*1.000*	*1.000*	*0.800*	*0.867*	*1.000*	*0.800*	*1.000*		*0.800*	*1.800*	*0.800*
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*		*0.971*	*0.971*	*0.971*
Grade adjustment factor, f_g	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Parking adjustment factor, f_p	*0.950*	*1.000*	*0.900*	*0.950*	*1.000*	*0.900*	*0.950*	*1.000*		*0.950*	*1.000*	*0.950*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*	*1.000*	*1.000*	*0.993*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*0.950*	*0.933*	*1.000*	*0.950*	*0.933*	*1.000*	*0.950*	*1.000*		*0.950*	*1.000*	*0.950*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*0.880*		*1.000*	*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*2664*	*5131*	*1660*	*2664*	*4447*	*1660*	*2664*	*1623*		*2664*	*3320*	*2664*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Fort Weaver Road & Geiger Road / Iroquois Road- 2017 - MM Peak Hour (Existing)*

Capacity Analysis

Phase number	1	6	2	5	2	2	4	4		3	3	3
Phase type	P	P	P	P	P	P	P	P		P	P	P
Lane Group												
Adjusted flow rate, v (veh/h)	242	1343	212	255	1018	25	360	193		30	171	186
Saturation flow rate, s (veh/h)	2664	5131	1660	2664	4447	1660	2664	1623		2664	3320	2664
Lost time, t_L (s), $t_L = I_1 + Y + e$	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0	5.0
Effective green time, g (s), $g = G + Y - t_L$	15.0	50.0	30.0	20.0	55.0	55.0	30.0	30.0		20.0	20.0	50.0
Green ratio, g/C	0.11	0.36	0.21	0.14	0.39	0.39	0.21	0.21		0.14	0.14	0.25
Lane group capacity,[1] c = s(g/C), (veh/h)	285	1,832	356	381	1,747	652	571	348		381	474	666
v/c ratio, X	0.848	0.733	0.596	0.670	0.583	0.038	0.631	0.555		0.080	0.360	0.279
Flow ratio, v/s	0.091	0.262	0.128	0.096	0.229	0.015	0.135	0.119		0.011	0.051	0.070
Critical lane group/phase (√)		√	√	√		√	√					√
Sum of flow ratios for critical lane groups, Y_c $Y_c = \Sigma$ (critical lane groups, v/s)	0.562											
Total lost time per cycle, L (s)	10											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.61**											

Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Adjusted flow rate,[2] v (veh/h)	*242*	*1343*	*212*	*255*	*1018*	*25*	*360*	*193*		*30*	*171*	*186*
Lane Group Capacity,[2] c (veh/h)	*285*	*1832*	*356*	*381*	*1747*	*652*	*571*	*348*		*381*	*474*	*666*
v/c ratio[2], X = v/c	***0.85***	***0.73***	***0.60***	***0.67***	***0.58***	***0.04***	***0.63***	***0.56***		***0.08***	***0.36***	***0.28***
Total green ratio,[2] g/C	*0.11*	*0.36*	*0.21*	*0.14*	*0.39*	*0.39*	*0.21*	*0.21*		*0.14*	*0.14*	*0.36*
Uniform delay, $d_1 = \dfrac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*61.38*	*39.19*	*49.54*	*56.87*	*33.47*	*26.20*	*49.97*	*49.05*		*52.02*	*54.21*	*32.13*
Incremental delay calibration,[3] k	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		*0.5*	*0.5*	*0.5*
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*25.60*	*2.64*	*7.18*	*9.06*	*1.43*	*0.11*	*5.22*	*6.26*		*0.41*	*2.12*	*1.04*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*		*0*	*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Delay = $d = d_1(PF) + d_2 + d_3$ (s/veh)	***87.0***	***41.8***	***56.7***	***65.9***	***34.9***	***26.3***	***55.2***	***55.3***		***52.4***	***56.3***	***33.2***
LOS by lane group (Exhibit 16-2)	***F***	***D***	***E***	***E***	***C***	***C***	***E***	***E***		***D***	***E***	***C***
Intersection delay, $d_1 = \dfrac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***47.1***											
Intersection Level of Service (Exhibit 16-2)	***D***											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information

Analyst: *Julian Ng*
Agency or Company: *JNI*
Date Performed: *February 15, 2018*
Analysis Time Period: *PM Peak Hour (Existing)*

Site Information

Intersection: *Fort Weaver Road & Geiger Road / Iroquois Road*
Area Type: ☐ CBD ☒ Other
Jurisdiction: *HDOT HWY*
Analysis Year: *- 2017 -*

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	341	1627	255	151	823	14	196	209	145	10	173	120
% heavy vehicles, %HV	2	2	2	2	2	2	2	2	2	2	2	2
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		

Signal Phasing Information

	SB			NB			EB			WB		
Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	*20.0*	*65.0*	*30.0*	*10.0*	*55.0*	*55.0*	*30.0*	*30.0*	*30.0*	*15.0*	*15.0*	*35.0*
Y + R (s) Cycle length, C = 140.0 s	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description: *Fort Weaver Road & Geiger Road / Iroquois Road- 2017 - PM Peak Hour (Existing)*

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*341*	*1,627*	*255*	*151*	*823*	*14*	*196*	*209*	*145*	*10*	*173*	*120*
Peak-hour factor, PHF	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*
Adjusted flow rate, v_p = V/PHF (veh/h)	*363*	*1731*	*271*	*161*	*876*	*15*	*209*	*222*	*154*	*11*	*184*	*128*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*363*	*1731*	*271*	*161*	*876*	*15*	*375*	*210*		*11*	*184*	*128*
Proportion[1] of LT or RT (P_{LT} or P_{RT})									*0.733*			

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*		*1900*	*1900*	*1900*
Number of lanes, N	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*1*		*2*	*1*	*2*
Approach width	*12*	*36*	*12*	*12*	*24*	*12*	*12*	*12*		*12*	*36*	*12*
Lane width, W	*6*	*12*	*12*	*6*	*8*	*12*	*6*	*12*		*6*	*36*	*6*
Lane width adjustment factor, f_w	*0.800*	*1.000*	*1.000*	*0.800*	*0.867*	*1.000*	*0.800*	*1.000*		*0.800*	*1.800*	*0.800*
Heavy-vehicle adjustment factor, f_{HV}	*0.977*	*0.977*	*0.977*	*0.977*	*0.977*	*0.977*	*0.977*	*0.977*		*0.977*	*0.977*	*0.977*
Grade adjustment factor, f_g	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Parking adjustment factor, f_p	*0.950*	*1.000*	*0.900*	*0.950*	*1.000*	*0.900*	*0.950*	*1.000*		*0.950*	*1.000*	*0.950*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*	*1.000*	*1.000*	*0.993*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Area type adj. factor, f_a (***0.90*** *CBD,* ***1.00*** *other)*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*0.950*	*0.933*	*1.000*	*0.950*	*0.933*	*1.000*	*0.950*	*1.000*		*0.950*	*1.000*	*0.950*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*0.901*		*1.000*	*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*2679*	*5161*	*1670*	*2679*	*4473*	*1670*	*2679*	*1672*		*2679*	*3340*	*2679*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Fort Weaver Road & Geiger Road / Iroquois Road- 2017 - PM Peak Hour (Existing)*

Capacity Analysis

Phase number	1	6	2	5	2	2	4	4		3	3	3
Phase type	P	P	P	P	P	P	P	P		P	P	P
Lane Group												
Adjusted flow rate, v (veh/h)	363	1731	271	161	876	15	375	210		11	184	128
Saturation flow rate, s (veh/h)	2679	5161	1670	2679	4473	1670	2679	1672		2679	3340	2679
Lost time, t_L (s), $t_L = I_1 + Y + e$	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0	5.0
Effective green time, g (s), $g = G + Y - t_L$	20.0	65.0	30.0	10.0	55.0	55.0	30.0	30.0		15.0	15.0	55.0
Green ratio, g/C	0.14	0.46	0.21	0.07	0.39	0.39	0.21	0.21		0.11	0.11	0.25
Lane group capacity,[1] c = s(g/C), (veh/h)	383	2,396	358	191	1,757	656	574	358		287	358	670
v/c ratio, X	0.948	0.722	0.757	0.841	0.499	0.023	0.653	0.586		0.037	0.514	0.191
Flow ratio, v/s	0.135	0.335	0.162	0.060	0.196	0.009	0.140	0.126		0.004	0.055	0.048
Critical lane group/phase (√)		√	√	√		√	√				√	
Sum of flow ratios for critical lane groups, Y_c Yc = Σ (critical lane groups, v/s)	0.591											
Total lost time per cycle, L (s)	10											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.64**											

Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Adjusted flow rate,[2] v (veh/h)	*363*	*1731*	*271*	*161*	*876*	*15*	*375*	*210*		*11*	*184*	*128*
Lane Group Capacity,[2] c (veh/h)	*383*	*2396*	*358*	*191*	*1757*	*656*	*574*	*358*		*287*	*358*	*670*
v/c ratio[2], X = v/c	***0.95***	***0.72***	***0.76***	***0.84***	***0.50***	***0.02***	***0.65***	***0.59***		***0.04***	***0.51***	***0.19***
Total green ratio,[2] g/C	*0.14*	*0.46*	*0.21*	*0.07*	*0.39*	*0.39*	*0.21*	*0.21*		*0.11*	*0.11*	*0.39*
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*59.49*	*30.23*	*51.59*	*64.22*	*32.09*	*26.04*	*50.25*	*49.42*		*56.03*	*59.06*	*27.89*
Incremental delay calibration,[3] k	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		*0.5*	*0.5*	*0.5*
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*34.67*	*1.93*	*13.92*	*33.83*	*1.01*	*0.06*	*5.70*	*6.86*		*0.24*	*5.20*	*0.63*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*		*0*	*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***94.2***	***32.2***	***65.5***	***98.0***	***33.1***	***26.1***	***55.9***	***56.3***		***56.3***	***64.3***	***28.5***
LOS by lane group (Exhibit 16-2)	***F***	***C***	***E***	***F***	***C***	***C***	***E***	***E***		***E***	***E***	***C***
Intersection delay, $d_1 = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***46.6***											
Intersection Level of Service (Exhibit 16-2)	***D***											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Tuesday, March 13, 2018
Analysis Year: **2017**
Project: **West Loch**
Peak Hour: **AM Peak Hour**
September 2017 counts
12.88 sec.

Intersection, Major Street: **(null)**
Minor Street: **West Loch Drive and Iroquois Road**

Movement Volume and Demand

Inputs	Units
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
1	1	1
4	5	3
<	v	>

===== (null) =====

1 (LEFT)	0	0	^
2 (THRU)	1	0	>
3 (RIGHT)	1	0	v

^	0	0	6 (RIGHT)
<	0	1	5 (THRU)
v	0	0	4 (LEFT)

Peak hour factor, PHF	0.85
Proportion heavy vehicles, P_{HV}	0.03

<	^	>
328	24	283
1	0	1
7 (LEFT)	8 (THRU)	9 (RIGHT)

Movement Calculations	Units	1	2	3	4	5	6	7	8	9	10	11	12
Demand flow rate, v_i	veh/hr	0	0	0	0	0	0	386	28	333	4	6	5
Conflicting flow rate, v_c	veh/hr	0			0			6	1	0	181	1	0
Critical headway, t_c	sec/veh	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
Follow up time headway, t_f	sec/veh	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
Potential capacity, $c_{p,x}$	veh/hr	1636			1636			1019	899	1091	783	899	1091
Probability of queue free state		1.000			1.000			0.621	0.969	0.695	0.995	0.993	0.996
f_k								0.991	1.000		0.678	1.000	
Movement capacity, $c_{m,l}$	veh/hr	1636			1636			1010	899	1091	531	899	1091
Volume-to-capacity ratio, $(v/c)_m$		**0.00**			**0.00**			0.38	0.03	0.31	0.01	0.01	0.00
Lane or shared lane capacity, c_{SH}	veh/hr							1010		1091	531	899	1091
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$								**0.38**		**0.31**	**0.01**	**0.01**	**0.00**
Control delay, d	sec/veh	7.2			7.2			10.8		9.7	11.8	9.0	8.3
Approach delay, d_A	sec/veh							**9.9**			**9.5**		
Level of Service {vi >1}								**B**		**A**	**B**	**A**	**A**
Approach Level of Service {vi >1}		-^			v-			**A**			**A**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

Adapted to estimate LOS for AWSC T-intersection [7 = West Loch Drive LT, 8|9 = Iroquois Rd EB, 10|11 = WB, 12 = WLD RT]

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Tuesday, March 13, 2018
Analysis Year: **2017**
Project: **West Loch**
Peak Hour: **MM Peak Hour**
9.30 sec.
West Loch Drive CLOSED, Iroquois Ave. extended

Intersection, Major Street: **(null)**
Minor Street: **West Loch Drive and Iroquois Road**

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
1	1	1
0	**12**	**0**
<	v	>

^	**0**	0	**6 (RIGHT)**
<	**0**	1	**5 (THRU)**
v	**0**	0	**4 (LEFT)**

===== (null) =====

1 (LEFT)	0	**0**	^
2 (THRU)	1	**0**	>
3 (RIGHT)	0	**0**	v

Peak hour factor, PHF	**0.85**
Proportion heavy vehicles, P_{HV}	**0.03**

<	^	>
265	**11**	**200**
1	0	1
7 (LEFT)	**8 (THRU)**	**9 (RIGHT)**

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	0	0	0	0	0	0	312	13	235	0	14	0
Conflicting flow rate, v_c	veh/hr	0			0			8	0	0	125	0	0
Critical headway, t_c	sec/veh	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
Follow up time headway, t_f	sec/veh	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
Potential capacity, $c_{p,x}$	veh/hr	1636			1636			1017	900	1091	853	900	1091
Probability of queue free state		1.000			1.000			0.693	0.986	0.784	1.000	0.984	1.000
f_k								0.988	1.000		0.776	1.000	
Movement capacity, $c_{m,l}$	veh/hr	1636			1636			1005	899	1091	662	899	1091
Volume-to-capacity ratio, $(v/c)_m$		**0.00**			**0.00**			0.31	0.01	0.22	0.00	0.02	0.00
Lane or shared lane capacity, c_{SH}	veh/hr							1005		1091	662	899	1091
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$								**0.31**		**0.22**	**0.00**	**0.02**	**0.00**
Control delay, d	sec/veh	7.2			7.2			10.2		9.2	10.4	9.1	8.3
Approach delay, d_A	sec/veh							**9.5**			**9.1**		
Level of Service {vi >1}								**B**		**A**		**A**	
Approach Level of Service {vi >1}		-^			v-			**A**			**A**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

Adapted to estimate LOS for AWSC T-intersection [7 = West Loch Drive LT, 8|9 = Iroquois Rd EB, 10|11 = WB, 12 = WLD RT]

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst:	JN (Julian Ng Inc.)	Analysis Year:	**2017**	Peak Hour:	**PM Peak Hour**	11.81 sec.
Date:	Tuesday, March 13, 2018	Project:	**West Loch**		**West Loch Drive CLOSED, Iroquois Ave. extended**	
Intersection, Major Street:	**(null)**	Minor Street:	**West Loch Drive and Iroquois Road**			

Movement Volume and Demand

Inputs	Units
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
1	1	1
0	**0**	**0**
<	v	>

===== (null) =====

1 (LEFT)	0	**0**	^
2 (THRU)	1	**0**	>
3 (RIGHT)	1	**0**	v

^	**0**	0	6 (RIGHT)
<	**0**	1	5 (THRU)
v	**0**	0	4 (LEFT)

<	^	>
292	**0**	**284**
1	0	1
7 (LEFT)	8 (THRU)	9 (RIGHT)

Peak hour factor, PHF	**0.85**
Proportion heavy vehicles, P_{HV}	**0.03**

Movement Calculations	Units	1	2	3	4	5	6	7	8	9	10	11	12
Demand flow rate, v_i	veh/hr	0	0	0	0	0	0	344	0	334	0	0	0
Conflicting flow rate, v_c	veh/hr	0			0			0	0	0	168	0	0
Critical headway, t_c	sec/veh	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
Follow up time headway, t_f	sec/veh	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
Potential capacity, $c_{p,x}$	veh/hr	1636			1636			1028	900	1091	800	900	1091
Probability of queue free state		1.000			1.000			0.666	1.000	0.694	1.000	1.000	1.000
f_k								1.000	1.000		0.694	1.000	
Movement capacity, $c_{m,l}$	veh/hr	1636			1636			1028	899	1091	555	899	1091
Volume-to-capacity ratio, $(v/c)_m$		**0.00**			**0.00**			0.33	0.00	0.31	0.00	0.00	0.00
Lane or shared lane capacity, c_{SH}	veh/hr							1028		1091	555	899	1091
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$								**0.33**		**0.31**	**0.00**	**0.00**	**0.00**
Control delay, d	sec/veh	7.2			7.2			10.3		9.8	11.5	9.0	8.3
Approach delay, d_A	sec/veh							**10.0**			**9.6**		
Level of Service {vi >1}								**B**		**A**			
Approach Level of Service {vi >1}		-^			v-			**B**					

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

Adapted to estimate LOS for AWSC T-intersection [7 = West Loch Drive LT, 8|9 = Iroquois Rd EB, 10|11 = WB, 12 = WLD RT]

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Thursday, March 22, 2018
Intersection, Major Street: **North Road**

Analysis Year: **2017**
Project: **West Loch**
Minor Street: **Iroquois Avenue**

Peak Hour: **AM Peak Hour**
September 2017 counts

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

Peak hour factor, PHF	0.85
Proportion heavy vehicles, P_{HV}	0.03

12 (RIGHT)	11 (THRU)	10 (LEFT)
0	0	0
0	**0**	**0**
<	v	>

^	**0**	0	6 (RIGHT)
<	**99**	1	5 (THRU)
v	**195**	0	4 (LEFT)

===== North Road =====

1 (LEFT)	0	**0**	^
2 (THRU)	1	**46**	>
3 (RIGHT)	1	**157**	v

<	^	>
165	**0**	**283**
1	0	1
7 (LEFT)	8 (THRU)	9 (RIGHT)

Movement Calculations	**Units**	1	2	3	4	5	6	7	8	9	10	11	12
Demand flow rate, v_i	veh/hr	0	54	185	229	116	0	194	0	333	0	0	0
Conflicting flow rate, v_c	veh/hr				239			629		54			
Critical headway, t_c	sec/veh				4.1			7.1		6.2			
Follow up time headway, t_f	sec/veh				2.2			3.5		3.3			
Potential capacity, $c_{p,x}$	veh/hr				1337			396		1018			
Probability of queue free state					0.828			0.509		0.673			
f_k								1.000	0.828		1.000	0.828	
Movement capacity, $c_{m,l}$	veh/hr				1337			396		1018			
Volume-to-capacity ratio, $(v/c)_m$					**0.17**			0.49		0.33			
Lane or shared lane capacity, c_{SH}	veh/hr							396		1018			
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$								**0.49**		**0.33**			
Control delay, d	sec/veh				8.2			22.6		10.2			
Approach delay, d_A	sec/veh								**14.8**				
Level of Service {v_i >9}					**A**			**C**		**B**			
Approach Level of Service {v_i >9}		-^			v-				**B**				

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst:	JN (Julian Ng Inc.)	Analysis Year:	**2017**	Peak Hour:	**MM Peak Hour**	8.03 sec.
Date:	Thursday, March 22, 2018	Project:	**West Loch**		**September 2017 counts**	
Intersection, Major Street:	**North Road**	Minor Street:	**Iroquois Avenue**			

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
1	0	1
0	**0**	**0**
<	v	>

^	**0**	0	**6 (RIGHT)**
<	**18**	1	**5 (THRU)**
v	**173**	0	**4 (LEFT)**

===== North Road =====

1 (LEFT)	0	**0**	^
2 (THRU)	1	**27**	>
3 (RIGHT)	1	**159**	v

<	^	>
139	**0**	**145**
1	0	1
7 (LEFT)	**8 (THRU)**	**9 (RIGHT)**

Peak hour factor, PHF	**0.74**
Proportion heavy vehicles, P_{HV}	**0.03**

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	0	36	215	234	24	0	188	0	196	0	0	0
Conflicting flow rate, v_c	veh/hr				251			528		36			
Critical headway, t_c	sec/veh				4.1			7.1		6.2			
Follow up time headway, t_f	sec/veh				2.2			3.5		3.3			
Potential capacity, $c_{p,x}$	veh/hr				1323			462		1041			
Probability of queue free state					0.823			0.594		0.812			
f_k								1.000	0.823		1.000	0.823	
Movement capacity, $c_{m,l}$	veh/hr				1323			462		1041			
Volume-to-capacity ratio, $(v/c)_m$					**0.18**			0.41		0.19			
Lane or shared lane capacity, c_{SH}	veh/hr							462		1041			
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$								**0.41**		**0.19**			
Control delay, d	sec/veh				8.3			18.0		9.3			
Approach delay, d_A	sec/veh								**13.5**				
Level of Service {v_i >9}					**A**			**C**		**A**			
Approach Level of Service {v_i >9}		-^			v-				**B**				

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual*. (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Thursday, March 22, 2018
Analysis Year: **2017**
Project: **West Loch**
Peak Hour: **PM Peak Hour**
September 2017 counts
9.51 sec.

Intersection, Major Street: **North Road**
Minor Street: **Iroquois Avenue**

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
1	0	1
0	**0**	**0**
<	v	>

^	**0**	0	6 (RIGHT)
<	**9**	1	5 (THRU)
v	**283**	0	4 (LEFT)

===== North Road =====

1 (LEFT)	0	**0**	^
2 (THRU)	1	**7**	>
3 (RIGHT)	1	**128**	v

Peak hour factor, PHF	**0.82**
Proportion heavy vehicles, P_{HV}	**0.03**

<	^	>
123	**0**	**256**
1	0	1
7 (LEFT)	8 (THRU)	9 (RIGHT)

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	0	9	156	345	11	0	150	0	312	0	0	0
Conflicting flow rate, v_c	veh/hr				165			710		9			
Critical headway, t_c	sec/veh				4.1			7.1		6.2			
Follow up time headway, t_f	sec/veh				2.2			3.5		3.3			
Potential capacity, $c_{p,x}$	veh/hr				1424			349		1079			
Probability of queue free state					0.758			0.571		0.711			
f_k								1.000	0.758		1.000	0.758	
Movement capacity, $c_{m,l}$	veh/hr				1424			349		1079			
Volume-to-capacity ratio, $(v/c)_m$					**0.24**			0.43		0.29			
Lane or shared lane capacity, c_{SH}	veh/hr							349		1079			
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$								**0.43**		**0.29**			
Control delay, d	sec/veh				8.3			22.8		9.7			
Approach delay, d_A	sec/veh							**14.0**					
Level of Service {v_i >5}					**A**			**C**		**A**			
Approach Level of Service {v_i >9}		-^			v-			**B**					

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: June 5, 2018
Intersection, Major Street: **Iroquois Avenue**

Analysis Year: **2017**
Project: **West Loch**
Minor Street: **Barracks Road**

Peak Hour: **AM Peak Hour**
September 2017 counts

Movement Volume and Demand

Inputs	Units
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
0	1	0
6	0	3
<	v	>

===== Iroquois Avenue =====

1 (LEFT)	0	18	^
2 (THRU)	1	303	>
3 (RIGHT)	0	0	v

^	11	0	6 (RIGHT)
<	458	1	5 (THRU)
v	0	0	4 (LEFT)

<	^	>
0	0	0
0	0	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Peak hour factor, PHF	0.85
Proportion heavy vehicles, P_{HV}	0.02

Movement Calculations	Units	1	2	3	4	5	6	7	8	9	10	11	12
Demand flow rate, v_i	veh/hr	21	356	0	0	539	13	0	0	0	4	0	7
Conflicting flow rate, v_c	veh/hr	552									944		545
Critical headway, t_c	sec/veh	4.1									7.1		6.2
Follow up time headway, t_f	sec/veh	2.2									3.5		3.3
Potential capacity, $c_{p,x}$	veh/hr	1026									243		540
Probability of queue free state		0.979									0.985		0.987
f_k								1.000	0.979		1.000	0.979	
Movement capacity, $c_{m,l}$	veh/hr	1026									243		540
Volume-to-capacity ratio, $(v/c)_m$		**0.02**									0.01		0.01
Lane or shared lane capacity, c_{SH}	veh/hr											384	
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$												**0.03**	
Control delay, d	sec/veh	8.6										14.6	
Approach delay, d_A	sec/veh										**14.6**		
Level of Service $\{v_i > 9\}$		**A**											
Approach Level of Service $\{v_i > 9\}$		-^			v¯						**B**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: June 5, 2018
Analysis Year: **2017**
Project: **West Loch**
Peak Hour: **MM Peak Hour**
September 2017 counts

Intersection, Major Street: **Iroquois Avenue**
Minor Street: **Barracks Road**

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

===== Iroquois Avenue =====

12 (RIGHT)	11 (THRU)	10 (LEFT)
0	1	0
14	0	6
<	v	>

1 (LEFT)	0	6	^
2 (THRU)	1	293	>
3 (RIGHT)	0	0	v

^	0	0	6 (RIGHT)
<	342	1	5 (THRU)
v	0	0	4 (LEFT)

<	^	>
0	0	0
0	0	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Peak hour factor, PHF	0.90
Proportion heavy vehicles, P_{HV}	0.03

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	7	326	0	0	380	0	0	0	0	7	0	16
Conflicting flow rate, v_c	veh/hr	380									719		380
Critical headway, t_c	sec/veh	4.1									7.1		6.2
Follow up time headway, t_f	sec/veh	2.2									3.5		3.3
Potential capacity, $c_{p,x}$	veh/hr	1186									344		670
Probability of queue free state		0.994									0.981		0.977
f_k								1.000	0.994		1.000	0.994	
Movement capacity, $c_{m,l}$	veh/hr	1186									344		670
Volume-to-capacity ratio, $(v/c)_m$		**0.01**									0.02		0.02
Lane or shared lane capacity, c_{SH}	veh/hr											522	
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$												**0.04**	
Control delay, d	sec/veh	8.1										12.2	
Approach delay, d_A	sec/veh											**12.2**	
Level of Service {v_i >9}		**A**											
Approach Level of Service {v_i >9}		-^			v-							**B**	

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: June 5, 2018
Intersection, Major Street: **Iroquois Avenue**

Analysis Year: **2017**
Project: **West Loch**
Minor Street: **Barracks Road**

Peak Hour: **PM Peak Hour**
September 2017 counts

Movement Volume and Demand

Inputs	Units
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
0	1	0
68	**0**	**11**
<	v	>

^	**2**	0	**6 (RIGHT)**
<	**263**	1	**5 (THRU)**
v	**0**	0	**4 (LEFT)**

===== **Iroquois Avenue** =====

1 (LEFT)	0	**9**	^
2 (THRU)	1	**405**	>
3 (RIGHT)	0	**0**	v

<	^	>
0	**0**	**0**
0	0	0
7 (LEFT)	**8 (THRU)**	**9 (RIGHT)**

Peak hour factor, PHF	**0.91**
Proportion heavy vehicles, P_{HV}	**0.02**

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	10	445	0	0	289	2	0	0	0	12	0	75
Conflicting flow rate, v_c	veh/hr	291									755		290
Critical headway, t_c	sec/veh	4.1									7.1		6.2
Follow up time headway, t_f	sec/veh	2.2									3.5		3.3
Potential capacity, $c_{p,x}$	veh/hr	1280									326		753
Probability of queue free state		0.992									0.963		0.901
f_k								1.000	0.992		1.000	0.992	
Movement capacity, $c_{m,l}$	veh/hr	1280									326		753
Volume-to-capacity ratio, $(v/c)_m$		**0.01**									0.04		0.10
Lane or shared lane capacity, c_{SH}	veh/hr											637	
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$												**0.14**	
Control delay, d	sec/veh	7.8										11.5	
Approach delay, d_A	sec/veh										**11.5**		
Level of Service {v_i >9}		**A**											
Approach Level of Service {v_i >9}		-^			v-						**B**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Monday, March 12, 2018
Intersection, Major Street: **North Road**

Analysis Year: **2017**
Project: **West Loch**
Minor Street: **Hanakahi Street**

Peak Hour: **AM Peak Hour**
Sept. 2017 counts

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
0	1	0
166	0	83
<	v	>

^	90	0	6 (RIGHT)
<	249	1	5 (THRU)
v	0	0	4 (LEFT

===== North Road =====

1 (LEFT)	0	132	^
2 (THRU)	1	152	>
3 (RIGHT)	0	0	v

<	^	>
0	0	0
0	1	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Peak hour factor, PHF	0.87
Proportion heavy vehicles, P_{HV}	0.03

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	152	175	0	0	286	103	0	0	0	95	0	191
Conflicting flow rate, v_c	veh/hr	390									816		338
Critical headway, t_c	sec/veh	4.1									7.1		6.2
Follow up time headway, t_f	sec/veh	2.2									3.5		3.3
Potential capacity, $c_{p,x}$	veh/hr	1176									296		707
Probability of queue free state		0.871									0.678		0.730
f_k								1.000	0.871		1.000	0.871	
Movement capacity, $c_{m,l}$	veh/hr	1176									296		707
Volume-to-capacity ratio, $(v/c)_m$		**0.13**									0.32		0.27
Lane or shared lane capacity, c_{SH}	veh/hr								0			483	
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$												**0.59**	
Control delay, d	sec/veh	8.5										22.7	
Approach delay, d_A	sec/veh										**22.7**		
Level of Service $\{v_i > 9\}$		**A**											
Approach Level of Service $\{v_i > 9\}$		-^			v¯						**C**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst:	JN (Julian Ng Inc.)	Analysis Year:	**2017**	Peak Hour:	**MM Peak Hour**
Date:	Monday, March 12, 2018	Project:	**West Loch**		**Sept. 2017 counts**
Intersection, Major Street:	**North Road**	Minor Street:	**Hanakahi Street**		

Movement Volume and Demand

Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
0	1	0
91	0	63
<	v	>

===== North Road =====

1 (LEFT)	0	128
2 (THRU)	1	132
3 (RIGHT)	0	0

^	77	0	6 (RIGHT)
<	128	1	5 (THRU)
v	0	0	4 (LEFT

<	^	>
0	0	0
0	1	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Peak hour factor, PHF	0.71
Proportion heavy vehicles, P_{HV}	0.04

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	180	186	0	0	180	108	0	0	0	89	0	128
Conflicting flow rate, v_c	veh/hr	289									781		235
Critical headway, t_c	sec/veh	4.1									7.1		6.2
Follow up time headway, t_f	sec/veh	2.2									3.5		3.3
Potential capacity, $c_{p,x}$	veh/hr	1281									312		808
Probability of queue free state		0.859									0.716		0.841
f_k								1.000	0.859		1.000	0.859	
Movement capacity, $c_{m,l}$	veh/hr	1281									312		808
Volume-to-capacity ratio, $(v/c)_m$		**0.14**									0.28		0.16
Lane or shared lane capacity, c_{SH}	veh/hr								0			490	
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$												**0.44**	
Control delay, d	sec/veh	8.3										18.1	
Approach delay, d_A	sec/veh										**18.1**		
Level of Service {v_i >9}		**A**											
Approach Level of Service {v_i >9}		-^			v-						**C**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Saturday, August 18, 2018
Analysis Year: **2017**
Project: **West Loch**
Peak Hour: **PM Peak Hour**
Sept. 2017 counts

Intersection, Major Street: **North Road**
Minor Street: **Hanakahi Street**

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
0	1	0
57	**0**	**64**
<	v	>

^	**43**	0	6 (RIGHT)
<	**81**	1	5 (THRU)
v	**0**	0	4 (LEFT

===== North Road =====

1 (LEFT)	0	**48**	^
2 (THRU)	1	**91**	>
3 (RIGHT)	0	**0**	v

Peak hour factor, PHF	**0.89**
Proportion heavy vehicles, P_{HV}	**0.03**

<	^	>
0	**0**	**0**
0	1	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	54	102	0	0	91	48	0	0	0	72	0	64
Conflicting flow rate, v_c	veh/hr	139									325		115
Critical headway, t_c	sec/veh	4.1									7.1		6.2
Follow up time headway, t_f	sec/veh	2.2									3.5		3.3
Potential capacity, $c_{p,x}$	veh/hr	1455									630		942
Probability of queue free state		0.963									0.886		0.932
f_k								1.000	0.963		1.000	0.963	
Movement capacity, $c_{m,l}$	veh/hr	1455									630		942
Volume-to-capacity ratio, $(v/c)_m$		**0.04**									0.11		0.07
Lane or shared lane capacity, c_{SH}	veh/hr								0			747	
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$												**0.18**	
Control delay, d	sec/veh	7.6										10.9	
Approach delay, d_A	sec/veh											**10.9**	
Level of Service {v_i >9}		**A**											
Approach Level of Service {v_i >9}		-^			v⁻							**B**	

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst:	JN (Julian Ng Inc.)	Analysis Year:	**2017**	Peak Hour:	**AM Peak Hour**
Date:	Monday, March 12, 2018	Project:	**West Loch**		**Sept. 2017 counts**
Intersection, Major Street:	**Kuhina Street**	Minor Street:	**Hanakahi Street**		

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
0	1	0
3	**288**	**1**
<	v	>

^	**2**	0	6 (RIGHT)
<	**2**	1	5 (THRU)
v	**1**	0	4 (LEFT)

===== Kuhina Street =====

1 (LEFT)	0	**7**	^
2 (THRU)	1	**1**	>
3 (RIGHT)	0	**128**	v

Peak hour factor, PHF	**0.81**
Proportion heavy vehicles, P_{HV}	**0.04**

<	^	>
108	**339**	**0**
0	1	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	9	1	158	1	2	2	133	419	0	1	356	4
Conflicting flow rate, v_c	veh/hr	5			159			283	105	80	313	183	4
Critical headway, t_c	sec/veh	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
Follow up time headway, t_f	sec/veh	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
Potential capacity, $c_{p,x}$	veh/hr	1630			1430			671	788	985	641	714	1086
Probability of queue free state		0.995			0.999			0.801	0.469	1.000	0.998	0.502	0.997
f_k								0.603	0.994		0.578	0.994	
Movement capacity, $c_{m,l}$	veh/hr	1630			1430			405	783	985	371	709	1086
Volume-to-capacity ratio, $(v/c)_m$		**0.01**			**0.00**			0.33	0.53	0.00	0.00	0.50	0.00
Lane or shared lane capacity, c_{SH}	veh/hr								639			710	
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$									**0.86**			**0.51**	
Control delay, d	sec/veh	7.2			7.5				35.9			15.2	
Approach delay, d_A	sec/veh							**35.9**			**15.2**		
Level of Service {v_i >9}									**E**			**C**	
Approach Level of Service {v_i >9}		-^			v‾			**E**			**C**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Monday, March 12, 2018
Intersection, Major Street: **Kuhina Street**

Analysis Year: **2017**
Project: **West Loch**
Minor Street: **Hanakahi Street**

Peak Hour: **MM Peak Hour**
Sept. 2017 counts

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
0	1	0
12	**244**	**0**
<	v	>

===== Kuhina Street =====

1 (LEFT)	0	**11**	^
2 (THRU)	1	**1**	>
3 (RIGHT)	0	**117**	v

^	**0**	0	6 (RIGHT)
<	**1**	1	5 (THRU)
v	**1**	0	4 (LEFT)

<	^	>
65	**268**	**2**
0	1	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Peak hour factor, PHF	**0.81**
Proportion heavy vehicles, P_{HV}	**0.04**

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	14	1	144	1	1	0	80	331	2	0	301	15
Conflicting flow rate, v_c	veh/hr	1			146			262	104	73	271	177	1
Critical headway, t_c	sec/veh	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
Follow up time headway, t_f	sec/veh	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
Potential capacity, $c_{p,x}$	veh/hr	1634			1447			693	789	993	684	719	1089
Probability of queue free state		0.992			0.999			0.884	0.580	0.998	1.000	0.581	0.986
f_k								0.660	0.991		0.666	0.991	
Movement capacity, $c_{m,l}$	veh/hr	1634			1447			457	781	993	456	713	1089
Volume-to-capacity ratio, $(v/c)_m$		**0.01**			**0.00**			0.18	0.42	0.00	0.00	0.42	0.01
Lane or shared lane capacity, c_{SH}	veh/hr								687			724	
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$									**0.60**			**0.44**	
Control delay, d	sec/veh	7.2			7.5				17.8			13.8	
Approach delay, d_A	sec/veh							**17.8**			**13.8**		
Level of Service {v_i >9}		**A**							**C**			**B**	
Approach Level of Service {v_i >9}		-^			v-			**C**			**B**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Monday, March 12, 2018
Analysis Year: **2017**
Project: **West Loch**
Peak Hour: **PM Peak Hour**
Sept. 2017 counts

Intersection, Major Street: **Kuhina Street**
Minor Street: **Hanakahi Street**

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
0	1	0
8	**265**	**2**
<	v	>

===== **Kuhina Street** =====

1 (LEFT)	0	**8**	^
2 (THRU)	1	**1**	>
3 (RIGHT)	0	**107**	v

^	**1**	0	**6 (RIGHT)**
<	**0**	1	**5 (THRU)**
v	**0**	0	**4 (LEFT)**

<	^	>
52	**216**	**1**
0	1	0
7 (LEFT)	**8 (THRU)**	**9 (RIGHT)**

Peak hour factor, PHF	**0.81**
Proportion heavy vehicles, P_{HV}	**0.04**

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	10	1	132	0	0	1	64	267	1	2	327	10
Conflicting flow rate, v_c	veh/hr	1			133			257	89	67	222	154	1
Critical headway, t_c	sec/veh	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
Follow up time headway, t_f	sec/veh	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
Potential capacity, $c_{p,x}$	veh/hr	1634			1462			699	805	1001	736	740	1090
Probability of queue free state		0.994			1.000			0.908	0.669	0.999	0.997	0.558	0.991
f_k								0.645	0.994		0.739	0.994	
Movement capacity, $c_{m,I}$	veh/hr	1634			1462			451	800	1001	544	736	1090
Volume-to-capacity ratio, $(v/c)_m$		**0.01**			**0.00**			0.14	0.33	0.00	0.00	0.44	0.01
Lane or shared lane capacity, c_{SH}	veh/hr								696			741	
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$									**0.48**			**0.46**	
Control delay, d	sec/veh	7.2			7.5				14.8			13.9	
Approach delay, d_A	sec/veh								**14.8**			**13.9**	
Level of Service {v_i >9}		**A**							**B**			**B**	
Approach Level of Service {v_i >9}		-^			v-				**B**			**B**	

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual*. (Build 2016-09-20)

INPUT WORKSHEET

General Information

Analyst *Julian Ng*
Agency or Company *JNI*
Date Performed *August 6, 2018*
Analysis Time Period *AM Peak Hour (Existing)*

Site Information

Intersection *Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.*
Area Type ☐ CBD ☒ Other
Jurisdiction *HDOT HWY*
Analysis Year *- 2017 -*

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	159	916	274	90	971	8	254	119	90	4	88	344
% heavy vehicles, %HV	2	2	2	2	2	2	2	2	2	2	2	2
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	*32.0*	*85.0*	*85.0*	*15.0*	*68.0*	*68.0*	*35.0*	*35.0*	*35.0*		*25.0*	*25.0*
Y + R (s) Cycle length, C = 180.0 s	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*		*5.0*	*5.0*

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.- 2017 - AM Peak Hour (Existing)*

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*159*	*916*	*274*	*90*	*971*	*8*	*254*	*119*	*90*	*4*	*88*	*344*
Peak-hour factor, PHF	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*
Adjusted flow rate, v_p = V/PHF (veh/h)	*183*	*1053*	*315*	*103*	*1116*	*9*	*292*	*137*	*103*	*5*	*101*	*395*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*183*	*1053*	*315*	*103*	*1116*	*9*	*202*	*227*	*103*		*106*	*395*
Proportion[1] of LT or RT (P_{LT} or P_{RT})										*0.043*		
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*		*1900*	*1900*
Number of lanes, N	*1*	*2*	*1*	*1*	*2*	*1*	*1*	*1*	*1*		*1*	*1*
Approach width	*12*	*36*	*12*	*12*	*24*	*12*	*12*	*12*	*12*		*10*	*12*
Lane width, W	*12*	*18*	*12*	*12*	*12*	*12*	*12*	*12*	*12*		*10*	*12*
Lane width adjustment factor, f_w	*1.000*	*1.200*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*0.933*	*1.000*
Heavy-vehicle adjustment factor, f_{HV}	*0.977*	*0.977*	*0.977*	*0.977*	*0.977*	*0.977*	*0.977*	*0.977*	*0.977*		*0.977*	*0.977*
Grade adjustment factor, f_g	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Parking adjustment factor, f_p	*0.900*	*1.000*	*0.900*	*0.900*	*1.000*	*0.900*	*0.900*	*1.000*	*0.900*		*1.000*	*0.900*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.990*	*1.000*	*1.000*	*0.990*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Area type adj. factor, f_a (*__0.90__ CBD, __1.00__ other)*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.950*	*1.000*	*1.000*	*0.950*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*0.999*	*0.999*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1670*	*4188*	*1670*	*1670*	*3490*	*1670*	*1670*	*1855*	*1670*		*1729*	*1668*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description *Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.- 2017 - AM Peak Hour (Existing)*

Capacity Analysis

Phase number	1	6	6	5	2	2	4	4	4		3	3
Phase type	P	P	P	P	P	P	P	P	P		P	P
Lane Group												
Adjusted flow rate, v (veh/h)	183	1053	315	103	1116	9	202	227	103		106	395
Saturation flow rate, s (veh/h)	1670	4188	1670	1670	3490	1670	1670	1855	1670		1729	1668
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0
Effective green time, g (s), $g = G + Y - t_L$	32.0	85.0	85.0	15.0	68.0	68.0	35.0	35.0	35.0		25.0	62.0
Green ratio, g/C	0.18	0.47	0.47	0.08	0.38	0.38	0.19	0.19	0.19		0.14	0.34
Lane group capacity,[1] c = s(g/C), (veh/h)	297	1,978	789	139	1,318	631	325	361	325		240	574
v/c ratio, X	0.616	0.532	0.399	0.740	0.846	0.014	0.622	0.629	0.317		0.440	0.688
Flow ratio, v/s	0.110	0.251	0.189	0.062	0.320	0.005	0.121	0.122	0.062		0.061	0.237
Critical lane group/phase (√)	√				√			√				√
Sum of flow ratios for critical lane groups, Y_c Yc = Σ (critical lane groups, v/s)	0.679											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.74**											

Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Adjusted flow rate,[2] v (veh/h)	*183*	*1053*	*315*	*103*	*1116*	*9*	*202*	*227*	*103*		*106*	*395*
Lane Group Capacity,[2] c (veh/h)	*297*	*1978*	*789*	*139*	*1318*	*631*	*325*	*361*	*325*		*240*	*574*
v/c ratio[2], X = v/c	***0.62***	***0.53***	***0.40***	***0.74***	***0.85***	***0.01***	***0.62***	***0.63***	***0.32***		***0.44***	***0.69***
Total green ratio,[2] g/C	*0.18*	*0.47*	*0.47*	*0.08*	*0.38*	*0.38*	*0.19*	*0.19*	*0.19*		*0.14*	*0.34*
Uniform delay, $d_1 = \dfrac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*68.33*	*33.49*	*30.90*	*80.60*	*51.22*	*35.03*	*66.44*	*66.54*	*62.24*		*71.08*	*50.70*
Incremental delay calibration,[3] k	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		*0.5*	*0.5*
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*9.25*	*1.03*	*1.51*	*29.43*	*6.85*	*0.04*	*8.68*	*8.07*	*2.55*		*5.76*	*6.61*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*		*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Delay = $d = d_1(PF) + d_2 + d_3$ (s/veh)	***77.6***	***34.5***	***32.4***	***110.0***	***58.1***	***35.1***	***75.1***	***74.6***	***64.8***		***76.8***	***57.3***
LOS by lane group (Exhibit 16-2)	***E***	***C***	***C***	***F***	***E***	***D***	***E***	***E***	***E***		***E***	***E***
Intersection delay, $d_1 = \dfrac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***54.2***											
Intersection Level of Service (Exhibit 16-2)	***D***											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information

Analyst *Julian Ng*
Agency or Company *JNI*
Date Performed *August 6, 2018*
Analysis Time Period *MM Peak Hour (Existing)*

Site Information

Intersection *Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.*
Area Type ☐ CBD ☒ Other
Jurisdiction *HDOT HWY*
Analysis Year *- 2017 -*

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	241	954	207	65	1020	15	159	75	96	8	72	241
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	*27.0*	*70.0*	*70.0*	*15.0*	*58.0*	*58.0*	*35.0*	*35.0*	*35.0*		*20.0*	*20.0*
Y + R (s) Cycle length, C = 160.0 s	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*		*5.0*	*5.0*

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.- 2017 - MM Peak Hour (Existing)*

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*241*	*954*	*207*	*65*	*1,020*	*15*	*159*	*75*	*96*	*8*	*72*	*241*
Peak-hour factor, PHF	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*
Adjusted flow rate, v_p = V/PHF (veh/h)	*268*	*1060*	*230*	*72*	*1133*	*17*	*177*	*83*	*107*	*9*	*80*	*268*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*268*	*1060*	*230*	*72*	*1133*	*17*	*122*	*138*	*107*		*89*	*268*
Proportion[1] of LT or RT (P_{LT} or P_{RT})										*0.100*		
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*		*1900*	*1900*
Number of lanes, N	*1*	*2*	*1*	*1*	*2*	*1*	*1*	*1*	*1*		*1*	*1*
Approach width	*12*	*36*	*12*	*12*	*24*	*12*	*12*	*12*	*12*		*10*	*12*
Lane width, W	*12*	*18*	*12*	*12*	*12*	*12*	*12*	*12*	*12*		*10*	*12*
Lane width adjustment factor, f_w	*1.000*	*1.200*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*0.933*	*1.000*
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*		*0.971*	*0.971*
Grade adjustment factor, f_g	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Parking adjustment factor, f_p	*0.900*	*1.000*	*0.900*	*0.900*	*1.000*	*0.900*	*0.900*	*1.000*	*0.900*		*1.000*	*0.900*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.990*	*1.000*	*1.000*	*0.990*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.950*	*1.000*	*1.000*	*0.950*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*0.996*	*0.996*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1660*	*4164*	*1660*	*1660*	*3470*	*1660*	*1660*	*1845*	*1660*		*1715*	*1654*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description *Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.- 2017 - MM Peak Hour (Existing)*

Capacity Analysis

Phase number	1	6	6	5	2	2	4	4	4		3	3
Phase type	P	P	P	P	P	P	P	P	P		P	P
Lane Group												
Adjusted flow rate, v (veh/h)	268	1060	230	72	1133	17	122	138	107		89	268
Saturation flow rate, s (veh/h)	1660	4164	1660	1660	3470	1660	1660	1845	1660		1715	1654
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0
Effective green time, g (s), $g = G + Y - t_L$	27.0	70.0	70.0	15.0	58.0	58.0	35.0	35.0	35.0		20.0	52.0
Green ratio, g/C	0.17	0.44	0.44	0.09	0.36	0.36	0.22	0.22	0.22		0.13	0.33
Lane group capacity,[1] c = s(g/C), (veh/h)	280	1,822	726	156	1,258	602	363	404	363		214	537
v/c ratio, X	0.957	0.582	0.317	0.463	0.901	0.028	0.336	0.342	0.295		0.415	0.498
Flow ratio, v/s	0.161	0.255	0.139	0.043	0.327	0.010	0.073	0.075	0.064		0.052	0.162
Critical lane group/phase (√)	√				√			√				√
Sum of flow ratios for critical lane groups, Y_c Yc = Σ (critical lane groups, v/s)	0.615											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.68**											

Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Adjusted flow rate,[2] v (veh/h)	*268*	*1060*	*230*	*72*	*1133*	*17*	*122*	*138*	*107*		*89*	*268*
Lane Group Capacity,[2] c (veh/h)	*280*	*1822*	*726*	*156*	*1258*	*602*	*363*	*404*	*363*		*214*	*537*
v/c ratio[2], X = v/c	***0.96***	***0.58***	***0.32***	***0.46***	***0.90***	***0.03***	***0.34***	***0.34***	***0.29***		***0.41***	***0.50***
Total green ratio,[2] g/C	*0.17*	*0.44*	*0.44*	*0.09*	*0.36*	*0.36*	*0.22*	*0.22*	*0.22*		*0.13*	*0.33*
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*65.92*	*33.96*	*29.38*	*68.68*	*48.28*	*32.85*	*52.70*	*52.78*	*52.19*		*64.60*	*43.49*
Incremental delay calibration,[3] k	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		*0.5*	*0.5*
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*43.73*	*1.37*	*1.14*	*9.58*	*10.52*	*0.09*	*2.49*	*2.30*	*2.06*		*5.82*	*3.28*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*		*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***109.6***	***35.3***	***30.5***	***78.3***	***58.8***	***32.9***	***55.2***	***55.1***	***54.2***		***70.4***	***46.8***
LOS by lane group (Exhibit 16-2)	***F***	***D***	***C***	***E***	***E***	***C***	***E***	***E***	***D***		***E***	***D***
Intersection delay, $d_1 = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***53.0***											
Intersection Level of Service (Exhibit 16-2)	***D***											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information

Analyst: Julian Ng
Agency or Company: JNI
Date Performed: August 6, 2018
Analysis Time Period: PM Peak Hour (Existing)

Site Information

Intersection: Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.
Area Type: ☐ CBD ☒ Other
Jurisdiction: HDOT HWY
Analysis Year: - 2017 -

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	316	970	277	42	741	11	201	97	76	6	61	196
% heavy vehicles, %HV	2	2	2	2	2	2	2	2	2	2	2	2
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	40.0	65.0	65.0	10.0	35.0	35.0	35.0	35.0	35.0		20.0	20.0
Y + R (s) Cycle length, C = 150.0 s	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description: Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.- 2017 - PM Peak Hour (Existing)

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	316	970	277	42	741	11	201	97	76	6	61	196
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adjusted flow rate, v_p = V/PHF (veh/h)	336	1032	295	45	788	12	214	103	81	6	65	209
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	336	1032	295	45	788	12	149	168	81		71	209
Proportion[1] of LT or RT (P_{LT} or P_{RT})										0.090		
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	1900	1900	1900	1900	1900	1900	1900	1900	1900		1900	1900
Number of lanes, N	1	2	1	1	2	1	1	1	1		1	1
Approach width	12	36	12	12	24	12	12	12	12		10	12
Lane width, W	12	18	12	12	12	12	12	12	12		10	12
Lane width adjustment factor, f_w	1.000	1.200	1.000	1.000	1.000	1.000	1.000	1.000	1.000		0.933	1.000
Heavy-vehicle adjustment factor, f_{HV}	0.977	0.977	0.977	0.977	0.977	0.977	0.977	0.977	0.977		0.977	0.977
Grade adjustment factor, f_g	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Parking adjustment factor, f_p	0.900	1.000	0.900	0.900	1.000	0.900	0.900	1.000	0.900		1.000	0.900
Bus blockage adjustment factor, f_{bb}	1.000	0.990	1.000	1.000	0.990	1.000	1.000	1.000	1.000		1.000	1.000
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Lane utilization adjustment factor, f_{LU}	1.000	0.950	1.000	1.000	0.950	1.000	1.000	1.000	1.000		1.000	1.000
Left-turn adjustment factor, f_{LT}	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Right-turn adjustment factor, f_{RT}	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Left-turn ped/bike adjustment factor, f_{Lpb}	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		0.997	0.997
Right-turn ped/bike adjustment factor, f_{Rpb}	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	1670	4188	1670	1670	3490	1670	1670	1855	1670		1726	1665

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.- 2017 - PM Peak Hour (Existing)

Capacity Analysis

Phase number	1	6	6	5	2	2	4	4	4		3	3
Phase type	P	P	P	P	P	P	P	P	P		P	P
Lane Group												
Adjusted flow rate, v (veh/h)	336	1032	295	45	788	12	149	168	81		71	209
Saturation flow rate, s (veh/h)	1670	4188	1670	1670	3490	1670	1670	1855	1670		1726	1665
Lost time, t_L (s), $t_L = I_1 + Y + e$	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0
Effective green time, g (s), $g = G + Y - t_L$	40.0	65.0	65.0	10.0	35.0	35.0	35.0	35.0	35.0		20.0	65.0
Green ratio, g/C	0.27	0.43	0.43	0.07	0.23	0.23	0.23	0.23	0.23		0.13	0.43
Lane group capacity,[1] c = s(g/C), (veh/h)	445	1,815	724	111	814	390	390	433	390		230	721
v/c ratio, X	0.755	0.569	0.408	0.404	0.968	0.031	0.382	0.388	0.208		0.310	0.289
Flow ratio, v/s	0.201	0.246	0.177	0.027	0.226	0.007	0.089	0.091	0.049		0.041	0.125
Critical lane group/phase (√)	√				√			√				√
Sum of flow ratios for critical lane groups, Y_c $Yc = \Sigma$ (critical lane groups, v/s)	0.559											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.62**											

Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Adjusted flow rate,[2] v (veh/h)	336	1032	295	45	788	12	149	168	81		71	209
Lane Group Capacity,[2] c (veh/h)	445	1815	724	111	814	390	390	433	390		230	721
v/c ratio[2], X = v/c	**0.75**	**0.57**	**0.41**	**0.40**	**0.97**	**0.03**	**0.38**	**0.39**	**0.21**		**0.31**	**0.29**
Total green ratio,[2] g/C	0.27	0.43	0.43	0.07	0.23	0.23	0.23	0.23	0.23		0.13	0.43
Uniform delay, $d_1 = \dfrac{0.50\ C\ [1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	50.49	31.96	29.25	67.14	56.94	44.40	48.40	48.47	46.33		58.76	27.53
Incremental delay calibration,[3] k	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	11.27	1.30	1.70	10.55	24.58	0.15	2.83	2.61	1.21		3.47	1.01
Initial queue delay, d_3 (s/veh) (Appendix F)	0	0	0	0	0	0	0	0	0		0	0
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	**61.8**	**33.3**	**31.0**	**77.7**	**81.5**	**44.5**	**51.2**	**51.1**	**47.5**		**62.2**	**28.5**
LOS by lane group (Exhibit 16-2)	***E***	***C***	***C***	***E***	***F***	***D***	***D***	***D***	***D***		***E***	***C***
Intersection delay, $d_1 = \dfrac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***51.1***											
Intersection Level of Service (Exhibit 16-2)	***D***											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

Appendix C
Intersection Analyses Worksheets
Conditions with West Loch Drive Closed

12 sheets follow

INPUT WORKSHEET

General Information

Analyst: Julian Ng
Agency or Company: JNI
Date Performed: February 15, 2018
Analysis Time Period: AM Peak Hour (No West Loch Drive)

Site Information

Intersection: Fort Weaver Road & Geiger Road / Iroquois Road
Area Type: ☐ CBD ☒ Other
Jurisdiction: HDOT HWY
Analysis Year: - 2017 -

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	80	963	101	377	1362	93	265	62	257	133	123	109
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	*10.0*	*45.0*	*30.0*	*25.0*	*60.0*	*60.0*	*30.0*	*30.0*	*30.0*	*20.0*	*20.0*	*30.0*
Y + R (s) Cycle length, C = 140.0 s	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description: Fort Weaver Road & Geiger Road / Iroquois Road- 2017 - AM Peak Hour (No West Loch Drive)

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*80*	*963*	*101*	*377*	*1,362*	*93*	*265*	*62*	*257*	*133*	*123*	*109*
Peak-hour factor, PHF	*0.88*	*0.88*	*0.88*	*0.88*	*0.88*	*0.88*	*0.88*	*0.88*	*0.88*	*0.88*	*0.88*	*0.88*
Adjusted flow rate, v_p = V/PHF (veh/h)	*91*	*1094*	*115*	*428*	*1548*	*106*	*301*	*70*	*292*	*151*	*140*	*124*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*91*	*1094*	*115*	*428*	*1548*	*106*	*370*	*293*		*151*	*140*	*124*
Proportion[1] of LT or RT (P_{LT} or P_{RT})									*0.997*			
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*		*1900*	*1900*	*1900*
Number of lanes, N	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*1*		*2*	*1*	*2*
Approach width	*12*	*36*	*12*	*12*	*24*	*12*	*12*	*12*		*12*	*36*	*12*
Lane width, W	*6*	*12*	*12*	*6*	*8*	*12*	*6*	*12*		*6*	*36*	*6*
Lane width adjustment factor, f_w	*0.800*	*1.000*	*1.000*	*0.800*	*0.867*	*1.000*	*0.800*	*1.000*		*0.800*	*1.800*	*0.800*
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*		*0.971*	*0.971*	*0.971*
Grade adjustment factor, f_g	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Parking adjustment factor, f_p	*0.950*	*1.000*	*0.900*	*0.950*	*1.000*	*0.900*	*0.950*	*1.000*		*0.950*	*1.000*	*0.950*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*	*1.000*	*1.000*	*0.993*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*0.950*	*0.933*	*1.000*	*0.950*	*0.933*	*1.000*	*0.950*	*1.000*		*0.950*	*1.000*	*0.950*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*0.865*		*1.000*	*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*2664*	*5131*	*1660*	*2664*	*4447*	*1660*	*2664*	*1596*		*2664*	*3320*	*2664*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: Fort Weaver Road & Geiger Road / Iroquois Road- 2017 - AM Peak Hour (No West Loch Drive)

Capacity Analysis

Phase number	1	6	2	5	2	2	4	4		3	3	3
Phase type	P	P	P	P	P	P	P	P		P	P	P
Lane Group												
Adjusted flow rate, v (veh/h)	91	1094	115	428	1548	106	370	293		151	140	124
Saturation flow rate, s (veh/h)	2664	5131	1660	2664	4447	1660	2664	1596		2664	3320	2664
Lost time, t_L (s), $t_L = I_1 + Y + e$	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0	5.0
Effective green time, g (s), $g = G + Y - t_L$	10.0	45.0	30.0	25.0	60.0	60.0	30.0	30.0		20.0	20.0	40.0
Green ratio, g/C	0.07	0.32	0.21	0.18	0.43	0.43	0.21	0.21		0.14	0.14	0.21
Lane group capacity,[1] c = s(g/C), (veh/h)	190	1,649	356	476	1,906	712	571	342		381	474	571
v/c ratio, X	0.478	0.663	0.323	0.900	0.812	0.149	0.648	0.856		0.397	0.295	0.217
Flow ratio, v/s	0.034	0.213	0.069	0.161	0.348	0.064	0.139	0.184		0.057	0.042	0.047
Critical lane group/phase (√)	√		√			√		√		√		
Sum of flow ratios for critical lane groups, Y_c Yc = Σ (critical lane groups, v/s)	0.612											
Total lost time per cycle, L (s)	10											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.66**											

Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Adjusted flow rate,[2] v (veh/h)	*91*	*1094*	*115*	*428*	*1548*	*106*	*370*	*293*		*151*	*140*	*124*
Lane Group Capacity,[2] c (veh/h)	*190*	*1649*	*356*	*476*	*1906*	*712*	*571*	*342*		*381*	*474*	*571*
v/c ratio[2], X = v/c	***0.48***	***0.66***	***0.32***	***0.90***	***0.81***	***0.15***	***0.65***	***0.86***		***0.40***	***0.29***	***0.22***
Total green ratio,[2] g/C	*0.07*	*0.32*	*0.21*	*0.18*	*0.43*	*0.43*	*0.21*	*0.21*		*0.14*	*0.14*	*0.29*
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*62.49*	*40.97*	*46.43*	*56.27*	*35.06*	*24.42*	*50.19*	*52.93*		*54.52*	*53.69*	*38.07*
Incremental delay calibration,[3] k	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		*0.5*	*0.5*	*0.5*
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*8.37*	*2.12*	*2.40*	*22.63*	*3.91*	*0.44*	*5.61*	*23.12*		*3.08*	*1.58*	*0.87*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*		*0*	*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Delay = $d = d_1(PF) + d_2 + d_3$ (s/veh)	***70.9***	***43.1***	***48.8***	***78.9***	***39.0***	***24.9***	***55.8***	***76.0***		***57.6***	***55.3***	***38.9***
LOS by lane group (Exhibit 16-2)	***E***	***D***	***D***	***E***	***D***	***C***	***E***	***E***		***E***	***E***	***D***
Intersection delay, $d_1 = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***49.4***											
Intersection Level of Service (Exhibit 16-2)	***D***											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information

Analyst *Julian Ng*
Agency or Company *JNI*
Date Performed *February 15, 2018*
Analysis Time Period *MM Peak Hour (No West Loch Drive)*

Site Information

Intersection *Fort Weaver Road & Geiger Road / Iroquois Road*
Area Type ☐ CBD ☒ Other
Jurisdiction *HDOT HWY*
Analysis Year *- 2017 -*

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	114	1345	195	304	1013	50	220	67	222	46	88	95
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	*10.0*	*50.0*	*30.0*	*20.0*	*60.0*	*60.0*	*30.0*	*30.0*	*30.0*	*20.0*	*20.0*	*30.0*
Y + R (s) Cycle length, C = 140.0 s	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Fort Weaver Road & Geiger Road / Iroquois Road- 2017 - MM Peak Hour (No West Loch Drive)*

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*114*	*1,345*	*195*	*304*	*1,013*	*50*	*220*	*67*	*222*	*46*	*88*	*95*
Peak-hour factor, PHF	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*	*0.92*
Adjusted flow rate, v_p = V/PHF (veh/h)	*124*	*1462*	*212*	*330*	*1101*	*54*	*239*	*73*	*241*	*50*	*96*	*103*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*124*	*1462*	*212*	*330*	*1101*	*54*	*310*	*243*		*50*	*96*	*103*
Proportion[1] of LT or RT (P_{LT} or P_{RT})									*0.992*			
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*		*1900*	*1900*	*1900*
Number of lanes, N	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*1*		*2*	*1*	*2*
Approach width	*12*	*36*	*12*	*12*	*24*	*12*	*12*	*12*		*12*	*36*	*12*
Lane width, W	*6*	*12*	*12*	*6*	*8*	*12*	*6*	*12*		*6*	*36*	*6*
Lane width adjustment factor, f_w	*0.800*	*1.000*	*1.000*	*0.800*	*0.867*	*1.000*	*0.800*	*1.000*		*0.800*	*1.800*	*0.800*
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*		*0.971*	*0.971*	*0.971*
Grade adjustment factor, f_g	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Parking adjustment factor, f_p	*0.950*	*1.000*	*0.900*	*0.950*	*1.000*	*0.900*	*0.950*	*1.000*		*0.950*	*1.000*	*0.950*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*	*1.000*	*1.000*	*0.993*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*0.950*	*0.933*	*1.000*	*0.950*	*0.933*	*1.000*	*0.950*	*1.000*		*0.950*	*1.000*	*0.950*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*0.866*		*1.000*	*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*2664*	*5131*	*1660*	*2664*	*4447*	*1660*	*2664*	*1598*		*2664*	*3320*	*2664*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description *Fort Weaver Road & Geiger Road / Iroquois Road- 2017 - MM Peak Hour (No West Loch Drive)*

Capacity Analysis

Phase number	1	6	2	5	2	2	4	4		3	3	3
Phase type	P	P	P	P	P	P	P	P		P	P	P
Lane Group												
Adjusted flow rate, v (veh/h)	124	1462	212	330	1101	54	310	243		50	96	103
Saturation flow rate, s (veh/h)	2664	5131	1660	2664	4447	1660	2664	1598		2664	3320	2664
Lost time, t_L (s), $t_L = I_1 + Y + e$	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0	5.0
Effective green time, g (s), $g = G + Y - t_L$	10.0	50.0	30.0	20.0	60.0	60.0	30.0	30.0		20.0	20.0	40.0
Green ratio, g/C	0.07	0.36	0.21	0.14	0.43	0.43	0.21	0.21		0.14	0.14	0.21
Lane group capacity,[1] c = s(g/C), (veh/h)	190	1,832	356	381	1,906	712	571	342		381	474	571
v/c ratio, X	0.652	0.798	0.596	0.867	0.578	0.076	0.543	0.710		0.131	0.202	0.181
Flow ratio, v/s	0.047	0.285	0.128	0.124	0.248	0.033	0.116	0.152		0.019	0.029	0.039
Critical lane group/phase (√)		√	√	√		√		√				√
Sum of flow ratios for critical lane groups, Y_c Yc = Σ (critical lane groups, v/s)	0.600											
Total lost time per cycle, L (s)	10											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.65**											

Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Adjusted flow rate,[2] v (veh/h)	*124*	*1462*	*212*	*330*	*1101*	*54*	*310*	*243*		*50*	*96*	*103*
Lane Group Capacity,[2] c (veh/h)	*190*	*1832*	*356*	*381*	*1906*	*712*	*571*	*342*		*381*	*474*	*571*
v/c ratio[2], X = v/c	***0.65***	***0.80***	***0.60***	***0.87***	***0.58***	***0.08***	***0.54***	***0.71***		***0.13***	***0.20***	***0.18***
Total green ratio,[2] g/C	*0.07*	*0.36*	*0.21*	*0.14*	*0.43*	*0.43*	*0.21*	*0.21*		*0.14*	*0.14*	*0.29*
Uniform delay, $d_1 = \dfrac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*63.30*	*40.46*	*49.54*	*58.70*	*30.38*	*23.63*	*48.91*	*50.97*		*52.41*	*52.95*	*37.66*
Incremental delay calibration,[3] k	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		*0.5*	*0.5*	*0.5*
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*16.06*	*3.73*	*7.18*	*22.46*	*1.28*	*0.21*	*3.68*	*11.79*		*0.71*	*0.96*	*0.70*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*		*0*	*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Delay = $d = d_1(PF) + d_2 + d_3$ (s/veh)	***79.4***	***44.2***	***56.7***	***81.2***	***31.7***	***23.8***	***52.6***	***62.8***		***53.1***	***53.9***	***38.4***
LOS by lane group (Exhibit 16-2)	***E***	***D***	***E***	***F***	***C***	***C***	***D***	***E***		***D***	***D***	***D***
Intersection delay, $d_1 = \dfrac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***47.2***											
Intersection Level of Service (Exhibit 16-2)	***D***											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information

Analyst: *Julian Ng*
Agency or Company: *JNI*
Date Performed: *February 15, 2018*
Analysis Time Period: *PM Peak Hour (No West Loch Drive)*

Site Information

Intersection: *Fort Weaver Road & Geiger Road / Iroquois Road*
Area Type: ☐ CBD ☒ Other
Jurisdiction: *HDOT HWY*
Analysis Year: *- 2017 -*

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	166	1802	255	302	928	21	196	101	253	19	22	15
% heavy vehicles, %HV	2	2	2	2	2	2	2	2	2	2	2	2
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	*20.0*	*58.0*	*30.0*	*17.0*	*55.0*	*55.0*	*30.0*	*30.0*	*30.0*	*15.0*	*15.0*	*35.0*
Y + R (s) Cycle length, C = 140.0 s	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description: *Fort Weaver Road & Geiger Road / Iroquois Road- 2017 - PM Peak Hour (No West Loch Drive)*

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*166*	*1,802*	*255*	*302*	*928*	*21*	*196*	*101*	*253*	*19*	*22*	*15*
Peak-hour factor, PHF	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*
Adjusted flow rate, v_p = V/PHF (veh/h)	*177*	*1917*	*271*	*321*	*987*	*22*	*209*	*107*	*269*	*20*	*23*	*16*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*177*	*1917*	*271*	*321*	*987*	*22*	*315*	*270*		*20*	*23*	*16*
Proportion[1] of LT or RT (P_{LT} or P_{RT})									*0.996*			
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*		*1900*	*1900*	*1900*
Number of lanes, N	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*1*		*2*	*1*	*2*
Approach width	*12*	*36*	*12*	*12*	*24*	*12*	*12*	*12*		*12*	*36*	*12*
Lane width, W	*6*	*12*	*12*	*6*	*8*	*12*	*6*	*12*		*6*	*36*	*6*
Lane width adjustment factor, f_w	*0.800*	*1.000*	*1.000*	*0.800*	*0.867*	*1.000*	*0.800*	*1.000*		*0.800*	*1.800*	*0.800*
Heavy-vehicle adjustment factor, f_{HV}	*0.977*	*0.977*	*0.977*	*0.977*	*0.977*	*0.977*	*0.977*	*0.977*		*0.977*	*0.977*	*0.977*
Grade adjustment factor, f_g	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Parking adjustment factor, f_p	*0.950*	*1.000*	*0.900*	*0.950*	*1.000*	*0.900*	*0.950*	*1.000*		*0.950*	*1.000*	*0.950*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*	*1.000*	*1.000*	*0.993*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*0.950*	*0.933*	*1.000*	*0.950*	*0.933*	*1.000*	*0.950*	*1.000*		*0.950*	*1.000*	*0.950*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*0.866*		*1.000*	*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*2679*	*5161*	*1670*	*2679*	*4473*	*1670*	*2679*	*1606*		*2679*	*3340*	*2679*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Fort Weaver Road & Geiger Road / Iroquois Road- 2017 - PM Peak Hour (No West Loch Drive)*

Capacity Analysis

Phase number	1	6	2	5	2	2	4	4		3	3	3
Phase type	P	P	P	P	P	P	P	P		P	P	P
Lane Group												
Adjusted flow rate, v (veh/h)	177	1917	271	321	987	22	315	270		20	23	16
Saturation flow rate, s (veh/h)	2679	5161	1670	2679	4473	1670	2679	1606		2679	3340	2679
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0	5.0
Effective green time, g (s), $g = G + Y - t_L$	20.0	58.0	30.0	17.0	55.0	55.0	30.0	30.0		15.0	15.0	55.0
Green ratio, g/C	0.14	0.41	0.21	0.12	0.39	0.39	0.21	0.21		0.11	0.11	0.25
Lane group capacity,[1] c = s(g/C), (veh/h)	383	2,138	358	325	1,757	656	574	344		287	358	670
v/c ratio, X	0.462	0.897	0.757	0.987	0.562	0.034	0.549	0.785		0.070	0.065	0.024
Flow ratio, v/s	0.066	0.371	0.162	0.120	0.221	0.013	0.118	0.168		0.008	0.007	0.006
Critical lane group/phase (√)		√	√	√		√		√		√		
Sum of flow ratios for critical lane groups, Y_c Yc = Σ (critical lane groups, v/s)	0.666											
Total lost time per cycle, L (s)	10											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.72**											

Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Adjusted flow rate,[2] v (veh/h)	*177*	*1917*	*271*	*321*	*987*	*22*	*315*	*270*		*20*	*23*	*16*
Lane Group Capacity,[2] c (veh/h)	*383*	*2138*	*358*	*325*	*1757*	*656*	*574*	*344*		*287*	*358*	*670*
v/c ratio[2], X = v/c	***0.46***	***0.90***	***0.76***	***0.99***	***0.56***	***0.03***	***0.55***	***0.78***		***0.07***	***0.07***	***0.02***
Total green ratio,[2] g/C	*0.14*	*0.41*	*0.21*	*0.12*	*0.39*	*0.39*	*0.21*	*0.21*		*0.11*	*0.11*	*0.39*
Uniform delay, $d_1 = \frac{0.50\ C\ [1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*55.07*	*38.21*	*51.59*	*61.39*	*33.11*	*26.15*	*48.97*	*51.95*		*56.23*	*56.20*	*26.05*
Incremental delay calibration,[3] k	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		*0.5*	*0.5*	*0.5*
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*3.98*	*6.42*	*13.92*	*46.65*	*1.30*	*0.10*	*3.74*	*16.31*		*0.47*	*0.35*	*0.07*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*		*0*	*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***59.0***	***44.6***	***65.5***	***108.0***	***34.4***	***26.2***	***52.7***	***68.3***		***56.7***	***56.5***	***26.1***
LOS by lane group (Exhibit 16-2)	***E***	***D***	***E***	***F***	***C***	***C***	***D***	***E***		***E***	***E***	***C***
Intersection delay, $d_1 = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***50.9***											
Intersection Level of Service (Exhibit 16-2)	***D***											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Monday, March 12, 2018
Intersection, Major Street: **North Road**

Analysis Year: **2017**
Project: **West Loch**
Minor Street: **Hanakahi Street**

Peak Hour: **AM Peak Hour**
West Loch Drive CLOSED

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
1	0	1
165	**0**	**91**
<	v	>

===== **North Road** =====

1 (LEFT)	0	**178**	^
2 (THRU)	1	**293**	>
3 (RIGHT)	0	**0**	v

^	**25**	0	**6 (RIGHT)**
<	**498**	1	**5 (THRU)**
v	**0**	0	**4 (LEFT**

<	^	>
0	**0**	**0**
0	1	0
7 (LEFT)	**8 (THRU)**	**9 (RIGHT)**

Peak hour factor, PHF	**0.87**
Proportion heavy vehicles, P_{HV}	**0.03**

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	205	337	0	0	572	29	0	0	0	105	0	190
Conflicting flow rate, v_c	veh/hr	601									1333		587
Critical headway, t_c	sec/veh	4.1									7.1		6.2
Follow up time headway, t_f	sec/veh	2.2									3.5		3.3
Potential capacity, $c_{p,x}$	veh/hr	982									131		511
Probability of queue free state		0.792									0.202		0.629
f_k								1.000	0.792		1.000	0.792	
Movement capacity, $c_{m,l}$	veh/hr	982									131		511
Volume-to-capacity ratio, $(v/c)_m$		**0.21**									0.80		0.37
Lane or shared lane capacity, c_{SH}	veh/hr								0		131		511
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$											0.80		**0.37**
Control delay, d	sec/veh	9.6									96.1		16.1
Approach delay, d_A	sec/veh										**44.6**		
Level of Service {v_i >9}		**A**									**F**		**C**
Approach Level of Service {v_i >9}		-^			v-						**E**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Monday, March 12, 2018
Intersection, Major Street: **North Road**

Analysis Year: **2017**
Project: **West Loch**
Minor Street: **Hanakahi Street**

Peak Hour: **MM Peak Hour**
West Loch Drive CLOSED

Movement Volume and Demand

Inputs	Units
Number of lanes	#
Demand volume (veh/hr), V_i	#

Peak hour factor, PHF	0.71
Proportion heavy vehicles, P_{HV}	0.04

===== North Road =====

12 (RIGHT)	11 (THRU)	10 (LEFT)
1	0	1
34	0	134
<	v	>

1 (LEFT)	0	155	^
2 (THRU)	1	207	>
3 (RIGHT)	0	0	v

^	136	0	6 (RIGHT)
<	196	1	5 (THRU)
v	0	0	4 (LEFT

<	^	>
0	0	0
0	1	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Movement Calculations	Units	1	2	3	4	5	6	7	8	9	10	11	12
Demand flow rate, v_i	veh/hr	218	292	0	0	276	192	0	0	0	189	0	48
Conflicting flow rate, v_c	veh/hr	468									1100		372
Critical headway, t_c	sec/veh	4.1									7.1		6.2
Follow up time headway, t_f	sec/veh	2.2									3.5		3.3
Potential capacity, $c_{p,x}$	veh/hr	1099									189		676
Probability of queue free state		0.801									0.003		0.929
f_k								1.000	0.801		1.000	0.801	
Movement capacity, $c_{m,l}$	veh/hr	1099									189		676
Volume-to-capacity ratio, $(v/c)_m$		**0.20**									1.00		0.07
Lane or shared lane capacity, c_{SH}	veh/hr								0		189		676
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$											**1.00**		**0.07**
Control delay, d	sec/veh	9.1									115.8		10.7
Approach delay, d_A	sec/veh										94.6		
Level of Service {v_i >9}		A									F		B
Approach Level of Service {v_i >9}		-^			v-						F		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual*. (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Saturday, August 18, 2018
Intersection, Major Street: **North Road**

Analysis Year: **2017**
Project: **West Loch**
Minor Street: **Hanakahi Street**

Peak Hour: **PM Peak Hour**
West Loch Drive CLOSED

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
1	0	1
66	**0**	**277**
<	v	>

===== North Road =====

1 (LEFT)	0	**55**	^
2 (THRU)	1	**154**	>
3 (RIGHT)	0	**0**	v

^	**236**	0	6 (RIGHT)
<	**135**	1	5 (THRU)
v	**0**	0	4 (LEFT

<	^	>
0	**0**	**0**
0	1	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Peak hour factor, PHF	**0.89**
Proportion heavy vehicles, P_{HV}	**0.03**

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	62	173	0	0	152	265	0	0	0	311	0	74
Conflicting flow rate, v_c	veh/hr	417									581		284
Critical headway, t_c	sec/veh	4.1									7.1		6.2
Follow up time headway, t_f	sec/veh	2.2									3.5		3.3
Potential capacity, $c_{p,x}$	veh/hr	1149									426		758
Probability of queue free state		0.946									0.270		0.902
f_k								1.000	0.946		1.000	0.946	
Movement capacity, $c_{m,l}$	veh/hr	1149									426		758
Volume-to-capacity ratio, $(v/c)_m$		**0.05**									0.73		0.10
Lane or shared lane capacity, c_{SH}	veh/hr								0		426		758
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$											**0.73**		**0.10**
Control delay, d	sec/veh	8.3									33.1		10.3
Approach delay, d_A	sec/veh										**28.7**		
Level of Service {v_i >9}		**A**									**D**		**B**
Approach Level of Service {v_i >9}		-^			v-						**D**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Monday, March 12, 2018
Intersection, Major Street: **Kuhina Street**

Analysis Year: **2017**
Project: **West Loch**
Minor Street: **Hanakahi Street**

Peak Hour: **AM Peak Hour**
West Loch Drive CLOSED

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
0	1	0
3	**295**	**1**
<	v	>

===== Kuhina Street =====

1 (LEFT)	0	**7**	^
2 (THRU)	1	**1**	>
3 (RIGHT)	0	**128**	v

^	**2**	0	6 (RIGHT)
<	**2**	1	5 (THRU)
v	**1**	0	4 (LEFT)

<	^	>
108	**344**	**0**
0	1	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Peak hour factor, PHF	**0.81**
Proportion heavy vehicles, P_{HV}	**0.04**

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	9	1	158	1	2	2	133	425	0	1	364	4
Conflicting flow rate, v_c	veh/hr	5			159			288	105	80	316	183	4
Critical headway, t_c	sec/veh	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
Follow up time headway, t_f	sec/veh	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
Potential capacity, $c_{p,x}$	veh/hr	1630			1430			667	788	985	638	714	1086
Probability of queue free state		0.995			0.999			0.800	0.461	1.000	0.998	0.490	0.997
f_k								0.593	0.994		0.571	0.994	
Movement capacity, $c_{m,l}$	veh/hr	1630			1430			396	783	985	365	709	1086
Volume-to-capacity ratio, $(v/c)_m$		**0.01**			**0.00**			0.34	0.54	0.00	0.00	0.51	0.00
Lane or shared lane capacity, c_{SH}	veh/hr								635			710	
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$									**0.88**			**0.52**	
Control delay, d	sec/veh	7.2			7.5				38.1			15.4	
Approach delay, d_A	sec/veh								**38.1**			**15.4**	
Level of Service {v_i >9}									**E**			**C**	
Approach Level of Service {v_i >9}		-^			v-				**E**			**C**	

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Monday, March 12, 2018
Intersection, Major Street: **Kuhina Street**

Analysis Year: **2017**
Project: **West Loch**
Minor Street: **Hanakahi Street**

Peak Hour: **MM Peak Hour**
West Loch Drive CLOSED

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
0	1	0
12	**258**	**0**
<	v	>

===== Kuhina Street =====

1 (LEFT)	0	**11**	^
2 (THRU)	1	**1**	>
3 (RIGHT)	0	**117**	v

^	**0**	0	6 (RIGHT)
<	**1**	1	5 (THRU)
v	**1**	0	4 (LEFT)

<	^	>
65	**354**	**2**
0	1	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Peak hour factor, PHF	**0.81**
Proportion heavy vehicles, P_{HV}	**0.04**

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	14	1	144	1	1	0	80	437	2	0	319	15
Conflicting flow rate, v_c	veh/hr	1			146			271	104	73	324	177	1
Critical headway, t_c	sec/veh	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
Follow up time headway, t_f	sec/veh	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
Potential capacity, $c_{p,x}$	veh/hr	1634			1447			684	789	993	631	719	1089
Probability of queue free state		0.992			0.999			0.883	0.446	0.998	1.000	0.557	0.986
f_k								0.640	0.991		0.556	0.991	
Movement capacity, $c_{m,l}$	veh/hr	1634			1447			438	781	993	351	713	1089
Volume-to-capacity ratio, $(v/c)_m$		**0.01**			**0.00**			0.18	0.56	0.00	0.00	0.45	0.01
Lane or shared lane capacity, c_{SH}	veh/hr								698			724	
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$									**0.75**			**0.46**	
Control delay, d	sec/veh	7.2			7.5				23.7			14.2	
Approach delay, d_A	sec/veh								**23.7**			**14.2**	
Level of Service {v_i >9}		**A**							**C**			**B**	
Approach Level of Service {v_i >9}		-^			v-				**C**			**B**	

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual*. (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Monday, March 12, 2018
Analysis Year: **2017**
Project: **West Loch**
Peak Hour: **PM Peak Hour**
West Loch Drive CLOSED
Intersection, Major Street: **Kuhina Street**
Minor Street: **Hanakahi Street**

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

===== **Kuhina Street** =====

12 (RIGHT)	11 (THRU)	10 (LEFT)
0	1	0
8	**487**	**2**
<	v	>

1 (LEFT)	0	**8**	^
2 (THRU)	1	**1**	>
3 (RIGHT)	0	**107**	v

^	**1**	0	6 (RIGHT)
<	**0**	1	5 (THRU)
v	**0**	0	4 (LEFT)

<	^	>
52	**416**	**1**
0	1	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Peak hour factor, PHF	**0.81**
Proportion heavy vehicles, P_{HV}	**0.04**

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	10	1	132	0	0	1	64	514	1	2	601	10
Conflicting flow rate, v_c	veh/hr	1			133			394	89	67	345	154	1
Critical headway, t_c	sec/veh	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
Follow up time headway, t_f	sec/veh	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
Potential capacity, $c_{p,x}$	veh/hr	1634			1462			567	805	1001	611	740	1090
Probability of queue free state		0.994			1.000			0.887	0.362	0.999	0.996	0.188	0.991
f_k								0.319	0.994		0.486	0.994	
Movement capacity, $c_{m,I}$	veh/hr	1634			1462			181	800	1001	297	736	1090
Volume-to-capacity ratio, $(v/c)_m$		**0.01**			**0.00**			0.35	0.64	0.00	0.01	0.82	0.01
Lane or shared lane capacity, c_{SH}	veh/hr								580			735	
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$									**1.00**			**0.83**	
Control delay, d	sec/veh	7.2			7.5				63.6			29.5	
Approach delay, d_A	sec/veh							**63.6**			**29.5**		
Level of Service {v_i >9}		**A**							**F**			**D**	
Approach Level of Service {v_i >9}		-^			v-			**F**			**D**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual*. (Build 2016-09-20)

INPUT WORKSHEET

General Information

Analyst Julian Ng
Agency or Company JNI
Date Performed August 6, 2018
Analysis Time Period AM Peak Hour (No West Loch Drive)

Site Information

Intersection Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.
Area Type ☐ CBD ☒ Other
Jurisdiction HDOT HWY
Analysis Year - 2017 -

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	166	1203	274	90	1319	8	254	119	90	4	88	349
% heavy vehicles, %HV	2	2	2	2	2	2	2	2	2	2	2	2
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	21.0	85.0	85.0	15.0	79.0	79.0	35.0	35.0	35.0		25.0	25.0
Y + R (s) Cycle length, C = 180.0 s	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.- 2017 - AM Peak Hour (No West Loch Drive)*

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*166*	*1,203*	*274*	*90*	*1,319*	*8*	*254*	*119*	*90*	*4*	*88*	*349*
Peak-hour factor, PHF	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*
Adjusted flow rate, v_p = V/PHF (veh/h)	*191*	*1383*	*315*	*103*	*1516*	*9*	*292*	*137*	*103*	*5*	*101*	*401*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*191*	*1383*	*315*	*103*	*1516*	*9*	*202*	*227*	*103*		*106*	*401*
Proportion[1] of LT or RT (P_{LT} or P_{RT})										*0.043*		
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*		*1900*	*1900*
Number of lanes, N	*1*	*2*	*1*	*1*	*2*	*1*	*1*	*1*	*1*		*1*	*1*
Approach width	*12*	*36*	*12*	*12*	*24*	*12*	*12*	*12*	*12*		*10*	*12*
Lane width, W	*12*	*18*	*12*	*12*	*12*	*12*	*12*	*12*	*12*		*10*	*12*
Lane width adjustment factor, f_w	*1.000*	*1.200*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*0.933*	*1.000*
Heavy-vehicle adjustment factor, f_{HV}	*0.977*	*0.977*	*0.977*	*0.977*	*0.977*	*0.977*	*0.977*	*0.977*	*0.977*		*0.977*	*0.977*
Grade adjustment factor, f_g	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Parking adjustment factor, f_p	*0.900*	*1.000*	*0.900*	*0.900*	*1.000*	*0.900*	*0.900*	*1.000*	*0.900*		*1.000*	*0.900*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.990*	*1.000*	*1.000*	*0.990*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.950*	*1.000*	*1.000*	*0.950*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*0.999*	*0.999*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1670*	*4188*	*1670*	*1670*	*3490*	*1670*	*1670*	*1855*	*1670*		*1729*	*1668*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description *Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.- 2017 - AM Peak Hour (No West Loch Drive)*

Capacity Analysis

Phase number	1	6	6	5	2	2	4	4	4		3	3
Phase type	P	P	P	P	P	P	P	P	P		P	P
Lane Group												
Adjusted flow rate, v (veh/h)	191	1383	315	103	1516	9	202	227	103		106	401
Saturation flow rate, s (veh/h)	1670	4188	1670	1670	3490	1670	1670	1855	1670		1729	1668
Lost time, t_L (s), $t_L = I_1 + Y + e$	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0
Effective green time, g (s), $g = G + Y - t_L$	21.0	85.0	85.0	15.0	79.0	79.0	35.0	35.0	35.0		25.0	51.0
Green ratio, g/C	0.12	0.47	0.47	0.08	0.44	0.44	0.19	0.19	0.19		0.14	0.28
Lane group capacity,[1] c = s(g/C), (veh/h)	195	1,978	789	139	1,532	733	325	361	325		240	472
v/c ratio, X	0.980	0.699	0.399	0.740	0.990	0.012	0.622	0.629	0.317		0.440	0.849
Flow ratio, v/s	0.114	0.330	0.189	0.062	0.434	0.005	0.121	0.122	0.062		0.061	0.241
Critical lane group/phase (√)	√				√			√				√
Sum of flow ratios for critical lane groups, Y_c $Yc = \Sigma$ (critical lane groups, v/s)	0.797											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.87**											

Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Adjusted flow rate,[2] v (veh/h)	*191*	*1383*	*315*	*103*	*1516*	*9*	*202*	*227*	*103*		*106*	*401*
Lane Group Capacity,[2] c (veh/h)	*195*	*1978*	*789*	*139*	*1532*	*733*	*325*	*361*	*325*		*240*	*472*
v/c ratio[2], X = v/c	***0.98***	***0.70***	***0.40***	***0.74***	***0.99***	***0.01***	***0.62***	***0.63***	***0.32***		***0.44***	***0.85***
Total green ratio,[2] g/C	*0.12*	*0.47*	*0.47*	*0.08*	*0.44*	*0.44*	*0.19*	*0.19*	*0.19*		*0.14*	*0.28*
Uniform delay, $d_1 = \dfrac{0.50\ C\ [1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*79.29*	*37.43*	*30.90*	*80.60*	*50.10*	*28.49*	*66.44*	*66.54*	*62.24*		*71.08*	*60.87*
Incremental delay calibration,[3] k	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		*0.5*	*0.5*
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*59.58*	*2.08*	*1.51*	*29.43*	*20.68*	*0.03*	*8.68*	*8.07*	*2.55*		*5.76*	*17.11*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*		*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Delay = $d = d_1(PF) + d_2 + d_3$ (s/veh)	***138.9***	***39.5***	***32.4***	***110.0***	***70.8***	***28.5***	***75.1***	***74.6***	***64.8***		***76.8***	***78.0***
LOS by lane group (Exhibit 16-2)	***F***	***D***	***C***	***F***	***E***	***C***	***E***	***E***	***E***		***E***	***E***
Intersection delay, $d_1 = \dfrac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***63.3***											
Intersection Level of Service (Exhibit 16-2)	***E***											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information

Analyst Julian Ng
Agency or Company JNI
Date Performed August 6, 2018
Analysis Time Period MM Peak Hour (No West Loch Drive)

Site Information

Intersection Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.
Area Type ☐ CBD ☒ Other
Jurisdiction HDOT HWY
Analysis Year - 2017 -

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	255	1131	207	65	1106	15	159	75	96	8	72	327
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	*28.0*	*78.0*	*78.0*	*10.0*	*60.0*	*60.0*	*35.0*	*35.0*	*35.0*		*17.0*	*17.0*
Y + R (s) Cycle length, C = 160.0 s	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*		*5.0*	*5.0*

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.- 2017 - MM Peak Hour (No West Loch Drive)

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*255*	*1,131*	*207*	*65*	*1,106*	*15*	*159*	*75*	*96*	*8*	*72*	*327*
Peak-hour factor, PHF	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*
Adjusted flow rate, v_p = V/PHF (veh/h)	*283*	*1257*	*230*	*72*	*1229*	*17*	*177*	*83*	*107*	*9*	*80*	*363*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*283*	*1257*	*230*	*72*	*1229*	*17*	*122*	*138*	*107*		*89*	*363*
Proportion[1] of LT or RT (P_{LT} or P_{RT})										*0.100*		
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*	*1900*		*1900*	*1900*
Number of lanes, N	*1*	*2*	*1*	*1*	*2*	*1*	*1*	*1*	*1*		*1*	*1*
Approach width	*12*	*36*	*12*	*12*	*24*	*12*	*12*	*12*	*12*		*10*	*12*
Lane width, W	*12*	*18*	*12*	*12*	*12*	*12*	*12*	*12*	*12*		*10*	*12*
Lane width adjustment factor, f_w	*1.000*	*1.200*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*0.933*	*1.000*
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*		*0.971*	*0.971*
Grade adjustment factor, f_g	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Parking adjustment factor, f_p	*0.900*	*1.000*	*0.900*	*0.900*	*1.000*	*0.900*	*0.900*	*1.000*	*0.900*		*1.000*	*0.900*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.990*	*1.000*	*1.000*	*0.990*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.950*	*1.000*	*1.000*	*0.950*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*0.996*	*0.996*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1660*	*4164*	*1660*	*1660*	*3470*	*1660*	*1660*	*1845*	*1660*		*1714*	*1653*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.- 2017 - MM Peak Hour (No West Loch Drive)

Capacity Analysis

Phase number	1	6	6	5	2	2	4	4	4		3	3
Phase type	P	P	P	P	P	P	P	P	P		P	P
Lane Group												
Adjusted flow rate, v (veh/h)	283	1257	230	72	1229	17	122	138	107		89	363
Saturation flow rate, s (veh/h)	1660	4164	1660	1660	3470	1660	1660	1845	1660		1714	1653
Lost time, t_L (s), $t_L = I_1 + Y + e$	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0
Effective green time, g (s), $g = G + Y - t_L$	28.0	78.0	78.0	10.0	60.0	60.0	35.0	35.0	35.0		17.0	50.0
Green ratio, g/C	0.18	0.49	0.49	0.06	0.38	0.38	0.22	0.22	0.22		0.11	0.31
Lane group capacity,[1] c = s(g/C), (veh/h)	291	2,030	809	104	1,301	623	363	404	363		182	517
v/c ratio, X	0.974	0.619	0.284	0.694	0.945	0.027	0.336	0.342	0.295		0.488	0.703
Flow ratio, v/s	0.170	0.302	0.139	0.043	0.354	0.010	0.073	0.075	0.064		0.052	0.220
Critical lane group/phase (√)	√				√			√				√
Sum of flow ratios for critical lane groups, Y_c Yc = Σ (critical lane groups, v/s)	0.651											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.72**											

Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Adjusted flow rate,[2] v (veh/h)	*283*	*1257*	*230*	*72*	*1229*	*17*	*122*	*138*	*107*		*89*	*363*
Lane Group Capacity,[2] c (veh/h)	*291*	*2030*	*809*	*104*	*1301*	*623*	*363*	*404*	*363*		*182*	*517*
v/c ratio[2], X = v/c	***0.97***	***0.62***	***0.28***	***0.69***	***0.94***	***0.03***	***0.34***	***0.34***	***0.29***		***0.49***	***0.70***
Total green ratio,[2] g/C	*0.18*	*0.49*	*0.49*	*0.06*	*0.38*	*0.38*	*0.22*	*0.22*	*0.22*		*0.11*	*0.31*
Uniform delay, $d_1 = \frac{0.50 C [1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*65.64*	*30.10*	*24.39*	*73.50*	*48.39*	*31.57*	*52.70*	*52.78*	*52.19*		*67.40*	*48.47*
Incremental delay calibration,[3] k	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		*0.5*	*0.5*
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*46.60*	*1.43*	*0.88*	*31.92*	*14.79*	*0.08*	*2.49*	*2.30*	*2.06*		*9.07*	*7.81*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*		*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Delay = $d = d_1(PF) + d_2 + d_3$ (s/veh)	***112.2***	***31.5***	***25.3***	***105.4***	***63.2***	***31.7***	***55.2***	***55.1***	***54.2***		***76.5***	***56.3***
LOS by lane group (Exhibit 16-2)	***F***	***C***	***C***	***F***	***E***	***C***	***E***	***E***	***D***		***E***	***E***
Intersection delay, $d_1 = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***53.8***											
Intersection Level of Service (Exhibit 16-2)	***D***											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information

Analyst: Julian Ng
Agency or Company: JNI
Date Performed: August 6, 2018
Analysis Time Period: PM Peak Hour (No West Loch Drive)

Site Information

Intersection: Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.
Area Type: ☐ CBD ☒ Other
Jurisdiction: HDOT HWY
Analysis Year: - 2017 -

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	389	1189	277	42	939	11	201	97	76	6	61	261
% heavy vehicles, %HV	2	2	2	2	2	2	2	2	2	2	2	2
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	40.0	78.0	78.0	10.0	48.0	48.0	35.0	35.0	35.0		17.0	17.0
Y + R (s) Cycle length, C = 160.0 s	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description: Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.- 2017 - PM Peak Hour (No West Loch Drive)

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	389	1,189	277	42	939	11	201	97	76	6	61	261
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adjusted flow rate, v_p = V/PHF (veh/h)	414	1265	295	45	999	12	214	103	81	6	65	278
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	414	1265	295	45	999	12	149	168	81		71	278
Proportion[1] of LT or RT (P_{LT} or P_{RT})										0.090		
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	1900	1900	1900	1900	1900	1900	1900	1900	1900		1900	1900
Number of lanes, N	1	2	1	1	2	1	1	1	1		1	1
Approach width	12	36	12	12	24	12	12	12	12		10	12
Lane width, W	12	18	12	12	12	12	12	12	12		10	12
Lane width adjustment factor, f_w	1.000	1.200	1.000	1.000	1.000	1.000	1.000	1.000	1.000		0.933	1.000
Heavy-vehicle adjustment factor, f_{HV}	0.977	0.977	0.977	0.977	0.977	0.977	0.977	0.977	0.977		0.977	0.977
Grade adjustment factor, f_g	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Parking adjustment factor, f_p	0.900	1.000	0.900	0.900	1.000	0.900	0.900	1.000	0.900		1.000	0.900
Bus blockage adjustment factor, f_{bb}	1.000	0.990	1.000	1.000	0.990	1.000	1.000	1.000	1.000		1.000	1.000
Area type adj. factor, f_a (**0.90** *CBD,* **1.00** *other)*	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Lane utilization adjustment factor, f_{LU}	1.000	0.950	1.000	1.000	0.950	1.000	1.000	1.000	1.000		1.000	1.000
Left-turn adjustment factor, f_{LT}	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Right-turn adjustment factor, f_{RT}	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Left-turn ped/bike adjustment factor, f_{Lpb}	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		0.996	0.996
Right-turn ped/bike adjustment factor, f_{Rpb}	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	1670	4188	1670	1670	3490	1670	1670	1855	1670		1725	1664

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.- 2017 - PM Peak Hour (No West Loch Drive)

Capacity Analysis

Phase number	1	6	6	5	2	2	4	4	4		3	3
Phase type	P	P	P	P	P	P	P	P	P		P	P
Lane Group												
Adjusted flow rate, v (veh/h)	414	1265	295	45	999	12	149	168	81		71	278
Saturation flow rate, s (veh/h)	1670	4188	1670	1670	3490	1670	1670	1855	1670		1725	1664
Lost time, t_L (s), $t_L = I_1 + Y + e$	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0
Effective green time, g (s), g = G + Y - t_L	40.0	78.0	78.0	10.0	48.0	48.0	35.0	35.0	35.0		17.0	62.0
Green ratio, g/C	0.25	0.49	0.49	0.06	0.30	0.30	0.22	0.22	0.22		0.11	0.39
Lane group capacity,[1] c = s(g/C), (veh/h)	417	2,042	814	104	1,047	501	365	406	365		183	645
v/c ratio, X	0.992	0.620	0.362	0.431	0.954	0.024	0.408	0.414	0.222		0.389	0.431
Flow ratio, v/s	0.248	0.302	0.177	0.027	0.286	0.007	0.089	0.091	0.049		0.041	0.167
Critical lane group/phase (√)	√				√			√				√
Sum of flow ratios for critical lane groups, Y_c Yc = Σ (critical lane groups, v/s)	0.666											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.73**											

Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Adjusted flow rate,[2] v (veh/h)	414	1265	295	45	999	12	149	168	81		71	278
Lane Group Capacity,[2] c (veh/h)	417	2042	814	104	1047	501	365	406	365		183	645
v/c ratio[2], X = v/c	**0.99**	**0.62**	**0.36**	**0.43**	**0.95**	**0.02**	**0.41**	**0.41**	**0.22**		**0.39**	**0.43**
Total green ratio,[2] g/C	0.25	0.49	0.49	0.06	0.30	0.30	0.22	0.22	0.22		0.11	0.39
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	59.83	30.11	25.52	72.26	54.92	39.48	53.61	53.69	51.32		66.66	36.03
Incremental delay calibration,[3] k	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	42.03	1.42	1.25	12.46	18.74	0.09	3.35	3.10	1.40		6.11	2.10
Initial queue delay, d_3 (s/veh) (Appendix F)	0	0	0	0	0	0	0	0	0		0	0
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	**101.9**	**31.5**	**26.8**	**84.7**	**73.7**	**39.6**	**57.0**	**56.8**	**52.7**		**72.8**	**38.1**
LOS by lane group (Exhibit 16-2)	**F**	**C**	**C**	**F**	**E**	**D**	**E**	**E**	**D**		**E**	**D**
Intersection delay, $d_1 = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	**54.5**											
Intersection Level of Service (Exhibit 16-2)	**D**											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

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Appendix D
Intersection Analyses Worksheets
Conditions with West Loch Drive Closed + Alternative 1

9 sheets follow:

Proposed Bypass Road stopped at North Road (Alternative 1) {6 sheets}
North Road stopped at Proposed Bypass Road (Alternative 1a) {3 sheets}

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Thursday, March 22, 2018
Analysis Year: **2017**
Project: **West Loch**
Peak Hour: **AM Peak Hour**
West Loch Drive CLOSED, Bypass road @ Navy PL
Intersection, Major Street: **North Road**
Minor Street: **Bypass Road**

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
0	1	0
99	**0**	**195**
<	v	>

===== North Road =====

1 (LEFT)	0	**46**	^
2 (THRU)	1	**157**	>
3 (RIGHT)	0	**0**	v

^	**283**	0	**6 (RIGHT)**
<	**165**	1	**5 (THRU)**
v	**0**	0	**4 (LEFT)**

<	^	>
0	**0**	**0**
0	0	0
7 (LEFT)	**8 (THRU)**	**9 (RIGHT)**

Peak hour factor, PHF	**0.85**
Proportion heavy vehicles, P_{HV}	**0.03**

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	54	185	0	0	194	333	0	0	0	229	0	116
Conflicting flow rate, v_c	veh/hr	527									654		361
Critical headway, t_c	sec/veh	4.1									7.1		6.2
Follow up time headway, t_f	sec/veh	2.2									3.5		3.3
Potential capacity, $c_{p,x}$	veh/hr	1046									381		687
Probability of queue free state		0.948									0.398		0.830
f_k								1.000	0.948		1.000	0.948	
Movement capacity, $c_{m,l}$	veh/hr	1046									381		687
Volume-to-capacity ratio, $(v/c)_m$		**0.05**									0.60		0.17
Lane or shared lane capacity, c_{SH}	veh/hr											448	
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$												**0.77**	
Control delay, d	sec/veh	8.6										35.3	
Approach delay, d_A	sec/veh											**35.3**	
Level of Service {v_i >9}		**A**											
Approach Level of Service {v_i >9}		-^			v-							**E**	

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Thursday, March 22, 2018
Intersection, Major Street: **North Road**

Analysis Year: **2017**
Project: **West Loch**
Minor Street: **Bypass Road**

Peak Hour: **AM Peak Hour**
West Loch Drive CLOSED, Bypass road @ Navy PL

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
1	0	1
99	0	195
<	v	>

===== North Road =====

1 (LEFT)	0	46	^
2 (THRU)	1	157	>
3 (RIGHT)	0	0	v

^	283	0	6 (RIGHT)
<	165	1	5 (THRU)
v	0	0	4 (LEFT)

<	^	>
0	0	0
0	0	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Peak hour factor, PHF	0.85
Proportion heavy vehicles, P_{HV}	0.03

Movement Calculations	**Units**	1	2	3	4	5	6	7	8	9	10	11	12
Demand flow rate, v_i	veh/hr	54	185	0	0	194	333	0	0	0	229	0	116
Conflicting flow rate, v_c	veh/hr	527									654		361
Critical headway, t_c	sec/veh	4.1									7.1		6.2
Follow up time headway, t_f	sec/veh	2.2									3.5		3.3
Potential capacity, $c_{p,x}$	veh/hr	1046									381		687
Probability of queue free state		0.948									0.398		0.830
f_k								1.000	0.948		1.000	0.948	
Movement capacity, $c_{m,l}$	veh/hr	1046									381		687
Volume-to-capacity ratio, $(v/c)_m$		**0.05**									0.60		0.17
Lane or shared lane capacity, c_{SH}	veh/hr										381		687
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$											**0.60**		**0.17**
Control delay, d	sec/veh	8.6									27.7		11.3
Approach delay, d_A	sec/veh										**22.2**		
Level of Service {v_i >9}		**A**									**D**		**B**
Approach Level of Service {v_i >9}		-^			v-						**C**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: *Thursday, March 22, 2018*
Intersection, Major Street: **North Road**

Analysis Year: **2017**
Project: **West Loch**
Minor Street: **Bypass Road**

Peak Hour: **MM Peak Hour**
West Loch Drive CLOSED, Bypass road @ Navy PL

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
0	1	0
18	0	173
<	v	>

^	145	0	6 (RIGHT)
<	139	1	5 (THRU)
v	0	0	4 (LEFT)

===== North Road =====

1 (LEFT)	0	27	^
2 (THRU)	1	159	>
3 (RIGHT)	0	0	v

<	^	>
0	0	0
0	0	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Peak hour factor, PHF	0.74
Proportion heavy vehicles, P_{HV}	0.03

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	36	215	0	0	188	196	0	0	0	234	0	24
Conflicting flow rate, v_c	veh/hr	384									574		286
Critical headway, t_c	sec/veh	4.1									7.1		6.2
Follow up time headway, t_f	sec/veh	2.2									3.5		3.3
Potential capacity, $c_{p,x}$	veh/hr	1182									431		756
Probability of queue free state		0.969									0.458		0.968
f_k											1.000	0.969	
Movement capacity, $c_{m,l}$	veh/hr	1182									431		756
Volume-to-capacity ratio, $(v/c)_m$		**0.03**									0.54		0.03
Lane or shared lane capacity, c_{SH}	veh/hr											449	
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$												**0.57**	
Control delay, d	sec/veh	8.1										23.3	
Approach delay, d_A	sec/veh										**23.3**		
Level of Service {v_i >9}		**A**											
Approach Level of Service {v_i >9}		-^			v¯						**C**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: *Thursday, March 22, 2018*
Analysis Year: **2017**
Project: **West Loch**
Peak Hour: **MM Peak Hour**
West Loch Drive CLOSED, Bypass road @ Navy PL

