University of California, Santa Barbara
Donald Bren School of Environmental Science and Management

Management Recommendations for Piute Ponds
Edwards Air Force Base, California

A Group Project submitted in partial satisfaction of the requirements for the degree of Master of Environmental Science and Management at the Donald Bren School of Environmental Science and Management

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MANAGEMENT RECOMMENDATIONS FOR PIUTE PONDS
EDWARDS AIR FORCE BASE, CALIFORNIA

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The Group Project is required of all students in the Masters of Environmental Science and Management (MESM) Program. It is a three-quarter activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Final Group Project Report is authored by MESM students and has been reviewed and approved by:

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ABSTRACT

The Piute Ponds Ecological Area, located in the Mojave Desert on Edwards Air Force Base, supports a diversity of flora and fauna and offers unique educational and recreational opportunities. However, no formal plan for managing Piute Ponds exists. This project used available data to assess the current quantity and quality of water inputs, as well as educational and recreational use of the ponds. To assess the ecological integrity of the ponds, the California Rapid Assessment Method was used. Based on assessment of the current status of the ponds, lessons learned from other wetland management areas, and surveying of stakeholders this project developed multiple future scenarios along with recommendations for specific management options. The primary focus of the management of Piute Ponds should be on ecological health, as indicated by the poll results. Our analysis concluded that the preferred future scenario entails keeping the same amount of water, but with an increase in managerial and financial resources.

ABBREVIATIONS AND ACRONYMS AND SYMBOLS

AA	assessment area
AFB	Air Force Base
AFI	Air Force Instruction
BASH	bird/wildlife aircraft strike hazard
BLM	Bureau of Land Management
BOD	biochemical oxygen demand
CDFG	California Department of Fish and Game
CDHS	California Department of Health Services
COD	chemical oxygen demand
CRAM	California Rapid Assessment Method
CRWQCB	California Regional Water Quality Control Board
CWA	*Clean Water Act*
DO	dissolved oxygen
EIR	Environmental Impact Report
EMWD	Eastern Municipal Water district
EMWD	Eastern Municipal Water District
ESRI	Environmental systems Research Institute
FOAM	Friends of the Arcata Marsh
GIS	Geographical Information System
ft/ft	feet per foot
IBI	integrated biological index
HGM	hydrogeomorphic
LACSD	Los Angeles County Sanitation District

ABBREVIATIONS AND ACRONYMS AND SYMBOLS (Continued)

LWRP	Lancaster Water Reclamation Plant
MEEC	Mojave Environmental Education Consortium
MESM	Masters of Environmental Science and Management
MOU	memorandum of understanding
MSL	mean sea level
MWR	morale, welfare, and recreation
mg	million gallons
mgd	million gallons per day
msl	mean sea level
NAAEE	North American Association for Environmental Education
NPDES	National Pollution Discharge Elimination System
NRCS	National Resources Conservation Service
PCB	polychlorinated biphenyls
PSR	pressure stress response
pH	potential for hydrogen
QA/QC	quality assurance/quality control
SEA	significant ecological area
TDS	total dissolved solids
TKN	total Kjeldahl nitrogen
U.S.	United States
U.S. EPA	United States Environmental Protection Agency
WDR	water discharge requirements
WEF	Wetlands Education Facility

ABBREVIATIONS AND ACRONYMS (Concluded)

WOW	Wetlands on Wheels
WRR	water reclamation requirements
WWTP	wastewater treatment plant

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EXECUTIVE SUMMARY

The Piute Ponds Ecological Area, located on Edwards Air Force Base (AFB) property in the Mojave Desert, receives treated wastewater year around from the Los Angeles County Sanitation District 14 Lancaster Water Reclamation Plant (LWRP). The water allows Piute Ponds to support a diversity of flora and fauna and offer educational and recreational opportunities. Expanding development in the Antelope Valley and competing interests for the projected increase in available treated water from the Los Angeles County Sanitation District water treatment plant create the need for a long-term management plan to protect and improve the ponds. Although some assessments of the area have been written for other purposes (Environmental Impact Reports and research), no formal plan for managing the Piute Ponds Ecological Area has been created and little stakeholder input has been sought. No formal assessment of the ecological integrity of the ponds has been completed, nor has there been assessment of educational or recreational activities.

This project developed recommendations for a management plan for the ponds, based on the assessment of the current status of the ponds and lessons learned from other wetland management areas. The current status of the ponds was assessed for several categories, including water quantity and quality, ecological health, and educational and recreational use. Assessment of the current quantity and quality of water entering Piute Ponds was achieved using data supplied by District 14. This data included the daily flows and a variety of water-quality metrics. The California Rapid Assessment Method (CRAM) was selected to measure the ecological health of the ponds as this method is well established, scientifically validated, and requires relatively few resources to perform (Collins et al., 2007). In addition, data on the bird populations using the ponds was gathered. Data on education and recreation at Piute Ponds was gathered from permit information on file, at Edwards AFB.

Assessment of the current status of the ponds was used as a baseline from which management recommendations were developed. Recommendations for a management plan for Piute Ponds will be most useful if they are applicable to multiple possible future scenarios. The two primary variables with respect to the future management and sustainability of Piute Ponds are the supply of water and the availability of fiscal and manpower resources. A total of nine scenarios are possible when current conditions at the ponds are evaluated against both lower and higher water supply levels, and lower and higher levels of available management resources. Each of these scenarios was screened to evaluate the likely effects on water quality, ecological health, recreation, and education. Scenarios that are most likely to occur, and which do not violate governing regulations or board orders, were carried forward for detailed analysis. Our analysis concluded that Scenario 6 (increased resources and current water quantity) was the preferred future scenario. These recommendations were based on input from stakeholders.

Input from stakeholders was gathered to help define priorities, refine goals and objectives, as well as identify potential issues or conflicts. A poll was sent out by Edwards AFB in both paper and electronic form asking stakeholders to rank choices in order of preference. Choices included: nature preserve, recreation, education, hunting, research and minimum management. The top choice was for the ponds to be primarily used as a nature preserve. Recommendations for future management policies were based on the poll results and our assessment and research of the ponds. Multiple recommendations were developed and outlined for water quantity and quality, ecological health, and educational and recreational activities. The resulting management recommendations were presented to Edwards AFB. Some of the key recommendations are shown as follows:

a. Implement a more comprehensive ecological and water quality monitoring program,
b. Install flow gauges, repair control structures,
c. Create a vibrant and successful volunteer program,
d. Remove invasive species, plant native trees, and build bird boxes and perches,
e. Create a website to provide information to the general public,
f. Increase the number of school tours,
g. Increase the number of signs, build picnic areas, and install viewing structures for bird watchers,
h. Use adaptive management to account for changing conditions.

1.0 INTRODUCTION

The Piute Ponds ecosystem is the largest freshwater marsh in Los Angeles County. It supports a diversity of wildlife, including federally and state listed species, and California species of concern (Cooper, 2004). The ponds are located in the Antelope Valley, a topographically closed basin within the western part of the Mojave Desert Province. The ecosystem includes Rosamond Dry Lake and a portion of Amargosa Creek, and is located on Edwards Air Force Base (AFB). These wetlands are primarily supplied with water from the LWRP treatment facility operated by the Los Angeles County Sanitation District 14 (District 14). The LWRP's service area of over 160,000 people includes the City of Lancaster, parts of the city of Palmdale, and outlying areas. Additionally, the plant is expected to increase capacity by the year 2020 due to rapid growth in the Antelope Valley (LACSD, 2004). Changes in the amount of effluent discharged to Piute Ponds and ultimately Rosamond Dry Lake are likely to occur due to population growth, plant upgrades, and prohibition of unauthorized overflows.

Effluent discharges that result in the overflow to Rosamond Dry Lake reduce the Air Force's ability to use the lakebed for ground and flight test programs and as an emergency runway, while reduced discharges could negatively impact the ecological health of Piute Ponds. Edwards AFB is interested in improving the quality of the wildlife habitat at Piute Ponds and expanding education and recreation programs. However, use of the ponds by wildlife and humans may negatively impact the flight test mission of Edwards AFB by increasing bird/wildlife aircraft strike hazard (BASH) risk, and security and liability issues (Miller and Payne, 2000). These potential impacts must be eliminated or minimized.

The quantity of water available to Piute Ponds is critical to any future plans. Piute Ponds receives secondary treated effluent from the LWRP and water from Amargosa Creek during storm events. The LWRP was built in 1959 and is the only consistent supply of water to the ponds. Through a memorandum of understanding (MOU) between the California Department of Fish and Game (CDFG), Edwards AFB, and District 14, Piute Ponds must cover a minimum surface area of 200 acres, and its current size is approximately 400 to 600 acres. The plant currently operates at approximately 15 million gallons per day (mgd) and will be expanded to 26 mgd in the near future. Objectives of the LWRP 2020 Plan and Environmental Impact Report (EIR) include eliminating unauthorized effluent-induced overflows from Piute Ponds to Rosamond Dry Lake and provide sufficient quantities of recycled effluent to maintain wildlife and recreational uses of Piute Ponds (LACSD, 2004). Mitigation measures in the 2020 EIR require District 14 to conduct a water-quality assessment for Piute Ponds, which includes procedures to ensure that water quality does not violate waste discharge requirements for receiving waters through controlled flushing flows or installation of a mutually-approved circulation system, and negotiate with Edwards AFB an appropriate means of protecting the Piute Ponds water quality. While the Air Force would like to enhance the Piute Ponds Ecological Area, any enhancement must take into account the future availability of water and other resources. The supply of sufficient amounts of effluent water may become contentious as demand increases due to population growth in the Antelope Valley.

The Piute Ponds Ecological Area is a unique ecosystem in the Mojave Desert, which supports a diversity of flora and fauna and provides a recreational resource for the surrounding communities. There are currently six significant ecological areas (SEA), designated to protect and maintain species diversity in the Antelope Valley. Two SEAs occur on Edwards AFB: Rosamond Dry Lake and Piute Ponds. Other sensitive habitats in the area include Amargosa Creek, the proposed Alkali Mariposa Lily Conservation Area, and current and proposed Antelope Valley SEAs.

In addition to its ecological value, Piute Ponds is recognized for its recreational and educational values. The largest recreational activity at Piute Ponds is bird watching; hunting for waterfowl takes place on a limited basis from fall through winter. Piute Ponds supports over 200 species of birds and is identified as an 'Important Bird Area of California' by the National Audubon Society and Bird Life International (Cooper, 2004). Single-day populations of greater than 5,000 waterfowl and 10,000 total birds have been recorded. The Air Force has recently encouraged increased visits by installing a walking tour marked with educational signs, rest rooms, and a covered kiosk (Hatch, 2006). Access to the area is controlled by Edwards AFB 95th Air Base Wing Environmental Management directorate. As the facilities at Piute Ponds have improved, requests for tours by elementary and high schools have increased. Colleges and universities have also shown interest in conducting research at the ponds. These requests indicate a demand for more educational programs at Piute Ponds.

1.1 Goals and Objectives

Protecting and enhancing this rare ecological area requires balancing the needs of multiple stakeholders, while efficiently allocating scarce natural and financial resources. Accurately projecting future ecological requirements, stakeholder needs, and urban encroachment pressures is necessary to properly develop management approaches. Analysis of current and anticipated requirements of Piute Ponds will be used by Edwards AFB to make management decisions and prepare long-term plans and budgets. Developing a management plan for the future is essential to preserving and enhancing this valuable resource. Edwards AFB aims to increase the educational, recreational, and ecological values of the Piute Ponds Ecological Area. Expanding development in the Antelope Valley and competing interests for the projected increase in available treated water from LWRP creates the need for a long-term management plan to help establish project needs and set priorities. Although some internal planning documents have been created, little stakeholder input has been sought, and a comprehensive plan for managing the Piute Ponds does not exist. No formal assessment of the ecological integrity of the ponds has been completed, nor has there been any assessment or planning for current and future educational or recreational activities.

1.2 Significance of Project

The purpose of this project is to develop management recommendations for Piute Ponds. Various management options are detailed, along with an approach for selecting options based on client and stakeholder interests and concerns. The final document incorporates consideration of competing interests for the reclaimed water, as well as the competing uses of Piute Ponds for recreation, education, and conservation. The document serves as a guide to Edwards AFB for future planning related to Piute Ponds until a formal management plan is put in place.

1.3 Questions

Major questions that shaped the research included:

a. What current issues need to be addressed to enhance and expand the ponds, and which issues are priorities?

b. What similar issues have been faced by other constructed wetlands, and how have they been resolved?

c. What are the likely impacts of varying the pond water levels and flows?

d. What do stakeholders envision for the future of the ponds?

e. What are the management options?

f. Taking the advantages and disadvantages of the various scenarios into account, along with the economic and political constraints, how can Edwards AFB select the most appropriate management option?

1.4 Description

Piute Ponds are a series of interconnected surface water impoundments constructed in 1961 to receive secondary treated effluent water from the LWRP and to prevent overflow onto the Rosamond Dry Lake on Edwards AFB (TYBRIN, 2006). Constructed in 1959 and operated by District 14, the LWRP is located 2 miles southwest of the Piute Ponds ecological area, just outside of the boundary of Edwards AFB. The facility responsibilities include collection, treatment, and disposal of treated domestic wastewater originating from the City of Lancaster and surrounding areas (CH2M HILL, 2005). Piute Ponds, which receive more than 2,450 million gallons (mg) of secondary treated wastewater from the LWRP each year, are the largest body of water on Edwards AFB as well as the largest marshland habitat in Antelope Valley. The LWRP discharges effluent to three main sites including Piute Ponds, Nebeker Ranch and Apollo Lakes. Additional water is delivered to Piute Ponds via stormwater runoff from Amargosa Creek (Edwards AFB, 2008b). Piute Ponds contains no substantial structures or developed areas; however, there is a mixture of culverts, spillways, and unpaved roads that allow perimeter access to the area. The sandbars and shorelines that run along the impoundments provide valuable habitat for a wide variety of wildlife, including migratory birds.

1.4.1 Location

Piute Ponds are located on the southwestern corner of Edwards AFB in Antelope Valley, California (Figure 1). Situated along the western edge of the Mojave Desert in Southern California, Edwards AFB is located on roughly 307,517 acres in the Antelope Valley. Approximately 100 miles northeast of Los Angeles, 90 miles northwest of San Bernardino, and 80 miles southeast of Bakersfield, Edwards AFB lies within portions of Los Angeles, Kern, and San Bernardino Counties. The cities of Rosamond and Mojave border the western region of the base, which runs adjacently along the Antelope Valley Freeway (SR-14) (Figure 2) (Edwards AFB, 2008b).

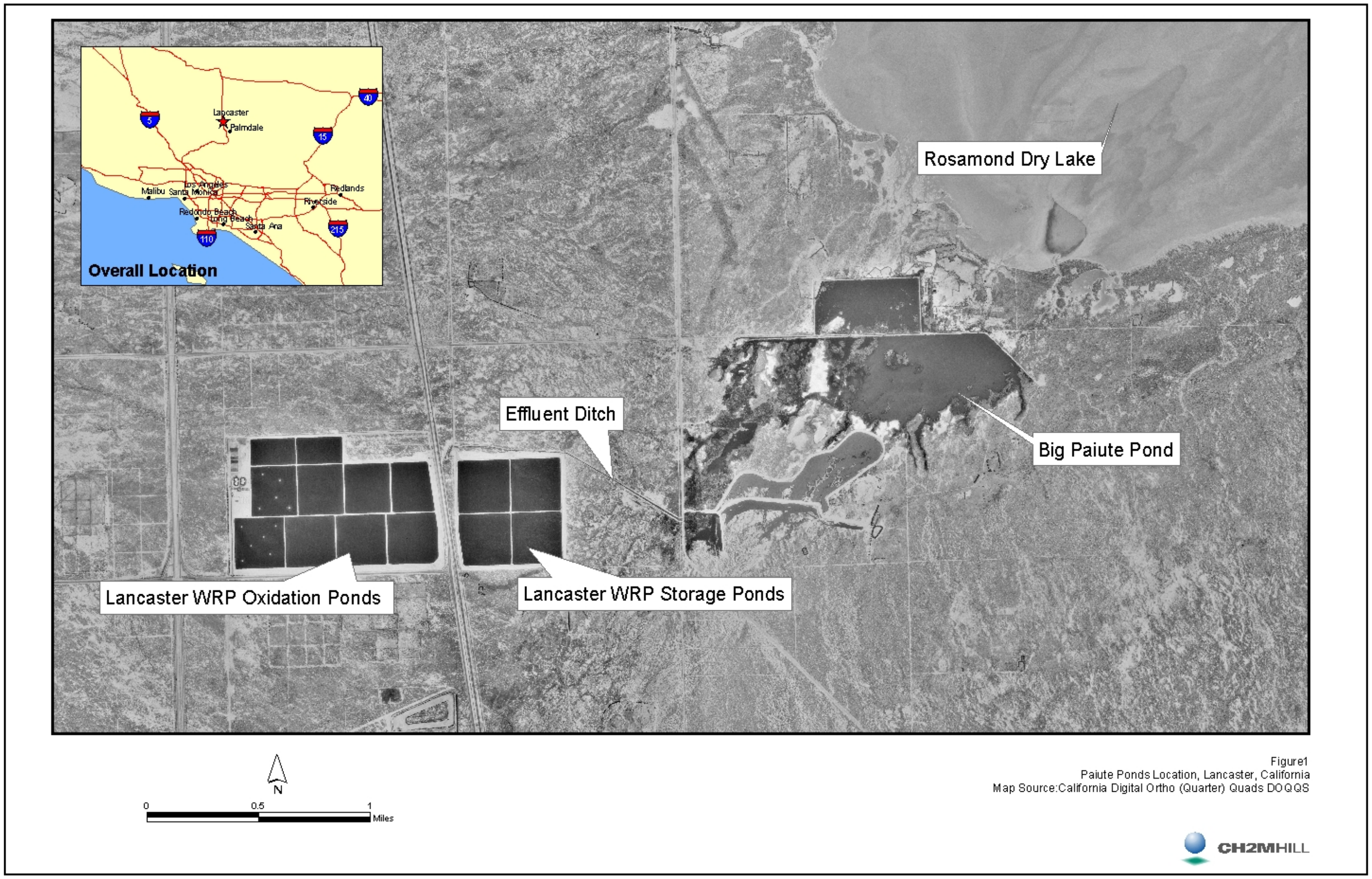


Figure 1. Piute Ponds Location on Edwards Air Force Base (Source: CH2M HILL, 2008a)

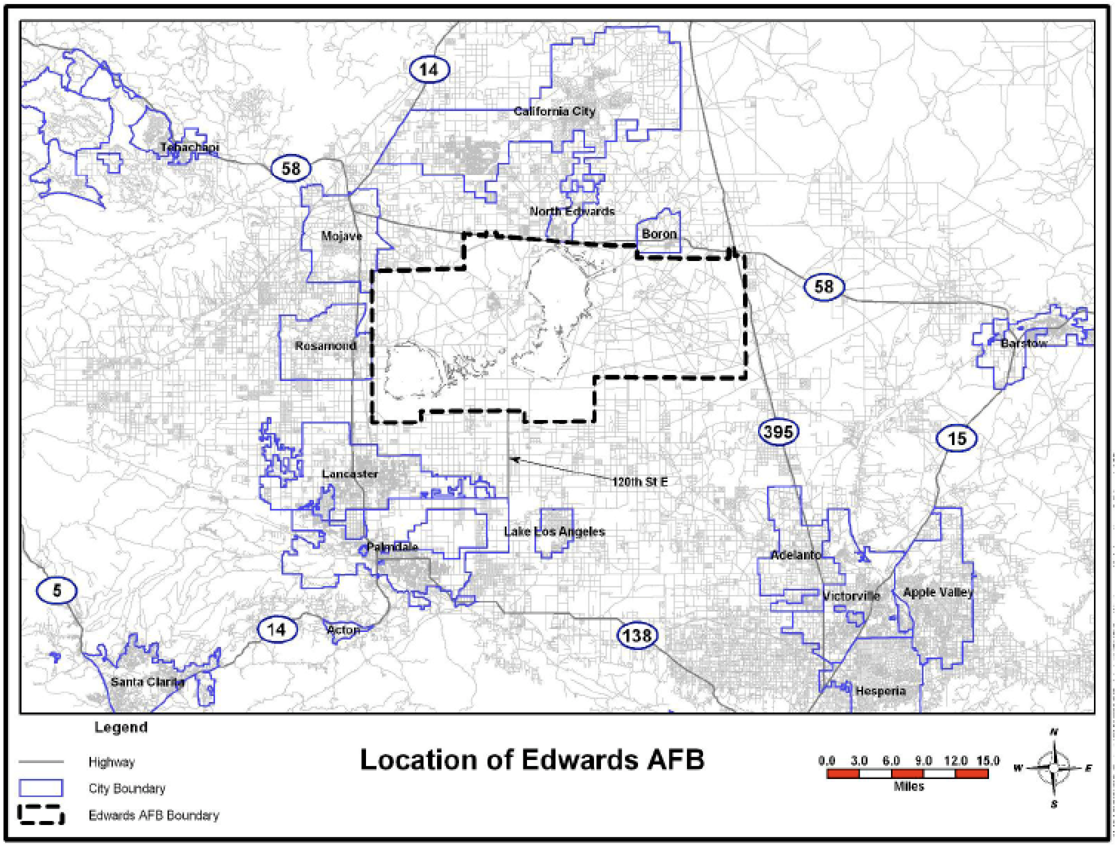


Figure 2. Location of Edwards Air Force Base (Source: Edwards AFB, 2008b).

1.4.2 Topography

Edwards AFB is situated in the Antelope Valley, a topographically closed (undrained) basin spanning approximately 2,400 square miles (Edwards AFB, 2008b). The Antelope Valley floor is essentially a bowl-shaped basin with no outlets and is situated between the San Gabriel Mountains to the south and the Tehachapi Mountains to the northwest (Figure 3). The San Gabriel and Tehachapi Mountain Ranges, which rise to altitudes of 9,399 and 7,981 fee above mean sea level (msl), respectively, deliver water and sediment to three playas, or dry lakebeds, located on Edwards AFB: Rosamond Dry Lake, Rogers Dry Lake, and Buckhorn Dry Lake. Topographical characteristics on Edwards AFB are comprised of open dry hills, alluvial fans, sand dunes, rock outcroppings, and flat-to-moderately-elevated hills, with surface elevations ranging from 2,267 feet above msl near Rogers Dry Lake to 3,424 feet above msl near Red Buttes along the eastern boundary of the base (Figure 4) (Edwards AFB, 2008b). Surface elevations in the vicinity of Piute Ponds range from approximately 2,300 feet above msl near the area directly below the ponds at the southwest corner of the base to 2,285 feet above msl near the southern edge of Rosamond Dry Lake (Charlton, 2005).

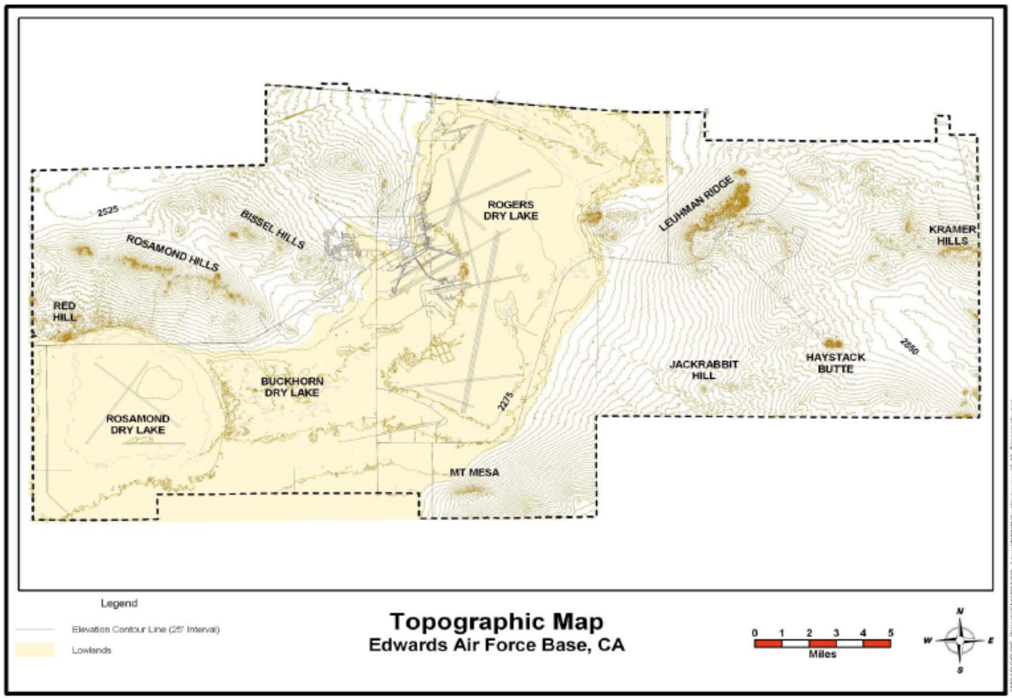


Figure 3. Topography and Dry Lake Bed Locations on Edwards Air Force Base (Source: Edwards AFB, 2008b).

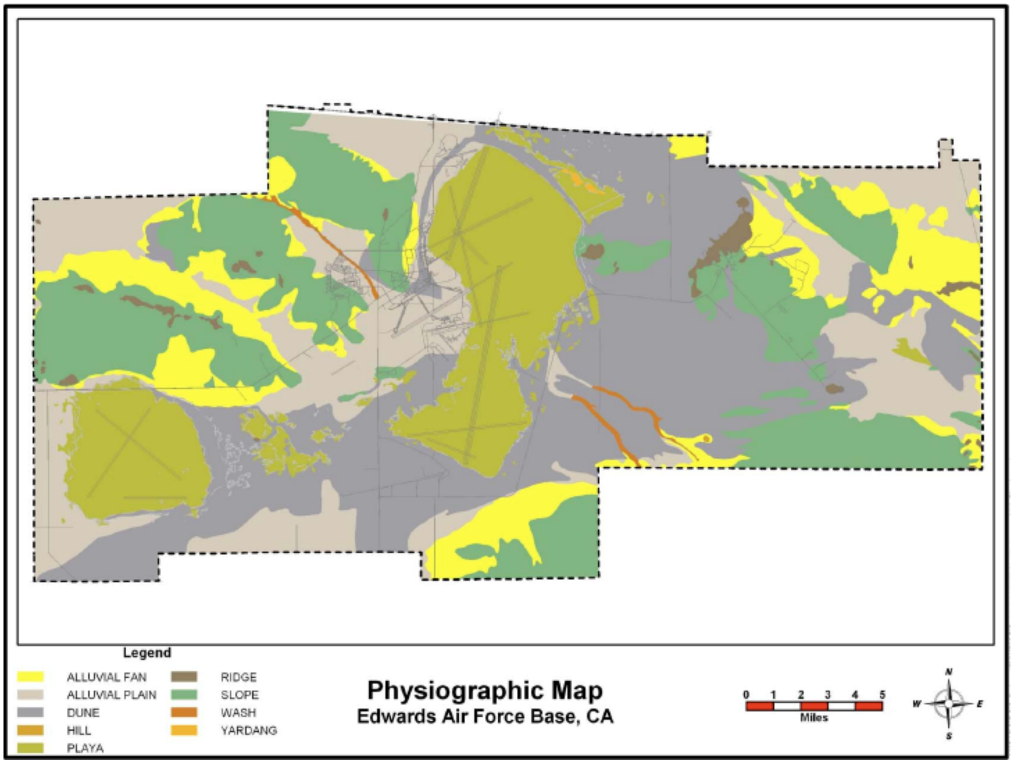


Figure 4. Topography of Edwards Air Force Base (Source: Edwards AFB, 2008b).

1.4.3 Climate

Situated in the southwestern portion of the Mojave Desert, Piute Ponds weather is characteristic of a semiarid, desert climate with extreme daily temperature fluctuations, including hot summer days, cold winter nights, infrequent precipitation, and strong seasonal winds (Edwards AFB, 2008b). During the summertime in Antelope Valley, the average temperature is 78° F (Fahrenheit), with lows and highs ranging from 63° F to 93° F. However, extreme temperatures during the summer have known to be as high as 119° F in August. During the winter, the mean temperature for the valley is 45° F, with temperatures ranging from 34° F to 57° F and has been known to drop as low as 8° F in January (LACSD, 2004). Humidity levels stay below 40 percent for most of the year, as the region receives an average annual precipitation of 5 inches, mostly between November and April (Edwards AFB, 2008b). A relatively small amount of precipitation occurs during the summer months, which is characterized mostly with occasional, localized thunderstorms. The sparse nature of the valley's precipitation patterns has an impact on water demands and use for local agriculture. As the growing season occurs, primarily between April and November, most farmers are heavily dependent on irrigation for their cultivated crops (LACSD, 2004).

1.4.4 Geology and Soils

Piute Ponds is part of the western portion of the Mojave Desert geomorphic province. The Antelope Valley is composed of thick deposits of alluvial and lacustrine (lakebed) materials filling the West Antelope, East Antelope, and Kramer structural basins (LACSD, 2004). The Piute Ponds area along with Rosamond Dry, Buckhorn Dry, and Rogers Dry Lakes are part of Lake Thompson, a desiccated late Quaternary-lake system. Lake Thompson achieved its maximum extent covering aproximately 950 km^2 (367 square miles) of the Antelope Valley during the late Pleistocene era (Orme, 2004) and is responsible for the majority of surface geology and sediments. Surface and shallow geological features in the area were predominantly formed by the deposition of fine sediments eroded from the surrounding mountains, which were depleted of coarse material and then deposited from suspension by evaporating water in the closed basin (Dienhart and McPherson, 1998). Surface soils in the area primarily consist of fine sands, silts, and clays transported in flowing water from the surrounding hills to the dry lakebed and low areas.

Surface soils around Piute Ponds consist primarily of Leuhman-Challenger Complex (64 percent), Leuhman Complex (23 percent) and Cajon Challenger Complex (10 percent), with smaller amounts of Wherry clay and Cajon loamy sand. Leuhman soils typically consist of very deep, moderately well drained soils formed in lake sediments with influence from windblown materials. Leuhman soils are found on alluvial flats with slopes from 0 to 2 percent. Challenger type soils generally consist of very deep, moderately well drained soils formed in windblown deposits overlaying lake sediments. Challenger soils are found on shallow dunes with slopes ranging from 0 to 9 percent.

Cajon type soils consist of very deep, somewhat excessively drained soils that form in sandy alluvium from granitic rock sediment sources. Cajon soils are formed on alluvial fans, fan aprons, fan skirts, inset fans and river terraces with slopes ranging from 0 to 15 percent. Wherry type soils consist of very deep, somewhat poorly drained, saline-sodic soils formed in lake sediments. Wherry soils are typically found in playas with slopes of 0 to 1 percent. These soil types form in areas with mean annual precipitation of about 5 inches and average annual temperatures of approximately 62° F. (Natural Resources Conservation Service [NRCS], 2008).

1.4.5 Basin Hydrology

The Antelope Valley is a hydrologically closed basin with no outlets to the ocean. As a result, any water that enters the region will either infiltrate into the groundwater aquifer, or will flow in the direction of the three dry lakes located near the center of the valley, Rogers, Rosamond, and Buckhorn Lakes (Figure 5). These dry lakebeds comprise the floodplain within the basin and receive water during the winter months and typically remain wetted through the winter months until summer. However, due to the dry hot climate of the Antelope Valley, as well as the impervious nature of the soil and substrate, most of the overland flow eventually evaporates on the dry lakebeds rather than infiltrating into the groundwater (LACSD, 2004).

There are a number of stream reaches and washes that transport surface water to the dry lakebeds on Edwards AFB. However due to the arid climate of the valley, these reaches and washes typically flow only during episodes of heavy rainfall or from snowmelt flowing from the surrounding mountain ranges. The primary streams flowing into Rosamond Lake include Amargosa and Anaverde Creeks from the southwest, Littlerock and Big Rock Washes from the south and Cottonwood Creek from the west (Charlton, 2005). During periods of above average rainfall activity, stormwater runoff via Amargosa Creek will deliver water into Piute Ponds (Edwards AFB, 2008).

The Antelope Valley Groundwater Basin can be characterized into 12 groundwater subbasins as follows:

a. Buttes
b. Chaffee
c. Finger Buttes
d. Gloster
e. Lancaster
f. Neenach
g. North Muroc
h. Oak Creek
i. Pearland
j. Peerless

k. West Antelope
l. Willow Springs

Edwards AFB, District 14, and Piute Ponds are all located within the Lancaster subbasin. Underlying much of the Antelope Valley, the Lancaster subbasin is the largest and most developed groundwater resource in the valley (Londquist et al., 1993). Characterized by alluvium, blue-clay layers, and bedrock features, the Lancaster subbasin can be divided up into three separate aquifers, all of which consist of poorly consolidated combinations of clay, silt, sand, and gravel; a shallow, unconfined aquifer, which is thin and located above the blue-clay layer, is generally unproductive; a thicker, confined middle aquifer that produces a vast majority of groundwater; the deepest confined aquifer, located below the blue-clay soil layer, is thinner and less productive than the middle aquifer. All of these aquifers consist of poorly consolidated combinations of clay silt, sand, and gravel beds (Charlton, 2005; CH2M HILL, 2005).

Recharge within the basin is primarily due to infiltration of surface water, both from rainfall and stormwater runoff from surrounding mountains along the boundaries of the basin. Infiltration occurs through the alluvial fans of Amargosa and Anaverde Creeks and Littlerock and Big Rock washes flowing from the San Gabriel Mountains on the southern boundary of the Antelope Valley (Edwards AFB, 2008; TYBRIN, 2006). Within the Lancaster subbasin, groundwater generally flows northeasterly from the foothills of the San Gabriel Mountains toward Rosamond and Rogers dry lakebeds; overland flow patterns follow a similar nature, generally moving from the margins of the basin toward the center of the basin and dry lakebeds (LACSD, 2004). An analysis of aquifer system compaction conducted approximately 8 miles east of Rosamond Lake showed that there was a downward gradient of approximately 0.3 foot per foot between the upper and middle aquifers (CH2M HILL, 2005). In 1999, groundwater levels in the upper aquifer were approximately 57 feet below ground surface (bgs) and groundwater levels in the middle aquifer ranged from 157 to 167 feet below ground surface. In recent years, over-pumping of the groundwater has caused localized depressions, thus altering this general pattern of groundwater movement in the subbasin (CH2M HILL, 2005).

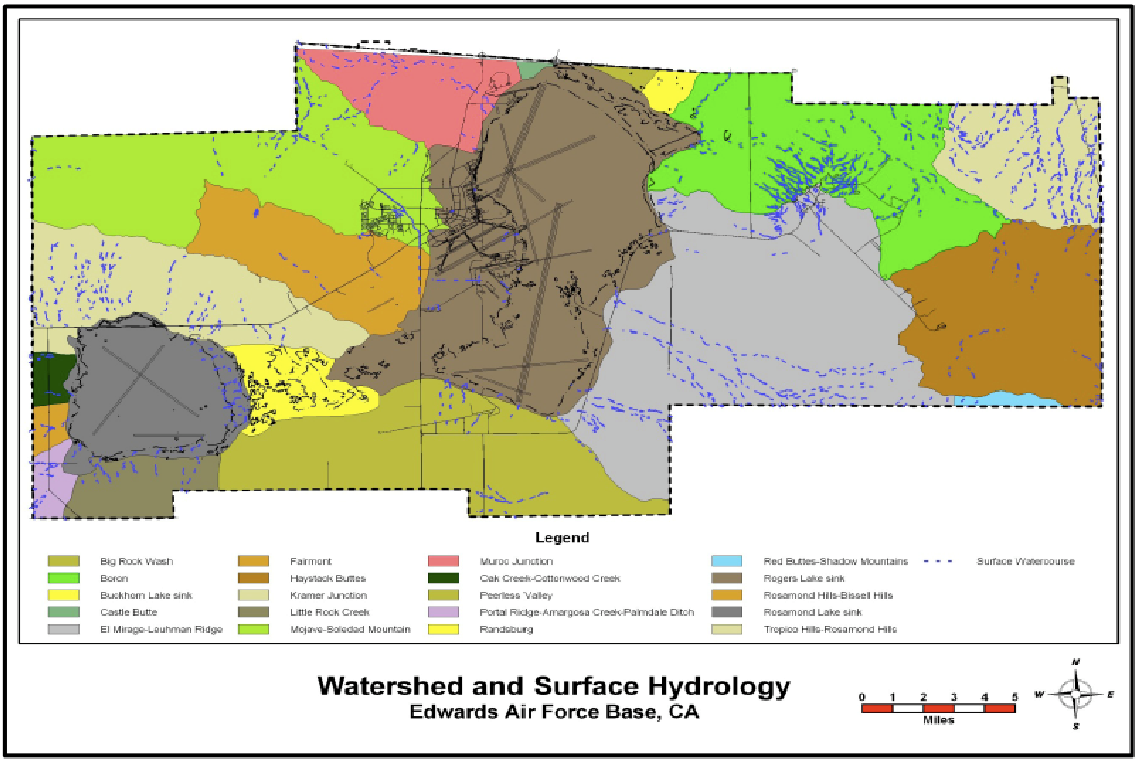


Figure 5. Hydrology of Edwards Air Force Base (Edwards AFB, 2008b)

1.4.6 Population of Area

Edwards AFB is located in the Antelope Valley in the high desert of Southern California within Los Angeles, Kern, and San Bernardino counties. The primary cities in the Antelope Valley are Lancaster and Palmdale. Edwards AFB is adjacent to the City of Lancaster. The City of Lancaster was established in the late 19th century (LACSD, 2004). Over the decades, Lancaster's population has fluctuated and tends to be dependent upon the aerospace industry in the area, especially Edwards AFB. As of July 2007, the population of Lancaster was recorded as being 143,616. The population has increased by 18.1 percent since the year 2000 (Lancaster, 2008). Even though there are fluctuations in the population, Lancaster and the Antelope Valley's growth rate continue to surpass Los Angeles' County-wide rates (LACSD, 2004). The population of the District 14 planning area (including most of the City of Lancaster as well as parts of the city of Palmdale and other unincorporated areas) was 137,818 in the year 2002 and is expected to increase to 252,248 by the year 2020. This is an increase of more than 100 percent (LACSD, 2004).

