He‘eia Stream Riparian Restoration & Education Project Phase III Final Report

Hawai‘i Department of Health Log # 13-109

Grant Amount $747,025.79

Hydrologic Unit Code 3028

Hui o Ko‘olaupoko

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Report: October 31, 2017

Grant Period: June 20, 2013- October 31, 2017

Acknowledgements

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Hapa Landscaping, (Subcontractor)

Hawaiʻi Pacific University (Subcontractor)

Hui Ku Maoli Ola (Subcontractor)

State of Hawaiʻi, Division of State Parks (Landowner)

Kamaʻāina Kids (Land lessee)

This project was funded under an EPA Section 319(h) grant.

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Executive Summary

Hui o Koʻolaupoko (HOK) is a 501(c)3 non-profit watershed management group established in 2007 to work with communities to improve water quality through ecosystem restoration and storm water management, focusing specifically in the Koʻolaupoko region of Oʻahu – from Makapuʻu to Kualoa. HOK implements innovative, on-the-ground projects that effectively manage and protect water quality and natural resources in Hawaiʻi. HOK's mission is to protect ocean health by restoring the ʻāina: mauka to makai.

The Heʻeia Stream Riparian Restoration & Education Project Phase III (DOH Log # 13-109) builds on HOK's past successes in the watershed (DOH Log # 09-113 and #12-079) by expanding restoration efforts to focus on upland landslide erosion control, riparian restoration at the Heʻeia Stream estuary, and focused education and outreach on non-point source pollution to Heʻeia residents and surrounding Koʻolaupoko communities.

Since 2015, HOK has been actively conducting on the ground restoration work at the Lower He'eia Stream Riparian Restoration Project area at the He'eia Estuary in an effort to improve stream functionality, improve fish passage and habitat for native aquatic species, and open foraging areas for shorebirds by removing invasive plant species to allow for the re-introduction of native plants.

Additionally, this work, addressed large upland areas of erosion, which were indicated in Dr. Eric Decarlo's 2009 (Water Quality in the Keaʻahala Stream Watershed and the Kahuhipa Storm Channel, below Windward Community College) paper as a significant source of pollution, after anthropogenic sources. Man-made erosion control materials and native vegetation were installed at one of two major erosion scars in upper the upper He'eia watershed. Along with the upper hillside erosion control, constructed sediment basins, similar to a rain garden, were built adjacent to the stream to capture sediment during the plant establishment period.

Focused education and outreach efforts implemented through this grant target schools and residents of the He'eia watershed to deliver place-based education on pollution sources, their specific impacts to the watershed and ways that every individual can take action to reduce their ecological footprint. For the residential outreach portion of this project, HOK employed the innovative methods of Community Based Social Marketing (CBSM), and surveys to identify behaviors that affect the island's watersheds. To develop formal in-classroom and field trip curriculum specific to the He'eia watershed which emphasized Hawaiian cultural values, HOK partnered with He'eia based non-profit Papahana Kuaola.

To date, HOK has hosted nearly 5000 students and community volunteers to the He'eia Estuary project site to learn about and lend a hand to the efforts. We have removed over four (4) acres of invasive plants and replanted over 2000 individual native plants (25 species). There has been a noticeable return of estuarine life to the project site with an increase in the number of fish observed, native and migratory bird species utilizing the area for foraging, and thriving communities of native plants. While project maintenance and monitoring will be ongoing, we take these numbers as a positive sign that our efforts are leading to a positive trend in the area's return to a functioning native estuary. We look forward to continuing our work and deepening our relationship with the surrounding community and non-profit partners.

Introduction and Purpose

This project addresses recommendations in Kailua Bay Advisory Council's 2007 Koʻolaupoko Watershed Restoration Action Strategy (KWRAS) for educational curriculum, management guidelines for pesticide and fertilizer management and water quality monitoring. Additionally, the document recommends contacting large landowners for riparian preservation and restoration and identifies the lower reach of Heʻeia Stream for restoration and conservation actions. There is currently no threat from development or agriculture pressure to the area to warrant any official preservation such as a conservation easement, thus a status-quo with regards to the land management provides enough protection to proceed with restoration efforts.

The work conducted by HOK under this project addresses targeted upland erosion control, riparian restoration at lower Heʻeia Stream and focused education and outreach in an overall effort to reduce non-point pollution inputs to the stream system (see Appendix B). The non-point pollution sources in Heʻeia Stream likely originate in part from the personal use of fertilizers and/or pesticides and other personal practices resulting in elevated levels of nitrates and nitrites. In addition to elevated levels of nitrates and nitrites, Heʻeia Stream is displaying evidence of sediment loading and turbidity via stream bank and hillside erosion and non-native vegetation domination in the riparian zone.

This effort, coupled with past and current efforts throughout the watershed, will result in the implementation of restoration on the majority of large, undeveloped land along the main stem of Heʻeia Stream.

