Kakahaiʻa overview USFWS

Chapter 3. Physical Environment

3.1 Refuge Introduction

Kakahaiʻa NWR is located in East Molokaʻi along the southeastern coast of the island, in the rain shadow of the mountains. The Refuge contains a 15-acre coastal freshwater marsh with a spring-fed pond on a narrow plain just above sea level at the foot of volcanic hills. An additional 5.5-acre managed impoundment was constructed in 1983 to provide shallow-water habitat for wading birds. Kamehameha V Highway bisects the southern ocean shoreline portion of the Refuge.

3.2 Climate

The Island of Molokaʻi is approximately 38 miles long and 10 miles wide and is oriented east to west. The island is mountainous in its eastern part, with a maximum elevation of 4,970 feet; however most of the island is less than 1,000 feet above sea level. There are three general regions: East Molokaʻi, which includes Wailau (East Molokaʻi volcano), the highest point on the island; the Hoolehua Plain; and West Molokaʻi, which includes the much smaller Maunaloa (West Molokaʻi volcano). The topography and orientation of the island have a profound influence on climate. The northeastern side of the island is exposed to prevailing trade winds and is very wet and forested. There is a rain shadow effect from the mountain range, creating arid conditions elsewhere.

Native Hawaiians recognized only two 6-month seasons: a warm season with drier weather and more reliable trade winds and a cooler wetter season with more storms and fewer trade winds. Modern analysis of climate records indicates the soundness of the Hawaiian system of seasons. The wet season is now considered to extend seven months from October-April and the dry season from May-September. During the wet season, there may be two, three, or as many as seven major storm events a year. Such storms typically bring heavy rains and are often accompanied by strong Kona winds that blow from the south. Rainfall is rare during the May-September dry season, which is typically warm and windy.

Maximum mean annual rainfall is more than 150 in/yr near the summit of Wailau in the northeastern part of the island (Giambelluca et al. 1986). Over Maunaloa, maximum mean annual rainfall is about 25 in/yr. Mean annual rainfall is less than 16 in/yr along the coastal areas of the southern and western parts of the island. There is no weather data available for the Refuge itself. The only local weather station with a fairly complete record is the Molokaʻi Airport COOP station, located in the center of the island in the Hoolehua Plain area. Annual precipitation for 1958-2009 averaged about 26 in/yr but has varied greatly from 11-43 in/yr (Figure 3.1). Gaps represent years with missing data.

Figure 3.1. Annual cycle of average monthly precipitation (top) and total annual precipitation with 5-year moving average (bottom) at Molokaʻi Airport, HI 1958-2009.

