DEPARTMENT OF TRANSPORTATION
STATE OF HAWAII

JUNE 30, 2019

HAWAII
Statewide Transportation Asset Management Plan

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Hawaii Statewide Transportation Asset Management Plan

June 30, 2019

DEPARTMENT OF TRANSPORTATION • STATE OF HAWAII •

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The State of Hawaii Department of Transportation (HDOT) is pleased to present its June 2019 Transportation Asset Management Plan. The State's transportation system remains committed to its mission and to preserving the investment it has made in its infrastructure. This Plan provides a solid foundation for making informed pavement and bridge infrastructure planning and programming decisions for the next 10 years. The benefits of this present-day transportation asset management plan are critical in developing a process for the State to achieve and sustain a state of good repair over the life cycle of its pavement and bridge assets.

Pavement and bridge infrastructure provide the central transportation network that allows for the efficient movement of people, goods, and services on each of our islands. If the transportation system cannot keep up with demand, we feel the effects in our schedules, our pocketbooks, and throughout our daily lives. This infrastructure needs regular maintenance and preservation activities to help it last longer and enable us to receive the most value from our transportation dollars.

The HDOT uses a data-driven, risk-based approach to asset management. Our Pavement Management System and Bridge Management System help to ensure that the right treatment is applied at the right time. The management systems optimize the asset condition and lowest practical life cycle to prioritize the right projects and best manage the transportation system.

This Transportation Asset Management Plan, as required by the FAST Act, describes those processes and formally defines HDOT's framework for asset management. Further, it projects needed levels of future investment to meet asset condition targets, contrasted with expected funding levels. This Plan evokes an important conversation regarding funding for a sustainable transportation system and allows a strong future for the State to provide it. We will also continue our collaborative efforts statewide to meet our future needs.

In addition, this Transportation Asset Management Plan is available online at the HDOT's Highway Division webpage (http://hidot.hawaii.gov/highways/).

Sincerely,

JADE T. BUTAY
Director of Transportation

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CHAPTER 1

Introduction

Overview

The Hawaii Department of Transportation (HDOT) is responsible for planning, designing, constructing, operating, and maintaining Hawaii's transportation assets. Maintaining the National Highway System (NHS) is a top priority for the HDOT because of its vital contribution towards the economy, national security, and mobility and because the pavements and bridges of the NHS represent the HDOT's two largest land transportation assets.

> The HDOT's mission is to provide a safe, efficient, accessible, and sustainable inter-modal transportation system that ensures the mobility of people and goods and enhances or preserves economic prosperity and the quality of life.
> To this end, the TAMP establishes and documents policies and processes to guide the efficient use of Hawaii's resources for infrastructure investments in a data-driven, performance-based, and risk-based approach that is transparent and defensible.

Transportation asset management is a process to systematically manage transportation infrastructure through the asset's life cycle, in a cost-effective way. The Moving Ahead for Progress in the 21st Century Act (MAP-21), signed into law in July 2012 and codified in 23 United States Code (U.S.C.) §119, requires all states to develop and implement a risk-based Transportation Asset Management Plan (TAMP) that provides strategies to achieve national goals and state-established condition and performance thresholds for the NHS.

What is in the TAMP?

A TAMP is a document that outlines a 10-year investment strategy for preserving existing assets. This plan enables the documentation of current system conditions, established condition targets, evaluates risks, and helps guide transportation investment decision making.

This TAMP focuses on pavement and bridges on the NHS to meet the requirements specified in 23 *Code of Federal Regulations* (CFR) Part 515. The HDOT will consider additional assets for future inclusion into the TAMP as additional data are collected, processes are enhanced or developed, TAMP operational funding is secured, and an adequate organizational structure is further established. Statewide, the HDOT Highways Division is responsible for multiple assets, which include pavement, bridges, drainage (structures and culverts), tunnels, highway lighting, overhead signs, traffic signals, transportation management systems (including interconnect fiber), sidewalks, guard rails, pavement markings, office buildings, maintenance yards, and other transportation-related facilities.

The TAMP is organized as follows:

Chapter 2 outlines the proposed TAMP approach and process.

Chapter 3 documents current asset conditions.

Chapter 4 establishes asset performance measures and targets.

Chapter 5 evaluates asset performance and quantifies the gaps in condition.

Chapter 6 addresses environmental vulnerability and sustainability.

Chapter 7 evaluates risks that could impact the system condition or reliability.

Chapter 8 documents life-cycle planning strategies.

Chapter 9 identifies available funding.

Chapter 10 recommends investment strategies.

Chapter 11 identifies areas of potential improvement in asset management.

Transportation asset management is by defined by FHWA as a "strategic and systematic process of operating, maintaining, and improving physical assets, with a focus on both engineering and economic analysis based upon quality information, to identify a structured sequence of maintenance, preservation, repair, rehabilitation, and replacement actions that will achieve and sustain a desired state of good repair over the life cycle of the assets at minimum practicable cost."

Challenges and Opportunities

The HDOT has historically focused on building infrastructure to increase capacity, expand access, enhance mobility, and improve safety and operations. However, the growing gap between funding needs and availability has severely constrained the HDOT's ability to grow and expand the transportation system. Economic realities necessitate greater focus and priority on maintaining and preserving existing assets and extending the assets' life to the greatest extent possible in the most fiscally responsible way.

The TAMP provides an opportunity for the HDOT to develop a strategic approach to managing its assets using economic, business, technology, and engineering considerations. Through the TAMP process, the HDOT will have more complete, accurate, and comprehensive data, analyses, and recommendations to make more informed and holistic decisions for the long-term public good. This will result in the most cost-effective investment decisions across multiple assets over time.

Hawaii's Transportation System

The state of Hawaii includes eight major islands, of which six are permanently inhabited and have functionally classified roadways. The statewide transportation system is approximately 9,800 lane miles. The federal-aid system, which consists of interstates, arterials, and collectors, is 40 percent of the entire system. Statewide, there are 1,172 bridges in total, with a total deck area of approximately 14,000,000 square feet.

Island State

Hawaii is the 50th and most recent state to join the United States, having joined on August 21, 1959, and is the only state composed entirely of islands. The state's eight major islands are Niihau, Kauai, Oahu, Molokai, Lanai, Kahoolawe, Maui, and the Island of Hawaii. The last, the largest island in the group, is often called the Big Island or Hawaii Island to avoid confusion with the state as a whole.

The Hawaiian Islands are home to more than 1.4 million people and draw over 9 million visitors each year. Hawaii's population is expected to grow to 1.65 million by 2045; this rise in population will bring greater pressure on natural resources and increasing demand on the transportation system.[1] Hawaii is the 4th smallest state in land area size and the 11th-least populous, but includes the 11th-largest city of the fifty U.S. states. The state's coastline is about 750 miles long, the 4th-longest in the U.S.

Uniqueness of Hawaii's Roadway System

All of Hawaii's islands are of volcanic origin, and as such, many of the islands feature one or more mountains or mountain ranges in the interior sections of the island, with flatter eroded topography along the coastline. Most of the major roadways that provide vehicular connectivity and mobility are constructed on these flatter coastline sections. On the islands of Hawaii and Maui, roadway systems completely encircle the island, forming a belt road or beltway. For other islands, roadways systems may encircle only a portion of the island, or roadways may continue along the coastline and end at some point, providing only one-way major access to communities.

Unlike other parts of the U.S., the useable land area in Hawaii is very limited. Many of the roadways are confined by developments abutting the facilities or by natural topographic features. Expansion of existing facilities or constructing alternative routes are cost-prohibitive and come with significant environmental impacts. In addition, the high cost of construction is exacerbated by the limited resources (including materials and labor) on the islands. Each island has its own unique system, vital to that island.

Typical belt road, between the ocean and mountain on the island of Maui: Honoapiilani Highway

Hawaii's existing functional classification system is like that of the rest of the U.S.; however, because of island geography and topography, Hawaii significantly relies on belt roads around the islands more so than the mainland. The functional classification of these belt roadways is either principal arterials on the NHS or minor arterials.

Because of the limited roadway options, the NHS serves many functions in many areas. The reliance on the NHS and the constrained geography may increase traffic and congestion on roadways designated as arterials. Many of these belt roadways carry a large volume of traffic and serve as the primary means to transport freight and goods and are essential to the well-being of the communities they serve. Furthermore, there can be significant adverse effects to those communities in the event of an emergency or other unplanned incident on the roadway system.

[1] DBEDT. 2018. Population and Economic Projections for the State of Hawaii to 2045.

As the primary road, the arterials also serve as both collectors and local roads, with small roads and driveways connecting directly to the principal arterial. Conversely, there may be roads on small islands or in other areas that are isolated from the remaining parts of the state. These roads may not meet the specific criteria for a given classification, but still operate as an arterial or collector.

Historic Roosevelt Bridge on Oahu

The Existing System

The NHS is a subset of the entire roadway system. It provides an interconnected system of freeway and principal arterial routes that serve population centers, ports, airports, military bases, public transportation facilities, and other intermodal transportation facilities and major travel destinations; meet strategic national defense requirements; and serve interregional travel. With Hawaii being an island state, although there are no inter-state or international border crossings, the NHS remains vital infrastructure providing service to the state.

Six of the eight major islands contain functionally classified roadways, and four of those islands include NHS routes: Hawaii, Maui, Oahu, and Kauai. These NHS roadways are under both state and county jurisdictions, as shown on Figure 1.1. The islands of Molokai and Lanai have both state and county roads (none of which are on the NHS). The islands of Niihau and Kahoolawe do not have any roads under the jurisdiction of the HDOT or individual county public works departments. The breakdown of NHS pavement and bridges compared to the statewide system is shown below in Table 1.1 and on Figure 1.2.

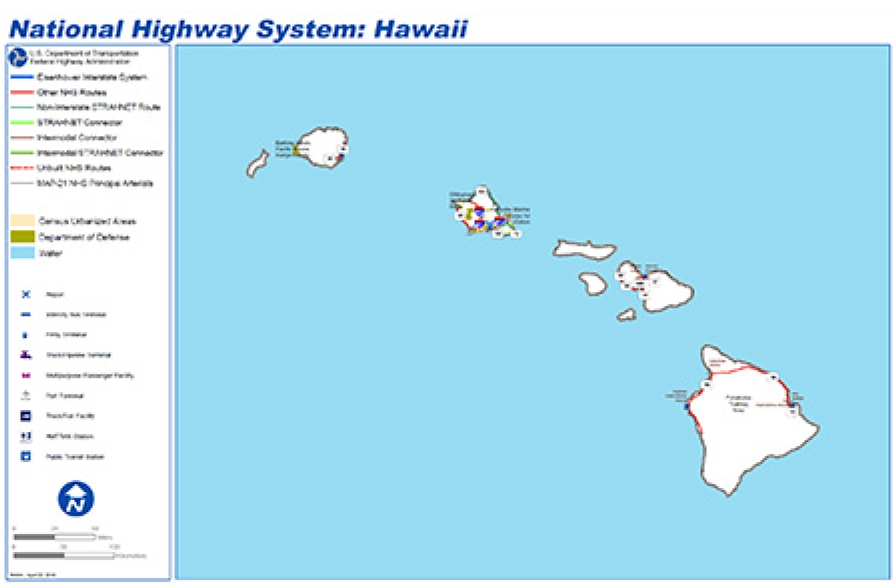


Figure 1.1. National Highway System

Source: http://www.fhwa.dot.gov/planning/national_highway_system/nhs_maps/hawaii/hi_hawaii.pdf

Table 1.1. NHS vs. Non-NHS Pavement and Bridges

NHS Pavement	1,433 lane miles
Non-NHS Pavement	8,322 lane miles
NHS Bridges	530 bridges (11,614,198 square feet of deck area)
Non-NHS Bridges	642 bridges (2,405,987 square feet of deck area)

Source: HDOT 2017

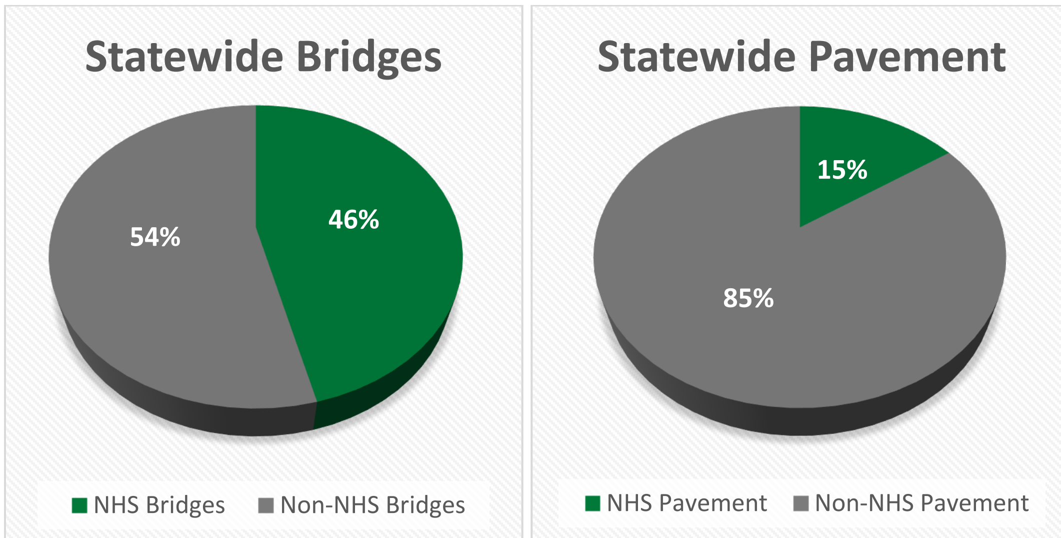


Figure 1.2. Percentage of NHS Pavement and Bridges on the State Land Transportation System

Although only 15 percent of the state's entire land transportation system is part of the NHS, those roads carry close to 50 percent of the daily volume of traffic, as shown on Figure 1.3. Similarly, the number of bridges that are on the NHS is 46 percent of the total number of bridges; however, the deck area of the NHS bridges is 86 percent of the total, as shown on Figure 1.3.

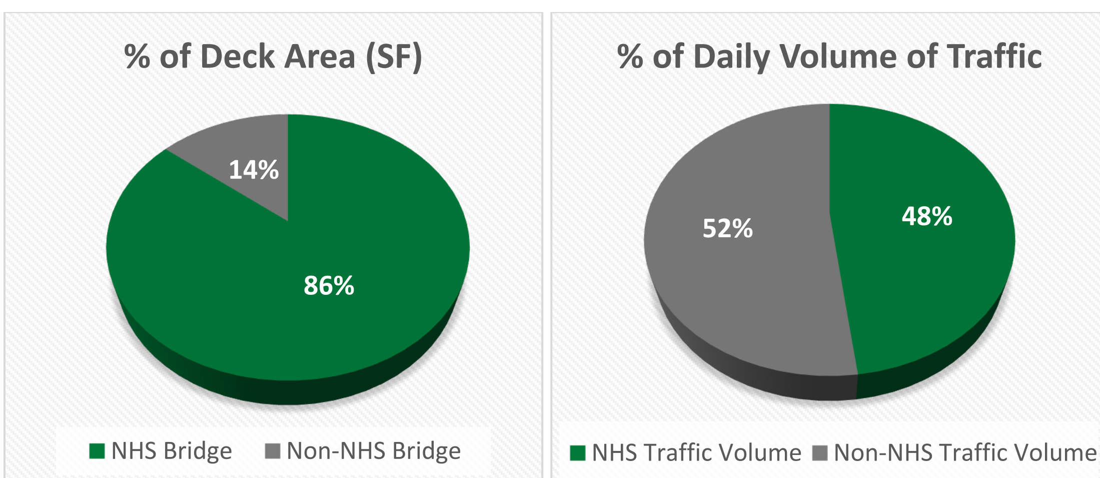


Figure 1.3. Daily Volume of Traffic and Deck Area on the NHS vs. the non-NHS

Local Jurisdictions

There are five counties in the State of Hawaii: Kauai County, comprising the islands of Niihau and Kauai; the City and County of Honolulu, comprising the island of Oahu; Maui County, comprising the islands of Maui, Molokai, Lanai, and Kahoolawe (with the exception of the Kalaupapa peninsula on Molokai); the County of Kalawao, which encompasses the Kalaupapa peninsula on the Island of Molokai (note that there are no state roads within the County of Kalawao); and Hawaii County, comprising the Island of Hawaii. Counties in Hawaii are the only legally constituted government bodies below state level. Honolulu is governed as the City and County of Honolulu, a county that covers the entire island of Oahu. Figure 1.4 shows the breakdown of pavement and bridges located within each county.

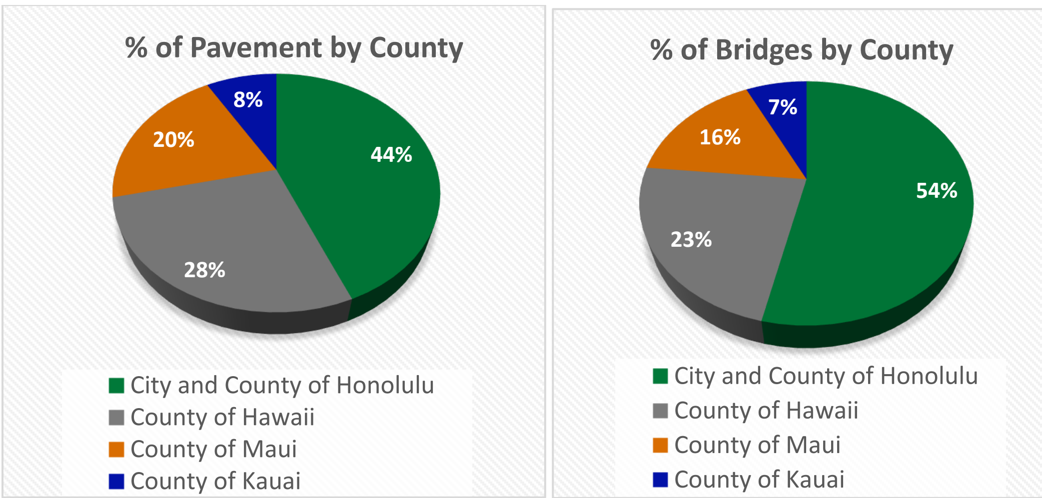


Figure 1.4. Percentage of Pavement and Bridges in each County

As shown on Figure 1.5, there are four districts within the HDOT:

A. Oahu District: Comprises the island of Oahu
B. Kauai District: Comprises the island of Kauai
C. Maui District: Comprises the islands of Maui, Molokai, and Lanai
D. Hawaii District: Comprises the island of Hawaii

There are also two metropolitan planning organizations (MPOs) within the state:

A. OahuMPO: Comprises the entire island of Oahu
B. Maui MPO: Comprises the entire island of Maui

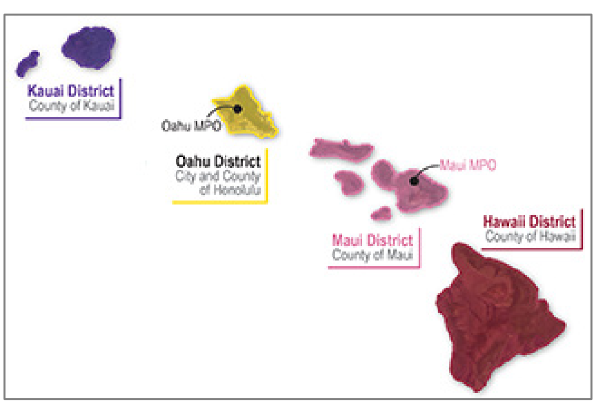


Figure 1.5. Jurisdiction Map in the State of Hawaii

CHAPTER 2

Asset Management Approach and Process

Asset management is an integrated set of processes to minimize the life cycle costs of owning and cost-effectively operating and maintaining assets. Asset management provides data-driven answers to the question of how to operate and maintain assets while accepting some level of risk and meeting the level of service the traveling public expects. The HDOT's executive leadership is committed to implementing asset management initiatives for the state's roadways so that valuable resources can be effectively used to provide maximum benefits to the people of Hawaii.

Asset Management uses data analyses to compare processes and results against desired results and performance goals and targets.

Federal Requirements

MAP-21 contains requirements for the development of TAMPs that include strategies leading to a program of projects that would make progress toward achieving the state targets for asset condition and performance of the NHS. MAP-21 requires a TAMP to include, at a minimum, the following seven components:

- A summary listing of the pavement and bridge assets on the NHS and a description of their condition
- Asset management objectives and measures
- Performance gap identification and analysis
- Risk management analysis
- Life cycle planning analysis
- A financial plan
- Investment strategies

MAP-21 also established seven national performance goals (23 U.S.C. 150(b)) (shown in Table 2.1) that provide general direction for investments in the national transportation system. State departments of transportation (DOTs) are responsible for monitoring and reporting on performance in these areas using national measures that have been developed by the U.S. DOT through a series of rulemaking processes. The measures are intended to carry out the National Highway Performance Program and assess the condition, performance, effectiveness, and progress of the Federal-Aid Highway Program at a regional, state, and national level.

Table 2.1. FHWA National Goals

Safety	To achieve a significant reduction in traffic fatalities and serious injuries on all public roads
Infrastructure Condition	To maintain the highway infrastructure asset system in a state of good repair
Congestion Reduction	To achieve a significant reduction in congestion on the National Highway System
System Reliability	To improve the efficiency of the surface transportation system
Freight Movement and Economic Vitality	To improve the National Highway Freight Network, strengthen the ability of rural communities to access national and international trade markets, and support regional economic development
Environmental Sustainability	To enhance the performance of the transportation system while protecting and enhancing the natural environment
Reduced Project Delivery Delays	To reduce project costs, promote jobs and the economy, and expedite the movement of people and goods by accelerating project completion through eliminating delays in the project development and delivery process, including reducing regulatory burdens and improving agencies' work practices

The Fixing America's Surface Transportation (FAST) Act was signed into law in December 2015 and includes provisions to (1) make the federal surface transportation system more streamlined, performance-based, and multimodal and (2) address challenges facing the U.S. transportation system. This includes improving safety, maintaining infrastructure condition, reducing traffic congestion, improving the efficiency of the system and freight movement, protecting the environment, and reducing delays in project delivery. The FAST Act builds on the changes and requirements of MAP-21 as they relate to asset management.

Governance

Asset management is viewed as a way of doing business, and organizational culture may be one of the most significant obstacles to advancing asset management in an agency. Implementation of the TAMP will require coordinated business processes between the HDOT's districts and branches to successfully achieve the performance goals and objectives.

Development of this TAMP has provided the opportunity to improve coordination between the HDOT's maintenance, preservation, and capital programs, as well as the Planning, Design, Materials and Testing Laboratory (Lab), Traffic, and individual district offices. To emphasize the HDOT's commitment to asset management, an Asset Management Leadership Team to guide the implementation of asset management throughout the HDOT and to monitor the progress at every step was created. The Leadership Team is led by the Highways Administrator and will comprise representatives from the following major branches:

- Planning
- Lab
- Design
- Traffic
- Project Coordination and Technical Services
- Budget Office
- District offices

The enhanced organization structure brings greater clarity to the process, better identifies the roles and responsibilities at each level, and brings new parties to the process. The overarching goals of the TAMP are to provide a process to help the HDOT achieve and sustain a state of good repair over the life cycle of the assets, and to improve or preserve the condition of the NHS. The HDOT's objectives are as follows:

GOAL: Provide a process to help HDOT achieve and sustain a state of good repair over the life cycle of its assets.

- Implement plans and projects to support the transportation asset management process
- Establish data governance and data collection standards
- Facilitate coordination, collaboration, and knowledge transfer within the team
- Communicate the transportation asset management activities to the executive levels of the HDOT
- Pursue the solicitation and promotion of asset management best practices
- Promote transportation asset management benefits and uses throughout the HDOT, counties, and other external stakeholders

The Leadership Team is supported by the activities of various subgroups, as highlighted on Figure 2.1.

Figure 2.1. Asset Management Leadership Team Subgroup Organization

The Approach

Consistent with best management practices, this TAMP uses a data-driven, performance-based, and risk-based approach that does the following:

- Guides decisions that are consistent with overarching national and state policies and goals
- Builds upon established policies, plans, and processes
- Uses a technical and data-driven process based on quality information
- Evaluates assets using performance-based targets
- Considers the life cycle of assets to develop preservation and investment strategies
- Tracks progress in a long-term, ongoing, and collaborative process
- Is transparent and defensible

The Process

The TAMP will use a data-driven and technical process that will objectively guide investment decisions to operate, maintain, and improve transportation assets, and will justify the HDOT's funding needs. The data collection and technical evaluation will be conducted in an ongoing and iterative process of activities, as shown on Figure 2.2 and described in this section.

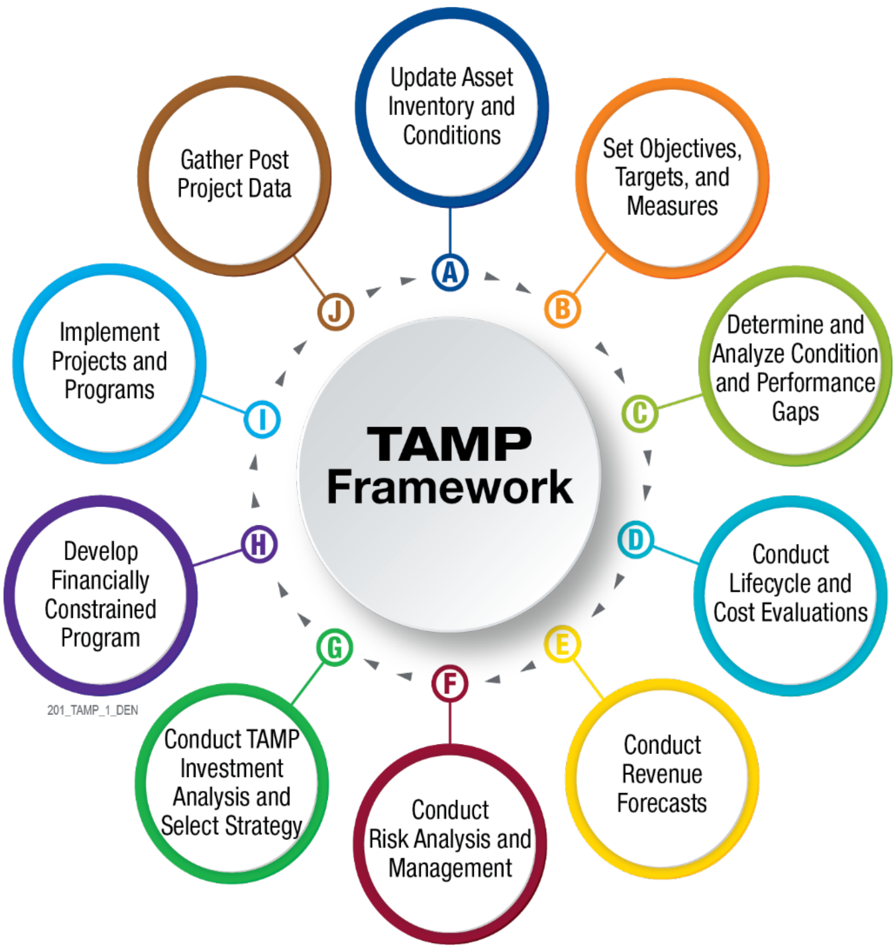


Figure 2.2. HDOT TAMP Framework and Activities

A. **Update Asset Inventory and Conditions**

- What assets do we have?
- What are the current conditions of the assets?
- How well are they performing?

B. **Set Objectives, Targets, and Measures**

- What are the objectives of the TAMP?
- What is the desired state?
- How will it be measured?

C. **Determine and Analyze Condition and Performance Gaps**

- What and where are the differences between actual and desired conditions?
- What are the differences between asset types?

D. **Conduct Life Cycle and Cost Evaluations**

- What is the expected life of the assets?
- How will the assets depreciate and decline in value and state of good repair?
- When will repairs or treatment be necessary to prevent assets from slipping from one level of maintenance to the next?
- What is the cost of the appropriate level of maintenance?

E. **Conduct Revenue Forecasts**

- What is the current revenue and sources?
- What factors might affect revenues in the future?
- How much money can we reasonably expect?
- What are the present inflation rate assumptions and future purchasing power?

F. **Conduct Risk Analysis and Management**

- What are the threats and risks that may prevent achieving desired goals?
- What are the strategies to avoid, minimize, mitigate, and manage risks?

G. **Conduct Investment Analysis and Select Strategy**

- What are the best investment strategies?
- What is the minimum life cycle cost of the assets?
- What life cycle treatment types can be considered?
- What is the cost of treatment type?
- What risks should be considered?
- Identify investment scenarios and select an investment strategy
- Perform gap analysis

H. **Develop Financially Constrained Program**

- Which projects from the pavement and bridge management systems should be carried forward to the Mid-Range Transportation Plan (MRTP)?
- Make cross-asset comparisons and decisions between the range of HDOT's programs
- Which projects should move forward to be programmed into the 10-year MRTP?

I. **Implement Programs and Projects**

- Include in MRTP and Statewide Transportation Improvement Program (STIP)
- Budget State funds
- Monitor costs and schedules
- Enter into contract with consultant or contractors
- Perform improvements

J. **Gather Post-Project Data**

- How are we doing?
- Gather data related to estimated vs. actual costs; estimated vs. actual service life by treatment type; completion date; treatment limits; and treatment type by location or mile post, as appropriate
- Update management systems and long-range plans with data

Figure 2.3. Plan-Do-Check-Act Process

Much like every Plan-Do-Check-Act process, as shown on Figure 2.3, the TAMP process starts all over again to ensure the best investments are being made. As operational budgets are planned for and secured, reorganizations are implemented, additional data are collected and made available, and data systems are enhanced or established, the HDOT will incorporate other relevant asset data into the TAMP as the program matures. Time is needed to further research and evaluate the availability of existing data and challenges in the extraction and conversion of such data into a new or enhanced data system, and then to determine additional data needs and develop budgetary and implementation timeline estimates. These will be presented in future updates to the TAMP.