This project consists of three major components addressing water quality issues:

1. Riparian Restoration
2. Upland Erosion Control
3. Education and Outreach

<u>Riparian Restoration</u>

This component will address non-point source pollution through riparian restoration at the Heʻeia stream mouth at Kāneʻohe Bay (see Appendix B). This will involve removing non-native vegetation from the riparian area to improve stream functionality and restore habitat for native aquatic species and improve fish passage, open foraging areas for shorebirds and remove invasive plant species to allow for the re-introduction of native plants.

Approximately 50 species of mangroves occur in tropical and subtropical environments, worldwide where they are considered, for the most part, native species throughout their range except in Hawai`i and some parts of Polynesia where they considered an invasive marine weed. Mangroves were introduced to Hawai`i on the island of Molokai in the early 1900's to stabilize mudflats and reduce erosion one of many ecosystem services attributed to mangroves in their native ranges. After mangroves arrived, they colonized tidal flats, riverbanks, fishponds, canals, protected reefs, embayments, lagoons and other low energy coastlines. Reportedly, their invasion and reduction of prime foraging and nesting habitat of four endangered water-bird species and overgrowth onto native archaeological sites (e.g. fishponds) has been especially problematic and costly to resource managers.

The exotic red mangrove, *Rhizophora mangle,* has altered hydrological inputs, organic matter dynamics, sedimentation patterns, and invertebrate food webs along invaded Hawaiian coastlines as well as increased numbers of exotic invertebrates. Efforts to remove mangroves (*Rhizophora mangle)* in He'eia Watershed were implemented with the hypothesis that doing so will improve water quality. Anecdotal evidence suggests benefits include an increase in oxygen levels and a decrease in Total Nitrogen with the removal of large quantities of leaf litter inputs.

A discussion and annotated bibliography of the negative impacts of mangroves was compiled by HOK and project contractors at Hawaii Pacific University and can be found in Appendix D.

Upland Erosion Control

This component includes addressing erosion scars in the upper He'eia watershed by installing erosion control materials and native vegetation at one of two major erosion scars (see Appendix B). A combination of native vegetation and geo-textile materials (biotechnical slope stabilization) has been used to stabilize slopes that have been deforested, eroded or excavated. These methods have been used commonly in Hawai'i particularly to address landslides along cuts forged for roads (e.g. the Pali Highway on O'ahu). Although a common occurrence along transportation corridors, this is the first known use of biotechnical slope stabilization used in the upper reaches of a Hawaiian ahupua'a to reduce sediment from impacting down-slope stream water quality. Along with addressing hillside erosion, constructed sediment basins called rain gardens will be built adjacent to the stream to capture sediment during the native vegetation establishment period. Rain Gardens, also known as engineered or constructed wetlands, utilize natural processes involving wetland vegetation, soils, and their associated microbial assemblages to assist in retaining and treating storm water.

Education and Outreach

The non-point pollution sources in He'eia Stream likely originate in part from the personal use of fertilizers and/or pesticides and other personal practices resulting in elevated levels of nitrates and nitrites. This project component will address the elevated levels of nitrites/nitrates by delivering a broader watershed education perspective about He'eia Stream. HOK will implement several outreach and education efforts to reach the He'eia population and deliver education about ways individuals can begin to decrease the amount of polluted storm water reaching He'eia Stream.

HOK will conduct residential outreach in the He'eia Watershed through mailings to homeowners, door-to-door outreach and homeowner workshops. HOK and project partner Papahana Kuaola will develop and deliver classroom curriculum and hands-on field experiences to area schools including Public, Private, Charter Schools and Kama'āina Kids Summer Program at He'eia State Park.

The following are a summary of the expected outcomes of the project:

- ✓ Remove invasive vegetation and replant ±1,400 linear feet of riparian habitat
- ✓ Remove invasive vegetation and replant ± four (4) acres of lower stream habitat
- ✓ Install 24,000 square feet of upland erosion control
- ✓ Send 2,200 in-mail flyers to He'eia homeowners
- ✓ Reach 8-10% (176-220) residents through individual RSWA
- ✓ Deliver watershed education to 250 students
- ✓ Conduct project effectiveness monitoring

Project Site Description

He‘eia Stream is listed on the Environmental Protection Agency’s (EPA) 2004 §303(d) list for nitrites and nitrates. The stream flows into Kāne‘ohe Bay from the Ko‘olau Mountains, draining approximately 2,843 acres (1,150 hectares) before entering central Kāne‘ohe Bay. He‘eia Stream is perennial with approximately 7.4 miles (11,909 meters) of mainstem and tributary streams. The average continuous mainstem flow is 2.8 cfs (Wilson Okamoto Corporation, 2004) with an average gradient of 11%. The watershed has a maximum elevation of 2,802 feet (854 meters) rising above its lowest elevation at sea level. He‘eia watershed is culturally significant with a variety of archaeological sites including Kawa‘ewa‘e and Leleahina Heiau and the very visible He‘eia Fishpond. The 2000 Census estimates 13,595 residents reside within the watershed. He‘eia Stream has a variety of land cover including: steep slope/shrub/scrub (48%), forested land (31%), development (18%), and wetlands (3%).