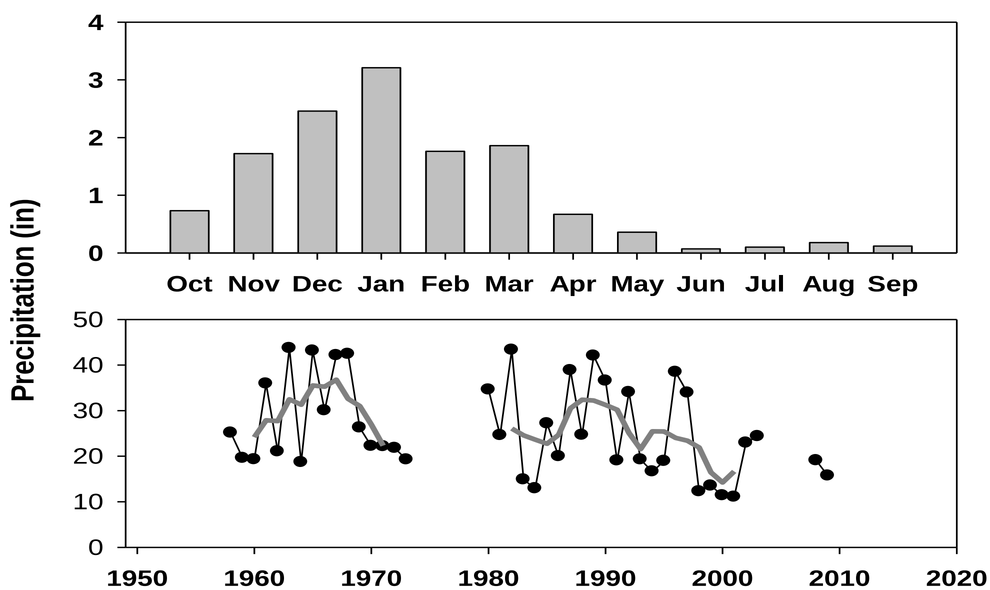
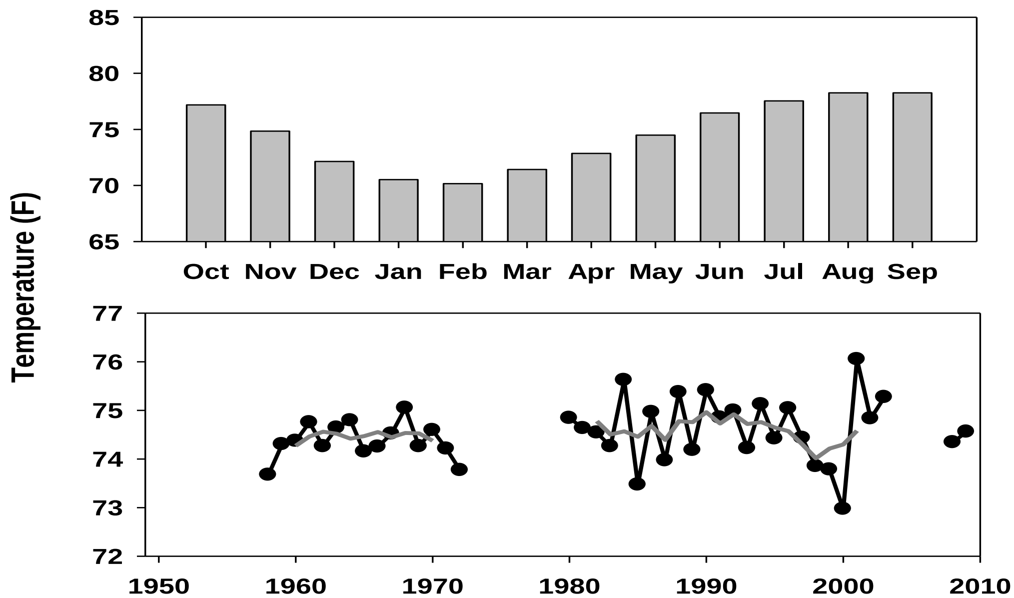


Figure 3.2. Annual cycle of average monthly temperature (top) and average annual temperature with 5-year moving average (bottom) at Moloka'i Airport, HI 1958-2009.



Average monthly temperatures for 1958-2009 (Figure 3.2) were fairly constant throughout each month of the year at 75 degrees F. Maximum monthly temperatures occured July-September and average 77-79 degrees F and minimum monthly temperatures occured January-March and average 70-72 degrees F.

Both short-term interannual climate variability and long-term decadal variability affect water resources and streamflows on Moloka'i. Many of the droughts in Hawai'i are related to El Niño events, which are associated with drier than normal winters (Oki 2004). The Pacific Decadal Oscillation (PDO) also influences Hawaiian climate. The pattern of ocean-atmosphere variability associated with El Niño-Southern Oscillation phenomenon occurs on a relatively short time scale of one to several years while the PDO is a longer term phenomenon occurring over one to several decades. Rainfall and streamflow tends to be low in winter during El Niño periods and high during La Niña periods, especially during positive (warm) phases of the PDO. Temperature may be affected by PDO phases, too.

3.2.1 Global Climate Change

The future climate change impacts expected for Hawai'i are warmer temperatures (air and ocean), more severe droughts and floods, and a rise in sea levels (Mimura et al. 2007). More recent observations and re-analyses of temperatures averaged over land and ocean surfaces show consistent warming trends in all small-island regions over the 1901-2004 period (Mimura et al. 2007). Giambelluca et al. (2008) reported that air temperatures at 21 weather stations in Hawai'i have increased at a rate of 0.3 degrees F/decade since 1975, which is comparable to the rate of increase in global temperatures. Rainfall intensity has reportedly increased 12 percent in Hawai'i between 1958-2006 (Fletcher 2010) but total rainfall has decreased about 15 percent over the last 20 years (Chu and Chen, 2005). These changes have and will continue to affect biologic and water resources on Molokaʻi and the other islands (Oki 2004).