1.4.7 Socioeconomic Factors

The City of Lancaster has a mean age of 31. Sixty-eight percent of the residents of Lancaster are in the middle-class and 26 percent of these residents earn over $100,000 a year (Edwards AFB, 2008b). The estimated median household income was approximately $50,000 for the year 2007, which is below the state average of approximately $60,000. The median home value is approximately $330,000 and the 2008 cost of living index is 140.9 which is high as the U.S. average is 100 (Lancaster, 2008).

1.4.8 Water Supply and Losses

The Piute Ponds system receives the majority of water from effluent flows from the District 14 LWRP, with a small amount coming from precipitation in the form of rainfall, and stormwater flows. The plant treats an average of 15 mgd; however, the amount of effluent which flows to Piute Ponds depends on the time of year. During the late fall, winter, and early spring months, agricultural and landscaping demands for reclaimed water decrease to almost zero and the majority of the effluent from the plant is diverted to the ponds. Evaporation rates during this timeframe are low and the high effluent discharge from the plant exceeds the capacity of the ponds, which eventually overflow to Rosamond Dry Lake. During the summer, demand for irrigation and landscaping increase and the influent to the ponds fluctuates from 3 to 6 mgd with an average of 4.5 mgd (Magnum, 2008). Overflows to Rosamond Dry Lake taper off in late March and eventually cease, after which, the water level in the ponds remains relatively constant with the plant effluent offset by percolation losses and evaporation. In 2007, overflows to Rosamond Dry Lake ceased on 2 April (LACSD, 2008). Evaporation varies between a seasonal low of approximately 0.4 mgd during the winter months and a high of approximately 2.8 mgd during the summer months (CH2M HILL, 2005). Percolation and seepage is estimated at approximately 6.2 inches per month (CH2M HILL, 2008a) which equals approximately 1.7 mgd.

The majority of rainfall at Piute Ponds occurs in the winter and usually averages between 2 and 6 inches per year. Piute Ponds also receives intermittent stream flow from Amargosa and Little Rock Creeks. Amargosa Creek receives runoff from the Sierra Pelona Mountains at the southwest end of the Antelope Valley while Littlerock Creek receives runoff from the San Gabriel Mountains (City of Lancaster, 2007). Estimates of the annual flow of these creeks were not available; a Piute Ponds water balance model developed by CH2M HILL assumed the flows to be zero and achieved good model calibration (CH2M HILL, 2008). This appears to be a valid assumption due to the fact that storm events large enough to generate flows, which reach Piute Ponds, only occur every 1 to 2 years.

1.4.9 Water Quality

Water quality issues result when treated wastewater is discharged to water bodies accessible to the public. Basic wastewater treatment levels include primary, secondary, and tertiary. Primary treatment removes the majority of the suspended solids and organic matter and involves a physical treatment process such as sedimentation. Secondary treatment removes biodegradable organic matter and suspended solids through biological and chemical processes and may include disinfection. Secondary treated effluent from the plant is currently disinfected with chlorine during hunting seasons. Tertiary treatment removes residual suspended solids using granular filtration or micro-screens. Disinfection as well as nutrient removal may also be included in tertiary treatment process (Metcalf and Eddy, 2003). Effluent water discharged to Piute Ponds receives secondary treatment with disinfectant and will have tertiary treatment when the LWRP upgrades are completed in the year 2010.

Major constituents found in wastewater include; suspended solids, biodegradable organics, nitrogen and phosphorus, pathogens, collodial and dissolved solids, and volatile organic compounds (VOCs). The LWRP provides quarterly and annual reports to Edwards AFB and the California Regional Water Quality Control Board (CRWQCB), Lahontan, documenting water quality sampling and analysis data, effluent management, and maintenance and construction activities at the ponds and the plant. Sampling and analysis is performed for, metals, pesticides, PCB, volatile organic compounds, annual base/neutral extractables, annual acid extractables, cyanides, phenols, petroleum hydrocarbons, chlorine content, turbidity, chemical oxygen demand, biochemical oxygen demand (BOD), disolved oxygen (DO), alkalinity, potential for hydrogen (pH), temperature, and flow volumes. In 2007, the LWRP effluent to Piute Ponds exceeded upper limits for coliform on three occasions, pH on one occasion, and was below lower limits for DO on three occasions. The low DO levels were attributed to anaerobic conditions induced by biological activity (LACSD, 2008). Water quality is of special concern due to the sensitivity of aquatic birds to contaminant residues. A study conducted by the U.S. Geological Survey determined contamination at Piute Ponds was below levels which are likely to adversely affect avian reproduction (USGS, 2002).

1.5 Regulatory Framework

1.5.1 Water Quality

State Water Resource Control Board

The primary laws covering water quality are the *Clean Water Act (CWA)*, as amended in 1987, and the *California Porter-Cologne Water Quality Control Act*. The *California Porter-Cologne Water Quality Control Act* gave the SWRCB oversight of water rights, pollution, and water quality. Oversight is administered through the CRWQCB Lahontan, who administers the Piute Ponds area. The local board is responsible for issuing permits for the discharge and use of treated effluent, issuing of National Pollution Discharge Elimination System (NPDES), permits (including for construction of 1 or more acres), and the issuing of water discharge requirements (WDR) to the District 14 wastewater treatment plant (WWTP). The WDRs include water quality standards as well as monitoring and reporting requirements. In 2002 the RWQCB issued a WDR for Piute Ponds setting water quality thresholds and requiring monitoring and annual reporting (CRWQCB Lahontan, 2008; Land Design Consultants, 2008).

California Department of Health Services (CDHS)

Under Title 22, the CDHS sets health standards for reclaimed water. The current standards are extremely stringent standards. The CDHS also issues guidelines for areas receiving reclaimed water (Land Design Consultants, 2008; County Sanitation Districts of Los Angeles County, 2004).

Los Angeles County

Los Angeles County issued the *Antelope Valley Area Wide General Plan* in 1986. This plan sets policies to limit the pollution of underground aquifers and to limit flooding (Land Design Consultants, 2008; LACSD, 2004).

City of Lancaster

The City of Lancaster has issued a variety of policies designed to protect the groundwater supply and encourage the use of reclaimed water (Land Design Consultants, 2008; LACSD, 2004).

1.5.2 Biological Resources

United States Army Corps of Engineers and the Environmental Protection Agency

The Army Corps of Engineers (Corps) has primary federal jurisdiction over wetlands under two laws: *The Rivers and Harbors Act* (navigable waters) and the *CWA* (waters of the U.S.).

The Corps has determined that Piute Ponds is not a water of the U.S. as defined by the *CWA* and, therefore, does not fall under its jurisdiction. Therefore, the District 14 WWTP does not require an NPDES permit and is not regulated by the EPA (Land Design Consultants, 2008; LACSD, 2004).

U.S. Fish and Wildlife Service (USFWS)

The USFWS has authority to regulate threatened and endangered species under the *Endangered Species Act.* Agencies must determine if a proposal will have a significant impact (including destruction of habitat) on any listed species. Any significant impact is considered a ‘take’ and is prohibited by the *Endangered Species Act.* No federally threatened or endangered species inhabit the ponds (Land Design Consultants, 2008; LACSD, 2004).

California Department of Fish and Game

The CDFG have primary responsibility for regulating wetlands and waters in California and gives comments on the Corps permit actions. Piute Ponds falls under

CDFG jurisdiction, although there has been no formal delineation, and the ponds are on federal land. Edwards AFB is required to follow all relevant state laws. The CDFG is also responsible for maintaining a list of threatened and endangered species under the *California Endangered Species Act*. Agencies must determine if a project will have a significant impact on a state listed species. In addition, certain species not listed as threatened or endangered on a state or federal level may be considered threatened under certain conditions under *California Environmental Quality Act* (CEQA) guidelines section 15380. This provision is mainly used for species that have been proposed for listing, but have not yet been listed. Species on Lists 1 and 2 of the California Native Plant Society usually fall into this category (Land Design Consultants, 2008; LACSD, 2004).

Additional Laws

Additional laws that may apply to Piute Ponds include:

a. The federal *Migratory Bird Treaty Act*, which forbids killing, possessing, or trading in migratory birds except within regulations set by the Secretary of the Interior;

b. Federal *Bald Eagle Protection Act*; and

c. California fish and game code 3503.5 1992, which protects birds of prey (including nests and eggs).

Planning Areas

Piute Ponds is located within the scope of the *West Mojave Plan* and will be subject to the plan's approval. This *West Mojave Plan*, overseen by the Bureau of Land Management, defines regional conservation strategy for threatened species. The *West Mojave Plan* defines desert wildlife management areas and critical habitat units. Piute Pond does not lie within either type of protected area. The nearest proposed conservation area is the Alkali Mariposa Lily conservation area, whose boundaries exclude the ponds (Land Design Consultants, 2008; LACSD, 2004).

Los Angeles County has designated the region as an SEA and Piute Ponds will fall under the restrictions imposed by this designation (Land Design Consultants, 2008; LACSD, 2004).

Memorandums of Understanding

District 14 has signed two MOUs which affect Piute Ponds. The first MOU is between Edwards AFB, CDFG, and LACSD. Signed in 1981, it requires District 14 to maintain at least 200 wetted acres for migratory bird habitat. The current 2020 plan envisions maintaining the ponds at their current size (approximately 400 acres) (LACSD, 2004). The second MOU was signed in 1991 between Edwards AFB and District 14 and forbids the WWTP from overflowing the ponds and flooding Rosamond Dry Lake. District 14 was later sued for noncompliance and has since stopped the overflows (Land Design Consultants, 2008; LACSD, 2004).

2.0 BACKGROUND

2.1 Elements of a Successful Management Plan

In order to generate our recommendations for a comprehensive management plan, the components of a good management plan, and the processes necessary to generate that plan were first identified. Piute Ponds requires a comprehensive plan, which integrates the water balance of natural and anthropogenic processes with ecological requirements and educational, recreational, and research activities. The CDFG, in cooperation with the California Waterfowl Association, has prepared *A Guide to Wetland Habitat Management in the Central Valley* (Smith, et al., 1994), which discusses management plans for various types of wetlands that can be applied, in part, at Piute Ponds. Examples of managing multiple use urban wetlands in California are provided in *Managing Urban Wetlands for Multiple Use: Research, Restoration, and Recreation* (Zedler and Leach, 1998).

A scientific framework should be applied in developing a wetland management plan, which preserves the biological diversity and health of the ecosystem while providing opportunities for recreation and research (Mazzotti and Morgenstern, 1996). Lane Council of Governments (1992) outlines the steps involved in developing a comprehensive wetland management plan, which are discussed in the Methodology Section of this report. Elements addressed in the plan included water quantity, water quality, biological resources, educational opportunities, and recreational opportunities. Each element was addressed in the following sections.

2.1.1 Water Resources (Water Quantity and Quality)

Water requirements for the Antelope Valley were reviewed to establish historic, current, and predicted flowrates to Piute Ponds through District 14 LWRP, as well as natural storm flows to the ponds. Regulatory requirements, Department of Defense regulations, and Air Force Instructions were researched to identify operating requirements and procedures. Management plans and related studies from other wastewater treatment sites and constructed wetlands were reviewed for examples and lessons learned. The *Final Lancaster Water Reclamation Plant 2020 Facilities Plan and Environmental Impact Report* (LACSD, 2004) provided information on the historic, current, and future status of the LWRP water supply to the Piute Ponds, as well as historic maintenance activities. Correctly estimating water quantity and flowrate are necessary, as these factors have a direct effect on the quality of the water and overall ecological health of Piute Ponds.

Surface water quality is the main concern for Piute Ponds. Communications with Edwards AFB personnel indicated that the ponds are naturally lined by thick clay soil, which effectively prevents contaminants from entering the groundwater. Water entering the ponds has no surface outlet beyond Rosamond Dry Lake, the low elevation point of the watershed. Because the ponds have no outlet, the balance between input and evaporation must be maintained to prevent overflows. Overflows into Rosamond Dry Lake are limited by a MOU between Edwards AFB and District 14 LWRP. The lack of overflow will result in less flushing of the ponds. With less flushing, pond salinity levels could increase. This could reduce ecological health of Piute Ponds as salinity and species richness are negatively correlated (Porter et al., 2007).

Detailed water quality data specific to Piute Ponds were available in publications provided by Edwards AFB and District 14. These documents created by the base, LWRP, and Edwards AFB contractors provided data to assess the quality of the water currently entering the wetlands and where efforts to improve water quality should focus. Water entering Piute Ponds is under the purview of LWRP, and improvement of these waters was not addressed in the management plan. The LWRP currently provides secondary treatment water, but has committed to providing tertiary treatment water by the year 2010 (LACSD, 2004). The LWRP is responsible for ensuring that water entering the wetlands meets regulatory requirements, and ensure that the water quality in the wetlands remains constant or improves in order to support current wildlife, recreation, and educational objectives.

Water quality improvements may begin with design and maintenance of the wetlands themselves. Natural and constructed wetlands can remove nutrients, sediment, and other contaminants from water, including wastewater. Such treatments may improve water quality in terms of reduced nitrate and ammonia concentrations, phosphorus concentrations, BOD, total suspended solids and bacterial pollution (Gersberg et al., 1986; Tanner, 1995; Verhoeven and Meuleman, 1999).

Review of reports provided by District 14 and Edwards AFB indicated that organic nitrogen in the form of nitrate is a potential water quality concern (Edwards AFB, N.D.). Both plants and bacteria in wetlands may aid in nitrate removal. Anaerobic wetland bacteria reduce nitrate to nitrogen gas, which is transferred to the atmosphere. This process may be influenced by the amount of water aeration that occurs (Schlesinger, 1997). Plants also assimilate nitrogen into their structures. This conversion may be enhanced by choosing appropriate wetland plants (Zedler and Kercher, 2005). However, this assimilation can result in excessive plant growth that then leads to decaying plant biomass, with a corresponding decrease in dissolved oxygen. With decreased flushing, the situation may be exacerbated and lead to eutrophication.

Water nutrient levels both impact and are impacted by vegetation composition. There is a wealth of information available about how vegetation composition and management techniques may influence the nitrogen removal abilities of the wetland as a whole. For example, studies indicate that the efficiency of ecological wastewater treatment systems high in nitrates could be improved by planting woody species, whereas systems with wastewater high in ammonia could be improved by planting a mix of woody and herbaceous species (Morgan et al., 2008). Herbaceous plant composition also influences nutrient levels; for example, bulrush (*Scirpus*) and reedgrass (*Phragmites australis*) remove more ammonia from wastewater than cattails (Gersberg et al., 1986).

Conversely, vegetation composition may itself be influenced by water nutrient concentrations. Water with very high nutrient loads is assumed to correlate with low plant species richness, but few studies have directly examined this question. Nutrient levels that surpass a certain threshold may substantially favor one plant (often an invasive species) over a diversity of other plants (Zedler and Kercher, 2005). The vegetation at Piute Ponds is dominated by invasive plants, a condition that may be tied to high nutrient loading in the input water. This is one of many ways that water quality influences biological resources at Piute Ponds.

2.1.2 Biological/Ecological Resources

The primary goal of Edwards AFB in the management of Piute Ponds is to improve the ecological health and integrity of the ponds. The first step in this process is to determine what ecological health and integrity really means. Wetland ecological integrity can be defined as "the ability to support and maintain a balanced and integrated adaptive community of organisms having a species composition, diversity and functional organization comparable to that of a natural or not impacted wetland" (Karr and Dudley, 1981). There is a large amount of literature on measuring ecosystem integrity in wetlands (e.g. Bartoldus, 1999; Fennessy et al., 2004; Hatfield, 2004; State of Victoria, 2007; U.S. EPA, 1998), and a number of methods have been developed to quantify this function (U.S. EPA, 2001). Current methodologies include the integrated biological index (IBI) (Karr, 1999; Mack, 2001; Stevenson, 2002), the hydrogeomorphic (HGM) approach (Brinson, 1993; Smith et al., 1995), and rapid assessment methods (Fennessy, 2004; Fennessy, 2007). It is also important to note that Piute Ponds are artificial, and it is inappropriate to directly compare them to natural wetlands.

The U.S. EPA recommends a three-tiered assessment system for wetland monitoring. Tier 1 consists of a landscape-level analysis to inventory and classify wetlands into basic types. Aerial photography, satellite data, or land surveys are most often used. Tier 2 consists of using existing data and/or on-ground rapid assessment to analyze the current state of the system. Quick qualitative field measurements are often employed at this stage. Tier 3 involves a more intense and time-consuming analysis of the wetland. Quantitative data are collected and compared to data from reference sites (U.S. EPA, 2002).

One of the most widely used Tier 3 methods is the IBI, which is based on monitoring a number of metrics for a given community of animals or plants. The community can consist of fish, macroinvertebrates, plants, or birds (although the bird model has been the least developed). Most IBI wetland assessments use plants or macroinvertebrates. A set of similar reference wetlands is selected, representing a gradient of disturbance. A wide variety of metrics are then sampled across the reference wetlands. The metrics are plotted across the disturbance gradient from least to most disturbed and analyzed to determine which best predict disturbance. The best predictors are bundled into an overall biological integrity score for each reference wetland. The wetland of interest can then be measured and compared against the gradient established by the reference wetlands (U.S. EPA, 2002). This methodology is time consuming and data intensive. In addition, it will be nearly impossible to find comparable reference wetlands across a disturbance gradient as the wetland in question (Piute Ponds) is man-made; therefore, by definition, no natural undisturbed reference wetlands exist.

The HGM approach is a Tier 3 functional method to wetland assessment. It aims to estimate the change in function (hydrological, biogeochemical, or physical) that may occur from a change in the wetland. Although HGM uses many of the same metrics as IBI, this method focuses on assessing each wetland function separately instead of combining them into a single index. This method also requires comparing the wetland of interest to a series of reference wetlands across a disturbance gradient. The HGM approach suffers the same limitations as IBI assessments. Edwards AFB does not have the resources to adequately perform this assessment, nor do the necessary reference wetlands exist.

Many Tier 2 methodologies have been developed to provide for rapid assessment of wetland status with minimal inputs of time and money. California has developed the CRAM, which can be performed by two trained observers in less than half a day. This method relies on qualitative judgments of metrics that have been previously divided into categories. The observer categorizes the metric, and the metrics are then combined into an overall score for the wetland (Collins et al., 2007). The CRAM provides the most attainable method for assessment and monitoring of the Piute Ponds wetland. The methodology is well established, scientifically validated, and requires relatively few resources to perform (Surtula et al., 2006). In addition, no reference wetland is required.

One question of special interest is the presence or absence of endangered species at the site. The presence of endangered species would require much more intense planning, monitoring, permitting, and management under the *Endangered Species Act of 1973*. Current reports indicate that no threatened or endangered species are present (LACSD, 2004). More recent survey's support this conclusion (Land Design Consultants, 2008).

One of the primary ecological services provided by Piute Ponds is providing habitat for migratory birds. Bird diversity, population, and health are particularly important because they enhance the pond's primary educational and recreational benefits of bird watching and duck hunting. There have been some attempts to use avian communities for IBI assessments; however, they are not well developed (U.S. EPA, 2002a). Colorado has developed a Tier 2 avian assessment method for some of its wetlands (Adamus and Kentula, 2006). This method might be adapted to Piute Ponds. Failing that, simple bird population metrics should be included in any assessment protocol. Avian monitoring should be part of any assessment and monitoring scheme, as increasing the bird population should be one of the primary goals of improving the ponds.

2.1.3 Environmental Education Opportunities

Just as ecological functions supporting bird species diversity can improve educational opportunities, educational programs can create positive feedback in support of ecological functions. Ehrenfeld (2004) stresses that wetland education provides students with an increased level of awareness and knowledge of ecological functions that support biodiversity, protect water quality, store floodwaters, and maintain stream flow. Piute Ponds also provides natural areas for passive recreation, education, and aesthetic appreciation for the surrounding communities. In order to understand the need for a sound environmental education program, it is necessary to understand the increasing pressure Piute Ponds is facing from expanding residential development and competition for water resources. Zedler and Leach (1998) stress that urban wetlands facing such increasing pressures cannot afford a hands-off management approach from society. Public support for managing ecological functions can be increased by improving public support for education, research, and passive recreation (Zedler and Leach, 1998). Athman and Monroe (2001) believe that education programs should incorporate stakeholder interests and concerns if they are relevant to the goals of enhancing general public support for the wetlands.

The U.S. EPA's website on wetland education outlines several educational activities, curriculum ideas, and educational tools available for developing an effective environmental education program. These education programs would teach students about different wetland types, as well as the importance of wetland habitats and their ecological services (U.S. EPA, 2007). When developing an environmental education program, the North American Association for Environmental Education (NAAEE) stresses the need to incorporate six key characteristics, which include fairness and accuracy, depth, emphasis on skills building, action orientation, instructional soundness, and usability. These guidelines aim to help educational leaders develop a program that recognizes the importance of viewing the environment within the context of human influence, and reinforcing the interdisciplinary functions of wetland ecosystems (NAAEE, 2008). Such a program at Piute Ponds would give opportunity to build relationships with the local community, foster good will, and form partnerships between Edwards AFB and the community. An environmental education program could provide a wide range of students, from elementary to college-level students and researchers, with hands on experience for learning about wetland ecology. Most importantly, it would create appreciation for wetlands as essential ecosystems and build support for conservation and restoration. This type of appreciation may also lead to increased recreational use of the ponds.

2.1.4 Recreational Opportunities

Currently, the primary recreational activities at Piute Ponds include bird watching and duck hunting, both of which are seasonal activities. Zedler and Leach (1998) point out that bird watching, which can be considered a passive form of recreation, is one of the biggest attractions at wetlands. Edwards AFB would like to improve existing activities and expand the options for future recreational use of Piute Ponds. Recreational possibilities include fishing (if water received were to be tertiary treated), themed nature walks, increased bird watching, as well as bike or walking paths for public use (U.S. EPA, 2008). Information on the types of recreational activities available for wetlands was gathered from both natural and constructed wetland websites, such as Bolsa Chica Wetlands in Southern California (Bolsa Chica Wetlands, 2008). Determining what recreational activities were feasible for Piute Ponds was done by examining similar wetland areas and parks (e.g. Lake Cachuma). Additionally, stakeholder websites, such as the Audubon Society and Ducks Unlimited, were referenced to determine what these organizations recommend for wetland recreation (Ducks Unlimited*,* 2008). These websites also revealed ways to improve existing activities such as bird watching (Audubon Society, 2008). Direct feedback was received from stakeholders as to what types of activities they envision for Piute Ponds. In collaboration with this project, Environmental Management of Edwards AFB sent out a poll to their existing stakeholders requesting input regarding desires and expectations for the ponds, including input on recreational activities.

Academic literature for wetland recreational ideas is limited. The scholarly data on wetland recreation activities is restricted to studies on how to evaluate the benefits of activities based on economic factors. An example article suggests that in evaluating which activities to expand, there is a need to look at the local and regional economic conditions to confirm a demand for the proposed activity. Bergstrom et al. (1990) suggests a method to determine the recreational value of wetlands by creating values for so called ‘non-use,’ ‘current-use,’ and ‘future-use’ activities in order to help determine which option would be the most beneficial from an economic standpoint. Unfortunately, such a detailed evaluation of recreational activities from an economic perspective was beyond the scope of this project.

Drivers for deciding which activities to include were based on feedback from Edwards AFB and the base’s identified stakeholders. Upon evaluating the possibilities for recreational activities, Edwards AFB will be able to decide which activities they may want to add, expand, or keep the same for their long-term management plan.

2.1.5 Multiple-Use Constructed Wetlands

Constructed wetlands are artificial marshes designed to duplicate the filtration processes of natural wetlands by utilizing physical features, such as wetland vegetation and soils, and biological and microbial activities to assist in the water quality improvement. Being increasingly recognized as an effective, low-cost wastewater treatment technology, constructed wetlands are created to emulate many of the same processes and characteristics of natural wetlands, but are implemented in a more controlled setting. By controlled setting, this refers to the design, operation, and maintenance of the constructed wetland, which initially involves understanding the type of wastewater being treated, whether it is municipal/agricultural wastewater or stormwater runoff (U.S. EPA, 1993). Design principles are then decided based upon the hydraulic capacity of the wetland, which is simply the ability of the wetland to process a given volume of water in a given period of time. This is especially important for controlling the treatment area and water depth, and can typically be accomplished by using hydraulic structures to ensure that water flows are uniformly distributed. Residence time, water temperature, system area size, and plant species density are also key principles to take into account when considering the use of constructed wetlands for wastewater treatment (Campbell and Ogden, 1999).

While some constructed wetland systems have been designed with the primary function of improving water quality, other systems have been created with multiple-use purposes and benefits in mind. These multiple-use artificial wetlands are still fed using treated wastewater effluent as a primary water source, but in turn are using the new water source as a mechanism for enhancing the environment through the creation and restoration of wetland habitat for migratory birds and wildlife (U.S. EPA, 1993). These multiple-use systems serve to highlight one of the most intriguing aspects of artificial wetlands, the ability to provide a relatively low cost, energy-efficient, natural means of improving water quality while at the same time, offering the potential for multiple benefits and values.

The ecological benefits of constructed wetlands include water quality improvements and the provision of valuable habitat and bird sanctuaries for migratory and resident waterfowl and other wildlife. Constructed wetlands also provide aesthetic benefits by serving as a venue for both public and school involvement in wetland education and research. Other aesthetic benefits include the provision of public park areas and recreation in the form of birding, hiking, and jogging, of which can be better achieved through improving visitor access (Campbell and Ogden, 1999).

Piute Ponds Artificial Wetlands

Piute Ponds are similar in nature to constructed wetlands in a couple of ways; the ponds are not hydraulically connected with the groundwater and receive municipal treated wastewater as its primary source of water. However, there is one key difference that separates Piute Ponds from typical constructed wetlands treatment systems. This distinction is characterized by the fact that wastewater treatment was not the intended purpose of Piute Ponds when they were first created in the early 1960's. In spite of this, Piute Ponds can be characterized as a unique, multiple-use venue that provides both ecologically and socially valuable benefits for wildlife and the local public, of which is largely characteristic of constructed wetlands. For these reasons, it can be expected that any future management options for Piute Ponds be shaped to exemplify those features of classic constructed wetlands treatment systems.

Case studies of successful, multiple-use constructed wetlands exist throughout the United States; these case studies demonstrate that wastewater treatment can be effectively integrated with educational, recreational, and wildlife habitat creation to enhance the ecological and aesthetic value and qualities of constructed wetland systems (U.S. EPA, 1993). Both the Arcata Marsh and Wildlife Sanctuary and the San Jacinto Multipurpose Constructed Wetlands are relevant examples of well-established, multiple-use artificial wetlands in California that can be used as models for Piute Ponds.

Arcata Marsh and Wildlife Sanctuary

Figure 6. Arcata Marsh and Wildlife Sanctuary (Source: Arcata's Wastewater Treatment Plant and Arcata Marsh and Wildlife Sanctuary, 2009a).

The Arcata Marsh and Wildlife Sanctuary were created by the City of Arcata and located in Humboldt County in Northern California (Figure 6). Situated amongst redwood forests, the Humboldt Bay, and the Pacific Ocean, the marsh and wildlife sanctuary is an integral part of the Arcata WWTP. The creation of the Arcata wastewater treatment plant, the marsh, and wildlife sanctuary was by no means an accident, but rather occurred as a result of a decision by the City of Arcata to restore the historic wetlands that once existed in that area. Through a series of oxidation ponds, treatment wetlands, and enhancement marshes, the wastewater is recycled and cleansed to permitted levels before being released to the Humboldt Bay (Arcata's Wastewater Treatment Plant and Arcata Marsh and Wildlife Sanctuary, 2009).

The four stages of treatment include: primary treatment, secondary treatment, tertiary treatment, and disinfection. The main purpose of primary treatment is to remove large suspended solids, which are illustrated in dark blue in Figure 7. Secondary treatment, as illustrated in dark green (Figure 7), involves removal of BOD in the oxidation ponds and further degradation of organic material through four treatment wetlands. Portions of the water from the treatment wetlands also go through chlorination and dechlorination before being sent to the enhancement marshes. The enhancement marshes are the area of the Arcata Marsh and Wildlife Sanctuary that provide both partial tertiary treatment and are open to the public for recreation. Water that leaves the enhancement marshes is sent through additional disinfection, where some of the water is dechlorinated and released to Humboldt Bay and the rest is returned to the enhancement marshes for further treatment (Arcata's Wastewater Treatment Plant and Arcata Marsh and Wildlife Sanctuary, 2009a).

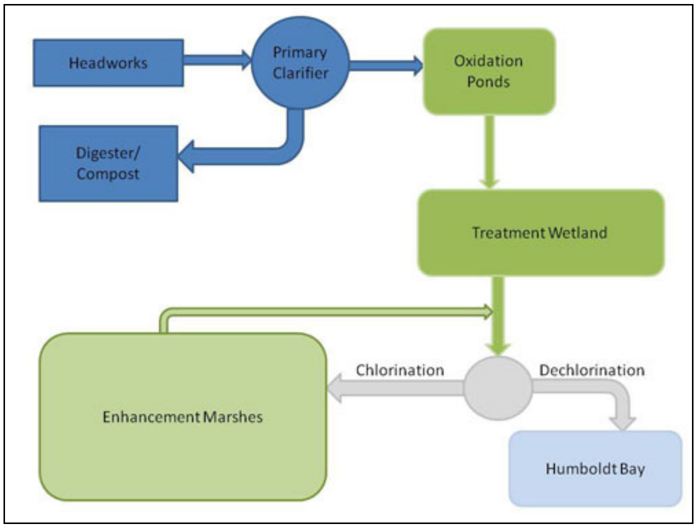


Figure 7. Treatment stages at Arcata Marsh and Wildlife Sanctuary (Source: Arcata's Wastewater Treatment Plant and Arcata Marsh and Wildlife Sanctuary, 2009a)

Arcata Marsh Interpretive Center

In addition to providing wastewater treatment, the Arcata Marsh and Wildlife Sanctuary provide both recreational and educational opportunities. The sanctuary is known for its bird watching activities, as the wetlands provide habitat for migrating birds along the Pacific Flyway. The wetlands also provide a place for recreational use, which includes over 5 miles of trails for activities such as jogging, bicycling, hiking, and leashed dog walking (Figure 8). The public can access these trails from five different parking lots (Arcata's Wastewater Treatment Plant and Arcata Marsh and Wildlife Sanctuary, 2009a).

Figure 8. Walking trails at Arcata Marsh and Wildlife Sanctuary (Source: Arcata's Wastewater Treatment Plant and Arcata Marsh and Wildlife Sanctuary, 2009)

Constructed out of the remains of a historic plywood mill in 1993, the Arcata Marsh Interpretive Center is owned by the City of Arcata and has been staffed with volunteers from a nonprofit organization called Friends of the Arcata Marsh (FOAM) for the last 20 years (Figure 9). Besides providing front desk help at the interpretive center and maintenance around the marshes, FOAM volunteers assist with enhancing visitors' understanding of the benefits the marsh provides to the surrounding community and environment. The interpretive center offers educational materials and tours to raise awareness and give the public a chance to learn about the innovative wetlands treatment, local wildlife, and the migratory birds that visit the sanctuary (Arcata's Wastewater Treatment Plant & Arcata Marsh and Wildlife Sanctuary, 2009b).

The center also provides learning experiences through interactive exhibits and art exhibits for over 15,000 visitors per year. For instance, each month the interpretive center hosts an art exhibit that illustrates the wildlife and unique landscape of the Arcata Marsh and Wildlife Sanctuary. These exhibitions provide an avenue for local artists to express their creativity through photos, drawings, paintings, and other media to portray the diverse plant and wildlife that inhabit the Arcata marshes. Other interactive exhibits provide visitors with hands-on opportunities to learn about topics such as wastewater treatment and the water cycle through visuals with features and knobs that are movable (Appropedia, 2009). Some of the exhibits at the interpretive center include:

a. How Water Becomes Wastewater
b. How Wastewater is Cleaned
c. Wetlands for Wastewater Treatment Enhancement
d. Life in a Treatment Marsh
e. Pacific Flyway
f. Sanctuary Map

The Arcata Marsh Interpretive Center also offers free birding information through pamphlets and brochures, tours, and a posting board called the Arcata Marsh Bird Alert. This posting board provides birders a place to leave notes about the types and locations of birds that have been spotted at the marshes and other bird watching trails in Northern California. Additional information on potential birding 'hot spots' and Bird of the Month are listed on the posting board. The Bird of the Month listing is typically about an important bird species that can be found in the Arcata Marsh (Appropedia, 2009).

Figure 9. Arcata Marsh Interpretive Center (Source: Arcata's Wastewater Treatment Plant and Arcata Marsh and Wildlife Sanctuary, 2009b)

The FOAM provides free, guided tours every Saturday throughout the year, which focus on the history of the marshes, the ecological benefits of the wetlands, and the local plants and wildlife. The Redwood Region Audubon Society also provides birding tours to the public every Saturday. The FOAM also provides educational opportunities to third and fourth grade classes through the Wetlands on Wheels (WOW) program, where students are taught about the Arcata Marsh and Wildlife Sanctuary and its role in treating municipal wastewater through slideshow presentations and work stations (Arcata's Wastewater

Treatment Plant and Arcata Marsh and Wildlife Sanctuary, 2009b). The FOAM also utilizes the unique resources at the Arcata Marsh and Wildlife Sanctuary to provide college research grants to students from Humboldt State University (Appropedia, 2009).

San Jacinto Multipurpose Constructed Wetlands

Another exemplary demonstration of the multiple-use potential of constructed wetlands is the San Jacinto Multipurpose Constructed Wetlands, which are located in Riverside County. The wetlands were constructed in 1991 as a result of a cooperative agreement between the U.S. Bureau of Reclamation and the Eastern Municipal Water District (EMWD) to serve multiple functions. These uses include the provision of the following:

a. Additional treatment of secondary treated wastewater from San Jacinto Water Reclamation Facility

b. Reclaimed water reuse

c. Environmental enhancement

d. Wildlife habitat for migratory and resident waterfowl and local listed species of concern

e. Public education and recreation opportunities.

The site was designed to have five separate wetland treatment areas, dual open water and marsh habitat areas, and a final enhancement wetland. Secondary treated water is first delivered to the five treatment wetlands prior to being recombined in the central, open water and habitat areas. From the open pond system, the water then flows into one final ‘polishing’ wetland (EMWD, 1999).

Located along the Pacific Flyway, the San Jacinto Multipurpose Constructed Wetlands were created with the intention of increasing habitat diversity and providing valuable territory for wintering waterfowl and shorebirds. Over 120 species of birds have been spotted since the wetlands were created, and recent increases in bird-species trends were determined to be a good indicator of the ecological health of the system (EMWD, 1999).

Wetlands Education Facility

The Wetlands Education Facility (WEF) opened in 1999. Originally constructed as the main office for the Eastern Municipal Water District in 1950, the education facility was relocated to the San Jacinto wetlands site in the late 1990’s (Malea Ortloff, personal communication, January 2009). As part of the *Wastewater Treatment for All Curious Beings Education Program,* the WEF staff began hosting tours of the wetlands habitat and the San Jacinto Water Reclamation Facility for the general public, schools, colleges, and universities. At the San Jacinto Regional Water Reclamation Facility, students have the opportunity to see for themselves what happens to water (bath, laundry, and toilet waters) after it goes down the drain. This tour includes viewing the processes used to treat wastewater to near drinking water standards and the multipurpose constructed wetlands area located adjacent to the treatment plant facility. Typically, tours of the treatment plant and wetlands last about 2 hours and take place November through April on Tuesdays, Wednesdays, and Fridays. The WEF also has partnerships with the Audubon Society, who conducts a 2-hour tour once a month focusing on bird species, and with the Boy and Girl Scouts of America who provide tours that assist scouts in obtaining water and soil samples for experiments (Malea Ortloff, personal communication, January 2009).

At the WEF, students learn about the multiple uses of recycled water and the natural habitat created from the wetlands. Students are also taught about how to prevent pollution that otherwise makes its way into the wastewater treatment facility, increasing the costs associated with treatment. At the WEF, students participate in small group activity stations where they experience hands-on science that integrates recycled water information into a wetlands based curriculum. Some of the activity stations include:

a. Viewing an environmental watershed exhibit that illustrates the damaging effects contaminants have on our environment
b. Observing a groundwater flow model that shows how water moves through underground aquifers, the importance of groundwater recharge, and the fate and transport of pollutants
c. Answering tour-related questions to gauge what students learned on the tour
d. Using pH strips at a water testing station to measure the pH of water and other liquids, reinforcing with the students that a neutral pH is optimal for the survival of aquatic life
e. Creating water use efficiency bracelets, which use different colored beads to identify the freshwater process and the importance of water conservation
f. Producing a water conservation pledge button to encourage people to save water
g. Looking at a variety of microorganisms through microscopes
h. Applying scientific methods to identify artifacts collected from the wetlands area
i. Conducting a groundwater/water recharge experiment using a test tube filled with sand, a pipette filled with water, and red dye to imitate pollutants
j. Participate in hands-on educational games such as recycled wastewater Pictionary and wastewater processes puzzles and activities.

The *Wastewater Treatment for All Curious Beings Education Program* not only includes tours and educational activities, but an educational DVD and activity book package as part of EMWD's aim to foster understanding of wastewater issues and to promote water efficiency (Malea Ortloff, personal communication, January 2009).

The WEF not only offers educational benefits for school groups and the public, but also is used as an environmental science laboratory for colleges and universities. University of California at Riverside and Mt. San Jacinto Community College use the site for ecological research and as an outdoor classroom and laboratory. The Eastern Municipal Water District coordinates and supervises research conducted by colleges, but does not financially participate in the research. Community fundraising efforts are also used to provide public amenities such as trail improvements, signage, and benches and tables around the San Jacinto Multipurpose Constructed Wetlands (UC Riverside Cooperative Extension, 2009).

Fulfilling its multi-purpose objective, the San Jacinto Multipurpose Constructed Wetlands have proven to be an integral part of wastewater treatment, environmental enhancement, and the creation of educational and recreational opportunities. The wetlands have gained both national and international recognition, receiving visitors from over 30 countries and 6 Native American tribes who are interested in using the wetlands as a model for their own wastewater treatment issues.

2.1.6 Successful Case Studies for Piute Ponds

With regard to the management of a multiple-use artificial wetland, both the Arcata Marsh and Wildlife Sanctuary and the San Jacinto Multipurpose Constructed Wetlands are ideal case studies, offering both educational and recreational opportunities while providing ecological benefits in the form of wastewater treatment and wildlife habitat. While Piute Ponds does not serve as a wastewater treatment system, it is clear that a significant amount of potential exists with regard to enhancing the educational and recreational opportunities. By using the Arcata Marsh and Wildlife Sanctuary and the San Jacinto Multipurpose Constructed Wetlands as exemplary frameworks, Edwards AFB can effectively implement and manage new educational and recreational activities at Piute Ponds.