The majority of the work for this project is concentrated on two sections of He‘eia Stream, the stream mouth and the upper portion of the watershed (see Appendix B). Riparian restoration work was conducted on the He‘eia stream mouth estuary at He‘eia State Park and along the He‘eia fishpond wall adjacent to He‘eia stream. Kama‘āina Kids has a 25-year lease on the property until 2035. The area is comprised of approximately five and a half (5.50) acres dominated by non-native species including mangrove and hau bush and an additional acre of cleared, public shoreline access. Prior to restoration efforts, non-native invasive species had converted the riparian area from a native vegetation regime to a near mono-culture vegetation make-up. As such, both mangroves (***Rhizophora mangle*)** and hau bush (*Hibiscus tiliaceus*) had encroached into the stream corridor reducing the potential for native fish passage and shorebird foraging.

Upland erosion control work was conducted in the upper reaches of the He‘eia ahupua‘a on land owned by Kamehameha Schools and leased by Papahana Kualoa, where three areas of mass wasting, more commonly referred to as ‘erosion scars’ are present. The erosion scar targeted for remediation through this project is located only 675 feet from He‘eia Stream. Following heavy rains, land managers here have observed significant evidence of red dirt flowing from the eroded sites downhill to He‘eia Stream (personal communication with Papaha Kuaola 10-5-12). Therefore, it is believed that the natural erosion processes are likely exasperated due to native vegetation being out-competed by non-native vegetation, resulting in a lack of ground cover for soil stability.

The education and outreach component will focus in the He‘eia watershed, a census-designated area in the Ko‘olaupoko District on the island of O‘ahu with a total population of 4,963, about 30% of whom identify as Native Hawaiian. Native Hawaiians had a strong spiritual relationship to the land and ocean, which is still evident today among people born and raised in Hawai‘i. In the 1960s-80s plans to develop He‘eia into high priced housing, marina, resort, and golf course were met with strong community opposition and were eventually abandoned for good. The community has always advocated against development in order to preserve cultural places, native habitats (He‘eia wetlands and He‘eia stream, which flows into Kāne‘ohe Bay), and traditional agriculture (taro patches and He‘eia Fishpond, a functioning traditional Hawaiian fishpond on O’ahu). He‘eia remains rural; and the community is united in preserving the remaining historical, cultural, and nature sites and, ultimately, Kāne‘ohe Bay.

Methods

There are two main methods used by HOK to deal with non-point source pollution in He‘eia Stream: on-the-ground restoration, and education/outreach, the approach for each is described below.

Restoration

In the riparian areas of lower He‘eia Stream, removal of invasive and non-native vegetation will be done via hand-tools, chainsaws and an excavator with brush cutting attachment called a Fecon. Cut materials will be chipped on site and used as mulch to be spread around the area to reduce erosion during the plant establishment period as well as serve to control weedy species. Other, more herbaceous, weedy species will be eradicated using Aquamaster; an EPA approved aquatic herbicide.

This work will be implemented in a phased approached. For example, Phase I will start work in areas with higher ground and not subject to tidal or annual flooding, invasive species will be cut to ground level and treated with an appropriate herbicide. Phase II will work in lower lying, tidal areas and leave mangrove stumps in the ground to provide a level of soil stability under flooding conditions. Mangrove stumps will not re-grow when cuts are exposed to salt water therefore no herbicide is needed to kill mangrove. All vegetation removed in initial clearing phases will be mulched or chipped on site. This restoration approach and sequence is very similar to the approach that has been used in previous and current HOK restoration projects throughout various windward O‘ahu watersheds.
Once vegetation is removed and the area is cleared, out-planting will be implemented with native endemic and indigenous plants that can tolerate the high salinity concentrations, tidal fluctuations, seasonally high freshwater flows, and coastal growing conditions. Additionally, the plant palette will be selected based on species known to be effective at both removing contaminants from the polluted runoff and soil stabilization. Plants will be grown at a local nursery within the ahupua‘a to minimize acclimation shock. Species include, but may not be limited to: ‘ae’ae, ‘akulikuli, ‘ahu’awa, makaloa, naio.─The vast majority of the out-planting will be conducted with the help of community volunteers.─Monthly maintenance and eradication of incipient species will help to nsure long-term survival. This will continue until the plants are established and large enough and to grow without regular maintenance. The goal after one year is to reach an 80% success rate with the plantings.