Intersection, Major Street: **North Road**
Minor Street: **Bypass Road**

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
1	0	1
18	0	173
<	v	>

^	145	0	6 (RIGHT)
<	139	1	5 (THRU)
v	0	0	4 (LEFT)

===== North Road =====

1 (LEFT)	0	27	^
2 (THRU)	1	159	>
3 (RIGHT)	0	0	v

<	^	>
0	0	0
0	0	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Peak hour factor, PHF	0.74
Proportion heavy vehicles, P_{HV}	0.03

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	36	215	0	0	188	196	0	0	0	234	0	24
Conflicting flow rate, v_c	veh/hr	384									574		286
Critical headway, t_c	sec/veh	4.1									7.1		6.2
Follow up time headway, t_f	sec/veh	2.2									3.5		3.3
Potential capacity, $c_{p,x}$	veh/hr	1182									431		756
Probability of queue free state		0.969									0.458		0.968
f_k											1.000	0.969	
Movement capacity, $c_{m,l}$	veh/hr	1182									431		756
Volume-to-capacity ratio, $(v/c)_m$		**0.03**									0.54		0.03
Lane or shared lane capacity, c_{SH}	veh/hr										431		756
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$											**0.54**		**0.03**
Control delay, d	sec/veh	8.1									22.8		9.9
Approach delay, d_A	sec/veh										**21.6**		
Level of Service {v_i >9}		**A**									**C**		**A**
Approach Level of Service {v_i >9}		-^			v-						**C**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: *Thursday, March 22, 2018*
Analysis Year: **2017**
Project: **West Loch**
Peak Hour: **PM Peak Hour**
West Loch Drive CLOSED, Bypass road @ Navy PL

Intersection, Major Street: **North Road**
Minor Street: **Bypass Road**

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
0	1	0
9	**0**	**283**
<	v	>

===== North Road =====

1 (LEFT)	0	**7**	^
2 (THRU)	1	**128**	>
3 (RIGHT)	0	**0**	v

^	**256**	0	6 (RIGHT)
<	**123**	1	5 (THRU)
v	**0**	0	4 (LEFT)

<	^	>
0	**0**	**0**
0	0	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Peak hour factor, PHF	**0.82**
Proportion heavy vehicles, P_{HV}	**0.03**

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	9	156	0	0	150	312	0	0	0	345	0	11
Conflicting flow rate, v_c	veh/hr	462									479		306
Critical headway, t_c	sec/veh	4.1									7.1		6.2
Follow up time headway, t_f	sec/veh	2.2									3.5		3.3
Potential capacity, $c_{p,x}$	veh/hr	1106									498		737
Probability of queue free state		0.992									0.307		0.985
f_k											1.000	0.992	
Movement capacity, $c_{m,l}$	veh/hr	1106									498		737
Volume-to-capacity ratio, $(v/c)_m$		**0.01**									0.69		0.01
Lane or shared lane capacity, c_{SH}	veh/hr											503	
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$												**0.71**	
Control delay, d	sec/veh	8.3										27.6	
Approach delay, d_A	sec/veh										**27.6**		
Level of Service $\{v_i > 5\}$													
Approach Level of Service $\{v_i > 9\}$		-^			v-						**D**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: *Thursday, March 22, 2018*
Analysis Year: **2017**
Project: **West Loch**
Peak Hour: **PM Peak Hour**
West Loch Drive CLOSED, Bypass road @ Navy PL
Intersection, Major Street: **North Road**
Minor Street: **Bypass Road**

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	**11 (THRU)**	**10 (LEFT)**
1	0	1
9	**0**	**283**
<	v	>

===== North Road =====

1 (LEFT)	0	**7**	^
2 (THRU)	1	**128**	>
3 (RIGHT)	0	**0**	v

^	**256**	0	**6 (RIGHT)**
<	**123**	1	**5 (THRU)**
v	**0**	0	**4 (LEFT)**

<	^	>
0	**0**	**0**
0	0	0
7 (LEFT)	**8 (THRU)**	**9 (RIGHT)**

Peak hour factor, PHF	**0.82**
Proportion heavy vehicles, P_{HV}	**0.03**

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	9	156	0	0	150	312	0	0	0	345	0	11
Conflicting flow rate, v_c	veh/hr	462									479		306
Critical headway, t_c	sec/veh	4.1									7.1		6.2
Follow up time headway, t_f	sec/veh	2.2									3.5		3.3
Potential capacity, $c_{p,x}$	veh/hr	1106									498		737
Probability of queue free state		0.992									0.307		0.985
f_k											1.000	0.992	
Movement capacity, $c_{m,l}$	veh/hr	1106									498		737
Volume-to-capacity ratio, $(v/c)_m$		**0.01**									0.69		0.01
Lane or shared lane capacity, c_{SH}	veh/hr										498		737
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$											**0.69**		**0.01**
Control delay, d	sec/veh	8.3									26.9		10.0
Approach delay, d_A	sec/veh										**26.4**		
Level of Service {v_i >5}											**D**		**A**
Approach Level of Service {v_i >9}		-^			v-						**D**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Thursday, March 22, 2018
Analysis Year: **2017**
Project: **West Loch**
Peak Hour: **AM Peak Hour**
West Loch Drive CLOSED, Iroquois Ave. extended

Intersection, Major Street: **Iroquois Avenue**
Minor Street: **North Road**

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
0	0	0
0	**0**	**0**
<	v	>

===== Iroquois Avenue =====

1 (LEFT)	0	**0**	^
2 (THRU)	1	**195**	>
3 (RIGHT)	0	**99**	v

^	**0**	0	6 (RIGHT)
<	**283**	1	5 (THRU)
v	**165**	0	4 (LEFT)

<	^	>
46	**0**	**157**
0	1	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Peak hour factor, PHF	**0.85**
Proportion heavy vehicles, P_{HV}	**0.03**

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	0	229	116	194	333	0	54	0	185	0	0	0
Conflicting flow rate, v_c	veh/hr				346			1009		288			
Critical headway, t_c	sec/veh				4.1			7.1		6.2			
Follow up time headway, t_f	sec/veh				2.2			3.5		3.3			
Potential capacity, $c_{p,x}$	veh/hr				1221			219		755			
Probability of queue free state					0.841			0.753		0.755			
f_k								1.000	0.841		1.000	0.841	
Movement capacity, $c_{m,l}$	veh/hr				1221			219		755			
Volume-to-capacity ratio, $(v/c)_m$					**0.16**			0.25		0.24			
Lane or shared lane capacity, c_{SH}	veh/hr								486				
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$									**0.49**				
Control delay, d	sec/veh				8.5				19.4				
Approach delay, d_A	sec/veh								**19.4**				
Level of Service $\{v_i > 9\}$					**A**								
Approach Level of Service $\{v_i > 9\}$		-^			v-				**C**				

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual*. (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Thursday, March 22, 2018
Analysis Year: **2017**
Project: **West Loch**
Peak Hour: **MM Peak Hour**
West Loch Drive CLOSED, Iroquois Ave. extended

Intersection, Major Street: **Iroquois Avenue**
Minor Street: **North Road**

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	**11 (THRU)**	**10 (LEFT)**
0	0	0
0	**0**	**0**
<	v	>

===== Iroquois Avenue =====

1 (LEFT)	0	**0**	^
2 (THRU)	1	**173**	>
3 (RIGHT)	0	**18**	v

^	**0**	0	**6 (RIGHT)**
<	**145**	1	**5 (THRU)**
v	**139**	0	**4 (LEFT)**

<	^	>
27	**0**	**159**
0	1	0
7 (LEFT)	**8 (THRU)**	**9 (RIGHT)**

Peak hour factor, PHF	**0.74**
Proportion heavy vehicles, P_{HV}	**0.03**

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	0	234	24	188	196	0	36	0	215	0	0	0
Conflicting flow rate, v_c	veh/hr				258			818		246			
Critical headway, t_c	sec/veh				4.1			7.1		6.2			
Follow up time headway, t_f	sec/veh				2.2			3.5		3.3			
Potential capacity, $c_{p,x}$	veh/hr				1316			295		796			
Probability of queue free state					0.857			0.877		0.730			
f_k								1.000	0.857		1.000	0.857	
Movement capacity, $c_{m,l}$	veh/hr				1316			295		796			
Volume-to-capacity ratio, $(v/c)_m$					**0.14**			0.12		0.27			
Lane or shared lane capacity, c_{SH}	veh/hr								639				
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$									**0.39**				
Control delay, d	sec/veh				8.2				14.2				
Approach delay, d_A	sec/veh								**14.2**				
Level of Service {v_i >9}					**A**								
Approach Level of Service {v_i >9}		-^			v-				**B**				

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

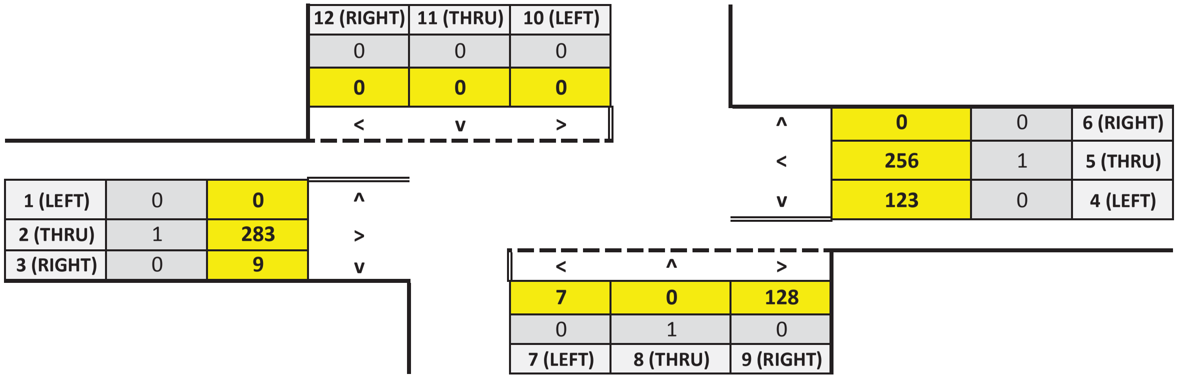
Analyst:	JN (Julian Ng Inc.)	Analysis Year:	**2017**	Peak Hour:	**PM Peak Hour**	3.74 sec.
Date:	Thursday, March 22, 2018	Project:	**West Loch**		**West Loch Drive CLOSED, Iroquois Ave. extended**	
Intersection, Major Street:	**Iroquois Avenue**	Minor Street:	**North Road**			

Movement Volume and Demand

Inputs	Units
Number of lanes	#
Demand volume (veh/hr), V_i	#

===== **Iroquois Avenue** =====

Peak hour factor, PHF	0.82
Proportion heavy vehicles, P_{HV}	0.03



12 (RIGHT)	11 (THRU)	10 (LEFT)
0	0	0
0	0	0
<	v	>

1 (LEFT)	0	0	^
2 (THRU)	1	283	>
3 (RIGHT)	0	9	v

^	0	0	6 (RIGHT)
<	256	1	5 (THRU)
v	123	0	4 (LEFT)

<	^	>
7	0	128
0	1	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Movement Calculations	Units	1	2	3	4	5	6	7	8	9	10	11	12
Demand flow rate, v_i	veh/hr	0	345	11	150	312	0	9	0	156	0	0	0
Conflicting flow rate, v_c	veh/hr				356			963		351			
Critical headway, t_c	sec/veh				4.1			7.1		6.2			
Follow up time headway, t_f	sec/veh				2.2			3.5		3.3			
Potential capacity, $c_{p,x}$	veh/hr				1211			235		696			
Probability of queue free state					0.876			0.964		0.776			
f_k								1.000	0.876		1.000	0.876	
Movement capacity, $c_{m,l}$	veh/hr				1211			235		696			
Volume-to-capacity ratio, $(v/c)_m$					**0.12**			0.04		0.22			
Lane or shared lane capacity, c_{SH}	veh/hr								632				
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$									**0.26**				
Control delay, d	sec/veh				8.4				12.7				
Approach delay, d_A	sec/veh								**12.7**				
Level of Service $\{v_i > 5\}$					A								
Approach Level of Service $\{v_i > 9\}$		-^			v‾				B				

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

Appendix E
Intersection Analyses Worksheets
Conditions with West Loch Drive Closed + Alternative 2

15 sheets follow

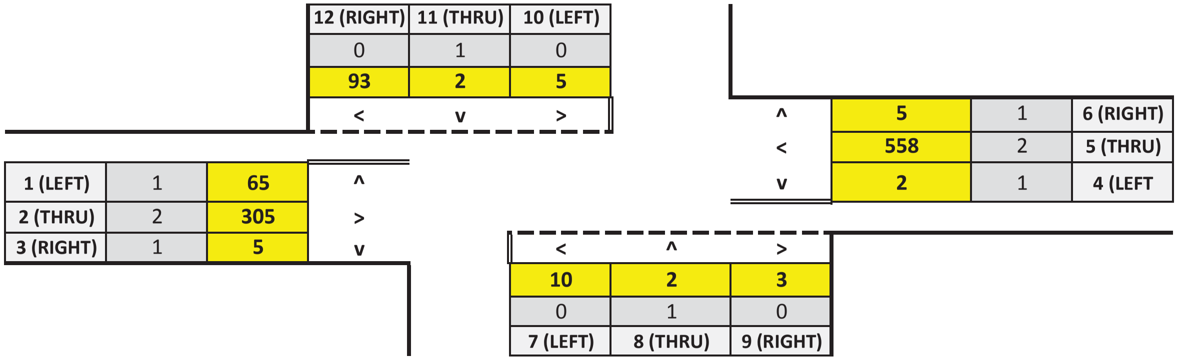
TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst:	JN (Julian Ng Inc.)	Analysis Year:	**2017**	Peak Hour:	**AM Peak Hour**
Date:	Friday, April 13, 2018	Project:	**West Loch**		**Sept. 2017 counts, Alternative 2**
Intersection, Major Street:	**Fort Weaver Road**	Minor Street:	**Kilaha Street**		

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

===== Fort Weaver Road =====

Peak hour factor, PHF	**0.87**
Proportion heavy vehicles, P_{HV}	**0.03**



12 (RIGHT)	11 (THRU)	10 (LEFT)
0	1	0
93	**2**	**5**
<	v	>

1 (LEFT)	1	**65**	^
2 (THRU)	2	**305**	>
3 (RIGHT)	1	**5**	v

^	**5**	1	**6 (RIGHT)**
<	**558**	2	**5 (THRU)**
v	**2**	1	**4 (LEFT**

<	^	>
10	**2**	**3**
0	1	0
7 (LEFT)	**8 (THRU)**	**9 (RIGHT)**

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	75	351	6	2	641	6	11	2	3	6	2	107
Conflicting flow rate, v_c	veh/hr	647			356			826	1152	175	972	1152	321
Critical headway, t_c	sec/veh	4.1			4.1			7.5	6.5	6.9	7.5	6.5	6.9
Follow up time headway, t_f	sec/veh	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
Potential capacity, $c_{p,x}$	veh/hr	943			1210			266	198	843	208	198	679
Probability of queue free state		0.921			0.998			0.957	0.988	0.996	0.972	0.988	0.843
f_k								0.783	0.919		0.926	0.919	
Movement capacity, $c_{m,l}$	veh/hr	943			1210			208	182	843	193	182	679
Volume-to-capacity ratio, $(v/c)_m$		**0.08**			**0.00**			0.06	0.01	0.00	0.03	0.01	0.16
Lane or shared lane capacity, c_{SH}	veh/hr								240			575	
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$									**0.07**			**0.20**	
Control delay, d	sec/veh	9.1			8.0				21.2			12.8	
Approach delay, d_A	sec/veh							**21.2**			**12.8**		
Level of Service $\{v_i > 9\}$		**A**											
Approach Level of Service $\{v_i > 9\}$		-^			v-			**C**			**B**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Friday, April 13, 2018
Intersection, Major Street: **Fort Weaver Road**

Analysis Year: **2017**
Project: **West Loch**
Minor Street: **Kilaha Street**

Peak Hour: **MM Peak Hour**
Sept. 2017 counts, Alternative 2

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
0	1	0
46	**1**	**3**
<	v	>

===== Fort Weaver Road =====

1 (LEFT)	1	**70**	^
2 (THRU)	2	**363**	>
3 (RIGHT)	1	**5**	v

^	**4**	1	6 (RIGHT)
<	**270**	2	5 (THRU)
v	**1**	1	4 (LEFT

<	^	>
5	**1**	**2**
0	1	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Peak hour factor, PHF	**0.87**
Proportion heavy vehicles, P_{HV}	**0.03**

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	80	417	6	1	310	5	6	1	2	3	1	53
Conflicting flow rate, v_c	veh/hr	315			423			736	895	209	683	897	155
Critical headway, t_c	sec/veh	4.1			4.1			7.5	6.5	6.9	7.5	6.5	6.9
Follow up time headway, t_f	sec/veh	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
Potential capacity, $c_{p,x}$	veh/hr	1253			1143			309	280	802	337	280	868
Probability of queue free state		0.936			0.999			0.981	0.996	0.997	0.990	0.996	0.939
f_k								0.890	0.935		0.945	0.935	
Movement capacity, $c_{m,l}$	veh/hr	1253			1143			275	262	802	319	261	868
Volume-to-capacity ratio, $(v/c)_m$		**0.06**			**0.00**			0.02	0.00	0.00	0.01	0.00	0.06
Lane or shared lane capacity, c_{SH}	veh/hr								326			755	
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$									**0.03**			**0.08**	
Control delay, d	sec/veh	8.1			8.2				16.4			10.2	
Approach delay, d_A	sec/veh							**16.4**			**10.2**		
Level of Service {v_i >9}		**A**											
Approach Level of Service {v_i >9}		-^			v‾			**C**			**B**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Friday, April 13, 2018
Intersection, Major Street: **Fort Weaver Road**

Analysis Year: **2017**
Project: **West Loch**
Minor Street: **Kilaha Street**

Peak Hour: **PM Peak Hour**
Sept. 2017 counts, Alternative 2

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
0	1	0
30	**1**	**4**
<	v	>

^	**5**	1	6 (RIGHT)
<	**411**	2	5 (THRU)
v	**2**	1	4 (LEFT

===== Fort Weaver Road =====

1 (LEFT)	1	**70**	^
2 (THRU)	2	**493**	>
3 (RIGHT)	1	**5**	v

Peak hour factor, PHF	**0.87**
Proportion heavy vehicles, P_{HV}	**0.03**

<	^	>
10	**2**	**3**
0	1	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	80	567	6	2	472	6	11	2	3	5	1	34
Conflicting flow rate, v_c	veh/hr	478			572			969	1210	283	922	1210	236
Critical headway, t_c	sec/veh	4.1			4.1			7.5	6.5	6.9	7.5	6.5	6.9
Follow up time headway, t_f	sec/veh	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
Potential capacity, $c_{p,x}$	veh/hr	1090			1006			209	182	718	226	182	770
Probability of queue free state		0.926			0.998			0.945	0.987	0.995	0.980	0.994	0.955
f_k								0.895	0.924		0.929	0.924	
Movement capacity, $c_{m,l}$	veh/hr	1090			1006			187	168	718	210	168	770
Volume-to-capacity ratio, $(v/c)_m$		**0.07**			**0.00**			0.06	0.01	0.00	0.02	0.01	0.04
Lane or shared lane capacity, c_{SH}	veh/hr								216			547	
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$									**0.08**			**0.07**	
Control delay, d	sec/veh	8.6			8.6				23.1			12.1	
Approach delay, d_A	sec/veh							**23.1**			**12.1**		
Level of Service $\{v_i >9\}$		**A**											
Approach Level of Service $\{v_i >9\}$		-^			v-			**C**			**B**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

INPUT WORKSHEET

General Information

Analyst *Julian Ng*
Agency or Company *JNI*
Date Performed *February 14, 2018*
Analysis Time Period *AM Peak Hour (Existing)*

Site Information

Intersection *Fort Weaver Road & Kimopelekane / North Road 2*
Area Type ☐ CBD ☒ Other
Jurisdiction *HDOT HWY*
Analysis Year *- 2016 -*

Volume and Timing Input

	NB			SB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	3	591	70	418	363	18	25	61	2	11	11	557
% heavy vehicles, %HV	2	2	2	2	2	2	2	2	2	2	2	2
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	20			20			20			20		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	100			100			100			100		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	28.4			28.4			28.4			28.4		
Green time (s)	*10.0*	*28.0*		*52.0*	*70.0*			*30.0*			*30.0*	*87.0*
Y + R (s) Cycle length, C = 120.0 s	*5.0*	*5.0*		*5.0*	*5.0*			*5.0*			*5.0*	*5.0*

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Fort Weaver Road & Kimopelekane / North Road 2- 2016 - AM Peak Hour (Existing)*

Volume Adjustment

	NB			SB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*3*	*591*	*70*	*418*	*363*	*18*	*25*	*61*	*2*	*11*	*11*	*557*
Peak-hour factor, PHF	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*
Adjusted flow rate, v_p = V/PHF (veh/h)	*3*	*679*	*80*	*480*	*417*	*21*	*29*	*70*	*2*	*13*	*13*	*640*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*3*	*759*		*480*	*438*			*101*			*26*	*640*
Proportion[1] of LT or RT (P_{LT} or P_{RT})	*0.004*	*-*	*0.105*	*1.096*	*-*	*0.048*	*0.287*	*-*	*0.020*	*0.500*	*-*	*1.000*
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*			*1900*			*1900*	*1900*
Number of lanes, N	*1*	*3*		*1*	*3*			*1*			*1*	*1*
Approach width	*12*	*36*		*12*	*36*			*12*			*10*	*10*
Lane width, W	*12*	*12*		*12*	*12*			*12*			*10*	*10*
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*0.933*	*0.933*
Heavy-vehicle adjustment factor, f_{HV}	*0.980*	*0.980*		*0.980*	*0.980*			*0.980*			*0.980*	*0.980*
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	*1.000*
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*			*1.000*			*1.000*	*0.900*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*		*1.000*	*0.993*			*1.000*			*1.000*	*1.000*
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.933*		*1.000*	*0.933*			*1.000*			*1.000*	*1.000*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*			*0.922*			*0.881*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*0.984*		*1.000*	*0.993*			*0.997*			*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*0.994*	*0.994*			*0.995*			*0.991*	*1.000*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.999*			*0.947*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0\ N\ f_w\ f_{HV}\ f_g\ f_p\ f_{bb}\ f_a\ f_{LU}\ f_{LT}\ f_{RT}\ f_{Lpb}\ f_{Rpb}$	*1676*	*5099*		*1666*	*5112*			*1702*			*1439*	*1565*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

OPPOSED BY SINGLE-LANE APPROACH

General Information

Project Description *Fort Weaver Road & Kimopelekane / North Road 2- 2016 - AM Peak Hour (Existing)*

Input	NB	SB	EB	WB
Cycle length, C (s)	*120.0*			
Total actual green time for LT lane group,[1] G (s)			*30.0*	*30.0*
Effective permitted green time for LT lane group,[1] g (s)			*30.0*	*30.0*
Opposing effective green time, g_0 (s)			*30.0*	*30.0*
Number of lanes in LT lane group,[2] N			*1*	*1*
Adjusted LT flow rate, v_{LT} (veh/h)			*29*	*13*
Proportion of LT volume in LT lane group, P_{LT}			*0.287*	*0.500*
Proportion of LT volume in opposing flow, P_{LT0}			*0.500*	*0.287*
Adjusted flow rate for opposing approach, v_0 (veh/h)			*26*	*101*
Lost time for LT lane group, t_L			*5*	*5*
Computation				
LT volume per cycle, LTC = $v_{LT}C/3600$			*0.967*	*0.433*
Opposing flow per lane, per cycle, $v_{olc} = v_0C/3600$ (veh/C/ln)			*0.867*	*3.367*
Opposing platoon ratio, R_{po}			*1.00*	*1.00*
$g_f = G[e^{-0.860(LTC\wedge 0.629)}] - t_L$ $g_f \leq g$ (except exclusive left-turn lanes)[3]			*7.927*	*13.047*
Opposing queue ratio, $qr_0 = \max[1 - R_{po}(g_0/C,0]$			*0.750*	*0.750*
$g_q = 4.943 v_{olc}^{0.762} qr_0^{1.061} - t_L$			*-1.734*	*4.187*
$g_u = g - g_q$ if $g_q \geq g_f$, or $g_u = g - g_f$ if $g_q < g_f$			*22.073*	*16.953*
$n = \max[(g_q - g_f)/2,0]$			*0*	*0*
$P_{THo} = 1 - P_{LTo}$			*0.500*	*0.713*
E_{L1} (refer to Exhibit C16-3)			*1.4*	*1.5*
$E_{L2} = \max[(1 - P_{THo}^{\ n})/P_{LTo}, 1.0]$			*1.0*	*1.0*
$f_{min} = 2(1 + P_{LT})/g$			*0.086*	*0.100*
$g_{diff} = \max[g_q - g_f, 0]$ (except when left-turn volume is 0)[4]			*0*	*0*
$f_{LT} = f_m = [g_f/g] + \left[\frac{g_u/g}{1 + P_{LT}(E_{L1} - 1)}\right] + \left[\frac{g_{diff}/g}{1 + P_{LT}(E_{L2} - 1)}\right]$ $(f_{min} \leq f_m \leq 1.00)$			*0.922*	*0.881*

Notes

1. Refer to Exhibits C16-4, C16-5, C16-6, C16-7, and C16-8 for case-specific parameters and adjustment factors
2. For exclusive left-turn lanes, N is equal to the number of exclusive left-turn lanes. For shared left-turn lanes, N is equal to the sum of the shared left-turn, through, and shared right-turn (ifone exists) lanes in that approach.
3. For exclusive left-turn lanes, g_f = 0, and skip the next step. Lost time, t_L, may not be applicable for protected-permitted case.
4. If opposing left-turn volume is 0, then g_{diff} = 0.

SUPPLEMENTAL WORKSHEET FOR PEDESTRIAN-BICYCLE EFFECTS ON PERMITTED LEFT TURNS AND RIGHT TURNS

General Information

Project Description *Fort Weaver Road & Kimopelekane / North Road 2- 2016 - AM Peak Hour (Existing)*

Permitted Left Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	28.0	70.0	30.0	30.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	86	34	80	80
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.043*	*0.017*	*0.040*	*0.040*
Opposing queue clearing green,[3,4] g_q (s)	*11.303*	*8.027*	*12.201*	*8.328*
Effective pedestrian green consumed by opposing vehicle queue, g_q/g_p if $g_q \geq g_p$ then $f_{Lpb} = 1.0$	*0.404*	*0.115*	*0.407*	*0.278*
$OCC_{pedu} = OCC_{pedg}\,[1 - 0.5(g_q/g_p)]$	*0.034*	*0.016*	*0.032*	*0.034*
Opposing flow rate,[3] v_0 (veh/h)	438	759	26	101
$OCC_r = OCC_{pedu}\,[e^{-(5/3600)v_0}]$	*0.019*	*0.006*	*0.031*	*0.030*
Number of cross-street receiving lanes,[1] N_{rec}	1	1	3	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.981*	*0.994*	*0.982*	*0.982*
Proportion of left turns,[5] P_{LT}	*0.004*	*1.096*	*0.287*	*0.500*
Proportion of left turns using protected phase,[6] P_{LTA}	0	0	0	0
$F_{Lpb} = 1.0 - P_{LT}(1 - A_{pbT})(1 - P_{LTA})$	*1.000*	*0.994*	*0.995*	*0.991*

Permitted Right Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	28.0	70.0	30.0	30.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
Conflicting bicycle volume,[1,7] v_{bic} (bicycles/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	86	34	80	80
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.043*	*0.017*	*0.040*	*0.040*
Effective green,[1] g (s)	28.0	70.0	30.0	30.0
$v_{bicg} = v_{bic}(C/g)$	86	34	80	80
$OCC_{bicg} = 0.02 + v_{bicg}/2700$	*0.052*	*0.033*	*0.050*	*0.050*
$OCC_r = OCC_{pedg} + OCC_{bicg} - (OCC_{pedg})(OCC_{bicg})$	*0.092*	*0.049*	*0.088*	*0.088*
Number of cross-street receiving lanes,[1] N_{rec}	1	1	3	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.908*	*0.951*	*0.947*	*0.947*
Proportion of right turns,[5] P_{RT}	*0.105*	*0.048*	*0.020*	*1.000*
Proportion of right turns using protected phase,[8] P_{RTA}	1	1	0	0
$FR_{pb} = 1.0 - P_{RT}(1 - A_{pbT})(1 - P_{RTA})$	*1.000*	*1.000*	*0.999*	*0.947*

Notes

1. Refer to Input Worksheet
2. If intersection signal timing is given, use Walk + flashing Don't Walk (use G + Y if no pedestrian signals). If signal timing must be estimated, use (Green Time - Lost Time per Phase) from Quick Estimation Control Delay and LOS Worksheet.
3. Refer to supplemental worksheets for left turns.
4. If unopposed left turn, then $g_q = 0$, $v_0 = 0$, and $OCC_r = OCC_{pedu} = OCC_{pedg}$
5. Refer to Volume Adjustment and Saturation Flow Rate Worksheet.
6. Ideally determined from field data; alternatively, assume it equal to (1 - permitted phase f_{LT})/0.95.
7. If $v_{blc} = 0$ then $v_{blcg} = 0$, $OCC_{blcg} = 0$, and $OCC_r = OCC_{pedg}$.
8. P_{RTA} is the proportion of protected green over the total green, $g_{prot}/(g_{prot} + g_{perm})$. If only permitted right-turn phase existis, then $P_{RTA} = 0$.

CAPACITY AND LOS WORKSHEET

General Information

Project Description *Fort Weaver Road & Kimopelekane / North Road 2- 2016 - AM Peak Hour (Existing)*

Capacity Analysis

Phase number	1	1		1	1			2			2	2
Phase type	P	P		P	P			P			P	P
Lane Group												
Adjusted flow rate, v (veh/h)	3	759		480	438			101			26	640
Saturation flow rate, s (veh/h)	1676	5099		1666	5112			1702			1439	1565
Lost time, t_L (s), $t_L = I_1 + Y + e$	5.0	5.0		5.0	5.0			5.0			5.0	5.0
Effective green time, g (s), $g = G + Y - t_L$	10.0	28.0		52.0	70.0			30.0			30.0	87.0
Green ratio, g/C	0.083	0.233		0.433	0.583			0.250			0.250	0.725
Lane group capacity,[1] c = s(g/C), (veh/h)	140	1,190		722	2,982			425			360	1,134
v/c ratio, X	0.021	0.638		0.665	0.147			0.237			0.072	0.564
Flow ratio, v/s	0.002	0.149		0.288	0.086			0.059			0.018	0.409
Critical lane group/phase (√)		√		√				√				
Sum of flow ratios for critical lane groups, Y_c $Yc = \Sigma$ (critical lane groups, v/s)	0.496											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.57**											

Lane Group Capacity, Control Delay, and LOS Determination

	NB			SB			EB			WB		
Lane Group	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Adjusted flow rate,[2] v (veh/h)	*3*	*759*		*480*	*438*			*101*			*26*	*640*
Lane Group Capacity,[2] c (veh/h)	*140*	*1190*		*722*	*2982*			*425*			*360*	*1134*
v/c ratio[2], X = v/c	***0.02***	***0.64***		***0.66***	***0.15***			***0.24***			***0.07***	***0.56***
Total green ratio,[2] g/C	*0.083*	*0.233*		*0.433*	*0.583*			*0.250*			*0.250*	*0.725*
Uniform delay, $d_1 = \dfrac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*50.51*	*41.43*		*27.06*	*11.39*			*35.88*			*34.37*	*7.68*
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*			*0.5*			*0.5*	*0.5*
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*0.28*	*2.62*		*4.79*	*0.10*			*1.31*			*0.39*	*2.03*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*			*0*			*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	*1.000*
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***50.8***	***44.1***		***31.9***	***11.5***			***37.2***			***34.8***	***9.7***
LOS by lane group (Exhibit 16-2)	***D***	***D***		***C***	***B***			***D***			***C***	***A***
Intersection delay, $d_1 = \dfrac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***26.5***											
Intersection Level of Service (Exhibit 16-2)	***C***											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		**Site Information**	
Analyst	*Julian Ng*	Intersection	*Fort Weaver Road & Kimopelekane / North Road 2*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*February 14, 2018*	Jurisdiction	*HDOT HWY*
Analysis Time Period	*MM Peak Hour (Existing)*	Analysis Year	*- 2016 -*

Volume and Timing Input

	NB			SB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	1	289	29	339	424	20	8	25	1	13	35	401
% heavy vehicles, %HV	2	2	2	2	2	2	2	2	2	2	2	2
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	20			20			20			20		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	100			100			100			100		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	28.4			28.4			28.4			28.4		
Green time (s)	*10.0*	*28.0*		*52.0*	*70.0*			*30.0*			*30.0*	*87.0*
Y + R (s) Cycle length, C = 120.0 s	*5.0*	*5.0*		*5.0*	*5.0*			*5.0*			*5.0*	*5.0*

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Fort Weaver Road & Kimopelekane / North Road 2- 2016 - MM Peak Hour (Existing)*

Volume Adjustment

	NB			SB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*1*	*289*	*29*	*339*	*424*	*20*	*8*	*25*	*1*	*13*	*35*	*401*
Peak-hour factor, PHF	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*
Adjusted flow rate, v_p = V/PHF (veh/h)	*1*	*332*	*33*	*390*	*487*	*23*	*9*	*29*	*1*	*15*	*40*	*461*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*1*	*365*		*390*	*510*			*39*			*55*	*461*
Proportion[1] of LT or RT (P_{LT} or P_{RT})	*0.003*	*-*	*0.090*	*0.765*	*-*	*0.045*	*0.231*	*-*	*0.026*	*0.273*	*-*	*1.000*
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*			*1900*			*1900*	*1900*
Number of lanes, N	*1*	*3*		*1*	*3*			*1*			*1*	*1*
Approach width	*12*	*36*		*12*	*36*			*12*			*10*	*10*
Lane width, W	*12*	*12*		*12*	*12*			*12*			*10*	*10*
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*0.933*	*0.933*
Heavy-vehicle adjustment factor, f_{HV}	*0.980*	*0.980*		*0.980*	*0.980*			*0.980*			*0.980*	*0.980*
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	*1.000*
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*			*1.000*			*1.000*	*0.900*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*		*1.000*	*0.993*			*1.000*			*1.000*	*1.000*
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.933*		*1.000*	*0.933*			*1.000*			*1.000*	*1.000*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*			*0.952*			*0.937*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*0.987*		*1.000*	*0.993*			*0.996*			*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*0.993*	*0.993*			*0.996*			*0.995*	*1.000*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.999*			*0.947*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1676*	*5111*		*1664*	*5108*			*1758*			*1535*	*1565*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

OPPOSED BY SINGLE-LANE APPROACH

General Information

Project Description *Fort Weaver Road & Kimopelekane / North Road 2- 2016 - MM Peak Hour (Existing)*

Input

	NB	SB	EB	WB
Cycle length, C (s)	*120.0*			
Total actual green time for LT lane group,[1] G (s)			*30.0*	*30.0*
Effective permitted green time for LT lane group,[1] g (s)			*30.0*	*30.0*
Opposing effective green time, g_0 (s)			*30.0*	*30.0*
Number of lanes in LT lane group,[2] N			*1*	*1*
Adjusted LT flow rate, v_{LT} (veh/h)			*9*	*15*
Proportion of LT volume in LT lane group, P_{LT}			*0.231*	*0.273*
Proportion of LT volume in opposing flow, P_{LT0}			*0.273*	*0.231*
Adjusted flow rate for opposing approach, v_0 (veh/h)			*55*	*39*
Lost time for LT lane group, t_L			*5*	*5*
Computation				
LT volume per cycle, LTC = $v_{LT}C/3600$			*0.300*	*0.500*
Opposing flow per lane, per cycle, $v_{olc} = v_0C/3600$ (veh/C/ln)			*1.833*	*1.300*
Opposing platoon ratio, R_{po}			*1.00*	*1.00*
$g_f = G[e^{-0.860(LTC\text{^}0.629)}] - t_L$ $g_f \leq g$ (except exclusive left-turn lanes)[3]			*15.044*	*12.203*
Opposing queue ratio, $qr_0 = \max[1 - R_{po}(g_0/C,0]$			*0.750*	*0.750*
$g_q = 4.943v_{olc}^{0.762}qr_0^{1.061} - t_L$			*0.781*	*-0.551*
$g_u = g - g_q$ if $g_q \geq g_f$, or $g_u = g - g_f$ if $g_q < g_f$			*14.956*	*17.797*
$n = \max[(g_q - g_f)/2,0]$			*0*	*0*
$P_{THo} = 1 - P_{LTo}$			*0.727*	*0.769*
E_{L1} (refer to Exhibit C16-3)			*1.5*	*1.4*
$E_{L2} = \max[(1 - P_{THo}^{\,n})/P_{LTo}, 1.0]$			*1.0*	*1.0*
$f_{min} = 2(1 + P_{LT})/g$			*0.082*	*0.085*
$g_{diff} = \max[g_q - g_f, 0]$ (except when left-turn volume is 0)[4]			*0*	*0*
$f_{LT} = f_m = [g_f/g] + \left[\frac{g_u/g}{1 + P_{LT}(E_{L1} - 1)}\right] + \left[\frac{g_{diff}/g}{1 + P_{LT}(E_{L2} - 1)}\right]$ $(f_{min} \leq f_m \leq 1.00)$			*0.952*	*0.937*

Notes

1. Refer to Exhibits C16-4, C16-5, C16-6, C16-7, and C16-8 for case-specific parameters and adjustment factors
2. For exclusive left-turn lanes, N is equal to the number of exclusive left-turn lanes. For shared left-turn lanes, N is equal to the sum of the shared left-turn, through, and shared right-turn (ifone exists) lanes in that approach.
3. For exclusive left-turn lanes, g_f = 0, and skip the next step. Lost time, t_L, may not be applicable for protected-permitted case.
4. If opposing left-turn volume is 0, then g_{diff} = 0.

SUPPLEMENTAL WORKSHEET FOR PEDESTRIAN-BICYCLE EFFECTS ON PERMITTED LEFT TURNS AND RIGHT TURNS

General Information

Project Description *Fort Weaver Road & Kimopelekane / North Road 2- 2016 - MM Peak Hour (Existing)*

Permitted Left Turns

	NB	SB	EB	WB
Effective pedestrian green time^{1,2} g_p (s)	28.0	70.0	30.0	30.0
Conflicting pedestrian volume,^{1} v_{ped} (p/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	86	34	80	80
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.043*	*0.017*	*0.040*	*0.040*
Opposing queue clearing green,^{3,4} g_q (s)	*11.303*	*8.027*	*12.201*	*8.328*
Effective pedestrian green consumed by opposing vehicle queue, g_q/g_p if $g_q \geq g_p$ then $f_{Lpb} = 1.0$	*0.404*	*0.115*	*0.407*	*0.278*
$OCC_{pedu} = OCC_{pedg}$ [1 - 0.5(g_q/g_p)]	*0.034*	*0.016*	*0.032*	*0.034*
Opposing flow rate,^{3} v_0 (veh/h)	510	365	55	39
$OCC_r = OCC_{pedu}$ [$e^{-(5/3600)v_o}$]	*0.017*	*0.010*	*0.030*	*0.033*
Number of cross-street receiving lanes,^{1} N_{rec}	1	1	3	3
Number of turning lanes,^{1} N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.983*	*0.990*	*0.982*	*0.980*
Proportion of left turns,^{5} P_{LT}	*0.003*	*0.765*	*0.231*	*0.273*
Proportion of left turns using protected phase,^{6} P_{LTA}	0	0	0	0
$F_{Lpb} = 1.0 - P_{LT}(1 - A_{pbT})(1 - P_{LTA})$	*1.000*	*0.993*	*0.996*	*0.995*

Permitted Right Turns

	NB	SB	EB	WB
Effective pedestrian green time^{1,2} g_p (s)	28.0	70.0	30.0	30.0
Conflicting pedestrian volume,^{1} v_{ped} (p/h)	20	20	20	20
Conflicting bicycle volume,^{1,7} v_{bic} (bicycles/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	86	34	80	80
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.043*	*0.017*	*0.040*	*0.040*
Effective green,^{1} g (s)	28.0	70.0	30.0	30.0
$v_{bicg} = v_{bic}$(C/g)	86	34	80	80
$OCC_{bicg} = 0.02 + v_{bicg}/2700$	*0.052*	*0.033*	*0.050*	*0.050*
$OCC_r = OCC_{pedg} + OCC_{bicg} - (OCC_{pedg})(OCC_{bicg})$	*0.092*	*0.049*	*0.088*	*0.088*
Number of cross-street receiving lanes,^{1} N_{rec}	1	1	3	3
Number of turning lanes,^{1} N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.908*	*0.951*	*0.947*	*0.947*
Proportion of right turns,^{5} P_{RT}	*0.090*	*0.045*	*0.026*	*1.000*
Proportion of right turns using protected phase,^{8} P_{RTA}	1	1	0	0
$FR_{pb} = 1.0 - P_{RT}(1 - A_{pbT})(1 - P_{RTA})$	*1.000*	*1.000*	*0.999*	*0.947*

Notes

1. Refer to Input Worksheet
2. If intersection signal timing is given, use Walk + flashing Don't Walk (use G + Y if no pedestrian signals). If signal timing must be estimated, use (Green Time - Lost Time per Phase) from Quick Estimation Control Delay and LOS Worksheet.
3. Refer to supplemental worksheets for left turns.
4. If unopposed left turn, then $g_q = 0$, $v_0 = 0$, and $OCC_r = OCC_{pedu} = OCC_{pedg}$
5. Refer to Volume Adjustment and Saturation Flow Rate Worksheet.
6. Ideally determined from field data; alternatively, assume it equal to (1 - permitted phase f_{LT})/0.95.
7. If $v_{blc} = 0$ then $v_{blcg} = 0$, $OCC_{blcg} = 0$, and $OCC_r = OCC_{pedg}$.
8. P_{RTA} is the proportion of protected green over the total green, $g_{prot}/(g_{prot} + g_{perm})$. If only permitted right-turn phase existis, then $P_{RTA} = 0$.

CAPACITY AND LOS WORKSHEET

General Information

Project Description *Fort Weaver Road & Kimopelekane / North Road 2- 2016 - MM Peak Hour (Existing)*

Capacity Analysis

Phase number	1	1		1	1			2			2	2
Phase type	P	P		P	P			P			P	P
Lane Group												
Adjusted flow rate, v (veh/h)	1	365		390	510			39			55	461
Saturation flow rate, s (veh/h)	1676	5111		1664	5108			1758			1535	1565
Lost time, t_L (s), $t_L = I_1 + Y + e$	5.0	5.0		5.0	5.0			5.0			5.0	5.0
Effective green time, g (s), g = G + Y - t_L	10.0	28.0		52.0	70.0			30.0			30.0	87.0
Green ratio, g/C	0.083	0.233		0.433	0.583			0.250			0.250	0.725
Lane group capacity,^{1} c = s(g/C), (veh/h)	140	1,193		721	2,979			439			384	1,134
v/c ratio, X	0.007	0.306		0.541	0.171			0.089			0.143	0.406
Flow ratio, v/s	0.001	0.071		0.234	0.100			0.022			0.036	0.295
Critical lane group/phase (√)		√		√							√	
Sum of flow ratios for critical lane groups, Y_c Yc = Σ (critical lane groups, v/s)	0.342											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.39**											

Lane Group Capacity, Control Delay, and LOS Determination

	NB			SB			EB			WB		
Lane Group	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Adjusted flow rate,^{2} v (veh/h)	*1*	*365*		*390*	*510*			*39*			*55*	*461*
Lane Group Capacity,^{2} c (veh/h)	*140*	*1193*		*721*	*2979*			*439*			*384*	*1134*
v/c ratio^2, X = v/c	***0.01***	***0.31***		***0.54***	***0.17***			***0.09***			***0.14***	***0.41***
Total green ratio,^{2} g/C	*0.083*	*0.233*		*0.433*	*0.583*			*0.250*			*0.250*	*0.725*
Uniform delay, $d_1 = \dfrac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*50.45*	*37.98*		*25.16*	*11.57*			*34.52*			*35.00*	*6.43*
Incremental delay calibration,^{3} k	*0.5*	*0.5*		*0.5*	*0.5*			*0.5*			*0.5*	*0.5*
Incremental delay^4, d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*0.09*	*0.66*		*2.90*	*0.12*			*0.40*			*0.78*	*1.08*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*			*0*			*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	*1.000*
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***50.5***	***38.6***		***28.1***	***11.7***			***34.9***			***35.8***	***7.5***
LOS by lane group (Exhibit 16-2)	***D***	***D***		***C***	***B***			***C***			***D***	***A***
Intersection delay, $d_1 = \dfrac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***20.8***											
Intersection Level of Service (Exhibit 16-2)	***C***											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information

Analyst: *Julian Ng*
Agency or Company: *JNI*
Date Performed: *February 14, 2018*
Analysis Time Period: *PM Peak Hour (Existing)*

Site Information

Intersection: *Fort Weaver Road & Kimopelekane / North Road 2*
Area Type: ☐ CBD ☒ Other
Jurisdiction: *HDOT HWY*
Analysis Year: *- 2016 -*

Volume and Timing Input

	NB			SB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	0	433	18	303	533	19	16	7	0	7	13	257
% heavy vehicles, %HV	2	2	2	2	2	2	2	2	2	2	2	2
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	20			20			20			20		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	100			100			100			100		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	28.4			28.4			28.4			28.4		
Green time (s)	*10.0*	*28.0*		*52.0*	*70.0*			*30.0*			*30.0*	*87.0*
Y + R (s) Cycle length, C = 120.0 s	*5.0*	*5.0*		*5.0*	*5.0*			*5.0*			*5.0*	*5.0*

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description: *Fort Weaver Road & Kimopelekane / North Road 2- 2016 - PM Peak Hour (Existing)*

Volume Adjustment

	NB			SB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*0*	*433*	*18*	*303*	*533*	*19*	*16*	*7*	*0*	*7*	*13*	*257*
Peak-hour factor, PHF	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*
Adjusted flow rate, v_p = V/PHF (veh/h)	*0*	*498*	*21*	*348*	*613*	*22*	*18*	*8*	*0*	*8*	*15*	*295*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*0*	*519*		*348*	*635*			*26*			*23*	*295*
Proportion[1] of LT or RT (P_{LT} or P_{RT})	*0.000*	*-*	*0.040*	*0.548*	*-*	*0.035*	*0.692*	*-*	*0.000*	*0.348*	*-*	*1.000*
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*			*1900*			*1900*	*1900*
Number of lanes, N	*1*	*3*		*1*	*3*			*1*			*1*	*1*
Approach width	*12*	*36*		*12*	*36*			*12*			*10*	*10*
Lane width, W	*12*	*12*		*12*	*12*			*12*			*10*	*10*
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*0.933*	*0.933*
Heavy-vehicle adjustment factor, f_{HV}	*0.980*	*0.980*		*0.980*	*0.980*			*0.980*			*0.980*	*0.980*
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	*1.000*
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*			*1.000*			*1.000*	*0.900*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*		*1.000*	*0.993*			*1.000*			*1.000*	*1.000*
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.933*		*1.000*	*0.933*			*1.000*			*1.000*	*1.000*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*			*0.861*			*0.940*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*0.994*		*1.000*	*0.995*			*1.000*			*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*0.996*	*0.996*			*0.987*			*0.993*	*1.000*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*0.947*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0\ N\ f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1676*	*5150*		*1669*	*5132*			*1583*			*1537*	*1565*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

OPPOSED BY SINGLE-LANE APPROACH

General Information

Project Description: *Fort Weaver Road & Kimopelekane / North Road 2- 2016 - PM Peak Hour (Existing)*

Input

	NB	SB	EB	WB
Cycle length, C (s)	*120.0*			
Total actual green time for LT lane group,[1] G (s)			*30.0*	*30.0*
Effective permitted green time for LT lane group,[1] g (s)			*30.0*	*30.0*
Opposing effective green time, g_0 (s)			*30.0*	*30.0*
Number of lanes in LT lane group,[2] N			*1*	*1*
Adjusted LT flow rate, v_{LT} (veh/h)			*18*	*8*
Proportion of LT volume in LT lane group, P_{LT}			*0.692*	*0.348*
Proportion of LT volume in opposing flow, P_{LT0}			*0.348*	*0.692*
Adjusted flow rate for opposing approach, v_0 (veh/h)			*23*	*26*
Lost time for LT lane group, t_L			*5*	*5*
Computation				
LT volume per cycle, LTC = v_{LT}C/3600			*0.600*	*0.267*
Opposing flow per lane, per cycle, $v_{olc} = v_0C/3600$ (veh/C/ln)			*0.767*	*0.867*
Opposing platoon ratio, R_{po}			*1.00*	*1.00*
$g_f = G[e^{-0.860(LTC\wedge 0.629)}] - t_L$ $g_f \leq g$ (except exclusive left-turn lanes)[3]			*11.079*	*15.629*
Opposing queue ratio, $qr_0 = \max[1 - R_{po}(g_0/C,0]$			*0.750*	*0.750*
$g_q = 4.943 v_{olc}{}^{0.762} qr_0{}^{1.061} - t_L$			*-2.025*	*-1.734*
$g_u = g - g_q$ if $g_q \geq g_f$, or $g_u = g - g_f$ if $g_q < g_f$			*18.921*	*14.371*
$n = \max[(g_q - g_f)/2,0]$			*0*	*0*
$P_{THo} = 1 - P_{LTo}$			*0.652*	*0.308*
E_{L1} (refer to Exhibit C16-3)			*1.4*	*1.4*
$E_{L2} = \max[(1 - P_{THo}{}^n)/P_{LTo}, 1.0]$			*1.0*	*1.0*
$f_{min} = 2(1 + P_{LT})/g$			*0.113*	*0.090*
$g_{diff} = \max[g_q - g_f, 0]$ (except when left-turn volume is 0)[4]			*0*	*0*
$f_{LT} = f_m = [g_f/g] + \left[\frac{g_u/g}{1 + P_{LT}(E_{L1} - 1)}\right] + \left[\frac{g_{diff}/g}{1 + P_{LT}(E_{L2} - 1)}\right]$ $(f_{min} \leq f_m \leq 1.00)$			*0.861*	*0.940*

Notes

1. Refer to Exhibits C16-4, C16-5, C16-6, C16-7, and C16-8 for case-specific parameters and adjustment factors
2. For exclusive left-turn lanes, N is equal to the number of exclusive left-turn lanes. For shared left-turn lanes, N is equal to the sum of the shared left-turn, through, and shared right-turn (ifone exists) lanes in that approach.
3. For exclusive left-turn lanes, g_f = 0, and skip the next step. Lost time, t_L, may not be applicable for protected-permitted case.
4. If opposing left-turn volume is 0, then g_{diff} = 0.