3.0 METHODOLOGY

To develop recommendations for a management plan for Piute Ponds, the steps outlined in Lane Council of Governments (1992) were followed. The steps include assessing the current health of the wetland, developing a vision for the plan, using lessons learned from other wetland management areas in plan development, and identifying and working with stakeholders (Lane Council of Governments, 1992). A series of future scenarios were then developed to help with the planning process. These scenarios were then analyzed to determine the best options for management. Specific management recommendations were developed and ranked by cost and feasibility.

3.1 Approach

The project was broken down in to four sections: water quality and quantity, ecology, recreation, and education. For each section, data were gathered on the current status of the ponds. The data were then analyzed and extrapolated to develop our future scenarios.

3.1.1 Ecology

Measuring the ecological health of a wetland is a complex process, and in the past many different methodologies have been used. The CRAM was selected because it is well established, scientifically validated, and requires relatively few resources to perform (Collins et al, 2007). The assessment was performed in October 2008 according to the CRAM handbook (Collins et al, 2007). Data on the resident bird population was also gathered. Data on the number of birds using the ponds, the number of different species, and the number of species that use the ponds for nesting was assessed from existing data and field surveys.

The CRAM was developed to provide a low-cost rapid method of evaluating California's wetlands. The goal of the CRAM survey is to

> *Provide rapid, scientifically defensible, standardized, cost-effective assessments of the status and trends in the condition of wetlands and the performance of related policies, programs and projects throughout California*

None of the existing wetland evaluation methods apply equally well to all kinds of wetlands in California. The HGM and the IBI are the most widely applied approaches; however, they require more time and resources than are usually available, and both have a somewhat limited range of applicability. The CRAM is intended to address these problems (Collins et al, 2007).

The CRAM provides information about the condition of a wetland and the stressors that affect that wetland. The CRAM can be performed on different scales, from small to large, and can be used to measure the reference conditions for a particular wetland type.

It can also be used to create a landscape-level profile of different wetland conditions within a region (Collins et al, 2007).

The CRAM is based on the Pressure Stress Response model. The Pressure Stress Response model states that 'pressures' such as recreation or urbanization can be sources of stress on a wetland, affecting its condition or 'state.' Management 'responds' to these pressures with changes designed to reduce or mitigate these pressures and thus improve the state of the wetland. Indicators of pressure, such as discharges or landfills describe variables that cause wetland degradation. Indicators of state describe the current wetland conditions. Indicators of response describe the management efforts to mitigate the wetland problems. The CRAM focuses on the state of the wetland. A separate stressor checklist is used to evaluate the pressures on the wetland (Collins et al., 2007).

The basic assumption of most rapid assessment methods is that ecological conditions vary predictably along gradients of stress, and that these conditions can be measured based on a limited set of variables. The CRAM metrics were designed according to three common criteria (Collins et al, 2007):

a. **The method should assess existing conditions**. Not past or future planned conditions.
b. **The method should be rapid**. It should require two people no more than one half day of fieldwork and one half a day for analysis.
c. **The method should be a site assessment based on field conditions**. It should not depend on aerial survey data, existing reports, or opinions of site managers.

The CRAM makes six additional assumptions about wetland conditions (Figure 10) (Collins et al., 2007):

a. Wetland condition is greatly determined by the quantities and quality of water and sediment that are either processed or exchanged with the surrounding landscape.
b. Climate, geology, and land use control the supply of water and sediment.
c. Land use accounts for anthropogenic stress. Geology and climate control the natural disturbance regime.
d. Biota (especially vegetation) mediates the effects of climate, geology, and land use on the wetland.
e. Stress most often originates outside the wetland itself.
f. Buffers around the wetland can mediate stress.

Factors controlling wetland conditions:

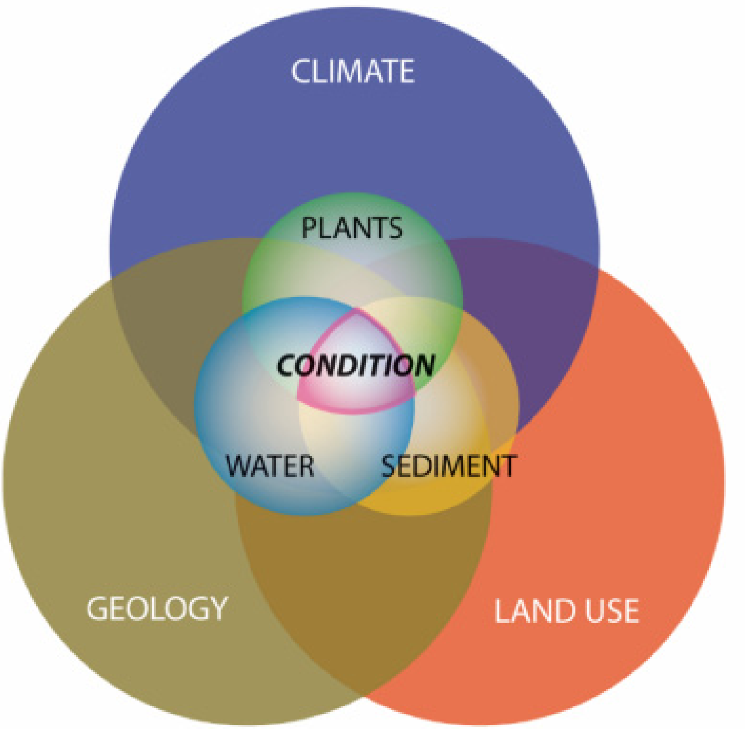


Figure 10. Relationship of Physical and Biotic Factors to Wetland Condition

In addition there are three major assumptions CRAM uses in scoring wetlands (Collins et al, 2007):

a. The societal value of a wetland (i.e., its ecological services) matters more than its intrinsic value.

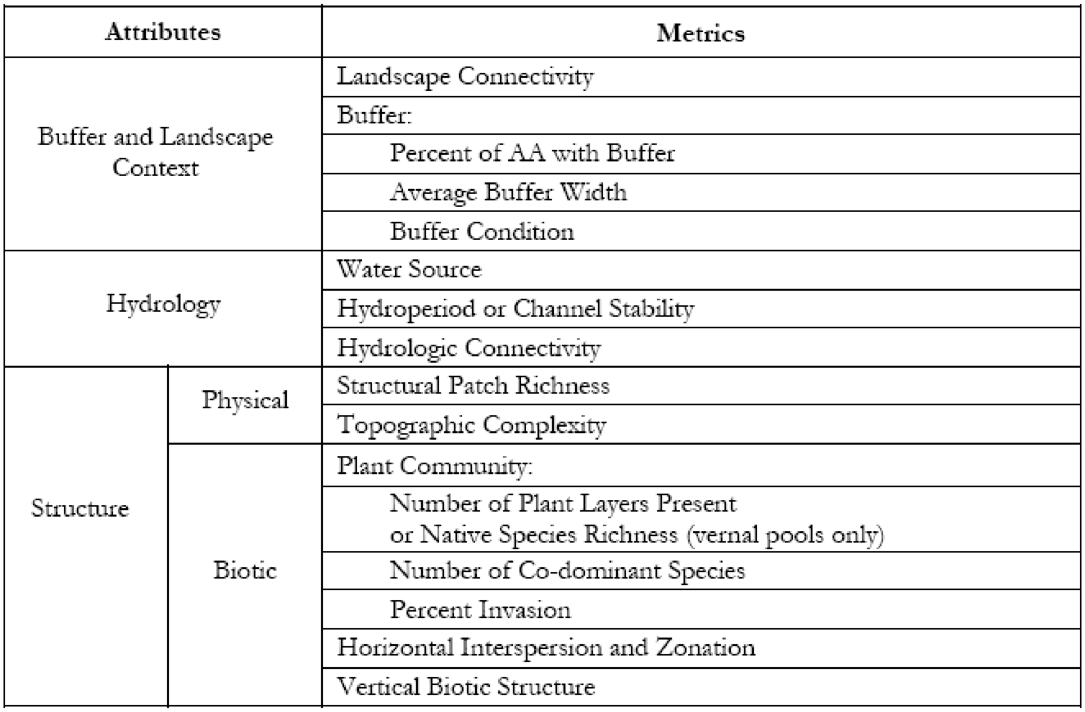
b. The value of the wetland depends on the diversity of services rather than the level of any one service.

c. The diversity of services increases with structural complexity and size of the wetland.

The result of these assumptions is that the CRAM gives higher scores to large, structurally complex wetlands.

The CRAM method uses assessment areas (AAs), which are surveyed for four attributes: Buffer and Landscape Context, Hydrology, Physical Structure, and Biotic Structure. Each attribute has a series of associated metrics. Each metric is a measurable field based ecologically relevant and has a dose/response relationship that can be distinguished from natural variation (Table 1). The metrics are added up and normalized to produce an attribute score that is a percentage of the best possible score. The score for the four attributes are averaged to produce a score for an AA. The scores for multiple AAs are averaged to produce an overall score for the wetland (Collins et al, 2007).

Table 1. The CRAM Attributes and Metrics (Collins et al, 2007)



Attributes		Metrics
Buffer and Landscape Context		Landscape Connectivity
		Buffer:
		Percent of AA with Buffer
		Average Buffer Width
		Buffer Condition
Hydrology		Water Source
		Hydroperiod or Channel Stability
		Hydrologic Connectivity
Structure	Physical	Structural Patch Richness
		Topographic Complexity
	Biotic	Plant Community:
		Number of Plant Layers Present or Native Species Richness (vernal pools only)
		Number of Co-dominant Species
		Percent Invasion
		Horizontal Interspersion and Zonation
		Vertical Biotic Structure

There are eight steps in a CRAM assessment (Collins et al., 2007):

a. Assemble background information about the management of the wetland.

b. Classify the wetland using this manual (see Section 3.2 and Figure 3.2).

c. Verify the appropriate season and other timing aspects of field assessment.

d. Estimate the boundary of the AA (subject to field verification).

e. Conduct the office assessment of stressors and on-site conditions of the AA.

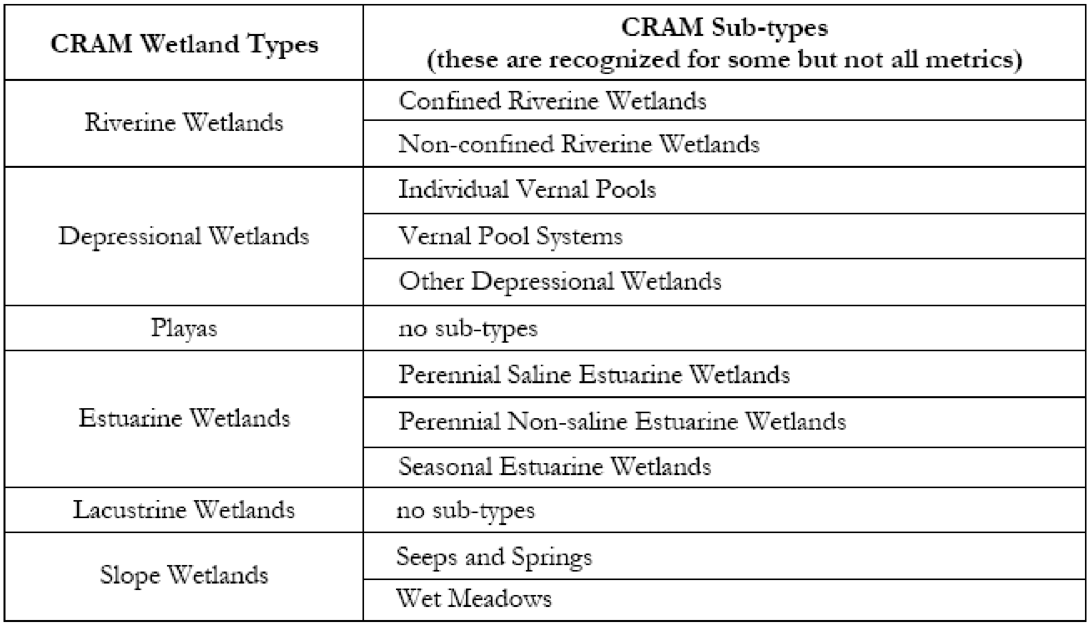
f. Conduct the field assessment of stressors and on-site conditions of the AA.

g. Complete CRAM assessment scores and quality assurance/quality control (QA/QC) procedures.

h. Upload CRAM results into regional and statewide information systems.

The first step is to delineate the wetland and determine the wetland type (Table 2). The field manual provides a flowchart to assist with this process. Next the assessment window must be determined. This is the time of year when the assessment should take place. It usually coincides with the growing season so as to maximize the vegetation at the site. One assessment window should be used for each wetland type surveyed (Collins et al., 2007).

Table 2. Wetland Types (Collins et al., 2007)



CRAM Wetland Types	CRAM Sub-types (these are recognized for some but not all metrics)
Riverine Wetlands	Confined Riverine Wetlands
	Non-confined Riverine Wetlands
Depressional Wetlands	Individual Vernal Pools
	Vernal Pool Systems
	Other Depressional Wetlands
Playas	no sub-types
Estuarine Wetlands	Perennial Saline Estuarine Wetlands
	Perennial Non-saline Estuarine Wetlands
	Seasonal Estuarine Wetlands
Lacustrine Wetlands	no sub-types
Slope Wetlands	Seeps and Springs
	Wet Meadows

The AA is the portion of the wetland that is assessed using CRAM. Each AA should include most, if not all of the natural variability in the form and structure of the wetland. The AA should also include the internal processes of the wetland that account for its resilience and resistance to disturbance. The primary consideration for delineating an AA is its hydrogeomorphic integrity. The AA boundaries should be established based on clear differences in surface hydrology, sediment supply, or geomorphology. The AA should be bounded by obvious physical changes in topography, hydrology, or infrastructure. These features control the sources, quantity and quality of water, and sediment supplied to the AA. The boundaries of an AA should not extend beyond any features that cause a major spatial change in water source or sediment source (Collins et al, 2007).

Larger AAs will tend to yield higher CRAM scores because CRAM is especially sensitive to wetland structural complexity. Larger AAs provide greater opportunity to encounter variability in structure. For this reason, AAs should be the same size for any given wetland type. The preferred size for an AA in a lacustrine wetland such as Piute Ponds is 2.0 hectares (ha), however the shape can vary. The minimum size for this type of wetland is 0.5 ha (Collins et al, 2007).

The number of assessment areas depends on the size of the wetland assessed and the purpose of the assessment. Multiple AAs might be required to assess a large project, while a single AA might suffice for an ambient survey. The AAs should be randomly selected from the set of all possible AAs. Three AAs should be used if the wetland is at least three times as large as the AA. If the score for the third AA differs by more than 15 percent from the average score of the first two AAs, then a fourth AA should be assessed. If the score of the fourth AA is more than 15 percent different from the average of the first three AAs, then a fifth AA should be assessed and so on (Collins et al, 2007).

Each metric is scored with a letter grade (A, B, C, and D). These letter grades are converted into whole integer scores (12, 9, 6, and 3 respectively). For the Hydrology and Physical Structure, the attribute scores are simply calculated as the sum of the metric scores. For the Buffer and Landscape Context, the calculation is slightly more complex (see CRAM Handbook). Raw attribute scores are then converted into a percentage of the maximum possible score to eliminate any weighting of one attribute relative to another. An overall AA score is calculated by averaging the attribute scores. The scores from multiple AAs are averaged to produce an overall wetland score (Collins et al., 2007).

The same CRAM score does not represent the same level of function or the same set of functions for different wetlands. Level 3 assessments are needed to relate CRAM scores to a level of an actual function in a specific wetland. Validation efforts however, indicate that CRAM scores are in general strongly correlated to a variety of wetland functions and services. Similar scores for different wetlands of the same type most likely represent the same overall condition and functional capacity. The CRAM assessment can therefore, be used to measure the progress of restoration or other management efforts (Collins et al., 2007).

The CRAM includes a number of quality assurance/quality control (QA/QC) requirements to insure the validity and quality of the data. Some of these recommendations include (Collins et al., 2007):

a. **AA Map Quality**–hardcopy maps must be clear enough to be readily digitized at a resolution of at least 3m.

b. **Summary Data Sheet**–all fields of information for site name, wetland type, date of assessment, personnel making the assessment, must be complete and legible.

c. **Summary Score Sheet**–every metric and attribute must have a correct score, and that the overall site score must be correctly calculated.

d. **Summary Stressor Sheet**–the stressor checklist must be completed.

The CRAM outlined above provides the best method of rapidly assessing the overall status of Piute Ponds at a minimum cost.

3.2 Developing a Vision for the Plan: Scenario Development Methodology

Recommendations for a management plan for Piute Ponds will be most useful if they are applicable to multiple possible future scenarios. The two primary variables with respect to the future management and sustainability of Piute Ponds are the supply of water (as translated to wetted acres) and the availability of financial and manpower resources. In addition to supplying treated water, District 14 LWRP also performs all routine maintenance, sampling, and regulatory reporting conducted at the ponds. Edwards AFB provides security, conducts limited surveys, studies, and monitoring at Piute Ponds, and provides access to the public for bird watching, educational, and hunting activities.

3.3 Management Scenario Matrices

A total of nine scenarios were possible when current conditions at the ponds were evaluated against both lower and higher water supply levels, and lower and higher levels of management and resources (Table 3).

The nine scenarios were screened to evaluate the likely effects on water quality, ecological health, recreation, and education. The likelihood of unauthorized overflows onto Rosamond Dry Lake was also evaluated. Information on the current water supply and management levels were gathered along with the current ecological health and utilization of the ponds for recreation and education. Scenarios which are not likely to occur, or which have a high risk of violating governing regulations or board orders, were not carried forward for detailed analysis. For example, scenarios that would lead to unauthorized overflows onto Rosamond Dry Lake were not carried forward. Initial hypotheses about the likely effects of each scenario on four criteria, and

Table 3. Available Water and Resource Scenarios

Scenario	Water Supply	Management and Resources
1	*Lower*	*Lower*
2	*Lower*	*Current Status*
3	*Lower*	*Higher*
4	*Current Status*	*Lower*
5 *(Current Status)*	*Current Status*	*Current Status*
6	*Current Status*	*Higher*
7	*Higher*	*Lower*
8	*Higher*	*Current Status*
9	*Higher*	*Higher*

Note: Water supply to maintain 400 wetted acres at current ecological health.

whether these effects are allowable under the Edwards AFB regulations, are summarized in Table 4. The likely effects of scenarios were further evaluated as part of the research.

Data on current management activities and operations and maintenance costs, as well as volunteer work was collected to project anticipated costs for each scenario. Table 5 was established based upon available data. Qualitative estimates (increase, decrease, or no change) were then made for each future scenario based upon information from modeling, projections, and information from stakeholders.

3.3.1 Scenario Limitations and Risks

Scenario limitations and risks are provided as follows:

a. **Access**–currently access is restricted and a permission letter is required for public access. Increased or open public access for recreational and educational purposes could increase security risks for Edwards AFB. Large increases of visitation would need to be evaluated by Edwards AFB for security concerns.

b. **BASH**–Bird/wildlife aircraft strike hazard increases with the number of birds and with bird activity. Although safety concerns with possible increases in the number or types at Piute Ponds have been raised there has been no documented increase in the frequency of bird strikes in the vicinity of Piute Ponds.

c. **Infrastructure**–there are minimal facilities (e.g. restrooms) in existence at the Piute Ponds. The primary limitation is lack of funding to increase facilities.

d. **Resources**–there is presently limited government and contractor staff dedicated to Piute Ponds. Volunteers supplement activities; however, this is on an as-needed basis.

e. **Water Quantity**–flushing flows are required to manage total dissolved solids (TDS) levels in the ponds and maintain the current ecological health status. Modeling studies estimate TDS levels return to acceptable levels under different flow volumes and rates. Large volumes and flows have the risk of wetting Rosamond Dry Lake. Field studies are required to validate flushing flow-modeling runs and access the potential to impact Rosamond Dry Lake.

Table 4. Scenario Hypotheses of Effects on Criteria and Permissibility

Scenario	Water Quality	Ecological Health	Recreation	Education	Flushing Volume of all Three Pond Volumes (million gallons)	Risk of Unauthorized Flows to Lakebed
1	No Change	Decrease	Decrease	Decrease	590	Moderate
2	Increase	Decrease	Decrease	No Change	590	Low
3	Increase	Increase	Increase	Increase	590	Low
4	Decrease	Decrease	Decrease	Decrease	780	High
5	No Change	No Change	No Change	No Change	780	Moderate
6	Increase	Increase	Increase	Increase	780	Low
7	Decrease	Decrease	Decrease	Decrease	980	High
8	Decrease	Decrease	Decrease	No Change	980	High
9	No Change	Increase	Increase	Increase	980	Moderate

Notes:
1. Scenarios 4, 7, and 8 were not evaluated for further analysis due to the high risk of unauthorized overflows to Rosamond Dry Lake.
2. Scenario 7, 8, and 9 would require additional pond construction or Edwards AFB authorizations for increased overflows to the lakebed

Table 5. Criteria Metrics and Sources

Criteria	Metric	Source
Management/resources	Man-hours or funds (normalized)/year	Edwards AFB, District 14
Water supply	Gallons per day /Pond acres	District 14
Water quality	Water quality parameter(s), total dissolved solids, dissolved oxygen, nutrients	District 14
Ecological health	California Rapid Assessment Method (California Rapid Assessment Method) number of species	Edwards AFB, District 14
Recreation	Number of visitors/hunters/year	Edwards AFB
Education	Number of tours/year	Edwards AFB

3.4 Stakeholder Feedback and Input

Gathering input from stakeholders was identified as a critical process in developing management recommendations for Piute Ponds, as the feedback would be instrumental in defining priorities, refining goals and objectives, and identifying potential issues or conflicts. Since very little stakeholder input has been sought on the management of Piute Ponds, our group recommended gathering input from stakeholders using two different approaches. First, we requested our management recommendations proposal be distributed to a wide range of important stakeholders, most of them located in the Antelope Valley. Second, at our recommendation, an informal opinion poll was conducted by Edwards AFB in December 2008 to assess stakeholder preference on the future management of Piute Ponds. Contact with stakeholders was coordinated by Edwards AFB and involved meetings, phone calls, written and email correspondence, and existing outreach forums such as Edwards AFB Environmental Safety and Occupational Health Board, Desert Manager's Group meetings, and the *Report to Stakeholders* Newsletter. Feedback from stakeholders, both from the proposal and the survey, was incorporated into the management plan recommendations for each category; including water resources, ecological health, and educational and recreational opportunities. Updates on project progress were provided to stakeholders as required.

3.4.1 Proposal Comments

A proposal outlining the background information, literature review, and the approach to developing management recommendations was developed at the onset of the project. This proposal was developed as a preliminary blueprint of the project; as such, additional feedback and guidance on the significance, objectives, and direction of the project was requested from pertinent stakeholders. The management recommendations proposal was distributed to over 30 stakeholders. The distribution list is as follows:

a. Antelope Valley Conservancy
b. Antelope Valley Resource Conservation District
c. Apollo Community Regional Park
d. Bureau of Indian Affairs
e. Bureau of Land Management
f. California Department of Fish and Game
g. California State Parks, Inland Empire District
h. California State Parks, Tehachapi District
i. Cal-Trans
j. City of Lancaster
k. City of Palmdale
l. Death Valley National Park
m. Department of Defense
n. Desert Manager’s Group
o. Ducks Unlimited
p. Imperial County Board of Supervisors
q. Joshua Tree National Park
r. Kerncrest Audubon Society
s. Kern County Board of Supervisors
t. Lahontan Regional Water Quality Control Board
u. Lancaster Water Reclamation Plant
v. Los Angeles Audubon Society
w. Mojave Environmental Education Consortium
x. Mojave National Preserve
y. Nevada Fish and Wildlife Office
z. San Bernardino County Board of Supervisors
aa. San Bernardino National Forest
bb. San Fernando Valley Audubon Society
cc. Sanitation Districts of Los Angeles County
dd. United States Fish and Wildlife Service
ee. United States Geological Survey

ff. W.M. Keck Science Center

3.4.2 Edwards Air Force Base Poll

An informal opinion poll was conducted by Edwards AFB in December 2008 to begin the process of gathering stakeholder input and determining preferences for the future of the ponds. The poll presented a list of possible future activities at Piute Ponds, and asked recipients to list their importance on a scale of 1 to 5 (Appendix A). People on the stakeholder mailing list, at the Desert Manager's Group meeting, and a subset of Edwards AFB's distribution list were invited to participate in the poll. Data from the poll was used, along with Edwards AFB's preferences, to rank the scenarios.

3.5 Scenarios Evaluation

Data were gathered to establish the baseline scenario for each criterion as listed in Table 6. Cost data were obtained from Edwards AFB, District 14, or estimated from other sources. The scenarios were evaluated, management options outlined, and recommendations developed. The scenarios were evaluated taking into account both Edwards AFB and stakeholder input.

Table 6. Criteria Metrics

Scenario 5 (Current Status)	Metric
Management/resources required	Man-hours or funds (normalized)/year
Water supply	Gallons per day
Water quality	Water quality parameter(s)
Ecological health	California Rapid Assessment Method (CRAM)
Recreation	Number of visitors/hunters/year
Education	Number of tours/year

4.0 DATA COLLECTION AND LIMITATIONS

4.1 Water Resources (Water Supply and Quality)

Several sources of data were used to evaluate water supply and quality at Piute Ponds. Influent flows to Piute Ponds from the LWRP as well as wastewater monitoring data were found in the LWRP Quarterly and Annual Monitoring Reports. The *Lancaster Water Reclamation Plant Annual Monitoring Report for 2007* (LACSD, 2007) provided influent and effluent flowrates and volumes, plant operations and maintenance information, sampling and analysis, reporting procedures requirements, and historical information on the LWRP and Piute Ponds. Regulatory requirements for LWRP effluent water quality are defined in the WDRs and water reclamation requirements (WRR) issued by the CRWQCB Lahontan (LACSD, 2007). The ponds effluent, evaporation, percolation, and overflow rates and losses, as well as water balance equations and hydrodynamic modeling simulations and results, were found in *Paiute Ponds Modeling Investigations: Hydrodynamic and Water Quality Modeling Studies* (CH2M HILL, 2008a).

Water data limitations include: accuracy of flows and volumes reported, the measurements of surface area and depths of the ponds, and frequency and type of water quality sampling. Water-flow data are limited by the accuracy of measurements of the LWRP effluent, and the lack of accurate flow gauges in the ponds. Pond-volume accuracy is limited by the lack of accurate surveys for pond area and depths with large differences in reported areas and volumes. The estimates of pond area and volume are highly dependent on seasonal fluctuations in effluent flow from LWRP, local streams, and evaporation loss rates, which may account for some of the discrepancies and limited depth data that may be outdated. Water quality sampling and analysis data are sufficient to determine compliance with WDRs; however, there are only three sampling points in the pond areas. Water quality measurements to access nutrient levels and biological health of the ponds are also lacking.

4.2 Biological/Ecological Health

Data on the ecological status of Piute Ponds was collected from a variety of sources. A thorough literature review of available reports was conducted, including the *Lancaster Water Reclamation Plant 2020 Plan* (LACSD, 2004), the *Edwards Air Force Base Integrated Natural Resource Management Plan* (2008b), and various other sources. In addition, Edwards AFB's personnel surveyed Piute Ponds using the CRAM (Edwards AFB, 2008a). To get information on the bird life at the ponds, several years of data from the eBird website (Ebird.org, 2008) were downloaded. The bird data available from online sources covered a 15-mile radius around Lancaster; however it was not categorized by specific location. Attempts to retrieve data from the Audubon Society's Christmas bird count for this area were unsuccessful. Data from the local Audubon chapter on the bird counts at Piute Ponds specifically was requested, but not received.

The primary source of bird data was eBird website (Ebird.org, 2008). EBird is an online database where amateur and professional birders can input their observation. Observations uploaded to eBird go through a screening process to ensure a high quality of data. Submitted reports are processed through a series of automated filters that flag rare birds, birds reported out of season for that location, or high species counts that exceed the norm. A regional team of volunteer scientists and expert birders review any flagged records. If the record cannot be verified using digital photographs, written notes, or other means, then it is kept in the database, but not included in information available to scientists or the public (eBird.org, 2008). For this project, data from 2003 to 2008 was downloaded and then scrubbed to remove birds not associated with wetlands. The purpose was to eliminate the bird sightings associated with the surrounding desert and not Piute Ponds. In addition, data from the Bird Survey conducted in 2000-2003 was reviewed (AMEC Earth and Environmental, 2003). Analysis of the long-term trends of the ponds was hindered by the lack of consistent long-term monitoring data.

To assess the overall health of the ecosystem, a CRAM survey was conducted by Edwards AFB's personnel on 9 October 2008. The survey is a Tier 2 rapid assessment method and does not provide the detailed data that a Tier 3 assessment would. It does however provide a baseline against which to measure future changes.

4.3 Environmental Education

Despite limited information on both current and historical educational activities and programs associated with Piute Ponds, information was gathered to assess the extent to which the ponds are used for educational purposes and to evaluate the future potential of the ponds as an environmental education resource. Correspondence with Edwards AFB's personnel, about past and current educational tours and activities implemented at Piute Ponds, was the principle source of data for assessing the environmental education status. Research was conducted on other environmental education facilities associated with wetland ecosystems in order to establish a reference environmental education program for Edwards AFB to use as a model for Piute Ponds.

4.3.1 Edwards AFB Staff Correspondence

Information relevant to the environmental education efforts at Piute Ponds was gathered through correspondence with Edwards AFB's personnel who coordinate educational tours with local schools. Data was requested on the number and relative frequency of school tours given at Piute Ponds, along with the grade levels for classes that have toured the ponds. Information on the number and types of educational tours given at Piute Ponds for the general public and for communities surrounding Edwards AFB was also collected through correspondence with personnel from Environmental Management at Edwards AFB. Outreach and public awareness efforts with local schools and colleges were also requested from Edwards AFB's personnel to assess the local communities' awareness level of Piute Ponds.

4.3.2 Wetlands Education Research

Research was conducted via Internet and literature on similar wetland habitats that have environmental education programs and facilities in order to gauge the full potential of Piute Ponds as an educational resource for local schools and community. Case studies of artificial wetland ecosystems were examined across all states in order to get a broad sense of possibilities with regard to educational activities, programs, and infrastructure that could be implemented at Piute Ponds. Due to the unique, desert location of Piute Ponds, wetland habitats located in California were studied more extensively with regard to the feasibility and costs of implementing environmental educational programs and infrastructure.

4.3.3 Limitations

Long-term information on the number and types of tours given at Piute Ponds was a significant limitation of the education data. Limited information on specific details of the educational activities occurring or that have occurred at Piute Ponds was another weakness in data collection. Another considerable limitation was on the quality of the educational tours at Piute Ponds, which would have provided insight not only on the usefulness of the area as an educational resource, but also on the general public's level of exposure to Piute Ponds.

4.4 Recreation Use

The current recreational activities that occur at Piute Ponds are duck hunting, bird watching and nature tours. These activities are regulated by Environmental Management at Edwards AFB. The Edwards AFB Natural Resources Manager is in charge of issuing hunting permits as well as issuing access letters to bird watchers and others that would like to visit the ponds. The data collected were records of permits issued in a 1-year-time hunting period as well as all of the access letters that were issued by the Natural Resources Manager within a period of one year. There is no data on the actual number of people that visit the ponds each year.

Research on wetland Internet sites throughout California was conducted to identify possible recreational activities at wetlands, whether they were natural, constructed, or artificial. There are many possibilities available and this information was used to develop recreational recommendations for Edwards AFB.

Data with regard to the quality of the recreational experience by users does not exist. However, the opinion poll issued by Edwards AFB has some written comments that signify the satisfaction of current users. These comments were used to determine what changes, if any, the users would like. The poll is not specific nor was its distribution scientific, and therefore, the results are not exact and may be somewhat biased.

The use and quality data from the poll were used to evaluate whether or not recreational activities should be increased, decreased, or improved at Piute Ponds. An example would be comments from users stating that they would like to see bike paths installed, to have more duck blinds built, or that visitors wish for things to remain the same with no improvements such as a nature center or other viewing structures. Recommendations on whether or not to change the recreational activities were based on comments received from the opinion poll. However, these results are not exact and recommendations can only be estimated based on interpretation.

After collecting and reviewing the data of the ponds for all four areas, baseline conditions of the ponds were established and outlined in the following current status section.

5.0 CURRENT STATUS OF PIUTE PONDS

The current status of Piute Ponds was assessed for the four criteria: water quality and quantity, ecology, recreation and education.

5.1 Effluent Flows and Water Quality

5.1.1 Piute Ponds Water Control Structures and Effluent Flows

Piute Ponds is comprised of five main ponds, numerous channels, and interconnected marsh areas (Figure 11). The largest pond is Big Piute Pond, which was formed in 1961 when a 1.3-mile-long dike was built along Avenue C (the C-Dike) to limit effluent flows to Rosamond Dry Lakebed. Big Piute Pond has a surface area of approximately 167 acres and an approximate capacity of 109 mg. Directly north and adjacent to Big Piute Pond is the North Buffer Pond, which has a surface area of 56 acres and volume of 36 mg. South of Big Piute Pond are two impoundments referred to as the North and South Duck Impoundment Ponds. These ponds are generally filled in September of each year and remain full until April. The North Duck Impoundment Pond has a surface area of approximately 56 acres and a volume of 36 mg, while the South Duck Impoundment Pond has a variable surface area covering approximately 15 acres and a volume of 10 mg. The fifth pond, referred to as Little Piute Pond or Shuttle Road Impoundment, has a surface area of approximately 11 acres and a volume of 7 mg. A bathymetric survey, performed in May 2003 at Piute Ponds, measured depths ranging from 0.5 to 6.5 feet in the ponds at Piute (CH2M HILL, 2008a). The average depth of Piute Ponds is approximately 2 feet.

The LWRP currently has a maximum design capacity of 16 mgd and treats an average of 15 mgd of domestic and industrial wastewater. The plant discharges secondarily treated effluent to storage ponds adjacent to the LWRP, Piute Ponds, Nebeker Ranch (irrigation of alfalfa crops), and Apollo Lakes in Apollo County Park (tertiary treated landscape and recreation irrigation). The discharge flows to Piute Ponds receive treatment in oxidation ponds and chlorination/dechlorination.

Effluent that flows to Piute Ponds is seasonal with the highest flows occurring in the winter months when diversions to Nebeker Ranch and Apollo Lakes decrease. In 2007, Piute Ponds received an average of 7 mgd with a maximum of 14 mgd in February, and a minimum of 2 mgd in April. Piute Ponds received a total of 2,458 mg of secondary effluent flows in 2007.

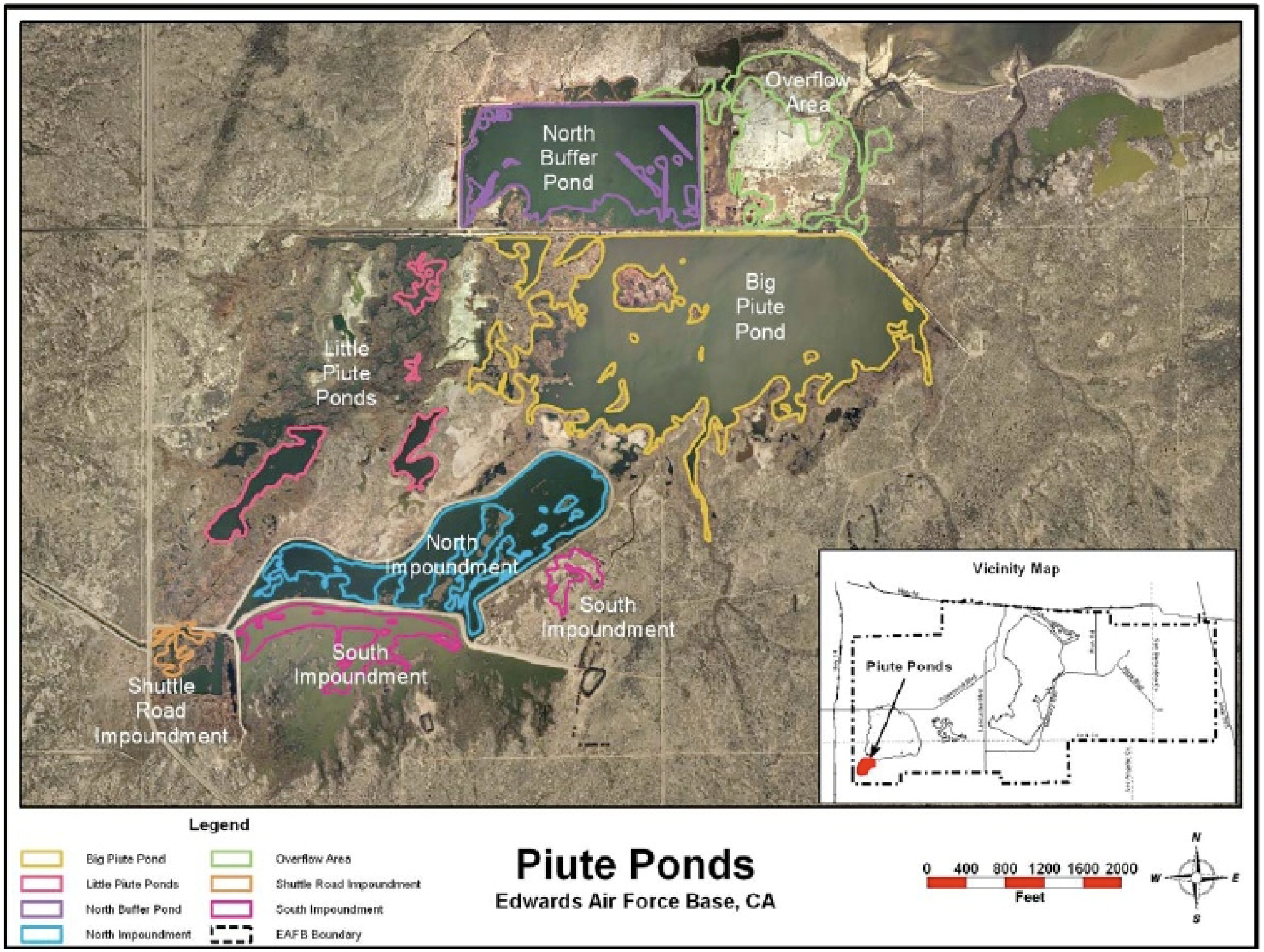


Figure 11. Piute Ponds Layout

Flow from the LWRP to Piute Ponds is carried via a surface effluent ditch and first enters the Shuttle Road Impoundment (Figure 12). Water flows from the Shuttle Road Impoundment, over a concrete spillway (Figure 12), and enters a heavily vegetated marsh system. Three main channels lead through the marsh to Big Piute Pond, while two culverts connect the Shuttle Road Impoundment to the Duck ponds. Flow to Big Piute is uncontrolled while the flow to the Duck ponds is controlled by stop logs. Big Piute Pond and the Buffer Pond are connected via an underground pipe with a submerged valve. When the ponds reach their storage capacity, water overflows the C-dike spillway on Big Piute Pond and flows to Rosamond Dry Lake. Maximum storage capacity in Piute Ponds (excluding the duck ponds) is estimated at approximately 156 mg at spillway crest water elevation (CH2M HILL, 2008a). Storage capacity is usually reached in November of each year with overflows continuing until April (Table 7.)