In order to address the upland erosion scars, HOK and sub-contractors will anchor erosion control matting and plant native vegetation, to the extent possible, at one upland erosion scar. This portion of the project will use the Pyramat High Performance TRM, Landlok Woven Turf Reinforcement Mats (TRMs) or similar product to shore-up approximately 24,000 sq. ft. of bare soil. TRMs will be anchored in place on the top, sides and bottom, as well as any location possible within the erosion scar itself. The mats will be overlapped on all sides of the erosion scar with the toe (bottom) of the eroded area built-up with coir-logs for additional stabilization and sediment trapping. Native vegetation will be installed, to the extent possible throughout the eroded area in an effort to re-establish vegetation for additional long-term erosion control.

To help ensure that erosion from this area does not reach He'eia Stream, three sediment basins, approximately 6,000 sq. ft. each, will be constructed in the natural drainage channels en route to He'eia Stream. The upland erosion treatment site will be maintained by land lessees Papahana Kuaola and Hui Ku Maoli Ola.

The monitoring and assessment activities associated with the restoration aspects of this project address the effects of mangrove removal, rain garden installation and slope stabilization in the He'eia watershed. pH, dissolved oxygen, conductivity, salinity, turbidity, total suspended solids, total nitrogen (TN), total phosphorus (TP), nitrite (NO_2), nitrate (NO_3), and ammonium (NH_4) were monitored upstream and downstream of mangrove removal before and during/after mangrove removal. Water quality was also monitored within He'eia stream above and below erosion control work and rain gardens. Sedimentation was assessed by monitoring for changes in elevation at the upland rain gardens. The intertidal zone at the He'eia estuary, which was exposed after mangrove removal, was assessed for changes in sediment elevation. Vegetation change was documented at photopoints along He'eia stream mouth estuary and in the upland rain gardens.

The water quality monitoring QAPP and Monitoring Protocol for this project can be found in Appendix C.

Education and Outreach

The second component to address non-point source pollution (NPSP) in the He'eia watewrshed is education and outreach. The education and outreach component focused first on disseminating best practice information to residents and secondly on developing place-based watershed education to be delivered to He'eia areas schools and paired with field trips to the project locations. Both efforts are intended to target residents of He'eia with place based and culturally relevant information about Hawaiian watershed health, NPSP and individual actions to protect and improve stream and ocean health.

In order to begin to address the residential practices of fertilizer and pesticide application and other non-point source pollution contributors, HOK worked to create Residential Storm Water Audits (RSWA) as a way to directly engage the community through direct mailings, Door-to-door campaigns, and home visits with interested homeowners.

Direct Mailings were sent to the approximately 2,200 residential, single-family dwellings in the He'eia watershed and contained information on HOK, NPSP and individual actions to protect and improve stream and ocean health, the dates an HOK representative will visit their neighborhood, and how they can schedule RSWA.

Door-to-door campaigning aimed to visit every residential home in He'eia offering information and free onsite RSWA or the option to schedule for a later date. Homes with no answers would be provided a door-hanger with information similar to the initial direct mailing.

The RSWA audit will provide information and assess opportunities regarding the following topics:

- ✓ Decreasing fertilizers/pesticide application, offer alternative solutions
- ✓ Installing native plants, provide a plant list
- ✓ Installing rain barrels, where, how to install
- ✓ Building rain gardens, offer HOK rain garden manual
- ✓ Assess property for erosion control or other issues contributing to NPSP
- ✓ Other proactive actions to reduce NPSP: washing cars on the grass, sweeping driveway, picking-up animal waste, etc.

Two Homeowners Clean-Water Workshops will be offered for residents of He‘eia Watershed and the broader community to learn about these issues and how to take action to improve and protect watershed health. Each participating homeowner will be given a survey to complete about current land use practices: e.g. do they use fertilizer, pesticides, native plants, sweep or hose driveway, etc. This information will be used to further refine HOK’s education and outreach materials and begin to track behavior changes over time. Additionally, each homeowner that participates will receive a Homeowners Clean Water Kit, which includes:

- One push broom and dustpan
- One container of non-phosphorus soap (for both car washing and cleaning dishes)
- One coupon for 50% off a native plant from Hui Ku Maoli Ola Native Plant Specialist
- Information about water quality problems, their origins and other actions for improved water quality

Information on the residential outreach methodologies and results can be found in Appendix H.

The place-based watershed education component of the project will focus on in-class room education and field experiences to increase knowledge of watersheds, identifying and reducing non-point source pollution, actions to improve watershed health, and how to relate these concepts to Hawaiian values. A curriculum based on a watershed/ahupua‘a foundation will be developed including in-class instruction, field visits including restoration work and post-field work reflection. The project will directly target Public, Private, Charter Schools within the He‘eia watewrshed and surrounding areas. Through participation in the curriculum, students should be able to identify the causes and effects of NPSP, understand how traditional Hawaiian knowledge is relevant to NPSP, and collect data to better understand the sources and solutions to NPSP. A minimum of 250 students will be reached through this effort.