Integration of the TAMP into HDOT's Planning and Programming Components

The HDOT has other plans, management systems, and programs that contain asset and other data. From these sources, policies, goals, and objectives are set; solutions are developed, evaluated, and prioritized; and projects are generated. These plans include, but are not limited to, the following:

- Hawaii Statewide Transportation Plan (HSTP)
- Statewide Federal-Aid Highways 2035 Transportation Plan
- Federal-Aid Highways 2035 Transportation Plan for the District of Kauai
- Federal-Aid Highways 2035 Transportation Plan for the District of Maui
- Federal-Aid Highways 2035 Transportation Plan for the District of Hawaii
- Oahu Regional Transportation Plan 2040
- Statewide Freight Plan
- Statewide Pedestrian Plan
- Bike Plan Hawaii

Figure 2.4 depicts the relationship between the TAMP and these transportation plans and programming components. The HSTP focuses on broad policy, goals, and objectives for the three primary modes of transportation—air, water, and land systems—as well as nonmotorized modes and intermodal connections. The statewide modal plans provide overarching goals and ensure equity and consistency among the regional or county plans.

Figure 2.4. TAMP and other Planning and Programming Components

Program development (Figure 2.4's teal boxes) is where each of the regional plans fit within the planning process as a facility master plan. Other facility master plans, such as the HDOT's Bike Plan, Statewide Pedestrian Master Plan, and the Statewide Freight Plan, are also developed in this part of the planning process. Each of these plans identifies needs and potential solutions to address the needs. The TAMP has a 10-year planning horizon and considers the needs and solutions developed in each of the facility master plans, as well as the regional plans. All of these plans identify priorities, which feed into the MRTP. The MRTP considers the State's goals and objectives, priorities, and project readiness. A cross-asset/program evaluation and prioritization is conducted.

As an example, based on the investment strategies of the TAMP, a preventative project (such as slurry sealing Kamehameha Highway) would be recommended. This slurry seal project would meet the State's system preservation goals and objectives, be prioritized in the TAMP, and move forward in the cross-asset evaluation to the MRTP.

The projects placed on the MRTP feed into the STIP, Transportation Improvement Plans (TIP), Capital Improvement Program (CIP), and Special Maintenance Program (SMP), and are implemented. This process ensures that all of the investments made in programming are consistent with the HDOT's long-term vision and mission.

Project management (the green boxes) includes budgeting and project development. It is the last step of the overall process, where individual projects are funded, permitted, designed, and constructed.

Figure 2.5 simply shows the progression of solutions from the 20-year long-range plan to the 10-year MRTP to the 4-year STIP.

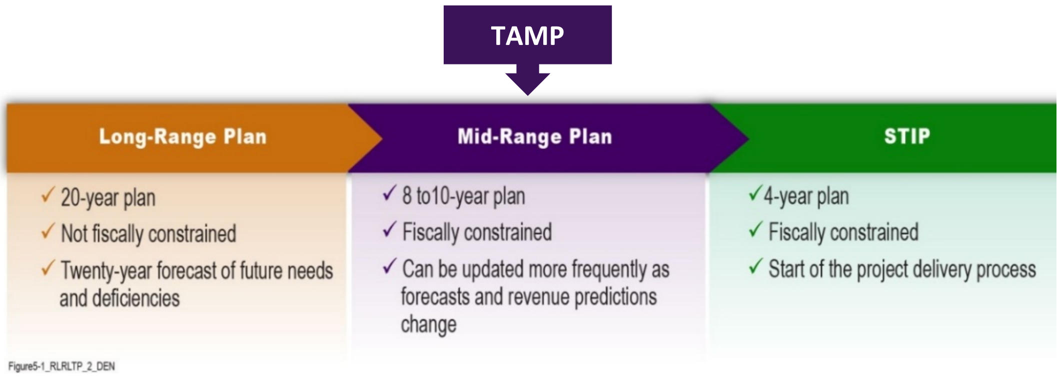


Figure 2.5. Implementation from Long-Range Plan to Mid-Range Plan to STIP

CHAPTER 3

Inventory and Condition

Overview

Information is necessary to develop a robust TAMP. To have a data-driven, performance-based TAMP, asset inventory and condition data are needed. These data provide the foundation for supporting asset management process, such as life cycle planning, prioritizing projects, and determining future needs.

As mentioned earlier, the HDOT has a lot of assets to maintain and manage. This TAMP is focused on NHS pavement and bridges, critical transportation infrastructure that is vital for Hawaii's economy and survival. Future TAMPs may include all of the State's pavement and bridges and other important infrastructure.

Federal Requirements

23 CFR Part 515 requires that the TAMP include a summary listing of NHS pavement and bridge assets and conditions, regardless of ownership. In addition, minimum standards for developing pavement and bridge management systems are listed under §515.13. The minimum management systems shall have procedures for:

A. Collecting, processing, storing, and updating inventory and condition data for all NHS pavement and bridge assets;

B. Forecasting deterioration for all NHS pavement and bridge assets;

C. Determining the benefit-cost over the life cycle of assets to evaluate alternative actions (including no action decisions), for managing the condition of NHS pavement and bridge assets;

D. Identifying short- and long-term budget needs for managing the condition of all NHS pavement and bridge assets;

E. Determining the strategies for identifying potential NHS pavement and bridge projects that maximize overall program benefits within the financial constraints.; and

F. Recommending programs and implementation schedules to manage the condition of NHS pavement and bridge assets within policy and budget constraints.

Hawaii's NHS System

As mentioned in Chapter 1, the NHS provides an interconnected system of freeway and principal arterial routes that connects communities, ports, airports, military bases, and major travel destinations. The majority of the NHS in Hawaii is under State jurisdiction, with a small percentage under county jurisdiction. The jurisdictional breakdown in Hawaii of pavement and bridges on the NHS is summarized on Table 3.1 and shown on Figures 3.1 and 3.2.

Table 3.1. NHS Pavement and Bridges

Jurisdiction	NHS Pavement (lane-miles)	NHS Bridges (each)
State	1329	520
Oahu District	852	380
Hawaii District	247	83
Maui District	177	42
Kauai District	53	15
City and County of Honolulu	80	9
County of Maui	0	0
County of Hawaii	24	1
County of Kauai	0	0
Total	**1,433**	**530**

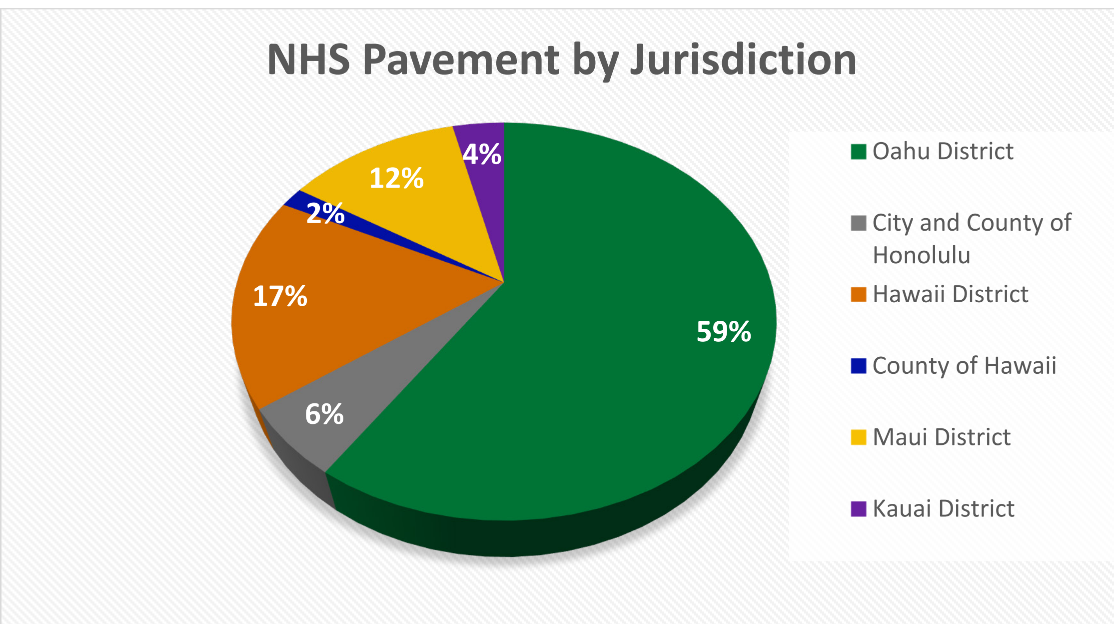


Figure 3.1. NHS Asset Jurisdiction – Pavement[1]

[1] Note that numbers have been rounded to the nearest whole percent.

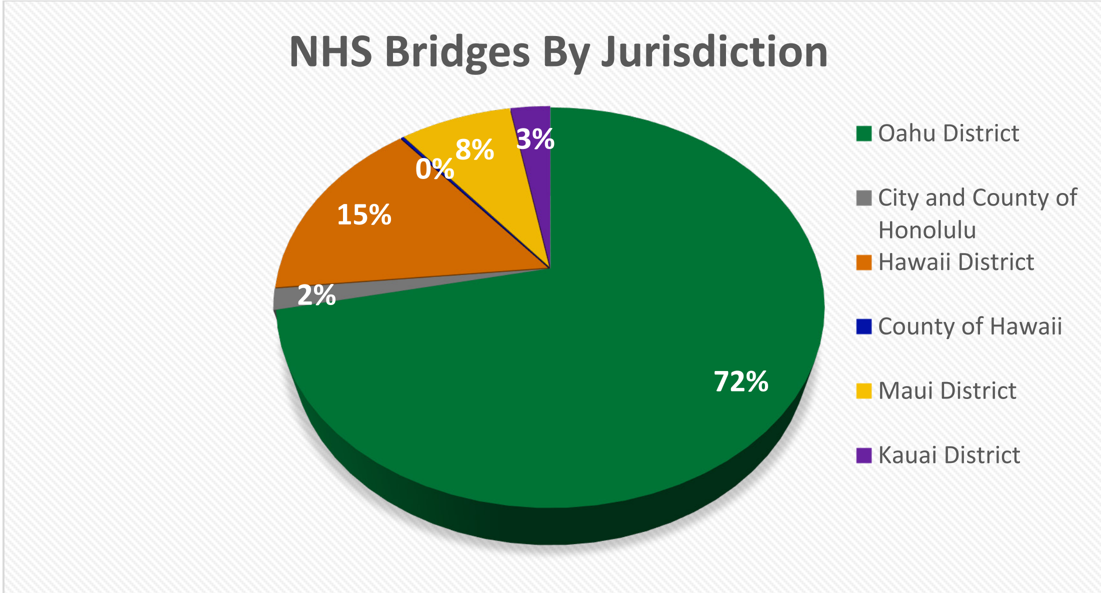


Figure 3.2. NHS Asset Jurisdiction – Bridges[1]

[1] Note that numbers have been rounded to the nearest whole percent.

Coordination with Counties and MPOs

The State Transportation Planning (STP) office implements the HDOT's transportation planning process. STP convenes quarterly (or as needed) meetings that bring together governmental agencies imperative to transportation planning in Hawaii, to coordinate and collaborate on the State's transportation planning process. Involved agencies include the HDOT Highways, Airports, and Harbors Divisions, City and County of Honolulu, County of Hawaii, County of Maui, County of Kauai, Federal Highway Administration (FHWA), Oahu MPO, Maui MPO, and other applicable governmental agencies. During the development of this TAMP, the process and methodology was shared with these important stakeholders.

The City and County of Honolulu and County of Hawaii are the only two jurisdictions that have roads on the NHS that are not owned by the HDOT. The HDOT met separately with each agency to discuss their pavement management and bridge management programs. Data collection, data sharing, risks, maintenance strategies, and how the pavement and bridge projects are prioritized were all discussed. The HDOT collects all of the NHS pavement data for the state.

The HDOT continues collaboration and coordination with the OahuMPO and Maui MPO to discuss the TAMP objectives, TAMP program needs, and program priorities, and share draft pavement and bridge performance targets. Important discussions about performance measures, impacts to other program needs, vision, and goals for their long-range transportation plans, as well as effects to the STIP and TIP, are covered. The HDOT has data sharing agreements with both MPOs.

Data Management

Through the Highway Performance Monitoring System (HPMS) program, the HDOT collects a variety of data on the federal-aid highway system, regardless of jurisdiction. These data are shared with the City and counties. Each jurisdiction manages their own pavement management system (PMS) but collaborates on lessons learned and successful preventative maintenance strategies. Bridge condition data are collected through bridge inspections done by the individual jurisdictions, then reported to the HDOT and ultimately to the FHWA, to support the National Bridge Inventory (NBI). The jurisdictions also share strategies and resources; for example, bridge inspectors from one jurisdiction may assist with bridge inspections in another (because of the limited number of bridge inspectors a jurisdiction may have). Recently, the HDOT has been using consultants for their bridge inspections across the state. Communication and coordination of the inspections is helping to ensure consistency and quality of the inspection reports.

The HDOT has numerous data management systems for storing and managing inventory and condition data.

The HDOT also understands the significance of the management and quality control of its data resources. Data provide the foundation of the Pavement and Bridge Management Systems. As part of the TAMP process and HDOT's commitment, the HDOT has established a Data Governance group to oversee the collection of all asset data collection and to establish data standards and guidelines. Recommendations for process improvements of data management are shared in Chapter 11.

Data management is at the foundation of a TAMP, as follows:

- Data access (How easy is it to retrieve the data?)
- Data quality (How accurate and useful are the data?)
- Data integration (Can different data sets be combined and from different sources?)
- Data governance (Who oversees the data and what are the policies for managing the data?)

HDOT Pavement Program

Hawaii Pavement Inventory

Pavements are a critical part of the HDOT transportation network, providing mobility and access to a wide variety of users and being used to move goods for the economic vitality of the state. Overall, the State and individual counties maintain over 9,800 lane-miles of pavement. The federal-aid highway system consists of approximately 3,864 lane-miles (Table 3.2). As the population and economy continues to grow, the state's pavement inventory is also expected to grow. However, as required by FHWA, this TAMP will only include the pavement conditions for the 1,433 lane-miles of interstate and non-interstate NHS. The HDOT plans to include the entire state system in future iterations of the TAMP.

Table 3.2. Federal-Aid Highway System Pavement Breakdown (excluding bridges)

Federal-Aid Highway System	Lane Miles
Interstate	290
Non-Interstate NHS	1,143
State Highways/Roads	1,087
County Highways/Roads	1,344

Pavement Conditions

The HDOT has adopted FHWA's pavement condition performance measures, as follows:

- Good condition: Suggests no major investment is needed.
- Fair condition: Suggests that minor investment and preventative maintenance is needed.
- Poor condition: Suggests major reconstruction investment is needed.

The pavement conditions are calculated based on data that the HDOT collects through the HPMS. The pavement conditions are determined by using quantitative data on the following metrics (and shown on Figure 3.3):

- **International Roughness Index (IRI)** is often referred to as pavement roughness. It is an indicator of irregularities in the pavement surface that adversely affect the ride quality of a vehicle (and therefore the road user).

- **Cracking** is measured by the percentage of cracks in the pavement surface. Cracks are often caused (or accelerated) by excessive loading, poor drainage, poor subbase, and construction flaws.

- **Rutting** is a typically caused by heavy traffic and heavy vehicles. It is measured in asphalt by the depth of the rut along the wheel path.

- **Faulting** is a difference in elevation across a concrete joint or crack (usually along concrete slab edges). It can be caused by misaligned concrete slabs, settlement, warping, or a combination thereof. There are two types of concrete pavement: jointed concrete pavement (JCP) and continuously reinforced concrete pavement (CRCP). Currently, only the jointed concrete pavement type is used in the state.

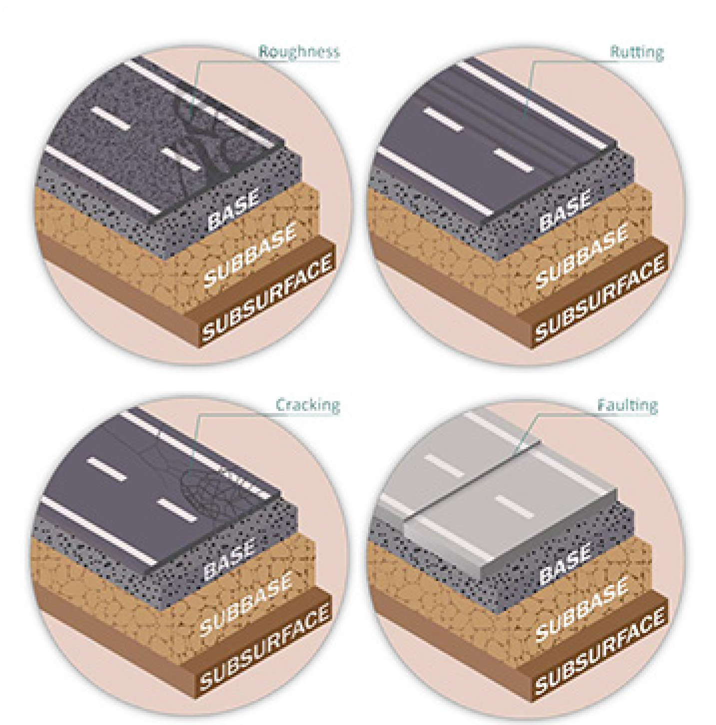


Figure 3.3. Four Pavement Condition Metrics

Source: Caltrans Draft Transportation Asset Management Plan, October 2017

Pavement Raveling

Rippling or Shoving

Wheel Track Rutting

Alligator Cracking

Potholes/Raveling

Examples of Bad Pavements

Examples of Good Pavements

It should also be noted the FHWA does allow the Present Serviceability Rating (PSR) to be used for roads where the speed limit is less than 40 miles per hour.

The FHWA provides guidance for pavement condition thresholds for each section of roadway, as shown in Table 3.3.

Table 3.3. Pavement Condition Thresholds

	Good	Fair	Poor
IRI (inches/mile)	<95	95-170	>170
Rutting (inches)	<0.20	0.20-0.40	>0.40
Faulting (inches)	<0.10	0.10-0.15	>0.15
Cracking (%)	<5	5-20 (asphalt) 5-15 (JCP) 5-10 (CRCP)	>20 (asphalt) >15 (JCP) >10 (CRCP)

Each pavement section is then determined to be in good, fair, or poor condition by the FHWA guidance for the Calculation of Pavement Measures shown in Table 3.4.

Table 3.4. Calculation of Pavement Measures

	Pavement Type		
	Asphalt and Jointed Concrete	Continuously Reinforced Concrete	
Overall Section Condition Rating	**3 metric ratings (IRI, cracking, rutting/faulting)**	**2 metric ratings (IRI and cracking)**	**Measures**
Good	All three metrics rated "Good"	Both metrics rated "Good"	**Percentage of lane-miles in "Good" condition**
Poor	Two out of three metrics rated "Poor:	Both metrics rated "Poor"	**Percentage of lane-miles in "Poor" condition**
Fair	All other combinations	All other combinations	

HDOT's Pavement Management System (PMS)

The HDOT collects statewide pavement condition data annually on the interstate routes and biennially on non-interstate routes. HDOT pavements consist of two types: flexible and rigid. Flexible pavements are typically asphalt pavement, while rigid pavement is jointed concrete (JCP). Figure 3.4 show the percentage of NHS pavement type in the state.

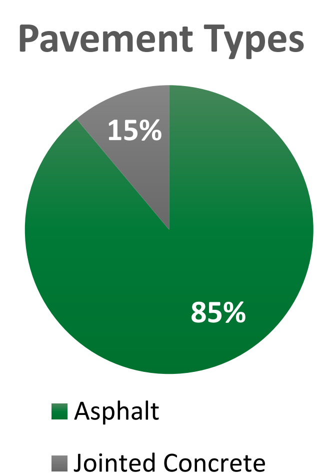


Figure 3.4. Percentage of NHS Pavement Type

The pavement data collected are entered into HDOT's PMS. The HDOT uses AASHTOWare Bridge Management (BrM) software that has been customized for pavements as its PMS, as shown on Figure 3.5. BrM uses a data-driven foundation that assigns a score for every pavement section. This is called the Utility Value, shown on Figure 3.6.

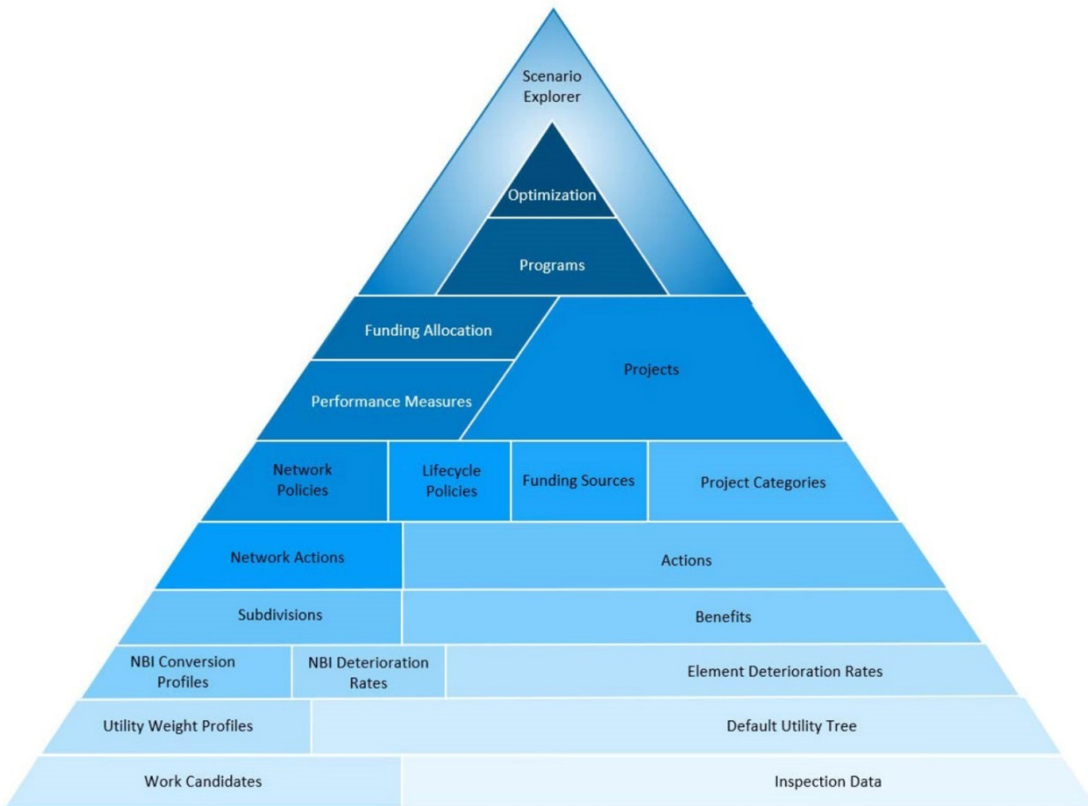


Figure 3.5. Pavement and Bridge Management Pyramid
Source: HDOT, *AASHTOWare BrM Software*

Deterioration models are developed for every element: asphalt and concrete. The BrM modeling system uses multi-objective decision-making to evaluate a utility value based on the weighted averages of conditions of the pavement elements, life cycle (preservation actions), risk, and mobility strategies. With consideration of the deterioration of the elements, all possible work actions are evaluated and the BrM program selects the work action that provides the highest increase in Utility Value (also known as benefit) divided by the cost of the work action. Ultimately, each project (work action) can be scored and ranked. The project score is based on the benefit/cost ratio times the structure weight of each section, which is based on the total surface area, traffic volume, and functional classification. Figure 3.7 shows a sample ranking of work actions for the HDOT's PMS.

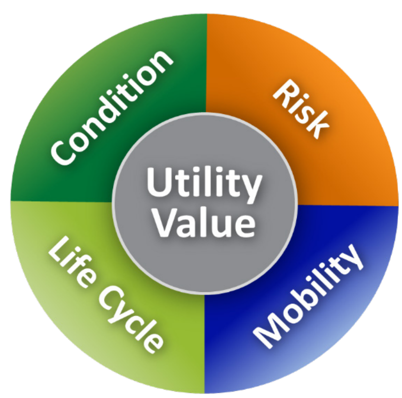


Figure 3.6. PMS Utility Value

Rank	Section	Route	Begin MP	End MP	Direction	District
1	Oahu_H-1_011.25_012.84_+MP	H-1	11.25	12.84	+MP	Oahu
	Recommended Action: Slab Jacking; Diamond Grinding		Cost: $2,229,173	Year: 2019		
2	Oahu_7601_000_000.41_-MP	7601	0.00	0.41	-MP	Oahu
	Recommended Action: Overlay; Asphalt Repair		Cost: $110,639	Year: 2019		
3	Oahu_63_005.75_008.28_-MP	63	5.75	8.28	-MP	Oahu
	Recommended Action: Slab Jacking; Diamond Grinding		Cost: $1,945,045	Year: 2019		
4	Oahu_8930_000_002.47_+MP	8930	0.00	2.47	+MP	Oahu
	Recommended Action: Slurry Seal		Cost: $1,443,652	Year: 2019		
5	Oahu_99_022.13_023.84_+MP	99	22.13	23.84	+MP	Oahu
	Recommended Action: Mill and Fill; Asphalt Repair		Cost: $2,383,570	Year: 2020		
6	Oahu_63_000_001.15_+MP	63	0.00	1.15	+MP	Oahu
	Recommended Action: Overlay; Asphalt Repair		Cost: $1,884,681	Year: 2020		
7	Hawaii_19_023.09_025.76_+MP	19	23.09	25.76	+MP	Hawaii
	Recommended Action: Mill and Fill; Asphalt Repair		Cost: $2,825,144	Year: 2020		
8	Maui_32B_000_000.17_+MP	32B	0.00	0.17	+MP	Maui
	Recommended Action: Overlay; Asphalt Repair		Cost: $252,071	Year: 2020		

Figure 3.7. Sample Report of PMS Work Recommendations by Rank
Source: AASHTOWare BrM Software

Figure 3.8 represents the process flow of HDOT's PMS and continuous feedback loop. Data are collected on HDOT's pavement inventory; BrM then conducts the pavement analysis and creates a draft prioritized list of recommendations. District Engineers review the recommendations and validate the findings. The draft list is finalized and the recommendations are designed and constructed. The performance of the recommendations is tracked and more data are collected, starting the PMS process again.

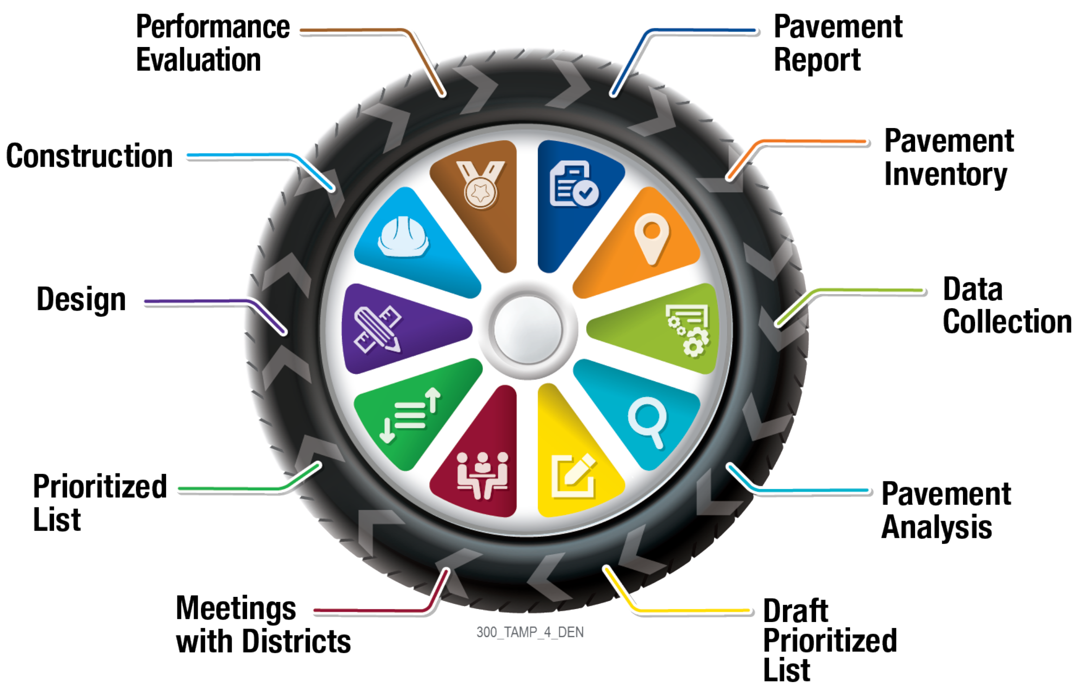


Figure 3.8. Pavement Wheel

Summary of NHS Pavement Conditions

Figure 3.9 summarizes the current condition of pavement (2017) on the NHS, while Table 3.5 summarizes NHS pavement inventory and conditions by jurisdiction.