In 2007, Piute Ponds overflowed to Rosamond Dry Lake from 1 January through 2 April and 28 November through 3 December 2007 (LACSD, 2007). The overflows from Piute Ponds to Rosamond Dry Lake provide a flushing effect, which decreases TDS levels and improves the overall water quality and esthetics of the ponds.

Figure 12. Views of Piute Ponds

Table 7. Summary of 2003 Period Averaged Water Balance Flows, CH2M HILL 2008

Period	Start Date (Day)	End Date (Day)	Inflow (mgd)	Percolation and Seepage (mgd)	Evaporation (mgd)	Overflow (mgd)
1	1/1/03(1)	3/2/03 (60)	14.3	1.33	0.5	12.4
2	3/2/03 (60)	3/22/03 (80)	12.9	1.33	0.8	10.7
3	3/22/03 (80)	5/2/03 (121)	1.1	1.33	1.3	0.0
4	5/2/03 (121)	6/2/03 (152)	3.9	1.33	2.4	0.0
5	6/2/03 (152)	9/2/03 (244)	4.1	1.33	2.8	0.0

6	9/2/03 (244)	10/2/03 (274)	3.9	1.33	1.9	0.0
7	10/2/03 (274)	11/2/03 (305)	3.1	1.33	1.4	0.0
8	11/2/03 (305)	11/17/03 (320)	12.1	1.33	0.4	7.1
9	11/17/03 (320)	1/2/04 (365)	12.7	1.33	0.5	10.7

Flows within Piute Ponds are primarily gravitational as there is currently no mechanical pumping. Flows and circulation patterns within open-water areas of Big Piute and the Buffer Pond are affected by the consistent westerly winds across the ponds, however the wind does not significantly alter the hydrodynamics in the marsh portions of the system. A field tracer dye study performed at Piute Ponds in November 2003 provides information on the hydraulics of the marsh system connecting the Shuttle Road Impoundment with Big Piute. This data was used to calibrate hydrodynamic models of Piute Ponds developed by CH2M HILL. With an effluent flow of approximately 12.5 mgd, dye released at the Shuttle Road Impoundment spillway first reached the outlet of the marsh system in approximately 15 hours and peak concentrations were reached in approximately 36 hours. Wetlands are acknowledged as systems that can help improve water quality (Carleton and Montal, 2007), and the Piute Pond marsh and pond system may provide some limited water quality improvement when water is flowing. Water movement through the wetlands resembles open channel flow in the ponds and channels, and porous medium flow in dense marsh areas. Tortuosity occurs where flow paths are obstructed by stems and litter and biofilm adherence may be responsible for removal of some solutes (Carleton and Montal, 2007). Biological activity and physical processes (evaporation and percolation) in the system also affect the water quality in the ponds. Flows within the Ponds are dependent on moderate to high levels of LWRP effluent or stream flow. The LWRP is currently expanding its capacity to 26 mgd and will stop unauthorized overflows to Rosamond Dry Lake by 2010. Although the LWRP expansion will result in higher quality tertiary treated effluent to Piute Ponds, eliminating all effluent-induced overflows to Piute Ponds will degrade the water quality in the ponds due to the lack of flushing overflows that reduce TDS levels.

5.1.2 LWRP and Piute Ponds Effluent Water Quality

The water quality in Piute Ponds is directly related to the LWRP effluent quality, volume, and timing of flows. The LWRP is subject to multiple WDRs and WRRs issued by the CRWQCB Lahontan, which establishes beneficial uses of the ponds and sets receiving water quality thresholds. The beneficial uses for minor surface waters of the Lancaster Hydrologic Area defined in the Lahontan Region Basin Plan, Antelope Hydrologic Unit are (CRWQCB, 2002):

a. Municipal and Domestic Supply

b. Agricultural Supply

c. Groundwater Recharge

d. Water Contact Recreation

e. Non-contact Water Recreation
f. Warm Freshwater Habitat
g. Wildlife Habitat

The receiving water limits for Piute Ponds are specified in Board Order Numbers R6V-2002-053 and R6V-2002-053A1. To meet these requirements, District 14 conducts effluent and surface water monitoring at Piute Ponds to ensure thresholds are met. Current and future water quality data along with future WDR requirements are presented in Table 8. The predicted data reflects the upgrades to the plant and a transition to 100 percent tertiary treated effluent scheduled for 2010.

Total Kjeldahl nitrogen (TKN) is a measurement of the total organic and ammonia nitrogen content: TKN = Organic N + NH_3 + NH_4^+, while total nitrogen (TN) is a measurement of all forms of nitrogen including nitrite and nitrate: TN = Organic N + NH_3 + NH_4^+ + NO_2^- + NO_3^- (Metcalf and Eddy, 2003). Natural levels of TKN in aquatic environments are typically reported at levels less than 2.0 mg/L, and concentrations above 3.0 mg/L may be considered excessive in natural waters (Galbrand, Lemieux, Ghaly, Cote, and Verma, 2008). Typical values of total nitrogen for natural wetlands range from .4 mg/L to 6.8 mg/L (Kadlec and Knight, 1996). Much higher levels of TKN and total nitrogen occurred in Piute Ponds from 2002 to 2007 with values of TKN reaching 55.4 mg/L and total nitrogen reaching 81.8 mg/L (Figures 13 and 14). Levels of both TKN and total nitrogen are lower at RS4 than RS2, indicating some biological and chemical conversion and losses of nitrogen in the Piute Ponds marsh areas located between RS2 and RS4. High levels of TKN and total nitrogen can lead to algal blooms, which result in lower DO levels. Natural levels of nitrate are typically lower than 1 mg/L, however direct toxic effects are usually not observed at levels less than 1000 mg/L (Galbrand et al., 2008). High levels of nitrate in the presence of sufficient levels of phosphorus can increase the severity of eutrophication, which has adverse effects on aquatic life. Nitrite is very unstable in aquatic environments and is quickly oxidized to nitrate by Nitrobacter bacteria. It is toxic to fish at low concentrations and reduces dissolved oxygen in the water column due to the oxidation to nitrate. Annual maximum, minimum, and average values in Piute Ponds are 1.6, .01, and 0.24 mg-N/L for nitrate, and 1.0, 0.01, and 0.09 for nitrite.

Table 8. Current LWRP Effluent Levels and Discharge Limits

Constituent	Existing Data[1]	Current Discharge Limits[2]	Predicted Data[3]	Future Discharge Limtis[4]
Nitrogen (TKN)	30.8 mg-N/L (20.8–40.9 mg-N/L)		2 mg-N/L	None
Total Nitrogen	32.5 mg-N/L (20.9–49.0 mg-N/L)		10 mg-N/L	Max annual avg. 10 mg-N/L
Ammonia	12.5 mg-N/L (3.4–30.2 mg-N/L)	5 to 18 mg-N/L (pH range 8.1-8.8)	1 mg-N/L	5 to 18 mg-N/L (pH range 8.1-8.8)
Dissolved Oxygen	7.7 mg/L (3.3–11.2 mg/L)	> 1mg/L >5.5 mg/L (30 day mean)		> 1mg/L > 5.5 mg/L
Soluble BOD	19 mg/L (9 – 38 mg/L)	40 mg/L	<5mg/L	30-day avg. = 40 mg/L
Soluble Carbonaceous BOD	12-14 mg/L < 6–38 mg/L)	40 mg/L	<5 mg/L	30-day avg. = 40 mg/L
Total Suspended Solids	134 mg/L (30–195 mg/L)		5 mg/L	Shall not cause nuisance
Coliform	<15 MPN/100ml	<20 MPN/100ml	<2.2 MPN/100ml	2.2 MPN/100mll

[1] Data from 2007 Lancaster Water Reclamation Plant Annual Monitoring Report, March 2008

[2] Data from California Regional Water Quality Control, Lahontan Region, Board Orders No. R6V-2002-053 A2, and R6V-2002-053A1.

[3] Data from Addendum No. 3 to Report of Waste Discharge for Lancaster Water Reclamation Plant Stage V Plant Expansion, Aug 2006

[4] Data from California Regional Water Quality Control, Lahontan Region, Board Orders No. R6V-2002-053 A2, and R6V-2002-053A1.

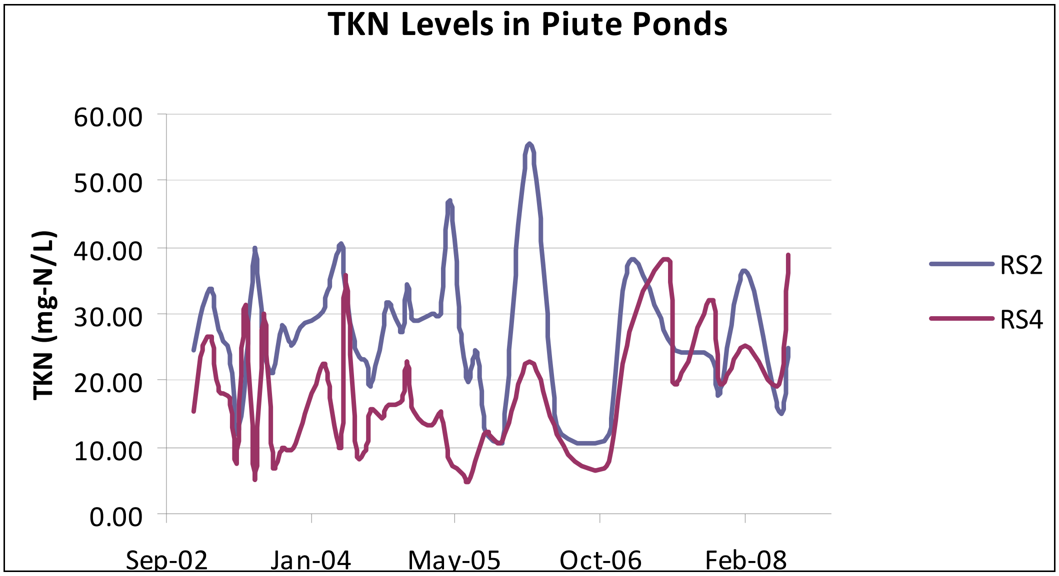


Figure 13. Total Kjeldahl Nitrogen Values for 2001 through 2008.

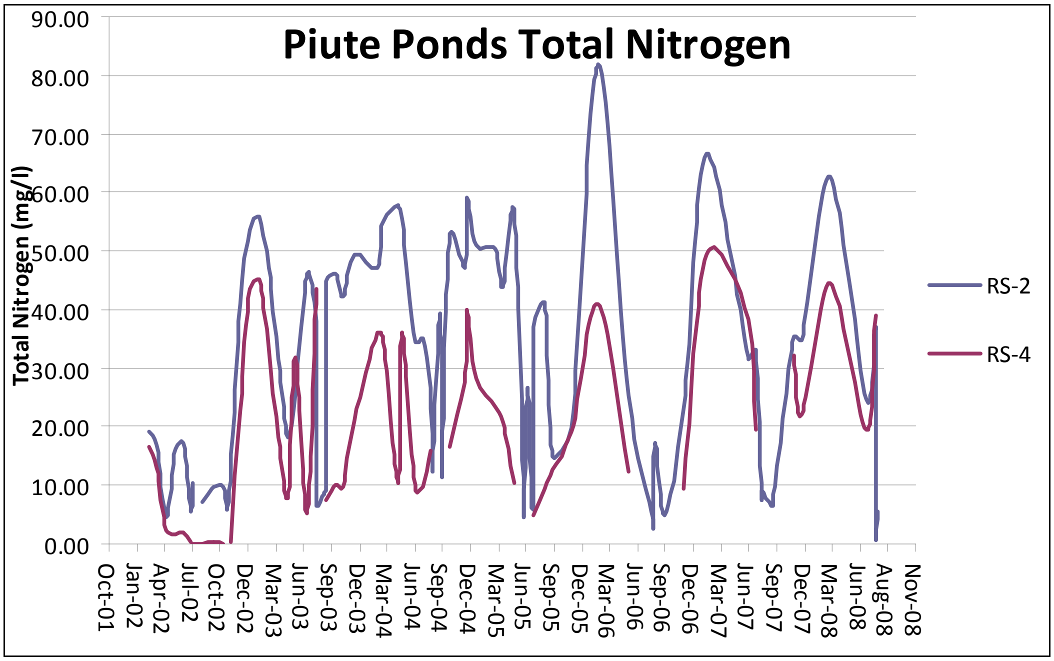


Figure 14. Total Nitrogen Values for 2001 through 2008

Ammonia levels are highly dependent on the pH and temperature of the ponds. The pH levels in the ponds range from 6.9 to 9.9 with average pH values ranging from 8.1 at RS2 to 8.8 at RS4. Average ammonium levels at Piute Ponds range from 9.9 mg-N/L at RS2 to 4.8 mg-N/L at RS-4, which is significantly higher than the average ammonium value for treatment wetlands in North America, which is 2.4 mg-N/L (Kadlec and Knight, 1996). Ammonium (NH_4^+) and ammonia (NH_3) shift in equilibrium according to pH with ammonia being the more dominant form at a pH of 8.5 or above, and higher water temperatures (Galbrand et al., 2008). Ammonia is a byproduct of the nitrogen cycle and is harmful to aquatic organisms at high concentrations. Ammonia concentrations ranging from 0.53 to 22.8 mg/L are considered toxic to fresh water organisms. Plants generally are more tolerant of ammonia than animals, and invertebrates are more tolerant than fish. High ammonia levels can kill aquatic plants, which are essential for wetland ecological health (Kadlec and Knight, 1996). The WDR ammonia limit for Piute Ponds is dependent on pH and ranges from approximately 5 mg-N/L to 18 mg-N/L. Average ammonium levels at Piute Ponds are within these limits; however, maximum ammonium levels have historically exceeded this limit in the ponds, which is harmful to the ecosystem (Figure 15). The expected LWRP effluent maximum ammonium level after conversion to 100 percent tertiary effluent is 1 mg-N/L, which should be well below the 2.4 mg-N/L value for ammonium in treatment wetlands.

Dissolved oxygen is one of the most important parameters in water quality as it is essential to the metabolism of all aerobic aquatic organisms (Galbrand et al., 2008). The WDRs for Piute Ponds specify wastewater discharged from the LWRP must have a DO concentration of no less than 1.0 mg/L and the DO concentrations within the ponds shall not be less than a 30-day mean concentration of 5.5 mg/L. Dissolved oxygen is often used as an indicator of the health of an aquatic ecosystem. Natural water systems require DO concentrations in the 5 to 6 mg/L range to support diverse populations (Cleveland, 1998). The water quality criteria specified in the Lahontan Basin Plan for warm, fresh-water habitat is a 30-day mean of 5.5 mg/L, a 7-day minimum of 4 mg/L, and a 1-day limit of 3.0 mg/L. The monthly average for DO from 2002 to 2008 ranged from 3.6 mg/L (August) to 12.5 mg/L (March) at RS4 (Figure 16).

Total dissolved solids are a measurement of the dissolved constituents (excluding gases) in the ponds and can affect both the survival and reproductive capabilities of aquatic organisms (Bodkin et al., 2007). Total dissolved solids can impact benthic organisms due to acute toxicity, and the additional energy

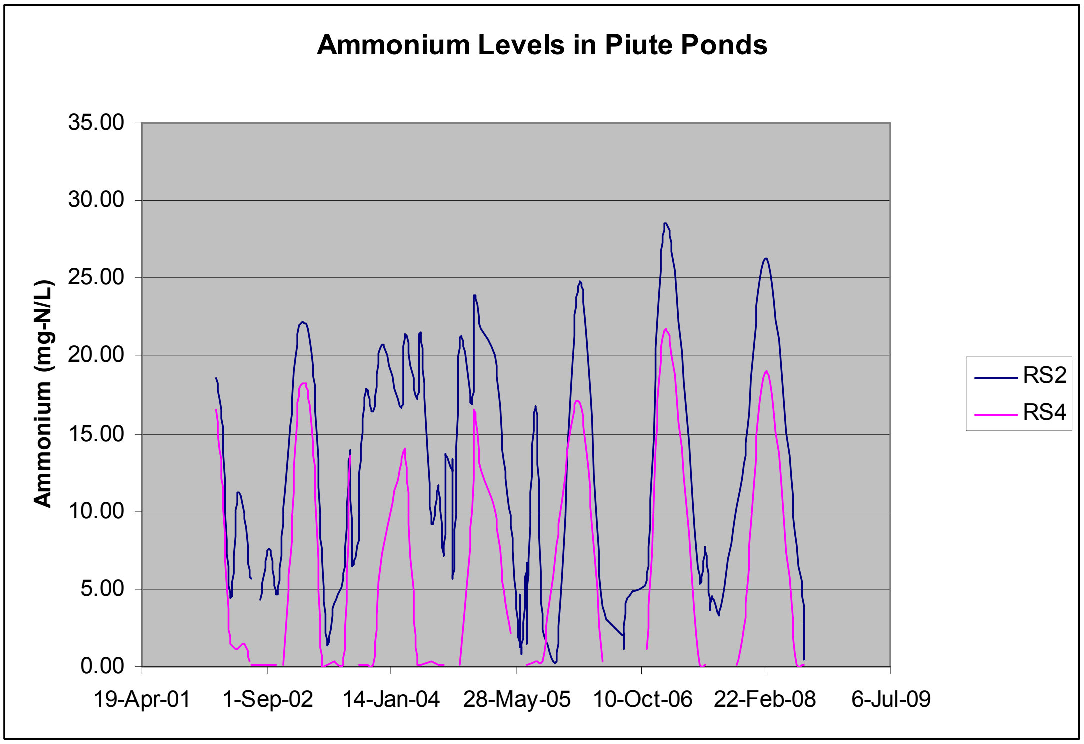


Figure 15. Ammonium Levels for 2001-2008

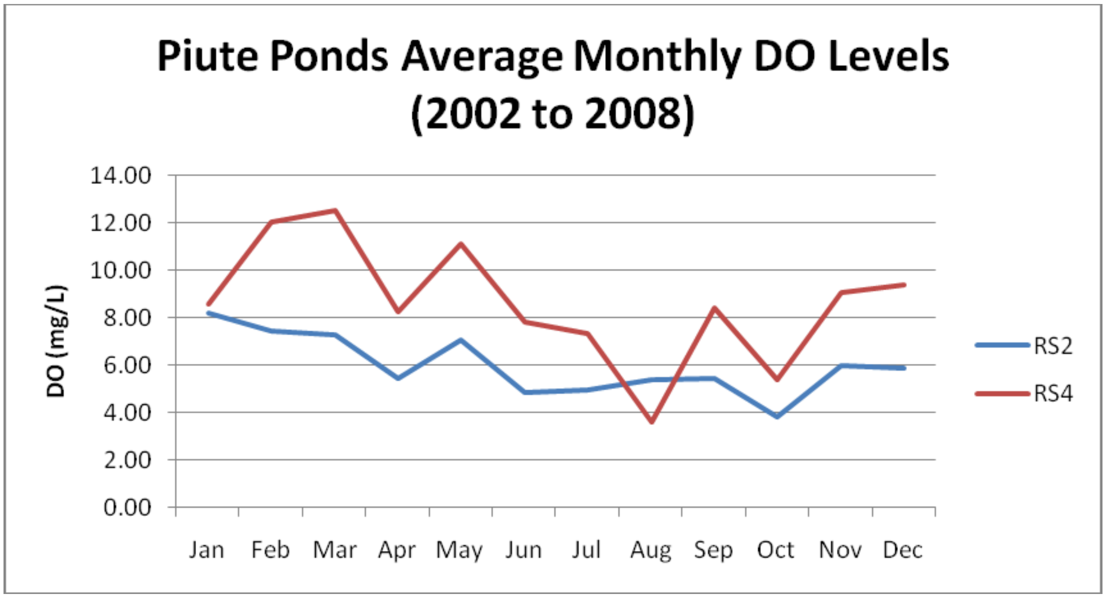


Figure 16. Dissolved Oxygen Levels from 2002-2008 (Average)

required for water and ion regulation can cause chronic stress. High concentrations of TDS can reduce water clarity, hinder photosynthesis, and increase water temperatures (Galbrand et al., 2008). Average monthly TDS levels during 1998 to 2008 ranged from 550 to 1314 mg/L with an average monthly TDS level of 904 (Figure 17). Levels are highest in the summer when evaporation is highest and flows into the ponds are low. The water quality objective (WQO) for TDS for Lake Palmdale, located 30 miles south of Piute Ponds, is set at an annual average of 585 mg/L, which is less than the 976mg/L average at Piute (1998 through 2008).

A comparison of TDS and DO levels in Piute Ponds reveals a strong inverse relationship. The TDS levels in the ponds are a direct function of the TDS effluent concentration, flow from the LWRP and evaporation rates. The DO level in the ponds is dependent on the effluent DO levels, water mixing and aeration, and biological activity in the ponds. The DO levels are lowest in the summer, as opposed to TDS levels, which are highest in the summer. Figure 17 displays monthly TDS and DO levels with the DO vertical scale reversed. The R-squared values of the displayed regression curves are approximately 0.96 for TDS and 0.65 for DO and, therefore, limiting the TDS levels in the ponds through periodic flushing may also control DO levels (Figure 18).

A TDS excel spreadsheet model was developed by CH2M HILL which predicts TDS concentration in Piute Ponds for different operational scenarios. The model uses monthly average hydrologic data including inflows, net evaporation, percolation and seepage losses, and overflows to Rosamond Dry Lakebed as inputs and calculates daily water surface elevations and TDS concentrations (CH2M HILL, 2008a). The model predicts that annual TDS concentrations can be maintained below 1000 mg/L with constant year-round flushing flows of .5 mgd or greater, which is close to the historic annual average of 976 mg/L. Peak annual TDS concentrations can be maintained below 1,000 mg/L with constant flows of 2 mgd. Model simulations also show periodic flushing are less likely to control TDS concentrations unless they occur for extended periods. Annual TDS concentrations can be maintained below 1,000 mg/L by discharging one pond volume (5.9 mgd) over evaporation and percolation loses for a 30-day period in August. Flushing three pond volumes for 90 days will reduce the average TDS to 872 mg/L (CH2M HILL, 2008a).

During the summer months, temperature levels and hardness (as $CaCO_3$) reach their highest levels while dissolved oxygen reaches its minimum values (Table 9). In 2007, the LWRP effluent to Piute Ponds exceeded upper limits for coliform on three occasions, pH on one occasion, and was below the lower limits for 1 day DO concentration (3 mg/L) on three occasions. The low DO levels were attributed to anaerobic conditions induced by biological activity (LACSD, 2008). Concentrations Effluent monitoring shows TDS concentrations are relatively consistent at sampling station RS2 located near where LWRP effluent first enters the ponds (Table 10).

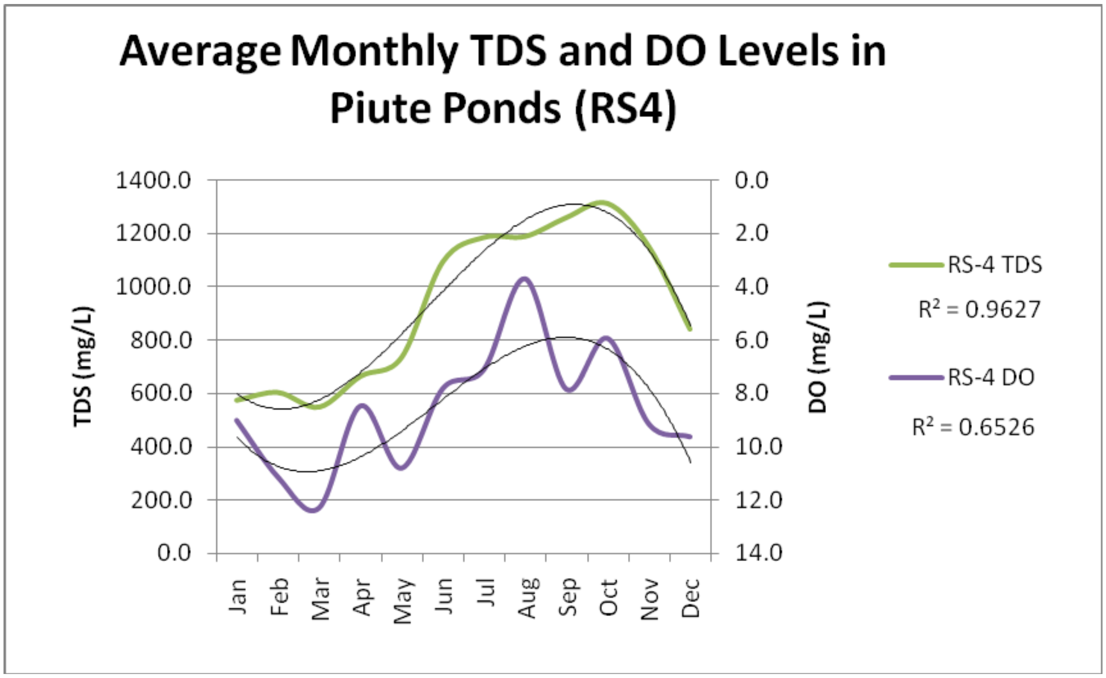


Figure 17. TDS and DO level from 1998-2008 (Average)

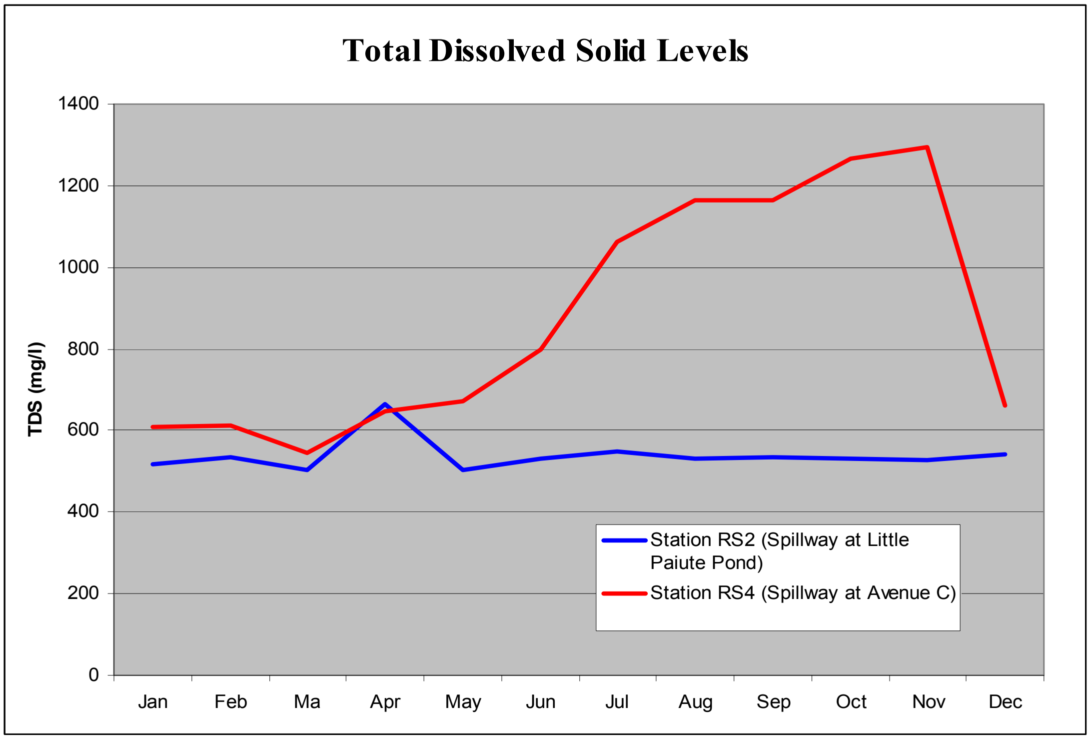


Figure 18. TDS Levels at Piute Ponds (2007)

Table 9. LWRP Effluent (Data 2007)

	pH 0-14	Temp ° C	DO mg/L	TDS mg/L	Hardness ($CaCO_3$) mg/L	
Jan-07	7.3	4.4	11.3	594.0	142.0	
Jun-07	7.4	29.9	1.4	787.0	194.5	
Oct-07	7.3	15.1	3.3	653.0	160.0	
Nov-07	7.4	14.3	5.6	584.0	134.0	
Mean	7.4	15.9	5.4	654.5	157.6	
Max	7.4	29.9	11.3	787.0	194.5	
Min	7.3	4.4	1.4	584.0	134.0	
Limit	6 to 9		>1 mg/L			

	Ammonia mg-N/L	Kjeldahl Nitrogen mg-N/L	Nitrate mg-N/L	Nitrite mg-N/L	Chloride mg/L	Chlorine Residual mg-Cl/L
Jan-07	28.6	37.9	0.1	0.0	131.0	0.1
Jun-09	6.7	30.4	0.0	0.4	210.0	0.1
Oct-07	10.3	23.5	0.5	1.1	187.0	
Nov-07	13.0	18.0	3.6	0.1	160.0	0.1
Mean	14.6	27.4	1.1	0.4	172.0	0.1
Max	28.6	37.9	3.6	1.1	210.0	0.1
Min	6.7	18.0	0.0	0.0	131.0	0.1

The maximum, minimum, and average TDS levels at RS2 are 718 mg/L, 513 mg/L, and 591 mg/L respectively. From January through May, TDS levels are slightly higher at sampling station RS4 where Piute spills to Rosamond Dry Lake when effluent discharge from the LWRP and seasonal precipitation and stream flow cause overflows. The TDS levels at RS4 steadily increase when overflows stop in April and reach their highest levels during the late summer and fall when flows into Piute Ponds are low (4 mgd) and evaporation rates are high (2 to 3 mgd). The maximum, minimum, and average TDS levels at RS4 are 1314 mg/L, 550 mg/L, and 904 mg/L respectively.

Other requirements specified in the WDRs for receiving waters at Piute include biostimulatory substances, color, sediment, floating materials, taste and odor, and turbidity (no nuisance or adverse affect to beneficial uses of receiving waters). The WDR requires pesticides and herbicides shall not exceed lowest detectable limits available or bioaccumulate in aquatic life, and the waters shall be maintained free of toxic substances as a result of discharge.

Table 10. Average monthly TDS levels at sampling stations RS2 and RS4 (1998 to 2008)

TDS (mg/L)	Jan	Feb	Ma	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Station RS2 (Spillway at Little Piute Pond)	520	535	530	644	616	718	637	598	669	629	551	513
Station RS4 (Spillway at Avenue C)	576	605	550	666	736	1095	1187	1191	1261	1314	1153	843

Metals concentrations in Piute Ponds have remained relatively constant since 1998 (Figures 19 and 20). Average concentration levels meet EPA recommended acute water quality criteria for fresh water with the exception of copper and silver. Maximum levels exceed the acute water quality criteria for cadmium, copper and silver (Table 11). A study conducted by the USGS at Piute Ponds evaluated contaminant effects on aquatic birds at Piute and concluded that contaminant concentrations in frogs and avian eggs were not found to occur at concentrations likely to adversely affect avian reproduction (USGS, 2002).

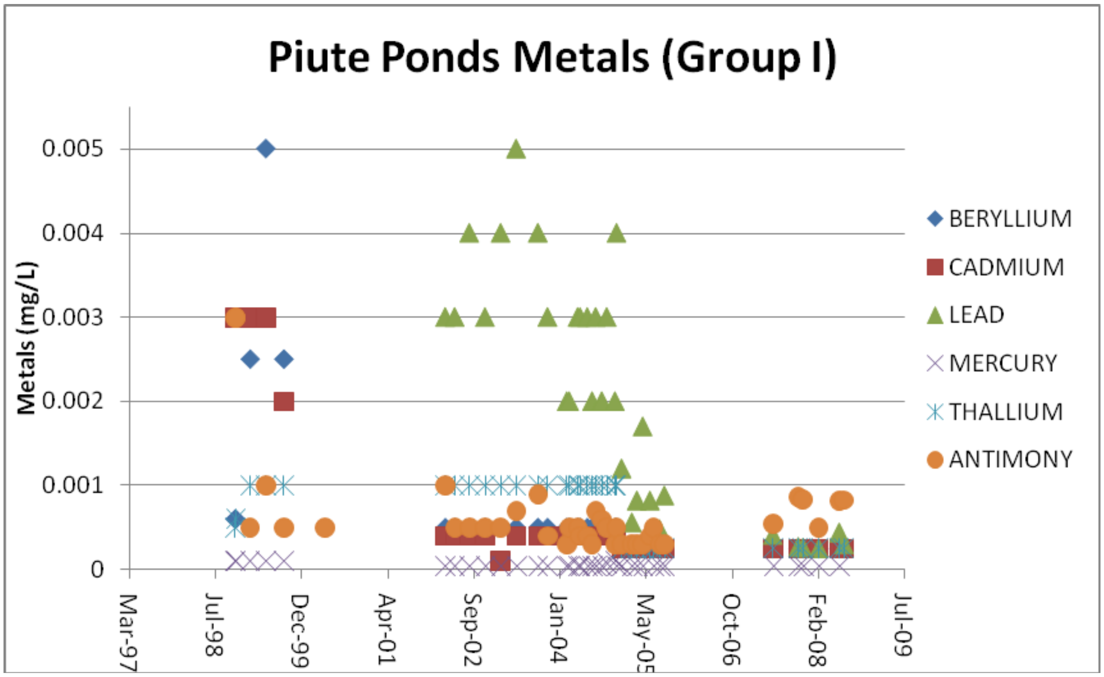


Figure 19. Piute Ponds Metals I

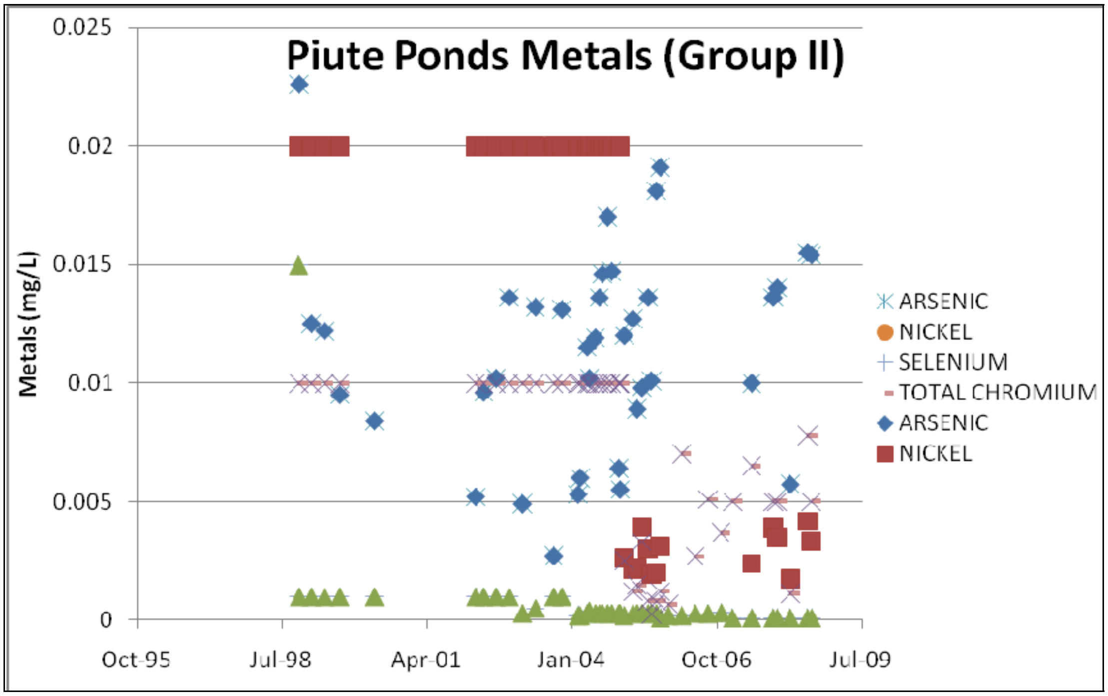


Figure 20. Piute Ponds Metals II

Table 11. EPA Water Quality Criteria

EPA Recommend Water Quality Criteria for Protection of Aquatic Life (ug/L)							
	Piute Ponds			Freshwater		Saltwater	
Description	Max	Min	Ave	Acute	Chronic	Acute	Chronic
Beryllium	5.0	0.1	0.626				
Cadmium	3.0	0.1	0.653	2.0	0.3		
Lead	20.0	0.3	4.391	65.0	2.5		
Mercury	0.1	0	0.051				
Thallium	1.0	0.3	0.700				
Antimony	3.0	0.3	0.657				
Arsenic	22.6	2.7	11.610	340.0	150.0	69.0	36.0
Nickel	20.0	1.7	13.680	470.0	52.0	74.0	8.2
Selenium	15.0	0.1	0.758		5.0	290.0	71.0
Total chromium	10.0	0.3	6.959	16.0	11.0	1,100	50.0
Copper	5,900.0	1.6	369.300	13.0	9.0	4.8	3.1
Silver	360.0	0.3	79.030	3.2		1.9	
Zinc	76.8	0	28.660	120.0	120.0	90.0	90.0

The water quality at Piute Ponds is an extremely important factor in determining the ecological health of the area. The current water quality is a direct function of the LWRP effluent and the amount of flushing flows which occur at the ponds. The current water quality at Piute Ponds meets the current WDRs and EPA recommended Water Quality Criteria for Protection of Aquatic Life except for high periodic ammonia levels and occasional exceedances (TDS, metals, coliform, low D.O.). The ammonia levels are expected to drop significantly when the LWRP converts to 100 percent effluent in 2010. The TDS levels are higher than other water bodies in the area and the *2020 Environmental Impact Report* for the LWRP requires sufficient flushing flows to maintain the current ecological health of the ponds. Although the overall water quality of the effluent will improve when the LWRP converts to 100 percent tertiary effluent flushing flows are required to keep TDS concentrations at historic levels to maintain current ecological status. Periodic flushing can maintain maximum average TDS levels below 1,000 mg/L, which is near historical levels and below most state regulatory standards for TDS (Bodkin et al., 2007).