HOK contracted He‘eia based non-profit Papahana Kuaola to develop formalized curriculum sets that contain all of the elements necessary to teach Observation & Data Collection Activities, the Mālama Ahupua‘a Interactive Lesson, and the corresponding Vocabulary Word visual aids, the Site Visit Packet that contains all of the information regarding protocol, orientation, and preparation for participant visits to Papahana Kuaola.

Information and photos of the developed curriculum and outcomes can be found in Appendix I.

Result and Analysis

For a full discussion of riparian restoration and upland erosion control activities, data, results, and analysis see Appendices B-G.

Riparian Restoration

Removing mangroves from He‘eia stream mouth estuary did not negitively affect water quality within the stream mouth estuary.

The lack of significant changes in water quality associated with mangrove removal in He‘eia stream mouth estuary might be explained by the timeline of mangrove removal activities. Paepae o He‘eia initiated mangrove removal along the He‘eia fishpond wall adjacent to He‘eia stream in late 2014 prior to mangrove removal conducted by Hui o Ko’olaupoko as part of this project. In addition, Paepae o He‘eia began removing mangroves from the fishpond wall southeast of the stream mouth even earlier; this could also have influenced stream mouth water quality by restricting or exacerbating tidal flow within the stream mouth estuary. Mangrove removal on the He‘eia State Park side of the stream conducted as part of this project did not begin until 2015 and continued through mid-2017; therefore water quality data reflecting ambient conditions after total mangrove removal from this project area and adjacent properties has concluded will be needed.

To more accurately assess the influence of mangrove removal on water quality in He‘eia stream mouth estuary, it is recommended that monitoring continue until after all mangroves are removed including those that are proposed to be removed even farther upstream (work proposed on property leased by Kāko‘o ‘Ōiwi, The Nature Conservancy, and Paepae o He‘eia).

Sediment elevation within the areas where mangroves were removed decreased over time. Sediment was lost through both oxidation of organic content and exported during tidal fluxes and stream flow. Organic sediment transported offshore in the quantities observed in this study unlikely had a negative impact on the offshore environment. Once transported offshore organic matter would likely be oxidized or consumed. Of greater concern to the offshore environment might be an increase in mineral sediments transported offshore. This study did not find a significant increase in total suspended solids in the water column of He`eia mouth estuarine waters, which indicates that an increase in sediment transport offshore was not affected by mangrove removal.

In Fall 2017, approximately three and a half years after mangrove removal began in the He‘eia stream mouth estuary, mangroves have not re-established. Mangrove maintenance continues as volunteers regularly remove germinating propagules. Vegetation has been recruited in the absence of mangroves based on elevation. Lower elevations regularly inundated by tides are mostly comprised of monotypic stands of the salt water tolerant ‘akulikuli or remain open mud flats. Areas at slightly higher elevations support a wide variety of common coastal species which have been out-planted by HOK staff and volunteers.

Upland Erosion Control

Significant differences in decreased turbidity and ammonium (NH_4) were found between periods before or after installing rain gardens and slope stabilization in the upper reaches of He‘eia stream. The decrease in difference in turbidity and ammonium (NH_4) between Ha‘iku Gauging Station (control or covariate) and Hui Kū Maoli Ola Lower (affected site) before and after installation of rain gardens and slope stabilization was likely attributable to not only the remediation conducted as part of this study but perhaps the cumulative effects of prior restoration efforts (removal of non-native plants and planting native species along the stream bank) conducted as part of an earlier Hui o Ko‘olaupoko and Hui Kū Maoli Ola project.

Erosion in the upper reaches of the Hawaiian watersheds is to a degree inevitable. Slope stabilization in the upper reaches of a steep natural or rural watershed in improving surface water quality as a part of this project has proven somewhat effective but costly. The TRMs have held in place well and reduced visible erosion and expansion of the scar, but two years after installation and out-planting, native (and non-native) plants have not been able to establish on the TRMs. Ideally, the TRMs and coir logs would have provided an ideal out-planting site to re-establish vegetation to the erosion scar and regain a level of soil stability through the plant’s root systems. Although this has not occurred, the TRMs have been successful in minimizing the expansion of the scar and sediment input in to the rain gardens as shown in the data and monitoring report in Appendix E.

Rain gardens, which are similar to terracing a slope as installed in this project, are an effective way to reduce erosion but may be more effective if they are placed between know nutrient and sediment sources and the receiving surface waters. Evidence from this project’s monitoring activities shows positive impacts associated with the installation of rain gardens in ameliorating sediment and nutrient export from land to surface waters in a rural landscape on steep slopes, which are common in Hawai‘i.

Education and Outreach

For a full discussion of education and outreach activities, data, results, and analysis see Appendices H & I.