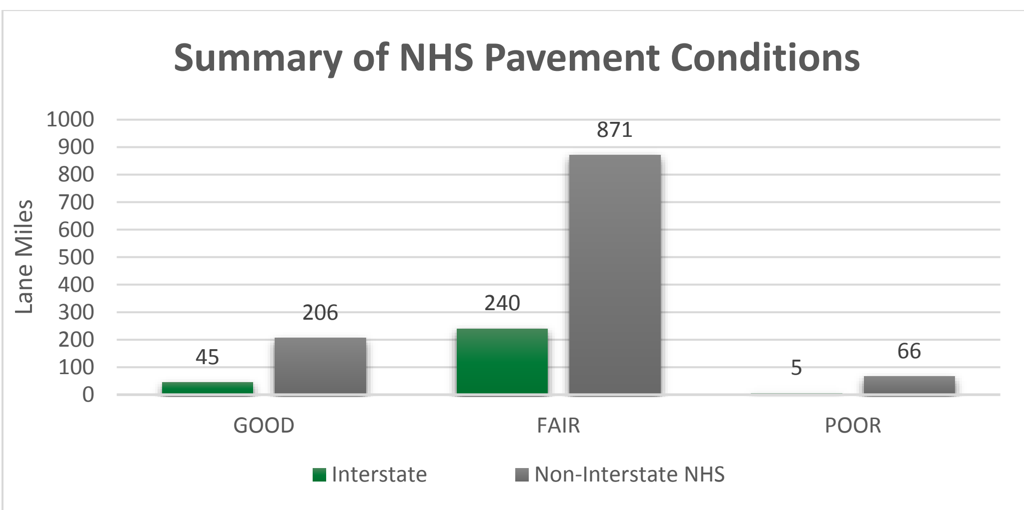
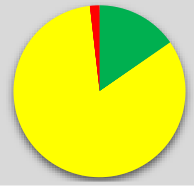
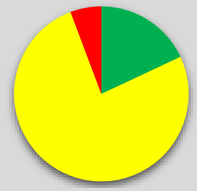
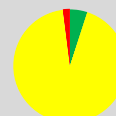
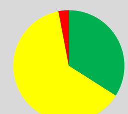
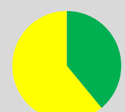
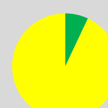


Figure 3.9. Summary of NHS Pavement Conditions

Table 3.5. NHS Pavement Inventory and Condition

	Lane- Miles	Good	Fair	Poor	
All NHS					
Interstate	290	15%	83%	2%	
Non-Interstate NHS	1143	18%	76%	6%	
By Jurisdiction					
Oahu District	852	5%	93%	2%	
Hawaii District	247	34%	63%	3%	
Maui District	177	39%	61%	0%	
Kauai District	53	7%	93%	0%	
City and County of Honolulu	80	0%	87%	13%	
County of Hawaii	24	0%	100%	0%	

HDOT Bridge Program

Hawaii Bridge Inventory

There are 1,172 total bridges on state and county roadways in Hawaii, of which 530 structures are on the NHS. A structure is considered to be a bridge (23 CFR 650 Subpart C –National Bridge Inspection Standards) if the following conditions are met:

- Is a structure including supports erected over a depression or an obstruction?
- Has a track or passageway for carrying traffic or other moving loads.
- Has an opening measured along the center of the roadway of more than 20 feet between undercopings of abutments or spring lines of arches or extreme ends of openings for multiple boxes.

NBI Component Condition Rating Values:

9 – Excellent
8 – Very Good
7 – Good
6 – Satisfactory
5 – Fair
4 – Poor
3 – Serious
2 – Critical
1 – "Imminent" Failure
0 – Failed

The majority of bridges in Hawaii are predominately concrete girder structures, although a small number of the bridges were originally constructed for the sugar plantation railroads and are of steel trestle construction, which were later retrofitted to carry vehicular traffic. The HDOT also has a small number of wood bridges that are in the process of being replaced by concrete structures. The majority of bridges in Hawaii are over 50 years old. In comparison, the average bridge-structure age of bridges nationwide is 40 years.[2] With the large number of older bridges in Hawaii, the HDOT implements repairs and rehabilitation to try to extend the service life of bridges as much as possible. Bridge replacement projects are expensive and usually challenging with environmental issues.

In accordance with 23 CFR §650, Subpart D, the HDOT maintains a bridge management system (BMS) that contains data for all state- and county-owned bridges in the state. The HDOT BMS is AASHTOWare BrM, which includes a programming module that meets FHWA requirements.

Data are collected from bridge inspection reports biannually using in-house forces or vendors. As recorded in the NBI, the HDOT determines and tracks structural condition and sufficiency ratings.

Bridge Conditions

The HDOT has adopted FHWA's bridge condition performance measures, as follows:

- Good condition (weighted by deck area)
- Fair condition (weighted by deck area)
- Poor condition (weighted by deck area)

The FHWA NBI standards for inspections are based on a minimum value rating for a bridge's three components: deck, superstructure, and substructure, as shown on Figure 3.10. The scale goes from 0 (worst) to 9 (best).

[2] TR News 2640-Sept-Oct 2009

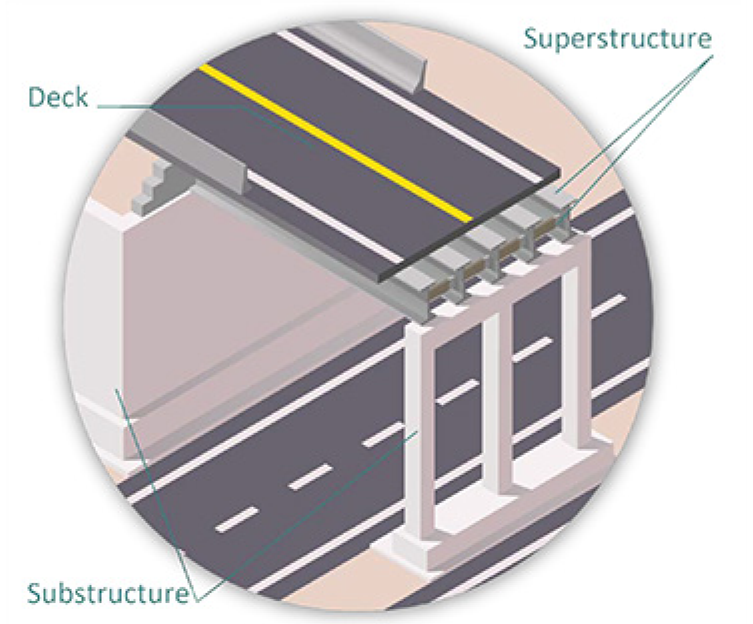


Figure 3.10. Bridge Components
Source: Caltrans Draft Transportation Asset Management Plan, October 2017

The FHWA has provided the following guidance for determining bridge condition:

- The lowest of the three ratings for deck, superstructure, and substructure determines the overall rating of the bridge as shown on Figure 3.11.
- A bridge is determined to be in poor condition when the minimum value of NBI deck, superstructure, and substructure is calculated and is considered to be in poor condition.

	Condition Rating Thresholds for Classification Type			
	NBI Rating Scale *(from 0 -9)*	9 8 7 Good	6 5 Fair	4 3 2 1 0 Poor
BRIDGE	Deck *(Item 58)*	≥ 7	5 or 6	≤ 4
BRIDGE	Superstructure *(Item 59)*	≥ 7	5 or 6	≤ 4
BRIDGE	Substructure *(Item 60)*	≥ 7	5 or 6	≤ 4

Figure 3.11. Bridge Condition Rating Thresholds
Source: FHWA

HDOT's Bridge Management System (BMS)

The HDOT recognizes the importance of transparency and documentation to support decisions in project generation and prioritization. AASHTOWare BrM software is used for HDOT's BMS. BrM uses a data-driven approach, as shown on Figure 3.5. The foundation of the bridge management pyramid is based on information from bridge inspection reports, which are conducted on a 24-month (or less) cycle. BrM uses the inspection data to assign a score for every bridge. This score, called the Utility Value, is based for four factors: bridge condition, life cycle, risk, and mobility, as shown on Figure 3.12.

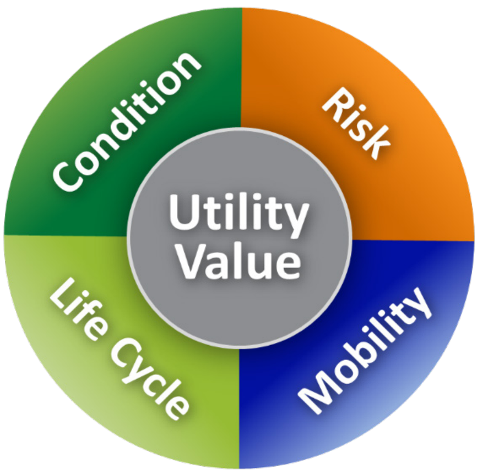


Figure 3.12. BMS Utility Value

The BrM modeling system uses a multi-objective decision-making to evaluate the factors based on the conditions of the many bridge elements, life cycle (preservation) strategies, risks, and mobility (such as functional classification, traffic volume, and length of a temporary bypass). All possible work actions are considered and the BrM program selects the option that provides the highest increase in Utility Value (also known as benefit), divided by the cost of the work action. Figure 3.13 shows a graph of how BrM optimizes. Ultimately, each project can be scored and ranked. The project score is based on the benefit/cost ratio times the structure weight of each section, which is based on the total surface area, traffic volume, and functional classification.

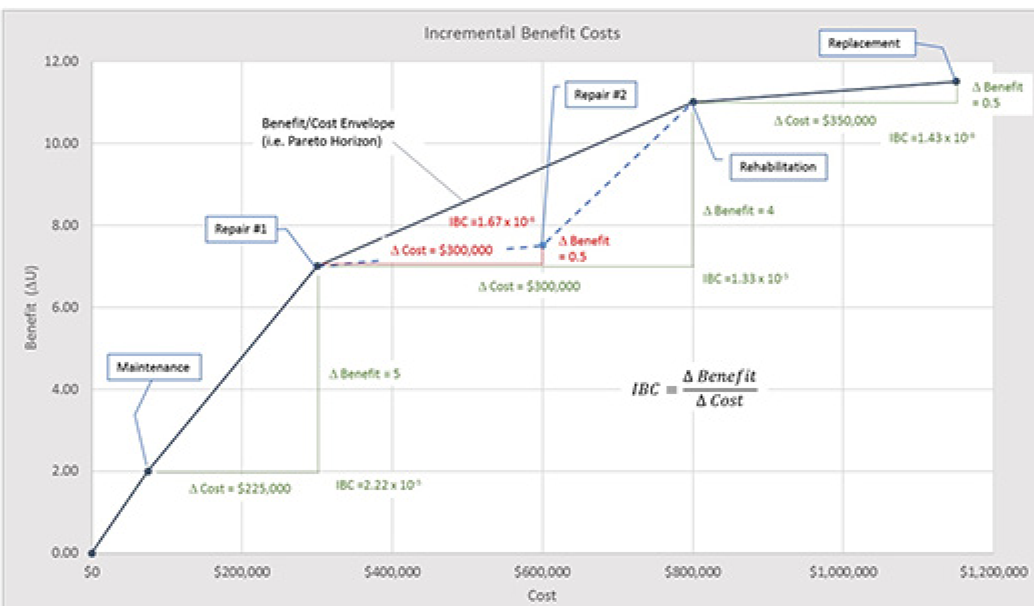


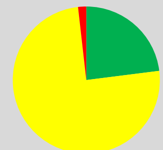
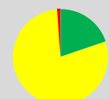
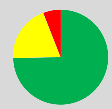
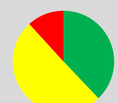
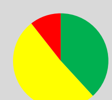
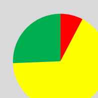
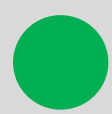
Figure 3.13. BrM Program Optimizer

Source: HDOT

Summary of NHS Bridge Conditions

Table 3.6 summarizes 2017 NHS bridge inventory and condition data by jurisdiction.

Table 3.6. NHS Bridge Inventory and Conditions

	Amount	Good	Fair	Poor	
All NHS					
NHS Bridges	530	23%	75%	2%	
By Jurisdiction					
Oahu District	380	20%	79%	1%	
Hawaii District	83	75%	19%	6%	
Maui District	42	38%	50%	12%	
Kauai District	15	38%	51%	11%	
City and County of Honolulu	9	25%	67%	8%	
County of Hawaii	1	100%	0%	0%	

Bridges in poor condition require additional monitoring, maintenance, or repair to ensure safe and continued service. If a bridge is in poor condition, it does not mean that it is unsafe or will immediately collapse. With updated federal legislation, FHWA requires that state DOTs maintain NHS bridges at less than 10 percent of the bridge deck area in poor condition. Table 3.7 provides a summary of the percentage of bridge deck area in poor condition for the last 5 years. Table 3.8 shows the number of bridges in poor condition for the last 5 years.

Table 3.7. Bridge Deck Area in Poor Condition[1]

Network System	Year				
	2013	2014	2015	2016	2017
NHS - ALL	1%	1%	2%	2%	2%
Interstate	0%	0%	0%	0%	0%
Non-Interstate NHS	5%	5%	5%	6%	9%
Non-NHS	6%	5%	6%	7%	5%

[1] Note that numbers have been rounded to the nearest whole percent.

Table 3.8. Number of Bridges in Poor Condition

Network System	Year				
	2013	2014	2015	2016	2017
NHS - ALL	20	21	23	24	31
Interstate	1	2	2	2	3
Non-Interstate NHS	19	19	21	22	29
Non-NHS	38	36	41	42	47

The data show that bridge conditions on the NHS in Hawaii are well below the FHWA threshold of 10 percent of total deck area of bridges on the NHS classified as poor condition.

Kapaa Stream Bridge on Kauai is in poor condition and is over 66 years old.

CHAPTER 4

Asset Management Performance Measures and Targets

A key component of asset management is using performance-based measures and targets to identify needed transportation improvements and monitor their effectiveness over time. To evaluate how well a project is performing, the transportation system is monitored and the results measured against the predetermined performance targets. Meeting these targets could mean that the implemented project was the appropriate one, and that there is value being gained from the dollars invested. If targets are not met, changes to the projects or priorities could be made to more effectively achieve the goal. Using these measures to assess roadway system performance after projects are implemented is an important part of the overall long-range planning process.

The performance management process, as illustrated on Figure 4.1, begins with shared goals and objectives, performance measures and targets for gauging progress, strategies for achieving the goals, and reporting to periodically assess and revise goals and objectives as needed.

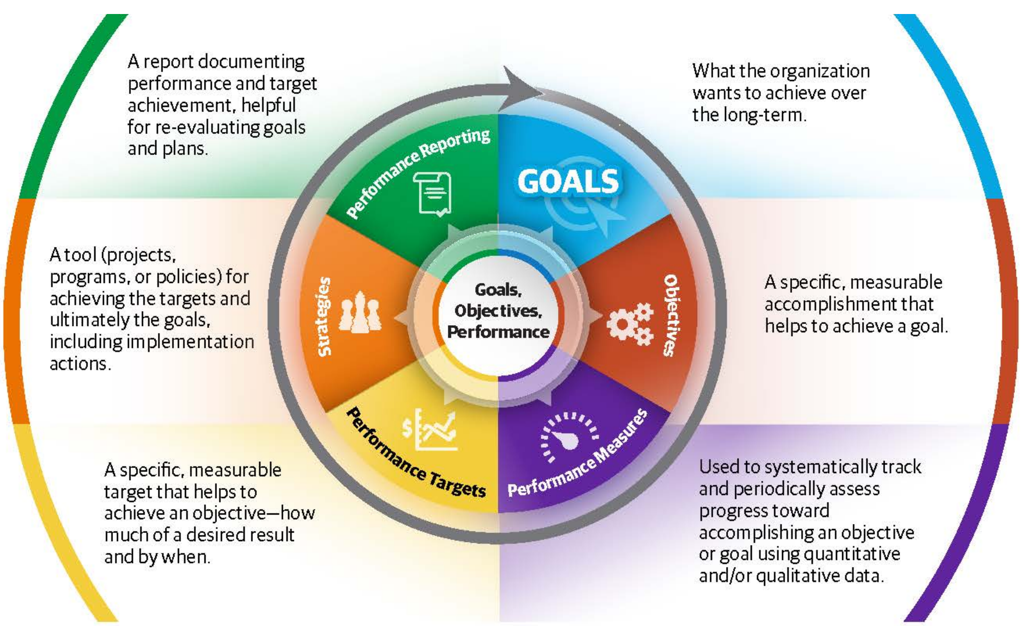


Figure 4.1. Performance Management Process

Long-range Planning Goals

Collectively, the long-range state, regional, and local plans guide the planning of Hawaii's transportation system and ultimately provide the basis for investment decisions in the system. These plans are developed within a consistent planning framework to ensure that the long-range planning process at the state and regional levels reflect the state's overall vision guiding future transportation investment decisions consistent with the HDOT mission.

Asset management is an integral part of the state's long-range transportation plans. As an example, system preservation and asset management are among key objectives for the HSTP Goal I, Mobility and Accessibility, and financing them are part of the objectives of Goal VII, Finance.

HDOT's Goals and Objectives

The overarching goal of the HDOT TAMP is to **provide a process to help the HDOT achieve and sustain a state of good repair over the life cycle of the assets, and to improve or preserve the condition of the NHS**. As noted in Chapter 2, the HDOT's objectives are as follows:

- Implement plans and projects to support the transportation asset management process.
- Establish data governance and data collection standards.
- Facilitate coordination, collaboration, and knowledge transfer within the team.
- Communicate the transportation asset management activities to the executive levels of the HDOT.
- Pursue the solicitation and promotion of best practices.
- Promote transportation asset management benefits and uses throughout the HDOT, counties, and other external stakeholders.

Performance Measures and Targets

The FHWA requires TAMPs to include performance measures and targets for asset condition for pavements and bridges on the NHS. The performance measures are intended to carry out the National Highway Performance Program and assess the condition, performance, effectiveness, and progress of the Federal-Aid Highway Program at a regional, state, and national level. Using the performance measures, states must define their desired state of good repair for the 10-year analysis period of the TAMP.

Table 4.1 presents the HDOT's performance measures and 10-year performance goals (desired state of good repair) for bridges and pavements on the NHS. The HDOT considered multiple risks and factors in its goal-setting, including the following:

- Existing inventory and conditions for all of the state's pavement and bridges
- Large number of older non-NHS bridges in the state's highway system that provide the only access to communities
- Other assets, such as drainage facilities, tunnels, highway lighting, signage, and traffic management facilities
- The needs of other programs (for example, capacity, congestion, bike and pedestrians, environment, and similar)
- Limited funding

- Shifting administrative and legislative priorities
- Project delivery resources available to deliver multiple bridges projects
- Diverting funds for emergency events

As part of the performance management rule, MAP-21 and the FAST Act set minimum condition levels for NHS pavements and bridges. States are required to have no more than 5 percent of their interstate pavements in poor condition and no more than 10 percent of NHS bridges, by total deck area, in poor condition. The HDOT meets both of these minimum condition requirements.

Table 4.1. HDOT's Performance Measures and Performance Goals for NHS Pavements and Bridges

Asset	Performance Measure	Current Condition 2017	2-Year Target 2019	4-Year Target 2021	Performance Goal (Desired Condition) 10-year Goal
Bridges	Percentage of NHS bridges classified in good condition	23%	20%	20%	20%
	Percentage of NHS bridges classified in poor condition	2%	2%	2%	2%
Pavements	Percentage of pavements on the Interstate in good condition	15%	N/A	7%	50%
	Percentage of pavements on the Interstate in poor condition	2%	N/A	4%	4%
	Percentage of non-Interstate NHS pavements in good condition	18%	15%	15%	25%
	Percentage of non-Interstate NHS pavements in poor condition	6%	4%	4%	2%

Note:

N/A = not applicable

State DOTS) are also required to establish 2- and 4-year targets that serve as interim indicators of changes in condition levels. The targets can help states determine how well they are progressing towards its long-term state of good repair goals. Table 4.1 also reflects the 2- and 4-year targets.

CHAPTER 5

Asset Management Performance Gap

As noted in Chapter 4, this TAMP provides an opportunity for the HDOT to develop performance measures and targets that unify federal, state, and regional goals and link observed performance to subsequent planning and programming decisions. These performance targets can be used to compare the current condition against the desired performance condition. Any gap between the two will inform the HDOT about the works that may be necessary to meet asset management objectives.

Federal Requirements

Performance gap means the gaps between the current asset condition and state DOT targets for asset condition, and the gaps in system performance effectiveness that are best addressed by improving the physical assets.

23 CFR Part 515 requires that states establish a performance gap analysis process for their TAMPs. As part of the gap analysis, the HDOT must compare the current asset performance to the target and/or desired performance condition. A projected asset performance is determined and compared to the target and/or the desired performance condition.

The following section describes the performance of Hawaii's bridges and pavement over the 2-, 4-, and 10-year periods. Projecting the conditions of the NHS pavement and bridges will allow the HDOT to see whether or not the asset performance will meet its goals.

Performance Gap Analysis Process

The HDOT is using the following steps to conduct its performance gap analysis:

A. Performance measures were proposed and established in Chapter 4 of this TAMP.

B. The current condition of the assets is presented in Chapter 3 of this TAMP.

C. BrM is used to conduct multiple performance-based scenarios based on condition and life cycle policies and consideration of the full life cycle. In addition, funding assumptions and risks are considered.

D. Based on the results of the different scenarios, the HDOT is able to identify a performance strategy and the gap between the desired condition or target and the current condition.

E. If a gap occurs between the desired condition/target and current condition, investment strategies will be identified to close or reduce the gaps.

What are the Gaps between Existing and Desired Performance?

The current asset conditions for NHS pavement and bridges was shared in Chapter 3. With the application of life cycle planning strategies, the HDOT is planning on investing in more preventative maintenance strategies to cost effectively minimize the life cycle cost and extend the overall pavement and bridge life.

The HDOT conducted a forecast of revenue over the next 10 years; this forecast is reflected in Chapter 9, Financial Plan. Based on the HDOT's financial plan and historic spending, HDOT ran a variety of performance scenarios in BrM. Based on these scenarios, the HDOT estimates that the average annual amount for NHS bridges should be $30 million per year over the next 10 years to meet the targets and goals.

Figure 5.1 shows the projected state of good repair and that an emphasis on life cycle planning strategies will keep more of the bridges in good condition over time. An emphasis on life cycle planning strategies means spending more on preservation work actions (at the minimum practical cost) vs. condition-based strategies, which would be addressing the worst-first work activities. Figure 5.1 also shows what happens to the state of good repair when no investment (funding) is made to the BMS.

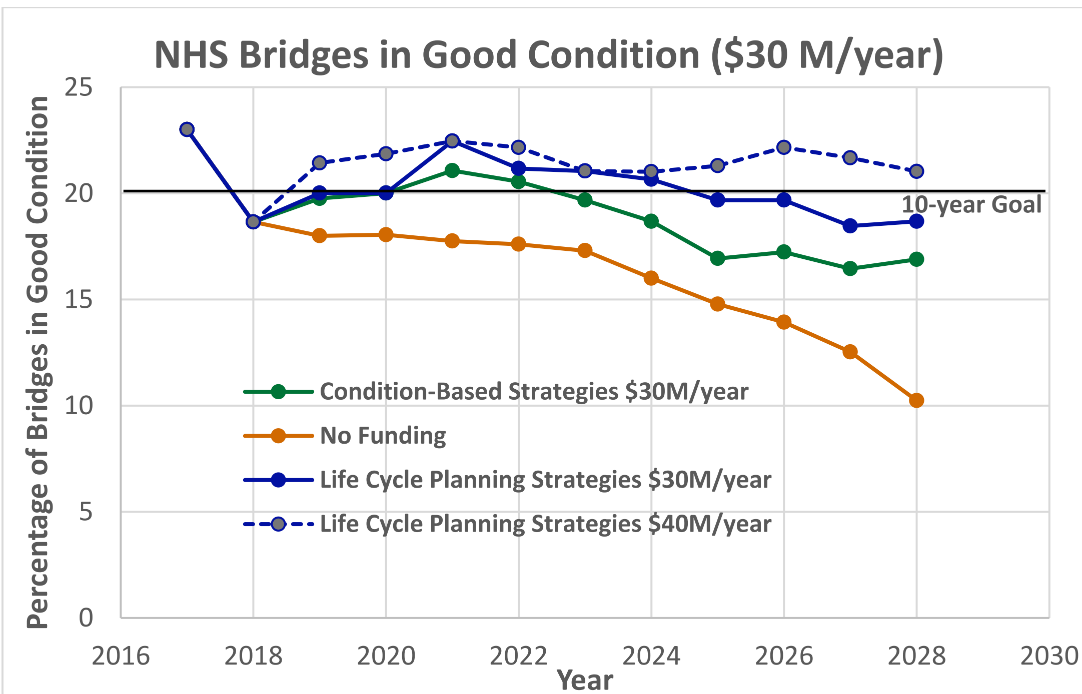


Figure 5.1. Projected State of Good Repair for NHS Bridges

Figure 5.2 shows the projected state of poor repair. In this case, the emphasis on life cycle planning strategies is less effective than an emphasis on bridge condition. This is due to the large number of bridges that are over 50 years old statewide (over 300 NHS bridges and over 400 non-NHS bridges). With the large number of older bridges, a larger investment is needed to replace and repair important older bridge elements both on and off the NHS to eliminate the poor condition. However, the HDOT realizes the importance of life cycle planning strategies to maintain and improve the state of good repair. Figure 5.2 also shows the increase to the state of poor repair when no investment (funding) is made to the BMS.

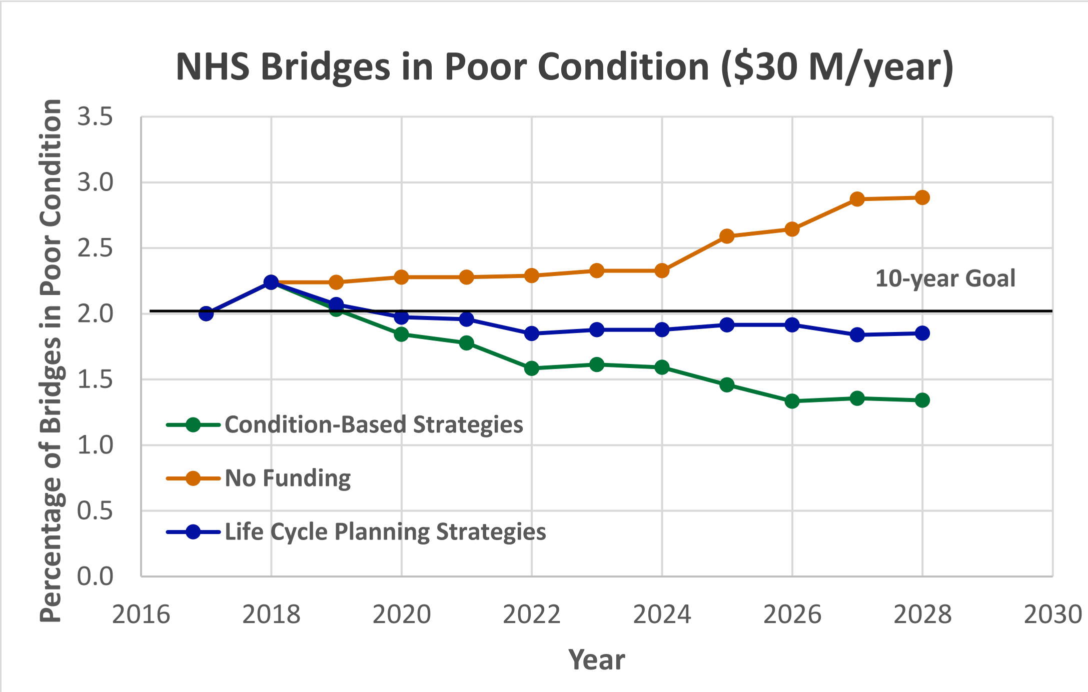


Figure 5.2. Projected State of Poor Repair for NHS Bridges

Table 5.1 presents the performance gap analysis for NHS bridges.

Table 5.1. NHS Bridge Asset Performance and Gap

NHS BRIDGES	Annual Funding	Good	Fair	Poor
Current Performance (2017)	$30-40 million	23%	75%	2%
2-year Target (2019)		20%		2%
2-year Projection	$30 million	20%		2%
4-year Target (2021)		20%		2%
4-year Projection	$30 million	22.5%		1.9%
10-Year Desired State of Repair (2027)		20%		2%
10-Year Projection	$30 million	18.5%		1.8%
10-Year Projected Gap		1.5%		No gap

As Table 5.1 indicates, the HDOT planned investments and life cycle strategies appear to be effective in HDOT meeting and exceeding its 2- and 4-year targets for NHS bridges. There is a 1.5 percent gap in obtaining HDOT's 10-year goal for NHS bridges in a state of good repair, although the HDOT is projecting to be successful in reducing the percentage of bridges in a state of poor repair. The HDOT believes it can reduce this gap by making additional investments in life cycle planning and bridge replacement based on the BrM data analysis. HDOT will re-evaluate the scenarios for the TAMP update and address the gaps then, if not already addressed through better maintenance and strategic bridge replacement. In addition, HDOT continues to work on ways to increase funding (Chapter 9, Financial Plan).

Figure 5.3 shows the projected state of good repair for Interstate pavements and that an emphasis on life cycle planning strategies will keep more of the pavement in good condition over time. An emphasis on life cycle planning strategies means spending more on preservation work actions (at the minimum practical cost) vs. condition-based strategies, which would be addressing the worst-first work activities. Figure 5.3 also shows what happens to the state of good repair when no investment (funding) is made to the PMS.

The HDOT looked at the forecast of revenue over the next 10 years, as well as the annual program and expenditures on the interstate. In 2017, $26 million was spent on the interstate in rehabilitation and reconstruction projects. This work is reflected in the significant jump in the state of good repair over the last year. Based on the HDOT's financial plan, historic spending, and a variety of performance scenarios run in BrM, the HDOT estimates that the average annual amount for Interstate should be $7 million per year over the next 10 years to meet the targets and goals.