5.2 Ecology

5.2.1 Vegetation

There are four main plant communities present at Piute Ponds, as defined by Holland's preliminary descriptions of the terrestrial natural communities of California (1986), and Keeler-Wolf (Sawyer, Keeler-Wolf, 1995). The communities are transmontane freshwater marsh, transmontane alkali marsh, alkali meadow and shadescale scrub at edges of ponds (Land Design Consultants, 2008). The boundaries between the vegetation communities are often indistinct with the different habitats blending into one another. There are also many sandbars and unvegetated shorelines that provide habitat for shorebirds.

Transmontane Freshwater Marsh

This community occurs in slow moving or still permanent freshwater. It is dominated by tule (*Shoenoplectus acutu*s var. *occidentalis*) and narrow leaf cattail (*Typha latifolia*) forming a closed overstory (Land Design Consultants, 2008). Bulrushes (*scripus* spp.) and sedges (*Carex* spp.) form an understory. This habitat occurs at edges of the permanent and some ephemeral ponds. On the upper banks of the levees small numbers of Fremont's cottonwood (*Populus fremontii* ssp. *fremontii*), narrow-leaved willows (*Salix exigua*), and black willow (*Salix gooddingii*) are found (Land Design Consultants, 2008). Nonnative salt cedar (*Tamarisk* spp.) is found in substantial clumps at the tops of the levees. Understory plants include arrow weed (*Pluchea sericia*), smartweed (*Polygonum* sp.), curly dock (*Rumex crispus*), pond weed (*Potamogeton pectinatus*), stinging nettle (*Urtica holosericea*), and spikeweed (*Hemizonia mohavensis*) (Land Design Consultants, 2008).

Transmotane Alkali Marsh

Transmotane Alkali Marsh is similar to the freshwater marsh above, but with more salt tolerant vegetation. It is usually located adjacent to perennial ponds, where ephemeral ponding occurs. Plant life includes tule, cattail, sedges saltgrass (Distichilis spicata) and borax weed (Nitrophila occidentalis) (Land Design Consultants, 2008).

Alkali Meadow

This community is dominated by perennial grasses and sedges. It is located in areas of seepage at the edges of the ponds particularly north of C-Dike. Plants include saltgrass, *Carex* spp., *Juncus* spp., and alkali cord grass (*Spartina gracilis*). Salt cedar occurs along the peripheries of this community (Land Design Consultants, 2008).

Shadescale Scrub

Named after its dominant shrub, shadescale (*Atriplex confertifolia*), is the major plant community surrounding Piute Ponds (Land Design Consultants, 2008). Shadescale Scrub grows on very heavy alkaline or saline soils underlain by an impermeable layer (Holland 1986). Other species present include: spiny hopsage (*Grayia spinosa*), winter fat (*Kraschenennikovia lanata*), spiny sagebrush (*Artemisia spinescens*), matchweeds (*Gutierrezia* spp.), cheeseweed (*Hymenoclea salsola*), blackbrush (*Coleogyne ramosissima*), spiny desert olive (*Menodora spinescens*), and various species of Mormon tea (*Ephedra* spp.) (Land Design Consultants, 2008).

5.3 Invasive Plant Species

There are relatively few invasive species at the site. Tamarisk trees have established themselves in patches on the levees and various weeds grow on the disturbed sides of the levees themselves. In the CRAM assessment, only one substantial invasive species was found, Russian Knapweed (*Acroptilon repens)*. The wide undisturbed desert surrounding the ponds is not ideal habitat for invasive species.

5.4 Wildlife

5.4.1 Macro Invertebrates

Macroinvertebrates are important as they provide a food source for fish, amphibians, and birds. The water based invertebrate community in Piute Ponds is relatively simple consisting mainly of common, widely distributed organisms. The Piute Ponds are extremely productive, supporting a diverse terrestrial invertebrate community with densities up to 100,000 organisms per square meter (Pratt, 1998). The majority of the macroinvertebrate taxa in Piute Ponds are: the chironomids or true flies, leeches, amphipods, and oligochaete worms. The invertebrates are mostly nocturnal and either reside in the muck at the bottom of the ponds or cling to the rocks and algae. The high invertebrate densities may be due to the fact that the ponds have never been dredged. The oligochaetes, with more than 50 percent of the organisms sampled, are by far the most abundant (Miller and Payne, 2000). Terrestrial insects dependant on the wetlands include four major groups: Diptera, Trichoptera, Odonata, and Ephemeroptera, all of which have immature aquatic stages and adult terrestrial stages. There are only a few species of snails and no freshwater mussels present. No endangered or threatened macroinvertebrates have been found at the ponds (Miller and Payne, 2000).

5.4.2 Fish

It is unclear whether there are any fish currently living in Piute Ponds. The ponds were stocked with mosquito fish last year (Hagan, 2008); however, it is the professional opinion of Edwards AFB that no mosquito fish survived. It is thought that the large numbers of African Clawed Frogs eat any fish that are stocked in the ponds. There is reference in a Lahontan Water Board document to three species of fish occurring in Piute Ponds; none of them native (CRWQCB, 2007). The species are brown bullhead (*Ameiurus nebulosus*); carp (*Cyprinidae*), and mosquito fish, (*Gambusia affinis*) (CRWQCB, 2007). Unfortunately the 2007 Lahontan Water Board document does not provide a source for the information on fish stocking and the information could not be independently verified. Fishermen have also reported some bass in the ponds (Fishingworks.com); however, their presence is not confirmed. The opinion of the Edwards AFB staff is that there are no fish currently living in the ponds although they have been stocked at various times in the past (Hagan, 2008). The high ammonia levels, often exceeding 20mg-N/L, and low DO levels in the summer make fish survival unlikely.

5.4.3 Amphibians

Four species of amphibians inhabit Piute Ponds: California toad (*Bufo boreas halophilus*), Pacific tree frog (*Pseudacris regilla*), bullfrog (*Rana catesbeiana*), and the African clawed frog (*Xenopus laevis*) (Land Design Consultants, 2008). The adult stage of the Pacific tree frog and California toad spend most of their time in terrestrial habitat. The African clawed frog and the Bullfrog are mostly aquatic. The nonnative African clawed frog is the most prevalent, with a population of at least 100,000 to 150,000 individuals (Land Design Consultants, 2008).

5.4.4 Reptiles

Reptiles include desert spiny lizard (*Sceloporus magister*), common side-blotched lizard (*Uta stansburiana*), Great Basin whiptail (*Aspidoscelis tigris tigris*), California king snake (*Lampropeltis getula californiae*), red coachwhip (*Masticophis flagellum piceus*), Great Basin gopher snake (*Pituophis catenifer deserticola*), two-striped garter snake (*Thamnophis hammondii*), and northern Mojave rattlesnake (*Crotalus scutulatus scutulatus*) (Land Design Consultants, 2008). With the exception of the two-striped garter snake, these species would usually be found in the shadescale scrub community.

5.4.5 Mammals

Common mammals that have been seen or can be expected due to the availability of suitable habitat include: desert cottontail (*Sylvilagus audubonii*), black tailed jackrabbit (*Lepus californicus*), white-tailed antelope ground squirrel (*Ammospermophilus leucurus*), Merriam's kangaroo rat (*Dipodomys merriami*), deer mouse (*Peromyscus maniculatus*), desert woodrat (*Neotoma lepida*), and coyote (*Canis latrans*) (Land Design Consultants, 2008). Most of the mammals prefer the shadescale scrub community although at times they might venture down to the edges of the ponds to drink. Bats may overfly the ponds searching for insects, but there are no structures to provide roosting habitat (Land Design Consultants, 2008).

5.4.6 Birds

Piute Ponds is the largest freshwater wetland in Los Angeles County. The large quantities of macroinvertebrates present in the ponds provide an excellent food source for migrating birds. The African clawed frogs that infest the ponds are also utilized as a food source, particularly by Black Crowned Night Herons (Charlton, 2005; LACSD, 2004). More than 200 avian species have been sighted at the ponds with especially large numbers present during the spring and fall migrations (County Sanitation Districts of Los Angeles County, 2004; Land Design Consultants, 2008). Piute Ponds is an important stopover point on the Pacific Flyway and has been designated and important bird area by the Audubon Society (Audubon Society, 2008). Gadwall, mallard, redhead, and ruddy ducks are known to nest onsite (LACSD, 2004) (Charlton, 2005). The ponds are also a post breeding congregation area for pelicans, black terns, herons and egrets (Land Design Consultants, 2008).

Other birds that breed at the ponds include the tricolored blackbird, white-faced ibis, northern Harrier, western snowy plover, Clark's grebe, and black crowned night Heron, of which more than 400 breeding pairs have been observed (LACSD, 2004; Charlton, 2005; Land Design Consultants, 2008). The bird data collected from the eBird website (National Audubon Society and Cornell Laboratory of Ornithology, 2008) and from the Christmas bird counts was not sufficient to analyze for long-term trends. The Ebird data were gathered at different times of the year, with different amounts of efforts, and could not easily be compared year to year. The Christmas bird counts are conducted by the Audubon Society at a wide variety of locations around the United States every December. They have been conducted for decades at most locations and are an excellent source for long-term trends in bird populations. Unfortunately, the counts cover a 15-mile radius, a much wider area than Piute Ponds. The data was not available for just the pond location. In addition, it should be noted that year-to-year comparisons of these metrics are difficult, as they may not reflect the health of the wetlands. Bird populations, particularly migratory ones, are affected by many factors beyond the ecological health of these particular ponds.

A comprehensive bird-monitoring program during all four seasons would provide a better measure of long-term trends in bird populations and usage of the ponds. Other methods such as plant and macroinvertebrate surveys would do a better job of directly reflecting the status of the ecosystem. When monitoring birds, the population rather than the number of species utilizing the ponds is probably a better measure of pond status. It appears that all or almost all of the avian species that are likely to use the ponds already do so. It is unlikely that any improvements made to the ponds would significantly attract more species (e.g., flamingos and trumpeter swans are not going to use the ponds). Although the number and variety of avian species should be monitored for changes, the population using the ponds and the population numbers breeding at the ponds will probably be more greatly affected by management decisions. Management could also focus on specific species considered at greater risk, such as the tricolored blackbird.

5.5 Threatened, Endangered and Sensitive Species

There are a total of 38 sensitive species in the region around Piute Ponds, 12 plants, 24 birds and 2 mammals (LACSD, 2004; Charlton, 2005). Piute Ponds and the surrounding area are poor habitat for the Mohave ground squirrel and desert tortoise; these animals have not been documented in the region (LACSD, 2004; Land Design Consultants, 2008). Sensitive plants include the Alkali Mariposa Lily (*Calochortus striatus*), listed by the California native plant society as '1B' and by the state of California as a state species of concern (LACSD, 2004; Charlton, 2005). The lily has been documented in the area; however, the ponds and their immediate surroundings are not included in the proposed alkali lily conservation area under the *West Mojave Plan* (Land Design Consultants, 2008).

The other plants likely to be found in the immediate vicinity of the ponds are the yellow spiny cape and Mojave spineflower, neither of which is federally or state listed (Charlton, 2005). Of the 24 sensitive bird species that have been observed at the ponds, the white-faced ibis is the only one that regularly nests there (Charlton, 2005; Land Design Consultants, 2008). The others use the ponds only transiently or nest occasionally (LACSD, 2004; Land Design Consultants, 2008). Western snowy plovers have been observed nesting at the site; however, they are thought to be from the unprotected interior population not the federally listed coastal population (Charlton, 2005; Land Design Consultants, 2008).

5.6 Habitat Complexity-Ecological Health–CRAM Report

At our recommendation, Edwards AFB performed a CRAM assessment in October of 2008 (Appendix G). The wetland was identified as a depressional lacustrine wetland and three plots were selected for analysis following the standard CRAM methodology (Figure 21). The CRAM report integrates attribute scores for four wetland characteristics: buffer and landscape context, hydrology, physical structure, and biotic structure. Average final attribute scores for the three plots were 50.76, 54.00, and 49.40 out of 100 respectively (Edwards AFB, 2008a). The average score for the wetland was 51.39 (Edwards AFB, 2008a) (Figure 22). These scores cannot be easily compared to other wetlands of different types; however, as a reference, Goleta Slough, an estuarine saline wetland located near the University of California Santa Barbara, has an overall CRAM score of 69 (Figure 23).

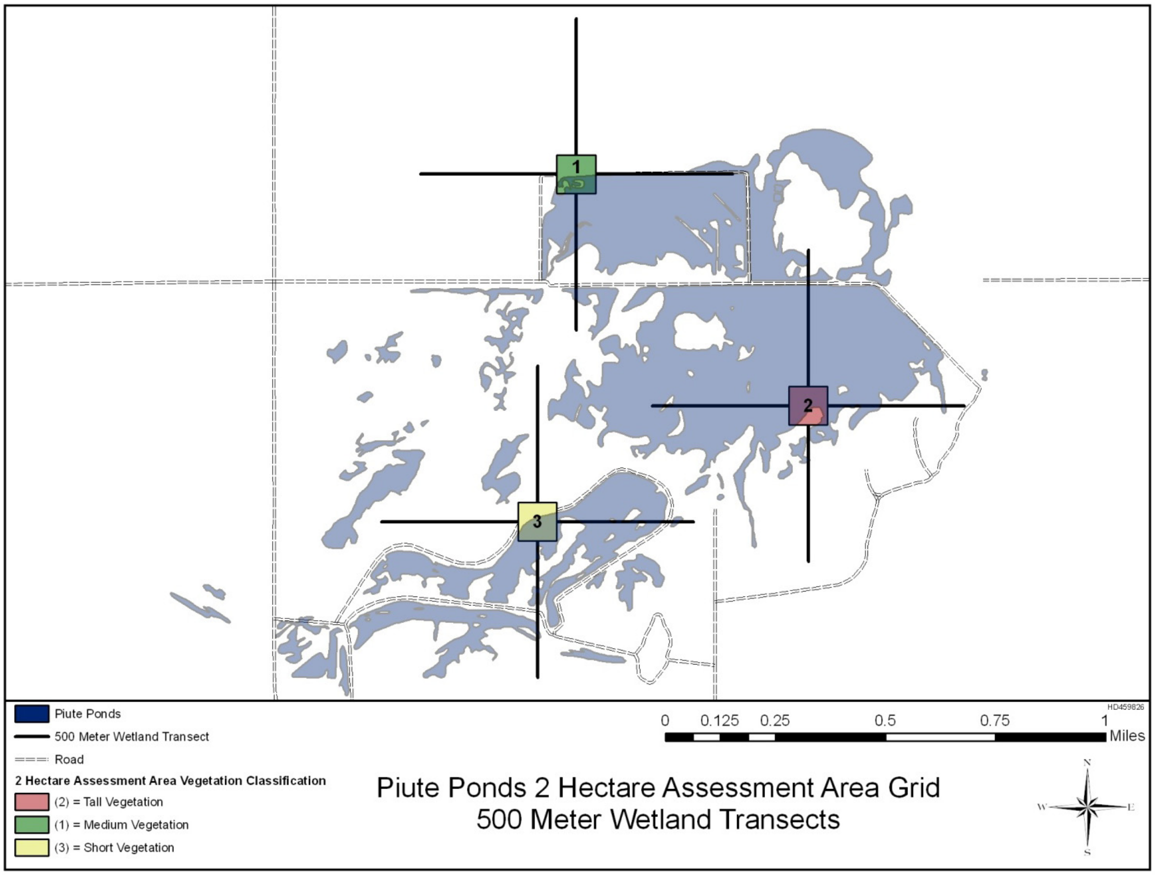


Figure 21. California Rapid Assessment Method Assessment Plots

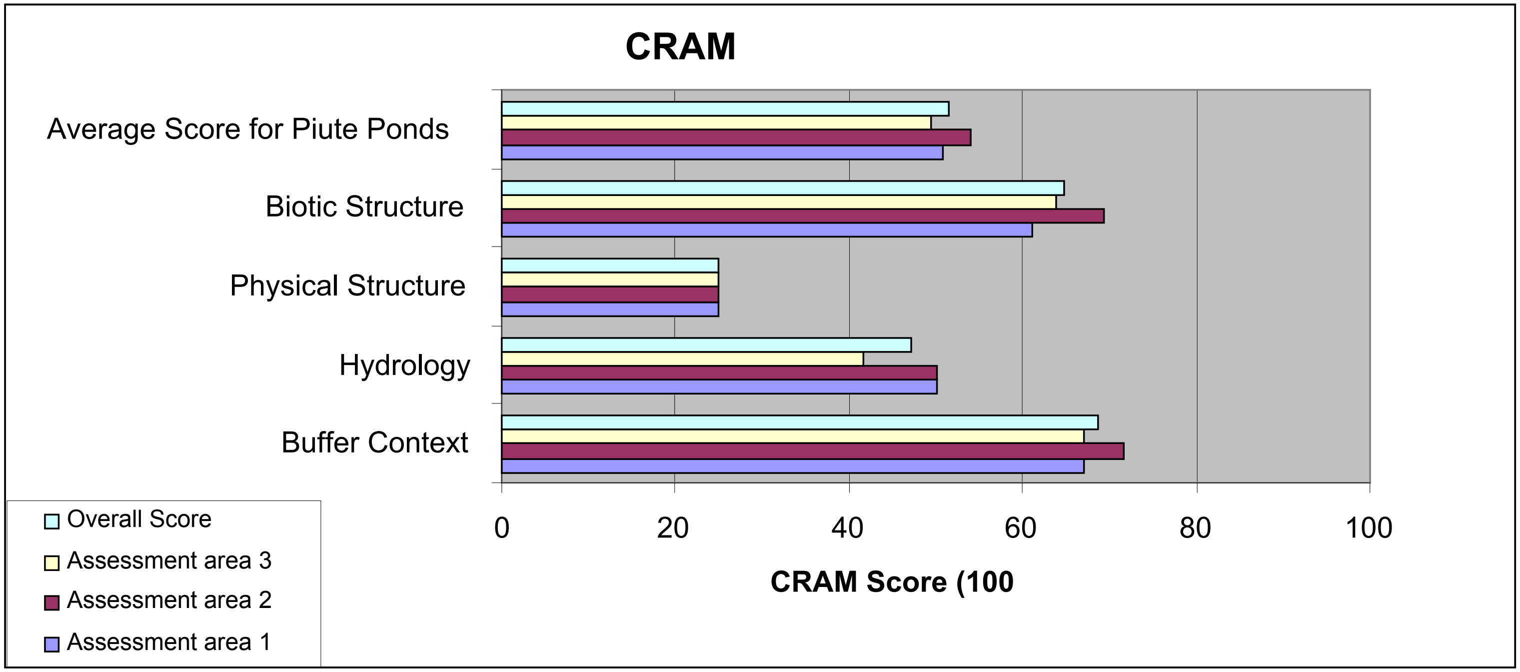


Figure 22. California Rapid Assessment Method Assessment Results (2008)

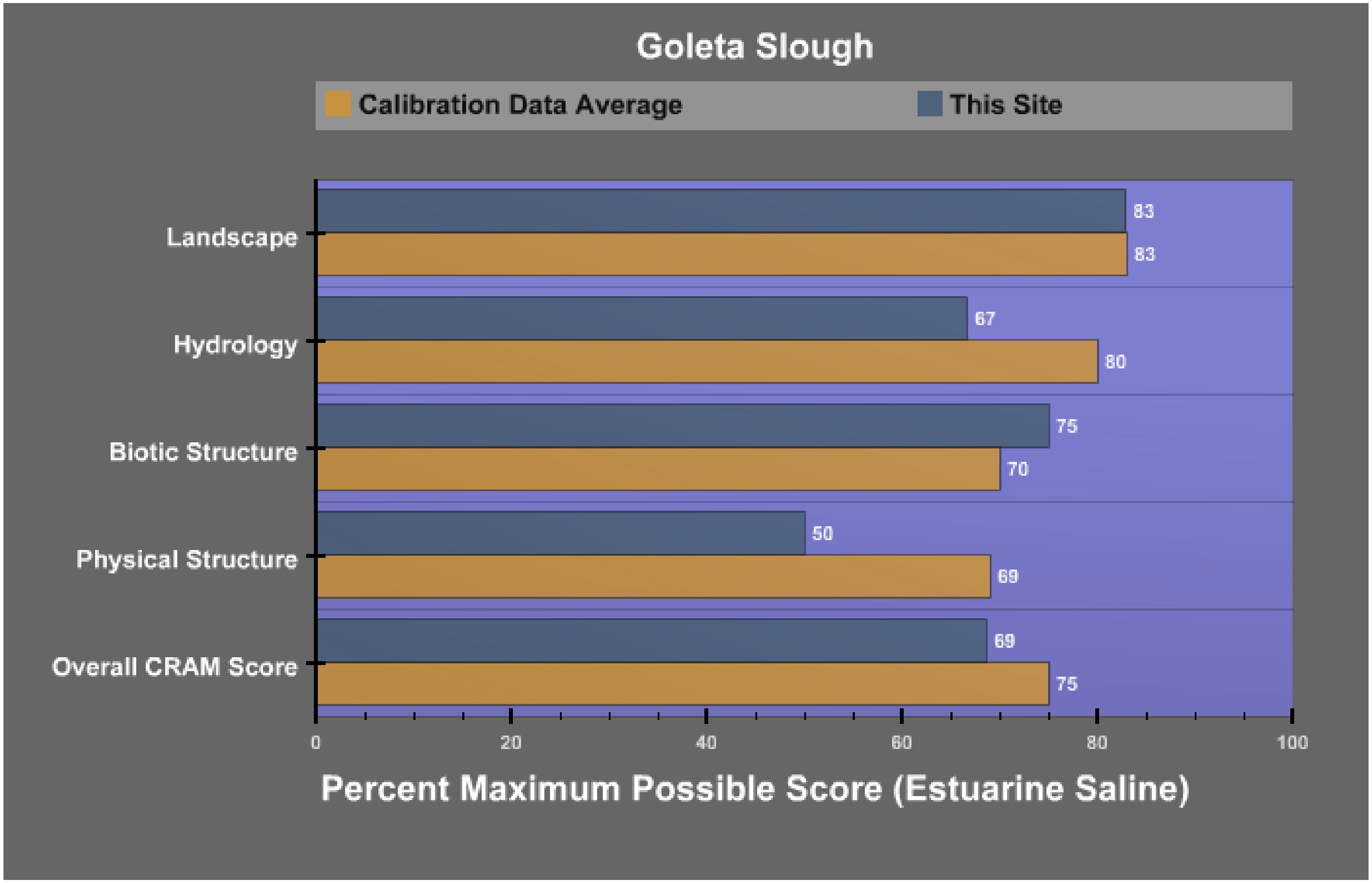


Figure 23. California Rapid Assessment Method Results for Goleta Slough (2004)

(http://www.cramwetlands.org/cramdisplay/#)

The Piute Ponds CRAM assessment revealed several areas of concern that resulted in a lower score. The artificial hydrology and altered hydroperiod resulted in lower hydrology scores (Edwards AFB, 2008a). This is unavoidable given the water source and it should be noted that without the artificial hydrology the ponds would not exist. Of more interest are the low scores the ponds received for physical structural complexity. Each assessment plot had only three patch types, resulting in a grade of D for patch richness (Edwards AFB, 2008a). The wetland also received a D across the board for topographic complexity. The ponds were rated as C or D for plant community metrics (Edwards AFB, 2008a). A high degree of horizontal biotic structure was present, but almost no vertical complexity. Invasive plants were rated as a relatively minor issue with 20 percent cover in one patch and none in the others (Edwards AFB, 2008a). There were no major disturbances listed (Edwards AFB, 2008a).

5.7 Environmental Education

Data on the educational opportunities and status was collected through correspondence with personnel at Edwards AFB. Information on the number and kinds of tours given at Piute Ponds was gathered through interviews with Environmental Management personnel at Edwards AFB who organize environmental education tours, which are primarily coordinated with the Mojave Environmental Educational Consortium (MEEC).

The Environmental Management at Edwards AFB coordinates outreach programs primarily for base related organizations. With regard to educational tours, Environmental Management conducts outreach to schools located on base as well as to schools within Muroc School District and is also responsible for organizing and distributing monthly publications to external and internal organizations and stakeholders.

Educational tours are coordinated by MEEC personnel, the participating school, and the Environmental Management personnel, and are structured to meet the needs of each teacher's specifications. There are two main kinds of tours given at Edwards AFB: Piute Ponds tours and Environmental Management tours. The following is a list of schools, both current and past, that have been involved with tours either at Environmental Management or Piute Ponds:

a. Barstow High School

b. Branch Elementary

c. Galileo Academy/Victor Elementary

d. Helendale Elementary

e. Joe Walker Middle School

f. Mesa Linda Middle School
g. Montara Elementary School
h. New Vista Elementary
i. Sandia Elementary
j. Shadow Hills Intermediate

Tours of Piute Ponds involve taking school groups out to the ponds and giving them a walking tour that explains the history of the ponds, along with other various points of interest such as identifying bird and plant species. Educational tours held at Environmental Management include a history of the base and table demonstrations that focused on cultural resources, natural resources, and geographic information systems (GIS). Natural Resources provide live animals such as tortoises and snakes and talks to the students about the different kinds of wildlife species found on the base. Cultural Resources typically displays artifacts, arrowheads, and other items for the students to see and touch that were found on or in proximity to the base. The GIS staff work interactively with the students on making a map of Piute Ponds using GIS software.

Over the past 3 years the age groups for school tours have ranged from elementary school to high school level; however, most of the time the ages range from 2nd grade through middle school. Edwards AFB does not have a set number of tours given each year. With respect to tours coordinated through MEEC, Edwards AFB gives five tours per year. If schools outside of the five tours contact Environmental Management requesting a tour, it is decided based on a case-by-case basis that is dependent on the current workload and tasks. Environmental Management and the Natural Resources personnel typically run educational tours; however, the base is in the process of developing a volunteer program to help guide the school tours. Edwards AFB is interested in enhancing public outreach efforts by advertising tours and research opportunities to school districts and colleges through an interactive website about Piute Ponds. (Herbert, 2008)

5.8 Recreation

Recreation activities currently conducted at the ponds only include duck hunting and bird watching. The quantity of hunting related permits issued in an average season are presented in (Table 12). There are 46 duck blinds in the Piute Ponds area, not all of which are actually in wetted ponds (Appendix B). Bird watchers are granted access to the ponds via a written letter that is issued by Edwards AFB Natural Resources Manager. A sample access letter is shown in Appendix C. The average number of access letters written in one fiscal year is 90, which may include granting access to parties as large as 30. There is no data on the actual number of visitors that visit the ponds each year for wildlife viewing.

Table 12. Permit Types

Permit Type	Quantity Issued	Cost ($)
Hunting–Active Duty Enlisted	14	25.00
Hunting–Non-Active Duty Enlisted	72	50.00
Daily Guest Hunting Permits	0	10.00
Seasonal Guest Hunting Permits	20	50.00
Duck Blind Reservation	66	50.00

Comprehensive records of the number of actual visitors to the ponds have not been kept; therefore, we cannot state the actual numbers, but can only estimate them based on the number of access letters issued.

Currently there are 9.68 miles of pedestrian trails, 2.55 miles of paved road, and 5.48 miles of unpaved road. Educational signs (Appendix D) are primarily located on the unpaved road that circles the north pond; there are a total of nine signs at the ponds. Facilities include two portable restrooms and a covered pavilion.

Now that the current status of the Piute Ponds has been established, it is necessary to examine the options for, and impacts of, different future management scenarios for the ponds. These scenarios are detailed in the next section.

6.0 SCENARIO DISCUSSION

6.1 Presentation of Scenarios

Nine scenarios were developed projecting effluent water supply from the LWRP and total annual resources expended by District 14 and Edwards AFB (Table 13). The current water supply is based upon the total annual volume of water required to maintain 400 acres at current ecological health levels. This volume is based upon evaporation and percolation losses and additional flushing flow volumes required to maintain the TDS at historic levels (overflows to Rosamond Dry Lake). Overflows to Rosamond Dry Lake must be approved by the Edwards AFB 95th Air Base Wing Commander. This total volume does not include flows from the various creeks, which also reach the ponds intermittently. Resources are defined as the annual value for manpower, materials, sampling and analysis, contracted research and studies, and volunteer efforts at the ponds. Resource availability was adjusted down and up by 25 percent for the lower and higher resource numbers.

Scenarios are based on present day water and resource availability as the baseline with the following modifications: the surface area of Big Piute, North Buffer Pond, and Shuttle Road Impoundment (Little Piute), and interconnecting marshes are estimated at 270 acres. These ponds and marsh are normally filled year round. The North and South Duck Ponds surface areas are estimated at 71 acres. These ponds are normally filled from November until April of each year. For the purpose of scenario modeling calculations (evaporation and percolation), these ponds were simulated empty for lower volume scenarios, filled half the year for the present day scenarios, and filled year round for higher volume scenarios. Currently, overflows from Piute Ponds occur from November until April. In 2010, overflows will be limited to the flow required to maintain Piute Ponds ecological and water quality as authorized by Edwards AFB. This requirement is listed in the LWRP 2020 plan (LACSD, 2004), but the specifics of how ecological health will be defined and measured are not spelled out. The details will need to be negotiated between Edwards AFB and District 14 as suggested in our recommendations.

Table 13. Scenarios

		Water Supply (Million Gallons)		
		Low 300 acres 1,800	Medium 400 acres 2,400	High 500 acres 3,000
Resource Availability	Lower $468K	1	4	7
	Current **$623K**	2	5	8
	Higher $780K	3	6	9

Scenario 1 simulates the ponds with less available water and less resource expenditures. The ponds would receive approximately 1,800 mg of water and approximately $470,000 would be spent on management (25 percent reduction from current expenditure levels).

Scenario 2 simulates the ponds with less available water and the current level of resource expenditures. The ponds would receive approximately 1,800 mg of effluent water and approximately $623,000 would be spent on management activities (current level).

Scenario 3 simulates the ponds with less available water and an increase in resource expenditures. The ponds would receive approximately 1,800 mg of effluent water and approximately $780,000 would be spent on management (25 percent increase in current expenditure levels).

Scenario 4 simulates that the ponds would receive approximately 2,400 mg of effluent water and approximately $470,000 would be spent on management (25 percent reduction in current expenditure). This scenario is not evaluated further as reduced management and oversight of the ponds at this effluent flow volume would likely result in unauthorized overflows to Rosamond Dry Lake.

Scenario 5 is the current day scenario with the exceptions noted above. The total effluent water flow delivered to Piute Ponds would be approximately 2,400 mg and approximately $623,000 would be spent on management.

Scenario 6 simulates the ponds would receive approximately 2,400 mg of effluent water and approximately $780,000 would be spent on management (25 percent increase from current expenditure).

Scenario 7 simulates the ponds with more available water and a decrease in resource expenditures. As with Scenario 4, this scenario is not evaluated in detail as reduced management and oversight of the ponds at the medium effluent flow volumes would likely result in unauthorized overflows to Rosamond Dry Lake.

Scenario 8 simulates the ponds with more available water and current levels of resource expenditures. As with Scenario 4 and 7, this scenario is not evaluated further as reduced management and oversight of the ponds at the high effluent flow volume would likely result in unauthorized overflows to Rosamond Dry Lake.

Scenario 9 simulates the ponds with more available water and an increase in resource expenditures. The ponds would receive approximately 3,000 mg of effluent water and approximately $780,000 would be expensed for management (25 percent increase from current expenditure levels). Although higher levels of effluent water may not be available from the LWRP due to recycled water demands, this scenario was carried forward for detailed analysis and management consideration if water is in fact available in the future.

6.1.1 Scenario Analysis: Water Quality, Water Quantity, Ecological Health, Recreation, Education

The future scenarios are developed based upon changes in available water and resources. Changes in water quantity can decrease or increase the overall water quality of Piute Ponds. Reductions in total pond area reduce the water requirements and can minimize some of the effects of reduced water volumes, smaller areas require less water and flushing. Decreases in available resources will result in a reduction of the overall maintenance and monitoring efforts at Piute Ponds. Reducing total pond area will reduce the required management costs. The average annual resources currently used for management of Piute Ponds are approximately $623,000. A reduction of 25 percent of available resources would reduce the total amount used for management to approximately $468,000. Required expenditures which are relatively fixed (chemicals for chlorination and dechlorination, and regulatory sampling and analysis) may not be able to be reduced significantly. Therefore, management tasks which are somewhat discretionary will have greater cuts. Reductions in general maintenance and monitoring will result in an overall degradation of Piute Ponds. Smaller area scenarios (Scenario 1, 2, and 3) will be affected less than larger area scenarios (Scenarios 7, 8, and 9) as the small footprints require less maintenance monitoring, sampling and analysis, and flushing. The overall level of water quality of Piute Ponds is of primary importance as it affects the overall ecological health of the area. The recreational and educational values of Piute Ponds are directly related to the ecological health including species population and diversity.

Because the quality of the ponds' area is a function of the resources expended per acre, the scenarios can be divided into three groups based on the average level of resources expensed per acre.

Group I which includes Scenarios 1, 5, and 9 will have approximately the same amount of resources expended per acre as today, while Group II (Scenarios 2, 3, and 6) will have more resources. Group III includes Scenarios 4, 7, and 8, which will not be carried forward for detailed analysis as previously discussed due to the likelihood of unauthorized overflows to Rosamond Dry Lakebed. The Group I scenarios (1, 5, and 9) simulate the current level of resources expended per area as today with varying amounts of water availability. Scenario 1 will have reduced pond acreages and effluent volume with less management resources and oversight.

In the Group I scenarios, the Piute Ponds area is reduced to approximately 300 acres. The Duck Ponds and/or the North Buffer Pond are not filled for part or all of the year. The water quality may be sustained at current levels due to the smaller footprint and reduced amounts of water required to flush. The overall ecological health of the area would be maintained as the resources and water quality are being reduced in proportion to one another. The amount of acres available for recreation will be reduced under this scenario as there would be fewer numbers of hunter blinds. There would also be a reduction in the overall quality of the hunting as fewer birds overall would be present. Other forms of recreation would also be reduced such as bird watching and nature walks due to reduced trail availability. There would be little or no effect on educational tours as tours generally occur at Big Piute which would not be impacted under this scenario.

Scenario 5 is the present day scenario and water quality, ecological health, and recreational and educational levels would remain unchanged.

Scenario 9 simulates increased wetted acreage and increased available resources. Under this scenario the Duck Ponds and North Buffer Pond would be filled and managed year round, and additional areas would be maintained (mudflat and marsh areas adjacent to the ponds). Water quality would be maintained at current levels and ecological health would likely remain the same as management resources would be increased in proportion to the increase in wetted area. Recreational activities could be increased with additional areas opened to hunters and for nature walks. Educational opportunities could also increase with additional acreage and nesting areas.

The Group II scenarios (2, 3, and 6) simulate increased levels of resources expended per acre with varying amounts of water availability. The allocation of increased resources would be determined by Edwards AFB and District 14 with the goal to maximize the ecological health and beneficial uses of the ponds. Under Scenario 2, the current level of resources is used to manage a reduced area (300 acres) and the Duck Ponds and/or the North Buffer Pond are not filled for part or all of the year. Because less area is required to be managed, management efforts will actually increase on a per acre basis.

Improvements in maintenance and water quality testing could allow for improved water quality. More comprehensive water quality testing for DO and nutrients would allow management to take remedial actions when problems were detected. The higher water quality and management efforts would likely improve the overall ecological health of the smaller pond area. Recreational opportunities will be decreased due to the reduced area as fewer hunter blinds and nature trails will be available. Educational opportunities will remain approximately the same as Big Piute pond is unaffected or improve slightly (due to higher water quality and ecological health).

Scenario 3 has the highest amount of resources available with reduced acreages. This scenario results in the highest resource expenditure per acre and should result in higher water quality and ecological health due to better maintenance, sampling and monitoring, modeling, and reporting. Although the total acreage is reduced to 300 acres, this scenario could result in the highest water quality and ecological health because maximum resources would be expensed per acre. The additional resources could allow more recommendations in Section 8 to be implemented.

Although the number of hunter locations would decrease overall, recreational opportunities could remain the same or improve as increased ecological health should result in higher ecological health, higher species diversity, and a larger number of birds and other animals per acre.

Scenario 6 simulates current area (400 acres) with increased management. As with scenarios 2 and 3, scenario 6 results in increased resource expenditure per acre which should result in an overall improvement to the ponds. Recreation and educational opportunities will increase due to improvements in the overall ecological health of the ponds.

Once the various scenarios were outlined, stakeholder input was needed to prioritize management options. Our group sought input in two ways: via feedback from stakeholders on our initial proposal and via an opinion poll conducted by Edwards AFB.

7.0 SUPPLEMENTARY DISCUSSION

7.1 Stakeholder Input

Comments on the proposal were received from approximately eight stakeholders. The comments were summarized and addressed by the group (Appendix E). The group also requested that follow-up letters be sent by Edwards AFB to the stakeholders who did not respond with feedback in order to the needed information and guidance.

The informal opinion poll was sent out by Edwards AFB to over 700 groups (e.g., through mail and the establishment of a survey website). The poll presented a list of activities and asked recipients to mark which ones they had participated in at Piute Ponds. The poll also presented a list of five possible future activities at Piute Ponds, and asked recipients to rank their importance of the activity on a scale of 1 to 5 (Appendix F).

There were 134 people who responded, which was a 19-percent response rate. Table 14 illustrates the number of visitors to Piute Ponds based on the specific activity. Seventy-three people stated they had visited Piute Ponds for recreational activities, and based on the associated comments, it was assumed that a vast majority of them were bird watchers. The next highest ranking was for guided tours. Guided tours for the general public or for schools were closely followed by duck hunting and educational activities, and based on the comments it was assumed that most of the responses related to education were teachers. Research projects were significantly lacking as an activity occurring at Piute Ponds.