SUPPLEMENTAL WORKSHEET FOR PEDESTRIAN-BICYCLE EFFECTS ON PERMITTED LEFT TURNS AND RIGHT TURNS

General Information

Project Description *Fort Weaver Road & Kimopelekane / North Road 2- 2016 - PM Peak Hour (Existing)*

Permitted Left Turns

	NB	SB	EB	WB
Effective pedestrian green time^{1,2} g_p (s)	28.0	70.0	30.0	30.0
Conflicting pedestrian volume,^{1} v_{ped} (p/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	86	34	80	80
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \le 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \le 5000$)	*0.043*	*0.017*	*0.040*	*0.040*
Opposing queue clearing green,^{3,4} g_q (s)	*11.303*	*8.027*	*12.201*	*8.328*
Effective pedestrian green consumed by opposing vehicle queue, g_q/g_p if $g_q \ge g_p$ then $f_{Lpb} = 1.0$	*0.404*	*0.115*	*0.407*	*0.278*
$OCC_{pedu} = OCC_{pedg}$ [1 - 0.5(g_q/g_p)]	*0.034*	*0.016*	*0.032*	*0.034*
Opposing flow rate,^{3} v_0 (veh/h)	635	519	23	26
$OCC_r = OCC_{pedu}$ [$e^{-(5/3600)v_0}$]	*0.014*	*0.008*	*0.031*	*0.033*
Number of cross-street receiving lanes,^{1} N_{rec}	1	1	3	3
Number of turning lanes,^{1} N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.986*	*0.992*	*0.981*	*0.980*
Proportion of left turns,^{5} P_{LT}	*0.000*	*0.548*	*0.692*	*0.348*
Proportion of left turns using protected phase,^{6} P_{LTA}	0	0	0	0
$F_{Lpb} = 1.0 - P_{LT}(1 - A_{pbT})(1 - P_{LTA})$	*1.000*	*0.996*	*0.987*	*0.993*

Permitted Right Turns

	NB	SB	EB	WB
Effective pedestrian green time^{1,2} g_p (s)	28.0	70.0	30.0	30.0
Conflicting pedestrian volume,^{1} v_{ped} (p/h)	20	20	20	20
Conflicting bicycle volume,^{1,7} v_{bic} (bicycles/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	86	34	80	80
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \le 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \le 5000$)	*0.043*	*0.017*	*0.040*	*0.040*
Effective green,^{1} g (s)	28.0	70.0	30.0	30.0
$v_{bicg} = v_{bic}$(C/g)	86	34	80	80
$OCC_{bicg} = 0.02 + v_{bicg}/2700$	*0.052*	*0.033*	*0.050*	*0.050*
$OCC_r = OCC_{pedg} + OCC_{bicg}$ - (OCC_{pedg})(OCC_{bicg})	*0.092*	*0.049*	*0.088*	*0.088*
Number of cross-street receiving lanes,^{1} N_{rec}	1	1	3	3
Number of turning lanes,^{1} N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.908*	*0.951*	*0.947*	*0.947*
Proportion of right turns,^{5} P_{RT}	*0.040*	*0.035*	*0.000*	*1.000*
Proportion of right turns using protected phase,^{8} P_{RTA}	1	1	0	0
$FR_{pb} = 1.0 - P_{RT}(1 - A_{pbT})(1 - P_{RTA})$	*1.000*	*1.000*	*1.000*	*0.947*

Notes

1. Refer to Input Worksheet
2. If intersection signal timing is given, use Walk + flashing Don't Walk (use G + Y if no pedestrian signals). If signal timing must be estimated, use (Green Time - Lost Time per Phase) from Quick Estimation Control Delay and LOS Worksheet.
3. Refer to supplemental worksheets for left turns.
4. If unopposed left turn, then $g_q = 0$, $v_0 = 0$, and $OCC_r = OCC_{pedu} = OCC_{pedg}$
5. Refer to Volume Adjustment and Saturation Flow Rate Worksheet.
6. Ideally determined from field data; alternatively, assume it equal to (1 - permitted phase f_{LT})/0.95.
7. If $v_{bic} = 0$ then $v_{bicg} = 0$, $OCC_{bicg} = 0$, and $OCC_r = OCC_{pedg}$.
8. P_{RTA} is the proportion of protected green over the total green, $g_{prot}/(g_{prot} + g_{perm})$. If only permitted right-turn phase exists, then $P_{RTA} = 0$.

CAPACITY AND LOS WORKSHEET

General Information

Project Description *Fort Weaver Road & Kimopelekane / North Road 2- 2016 - PM Peak Hour (Existing)*

Capacity Analysis

Phase number	1	1		1	1			2			2	2
Phase type	P	P		P	P			P			P	P
Lane Group												
Adjusted flow rate, v (veh/h)	0	519		348	635			26			23	295
Saturation flow rate, s (veh/h)	1676	5150		1669	5132			1583			1537	1565
Lost time, t_L (s), $t_L = I_1 + Y + e$	5.0	5.0		5.0	5.0			5.0			5.0	5.0
Effective green time, g (s), $g = G + Y - t_L$	10.0	28.0		52.0	70.0			30.0			30.0	87.0
Green ratio, g/C	0.083	0.233		0.433	0.583			0.250			0.250	0.725
Lane group capacity,^{1} c = s(g/C), (veh/h)	140	1,202		723	2,993			396			384	1,134
v/c ratio, X	0.000	0.432		0.481	0.212			0.066			0.060	0.260
Flow ratio, v/s	0.000	0.101		0.208	0.124			0.016			0.015	0.189
Critical lane group/phase (√)		√		√				√				
Sum of flow ratios for critical lane groups, Y_c Yc = Σ (critical lane groups, v/s)	0.326											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.37**											

Lane Group Capacity, Control Delay, and LOS Determination

	NB			SB			EB			WB		
Lane Group	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Adjusted flow rate,^{2} v (veh/h)	*0*	*519*		*348*	*635*			*26*			*23*	*295*
Lane Group Capacity,^{2} c (veh/h)	*140*	*1202*		*723*	*2993*			*396*			*384*	*1134*
v/c ratio^2, X = v/c	***0.00***	***0.43***		***0.48***	***0.21***			***0.07***			***0.06***	***0.26***
Total green ratio,^{2} g/C	*0.083*	*0.233*		*0.433*	*0.583*			*0.250*			*0.250*	*0.725*
Uniform delay, $d_1 = \dfrac{0.50\ C\ [1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*50.42*	*39.22*		*24.34*	*11.89*			*34.31*			*34.26*	*5.59*
Incremental delay calibration,^{3} k	*0.5*	*0.5*		*0.5*	*0.5*			*0.5*			*0.5*	*0.5*
Incremental delay^4, d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*0.00*	*1.13*		*2.28*	*0.16*			*0.32*			*0.30*	*0.56*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*			*0*			*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	*1.000*
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***50.4***	***40.4***		***26.6***	***12.0***			***34.6***			***34.6***	***6.1***
LOS by lane group (Exhibit 16-2)	***D***	***D***		***C***	***B***			***C***			***C***	***A***
Intersection delay, $d_1 = \dfrac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***22.4***											
Intersection Level of Service (Exhibit 16-2)	***C***											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information

Analyst: *Julian Ng*
Agency or Company: *JNI*
Date Performed: *August 6, 2018*
Analysis Time Period: *AM Peak Hour (No West Loch Drive)*

Site Information

Intersection: *Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.*
Area Type: ☐ CBD ☒ Other
Jurisdiction: *HDOT HWY*
Analysis Year: *- 2017 -*

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	166	1203	274	90	1319	8	254	119	90	4	88	349
% heavy vehicles, %HV	2	2	2	2	2	2	2	2	2	2	2	2
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	*21.0*	*85.0*	*85.0*	*15.0*	*79.0*	*79.0*	*35.0*	*35.0*	*35.0*		*25.0*	*25.0*
Y + R (s) Cycle length, C = 180.0 s	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*		*5.0*	*5.0*

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description: *Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.- 2017 - AM Peak Hour (No West Loch Drive)*

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*166*	*1,203*	*274*	*90*	*1,319*	*8*	*254*	*119*	*90*	*4*	*88*	*349*
Peak-hour factor, PHF	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*	*0.87*
Adjusted flow rate, v_p = V/PHF (veh/h)	*191*	*1383*	*315*	*103*	*1516*	*9*	*292*	*137*	*103*	*5*	*101*	*401*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*191*	*1383*	*315*	*103*	*1525*	*9*	*202*	*227*	*103*		*106*	*401*
Proportion[1] of LT or RT (P_{LT} or P_{RT})										*0.043*		
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*	*1900*	*1900*	*1900*		*1900*	*1900*	*1900*		*1900*	*1900*
Number of lanes, N	*1*	*2*	*1*	*1*	*3*		*1*	*1*	*1*		*1*	*1*
Approach width	*12*	*36*	*12*	*12*	*36*		*12*	*12*	*12*		*10*	*12*
Lane width, W	*12*	*18*	*12*	*12*	*12*		*12*	*12*	*12*		*10*	*12*
Lane width adjustment factor, f_w	*1.000*	*1.200*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*		*0.933*	*1.000*
Heavy-vehicle adjustment factor, f_{HV}	*0.977*	*0.977*	*0.977*	*0.977*	*0.977*		*0.977*	*0.977*	*0.977*		*0.977*	*0.977*
Grade adjustment factor, f_g	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Parking adjustment factor, f_p	*0.900*	*1.000*	*0.900*	*0.900*	*1.000*		*0.900*	*1.000*	*0.900*		*1.000*	*0.900*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.990*	*1.000*	*1.000*	*0.993*		*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.950*	*1.000*	*1.000*	*0.933*		*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*		*0.999*	*0.999*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0\ N\ f_w\ f_{HV}\ f_g\ f_p\ f_{bb}\ f_a\ f_{LU}\ f_{LT}\ f_{RT}\ f_{Lpb}\ f_{Rpb}$	*1670*	*4188*	*1670*	*1670*	*5161*		*1670*	*1855*	*1670*		*1729*	*1668*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.- 2017 - AM Peak Hour (No West Loch Drive)*

Capacity Analysis

Phase number	1	6	6	5	2		4	4	4		3	3
Phase type	P	P	P	P	P		P	P	P		P	P
Lane Group												
Adjusted flow rate, v (veh/h)	191	1383	315	103	1525		202	227	103		106	401
Saturation flow rate, s (veh/h)	1670	4188	1670	1670	5161		1670	1855	1670		1729	1668
Lost time, t_L (s), $t_L = I_1 + Y + e$	5.0	5.0	5.0	5.0	5.0		5.0	5.0	5.0		5.0	5.0
Effective green time, g (s), $g = G + Y - t_L$	21.0	85.0	85.0	15.0	79.0		35.0	35.0	35.0		25.0	51.0
Green ratio, g/C	0.12	0.47	0.47	0.08	0.44		0.19	0.19	0.19		0.14	0.28
Lane group capacity,[1] c = s(g/C), (veh/h)	195	1,978	789	139	2,265		325	361	325		240	472
v/c ratio, X	0.980	0.699	0.399	0.740	0.673		0.622	0.629	0.317		0.440	0.849
Flow ratio, v/s	0.114	0.330	0.189	0.062	0.296		0.121	0.122	0.062		0.061	0.241
Critical lane group/phase (√)	√				√			√				√
Sum of flow ratios for critical lane groups, Y_c $Yc = \Sigma$ (critical lane groups, v/s)	0.658											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.72**											

Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Adjusted flow rate,[2] v (veh/h)	*191*	*1383*	*315*	*103*	*1525*		*202*	*227*	*103*		*106*	*401*
Lane Group Capacity,[2] c (veh/h)	*195*	*1978*	*789*	*139*	*2265*		*325*	*361*	*325*		*240*	*472*
v/c ratio[2], X = v/c	***0.98***	***0.70***	***0.40***	***0.74***	***0.67***		***0.62***	***0.63***	***0.32***		***0.44***	***0.85***
Total green ratio,[2] g/C	*0.12*	*0.47*	*0.47*	*0.08*	*0.44*		*0.19*	*0.19*	*0.19*		*0.14*	*0.28*
Uniform delay, $d_1 = \frac{0.50\ C\ [1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*79.29*	*37.43*	*30.90*	*80.60*	*40.22*		*66.44*	*66.54*	*62.24*		*71.08*	*60.87*
Incremental delay calibration,[3] k	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		*0.5*	*0.5*	*0.5*		*0.5*	*0.5*
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*59.58*	*2.08*	*1.51*	*29.43*	*1.62*		*8.68*	*8.07*	*2.55*		*5.76*	*17.11*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*	*0*	*0*	*0*		*0*	*0*	*0*		*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***138.9***	***39.5***	***32.4***	***110.0***	***41.8***		***75.1***	***74.6***	***64.8***		***76.8***	***78.0***
LOS by lane group (Exhibit 16-2)	***F***	***D***	***C***	***F***	***D***		***E***	***E***	***E***		***E***	***E***
Intersection delay, $d_1 = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***53.7***											
Intersection Level of Service (Exhibit 16-2)	***D***											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information

Analyst: Julian Ng
Agency or Company: JNI
Date Performed: August 6, 2018
Analysis Time Period: MM Peak Hour (No West Loch Drive)

Site Information

Intersection: Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.
Area Type: ☐ CBD ☒ Other
Jurisdiction: HDOT HWY
Analysis Year: - 2017 -

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	255	1131	207	65	1106	15	159	75	96	8	72	327
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	30.0	70.0	70.0	15.0	55.0	55.0	35.0	35.0	35.0		20.0	20.0
Y + R (s) Cycle length, C = 160.0 s	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description: Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.- 2017 - MM Peak Hour (No West Loch Drive)

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	255	1,131	207	65	1,106	15	159	75	96	8	72	327
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Adjusted flow rate, v_p = V/PHF (veh/h)	283	1257	230	72	1229	17	177	83	107	9	80	363
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	283	1257	230	72	1246	17	122	138	107		89	363
Proportion[1] of LT or RT (P_{LT} or P_{RT})										0.100		
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	1900	1900	1900	1900	1900		1900	1900	1900		1900	1900
Number of lanes, N	1	2	1	1	3		1	1	1		1	1
Approach width	12	36	12	12	36		12	12	12		10	12
Lane width, W	12	18	12	12	12		12	12	12		10	12
Lane width adjustment factor, f_w	1.000	1.200	1.000	1.000	1.000		1.000	1.000	1.000		0.933	1.000
Heavy-vehicle adjustment factor, f_{HV}	0.971	0.971	0.971	0.971	0.971		0.971	0.971	0.971		0.971	0.971
Grade adjustment factor, f_g	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000		1.000	1.000
Parking adjustment factor, f_p	0.900	1.000	0.900	0.900	1.000		0.900	1.000	0.900		1.000	0.900
Bus blockage adjustment factor, f_{bb}	1.000	0.990	1.000	1.000	0.993		1.000	1.000	1.000		1.000	1.000
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000		1.000	1.000
Lane utilization adjustment factor, f_{LU}	1.000	0.950	1.000	1.000	0.933		1.000	1.000	1.000		1.000	1.000
Left-turn adjustment factor, f_{LT}	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000		1.000	1.000
Right-turn adjustment factor, f_{RT}	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000		1.000	1.000
Left-turn ped/bike adjustment factor, f_{Lpb}	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000		0.996	0.996
Right-turn ped/bike adjustment factor, f_{Rpb}	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000		1.000	1.000
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	1660	4164	1660	1660	5131		1660	1845	1660		1715	1654

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.- 2017 - MM Peak Hour (No West Loch Drive)

Capacity Analysis

Phase number	1	6	6	5	2		4	4	4		3	3
Phase type	P	P	P	P	P		P	P	P		P	P
Lane Group												
Adjusted flow rate, v (veh/h)	283	1257	230	72	1246		122	138	107		89	363
Saturation flow rate, s (veh/h)	1660	4164	1660	1660	5131		1660	1845	1660		1715	1654
Lost time, t_L (s), $t_L = I_1 + Y + e$	5.0	5.0	5.0	5.0	5.0		5.0	5.0	5.0		5.0	5.0
Effective green time, g (s), $g = G + Y - t_L$	30.0	70.0	70.0	15.0	55.0		35.0	35.0	35.0		20.0	55.0
Green ratio, g/C	0.19	0.44	0.44	0.09	0.34		0.22	0.22	0.22		0.13	0.34
Lane group capacity,[1] c = s(g/C), (veh/h)	311	1,822	726	156	1,764		363	404	363		214	568
v/c ratio, X	0.909	0.690	0.317	0.463	0.706		0.336	0.342	0.295		0.415	0.639
Flow ratio, v/s	0.170	0.302	0.139	0.043	0.243		0.073	0.075	0.064		0.052	0.220
Critical lane group/phase (√)	√				√			√				√
Sum of flow ratios for critical lane groups, Y_c Yc = Σ (critical lane groups, v/s)	0.540											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.60**											

Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Adjusted flow rate,[2] v (veh/h)	283	1257	230	72	1246		122	138	107		89	363
Lane Group Capacity,[2] c (veh/h)	311	1822	726	156	1764		363	404	363		214	568
v/c ratio[2], X = v/c	**0.91**	**0.69**	**0.32**	**0.46**	**0.71**		**0.34**	**0.34**	**0.29**		**0.41**	**0.64**
Total green ratio,[2] g/C	0.19	0.44	0.44	0.09	0.34		0.22	0.22	0.22		0.13	0.34
Uniform delay, $d_1 = \dfrac{0.50\ C\ [1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	63.66	36.26	29.38	68.68	45.50		52.70	52.78	52.19		64.60	44.15
Incremental delay calibration,[3] k	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5		0.5	0.5
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	32.31	2.17	1.14	9.58	2.41		2.49	2.30	2.06		5.82	5.43
Initial queue delay, d_3 (s/veh) (Appendix F)	0	0	0	0	0		0	0	0		0	0
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	1.000	1.000	1.000	1.000	1.000		1.000	1.000	1.000		1.000	1.000
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	**96.0**	**38.4**	**30.5**	**78.3**	**47.9**		**55.2**	**55.1**	**54.2**		**70.4**	**49.6**
LOS by lane group (Exhibit 16-2)	**F**	**D**	**C**	**E**	**D**		**E**	**E**	**D**		**E**	**D**
Intersection delay, $d_1 = \dfrac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	**49.2**											
Intersection Level of Service (Exhibit 16-2)	**D**											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*August 6, 2018*	Jurisdiction	*HDOT HWY*
Analysis Time Period	*PM Peak Hour (No West Loch Drive)*	Analysis Year	*- 2017 -*

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	389	1189	277	42	939	11	201	97	76	6	61	261
% heavy vehicles, %HV	2	2	2	2	2	2	2	2	2	2	2	2
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	*40.0*	*65.0*	*65.0*	*10.0*	*35.0*	*35.0*	*35.0*	*35.0*	*35.0*		*20.0*	*20.0*
Y + R (s) Cycle length, C = 150.0 s	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*		*5.0*	*5.0*

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.- 2017 - PM Peak Hour (No West Loch Drive)*

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*389*	*1,189*	*277*	*42*	*939*	*11*	*201*	*97*	*76*	*6*	*61*	*261*
Peak-hour factor, PHF	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*
Adjusted flow rate, v_p = V/PHF (veh/h)	*414*	*1265*	*295*	*45*	*999*	*12*	*214*	*103*	*81*	*6*	*65*	*278*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*414*	*1265*	*295*	*45*	*1011*	*12*	*149*	*168*	*81*		*71*	*278*
Proportion[1] of LT or RT (P_{LT} or P_{RT})										*0.090*		
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*	*1900*	*1900*	*1900*		*1900*	*1900*	*1900*		*1900*	*1900*
Number of lanes, N	*1*	*2*	*1*	*1*	*3*		*1*	*1*	*1*		*1*	*1*
Approach width	*12*	*36*	*12*	*12*	*36*		*12*	*12*	*12*		*10*	*12*
Lane width, W	*12*	*18*	*12*	*12*	*12*		*12*	*12*	*12*		*10*	*12*
Lane width adjustment factor, f_w	*1.000*	*1.200*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*		*0.933*	*1.000*
Heavy-vehicle adjustment factor, f_{HV}	*0.977*	*0.977*	*0.977*	*0.977*	*0.977*		*0.977*	*0.977*	*0.977*		*0.977*	*0.977*
Grade adjustment factor, f_g	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Parking adjustment factor, f_p	*0.900*	*1.000*	*0.900*	*0.900*	*1.000*		*0.900*	*1.000*	*0.900*		*1.000*	*0.900*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.990*	*1.000*	*1.000*	*0.993*		*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.950*	*1.000*	*1.000*	*0.933*		*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*		*0.997*	*0.997*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0\ N\ f_w\ f_{HV}\ f_g\ f_p\ f_{bb}\ f_a\ f_{LU}\ f_{LT}\ f_{RT}\ f_{Lpb}\ f_{Rpb}$	*1670*	*4188*	*1670*	*1670*	*5161*		*1670*	*1855*	*1670*		*1726*	*1665*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description *Fort Weaver Rd. & Keoneula Blvd./Hanakahi St.- 2017 - PM Peak Hour (No West Loch Drive)*

Capacity Analysis

Phase number	1	6	6	5	2		4	4	4		3	3
Phase type	P	P	P	P	P		P	P	P		P	P
Lane Group												
Adjusted flow rate, v (veh/h)	414	1265	295	45	1011		149	168	81		71	278
Saturation flow rate, s (veh/h)	1670	4188	1670	1670	5161		1670	1855	1670		1726	1665
Lost time, t_L (s), $t_L = I_1 + Y + e$	5.0	5.0	5.0	5.0	5.0		5.0	5.0	5.0		5.0	5.0
Effective green time, g (s), $g = G + Y - t_L$	40.0	65.0	65.0	10.0	35.0		35.0	35.0	35.0		20.0	65.0
Green ratio, g/C	0.27	0.43	0.43	0.07	0.23		0.23	0.23	0.23		0.13	0.43
Lane group capacity,[1] c = s(g/C), (veh/h)	445	1,815	724	111	1,204		390	433	390		230	721
v/c ratio, X	0.930	0.697	0.408	0.404	0.840		0.382	0.388	0.208		0.310	0.385
Flow ratio, v/s	0.248	0.302	0.177	0.027	0.196		0.089	0.091	0.049		0.041	0.167
Critical lane group/phase (√)	√				√			√				√
Sum of flow ratios for critical lane groups, Y_c Yc = Σ (critical lane groups, v/s)	0.576											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.64**											

Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Adjusted flow rate,[2] v (veh/h)	*414*	*1265*	*295*	*45*	*1011*		*149*	*168*	*81*		*71*	*278*
Lane Group Capacity,[2] c (veh/h)	*445*	*1815*	*724*	*111*	*1204*		*390*	*433*	*390*		*230*	*721*
v/c ratio[2], X = v/c	***0.93***	***0.70***	***0.41***	***0.40***	***0.84***		***0.38***	***0.39***	***0.21***		***0.31***	***0.38***
Total green ratio,[2] g/C	*0.27*	*0.43*	*0.43*	*0.07*	*0.23*		*0.23*	*0.23*	*0.23*		*0.13*	*0.43*
Uniform delay, $d_1 = \dfrac{0.50\ C\ [1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*53.63*	*34.51*	*29.25*	*67.14*	*54.82*		*48.40*	*48.47*	*46.33*		*58.76*	*28.90*
Incremental delay calibration,[3] k	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		*0.5*	*0.5*	*0.5*		*0.5*	*0.5*
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + \dfrac{\quad}{8kIX/cT]}}$ (s/veh)	*28.24*	*2.24*	*1.70*	*10.55*	*7.12*		*2.83*	*2.61*	*1.21*		*3.47*	*1.55*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*	*0*	*0*	*0*		*0*	*0*	*0*		*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***81.9***	***36.8***	***31.0***	***77.7***	***61.9***		***51.2***	***51.1***	***47.5***		***62.2***	***30.5***
LOS by lane group (Exhibit 16-2)	***F***	***D***	***C***	***E***	***E***		***D***	***D***	***D***		***E***	***C***
Intersection delay, $d_1 = \dfrac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***49.9***											
Intersection Level of Service (Exhibit 16-2)	***D***											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Monday, March 12, 2018
Intersection, Major Street: **North Road**

Analysis Year: **2017**
Project: **West Loch**
Minor Street: **Hanakahi Street**

Peak Hour: **AM Peak Hour**
West Loch Drive CLOSED

Movement Volume and Demand

Inputs	Units
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
1	0	1
165	**0**	**91**
<	v	>

^	**25**	0	**6 (RIGHT)**
<	**498**	1	**5 (THRU)**
v	**0**	0	**4 (LEFT**

===== North Road =====

1 (LEFT)	0	**178**	^
2 (THRU)	1	**293**	>
3 (RIGHT)	0	**0**	v

<	^	>
0	**0**	**0**
0	1	0
7 (LEFT)	**8 (THRU)**	**9 (RIGHT)**

Peak hour factor, PHF	**0.87**
Proportion heavy vehicles, P_{HV}	**0.03**

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	205	337	0	0	572	29	0	0	0	105	0	190
Conflicting flow rate, v_c	veh/hr	601									1333		587
Critical headway, t_c	sec/veh	4.1									7.1		6.2
Follow up time headway, t_f	sec/veh	2.2									3.5		3.3
Potential capacity, $c_{p,x}$	veh/hr	982									131		511
Probability of queue free state		0.792									0.202		0.629
f_k											1.000	0.792	
Movement capacity, $c_{m,l}$	veh/hr	982									131		511
Volume-to-capacity ratio, $(v/c)_m$		**0.21**									0.80		0.37
Lane or shared lane capacity, c_{SH}	veh/hr										131		511
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$											0.80		**0.37**
Control delay, d	sec/veh	9.6									96.1		16.1
Approach delay, d_A	sec/veh										**44.6**		
Level of Service {v_i >9}		**A**									**F**		**C**
Approach Level of Service {v_i >9}		-^			v-						**E**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Monday, March 12, 2018
Intersection, Major Street: **North Road**

Analysis Year: **2017**
Project: **West Loch**
Minor Street: **Hanakahi Street**

Peak Hour: **MM Peak Hour**
West Loch Drive CLOSED

Movement Volume and Demand

Inputs	Units
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
1	0	1
34	**0**	**134**
<	v	>

^	**136**	0	6 (RIGHT)
<	**196**	1	5 (THRU)
v	**0**	0	4 (LEFT

===== **North Road** =====

1 (LEFT)	0	**155**	^
2 (THRU)	1	**207**	>
3 (RIGHT)	0	**0**	v

<	^	>
0	**0**	**0**
0	1	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Peak hour factor, PHF	**0.71**
Proportion heavy vehicles, P_{HV}	**0.04**

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand flow rate, v_i	veh/hr	218	292	0	0	276	192	0	0	0	189	0	48
Conflicting flow rate, v_c	veh/hr	468									1100		372
Critical headway, t_c	sec/veh	4.1									7.1		6.2
Follow up time headway, t_f	sec/veh	2.2									3.5		3.3
Potential capacity, $c_{p,x}$	veh/hr	1099									189		676
Probability of queue free state		0.801									0.003		0.929
f_k											1.000	0.801	
Movement capacity, $c_{m,l}$	veh/hr	1099									189		676
Volume-to-capacity ratio, $(v/c)_m$		**0.20**									1.00		0.07
Lane or shared lane capacity, c_{SH}	veh/hr										189		676
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$											**1.00**		**0.07**
Control delay, d	sec/veh	9.1									115.8		10.7
Approach delay, d_A	sec/veh											**94.6**	
Level of Service {v_i >9}		**A**									**F**		**B**
Approach Level of Service {v_i >9}		-^			v-							**F**	

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Monday, March 12, 2018
Analysis Year: **2017**
Project: **West Loch**
Peak Hour: **PM Peak Hour**
West Loch Drive CLOSED

Intersection, Major Street: **North Road**
Minor Street: **Hanakahi Street**

Movement Volume and Demand

Inputs	Units
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
1	0	1
66	**0**	**277**
<	v	>

===== **North Road** =====

1 (LEFT)	0	**55**	^
2 (THRU)	1	**154**	>
3 (RIGHT)	0	**0**	v

^	**236**	0	**6 (RIGHT)**
<	**135**	1	**5 (THRU)**
v	**0**	0	**4 (LEFT**

7 (LEFT)	8 (THRU)	9 (RIGHT)
<	^	>
0	**0**	**0**
0	1	0

Peak hour factor, PHF	**0.89**
Proportion heavy vehicles, P_{HV}	**0.03**

Movement Calculations	Units	1	2	3	4	5	6	7	8	9	10	11	12
Demand flow rate, v_i	veh/hr	62	173	0	0	152	265	0	0	0	311	0	74
Conflicting flow rate, v_c	veh/hr	417									581		284
Critical headway, t_c	sec/veh	4.1									7.1		6.2
Follow up time headway, t_f	sec/veh	2.2									3.5		3.3
Potential capacity, $c_{p,x}$	veh/hr	1149									426		758
Probability of queue free state		0.946									0.270		0.902
f_k											1.000	0.946	
Movement capacity, $c_{m,l}$	veh/hr	1149									426		758
Volume-to-capacity ratio, $(v/c)_m$		**0.05**									0.73		0.10
Lane or shared lane capacity, c_{SH}	veh/hr										426		758
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$											**0.73**		**0.10**
Control delay, d	sec/veh	8.3									33.1		10.3
Approach delay, d_A	sec/veh										**28.7**		
Level of Service {v_i >9}		**A**									**D**		**B**
Approach Level of Service {v_i >9}		-^			v¯						**D**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

Appendix F
Intersection Analyses Worksheets
Conditions with West Loch Drive Closed + Alternative 3

3 sheets follow

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Friday, April 13, 2018
Intersection, Major Street: **North Road**

Analysis Year: **2017**
Project: **West Loch**
Minor Street: **Hanakahi Street**

Peak Hour: **AM Peak Hour**
West Loch Drive CLOSED alt3

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
1	0	1
165	**0**	**91**
<	v	>

^	**25**	1	6 (RIGHT)
<	**498**	1	5 (THRU)
v	**0**	0	4 (LEFT

===== North Road =====

1 (LEFT)	1	**178**	^
2 (THRU)	1	**293**	>
3 (RIGHT)	0	**0**	v

<	^	>
0	**0**	**0**
0	1	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Peak hour factor, PHF	**0.87**
Proportion heavy vehicles, P_{HV}	**0.03**

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**10**	**12**
Demand flow rate, v_i	veh/hr	205	337	0	0	572	29	0	0	0	105	105	190
Conflicting flow rate, v_c	veh/hr	601									572	746	572
Critical headway, t_c	sec/veh	4.1									7.1	4.0	6.2
Follow up time headway, t_f	sec/veh	2.2									3.5	3.5	3.3
Potential capacity, $c_{p,x}$	veh/hr	982									432	631	521
Probability of queue free state		0.792									0.758	0.834	0.636
f_k											1.000	0.792	
Movement capacity, $c_{m,l}$	veh/hr	982									432	500	521
Volume-to-capacity ratio, $(v/c)_m$		**0.21**									0.24	0.21	0.36
Lane or shared lane capacity, c_{SH}	veh/hr										432	500	521
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$											0.24	**0.21**	**0.36**
Control delay, d	sec/veh	9.6									16.0	14.1	15.8
Approach delay, d_A	sec/veh										**20.9**		
Level of Service {v_i >9}		**A**									30.1	**D**	**C**
Approach Level of Service {v_i >9}		-^			v¯						**C**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Friday, April 13, 2018
Analysis Year: **2017**
Project: **West Loch**
Peak Hour: **MM Peak Hour**
West Loch Drive CLOSED alt3
Intersection, Major Street: **North Road**
Minor Street: **Hanakahi Street**

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
1	0	1
34	**0**	**134**
<	v	>

===== North Road =====

1 (LEFT)	1	**155**	^
2 (THRU)	1	**207**	>
3 (RIGHT)	0	**0**	v

^	**136**	1	6 (RIGHT)
<	**196**	1	5 (THRU)
v	**0**	0	4 (LEFT

<	^	>
0	**0**	**0**
0	1	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Peak hour factor, PHF	**0.71**
Proportion heavy vehicles, P_{HV}	**0.04**

Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**10**	**12**
Demand flow rate, v_i	veh/hr	218	292	0	0	276	192	0	0	0	189	189	48
Conflicting flow rate, v_c	veh/hr	468									276	728	276
Critical headway, t_c	sec/veh	4.1									7.1	4.0	6.2
Follow up time headway, t_f	sec/veh	2.2									3.5	3.5	3.3
Potential capacity, $c_{p,x}$	veh/hr	1099									679	639	765
Probability of queue free state		0.801									0.722	0.705	0.937
f_k											1.000	0.801	
Movement capacity, $c_{m,l}$	veh/hr	1099									679	512	765
Volume-to-capacity ratio, $(v/c)_m$		**0.20**									0.28	0.37	0.06
Lane or shared lane capacity, c_{SH}	veh/hr										679	512	765
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$											0.28	**0.37**	**0.06**
Control delay, d	sec/veh	9.1									12.3	16.1	10.0
Approach delay, d_A	sec/veh										**24.7**		
Level of Service {v_i >9}		**A**									28.4	**D**	**B**
Approach Level of Service {v_i >9}		-^			v-						**C**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

TWSC Intersection Planning Method (*HCM 6* worksheet)

Analyst: JN (Julian Ng Inc.)
Date: Friday, April 13, 2018
Intersection, Major Street: **North Road**

Analysis Year: **2017**
Project: **West Loch**
Minor Street: **Hanakahi Street**

Peak Hour: **PM Peak Hour**
West Loch Drive CLOSED alt3

Movement Volume and Demand	
Inputs	**Units**
Number of lanes	#
Demand volume (veh/hr), V_i	#

12 (RIGHT)	11 (THRU)	10 (LEFT)
1	0	1
66	**0**	**277**
<	v	>

===== **North Road** =====

1 (LEFT)	1	**55**	^
2 (THRU)	1	**154**	>
3 (RIGHT)	0	**0**	v

^	**236**	1	6 (RIGHT)
<	**135**	1	5 (THRU)
v	**0**	0	4 (LEFT

<	^	>
0	**0**	**0**
0	1	0
7 (LEFT)	8 (THRU)	9 (RIGHT)

Peak hour factor, PHF	**0.89**
Proportion heavy vehicles, P_{HV}	**0.03**

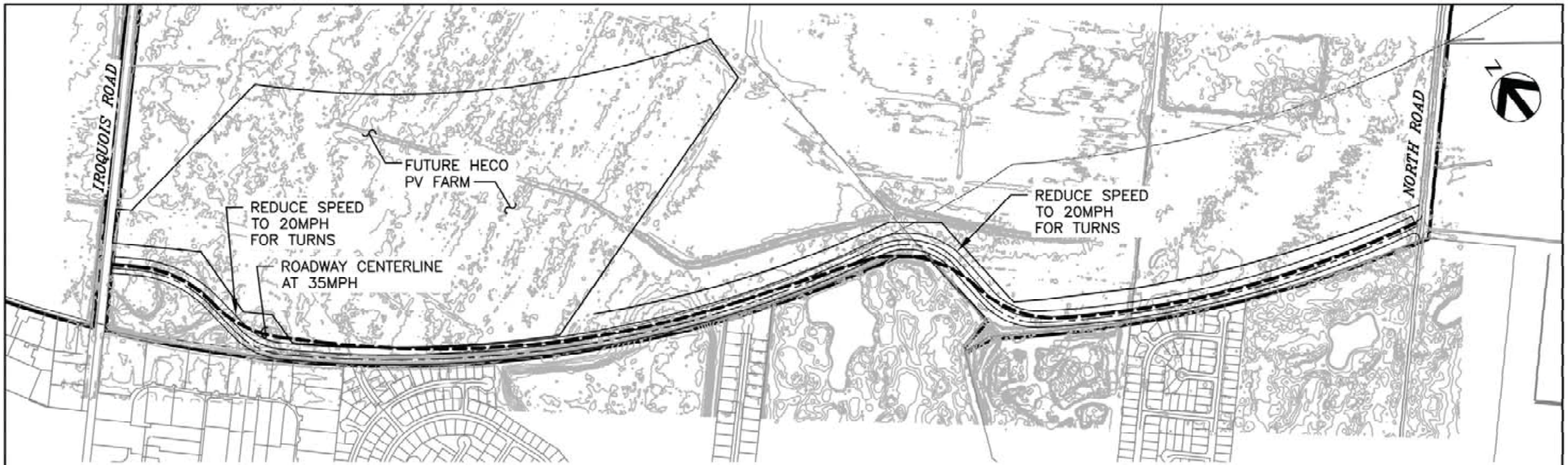
Movement Calculations	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**10**	**12**
Demand flow rate, v_i	veh/hr	62	173	0	0	152	265	0	0	0	311	311	74
Conflicting flow rate, v_c	veh/hr	417									152	297	152
Critical headway, t_c	sec/veh	4.1									7.1	4.0	6.2
Follow up time headway, t_f	sec/veh	2.2									3.5	3.5	3.3
Potential capacity, $c_{p,x}$	veh/hr	1149									819	852	899
Probability of queue free state		0.946									0.620	0.635	0.917
f_k											1.000	0.946	
Movement capacity, $c_{m,l}$	veh/hr	1149									819	806	899
Volume-to-capacity ratio, $(v/c)_m$		**0.05**									0.38	0.39	0.08
Lane or shared lane capacity, c_{SH}	veh/hr										819	806	899
Lane or shared lane volume-to-capacity ratio, $(v/c)_{SH}$											0.38	**0.39**	**0.08**
Control delay, d	sec/veh	8.3									12.1	12.3	9.4
Approach delay, d_A	sec/veh										**21.4**		
Level of Service {v_i >9}		**A**									24.3	**C**	**A**
Approach Level of Service {v_i >9}		-^			v¯						**C**		

Spreadsheet Analysis based on Computational engine developed by contractor for *NCHRP Project 07-22, Planning and Preliminary Applications Guide to the Highway Capacity Manual* . (Build 2016-09-20)

Appendix G
Traffic Mitigation Concept Plans
Prepared by HDR Engineering

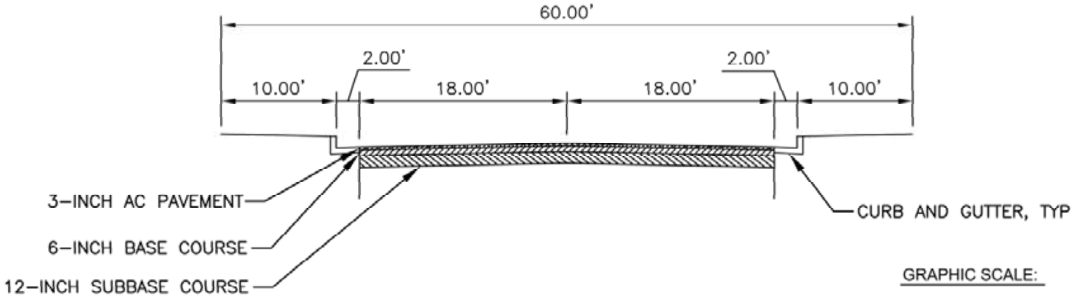
7 sheets follow:

Figure 1: Alternative 1 Topographic Plan and Roadway Section (1 page)
Figure 2: Alternative 2 – Puuloa Range Training Facility (1 page)
Figure 3: Alternatives 2 & 3 – Fort Weaver Road (1 of 2 pages)
Figure 4: Alternatives 2 & 3 – Fort Weaver Road (2 of 2 pages)
Figure 5: Alternative 3 – Kulana Place to Kilaha Street (1 page)
Figure 6: Alternative 3 – Apoke Place to Iroquois Avenue (1 page)
Figure 7: Alternative 3 – North Road from Aiami Place to Aala Place (1 page)



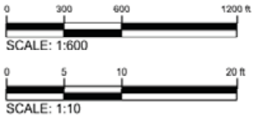
ALTERNATIVE 1 TOPOGRAPHIC PLAN
SCALE: 1" = 600'

Cut/Fill Summary	
Alternative 1 Roadway	
Cut	42,500 Cu. Yd.
Fill	38,500 Cu. Yd.
Net	4,000 Cu. Yd.<Cut>



ALTERNATIVE 1 ROADWAY SECTION
SCALE: 1" = 10'

GRAPHIC SCALE:



PRELIMINARY CONCEPT
NOT FOR CONSTRUCTION

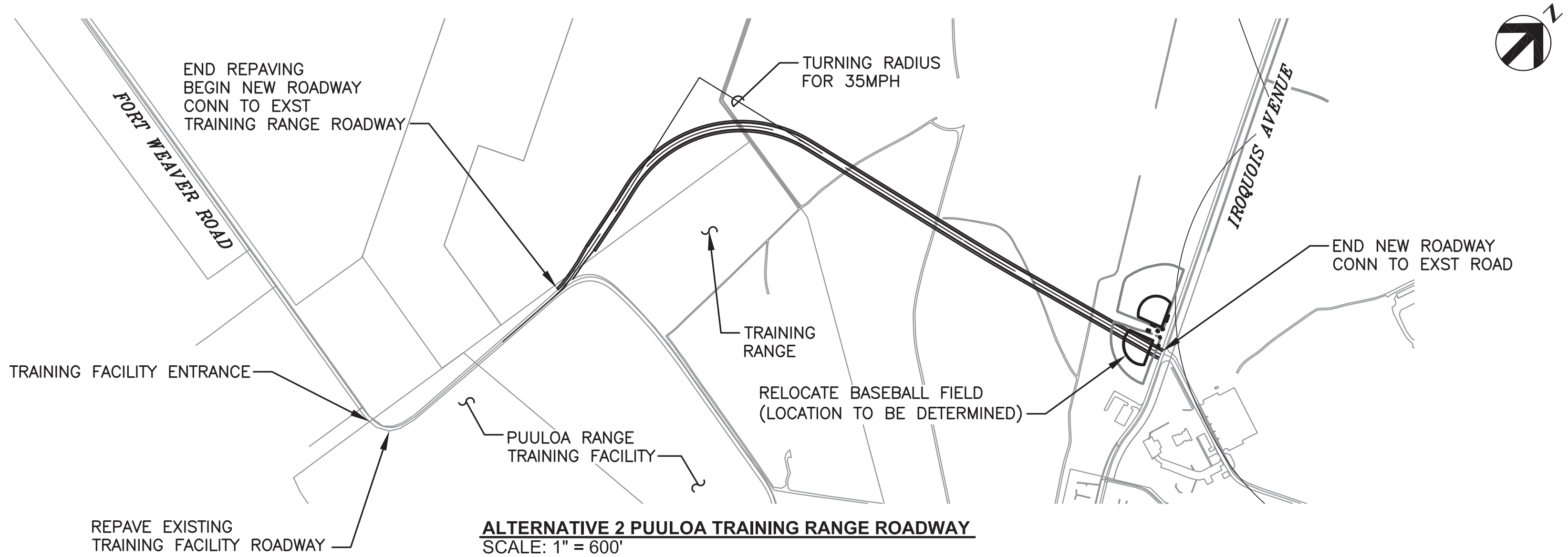
HDR

WEST LOCH TRAFFIC STUDY
WEST LOCH ANNEX, HAWAII

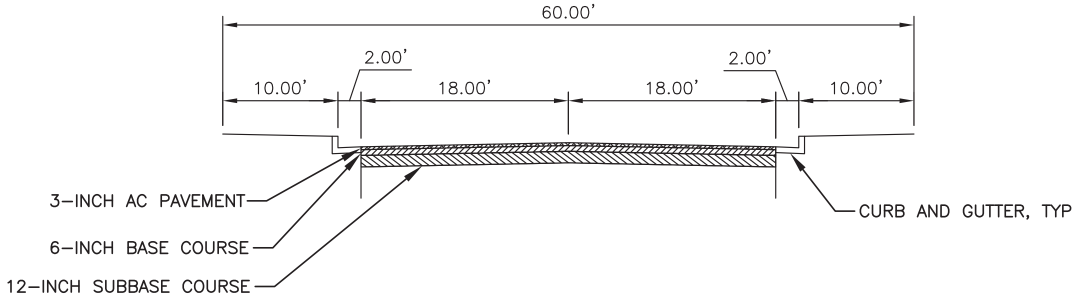
ALTERNATIVE 1 TOPOGRAPHIC PLAN AND ROADWAY SECTION

DATE
APR 2018

FIGURE
1

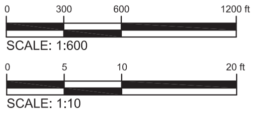


ALTERNATIVE 2 PUULOA TRAINING RANGE ROADWAY
SCALE: 1" = 600'



ALTERNATIVE 2 NEW ROADWAY SECTION
SCALE: 1" = 10'

GRAPHIC SCALE:



PRELIMINARY CONCEPT
NOT FOR CONSTRUCTION

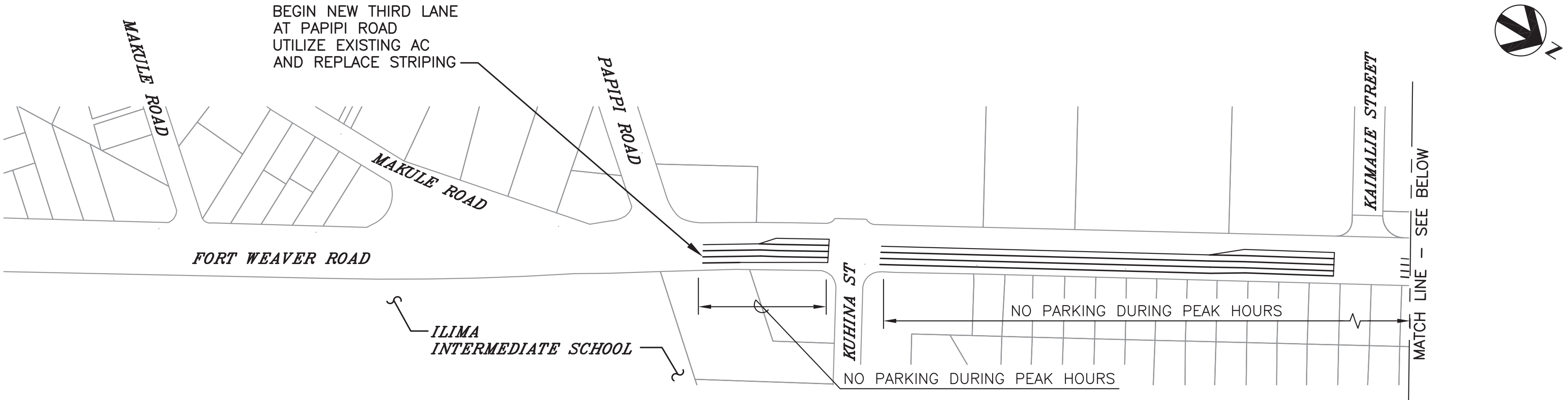
HDR

WEST LOCH TRAFFIC STUDY
WEST LOCH ANNEX, HAWAII

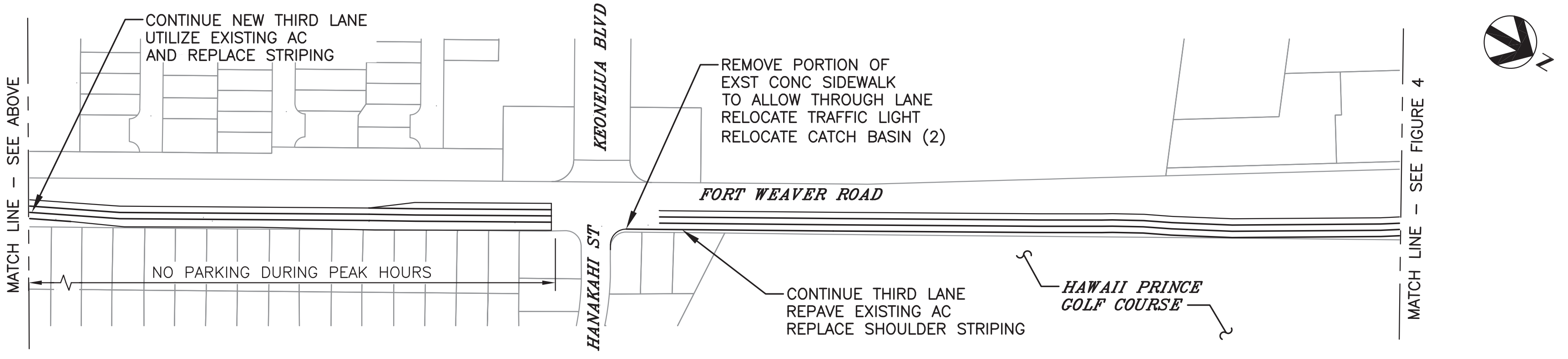
ALTERNATIVE 2 – PUULOA RANGE TRAINING FACILITY

DATE
APR 2018

FIGURE
2



ALTERNATIVE 2 AND 3 - FORT WEAVER ROAD IMPROVEMENTS
SCALE: 1" = 200'



ALTERNATIVE 2 AND 3 - FORT WEAVER ROAD IMPROVEMENTS
SCALE: 1" = 200'

GRAPHIC SCALE:
0 100 200 400 ft
SCALE: 1:200

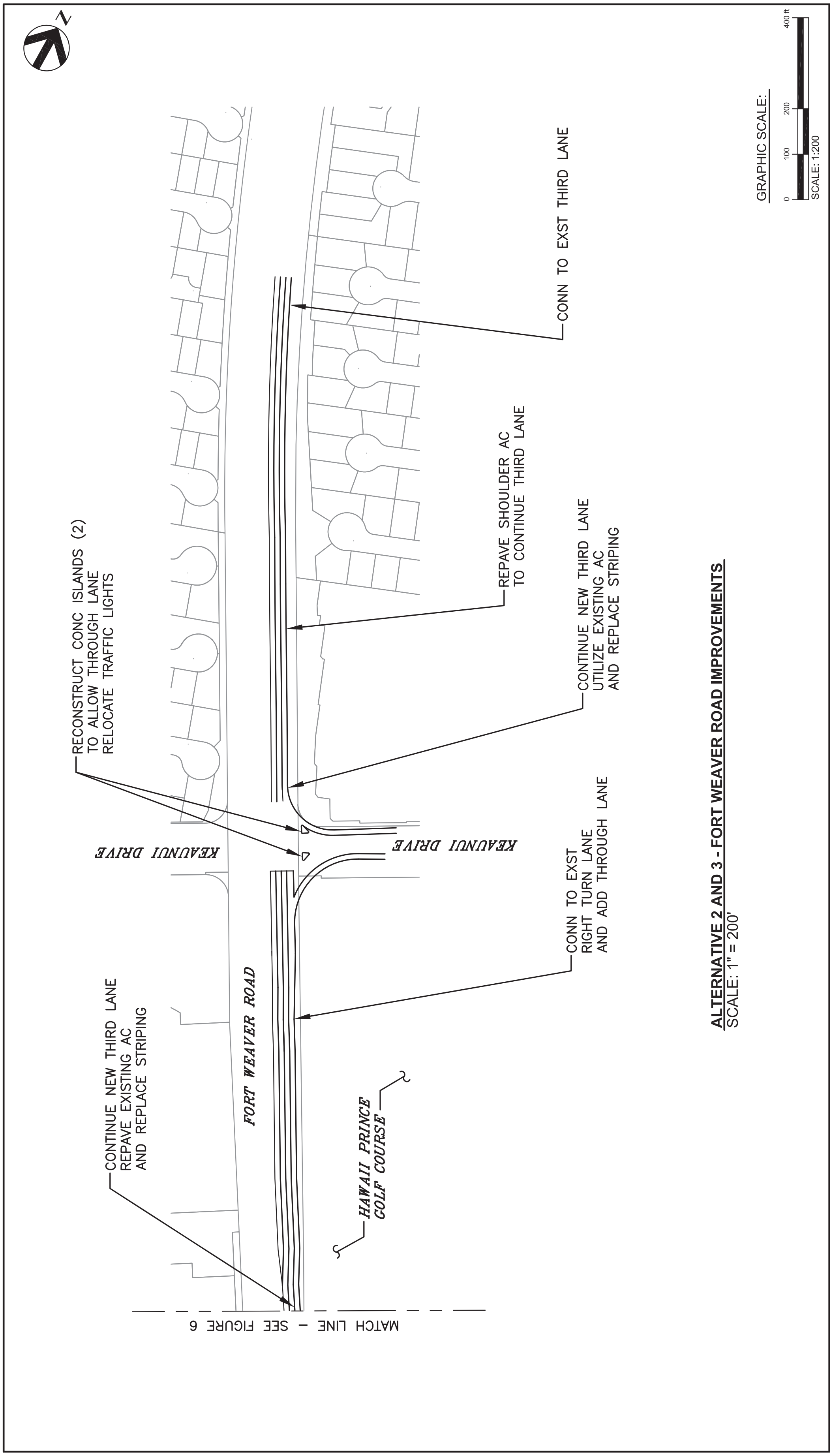
PRELIMINARY CONCEPT
NOT FOR CONSTRUCTION

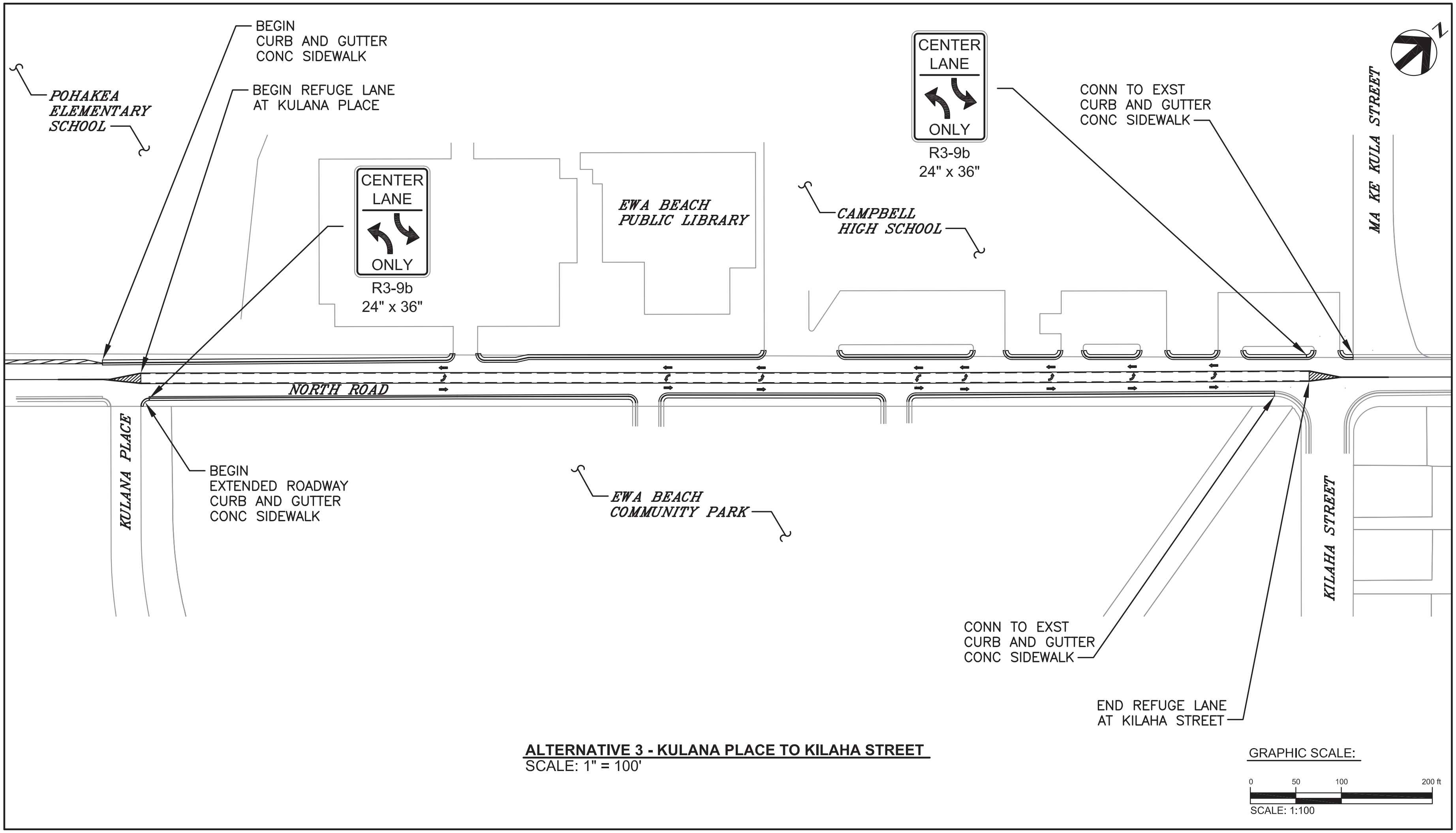
HDR

WEST LOCH TRAFFIC STUDY
WEST LOCH ANNEX, HAWAII

ALTERNATIVE 2 & 3 – FORT WEAVER ROAD

DATE
APR 2018
FIGURE
3


N
GRAPHIC SCALE:
0
100
200
400 ft
SCALE: 1:200
CONN TO EXST THIRD LANE
REPAVE SHOULDER AC TO CONTINUE THIRD LANE
CONTINUE NEW THIRD LANE UTILIZE EXISTING AC AND REPLACE STRIPING
RECONSTRUCT CONC ISLANDS (2) TO ALLOW THROUGH LANE RELOCATE TRAFFIC LIGHTS
KEAUNUI DRIVE
KEAUNUI DRIVE
CONN TO EXST RIGHT TURN LANE AND ADD THROUGH LANE
CONTINUE NEW THIRD LANE REPAVE EXISTING AC AND REPLACE STRIPING
FORT WEAVER ROAD
HAWAII PRINCE GOLF COURSE
MATCH LINE – SEE FIGURE 6
ALTERNATIVE 2 AND 3 - FORT WEAVER ROAD IMPROVEMENTS
SCALE: 1" = 200'
PRELIMINARY CONCEPT
NOT FOR CONSTRUCTION
FDR
WEST LOCH TRAFFIC STUDY
WEST LOCH ANNEX, HAWAII
ALTERNATIVE 2 & 3 – FORT WEAVER ROAD
DATE
APR 2018
FIGURE
4



