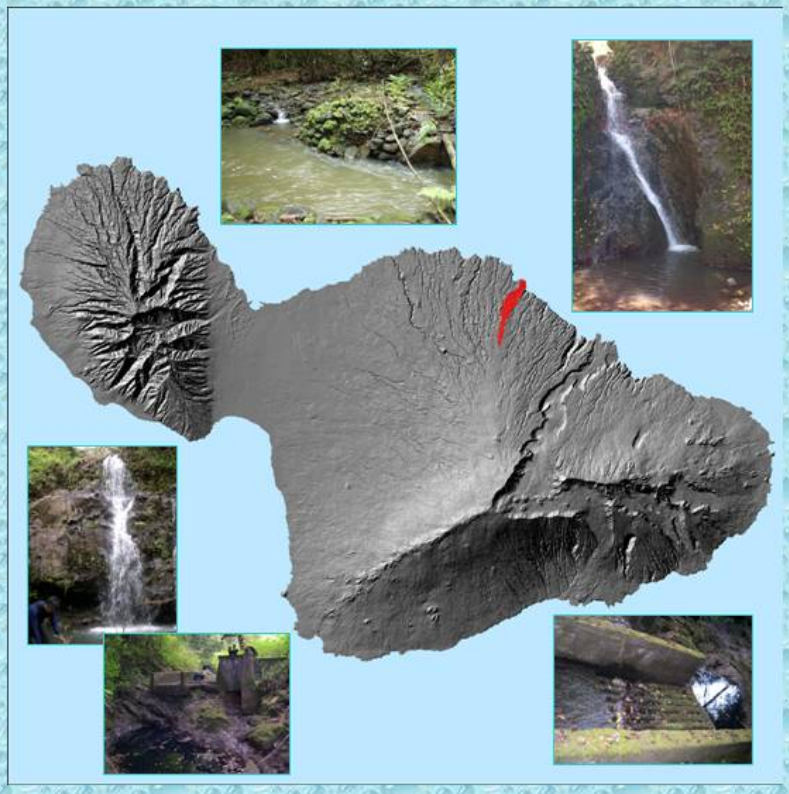
Report on Hanehoi Stream
Maui, Hawaii



June 2008

State of Hawai'i
Department of Land and Natural Resources
Division of Aquatic Resources

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Report on Hanehoi Stream
Maui, Hawai‘i

June 2008

Prepared for
Commission on Water Resource Management
Department of Land and Natural Resources
State of Hawai‘i

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Table of Contents

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Section 1: Overview

Introduction:

This report is an accounting of the aquatic resources that have been observed in Hanehoi Stream, Maui. The report was generated to provide some information to aid in the instream flow determination for the East Maui Streams at the request of the Commission on Water Resource Management (CWRM). The focus of this report is the animals that live in the stream and the data collected during surveys of the stream. The report covers six main sections, including:

- Overview
- Watershed Atlas Report
- DAR Point Quadrat Survey Report
- DAR Insect Survey Report
- An Analysis of Depth Use vs. Availability
- Photographs of stream taken during stream surveys

The overview provides the introduction for the purpose of this report, a summary of the findings on the stream and its animals, and a discussion of the importance of the findings and how stream conditions influence native species populations. The Watershed Atlas Report provides a description of the watershed and its aquatic resources from Division of Aquatic Resources (DAR) and other published and unpublished surveys as well as a rating of the condition of the stream compared to other streams on Maui as well as statewide. The DAR Point Quadrat Survey Report describes the distribution, habitats, and species observed during the standardized DAR stream surveys. The DAR Insect Survey Report describes the distribution, habitats, and species of insects observed in the stream. The analysis of depth use vs. availability looks at habitat use by native species and the availability of suitable depths in the stream. Finally, the photographs provide context to the conditions that the stream surveyors encountered in the stream.

This overview reports on the highlights of these findings and provides a discussion of the importance of the information presented. We hope that this format provides the reader with a simplified, general discussion and understanding of the condition of Hanehoi Stream while also providing substantial evidence to support the conclusions presented.

Findings for Hanehoi Stream, Maui:

Hanehoi is a small (1.5 sq miles), narrow watershed. It is mostly zoned conservation (68%) and agricultural (32%) and the land cover is mostly evergreen forest (68%), scrub (10%), and grassland (20%). Above the Hana Highway the remnants of ancient taro patches (loi) still exist. These taro patches are no longer in use. Cattle ranching take place in this watershed. Point quadrat and aquatic insect surveys of have been completed in Hanehoi Stream with the earliest surveys recorded from 1929 and have continued to

the present. This watershed rates below average in comparison to other watersheds in Maui and statewide. It has a total watershed rating of 6 out of 10, a total biological rating of 2 out of 10, and a combined overall rating of 4 out of 10.

Native species observed in the stream include the following categories and species:

Fish – no native fish species observed.

Crustaceans - *Atyoida bisulcata*

Mollusks – no native mollusk species observed.

Introduced species observed in this stream includes the following categories and species:

Fish - *Poecilia reticulata* and *Xiphophorus helleri*

Crustaceans - *Macrobrachium lar* and *Procambarus clarkii*

Mollusks – *Melanoides tuberculata* and *Physidae*

A total of 17 species of aquatic insects were collected during 3 days of sampling along Hanehoi Stream. Of the insects collected 11 species, or 65 percent of the total, were considered native to the Hawaiian Islands. Two native dragonflies were observed: *Anax strenuus* and *Pantala flavescens* and two native damselflies: *Megalagrion nigrohamatum nigrohamatum,* and *Megalagrion pacificum* which is currently a candidate for listing as an endangered native damselfly.

The only native amphidromous animal observed was *Atyoida bisulcata.* Not enough observations were made to determine depth suitability patterns, but the average depth at which *Atyoida bisulcata* was observed was 22.5 inches deep. The diversions resulted in an increase frequency of dry or shallow sites as compared to streams statewide. The distribution of depths in comparison to elevation showed that the stream was shallower downstream of diversions then would be expected in a normal stream. This is likely restricting habitat for climbing native amphidromous animals.

Photographs were taken of interesting features of stream habitat and diversions. Photographs show Hanehoi is a small stream and that dry sections exist downstream of diversions. The diversions also created migratory barriers for upstream and downstream movement of amphidromous animals. The photos show that most suitable habitat is now found upstream of the highest diversion.

Discussion for Hanehoi Stream, Maui:

Hanehoi Stream is a small and steep stream with many large waterfalls making access to some areas difficult. The stream has a waterfall near the mouth of the stream which will limit upstream migration of non-climbing native amphidromous animals. Currently little water exists in this stream.

During the surveys of the middle reach of Hanehoi Stream, all fish and macroinvertebrates observed were introduced species. None of the expected native animals were seen in this reach. The only native animal observed was Atyid shrimp in the upper reach of Hanehoi Stream. The lack of water in the downstream reaches likely

prevents most of the upstream migration of native animals and provides little habitat to animals that do make the upstream journey. Overall, the observed fish and macroinvertebrate assemblage in Hanehoi suggests that conditions in the stream are unsuitable for most native species to exist.

Hanehoi Stream contains a highly degraded aquatic insect biota in its lower reaches that have been dewatered by ditch diversions, while by contrast supporting a robust, native-dominated aquatic insect assemblage in the upper reaches above the points of diversion. The latter assemblage also contains one species, the native damselfly *Megalagrion pacificum,* that is currently proposed for listing as Endangered under the federal Endangered Species Act. Restoration of flow to the dewatered sections of this catchment would in all likelihood result in a corresponding restoration of native aquatic insect diversity, but only if steps were taken to avoid utilizing ditch waters that are heavily colonized by invasive poeciliid fishes (mosquitofish, swordtails, etc.).

Hanehoi Stream and its watershed do not rate highly when compared to other streams on Maui and statewide. This suggests that Hanehoi Stream has limited potential to be a high quality stream with substantial habitat for a wide range of native animals. Much of the low rating score comes from the observation of few native animals in comparison to introduced animals. While the natural stream morphology of Hanehoi stream may limit its suitability for a wide range of native amphidromous animals, Hanehoi should be expected to contain *Lentipes concolor*, but this species has not been observed in the stream. Restoration of stream flows would likely benefit upstream species such as *Lentipes concolor*, *Atyoida bisulcata*, and native insects.

No surveys have been done for larval recruitment on this stream. The terminal waterfall likely restricts a number of species from migrating into this stream, although *Lentipes concolor* was expected to be present it was not observed. For the animals that do make it into Hanehoi Stream, the natural downstream drift of newly hatched larvae is interrupted by the stream diversion. The water from the stream is diverted into irrigation ditches and likely entrains any downstream drifting larvae.

Crayfish, *Procambarus clarkii,* and juvenile poeciliids were observed in the stream near the Jeep Trail by Lowrie Ditch. These introduced species can continuously restock their populations in the middle and lower reaches of the stream from these upstream sources, so large flood events are unlikely to eliminate them from the stream. Control of introduced species would be important to achieve the maximum biological benefit from an increase in stream flow.