Residential Outreach

In order to develop a successful outreach campaign targeting residential non-point source pollution, Hui o Ko‘olaupoko (HOK) employed the use of a survey to determine which behavior(s) to address in the Community-Based Social Marketing (CBSM) campaign. The survey mainly focused on gathering information about penetration of broad categories of residential activities that have the potential to cause high nutrient levels in streams including fertilizer and pesticide use; mowing practices; yard waste disposal and/or illegal dumping; bare soils/erosion; car washing; pet waste; grey water and sewer/septic/systems/cesspools. HOK electronically distributed the online survey to contacts throughout the island of O‘ahu and received 204 responses. Demographic questions showed that the majority of respondents owned their homes and had grass covering the majority of their property and over 50% of respondents

do their own landscaping. Additionally, the majority of respondents were white/Caucasian; females between the ages of 40 to 59; hold an advanced degree; and/or have over $100,000 household income. Additionally, in response to knowledge questions, almost all respondents had a basic knowledge of storm water pollution issues.

From the survey, as well as data gathered from experts, HOK analyzed each activity category for penetration, impact and potential, and, determined desired fertilizer use had the lowest penetration, high impact and high potential for modification of current behaviors. Therefore, HOK determined fertilizer activities to be the primary behavioral category to address in CBSM outreach efforts. Based on further analysis of penetration, impacts and potential, HOK determined secondary behaviors to include grass cutting behaviors, yard waste management, proper car washing behaviors, and pet waste management on the property. Areas and behaviors that will not be targeted include pesticides (since ultimately these do not contribute to nutrient levels), illegal dumping, bare soils and erosion, grey water systems, cesspool or septic systems.

Our demographic information shows that many of the respondents were already familiar with HOK and are therefore more likely aware and supportive of environmental conscious behaviors. However, in spite of this bias, HOK is confident that in general, the respondents represent the He‘eia target population adequately enough to draw generalized questions and move forward in our follow-up survey and analysis activities.

Curriculum Development

HOK contracted He‘eia based non-profit Papahana Kuaola to develop formalized curriculum sets that contain all of the elements necessary to teach the Mālama Ahupua‘a Interactive Lesson, and, the Site Visit Packet that contains all of the information regarding protocol, orientation, and preparation for field visits to Papahana Kuaola.

The contract between Papahana Kuaola (PK) and Hui o Ko‘olaupoko (HOK) began on February 1, 2014, to begin work on the Non-Point Source Pollution (NPSP) Project. This collaborative project allowed PK to provide the kind of community programming that is consistent with its mission of environmental restoration and sustainability through traditional Hawaiian knowledge that honors the connection between kānaka, ‘āina and ākua.

As of March 2015, the contract end date with PK, they had contacted and received confirmation of partnerships with grades one through four at three educational institutions: Enchanted Lake Elementary, Hau‘ula Elementary School (Hawaiian Language Immersion Program), and Ke Kula ‘o Samuel M. Kamakau (Laboratory Public Charter School- Hawaiian Language Immersion) for a total of 250 students. PK staff completed the inital classroom visits for 149 students, and 11 teachers/teacher’s aides in March 2015. During this session, student groups were taught the Mālama Hawai‘i curriculum, completed the classroom data collection activity, and were provided individual homework activities that strengthen an understanding of Aloha ‘Āina values and non-point source pollution.

Here is a broad overview of the current contents of curriculum that have been developed.

Initial classroom visits generally include:

- an orientation, and a brief introduction to the Kumulipo,
- the teaching of an oli (Mālama Hawai‘i) – composed by Kihei Nahale-a for this curriculum
- an interactive Mālama Ahupua‘a activity,
- introduction of vocabulary words, a classroom data collection activity (Kilo Honua),
- and an independent follow up activity booklet that builds upon the foundations of Mālama Hawai‘i and broadens awareness of non-point source pollution.

Site visitations generally include small group rotations of:

- Mālama ‘Āina – Restoration activities (Varies based on culturally appropriate moon phase activities) including Planting, Weeding, Mulching, etc.
- Mālama Ahupua‘a – Review of Mālama Ahupua‘a Activity, Oli Mālama Hawai‘i, & Vocabulary
- Mālama i kou waiwai – Guided walk which includes building relationship with ‘āina through learning about wai (sources of life/water, cultural signficance/use of water resources, and the importance of caring for water)
- Enviroscape – Interactive Model of Non-Point Source Pollution within a community

Final classroom visits generally include:

- Oli Review & Vocabulary Review
- Interactive Aloha ‘Āina Art Activity - Individual Commitment to Mālama Hawai‘i
- Post-Assessment given to teachers and aides.