The low resolution of many global circulation models is problematic for representing Hawaiʻi which is strongly influenced by steep topography, aspect, and location. This information is not included in global climate models. Typically, the models represent the islands as a single grid cell or ignore the islands completely. Higher resolution regional climate models project increasing temperature and precipitation for the islands in the future, with an increase in extreme events such as floods and droughts. Temperatures for the North Pacific region are forecast to increase 0.9-1.1 degrees F from 2010-2039 relative to the 1961-1990 period (Mimura et al. 2007).

Precipitation is forecast to change by -6.3 to +9.1 percent for the same region relative to the same period. Timm and Diaz (2009) were the first authors to evaluate global climate model performance for Hawaiʻi and downscale climate scenarios for Hawaiian rainfall. Based on statistical downscaling of climate model output, they concluded that the most likely scenario is a 5-10 percent reduction of wet-season precipitation and a 5 percent increase during the dry season, as a result of changes in the wind field. Future changes in precipitation are less certain because they depend on how El Niño might change which is unknown. Warmer air temperatures will increase water use and demand (evaporation and consumptive use), which will exacerbate water supply concerns and environmental stresses. A number of studies suggest that climate change could be a major factor in accentuating the current climate regimes and the changes that come with ENSO events (Mimura et al. 2007).

The Service is supporting the development of regional Landscape Conservation Cooperatives (LCC) that will integrate local climate models with models of climate-change responses by species, habitats, and ecosystems. The regional version of these LCC is the Pacific Islands Climate Change Cooperative (PICCC), headquartered in Honolulu, Hawaiʻi, but working across the Pacific. The PICCC was established in 2010 to assist those who manage native species, island ecosystems, and key cultural resources in adapting their management to climate change for the continuing benefit of the people of the Pacific Islands. The PICCC steering committee consists of more than 25 Federal, State, private, indigenous, and non-governmental conservation organizations and academic institutions, forming a cooperative partnership.

3.2.2 Ecological Responses to Climate Change

Evidence suggests that recent climatic changes have affected a broad range of individual species and populations in both the marine and terrestrial environment. Organisms have responded by changes in phenology (timing of seasonal activities) and physiology; range and distribution; community composition and interaction; and ecosystem structure and dynamics. The reproductive physiology and population dynamics of amphibians and reptiles are highly influenced by environmental conditions such as temperature and humidity. For example, sea turtle sex is determined by the temperature of the nest environment; thus, higher temperatures could result in a higher female to male ratio. In addition, increases in atmospheric temperatures during seabird nesting seasons will also have an effect on seabirds and waterbirds (Duffy 1993, Walther et al. 2002, Baker et al. 2006). Changes in ocean temperature, circulation, and storm surge due to climate change will impact seabird breeding and foraging. The ENSO has been shown to cause seabirds to abandon habitats, nest sites, and foraging areas for colder/warmer waters. Studies have found that nesting success is reduced for some species during this climatic event. Oceanographic changes associated with ENSO may also increase or decrease food supply for seabirds and subsequently impact populations that forage offshore. Shifts in marine temperature, salinity, turbidity, currents, depth, and nutrients will have an impact on seabird and water bird prey composition and availability. Although these potential changes may impact seabirds throughout the Hawaiian Islands, contrary evidence suggests that seabirds may have coped with and evolved around climatic changes in the past (Duffy 1993).

Warming has also caused species to shift toward the poles or higher altitudes and changes in climatic conditions can alter community composition. For example, increases in nitrogen availability can favor those plant species that respond to nitrogen rises. Similarly, increases in CO_2 levels can impact plant photosynthetic rates, decrease nutrient levels, and lower herbivore weights. Although there is uncertainty regarding these trajectories, it is probable that there will be ecological consequences (Vitousek 1994, Walther et al. 2002, Ehleringer et al. 2002).

Climate change has the potential to influence two important ecological issues in the State of Hawaiʻi: endangered species and pest species. The majority of U.S. endangered species are found in the State of Hawaiʻi. Species declines have resulted from habitat loss, introduced diseases, and impacts from pest species. Changes in climate will add an additional threat to the survival of these species. For example, warmer night temperatures can increase the rate of respiration for native vegetation, resulting in greater competition from pest plants. Furthermore, climate change may enhance existing pest species issues because alterations in the environment may increase the dispersal ability of flora or fauna. Species response to climate change will depend on the life history, distribution, dispersal ability, and reproduction requirements of the species (DBEDT and DOH 1998, Middleton 2006, Giambelluca 2008).