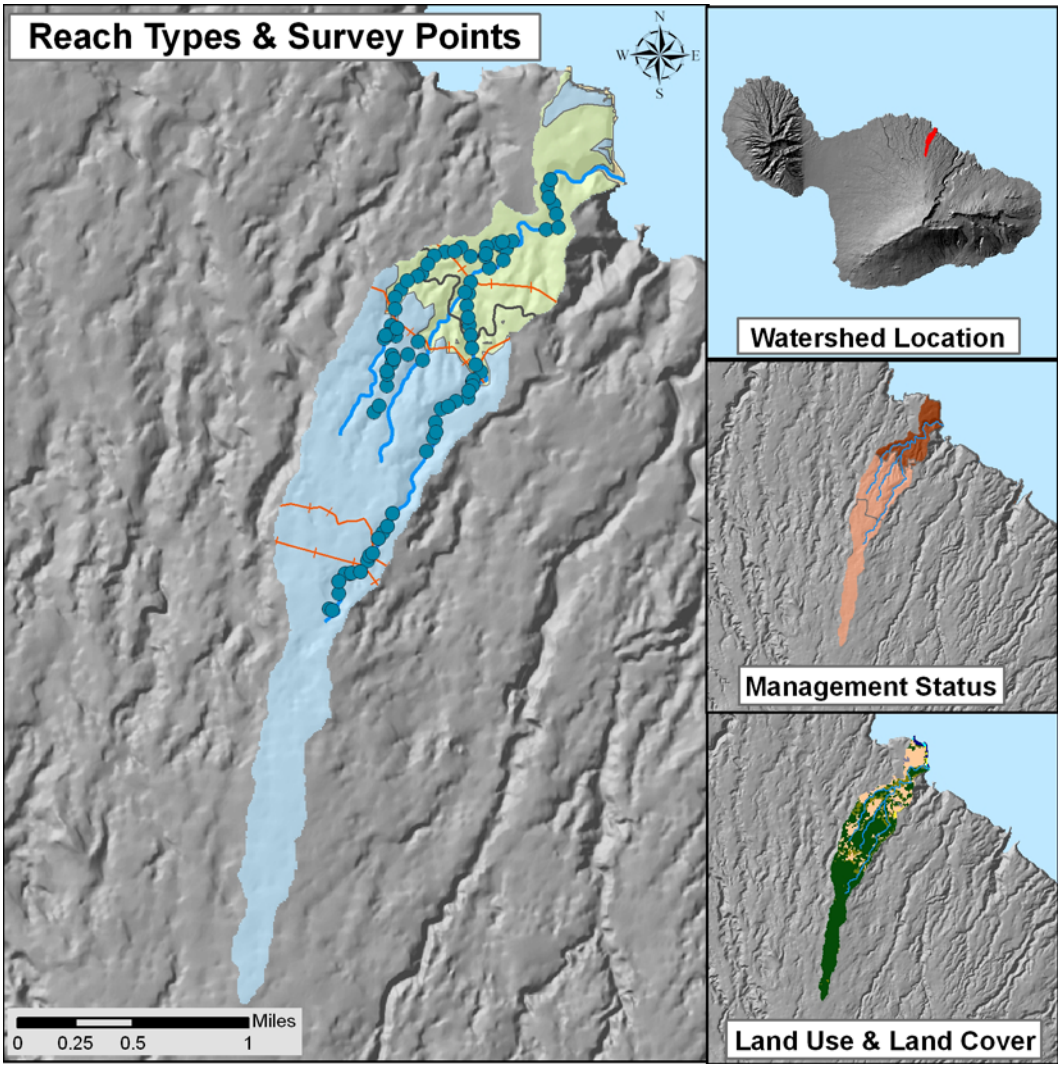
This stream is currently intermittent as a result of multiple diversions. This is not a large stream and may have become intermittent naturally in periods of prolonged drought, although the stream is now nearly permanently intermittent as a result of water diversions. The intermittent nature of this stream currently reduces habitat and restricts instream migration for the native animals. A more consistent flow would reconnect habitats and allow for upstream migration of native species.

There are three different diversion sites on this stream. In addition to the water removed by the irrigation ditches, there are two pipes providing downstream water for taro farmers. The majority of habitat for stream animals is absent in the stream as a result of the water diversions. A major issue regarding the diversions on Hanehoi Stream is the use of pipes at the diversions which restrict downstream flow and prohibit upstream migration. Currently, there is little ability for upstream migration as a result of the design of the diversion even when water is flowing down the natural stream channel.

Section 2: Watershed Atlas Report

DAR Watershed Code: 63011

Hanehoi, Maui



WATERSHED FEATURES

Hanehoi watershed occurs on the island of Maui. The Hawaiian meaning of the name is unknown. The area of the watershed is 1.5 square mi (4 square km), with maximum elevation of 2287 ft (697 m). The watershed's DAR cluster code is 3, meaning that the watershed is medium small, steep in the upper watershed, and with some embayment. The percent of the watershed in the different land use districts is as follows: 31.8% agricultural, 68.2% conservation, 0% rural, and 0% urban.

Land Stewardship: Percentage of the land in the watershed managed or controlled by the corresponding agency or entity. Note that this is not necessarily ownership.

Military	Federal	State	OHA	County	Nature Conservancy	Other Private
0.0	0.0	71.8	0.0	0.0	0.0	28.2

Land Management Status: Percentage of the watershed in the categories of biodiversity protection and management created by the Hawaii GAP program.

Permanent Biodiversity Protection	Managed for Multiple Uses	Protected but Unmanaged	Unprotected
0.0	71.8	0.0	28.2

Land Use: Areas of the various categories of land use. These data are based on NOAA C-CAP remote sensing project.

	Percent	Square mi	Square km
High Intensity Developed	0.1	0.00	0.00
Low Intensity Developed	0.7	0.01	0.03
Cultivated	0.0	0.00	0.00
Grassland	20.1	0.31	0.80
Scrub/Shrub	9.8	0.15	0.39
Evergreen Forest	67.7	1.03	2.68
Palustrine Forested	0.0	0.00	0.00
Palustrine Scrub/Shrub	0.0	0.00	0.00
Palustrine Emergent	0.0	0.00	0.00
Estuarine Forested	0.0	0.00	0.00
Bare Land	0.5	0.01	0.02
Unconsolidated Shoreline	0.3	0.00	0.01
Water	0.8	0.01	0.03
Unclassified	0.0	0.00	0.00

STREAM FEATURES

Hanehoi is a perennial stream. Total stream length is 5.4 mi (8.7 km). The terminal stream order is 2.

Reach Type Percentages: The percentage of the stream's channel length in each of the reach type categories.

Estuary	Lower	Middle	Upper	Headwaters
0.0	3.7	49.5	46.8	0.0

The following stream(s) occur in the watershed:

Hanehoi Huelo

BIOTIC SAMPLING EFFORT

Biotic samples were gathered in the following year(s):

1929 1980 2007 2008

Distribution of Biotic Sampling: The number of survey locations that were sampled in the various reach types.

Survey type	Estuary	Lower	Middle	Upper	Headwaters
DAR Point Quadrat	0	0	41	52	1

BIOTA INFORMATION

Species List

Native Species		Native Species	
Algae	*Cloniophora macrocladia*	**Insects**	*Megalagrion pacificum*
Crustaceans	*Atyoida bisulcata*		*Megalagrion sp*

Introduced Species

Amphibians	*Bufo marinus*
	Rana catesbiana
	Ranidae
Crustaceans	*Macrobrachium lar*
	Procambarus clarkii
Fish	*Poecilia reticulata*
	Xiphophorus helleri
Snails	*Melanoides tuberculata*
	Physida

Species Size Data: Species size (inches) observed in DAR Point Quadrat Surveys.

Scientific Name	Status	Minimum Size	Maximum Size	Average Size
Cloniophora macrocladia	Indigenous	0.5	0.5	0.5
Bufo marinus	Introduced	0.25	0.25	0.3
Ranidae	Introduced	1.5	2.5	1.8
Atyoida bisulcata	Endemic	0.75	2.5	1.1
Macrobrachium lar	Introduced	2	6	3.3
Procambarus clarkii	Introduced	0.5	3	1.7
Poecilia reticulata	Introduced	0.25	1.5	0.5
Xiphophorus helleri	Introduced	1	3	2.0
Megalagrion pacificum	Endemic	1.75	1.75	1.8
Megalagrion sp.	Endemic	1.25	1.25	1.3
Melanoides tuberculata	Introduced	1	1	1.0
Physidae	Introduced	0.25	0.25	0.3

Average Density: The densities (#/square yard) for species observed in DAR Point Quadrat Surveys averaged over all sample dates in each reach type.

Scientific Name	Status	Estuary	Low	Mid	Upper	Headwaters
Atyoida bisulcata	Endemic				0.34	
Megalagrion pacificum	Endemic				0.07	
Megalagrion sp.	Endemic			0.08		
Cloniophora macrocladia	Indigenous			0.08		
Bufo marinus	Introduced				5.84	
Macrobrachium lar	Introduced			0.24	0.14	
Melanoides tuberculata	Introduced			0.32		
Physidae	Introduced			0.08		

Poecilia reticulata	Introduced	5.61	1.92
Procambarus clarkii	Introduced	0.48	0.48
Ranidae sp.	Introduced		0.21
Xiphophorus helleri	Introduced	0.32	

Species Distributions: Presence (P) of species in different stream reaches.

Scientific Name	Status	Estuary	Lower	Middle	Upper	Headwaters
Atyoida bisulcata	Endemic				P	
Megalagrion pacificum	Endemic				P	
Megalagrion sp.	Endemic			P		
Cloniophora macrocladia	Indigenous			P		
Bufo marinus	Introduced				P	
Rana catesbiana	Introduced			P		
Ranidae sp.	Introduced				P	
Macrobrachium lar	Introduced			P	P	
Procambarus clarkii	Introduced			P	P	
Poecilia reticulata	Introduced			P	P	
Xiphophorus helleri	Introduced			P		
Melanoides tuberculata	Introduced			P		P
Physidae	Introduced			P		

HISTORIC RANKINGS

Historic Rankings: These are rankings of streams from historical studies. "Yes" means the stream was considered worthy of protection by that method. Some methods include non-biotic data in their determination. See Atlas Key for details.

Multi-Attribute Prioritization of Streams - Potential Heritage Streams (1998): No

Hawaii Stream Assessment Rank (1990): not ranked

U.S. Fish and Wildlife Service High Quality Stream (1988): No

The Nature Conservancy- Priority Aquatic Sites (1985): No

National Park Service - Nationwide Rivers Inventory (1982): No

Current DAR Decision Rule Status: The following criteria are used by DAR to consider the biotic importance of streams. "Yes" means that watershed has that quality.

Native Insect Diversity > 19 spp.	Native Macrofauna Diversity > 5 spp.	Absence of Priority 1 Introduced
No	No	No
Abundance of Any Native Species	**Presence of Candidate Endangered Species**	**Endangered Newcomb's Snail Habitat**
No	Yes	No

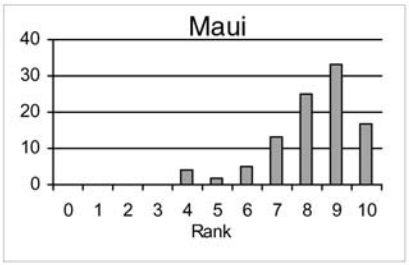
CURRENT WATERSHED AND STREAM RATINGS

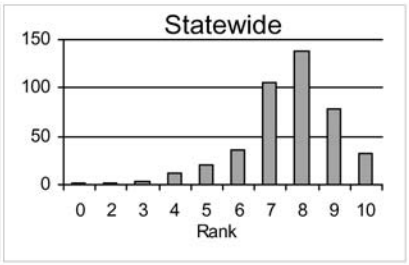
The current watershed and stream ratings are based on the data contained in the DAR Aquatic Surveys Database. The ratings provide the score for the individual watershed or stream, the distribution of ratings for that island, and the distribution of ratings statewide. This allows a better understanding of the meaning of a particular ranking and how it compares to other streams. The ratings are standardized to range from 0 to 10 (0 is lowest and 10 is highest rating) for each variable and the totals are also standardized so that the rating is not the average of each component rating. These ratings are subject to change as more data are entered into the DAR Aquatic Surveys Database and can be automatically recalculated as the data improve. In addition to the ratings, we have also provided an estimate of the confidence level of the ratings. This is called rating strength. The higher the rating strength the more likely the data and rankings represent the actual condition of the watershed, stream, and aquatic biota.