Table 14. Number of Visitors to Piute Ponds Based on Activity

Guided Tour	Recreation (Hiking, Biking, Fishing, Bird Watching, and Nature Walk)	Education (Nature Area, Children's Programs)	Hunting (Ducks and Other Waterfowl)	Research (Research Projects With Colleges Or Universities)
22	73	21	21	5

Figure 24 illustrates the level of interest in each proposed activity. Feedback showing the range of comments and management options preferred by the stakeholders were collected (Appendix F).

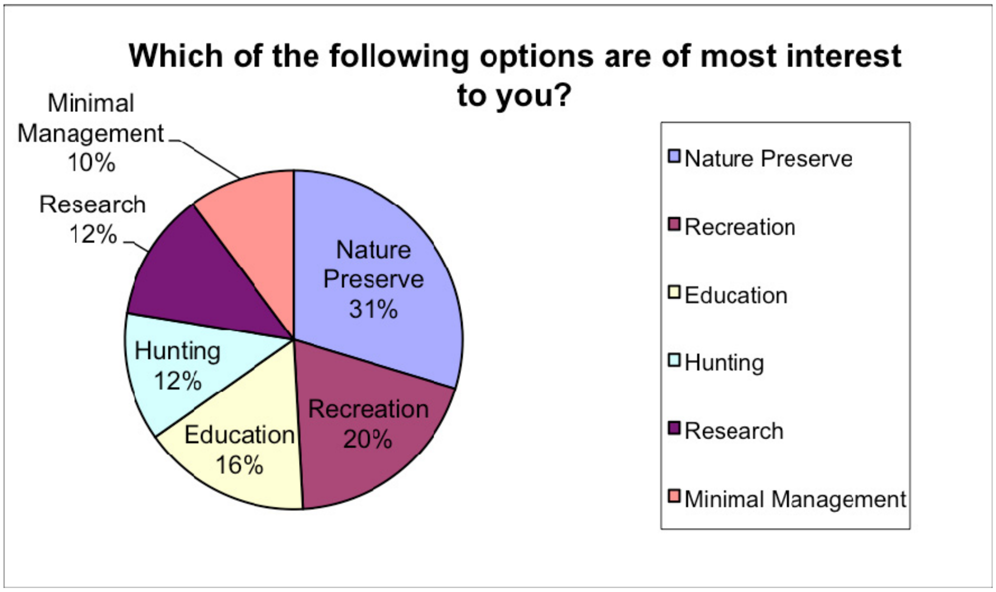


Figure 24. Poll results showing the level of interest in each proposed activity.

Table 15 outlines the preferences of future activities at Piute Ponds. The respondents ranked their preference of future activities at Piute Ponds. Surprisingly, the poll results indicated significant interest in turning the area into a nature preserve, with very limited, low-impact recreational activities. This analysis was based on a weighted score given to each of the proposed activities. For example, there were 106 responses that preferred to see Piute Ponds turned into a nature preserve. For each of these responses, the recipients were asked to assign a rank from 1 to 5, with 5 being the most interest. The total numbers of responses were then added up based on the rank score to produce a total weighted score. For a proposed nature preserve, this score was 437, which was the greatest score out of all the proposed activities, indicating that a majority of people prefer this option.

Recreation was ranked as the second most popular preferred activity, with a majority of comments stating preference with low impact recreation activities such as walking, hiking, and bird watching. Recreation such as fishing, boating, and camping were highly discouraged by poll takers. Education was ranked as the third most preferable activity, with a majority of the comments on education stating they would like to take more school groups out to Piute Ponds as well as see an increase in guided tours. Research opportunities with colleges and universities were another highly preferred activity; however, there was only one comment received specifically stating a preference for increased research project opportunities. Responses favoring hunting activities at Piute Ponds ranked below each of the previously stated activities, except for minimum management as required by regulations.

Table 15. Number of Responses Regarding Preference of Future Activities at Piute Ponds

Category	Nature Preserve	Recreation	Education	Research	Hunting	Minimum Management
Final Rank	**1**	**2**	**3**	**4**	**5**	**6**
Number of Responses per category	106	107	103	101	104	92
Sum of responses	437	404	376	349	267	250

Notes:
1. Nature Preserve is ecological and wildlife values with limited low impact recreation
2. Recreation is hiking, biking, fishing, boating, camping, and bird watching
3. Education is tours, nature area, and children's programs
4. Research is research projects with colleges or universities
5. Hunting is ducks and other waterfowl
6. Minimum management indicates minimum management and maintenance required by regulations and law.

There were several comments addressing the hunting activities at the ponds, some requesting that Edwards AFB not limit the area for hunting, and some asking that the base eliminate hunting altogether as it interferes with bird watching. However, comments were more heavily swayed towards eliminating hunting at Piute Ponds. If this option was to be considered, a great deal of consideration must be taken into account by Edwards AFB with regard to the partnerships with organizations such as Ducks Unlimited, who are involved with the duck hunting activities at the ponds. Risks of losing a valued partnership, as well as much needed restoration funding would be issues that the base would have to consider if duck hunting activities were to completely cease at Piute Ponds. It was reassuring to see that the least favored option was seeing Piute Ponds minimally managed, which supports the recommendation to enhance the management and resources available for the ponds.

7.2 Funding and Resources

Additional resources are needed to improve Piute Ponds. District 14 is moving to tertiary effluent treatment and better management of overflows which will improve water quality; however, improving the ecological health of the ponds and adding recreational and educational opportunities will require a different source of funding. Securing these resources should be a top priority of Edwards AFB. There are a variety of possible sources of both money and manpower that should be investigated. Edwards AFB might be able to secure additional funding from Air Force Environmental Funding, Air Force Morale, Welfare, and Recreation (MWR) Funding, or Department of Defense legacy funds. There is also the possibility of establishing a use fee for Piute Ponds, although this would create several complications. Additional resources would be needed to collect and manage the fees. Enforcement of payment would also be an issue. Groups who currently have free access, particularly birders could be expected to protest the new fees. Fees would also discourage access if improving and increasing usage is one of the goals of Edwards AFB. Another source of funding would be to form partnerships with nonprofit organizations, similar to what was done with Ducks Unlimited in the creation of the duck hunting ponds. Both Ducks Unlimited and the Audubon Society are good candidates for partnerships. Edwards AFB could also investigate partnerships with local school districts to increase educational resources. Local high schools and universities would be ideal candidates to help with ecological monitoring programs. The Audubon Society could assist with bird monitoring programs. The MEEC could be a good source of information and volunteer resources for educational programs. The creation of a robust volunteer program would be one of the best methods to increase the resources available for managing the ponds. Volunteers could help with removing invasive species, planting native species, installing bird boxes, helping give tours of the ponds, staffing entrance stations or information kiosks, and monitoring the ecology of the ponds. Other possible sources of funding include grants and private donations.

7.3 Risks and Concerns

Changes in the amount of water and resources expended at Piute Ponds will result in changes in risk levels with respect to cost, safety, base security, BASH, and liability. Maintaining or increasing the acreages at Piute Ponds will require increased expenditures in the future. Additional Air Force and District 14 funds and volunteer resources will be required to maintain or improve the larger Piute Ponds. Future funding is uncertain and there is a risk that it could be reduced. Additional volunteer resources could offset some budget reductions with respect to general maintenance, upkeep, and improvements; however, sampling, analysis, and reporting as well as chlorination/dechlorination costs are generally fixed. Future reductions in available budgets are a risk which should be further evaluated.

Any change in the use of Piute Ponds will affect safety and base security. Increases in the number and frequency of visitors and tours will expose the base to increased risk of safety, security, and liability. There are no regular patrols at Piute Ponds and the base could potentially be liable for accidents occurring on base property. Likewise, increased visitors could increase the security risk, although the area is currently unfenced and open to access. An increased risk to security from increased visitors is minor due to the remote location of Piute Ponds and the large distance to sensitive Air Force assets. Incursions onto Rosamond Dry Lake could occur; however, there have been no reported incursions onto the Lakebed from the Piute area since its establishment. A reduced number and frequency of visitors will likewise reduce overall risk in these areas. Improvements in the ecological health of Piute Ponds may increase the bird population, which will increase the chance of BASH. Although there is no recorded BASH in the Piute Ponds area, an increase in the number of birds could result in aircraft bird strikes.

After evaluating data, limitations, current status, scenarios, poll results and miscellaneous issues such as BASH, our group was able to develop recommendations for Edwards AFB as outlined in the following section.

8.0 PIUTE PONDS MANAGEMENT RECOMMENDATIONS

8.1 Recommendations for Piute Ponds

The overall purpose for developing recommendations for a management plan for Piute Ponds was to provide Edwards AFB with ways of enhancing the wetland ecosystem, while at the same time, ensuring that the ecosystem sustains its ecological needs and health. Recommendations for enhancing the water quality, ecological health, environmental education, and recreational opportunities at Piute Ponds are provided in the following sections.

8.1.1 Water Quality and Quantity Recommendations

Recommendations for water quality and quantity (Table 16) are grouped together as they are fundamentally linked; water quality is highly dependent on the timing and quantity of effluent flows delivered to Piute Ponds. Of primary importance are accurate measurements of flows into, between, and overflows out of the ponds, and the water quality data collected, and limiting unnecessary effluent overflows which impact Rosamond Dry Lakebed.

Table 16. Recommendations to Improve Water Quality

Recommendation	Cost	Benefit
Install accurate flow gauges	$$	Flow monitoring/modeling
Improve flow control structures	$$$	Flow control
Dredge channels for better flow	$$$	Water quality
Install on-site weather telemetry	$$	Modeling
Perform permeability study	$$	Monitoring/modeling
Develop Comprehensive Water Sampling and Analysis/Monitoring Plan	$$$	Monitoring/modeling
Include biological water quality sampling	$$	Monitoring/modeling
Install auto samplers	$$	Monitoring/modeling
Utilize Base Environmental Analytical Laboratory for additional sampling and analysis	$$	Monitoring/modeling
Model overflows to Rosamond Dry Lake	$$	Modeling
Remote (sensing) monitoring of overflows	$	Modeling/Mission impact
Field surveys of overflows effects	$$	Reduce Mission impact
Coordinate overflows with w/AFFTC	$	Flow Control

Notes: 1. $–Less than $1,000

2. $$–From $1,001 to $10,000

3. $$$–From $10,001 to $100,000

4. $$$$–From $100,001 to $1,000,000

Install Accurate Flow Gauges ($$): There is limited flow data within the ponds, and there are no measurements or estimates of natural stream flows into or out of Piute Ponds. Flows between the marsh and pond areas should be monitored to improve modeling and provide data to control overflows. Natural flows to the ponds should be measured and included in modeling efforts. Accurate measurements of water inflow are critical in developing and calibrating an accurate water balance model for all ponds and marsh areas at Piute Ponds, which take into account the seasonal changes in inputs (effluent, precipitation, and stream flow) and losses (percolation, evaporation, and overflows). Site measurements of temperature and windspeed would also be useful in developing this model.

Improve Flow Control Structures and Dredge Channels to Improve Flows ($$$): Flow control between Piute Ponds is limited. Improved flow-control structures would allow for better control of pond and marsh flows and would help control overflows. Repair of existing flow-control structures and installation of additional flow-control structures would allow better control of water movement between ponds and marsh areas as well as overflows; it would also allow optimal flushing of the ponds to maintain or improve water quality. Dredging existing flow channels would improve flows between pond and marsh areas.

Install On-Site Weather Telemetry ($$): Installation of weather telemetry equipment to monitor temperature, windspeed and evaporation would allow for improved calibration of water balance models and simulations. Inputting real-time data into models and simulations would allow for accurate and timely adjustments of flow to prevent unauthorized overflows to Rosamond Dry Lakebed.

Perform Permeability Study ($$): Perform permeability field tests and studies to accurately quantify losses due to percolation and seepage.

Develop Comprehensive Water Sampling and Analysis/Monitoring Plan ($$$): A comprehensive sampling, analysis, and monitoring plan should be written for Piute Ponds. The goal of the plan would be to standardize field sampling, laboratory analysis, and reporting to meet WDR requirements and additional water quality parameters needed to maintain the ecological health of Piute Ponds. The plan would integrate WDR sampling requirements with additional sampling, analysis, and monitoring requirements needed to maintain the ecological health of the ponds and limit overflows to Rosamond Dry Lakebed. Water sampling at the ponds should be better formalized in a site specific water quality monitoring plan, which would improve the overall data collected at Piute. Sampling and analysis above minimum regulatory required sampling should be conducted and the number of sampling sites, frequency, and types of analysis increased. Additional data points and analysis is required to better understand the organic processes within the ponds. Monthly sampling for chlorophyll, organic phosphorus, and total nutrient concentrations at multiple locations within all ponds and marsh areas would allow full calibration of a water quality model (CH2M HILL, 2005).

Utilize the Edwards Base Environmental Analytical Lab (BEAL) for Additional Sampling and Analysis ($): To reduce over sampling and analysis costs, the BEAL could be utilized for some sampling and analysis efforts. As the BEAL is not certified, the analysis and results should not be used to determine compliance with WDR requirements.

Model Flushing Overflows to Rosamond Dry Lake ($$): Once the water balance model is accurately calibrated, simulations to optimize the flows and water quality within the ponds could be made. Acquiring additional high resolution remote sensing data, on-surface elevation, moisture content, and field surveys would allow calibration of modeling and simulations and monitoring of overflows and flooding of Rosamond Dry Lakebed. Scenarios should include intermittent flushing, continuous flushing, and pulsing. Continuous wetting of the mudflat area between Piute Ponds and Rosamond Dry Lakebed would allow additional flushing volumes without impacting the lakebed. Overflows which would impact the lakebed can be coordinated with the AFFTC. By developing and calibrating accurate water balance flow models and running overflow simulations, effluent induced overflows, which reach Rosamond Dry Lake can be minimized and greatly reduce or eliminate negative impacts to the mission of the AFFTC.

8.1.2 Ecological Health

There are multiple possible methods for improving the ecological health of Piute Ponds (Table 17). They range from very expensive to relatively inexpensive, especially if volunteer labor is used.

Table 17. Recommendations for Enhancing Ecological Health

Recommendation	Cost	Benefit
Construct new Ponds	$$$-$$$$	Increase available habitat
Improve Water Flow/Rotate Ponds	$$$$	Improve water quality and allow ponds to periodically go dry to regenerate
Remove Nonnative Plant Species	$-$$$*	Improve quality of habitat
Plant Native Species	$-$$$*	Improve quality of habitat
Increase Diversity of Habitat	$$$-$$$$	Increase number and variety of birds
Add Islands for Bird Breeding	$$-$$$$	Increase number and success of breeding birds
Add Fish to Ecosystem	$-$$$$	Increase complexity of ecosystem and add level to food chain
Remove African Clawed Frogs	**	Improve quality of habitat, allow fish to flourish
Add Bird Boxes/Perches	$	Increase number of birds, help with breeding

Increase Monitoring	$$-$$$$	Improve knowledge of pond ecosystem, allow for better decision making
Increase Volunteer Program	$	Increase awareness, foster sense of ownership, improve community relations, Provide inexpensive labor

$–Less than $1,000
$$–Less than 10,000
$$$–Less than $100,000
$$$$–Less than $1,000,000

**Depending on extent of planting/removal and use of volunteers*
***No current method exists*

Construct New Ponds ($$$$): If the water supply increases as assumed in Scenarios 6 and 7, then additional ponds will be needed to hold the water and evaporate it. Otherwise, the overflows to Rosamond Dry Lake would increase. Increasing the pond area would increase the habitat for birds and other wildlife including rare species. Constructing new ponds would require the construction of new levees. This would be an expensive proposition. Levee construction would cost in the $100,000 to $1,000,000 range. An expenditure of this magnitude is unlikely to occur. In addition, District 14 has allocated for all future effluent and is unlikely to increase the flow to Piute Ponds beyond what is required to maintain it in its current condition. Additional ponds would require a full environmental impact report and could negatively affect currently existing archaeological and natural resources in the area. There is a possibility that cost of construction could be offset by wetlands banking if the new ponds were used to mitigate the effects of development elsewhere.

Remove Nonnative Species of Plants ($-$$$): Invasive species often form monocultures that do not support the diversity of wildlife that native plant species do. Removing the nonnative species would promote a more natural native habitat, which supports a greater diversity native species and would improve the ecological health of the ecosystem as measured by the CRAM assessment. Removing the nonnative plants would prevent them from spreading and further degrading the habitat.

There are three basic methods of invasive plant removal: removal by hand, mechanical removal, and chemical removal with the application of herbicides. Fire is also sometimes an option, but seems inappropriate here, due the wetlands nature of the resource. Pulling the invasives by hand, or with basic hand tools such as weed wrenches, is the simplest method of control. It has little negative impact as long as the right plants are pulled. Mechanical removal involves removing natives by flailing or disking the area with a tractor. Large areas can be covered, but the technique is not selective. Everything is destroyed. The removal must be timed to interrupt the growing cycle, late enough that the invasive cannot regenerate that season, but early enough that they have not yet gone to seed. Often more than one application is necessary. Mechanical removal can be difficult in wetlands where tractors are ineffective. Controlling invasives with herbicides can be very effective; however, it risks contaminating the environment with the chemicals. Herbicide use should be kept to a minimum, and used only when other methods are not practical. Nonpersistent herbicides that are safe for aquatic environments should be used. The specific herbicides will depend on the plants to be eliminated. An ongoing program is usually needed as a single season of removal is rarely enough. Removal must continue until the seed bank of the invasive is depleted, or native cover can establish itself and exclude the invasives.

The main invasive species found by the CRAM survey was Russian knapweed (*Acroptilon repens*). There are also some stands of tamarisk trees. Russian knapweed is a difficult plant to control due to its extensive underground root system from which it can resprout. Multiple control methods are usually needed over the course of several seasons. Ultimate control is usually dependant on the establishment of native cover to outcompete and suppress the weed. Detailed information on Russian knapweed control can be found at The University of Nevada Cooperative Extension (2008). Controlling tamarisk usually requires removing the trees with chainsaws and then painting the stumps with herbicide to prevent regrowth.

The cost of plant removal varies by species and by method. It can be very expensive if mechanical removal is used or relatively inexpensive for chemical application or if volunteers are used for hand pulling. An ongoing monitoring and weed management plan should be developed to ensure the long-term health of the ecosystem.

Plant Native Species ($-$$$): Planting native species at Piute Ponds would promote a more natural, native habitat, which generally supports a greater diversity of wildlife than habitat dominated by nonnative species. Increasing the quality of the existing habitat would likely benefit the bird population as well as other animals. The initial focus of a planting project should be on trees. Trees are in short supply at the ponds and increasing the number would provide habitat complexity that is currently missing. Black willows (*Salix gooddingii*), narrow leaf willows (*Salix exigua*), and cottonwoods (*Populus fremontii* ssp. *fremontii*) are the most likely species to focus on. If an ongoing long-term native planting program is established, then it would be advantageous to set up a greenhouse to raise the plants rather than purchase them. Seeds should be gathered from plants in the Piute Ponds area whenever possible in order to maintain the local genetic phenotypes. The cost of planting is generally inexpensive, but can increase in cost dramatically if irrigation is required. Edwards AFB estimated the cost of planting 15 cottonwood trees at $15,000. This is a very high estimate that includes a full irrigation system. One could drive out in a pickup with a water tank and hand water the trees once or twice a week for the first year. This should not take more than a couple of hours of time per week. Planting should also be done in the fall or winter after the first rainfall. This will increase the plant survival rate. Volunteers could be used for both the planting and for follow-up weeding and watering to lower costs.

Improve Flow/Rotate Ponds ($$$$): Currently the water flow at the ponds is poor. There is little circulation to help aerate the water and prevent it from becoming brackish and stagnant. The only flow occurs when the water overflows the C-Dike onto the dry lakebed. In addition, there is currently no method to bypass and dry out an individual pond for maintenance, dredging, or to allow it to regenerate. In this climate, ponds are generally ephemeral, drying out during the summer months. Rotating the ponds and allowing them to dry out for a period of time might improve their health. Improving the flow of the ponds would help improve the water quality and help the ecology of the ponds. Making these previously mentioned changes would require substantial reengineering of the ponds and the installation of new control structures. These changes would be expensive and are unlikely to occur without outside funding. Ducks Unlimited has expressed some interest in restoring Piute Ponds and might be one source of funding to explore. The expense could also be incorporated into the cost of constructing new ponds. A less expensive alternative might be to install an agricultural pump to move water from the lower end of the ponds at the C-Dike or the north ponds and pump it back up to the inlet. This would help to keep the water circulating and aerated. It would require a large pump and a substantial length of pipe (1 to 2km). There is no source of electricity at the ponds so powerlines would need to be installed. Alternately, solar power might be an option. Additionally maintenance and upkeep costs would need to be considered. This option is still likely to cost in the hundreds of thousands of dollars.

Increase Diversity of Habitat ($$$-$$$$): Currently the ponds provide a diversity of habitats; however, these habitats need to be mapped at a smaller scale. This detailed analysis is needed to determine which habitats, are in short supply. Different migratory waterfowl require different habitats. Diving duck, dabbling ducks, and wading birds each require a different depth of water to feed. Mudflat habitat for wading birds is the most serious concern. With the elimination of overflows to Rosamond Dry Lake, a substantial amount of this habitat would be eliminated and a reduction in the wading bird population is likely. Solutions include allowing overflows to the edge of the lake, but not onto it, or modifying some of the ponds to increase the shallow wading and mudflat habitat along the shorelines. Increasing the quantity of habitats in short supply would help maintain and increase the bird populations that use the ponds. The cost of this kind of modification could be expensive; however, it could be combined with maintenance dredging, the creation of additional ponds, or other activities to reduce the overall cost.

Add Islands for Bird Breeding ($$$-$$$$): Adding islands in the ponds for bird breeding is another possibility for improving bird life at Piute Ponds. It would increase the chance for birds to successfully breed by protecting them from predators such as coyotes and foxes. This would likely increase the number of breeding birds as well as their breeding success rate. To build islands, dredged material from the pond bottoms could be piled up and sculpted into the required shapes. If the pond were dry, this could be done with a bulldozer in relatively little time. Adding islands could be expensive if done as a separate project; however, the cost could be reduced by combining it with dredging or other maintenance activities.

Add Fish to Ecosystem ($-$$$$): Currently there are no fish in Piute Ponds. Attempts have been made in the past to stock fish, including mosquito fish, but they have been unsuccessful. It is believed that the large African clawed frog population eats the small fish before they can grow and mature. In addition the high ammonia levels and low DO levels in the summer make long-term fish survival unlikely. If fish could be established, it would increase the complexity of the food web in the ponds and provide an additional food source for larger birds such as cranes and herons. If large fish could be established, they might prey on the clawed frogs and tadpoles and help control the population and bring it into balance. It is known that exotic largemouth bass prey on the frogs in their native range in Africa. Establishing mosquito fish would be useful in controlling mosquito problems arising from the stagnant water. Although the ponds are some distance from population centers, this would still be beneficial to help prevent disease transmission.

Another possibility would be the introduction of the endangered Mojave tui chub (*Gila bicolor mohavensis*). The tui chub is an endangered species endemic of the Mojave Desert. Currently, the USFWS recovery plan includes establishing at least six additional viable populations in the region. One population is already being established on Edwards AFB in a pond on the golf course. Piute Ponds would provide a large undisturbed habitat for the Chub. The USFWS would pay for the program and would relieve Edwards AFB of responsibility under the *Endangered Species Act* if the fish did not survive. Currently the water quality is not high enough to support the fish and it is uncertain whether they could survive the frog population. Additional research would be needed to move forward with this program, but it potentially offers large benefits to an endangered species and should be investigated further, particularly if water quality improves with tertiary treatment.

An additional benefit to adding fish is that sport fishing could become a recreational activity if there is sufficient interest. More research would be needed on which species could survive in the specific pond conditions and which ones might feed on the frogs and tadpoles. Adding fish could also have unpredictable effects on the ecosystem and could potentially decrease water quality.

Remove Nonnative African Clawed Frogs (Unknown): African clawed frogs are nonnative and are considered an invasive species. They have overrun Piute Ponds and their population numbers in the hundreds of thousands. Removing the frogs or controlling their population would restore a more natural ecosystem and allow native frogs, fish, and amphibians a better chance of survival. Unfortunately there is currently no way to eliminate such a large population of this species. The ponds would either have to be completely drained for substantial periods as the frogs can survive a pond drying up for up to 8 months, or the ponds would have to be completely poisoned, which would likely kill all the other pond life as well. Neither option is viable. The only possibility is if a natural predator can be found and established that could exert some biological control. So far there is no record of this technique ever being applying for African clawed frogs.

Add Bird Boxes/Perches ($-$$): Piute Ponds are notable for their lack of tree cover and dead snags. There are few cavities for breeding and few perches for raptors. This shortage could partially be alleviated by the construction of bird boxes (Figure 25) and raptor perches. Although some bird boxes already exist at Piute Ponds, more could be added. Bird boxes would help increase the breeding bird population by providing safe nesting sites. They could be sized for specific birds of interest (e.g., owls and bluebirds). Raptor perches could also be installed. This is a relatively low-cost option to improve the bird habitat at the ponds. It is also easy to scale to the amount of available funds. The more funding is available, the more bird boxes could be installed. Volunteers could also be used for the construction, installation, and monitoring.

Figure 25. Artificial Bird Nest

Increase monitoring ($$-$$$$): While increased monitoring will not directly impact the ecological health of Piute Ponds, monitoring is necessary to assess progress and focus management efforts and resources in the most effective manner. For this reason, a comprehensive monitoring and assessment plan should be developed. It should be integrated with the water quality monitoring plan recommended as previously mentioned. The recent CRAM survey was designed to provide an overall baseline of pond health for future comparison purposes. It should be repeated annually or biannually to detect changes and trends in the pond ecosystems. In addition, a rapid macroinvertebrate survey is recommended. Invertebrate populations are a prime indicator of water quality and ecosystem health. A full Tier 3 IBI or HGM assessment of the ponds would be useful to provide more detailed information on the pond ecosystem and fill in the gaps in the CRAM survey. Detailed GIS mapping of invasive species would provide information on the scope of this problem and provide a baseline to assess progress. A detailed map of the microhabitats of the ponds would also be useful for assessing which habitats are limited. An effective annual bird survey should be part of any monitoring program. The bird life is the focus of much of the recreation of the ponds and is one of the main reasons for improving them. Surveys should be conducted annually. They should be conducted at multiple times of the year in different seasons to capture the full range of birdlife that utilizes the ponds. The Audubon Society might be willing to partner with Edwards AFB to help conduct the surveys. The cost of this monitoring will vary widely depending on exactly what is done; however, costs may be substantial. The recent CRAM survey cost only $1,600 (Edwards AFB, 2009). A full Tier 3 IBI or HGM assessment would cost $100,000 to $150,000 depending on how much field surveying is needed to be completed (Edwards AFB, 2009). A simple volunteer-based water-quality and survey-based monitoring program could be conducted for very little money. District 14 in their recent EIR is required to maintain the ponds in their current ecological state. This would indicate that they should fund much of the monitoring. How do they know what the current ecological state is and how will they know if it decreases unless they have a monitoring plan? Overall, the more information that can be gathered, the better the knowledge of the ecosystem and the better the management decisions would be.

Increase Volunteer Program ($): Many of the recommended activities could be conducted using volunteers. Volunteers could be used for removing invasive species, planting native species, building and installing bird boxes and perches, ecological monitoring and even for trash cleanup. Volunteers could also be helpful in a number of recreational and educational activities. The cost of a volunteer program comes from the time spent by the staff to manage it, lead workgroups, and put out a newsletter. Some of these functions could be managed by the volunteers themselves once the program is up and running. This would be an inexpensive way to leverage manpower for improving the ponds and build awareness and community participation at the same time. It would help foster a sense of ownership by the community and could improve relations between the base and the community. It would provide resources for some of the labor intensive projects that otherwise might go uncompleted.

8.1.3 Environmental Education

Table 18. Recommendations to Improve Environmental Education

Recommendation	Source	Cost	Benefit
Specialized Public and School Tours of Piute Ponds	Piute Group	$	Increase diversity of curriculum and educational experience at Piute Ponds

Piute Ponds Website	Piute Group	$	Increase public awareness of Piute Ponds by providing general information
Geological Information System Resources	Piute Group	$$	Enrich and diversify educational curriculum
Speaker and Lecture Series	Piute Group	$	Increase public awareness of Piute Ponds and enhance educational experience for students
Exhibits and Displays	Piute Group	$	Increase public awareness of Piute Ponds and engage students in activities related to the ponds
Wetlands Curriculum	Piute Group	$	Enhance wetlands curriculum for students at Piute Ponds
Shuttle for School Tours	Piute Group	$$$	Increase public awareness and promote outreach of Piute Ponds to schools; assist in transportation
Satisfaction Survey–Adaptive Management	Piute Group	$	Evaluate the quality and effectiveness implemented programs and activities

$–Less than $1,000
$$–Less than 10,000
$$$–Less than $100,000
$$$$–Less than $1,000,000

Specialized Tours of Piute Ponds ($): As part of a partnership with MEEC, Edwards AFB provides tours of Piute Ponds that largely provide science-based educational experiences for students K through 12. Specializing in tours to different themes could enhance the variety of information and activities taught to the students at Piute Ponds. Themed tours can be carried out in two ways; one option would center tours on various educational topics. Another option would provide tours led by specialists (biologists, naturalists, engineers, GIS technicians, and anthropologists) in the individual field of study. Topics for all tours include:

- Artificial Wetlands
- Birds
- Biodiversity
- Cultural Resources
- Ecosystems

- Environmental Stewardship
- Geology
- Insects
- Natural Resources
- Restoration Ecology
- Water Quality
- Wetland Conservation

Costs for developing specialized tours include the number of hours spent by Edwards AFB's personnel on preparing for and conducting the tours.

Website ($): Public awareness could be greatly improved by creating a website for Piute Ponds that offers the following:

- Directions to Piute Ponds
- Map of the ponds
- Guidance on gaining access to Piute Ponds
- Rules and regulations of Piute Ponds
- Types of recreation allowed (e.g., bird watching, duck hunting, walking/hiking, and photography)
- Photos of Piute Ponds
- Virtual tour of Piute Ponds
- Sound clips of wildlife and birds.

A website for Piute Ponds could be created by Edwards AFB with additional assistance provided by local high schools and volunteers. Total costs for designing a website would be based on the number of hours spent by Edwards AFB.

Satisfaction Survey–Adaptive Management ($): While a majority of responses from the Piute Ponds poll preferred the area to be turned into a nature preserve with very limited access, educational programs and recreational activities, the rationale behind these particular public responses is unknown without requesting additional feedback surveys from the Piute Ponds visitors.

There is also currently an unknown method of measuring the quality of the educational and recreational activities occurring at Piute Ponds. It is highly recommended that a method for measuring the quality, success, and effectiveness of the recommended educational and recreational activities, and infrastructure be implemented by Edwards AFB. This can be accomplished two ways; one method would be to provide a satisfaction survey to each participant at the end of each school tour, nature walk, bird watching event, or hunting day. Edwards AFB's personnel could then collect the surveys, evaluate the comments and feedback, and then make improvements and changes to the activities accordingly. A comment box could be left out at the main Piute Ponds entranceway to collect feedback from visitors if Edwards AFB's personnel were not present. Comments could also be collected electronically through a website forum or through an electronic web survey that could be accessed via a website. Another method to evaluate the quality and success of implemented educational and recreational activities at Piute Ponds would be to have Edwards AFB send out another opinion poll to its stakeholders and to the general public 1 to 2 years after the activities and programs are implemented. This could potentially provide the base with current feedback on the effectiveness and value of the educational and recreational opportunities and allow the base to make further changes based on the most recent stakeholder feedback. Costs for this recommendation include the printing costs associated with creating and distributing the surveys as well as the number of hours spent by Edwards AFB's personnel for collecting and evaluating the results.

Geographical Information System Resources for Environmental Education ($$): Edwards AFB demonstrates the capabilities of GIS software through interactive activities for students who visit the base. These interactive workstations coordinated between the GIS personnel at Edwards AFB and students could be further enriched by investing in GIS educational software tailored to primary, secondary, and postsecondary curricula. If individual school funding permits, GIS software could be acquired by each school for use in each classroom. Further instruction on GIS capabilities related to Piute Ponds could be given to the students by Edwards AFB GIS personnel during visits to the base. Investments in other GIS-specific educational resources, such as textbooks and workbooks, could also aid in enriching students' knowledge of GIS capabilities. For example, Environmental Systems Research Institute (ESRI) developed a book series called Our World GIS Education to enhance the interactive mapping experience for students of all levels. These books are arranged by skill level and provide lessons and projects for teachers that allow them to incorporate GIS into the curriculum. These books can be purchased from ESRI or Amazon.com and are relatively inexpensive per set.

Speaker/Lecture Series ($): Developing and coordinating professionals and/or specialists focusing on wetland habitats would be a simple and cost-effective means of promoting Piute Ponds to schools and local communities. Speakers could be hosted directly at Environmental Management on Edwards AFB, or could occur out at Piute Ponds.

Exhibits and Displays ($): Awareness is a key factor in making Piute Ponds a significant educational resource for the community. Students could collaborate on creating a hands-on exhibition depicting Piute Ponds to be displayed at the Environmental Management lobby on Edwards AFB and would bring awareness not only to the students who visit for field trips, but to the general base population. Having students work collaboratively on constructing a wetlands based display would also be beneficial in enhancing their knowledge on topics such as wetland ecosystem functions, bird and wildlife species identification, food web dynamics, plant species, wetland habitat conservation, and water quality.

Wetlands Curriculum ($): School tours coordinated in support of MEEC could be improved by providing curriculum packets or workbooks for the students specifically designed for wetland ecosystems. Educating students on the benefits and values provided to the environment and wildlife by wetland ecosystems would be a key component. Incorporating how artificial wetlands such as Piute Ponds are a beneficial and functional component of wastewater treatment is important given the unique nature of Piute Ponds. Figure 26 and 27 are examples of workbooks for the students in grades Kindergarten through 5th grade.

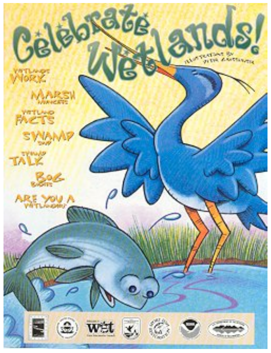


Figure 26. Project Wet, Celebrate Wetlands

(http://www.projectwet.org/kids/)

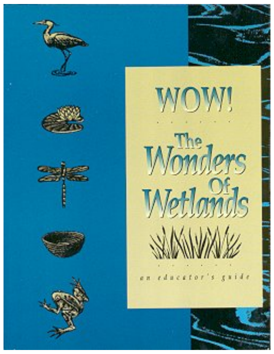


Figure 27. Environmental Concern: We're All About Wetlands, WOW! The Wonders of Wetlands

(http://www.wetland.org/)

Shuttle for School Tours ($$$): While the EnviroBus Buck Transportation Grant Program provides grants for school bus field trips to sites such as Piute Ponds, the development of a permanent shuttle to assist in picking up/dropping off students from schools would improve transportation and accessibility issues and encourage more schools to visit Piute Ponds. Shuttle buses would also encourage schools outside of the local school district to visit Piute Ponds by offering a method of transportation for the students and teachers. The shuttle could be extended to travel to day camps, daycare centers, and nature schools in the area. For schools that are unable to visit Piute Ponds, Edwards AFB could also invest in a customized mobile classroom to bring a hands-on wetlands experience of Piute Ponds to the students. *Wetlands on Wheels*, launched by the

Education Division of the nonprofit organization Environmental Concern, is an example of a mobile educational resource vehicle as depicted in Figure 28.

Figure 28. Environmental Concern: We're All About Wetlands, Wetlands on Wheels

(http://www.wetland.org/education_wetlandsonwheels.htm)

8.1.4 Recreation

Table 19. Recommendations to Improve Recreation

Recommendation	Source	Cost	Benefit
Improve Accessibility (overlaps with education)	Piute Group	$	More people will visit the ponds
Create themed nature walks (overlaps with education)	Piute Group	$	Will improve the experience of visitors
Increase the number of informational signs (overlaps with education)	Piute Group	$$	Will increase the education of visitors
Install viewing/seating/ picnic structures	Piute Group	$ (Depends on quantity purchased)	Will improve the experience of visitors
Improve dirt roads and walking trails	Piute Group	$$$	To improve accessibility as well as diversity of trails

$–Less than $1,000
$$–Less than 10,000
$$$–Less than $100,000
$$$$–Less than $1,000,000

Improve Accessibility ($): In order to increase the number of visitors to the ponds, access information needs to be improved. There are no directional signs on Rosamond Boulevard, or off of Sierra Highway, which could direct the public to the ponds. To increase the visibility of the ponds, signs could be installed along the roadways adjacent to the ponds. In addition, instruction needs to be given to Main Gate personnel as to the location of the ponds so that they may direct visitors. In conjunction with the education website, instructions on where the ponds are located as well as procedures to follow in order to gain access would be listed. Consideration should be given to setting up an automated system on the website for granting access for bird watchers and wildlife viewers, thus replacing the current memo format.

Themed Nature Walks ($): Nature walks led by volunteers or Environmental Management personnel could draw in more visitors, including base personnel and families to the ponds. Possibilities include full moon nature walks, which would occur on the eve of the full moon. These could take place either monthly or quarterly as resources allow. Other possibilities include wildlife photography walks, star gazing events, family themed nature walks, as well as archaeologically themed tours.

Informational Signs ($$): Increasing the number of educational signs at the ponds would improve the experience of visitors, whether they be duck hunters, birdwatchers, general public or school children. Signs describing the general history (e.g. the name Piute and relation to the Piute [Paiute] Native American tribe), habitat, the flora and fauna, the archaeological history and surrounding geography (e.g. the desert environment or the San Gabriel Mountains) could be added to the existing signs (Figure 29).

Figure 29. Informational Sign

Viewing and seating structures ($): Many wetlands have seating and viewing structures (e.g. bird hides) scattered throughout their location so that wildlife viewers or walkers/hikers may have an area to be more comfortable when viewing wildlife as well as to be used as a resting place. The ponds have no such facilities at this time. Installing a few benches or a picnic table under the pavilion for school children and others to eat lunch at would be a great enhancement to the ponds. A sample of a metal picnic table, which could be installed under the existing pavilion, is shown in Figure 30. The cost of the picnic tables range from $500 to $1,000.