3.3 Geology and Soils

The Hawaiian Islands were created by a geologic hot spot underneath the surface of the earth. As the earth's crust has moved over this spot, magma has created new islands in the form of volcanoes. Iron-rich, quartz-poor rock flowed out of thousands of vents as highly fluid lava. The Island of Molokaʻi is the fifth largest of the Hawaiian Islands. The island was formed by volcanic activity at Wailau (elev. 4970 ft) and Maunaloa (elev. 1430 ft). The two volcanoes are connected by the Hoolehua Plain, created by lava flows from Wailau. Most of the island's population and development occurs in this area and along the south shore of the island. No perennial streams exist in the Hoolehua Plain, water is supplied from diverted streamflow from East Molokaʻi and from groundwater development.

The exposed rocks of East Molokaʻi are classified as East Molokaʻi volcanics and Kalaupapa volcanics. Kaunakakai Stream flows over the East Molokaʻi volcanics, which is divided into two informal members—a lower member consisting of shield-stage tholeiitic, olivine-tholeiitic, and picritic-tholeiitic basalts and postshield-stage alkalic basalt; and an upper member consisting of postshield-stage mugearite and lesser amounts of hawaiite and trachyte (Langenheim and Clague 1987). The upper member forms a relatively thin (50-500ft thick) veneer over the lower member (Stearns and Macdonald 1947). The northeastern part of Wailau contains numerous intrusive volcanic dikes, which form a dike complex and reduce bulk permeability of the rocks in the area. The volcanic rocks of West Molokaʻi are separated from the East Molokaʻi volcanics by an erosional surface that forms a hydrologic confining unit over the West Moloka‘i volcanics (Langenheim and Clague 1987).

3.4 Hydrology

Precipitation is the source of all freshwater on Moloka‘i. The windward (northeast) side is wettest, due to the orographic lifting of moisture-laden northeasterly trade winds along the windward slope of Wailau. Maunaloa is considerably drier because it does not extend upward into the cloud-forming zone at higher altitudes. Most of the fresh groundwater on the island is in East Moloka‘i because of the higher precipitation in this area. Groundwater levels are highest in the mountainous interior parts of the island, particularly in the northeast, and lowest near the coast. Freshwater floats on top of saltwater near sea level within the more permeable lava flows on the flanks of the volcanoes (Shade 1997).

The State Commission on Water Resource Management (CWRM) designated the Island of Moloka‘i as a Groundwater Management Area in 1992. With this designation, the State was authorized to protect the groundwater resources of Moloka'i by managing groundwater withdrawals from the aquifer through a permitting process. Most of the groundwater withdrawn on Moloka‘i is from Kualapu‘u in the southeast coastal area and the dike complex in the northeastern part of the island (Oki 2007). Several existing production wells have experienced rising salinity as a result of the declining water levels and a rising brackish-water transition zone caused by the cumulative effect of withdrawals. Any new groundwater development must be approved by the CWRM, and the State manages groundwater withdrawals from the aquifer through a permitting process. There are several existing groundwater wells in the vicinity of Kakahai‘a NWR (Oki 2007).