WATERSHED RATING: Hanehoi, Maui

Land Cover Rating: Rating is based on a scoring sytem where in general forested lands score positively and developed lands score negatively.

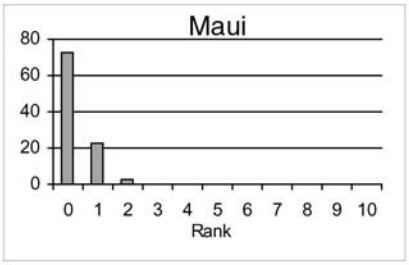
Watershed Rating
9

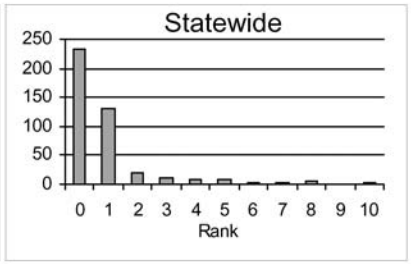




Shallow Waters Rating: Rating is based on a combination of the extent of estuarine and shallow marine areas associated with the watershed and stream.

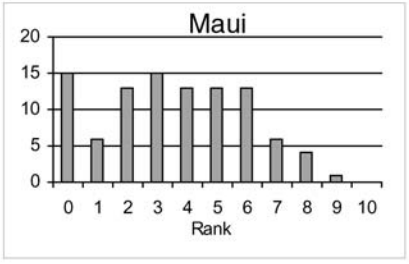
Watershed Rating
0

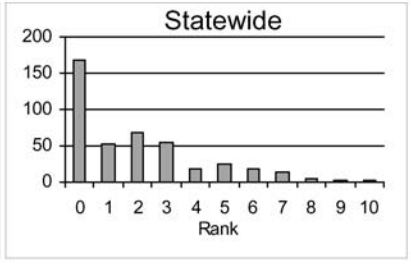




Stewardship Rating: Rating is based on a scoring system where higher levels of land and biodiversity protection within the watershed score positively.

Watershed Rating
5

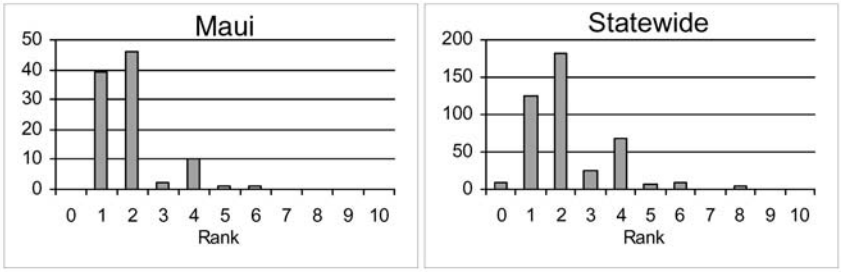




WATERSHED RATING (Cont): Hanehoi, Maui

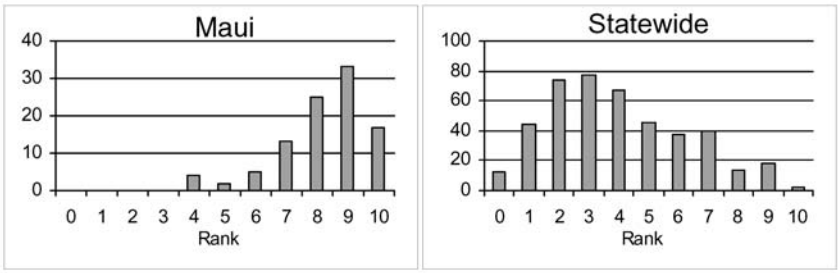
Size Rating: Rating is based on the watershed area and total stream length. Larger watersheds and streams score more positively.

Watershed Rating
2



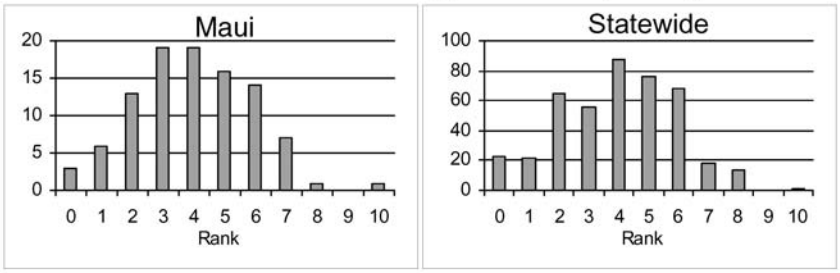
Wetness Rating: Rating is based on the average annual rainfall within the watershed. Higher rainfall totals score more positively.

Watershed Rating
6



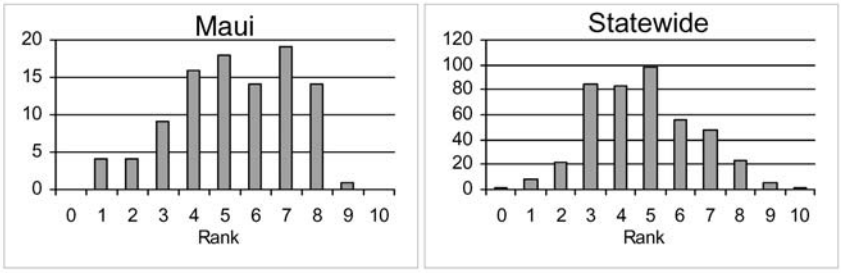
Reach Diversity Rating: Rating is based on the types and amounts of different stream reaches available in the watershed. More area in different reach types score more positively.

Watershed Rating
4



Total Watershed Rating: Rating is based on combination of Land Cover Rating, Shallow Waters Rating, Stewardship Rating, Size Rating, Wetness Rating, and Reach Diversity Rating.

Watershed Rating
6

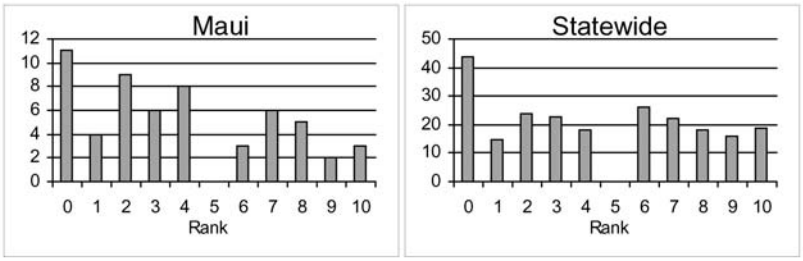


BIOLOGICAL RATING: Hanehoi, Maui

Native Species Rating: Rating is based on the number of native species observed in the watershed.

Stream Rating

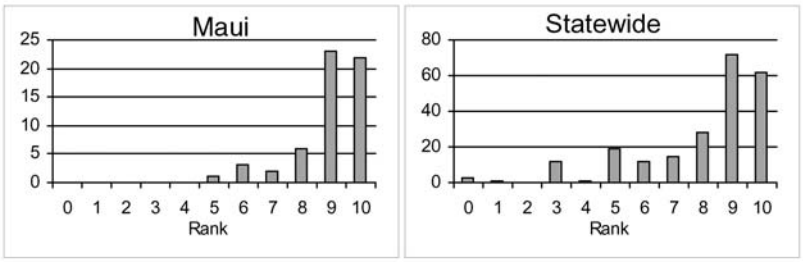
1



Introduced Genera Rating: Rating is based on the number of introduced genera observed in the watershed.

Stream Rating

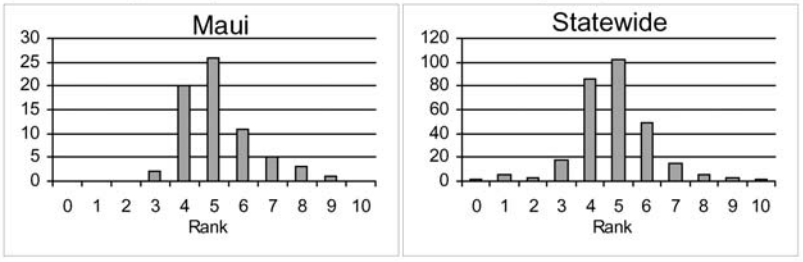
6



All Species' Score Rating: Rating is based on the Hawaii Stream Assessment scoring system where native species score positively and introduced species score negatively.

Stream Rating

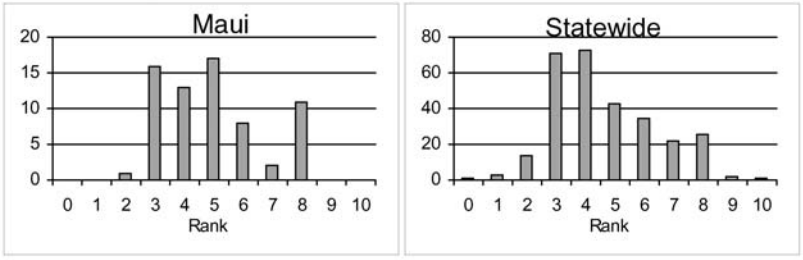
4



Total Biological Rating: Rating is the combination of the Native Species Rating, Introduced Genera Rating, and the All Species' Score Rating.