Figure 30. Picnic Table

(http://www.picnictablesource.com/items.asp?Cc=MPT%2DAL)

Benches for wildlife viewing could be placed around the various ponds. The bench shown in Figure 31 costs less than $400.

Figure 31. Bench

Improve Roads and trails ($$$): The existing roads and trails at Piute Ponds are minimally maintained by District 14. Improving the quality of the roads would make other pond areas more accessible to visitors as some areas can only best be reached by car. If more ponds were readily accessible it would improve the options available to all visitors, whether they be birdwatchers or duck hunters. Volunteers could be a low-cost option for improving the trails. Without funding, installing either gravel or paved roads is not feasible as the cost would be in the one hundred thousands. Therefore, maintenance by volunteers would be the best alternative for improving existing trails at the ponds.

All of these recommendations will be available to the base to select at their own discretion. Our results and conclusions are summarized in the following section of this report.

9.0 CONCLUSIONS

The primary focus of the management of Piute Ponds should be on the ecological health. The educational and recreational opportunities are in part, dependant on this factor and the poll results indicate that this is where the stakeholders want attention focused. The most preferred future scenario is Scenario 6, with the same amount of water, but an increase in resources. It is unlikely that District 14 will increase the water supply to the ponds. Additional resources are needed if educational or recreational activities are to be increased and most likely just to maintain the ponds at their current ecological status.

One of the most important recommendations is to formalize the quantity of water supplied by District 14 with an MOU. Currently, District 14 EIR states that they will supply enough water to maintain or enhance the existing area of Piute Ponds. A definition of the quantity of water needed to maintain Piute Ponds and a definition of the current ecological status should be negotiated and agreed upon. A monitoring program will be necessary to ensure that the ecological status does not deteriorate. Installation of flow gauges, repairing control structures, and implementing a more comprehensive water quality monitoring program should also be priorities. Either modeling or surveying the overflows to Rosamond Dry Lake would allow for some overflow and flushing of the ponds to occur. This is highly desirable to maintain the water quality.

The creation of a vibrant and successful volunteer program should also be a top priority. This would build community awareness and participation and create a sense of ownership. It would provide manpower to complete some of the recommended projects if funding is not available. The frequency and variety of tours offered at Piute Ponds could be improved by establishing a permanent volunteer program at Edwards AFB.

To improve the ecological health of the ponds, the best options are removing invasive species, planting native trees, and building bird boxes and perches. All of these options are inexpensive and can use volunteers. They can be scaled to the amount of funding available. Increased monitoring is also necessary and can also be scaled to the available funding. Building bird islands is also an option if the ponds need to be dredged, as the additional cost would then be minimal. Additional research should be conducted on the possibility of introducing the Mojave tui chub.

To enhance the environmental education, creating a website to provide information to the general public would be the simplest and most cost-effective recommendation. A website could include maps of the area, as well as directions on how to access Piute Ponds. It could also include curriculum activities and projects for teachers and students to do while visiting Piute Ponds. If feasible, integrating a virtual tour of Piute Ponds would greatly enhance the public awareness. Increasing the number of school tours is another key recommendation for enhancing educational programs and for promoting Piute Ponds as an educational resource. Developing themed or specialized educational tours and nature walks at Piute Ponds would be one way of improving the diversity of education offered to the students, and would attract the attention of schools outside of the MEEC program. If funding were available, creating a permanent shuttle program for the school tours would be an effective way of increasing outreach opportunities.

Some of the top recommendations for improving the recreational activities at Piute Ponds would be to increase the number of informational signs, building picnic areas, and installing viewing structures, primarily for bird watchers. These improvements are cost effective and simple methods of enhancing the recreational activities for visitors to Piute Ponds.

It is also recommended that adaptive management be used in any future management plan. Adaptive management will allow Edwards AFB to respond to changing conditions and adopt the most successful management practices while discontinuing those that prove ineffective. Additional stakeholder input should be sought to gauge the success of future educational and recreational activities and the results incorporated into management plans.

In conclusion, there are multiple relatively inexpensive options that could improve the water quality, ecology, recreation, and education values of Piute Ponds. The various scenarios will provide options in the face of future uncertainties. Establishing a strong volunteer program, creating and implementing a comprehensive monitoring plan, reaching a final agreement with District 14, and utilizing adaptive management will create a strong groundwork for the future of the ponds. It is hoped that these recommendations will help Edwards AFB in the future management of this valuable resource.

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APPENDIX A: PIUTE PONDS OPINION POLL

Edwards Air Force Base is evaluating management options for Piute Ponds. Input is being sought on previous use of Piute Ponds, as well as expected use in the future.

1. **For which of the following activities have you visited Piute Ponds? Please mark as many options as apply:**

   __Guided tour

   __Recreation (hiking, biking, fishing, bird watching, nature walk)

   __Education (nature center, children's programs)

   __Hunting (ducks and other waterfowl)

   __Research (research projects with colleges or universities)

2. **What is the most recent date that you visited Piute Ponds?**

   ____

3. **Which of the following options are you interested in seeing developed or continued at Piute Ponds? Please rate on a scale of 1 to 5 your level of interest in the following options, with 1 being the least and 5 being the most interested. You may rate more than one option with the same level of interest:**

   __Nature Preserve (ecological and wildlife values with limited low impact recreation)

   __Recreation (hiking, biking, fishing, boating, camping, bird watching, nature walks, etc)

   __Education (tours, nature center, children's programs, etc)

   __Hunting (ducks and other waterfowl)

   __Research (research projects with colleges and universities)

   __Minimum Management (minimum management and maintenance required by regulations and law)

Additional Comments:

____

____

____

____

APPENDIX B: SAMPLE ACCESS PERMIT FOR BIRD WATCHING

The following form is a sample of the permit requesting access to Piute Ponds for bird watching.

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 95TH AIR BASE WING (AFMC)
EDWARDS AIR FORCE BASE, CALIFORNIA

95 SPTG/CC
36 North Wolfe Avenue
Edwards Air Force Base, California 93524-6745

____
____
____

Dear ____________________________

Your request to enter Edwards AFB to observe birds at Piute Ponds/Branch Park/South Base Ponds is approved. Your grant of access is valid for yourself and _____other guests during daylight hours from _______________ to _______________. There is no bird watching allowed at Piute Ponds on designated hunting days (Sundays, Wednesdays, federal holidays, and an occasional Saturday) during hunting season (mid-October to mid-January). This authorization letter, or a copy, must be in your possession at all times, and will be presented to a member of the Security Forces upon request. Note the following restrictions that apply to use of the areas authorized in this letter:

- You must contact the Security Police at (661) 277-3340, 48 hours prior to arrival and notify them of your anticipated arrival and departure dates/times

- Foot travel in all areas is restricted to dry ground surfaces

- Body contact with the water in Piute Ponds is prohibited

- Photography of aircraft is prohibited

- All vehicles must stay on existing roads

- Space shuttle landings and special military operations may require that Edwards AFB temporarily rescind this authorization

- This authorization letter is for bird watching only–it does not authorize hunting, media visits, or other activities

A copy of your field notes or a species list with approximate numbers observed would be greatly appreciated. Any special or unusual sightings or behavior, such as rare birds or evidence of species breeding, would be especially helpful. Please submit your data to Mr. Mark Hagan at Natural Resources Section, AFFTC/EMXC, 5 E. Popson Ave., Edwards AFB, CA 93524-1130.

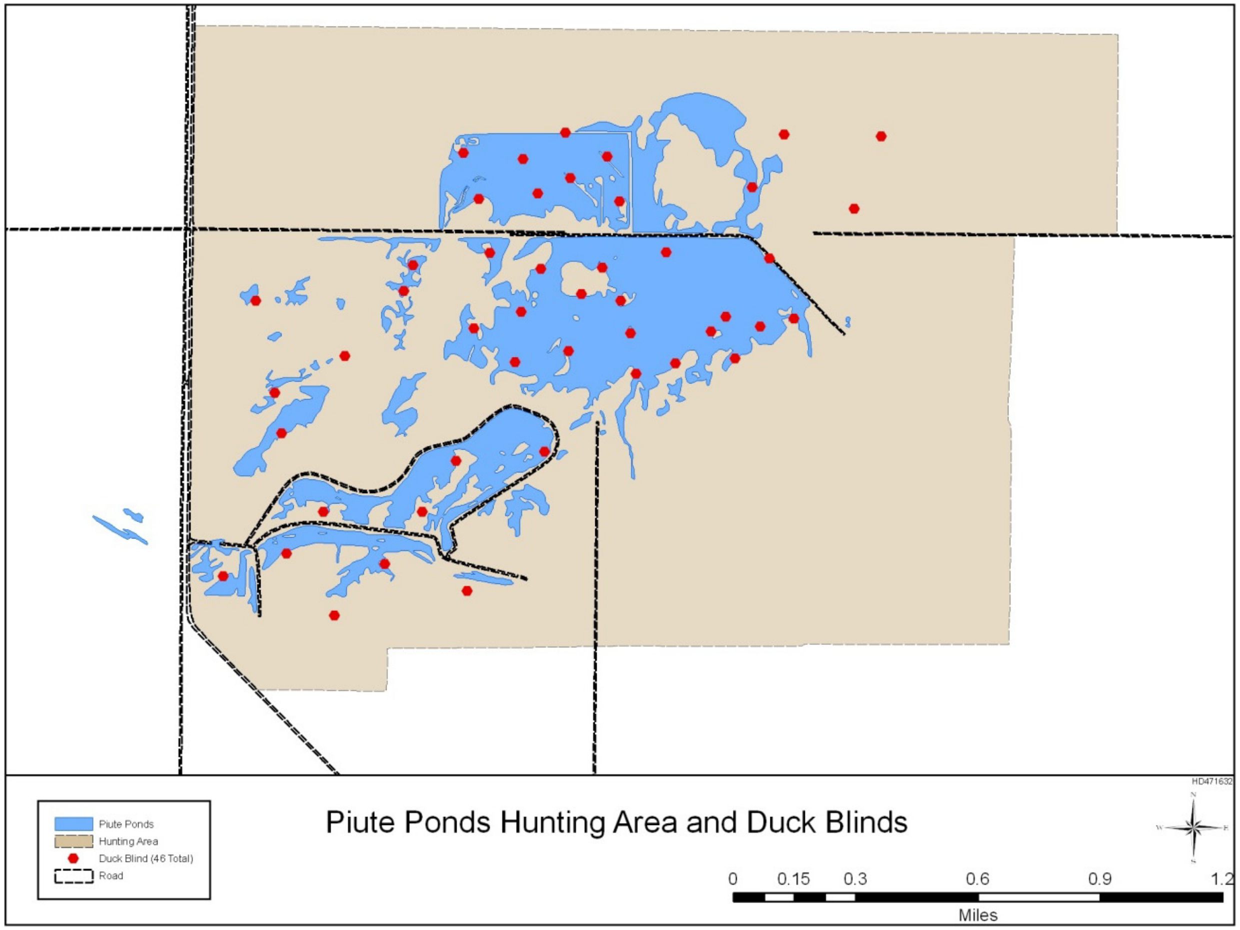
Remember that Edwards AFB is a military installation with restricted access and unauthorized entry constitutes trespass. Failure to comply with the conditions in this letter will result in the revocation of the privileges contained herein and could have further consequences. Additionally, you are directly responsible for the acts of any guest whom you bring onto the installation.

For additional information or assistance please contact Mr. Mark Hagan at (661) 277-1418 or Mr. Chris Rush at (661) 277-1425. I hope your observation and study efforts prove both productive and enjoyable.

Sincerely,

Colonel, USAF
Commander

APPENDIX C: DUCK BLINDS



APPENDIX D: PIUTE PONDS INFORMATIONAL SIGN

Welcome to Piute Ponds

Suggestions

Bring your camera.
Bring your binoculars.
Bring your walking shoes.
Bring your hat and sunscreen.
Bring your sense of adventure.
Use the facilities before you go.
This is an easy 1.4-mile walk with informational signs placed for your convenience.
We hope you enjoy your time spent here.

Rules

- Stay on trails.
- Stay out of the water.
- Do not feed the wildlife.
- No dumping of trash.
- No loud noises that would scare the wildlife.
- Dogs must be on a leash.
- No shooting, except during hunting season.
- During hunting season (November through January), please call hunting hotline prior to entering area : 661-277-1449.

❶ Vegetation ❷ Hunting ❸ Insects/Amphibians ❹ Birds/Nests ❺ Waterfowl ❻ Mammals

The Piute Ponds were formed in 1961 by the construction of a dike to contain discharged reclaimed water from the nearby Los Angeles County District 14 sewage treatment plant. Treated water was spilling over into the dry lakebed that serves as an aircraft landing site.

If you are quiet, and observe, you will experience the wonder of Piute Ponds!

APPENDIX E: PROPOSAL COMMENTS AND RESPONSES FOR MANAGEMENT RECOMMENDATIONS FOR PIUTE PONDS

Edwards Air Force Base received the following comments on the Management Recommendations for Piute Ponds Proposal. Approximately 40 copies of the proposal were mailed or submitted electronically based on the distribution list and upon request. About eight comment letters or emails were received on the proposal and were compiled addressed by the group.

San Fernando Valley Audubon Society

General Comments

Comment: Urges Edwards AFB to "continue its fine tradition of stewardship for this resource by preserving Piute Ponds and the associated wetlands current wetted size of 600 to 800 acres, undertaking restoration projects that enhance wildlife habitat, monitoring both migrating and resident bird populations and providing access for bird watching in future management plans.

Response: Agree with recommendation and it will be included in the final document.

Comment: Some board members are very concerned with changes in water treatment practices which could result in a gain or loss of water for Piute Ponds, as well as the increased urbanization of the surrounding areas which might someday result in competition for water resources.

Response: Agree with comment and will seek to formalize MOU for quantity of water.

Comment: Other board members are concerned with the Piute Ponds complex being viewed as a liability by the air force because of the aircraft/bird strikes.

Response: Concern will be addressed in Scenario Risks section of final report.

Comment: Some board members wonder what the purpose and benefit of a new management plan might be.

Response: No formal management plan currently exists for Piute Ponds. Further details are explained in the Significance section of the final report.

Comment: Scenarios 6,7,8,9 would best maintain or increase water quantity and quality, preserve and enhance wildlife habitat, provide educational and recreational opportunities that have a limited effect on Piute Ponds and monitor the ecological health of the ponds and their associated wetlands. It is recommended that the Piute group research the feasibility and impacts of these scenarios further.

Response: Recommendation already incorporated into final report under Scenarios and Recommendations section.

Comment: Overflows can occur without damaging the dry lakebed, since the current ponds no spill over into the adjacent desert without damaging the ponds. Is the MOU strictly because of the fact that the dry lakebed is used as an emergency landing area, or is there fear of damaging the dry lakebed?

Response: The overflow helps the integrity of the lakebeds, but limits the use for emergency landings.

Comment: There is an outlet to the ponds other than the dry lakebed. Water from the north pond flows into the Mojave Desert.

Response: All flow eventually goes to the dry lakebed, even if it overflows into the Mojave Desert.

Water Quality and Quantity Comments

Comment: The amount of water available to Piute Ponds and associated wetlands should be maintained at 600 – 800 acres or increased.

Response: The amount of water is to be determined and evaluated in conjunction with District 14.

Comment: Formal agreements with existing agencies securing this water are desirable, including provisions that take into consideration increased evaporation of surface water due to increased temperatures from climate change.

Response: Agree with comment and will be included in Recommendations section of final report. Further details will be included in MOU with District 14.

Comment: Future water management plan should have goal of creating a variety of wildlife habitat by varying water depth at different points in Piute Ponds.

Response: Agree with comment and will be included in Recommendations section of final report.

Ecological Health Comments

Comment: Urges Edwards AFB to continue ecological monitoring and to use the data already collected by Mark Hagan and Wanda Deal, as well as Kimball Garrett, Ornithology Collections Manager at the LA County Museum of Natural History as a baseline for monitoring the ecological health of Piute Ponds and the associated wetlands.

Response: Agree with comment and will be incorporated into final report.

Comment: Restoration efforts to combat the problem of increased nitrate concentration in conjunction with control of invasive species are essential to maintaining a healthy wetland ecosystem and should be made a priority in the recommendations.

Response: Agree with comment and will be included in final report.

Comment: Does not agree that monitoring year round residents of bird populations would provide a better metric for the status of the ponds. One issue with this approach is that the data would not provide a complete picture of species richness and evenness on Edwards AFB and neglect to see the ponds as significant migration and wintering grounds.

Response: To be address in Methodology section in final report.

Recreational Comments

Comment: Edwards AFB should continue to provide access for birdwatchers and other traditional recreational users like hunters. It is questionable whether creating a campground would be a desirable addition to Piute Ponds because of the lack of shade and wonder if the ponds are too shallow to support game fish. Fish introductions are also a concern because they can impact the primary production of aquatic ecosystems and even bring about undesirable secondary effects like trophic cascade. Edwards AFB is strongly urged to carefully study the impacts of these activities before taking action.

Response: Agree and will be included in Recreation section of final report.

County of Los Angeles Department of Parks and Recreation

General Comments

Comment: The project site is located within a County designated Significant Ecological Area (SEA), "Rosamond Dry Lake and Piute Ponds". As such, the project would normally be subject to review by the County's Significant Ecological Area Technical Advisory Committee (SEATAC). The County Department of Regional Planning, Impact Analysis Section is responsible for coordinating proposed project reviews with SEATAC.

Response: Formal plans will be sent to LA County when completed for review under standard NEPA procedures.

U.S. Fish and Wildlife Service

Ecological Health Comment

Comment: Piute Ponds should be managed at an ecosystem level to maximize the diversity of aquatic, wetland, and riparian habitats. Although emphasis for managing Piute Ponds should be put on the migratory birds (e.g. tricolored blackbirds, etc.), listed species and prelisting recovery (e.g. western snowy plover-inland population), one of the best ways to do this is to manage the ecosystem by the defining the components. Since Piute is a complex of varying types of wetlands (i.e. deep pools and shallow areas, open water and emergent vegetation, etc.), it seems that it would be important to define the assessment area, perhaps developing and implementing techniques tailored to the various types of aquatic habitat.

Response: Agree with comment and will be included in the Recommendations section of final report.

Comment: The definition of an assessment area is important because it influences how the data is collected and how the results are reported, understood, and used (e.g. by area of wetland resource, by wetland). It is important that the definition of the assessment area be thoroughly evaluated prior to the implementation of monitoring efforts. This evaluation should consider:

- How well the definition can be applied in sample design and site selection (e.g., can it be used with mapped or GIS information)
- How well and consistently the definition can be applied in the field
- How ecologically meaningful the results will be
- How useful the results will be in achieving the objectives of the monitoring or management program.

Key reference to check out:

Fennessy, M.S., A.D. Jacobs, and M.E. Kentula. 2004. Review of Rapid Methods for Assessing Wetland Condition. EPA/620/R-04/009. U.S. Environmental Protection Agency, Washington, D.C.

Response: Will most likely be included in a formal monitoring plan when developed by Edwards AFB.

District 14

General Comments

Comment: Supports a long-term management plan for Piute Ponds and is interested in being involved in the process.

Response: Agree with comment.

Comment: The primary purpose for commenting on the proposal is to ensure consistency with approved *Final Lancaster Water Reclamation Plant 2020 Facilities Plan and Environmental Impact Report* and all related agreements and commitments.

Response: Agree with comment.

Water Quality and Quantity Comments

Comment: Recommends that the scope of work in the draft proposal, particularly flow scenarios that would increase effluent flow to the ponds, be reconsidered given the Edwards AFB position to the Regional Board and the resulting constraints regarding overflow to Rosamond Dry Lake.

Response: Agree with recommendation and states that Edwards AFB must approve all flushing overflows. For further details see Scenario section.

Comment: A flushing program with overflows to Rosamond Dry Lake could restore mudflat habitat that is important to certain bird species. D14 believes that recommendations on a salinity management program are an essential requirement of the Piute Ponds Management Plan. Such recommendations should consider potential flushing by stormwater runoff, which is not accounted for in the D14s hydrodynamic water quality model for Piute Ponds.

Response: Agree with recommendation.

Recreational Comments

Comment: The proposal should acknowledge that Piute Ponds are man-made ponds that have been and will continue to be sustained with treated wastewater. As such, it is inappropriate to consider the use of the ponds for fishing.

Response: To be addressed in Recommendations section of final report.

Department of Transportation

General Comments

Comment: One question of special interest is the presence or absence of endangered species at the site. The referenced EIR in the report is dated 2004, however the Bio Studies for the EIR was conducted in 2001. Based on this information, the presence/absence findings are not current and may not still support a valid conclusion on the absence of endangered species on the site. Further, the presence/absence surveys for Desert Tortoise (DT) and Mohave Ground Squirrel (MGS) may not have been conducted according to the USFWS and DFG's protocols.

Response: Edwards AFB resurveys the base property as established by the *Integrated Natural Resources Management Plan*, which is approved by USFWS.

Kerncrest Audubon Society

General Comments

Comment: Concerns with the season(s) of the year when the CRAM study will be done, since the area is a national Important Bird Area. Surveys must be done in spring, fall, and winter to adequately cover the numerous bird species using Piute Ponds.

Response: Agree with concern and will take into consideration when developing management recommendations.

Comment: Edwards AFB is urged to remember that the area is a desert and that the water resource is finite, especially with consideration to continuing development of housing and attendant malls and businesses.

Response: Agree with comment.

Los Angeles Audubon Society

Recreational Comments

Comment: Recommends looking at Arcata Marsh and Wildlife Sanctuary as a reference for Piute Ponds, especially with regard to potential wildlife viewing recreational opportunities and the potential economic benefits of that wildlife viewing recreation.

Response: Agree with comment and will be included in Recommendations section of final document.

Comment: The recreational data that was gathered from permit applications at Edwards AFB does not give the full picture of the current wildlife viewing at Piute Ponds unless permit applications show actual numbers of wildlife viewers who accompanied permit holders. LA Audubon and other chapters of Audubon conduct regular educational field trips of ten or more participants who may accompany a permit holder, and permit holders frequently bring guests when visiting Piute Ponds on their own.

Response: To be addressed in Data and Current Status section of final report.

Mojave Environmental Education Consortium (MEEC)

General Comments

Comment: Agree with environmental education components

APPENDIX F: STAKEHOLDER FEEDBACK ON OPINION POLL

The following table shows the feedback received from the opinion poll sent out by Edwards AFB. The options for the poll were as follows:

Nature Preserve
Hunting
Education
Recreation
Research
Minimal Management

For which of the following activities have you visited Piute Ponds? Please mark as many options as apply:					Last visit to Piute Ponds?	Which of the following options are you interested in seeing developed or continued at Piute Ponds? Please rate on a scale of 1 to 5 your level of interest in the following options, with 1 being the least and 5 being the most interested. You may rate more than one option with the same level of interest:						Additional Comments:
Guided tour	Recreation	Education	Hunting	Research		Nature Preserve	Recreation	Education	Hunting	Research	Minimum Management	
	1				End of April, 2008	5	3	2	1	2	4	You have a fabulous habitat there in the confines of your facility! Thanks so much for sharing it with the public. We didn't have much notice that we would be in your area, but Jennifer Beich was most helpful getting us permission, quickly. The day we were actually there, we were escorted by John McGee, who was very much in charge, while also allowing us the freedom to look where we chose. Terrific guy! We logged 43 species of birds that day. We strongly encourage you to continue to allow access of this area, but keep it wild and natural.
1	1				October 2008 (don't have exact date. But I hope to visit the ponds at least three times a year.	5	4	2	1	3		(Did not answer last column, did not know what it meant)–Edwards AFB does a wonderful job of maintaining a wonderful ecosystem in the Antelope Valley. The ponds are a vital area for bird migration and maintaining other wildlife. It also seems to be a great public relations tool for the Air Force.

						5	2	4	2	3	3	
						5	1	5	1	4	1	
1					2 years ago	5	5	5	1	5	1	Excellent opportunity to use existing resource to advance understanding of a wetland in an avid environment.
	1				Spring 2008	5	5	4	2	3	5	Also, visited Ponds for USGS Survey
				1	Spring 2006	5	4	5	2	5	2	Research for projects with contracted surveys.
1					Aug-07							
1					DMG Meeting - 2004?	1	5	2		3	4	Edwards should get a mitigator credit for chub.
						5	3	4	4	3	2	1.) Keep it managed at broadly as you can. 2.) Rec. hunting in this area may be a good idea if it were well regulated.
	1	1			Spring 2008	1	2	3	5	4		
	1				2/18/06	5	5	3	3	3	3	The Piute Ponds are a wonderful resource that should be open to the public in a controlled fashion. Thanks for the opportunity to come out and study the birds.
	1	1			3/6/08	4	1	4	3	5		
	1				3/4/08	5	4	2		3		
	1					5	2	4	1	5	5	From the perspective of a bird watcher, I prefer to see the ponds remain as they are. I assume this means minimum management
	1		1		12/2/08	3			5	4	5	
1					5/19/99		5	5				
	1	1			Mar-05	1	4	2	5	3		Piute Ponds is a very important wildlife position. It is a major stopover for migrating birds, as well as an important water source for native animals. Preservation of this area is vitally important for our planet's preservation.
						5		5			5	No motorcycles or off-road vehicles to ruin the area.

						1	5	5	5	5	5	We are always being told what we can do and can not do, we need minimum management required by law, regulations. We need to do what, will take the least amount of money, right now ME, US TAX PAYERS don't want to see money spent on anything extra, I have emailed the Governors' office about spending money on this kind of programs, when we make cuts everyone has to do their part, so this country can get back on its feet. In better times this would be great until our countries financial situation turns around, we must go with (minimum management and maintenance) that is required. But this is not to say that we should stop research projects with colleges or universities, and we should keep nature tours for children, but a lot of things in government has got to go as I keep telling my congressman Kevin McCarthy, and my Senator, in Washington DC and my Congressman in Bakersfield, CA, is work to help with our financial situation, our governor also very well understands the budget problems so you can see where I stand. Thank you. Bob Glenn 661-823-8833 1480 Arabian Dr., Tehachapi, CA 93215
1		1				5		5		5		Keep the Ponds controlled, with limited access on pre-arranged basis… not a public recreation site… or the area will be ruined and become a trash dumb.
	1	1	1	1	5/21/90	5	3	5	2	4	1	
						5	4	4	1	4	3	
1	1				4/26/08	5	4	3	1	5	5	My most recent visit was the Lockheed-Martin-sponsored tree planting
						5	5	5	1	1	5	I've never been to the pond and didn't actually know where it was…but I have heard of it.
1	1	1			7/8/08	5	3	5	0	2	1	There should not be any hunting at this place
1					Pending 2009	5	5	3	1	3	3	Protect this valuable Resource for Future visitor
	1				1999 (Due to access issued and security (personal))	3	5	5	3	3	2	

	1	1			5/10/08	5	5	5	1	3	5	We need to keep Nature and the Eco System as natural as possible
					Have never visited- However Friends have	4		5				
					Never been there	5	4	3	3	3	3	Although I've never been there, I like to see preserves established to insure "other than humans" can have some habitat. We humans destroy so much in our quest for whatever. Too bad we don't show "survival of the fittest".
1					5/1/08	1	1	1	1	1	5	I am deeply concerned that a wide variety of invasive species are hosted at the Piute Ponds, impacting native species in the area. Non-native plants at Piute Ponds transmit seed via the wind to neighboring natural areas. Overflow flooding can spread the African clawed frog. Any way you look at it, the "ponds" are not natural waters, the "wetlands" are not native riparian vegetation, and the birds attracted to the site are not native to our area. In my opinion, Piute Ponds should be reduced and eliminated, and ideally the natural Amargosa Creek runoff would be restored to sustain the landing surface of the dry lake.
		1			not recently	4	5	5	1	4	4	
	1				?							This is not a naturally occurring freshwater marsh. It only exists as a result of the effluent from Edwards AFB. Therefore, it should not be protected as if it were a pristine part of nature. I suggest that in the interest of efficiency and security of the base, access should be limited.
	1				7/2/04		5				1	I loved to go birding at Piute Pond. It was the best birding in Kern County. I would love to see it continue just as it is. Please do not mess with its use. Thank you. Judith J. Stemmler
	1	1			7/2//2004							
	1	1			7/2/04		5				1	
	1				3/4/08	5	1	3	1	4	1	This is a very important bird habitat and I would like to see it preserved as such, Birders are very low impact users of the resource.

	1				9/20/08	5	1	3	3	4	2	It would be nice to have the area more open to the public for limited use (walking, hiking [on established trails], bird watching, etc.), but I would not like to see the area opened to general fishing, boating, biking, camping, etc. The latter uses would destroy the ecological value of the site. Piute Ponds should be maintained in its current state.
	1				9/20/08	5	3	4	1	2	3	It would be nice if access was easier (not requiring a letter) or if that's not possible, that permission is renewed automatically or given for a longer period than one year. Also, it would be nice if access were possible via D Street (there is a gate there now but it is usually locked.)
	1				2/23/08	5	5	3	0	4	1	Great area and habitat for birding and wildlife and should be kept that way with regular maintenance. No or very limited hunting. They don't even pick up their empty shells. Birding and nature walks should be top priority. Would visit more if I lived closer. Audubon member.
	1				2/7/08	5	4	3	1	1	2	Please save Piute Ponds as the Nature reserve it has become for thousands of waterfowl and other birds!
		1			12/23/08	5	5	5	2	4	3	I frequent the ponds regularly and find it one of the most fascinating areas in the Antelope Valley. I have been able to observe and photograph birds and at least once this year a rare sighting… The Trumpeter swan that visited early 2008. It was great resource for the nature lovers here.
	1				2/3/00	4	5	3	1	2	1	
	1	1			4/13/08	2	2	5	1	5	5	Piute Ponds is a very important birding location in Southern CA. In California's ever shrinking natural habitat areas, it is a necessary migration stopping point for thousands of migrating birds flying in both directions. The Ponds have all the necessary ingredients that makes this migration stopover great, it has water, safety, vegetation and isolation. It is also a vital habitat for many local non-migratory species. It is crucial that the water, vegetation and access is closely monitored and managed. Please do not

												let it get developed or turned into a multi use recreational area. I put a 2 under recreation above because if you allow hiking, biking, fishing, boating, camping in this area it will absolutely destroy the bird habitat. I have been studying and watching birds for over 30 years and have seen over 500 species, I have been to several wildlife areas with limited access that have been turned into "recreational use" areas and the birds leave. I hop! e that you can maintain the limited access, and preserve this very important birding area. Thank you for asking me my opinion. I have been going to Piute Ponds with birding groups in the past and have not needed a permission letter, but if I could get one now for this coming year I would greatly appreciate it. Thanks again Brian M. Ashton 18908 Cabral Sty. Canyon Country, CA 91351 661.251.3433
	1				9/12/08	5	3	3	1	5	0	
			1		12/28/08	4	2	1	5	3	0	I hunt ducks and waterfowl in the area and would like to continue to do this as waterfowl management.
	1				1/2/09	5	5	3	3	2	3	I try to go to Piute Ponds at least 1 day out of every weekend. Bird's and other wildlife thrive in the middle of the desert because of the limited access and use. My wife and I both find it wonderful the way that it is. Don and Jill Davis
	1				12/19/08	5	5	2	0	3	5	I use this area for photography, mostly birds. Not sure how much of the area surrounding Piute Ponds is open for exploration and photography? I typically visit the Ponds at least once a week, sometimes more during the summer. Too bad hunting is allowed because the birds are very skittish. Makes it a challenge to photograph the wildlife. Thanks, Mike Smith
		1			4/26/09	5	4	5	3	5	4	
			1		12/31/08				5			
	1				Over two years ago	5	4	2	1	3		We have not been to Piute Ponds recently due to travel.
	1				4/24/08	5	5					

			1		11/27/08		3		5			
	1				4/6/08	5	1	5	5	5	1	Hi. I work at the Veteran's Admin in LA so I know it is not always easy to find the funding for projects like the ponds. Additional management of the ponds to enhance what you already have (such as the new" ponds and some road repair, plant species management, etc.) would be in the best interests of the wildlife you serve. But you have done a superb job in the past and I would like to see no major changes. As a bird watcher I have to say ALL the hunters I have ever met at the ponds have been polite, friendly folks. I think camping might be a bit much for the ponds and would ruin the surrounding habitat as people let their dogs run through the brush, etc. (Camping would also introduce trash and sanitation problems) Biking would add an element that would stress out birds and might force them out of the ponds and lessen the hunting stocks. The only boating I would like to see is for the hunters. The ponds are very serene and peaceful and recreational! l boating would ruin them. As a bird watcher, I have seen some very sensitive species in the ponds and surrounding brush that you cannot see elsewhere. These species of birds and probably many animals and insects and plant life are limited in their choices of home and the ponds provide them with a place to survive. Thank you for letting me participate in your survey, especially on-line. I will send an e-mail to Wanda regarding the mailing list. If you have any questions regarding my comments my e-mail is
1	1				1/6/07	5	1	5	5	5	1	Piute Pond is a sanctuary for wild life. It needs to be respected. Thank you so much for doing such a great job with the ponds. We are bird watchers and have always appreciated the opportunity to visit the ponds. Thank you for taking the survey and asking for our opinions, it shows that you care. Thank you. I would be interested in donating to the maintenance or upkeep of the Ponds. Please keep the birds coming and preserve the wildlife. Biking, fishing,

												camping will only disturb the environment and not very conducive to preserving the environment. I would like to nature walk, education programs, guided tours implemented. Thank you so much for your concerns!!!!
	1				1/6/08	5	5					
			1		12/10/08	5	4	3	5	3	4	
			1		1/4/09	1	5	4	5	5	1	I would like to see the entire Piute Ponds area managed for better duck populations. The North pond area 14 my opinion needs a lot of work. Would like to see more water directed to the North pond areas.
	1				1/3/09	5	5		5			Piute is very well managed as is.
												Any of the four options in #3 or any combination is acceptable.
	1				1990	5	5	5	1	4	5	Need a Senior Bus, from Palmdale with pickup in Lancaster-from Senior Centers noone is aware of area. Piute Ponds in add in A.V. paper-Summer time. Joseph Yore (Need some Deer-Ya)
			1			1	2	4	5	3		
						5	5	4	1	4	4	
	1				12/20/08	4	5	3	1	3	2	
	1				10/14/08	5	5	5	4	5	4	Improvement of road access to southern ponds would be nice.
	1				8/22/07	5	5	3	1	1	1	Fantastic area for watching birds. I greatly appreciate being granted access to the Piute Ponds. Thank You!!
			1		1/7/09	5	1	1	5	5	1	Edwards AFB has supported hunting and the education to the youth hunter. The use of this area and the education/development it has brought to my family has been wonderful. Please keep up the great work and allow the hunting to be a part of Piute ponds.
	1				2/19/01	5	5	5	3	5	5	
					2/19/01	5	5	5	3	5	5	Thank You for the opportunity to share my opinions.
			1		1/4/09		1	3	5	3		I used to drive 262 miles 1 way to hunt ducks at Los Banos Wildlife area. This area is so convenient, but I am wondering if you are going to make this a non hunting area? I have been hunting

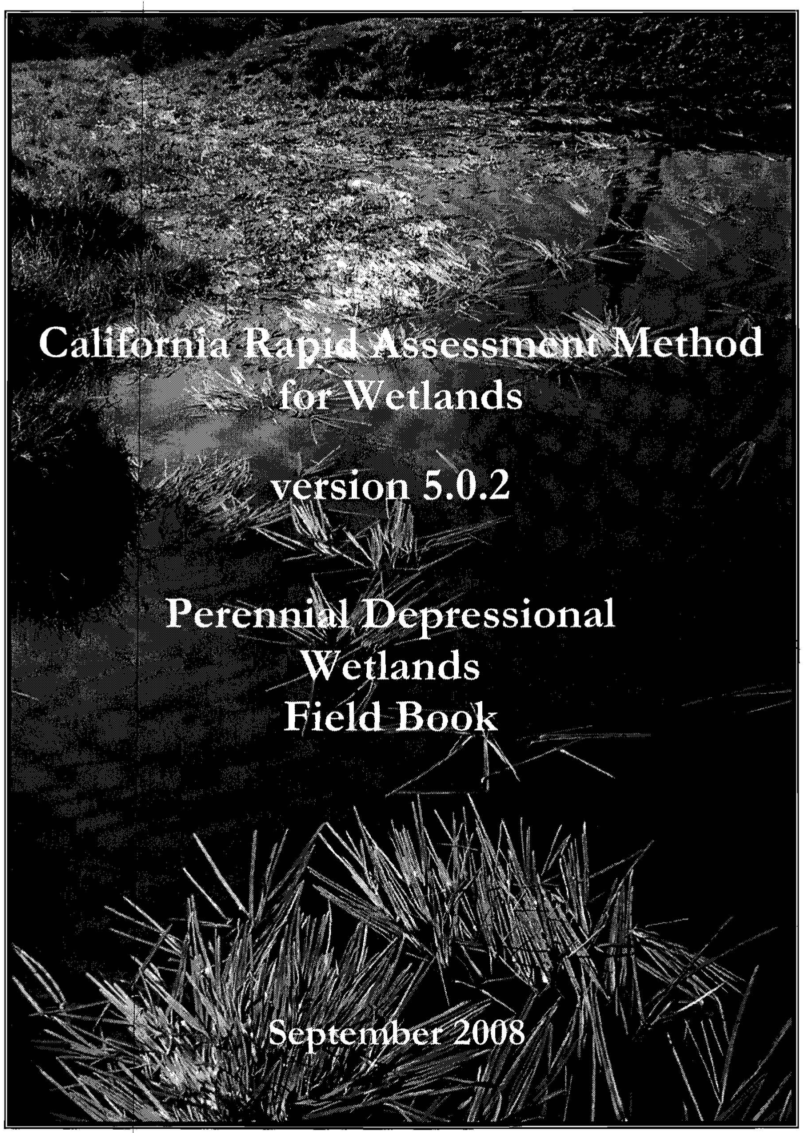
												on base for about 10 years. It is the reason that I stay employed on Edwards AFB as a contractor. In fact I shudder to think of what I will do when I someday retire and have no connection to the base. I think the area, with some improvements could be so much more, than it is now. John Denton
			1		1/7/09	4	3	2	5	1		
1	1				2008	5	4	5	4	5	1	I recognize that hunters support wetlands and we need their support (certain days open for hunting). I am concerned as a birder/nature walk guide that too many boats/fisherman will keep the waterfowl away from the ponds.
			1		2008				5		5	1. Keep it a Wildlife/Water Fowl priority. Fishing also. 2. Need to do some Reed,Cat tail growth control-most of the really great hidden ponds are now gone. 3. The sewage sediments is a real mess and dangerous to the area. Did not always be this way.
			1		12/17/08			5	5	3	1	I want to rate Nature Preserve a 5, but I fear some might interpret it as mutually exclusive of hunting. I would like to see enhancements made to increase the wildlife capacity at the ponds (including but not limited to dredging, planting food and habitat enhancement). I believe hunting can be a source of funding to help manage the ponds for the benefit of all. Mac Frey
1	1				8/30/08	1	4	3	2	3	1	As someone who has been birding, and leading bird trips, at the Piute Ponds, I am continuously impressed with the amount of life it supports. Many bird species occur at the Piute Ponds and nowhere else in the western Mojave (or LA County). There is potential for management to encourage even more sensitive bird species to reside there, but it's also excellent as it is.
			1		12/31/08	5	5	5	5	5	5	
	1				6/4/08	5	5	3	2	4	1	Thank you for sharing this wonderful area with the public. My 83 yr old father enjoys seeing the birds and tells me the stories about Edwards when he worked out there.