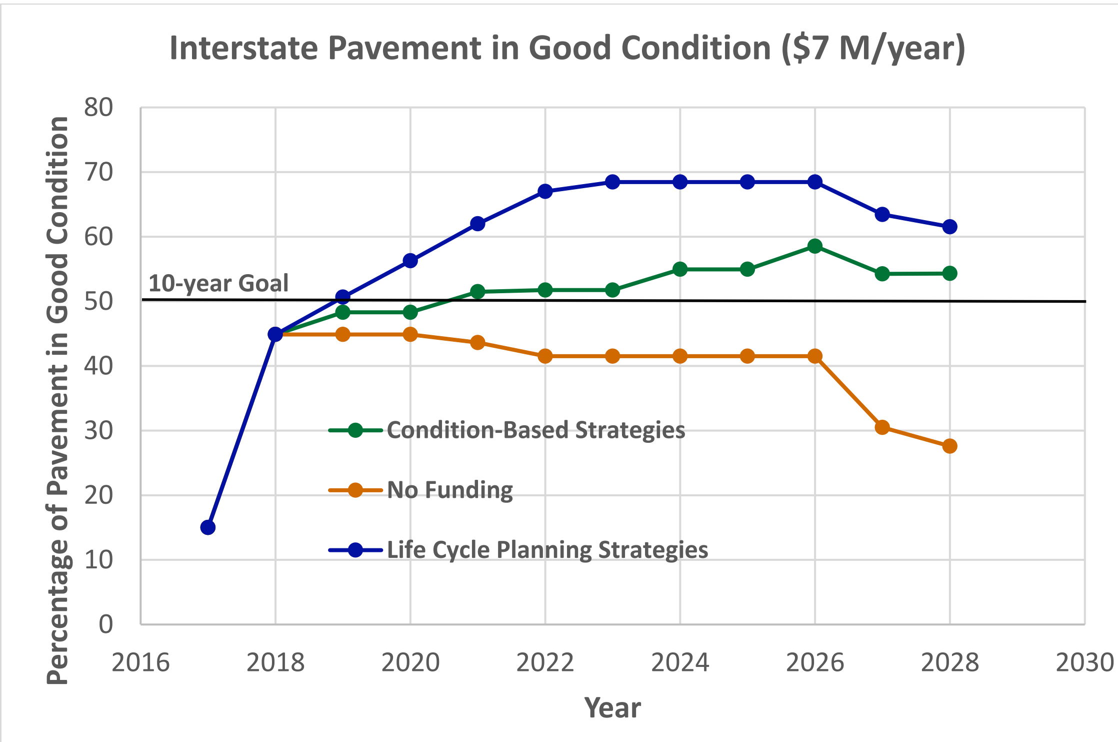


Figure 5.3. Projected State of Good Repair for Interstate Pavements

Figure 5.4 shows the projected state of poor repair. In this case, the emphasis on life cycle planning strategies is less effective than an emphasis on pavement condition. This is likely due to the current age and condition of the interstate. Preventative work activities will not be effective enough to prevent the good and fair pavement from reaching a poor condition (thus the increase in the percentage of poor condition). The significant investment made in 2017 to the interstate in rehabilitation and reconstruction projects is reflected in the significant reduction of Interstate pavement in the state of poor repair over the last year. Figure 5.4 also shows the increase to the state of poor repair when no investment (funding) is made to the PMS.

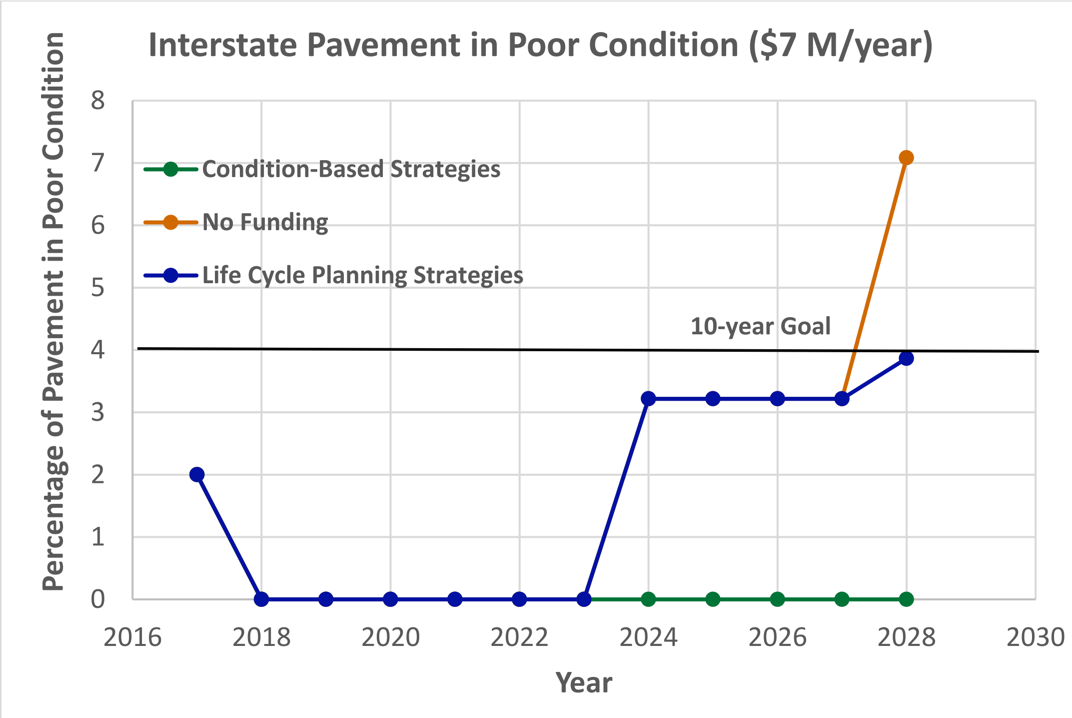


Figure 5.4. Projected State of Poor Repair for Interstate Pavements

Table 5.2 presents the performance gap analysis for the NHS Interstate. As Table 5.2 indicates, the HDOT planned investments and life cycle strategies appear to be effective in HDOT meeting and exceeding its 4-year target and 10-year goal for the interstate. There is no performance gap for the interstate.

Table 5.2. NHS Interstate Asset Performance and Gap

NHS INTERSTATE	Annual Funding	Good	Fair	Poor
Current Performance (2017)	$26 million	15%	83%	2%
4-year Target (2021)		7%		4%
4-year Projection	$7 million	62%		0%
10-year Desired State of Repair (2027)		50%		4%
10-year Projection	$7 million	63%		3.2%
10-year Projected Gap		No gap		No gap

Figure 5.5 shows the projected state of good repair for non-interstate NHS pavements. Based on the wide variety of performance scenarios run in BrM, it was discovered that the most effective strategy is one that has an equal emphasis on life cycle planning strategies and condition-based strategies. This scenario will keep more of the pavement in good condition over time. Figure 5.5 also shows what happens to the state of good repair when no investment (funding) is made to the PMS.

The HDOT looked at the forecast of revenue over the next 10 years, as well as the annual program and expenditures on the non-interstate NHS pavement. Based on the HDOT's financial plan, historic spending, and a variety of performance scenarios, the HDOT estimates that the average annual amount for non-interstate NHS pavement should be $30 million per year over the next 10 years to meet the targets and goals.

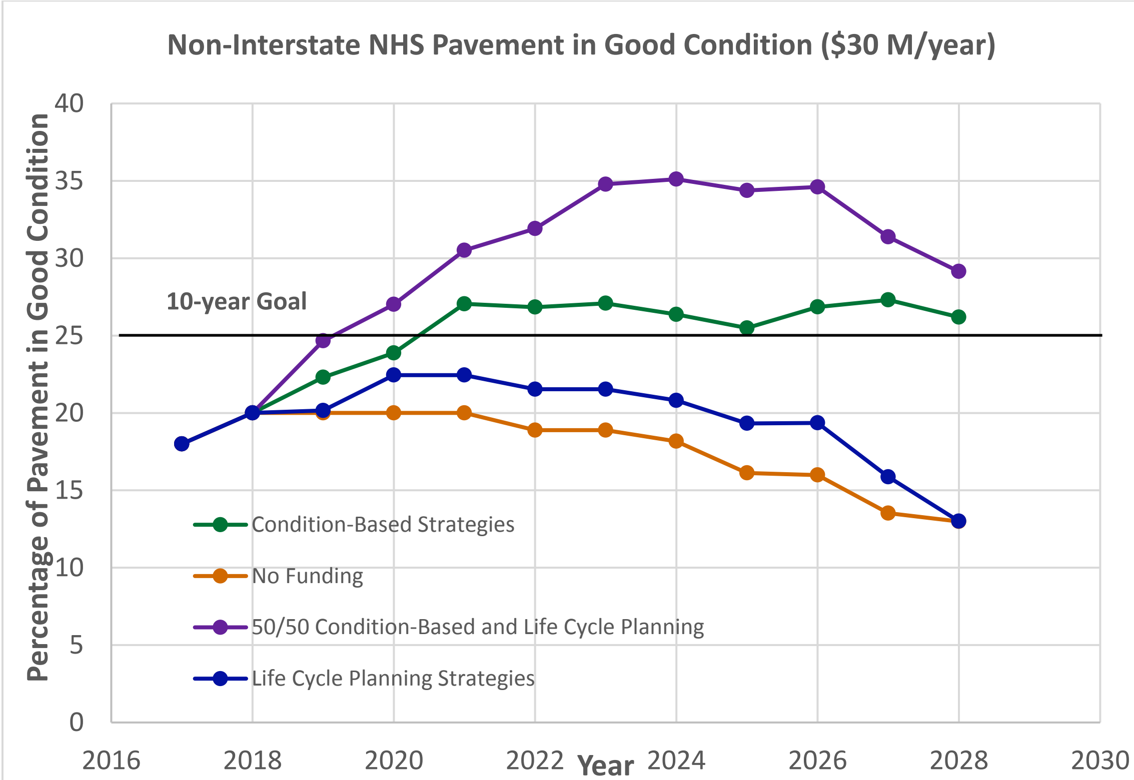


Figure 5.5. Projected State of Good Repair for Non-Interstate NHS

Figure 5.6 shows the projected state of poor repair. In this case, the emphasis on life cycle planning strategies is less effective than an emphasis on pavement condition. The equal emphasis on life cycle planning strategies and condition-based strategies is also less effective than an emphasis on pavement condition. Again, this is likely due to the current age and condition of the non-interstate NHS pavements. Preventative work activities will not be effective enough to prevent the pavement from reaching a poor condition. Figure 5.5 also shows the increase to the state of poor repair when no investment (funding) is made to the PMS.

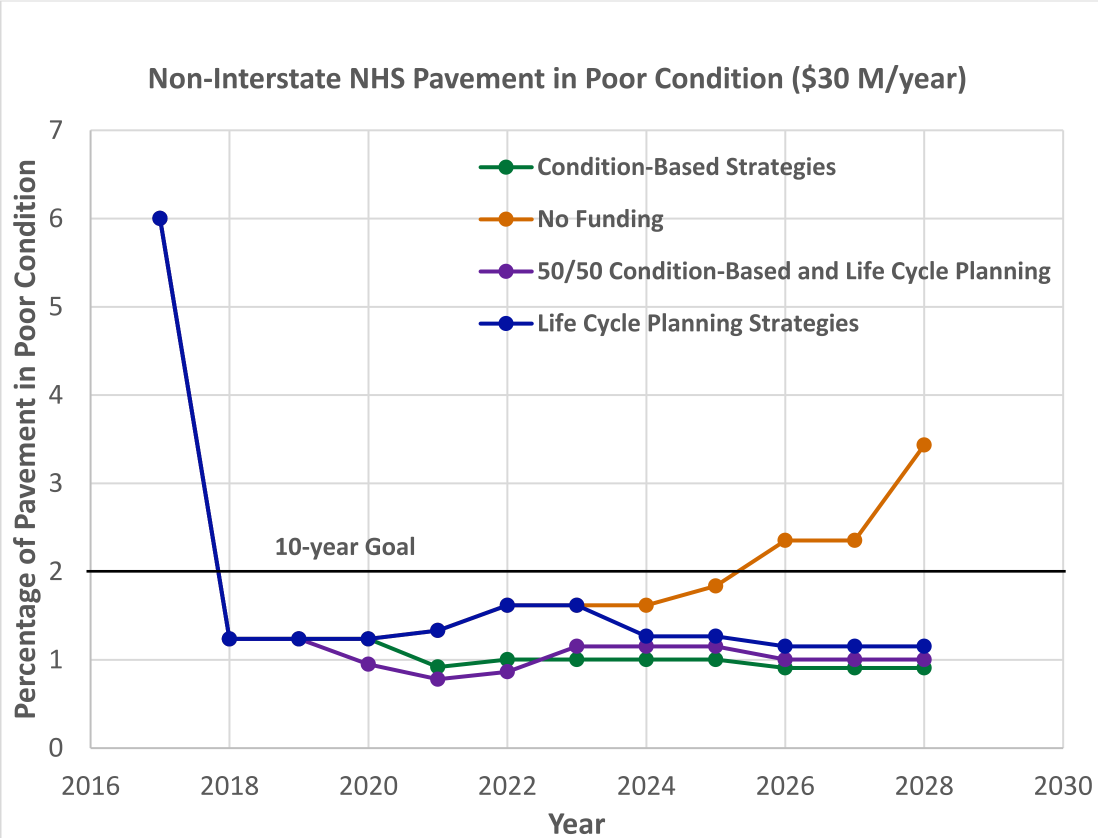


Figure 5.6. Projected State of Poor Repair for Non-Interstate NHS

Table 5.3 presents the performance gap analysis for the non-interstate NHS pavement. As Table 5.3 indicates, the HDOT planned investments and 50/50 condition-based and life cycle planning strategies are effective in HDOT meeting and exceeding its 2- and 4-year targets and its 10-year goal for the non-interstate NHS pavement. There is no performance gap for the non-interstate NHS pavement.

Table 5.3. Non-Interstate NHS Pavement Asset Performance and Gap

Non-Interstate NHS Pavement	Annual Funding	Good	Fair	Poor
Current Performance (2017)	$30 million	18%	76%	6%
2-year Target (2019)		15%		4%
2-year Projection	$30 million	25%		1%
4-year Target (2021)		15%		4%
4-year Projection	$30 million	30%		1%
10-year Desired State of Repair (2027)		25%		2%
10-year Projection	$30 million	31%		1%
10-year Projected Gap		No gap		No gap

CHAPTER 6

Environmental Vulnerability

Unique Challenges in Hawaii

Because of its location in a tropical zone, predominant coastal environment, geologic and topographic factors, and renewable energy policy, there are many challenges to Hawaii and its land transportation system. Hawaii's dependence on imported supplies, along with its geographic isolation, presents additional challenges when considering construction resources and emergency recovery and response factors. In addition to these local factors, global warming and sea level rise also presents significant challenges to Hawaii.

This chapter expands on the unique challenges that the state faces. The HDOT often struggles with its effort to conduct business in a way that limits negative impacts on the environment and does not degrade conditions, yet still addresses FHWA national goals and serves its own agency mission to provide a safe, efficient, accessible, and sustainable inter-modal transportation system that ensures the mobility of people and goods and enhances and/or preserves economic prosperity.

As a transportation agency, this leads to an important consideration of cost and trade-offs for the HDOT. For example, a less expensive alternative in the short run may in fact be a higher cost in the long run, when the factors of environmental degradation (and impacts) are included. These challenges are also important considerations in the HDOT's Risk Register. As the emphasis on transportation asset management continues to grow and the HDOT works on formalizing processes and policies, tough decisions will need to be made about preserving assets that are subject to climate change and natural disasters. The consideration of alternate routes will be necessary.

Tropical Climate

Hawaii's climate includes mild temperatures throughout the year, moderate humidity, and northeasterly trade winds. As shown on Figure 6.1, rainfall varies considerably by location, with distinct differences depending on windward or leeward exposure and elevation.

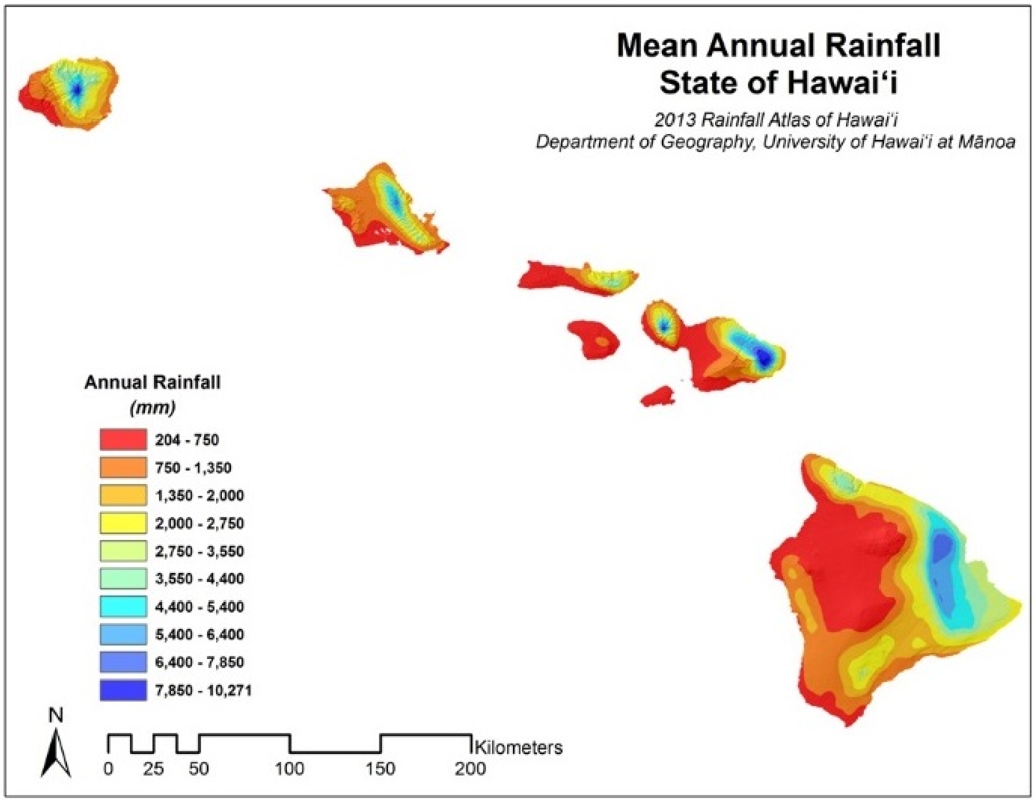


Figure 6.1. Annual Rainfall in Hawaii

Although Hawaii's climate remains moderate, climate change is influencing the state's climate. Surface temperature is rising and Hawaii is getting warmer. Data over the past 30 years show an average increase of 0.3 degree Fahrenheit (°F) per decade.[3] Most of the warming is related to higher minimum temperatures compared to the maximums, resulting in narrowing of the daily temperature range.

Figure 6.1 indicates the annual rainfall in Hawaii. A declining trend in rainfall has been widely reported; however, when a longer time frame is considered (using a period beginning in 1920, when observations began), analyses indicate that in many areas of the state, drying trends are significant primarily for the last few years. In addition, the only region with persistent trends is the Kona region of Hawaii Island, which has experienced a long-term drying trend (particularly in the dry season).[4]

While recent years have seen decreases in rainfall levels, the amount of rain falling in the heaviest downpours (defined as the heaviest 1 percent of all events) has increased approximately 12 percent in Hawaii between 1958 and 2007.[5] Intense rain can challenge emergency management agencies and first responders and trigger other severe impacts, including flash flooding and mudslides and debris flows over roads and bridges. Beginning

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[3] Fletcher, Chip. 2010. *Hawaii's Changing Climate*. Briefing Sheet. University of Hawaii Sea Grant College Program, Center for Island Climate Adaptation and Policy.

[4] Giambelluca, T.W., Q. Chen, A.G. Frazier, J.P. Price, Y.-L. Chen, P.-S. Chu, J.K. Eischeid, and D.M. Delparte. 2013. "Online Rainfall Atlas of Hawai'i." *Bull. Amer. Meteor. Soc.* 94, 313-316, doi: 10.1175/BAMS-D-11-00228.1 and Frazier, A.G. and T.W. Giambelluca. 2015. "Rainfall Trends through Time: A Running Trend Analysis of Hawaiian Rainfall." American Geophysical Union, Fall Meeting 2015, Abstract.

[5] Kershner, J. 2010. *Hawaii's Changing Climate: Legislative Briefing Sheet 2010*. [Case study on a project of the University of Hawaii and Center for Island Climate Adaptation and Policy]. Product of EcoAdapt's State of Adaptation Program. December. https://www.soest.hawaii.edu/coasts/publications/ClimateBrief_low.pdf.

*o*n April 13, 2018, the Island of Kauai had over 48 inches of rainfall within 24 hours, potentially setting a new national record for the heaviest rainfall within 24 hours. This significant increase in rainfall intensity caused massive flood damage and multiple landslides. The communities along the northern portion of the island were isolated by the damage to Kuhio Highway, the only road that provides access.

Multiple landslides block Kuhio Highway after heavy rains on the Island of Kauai in April 2018.
Source: HDOT staff, 2018

Hurricane season in the Hawaiian Islands is roughly from June through November, when hurricanes and tropical storms are most probable in the North Pacific. These storms tend to originate off the coast of Mexico and track west or northwest towards the islands. Since 1950, 25 hurricanes and 37 tropical storms have affected Hawaii (Figure 6.2), causing over $5 billion (in 1998 dollars) worth of damage.[6] These storms bring heavy wind, rain, flooding, and storm surges. Roadways have been affected by flooding, rockslides, mudslides, washouts, and shoreline erosion that has required emergency assistance in the past.

From 1915 to 1998, Hawaii had 68 recorded major flood events, resulting in 147 lives lost and over $688 million (in 2017 dollars) worth of property damage.[7] The cost and damage of every tropical storm increases. The estimated cost of damage from Tropical Storm Iselle in 2014 was $81.9 million (in 2017 dollars) and one life lost.

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[6] Fletcher, C.H., E.E. Grossman, B.M. Richmond, and A.E. Gibbs. 2002. *Atlas of Natural Hazards on the Hawaiian Coast*. U.S. Geological Survey, Denver, CO, Geologic Investigations Series I-2761, 182p. http://geopubs.wr.usgs.gov/i-map/i2761/.

[7] Ibid.

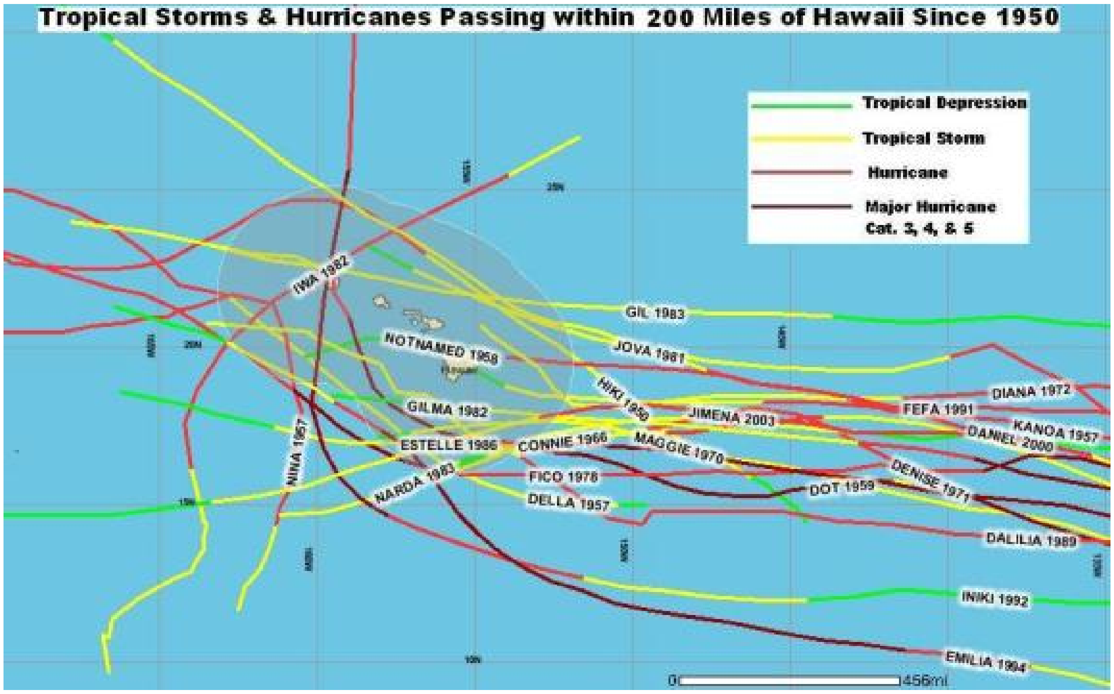

Figure 6.2. Hurricane Tracks near Hawaii

Based on a Federal Support Concept of Operations for a catastrophic hurricane impacting the State of Hawaii report (CONOP) developed by Federal Emergency Management Agency (FEMA) and the State of Hawaii, effects of hurricanes vary with the strength of the storm event. FEMA and the State estimated sea level rises for hurricane strength categories 1-5 as noted in Table 6.1.

Table 6.1. Estimated Storm Surge by Hurricane Categories

Hurricane Strength	Avg. Wind Speed	Estimated Storm Surge	
		Open Bays & Inlets	Across Reef Flats
Category 1	74–95 mph	4–5 feet	2–3 feet
Category 2	96–110 mph	6–8 feet	3–5 feet
Category 3	111–130 mph	9–12 feet	5–7 feet
Category 4	130–155 mph	13–18 feet	8–12 feet
Category 5	155+ mph	Over 25 feet	12–18 feet

Note:
mph = miles per hour

Hurricane Iniki, a Category 4 storm, hit the Island of Kauai in 1992 and created widespread damage that required years to recover from. The 10-foot inundation level on the Island of Oahu caused by a Category 4 storm would submerge the Honolulu International Airport, Joint Base Pearl Harbor-Hickam, and Honolulu Harbor, which would have a crippling effect on the movement of the military, equipment, and supplies needed for response and recovery.

Damage caused by Hurricane Iniki on the Island of Kauai in 1992.
Source: https://gowiggle.wordpress.com/2010/06/29/two-stories-one-amazing-place-kauai-and-hurricane-iniki/

Coastal Environment

Because of Hawaii's location in the middle of the Pacific Ocean and the close proximity of the belt roadways to the coastline, the HDOT land transportation facilities are constantly exposed to the salty, marine environment. Tradewinds blow moisture and salt onto the islands; even facilities located in the interior of the islands, miles from the coastline, are affected. Hawaii also receives seasonal ocean swells, predominantly from the south in the summer and from the north in the winter (Figure 6.3). These seasonal ocean swells, along with storm surge activities, frequently cause shoreline erosion and damage, necessitating that the HDOT develop and implement a shoreline protection program. In addition, the HDOT has had to perform emergency repairs along the shoreline in the past.

Ocean wave erosion of the pavement and underlying foundation along Kamehameha Highway in Kaaawa

Source: HDOT staff, 2015

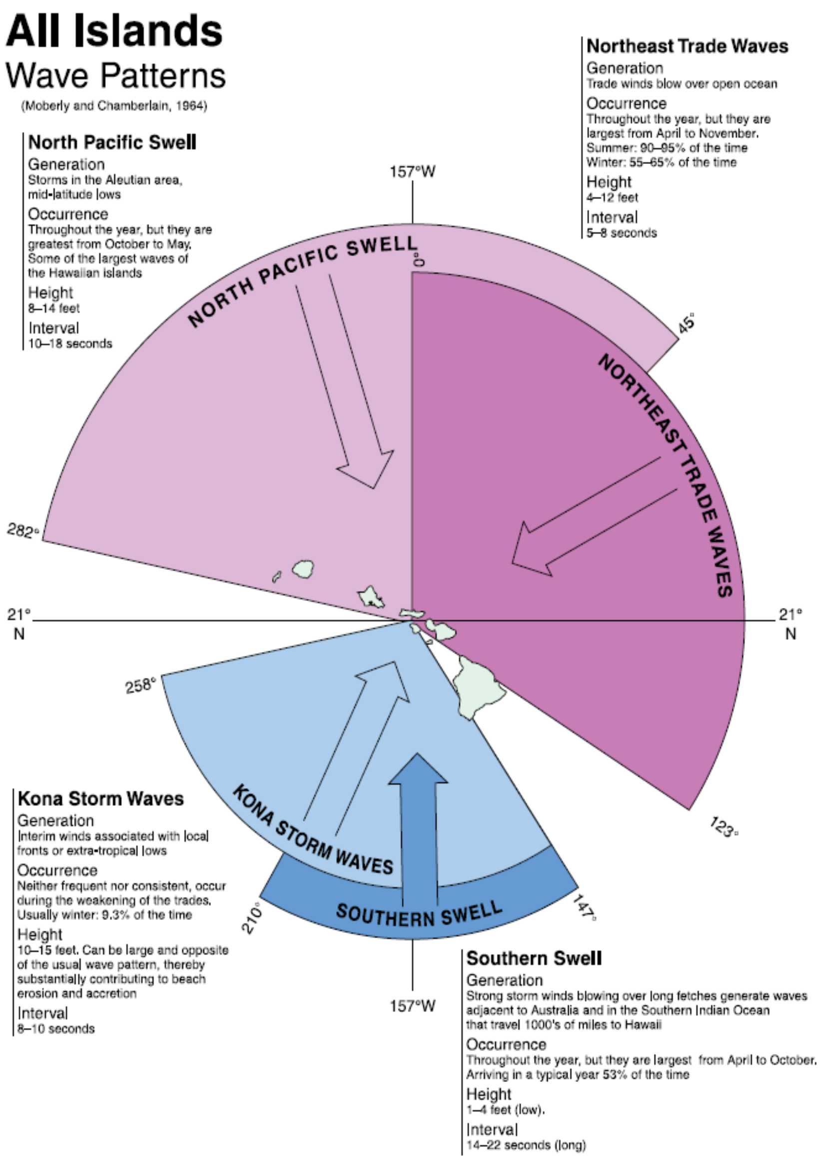

Figure 6.3. Wave Patterns around Hawaii

Source: Fletcher et al., 2002

Seismic Activity

The area surrounding Hawaii is also volcanically and seismically active and labeled as one of the highest hazard ratings in the country.[8] While thousands of earthquakes occur every year, most are so small they can only be detected by sensitive instruments. Some are strong enough to be felt on one or more islands, and a few major earthquakes have statewide impacts.