Stream Rating

2

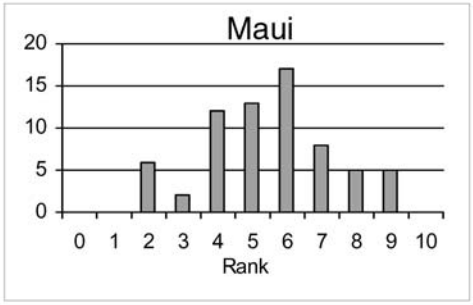


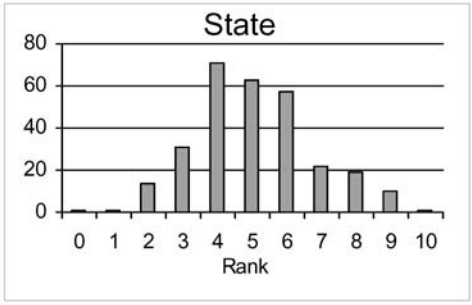
OVERALL RATING: Hanehoi, Maui

Overall Rating: Rating is a combination of the Total Watershed Rating and the Total Biological Rating.

Watershed Rating

4



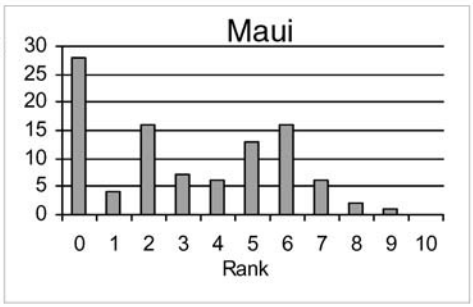


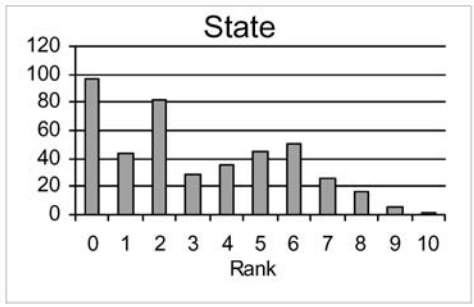
RATING STRENGTH: Hanehoi, Maui

Rating Strength: Represents an estimate of the overall study effort in the stream and is a combination of the number of studies, number of different reaches surveyed, and the number of different survey types.

Information Rating

5





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2006. Polhemus, D.A. Megalagrion Survey Notes in spreadsheet form.

2008. Hawai‘i Division of Aquatic Resources. DAR Point Quadrat Survey Data from the DAR Aquatic Surveys Database.

Appendix 1: Scientific and Common Names

Appendix 1: Scientific and Common Names (continued)

CN = Common Name and HN = Hawaiian Name

Algae

Indigenous

Cloniophora macrocladia
CN: none; HN: none.

Amphibian

Introduced

Bufo marinus
CN: marine toad; HN: none.

Rana catesbiana
CN: american bull frog; HN: none.

Ranidae sp.
CN: none; HN: none.

Ranidae sp.
CN: unidentified frog; HN: none.

Ranidae sp.
CN: unidentified frog tadpole; HN: none.

Crustacean

Endemic

Atyoida bisulcata
CN: Mountain opae; HN: `opae kala`ole.

Introduced

Macrobrachium lar
CN: none; HN: none.

Procambarus clarkii
CN: none; HN: none.

Fish

Introduced

Poecilia reticulata
CN: Guppy (AFS), Rainbow fish (Yamamoto & Tagawa, 2000), Millions fish (Yamamoto & Tagawa, 2000); HN: none.

Xiphophorus helleri
CN: Green swordtail; HN: none.

Insect

Endemic

Appendix 1: Scientific and Common Names (continued)

CN = Common Name and HN = Hawaiian Name

Megalagrion pacificum
CN: Pacific Hawaiian damselfly; HN: none.

Megalagrion sp.
CN: damselfly larvae; HN: none.

Snail

Introduced

Melanoides tuberculata
CN: none; HN: none.

Physidae sp.
CN: none; HN: none.

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Section 3: DAR Point Quadrat Survey Report

Results of DAR Point Quadrat Survey Report for Hanehoi Stream, Maui for Surveys from 11/26/2007 to 3/4/2008.

This Division of Aquatic Resources (DAR) stream surveys report is produced using the Point Quadrat Methodology. Trained biologists and technicians survey a series of randomly located points in a stream to generate an assessment of composition of species and habitats in the stream. The Point Quadrat Methodology is only one of several different techniques that could be chosen for the surveys and is used to develop a statistically comparable stream survey. The following information represents an accounting of the observations that will be used in overall stream management efforts by DAR. . All density measurements are in number of animals per square yard in the reach.

Table 1. The watersheds (watershed ID), region, and island surveyed in this report are:

Hanehoi (ID: 63011), Makawao, Maui

Table 2. Survey Team Personnel:

Hau, Skippy
Higashi, Glenn
Kuamoo, Darrell
Nishimoto, Robert
Nishiura, Lance
Sakihara, Troy
Shimoda, Troy
Shindo, Tim

Table 3. The distribution of sites by reach during this survey effort.

	Reaches					
Survey Type	Estuary	Lower	Middle	Upper	Headwater	**Total**
Point Quadrat (random)		41	52	1		**94**

Lower Reach of Hanehoi stream, Maui, Hawai‘i

Little lower reach existed on Hanehoi stream due to the waterfall at the mouth of the stream. Therefore, surveys were conducted in the lower reach.

Middle Reach of Hanehoi stream, Maui, Hawai'i

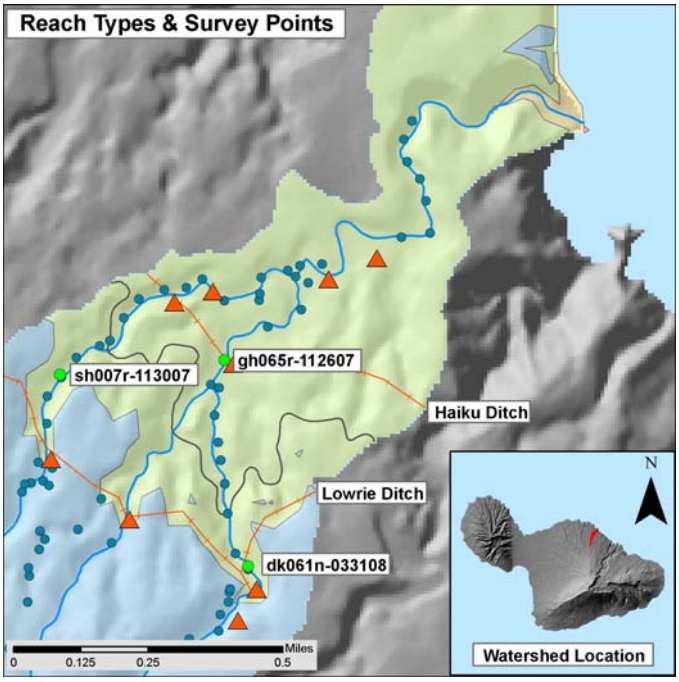

Figure 1. Locations of DAR Point Quadrat Surveys done in the middle reach of Hanehoi Stream. Blue dots are survey locations and green dots are location with photographs. The hatched orange lines are irrigation ditches. The colors represent the different reach delineations.

Middle Reach:

Habitat Types

Cascade	Riffle	Run	Pool	Plunge	Side pool	No water
	3	16	11			7

Substrate Types in Surveys (%)

Detritus	Sediment	Sand	Gravel	Cobble	Boulder	Bedrock
10	17	0	11	19	32	10

Category	Status	*Scientific Name*	Reach	Avg. Density	Total # observed
Algae	Indigenous	*Cloniophora macrocladia*	Middle	0.07	1
Crustaceans	Introduced	*Procambarus clarkii*	Middle	0.44	6
Crustaceans	Introduced	*Macrobrachium lar*	Middle	0.22	3
Fish	Introduced	*Poecilia reticulata*	Middle	6.56	89
Fish	Introduced	*Xiphophorus helleri*	Middle	0.29	4
Snails	Introduced	*Physidae*	Middle	0.07	1
Snails	Introduced	*Melanoides tuberculata*	Middle	0.37	5

Upper Reach of Hanehoi stream, Maui, Hawai‘i

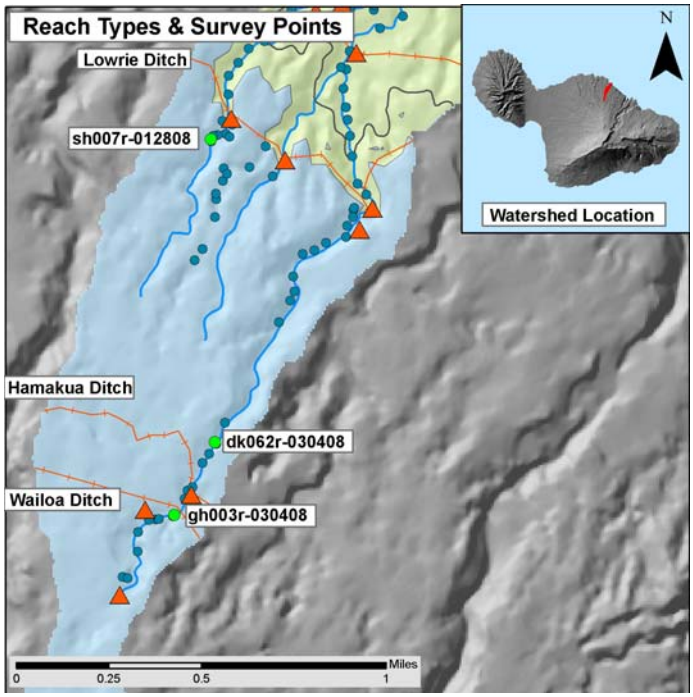

Figure 2. Locations of DAR Point Quadrat Surveys done in the upper reach of Hanehoi Stream. Blue dots are survey locations and green dots are location with photographs. The hatched orange lines are irrigation ditches. The colors represent the different reach delineations.