ALTERNATIVE 3 - KULANA PLACE TO KILAHA STREET
SCALE: 1" = 100'

PRELIMINARY CONCEPT
NOT FOR CONSTRUCTION

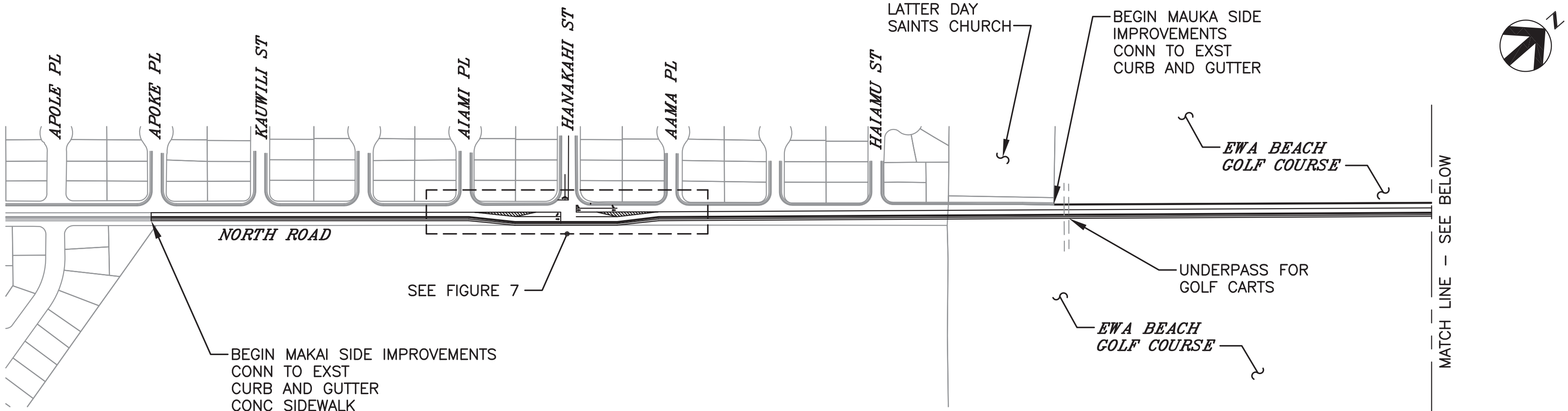
HDR

WEST LOCH TRAFFIC STUDY
WEST LOCH ANNEX, HAWAII

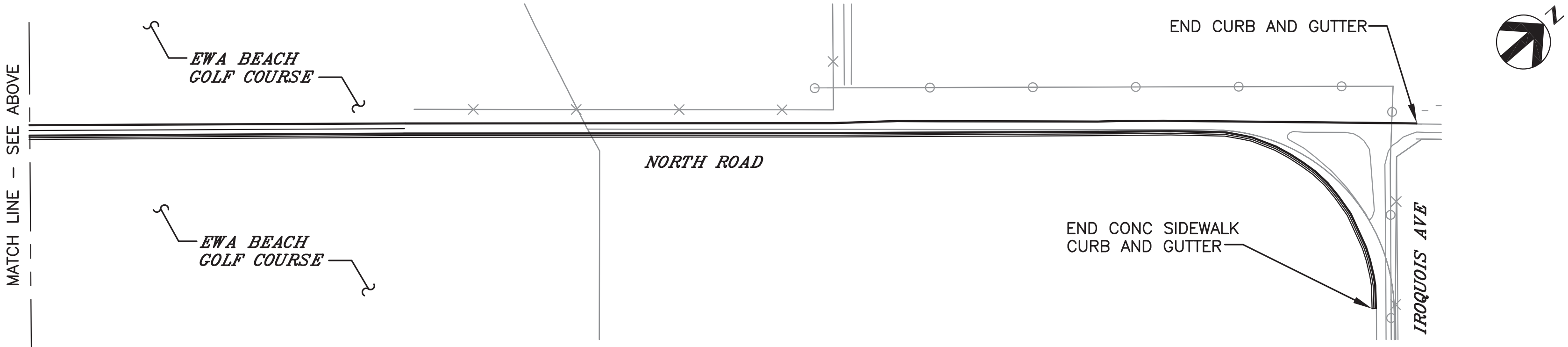
ALTERNATIVE 3 – KULANA PLACE TO KILAHA STREET

DATE
APR 2018

FIGURE
5



ALTERNATIVE 3 - NORTH ROAD - APOKE PL TO IROQUOIS AVE
SCALE: 1" = 250'



ALTERNATIVE 3 - NORTH ROAD - APOKE PL TO IROQUOIS AVE
SCALE: 1" = 250'

GRAPHIC SCALE:
0 125 250 500 ft
SCALE: 1:250

PRELIMINARY CONCEPT
NOT FOR CONSTRUCTION

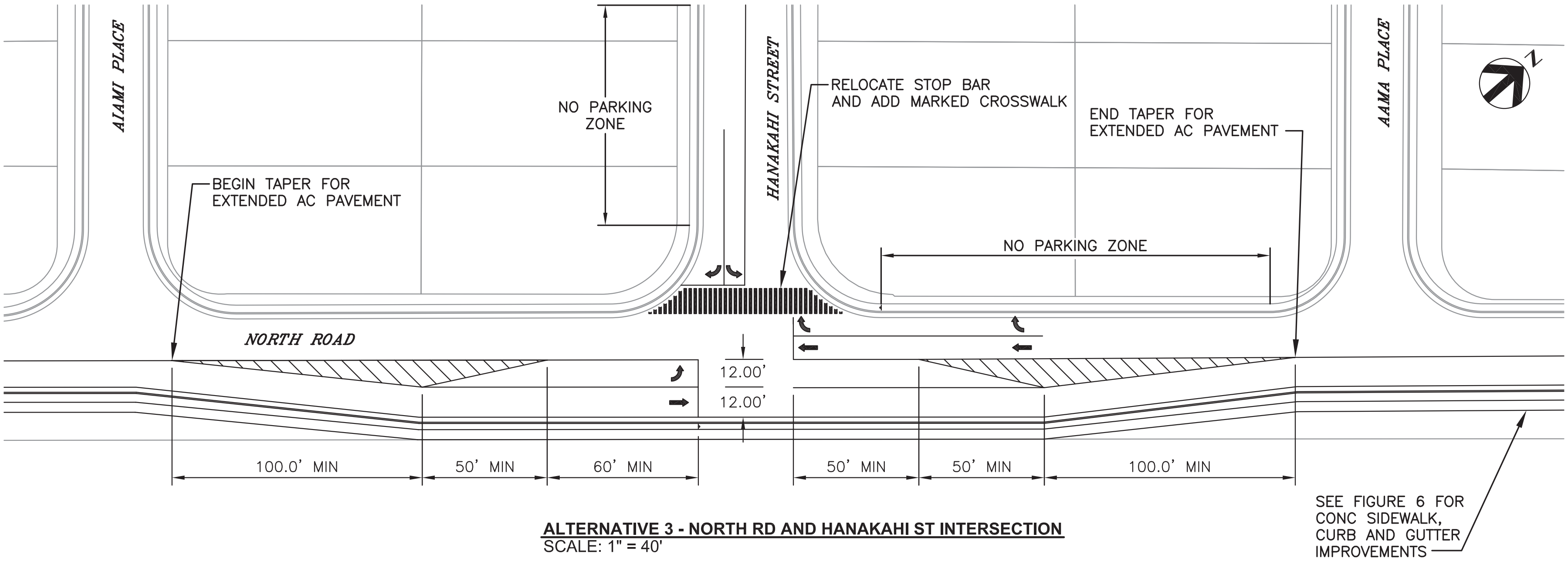
HDR

WEST LOCH TRAFFIC STUDY
WEST LOCH ANNEX, HAWAII

ALTERNATIVE 3 – APOKE PL TO IROQUOIS AVE

DATE
APR 2018

FIGURE
6



ALTERNATIVE 3 - NORTH RD AND HANAKAHI ST INTERSECTION
SCALE: 1" = 40'

NOTE:
TYPICAL WIDTH FOR PLANTING STRIP IS 3.5 FT WIDE AND SIDEWALK IS 4 FT WIDE. BETWEEN AIAMI PLACE AND AAMA PLACE, PLANTING STRIP WIDTH IS REDUCED TO 2.3 FT WIDE.

GRAPHIC SCALE:
0 20 40 80 ft
SCALE: 1:40

PRELIMINARY CONCEPT
NOT FOR CONSTRUCTION

WEST LOCH TRAFFIC STUDY
WEST LOCH ANNEX, HAWAII

ALTERNATIVE 3 – NORTH RD FROM AIAMI PL TO AALA PL

DATE
APR 2018

FIGURE
7

Appendix C

Noise Analysis

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D. L. ADAMS
ASSOCIATES
acoustics | performing arts | technology

1536 Ogden Street
Denver, CO 80218
www.dlaa.com
303.455.1900

November 30, 2018

Milton M. Arakawa
HFF Planners
Pacific Guardian Center, Makai Tower
Honolulu, HI 96813

Subject: West Loch Drive – Bypass Road Noise Analysis (DLAA #18-029)

Dear Milton,

We have reviewed the schematic level plans to relocate West Loch Drive, referred to as "Bypass Road," along with the West Loch Annex Traffic Study issued by Helbert Hastert & Fee (HHF) in August 2018 with respect to environmental noise impact. The following acoustical report outlines existing noise levels at nearby residential areas based on long-term measurements. The report also summarizes the potential noise impact of both the construction of the new Bypass Road as well the noise impact from traffic on the relocated road. Recommendations to reduce noise levels at nearby residential areas are also presented for your consideration.

Summary

The following bullet points summarize the overall findings from our acoustical analysis. Detailed info for these items is provided in the following sections.

- Based on on-site measurements at the Hawaii Prince Golf Course and at a residence at 1032 Ho'omalie Street, average existing daytime overall noise levels range from 53 dBA to 56 dBA. Average nighttime levels were measured to be between 40 dBA and 46 dBA.

- Without any noise mitigation strategies, DLAA estimates that peak construction noise levels from the loudest equipment and activities will result in overall noise levels between 58– 86 dBA at the nearest residences on Ho'Oka'Ahea Street, Kuano'o Street, and Hanaloa Street.

- Without any noise mitigation strategies, DLAA estimates that traffic on West Loch Drive Bypass Road will result in a peak hourly average 56 - 66 dBA at the nearest residences on Ho'Oka'Ahea Street, Kuano'o Street, and Hanaloa Street. For reference, this is in compliance with the Noise Abatement Criteria (NAC) for residential areas set by the Federal Highway Administration's (FHWA) standard *Highway Traffic Noise Regulation: Analysis and Abatement Guidance* and in 23 CFR 772.

- Where peak hour traffic noise levels are calculated to be at least 5 dB above the existing ambient daytime noise level, sound mitigation strategies should be considered, per

FHWA. Such an increase in noise levels may be considered to be a “substantial increase.” This analysis predicts that any property within 30-40 feet of the center of the Bypass Road will produce noise levels at least 5 dB(A) above the existing background level with traffic traveling at 40 mph. Such properties may include residences on Makalea Street, Ho’omalie Street, Ho’Oka’Ahea Street, Hanaloa Street, and Kauiki Street. Noise barriers between the Bypass Road and nearby properties may need to be designed and included in the project. However, if noise barriers cannot break the line of sight between the Bypass Road and nearby upper story windows or building facades, alternative or additional mitigation measures, such as reduced speeds or increased distances between the Bypass Road and the nearest receivers, may need to be explored.

- If traffic speeds can be limited to 30 mph, our noise prediction models indicate that the impact will not result in a “substantial increase” of 5 dB(A) or greater at properties on Ho’Oka’Ahea Street (Receiver 1) or Kuano’o St (Receiver 2) where the center of Bypass Road is assumed to be at least 60’ from the property lines. The traffic source noise calculations use methods outlined in the FTA Transit Noise & Vibration Impact Assessment Manual. The calculation assumes that 15% of the total traffic count during peak hours are heavy diesel vehicles. According to our model, prohibiting heavy vehicles from using the Bypass Road would reduce the noise impact by an additional 2 dB(A).

  However, the noise impact model shows a “substantial noise increase” at residential properties located at Hanaloa Street (Receiver 3) where the center of the Bypass Road is assumed to be 30’ from the property lines even with reducing traffic speeds to 30 mph and prohibiting heavy vehicles. Increasing the distance from the center of the Bypass Road to properties along Hanaloa Street to 60’, would result in similar noise levels shown for Receiver Positions 1 & 2.

- If FHWA approval is required, a more detailed traffic study should be conducted to inform the acoustical analysis with specific vehicle types and future traffic predictions. Noise abatement measures should be considered in further detail and recommended in accordance with FWHA’s standard 23 CFR 772.13. These steps, along with an acoustical model built in FHWA’s *Traffic Noise Model* (TNM), are required for FHWA approval.

State & Federal Regulations

For construction activities that exceed the maximum noise levels listed in Table 1 below, Section 11-46-7 of Hawaii’s Administrative Rules allows the Department of Health to issue permits or noise variances specific to the project, which would be in the public interest, and which may be subject to reasonable conditions which the DOH may prescribe. Construction noise level predictions for this project are detailed in later sections of this report.

Table 1. State of Hawaii's Maximum Permissible Sound Levels (applicable to construction noise)

Zoning District	Daytime (7 a.m to 10 p.m.)	Nighttime (10 p.m. to 7 a.m.)
Class A (Residential)	55 dBA	45 dBA

Since the Bypass Road would be built by a Federal Agency with Federal funds but eventually owned by a non-federal government agency, the appropriate noise standard would be the Federal Highway Administration's (FHWA) standard *Highway Traffic Noise Regulation: Analysis and Abatement Guidance* section 23 CFR Part 772. The applicable FHWA criteria is listed in Table 2 below. If traffic noise levels are shown to exceed these levels, FHWA requires that the highway agency must consider highway traffic noise abatement measures and implement them if found to be feasible and reasonable.

Table 2. FHWA's Noise Abatement Criteria (NAC) (applicable to traffic noise)

Zoning District	Leq (h)	L10 (h)
Category B (Residential)	67 dBA	70 dBA

Existing Noise Assessment

On-site long-term acoustical measurements were conducted at two locations from Saturday September 22nd, 2018 to Wednesday September 26th, 2018. One sound level meter was located at 1032 Ho'omalie Street and a second sound level meter was located at the Hawaii Prince Golf Course. Please see Figure 1 attached for a map of measurement locations. Average sound levels were recorded in 60-minute intervals.

The most frequent and potentially disturbing noise sources at both locations was overhead air traffic. It also should be noted that the golf course had additional localized noise sources such as sprinklers and lawn mowers. The results of the on-site measurements are shown in Table 3 and Figure 2, attached. The metrics shown include the average day noise level (Ld), the average night level (Ln), and the Day-night level (Ldn). The Ldn is a 24-hour average noise level, however the noise between 10 pm and 7 am is artificially increased by 10 dB. For reference, the standard for site acceptability according to Housing and Urban Development (HUD) is a Ldn of 65 dB.

Table 3. Summary of On-Site Noise Monitoring

Measurement Location	Average Daytime Level (Ld)	Average Nighttime Level (Ln)	Average Day-Night Level (Ldn)
1032 Ho'omalie Street	53 dBA	40 dBA	52 dBA
Hawaii Prince Golf Course	56 dBA	46 dBA	56 dBA

Procedure & Analysis

To help better understand and interpret our analysis, we have included a Sound Level Decibel Loudness Comparison Chart in Table 4 below for reference.

Table 4. Sound Level Decibel Loudness Comparison

Noise Source at a Given Distance	Sound Pressure Level
Jet Takeoff at 200’, Auto Horn at 3’	125 dBA
Rock Concert	110 dBA
Impact or Vibratory Pile Driver at 50’	100 dBA
Motorcycle at 25’, Jackhammer at 50’	90 dBA
Diesel Truck 40 mph at 50’, Chainsaw at 50’	85 dBA
Garbage Disposal at 3’, Backhoe at 50’	80 dBA
Passenger car at 65 mph at 25’, Dump Truck at 50’	75 dBA
Vacuum cleaner at 10’, Freight Train at 100’	70 dBA
Measured average daytime background level in downtown Aspen	65 dBA
Measured background at private home outside of Aspen	50 dBA
Whisper at 5’	30 dBA
Threshold of hearing	0 dB

* Data in Table 4 compiled from a combination of DLAA field measurements, Peterson & Gross 1974, and US-DOT FHA Construction Noise Handbook

Our acoustical analysis methods and assumptions include:

1. The acoustical analysis used CadnaA modeling software to predict construction and traffic noise propagation. Using Google Earth as a reference, residential buildings within 300’ or within direct line of sight of West Loch Drive Bypass Road were included in the model. The building heights, shapes and heights were approximated based on Google Earth and Google Street Views. All structures located further than 300’ within acoustical shadows of nearfield structures from the West Loch Drive Bypass Road were ignored. Based on CadnaA modeling results, all construction and traffic noise activities will result in peak levels below 45 dBA at such locations.
2. The local site topography was assumed to be flat.
3. The bypass road is assumed to be smooth asphalt.
4. The center of the Bypass Road was assumed to be located 60’ from the residential property lines on Ho’Oka’Ahea Street (Receiver 1) and Kuano’o St (Receiver 2) and 30’ from the residential property lines located on Hanaloa Street (Receiver 3).
5. Traffic data used to predict traffic noise levels came from the West Loch Annex Traffic Study prepared by Julian Ng Incorporated dated August 2018. The hourly Leq was calculated by using the traffic counts from the hour of 0700 – 0800, which was the busiest hour recorded. The northbound traffic was 286 vehicles and southbound was 332 vehicles for a total of 618 vehicles.

6. The hourly Leq calculation was conducted in accordance with the FTA Transit Noise and Vibration Impact Assessment manual. This was deemed to be the most applicable method to predict source level traffic noise from traffic count data. To provide a conservative noise prediction, correction factors for 40 mph traffic speeds were applied in accordance with Table 10-1 of the FTA Assessment manual even though the Bypass Road is likely to have a design speed of 30 mph. Based on the FTA noise calculation method, it can be assumed that traffic speeds of 30 mph will result in noise levels roughly 5 dB below predicted noise levels using speeds of 40 mph. Please see the attached Hourly Leq Calculated spreadsheet.
7. The number of heavy vehicles was assumed to be 15% of total vehicles. Since the Traffic Study did not delineate vehicle types, DLAA used HUD's Nosie Guidebook reference standard of 15% heavy vehicles when specific vehicle type data is unavailable. The FTA reference level used for heavy vehicles was "Buses (diesel-powered)".
8. This report does not assess the noise impacts of any predicted increase in future traffic volumes.
9. The construction noise analysis modeled noise transmission from three different noise sources. Each source had a unique octave band sound power data set. The octave bands ranged from 63 Hz to 8000 Hz.

Construction Noise Sources

Measured octave band sound data published by the U.K.'s Department for Environment Food and Rural Affairs (DEFRA) was used for both frequency content and overall noise levels. The advantages in using this dataset is that it is both expansive in equipment types and sizes and also includes octave band data rather than simply overall sound pressure or overall sound power levels. HFF Planners provided a list of equipment types likely to be used in the road construction. The three loudest pieces of equipment were deemed to be bulldozers, vibratory rollers, and dump trucks. The overall sound levels for the equipment used in our analysis is shown in Table 5.

Table 5. Noise Sources Used in Analysis

Source	Overall Level at 32'
Bulldozer (238 kW)	80 dBA
Vibratory Roller (20 kW)	73 dBA
Dump Truck	87 dBA

Specific Source and Receiver Positions

Generally, the construction noise analysis used three source positions which are nearest residential areas. These positions are referred to as S1, S2, and S3 and shown in Figure 3, attached. The nearest residential receiver positions are referred to as R1, R2, and R3 and are also shown in Figure 3.

Summary of Construction Noise Calculations

Table 6 displays calculated peak noise levels for all three noise sources at all three receiver positions without any mitigation strategies. The calculated noise contours for the three construction noise sources are shown in Figures 4-9.

Table 6. Calculated Maximum Construction Noise Levels at Receiver Positions 1-3

Source	R1	R2	R3
Bulldozer (238 kW)	73 dBA	64 dBA	79 dBA
Vibratory Roller (20 kW)	66 dBA	58 dBA	72 dBA
Dump Truck (306 kW)	81 dBA	72 dBA	86 dBA

The predicted peak levels from construction noise are preliminary. If construction during nighttime or weekend hours is necessary, a Noise Variance issued by the City and County of Honolulu will be required. In that case, a detailed noise impact analysis should be included in the Construction Noise Mitigation and Management Plan. The effect and design of temporary noise barriers, exhaust mufflers, reverse alarms, and project scheduling should be included in such an analysis. At this point, we simply recommend reducing the impact of construction by limiting construction activities to weekdays between 7:00am and 6:00pm.

Traffic Noise Modeling

As displayed in the attached Hourly Leq Calculation Spreadsheet, the peak hourly Leq is calculated to be 65 dBA at a reference distance of 50’ from the center of the Bypass Road. This assumes a traffic speed of 40 mph and that 15% of all traffic is heavy diesel vehicles. Calculated average traffic noise levels at the three receiver positions are listed in Table 7. All peak hourly average noise levels at all receiver positions are shown to meet the FHWA criteria of 67 dBA.

Table 7. Calculated Traffic Noise Levels at Receiver Positions 1-3 Without Mitigation

Metric	R1	R2	R3
Peak Hour Average Noise Level (Leq)	61 dBA	56 dBA	66 dBA

Please refer to Figures 10-12 attached for calculated traffic noise contour maps.

Should you have any questions about any information contained in this report, please feel free to contact DLAA.

Sincerely,

Ted Pitney
Project Manager

Enclosed: Figures 1-2: On-Site Noise Monitoring
Figure 3: Noise Modeling Layout
Figures 4-9: Construction Noise Mapping
Figures 10-12: Traffic Noise Mapping
Traffic Data Used in Noise Modeling
Hourly Leq Calculation Spreadsheet

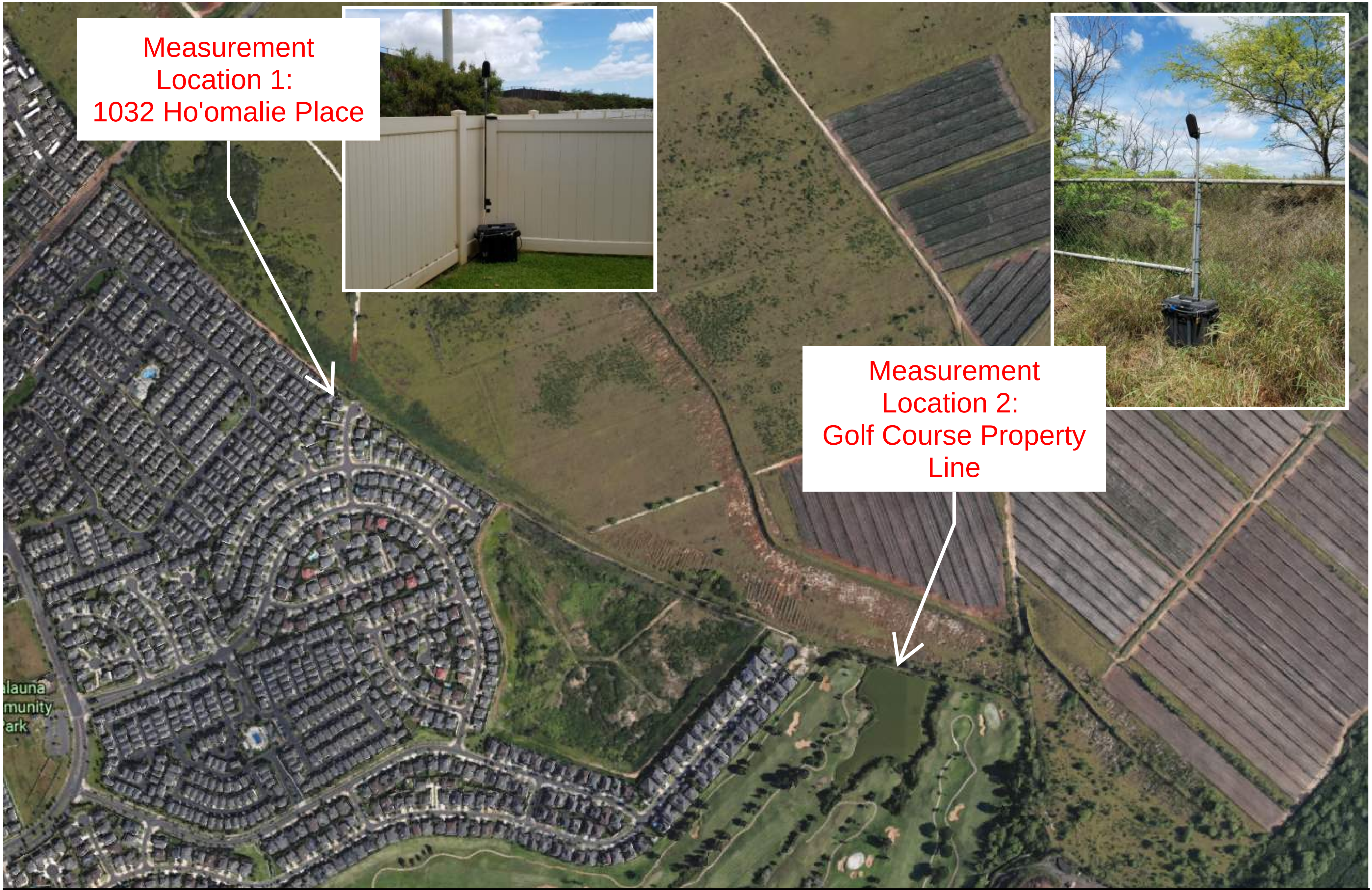

Figure 1. On-Site Measurement Locations
West Loch Drive Bypass Noise Analysis
DLAA #18-029 10/26/2018

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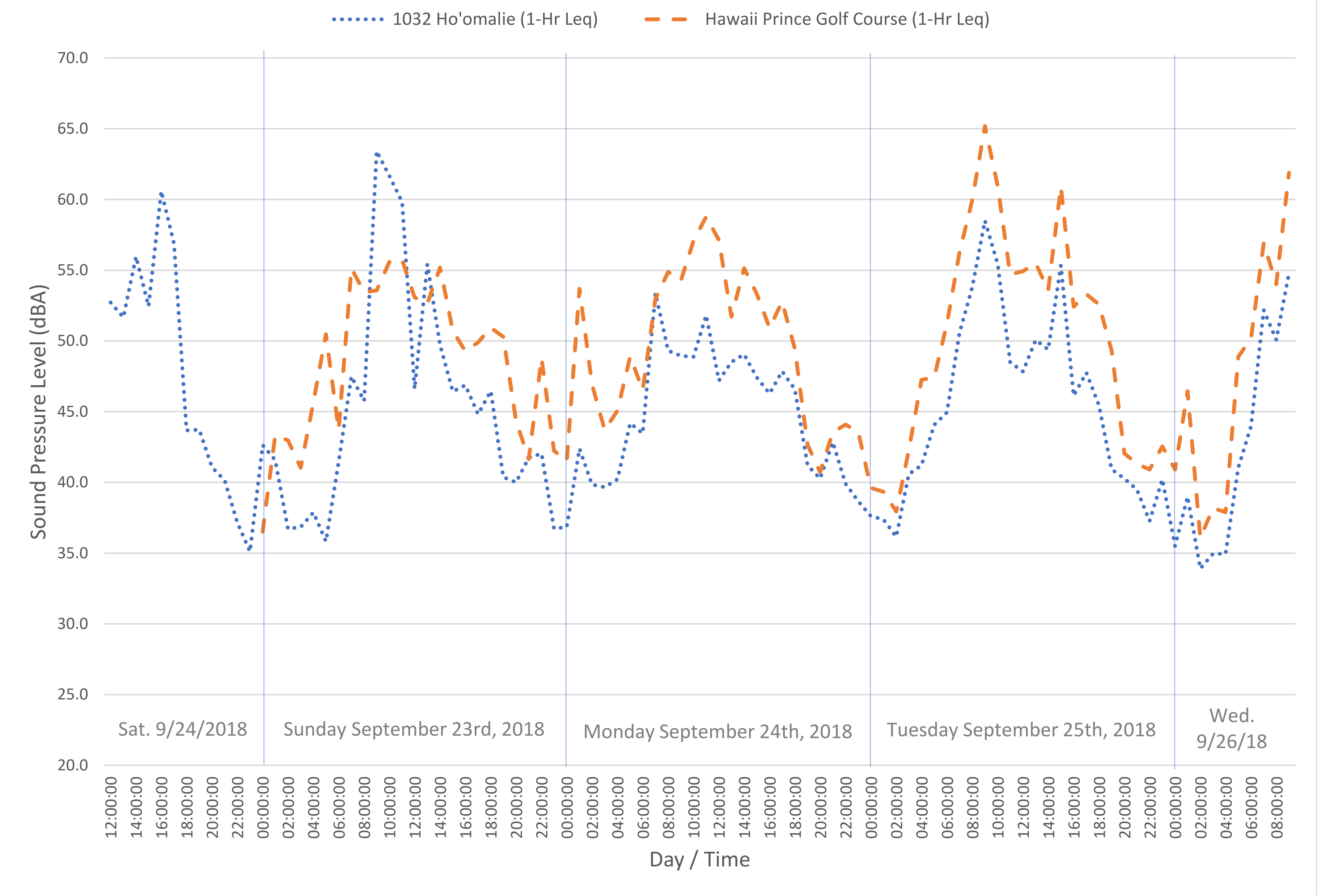
Figure 2. On-Site Noise Monitoring Results



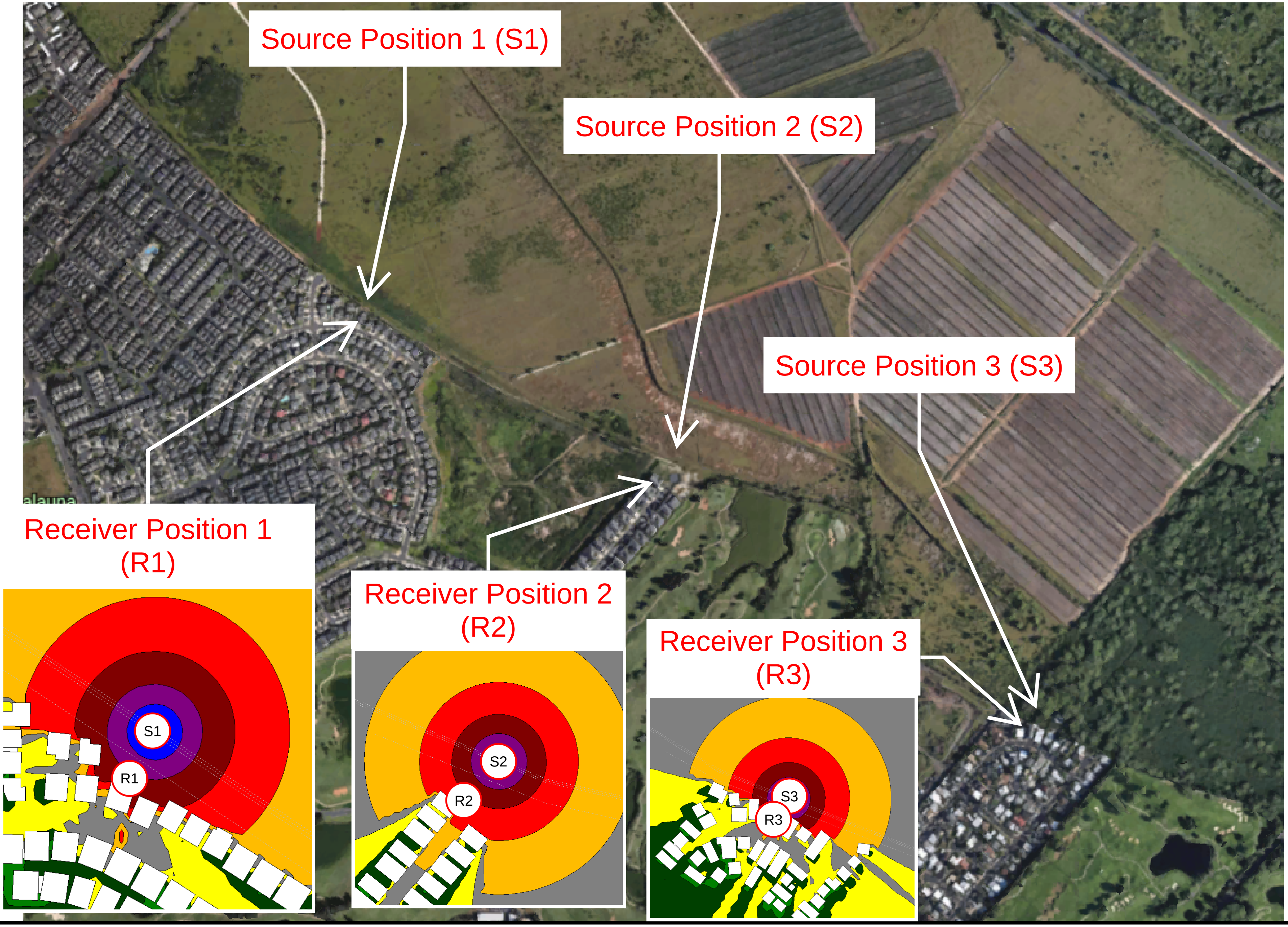


Figure 3. Source & Receiver Positions for Noise Modeling
West Loch Drive Bypass Noise Analysis
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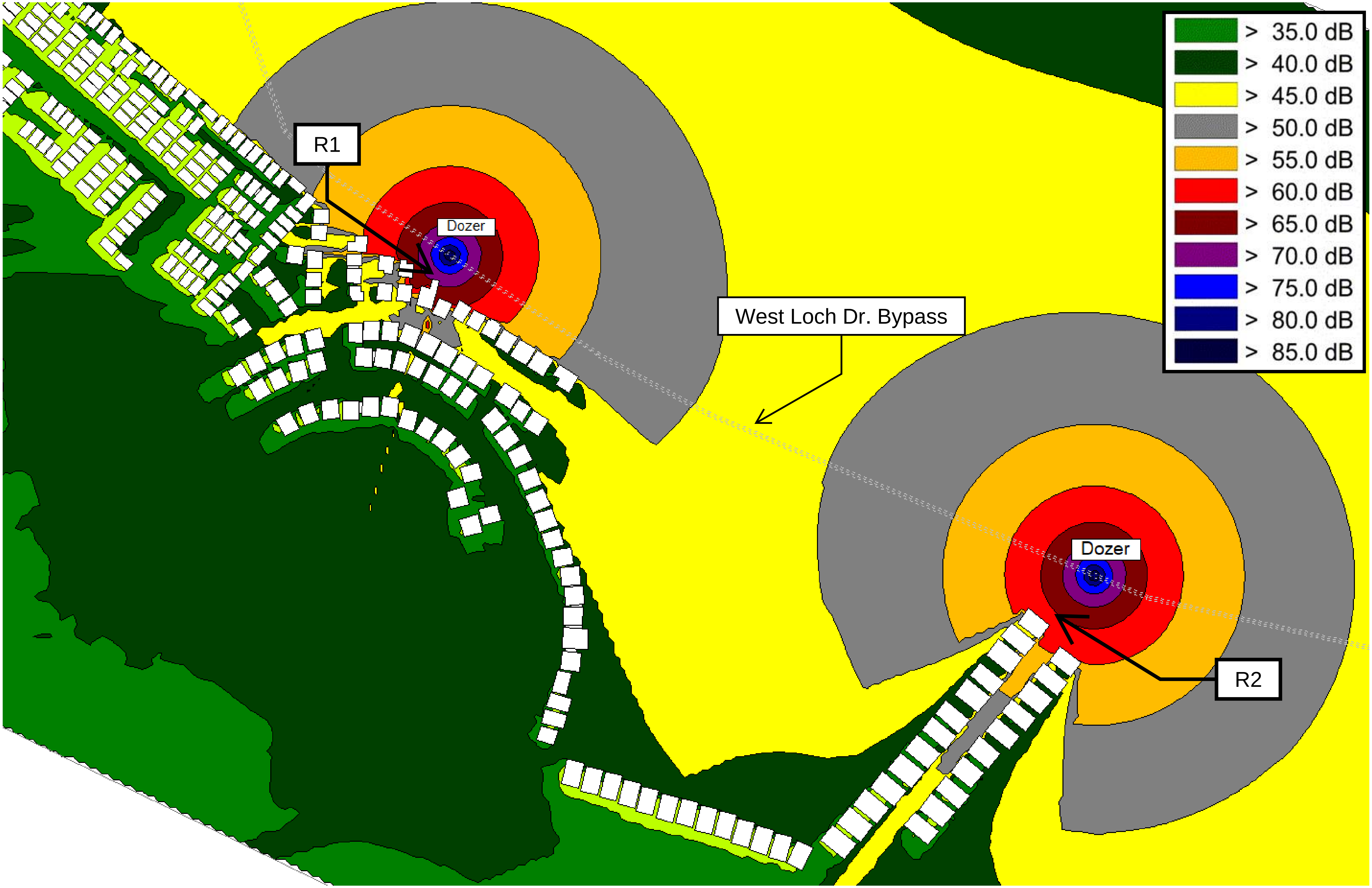

Figure 4. Bulldozer Noise Modeling Results, S1 & S2 Locations
West Loch Drive Bypass Noise Analysis
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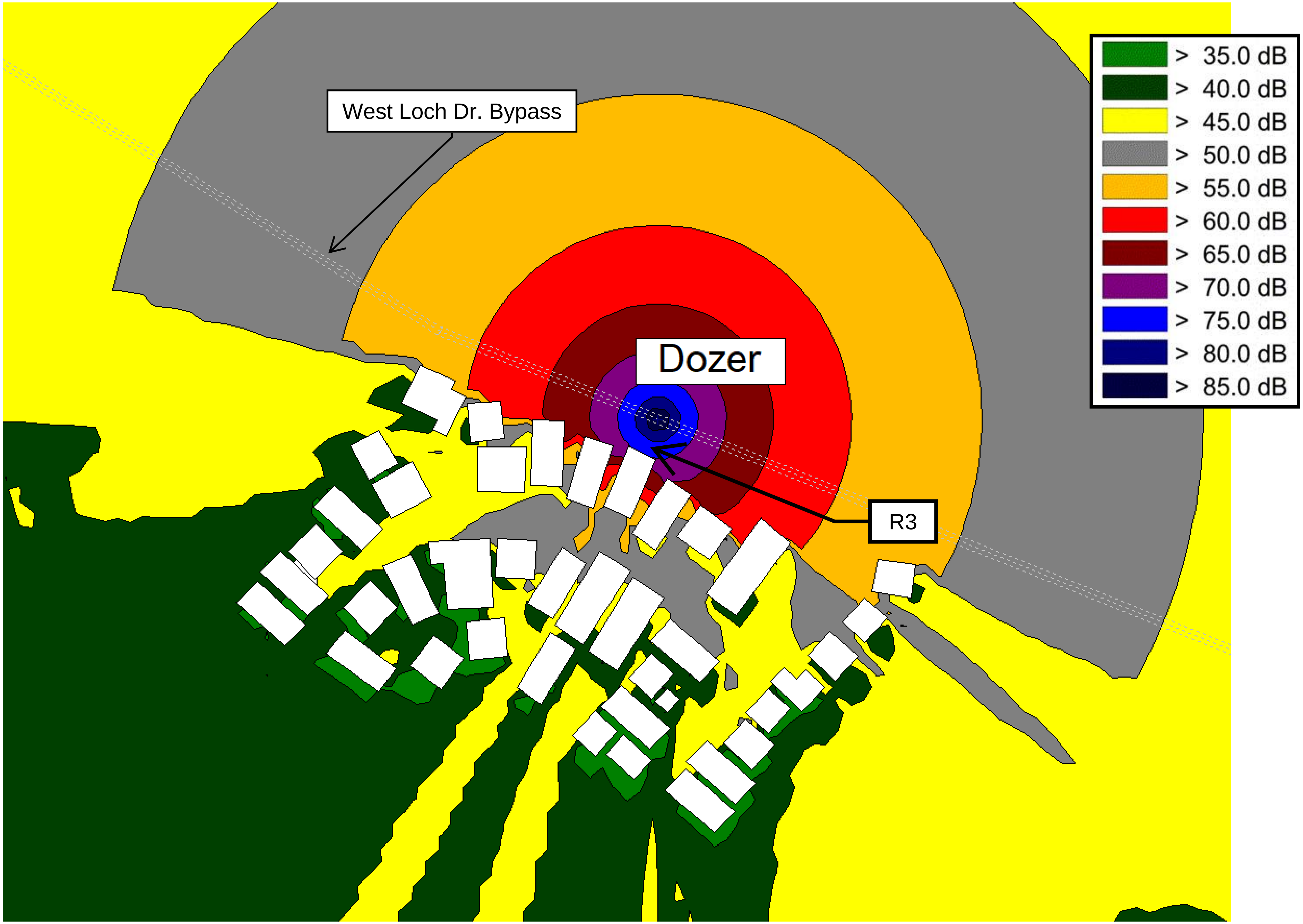

Figure 5. Bulldozer Noise Modeling Results, S3 Location
West Loch Drive Bypass Noise Analysis
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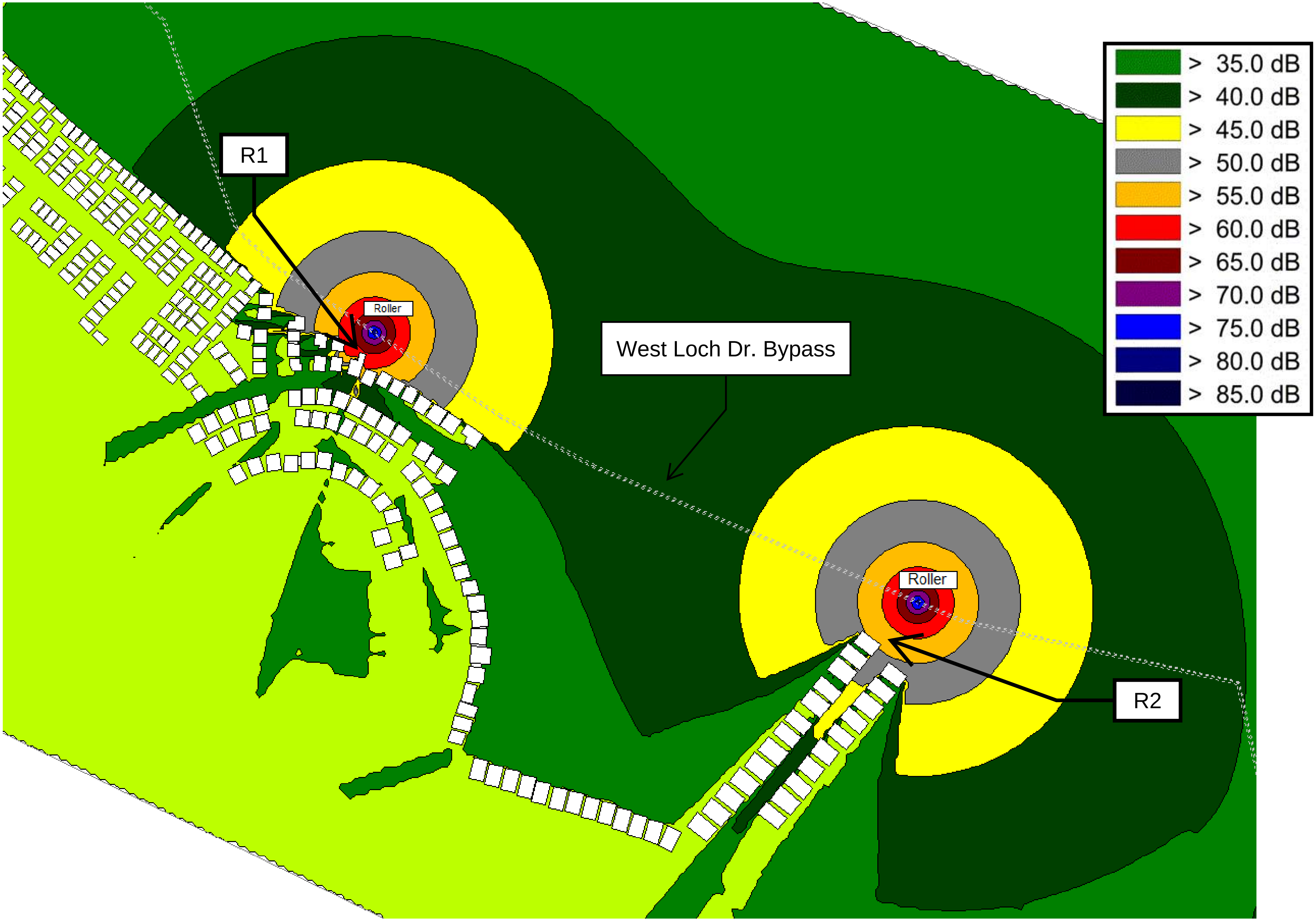

Figure 6. Roller Noise Modeling Results, S1 & S2 Locations
West Loch Drive Bypass Noise Analysis
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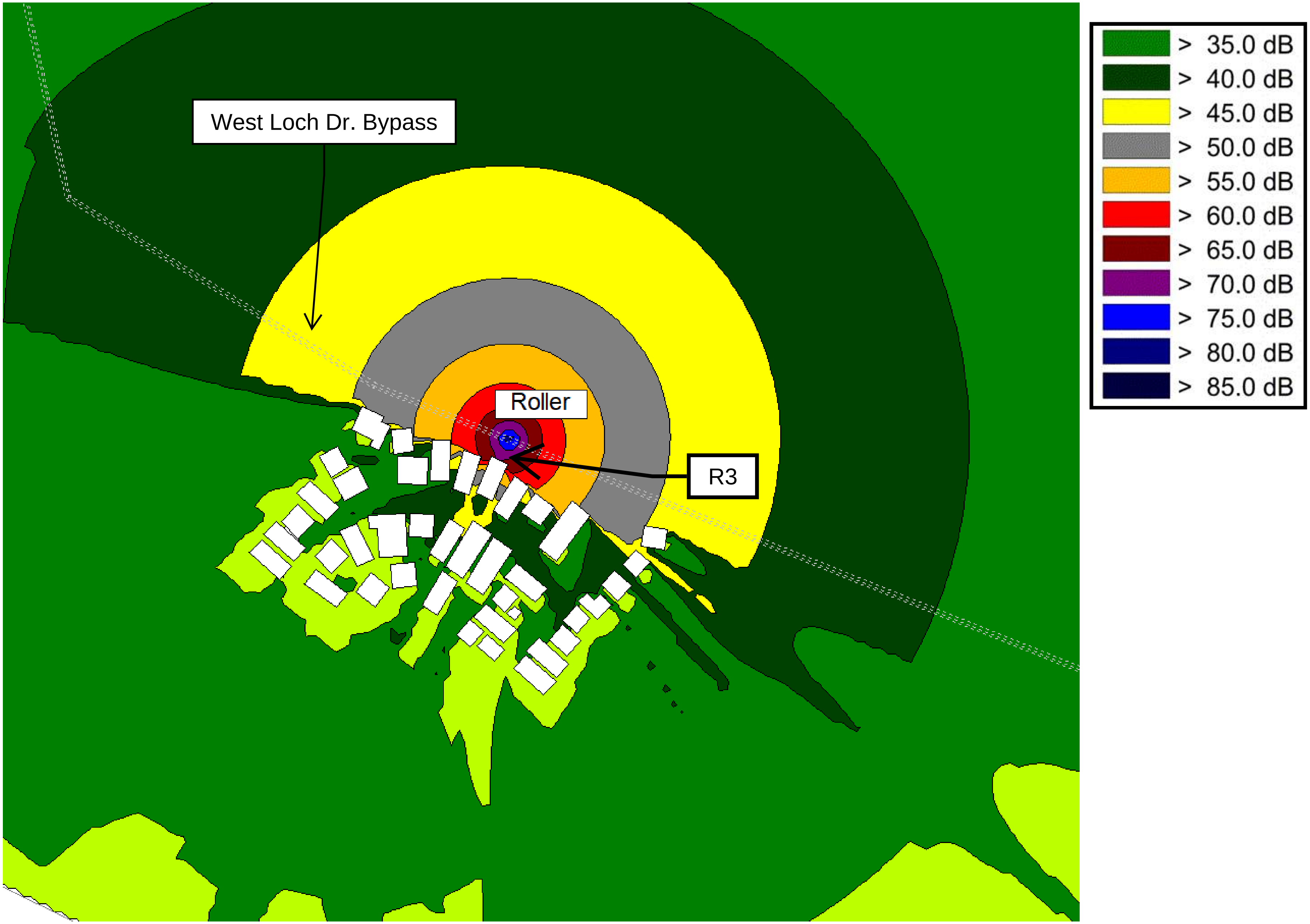