Due to classroom schedules, student availability, and efforts to follow individual school’s availability, adjustments had to be made to the original curriculum delivery schedule and fell slightly behind the contract deliverable dates. Despite these shifts, the entire curriculum will be shared with each of the educational institutions, and all students, teachers, and parent participants will have the opportunity to engage in learning about Aloha ‘Āina/Non-Point Source pollution. For example: Site-visits to Waipao have been adjusted – because schools have been unable to accommodate a 6-hour visit – due to the limitations of school hours, travel time required to visit Waipao/return to school, and bus contracts that limit school day transportation times. Additionally, some school‘s initial classroom visits have been extended from 1 hr to 2.5 hrs.

Post-Assessments for evaluating the curriculum, classroom and field experiences were given to all teachers that participated. All responses showed positive impacts with responders answering with an average of 1.05 (with 1 being Strongly Agree and 5 being Strongly Disagree). When asked for written feedback on the event, responders stated that their favorite parts of the day included: hands on activities, outside activities, seeing real life jobs and mālama ‘āina practitioners, and the wrap up activity created mālama ‘āina action reminders. Some suggestions for improvement included: smaller group and break-away sessions, condensing material for young grade levels, more time for older students, have a malama aina action immediately after

each session to solidify the lesson's message/actions, more visual material in each session, and for more take-home material/activity books (in Hawaiian when applicable).

Details of the curriculum can be found in Appendix I.

Conclusions and Discussions of Project Success, Strengths, and Challenges

Riparian Restoration

Although there are many questions about the consequences of removing mangroves on stream mouth estuaries and other coastal systems in Hawai‘i that are still unanswered, the He‘eia stream mouth estuary is the perfect field laboratory for designing restoration/remediation activities accompanied by rigorous monitoring and experimental designs to answer these questions.

Perhaps the biggest social success of this project is that mangrove re-establishment has been held in check through extensive volunteer efforts. Since 2015, nearly 1800 volunteers have contributed 5000 hours to the efforts. The amount of volunteer hours contributed to this project is equal to nearly 2.5 FTE positions or a savings of $129,600 ($40,000 annual salary plus 35% fringe). With these numbers, we feel the project has had a great success on educating the public about water quality, watershed issues, and the steps needed to improve and protect ocean health.

HOK believes one of the reasons we have been successful with community volunteers is simply because of the nature of project and tasks and our standard for delivering a quality learning experience at each volunteer event, rather than just a week pulling workday. We have hosted school groups, military service organizations and the general public from across Oahu. Additionally, we have hosted travelers, tourist and corporate businesses retreats. Because of these efforts, our work has been showcased to a larger audience than just resident of Ko‘olaupoko, the island of Oahu or the State of Hawaii.

Due to HOK's limited staff and ability to conduct monitoring in-house, Dr. Susan Carstenn of Hawaii Pacific University was contracted to conduct all aspects of water quality monitoring. At the conclusion of this project, it is our professional recommendation that this contractor not be utilized in the future for any work with HOK. There were many issues related to the timeliness of monitoring and data reports and questions still linger as to the thoroughness of collection protocols, monitoring activities and data analysis despite have in the QAPP and Monitoring and Analysis Plan in place.

Unfortunately, HOK encountered issues with our initial mangrove removal contractor Hui Ku Maoli Ola as well, during two phases of the clearing work in early 2015 and again in Fall 2017. In 2015, work was started without notification to HOK or the landowner and lasted significantly longer than anticipated was not conducted in accordance with the agreed upon Scope Of Work which happened again in 2017. The main issues stemmed from on site discussions of how invasive species removal was to be conducted, that being written into the contracts and then work being conducted in a different and potentially environmentally hazardous manner.

For work with future monitoring contractors, HOK will require through quarterly reports showing details of work to date, raw data, preliminary analysis, and any significant observations associated with project/environmental conditions during that quarter. This more in-depth reporting requirement will ensure that contractors/researchers are collecting timely data and are on track to deliver a final report which provides definitive analysis and direction for recommendations on future work.

Upland Erosion Control

Erosion in the upper reaches of the Hawaiian watersheds is to a degree inevitable. Slope stabilization in the upper reaches of a steep natural or rural watershed in improving surface water quality as a part of this project has proven somewhat effective but costly. The TRMs have held in place well and reduced visible erosion and expansion of the scar, but two years after installation and out-planting, native (and non-native) plants have not been able to establish on the TRMs. Ideally, the TRMs and coir logs would have provided an ideal out-planting site to re-establish vegetation to the erosion scar and regain a level of soil stability through the plant's root systems. Although this has not occurred, the TRMs have been successful in minimizing the expansion of the scar and sediment input in to the rain gardens as shown in the data and monitoring report in Appendix E.

Evidence from this project's monitoring activities shows positive impacts associated with the installation of rain gardens in ameliorating sediment and nutrient export from land to surface waters in a rural landscape on steep slopes. In retrospect, more monitoring of the remediated erosion scar and the untouched neighboring scars should have been conducted for comparison studies. HOK also should have required more in-depth reporting from the remediation contractor and land lessee detailing the time, effort, and challenges associated with the TRM installation and any visual observations pre & post installation.