Upper Reach:

Habitat Types

Cascade	Riffle	Run	Pool	Plunge	Side pool	No water
1	4	13	12	2		7

Substrate Types in Surveys (%)

Detritus	Sediment	Sand	Gravel	Cobble	Boulder	Bedrock
6	3	1	15	19	38	18

Category	Status	*Scientific Name*	Reach	Avg Density	Total # observed
Amphibians	Introduced	*Ranidae* sp.	Upper	0.07	1
Crustaceans	Introduced	*Procambarus clarkii*	Upper	0.22	3
Crustaceans	Introduced	*Macrobrachium lar*	Upper	0.15	2
Crustaceans	Endemic	*Atyoida bisulcata*	Upper	1.35	18

Headwaters Reach:

Habitat Types

Cascade	Riffle	Run	Pool	Plunge	Side pool	No water
		1				

Substrate Types in Surveys (%)

Detritus	Sediment	Sand	Gravel	Cobble	Boulder	Bedrock
10		10	60		20	

Category	Status	*Scientific Name*	Reach	Avg Density	Total # observed
Snails	Introduced	*Melanoides tubercuala*	Headwaters	9	1

Section 4: DAR Aquatic Insect Report

AN ASSESSMENT OF AQUATIC INSECT DIVERSITY IN HANEHOI STREAM, EAST MAUI WATERSHED

Introduction

From 26 November 2007 to 16 May 2008**,** collections of aquatic insects were made from the Hanehoi Stream catchment of eastern Maui, at elevations ranging from 230 to 1245 feet. This work, conducted in conjunction with more comprehensive biological surveys conducted by the State of Hawaii's Division of Aquatic Resources, and hydrological surveys conducted by the State's Commission on Water Resource Management, was intended to provide a preliminary estimate of aquatic insect species diversity in this stream system.

Aquatic insects are defined herein as those species spending some significant portion of their life cycle within the stream itself or in the immediately adjacent wet riparian zone. Ecological terms follow those defined in Polhemus et al. (1992).

Description of study site

The Hanehoi catchment lies on the northern slope of Haleakala volcano in eastern Maui. Hanehoi Stream is less than 3 miles in length, heading at an elevation of approximately 1800 feet on the broad slopes east of the secondary summit of Ulalena, and entering the sea at Hoalua Bay. The catchment occupies part of a broad planeze bounded on the west by the deep valley of Opana Stream, and on the east by the similarly deep valley of Kailua Stream, both of which head at elevations above 4000 feet. All of the other drainages lying within the roughly trapezoidal sector bounded by these two large gulches, including Hanehoi Stream, occupy less deeply incised valleys and have headwaters at or below 2500 feet elevation. The general surface geology of this portion of Haleakala consists of flows from the Kula lava series, over which the streams cascade in a stair step profile of alternating vertical falls and lower gradient reaches. Along the lower sections of these streams, within a mile of the sea, the older, underlying Honomanu series lavas have also been exposed, generally forming large waterfalls that create significant interruptions in the bed profiles, often marking the transition from the terminal reach to the midreach as one progresses upstream.

The general hydrology and physical characteristics of the Hanehoi catchment have been studied in detail by the State of Hawaii's Commission on Water Resource Management, and are not considered in further detail here.

Six stations were sampled along Hanehoi Stream between 290 and 1245 feet elevation. Details on the locations of these 6 sampling stations may be found in Tables 1–6. These stations were a subset of those used by other DAR biologists making point quadrat censuses of native fish populations along this same stream.

Methods

A total of 3 days of sampling time were spent making collections along Hanehoi Stream, using hand netting and localized pyrethrin fogging of hygropetric habitats. Insects were taken both within and beside the stream, and from the air above. The specimens collected were stored in 75 percent ethanol in the field, and subsequently transported to the Bishop Museum in Honolulu for curation and identification. For Odonata, some specimens were dry vouchered in glassine envelopes, and for large, easily recognized species of Anisoptera (dragonflies) sight records were taken in lieu of field captures.

Water temperatures were measured at all sampling stations, and varied from 18° to 22.5° C. The water temperatures and elevations at individual stations may be found in Tables 1-6.

Results

A total of 17 species of aquatic insects were collected during 3 days of sampling along Hanehoi Stream. These taxa are detailed in Tables 1–7 below. Of the taxa collected 11 species, or 65 percent of the total, were taxa considered native to the Hawaiian Islands.

Table 1: Aquatic insect taxa sampled from Hanehoi Stream, Station 1, at head of lower falls, 290 ft., water temp. 21.5 °C., 26 November 2007, 09:50–10:30 hrs. 20°54'27.2"N, 156°13'06.0"W

Insect Taxon	Taxon Type
DIPTERA	
Culicidate	
Aedes albopictus (Skuse)	I
HETEROPTERA	
Mesoveliidae	
Mesovelia amoena Uhler	I
ODONATA	
Coenagrionidae	
Ischnura ramburii (Selys-Longchamps)	I
Number of taxa present	
Native	0
Introduced	3
Total	3
Percentage of native species richness	0 %

Table 2: Aquatic insect taxa sampled from Hanehoi Stream, Station 2, midreach below junction with first major tributary below Hana Road, 385 ft., water temp. 22.5 °C., 26 November 2007, 11:45–12:00 hrs. 20°54'15.9"N, 156°13'19.6"W

Insect Taxon	Taxon Type
TRICHOPTERA	
Hydropsychidae	
Cheumatopsyche pettiti (Banks)	I
Number of taxa present	
Native	0
Introduced	1
Total	1
Percentage of native species richness	0 %

Table 3: Aquatic insect taxa sampled from Hanehoi Stream, Station 3, standing pool in dry bed above first major tributary below Hana Road, 405 ft., water temp. 22 °C., 26 November 2007, 12:15–12:30 hrs. (photo). 20°54'08.7"N, 156°13'19.3"W

Insect Taxon	Taxon Type
DIPTERA	
Culicidate	
Aedes albopictus (Skuse)	I
HETEROPTERA	
Veliidae	
Microvelia vagans (White)	N
Number of taxa present	
Native	1
Introduced	1
Total	2
Percentage of native species richness	50 %

Table 4: Aquatic insect taxa sampled from Hanehoi Stream, Station 4, at Hana Road, 530 ft., water temp. 22 °C., 26 November 2007, 13:00–14:00 hrs. (photo). 20°53'51.5"N, 156°13'27.3"W

Insect Taxon	Taxon Type
DIPTERA	
Culicidate	
Aedes albopictus (Skuse)	I
Ephydridae	
Limonia stygipennis (Alexander)	N
HETEROPTERA	
Saldidae	
Saldula exulans (White)	N

ODONATA	
Aeschnidae	
Anax strenuus (Hagen)	N
Libellulidae	
Pantala flavescens (Fabricius)	N
Coenagrionidae	
Ischnura posita (Hagen)	I
TRICHOPTERA	
Hydropsychidae	
Cheumatopsyche pettiti (Banks)	I
Number of taxa present	
Native	4
Introduced	3
Total	7
Percentage of native species richness	57 %

Table 5: Aquatic insect taxa sampled from Hanehoi Stream, Station 5, above Wailoa Ditch intake, 1220–1245 ft., water temp. 18 °C., 28 January 2008, 11:30–14:00 hrs. (photo). 20°53'01.6"N, 156°13'52.3"W

Insect Taxon	Taxon Type
COLEOPTERA	
Carabidae	
Metacolpodes buchanani (Hope)	I
DIPTERA	
Chironomidae	
Telmatogeton torrenticola (Terry)	N
Dolichopodidae	
Campsicnemus truncatus (Hardy & Kohn)	N
Dolichopus exsul (Aldrich)	I
Tipulidae	
Limonia jacoba (Alexander)	N
Limonia stygipennis (Alexander)	N
HETEROPTERA	
Mesoveliidae	
Mesovelia amoena Uhler	I
Saldidae	
Saldula exulans (White)	N
Saldula procellaris (Kirkaldy)	N
Veliidae	
Microvelia vagans (White)	N
ODONATA	
Libellulidae	
Pantala flavescens (Fabricius)	N
Coenagrionidae	
Megalagrion n. nigrolineatum (Perkins)	N
Megalagrion pacificum (McLachlan)	N

TRICHOPTERA	
Hydropsychidae	
Cheumatopsyche pettiti (Banks)	I
Number of taxa present	
Native	10
Introduced	4
Total	14
Percentage of native species richness	71 %

Table 6: Aquatic insect taxa sampled from Hanehoi Stream, Station 6, trib. below below New Hamakua Ditch, 1 mi. NW of Hanehoi Stream, 1200 ft., water temp. 24 °C., 1 May 2008, 11:45–12:00 hrs. (photo).
20°53'13.5"N, 156°14'00.3"W

Insect Taxon	Taxon Type
ODONATA	
Coenagrionidae	
Megalagrion pacificum (McLachlan)	N

Table 7: Summary of aquatic insect species taken across all combined sampling stations on Hanehoi Stream, from 290–1245 ft. elevation.

Insect Taxon	Taxon Type	
COLEOPTERA		
Carabidae		
Metacolpodes buchanani (Hope)	I	
DIPTERA		
Chironomidae		
Telmatogeton torrenticola (Terry)	N	
Dolichopodidae		
Campsicnemus truncatus (Hardy & Kohn)	N	Skating on pools
Dolichopus exsul Aldrich	I	On plants at road
Tipulidae		
Limonia jacoba (Alexander)	N	
Limonia stygipennis (Alexander)	N	
HETEROPTERA		
Mesoveliidae		
Mesovelia amoena Uhler	I	
Saldidae		
Saldula exulans (White)	N	
Saldula procellaris (Kirkaldy)	N	
Veliidae		
Microvelia vagans (White)	N	
ODONATA		
Aeschnidae		
Anax strenuus (Hagen)	N	
Libellulidae		
Pantala flavescens (Fabricius)	N	

Coenagrionidae	
Ischnura posita (Hagen)	I
Ischnura ramburii (Selys-Longchamps)	I
Megalagrion n. nigrolineatum (Perkins)	N
Megalagrion pacificum (McLachlan)	N
TRICHOPTERA	
Hydropsychidae	
Cheumatopsyche pettiti (Banks)	I
Number of taxa present	
Native	11
Introduced	6
Total	17
Percentage of native species richness	65 %

Table 8. Species richness versus elevations of sampling stations on Hanopou and Hanehoi Streams

Stream and Sampling Station	Elevation	% Native Species Richness
Station 1	290	0
Station 2	385	0
Station 3	405	50
Station 4	530	57
Station 5	1220*	71

* = above point of uppermost diversion on system

Discussion

The present surveys clearly demonstrate that for aquatic insects, both the species richness and the percentage of native species representation decrease steadily as one moves downward in elevation through the Hanehoi catchment (see Tables 1–8). In particular the aquatic insect biota of the dewatered mid- and terminal reaches of this stream is a highly reduced subset of that which would otherwise prevail. In the dewatered reaches of Hanehoi stream, the aquatic insect community of the remnant pools is reduced to a two species community consisting of the introduced mosquito *Aedes albopictus*, and the small native water bug *Microvelia vagans*. The latter is an adaptable generalist that feeds on fallen insects that become trapped in the surface film, and as such can also colonize temporary pools in roads and trails. In areas where some degree of flow is present, this basic community of "mozzies and micros" may be further augmented by the introduced dolichopodid fly *Dolichopus exsul* which is a ubiquitous component of disturbed aquatic ecosystems in lowland Hawaii. Native species that formerly occupied such stream reaches, such as the native damselfly *Megalagrion pacificum*, were notably absent from such dewatered reaches.