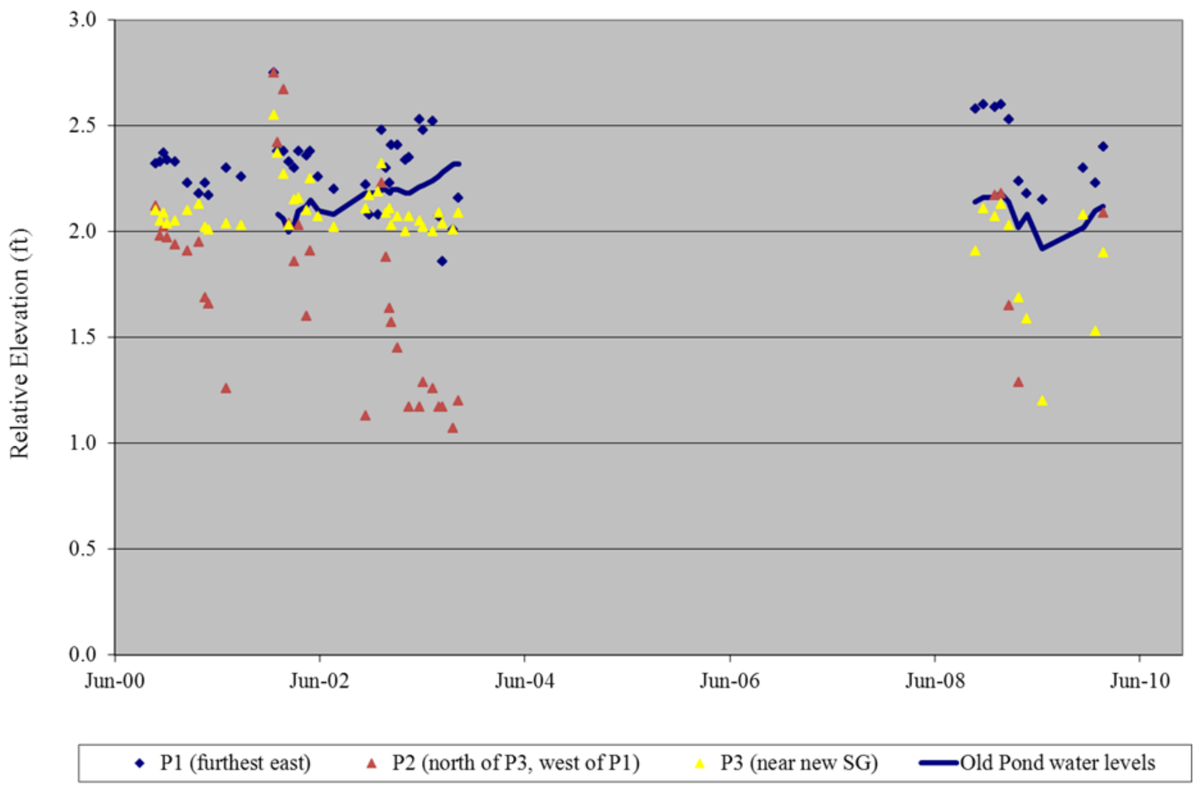
Stearns and Macdonald (1974) indicated that several streams on the southern slope of Wailau are perennial in their upper reaches but do not flow continuously to the coast because of seepage loss and evaporation. These streams are generally perennial where they flow over lavas of the upper member of the East Moloka‘i Volcanics and where water discharges from springs or drains swamps. Where streams flow over the more permeable lower member, surface water is more readily lost to infiltration.

Kakahai‘a NWR is in the driest part of the island and is underlain by the Kawela groundwater aquifer (Shade 1997). The Refuge consists of two wetlands: Old Pond is a natural wetland and New Pond is a constructed wetland. For some years, New Pond was supplied with water by a pump from Old Pond. However, thick vegetation growth in Old Pond began to impede the movement of water, drying out the area around the supply pump, so this was discontinued. For most of the year, New Pond is now dry.

Old Pond depends on groundwater in the form of natural spring discharge for its water supply. Occasional runoff from the surrounding hills is secondary source of water. Spring discharge into the pond is diffuse and cannot be measured directly but we have regularly recorded groundwater levels in three piezometers on the Refuge since 2002. This is an indirect measurement of hydrologic conditions and spring discharge at the Refuge. The record of measurements is shown below (Figure 3.3). Gaps represent years with missing data. The less frequent measurements in P2 shown in recent years are because that piezometer has been dry more frequently recently.

The record shows seasonal and annual variability but little long-term change in water levels. However, there has been an increasing frequency of "dry" measurements in one of the piezometers, P2, in recent years. These water level measurements are useful in terms of detecting changes and impacts to Refuge hydrology.

Figure 3.3 Old Pond water levels and groundwater levels, 2000-2010.



The closest streamflow gage is the USGS gage at Kawela Gulch (Site No. 16415600), located about 1,500 feet west of the Refuge at the mouth of Kawela Stream. The site elevation is 40 feet above sea level, the drainage area above the gage is 5.3 square miles, and the period of record is 2004-present. The stream has been dry 60 percent of the time, based on daily flow records. The monthly flows are shown in Table 3.1. Flow is greater during the winter months in response to greater rainfall.