The 2006 Kiholo Bay earthquake occurred on Sunday, October 15, 2006, with a magnitude (M) of 6.7. The earthquake was centered 13 miles southwest of Puako, just offshore of the Kona Coast of the Big Island, at a depth of 18 miles. It produced several aftershocks, including one 7 minutes after the main shock that measured M6.1. This earthquake caused widespread damage, including to roadways and bridges operated by the HDOT and the counties.

As seen on Figure 6.4, the overwhelming majority of earthquakes in Hawaii occur on and around Hawaii Island, especially in the southern districts, where earthquakes are associated with volcanic activities.

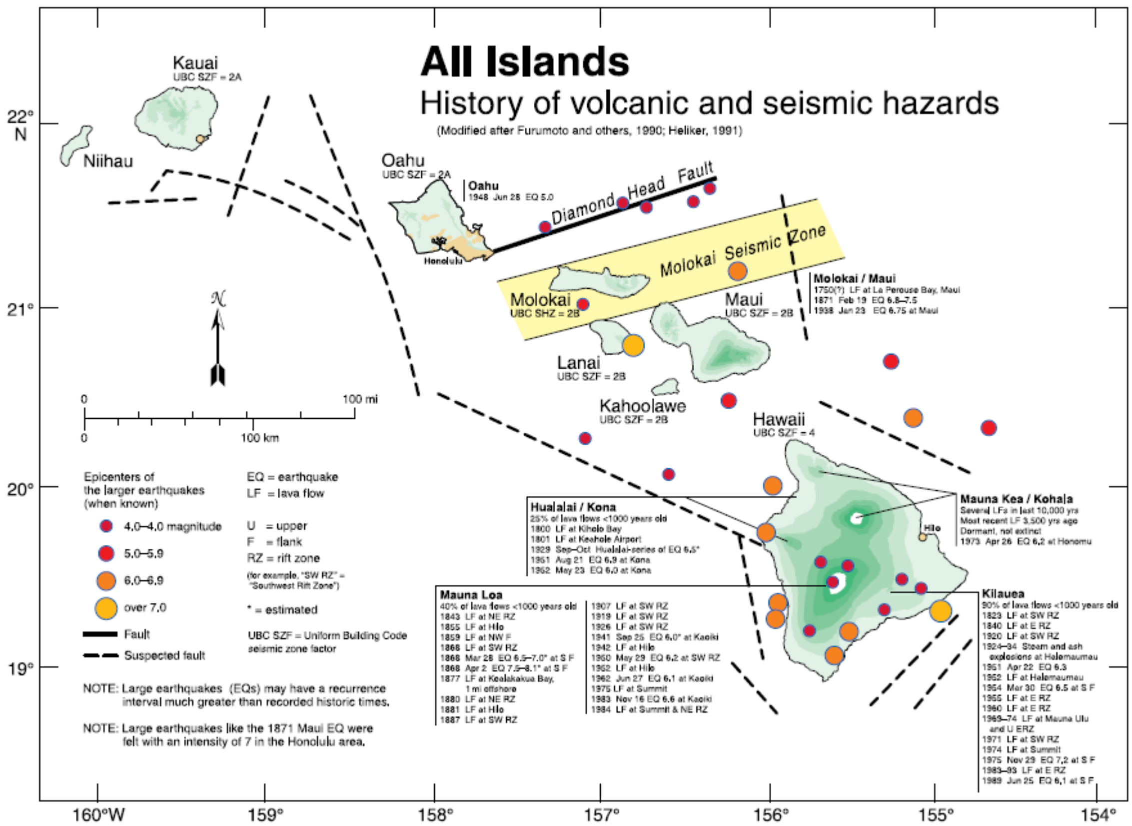

Figure 6.4. Historic Volcanic and Seismic Events

Source: Atlas of Natural Hazards in the Hawaiian Coastal Zone (USGS, 2002)

[8] FEMA. 2019. https://www.fema.gov/earthquake-hazard-maps. Last updated January 14, 2019.

2006 Kiholo Bay Earthquake Damage

According to the U.S. Geological Survey, since 1823, the state of Hawaii has had about one hundred M3 or greater earthquakes, ten M4 or greater earthquakes, and one M5 or greater earthquake (Table 6.2). There have been, on average, one M6 or greater earthquake every 10 years and two M7 or greater earthquakes every 100 years.[9]

Table 6.2. Earthquake Frequencies in Hawaii

Magnitude	Average Earthquakes per Year	Averages Days between Earthquakes
3.0–3.9	102[1]	3.5
4.0–4.9	11[1]	32
5.0–5.9	0.7[1]	533 (1.5 years)
6.0–6.9	0.1[1]	2,818 (7.7 years)
7+	0.02[2]	20,378 (55.8 years)

1 Earthquakes in Hawaiian Volcano Observatory catalog between 1960 and 2013 (inconsistent magnitude reporting before 1960).

2 Includes earthquakes from 1823 to 2013. Magnitudes before 1960 from Klein and Wright (2000).
Average number of earthquakes per year and days between earthquakes are for magnitude ranges from 3.0 and above. Data from earthquake catalogs between 1823 and 2013.

Source: USGS Volcano Hazards Program (https://volcanoes.usgs.gov/observatories/hvo/about_earthquakes.html)

Because the Big Island is in a seismically active zone, there have been historical lava flow events that have caused significant effect to roadway facilities. In 1950, lava flows from Mauna Loa crossed over Route 11, the major belt route located along the southwestern portion of the Island of Hawaii. More recently, in 2014, lava flow activity in the Kilauea area of the Big Island of Hawaii prompted emergency response activities by the County of Hawaii, HDOT, and National Park Service in anticipation of the lava flow crossing Route 130, the major roadway serving the Pahoa and Kapalama Estates communities (Figure 6.5). Hualalai,

[9] USGS Website, Volcano Hazards Program, Hawaiian Volcano Observatory, About Earthquakes in Hawaii at https://volcanoes.usgs.gov/observatories/hvo/about_earthquakes.html. Accessed 1/26/18.

located in the western part of the island, is also considered an active volcano. Two other mountains, Mauna Kea and the Kohala Mountains, are considered dormant and extinct respectively.

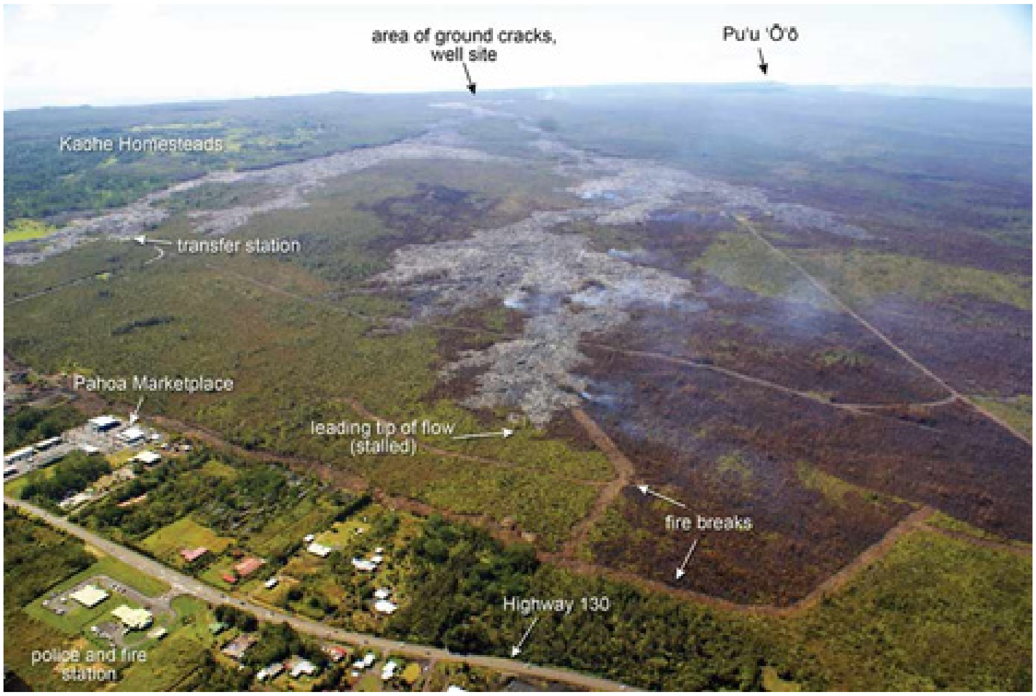

Figure 6.5. 2014 Lava Flow, Pahoa, Hawaii

Haleakala, on the island of Maui, is also considered active, although the last eruption occurred in 1790. Figure 6.6 shows the lava flow hazard map for the islands of Maui and Hawaii. All other mountains on Maui and on all other remaining islands are considered dormant or extinct.

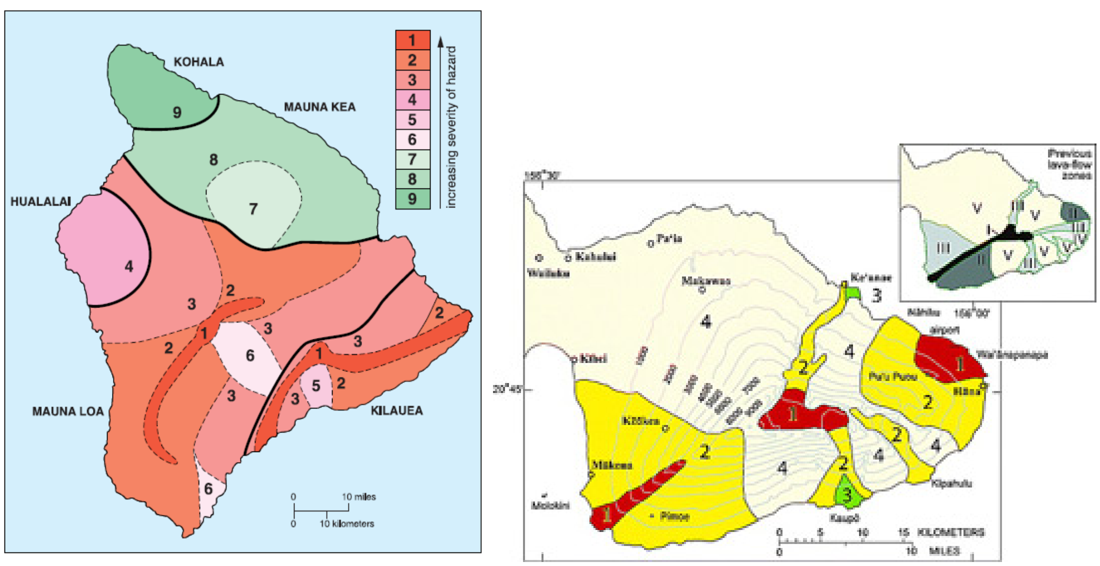

Figure 6.6. Lava Flow Hazard Map for the Islands of Hawaii and Maui

On May 3, 2018, Kilauea erupted and eventually destroyed 716 homes and covered nearly 14 square miles. The 4½-month-long eruption is considered an unprecedented event in Hawaii. Over a billion cubic yards of lava were produced by 24 open fissures. 58 miles of road and 1,337 acres of farmland were covered by lava or lost, and 875 acres of new land were created at ocean entries. Figure 6-7 shows a preliminary USGS map of the lava flow thickness at the Kilauea Lower East Rift Zone. The Hawaii National Guard deployed approximately 700 soldiers and airmen to staff security checkpoints, monitor volcanic gas emissions, build emergency housing and perform other duties. The American Red Cross provided 138 days of shelter operations and had 702 volunteers.

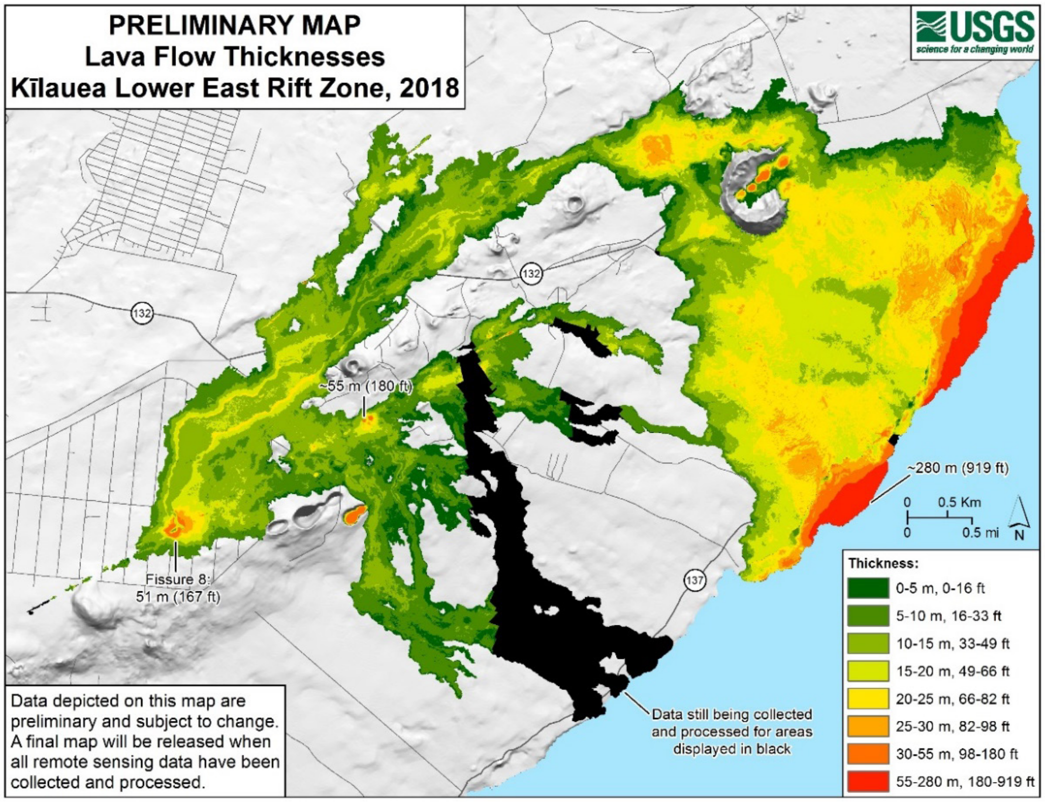

Figure 6.7. 2018 USGS Lava Flow, Pahoa, Hawaii
https://volcanoes.usgs.gov/observatories/hvo/maps_uploads/image-545.jpg

Lava burning across an existing roadway, Pahoa, Hawaii (2018)

"In my over 34 years of service with the Hawaii National Guard, 2018 by far ended up as the busiest and most challenging year," said Brigadier General Kenneth Hara in an email. "The Kilauea lava support mission was the longest state active duty mission that the Hawaii National Guard has ever been on. Usually disasters occur and we respond, then it is followed by a recovery phase. This event did not leave the response phase for about three months."

Climate Change and Sea Level Rise

In 2017, the State of Hawaii Department of Land and Natural Resources' Hawaii Climate Change Mitigation and Adaptation Commission released the *Hawaiʻi Sea Level Rise Vulnerability and Adaptation Report*. Historically, the sea level has risen 2 inches per decade in Hilo, on Hawaii Island, and 0.6 to 1 inch per decade at other locations in the state. With climate change associated with global warming (Figure 6.8), sea level rise is likely to continue or increase, which will in turn put more coastal roadway facilities at risk.

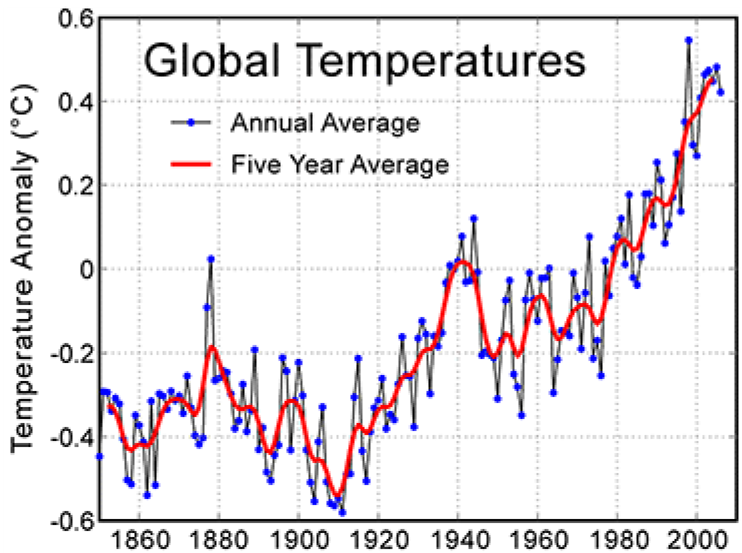

Figure 6.8. Global Warming Graph
Source: Fletcher et al., 2002

The observed rate of global sea level rise has been accelerating from 0.02 inch (0.6 millimeter [mm]) per year between 1900 and 1930 to 0.17 inch (4.4 mm) per year between 2010 and 2015. According to the 2013 Intergovernmental Panel on Climate Change report, sea level rise could range from 1.6 feet (0.5 meter) to 3.3 feet (0.98 meter) by 2100, as recent evidence suggests that ice sheets and glaciers are melting at rates greater than predicted. Hawaii specific projections are in line with global projections of sea level rise with a mean height of 3 feet by 2100. Such a rise in sea levels will greatly increase the likelihood of damage to coastal roadways and facilities in Hawaii.

Existing sections of NHS routes in Hawaii are regularly inundated by seasonal storm surges, such as Route 83, Kamehameha Highway, along on the North Shore of Oahu and Route 30, Honoapiilani Highway, on the western shore of Maui. As the ocean levels rise along with more severe weather events brought on by global warming, additional sections of coastal roadway will be at risk.

In addition to anticipated ocean inundation with sea level rise, a corresponding water table rise is anticipated in some coastal areas. Not only will roads be inundated from the ocean, but depending on topography, areas upland from the roadways will be inundated from the water table increase, possibly requiring additional and substantial roadway relocation considerations. Route 310, North Kihei Road, on the southern portion of the Maui's isthmus, is an example where the roadway elevation is close to sea level and the road is constructed on sandy soil, and immediately inland from the roadway is a brackish water marshland.

On July 16, 2018, the Mayor of the City and County of Honolulu issued Directive No. 18-2 on the City and County of Honolulu (City) Actions to Address Climate Change and Sea Level

Rise. Directive 18-2 references the findings and recommendations of the City Climate Change Commission Sea Level Rise Guidance (Guidance) and accompanying Climate Change Brief, both adopted on June 5, 2018, and the State of Hawaii Sea Level Rise Vulnerability and Adaptation Report. The Guidance states that the research finds that it is reasonable to set 6 feet of sea level rise as a planning benchmark toward the end of 2100. Critical infrastructure projects with long lifespans and low risk tolerance should plan accordingly, as the areas where 6 feet of sea level rise will occur will experience chronic high tide flooding decades earlier.

Endangered Species Capital of the World

The uniqueness of the Hawaiian Islands has made it home to a unique variety of plant and animal species. According to the United State Fish and Wildlife Service, there are currently 437 threatened and endangered species in the State of Hawaii, earning it the nickname of the Endangered Species Capital of the world. In addition, as the number of federal and state environmental regulations has increased, so has the complexity of complying with such regulations. These circumstances have negatively impacted the timely delivery of a variety of construction projects in Hawaii, including projects by the HDOT. These are all realities that the HDOT encounters and must adjust for in the planning and programming of projects.

Hawaiian hoary bat - Photo credit Jack Jeffrey (www.fws.gov)

Dependence on Imported Goods and Supplies

With a lack of diverse natural resources, recent volcanic origin, and limited land area, Hawaii must import the vast majority of consumable goods and supplies for production and economic reasons. The vast majority of commodities arrive via ocean freight in Honolulu; from there, goods and supplies are shipped to the neighbor islands or distributed locally via Oahu's roadway network.

Hawaiian gardenia - Photo credit Dr. Lamoureux/ University of Hawaiʻi

Following the recent evolution in the method of retail delivery, supplies are ordered and scheduled to arrive just in time to replenish depleted stocks in the islands. Data obtained by the State Legislature in 2013 revealed that Hawaii currently has an inventory of fresh produce that would supply consumers for no more than 10 days. A total of 90 percent of the beef, 67 percent of the fresh vegetables, 65 percent of the fresh fruits, and 80 percent of all milk purchased in the state are imported. 100 percent of petroleum oil is imported, thereby rendering the state even more vulnerable to fluctuations in global commodity prices and supplies. Also imported are the majority of construction materials such as steel, cement, sand, wood, and other supplies.

Geographic Isolation

The Hawaiian Islands are also the most isolated group of islands in the world. Table 6.3 shows the distances from Honolulu to a number of major Pacific Rim ports, along with approximate air and sea travel time between them. The sea travel times shown are based on a speed of 24 knots, the average speed of a container ship.

Table 6.3. Distances between Hawaii and Major Pacific Rim Ports

Destination	Distance	Approximate	
		Air Time	Sea Time
Los Angeles, CA	2,558 miles	5 ½ hours	5 days
Seattle, WA	2,678 miles	6 hours	5 days
Tokyo, Japan	3,854 miles	8 hours	7 days
Taipei, Taiwan	5,105 miles	12 hours	9 days

Effects to Recovery and Response

Evacuation and response and recovery during a catastrophic event is extremely compromised by a combination of factors, including geographic isolation, dependence on imported goods and supplies, tropical climate, seismic zone location, and major transportation infrastructure constructed in low lying areas. During hurricane events, airport, harbors, and certain highway assets are vulnerable to damage; Hawaii would be required to operate on its own without expecting substantial outside support for a week or more because any anticipated assistance would be provided by sea or air.

CHAPTER 7

Risk Management Assessments

Overview and Requirements

Overview

The Interagency Security Committee 2013 *Risk Management Process for Federal Facilities: An Interagency Security Committee Standard* states, "Risk is a function of the values of threat, consequence, and vulnerability. The objective of risk management is to create a level of protection that mitigates vulnerabilities to threats and the potential consequences, thereby reducing risk to an acceptable level." Thus, the identification of threats by an implementing agency, followed by an assessment of likelihood and consequences, then by response strategies to preemptively manage the risks, increases the possibility of the agency being successful in meeting its goals and objectives. With the increased emphasis on performance-based planning and programming, it is even more important to manage risk. By managing risk, agencies can achieve their goals, objectives, and targets.

Risk management enables agencies to thrive amidst uncertainty by being more understanding of and better poised to respond to the full range of possible outcomes—both threats and opportunities—that may impact the success of their organization.

Federal Requirement

23 CFR Part 515 requires that the transportation asset management plan include "life cycle cost and risk management analysis." The FHWA considers risk the positive or negative effects of uncertainty or variability upon agency objectives. Risk management generally consists of the cultures, processes, and structures that are directed towards the effective management of potential opportunities and threats. However, the FHWA recognizes that different agencies can use different definitions. The FHWA requires transportation agencies to consider risk as part of the strategic and systematic process of operating, maintaining, and improving physical assets and managing their highway network with a focus on the program and agency level. A risk-based plan can make tradeoffs based on risk. In addition, risk should be considered at the project level to control cost, scope, and schedule.

State DOTs are required to establish a management plan that identifies risks to assets and the highway system, including those associated with current and future conditions, such as extreme weather events and climate change. The risk analysis needs to account for roads and bridges that require repeated repair or reconstruction as a result of emergencies. State DOTs would be required to identify high priority assets and develop a plan to address and monitor risks to those assets. The proposed rule is designed to ensure that state transportation asset management plans are truly risk-based, as required by MAP-21, by ensuring that states have the information required to minimize impacts and increase asset and system resiliency.

HDOT's Risk Management Process

Management of Risk

The HDOT uses a continuous cycle of risk management. Figure 7.1 shows the steps of the risk management cycle. The following pages describe each step in more detail.

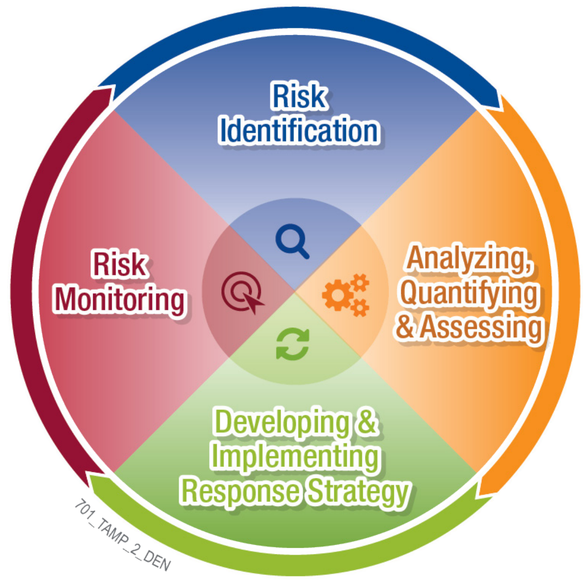

Figure 7.1. Risk Management Cycle

A. Risk Identification – The identification and documentation of the material threats to the organization's achievement of its objectives and goals is accessed in Step 1. A risk matrix is developed for each identified risk, as shown in Table 7.1.

B. Analyzing, Quantifying & Assessing Risks – Identifying the probability and consequences of each risk occurs at Step 2.

C. Developing & Implementing Response Strategies – The formulation of methods and implementation measures to avoid, minimize, transfer (share), or mitigate risks at the organizational, programming, and project levels is completed at Step 3. This may include project prioritization or project specific implementation considerations.

D. Risk Monitoring – Step 4 includes the continual measurement and monitoring of the risk strategies using a risk register.

Risk Identification and Levels of Risks

The HDOT realizes that more than the identification of risk needs to occur. The management and consideration of the risks needs to occur at multiple levels to be effective: a higher, organizational level; the programming level; and the project implementation level. For example, for anticipated severe weather caused by climate change, at the global level, the HDOT may elect to set a design policy for certain facilities using a larger design storm event (such as a 500-year event instead of 100-year). At the project selection and prioritization process (programming) stage, if it is recognized that a bridge structure is located in an area with repeated flooding history, that particular bridge may be given additional priority considerations. Finally, when the project is designed, the HDOT may determine that using a larger design storm event or selecting a certain type of foundation (for example, using drilled shafts because of scour history) is appropriate given the identified risks for the structure. Figure 7.2 illustrates this principle.

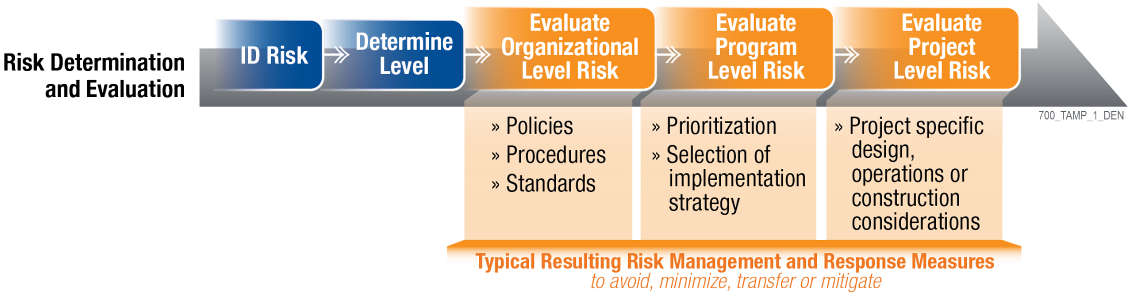

Figure 7.2. Levels of Risks, Management, and Response

This approach allows the HDOT to develop and address response measures to risks at the appropriate levels. Risks related to asset management often faced by the HDOT include those noted in Table 7.1.

Table 7.1. HDOT Risks related to Asset Management

Risk Category	Risk Description	Organization	Program	Project
Hazard	Severe weather events (tropical storms, hurricanes, and tsunamis)	X	X	X
	Climate change and sea level rise	X	X	X
	Shoreline erosion	X	X	X
	Rockfall/slope stability	X	X	X
	Lava flows	X	X	X
	Earthquakes	X	X	X
Financial	Dependence on fuel tax revenues	X	X	
	Lack of financial data to make appropriate TAMP planning decisions	X		
	Continuous short-term federal transportation bills or extensions	X	X	
	Renewable energy policies	X	X	
Organizational	Changes in administration or division priorities	X		
	HDOT and its partnering agencies staff shortage	X	X	X
	Loss of organizational or departmental information as a result of HDOT and its partnering agencies' staff turnover and retirements	X	X	X
	Weak program processes and management	X	X	X
Strategic	Uncertainties or incompleteness of data	X	X	X
	Complexity and amount of Environmental Regulations impacting project delivery	X	X	X
	Length of procurement	X	X	X
	Ineffective maintenance practices	X	X	
	Uncertainties in life cycle forecasting due to lack of industries' ability to implement a variety of preventative maintenance measures	X	X	
	Resistance to culture change and TAMP sustainment	X	X	X

After a risk has been identified (step 1), the probability or likelihood of the risk occurring is considered and the impact of each risk accessed (step 2). This information is inputted into a risk matrix, as shown in Table 7.2. Table 7.2 also includes the probability inputs and impact inputs. A risk matrix is developed for each identified risk. Following this approach, the highest priority risk would be almost certain to occur and have extreme consequences. The lowest priority risk would be rare and would have negligible consequences.