By contrast, the uppermost station sampled during this survey, lying along stream reach above the highest point of diversion in the system, supported a rich aquatic insect assemblage with 14 species present, with 70 percent of these being native species. These assemblages also included native damselflies in the genus *Megalagrion*, including *M. pacificum*, which is currently a candidate for listing as Endangered under the federal Endangered Species Act. *Megalagrion pacificum* was found above the ditch diversions, but was not found at any sampling station below the diversions. This strongly implies that the diversions are to some extent limiting the range of this federal listing candidate in this catchment.

This can be illustrated by comparing the terminal reach stations along both streams to the lower reach of Hanawi Stream further to the east on the Hana Coast (Englund and Polhemus, 1993), which is fed by resurgent groundwater from Big Spring and thus retains a flow regime representative of undiverted East Maui streams. This comparative data is provided in Tables 9 and 10.

Table 9: Aquatic insect taxa sampled from Hanawi Stream, Station 1, nr. Nahiku, 0-100 ft., water temp. 19.5° C., 8 October 1992. 20°49'40"N, 156°05'55"W

Insect Taxon	Taxon Type
DIPTERA	
Canaceidae	
Procanace acuminata Hardy & Delfinado	N
Procanace constricta Hardy & Delfinado	N
Ceratopogonidae	
Forcipomyia sp. undet.	N
Chironomidae	
Telmatogeton torrenticola (Terry)	N
Calopsectra hawaiiensis Hardy	N
Culicidae	
Aedes albopictus (Skuse)	I
Ephydridae	
Neoscatella amnica Tenorio	N
Neoscatella clavipes Wirth	N
Neoscatella warreni (Cresson)	N
Dolichopodidae	
Chrysosoma fraternum Van Duzee	N
Chrysotus pallidipalpus Van Duzee	N
Tipulidae	
Limonia advena (Alexander)	I
Limonia jacobus (Alexander)	N
HETEROPTERA	
Veliidae	
Microvelia vagans White	N
Mesoveliidae	
Mesovelia amoena Uhler	I
Saldidae	
Saldula exulans (White)	N

LEPIDOPTERA	
Cosmopterigidae	
Hyposmocoma sp. undet. 1	N
Hyposmocoma sp. undet. 2	N
ODONATA	
Aeschnidae	
Anax strenuus Hagen	N
Libellulidae	
Pantala flavescens (Fabricius)	N
Coenagrionidae	
Megalagrion blackburni McLachlan	N
Megalagrion pacificum (McLachlan)	N
Megalagrion calliphya (McLachlan)	N
TRICHOPTERA	
Hydropsychidae	
Cheumatopsyche pettiti (Banks)	I
Number of taxa present	
Native	20
Introduced	4
Total	24
Percentage of native species richness	83 %

Table 10: Species richness at lower elevation sampling stations on Hanehoi Stream, and comparison to lower Hanawi Stream

Stream and Sampling Station	Elevation	Total Species	% Native Species Richness
Hanehoi Stream			
Station 1	290	3	0
Station 2	385	1	0
Hanawi Stream			
Station 1	100	24	83

By contrast, the uppermost stations sampled during this survey, lying along stream reaches above the highest point of diversion in each system, supported rich aquatic insect assemblages with 17 species present, with 65 percent of these being native species. These assemblages consistently included native damselflies in the genus *Megalagrion*, including *M. pacificum*, which is currently a candidate for listing as Endangered under the federal Endangered Species Act. *Megalagrion pacificum* was found in the both the Honopou and Hanehoi stream catchments above the ditch diversions, but was not found at any sampling station below the diversions. This strongly implies that the diversions are to some extent limiting the range of this federal listing candidate in these catchments.

Restoration of stream flows could potentially lead to the gradual development of a richer and more native aquatic insect community in the dewatered sections of these stream catchments. However, such flow restoration would need to be conducted with great care to ensure that the restored waters were derived from the streams themselves, and not commingled with ditch flows. Utilizing ditch flows would result in the introduction of invasive species which would effectively preclude the establishment of native species even if more water were provided. Therefore, stream waters and ditch waters should be segregated as strictly as possible to avoid biological contamination of target catchments by restoration flows.

For example, surveys along the New Hamakua Ditch found it to be swarming with alien poeciliid fishes, which were concentrated due to the low flow conditions. As a result, no native aquatic insects were present in or along the ditch, even though its clear waters provided potentially suitable habitat. The presence of Poeciliidae illustrates how the ditches provide lateral conduits for invasive species, and why simple flow restoration based on ditch water will not necessarily result in restoration of native biota. Because of the design of the intakes, particularly those on the Wailoa Ditch which have sharp, steep internal drops, the poeciliids do not bleed upstream past the diversion points. On gaining systems such as the Hoolawanui and the Nailiilihaele, where the ditch waters do not intermingle with those of the seepage fed pools that form downstream of the diversions in the otherwise dry bed due to hyporheic resurgence, species such as *Megalagrion pacificum* can successfully colonize the habitats thus formed. In such cases, restoration of flow from a direct ditch release would in fact probably be deleterious. A preferable solution for obtaining restoration flows would be ditch bypasses, via which water from upstream of the ditch intake could be shunted around the intake to a point downstream, thus bypassing the biologically contaminated ditch.

An alternate problem that was discussed in the context of the Waiahole Stream restoration case on Oahu was the possibility that restoration flows could re-establish connectivity between invasive-dominated terminal reaches and native-dominated mid- and headwater reaches. This does not seem to be a major problem in the case of the East Maui Watershed due to the presence of numerous large waterfalls that have formed along these stream courses as they cut into the Honomanu and Kula series lavas. Such natural breaks in the stream profile, which are effective filters to the upstream migration of invasive fishes, were not present in the Waiahole system, but are by contrast commonplace on Maui.

Summary

In summary, the Hanehoi catchment contains a highly degraded aquatic insect biota in its lower reaches that have been dewatered by ditch diversions, while by contrast supporting a robust, native-dominated aquatic insect assemblage in the upper reaches above the points of diversion. The latter assemblage also contains one species, the native damselfly *Megalagrion pacificum*, which is currently proposed for listing as Endangered under the federal Endangered Species Act. Restoration of flow to the dewatered sections of this

catchment would in all likelihood result in a corresponding restoration of native aquatic insect diversity, but only if steps were taken to avoid utilizing ditch waters that are heavily colonized by invasive poeciliid fishes.

Literature Cited

Englund, R. and D. A. Polhemus. 1993. A survey of the fish and aquatic insect fauna of the Hanawi and Makamakaole Streams, Maui, Hawaii. Unpublished consultant's report prepared for Natural Area Reserves System, Hawaii State Dept. of Land and Natural Resources. 64 pp.

Polhemus, D. A., J. Maciolek and J. Ford. 1992. An ecosystem classification of inland waters for the tropical Pacific islands. Micronesica, 25 (2): 155–173.

Section 5: An Analysis of Depth Use vs. Availability

Introduction:

As part of an ongoing collaboration between the Division of Aquatic Resources and Bishop Museum, we have been analyzing the relationship between instream measures of habitat and the occurrence of native animals. The intention of this research is to better understand the habitat requirements of these animals to improve management of the stream environment. While this research effort is not complete, we have tried to provide some information to aid in the instream flow determination for the East Maui Streams at the request of the Commission on Water Resource Management.

The amount of water in a stream is important to the fishes and macroinvertebrates that inhabit the stream. One measure of the amount of water needed in the stream to create suitable habitat is the depth of the water in a survey site. The deeper areas of a stream may be important to the animals to provide safety from predatory birds, a refuge from fluctuations in discharge, or as a buffer to changes in temperature as larger volumes of water heat or cool more slowly than smaller water volumes. Depth is also closely related to stream discharge. Given a specific stream bed form, increased discharge results in increases in depth and velocity. Conversely, if water is diverted from a stream, the decrease in downstream discharge results in slower, shallower water. Surveyors record the quadrat depth when using the DAR Point Quadrat technique, but do not measure velocity; therefore we used the depth in this analysis.

In this report, we compare the depth measured for each site during the DAR Point Quadrat Surveys of Hanehoi Stream, Maui to the depths where animals were observed. Additionally, we also compared the observations for Hanehoi Stream to depth observations for all streams statewide surveyed using the Point Quadrat Surveys to see if the pattern for Hanehoi Stream is consistent with other Hawaiian streams. Finally, the distribution of average site depth by elevation groups is provided.

Methods:

All data reflected in this report came from the DAR Aquatics Surveys Database. For each random survey site in Hanehoi Stream, Maui (Watershed code = 63011) the depth and animals observed were queried from the database. Additionally, the same information was collected for all survey sites statewide.

To compare the depth suitability for the stream animals, availability, utilization, and suitability criteria were developed following standardized procedures (Bovee 1982). In general, this method based habitat utilization on the presence/absence data, and does not take into account site density. Depth availability is the frequency of each depth category based on the distribution of depths observed in the field survey. Percent availability is calculated by dividing the number of observations for a depth category by the total number of observations and multiplying by 100. Utilization is the frequency of occurrence for an individual species in each depth category. Percent utilization is calculated by dividing the number of sites with a species observed for a depth category by the total number of sites with a species observed and multiplying by 100. Suitability

is developed by dividing the percent utilization for each depth category with the percent availability for each depth category. The standardized suitability has the range adjusted so that the largest value for each species equals 1 (suitable) and the lowest value equals 0 (unsuitable).

To compare the site depths observed in the stream to the average site depths statewide, the percent frequency of occurrence for each depth bin was calculated from the data for Hanehoi Stream and for all sites statewide in the DAR Point Quadrat Surveys. Additionally, the difference between the percent frequencies for each depth bin was plotted in a histogram to clearly show where the differences occurred.

To examine where in the stream changes in available depths occurred, the average depth was determined for a number of elevation bins. The determination of the distribution of the elevation bins was influenced by the number of samples in a depth bin. Where possible at least 5 samples were needed to create a depth bin.