Another USGS streamflow gage close to the Refuge is at Kaunakakai Gulch (Site No. 16414200), located about 6 miles west of the Refuge and just north of the town of Kaunakakai at an elevation of 75 feet. Hydrologic conditions at this site are likely very similar to the Refuge, although the area is underlain by a different aquifer system (Shade 1997). The period of record for this site is from 2003 to the present (Figure 3.2). Streamflow is sporadic and seasonal and most common during the wetter winter months in response to rainfall. The stream was estimated to be dry 91 percent of the time during water years 2004-2006 (Oki 2007). No known diversions exist upstream from the gauging station. Oki (2007) reports that the stream becomes perennial further downstream near the coast, where it is hydraulically connected to the groundwater system.

Table 3.1. Monthly streamflow data for Kawela Gulch(USGS Site No. 16415600), located just west of Kakahai'a NWR. .

YEAR	Monthly mean in cfs (Calculation Period: 2004- 2009)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004										0.12	2.94	3.6
2005	12.7	1.82	6.85	3.67	0.36	0.53	1.52	0.03	2.59	3.71	4.01	0
2006	2.69	3.16	11	10.6	2.66	0	0.83	0.1	0	1.77	7.37	1.4
2007	1.99	1.38	4.95	1.73	0.13	0.25	3.79	0.93	0.2			
2008										0.13	1.76	7.6
2009	4.31	2.48	2.29	0.22	0	0.6	0.08	2.07	0.01			
Mean of Monthly Discharge	5.4	2.2	6.3	4.1	0.79	0.34	1.6	0.78	0.7	1.4	4	3.1

Blank boxes indicate missing data due to malfunctioning equipment.

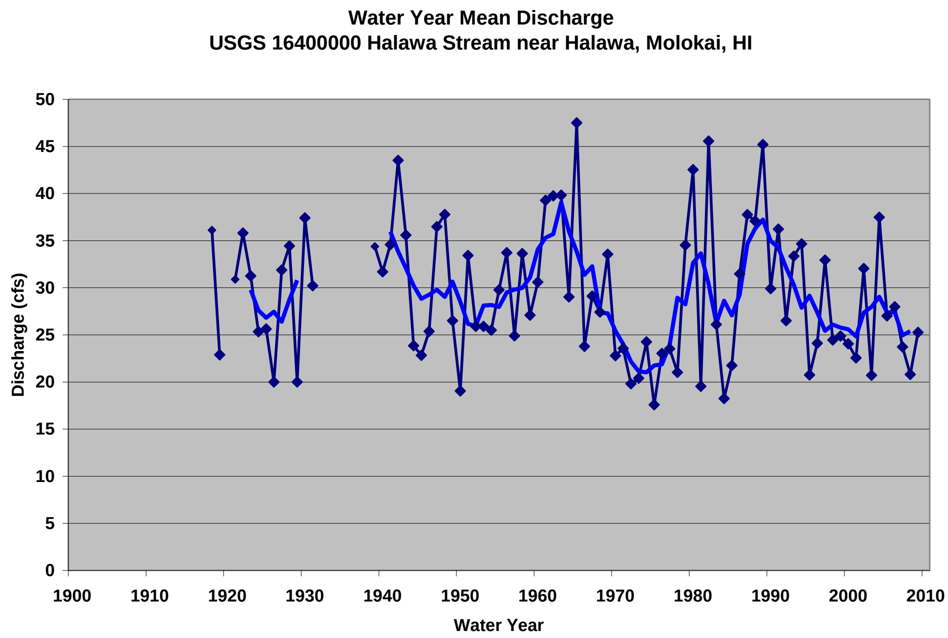
Table 3.2 Monthly streamflow data for Kaunakakai Gulch (USGS Site No. 16414200)..