Table 7.2. Risk Matrix

Probability	VH					
	H					
	M					
	L				X	
	VL					
		VL	L	M	H	VH
		Impact				

Risk Matrix - Probability Input		
VL	-	Some certainty it will occur within the next 20 years
L	-	Somewhat certain it may occur within the next 8 years
M	-	Likely to occur within the next 4 years
H	-	Currently occurring to some extent
VH	-	Occurring daily or almost certain to occur

Risk Matrix - Impact Input		
VL	-	Little noticeable impact to the system; system minimally affected; little or no public awareness and pressure; most HDOT operational processes unaffected
L	-	Some noticeable impact to the system performance; some localized but noticeable difference in performance; general public complaints, but mostly accepts; HDOT operational processes slightly affected
M	-	Noticeable impact to the system performance; portions of system poorly performing; localized public complaints; some public awareness; some effect to operational processes
H	-	Large Impacts to the overall system performance; large portions of system poorly performing; public aware and concerned; widespread effect on operational processes
VH	-	Catastrophic to overall system performance; public safety & health severely compromised; widespread impact, loss of public trust and confidence; large segments of society and operational processes not functioning

Risk Response Strategies and Risk Monitoring

Strategies for each risk are developed and placed in a risk register, similar to the sample shown on Figure 7.3. The risk register is used to do the following:

- Identify the risk (risk item, cause, and effect)
- Conduct a qualitative risk assessment (probability, impact, and risk matrix)

- Develop the risk response plan (response strategy and actions)
- Monitor and Control (responsible office/lead, monitoring frequency, and status updates)

The risks are continually measured and monitored. The HDOT reviews the risk register annually or more frequently, as needed. The risk register inputs are shown on Table 7.3. The HDOT risk register for the TAMP is included in Appendix A.

Risk Management Register for HDOT														
Risk Identification							Qualitative Risk Assessment			Risk Response Plan		Monitoring and Control		
#	Status	Risk Category	Risk Item	Cause	Effect	Threat or Opportunity	Probability	Impact	Risk Matrix	Response Strategy	Response Actions	Responsible Entity/Lead Office	Monitoring Frequency	Status Update
1	Active	Hazard	Climate Change: Severe Weather Events, Tropical Storms, and Hurricanes	Flooding and storm drainage capacity	Loss of access	Threat	Moderate	Very High		Mitigate	HDOT to review design storm to determine impacts (construction cost, etc.) and then make a decision to adopt change or not	HWY-D	TBD	
2	Active	Hazard	Climate Change: Sea Level Rise	Shoreline erosion, inundation, and flooding	Loss of access	Threat	Very Low	High		Accept	HDOT to monitor ongoing data and studies. HDOT to continue to update asset inventory data and to consider SLR for new roadway alignments in long-range plans.	HWY-P, -D, -C, -L	As required, ongoing	Ongoing
3	Active	Hazard	Earthquakes	Bridge, rockfall, or roadway fill failures	Loss of access	Threat	Very Low	Very High		Accept	HDOT to continue to update asset inventory data. HDOT to develop/update emergency response procedures and interagency MOUs. HDOT to continue to bridge seismic retrofit and rockfall programs.	HWY-P, -D, -C, -L	As required, ongoing	Ongoing

Figure 7.3. Sample Risk Register

Table 7.3. Risk Register Inputs

Status	Active – risk strategy implemented or to be implemented Closed – risk item avoided or eliminated due to implementing strategy
Risk Category	Hazards – item related to climate, weather, and/or emergencies Financial – item related to budgeting and/or revenues involving federal, state, or other funds Organizational – item related to HDOT policy, processes, personnel, or culture Strategic – item related to data, program processes, operations, or similar
Matrix Reference	Reference number assigned to Risk Matrix developed for a particular Risk Item
Response Strategy	Avoid – strategies to reduce or eliminate a risk Minimize – strategies to reduce or minimize the effects Transfer – strategies to transfer (or share) risk to other parties Mitigate – strategies to take acceptable actions to address risk, but may require resources Accept – typically associated with initiatives (e.g., Everyday Counts), where this may result in possible opportunities, but may affect schedules or cost
Lead Office	Office in HDOT that would be responsible to assess, develop response strategies lead, or participate in the implementation, and monitor effectiveness of implemented strategy

How Risk is Considered in Programming and Projects

In addition to the steps performed in the risk management cycle and including the compilation of the risk register, the HDOT uses additional risk consideration when prioritizing projects for programming and implementation. For example, a bridge categorized as fracture critical will introduce additional risks to the HDOT, and a higher priority would be given when a project for this structure is generated from the BMS. As the list of bridge projects is further evaluated for project selection, this structure-specific priority would follow the project, and the HDOT could give this fracture critical bridge additional priority over other bridges. This analysis would be performed at the management system or program level (that is, at the BMS level within the BrM software). Figure 7.4 shows how the HDOT's BrM program incorporates a separate Utility Value for each bridge, which is based on bridge condition, life cycle, risk, and mobility.

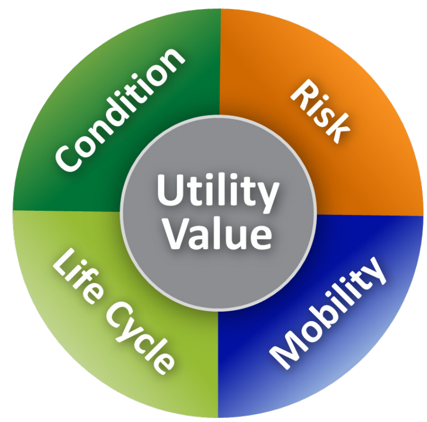

Figure 7.4. BrM Utility Value

After a project is selected for implementation, additional risks may be considered and either eliminated, minimized, or mitigated at the project level in design. Examples of such other risk-related concerns include maintenance history related to overtopping, scouring, over-height and over-weight vehicle movements, economic importance (for example, Sand Island Bridge, a significant freight route), and limited right-of-way.

Therefore, in addition to project identification and prioritization using asset condition and other technical factors within each management system, specific risks are recognized, and additional prioritization considerations are given in addition to the normal prioritization factors within the management system processes.

In addressing these organizational and program-level risks, and further considering project-specific risks, the HDOT is fulfilling the FHWA requirement to consider risk in asset management.

Continued Risk Monitoring and Data Collection

After projects are constructed, the HDOT collects post project data to confirm if unit cost estimates, and other assumptions were accurate. The data are also used to determine the effectiveness of risk response measures incorporated in the projects. These data and inspection data provide the foundation for the Bridge and Pavement Management Systems to update asset inventories, forecasting models, and input into the applicable risk registers.

Dependent on the type of data, collection frequencies can be matched with normal cycles prescribed by federal requirements or existing or newly developed HDOT procedures, or as applicable upon completion of projects.

In special circumstances, the HDOT considers incorporating research studies as part of projects that may provide opportunities for alternative construction materials or methods that may be used for risk management responses. Collection of such data would be determined by procedures established in the research project.

More specifically, for sea level rise, HDOT realizes that the sea level rise combined with increasingly dangerous storms puts our belt roads at risk. To address issues at a system level HDOT has partnered with The University of Hawaii Civil and Environmental Engineering (UH CEE) Department to prepare the State Highway Shoreline Protection Study. This UH CEE Project is divided into two parts:

- A statewide field investigation for each island
- An assessment of the coastal hazard exposure of Hawaii's State Highway network

The field investigation phase identified shoreline locations requiring "immediate" mitigation measures. In July 2018, UH CEE provided HDOT with a preliminary inventory of coastal road sections that were ranked in terms of the urgency for remediation. UH CEE is now assessing the coastal hazard exposure of segments of the Hawaii's State Highway network under different climate conditions including sea level rise scenarios. These findings look at the overall vulnerability of the state-owned coastal roads and will be available by the end of June 2019.

HDOT is also developing a Resiliency Plan that will identify asset vulnerabilities to climate change stressors. The Plan will be developed in phases and is currently in Phase 1. This phase will be approximately 6 months in duration and will include the following actions:

- Establish the baseline data and information to better understand the exposure and risks to the State Highway system from the impacts that may occur from climatic events.
- Develop a comprehensive inventory of potential system impacts; that is, an exposure assessment of HDOT's State Highway assets.
- Identify best practices towards agency resiliency to develop recommendations for reducing vulnerabilities through HDOT policies and programs.

Overall, the Plan will inform effective planning and align investment with an operational and safe State Highway system. Later phases will include developing a fuller set of policy recommendations across agency departments, identifying specific information and data needed to lead effectively to long-range and capital decisions, prioritized locations to focus resources, and methods by which to incorporate risk and uncertainty as a part of agency practice. The information and data gathered during this initial effort will be foundations to those later efforts.

In addition, stronger storms have increased the number of rockfalls on our roads. HDOT is developing a Rockfall Plan that will identify areas of high vulnerability for rockfalls. While many of these occur off the NHS, most recently a rockfall above the Pali Tunnels closed Pali Highway for over a month. Repair work on this important NHS road continues.

Evaluation of Facilities Repeatedly Requiring Repair and Reconstruction Due to Emergency Events

As part of the federal requirements, state DOTs are required to identify roads and bridges that require repeated repair or reconstruction as a result of emergencies. State DOTs are required to identify high priority assets and develop a plan to address and monitor risks to those assets. The proposed rule is designed to ensure that state transportation asset management plans are truly risk-based, as required by MAP-21, by ensuring that states have the information required to minimize impacts and increase asset and system resiliency.

As defined by 23 CFR 667.3, *emergency event* means a natural disaster or catastrophic failure resulting in an emergency declared by the Governor of the state or an emergency or disaster declared by the President of the United States.

Damage to Pali Highway as a result of multiple landslides on February 18, 2019. Reconstruction of the roadway with the soil nails occurred from April 2018 to April 2019. Large boulders at risk of falling down to the Pali Highway. Two separate landslides affected both Kailua-bound and Honolulu-bound traffic.

Bulk of the debris is removed at the landslide location at the Kailua bound direction. The slope along the Honolulu bound direction needs to be stabilized before it can be reopened.

The HDOT conducted a statewide evaluation of all emergency events dating back to January 1997, a total of 33 FEMA events between January 1997 and May 2019. There were approximately 60 State Proclamations between January 1997 and May 2019. Using an iterative process, the HDOT cross-referenced the two lists with emergency projects that identified work on a road, highway, or bridge with reconstruction elements (permanent repair). Not every emergency event caused permanent damage to the transportation assets. Emergency repairs that minimized the extent of the damage, protected the remaining facilities, or helped to restore essential traffic were not included (23 CFR 668.103). The HDOT has included a complete summary of the emergency events and transportation assets affected in Appendix B. There is no transportation asset that has been replaced or reconstructed on two or more occasions as a result of emergency events.

Damage to Kuhio Highway as a result of heavy rains in April 2018. Reconstruction of the roadway with the soil nails occurred from April 2018 to April 2019.

CHAPTER 8

Life Cycle Planning

Life cycle planning is an integral part of the TAMP approach and can be applied to any highway asset that relies on maintenance and perseveration activities to cost-effectively extend its service life. Life cycle planning is performed at the network level, where the needs of all assets in a system are considered over a specified period. The general stages of an asset life cycle are shown on Figure 8.1.

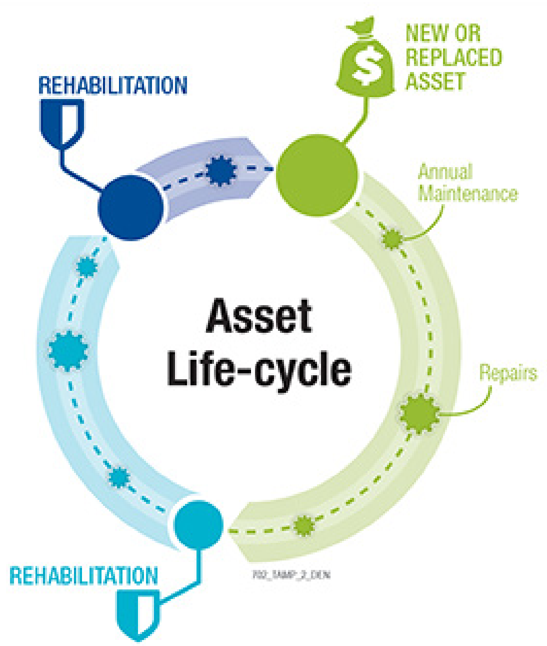

Figure 8.1. Stages of an Asset Life Cycle

Life cycle planning considers the cost and benefits of an asset from the time its need is identified until the need no longer exists and the asset is replaced or retired. It requires consideration of future outcomes and not just current performance. By considering the current condition of system assets relative to their life cycle, actions can be developed which reduce long-term costs, which in turn allows a wider range of investment choices. To this end, the HDOT's TAMP is based on a maintenance and preservation philosophy to prolong the service life of HDOT assets and get the best return on the HDOT's investment.

Life cycle planning saves money. It helps to achieve the lowest practical cost for improving and preserving HDOT's transportation

Federal Requirements

FHWA requires that state DOTs establish a process for conducting life cycle planning at the network level for NHS pavements and bridges. FHWA defines life cycle planning as "a process to estimate the cost of managing an asset class, or asset sub-group over its whole life with consideration for minimizing cost while preserving or improving the condition." Life cycle planning should include potential work types, including treatment options and unit costs, identification of deterioration models, a strategy for minimizing life cycle costs and achieving asset performance targets.

Life Cycle Planning Process

The HDOT is using the following steps to conduct its life cycle planning analysis:

A. **Select and identify the asset classes and networks that will be analyzed.** The HDOT will decide how best to develop a life cycle planning scenario for its transportation network. For example, a different life cycle planning scenario may be developed for the NHS system vs. the rest of the State's transportation system.

B. **Define life cycle planning strategies.** Each life cycle planning strategy will include a variety of treatment options that considers the condition and asset performance needs over the life of the asset. The following section shares some of the preservation treatments that the HDOT uses and the importance of implementing preventative maintenance.

C. **Set life cycle planning scenario inputs.** Establish the analysis period to be used, desired state of good repair, risks, performance gaps, anticipated funding levels (which comes from Financial Planning), and any constraints or requirements, such as minimum pavement and/or bridge conditions, that must be taken into consideration in evaluating life cycle planning scenarios.

D. **Develop the life cycle planning scenarios.** Using the asset strategies developed in step B and the inputs from step C, develop life cycle planning scenarios. Because of the iterative nature of the analysis, the development of these scenarios may lead back to step B and the development of new asset strategies.

E. **Provide input to financial planning.** Use the information from step D to provide input to the Financial Planning process and the performance gap analysis.

Minimizing the Whole Life Cost

While the HDOT strives to make facilities, equipment, and other assets function for a long, useful life at the lowest reasonable cost, they are challenged by the dual problems of deferred maintenance and balancing current needs with future needs. The HDOT's life cycle planning process is guided by our BMS and PMS that uses deterioration models for elements, specific work actions, and costs to generate system-wide recommendations. The HDOT is committed in investing in life cycle planning strategies, which prioritizes preventative maintenance.

Figure 8.2 shows the importance of how timely investments in an asset can result in improved condition and lower long-term cost. Figure 8.2 reflects the HDOT's previous practice of rehabilitating asphalt pavement (mill and fill) every 12 years until a full reconstruction is needed after 60 years. With the consideration of a 2 percent inflation rate per year, the full pavement life cycle cost is $29.0 million. Figure 8.2 also reflects the implementation of preventative maintenance activities over the full pavement life cycle. With the consideration of a 2 percent inflation rate per year, the full pavement life cycle cost is $21.4 million.

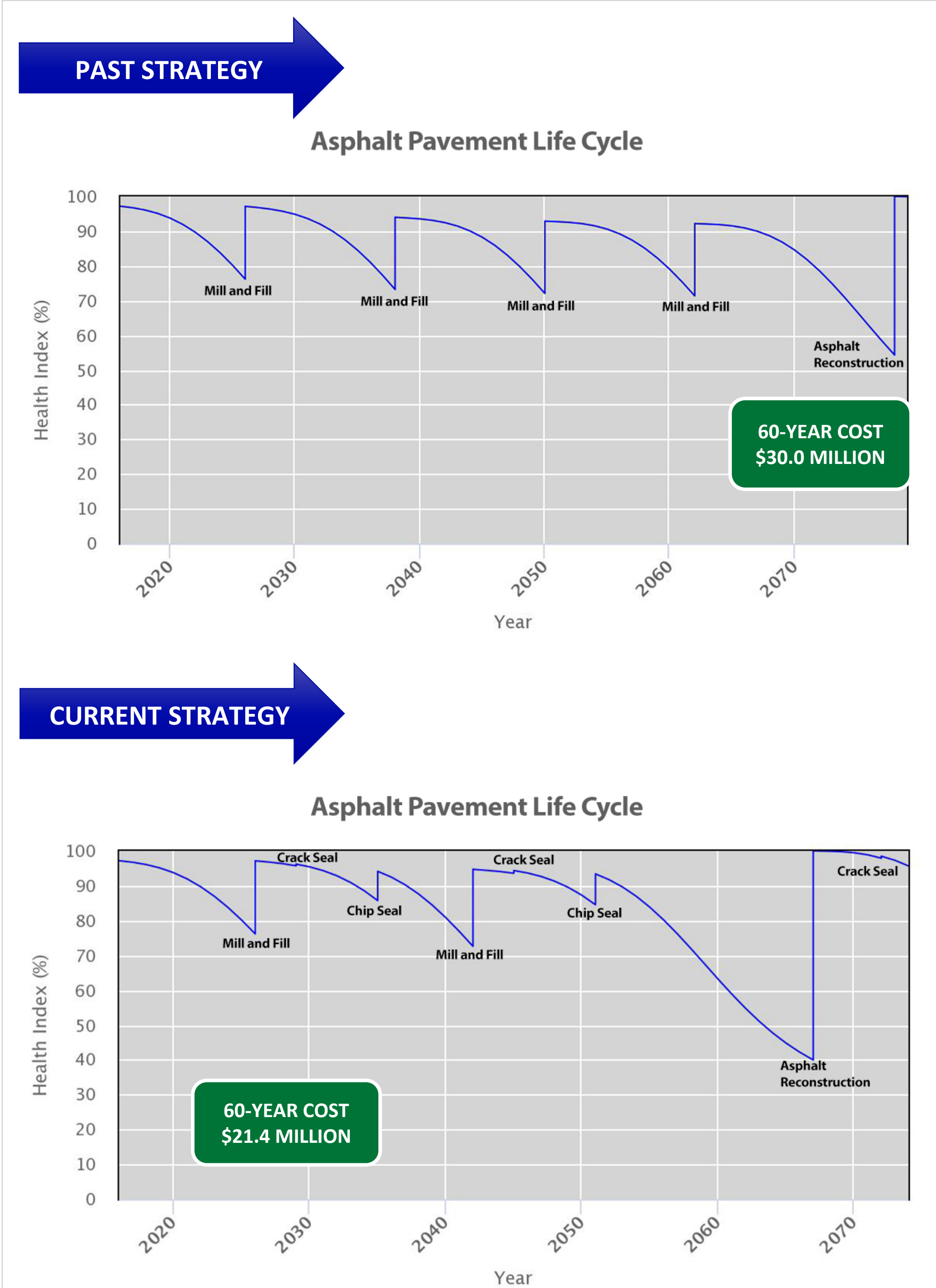

Figure 8.2. Pavement Preservation Strategies

Life Cycle Planning Strategies

A preservation strategy is designed to include low-cost treatments for assets already in good condition and to keep these assets in good condition longer. It optimizes the timing of rehabilitation and replacement options, as effective preventative maintenance activities involve a small, near-term expenditure calculated to avoid or delay a later, much larger expenditure. Agencies have found that asset strategies employing low-cost treatments that extend service life, preserve desired asset conditions longer, and postpone the need for rehabilitation can be effective at reducing performance gaps. This approach also enables agencies to reallocate more funding towards other preservation needs by deferring the need for more costly rehabilitation activities.

The HDOT is committed to achieving the lowest practical cost for improving and preserving HDOT's transportation assets over the service life of its assets. As the next section shares, the HDOT is committed to activities or strategies that prevent, delay, or reduce deterioration of its elements, keeps it assets in good or fair condition, and extends their service life. These maintenance and preventative activities may be cyclic or condition driven.

Preservation Treatments

Preservation strategies for pavements consider a spectrum of different treatments (that is, "mixes of fixes"). Using a combination of treatments means allocating reconstruction, rehabilitation, and preservation work in proportions that best meets the network needs at the lowest practical cost. The HDOT also implements best practices in its maintenance work activities for pavement. Street sweeping, inlet cleaning, pothole repairs, and field inspections are done annually, in addition to the preservation, rehabilitation, and reconstruction work activities.

Table 8.1 shows the pavement preservation and rehabilitation treatments that the HDOT is pursuing. These work activities are incorporated into the asset management process and the HDOT's PMS. The PMS recommends a program of work activities based on various funding scenarios and the goal of more cost-effectively extending the life of pavements in good condition statewide at the lowest practical cost.

Table 8.1. Pavement Life Cycle Work Activities

Work Activity	Activity Type	Frequency (years)	Unit Cost
Preservation/ Preventative	Asphalt Crack Seal	3	$6/foot
	Asphalt Slurry Seal	5	$30/square foot
	Asphalt Chip Seal	5	$30/square foot
	Asphalt Thin Overlay	8	$40/square foot
	Concrete Joint Resealing	10	$30 each
	Concrete Spall Repair	5	$100 each
	Concrete Diamond Grinding	10	$40/square foot
Rehabilitation	Asphalt Localized Repair	5	$30/square foot
	Asphalt Mill and Fill	15	$45/square foot
	Concrete Slab Jacking	10	$160 /square foot
	Concrete Dowel Bar Retrofit	15	$20/square foot
	Concrete Slab Replacement	15	$15,000 each
Reconstruction	Asphalt Reconstruction	30	$135/square foot
	Concrete Reconstruction	40	$1,600/square foot

The BrM program also conducts a life cycle cost analysis for bridges for given treatments or work to ensure the lowest practical cost over the life span of a structure. The BrM considers the deterioration of 70 bridge elements and 43 different defects. Similar to the PMS, the BMS produces a recommendation of work activities based on various funding scenarios and the goal of more cost-effectively extending the life of bridges in good condition statewide. The HDOT also implements best practices in its maintenance work activities for bridges. Crack sealing, spall repairs, inlet cleaning, and bridge inspections are done annually, in addition to the preservation, rehabilitation, and reconstruction work activities. Table 8.2 has the bridge work activities and preventative measures that have been incorporated into BrM.

Table 8.2. Bridge Life Cycle Work Activities

Work Activity	Activity Type	Frequency (years)	Unit Cost
Preservation/ Preventative	Paint Structure	10	$45/square foot
	Scour Countermeasures	10	$100/square foot
	Repair Joints	10	$75/foot
	Deck Repair	7	$80/square foot
	Repair Concrete Superstructure	10	$60-10,000 (greatly varies per element of the structure as well as the units [linear foot or each])
	Repair Steel Superstructure	10	
	Repair Concrete Substructure	10	
	Repair Steel Substructure	10	
	Repair Culvert	10	$400/foot
Rehabilitation	Deck Overlay	20	$100/square foot
	Replace Joints	15	$400-$2,500/foot
	Rehab Concrete Superstructure	20	$600-125,000 (greatly varies per element of the structure as well as the units [linear foot or each]))
	Rehab Steel Superstructure	20	
	Rehab Concrete Substructure	20	
	Rehab Steel Substructure	20	
	Rehab Culvert	20	$200/square foot
	Seismic Retrofit		$100/square foot
Replacement	Replace Bridge	75	$700/square foot


Kalanianaole Highway on the Island of Oahu

Implementation

The HDOT is using the following steps to life cycle planning process implementation:

A. **Select and identify the asset classes and networks that will be analyzed.** For this TAMP, the HDOT has selected the NHS bridge and pavement network.

B. **Define life cycle planning strategies.** The HDOT's BrM program is able to forecast condition and investment needs by asset class and work activity by using deterioration models and historical cost data. The BrM uses multi-objective decision-making which allows the HDOT to predict infrastructure investment needs and condition into the future under a range of scenarios.

C. **Set life cycle planning scenario inputs.** The HDOT is using a 10-year period, its desired state of good repair goals, estimated funding levels, and risk/environmental considerations for the life cycle planning scenarios.

D. **Develop the life cycle planning scenarios.** Using the life cycle planning strategies developed in step B and the inputs from step C, the BrM develops life cycle planning scenarios. With the iterative nature of the analysis, the development of these scenarios may lead back to step B and the development of work activity strategies and varying inputs from step C to produce the lowest practical cost for improving and preserving HDOT's transportation assets.

E. **Provide input to financial planning.** Using the information from step D, the funding level from the Financial Planning process is validated and the performance gap analysis is assessed.

The preservation strategies are implemented at the network level so that the HDOT can devise an optimal long-term strategy. BrM can also produce a strategy that is used to assist the districts in generating a district's individual programs and projects, after the network level priorities are established. It allows the districts to choose and schedule their own projects and treatments while still implementing the statewide optimal strategy.

Historic Hanalei Bridge is a steel bridge that is repainted every few years.

As the various strategies and work activities are implemented, the HDOT will continue to collect data on the cost and effectiveness. The HDOT will use the data to reinforce or revise the predictive models of how the assets will deteriorate following different types of treatments. The modeling of future asset conditions based on funding assumptions and application of life cycle strategies will continued to be improved and inputted to BrM.

Risk and Environmental Considerations

As reflected in Chapter 7, the HDOT's life cycle planning process allows the HDOT to consider a wide variety of risks, including environmental conditions such as extreme weather events (for example, major storms, flooding, hurricanes, and earthquakes). These events contribute to accelerated deterioration rates, increased repair costs, and poor conditions. Because the HDOT's operation and maintenance budget also funds restoration of state highways after landslides, storm damage, traffic accidents, earthquakes, and any other catastrophic events, it is critical that the budgeting process identifies assets that are vulnerable to environmental risks and includes strategies that reflect the unique needs of these vulnerable assets.

CHAPTER 9

Financial Plan

The purpose of the TAMP financial plan is to create a link between performance targets and project prioritization and funding. The financial plan summarizes current revenue sources, trends, and projections, estimates funding needs, and identifies potential funding needs, and potential funding gaps.

Federal Requirements

23 CFR § 515.7 (d) requires state DOTs to establish a process for the development of an asset management financial plan spanning 10 years. The financial plan shall:

- Include the estimated cost to implement the investment strategies by State fiscal year and work type.
- Include the estimated funding levels that are expected to be reasonably available, by fiscal year, to address the costs of implementing the strategies, by work type.
- Identifies anticipated sources of available funding.
- Includes a summary asset valuation for the State's NHS pavement and bridges

Financial Plan Process

The HDOT is using the following steps to develop its financial plan:

A. **Identify Available Revenue.** The first step in TAMP financial planning is to identify what sources of revenue are available for asset management. In addition, the amount of annual funding available for asset management for the duration of the TAMP needs to be estimated.

B. **Estimate Funding Needs.** In the TAMP financial plan, funding needs are generally described as the amount of money needed in each year of the TAMP period to implement the asset strategies recommended by the life cycle planning, to manage risks, and to address other performance gaps detailed in the TAMP. Estimating the funding needs is not as straightforward as projecting revenue because the funding needs will be dependent on condition targets that the HDOT has selected.

C. **Quantify Funding Gaps.** In step 3, the results of the revenue projections of step 1 and the funding needs analysis of step 2 will be compared. The results of this analysis will indicate if the project annual funding levels are sufficient to achieve the condition targets and mitigate risks and identify whether there is a funding gap or funding surplus.

D. **Selecting an Investment Strategy.** Selecting an investment strategy will be an iterative process. If a funding gap is identified, the HDOT will need to conduct a cross-asset (trade-off) analysis. This gap can be addressed in several ways, such as increasing the level of funding, redistributing funding from other programs to asset management, lowering the condition targets, changing life cycle planning strategies, or modifying the HDOT's risk mitigation approach and level of tolerance.

Revenue Sources

Revenue sources for the HDOT highway transportation system are predominantly state and federal taxes and fees. The HDOT may also collect additional funds on a case-by-case basis from private entities such as utility companies, private developers, or other county and state agencies, to perform project-related work such as utility relocations and betterments that may be specific to individual projects. For the purposes of the TAMP financial plan, such project-specific funds are not included.

State Revenue Sources

The HDOT collects revenues from multiple sources in the form of taxes, fees, and surcharges that are deposited into the State Highways Special Fund. These sources include the following:

- State fuel taxes
- Vehicle registration fees
- Rental / tour vehicle surcharge
- Vehicle weight taxes
- Interest earned from investments
- Miscellaneous (for example, weight tax penalties, motor vehicle inspection charges, rents from highway properties, commercial license fees, and similar)

The state revenue provided from these sources between 2015 and 2017 is summarized in Table 9.1. Typically, the most significant portion of the HDOT's funding comes from the state fuel tax and the vehicle weight tax. Collected state revenues are expended to pay for the HDOT's operational, routine maintenance, special maintenance, revenue bond debt service, and other expenses.

As shown in Table 9.1, revenues increased between 2015 and 2016 but decreased between 2016 and 2017. The actual annual obligation is dependent on the State Legislature.

Table 9.1. State Revenue Resources (In Millions)

Revenue Source	FY 2015	FY 2016	FY 2017
State Fuel Taxes	$86.6	$87.7	$83.0
Vehicle Registration Fees	$44.5	$44.1	$45.7
Rental Vehicle/Tour Vehicle	$51.9	$54.9	$53.2
Vehicle Weight Taxes	$76.0	$79.4	$81.5
Other Fees and Vehicle Penalties	$9.7	$11.4	$11.8
Total	**$268.7**	**$277.5**	**$275.2**

FY = fiscal year

Figure 9.1 shows the approximate percentage of state funding by source, based on 2017 revenues.