Results:

There was insufficient data on native species to determine depth suitability criteria for Hanehoi Stream. The only native amphidromous animal observed was *Atyoida bisulcata*, and this species was only observed in four sites. The average depth for these four sites was 22.5 inches deep with a depth range of 4 to 60 inches deep. The average of the 80 random point quadrat survey sites were 8.44 inches deep, with more than 50% of the observations being 5 inches in depth or shallower.

The pattern of the distribution of observed depths in Hanehoi Stream in comparison to the statewide average depths reveals that shallow sites are much more common in Hanehoi than in most Hawaiian Streams (Figure 1). The sample size was 80 sites for Hanehoi Stream in comparison to 6084 sites statewide. There were approximately 49% more sites 6 inches in depth or shallower than observed in the statewide data set (Figure 2). In contrast to the increase in shallow sites, there was a decrease in all depth bins deeper than 14 inches.

When observing the distribution of average depth as a function of elevation, the depths did not stay stable or increase in a downstream direction as expected (Figure 3). The elevation group below 375 m was much shallower than above 375 m. The average depth observed below 375 m was between 2 and 10 inches while above 375 m the depth averaged 15 inches.

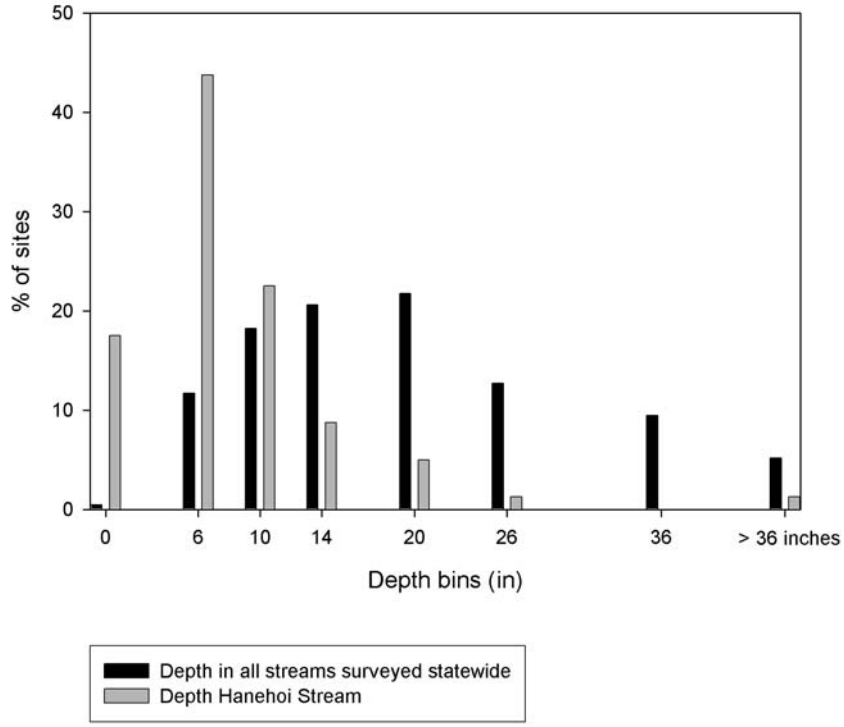

Figure 1. Comparison of percent availability for depth categories between Hanehoi Stream, Maui and all streams statewide in the DAR Aquatics Surveys Database.

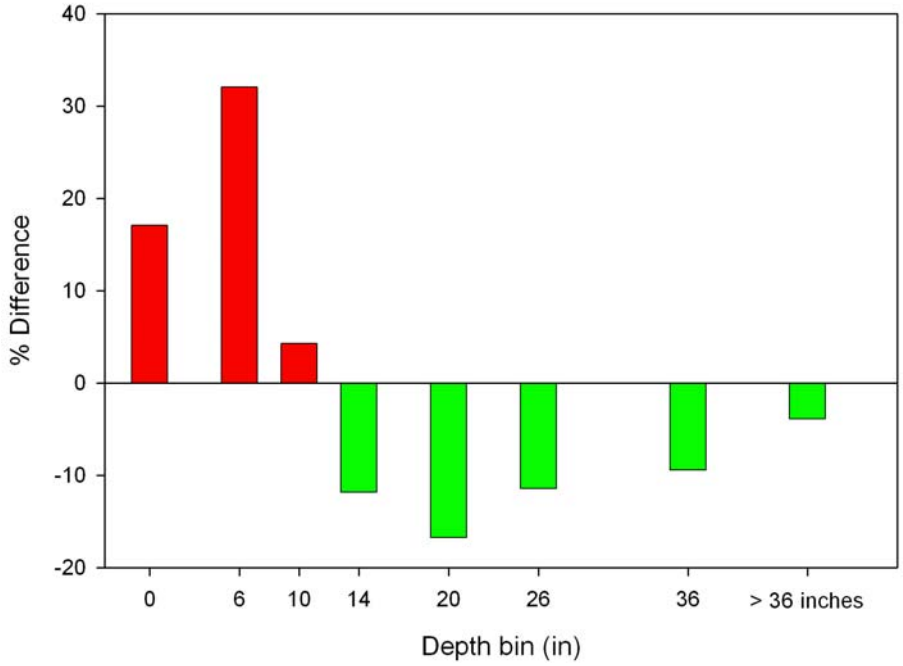

Figure 2. Percent difference in depth categories between Hanehoi Stream, Maui and all streams statewide in DAR Aquatics Surveys Database. Positive values (red) denote an increase in the percent frequency of a depth category in Hanehoi Stream as compared to streams statewide. Negative values (green) denote a decrease in the percent frequency of a depth category in Hanehoi Stream as compared to streams statewide.

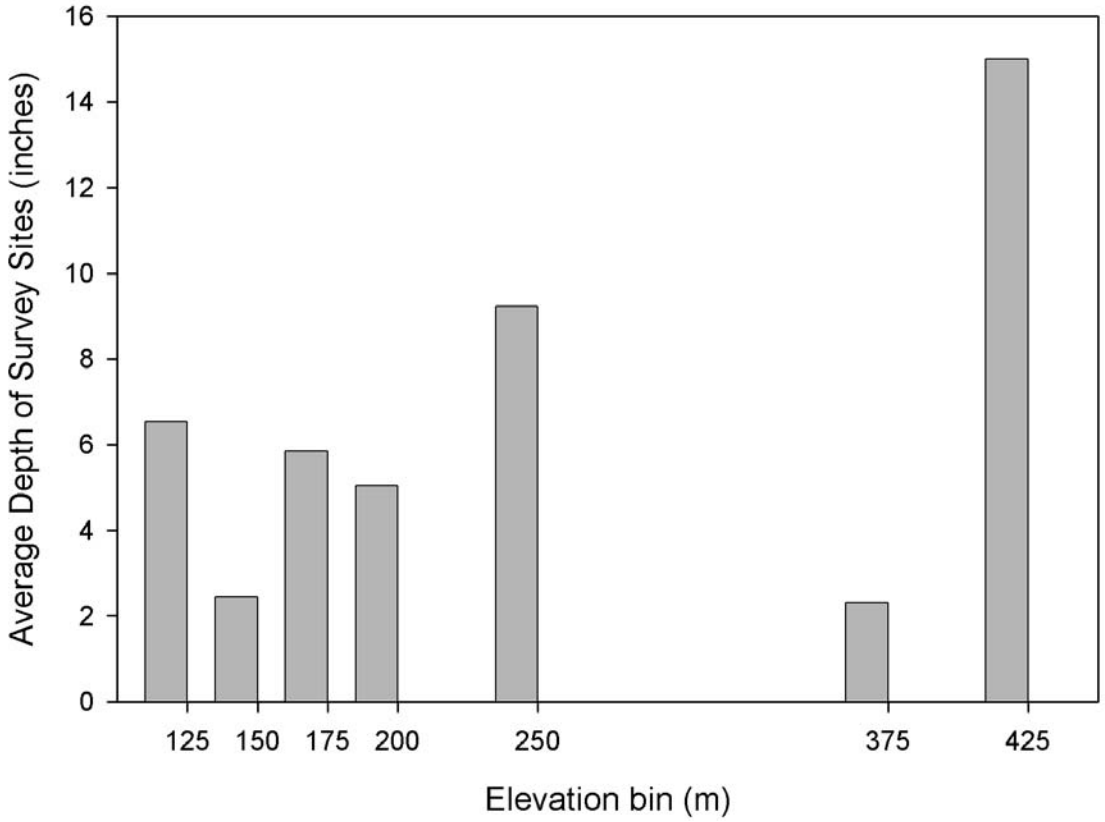

Figure 3. Average depth observed in Point Quadrat Survey Sites in Hanehoi Stream for different elevation bins. The elevation bins include all sites up to and including the elevation value. For example, the first bin would include all sites with elevations from 0 up to and including 30 m, the second bin would include all sites greater than 30 m and up to and including 50 m, and so on. The lowest elevation surveyed in Hanehoi Stream was 94 m above sea level.

Conclusions:

Few native amphidromous animals were observed in Hanehoi Stream. *Atyoida bisulcata* was only observed in 4 sites and the average depth at the sites was approximately 22.5 inches. The general pattern observed in Hanehoi Stream was consistent with depth suitability findings for *Atyoida bisulcata* statewide suggesting that these native animals in Hanehoi behave in a fairly typical pattern although there is not much data to support this observation.

While the *Atyoida bisulcata* that exists in Hanehoi Stream display normal depth selectivity, the availability of suitable depths was quite different in Hanehoi Stream than observed in streams statewide. The frequency of sampling a shallow site 6 inches in depth or less went from about 12 in 100 sites statewide to more then 61 in 100 sites in

Hanehoi. Field surveyors noted that the native animals were restricted to disconnected deep pools in an otherwise dry or shallow stream bed downstream of diverted stream sections. In sections where water still flowed, the stream animals were observed in a wider range of habitats.

Field surveyors repeatedly noted that the dry or shallow sections of the stream were associated with stream diversions and this is supported by images in the photograph section of this report. A shallower than average stream was observed when the distribution of average depths was plotted as a function of elevation. While this pattern is not conclusive proof that all water lost from the stream as it flows downstream is associated with water diversions, it does suggest that much of this stream is currently unsuitable for native animals.

Return of water into Hanehoi Stream would likely have a beneficial effect on the availability of suitable depths for native species in the currently dewatered or shallow stream sections. The species expected to benefit the most from the increased habitat would be *Lentipes concolor*, *Atyoida bisulcata,* and native insects.