YEAR	Monthly mean in cfs (Calculation Period: 2003- 2009) Calculation period restricted by USGS staff due to special conditions at/near site											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003			0.392					0	0	0	1.54	2.61
2004	12.3	1.7	8.3	3.4	0.9	0.0	0.0	0.0	0.0	0.0	1.1	0.6
2005	6.2	0.1	4.4	0.4	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0
2006	0.0	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0
2007	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.4	13.3
2008	1.7	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.6
2009	0.5	0.3	0.3	0.0	0.0	0.0	0.0	0.4	0.0			
Mean of Monthly Discharge	3.5	0.72	2.1	0.63	0.16	0	0.01	0.06	0	0.17	0.83	3

Near the coast in this area, the main groundwater-flow system consists of a freshwater lens system (Gingerich and Oki 2000) within dike-free rocks. In general, a freshwater-lens system includes a lens-shaped freshwater body, an intermediate transition zone of brackish water, and underlying salt water. In the Kaunakakai Stream area, the freshwater-lens system exists in the volcanic rocks and sedimentary deposits near the coast. Alluvium overlies the volcanic rocks near the mouth of Kaunakakai Stream, where groundwater levels probably range from near sea level to about 2 feet above mean sea level. Both groundwater levels and stream stage are expected to be affected by ocean tides and longer-term variations in sea level. On the basis of water quality information from nearby wells, the salinity of groundwater near the mouth of Kaunakakai Stream is likely brackish because of mixing with saltwater from the ocean. Hydrologic conditions at Kakahai‘a NWR are likely very similar to this location.

The only long-term streamflow gage on the Island of Moloka‘i is at Halawa Stream, located on the northeastern tip of the island at an elevation of 210 feet above sea level. The drainage area above the stream is 4.62 square miles and the period of record is 1918- present. It is useful to look at the annual flows for any long-term trends or changes, since this gage reflects the response to climate rather than anthropogenic activities (Figure 3.4). The streamflow data confirms the drying trend since 1990 that can be observed in the precipitation data from the airport. The 1970s were also quite dry, according to the streamflow data. Precipitation data from these years was missing at the airport. Oki (2004) reported a statistically significant decrease in annual median flow and annual baseflow for this site for the period of record.

Figure 3.4 Annual stream discharge at USGS streamflow gage Halawa Stream, 1918-2009. The line is a 5-year centered moving average.



Mass erosion caused by large goat populations in the uplands allow for flash flooding to occur on the Refuge during heavy rains. Poor drainage due to residential retaining walls and recurring blockages along the Kawela Stream and bridge has compounded the problem.

3.5 Topography/Bathymetry

We have no data on the current bathymetry of the ponds. The upper watershed has undergone changes in land use over the decade resulting in flood waters with a high volume of suspended sediments that enter the north side of the Refuge during winter months. Surface water drainage from the Kawela watershed is not a major factor in water levels in Old and New Ponds because the ponds are disconnected from surface flows; however, large amounts of water flow into other areas of the Refuge and have damaged the levees. We have identified the need for a comprehensive hydrological assessment to evaluate wetland needs in relation to upper watershed land-use changes. An evaluation of the groundwater source is essential as Old Pond receives its water from this source.

3.6 Environmental Contaminants

The Maui Department of Water Supply (DWS) conducts annual testing of groundwater wells in the Kawela watershed. The most recent report is a review of testing conducted and compiled in 2009 for reporting in July 2010. The DWS tested for more than 100 substances in the water, including bacteria, pesticides and herbicides, asbestos, lead, copper, and petroleum products. The only measurable contaminant found was nitrate (as N) with the highest detection level of 0.31 ppm, well below the EPA allowable limit of 10.0 ppm. The typical source of this trace contaminant is from erosion of natural deposits. In summary, no sources of environmental contamination have been detected or are suspected of adversely affecting the Refuge (DWS 2010).

3.7 Land Use

Immediately above and adjacent to Kakahaiʻa NWR is the residential development of Kawela Plantations, which spans 6000 acres of former Molokaʻi Ranch agricultural land with 210 1-acre residential/agricultural lots. Kamehameha V Highway bisects the wetland area from the makai (ocean-side) section of the Refuge. This shoreline area is operated as Kakahaiʻa Park through a cooperative agreement with Maui County. Located just 5.5 miles east of the main city of Kaunakakai, the park is used primarily for picnicking and shoreline fishing.

3.7.1 Previous Land Uses

Molokaʻi was first settled 450-650 CE. As agriculture developed, the landscape began to transform and has undergone alterations throughout its history of human settlement. Polynesian voyagers stocked their canoes with pigs, chickens, and dogs as well as crops needed for colonization. The native lowland forests were cleared and replaced with taro, sweet potato, yam, banana, sugarcane, breadfruit, and coconut. The land was modified with advanced farming practices that included irrigation from streams, terracing, mulching, and use of green manure. Slash and burn techniques were used to clear land for crops and to encourage the growth of pili grass used in house thatching (Roberts 2000, Ross 2011).