Education and Outreach

Outreach

For the residential outreach portion of this project, HOK hosted a homeowner workshop with only twenty participants, despite the invitation of 2,200 residents. Moving forward, HOK felt that in order to reach our target homeowner audience, interacting with them face-to-face would have a greater impact on behavior changes, thus a greater effort was placed on conducting the RSWAs and developing the outreach survey.

In future projects it will be useful to refer more to the survey's objective statement. Since the objective statement of this survey was to determine the behavior to address in the community, it would have been useful to form survey questions to specifically address impact, probability, and penetration of each behavior. Effective example questions that address how the behavior of fertilizer use may be affecting the community would be: **Penetration:** Do you use Fertilizer? **Impact:** How much fertilizer do you use per year? **Probability:** How likely are to change your behavior if: (Statements + Rating Scale). In this survey, HOK worked to identify questions that

could lead to erroneous data. However, one example of a question that did not achieve our intent was: "Do you check the weather before applying fertilizer to your lawn?" The original intent was to determine whether individuals water their grass before a rain event. Unfortunately, the way that the question was phrased, we only know if someone checked the weather but we cannot assume any subsequent behavior of whether they fertilized or not based on the weather.

Education

The partnership with Papahana Kuaola for development of culturally appropriate and place-based curriculum proved to be beneficial for both entities. The material developed will be available for use by both entities and effectively conveys scientific data and terminology while making a more real-world and easy to grasp connection to the students' immediate natural surroundings. For some schools involved the depth of the Hawaiian cultural connections to the NPSP teachings reinforced their schools' curriculum (Kamakau) while for other schools (Enchanted Lake) both concepts were new introductions and made delivering the cultural aspects more challenging.

Some suggestions for future implementation of the curriculum included: smaller group and break-away sessions, condensing material for young grade levels while expanding material for older students, have a malama aina action immediately after each session to solidify the lesson's message/actions, more visual material in each session, and for more take-home material/activity books (in Hawaiian when applicable).

Recommendations For Future Projects

Overall, a project of this size was implemented with very few issues or problems. However, lessons were learned that will be incorporated into future He'eia Watershed work as well as other HOK restoration projects.

Monitoring as a part of this estuarine restoration project showed no negative impact on water quality though it is still unclear whether offshore environments were affected by sediment transport. Future monitoring studies should evaluate the condition of offshore environments.

Continual efforts will be required to prevent mangrove reestablishment on the estuary project until mangrove propagule sources are removed from surrounding properties. Existing, planted and naturally recruited vegetation hold the potential to stabilize sediment until a new sediment production, oxidation and transportation equilibrium is established. If this projects' findings hold true, as mangrove removal and monitoring continues within this watershed then removing mangroves from areas from where they impacting stream habitat and cultural resources throughout Hawai'i may be warranted.

As with all community work, there has been some level of resistance from within the community, particularly in regards to the riparian work at the estuary. Most concerns question the need for or impact of mangrove removal on the estuary and the honoring of significant historic and family sites within the project areas. Nevertheless, progress has been made with several stakeholders in the watershed, talking about the various projects happening in the

watershed and how perceived environmental impacts are leading to native habitat restoration and overall positive environmental changes in the area. HOK plans to share the project results with these stakeholders and tie them in to earl planning phases of future work as well.

Additionally, working more closely with homeowners and providing them with additional workshops and resources to understand their role in watershed health. One area all partners could have improved upon was the general outreach with adjacent neighbors to let them know about the project, what to expect, opportunities to be involved, etc. This was highlighted with some neighbors voicing concerns about the project.

For future residential outreach projects, more mailings and opportunities to meet the neighbors through workshops or tours of the project site(s) could be an important outreach tool. However, the events should both be informal, such as tours and educational with formal workshops on residential solutions to nonpoint source pollution. In order for this outreach effort to be effective, additional monetary resources and possible PR consultants need to be involved.

HOK biggest recommendation and lesson learned is to work even more closely with project partners and contractors, particularly implementing quarterly interim progress reports and overseeing that scope of work, tasks, deliverables, methods and BMPs are being followed in the agreed upon and most environmentally friendly manner.

References & Work Cited

Please see appendices for specific references related to each project component.

Appendices &Deliverables

Appendix A: Budget Summary

Appendix B: Project Maps: He'eia Watershed, Erosion Project, Riparian Project

Appendix C: Water quality monitoring QAPP and Monitoring Protocol

Appendix D: Mangrove Annotated Bibliography

Appendix E: Water quality monitoring report

Appendix F: Riparian restoration project photos

Appendix G: Upland erosion remediation photos

Appendix H: Homeowner outreach material

Appendix I: Non-point source curriculum material