Figure 7. Roller Noise Modeling Results, S3 Location
West Loch Drive Bypass Noise Analysis
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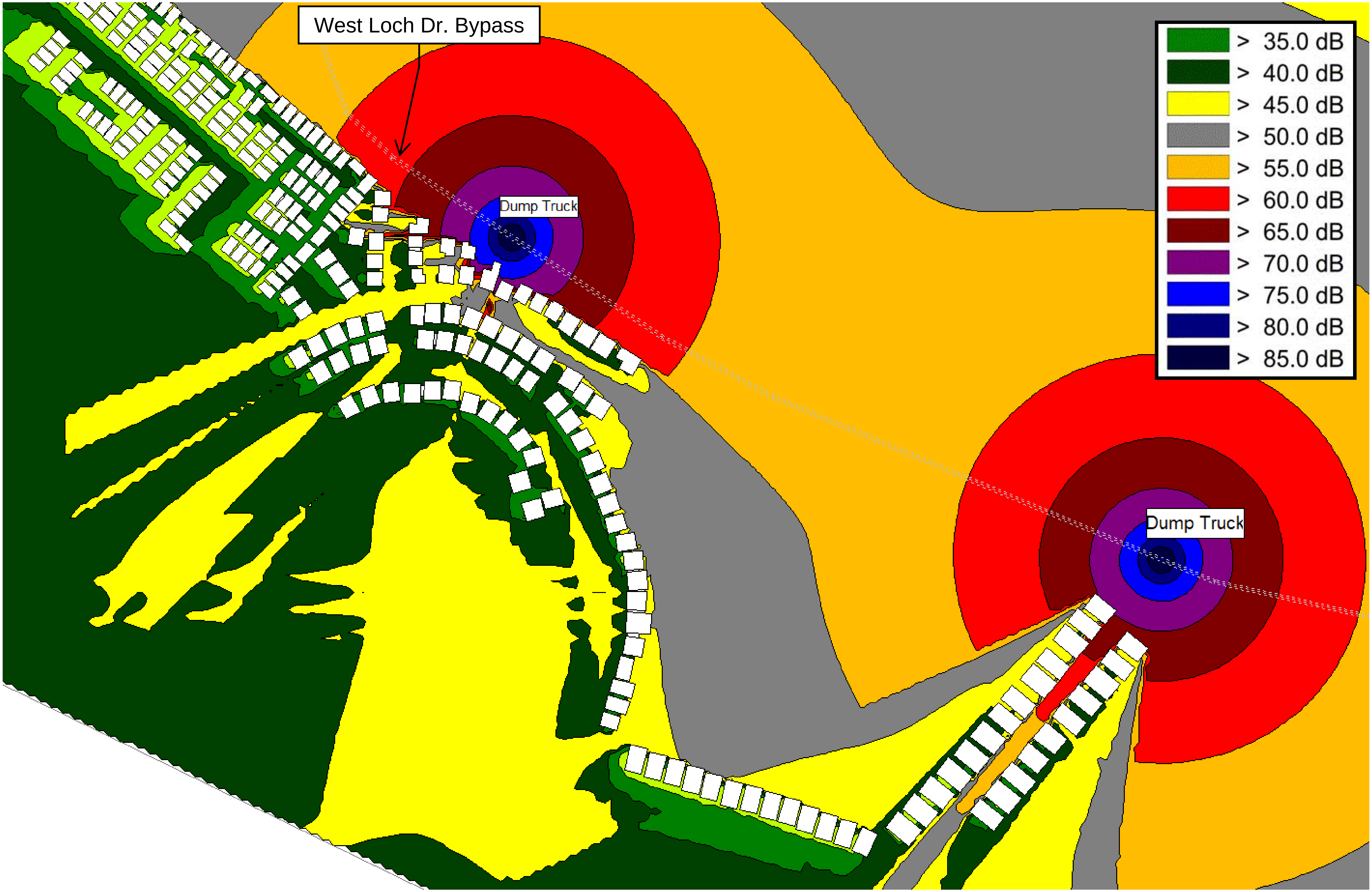

Figure 8. Dump Truck Noise Modeling Results, S1 & S2 Locations
West Loch Drive Bypass Noise Analysis
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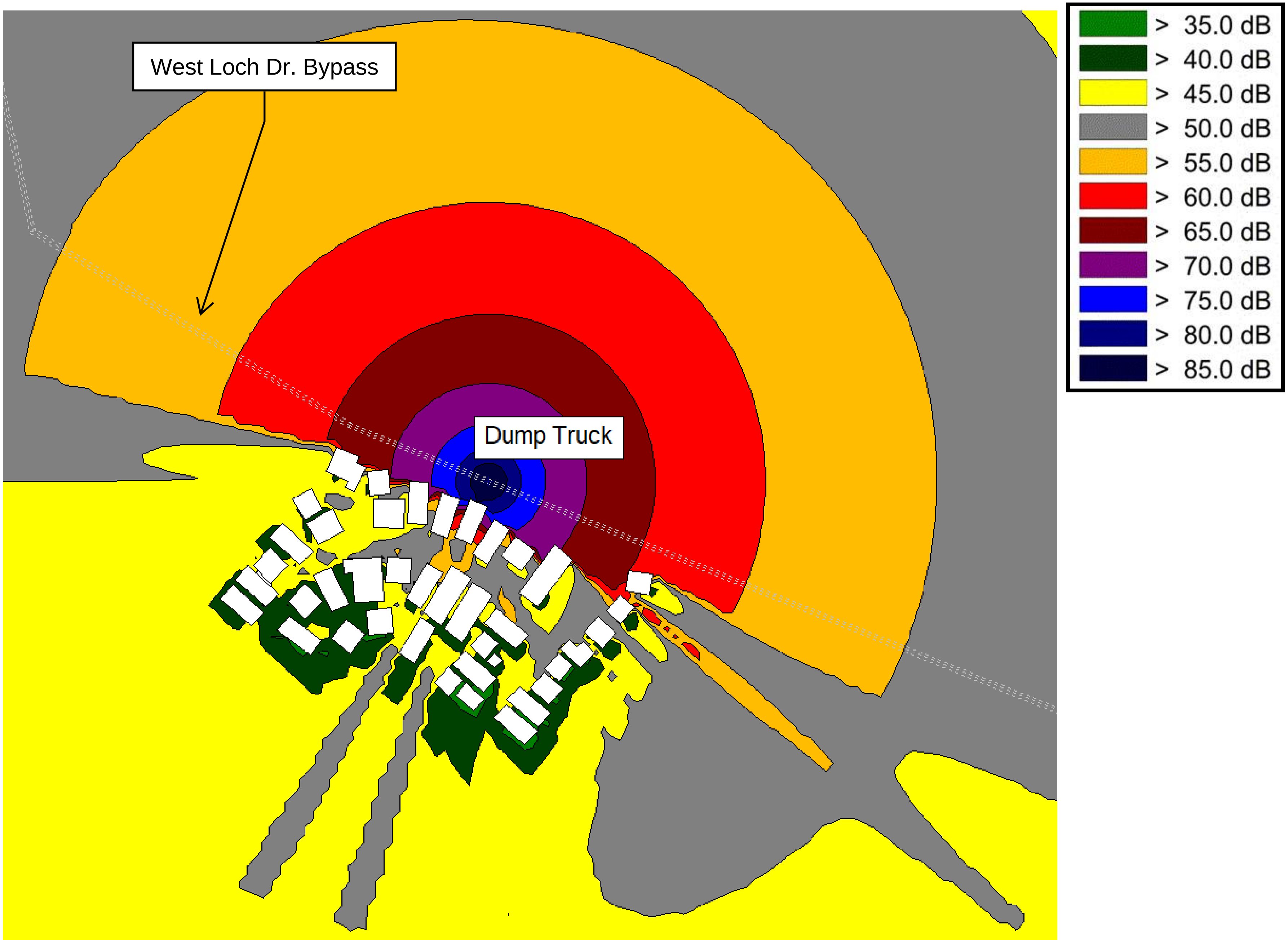

Figure 9. Dump Truck Noise Modeling Results, S3 Location
West Loch Drive Bypass Noise Analysis
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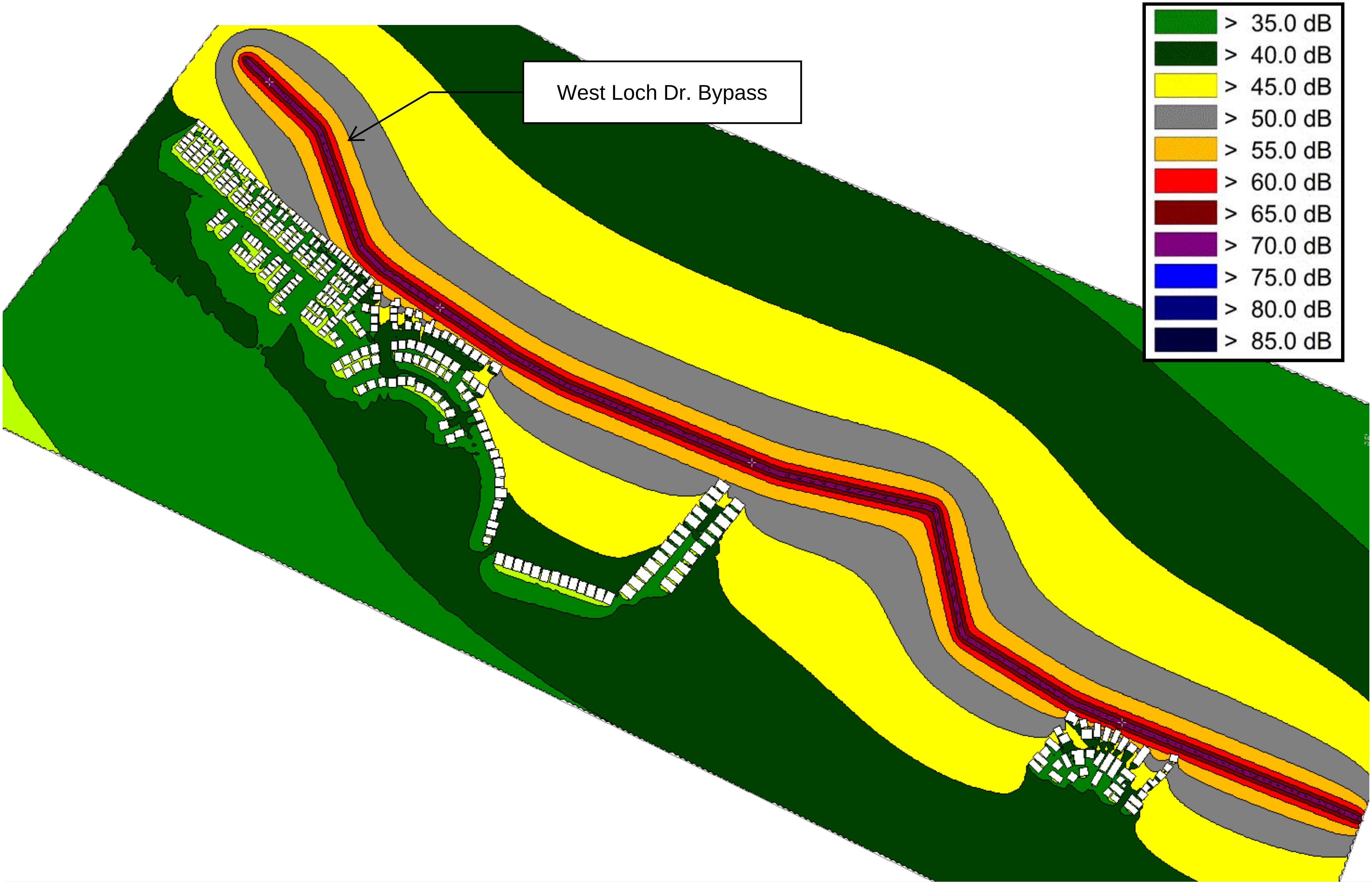

Figure 10. Peak Hour Traffic Average Noise Levels (Leq)
West Loch Drive Bypass Noise Analysis
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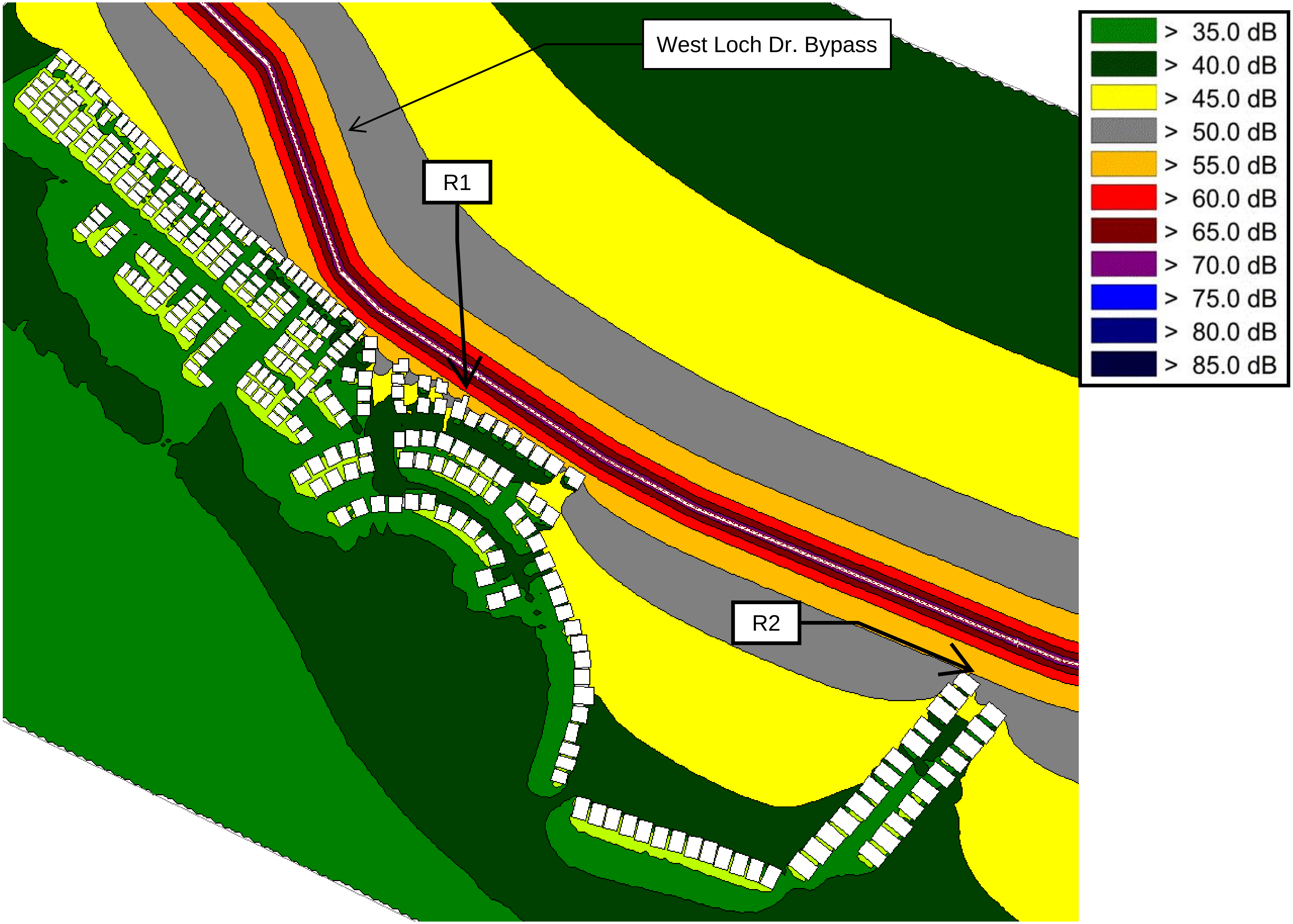

Figure 11. Peak Hour Traffic Average Noise Levels (Leq) at R1 & R2
West Loch Drive Bypass Noise Analysis
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Figure 12. Peak Hour Traffic Average Noise Levels (Leq) at R3
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Traffic Data Used in DLAA Traffic Noise Modeling - 10/26/2018

3 Effects of Closing West Loch Drive (No Mitigation)

The closure of West Loch Drive, assuming no mitigation measures are taken, would result in traffic diversion onto parallel roadways. The diverted traffic would include not only traffic originating from or destined to the West Loch Annex front gate and Kapilina but also traffic traveling between Iroquois Road and North Road. In Table 9, Columns A + B and D + E show the traffic volumes that would be diverted; columns C and F show the counts of vehicles that would not use Iroquois Avenue (i.e., would not go to or come from West Loch Annex front gate or Kapilina).

Table 9 – Traffic on West Loch Drive

Time Period/Movement	Southbound Vehicles				Northbound Vehicles			
	A*	B*	A + B	C*	D*	E*	D + E	F*
0000 – 0100 hours	26	0	26	0	6	0	6	0
0100 – 0200 hours	16	0	16	0	12	0	12	0
0200 – 0300 hours	10	0	10	0	9	0	9	1
0300 – 0400 hours	7	0	7	0	16	0	16	1
0400 – 0500 hours	65	0	65	1	175	0	175	0
0500 – 0600 hours	90	0	90	1	325	0	325	6
0600 – 0700 hours	110	0	110	3	302	3	305	15
0700 – 0800 hours	283	3	286	99	328	4	332	46
0800 – 0900 hours	112	0	112	14	229	0	229	11
0900 – 1000 hours	76	1	77	3	171	5	176	3
1000 – 1100 hours	92	1	93	6	138	2	140	4
1100 – 1200 hours	96	0	96	5	148	0	148	2
1200 – 1300 hours	120	1	121	0	116	0	116	1
1300 – 1400 hours	167	1	168	5	119	2	121	5
1400 – 1500 hours	180	0	180	21	263	0	263	28
1500 – 1600 hours	223	2	225	6	189	0	189	10
1600 – 1700 hours	284	0	284	9	292	0	292	7
1700 – 1800 hours	306	0	306	3	152	0	152	7
1800 – 1900 hours	256	0	256	3	144	0	144	8
1900 – 2000 hours	220	0	220	2	83	0	83	4
2000 – 2100 hours	121	0	121	2	77	0	77	4
2100 – 2200 hours	117	0	117	4	48	0	48	1
2200 – 2300 hours	75	0	75	1	32	0	32	2
2300 – 2400 hours	49	0	49	3	25	0	25	3
24-hour Total	**3,101**	**9**	**3,110**	**191**	**3,399**	**16**	**3,415**	**169**

*Note: From manual counts: Movements A, B, D, & E taken 12 September 2017, C & F taken 6 & 7 September 2017

A = Right turns from Iroquois Road to West Loch Drive
B = Left turns from West Loch Annex back gate to West Loch Drive
C = Though movements southwest direction on North Road across Iroquois Avenue
D =Left turns from West Loch Drive to Iroquois Road
E = Right turns from West Loch Drive to West Loch Annex back gate
F = Through movements northeast direction on North Road across Iroquois Avenue

West Loch Bypass Road
Hourly Leq Calculation from Traffic Counts
Method: FTA Transit Noise & Vibration Impact Assessment Manual
DLAA# 18-029
10/26/2018

Source (Table 5-3 in FTA Assessment Manual)	**Ref dBA @ 50', 50mph**	**Correction for 40 mph**	**Correction for 30 mph**	**40 mph**	**30 mph**	**40 mph Lw**	**30 mph Lw**
Automobiles & Vans	74	-1.9	-4.4	72.1	69.6	103	101
Buses (diesel)	82	-1.9	-4.4	80.1	77.6	111	109

Vehicle Data (HHF traffic report)	**Max south**	**Max North**	**Total Vehicles**	**Autos (85%)**	**Heavy (15%)**
Vehicles Per Hour	286	332	618	525	93

Constants (Table 5-4 in FTA Assessment Manual)

Vehicle Speed	30	40
Speed Contant Diesel Buses	15	15
Speed Contant Autos	30	30

Results	**30 mph**	**40 mph**
Houly Leq (autos , @ 50')	54.5	60.8
Houly Leq (heavy @ 50')	58.3	62.7
Hourly Leq (combined @ 50')	59.9	64.9
Hourly Leq (combined Lw w/ factor Q of 2)	91.5	96.5
Hourly Leq (combined @ 25m for CadnaA w/ Q2)	**55.5**	**60.6**

* CadnaA source level is a referenced at 25 meters

Appendix D-1

Air Quality Study

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AIR QUALITY STUDY

FOR THE PROPOSED

WEST LOCH DRIVE CLOSURE PROJECT

PEARL HARBOR, OAHU, HAWAII

Prepared for:

Helber Hastert & Fee, Planners

January 2019

B.D. NEAL & ASSOCIATES

Applied Meteorology • Air Quality • Computer Science

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1.0 SUMMARY

The U.S. Navy is proposing the closure of West Loch Drive at Joint Base Pearl Harbor-Hickam, West Loch Annex on the island of Oahu. The closure of West Loch Drive would alleviate existing safety concerns and provide for future planned development at West Loch Annex. The proposed project would provide a replacement roadway in the same general vicinity. This study examines the potential short- and long-term air quality impacts that could occur as a result of construction and use of the proposed facilities and suggests mitigative measures to reduce any potential air quality impacts where possible and appropriate.

Both federal and state standards have been established to maintain ambient air quality. At the present time, six parameters are regulated by the U.S. Environmental Protection Agency including: particulate matter, sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone and lead. The Hawaii Department of Health regulates these same six parameters in addition to hydrogen sulfide. Hawaii air quality standards are comparable to the national standards except those for nitrogen dioxide and carbon monoxide which are more stringent than the national standards.

Regional and local climate together with the amount and type of human activity generally dictate the air quality of a given location. The climate of the Pearl Harbor area is very much affected by its leeward and coastal situation. Winds are predominantly trade winds from the east northeast except for occasional periods when kona storms may generate strong winds from the south or when the trade winds are weak and landbreeze-seabreeze circulations may develop. Wind speeds typically vary between about 5 and 15 miles per hour providing relatively good ventilation much of the time. Temperatures in leeward areas of Oahu are generally very moderate with average daily temperatures ranging from about 70°F to 84°F. The extreme minimum temperature recorded at nearby Daniel K. Inouye International Airport is 54°F, while the extreme maximum temperature is 95°F. This area of Oahu is one of the drier locations in the state with rainfall often highly variable from one year to the next. Monthly rainfall has been measured to vary from as little as a trace to as much as 10 inches or more. Average annual rainfall amounts to about 18 inches with summer months being the driest.

Except for periodic impacts from volcanic emissions (vog) and possibly occasional localized impacts from traffic congestion, the present air quality of the project area appears to be reasonably good based on nearby air quality monitoring data. Air quality data from the nearest monitoring stations operated by the Hawaii Department of Health suggest that all national air quality standards are currently being met.

If the proposed project is implemented, there may be some short- and/or long-term impacts on air quality that may occur either directly or indirectly as a consequence of project construction and use. Short-term impacts from fugitive dust could occur during the project construction phases. To a lesser extent, exhaust emissions from construction equipment, from the minor disruption of traffic, and from workers' vehicles may also affect air quality during the period of construction. State air pollution control regulations require that there be no visible fugitive dust emissions at the property line. Hence, an effective dust control plan must be implemented to ensure compliance with state regulations. Fugitive dust emissions can be controlled to a large extent by watering of active work areas, using wind screens, keeping adjacent paved roads clean, and by covering of open-bodied trucks. Other dust control measures to consider include limiting the area that is disturbed at any given time and/or mulching or chemically stabilizing inactive areas that have been worked. Paving and landscaping of project areas early in the construction schedule will also reduce dust emissions. Exhaust emissions can be mitigated by moving construction equipment and workers to and from the project site during off-peak traffic hours.

To assess the potential long-term impact of emissions from project-related motor vehicle traffic operating on roadways in the project area after construction is completed, a computerized air quality modeling study was undertaken using the U.S. EPA’s MOVES2014a and CAL3QHC emissions and dispersion models. (Note: The initial air quality analysis for this project was conducted prior to the release of a subsequent version of the MOVES software [MOVES2014b]. According to USEPA, the software changes relate primarily to nonroad equipment emissions and do not significantly change the onroad criteria emission estimates. Because the analysis for this project only evaluated carbon monoxide emissions for onroad vehicles, there would be little to no difference between MOVES2014a and MOVES2014b.) The air quality modeling study estimated current highest concentrations of carbon monoxide at intersections in the project vicinity and predicted future levels with the proposed project based on the project traffic study. Carbon monoxide is selected for modeling because it is both the most stable and the most abundant of the pollutants generated by motor vehicles. Furthermore, carbon monoxide air pollution is generally considered to be a microscale problem that can be addressed locally to some extent, whereas other air pollutants from motor vehicles most often are regional issues that cannot be addressed by a single project. Model results indicated that present 1-hour and 8-hour highest estimated carbon monoxide concentrations are well within both the state and the national ambient air quality standards. With the project, estimated maximum carbon monoxide concentrations indicated no significant impact compared to the present project case. Concentrations would remain well within standards. Implementing mitigation measures for long-term traffic-related air quality impacts would be unnecessary.

2.0 INTRODUCTION

The U.S. Navy is proposing the closure of West Loch Drive to pubic traffic. West Loch Drive is located within the Joint Base Pearl Harbor-Hickam West Loch Annex on the island of Oahu (see Figure 1 for project location). Closure is proposed due to existing safety concerns and the future planned development at West Loch. Three mitigation alternatives were identified and analyzed for the project traffic study. Alternative 1, which is the favored alternative and is the alternative that was assumed for this air quality study, would replace West Loch Drive with a similar two-lane roadway. The probable alignment of the new “bypass road” would be along the installation western boundary, creating new intersections at Iroquois Road and at North Road.

The purpose of this study is to describe existing air quality in the project area and to assess the potential short- and long-term direct and indirect air quality impacts that could result from construction and use of the proposed facilities as planned.

Measures to mitigate project impacts are suggested where possible and appropriate.

3.0 AMBIENT AIR QUALITY STANDARDS

Ambient concentrations of air pollution are regulated by both national and state ambient air quality standards (AAQS). National AAQS are specified in Section 40, Part 50 of the Code of Federal Regulations (CFR), while State of Hawaii AAQS are defined in Chapter 11-59 of the Hawaii Administrative Rules. Table 1 summarizes both the national and the state AAQS that are specified in the cited documents. As indicated in the table, national and state AAQS have been established for particulate matter, sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone and lead. The state has also set a standard for hydrogen sulfide. National AAQS are stated in terms of both primary and secondary standards for most of the regulated air pollutants. National primary standards are designed to protect the public health with an "adequate margin of safety". National secondary standards, on the other hand, define levels of air quality necessary to protect the public welfare from "any known or anticipated adverse effects of a pollutant". Secondary public welfare impacts may include such effects as decreased visibility, diminished comfort levels, or other potential injury to the natural or man-made environment, e.g., soiling of materials, damage to vegetation or other economic damage. In contrast to the national AAQS, Hawaii State AAQS are given in terms of a single standard that is designed "to protect public health and welfare and to prevent the significant deterioration of air quality".

Each of the regulated air pollutants has the potential to create or exacerbate some form of adverse health effect or to produce environmental degradation when present in sufficiently high concentration for prolonged periods of time. The AAQS specify a maximum allowable concentration for a given air pollutant for one or more averaging times to prevent harmful effects. Averaging times vary from one hour to one year depending on the pollutant and type of exposure necessary to cause adverse effects. In the case of the short-term (i.e., 1- to 24-hour) AAQS, both national and state standards allow a specified number of exceedances each year.

The Hawaii AAQS are in some cases considerably more stringent than the comparable national AAQS. In particular, the Hawaii 1-hour AAQS for carbon monoxide is four times more stringent than the comparable national limit.

The national AAQS are reviewed periodically, and multiple revisions have occurred over the past 30 years. The latest revisions include the nitrogen dioxide and sulfur dioxide standards in 2010, the particulate matter standards in 2012 and the ozone standard in 2015. In general, the national AAQS have become more stringent with the passage of time and as more information and evidence become available concerning the detrimental effects of air pollution. Changes to the Hawaii AAQS over the past several years have tended to follow revisions to the national AAQS, making several of the Hawaii AAQS the same as the national AAQS.

4.0 REGIONAL AND LOCAL CLIMATOLOGY

Regional and local climatology significantly affects the air quality of a given location. Wind, temperature, atmospheric turbulence, mixing height and rainfall all influence air quality. Although the climate of Hawaii is relatively moderate throughout most of the state, significant differences in these parameters may occur from one location to another. Most differences in regional and local climates within the state are caused by the mountainous topography.

Hawaii lies well within the belt of northeasterly trade winds generated by the semi-permanent Pacific high-pressure cell to the north and east. On the island of Oahu, the Koolau and Waianae Mountain Ranges are oriented almost perpendicular to the trade winds, which accounts for much of the variation in the local climatology of the island. The site of the proposed project is located in the leeward area of the Koolau Mountains.

Wind frequency data for the Daniel K. Inouye International Airport (HNL) (formerly known as Honolulu International Airport), which is located about 3 miles to the south of the project site, are given in Table 2-A. These data, which were collected several years ago, can be expected to be reasonably representative of the project area, although there is some evidence that the northeast trade winds have diminished slightly and east trade winds have increased (Garza et al., 2012). Wind frequency for HNL show that the annual prevailing wind direction for this area of Oahu is east northeast. On an annual basis, 34.7 percent of the time the wind was from this direction, and more than 62 percent of the time the wind was in the northeast quadrant. Winds from the south were infrequent occurring only a few days during the year and mostly in winter in association with kona storms. Wind speeds averaged about 10 knots (12 mph) and mostly vary between about 5 and 15 knots (6 and 17 mph).

More recent trade wind direction trend data for the period of 1984-2009 (see Table 2-B) indicate a downward trend in northeast trade wind frequency, although it remained the most common annual wind direction (59 percent of the time) (Garza et al., 2012). The second most common wind was from the east, occurring 17 percent of the time; and, as in the earlier data set, winds from the south were much less frequent (4 percent).

Air pollution emissions from motor vehicles, the formation of photochemical smog and smoke plume rise all depend in part on air temperature. Within the temperature range in Hawaii, cooler temperatures tend to result in lower emissions of carbon monoxide from automobiles, lower concentrations of photochemical smog and lower ground-level concentrations of air pollution from elevated plumes. In Hawaii, the annual and daily variations of temperature depend to a large degree on elevation above sea level, distance inland and exposure to the trade winds. Average temperatures at locations near sea level generally are warmer than those at higher elevations. Areas exposed to the trade winds tend to have the least temperature variation, while inland and leeward areas often have the most. Based on more than 25 years of data collected at the Daniel K. Inouye International Airport, average annual daily minimum and maximum temperatures in the project area are about 70°F and 84°F, respectively [1]. The extreme minimum temperature on record at the airport is 54°F, and the extreme maximum is 95°F.

Small scale, random motions in the atmosphere (turbulence) cause air pollutants to be dispersed as a function of distance or time from the point of emission. Turbulence is caused by both mechanical and thermal forces in the atmosphere. It is oftentimes measured and described in terms of Pasquill-Gifford stability class. Stability class 1 is the most turbulent and class 6 the least. Thus, air pollution dissipates the best during stability class 1 conditions and the worst when stability class 6 prevails. Stability class 6 typically occurs in rural areas during the night when there is a lot of cooling of the surface due radiative processes. Urban and suburban areas with a lot of paved surfaces tend to inhibit stability class 6. In the project area, which is largely urban, stability class 5 is probably the highest stability class that occurs, developing during clear, calm nighttime or early morning hours when temperature inversions form due to radiational cooling. Stability classes 1 through 4 occur during the daytime, depending mainly on the amount of cloud cover and incoming solar radiation and the onset and extent of the sea breeze.

Mixing height is defined as the height above the surface through which relatively vigorous vertical mixing occurs. Low mixing heights can result in high ground-level air pollution concentrations because contaminants emitted from or near the surface can become trapped within the mixing layer. In Hawaii, minimum mixing heights tend to be high because of mechanical mixing caused by the trade winds and because of the temperature moderating effect of the surrounding ocean. Low mixing heights may sometimes occur, however, at inland locations and even at times along coastal areas early in the morning following a clear, cool, windless night. Coastal areas also may experience low mixing levels during sea breeze conditions when cooler ocean air rushes in over warmer land.

Rainfall can have a beneficial effect on the air quality of an area in that it helps to suppress fugitive dust emissions, and it also may "washout" gaseous contaminants that are water-soluble. Rainfall in Hawaii is highly variable depending on elevation and on location with respect to the trade wind. The project area is one of the drier areas on Oahu due to its leeward and near sea level location. Average annual rainfall measured at nearby Daniel K. Inouye International Airport amounts to about 18 inches [1]. Most of the rainfall usually occurs during the winter months. Monthly rainfall may vary from as little as a trace to more than 10 inches. Recent studies have shown that over the past 30 to 40 years, northeast trade wind days have tended to decrease (Garza et al., 2012). In contrast, east trade winds were found to increase in frequency, though this increase did not fully offset the decrease in northeast trade winds. This has resulted in a trend of decreasing northeast trade wind speeds, and decreasing trade wind rainfall.

5.0 PRESENT AIR QUALITY

Present air quality in the project area is mostly affected by air pollutants from motor vehicles. Table 3 presents an air pollutant emission summary for the island of Oahu for calendar year 2014. The emission rates shown in the table pertain to manmade emissions only, i.e., emissions from natural sources are not included. Much of the particulate emissions on Oahu originate from area sources, such as the mineral products industry and agriculture. Sulfur oxides are emitted almost exclusively by point sources, such as power plants, refineries and other industrial sources. Nitrogen oxides emissions emanate predominantly from industrial point sources, although area sources (mostly motor vehicle traffic) also contribute a significant share. The majority of carbon monoxide emissions occur from area sources (motor vehicle traffic), while hydrocarbons are emitted mainly from point sources. In the specific project area, there are currently manmade emissions from ongoing mass transit construction, ships and aircraft. Pollutant emissions from these types of activities are generally accounted for in Table 3. Due to the distances of these activities from the study areas and (in the case of the mass transit construction) temporary nature of the activity, they are not expected to measurably affect pollutant emissions levels relevant to this study and are not quantitatively assessed.

Natural sources of air pollution emissions that could affect the project area at times but cannot be quantified very accurately include the ocean (sea spray), plants (aero-allergens), wind-blown dust, and perhaps distant volcanoes on the island of Hawaii.

The State Department of Health operates a network of air quality monitoring stations at various locations on Oahu. Each station, however, typically does not monitor the full complement of air quality parameters. Table 4 shows annual summaries of air quality measurements that were made nearest to the project area for several of the regulated air pollutants for the period 2011 through 2015. These are the most recent data that are currently available.

As indicated in Table 4, during the 2011-2015 period, sulfur dioxide, particulate, carbon monoxide and nitrogen dioxide were monitored by the State Department of Health at an air quality station located at Kapolei. Ozone was monitored at Sand Island. The concentrations reported were consistently low compared to the standards for all parameters except for ozone. Maximum 8-hour ozone concentrations reached up to about 75% of the standard. Ozone concentrations tend to be high in Hawaii due to the abundant sunshine and the island setting.

6.0 SHORT-TERM IMPACTS OF PROJECT

Short-term direct and indirect impacts on air quality could potentially occur due to project construction. For a project of this nature, there are two potential types of air pollution emissions that could directly result in short-term air quality impacts during project construction: (1) fugitive dust from vehicle movement, soil excavation and demolition activities; and (2) exhaust emissions from on-site construction equipment. Indirectly, there also could be short-term impacts from slow-moving construction equipment traveling to and from the project site, from a temporary increase in local traffic caused by commuting construction workers, and from the disruption of normal traffic flow caused by roadway lane closures.

Fugitive dust emissions may arise from the grading and dirt-moving activities associated with demolition, site clearing and preparation work. The emission rate for fugitive dust emissions from construction activities is difficult to estimate accurately. This is because of its elusive nature of emission and because the potential for its generation varies greatly depending upon the type of soil at the construction site, the amount and type of dirt-disturbing activity taking place, the moisture content of exposed soil in work areas, and the wind speed. State of Hawaii Air Pollution Control Regulations [2] prohibit visible emissions of fugitive dust from construction activities at the property line. Thus, an effective dust control plan for the project construction phase is essential.

Adequate fugitive dust control can usually be accomplished by the establishment of a frequent watering program to keep bare-dirt surfaces in construction areas from becoming significant sources of dust. In dust-prone or dust-sensitive areas, other control measures such as limiting the area that can be disturbed at any given time, applying chemical soil stabilizers, mulching and/or using wind screens may be necessary. Control regulations further stipulate that open-bodied trucks be covered at all times when in motion if they are transporting materials that could be blown away. Haul trucks tracking dirt onto paved streets from unpaved areas is often a significant source of dust in construction areas. Some means to alleviate this problem, such as road cleaning or tire washing, may be appropriate. Paving of parking areas and/or establishment of landscaping as early in the construction schedule as possible can also lower the potential for fugitive dust emissions.

On-site mobile and stationary construction equipment also will emit air pollutants from engine exhausts. The largest of this equipment is usually diesel-powered. Nitrogen oxides emissions from diesel engines can be relatively high compared to gasoline-powered equipment, but the annual standard for nitrogen dioxide is not likely to be violated by short-term construction equipment emissions. Also, the new short-term (1-hour) standard for nitrogen dioxide is based on a three-year average; thus, for construction projects that typically do not extend beyond a year or two, it is unlikely that relatively short-term construction emissions would exceed the standard. Carbon monoxide emissions from diesel engines are low and should be relatively insignificant compared to vehicular emissions on nearby roadways. Motor vehicle traffic on roadways is mostly powered by gasoline engines, which inherently emit more carbon monoxide than diesel engines.

Project construction activities, if unmitigated, can obstruct the normal flow of traffic for short periods of time such that overall vehicular emissions in the project area could temporarily increase. This potential problem should be avoided by keeping roadways open during peak traffic hours and by moving heavy construction equipment and workers to and from construction areas during periods of low traffic volume.

7.0 LONG-TERM IMPACTS OF PROJECT

After construction is completed, use of the proposed facilities may result in increased motor vehicle traffic or change the traffic pattern in the project area, potentially causing long-term impacts on ambient air quality. Motor vehicles with gasoline-powered engines are significant sources of carbon monoxide. They also emit nitrogen oxides and other pollutants.

Federal air pollution control regulations require that new motor vehicles be equipped with emission control devices that reduce emissions significantly compared to a few years ago. In 1990, the

President signed into law the Clean Air Act Amendments of 1990, which revised and expanded the Act and provided the U.S. Environmental Protection Agency broader authority to implement and enforce regulations reducing air pollutant emissions. This legislation required further emission reductions from stationary and mobile sources, which have been phased in since 1994 (e.g., Title IV of the 1990 Amendments to the Clean Air Act Acid Rain Deposition Control, which began in 1995). Additional restrictions were signed into law during the Clinton administration (e.g., 40 CFR Part 50 National Ambient Air Quality Standards for Particulate Matter in 1997), and these began to take effect during the following decade. The added restrictions on emissions from new motor vehicles will lower average emissions each year as more and more older vehicles leave the state's roadways. For example, under the Obama Administration, fuel economy standards for new cars and light trucks were issued for model years 2017-2025 (known as corporate average fuel economy [CAFE] standards) were issued, which would nearly double the fuel efficiency of new cars and light trucks over that of similar vehicles that were currently on the road. These restrictions are factored into the emissions estimates for the project discussed later. In August 2018, the Trump Administration proposed a pause in the rate of emissions reductions established by the CAFE program. The Trump Administration’s proposal would freeze the fuel economy standards at 2020 levels. Even if the Trump Administration proposal were implemented, the reductions in pollutant emissions required under prior provisions would result in substantial improvements (i.e., declines in pollutant emissions).

To evaluate the potential long-term ambient air quality impact of motor vehicle traffic using the proposed new roadway facilities, computerized emission and atmospheric dispersion models can be used to estimate ambient carbon monoxide concentrations along roadways within the project area. Carbon monoxide is selected for modeling because it is both the most stable and the most abundant of the pollutants generated by motor vehicles. Furthermore, carbon monoxide air pollution is generally considered to be a microscale problem that can be addressed locally to some extent, whereas nitrogen oxides air pollution most often is a regional issue that cannot be addressed by a single project.

For this project, two scenarios were evaluated for the carbon monoxide modeling study: year 2017 with present conditions and year 2017 with the project. To begin the modeling study of the two scenarios, critical receptor areas in the vicinity of the project were identified for analysis. Generally speaking, roadway intersections are the primary concern because of traffic congestion and because of the increase in vehicular emissions associated with traffic queuing. For this study, four of the key intersections identified in the traffic study [3] were selected for air quality analysis. These included the following intersections:

- West Loch Drive at Iroquois Road
- North Road at Iroquois Avenue
- Bypass Road at Iroquois Road
- Bypass Road at North Road.

The West Loch Drive at Iroquois Road intersection would only exist for the present scenario, while the two Bypass Road intersections would only exist with the project. The traffic study describes the existing and projected future traffic conditions and laneage configurations of the study intersections in detail.

The main objective of the modeling study was to estimate maximum 1-hour average carbon monoxide concentrations for each of the three scenarios studied. To evaluate the significance of the estimated concentrations, a comparison of the predicted values for each scenario was made. Comparison of the estimated values to the national and state AAQS was also used to provide another measure of significance.

Maximum carbon monoxide concentrations typically coincide with peak traffic periods. The traffic impact assessment report evaluated both morning and afternoon peak-traffic periods. Typically, afternoon peak-hour traffic volumes are higher, but atmospheric dispersion conditions are generally worse during the morning. Thus, the air quality study evaluated both morning and afternoon peak-traffic periods.

Vehicular carbon monoxide emissions for each year studied were calculated using EPA's Motor Vehicle Emission Simulator (MOVES) computer model [4]. Federal Corporate Fuel Economy (CAFE) standards as well as other federal emission regulations are factored into MOVES. The Trump Administration recently proposed changes to the CAFE standards, but it is not expected that this will have a significant affect on the conclusions reached in this study.

MOVES was configured for a project-level analysis specifically for Hawaii. Assumptions included an urban, unrestricted road type, default fuel supply and fuel formulation, default vehicle age distribution and morning and afternoon ambient temperatures of 70°F and 90°F, respectively. MOVES emission factors were generated both for idling and for moving traffic.

After computing vehicular carbon monoxide emissions through the use of MOVES, these data were then input to an atmospheric dispersion model. EPA air quality modeling guidelines [5] currently recommend that the computer model CAL3QHC [6] be used to assess carbon monoxide concentrations at roadway intersections, or in areas where its use has previously been established, CALINE4 [7] may be used. Until a few years ago, CALINE4 was used extensively in Hawaii to assess air quality impacts at roadway intersections. In December 1997, the California Department of Transportation recommended that the intersection mode of CALINE4 no longer be used because it was thought the model had become outdated. Studies have shown that CALINE4 may tend to over-predict maximum concentrations in some situations. Therefore, CAL3QHC was used for the subject analysis.

CAL3QHC was developed for the U.S. EPA to simulate vehicular movement, vehicle queuing and atmospheric dispersion of vehicular emissions near roadway intersections. It is designed to predict 1-hour average pollutant concentrations near roadway intersections based on input traffic and emission data, roadway/receptor geometry and meteorological conditions.

Input peak-hour traffic data were obtained from the traffic study cited previously. This included vehicle approach volumes, saturation capacity estimates, intersection laneage and signal timings. All emission factors that were input to CAL3QHC for free-flow traffic on roadways were obtained from MOVES based on assumed free-flow vehicle speeds corresponding to the posted or design speed limits.

Model roadways were set up to reflect roadway geometry, physical dimensions and operating characteristics. Concentrations predicted by air quality models generally are not considered valid within the roadway-mixing zone. The roadway-mixing zone is usually taken to include 3 meters on either side of the traveled portion of the roadway. Model receptor sites were thus located at the edges of the mixing zones near all intersections that were studied for all three scenarios. This acknowledges that pedestrian sidewalks already exist or may exist in the future in these locations. All receptor heights were placed at 1.8 meters above ground to simulate levels within the normal human breathing zone.

Input meteorological conditions for this study were defined to provide "worst-case" or highest estimated results. One of the key meteorological inputs is atmospheric stability category. For these analyses, atmospheric stability category 5 was assumed for the morning cases, while atmospheric stability category 4 was assumed for the afternoon cases. These are the most conservative stability categories that are generally used for estimating worst-case pollutant dispersion within urban areas for these periods. A surface roughness length of 100 cm and a mixing height of 1000 meters were used in all cases. Worst-case wind conditions were defined as a wind speed of 1 meter per second with a wind direction resulting in the highest predicted concentration. Concentration estimates were calculated at wind directions of every 5 degrees.

Existing background concentrations of carbon monoxide in the project vicinity are believed to be at reasonably low levels. Department of Health monitoring stations for locations on Oahu report average carbon monoxide concentrations of less than 1 ppm. Background contributions of carbon monoxide from sources or roadways not directly considered in the analysis were conservatively accounted for by adding a background concentration of 1 ppm to all predicted concentrations for 2017.

Predicted Maximum 1-Hour Concentrations

Table 5 summarizes the final results of the modeling study in the form of the estimated maximum 1-hour morning and afternoon ambient carbon monoxide concentrations. These results can be compared directly to the state and the national AAQS. Estimated maximum carbon monoxide concentrations are presented in the table for two scenarios: year 2017 with existing traffic and year 2017 with the project. The locations of these estimated maximum 1-hour concentrations all occurred at or very near the indicated intersections.

As indicated in the table, the highest estimated 1-hour concentration at the two intersections studied for the present (2017) case was 1.4 ppm. This was projected to occur during the afternoon at both locations. This is well within both the national AAQS of 35 ppm and the state standard of 9 ppm.

With the proposed project, the highest 1-hour carbon monoxide concentration in the project area was predicted to reach 1.5 ppm. This was predicted to occur during the afternoon peak traffic hour at the intersection of the new Bypass Road and North Road. Peak-hour concentrations at the other end of the new Bypass Road (Bypass Road at Iroquois Road) would be slightly lower in the afternoon. Compared to the existing case, predicted concentrations for the year 2017 with the project increased slightly or remained unchanged. Forecast maximum concentrations remained well within the state and federal standards.

Predicted Maximum 8-Hour Concentrations

Maximum 8-hour carbon monoxide concentrations were estimated by multiplying the maximum 1-hour values by a persistence factor of 0.5. This accounts for two factors: (1) traffic volumes averaged over eight hours are lower than peak 1-hour values, and (2) meteorological conditions are more variable (and hence more favorable for dispersion) over an 8-hour period than they are for a single hour. Based on monitoring data, 1-hour to 8-hour persistence factors for most locations generally vary from 0.4 to 0.8 with 0.6 being the most typical. One study based on modeling [8] concluded that 1-hour to 8-hour persistence factors could typically be expected to range from 0.4 to 0.5. EPA guidelines [9] recommend using a value of 0.7 unless a locally derived persistence factor is available. Recent monitoring data for locations on Oahu reported by the Department of Health [10] suggest that this factor may range between about 0.2 and 0.6 depending on location and traffic variability. Considering the location of the project and the traffic pattern for the area, a

1-hour to 8-hour persistence factor of 0.5 will likely yield reasonable estimates of maximum 8-hour concentrations.

The resulting estimated maximum 8-hour concentrations are indicated in Table 6. For the 2017/present scenario, the estimated highest 8-hour carbon monoxide concentrations for the two locations studied ranged from 0.6 to 0.7 ppm. The estimated highest concentrations for the existing case were well within both the state standard of 4.4 ppm and the national limit of 9 ppm.

For the year 2017 with project scenario, predicted maximum concentrations at the two intersections studied ranged from 0.7 to 0.8 ppm, similar to the existing scenario, and the predicted concentrations were within the standards.

Conservativeness of Estimates

The results of this study reflect several assumptions that were made concerning both traffic movement and worst-case meteorological conditions. One such assumption concerning worst-case meteorological conditions is that a wind speed of 1 meter per second (2 miles per hour or 1.9 knots) with a steady direction for 1 hour will occur. A steady wind of 1 meter per second blowing from a single direction for an hour is extremely unlikely and may occur only once a year or less. With wind speeds of 2 meters per second (4.5 miles per hour or 3.5 knots), for example, computed carbon monoxide concentrations would be only about half the values given above. As generally indicated in Table 2, wind speeds of at least 2 meters per second (4 knots) occur over 90 percent of the time on an annual basis. Wind speeds of 7 to 16 knots (3 to 8 meters per second) occur with the greatest frequency (65 percent), and would be typical near the areas studied.

8.0 CONCLUSIONS AND RECOMMENDATIONS

Based on ambient air quality data that are available from the Department of Health, it is likely that all state and federal ambient air quality standards are currently being met in the project area.

Project-related short-term impacts on air quality may occur from the emission of fugitive dust during construction phases. To control dust, the project construction contractor should prepare a dust control plan that will ensure that state regulations related to fugitive dust will be met. Typical dust control measures include:

- Watering of active work areas and any temporary unpaved work roads at least twice daily on days without rainfall
- Use of wind screens around the project perimeter and/or limiting the area that is disturbed at any given time
- Mulching or use of chemical soil stabilizers to control wind erosion of inactive areas of the site that have been disturbed
- Covering of dirt-hauling trucks when traveling on roadways to prevent windage
- Implementing a routine road cleaning and/or tire washing program to reduce fugitive dust emissions that may occur as a result of trucks tracking dirt onto paved roadways in the project area
- Establishment of landscaping early in the construction schedule.

The specific dust control measures used will depend, in part, on the amount and nature of earthwork that is needed, soil type, wind and precipitation conditions, and the nearness of neighbors.

During construction phases, emissions from engine exhausts (primarily consisting of carbon monoxide and nitrogen oxides) will also occur both from on-site construction equipment and from vehicles used by construction workers and from trucks traveling to and from the project. Increased vehicular emissions due to disruption of traffic by construction equipment and/or commuting construction workers can be alleviated by moving equipment and personnel to the site during off-peak traffic hours.

After the proposed project is completed, any long-term impacts on air quality in the project area due to emissions from project-related motor vehicle traffic should be negligible. Maximum concentrations of carbon monoxide should remain within both the state and the national ambient air quality standards. Implementing any air quality mitigation measures for long-term traffic-related impacts is unnecessary.

REFERENCES

1. "Local Climatological Data, Annual Summary with Comparative Data, Honolulu, Hawaii, 1995", National Oceanic and Atmospheric Administration, National Climatic Data Center, Asheville, NC.

2. State of Hawaii. Hawaii Administrative Rules, Chapter 11-60, Air Pollution Control.

3. Julian Ng Incorporated, West Loch Annex Traffic Study, Joint Base Pearl Harbor-Hickam West Loch Annex, August 2018.

4. User Guide for Motor Vehicle Emission Simulator (MOVES), U.S. Environmental Protection Agency, Office of Transportation and Air Quality, Assessment and Standards Division, Ann Arbor, Michigan, July 2014, EPA-420-B-14-055.

5. Revision to the Guideline on Air Quality Models, U.S. Environmental Protection Agency, Federal Register, 40 CFR Part 51, November 9, 2005.

6. User's Guide to CAL3QHC Version 2.0: A Modeling Methodology for Predicting Pollutant Concentrations Near Roadway Intersections, U.S. Environmental Protection Agency, November 1992.

7. CALINE4 - A Dispersion Model for Predicting Air Pollutant Concentrations Near Roadways, FHWA/CA/TL-84/15, California State Department of Transportation, November 1984 with June 1989 Revisions.

8. "Persistence Factors for Mobile Source (Roadway) Carbon Monoxide Modeling", C. David Cooper, Journal of the Air & Waste Management Association, Volume 39, Number 5, May 1989.

9. Guideline for Modeling Carbon Monoxide from Roadway Intersections, U.S. Environmental Protection Agency, EPA-454/R-92-005, November 1992.

10. Annual Summaries, Hawaii Air Quality Data, 2006-2010, State of Hawaii Department of Health.

11. Garza, J. A., P. S. Chu, C. W. Norton, and T. A. Schroeder. Changes of the prevailing trade winds over the islands of Hawaii and the North Pacific , J. *Geophys. Res.*, 117, D11109, doi;10.1029/2011JD016888. June 2012.