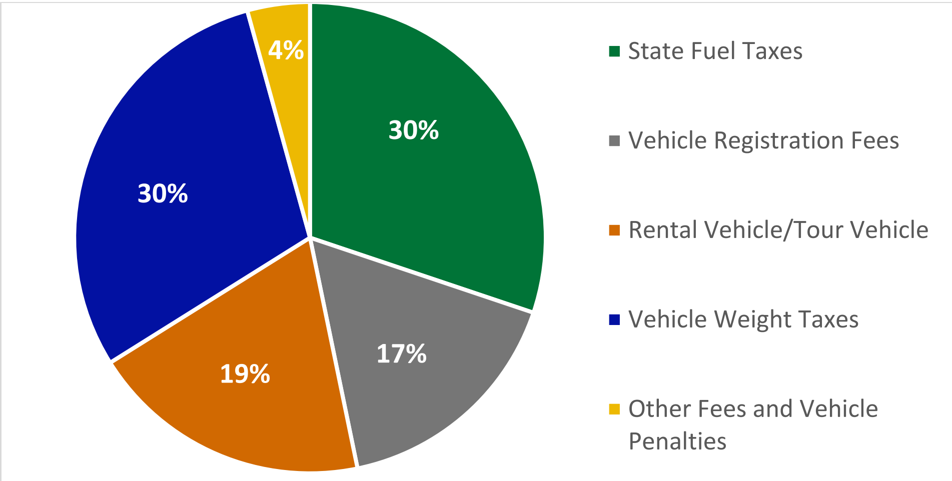

Figure 9.1. State Revenues Sources (2017)

Federal Revenue Sources

In addition to state revenues, the HDOT receives federal funding from the FHWA. Federal land transportation revenues are generated primarily from gasoline and diesel fuel tax: 18.4 cents and 24.4 cents per gallon, respectively. Further to the gasoline and diesel fuel tax, additional means of revenue include special fuel (for example, liquefied petroleum, M85, and compressed natural gas) taxes, truck tire sales tax, truck and trailer sales tax, and heavy vehicle use tax. The above taxes are collected and deposited into the Federal Highway Trust Fund.

Under MAP-21 and the FAST Act, FHWA distributes (apportions) funds to the states based on a formula (Formula Funds) that considers highway statistics under the following seven core programs:

- National Highway Performance Program
- National Highway Freight Program
- Surface Transportation Block Grant Program
- Congestion Mitigation and Air Quality Improvement Program
- Highway Safety Improvement Program
- Railway-Highway Grade Crossings Program
- Metropolitan Planning Program

States have the discretion to implement projects that are eligible under the above program areas.

While federal funds are apportioned to the states by formula or other means, only a percentage of these funds can be committed (obligated) to federal undertakings by a state. This form of control set by Congress is referred to as Obligation Limitation (OL). The OL is determined every fiscal year and can vary year-to-year depending on current federal fiscal policies and economic conditions; historically, the annual OL has been in the low 90 percent. For example, in 2017, the HDOT received approximately $159 million in formula OL and $174 million in formula funds, reflecting a 91.4 percent ratio.

Because OL is the limiting factor in committing funds to federal undertakings by the HDOT, for the purposes of this financial plan, all federal formula revenue amounts to the HDOT will reflect OL amounts.

In addition to the seven core programs, states may receive FHWA funds beyond Formula Funds, in certain situations. These situations may include the following:

- Emergency relief
- Special or exempt funds
- Special authorizations (for example, the 2009 American Reinvestment and Recovery Act)

In the fourth quarter of every federal fiscal year, states may submit a request for redistribution, a process whereby additional formula OL are provided to states that can demonstrate they have project funding needs that exceed available OL for a given year. Depending on the available redistribution amount available nationwide, redistribution amounts awarded to a state may or may not match the requested amount. Because the redistribution availability and awarded amounts cannot be predicted and is on a case-by-case basis, the TAMP does not include any assumed redistribution amounts. If the HDOT has projects ready to receive funding in a given year that exceeds available OL amounts, the HDOT will weigh all factors and make a decision to request for redistribution.

Figure 9.2. presents the federal revenues (OL funds) received between 2015 and 2017. Funding ranged from $151 million to $160 million in the past 3 years.

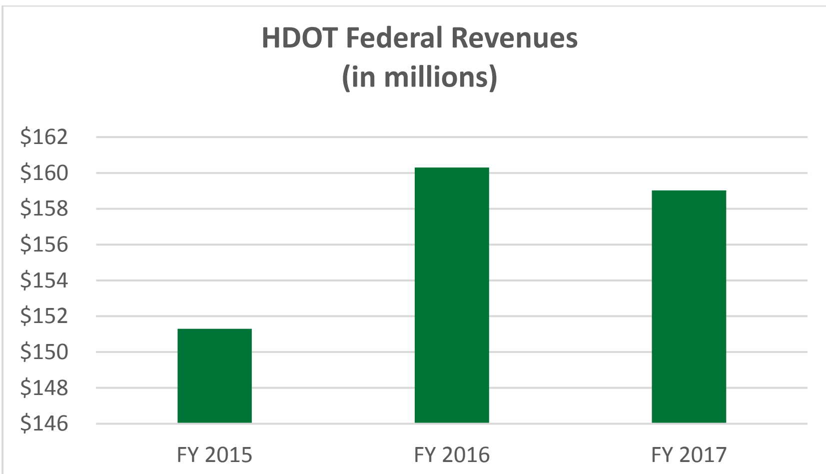

Figure 9.2. HDOT Federal Revenues (2015-2017)
Source: HDOT, Highways Division, 2018.

Combined Annual Revenue

Table 9.2 presents the combined state and federal funding received between 2015 and 2017 (based on the data above).

Table 9.2. HDOT Highways Division Annual Revenue (In Millions)

Resource	FY 2015	FY 2016	FY 2017
State Revenues	$268.70	$277.50	$275.20
Federal Revenues[1]	$151.30	$160.30	$159.02
Total Revenues	$420.00	$437.80	$434.22

Source: HDOT Highways Division, 2018.

[1]Federal fiscal year is October 1 to September 30.

Revenue Forecasts

The following information presents the estimated future level of funding, taking into consideration variables and uncertainties to the revenue streams and adjustments for inflation.

Variables and Uncertainties to Revenue Streams

Anticipated Decline in Fuel Tax Revenues

The previously mentioned major contributor to both state and federal revenue is fuel tax. In 2017, about 30 percent of the HDOT's annual revenue was generated from fuel tax. State fuel tax rates are shown in Table 9.3.

Table 9.3. 2017 Hawaii Fuel Tax Rates

Fuel Type	Tax per Gallon
Gasoline	16 cents
Diesel – non-highway highway	1 cent
Diesel – highway use	16 cents
Liquefied petroleum	5.2 cents

Source: State of Hawaii Department of Taxation data, 2018

However, there are several factors which could result in a future decline in fuel tax revenues at both the state and federal level. This includes increased fuel efficiency for gasoline and diesel-powered vehicles, the use of hybrid vehicles, policies towards renewable energy resulting in reduced consumption of fossil fuels, and general changes in travel patterns. These factors are discussed in the following sections.

Increased Fuel Efficiency

The average new U.S. vehicle fuel efficiency has steadily trended upwards, as shown on Figure 9.3, and is projected to continue to improve into the future. Because fuel tax revenues are based on rates multiplied by fuel consumed, decreased consumption equates to decreased revenues.

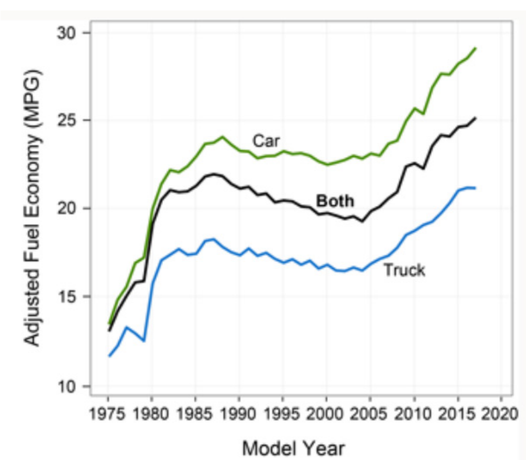

Figure 9.3. Average US Vehicle Fuel Efficiency

Source: US Environmental Protection Agency. 2017. Light-Duty CO_2 and Fuel Economy Trends. https://www.epa.gov/fuel-economy-trends/highlights-co2-and-fuel-economy-trends#Highlight1.

Renewable Energy Policies

On June 8, 2015, Hawaii Governor David Ige signed a bill that sets the state's renewable energy goal at 100 percent by 2045. In 2017, leaders from all the islands recognized this commitment through a proclamation to transform Hawaii's public and private ground transportation to 100 percent renewable fuel sources by 2045. In their specific proclamations, the City and County of Honolulu, the County of Maui, and the County of Kauai pledged to lead the way by transitioning their entire fleet vehicles to 100 percent renewable power by 2035; the County of Hawaii plans to establish a goal toward the same end. By 2045, all electricity will be from renewable energy sources: a mix of solid waste (H-Power), solar, wind, and geothermal power. Currently, Hawaii produces about 21 percent of its electricity from renewable energy and depends upon imported fossil fuels for the rest. The signed proclamations solidify Hawaii's role as a global renewable energy leader, with the state and all four counties becoming the first in the nation to commit to a 100 percent renewable transportation future.

Hybrid and Electric Vehicles

As part of the state's renewable energy goal, the state and counties are encouraging the use of Plug-In Hybrid (PIV) and electric vehicles. The use of hybrid and PIV is expected to increase. As automobile battery technology improves and PIV and hybrid vehicle costs decrease, combined with government-offered incentives, the number of people driving an alternative fuel vehicle will increase, which will negatively affect fuel tax revenues. In Hawaii, qualified PIVs are affixed with special state-issued plates that may use high occupancy vehicle (HOV) lanes regardless of the number of passengers and can park free of charge at state or county facilities. In addition to this, some governmental agencies and commercial development provide free electrical charging stations for PIVs.

Evolving Travel Patterns

Compounding the decreased fuel consumption are declining household travel trends and a changing workforce and commuting pattern. The National Household Travel Survey (NHTS) data reflect daily travel behavior of the American public. Americans drove 30 billion fewer vehicle miles in 2008-2009 than in the 2001-2002 NHTS survey period, despite a nearly 10 percent population increase over that time. Possible factors causing this decline may include the recession, high gas prices during the summer of 2008, changing demographics (for example, the aging of the population and smaller household sizes), changing lifestyles of Americans (such as increases in telecommuting and cyber shopping, or different travel preferences), an increase in the availability of quality transit service and other alternatives to driving, or roadway congestion. These and other factors have contributed to a negative effect on fuel tax revenue. Going forward, as the U.S. population ages and demographics and future generational workforce behavior changes, there are additional uncertainties that could affect fuel tax revenues.

Along with evolving travel patterns, the Honolulu Authority for Rapid Transportation (HART) is building a $9 billion, 20-mile elevated rail system to connect West Oahu to the City's urban core. The rail is anticipated to be fully operable by 2025 and is estimated to remove 40,000 car trips from Honolulu's congested highways. It will provide a fast, safe, and reliable alternative to driving.

Federal Highway Trust Fund Shortfalls

With the last reauthorization of the FAST Act, revenue sources for the Federal Highway Trust Fund (FHTF) have been provided for 2016 to 2020. While the FAST Act guarantees funding for this period, the revenue is a combination of fuel tax and other traditional road transportation fees, supplemented by other federal general funds. After 2020, it is anticipated that outlays from the FHTF will exceed collections because of the loss of federal general fund revenues, and Congress will once again be faced with the long-term problem of outlays exceeding collections. The current political climate remains either divided or against any support to fuel tax increases.

Table 9.4 presents the projections of the FHTF Highway account balance through 2020. As shown in Table 9.4, a significant decrease in the FHTF end-of-year balance is projected by 2020.

Table 9.4. Projections of Federal Highway Trust Fund, Highway Account

	Billions of Dollars by Fiscal Year				
	2016 (Actual)	2017	2018	2019	2020
Start-of-Year Balance	$9	$51	$42	$32	$21
Revenues and Interest[1]	$36	$36	$37	$37	$36
Intragovernmental Transfers	$52	$0	$0	$0	$0
Outlays	$44	$44	$44	$45	$46
End-of-Year Balance	**$51**	**$42**	**$32**	**$21**	**$10**

Notes:

1 Some of the taxes that are credited to the Highway Trust Fund are scheduled to expire on September 30, 2020, including the taxes on certain heavy vehicles and tires and all but 4.3 cents of the federal tax on motor fuels. However, under the rules governing baseline projections, these estimates reflect the assumption that all the expiring taxes credited to the fund will continue to be collected after fiscal year 2020.

Source: Congressional Budget Office. June 2017 Baseline.
https://www.cbo.gov/sites/default/files/recurringdata/51300-2017-06-highwaytrustfund.pdf.

Alternative Tax or Fee Collections

An increase in the fuel tax rate, possibly combined with an alternative form of vehicle tax or fee collection, is required to evolve from the current fuel tax collection model. Recognizing the political difficulties faced by Congress, several states have moved forward with pilot projects to study alternative tax collection based on vehicle miles traveled in lieu of gasoline or diesel fuel tax. The HDOT is a participant in the Western Road Usage Charge Consortium, a coalition committed to research and development of a new transportation funding method to collect a road usage charge based on actual road usage. The HDOT will likely need to move towards alternative forms of collecting taxes or fees, which could result in positive, yet uncertain, changes to the revenue stream.

In the last few years, there have been a variety of attempts made to increase State funding for the HDOT at the Hawaii State Legislature. These attempts range from increases to the motor vehicle registration fee, state fuel tax, and state vehicle weight tax. All of these attempts have failed and the HDOT Highways Division continues its struggle to meet the community’s needs with limited funding.

Inflation

The State accounts for inflation when developing financial plans that include distribution of future federal dollars. Inflation is defined as a sustained increase in the general level of prices for goods and services. It is measured as an annual percentage increase as reported in the

Consumer Price Index (CPI), generally prepared monthly by the U.S. Bureau of Labor Statistics. Inflation should be considered when making investment decisions because it erodes future purchasing power.

Because the inflation rate is variable and dependent on not only very dynamic domestic but international factors as well, and prediction is difficult, the HDOT uses the average of the last complete 4 years of urban consumer CPI (CPI-U) rounded up to the nearest whole percent to program transportation projects in future years. Based on the current CPI-U data, the inflation rate is 1 percent and became effective October 1, 2017. For consistency, this rate is used for the TAMP revenue forecasts. The HDOT will recalculate the inflation rate whenever the TAMP is due for FHWA recertification. The rate is calculated as shown in Table 9.5.

Table 9.5. Inflation Rate Projection

Year	Year-end CPI-U	Difference
2013	232.957	+1.5%
2014	236.736	+1.6%
2015	237.017	+0.1%
2016	240.008	+1.2%
Average		0.967% Rounded to +1.0%

CPI-U is a measure that examines the changes in the price of a basket of goods and services purchased by urban consumers. The urban consumer population is considered a better representative measure of the public, because most of the country's population (close to 90 percent of the total population) lives in highly populated areas. Although it has been observed that certain economic patterns in Hawaii lag the continental U.S., a 10-year future projection reasonably reflects the national average.

Projected Revenue

With the uncertainty of Congressional political support in increasing fuel taxes or any imminent alternative form of vehicle or fuel tax collection, the HDOT considered two federal revenue scenarios for the TAMP:

1. Federal funding levels will follow FAST funding levels from 2015 to 2020, then remain flat thereafter from 2020 levels.
2. Federal funding levels will follow FAST funding levels from 2015 to 2020, then decline to an amount that can be sustained by current federal collections.

Because it is difficult to predict what actions Congress will take, and public sentiment is that U.S. lawmakers will be under considerable public and political pressure, it is assumed that federal funding will remain status quo at 2016 levels.

For state revenues, the following assumptions are used:

- The HDOT will continue to sell $40 million of highway revenue bonds annually for CIP purposes.
- HDOT funding for SMP activities is dependent on the State Legislature actions, which can increase or decrease the available amounts. For the purposes of determining a State-projected revenue, a 0.5 percent annual increase is being used.

Based on the available information and assumptions regarding funding variables and risks, the projected revenue for the 10-year period from 2018 to 2027 was determined and is presented in Table 9.6.

Funding is expected to grow from approximately $437 million in 2018 to $450 million by 2027. The growth in funding dollars is assumed to be from state-generated revenue sources, as the federal fund contribution was assumed to be held constant.

Table 9.6. HDOT Highways Division Projected Revenue (In Millions)

Fiscal Year	State Revenues Appropriated	Federal Revenues Obligated	Total Revenue
2018	$276.58	$160.30	$436.88
2019	$277.96	$160.30	$438.26
2020	$279.35	$160.30	$439.65
2021	$280.75	$160.30	$441.05
2022	$282.15	$160.30	$442.45
2023	$283.56	$160.30	$443.86
2024	$284.98	$160.30	$445.28
2025	$286.40	$160.30	$446.70
2026	$287.83	$160.30	$448.13
2027	$289.27	$160.30	$449.57

HDOT Expenditures

HDOT revenue, or funding, goes to two primary functions – Administration/Debt Service/Operations and Programs/Projects. Of the total HDOT revenue, approximately 58 percent goes to Programs and Projects (approximately $255 million). Figure 9.4 shows the typical breakdown of HDOT expenditures.

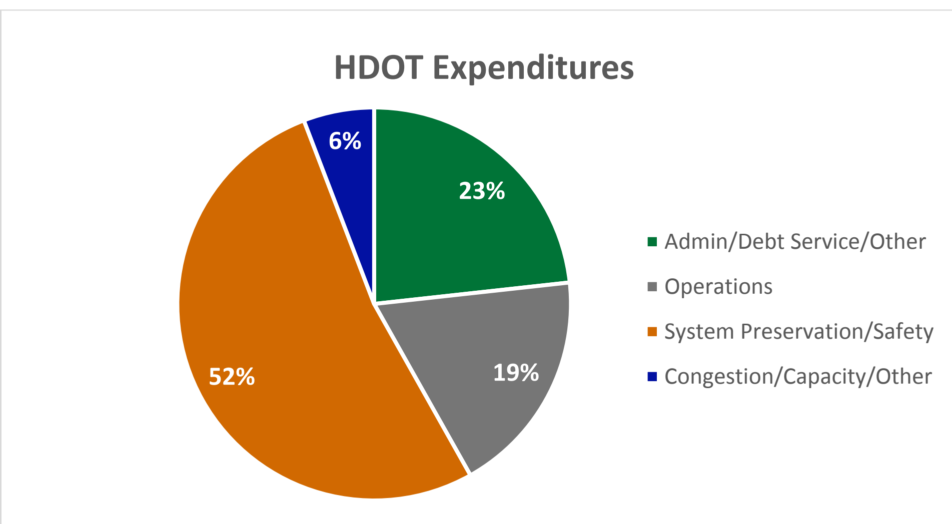

Figure 9.4. HDOT Expenditures by Function and Programs

Funding Needs and Gaps

The Statewide Federal-Aid Highways 2035 Transportation Plan (July 2014) identified the growing gap between funding needs and available funds. It has become increasingly difficult to generate revenue from existing and new sources. The challenge is to find sustainable solutions that allow Hawaii's economy and communities to achieve their goals.

Statewide Gap

Table 9.7, taken from the Statewide Federal-Aid Highways 2035 Transportation Plan, shows the dollars needed to implement all of the statewide transportation needs vs. the project revenue between 2014 and 2035.

Table 9.7. Statewide Need and Revenue (between 2014 and 2035)

District	Estimated Need ($B)	Expected Revenue ($B)	Funding Gap ($B)
Oahu	$16.7	$3.6	($13.1)
Maui	$3.7	$1.6	($2.1)
Hawaii	$7.4	$1.2	($6.2)
Kauai	$3.1	$0.6	($2.5)
TOTAL	**$30.2**	**$7.0**	**($23.9)**

Source: Exhibit 4.4, HDOT Statewide Federal-Aid Highways 2035 Transportation Plan, July 2014

The HDOT anticipates that based on the estimated transportation needs and available forecasted funds, expenses will likely outweigh revenues, resulting in an overall funding gap. The statewide funding gap for transportation improvements (that is, safety, system preservation, capacity, congestion, multimodal, and similar projects) is over $23 billion. This will require the state to prioritize solutions to ensure effective use of available funding resources, and equitably distribute limited funds. This also enforces the need to use life cycle planning strategies to achieve the lowest practical cost for improving and preserving HDOT's transportation assets.

TAMP NHS Funding

The HDOT's performance goal is to maintain and improve the overall condition of its NHS assets over the next 10 years. The HDOT will prioritize its NHS assets and strive to maintain its current funding of the system preservation program, understanding that there will be consequences to its other programs and non-NHS assets. The HDOT is committing a total of $37 million annually for NHS pavements and $30 million annually for NHS bridges. The $67 million commitment represents 30 percent of the HDOT's entire budget for its system preservation and safety programs. Table 9.8 reflects the annual funding for the next 10 years by work activity.

Table 9.8. Annual Funding for NHS Assets (In Millions)

Asset	Maintenance	Preventative	Rehabilitation	Reconstruction	Initial Construction	Annual Funding
NHS Bridges	$1 - 3	$3 - 6	$15 - 20	$5 - 10	$0	$30
NHS Interstate Pavement	$0.5 - 1	$1 - 2	$3 - 5	$1 - 2	$0	$7
NHS Non-Interstate Pavement	$1 - 3	$2 - 5	$15 - 20	$5 - 10	$0	$30

Chapters 10 and 11 reinforces the investment strategies and process improvements that will be implemented to achieve the HDOT's long-term performance goals. However, the HDOT understands that funding needs may change over time due to the amount of funding available, the backlog of work types, accelerated deterioration or slower deterioration on different parts of the system, and agency capacity to get work done. The HDOT expects to review and amend the 10-year goals and funding commitments when the TAMP is reviewed in 4 years.

Summary Valuation of NHS Assets

FHWA requires an estimate of the asset value for bridges and pavements on the NHS be included in the TAMP. This asset valuation is summarized in Table 9.9.

Table 9.9. Summary of Inventory and Asset Value of NHS Pavement and Bridge Assets

National Highway System Asset	Count	2017 Asset Value
Bridges	11.6 million square feet (deck area)	$2.1 billion
Interstate Pavements	54.9 centerline miles	$2.2 billion
Non-Interstate Pavements	394.8 centerline miles	$0.5 billion
Total	-	**$4.8 billion**

Asset value is recorded at estimated historical cost and does not take into account maintenance or rehabilitation. Therefore, replacement value is often more meaningful when analyzing future costs. The replacement values of NHS pavement and bridge assets are summarized in Table 9.10.

Table 9.10. Replacement Value of NHS Pavement and Bridge Assets

National Highway System Asset	Count	Unit Replacement Cost	Current Replacement Value
Interstate Bridges	9.6 million square feet (deck area)	$7,000/ square foot	$67.2 billion
Non-Interstate Bridges	2.3 million square feet (deck area)	$5,000/ square foot	$11.5 billion
Pavements	739 centerline miles	$5 million/centerline mile	$3.7 billion
Total	-		**$83.4**

CHAPTER 10

Investment Strategies

Investment strategies are the culmination of the risk management, life cycle planning, and performance gap analyses and results, and take into consideration the anticipated available funding and estimated cost of future work. It is through this TAMP process that the HDOT will determine how best to invest in and prioritize projects that will achieve the performance targets and national and statewide goals.

In accordance with FWHA requirements, the TAMP must identify investment strategies that make progress towards:

- Achieving a desired state of good repair over the life of the assets.
- Improving or preserving the asset condition and performance.
- Achieving the targets for asset condition and performance of the NHS.
- Achieving national performance goals.

Performance - Based Investment

Table 10.1 shows the HDOT's commitment in its financial plan and investment in life cycle planning strategies to keep the existing transportation system in a state of good repair over the next 10 years and reach the HDOT's performance goal for NHS bridges and pavements.

Table 10.1. Condition, Targets, and 10-Year Investment Levels

Asset	Current Condition 2017	10-Year Target	10-Year Projection	Investments Required to Achieve Targets in 2027
NHS bridges	Good- 23%	20%	18.5%	$30 million annually
	Poor- 2%	2%	1.8%	
Interstate Pavements	Good- 15%	50%	63%	$7 million annually
	Poor- 2%	4%	3.2%	
Non-Interstate NHS pavements	Good- 18%	25%	31%	$30 million annually
	Poor- 6%	2%	1%	

Strategies

Shortfalls in available funding will continue to be a key factor in planning and prioritizing future transportation investments. The TAMP recognizes the need to make hard investment decisions and provides a data- and technical-driven prioritization process that will objectively guide investment decisions. Overall, the funding allocation emphasizes statewide needs by program and asset, rather than by district. The HDOT's commitment to its PMS and BMS also reflects the network prioritization approach vs. a district approach.

The HDOT's investment strategies are consistent with national and statewide goals of improving or enhancing current assets and preserving and maintaining the existing system through low cost treatments. The combined results from Life Cycle Planning, Performance Gap Analysis, Risk Analysis, the Financial Plan, and Pavement and Bridge Management Systems form the foundation for establishing these investment strategies.

Figure 10.1 reflects the HDOT's enhanced approach to asset management and funding strategies.

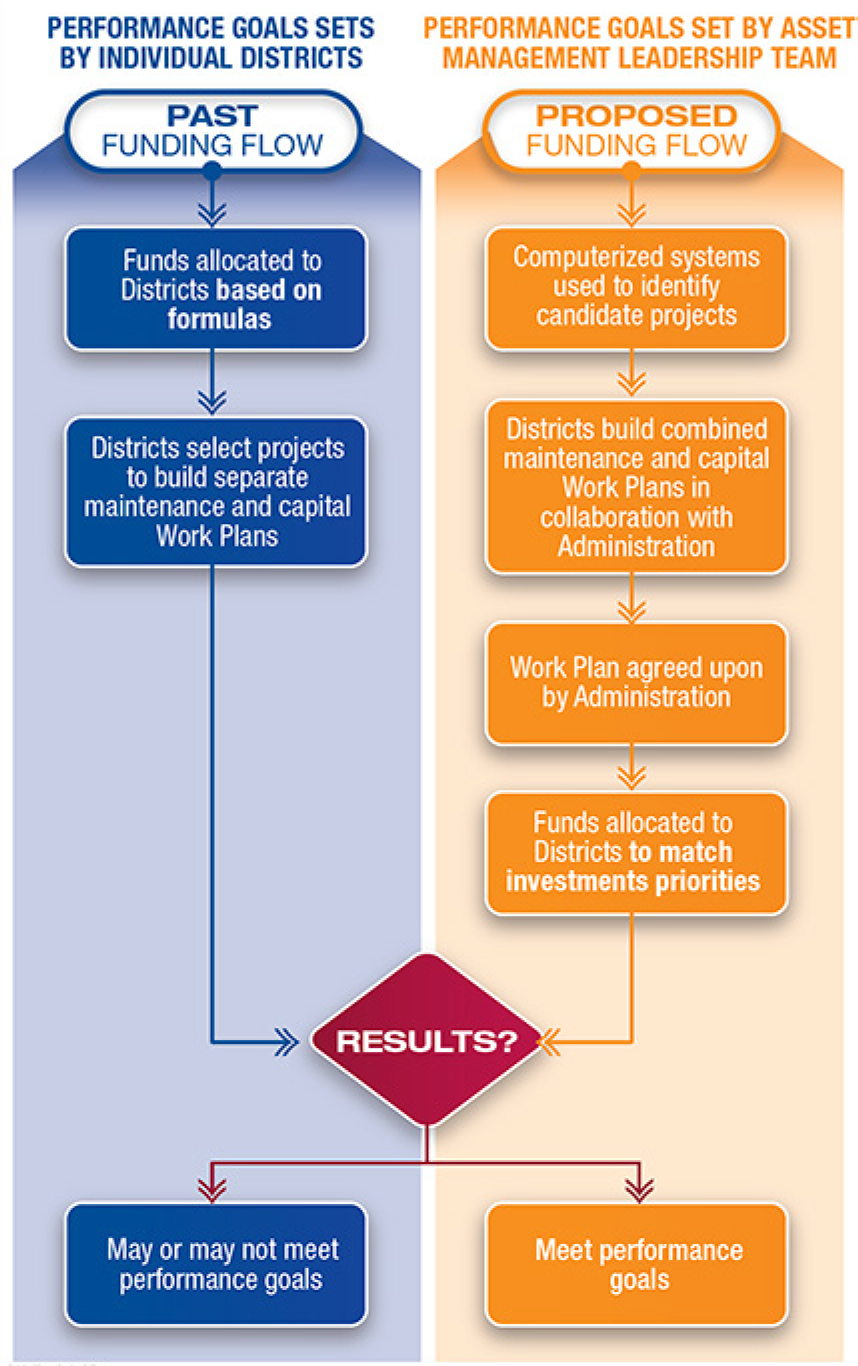

Figure 10.1. Enhanced Investment Strategies

Computerized Systems Used to Identify Projects

Pavement data and condition surveys are collected annually on Oahu and biannually in Hawaii Island, Kauai, Maui, Molokai, and Lanai. The data are inputted into the HDOT's PMS. With the PMS, the HDOT runs pavement deterioration models, determines the appropriate life cycle cost management plan, and prioritizes life cycle planning strategies on pavement projects statewide. In addition, bridge inspection data and conditions are collected and inputted into the BMS. The appropriate bridge repair or replacement is determined by multiple factors, such as implementation of life cycle planning strategies, structural deficiency, volume of trucks and cars on the route, and risk. The bridge program also prepares a prioritized list of bridge projects. Both the PMS and BMS have a data-driven foundation and methodology.

Districts Build Combined Maintenance and Capital Workplans in Collaboration with Administration

Instead of each district developing its own Special Maintenance Plan and budget, the prioritized pavement and bridge lists are combined to strategically evaluate the pavement conditions and bridge conditions statewide. The life cycle planning and financial plan help to determine the lowest cost strategy (best cost/benefit value) for asset management.

Workplan Agreed Upon by Administration

The Administration reviews the recommendations of the programming and evaluates if any other considerations are necessary. The pavement and bridge project lists are approved by the Administration.

Funds Allocated to Match Investment Priorities

Projects are funded by federal and/or state funds based on this data- and technical-driven prioritization process and approach.

Supporting FHWA's National Goals

The HDOT's investment strategy to use life cycle planning strategies to achieve the lowest practical cost for improving and preserving HDOT's transportation assets supports the HDOT's goal to provide a process to help HDOT achieve and sustain a state of good repair over the life cycle of its assets.