Significant sections of the coastline were modified between 1000-1400 CE with the creation of over 50 coastal fishponds ranging in size from a few acres to several hundreds of acres across and 1-30 feet deep. Native Hawaiians used lava boulders and coral to build the semi-circular walls of the ponds which would keep the fish inside while allowing the sea water to ebb in and out. The fish from these ponds were only eaten by the aliʻi (chiefs and royalty). Both down-slope and along-shore sediment transport patterns were altered. Many of these fishponds formed catchment basins for sediments coming off the expanded terraces and agricultural lands (Roberts 2000, Hawaiianweb 2006).

Prior to the fishpond construction, it is likely that the marsh was located closer to the springs along the present inland margin of the pond. The fishpond was created by removing vegetation, excavating the pond, and using the mud to form an earthen berm. A rock wall was constructed in areas where the earthen berm was not a sufficient barrier (Weisler 1983). A ditch was built between the pond and the sea in order to permit the flow of seawater and young fish. This flow was regulated by a gate, or makaha (Summers 1964). Small fry were introduced to the pond including awa (milkfish), ‘ama‘ama (mullet), aholehole, and ‘o‘opu (gobies). Similar to other Hawaiian fishponds, the perimeter may have been planted with taro, sweet potato, sugarcane, or ti (Weisler 1983).

The thin sandy strip of land separating the pond from the sea suggests that the area was formerly a bay open to the sea (Estioko-Griffin 1987). Numerous rounded basalt boulders located along the strip of land, which are facilitating beach erosion, resemble boulders found in the Kawela Gulch stream course. Weisler (1983) suggests that due to the historic and current location of Kawela Stream, these boulders were intentionally brought from the gulch to construct a seaward boundary for the pond. Thus, Kakahai‘a may have initially been a loko kuapa, a fishpond composed of a continuous stone wall connecting two protruding points along the shoreline, which has subsequently been buried due to sand accretion (Weisler 1983).

The arrival of Europeans in the 1770s brought the the introduction of goats, horses, cattle, and sheep. Ellis (1827) was the first to provide a written description of the island and estimated the population not to exceed 3,000. In 1828, Reverends Green and Andrews, while on a tour of Moloka‘i, estimated that the population was 5,000 and that there were 1,000 houses, although only 700 houses were actually counted (Missionary Herald 1829).

The Kawela ahupua‘a became part of King Kamehameha V’s ranch in the 1850s and was used as grazing land for cattle. The Duke of Edinburgh had deer transported from Japan to Moloka‘i as a gift to Kamehameha V in 1870. The growing herds quickly increased and endemic plants quickly declined, leaving vast areas barren due to soil compaction that increased runoff and accelerated erosion (Roberts 2000).

The Hawaiian Sugar Planters’ Association leased the Kawela lands in 1928, constructed a quarantine station for imported experimental varieties of sugarcane, and planted cane on the alluvial flats which was immediately flooded by heavy rains. To mitigate future flooding, the Planters’ relocated the stream to its present location by dozing boulders and river rocks in a straight line to the ocean. In 1935, the sugarcane fields were tilled-under and planted in mango trees, which remain today.

Weisler and Kirch (1982) estimated that since 1880, the Kawela shoreline increased by 1 foot per year. Although some farmers remained on ancestral land east and west of Kawela Stream, upland residences gave way to Western-style habitation along the coast. In 1901, Kakahai‘a Pond was used to produce rice and several residences were established along the pond edges to facilitate cultivation (Weisler 1983, Shallenberger 1977). During this time, the pond was much larger, with surface water areas estimated at 31 acres. A 1940, USGS aerial (page 3-12) shows much of the pond in rice production, which continued until 1950, at which time the Yuen family leased the pond from the McCorriston Trust and excavated the area to cultivate catfish and seabass. The surrounding area was used to raise pigs and produce kiawe charcoal until 1975. Five years later, the Kawela Plantation Development began construction on the upland ridges above the pond, further increasing siltation to the pond.

Kakahaiʻa aerial view, 1940 USGS

Kakahaiʻa aerial view, 1975 Air Survey Hawaiʻi