Figure 1 - Project Location

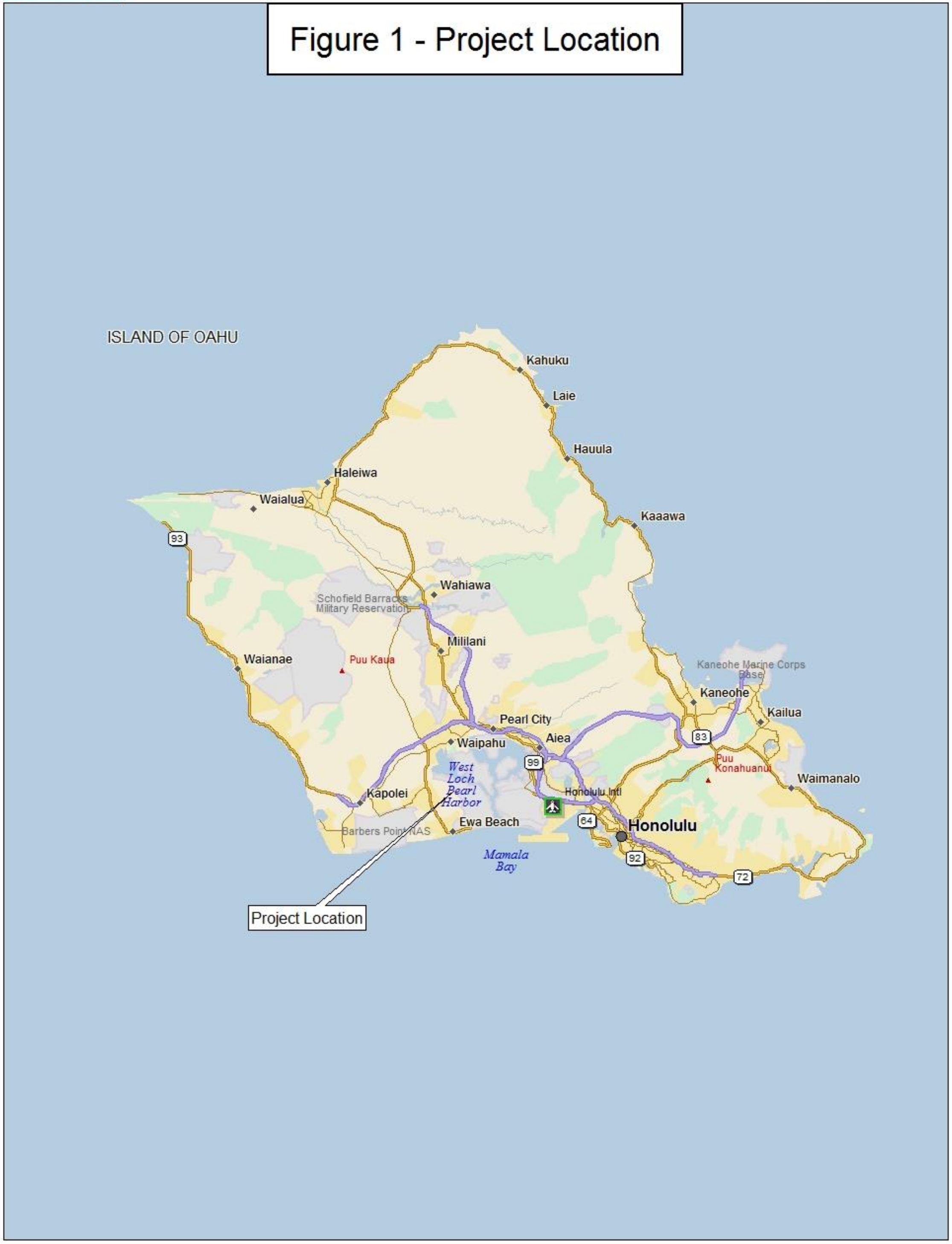

Figure 2: Intersections Analyzed

Table 1

SUMMARY OF STATE OF HAWAII AND NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutant	**Averaging Time**	**Maximum Allowable Concentration**		
		National Primary	**National Secondary**	**State of Hawaii**
Particulate Matter (<10 microns)	Annual 24 Hours	- 150 μg/m^3 (a)	- 150 μg/m^3 (a)	50 μg/m^3 150 μg/m^3 (b)
Particulate Matter (<2.5 microns)	Annual 24 Hours	12 μg/m^3 (c) 35 μg/m^3 (d)	15 μg/m^3 (c) 35 μg/m^3 (d)	- -
Sulfur Dioxide	Annual 24 Hours 3 Hours 1 Hour	- - - 0.075 ppm (e)	- - 0.5 ppm (b) -	80 μg/m^3 365 μg/m^3 (b) 1300 μg/m^3 (b) -
Nitrogen Dioxide	Annual 1 Hour	0.053 ppm 0.100 ppm (f)	0.053 ppm -	70 μg/m^3 -
Carbon Monoxide	8 Hours 1 Hour	9 ppm (b) 35 ppm (b)	- -	5 mg/m^3 (b) 10 mg/m^3 (b)
Ozone	8 Hours	0.070 ppm (g)	0.070 ppm (g)	157 μg/m^3 (b)
Lead	3 Months Quarter	0.15 μg/m^3(h) -	0.15 μg/m^3(h) -	- 1.5 μg/m^3
Hydrogen Sulfide	1 Hour	-	-	35 μg/m^3 (b)

[a] Not to be exceeded more than once per year on average over a 3-year period.

[b] Not to be exceeded more than once per year.

[c] Three-year average of the weighted annual arithmetic mean.

[d] 98th percentile value of the 24-hour concentrations averaged over three years.

[e] Three-year average of annual 99th percentile daily 1-hour maximum.

[f] 98th percentile value of the daily 1-hour maximum averaged over three years.

[g] Three-year average of annual fourth-highest daily 8-hour maximum.

[h] Maximum arithmetic 3-month mean concentration for a 3-year period.

Table 2-A

ANNUAL WIND FREQUENCY FOR HONOLULU INTERNATIONAL AIRPORT 1965-1974(%)

Wind Direction	Wind Speed (knots)									Total
	0-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	>40	
N	0.5	2.5	1.3	0.5	0.0	0.0	0.0	0.0	0.0	4.8
NNE	0.3	1.2	1.6	1.5	0.2	0.0	0.0	0.0	0.0	4.7
NE	0.3	2.1	6.1	11.0	3.2	0.3	0.0	0.0	0.0	23.0
ENE	0.2	2.5	10.9	16.6	4.1	0.3	0.0	0.0	0.0	34.7
E	0.1	1.0	2.5	2.8	0.5	0.0	0.0	0.0	0.0	7.0
ESE	0.0	0.3	0.4	0.3	0.0	0.0	0.0	0.0	0.0	1.1
SE	0.0	0.3	0.8	1.0	0.1	0.0	0.0	0.0	0.0	2.2
SSE	0.1	0.4	1.2	0.7	0.1	0.0	0.0	0.0	0.0	2.4
S	0.1	0.5	1.4	0.6	0.1	0.0	0.0	0.0	0.0	2.7
SSW	0.0	0.3	0.8	0.3	0.0	0.0	0.0	0.0	0.0	1.5
SW	0.0	0.2	0.8	0.4	0.0	0.0	0.0	0.0	0.0	1.5
WSW	0.0	0.3	0.5	0.4	0.0	0.0	0.0	0.0	0.0	1.2
W	0.1	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	1.1
WNW	0.2	1.4	0.3	0.1	0.0	0.0	0.0	0.0	0.0	2.0
NW	0.4	2.3	0.8	0.1	0.0	0.0	0.0	0.0	0.0	3.8
NNW	0.5	2.3	0.8	0.2	0.0	0.0	0.0	0.0	0.0	3.8
Calm	2.5									2.5
Total	5.4	18.3	30.6	36.5	8.5	0.7	0.0	0.0	0.0	100.0

Source: Climatography of the United States No. 90 (1965-1974), Airport Climatological Summary, Honolulu International Airport, Honolulu, Hawaii, U.S. Department of Commerce, National Climatic Center, Asheville, NC, August 1978.

Table 2-B

ANNUAL WIND DIRECTION FREQUENCY FOR HONOLULU INTERNATIONAL AIRPORT 1984-2009(%)

Wind Direction	Wind Frequency
N	5%
NE	59%
E	17%
SE	5%
S	4%
SW	5%
W	4%
NW	2%

Source: Garza, J.A., P.-S. Chu, C.W. Norton, and T.A. Schroeder (2012), Changes of the prevailing trade winds over the islands of Hawaii and the North Pacific, *J. Geophys. Res., 117,* D11109, doi: 10.1029/2011JD016888.

Table 3

AIR POLLUTION EMISSIONS INVENTORY FOR ISLAND OF OAHU, 2014

Air Pollutant	Total (tons/year)
Particulate (PM10)	16,685
Particulate (PM2.5)	4,649
Sulfur Oxides	14,778
Nitrogen Oxides	29,337
Carbon Monoxide	108,267
Hydrocarbons	23,289

Source: U.S. EPA, National Emissions Inventory, 2014

Table 4

ANNUAL SUMMARIES OF AIR QUALITY MEASUREMENTS FOR MONITORING STATIONS NEAREST WEST LOCH DRIVE CLOSURE PROJECT

Parameter / Location	2011	2012	2013	2014	2015
Sulfur Dioxide / Kapolei					
1-Hour Averaging Period:					
Highest Concentration (ppm)	0.019	0.012	0.016	0.024	0.026
99th Percentile Concentration (ppm)	-	-	-	0.021	0.013
No. of Averages Greater than 0.075 ppm	0	0	0	0	0
3-Hour Averaging Period:					
Highest Concentration (ppm)	0.013	0.007	0.011	0.019	0.015
2nd Highest Concentration (ppm)	0.004	0.006	0.011	0.013	0.011
No. of State AAQS Exceedances	0	0	0	0	0
24-Hour Averaging Period:					
Highest Concentration (ppm)	0.003	0.004	0.005	0.008	0.004
2nd Highest Concentration (ppm)	0.003	0.004	0.005	0.005	0.004
No. of State AAQS Exceedances	0	0	0	0	0
Annual Average Concentration (ppm)	0.002	0.002	0.002	0.002	0.001
Particulate (PM-10) / Kapolei					
24-Hour Averaging Period:					
Highest Concentration (μg/m^3)	51	40	39	32	32
2nd Highest Concentration (μg/m^3)	38	36	39	32	32
No. of State AAQS Exceedances	0	0	0	0	0
Annual Average Concentration (μg/m^3)	16	16	14	15	16
Particulate (PM-2.5) / Kapolei					
24-Hour Averaging Period:					
Highest Concentration (μg/m^3)	21	24	16	14	17
98th Percentile Concentration (μg/m^3)	13	15	16	11	14
No. of Averages Greater than 35 μg/m^3	0	0	0	0	0
Annual Average Concentration (μg/m^3)	5	7	3	4	4
Carbon Monoxide / Kapolei					
1-Hour Averaging Period:					
Highest Concentration (ppm)	1.2	1.5	1.3	2.7	2.4
2nd Highest Concentration (ppm)	1.2	1.3	1.3	1.4	2.1
No. of State AAQS Exceedances	0	0	0	0	0
8-Hour Averaging Period:					
Highest Concentration (ppm)	1.0	1.1	1.0	1.3	1.7
2nd Highest Concentration (ppm)	1.0	1.1	1.0	1.3	1.6
No. of State AAQS Exceedances	0	0	0	0	0

Table 4 (cont.)

ANNUAL SUMMARIES OF AIR QUALITY MEASUREMENTS FOR MONITORING STATIONS NEAREST WEST LOCH DRIVE CLOSURE PROJECT

Parameter / Location	2011	2012	2013	2014	2015
Nitrogen Dioxide / Kapolei					
1-Hour Averaging Period:					
Highest Concentration (ppm)	0.025	0.027	0.031	0.043	0.031
98th Percentile Concentration (ppm)	0.025	0.023	0.030	0.025	0.022
No. of Averages Greater than 0.100 ppm	0	0	0	0	0
Annual Average Concentration (ppm)	0.003	0.003	0.003	0.004	0.004
Ozone / Sand Island					
8-Hour Averaging Period:					
Highest Concentration (ppm)	0.047	0.045	0.051	0.062	0.052
2nd Highest Concentration (ppm)	0.047	0.044	0.050	0.061	0.050
4th Highest Concentration (ppm)	0.046	0.044	0.047	0.057	0.049
No. of Daily Max 8-hr Ave > 0.075 ppm	0	0	0	0	0

Source: State of Hawaii Department of Health, “Annual Summaries, Hawaii Air Quality Data, 2011 - 2015”

Table 5

ESTIMATED HIGHEST 1-HOUR CARBON MONOXIDE CONCENTRATIONS ALONG ROADWAYS NEAR WEST LOCH DRIVE CLOSURE PROJECT
(parts per million)

Roadway Intersection	Year/Scenario			
	2017/Present		2017/With Project	
	AM	PM	AM	PM
West Loch Drive at Iroquois Road	1.4	1.4	-	-
North Road at Iroquois Avenue	1.3	1.4	-	-
Bypass Road at Iroquois Road	-	-	1.4	1.4
Bypass Road at North Road	-	-	1.3	1.5

Hawaii State AAQS: 9
National AAQS: 35

Table 6

ESTIMATED HIGHEST 8-HOUR CARBON MONOXIDE CONCENTRATIONS ALONG ROADWAYS NEAR WEST LOCH DRIVE CLOSURE PROJECT

(parts per million)

Roadway Intersection	Year/Scenario	
	2017/Present	2017/With Project
West Loch Drive at Iroquois Road	0.7	-
North Road at Iroquois Avenue	0.6	-
Bypass Road at Iroquois Road	-	0.7
Bypass Road at North Road	-	0.8

Hawaii State AAQS: 4.4
National AAQS: 9

Appendix D-2

Greenhouse Gas Estimates

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GREEN FOOTSTEP

YOUR BUILDING, YOUR CARBON, AND WHAT YOU CAN DO ABOUT IT

Rocky Mountain Institute

REPORT

Project Name:	PH Project
Location:	HICC Miscellaneous, United States, NORTH AMERICA
Created by:	Milton Arakawa
Date:	Feb 16, 2019

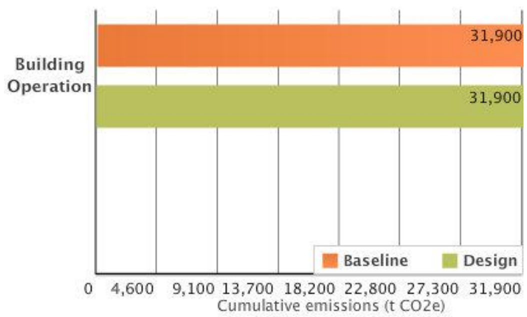
Your building will consume 45 kBtu per sq. ft. of energy each year in order to operate. Based on the mix of fuels used at the building and those used to create electricity in HICC Miscellaneous, United States, NORTH AMERICA, this amount of energy translates to 1275 t CO2e of emissions each year (including non-building operational emissions, if applicable). Your total annual offset emissions, based on your amount of on-site renewable energy and off-site carbon investments, is equal to 0 t CO2e each year, which yields a net annual operational emissions of 1275 t CO2e.

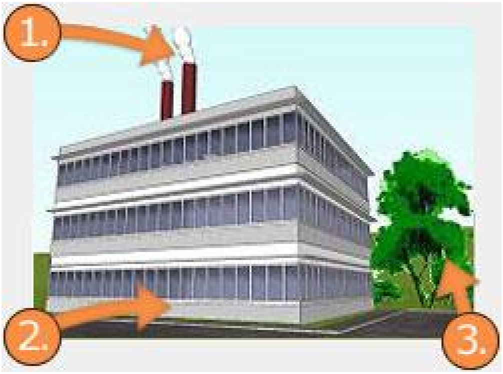
How do the emissions from this project translate to climate change? The total cumulative emissions of your building over its estimated lifetime is 120,000, which is a 0 percent reduction from the baseline you defined for your project. These emissions will result in a net increase in the atmospheric concentration of greenhouse gas. In order to avoid sea level rise above one meter and other effects of climate change, we need to stop increasing and stabilize this concentration of greenhouse gas at 450 ppm. (This information is based on the IPCC AR4 Synthesis Report, found at www.ipcc.ch.)

DATA SUMMARY

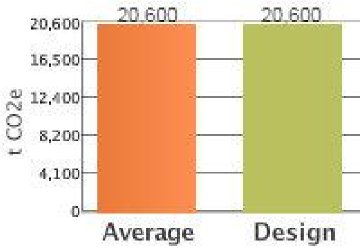
Cumulative Emissions Over 25 Years

1. Operational Emissions - 25 Years

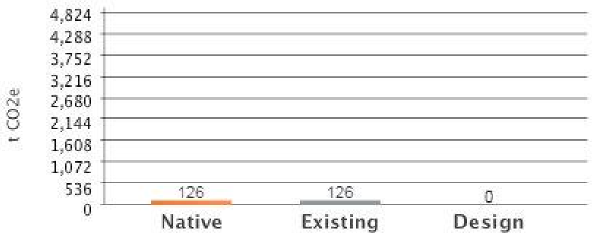




2. Embodied Emissions from Construction



3. Average Site Carbon Storage



Does your building meet the Architecture 2030 Challenge?	NO

Site by: **FIREANT STUDIO**

Appendix E

Section 106 Correspondence

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DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE NAVY
COMMANDER
NAVY REGION HAWAII
850 TICONDEROGA ST STE 110
JBPHH, HAWAII 96860-5101

5750
Ser N4/ 0659
13 NOV 2018

CERTIFIED NO: 7016 0910 0001 0891 9769

Dr. Alan Downer
Deputy State Historic Preservation Officer
Department of Land and Natural Resources
Kakuihewa Building, Room 555
601 Kamokila Boulevard
Kapolei, HI 96707

Dear Dr. Downer:

SUBJECT: SECTION 106 CONSULTATION FOR PROPOSED CONSTRUCTION OF MAGAZINES FOR LONG ORDNANCE AT JOINT BASE PEARL HARBOR-HICKAM (JBPHH) WEST LOCH ANNEX, DISTRICT OF EWA, AHUPUAʻA OF HONOULIULI, ON THE ISLAND OF OʻAHU, TMK (1)9-1-1:01

In accordance with the Programmatic Agreement (PA) Among The Commander Navy Region Hawaii, the Advisory Council on Historic Preservation and the Hawaii State Historic Preservation Officer Regarding Navy Undertakings in Hawaii (amended 2012), the subject project to construct 24 new ammunition storage magazines and related improvements is considered new construction requiring further review. The proposed project is located at Joint Base Pearl Harbor-Hickam (JBPHH), West Loch Annex, Oʻahu, Hawaiʻi.

PROJECT DESCRIPTION

The Navy proposes to construct 24 Type D box magazines and related improvements at West Loch Annex munitions storage facility [see Enclosure 1]. West Loch Annex lies within the U.S. Naval Base Pearl Harbor National Historic Landmark (PHNHL) and comprises ammunition handling wharves, torpedo and missile intermediate maintenance operations, and a helicopter landing area. A detailed planning utilization analysis, known as the Fleet Concentration Area Magazine Study (FCAMS), was conducted to assess the current available storage capacity of Navy magazines. The FCAMS identified a requirement for additional 24 standard earth covered Type D Box Magazines is needed to satisfy current ordnance load requirements.

Type D box magazines are above-ground structures for ordnance storage. The standard magazine dimensions are each approximately 160 feet (48.9 meters) wide by 50 feet (15.2 meters) long and 20 feet (6.1 meters) in height [Enclosure 2]. The magazines would be constructed of reinforced concrete covered by a minimum of 2 feet of earth and placed adjacent to existing magazines (see Enclosure 1). The Type D magazines are similar in appearance to the existing historic magazines: earth-covered structure with berm-like appearance but are approximately 60 feet longer than the historic magazines. Unmaintained vegetation between magazine areas would provide screening between the new and historic structures.

Related improvements would include a paved and a gravel access road, concrete pads, a chain-link security fence, over-watch tower, over-watch station, gate/sentry house, a utility building, a swing gate, and buried utilities. The security fence and gravel patrol road would extend from Iroquois Road to Iroquois Drive along the southern boundary of the Annex and the locations of other improvements are shown in Enclosure 1.

The proposed improvements and construction require clearing, grubbing, grading, and excavation. Subsurface excavations for building footings and related improvements would not exceed 4 feet (1.2 meters) in depth and associated utilities would not exceed 6 feet (1.8 meters) in depth.

AREA OF POTENTIAL EFFECT

The area of potential effect (APE), as proposed, includes the project area of the proposed 24 Type D box magazines and related improvements [see Enclosure 1]. The APE is approximately 24.28 hectares (60 acres) in the magazine location and approximately 52.6 hectares (130 acres) in the area of the access road. Pursuant to Stipulation VI. of the 2012 PA, the Navy is requesting concurrence with the State Historic Preservation Officer (SHPO) on the APE. The APE includes a buffer zone to provide flexibility for minor design modifications and for equipment staging areas during construction.

IDENTIFICATION OF HISTORIC PROPERTIES

The Navy has conducted several archaeological and historic architectural studies in the area. No historic properties were in identified in the APE. However, historic properties were identified nearby within West Loch Annex including traditional Hawaiian archaeological sites, 19th century agricultural features, and World War II and Cold War Era buildings and structures related to ordnance storage (Table 1). These studies also provide information regarding past land use, and data to support modeling for areas of high and low potential of archaeological sites established in the Integrated Cultural Resources Management Plan [Enclosure 8 and Enclosure 9].

TABLE 1: PREVIOUS STUDIES

Type	Author
Archaeological reconnaissance survey	Davis and Butchard 1991
Archaeological assessment	Wulzen and Rosendahl 1995
Archaeological reconnaissance survey	Jensen and Head 1997
Archaeological inventory and subsurface testing	Rieth 2011
Cultural landscape study	TEC Inc, - Joint Venture 2011
Archaeological inventory and subsurface testing	Sholin et al. 2013
Archaeological inventory and subsurface testing	Filimoehala et al. 2015
Traditional cultural property study	Vernon et al. 2016

These investigations range from archaeological reconnaissance and inventory surveys, a cultural landscape study and traditional cultural property study. These studies have identified cultural resources and (potentially) eligible historic properties in West Loch which include traditional Hawaiian archaeological sites, 19th century agricultural features, and WWII and Cold War Era buildings and structures related to ordnance storage. Data gathered and presented in the Integrated Cultural Resource Management Plan (Helber, Hastert & Fee Planners 2008) [Enclosure 7] provide information regarding past land use, areas with a documented absence of archaeological sites, and areas of high and low potential of archaeological sites. [Enclosure 8 and Enclosure 9].

West Loch Annex is located in the northeast corner of the ‘Ewa Plain. Views provided by consulting parties and others are summarized as consistent with background research that describes ‘Ewa as a place associated with the Lō *ali‘i* (royalty or chiefs) of O‘ahu who were important political personages from the early 14th to 18th centuries. The general land use history of the ‘Ewa Plain is characterized by traditional Hawaiian habitation and dryland agriculture, followed by commercial land use in the late 19th and early 20th century that consisted of salt works, ranching, and sugar plantations.

A cluster of traditional Hawaiian sites is located north of the APE [see Enclosure 8 and Enclosure 9]. This area was originally identified by Jensen and Head (1997) and then resurveyed by Rieth (2011) [see Enclosure 7]. These are multi-component agricultural and habitation sites characterized by surface features, subsurface deposits, and traditional Hawaiian artifacts. The sites within this area are eligible, or potentially eligible, for listing in the National Register of Historic Places (NRHP).

Construction of the West Loch ammunition depot began in 1932. The design of magazines and other structures at West Loch correlate strongly with their principal function: the storage, handling and maintenance, and transport of ordnance. Operations, storage and administrative facilities comprise the majority of the facility types.

In 2007 the Navy adopted a Section 106 Program Comment for World War II and Cold War era (1939-1974) ammunitions storage facilities that provides the Department of Defense (DoD) with an alternative way to comply with their responsibilities under Section 106 of the NHPA with regard to the effect of management actions on World War II and Cold War Era ammunition storage facilities that may be eligible for listing in the NRHP. This program comment applies to ammunition storage facilities that are identified by one of 55 specific DoD category codes. Within West Loch there are 130 ammunition storage facilities, of these, 50 facilities that range from high explosive magazines, to small arms magazines and inert storehouses are covered by the program comment.

Six high explosive historic magazines (Facility Nos. 232-237) and two historic inert storehouses (Facility Nos. 238 and 239) within the vicinity of the proposed 24 Type D magazines are addressed under the ACHP program comment [Enclosure 9]. These magazines are a group of similar, widely-spaced ammunition storage facilities and an associated observation tower (Facility No. S389). These buildings are small arms magazine storage facilities that were built in 1943. Each magazine is surrounded by a small, maintained cleared open area bounded by dense scrubby trees. The magazine buildings are eligible for listing on the NRHP and are contributing elements to the PHNHL. The observation tower is eligible for the NNRHP; however, it is not a contributing resource of the PHNHL. A group of three magazines was constructed south of the historic magazines in 1991 and another group of five magazines to the north in 2011 [Enclosure 10]. They will not be demolished as a part of the proposed undertaking.

Existing information on historic properties within the APE has been reviewed, and background research has been completed. In addition, information has previously been sought from consulting parties, other organizations and individuals on historic properties and potential effects on them through earlier consultations in support of the Integrated Cultural Resources Management Plan and the PA. Information from Native Hawaiian organizations (NHOs) have been gathered through communications with the Navy Region Cultural Resources Manager and other efforts such as the 2016 Traditional Cultural Property study (Vernon et al.). Pursuant to 36 CFR § 800.4(b)(1), a reasonable and good faith effort has been made to carry out appropriate identification efforts, considering the magnitude and nature of the undertaking and the nature and extent of potential effects on historic properties. No historic properties have been identified within the APE.

DETERMINATION OF EFFECTS

The proposed undertaking would not alter the historic setting of adjacent historic magazines because the new structures will be similar in appearance and unmaintained vegetation between magazine areas would provide screening between the new and historic structures. Contract language will ensure that this commitment is adhered to.

An assessment of adverse effects has been applied to the undertaking pursuant to 36 CFR § 800.5(a)(1), and in consideration of the aforementioned information, the Navy has determined that the proposed project to construct 24 new magazines and make associated improvements will result in "no adverse effect" to historic properties. In the event that NAGPRA cultural items are discovered, all work in the vicinity will stop and the remains will be stabilized and protected. Treatment will proceed under the authority of NAGPRA.

Pursuant to IX.B.1 of the 2012 PA, the Navy is requesting concurrence with the finding of effect. Should you or your staff have any questions or concerns, please contact Ms. Megan Hawkins of our Environmental Planning Business Line, NAVFAC Pacific, at 808-472-1071 or email at megan.hawkins2@navy.mil.

Sincerely,

M. R. DELAO
Captain, CEC, U.S. Navy
Regional Engineer
By direction of the
Commander

Enclosures:

1. Location of Pearl Harbor National Historic Landmark boundary and the project APE within Joint Base Pearl Harbor-Hickam West Loch annex (formerly Naval Magazine West Loch Branch).
2. Plan and section of Type "D" magazine.
3. Plan and section of the over-watch tower proposed at Iroquois Road.
4. Plan and section of over-watch station at Iroquois Road.
5. Plan and section of vehicle inspection canopy proposed at Iroquois Road.
6. Plan and section of utility building proposed at Iroquois Road.
7. Previous archaeological surveys within West Loch Annex.
8. West Loch portion of the PHNC archaeological site analysis map.
9. West Loch portion of the PHNC archaeological site management Areas.
10. Historic and modern magazines located adjacent to the area of the proposed 24 Type D magazines at West Loch.

Copy to:
Dr. Kamana'opono Crabbe, Office of Hawaiian Affairs

Mr. Shad Kane, Oahu Council of Hawaiian Civic Clubs

Reference:

Davis, Bertell, D. and Greg C. Burtchard

1991 *Archaeological Inventory Survey of the Proposed PPV Housing, West Loch Unit of the Lualualei Naval Ammunition Depot, Pu'uloa, 'Ewa, O'ahu, Hawai'i.* Prepared for Belt Collins and Associates. Prepared by the International Archaeological Research Institute, Inc. (IARII), Honolulu, Hawaii.

Helber Haster & Fee, Planners

2008 Commander, Navy Region Hawaii, Oahu Integrated Cultural Resources Management Plan (ICRMP). Prepared for Commander, Navy Region Hawaii under Contract with Navy Facilities Engineering Command, Pacific.

Jensen, Peter M. and James Head

1997 *Archaeological Reconnaissance Survey Naval Magazine Lualualei NAVMAG-West Loch, Lands of Pu'uloa, Honouliuli, Waikele, and Waipi'o District of 'Ewa, Island of O'ahu.* Prepared for Department of the Navy, Naval Facilities Engineering Command, Pacific, Pearl Harbor, Hawaii. Paul H. Rosendahl, Ph.D., Hilo, Hawaii.

Filimoehala, Christopher, Myra J. Tomonari-Tuggle, Timothy M. Rieth, and Daniel Knecht

2015 *Archaeological Inventory Survey and Subsurface Testing at the West Loch Agricultural Outlease Area in Support of Navy Renewable Energy Projects in Hawaii.* Prepared for Prepared for Department of the Navy, Naval Facilities Engineering Command, Pacific, Pearl Harbor, Hawaii. International Archaeological Research Institute, Inc., Honolulu.

Rieth, Timothy

2011 *Archaeological Re-Location Survey and Subsurface Testing, Naval Magazine West Loch Branch, Pearl Harbor, TMK: (1) 9-1-1:01 (Portion).* Prepared for Department of the Navy, Naval Facilities Engineering Command, Pacific, Pearl Harbor, Hawaii. International Archaeological Research Institute, Inc., Honolulu.

Sholin, Carl E., Nathan DiVito, and Thomas S. Dye

2013 *Archaeological Inventory Survey for the Army Garrison Hawaii Munitions Storage Complex, Navy Munitions Command East Asia Division Detachment Pearl Harbor, Joint Base Pearl Harbor-Hickam (JBPHH) West Loch Annex.* Prepared for the Department of the Navy, Pearl Harbor Hawaii. Prepared by T. S. Dye and Colleagues, Honolulu, Hawaii.

TEC Inc. – Joint Venture

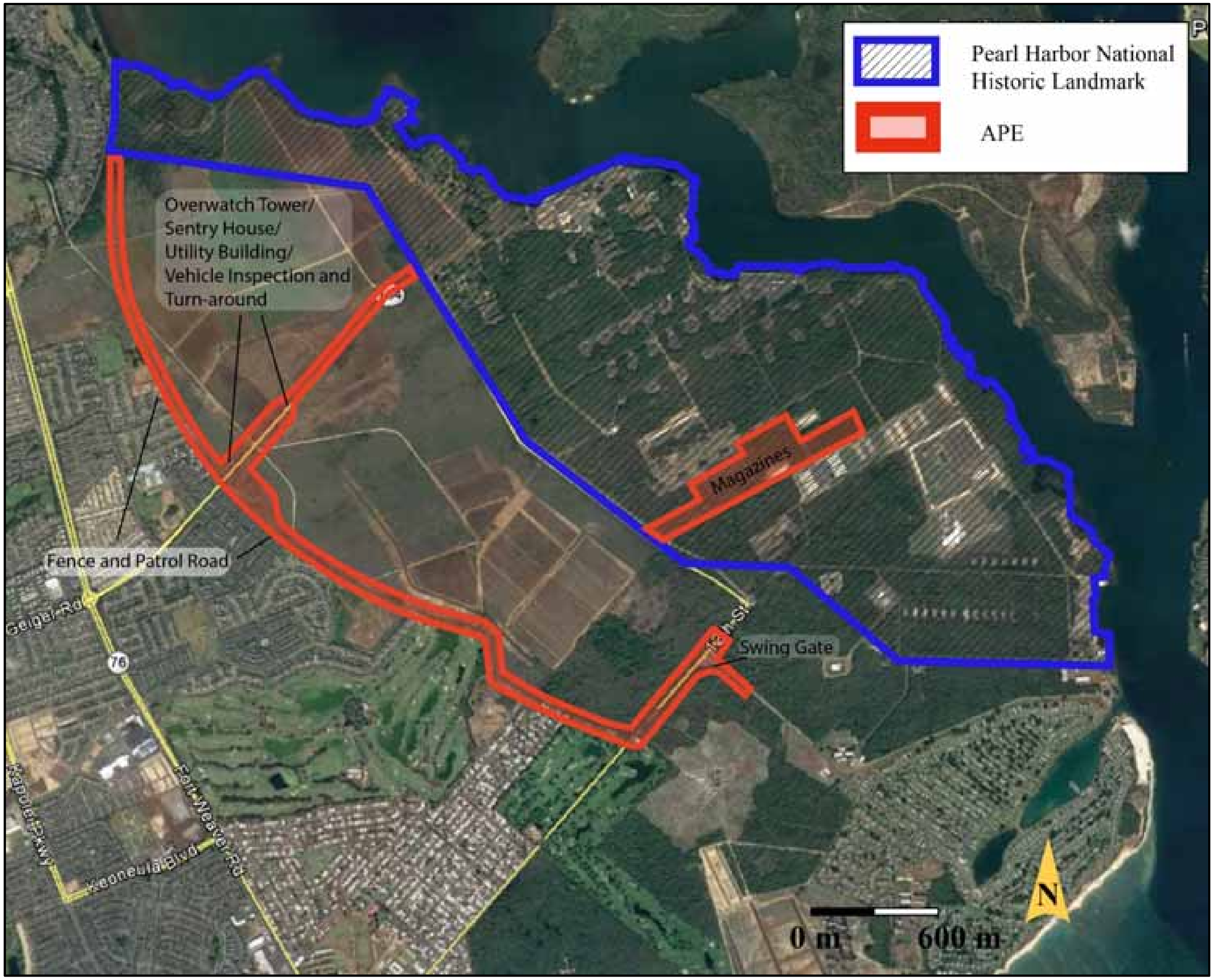
2011 *Pearl Harbor Navy Complex (PHNC) Cultural Landscape Report*. Prepared for Commander Navy Region Hawaii, Pearl Harbor Hawaii. Prepared by A Joint Venture of TEC Inc., AECOM TS Inc., and EDAW, Inc. Honolulu Hawaii and by NAVFAC Pacific, Pearl Harbor, Hawaii.

Vernon, Nicole I., Maria E. Orr, and Sara Collins

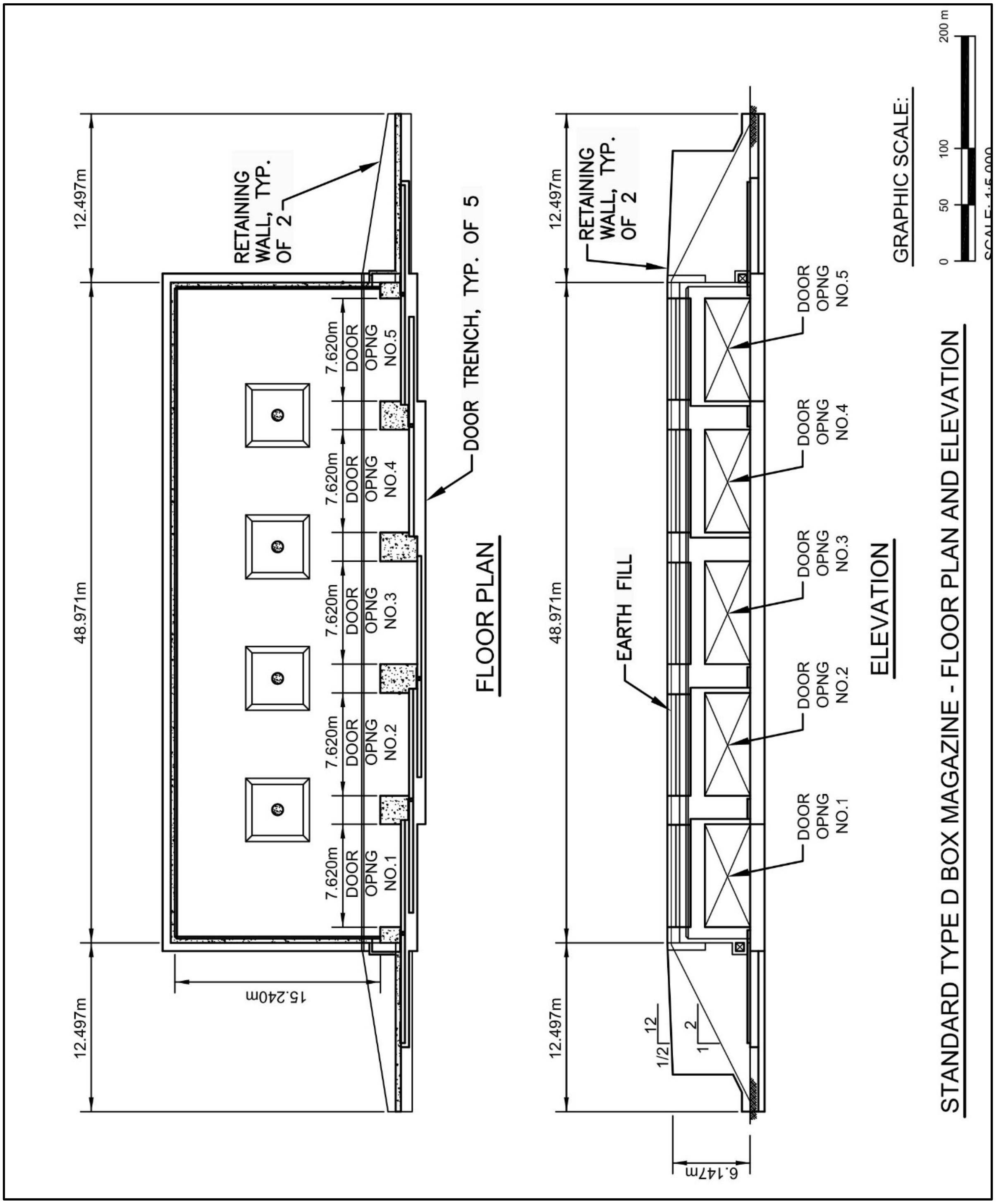
2016 A Native Hawaiian Traditional Cultural Places Study for Joint Base Pearl Harbor-Hickam, Oʻahu Island, Hawaiʻi. Prepared for Commander, Pacific Division, Naval Facilities Engineering Command, Pearl Harbor, Hawaii. Pacific Consulting Services, Inc.

Wulzen, Warren and Paul Rosendahl

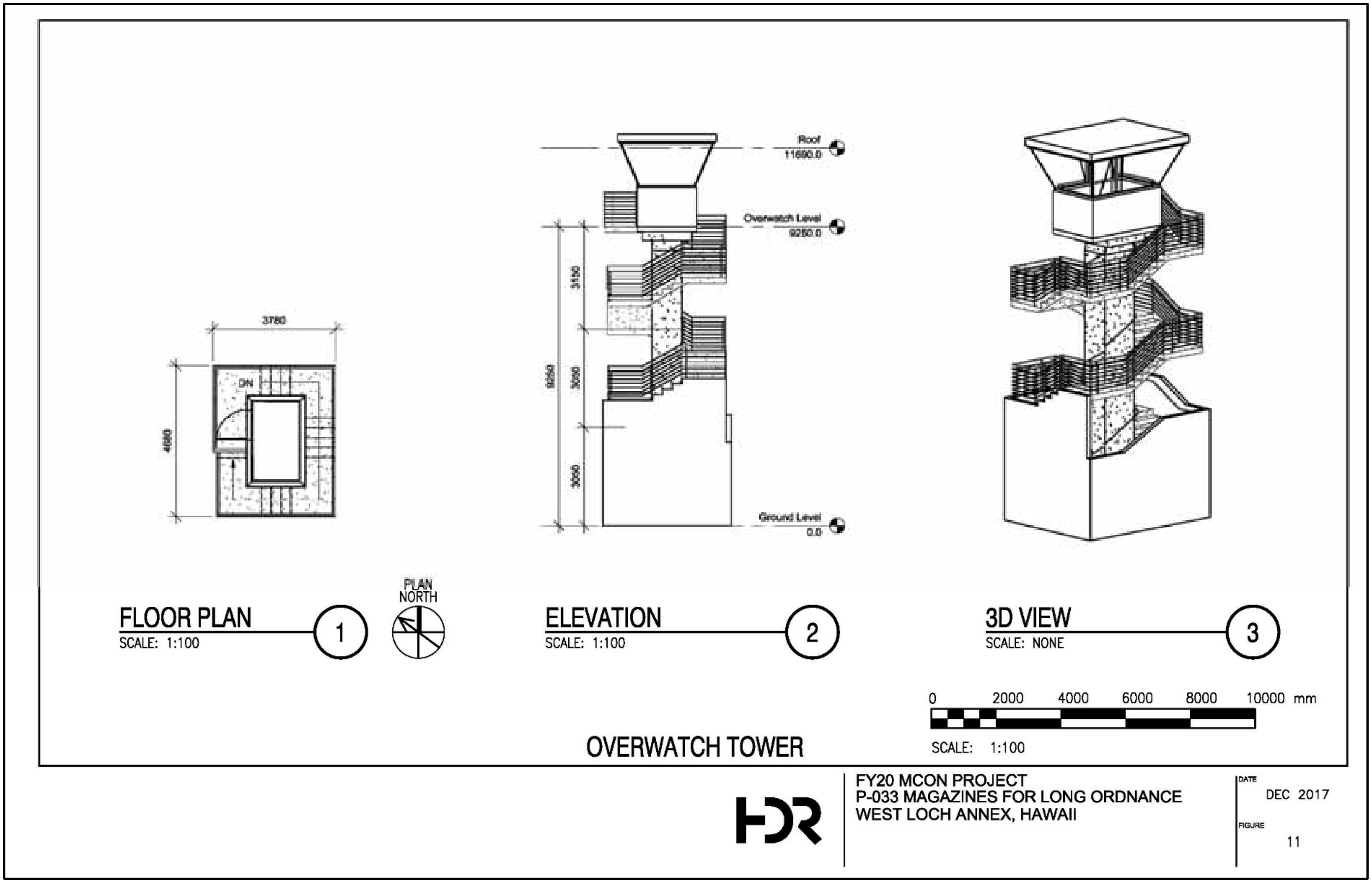
1995 *Archaeological Assessment of Seven BRAC 93 Project Areas at Naval Magazine, Lualualei, West Loch Station, Naval Air Station Barbers Point, and Marine Corps Base Hawaii, Kaneohe Bay, Land of Honouliuli, 'Ewa District; and Lands of Kāne'ohe and He'eia, Ko'olau Poko District, Island of O'ahu.* Prepared for Belt Collins Hawaii, Honolulu, Hawaii. Prepared by Paul H. Rosendahl, Ph.D Inc. (PRHI), Hilo, Hawaii.



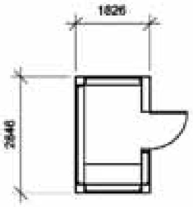
Enclosure 1. Location of Pearl Harbor National Historic Landmark boundary and the project APE within Joint Base Pearl Harbor-Hickam West Loch Annex (formerly Naval magazine West Loch Branch).



Enclosure 2. Plan and section of a standard Type "D" magazine.

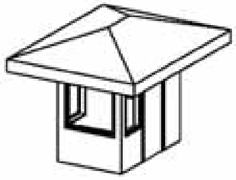


Enclosure 3. Plan and section of the over-watch tower proposed at Iroquois Road.



FLOOR PLAN
SCALE: 1:100
1

ELEVATION
SCALE: 1:100
2



3D VIEW
SCALE: NONE
3

SCALE: 1:100

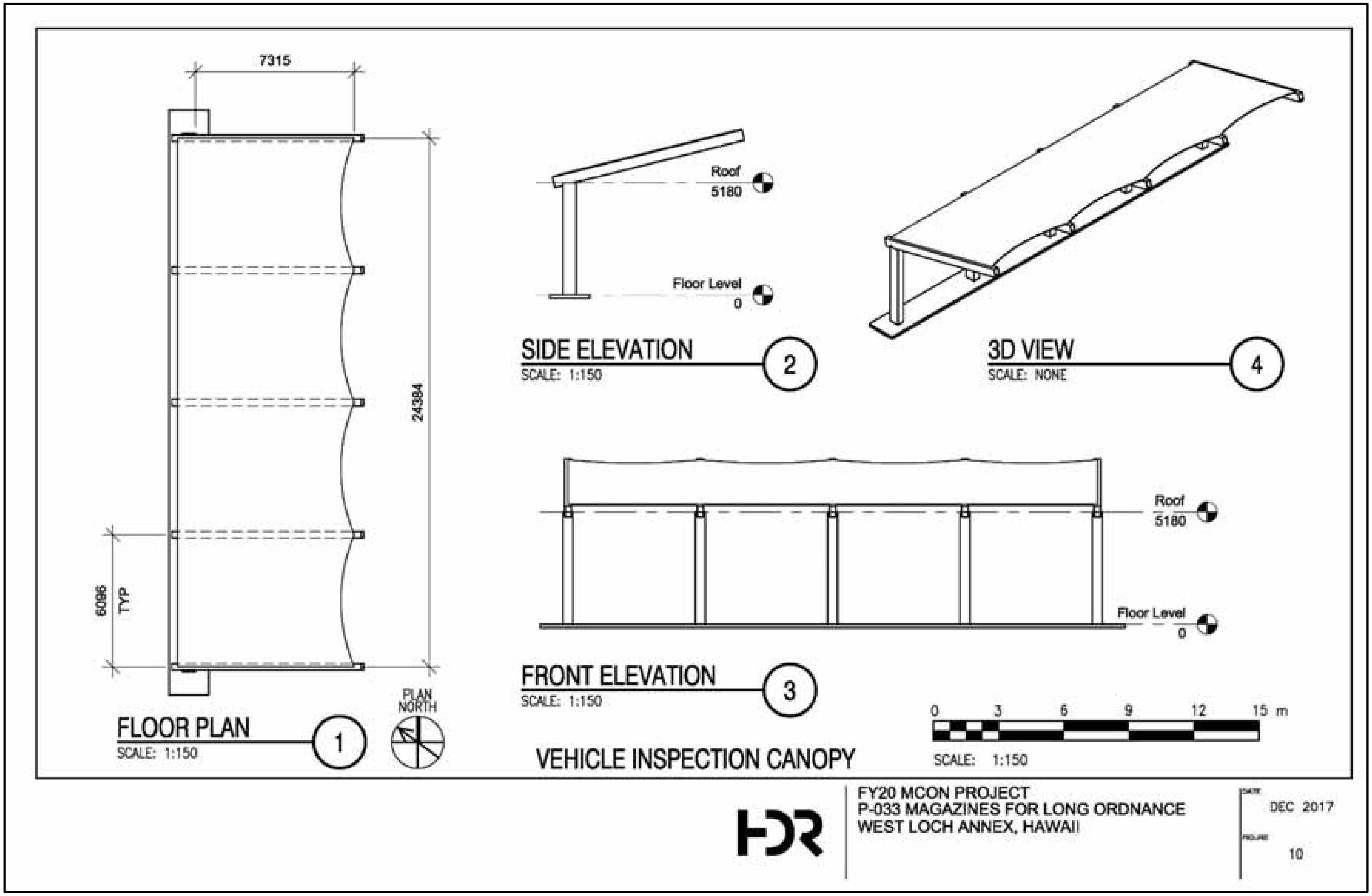
OVERWATCH STATION

FY20 MCON PROJECT
P-033 MAGAZINES FOR LONG ORDNANCE
WEST LOCH ANNEX, HAWAII

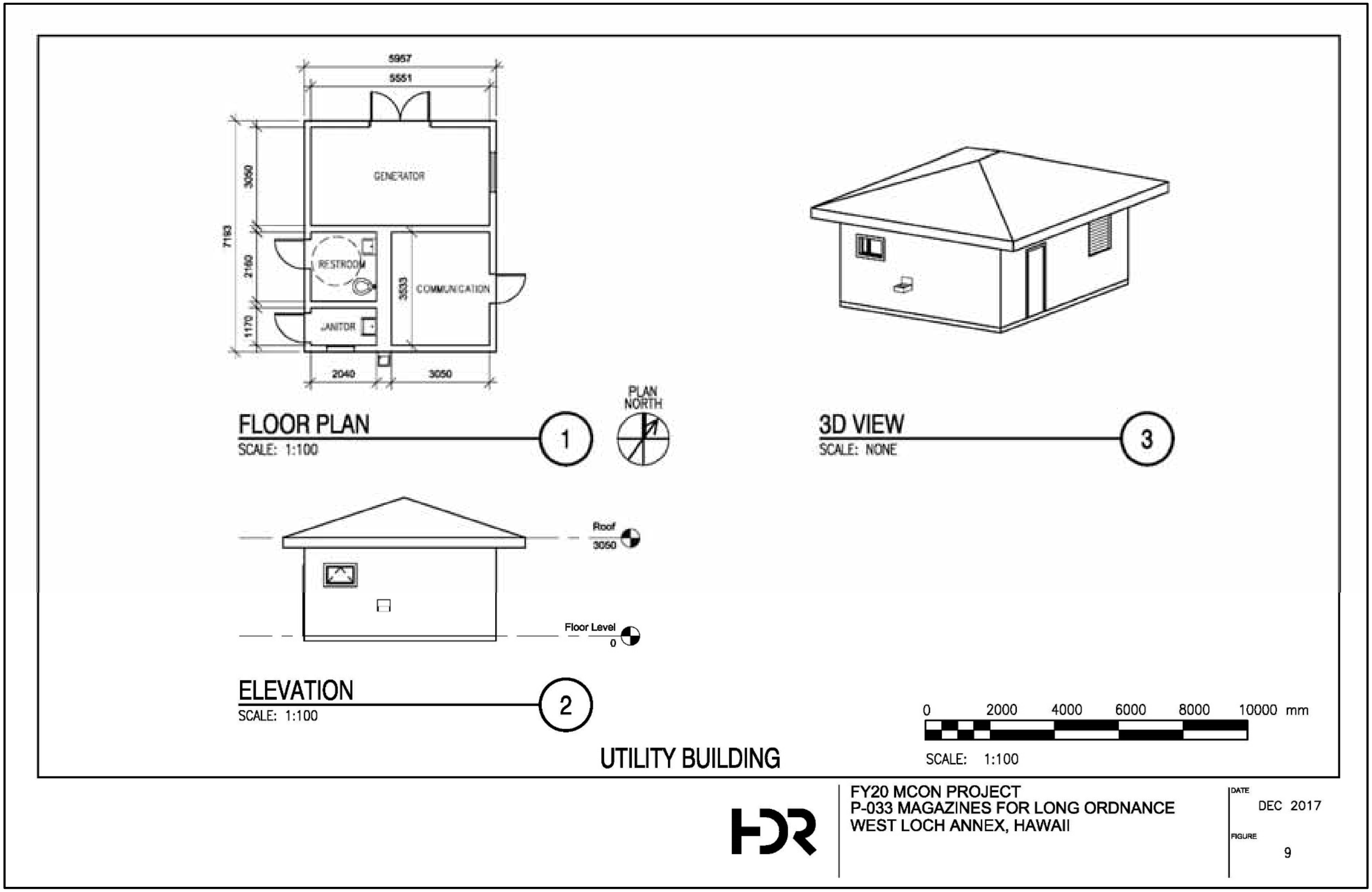
DATE
DEC 2017

FIGURE
12

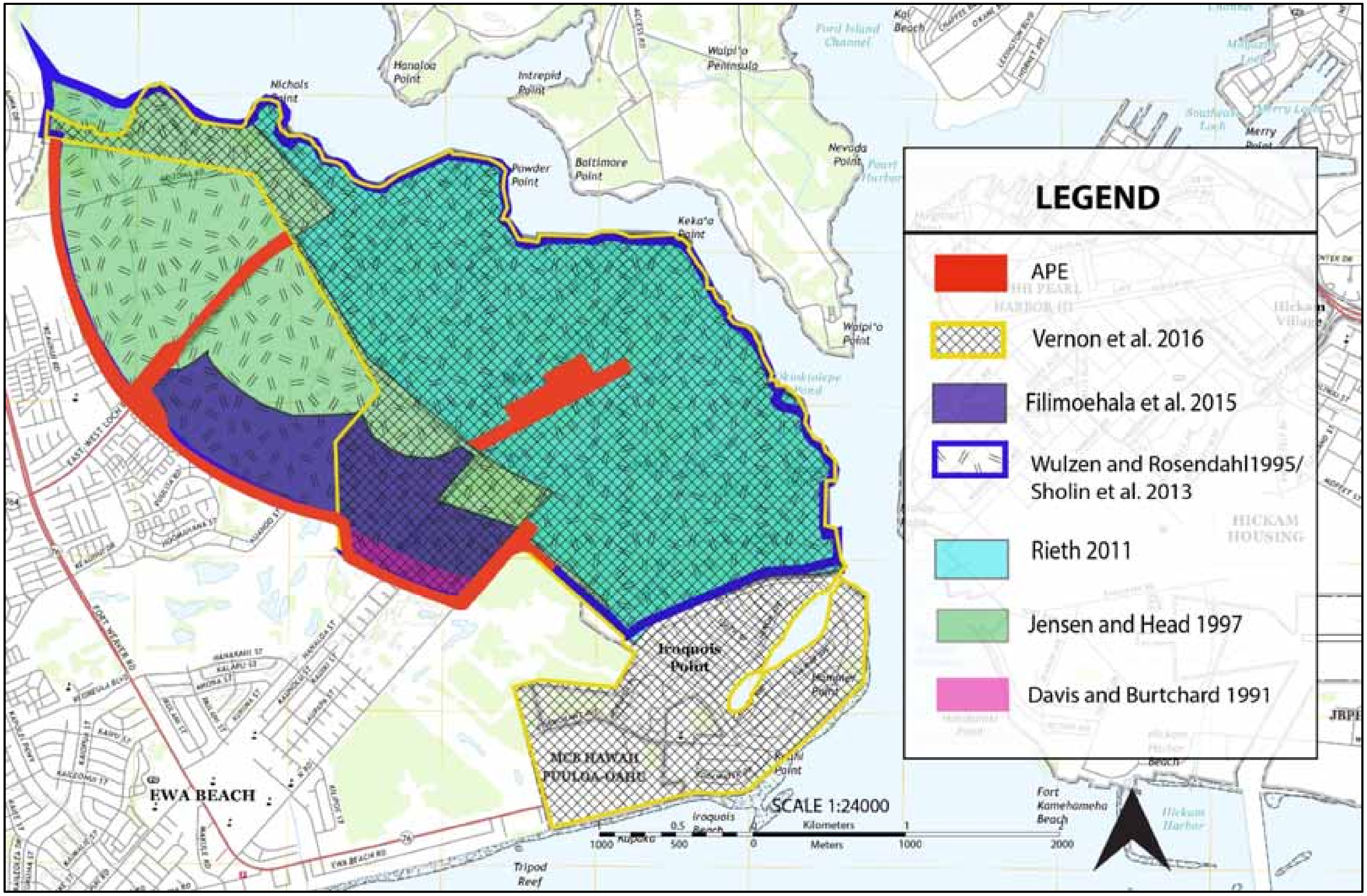
Enclosure 4. Plan and section of over-watch station at Iroquois Road.