In addition, the investment strategy also supports FHWA's National Goals, shared in Table 2.1 in Chapter 2 and shown in Table 10.2.

Table 10.2. HDOT Investment Strategies Support FHWA National Goals

Safety	**To achieve a significant reduction in traffic fatalities and serious injuries on all public roads** Maintaining and programming HDOT's NHS pavement and bridge projects based on life cycle planning strategies will help to extend the life of the existing NHS infrastructure and maintain them in a state of good and fair condition at the lowest minimal life cycle cost. Maintaining a state of good and fair condition directly supports this goal and results in a safer roadway where users do not need to be concerned about facility failures.
Infrastructure Condition	**To maintain the highway infrastructure asset system in a state of good repair** Maintaining and programming HDOT's NHS pavement and bridge projects based on life cycle planning strategies will help to extend the life of the existing NHS infrastructure and maintain them in a state of good and fair condition at the lowest minimal life cycle cost. The preventative and rehabilitation treatments directly help to minimize the state of poor repair facilities and reconstruction costs by reducing the deterioration rate of assets in the state of good and fair condition. This is opposed to a "worst-first" strategy, where good and fair condition facilities are allowed to deteriorate while the majority of funding goes to expensive reconstruction projects on the state of poor repair facilities. The life cycle planning strategy directly supports this national goal.
Congestion Reduction	**To achieve a significant reduction in congestion on the National Highway System** Nearly 50% of the state's daily traffic travels on the NHS. Maintaining and programming HDOT's NHS pavement and bridge projects based on life cycle planning strategies will help to extend the life of the existing NHS infrastructure and maintain them in a state of good and fair condition at the lowest minimal life cycle cost. The preventative and rehabilitation treatments directly help to minimize the state of poor repair facilities and reduce the number of reconstruction projects. Reconstruction projects cost more and the projects take longer, which leads to more work zone closures, which directly leads to more congestion. Maintaining a state of good and fair condition directly supports this goal and results in less costly and lengthy reconstruction projects.
System Reliability	**To improve the efficiency of the surface transportation system** Nearly 50% of the state's daily traffic travels on the NHS. The NHS also serves as the primary route for transporting goods and services in the state. Maintaining and programming HDOT's NHS pavement and bridge projects based on life cycle planning strategies will help to extend the life of the existing NHS infrastructure and maintain them in a state of good and fair condition at the lowest minimal life cycle cost. Maintaining a state of good and fair condition directly supports this goal and results in a more reliable roadway where users do not need to be concerned about facilities in poor condition.
Freight Movement and Economic Vitality	**To improve the national freight network, strengthen the ability of rural communities to access national and international trade markets, and support regional economic development** Minimizing congestion and improving system reliability on the NHS directly leads to improving the National Highway Freight Network, strengthens the ability of rural communities to access national and international trade markets, and supports regional economic development. In general, the NHS network in the state is Hawaii's freight network. The NHS network also links communities and ports to major business centers, which in turn supports economic development. Maintaining NHS roads and bridges in a state of good repair directly supports the National Highway Freight Network and regional economic development.

Table 10.2. HDOT Investment Strategies Support FHWA National Goals

Environmental Sustainability	**To enhance the performance of the transportation system while protecting and enhancing the natural environment** As congestion on the NHS is reduced (by maintaining the state of good and fair conditions) and system reliability increases (by minimizing poor conditions), travel time is reduced and the amount of CO2 emissions are reduced. In addition, the volume of gas and other fossil fuels reduce, which is a benefit to the natural environment.
Reduced Project Delivery Delays	**To reduce project costs, promote jobs and the economy, and expedite the movement of people and goods by accelerating project completion through eliminating delays in the project development and delivery process, including reducing regulatory burdens and improving agencies' work practices** With the HDOT's shift to an investment strategy that prioritizes life cycle planning strategies, the number of maintenance and preservation projects will increase. These types of projects are typically eligible for a categorical exclusion and the design is straight-forward and simple. The length of project delivery will be reduced and result in a reduction in delays. This will also reduce the number of large reconstruction and replacement projects, which will also reduce project delays.

NHS Effective Performance

As noted in Chapter 1, the NHS serves multiple functions in Hawaii. The NHS carries large volumes of traffic and is the primary means to transport freight and goods. The NHS often provides the only access to communities; as such, the NHS system is essential to the community's well-being. As reflected in Table 10.2, the HDOT's TAMP goal and objectives directly supports FHWA's National Goals, the performance of the NHS, and the HDOT's targets for a state of good repair. An investment strategy that prioritizes life cycle planning strategies will help to extend the life of the existing NHS infrastructure and maintain them in a state of good and fair condition at the lowest minimal life cycle cost. These activities will improve safety, infrastructure condition, congestion, system reliability, and freight movement and economic vitality, which directly improves the effectiveness of the NHS.

The State's NHS pavements carries 50% of the state's daily volume of traffic.

Through this TAMP and the HDOT's investment strategy approach of life cycle planning, the HDOT supports the NHS and prioritizes the NHS assets to ensure its effective performance. The NHS assets are prioritized to ensure the NHS remains effective in Hawaii.

Trade Offs

The HDOT is in the process of developing its MRTP. As mentioned in Chapter 2, the MRTP will provide the link between the long-range plans and the 4-year STIP. Figure 10.2 shows the progression of solutions through the long-range plan, MRTP, and the STIP. During the programming of the MRTP, trade-off analysis between the priorities from various HDOT programs will need to be considered and compared. In addition to using a data- and technical-driven prioritization process, the HDOT will have to implement other tough policies. The MRTP will need to include a variety of funding scenarios.

To meet the HDOT's asset management and safety performance goals, the Administration has adopted a "fix or repair it first" approach that prioritizes maintenance, rehabilitation, and safety projects over capacity projects. Other strategies include focusing on the NHS pavement and bridge assets to achieve the lowest practical cost for improving and preserving HDOT's transportation assets.

Figure 10.2. Implementation from Long-Range Plan to STIP

CHAPTER 11

Process Improvements

TAMP Governance and Sustainment

In addition to the development and implementation of a TAMP, the FHWA must re-certify the TAMP once every 4 years. If required, FHWA will identify specific findings and actions that are necessary to correct deficiencies. Failure to establish an accepted TAMP by the FHWA will result in a lowered federal participation rate of 65 percent for projects on the NHS.

In addition, the FHWA will conduct an annual TAMP consistency determination. For the 12 months preceding the consistency determination, the HDOT shall show that its funding allocations are reasonably consistent with the investment strategies specified in its TAMP. If the planned and actual levels of investment for various work activities are reasonably close, then the alignment exists. Failure to receive a positive consistency determination by the FHWA will result in a lowered federal participation rate of 65 percent for projects on the NHS.

Failure to establish an accepted TAMP and failure to obtain a positive annual Consistency Determination by FHWA will result in a lowered federal participation rate of 65 percent for projects on the NHS.

States must make progress towards achieving their targets for NHS-mandated assets. If a state fails to meet targets and asset conditions falls below minimum conditions, the FHWA may impose funding actions with the intent to divert resources to improve the interstate system and NHS bridges in accordance with 23 USC §119(f).

The goal of the federal performance measures is to establish transparent, formalized policies and processes that aid the various DOTs to make consistent and defensible decisions in asset investments, regardless of whether they are on or off the NHS. The TAMP performance measures will satisfy this need and can also be used to justify HDOT investment decisions and legislative funding requests. The HDOT's top officials are committed to providing resources, including funding, training, and personnel for the long-term sustainment of the asset management program.

Continuous Review (Living Document)

It is recognized that the TAMP program will not be static and it is good business practice to continuously re-evaluate practices and procedures. The HDOT's administration is working on its organizational structure to build a stronger connection between its mission and the transportation asset management goals and objectives. This requires a strategy and successful implementation that needs to address culture change, identification of new requirements and functions, HDOT reorganization, process review and changes, operational budgeting, and contracting actions.

The Asset Management Leadership Team has already identified some key process improvements, as follows:

- **Planning and Programming**
  - Strengthen the programming process – providing detailed information on the data, tools, and measures that are used to support transportation asset management decisions and actions
  - Merge capital and maintenance activities into a district's work plan
  - Develop an asset management training plan that identifies who needs asset management training
- **Data Governance**
  - Strengthen information systems and data – investing, as necessary, in the data and information systems needed to be confident in transportation asset management decisions and actions
  - Establish data collection standards and implement a data governance plan
  - Explore opportunities for using technology to improve data collection activities and improve organizational efficiency
  - Integrate the maintenance management processes of the districts into the asset management program
  - Continue to work with the County of Hawaii and the City and County of Honolulu on sharing data on the NHS
- **Infrastructure**
  - Continue with the process improvements on the AASHTOWare BrM software for the pavement and bridge management systems
  - Identify and implement opportunities to incorporate new means, methods, treatments, specifications, and technology into the construction of preservation treatments for both pavement and bridges.
  - Work with Planning and Programming to include all state roads and bridges in the TAMP
  - Continue to add other assets, such as drainage and traffic management facilities, in future versions of the TAMP

Appendix A

Risk Register

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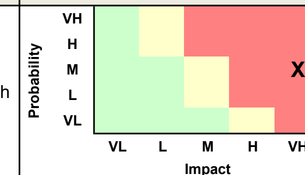
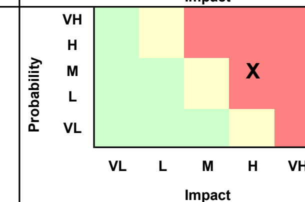
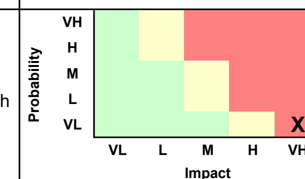
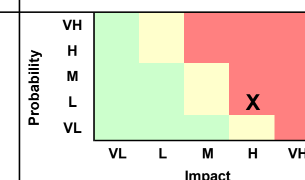
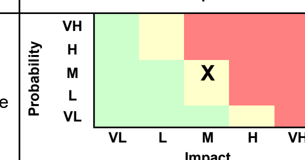
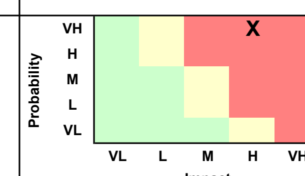
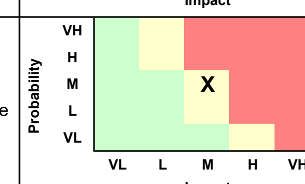
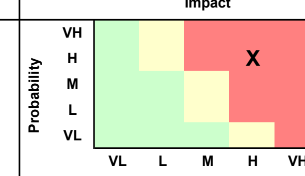
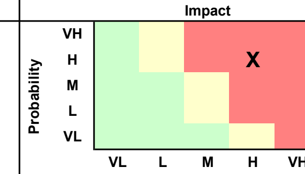
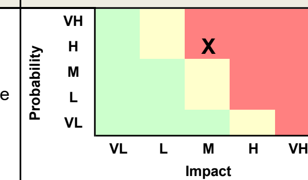
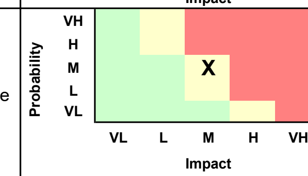
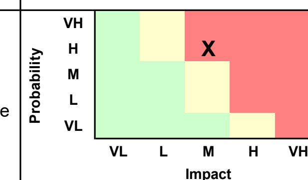
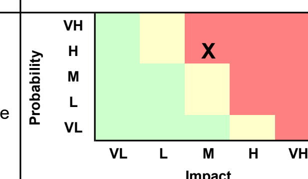
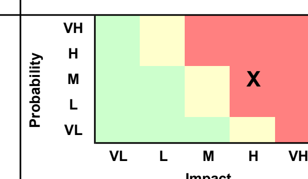
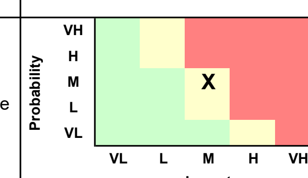
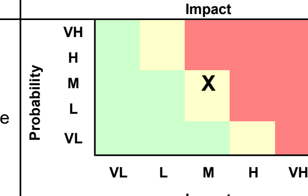
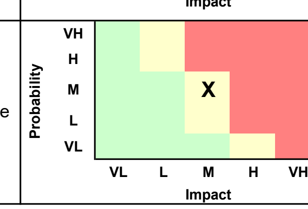
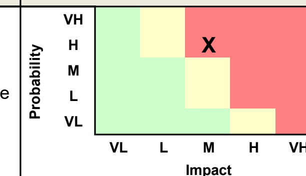
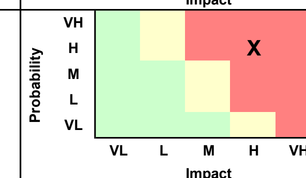
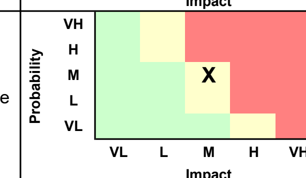
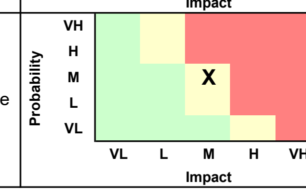
TAMP Risk Management Register for HDOT

Risk Identification							Qualitative Risk Assessment			Risk Response Plan		Monitoring and Control		
#	Status	Risk Category	Risk Item	Cause	Effect	Threat or Opportunity	Probability	Impact	Risk Matrix	Response Strategy	Response Actions	Responsible Entity/Lead Office	Monitoring Frequency	Status Update
1	Active	Hazard	Severe Weather Events, Tropical Storms, Hurricanes, and Tsunamis	Flooding, landslides, bridge failures, and storm drainage capacity	Loss of access	Threat	Moderate	Very High		Mitigate	HDOT to review design storm to determine impacts (construction cost, etc.) and then make a decision to adopt change or not	HWY-D	TBD	Ongoing
2	Active	Hazard	Climate Change: Sea Level Rise	Shoreline erosion, inundation, and flooding	Loss of access	Threat	Moderate	High		Accept	HDOT to monitor ongoing data and studies. HDOT to continue to update asset inventory data and to consider SLR for new roadway alignments in long-range plans. HDOT should participate in larger policy discussions with other State/City/County agencies.	HWY-P, -D, -C, -L and other State and City/County agencies	As required, ongoing	Ongoing
3	Active	Hazard	Earthquakes	Bridge failures, landslides, rockfall, or roadway slope/fill failures	Loss of access	Threat	Very Low	Very High		Accept	HDOT to continue to update asset inventory data. HDOT to develop/update emergency response procedures and interagency MOUs. HDOT to continue to bridge seismic retrofit and rockfall programs.	HWY-P, -D, -C, -L	As required, ongoing	Ongoing
4	Active	Hazard	Lava Flows	Volcanic Activity; lava crossing roadways	Loss of access	Threat	Low	High		Accept	HDOT to continue interagency MOUs and emergency response procedures. Look for alternate routes in active lava zones.	HWY-P, -D, -C, -L	As required, ongoing	Ongoing
5	Active	Hazard	Repeated (Emergency) Damage of Facilities	Natural disaster events	Loss or interruption of access	Threat	Moderate	Moderate		Mitigate	HDOT to perform 20-year look back to determine susceptible facilities and note past restoration activities. HDOT to proactively consider additional hardenings and/or other alternatives for future work.	HWY-C, District Offices, HWY-D, HWY-L	As required, ongoing	Ongoing
6	Active	Financial	Federal Revenues	High dependence on fuel tax collection	Reduction in Federal Revenues	Threat	Very High	High		Mitigate	HDOT to continue participating in national initiatives in alternative tax or fee collection methods	HWY-S	As required, ongoing	Ongoing
7	Active	Financial	Continuous short-term federal transportation bills or extensions	High dependence on Congress and the President to continue to support and fund transportation bills	Delay in Federal Oversight and Funding	Threat	Moderate	Moderate		Accept	HDOT to continue to monitor to see if it impacts the funding of any TAMP activities.	HWY-S	As required, ongoing	Ongoing
8	Active	Financial	State Revenues	High dependence on fuel tax collection and dependence on state obligations from the Legislature	Reduction in State Highway Revenues available for programs and projects	Threat	High	High		Accept	HDOT to continue working with State Legislature to diversify revenue collection methods or updating fee schedules.	HWY-S	As required, ongoing	Ongoing
9	Active	Financial	Renewable Energy policies	Increase use of hybrid, electric, and fuel efficient vehicles	Reduction in State Highway Revenues	Threat	High	High		Mitigate	HDOT to continue working with State Legislature to diversify revenue collection methods or updating fee schedules.	HWY-S	As required, ongoing	HWY-S is conducting a Road Usage Charge pilot to establish stability in the States' revenue generation

TAMP Risk Management Register for HDOT

Risk Identification							Qualitative Risk Assessment			Risk Response Plan		Monitoring and Control		
#	Status	Risk Category	Risk Item	Cause	Effect	Threat or Opportunity	Probability	Impact	Risk Matrix	Response Strategy	Response Actions	Responsible Entity/Lead Office	Monitoring Frequency	Status Update
10	Active	Financial	Lack of financial data to make appropriate TAMP planning decisions	Current method of collecting data	Impact to TAMP life cycle policy decisions and funding decisions	Threat	High	Moderate		Mitigate	HDOT to continue to develop new policies and processes to efficiently collect the necessary financial data.	HWY-S, HWY-P, HWY-A	As required, ongoing	Ongoing
11	Active	Organizational	Program Prioritization	Weak program processes and management for pavement and bridges, including resistance to culture change	Impacts to an ineffective performance-based planning and programming process	Opportunity	Moderate	Moderate		Mitigate	Further develop the HDOT's pavement management system and bridge management system. Provide staff resources to support the management systems.	HWY-D, -L	As required, ongoing	Ongoing
12	Active	Organizational	Staff Shortage	Length of the State's hiring process and lack of interest in working for the public sector	Limited staff resources available to complete the standard processes and analyses	Threat	High	Moderate		Mitigate	Develop a hiring campaign and work with HR to expedite the hiring process.	HDOT Administration	As required, ongoing	Ongoing
13	Active	Organizational	Lack of educational and training programs	New techniques, regulations (both federal and state), materials, and design methodologies require HDOT staff to remain relevant as the industry advances and evolves.	Lack of knowledge can lead to inefficient delivery of projects, schedule delays, and costly change orders	Threat	High	Moderate		Minimize	Develop a training program and strategies to keep staff educated and engaged.	HDOT Administration	As required, ongoing	Ongoing
14	Active	Organizational	Staff Turnover and Retirement	Loss of important information and processes due to high levels of retirement and staff turnover	Impacts to time and budgets for staff education	Threat	Moderate	High		Minimize	Develop a mentoring program and strategies to engage and keep staff	HDOT Administration	As required, ongoing	Ongoing
15	Active	Organizational	Changes in administration, or division priorities	Change in political/administrative priorities	Programs are implemented ineffectively and become less performance-based (subject to changing priorities)	Threat	Moderate	Moderate		Mitigate	Rely and focus on a data- and performance-driven process to establish priorities	HDOT Administration	As required, ongoing	Ongoing
16	Active	Strategic	Maintenance Policies	Lack of clear maintenance policies (including other policies on right-of-way acquisitions and utility agreements)	Impacts to pavement and bridge conditions and project delivery	Opportunity	Moderate	Moderate		Mitigate	Develop consistent maintenance policies District-wide for pavement and bridge. Establish clear project delivery policies.	HWY-P, -D, -L, Districts	As required, ongoing	Ongoing
17	Active	Strategic	Data Management	Lack of resources to collect and process the appropriate data needed for Bridge Management Program and Pavement Management Program.	Impacts to an ineffective performance-based planning and programming process	Opportunity	Moderate	Moderate		Mitigate	Create a new Programming and Data Management Division. Provide resources within HWY-DB and HWY-L for BMS and PMS.	HWY-P, -L, -DB, Districts	As required, ongoing	Ongoing

TAMP Risk Management Register for HDOT

Risk Identification							Qualitative Risk Assessment			Risk Response Plan		Monitoring and Control		
#	**Status**	**Risk Category**	**Risk Item**	**Cause**	**Effect**	**Threat or Opportunity**	**Probability**	**Impact**	**Risk Matrix**	**Response Strategy**	**Response Actions**	**Responsible Entity/Lead Office**	**Monitoring Frequency**	**Status Update**
18	Active	Strategic	Length of procurement	State process for procurement is lengthy	Delay in project implementation (delivery)	Threat	High	Moderate		Transfer	Work closely with other the State Procurement Office, Attorney General, and FHWA	HDOT Administration	As required, ongoing	Ongoing
19	Active	Strategic	Complexity of environmental regulations	Multiple environmental challenges in Hawaii with numerous endangered species and historic/cultural resources	Delay in project implementation (delivery)	Threat	High	High		Minimize	Develop environmental guidelines and standards for the project managers	HWY-D	As required, ongoing	Ongoing
20	Active	Strategic	Uncertainties in life cycle planning and lack of effective preventative practices in Hawaii	The technology or equipment for a wide variety of preventative strategies are not available in Hawaii	Limited strategies for preventative maintenance	Opportunity	Moderate	Moderate		Mitigate	Discuss the priority of preventative work with the asphalt industry and encourage new resources	HWY-P, -D, -C, -L, Districts	As required, ongoing	Ongoing
21	Active	Strategic	Resistance to culture change and TAMP sustainment	Staff are used to the old way of doing business	Slower implementation of strategies	Opportunity	Moderate	Moderate		Mitigate	Provide education on the TAMP and how the revised processes will save time and money	HWY-P, -D, -C, -L, Districts	As required, ongoing	Ongoing

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Appendix B

Summary of Facilities Repeatedly Requiring Repair and Reconstruction Due to Emergency Events

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Summary of Facilities Repeatedly Requiring Repair and Reconstruction Due to Emergency Events

	Island	Project ID	Project Number	Project Title	Route #	Mile Post Begin	Mile Post End	Event Description	Declaration Date
1	HAWAII	0011-1004-D1C1	ER-12(2)	MAMALAHOA HIGHWAY, EMERGENCY REPLACEMENT OF FORD CROSSING (MAKAKUPU BRIDGE) AND EMERGENCY REPLACEMENT OF KAALAALA STREAM BRIDGE	11	49.11	49.82	DR-1348 Storm Damage to 4 bridges on Mamalahoa Hwy in Kau	11/9/00
2	HAWAII	0011-1005-D1C1	ER-12(3)	MAMALAHOA HIGHWAY, EMERGENCY REPLACEMENT OF PAAUAU STREAM BRIDGE, IMPROVEMENTS AT KAMANI STREET, AND REHABILITATION OF VARIOUS BRIDGES	11	49.11	51.32	DR-1348 Storm Damage to 4 bridges on Mamalahoa Hwy in Kau	11/9/00
3	HAWAII	0011-1002-D1C1	ER-12(1)R	MAMALAHOA HIGHWAY, EMERGENCY REPLACEMENT OF KEAIWA STREAM BRIDGE	11	50.35	50.45	DR-1348 Storm Damage to 4 bridges on Mamalahoa Hwy in Kau	11/9/00
4	HAWAII	0019-1068-D1C1	ER-15(21)	EMERGENCY EARTHQUAKE ROCKFALL REPAIRS, VARIOUS LOCATIONS ON HAWAII, UNIT 3 (ROUTE 19, HAWAII BELT ROAD, M.P. 12.9 TO 45.0)	19	12.9	45	DR-1664 6.5 Earthquake near Pauanahulu, Hawaii County	10/15/06
5	MAUI	0030-1045-D1C1	ER-17(002)?	HONOAPIILANI HIGHWAY, EMERGENCY SHORELINE REPAIRS, MILE POST 13 TO MILE POST 16 (PERMANENT WORK)	30	13	16	DR-4194 TROPICAL STORM ISELLE --WIND, RAIN, SURF, SURGE, FLOOD	8/6/14
6	MAUI	0030-1038-D1C1	30C-01-12	HONOAPIILANI HIGHWAY, SHORELINE IMPROVEMENTS IN THE VICINITY OF LAUNIUPOKO (D/B - EMERGENCY PROJECT)	30	18.1	18.5	Launiupoko - Honoapiilani Highway Erosion due to waves and rain in Launiupoko	6/8/12
7	KAUAI	0050-1051-D1C1	50A-01-13	KAUMUALII HIGHWAY, EMERGENCY SHORELINE IMPROVEMENTS, VICINITY OF KEKAHA, M.P. 27 (PERMANENT WORK)	50	27	27	Waves eroded 15 feet of shoulder on Kaumualii Hwy in Kekaha area.	7/25/12
8	Kauai	0056-1047-D1C1	ER-16(001)	KUHIO HIGHWAY, EMERGENCY CULVERT REPLACEMENT IN KILAUEA AT M.P. 22.5	56	22.5	22.5	DR-4062 Severe Storms, Flooding, and Landslides GOV procs. 2012 Rains and Flooding (Kuhio Highway near Kilauea, emergency repairs to 15-ft diameter culvert running beneath Kuhio Highway following a partial collapse)	3/3/2012; 3/8/12; 3/22/12; 4/18/12

Summary of Facilities Repeatedly Requiring Repair and Reconstruction Due to Emergency Events

	Island	Project ID	Project Number	Project Title	Route #	Mile Post Begin	Mile Post End	Event Description	Declaration Date
9	KAUAI	0056-1017-D1C1	ER-14(1)	KUHIO HIGHWAY EMERGENCY REPAIRS, VICINITY OF MP 21.7 (WAILAPA STREAM)	56	21.7	21.7	DR-1640 Flood (40 days of rain) & Kaloko Dam Breach. GOV proc. 2006 Flooding	5/1/06; 3/2/06; 3/12/06; 9/15/06
10	OAHU	0072-1005-D1C1	61C-02-04	KALANIANAOLE HIGHWAY, EMERGENCY LANDSLIDE REPAIRS, AT CASTLE JUNCTION	61	9.5	9.81	EMERGENCY PROCALAMATION ISSUED BY THE GOVERNOR WAIVING STATE ENVIRONMENTAL AND PERMIT REQUIREMENTS.	
11	OAHU	0061-1004-D1C2	61D-02-06	KAILUA ROAD, PERMANENT REPAIRS, FOR ROCKFALL AND LANDSLIDE MITIGATION	61	10.24	10.6	DR-1640 Flood (40 days of rain) & Kaloko Dam Breach. GOV procs. 2006 Flooding	5/1/06; 3/2/06; 3/12/06; 9/15/06
12	OAHU	0083-1003-D1C1	STP-083-1(45)	KAMEHAMEHA HIGHWAY, WAIMEA BAY, EMERGENCY ROCKFALL REMEDIATION	83	5.64	5.9	Gov Ben Cayetano delcared a state of emergency and closed the highway for 3 months until safety improvements could be completed. Installing 10-ft-high 1,000-ft long fence and moving the road away from the cliff, adding 21 feet to Kam Hwy;	March 2000
13	Hawaii	HAWA-1034-D1C!	ER-15(19)	EMERGENCY EARTHQUAKE ROCKFALL REPAIRS, VARIOUS LOCATIONS ON HAWAII, UNIT 1 (ROUTE 250, KOHALA MOUNTAIN ROAD, M.P. 2.7 & 7.9) (ROUTE 270, AKONI PULE HWY,M.P. 14.5 TO 28.4)	250	2.7	7.9	DR-1644 Earthquake; Gov Proc. 2006 earthquake	10/16/06; 10/17/06
14	Hawaii	HAWA-1034-D1C!	ER-15(19)	EMERGENCY EARTHQUAKE ROCKFALL REPAIRS, VARIOUS LOCATIONS ON HAWAII, UNIT 1 (ROUTE 250, KOHALA MOUNTAIN ROAD, M.P. 2.7 & 7.9) (ROUTE 270, AKONI PULE HWY,M.P. 14.5 TO 28.4)	270	14.5	28.4	DR-1644 Earthquake; Gov Proc. 2006 earthquake	10/16/06; 10/17/06
15	MOLOKAI	0450-1002-D1C1	ER-12(4)	KAMEHAMEHA V HIGHWAY, EMERGENCY REPLACEMENT OF KAWAIKAPU BRIDGE	450	17.81	17.96	DR-1348 Severe Storms and Flooding	11/8/00

Summary of Facilities Repeatedly Requiring Repair and Reconstruction Due to Emergency Events

	Island	Project ID	Project Number	Project Title	Route #	Mile Post Begin	Mile Post End	Event Description	Declaration Date
16	KAUAI	0056-1057-D1C9A	ER-19(008)	KUHIO HIGHWAY, EMERGENCY ROAD REPAIRS AT LUMAHAI	560	5.1	5.3	KAUAI, HON FLOOD beginning Apr 14, 2018--RAIN, FLOOD	4/15/18; 4/18/18; 6/17/18; 8/16/18; 10/15/18; 12/14/18; 2/12/19
17	KAUAI	0560-1004-D1C1	BR-0560(014)	KUHIO HIGHWAY, REPLACEMENT AND STRENGTHENING OF WAINIHA BRIDGES	560	6.25	7	Possible failure of Wainiha Stream Bridge #2; Possible Failure of Wainiha Bridges #1 & #3	9/22/04; 10/29/07
18	KAUAI	0056-1057-D1C2A	ER-19(002)	Kuhio Highway, Emergency Slope Stabilization in the Vicinity of Wainiha	560	5.43	6.32	KAUAI, HON FLOOD beginning Apr 14, 2018--RAIN, FLOOD	4/15/18; 4/18/18; 6/17/18; 8/16/18; 10/15/18; 12/14/18; 2/12/19
19	KAUAI	0560-1016-D1C1	560A-01-18	KUHIO HIGHWAY, EMERGENCY SLOPE STABILIZATION IN THE VICINITY OF HAENA AND WAINIHA	560	6.73		KAUAI, HON FLOOD beginning Apr 14, 2018--RAIN, FLOOD	4/15/18; 4/18/18; 6/17/18; 8/16/18; 10/15/18; 12/14/18; 2/12/19

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