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Section 6: Photographs taken during stream surveys

Estuary:

Terminal waterfall near ocean. No surveys performed or photographs taken.

Lower Reach:

Terminal waterfall near ocean. No surveys performed or photographs taken.

Middle Reach:

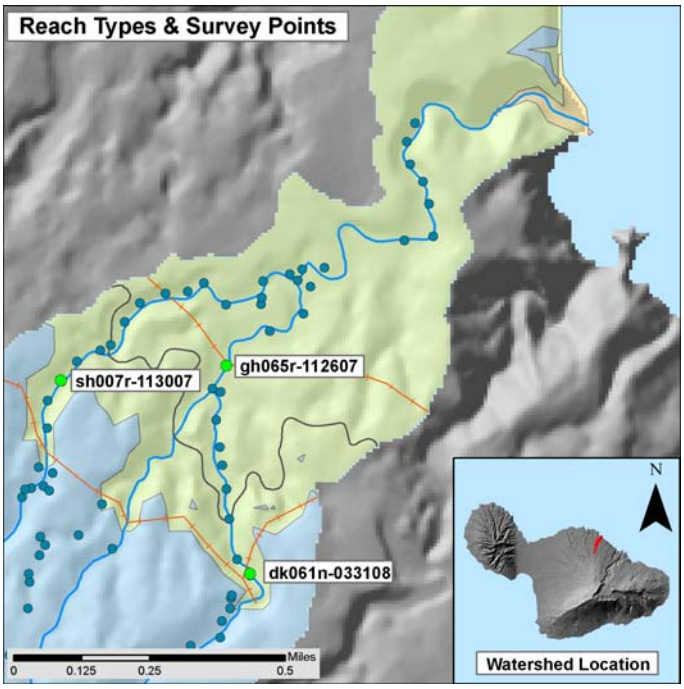


Figure 1. Locations of DAR Point Quadrat Surveys done in the middle reach of Hanehoi Stream. Blue dots are survey locations and green dots are location with photographs. The hatched orange lines are irrigation ditches. The colors represent the different reach delineations.

Water flowing from two pipes with diversion into Irrigation Ditch above diversion by Ernie Schupp taro patches (lo'i).

Better view of control gate.

Poelua Stream above diversion by Ernie Schupp taro patches (lo'i).

Upper Reach:

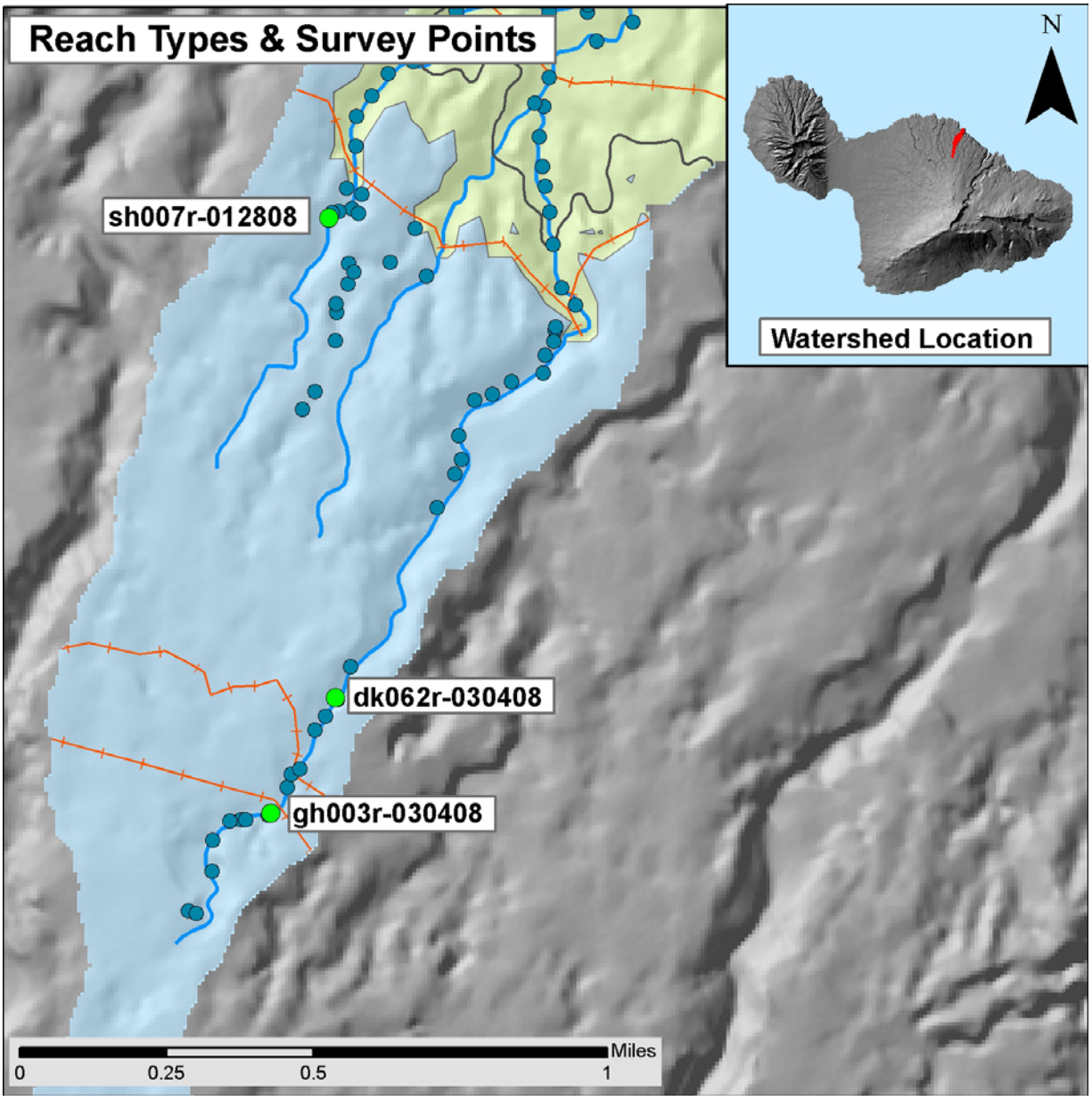


Figure 2. Locations of DAR Point Quadrat Surveys done in the upper reach of Hanehoi Stream. Blue dots are survey locations and green dots are location with photographs. The hatched orange lines are irrigation ditches. The colors represent the different reach delineations. Labels are associated photograph site code.

Pipe over Lowrie Irrigation ditch Hanehoi Stream (above Hana Highway and Ernie Schupp). Pipes make it difficult or impossible for upstream migration of native animals except at flood flows when the diversion is completely overtopped by the stream flow.

One pipe allowed to flow over irrigation ditch

Puolua Stream flowing into Lowrie Irrigation Ditch. Any downstream larval drift would be captured by the irrigation ditch.

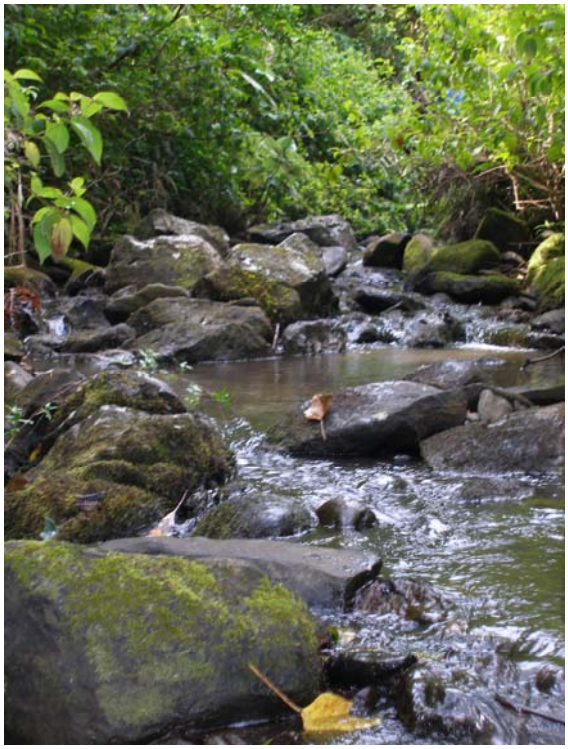
Note the two pipes on the right that pass over the ditch and transport water from stream. They are connected to one pvc pipe which empties back into the stream downstream.

Water collection by two pipes over Lowrie Ditch.

Upstream view of first diversion above jeep road at site gh003r-030408

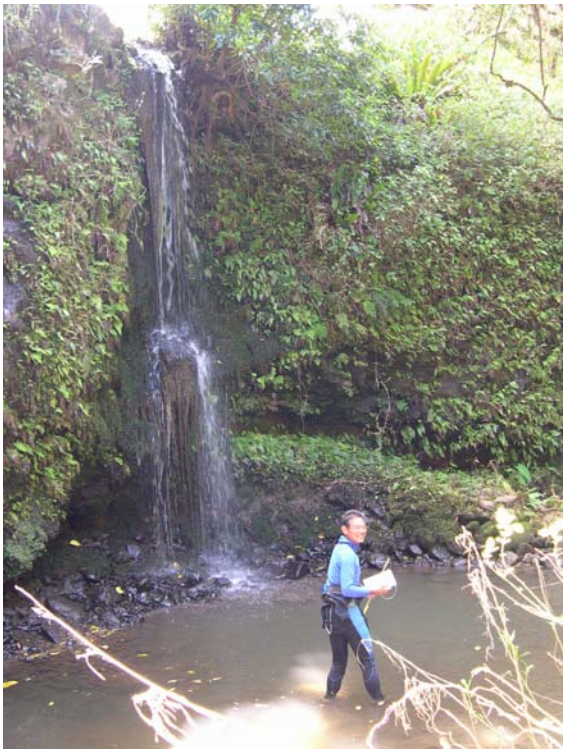
Downstream view of diversion flume at same site gh003r-030408.

Habitat of the native damselfly, *Megalagrion pacificum* (inset)



Stream above upper diversion (05/15/08 R. Sparks photo). Note that suitable native animal habitat exists in the stream above the upper diversions. This is also the reach where native atyid shrimp were observed.

Waterfall above upper diversion (05/15/08 R. Sparks photo).



Hanehoi waterfall near survey site tts069r-030308. Waterfall upstream of final survey site (tts072r-030308). We were unable to pass on upstream to continue surveys.