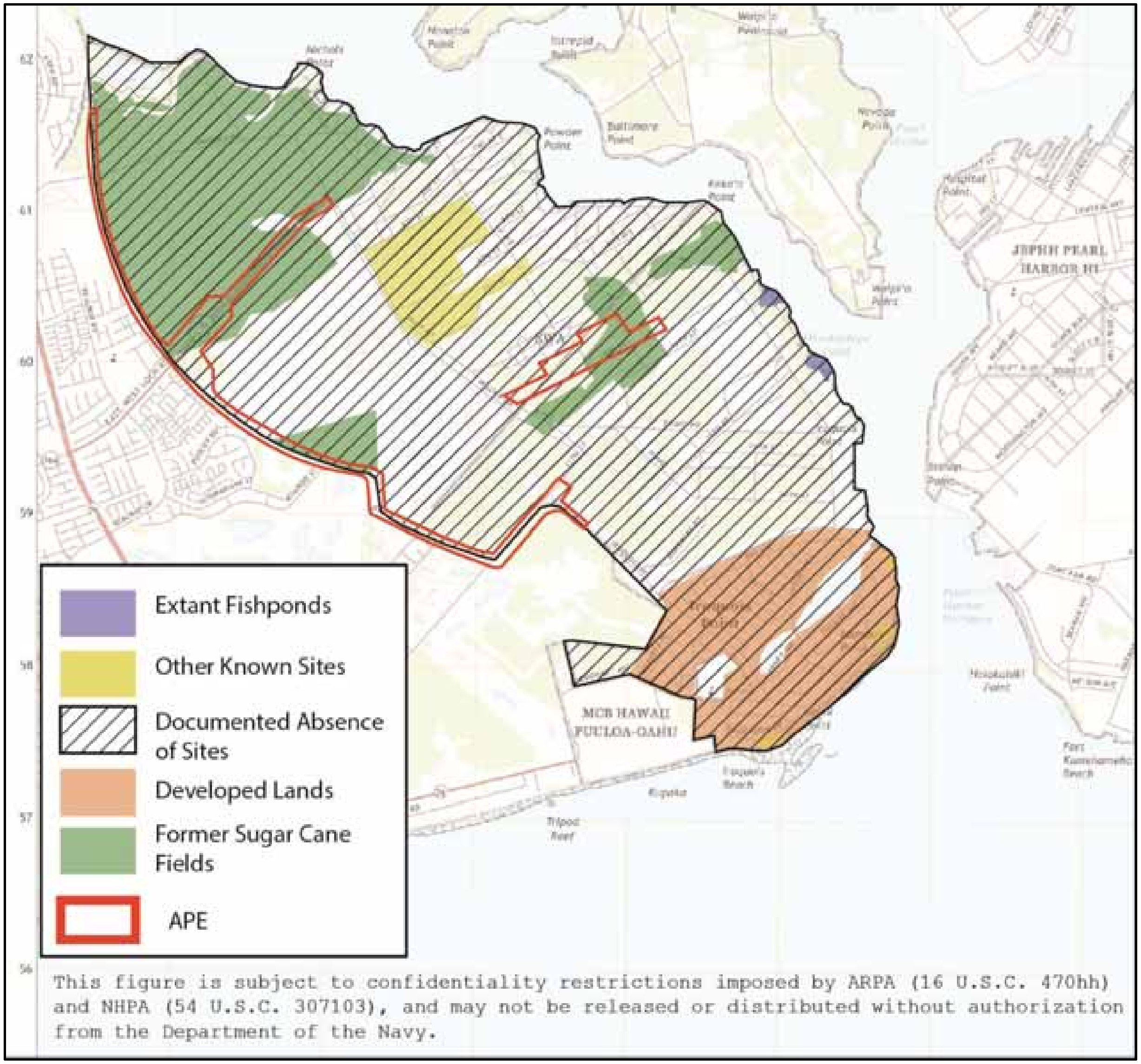
Enclosure 5. Plan and section of vehicle inspection canopy proposed at Iroquois Road.



Enclosure 6. Plan and section of utility building proposed at Iroquois Road.

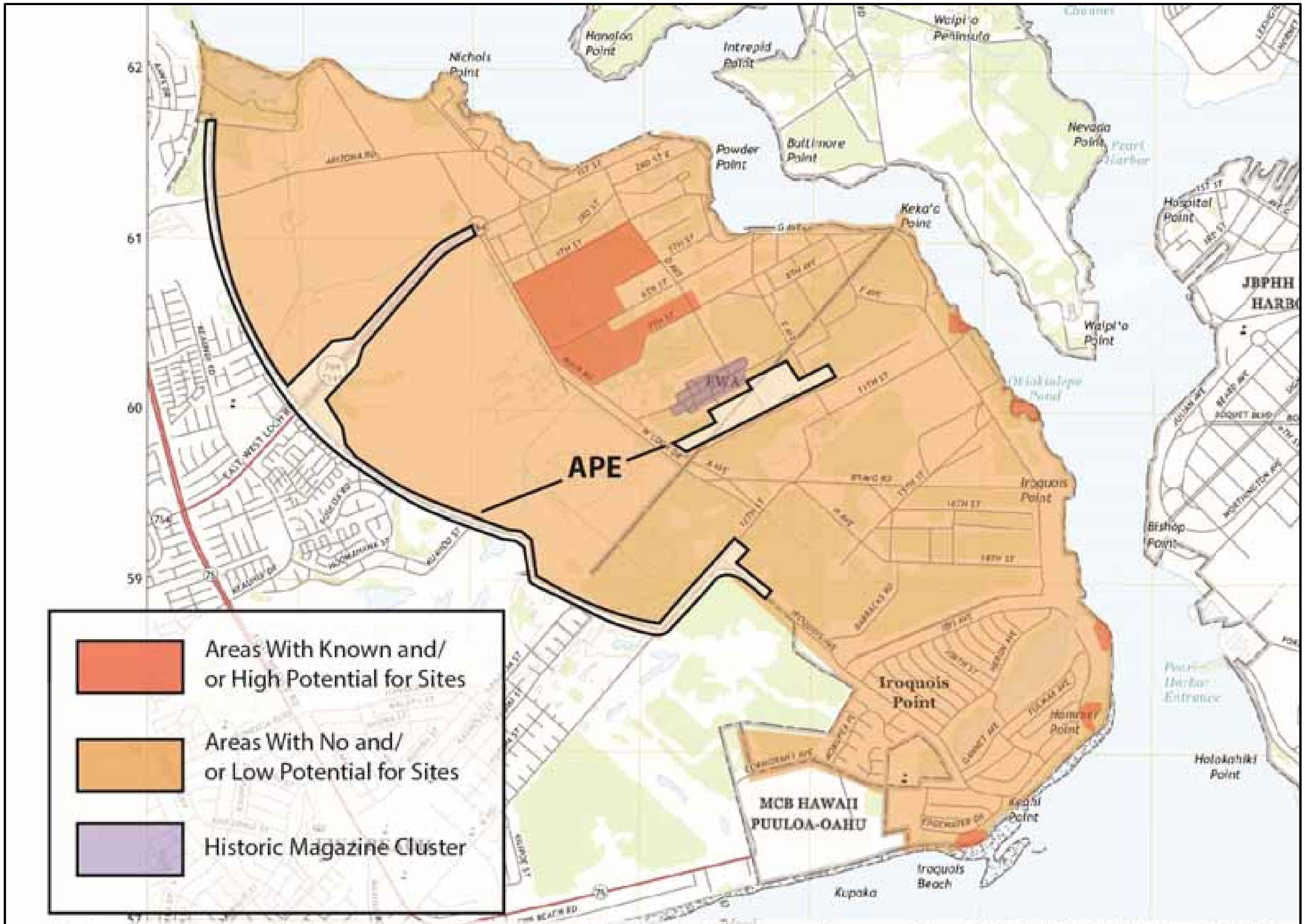


Enclosure 7. Previous investigations with West Loch Annex.



This figure is subject to confidentiality restrictions imposed by ARPA (16 U.S.C. 470hh) and NHPA (54 U.S.C. 307103), and may not be released or distributed without authorization from the Department of the Navy.

Enclosure 8. West Loch portion of PHNC Archaeological Site Analysis map (ICRMP 2008) depicting APE in former sugar cane fields and in an area with a documented absence of archaeological sites.



This figure is subject to confidentiality restrictions imposed by ARPA (16 U.S.C. 470hh) and NHPA (54 U.S.C. 307103), and may not be released or distributed without authorization from the Department of the Navy.

Enclosure 9. West Loch portion of the PHNC Archaeological Site Management Areas (2008 ICRMP).

Enclosure 10. Historic and modern magazines located adjacent to the area of the proposed 24 Type" D" Magazines at West Loch.

DAVID Y. IGE
GOVERNOR OF HAWAII

SUZANNE D. CASE
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

ROBERT K. MASUDA
FIRST DEPUTY

DEAN D. UYENO
ACTING DEPUTY DIRECTOR - WATER

AQUATIC RESOURCES
BOATING AND OCEAN RECREATION
BUREAU OF CONVEYANCES
COMMISSION ON WATER RESOURCE MANAGEMENT
CONSERVATION AND COASTAL LANDS
CONSERVATION AND RESOURCES ENFORCEMENT
ENGINEERING
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
KAHOOLAWE ISLAND RESERVE COMMISSION
LAND
STATE PARKS

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

STATE HISTORIC PRESERVATION DIVISION
KAKUHIHEWA BUILDING
601 KAMOKILA BLVD, STE 555
KAPOLEI, HAWAII 96707

January 3, 2019

IN REPLY REFER TO:
Log No.: 2018.02711
2018.02899
Doc. No.: 1901SH04
Archaeology, Architecture

Captain M. R. Delao
Department of the Navy
Commander Navy Region Hawai'i
850 Ticonderoga Street Suite 110
JBPHH, Hawai'i 96860-5101

Dear Captain Delao:

SUBJECT: **National Historic Preservation Act (NHPA) Section 106 Review –**
Initiation of Section 106 and Request for Concurrence with the Effect Determination
Proposed Construction of Magazines for Long Ordnance at Joint Base Pearl Harbor Hickam West Loch Annex, Ref. No. 5750 Ser N4/ 0659
Honouliui Ahupua'a, 'Ewa District, Island of O'ahu
TMK: (1) 9-1-001:001

The State Historic Preservation Division (SHPD) received a letter dated November 13, 2018 from the Department of the Navy (Navy) to initiate Section 106 consultation and request the State Historic Preservation Officer's (SHPO's) concurrence for a project to construct Magazines for Long Ordnance at Joint Base Pearl Harbor-Hickam (JBPHH) West Loch Annex on the island of Oahu. The SHPD received this submittal on November 16, 2018 (SHPD Log No. 2018.02711). At the request of the Navy, a meeting was held at the SHPD office in Kapolei, Oahu on November 30, 2018 to discuss the project. As a result of the meeting, additional information pertaining to the project was provided to SHPD by the Navy on December 6, 2018 and December 10, 2018 (SHPD Log No. 2018.02899).

The Navy has determined the proposed project is a federal undertaking as defined in 36 CFR 800.16(y).

The Navy proposes to construct 24 Type D box magazines and related improvements at West Loch Annex munitions storage facility. West Loch Annex lies within the U.S. Naval Base Pearl Harbor National Historic Landmark (PHNHL) and comprises ammunition handling wharves, torpedo and missile intermediate maintenance operations, and a helicopter landing area.

Type D box magazines are above-ground structures for ordnance storage. The standard magazine dimensions are each approximately 160 feet (48.9 meters) wide by 50 feet (15.2 meters) long and 20 feet (6.1 meters) in height. The magazines would be constructed of reinforced concrete covered by a minimum of 2 feet of earth and placed adjacent to existing magazines. The Type D magazines are similar in appearance to the existing historic magazines which are an earth-covered structure with berm-like appearance but would be approximately 60 feet longer than the historic magazines.

Related improvements would include a paved and a gravel access road, concrete pads, a chain-link security fence, over-watch tower, over-watch station, gate/sentry house, a utility building, a swing gate, and buried utilities. The security fence and gravel patrol road would extend from Iroquois Road to Iroquois Drive along the southern boundary of the Annex. The proposed improvements and construction require clearing, grubbing, grading, and excavation. The clearing, grading, and grubbing activities will remove surface material and not exceed 1 meter (3.2 feet) in depth. Subsurface excavations for building footings and related improvements would not exceed a depth of 1.2 meters (4 feet) and associated utilities would not exceed a depth of 1.8 meters (6 feet).

Transportation of vehicles and equipment from the proposed magazine area to the related improvements areas will stay within the pre-existing footprints of public roads (i.e., Iroquois Road, A Avenue, and 12th Street/North Road).

The area of potential effect (APE) includes the project area of the proposed 24 Type D box magazines and related improvements. The APE is approximately 24.28 hectares (60 acres) in the magazine location and approximately 52.6 hectares (130 acres) in the area of the access road. The APE includes a buffer zone to provide flexibility for minor design modifications and for equipment staging areas during construction. Pursuant to Stipulation VI. of the 2012 PA, the Navy is requesting concurrence from the SHPO on the APE. **The SHPO concurs with the APE.**

No archaeological investigations were conducted in support of the proposed project; however, the Navy's letter states the Navy has conducted several archaeological and historical architectural studies in the area. These investigations include archaeological reconnaissance and inventory surveys, a cultural landscape study and traditional cultural property study. Historic properties were identified nearby within West Loch Annex including traditional Hawaiian archaeological sites, 19th century agricultural features, and World War II and Cold War Era buildings and structures related to ordnance storage. A cluster of traditional Hawaiian sites is located north of the APE. This area was originally identified by Jensen and Head (1997) and then resurveyed by Rieth (2011). These are multi-component agricultural and habitation sites characterized by surface features, subsurface deposits, and traditional Hawaiian artifacts. The sites within this area are eligible, or potentially eligible, for listing in the National Register of Historic Places (NRHP).

Construction of the West Loch ammunition depot began in 1932. In 2007 the Navy adopted a Section 106 Program Comment for World War II and Cold War era (1939-1974) ammunitions storage facilities that provides the Department of Defense (DoD) with an alternative way to comply with their responsibilities under Section 106 of the NHPA with regard to the effect of management actions on World War II and Cold War Era ammunition storage facilities that may be eligible for listing in the NRHP. Within West Loch there are 130 ammunition storage facilities, of these, 50 facilities that range from high explosive magazines, to small arms magazines and inert storehouses are covered by the program comment. Six high explosive historic magazines (Facility Nos. 232-237) and two historic inert storehouses (Facility Nos. 238 and 239) within the vicinity of the proposed 24 Type D magazines are addressed under the ACHP program comment. The magazine buildings are eligible for listing on the NRHP and are contributing elements to the PHNHL. The observation tower is eligible for the NRHP; however, it is not a contributing resource of the PHNHL.

The Navy did not identify any historic properties within the boundaries of the APE.

The Navy states that proposed undertaking would not alter the historic setting of adjacent historic magazines because the new structures will be similar in appearance and unmaintained vegetation between magazine areas would provide screening between the new and historic structures. Contract language will ensure that this commitment is adhered to.

The SHPO concurs with the Navy's determination that the proposed project will result in *no adverse effect.*

The Department of the Navy is the office of record for this undertaking. Please maintain a copy of this letter with your environmental review record for this undertaking.

Please contact Stephanie Hacker, Historic Preservation Archaeologist IV, at Stephanie.Hacker@hawaii.gov or at (808) 692-8046 for matters regarding archaeological resources or this letter.

Aloha,
Susan A. Lebo

Signed For
Alan S. Downer, PhD
Administrator, State Historic Preservation Division
Deputy State Historic Preservation Officer

cc: Megan Hawkins, Navy (megan.hawkins2@navy.mil)

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE NAVY
COMMANDER
NAVY REGION HAWAII
850 TICONDEROGA ST STE 110
JBPHH, HAWAII 96860-5101

5750
Ser N4/0514
29 APR 2019

CERTIFIED NO: 7016 0910 0001 0891 7192

Dr. Alan Downer
Deputy State Historic Preservation Officer
Department of Land and Natural Resources
Kakuhihewa Building, Room 555
601 Kamokila Boulevard
Kapolei, HI 96707

Dear Dr. Downer:

SUBJECT: REINITIATION OF SECTION 106 CONSULTATION FOR PROPOSED CONSTRUCTION OF MAGAZINES FOR LONG ORDNANCE AT JOINT BASE PEARL HARBOR-HICKAM (JBPHH) WEST LOCH ANNEX, DISTRICT OF EWA, AHUPUA'A OF HONOULIULI, ON THE ISLAND OF O'AHU, TMK (1) 9-1-1:01

The Navy is reinitiating consultation under Section 106 of the National Historic Preservation Act for the subject project to construct 24 new ammunition storage magazines and related improvements. The proposed project is located at Joint Base Pearl Harbor-Hickam (JBPHH), West Loch Annex, O'ahu, Hawai'i. The Section 106 consultation for the subject project concluded on January 3, 2019 in which the SHPO concurred with the Area of Potential Effects (APE) and the Navy's determination that the proposed project will result in *no adverse effect* (Log No. 2018.02711/2018.02899; Doc. No. 1901SH04). Since that time, additional requirements have been added to the undertaking. This letter amends the previously consulted on APE [Enclosure 1]. Details regarding changes to the undertaking are described below.

PROJECT DESCRIPTION

The project proposes to construct 24 new ammunition storage magazines and related improvements at JBPHH, West Loch Annex. The revised APE comes as a result of additional requirements for increased fencing, an extended perimeter road for security, and utilities [Enclosure 1].

Perimeter Fence and Patrol Road

Proposed additional security fencing and paved perimeter road would be located from the northern terminus of the previously proposed fence line/road to the coastal margin east of the Pearl Harbor National Wildlife Refuge [Enclosure 2]. The proposed additional security fence and perimeter road will be installed in the area separating the former agricultural lands located at West Loch Annex from residential communities and a wetland area with a Wildlife Refuge. Ground disturbing activities will be located in disturbed agricultural lands located east of the wetlands. The APE has been extended to include these additional requirements.

Entry Control Point (ECP)

The proposed new ECP would be located on Iroquois Road at the boundary of the residential area and agricultural fields [Enclosure 3]. The APE has been widened at the location of the proposed vehicle inspection area to account for modifications to the proposed access road, denial turnaround road, and inspection pull-out area. This area would include: a patrol route gate, utility building, gate/sentry house, overwatch tower, overwatch station, access road, denial road, inspection pull-out area. Ground disturbing activities would be located on both the formal paved road (Iroquois Road) as well as the disturbed agricultural lands on either side of the road.

Demolition of Existing Back-Gate (Facility 354)

The existing back-gate (Facility 354) is located within the footprint of 1st Street, a formal-paved road, between West Loch Drive and A Avenue [Enclosure 4]. The area currently serves as an exit point from West Loch Annex. The APE has been expanded to include the proposed demolition of the existing back-gate (Facility 345) as it would no longer be required.

Iroquois Road Utilities

Fresh water and electrical subsurface utilities would be installed along Iroquois Road [Enclosure 4]. The APE has been widened on both sides of Iroquois Road to include these additional requirements. Iroquois Road is a formal-paved road that transects agricultural fields. There is a considerable amount of disturbance such as a mechanical grading on either side of Iroquois Road. Of note, there is a large ditch running parallel to Iroquois Road on the northwest side that extends from West Loch Drive to an informal dirt road located just north of the residential area. It is anticipated that the fresh water utilities would be installed either in this location or between the road and the ditch. The subsurface fresh water utilities would run parallel with Iroquois Road from the proposed ECP to an existing water line connection near the intersection of Iroquois Road and West Loch Drive, by the existing back-gate (Building 354). The subsurface electrical utilities will also run parallel with Iroquois Road from the proposed ECP to an existing primary power connection that currently serves the existing back-gate (Building 354).

1St Street and D Street Utilities

Telecommunication utilities would extend from the existing primary power connection located at the existing back-gate (Facility 354) on 1st Street to a telephone exchange facility (Facility 52) on D Avenue [Enclosure 5]. Both 1st Street and D Avenue are formal-paved roads that are used by Annex personnel. Above ground utilities would also extend from 1st Street to an existing electrical hookup located between 1st Place and 1st Street. Additional subsurface telecommunication utilities would be installed beneath 1st Street.

The subsurface utility section would extend approximately 150 feet from the above mentioned existing primary power connection and would connect to a series of pre-existing power line poles and continue to run on overhead lines on 1st Street. The utilities would run parallel with 1st Street from A Avenue and connect with pre-existing poles on D Avenue. These utilities would continue to run on overhead lines parallel with D Avenue until they connect to Building 52 located on D Avenue, just past the 4th Street intersection. The proposed utility connection from the overhead pole to Building 52 on D Street would not extend beyond the pole and building footprint. No ground disturbance is anticipated for the above ground utilities.

Magazine Area Utilities

The APE has been enlarged southeast of 10th Street, northeast of E Avenue, and southwest of 9th Street to include the additional utilities as well as to serve as a large buffer zone for equipment and potential laydown areas [Enclosure 6]. In addition to utilities proposed for the previously defined APE, fresh water, telecommunication, and electrical subsurface utilities lines have been added to the project scope. These subsurface utilities would be connected to a network of pre-existing subsurface utilities located along E Avenue, 9th Street, 10th Street, and 11th street. Fresh water and telecommunication utilities would run between 10th Street and 11th Street and within a formally paved area between a series of Quonset huts (K-28 through K-33). These are a cluster of Quonset huts that were constructed in 1943 and subsequently used for inert storage. A series of additional fresh water, telecommunication, and electric subsurface utilities would be installed along 10th Street. Note that the proposed subsurface utilities are not anticipated to tie into pre-existing subsurface utilities that extend perpendicular through 10th and 11th Streets, in between buildings K-19 through K-24 and K-28 through K-33. However, the APE has been expanded here to provide flexibility during the construction phase.

E Avenue, 9th Street, 10th Street, and 11th Street are all formal-paved roads that are used by Annex personnel. E Avenue is characterized as having dense vegetation on both sides and an ordnance pad extending northeast from said road. Ninth Street is characterized has having dense vegetation on both sides and magazines constructed in 1943 and 1991 extending southwest from the street. The area between 10th Street and 11th Street is characterized by dense vegetation with occasionally exposed limestone bedrock. There are no buildings or structures in the location of the proposed utilities and the visibility between the two streets and is obscured by the dense vegetation. Additional utilities are also required along 9th Street and D Avenue. Vegetation clearance for the magazines and associated utilities will be limited to the project footprint and laydown areas. All additions in the magazine area are captured in the revised APE.

AREA OF POTENTIAL EFFECTS

The APE, as described in the Navy's 13 November 2018 Section 106 consultation letter (5750 Ser N4/0659) to SHPO, includes the project area of the proposed 24 Type D box magazines and related improvements [see Enclosure 1]. The additional requirements of an extended security fence/patrol road, back-gate demolition, modifications to the ECP, and installation of additional overhead and subsurface utilities increases the APE from 76.8 hectares (190 acres) to 125.4 (310 acres); the magazine portion of the APE is 36.4 hectares (90 acres) and related improvements portion of the APE is 89 hectares (220 acres).

Pursuant to Stipulation VI. of the 2012 PA, the Navy is requesting concurrence with the State Historic Preservation Officer (SHPO) on the revised APE. The revised APE still includes a buffer zone to provide flexibility for minor design modifications and for equipment staging areas during construction.

IDENTIFICATION OF HISTORIC PROPERTIES

As discussed in the 13 November 2018 Section 106 consultation letter (5750 Ser N4/0659), the Navy has conducted several archaeological and historic architectural studies at West Loch (Table 1; Enclosure 7). These reports were provided to SHPO on 06 December 2018. While there are a few sites listed on the State Inventory of Historic Places within the revised APE, these are not eligible for listing in the National Register of Historic Places (NRHP) and **no historic properties are present** in the revised APE. Additionally, a site visit of the proposed project area was conducted on 27 December 2018 with Mr. Shad Kane and Mr. Clifford Loo of the Oahu Council of Hawaiian Civic Clubs (OCHCC) and Lauren Morawski of the Office of Hawaiian Affairs (OHA). Mr. Kane, Mr. Loo, and Ms. Morawski viewed the locations of the proposed magazines and the perimeter fence and patrol road. At this time, it was agreed that there are no cultural resources concerns within the proposed APE and that the proposed undertaking will not affect historic properties within West Loch Annex.

TABLE 1: PREVIOUS STUDIES

Type	**Author**
Archaeological reconnaissance survey	Davis and Butchard 1991
Archaeological assessment	Wulzen and Rosendahl 1995
Archaeological reconnaissance survey	Jensen and Head 1997
Integrated Cultural Resource Management Plan (ICRMP)	Helber Haster & Fee, Planners 2008
Archaeological inventory and subsurface testing	Rieth 2011
Cultural Landscape Report (CLR)	TEC Inc, - Joint Venture 2011
Archaeological inventory and subsurface testing	Sholin et al. 2013
Archaeological inventory and subsurface testing	Filimoehala et al. 2015
Traditional cultural property study	Vernon et al. 2016

FINDING OF EFFECTS

The Navy's 13 November 2018 Section 106 consultation letter (5750 Ser N4/0659) stated that this undertaking would result in "no adverse effect" on historic properties. However, reassessing the information on the identification of historic properties summarized above, there are no historic properties present within the APE and the appropriate finding of effect pursuant to 36 CFR § 800.4(d)(1) is "no historic properties affected." In the event that NAGPRA cultural items are discovered, all work in the vicinity will stop and the remains will be stabilized and protected. Treatment will proceed under the authority of NAGPRA.

Pursuant to IX.B.1 of the 2012 PA, the Navy is requesting concurrence with the expanded APE and the finding of effect. Should you or your staff have any questions or concerns, please contact Ms. Megan Hawkins of our Environmental Planning Business Line, NAVFAC Pacific, at 808-472-1071 or email at megan.hawkins2@navy.mil.

Sincerely,

M. R. DELAO
Captain, CEC, U.S. Navy
Regional Engineer
By direction of the
Commander

Enclosures:
1. APE additions due to additional scope requirements
2. APE additions to include extension of perimeter fence/patrol road
3. APE additions to include Entry Control Point (ECP) modifications and subsurface utilities along Iroquois Road
4. APE additions to include demolition of existing back-gate (Building 354)
5. APE additions to include subsurface and overhead utilities from 1st Street to D Avenue
6. APE additions to include subsurface utilities in the proposed magazine area
7. Archaeological and cultural resource surveys conducted at West Loch Annex

Copy to: Dr. Kamanaʻopono Crabbe, Office of Hawaiian Affairs
Mr. Shad Kane, Oahu Council of Hawaiian Civic Clubs
Mr. Clifford Loo, Oahu Council of Hawaiian Civic Clubs

Reference:

Davis, Bertell, D. and Greg C. Burtchard
1991 *Archaeological Inventory Survey of the Proposed PPV Housing, West Loch Unit of the Lualualei Naval Ammunition Depot, Pu'uloa, 'Ewa, O'ahu, Hawai'i.* Prepared for Belt Collins and Associates. Prepared by the International Archaeological Research Institute, Inc. (IARII), Honolulu, Hawaii.

Helber Haster & Fee, Planners
2008 Commander, Navy Region Hawaii, Oahu Integrated Cultural Resources Management Plan (ICRMP). Prepared for Commander, Navy Region Hawaii under Contract with Navy Facilities Engineering Command, Pacific.

Jensen, Peter M. and James Head
1997 *Archaeological Reconnaissance Survey Naval Magazine Lualualei NAVMAG-West Loch, Lands of Puʻuloa, Honouliuli, Waikele, and Waipiʻo District of ʻEwa, Island of Oʻahu.* Prepared for Department of the Navy, Naval Facilities Engineering Command, Pacific, Pearl Harbor, Hawaii. Paul H. Rosendahl, Ph.D., Hilo, Hawaii.

Filimoehala, Christopher, Myra J. Tomonari-Tuggle, Timothy M. Rieth, and Daniel Knecht
2015 *Archaeological Inventory Survey and Subsurface Testing at the West Loch Agricultural Outlease Area in Support of Navy Renewable Energy Projects in Hawaii.* Prepared for Prepared for Department of the Navy, Naval Facilities Engineering Command, Pacific, Pearl Harbor, Hawaii. International Archaeological Research Institute, Inc., Honolulu.

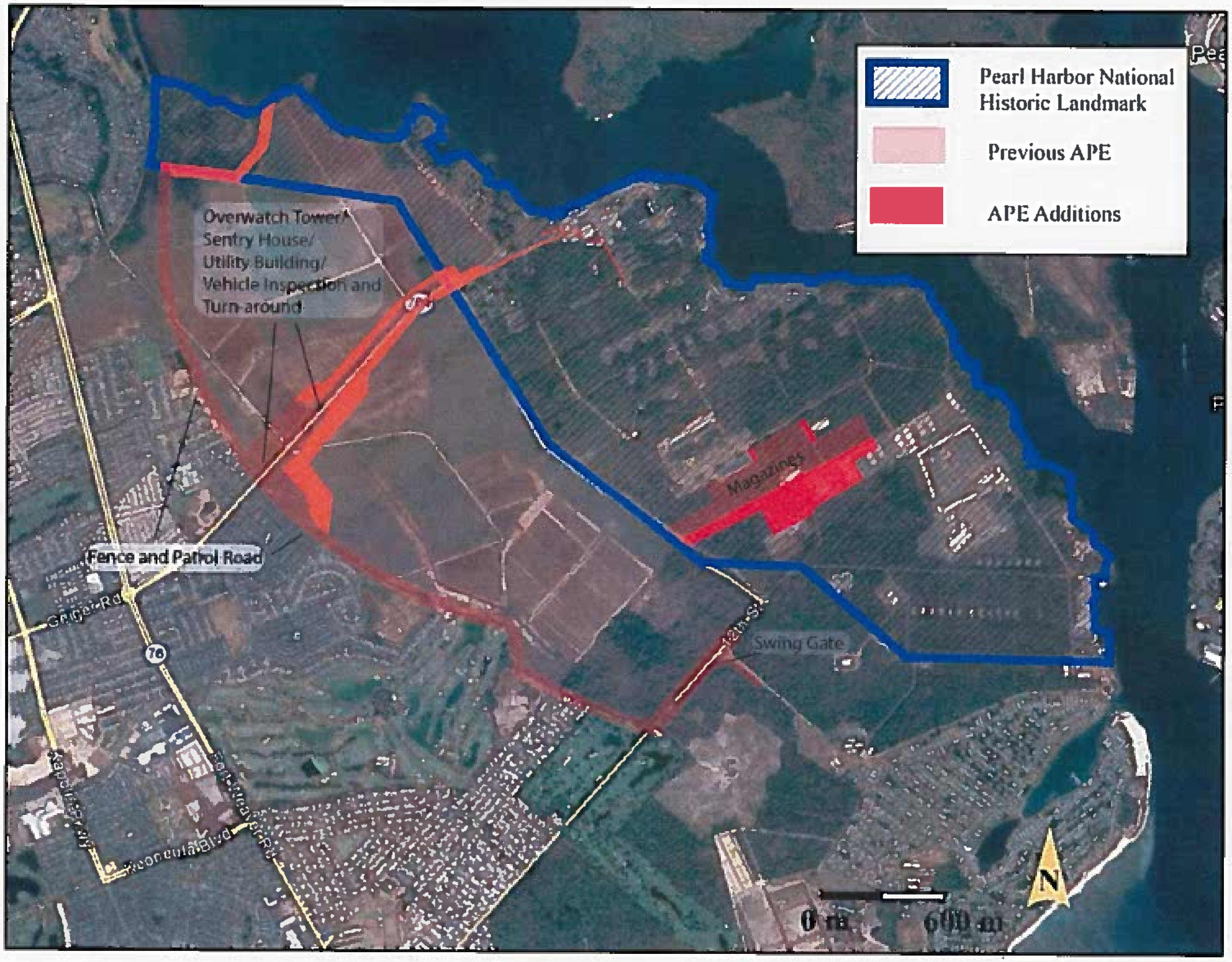
Rieth, Timothy
2011 *Archaeological Re-Location Survey and Subsurface Testing, Naval Magazine West Loch Branch, Pearl Harbor, TMK: (1) 9-1-1:01 (Portion).* Prepared for Department of the Navy, Naval Facilities Engineering Command, Pacific, Pearl Harbor, Hawaii. International Archaeological Research Institute, Inc., Honolulu.

Sholin, Carl E., Nathan DiVito, and Thomas S. Dye
2013 *Archaeological Inventory Survey for the Army Garrison Hawaii Munitions Storage Complex, Navy Munitions Command East Asia Division Detachment Pearl Harbor, Joint Base Pearl Harbor-Hickam (JBPHH) West Loch Annex.* Prepared for the Department of the Navy, Pearl Harbor Hawaii. Prepared by T. S. Dye and Colleagues, Honolulu, Hawaii.

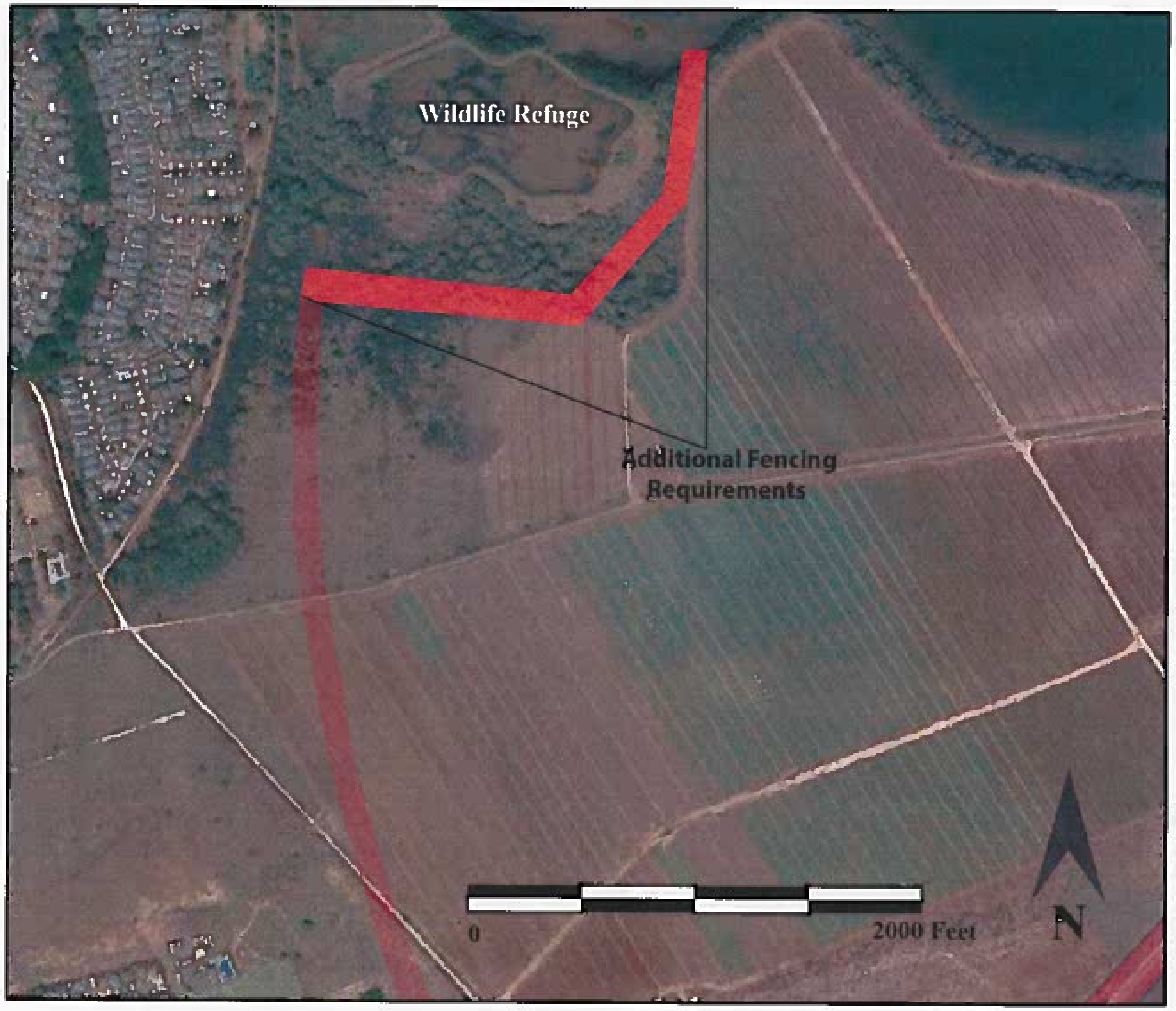
TEC Inc. – Joint Venture
2011 *Pearl Harbor Navy Complex (PHNC) Cultural Landscape Report*. Prepared for Commander Navy Region Hawaii, Pearl Harbor Hawaii. Prepared by A Joint Venture of TEC Inc., AECOM TS Inc., and EDAW, Inc. Honolulu Hawaii and by NAVFAC Pacific, Pearl Harbor, Hawaii.

Vernon, Nicole I., Maria E. Orr, and Sara Collins
2016 A Native Hawaiian Traditional Cultural Places Study for Joint Base Pearl Harbor-Hickam, Oʻahu Island, Hawaiʻi. Prepared for Commander, Pacific Division, Naval Facilities Engineering Command, Pearl Harbor, Hawaii. Pacific Consulting Services, Inc.

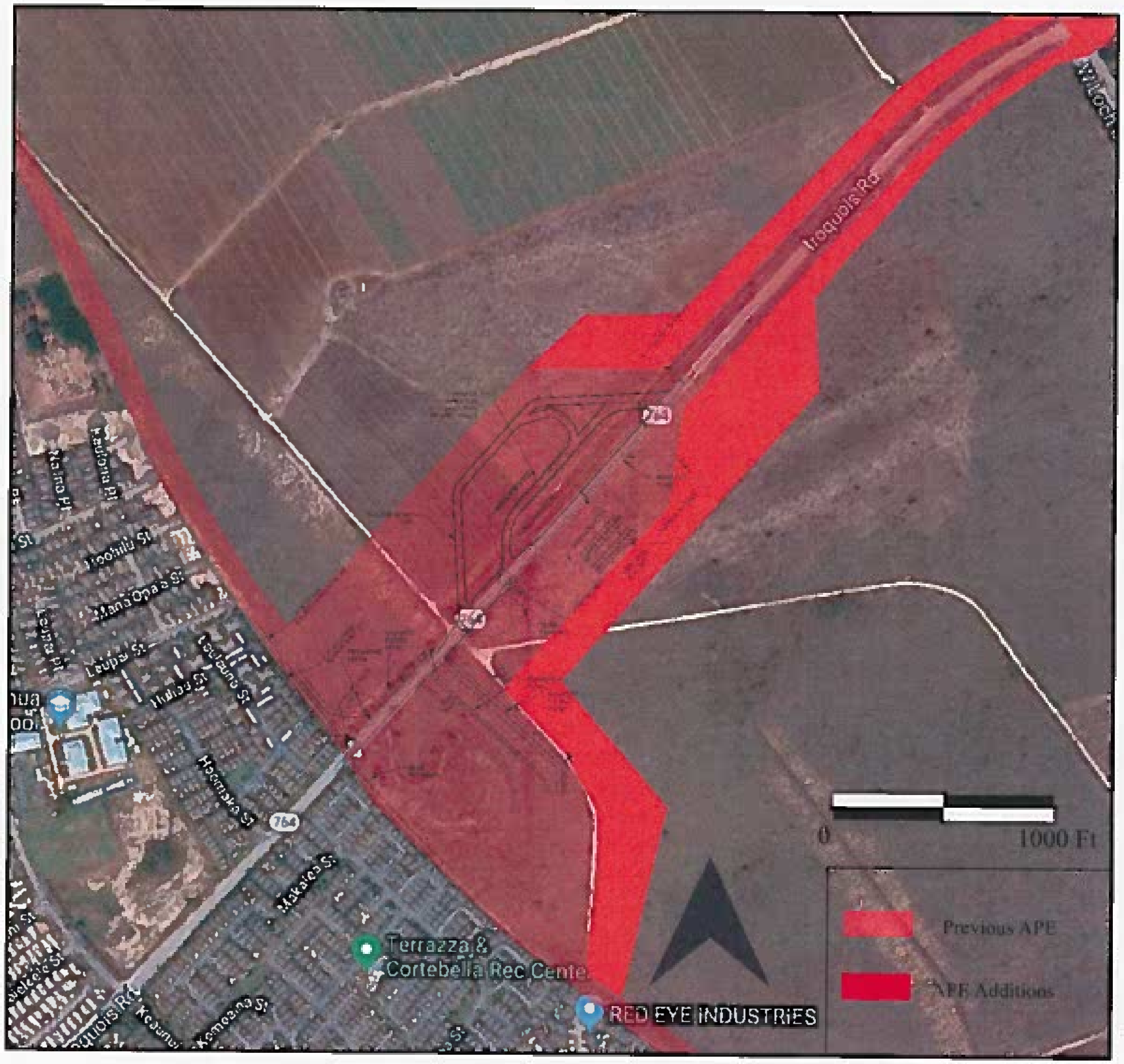
Wulzen, Warren and Paul Rosendahl
1995 *Archaeological Assessment of Seven BRAC 93 Project Areas at Naval Magazine, Lualualei, West Loch Station, Naval Air Station Barbers Point, and Marine Corps Base Hawaii, Kaneohe Bay, Land of Honouliuli, 'Ewa District; and Lands of Kāne'ohe and He'eia, Ko'olau Poko District, Island of O'ahu.* Prepared for Belt Collins Hawaii, Honolulu, Hawaii. Prepared by Paul H. Rosendahl, Ph.D Inc. (PRHI), Hilo, Hawaii



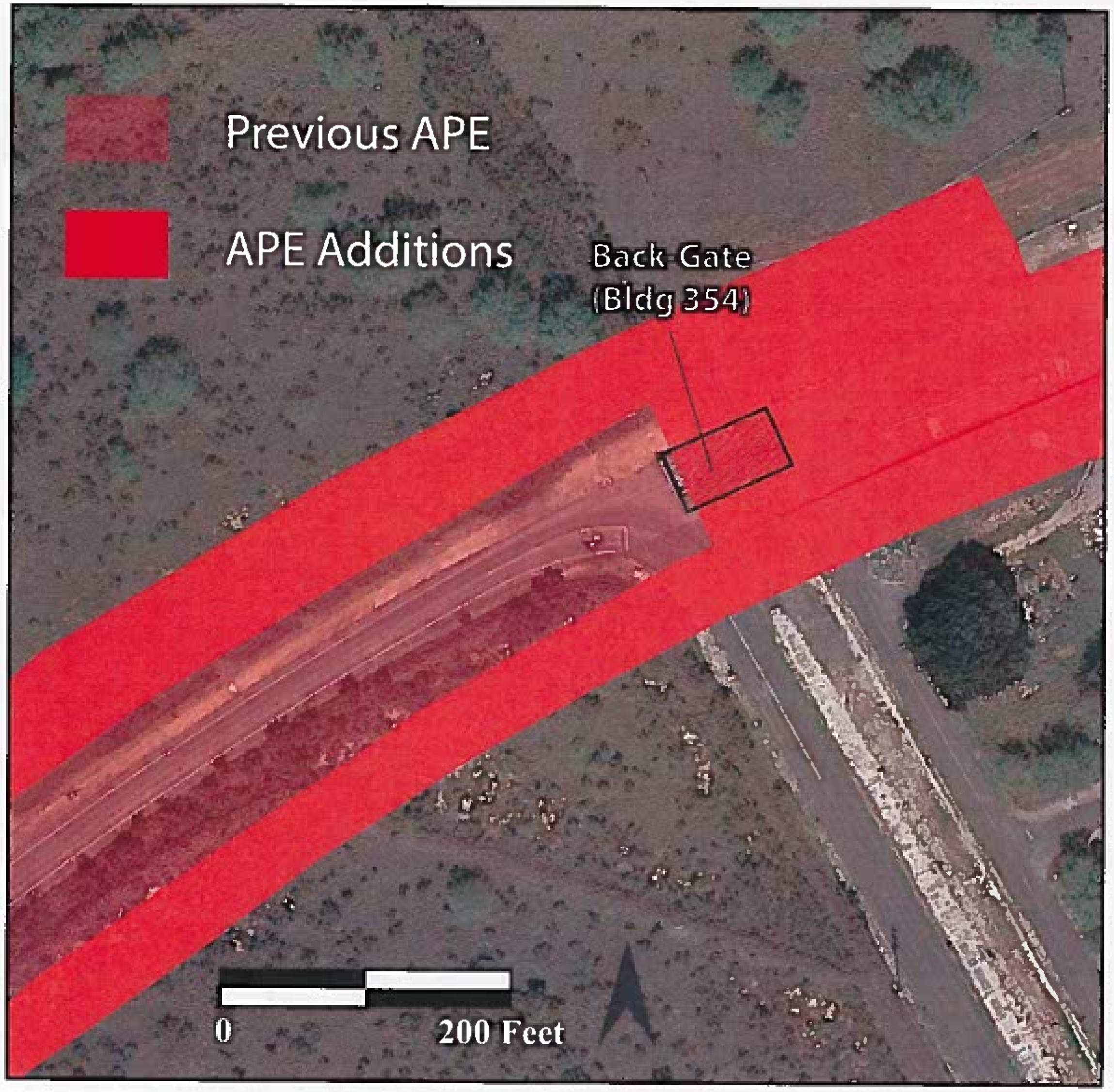
Enclosure 1. APE additions due to additional scope requirements.



Enclosure 2. APE additions to include extension of perimeter fence/ patrol road.



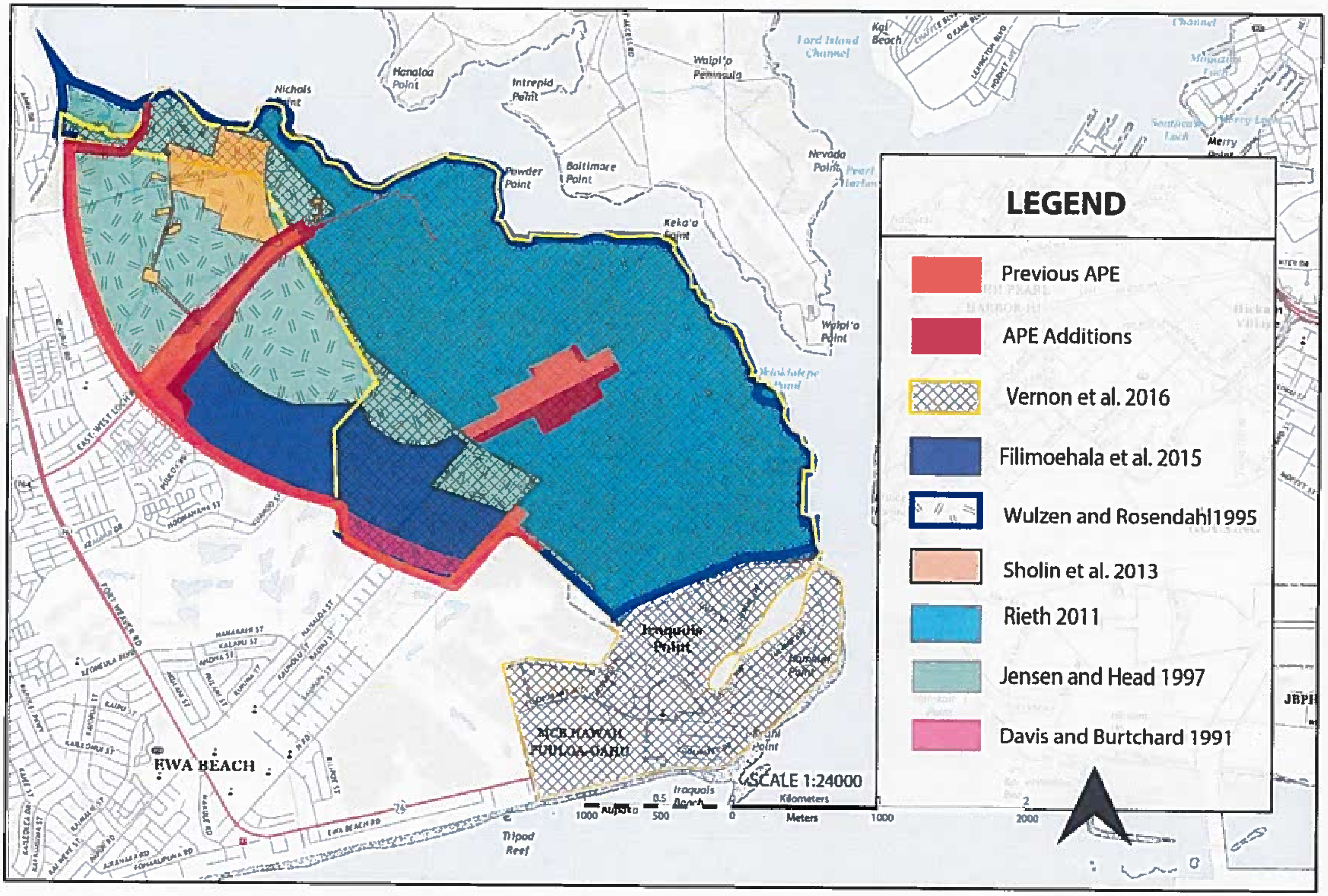
Enclosure 3. APE additions to include Entry Control Point (ECP) modifications and subsurface utilities along Iroquois Road.



Enclosure 4. APE additions to include demolition of existing back-gate (Building 354).

Enclosure 5. APE additions to include subsurface and overhead utilities from 1st Street and D Avenue.

Enclosure 6. APE additions to include subsurface utilities and extra buffer in the proposed magazine area.



Enclosure 7. Archaeological and cultural resource surveys conducted at West Loch Annex.