	1				9/3/01	5	5	1	1	1	5	mail received neglected to include https:// as part of the web address.
	1				9/27/08	5	5	5	1	3	3	Piute Ponds is a wonderful resource, and I applaud Edwards AFB for any steps taken to not only preserve, but also enrich, this area.
	1	1			5/23/03	4	5	5	3	5	1	I used Piute Pond on a regular basis to enrich my class curriculum with amazing results. My job has since changed, but I recently worked with some of the students I had in 2003, and they shared comments about that year. They reported that they "remembered everything about Piute" and that "that was the best year they had in school." The opportunity to connect the classroom curriculum with "real" science through Piute Pond makes it an invaluable resource to our local schools. It also provides another way to connect to our community beyond aerospace, and to link to a part of our desert environment most people are unaware of.
		1				3	4	5	1	2		
	1			1	2007	5	3	4	2	5	1	The Wetland at Piute ponds provide important Natural Resource values; appreciate the Air Force's consideration of these resources.
	1				2006	5	5					
			1		12/21/08				5			I used to hunt ducks at our duck club right on the other side of the treatment plants as a child. Our club is long gone as is all the other clubs in the valley. The Piute is the only one left. I would like to see the Piute stay a hunting club for generations to come.
1	1	1		1	12/20/08	5	5	3	5	5		
	1					5	5	5	5	5	5	Nature Preserves should be preserved for public and education whenever possible. Our wildlife and hunting are very important.
	1				2006	5	3			5		As the largest freshwater marsh in LA County, I would like to see the Piute Ponds treated as a Nature Reserve, following, the European model; this includes collecting scientific data at the ponds, which is currently lacking (to the best of my knowledge), especially for

												wetland birds of interest (waterfowl, other waterbirds, tricdael and yellow-headed blackbirds, etc.). Attached is my card, with several publications on wetland birds (not in CA). Our company currently has 4 wind farm projects in Southern Kern County, and is about to srsh an on-call service agreement with the City of Lancaster. If you develop a management plan for Piute Ponds that incorporates scientific methods, we would like to be part of that effort. Sincerely, Doug McNair
	1				12/11/08	5			3		5	I am a birder and it is an awesome place to observe a wide variety of species on a year round basis. The little amount of development allows for peace and solitude in an otherwise busy world. The duck hunters helped in developing it so I do not think they should be precluded from use. Thanks you for taking my comments.
					11/5/08							we birdwatchers in los Angeles value Piute ponds greatly. thanks for maintaining them and allowing us to bird them.
	1											
	1				9/18/08	3	5	1	1	1	1	
						1	5	5	2	5	1	Warm water panfish like crappie may do well here for recreational fishing. I have never seen readily available info on how to get on base to visit these ponds, such as signage possible on Ave E.
						1	4	5	1	3	1	I've actually never had the honor of visiting. I teach Chem and Physics at Eastside High. Thanks! Dr. Chapleau
			1		1/7/09							
	1		1		12/28/08		4	1	5	2	3	
	1				12/13/08	1	1	2	5	2	5	Access from the South-Division and Ave. E are from the West on Ave. C Note: I was unable to bring up your web site.?
1	1				2007	5	4	3	0	5	0	An important resource! Please continue to allow birding access. A permit or fee system could fund it.
			1		12/31/08	3	1	1	5	1	3	
	1					5	5	5	1	4	5	We often talk about returning but forget

												to renew our permit. I will do so now and I hope you can con't the programs listed, although I'm against hunting (minority, I'm sure)
	1				2008							The ponds provide an ideal habitat for wintering birds and summer nesting birds.
	1	1			6/13/08	5	3	3	2	4	2	
			1		1/11/09							Drain,level ponds. Then only flood 2-3 feet, for safety. Increase pond area and number of blinds. Open hunting to Antelope valley residents twice monthly, use fees collected for new good blinds and expansion. Change jump shooting time to 8:00AM. Have designated parking areas and enforce it.
	1				2008	5	5	3	1	3	1	The first time we went to Piute Ponds, we assumend that someone at the Air Force Base Gate would be able to give us directions. We were wrong, although everyone tried and was very nice.
	1					5	4	3	1	2		I am an avid birdwatcher and environmentalist, as well as a licensed master Falconer. Piute Ponds provide a important migration layover for many species. I have seen Golden Eagles, Prairie Falcons, and other raptors there, and have heard of Peregrine Falcon sightings as well.
1	1	1			9/8/08	5	3	4	1	4	2	
11	34	13	5	2		87	88	84	85	83	74	
						370	336	307	222	292	206	

APPENDIX G: CRAM SURVEY RESULTS



California Rapid Assessment Method
for Wetlands

version 5.0.2

Perennial Depressional
Wetlands
Field Book

September 2008

Basic Information Sheet: Perennial Depressional Wetlands

Your Name: DAVID CHARLTON

Assessment Area Name: PIUTE PONDS

Assessment No.	1	**Date (m/d/y)**	10	9	08

Assessment Team Members for This AA

WES KING

AA Category:

☐ Restoration ☐ Mitigation ☐ Impacted ☒ Other

Which best describes the type of depressional wetland?

☐ freshwater marsh ☐ alkaline marsh ☐ alkali flat ☒ other (specify):

IMPOUNDMENT

Which best describes the hydrologic state of the wetland at the time of assessment?

☒ ponded/inundated ☐ saturated soil, but no surface water ☐ dry

What is the apparent hydrologic regime of the wetland?

Long-duration depressional wetlands are defined as supporting surface water for > 9 months of the year (in > 5 out of 10 years.) *Medium-duration* depressional wetlands are defined as supporting surface water for between 4 and 9 months of the year. *Short-duration* wetlands possess surface water between 2 weeks and 4 months of the year.

☒ long-duration ☐ medium-duration ☐ short-duration

Does your wetland connect with the floodplain of a nearby stream? ☐ yes ☒ no

Is the topographic basin of the wetland ☒ distinct **or** ☐ indistinct **?**

An *indistinct*, such as vernal pool complexes and large wet meadows, which may be intricately interspersed with uplands or seemingly homogeneous over very large areas, topographic basin is one that lacks obvious boundaries between wetland and upland. Examples of such features are seasonal, depressional wetlands in very low-gradient landscapes.

Photo Identification Numbers and Description:

	Photo ID No.	Description	Latitude	Longitude	Datum
1		North			
2		South			
3		East			
4		West			
5					
6					

Comments:

NO PHOTOS YET

Scoring Sheet: Perennial Depressional Wetlands

AA Name:				**(m/d/y)** 10 14 08
Attributes and Metrics		**Scores**		**Comments**
Buffer and Landscape Context				
Landscape Connectivity (D)		C= 6		$D+[C\times(A\times B)^{1/2}]^{1/2}$
Buffer submetric A: *Percent of AA with Buffer*	C= 6	▨		$6+[12\times(6\times12)^{1/2}]^{1/2}$
Buffer submetric B: *Average Buffer Width*	A=12	▨		$6+[12\times72^{1/2}]^{1/2}$ $6+[12\times8.49]^{1/2}$
Buffer submetric C: *Buffer Condition*	A= 12	▨		$6+10.09=16.09$
$D+[C\times(A\times B)^{1/2}]^{1/2}$ = **Attribute Score**		Raw 16.09	Final 67.04	Final Attribute Score = (Raw Score/24)100
Hydrology				
Water Source		6		
Hydroperiod or Channel Stability		3		
Hydrologic Connectivity		9		
Attribute Score		Raw 18	Final 50	Final Attribute Score = (Raw Score/36)100
Physical Structure				
Structural Patch Richness		D= 3		
Topographic Complexity		D = 3		
Attribute Score		Raw 6	Final 25	Final Attribute Score = (Raw Score/24)100
Biotic Structure				
Plant Community submetric A: *Number of Plant Layers*	C= 6	▨		
Plant Community submetric B: *Number of Co-dominant species*	C= 6	▨		
Plant Community submetric C: *Percent Invasion*	B = 9	▨		
Plant Community Metric (*average of submetrics A-C*)		C=7		
Horizontal Interspersion and Zonation		A = 12		
Vertical Biotic Structure		D = 3		
Attribute Score		Raw 22	Final 61	Final Attribute Score = (Raw Score/36)100
Overall AA Score		203.04		**Average of Final Attribute Scores** 50.76

↑
Total of all final attribute score:

Scoring Sheet: Perennial Depressional Wetlands #2

AA Name:		**(m/d/y)**	10	14 08
Attributes and Metrics		**Scores**		**Comments**
Buffer and Landscape Context				$D+[C\times(A\times B)^{1/2}]^{1/2}$
Landscape Connectivity (D)		C= 6		$6+[12\times(9\times12)^{1/2}]^{1/2}$
Buffer submetric A: *Percent of AA with Buffer*	B=9	▨		$6+[12\times 108^{1/2}]^{1/2}$
Buffer submetric B: *Average Buffer Width*	A=12	▨		$6+[12\times 10.39]^{1/2}$
Buffer submetric C: *Buffer Condition*	A=12	▨		6+ 11.17 = 17.17
$D + [C \text{ x } (A \text{ x } B)^{½}]^{½}$ = **Attribute Score**		Raw 17.17	Final 71.54	Final Attribute Score = (Raw Score/24)100
Hydrology				
Water Source		C= 6		
Hydroperiod or Channel Stability		D= 3		
Hydrologic Connectivity		B= 9		
Attribute Score		Raw 18	Final 50	Final Attribute Score = (Raw Score/36)100
Physical Structure				
Structural Patch Richness		D=3		
Topographic Complexity		D=3		
Attribute Score		Raw 6	Final 25	Final Attribute Score = (Raw Score/24)100
Biotic Structure				
Plant Community submetric A: *Number of Plant Layers*	C= 6	▨		
Plant Community submetric B: *Number of Co-dominant species*	D=3	▨		
Plant Community submetric C: *Percent Invasion*	A=12	▨		
Plant Community Metric (*average of submetrics A-C*)		C=7		
Horizontal Interspersion and Zonation		C= 6		
Vertical Biotic Structure		A= 12		
Attribute Score		Raw 25	Final 69.44	Final Attribute Score = (Raw Score/36)100
Overall AA Score		215.98		**Average of Final Attribute Scores** 54.00

↑ total of all final attribute scor

3

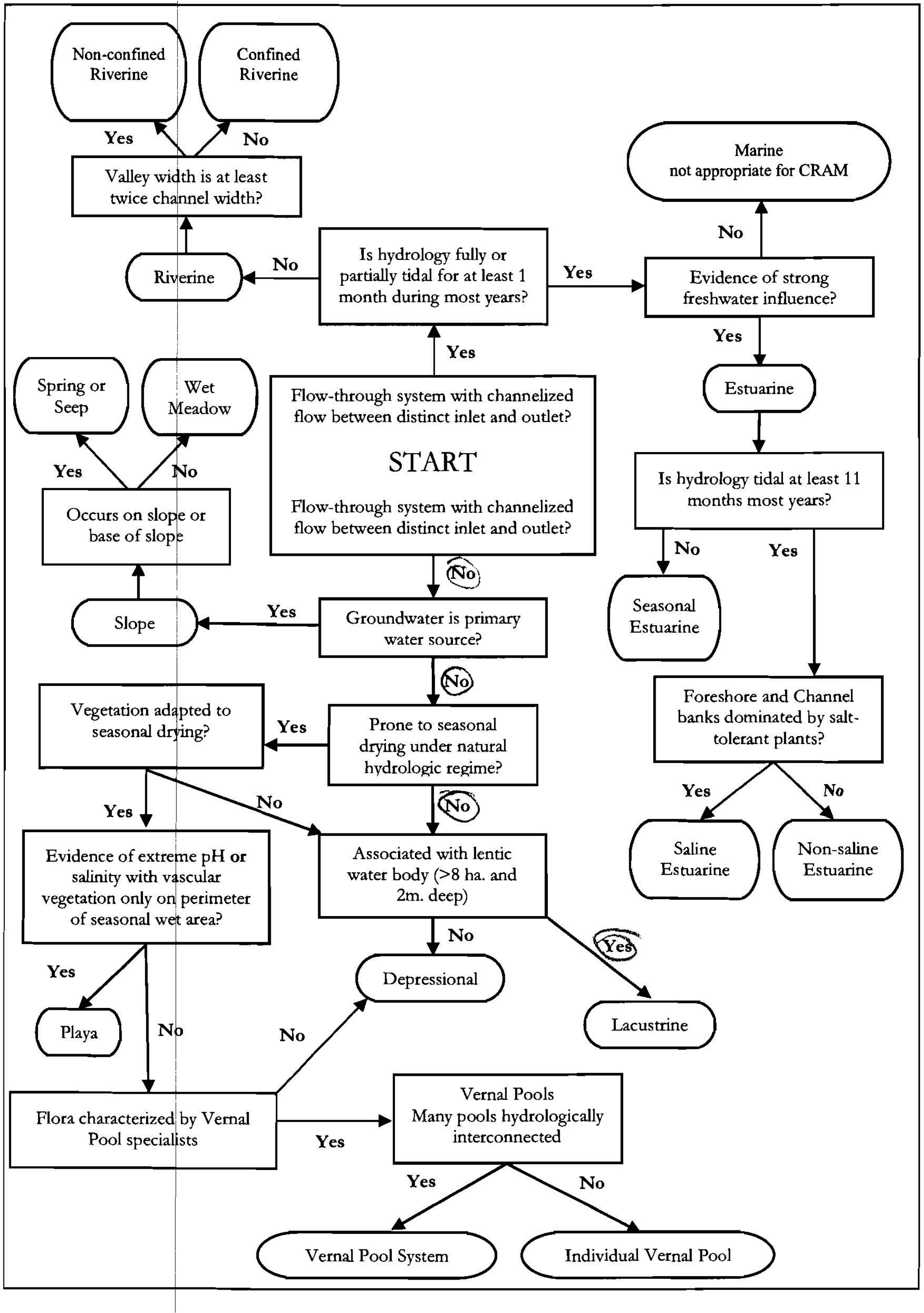
Scoring Sheet: Perennial Depressional Wetlands #3

AA Name: DAVID CHARLTON			**(m/d/y)** 10 / 14 / 08
Attributes and Metrics	**Scores**		**Comments**
Buffer and Landscape Context			$D+[C\times(A\times B)^{1/2}]^{1/2}$
Landscape Connectivity (D)	6		$6+[12\times(6\times12)^{1/2}]^{1/2}$
Buffer submetric A: Percent of AA with Buffer	6		$6+[12\times(72)^{1/2}]^{1/2}$ $6+[12\times8.49]^{1/2}$
Buffer submetric B: Average Buffer Width	12		$6+10.09=16.09$
Buffer submetric C: Buffer Condition	12		
$D+[C \times (A \times B)^{1/2}]^{1/2}$ = **Attribute Score**	Raw 16.09	Final 67.04	Final Attribute Score = (Raw Score/24)100
Hydrology			
Water Source	C 6		
Hydroperiod or Channel Stability	D 6		
Hydrologic Connectivity	D 3		
Attribute Score	Raw 15	Final 41.67	Final Attribute Score = (Raw Score/36)100
Physical Structure	DUCK PONDS		
Structural Patch Richness	3 | 6		
Topographic Complexity	3		
Attribute Score	Raw 6	Final 25	Final Attribute Score = (Raw Score/24)100
Biotic Structure			
Plant Community submetric A: Number of Plant Layers	C 6		
Plant Community submetric B: Number of Co-dominant species	C 6		
Plant Community submetric C: Percent Invasion	A 12		
Plant Community Metric (*average of submetrics A-C*)	8		
Horizontal Interspersion and Zonation	12		
Vertical Biotic Structure	3		
Attribute Score	Raw 23	Final 63.89	Final Attribute Score = (Raw Score/36)100
Overall AA Score	197.60		**Average of Final Attribute Scores** 49.40

↑ Total of all final attribute scores

Identify Wetland Type

Figure 3.2: Flowchart to determine wetland type and sub-type.



3.2.2.2 Depressional Wetlands

Note: This section was primarily based on perennial depressional wetlands and caution should be applied in the interpretation of scores in seasonal depressional wetlands. The depressional module will be revised during the CRAM validation/calibration process in 2008-2009.

Depressional wetlands exist in topographic lows that do not usually have outgoing surface drainage except during extreme flood events or heavy rainfall. Precipitation is their main source of water. Depressional wetlands can have distinct or indistinct boundaries. Many depressional wetlands are seasonal, and some lack surface ponding or saturated conditions during dry years. A complex of shallows and seasonally wet swales and depressions created by the slight topographic relief of a vernal pool system is an example of an indistinct depressional wetland. The margins of distinct depressional wetlands are relatively easy to discern in aerial photos and in the field. Examples of distinct depressional wetlands include sag ponds, snowmelt ponds, kettle-holes in moraines, cutoff ox-bows on floodplains, and water hazards on golf courses.

3.2.2.3 Other Depressional Wetlands

Depressional wetlands other than vernal pools can be seasonal or perennial, but their flora and fauna are mostly not characteristic of vernal pools, and they lack the impervious substrate that controls vernal pool hydrology. They differ from lacustrine wetlands by lacking an adjacent area of open water at least 2 m deep and 8 ha total area). They differ from playas by lacking an adjacent area larger than the wetland of either alkaline or saline open water less than 2 m deep or non-vegetated, fine-grain sediments. Unlike slope wetlands (i.e., springs and seeps), depressional wetlands depend more on precipitation than groundwater as their water source.

Establish the Assessment Area (AA)

Table 3.5: Examples of features that *should* be used to delineate AA boundaries.

Flow-Through Wetlands	**Non Flow-Though Wetlands**	
Riverine, Estuarine and Slope Wetlands	**Lacustrine, Wet Meadows, Depressional, and Playa Wetlands**	**Vernal Pools and Vernal Pool Systems**
☐ diversion ditches ☐ end-of-pipe large discharges ☐ grade control or water height control structures ☐ major changes in riverine entrenchment, confinement, degradation, aggradation, slope, or bed form ☐ major channel confluences ☐ water falls ☐ open water areas more than 50 m wide on average or broader than the wetland ☐ transitions between wetland types ☐ foreshores, backshores and uplands at least 5 m wide ☐ weirs, culverts, dams, levees, and other flow control structures	☒ above-grade roads and fills ☒ berms and levees ☐ jetties and wave deflectors ☒ major point sources or outflows of water ☒ open water areas more than 50 m wide on average or broader than the wetland ☐ foreshores, backshores and uplands at least 5 m wide ☐ weirs and other flow control structures	☐ above-grade roads and fills ☐ major point sources of water inflows or outflows ☐ weirs, berms, levees and other flow control structures

Table 3.6: Examples of features that should *not* be used to delineate any AAs.

☐ at-grade, unpaved, single-lane, infrequently used roadways or crossings
☐ bike paths and jogging trails at grade
☐ bare ground within what would otherwise be the AA boundary
☐ equestrian trails
☐ fences (unless designed to obstruct the movement of wildlife)
☐ property boundaries
☐ riffle (or rapid) – glide – pool transitions in a riverine wetland
☐ spatial changes in land cover or land use along the wetland border
☐ state and federal jurisdictional boundaries

Table 3.7: Recommended maximum and minimum AA sizes for each wetland type.
Note: Wetlands smaller than the recommended AA sizes can be assessed in their entirety.

Wetland Type	Recommended AA Size
Slope	
Spring or Seep	Maximum size is 0.50 ha (about 75 m x 75 m, but shape can vary); there is no minimum size.
Wet Meadow	Maximum size is 2.25 ha (about 150 m x 150 m, but shape can vary); minimum size is 0.1 ha (about 30 m x 30 m).
Depressional	
Vernal Pool	There are no size limits (see Section 3.5.6 and Table 3.8).
Vernal Pool System	There are no size limits (see Section 3.5.6 and Table 3.8).
Other Depressional	**Maximum size is 1.0 ha (about 100 m x 100 m, but shape can vary); there is no minimum size.**
Riverine	
Confined and Non-confined	Recommended length is 10x average bankfull channel width; maximum length is 200 m; minimum length is 100 m. AA should extend laterally (landward) from the bankfull contour to encompass all the vegetation (trees, shrubs vines, etc) that probably provide woody debris, leaves, insects, etc. to the channel and its floodplain (Figure 3.4); minimum width is 2 m.
Lacustrine	Maximum size is 2.25 ha (about 150 m x 150 m, but shape can vary); minimum size is 0.5 ha (about 75 m x 75 m).
Playa	Maximum size is 2.25 ha (about 150 m x 150 m, but shape can vary); minimum size is 0.5 ha (about 75 m x 75 m).
Estuarine	
Perennial Saline	Recommended size and shape for estuarine wetlands is a 1 ha circle (radius about 55 m), but the shape can be non-circular if necessary to fit the wetland and to meet hydro-geomorphic and other criteria as outlined in Sections 3.5.1-3. The minimum size is 0.1 ha (about 30 m x 30 m).
Perennial Non-saline	
Seasonal	

Attribute 1: Buffer and Landscape Context

Landscape Connectivity

Definition: The landscape connectivity of an Assessment Area is assessed in terms of its spatial association with other areas of aquatic resources, such as other wetlands, lakes, streams, etc. It is assumed that wetlands close to each other have a greater potential to interact ecologically and hydrologically, and that such interactions are generally beneficial.

For all wetlands except riverine: On digital or hardcopy site imagery, draw a straight line extending 500 m from the AA boundary in each of the four cardinal compass directions. Along each transect line, estimate the percentage of the segment that passes through wetland or aquatic habitat of any kind, including open water. Use the worksheet below to record these estimates.

#1

Worksheet for Landscape Connectivity Metric for All Wetlands Except Riverine

	Percentage of Transect Lines that Contains Wetland Habitat of Any Kind	
	Segment Direction	Percentage of Transect Length That is Wetland
North		0
South		100
East		100
West		13.86
Average Percentage of Transect Length That Is Wetland		53.46

Table 4.1: Rating for Landscape Connectivity for all wetlands except Riverine.

Rating	Alternative States
A	An average of 76 – 100 % of the transects is wetland habitat of any kind.
[✓ B]	An average of 51 – 75 % of the transects is wetland habitat of any kind.
C	An average of 26 – 50 % of the transects is wetland habitat of any kind.
D	An average of 0 – 25 % of the transects is wetland habitat of any kind.

Attribute 1: Buffer and Landscape Context

Landscape Connectivity

Definition: The landscape connectivity of an Assessment Area is assessed in terms of its spatial association with other areas of aquatic resources, such as other wetlands, lakes, streams, etc. It is assumed that wetlands close to each other have a greater potential to interact ecologically and hydrologically, and that such interactions are generally beneficial.

For all wetlands except riverine: On digital or hardcopy site imagery, draw a straight line extending 500 m from the AA boundary in each of the four cardinal compass directions. Along each transect line, estimate the percentage of the segment that passes through wetland or aquatic habitat of any kind, including open water. Use the worksheet below to record these estimates.

2

Worksheet for Landscape Connectivity Metric for All Wetlands Except Riverine

	Percentage of Transect Lines that Contains Wetland Habitat of Any Kind	
	Segment Direction	Percentage of Transect Length That is Wetland
North		82.17
South		29.92
East		83.50
West		100
Average Percentage of Transect Length That Is Wetland		73.89

Table 4.1: Rating for Landscape Connectivity for all wetlands except Riverine.

Rating	Alternative States
A	An average of 76 – 100 % of the transects is wetland habitat of any kind.
[✓ B]	An average of 51 – 75 % of the transects is wetland habitat of any kind.
C	An average of 26 – 50 % of the transects is wetland habitat of any kind.
D	An average of 0 – 25 % of the transects is wetland habitat of any kind.

Attribute 1: Buffer and Landscape Context

Landscape Connectivity

Definition: The landscape connectivity of an Assessment Area is assessed in terms of its spatial association with other areas of aquatic resources, such as other wetlands, lakes, streams, etc. It is assumed that wetlands close to each other have a greater potential to interact ecologically and hydrologically, and that such interactions are generally beneficial.

For all wetlands except riverine: On digital or hardcopy site imagery, draw a straight line extending 500 m from the AA boundary in each of the four cardinal compass directions. Along each transect line, estimate the percentage of the segment that passes through wetland or aquatic habitat of any kind, including open water. Use the worksheet below to record these estimates.

3

Worksheet for Landscape Connectivity Metric for All Wetlands Except Riverine

	Percentage of Transect Lines that Contains Wetland Habitat of Any Kind	
	Segment Direction	Percentage of Transect Length That is Wetland
North		33.26
South		100
East		80.07
West		0
Average Percentage of Transect Length That Is Wetland		53.33

Table 4.1: Rating for Landscape Connectivity for all wetlands except Riverine.

Rating	Alternative States
A	An average of 76 – 100 % of the transects is wetland habitat of any kind.
[✓ B]	An average of 51 – 75 % of the transects is wetland habitat of any kind.
C	An average of 26 – 50 % of the transects is wetland habitat of any kind.
D	An average of 0 – 25 % of the transects is wetland habitat of any kind.

Percent of AA with Buffer

Definition: The buffer is the area adjoining the AA that is in a natural or semi-natural state and currently not dedicated to anthropogenic uses that would severely detract from its ability to entrap contaminants, discourage forays into the AA by people and non-native predators, or otherwise protect the AA from stress and disturbance.

To be considered as buffer, a suitable land cover type must be at least 5 m wide and extend along the perimeter of the AA for at least 5 m. The maximum width of the buffer is 250 m. At distances beyond 250 m from the AA, the buffer becomes part of the landscape context of the AA.

Any area of open water at least 30 m wide that is adjoining the AA, such as a lake, large river, or large slough, is not considered in the assessment of the buffer. Such open water is considered to be neutral, neither part of the wetland nor part of the buffer. There are three reasons for excluding large areas of open water (i.e., more than 30 m wide) from Assessment Areas and their buffers. First, assessments of buffer extent and buffer width are inflated by including open water as a part of the buffer. Second, while there may be positive correlations between wetland stressors and the quality of open water, quantifying water quality generally requires laboratory analyses beyond the scope of rapid assessment. Third, open water can be a direct source of stress (i.e., water pollution, waves, boat wakes) or an indirect source of stress (i.e., promotes human visitation, encourages intensive use by livestock looking for water, provides dispersal for non-native plant species), or it can be a source of benefits to a wetland (e.g., nutrients, propagules of native plant species, water that is essential to maintain wetland hydroperiods, etc.). However, any area of open water at least 30 m wide that is within 250 m of the AA but is not adjoining the AA is considered part of the buffer.

In the example below (Figure 4.2), most of the area around the AA (outlined in white) consists of non-buffer land cover types. The AA adjoins a major roadway, parking lot, and other development that is a non-buffer land cover type. There is a nearby wetland but it is separated from the AA by a major roadway and is not considered buffer. The open water area is neutral and not considered in the estimation of the percentage of the AA perimeter that has buffer. In this example, the only areas that would be considered buffer is the area labeled "Upland Buffer".

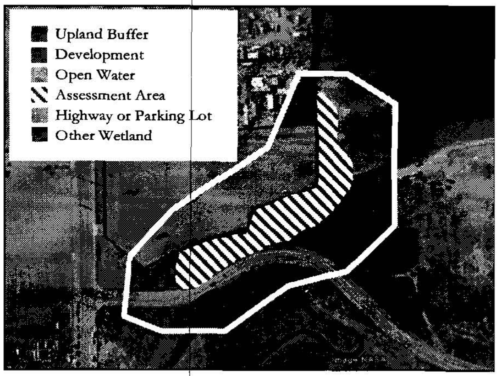


Figure 4.2: Diagram of buffer and non-buffer land cover types.

Table 4.4: Guidelines for identifying wetland buffers and breaks in buffers.

Examples of Land Covers Included in Buffers	**Examples of Land Covers Excluded from Buffers** Notes: buffers do not cross these land covers; areas of open water adjacent to the AA are not included in the assessment of the AA or its buffer.
☐ bike trails ☐ dry-land farming areas ☐ foot trails ☐ horse trails ☐ links or target golf courses ☐ natural upland habitats ☐ nature or wildland parks ☐ open range land ☐ railroads ☒ roads not hazardous to wildlife ☐ swales and ditches ☐ vegetated levees	☐commercial developments ☐fences that interfere with the movements of wildlife ☐intensive agriculture (row crops, orchards and vineyards lacking ground cover and other BMPs) ☐paved roads (two lanes plus a turning lane or larger) ☐lawns ☐parking lots ☐horse paddocks, feedlots, turkey ranches, etc. ☐residential areas ☐sound walls ☐sports fields ☐traditional golf courses ☐urbanized parks with active recreation ☐pedestrian/bike trails (i.e., nearly constant traffic)

Table 4.5: Rating for Percent of AA with Buffer.

FOR 1,2+3

Rating	**Alternative States (not including open-water areas)**
[✓ A]	Buffer is 75 - 100% of AA perimeter.
B	Buffer is 50 – 74% of AA perimeter.
C	Buffer is 25 – 49% of AA perimeter.
D	Buffer is 0 – 24% of AA perimeter.

Average Buffer Width

Definition: The average width of the buffer adjoining the AA is estimated by averaging the lengths of eight straight lines drawn at regular intervals around the AA from its perimeter outward to the nearest non-buffer land cover or 250 m, which ever is first encountered. It is assumed that the functions of the buffer do not increase significantly beyond an average width of about 250 m. The maximum buffer width is therefore 250 m. The minimum buffer width is 5 m, and the minimum length of buffer along the perimeter of the AA is also 5 m. Any area that is less than 5 m wide and 5 m long is too small to be a buffer. See Table 4.4 above for more guidance regarding the identification of AA buffers.

Table 4.6: Steps to estimate Buffer Width for all wetlands.

Step 1	Identify areas in which open water is directly adjacent to the AA, with no vegetated intertidal or upland area in between. These areas are excluded from buffer calculations.
Step 2	Draw straight lines 250 m in length perpendicular to the AA through the buffer area at regular intervals along the portion of the perimeter of the AA that has a buffer. For one-sided riverine AAs, draw four lines; for all other wetland types, draw eight lines (see Figures 4.3 and 4.4 below).
Step 3	Estimate the buffer width of each of the lines as they extend away from the AA. Record these lengths on the worksheet below.
Step 4	Estimate the average buffer width. Record this width on the worksheet below.

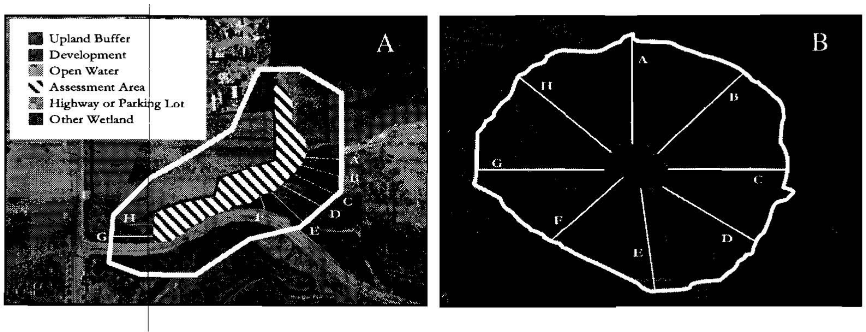


Figure 4.3: Examples of the method used to estimate Buffer Width. Note that the width is based on the lengths of eight lines A-H that extend at regular intervals though the buffer areas, whether only a small part of the 250 m zone around the AA is buffer (A) or all of the zone around the AA is buffer (B).

Worksheet for calculating average buffer width of AA for 1, 2, 3

Line	Buffer Width (m)
A	250 m
B	"
C	"
D	"
E	"
F	"
G	"
H	"
Average Buffer Width	"

Table 4.7: Rating for average buffer width.

Rating	Alternative States
[✓ A]	Average buffer width is 190 – 250 m.
B	Average buffer width 130 – 189 m.
C	Average buffer width is 65 – 129 m.
D	Average buffer width is 0 – 64 m.

Buffer Condition

Definition: The condition of a buffer is assessed according to the extent and quality of its vegetation cover and the overall condition of its substrate. Evidence of direct impacts by people are excluded from this metric and included in the Stressor Checklist. Buffer conditions are assessed only for the portion of the wetland border that has already been identified or defined as buffer, based on Section 4.1.2 above. If there is no buffer, assign a score of D.

Table 4.8: Rating for Buffer Condition. Sn 1,2,3

Rating	Alternative States
[✓ A]	Buffer for AA is dominated by native vegetation, has undisturbed soils, and is apparently subject to little or no human visitation.
B	Buffer for AA is characterized by an intermediate mix of native and non-native vegetation, but mostly undisturbed soils and is apparently subject to little or no human visitation.
C	Buffer for AA is characterized by substantial amounts of non-native vegetation AND there is at least a moderate degree of soil disturbance/compaction, and/or there is evidence of at least moderate intensity of human visitation.
D	Buffer for AA is characterized by barren ground and/or highly compacted or otherwise disturbed soils, and/or there is evidence of very intense human visitation.

Attribute 2: Hydrology

Water Source

Definition: Water Sources directly affect the extent, duration, and frequency of saturated or ponded conditions within an Assessment Area. Water Sources include the kinds of direct inputs of water into the AA as well as any diversions of water from the AA. Diversions are considered a water source because they affect the ability of the AA to function as a source of water for other habitats while also directly affecting the hydrology of the AA.

A water source is direct if it supplies water mainly to the AA, rather than to areas through which the water must flow to reach the AA. Natural, direct sources include rainfall, ground water discharge, and flooding of the AA due to high tides or naturally high riverine flows. Examples of unnatural, direct sources include stormdrains that empty directly into the AA or into an immediately adjacent area. For seeps and springs that occur at the toes of earthen dams, the reservoirs behind the dams are direct water source. Indirect sources that should not be considered in this metric include large regional dams or urban storm drain systems that do not drain directly into the AA but that have systemic, ubiquitous effects on broad geographic areas of which the AA is a small part. For example, the salinity regimes of estuarine wetlands in San Francisco Bay are affected by dams in the Sierra Nevada, but these effects are not direct. But some of the same wetlands are directly affected by nearby discharges from sewage treatment facilities. Engineered hydrological controls, such as weirs, tide gates, flashboards, grade control structures, check dams, etc., can serve to demarcate the boundary of an AA (see Section 3.5), but they are not considered water sources.

The typical suite of natural water sources differs among the wetland types. The water for estuarine wetlands is by definition a combination of marine (i.e., tidal) and riverine (i.e., fluvial) sources. This metric is focused on the non-tidal water sources that account for the conditions during the growing season, regardless of the time of year when these sources exist. To assess water source, the plant species composition of the wetland should be compared to what is expected, in terms of the position of the wetland along the salinity gradient of the estuary, as adjusted for the overall wetness of the water year. In general, altered sources are indicated by vegetation that is either more tolerant of saline conditions or less tolerant than would be expected. If the plant community is unexpectedly salt-tolerant, then an unnatural decrease in freshwater supply is indicated. Conversely, if the community is less salt-tolerant than expected, than an unnatural increase in freshwater is indicated.

Table 4.9: Rating for Water Source.

Rating	Alternative States
A	Freshwater sources that affect the dry season condition of the AA, such as its flow characteristics, hydroperiod, or salinity regime, are precipitation, groundwater, and/or natural runoff, or natural flow from an adjacent freshwater body, or the AA naturally lacks water in the dry season. There is no indication that dry season conditions are substantially controlled by artificial water sources.
B	Freshwater sources that affect the dry season condition of the AA are mostly natural, but also obviously include occasional or small effects of modified hydrology. Indications of such anthropogenic inputs include developed land or irrigated agricultural land that comprises less than 20% of the immediate drainage basin within about 2 km upstream of the AA, or that is characterized by the presence of a few small stormdrains or scattered homes with septic systems. No large point sources or dams control the overall hydrology of the AA.
[✓ C]	Freshwater sources that affect the dry season conditions of the AA are primarily urban runoff, direct irrigation, pumped water, artificially impounded water, water remaining after diversions, regulated releases of water through a dam, or other artificial hydrology. Indications of substantial artificial hydrology include developed or irrigated agricultural land that comprises more than 20% of the immediate drainage basin within about 2 km upstream of the AA, or the presence of major point source discharges that obviously control the hydrology of the AA. OR Freshwater sources that affect the dry season conditions of the AA are substantially controlled by known diversions of water or other withdrawals directly from the AA, its encompassing wetland, or from its drainage basin.
D	Natural, freshwater sources that affect the dry season conditions of the AA have been eliminated based on the following indicators: impoundment of all possible wet season inflows, diversion of all dry-season inflow, predominance of xeric vegetation, etc.

Sn 1,2,3

Hydroperiod or Channel Stability

Definition: Hydroperiod is the characteristic frequency and duration of inundation or saturation of a wetland during a typical year. The natural hydroperiod for estuarine wetlands is governed by the tides, and includes predictable variations in inundation regimes over days, weeks, months, and seasons. Depressional, lacustrine, playas, and riverine wetlands typically have daily variations in water height that are governed by diurnal increases in evapotranspiration and seasonal cycles that are governed by rainfall and runoff. Seeps and springs that depend on groundwater may have relatively slight seasonal variations in hydroperiod.

Channel stability only pertains to riverine wetlands. It is assessed as the degree of channel aggradation (i.e., net accumulation of sediment on the channel bed causing it to rise over time), or degradation (i.e., net loss of sediment from the bed causing it to be lower over time). There is much interest in channel entrenchment (i.e., the inability of flows in a channel to exceed the channel banks) and this is addressed in the Hydrologic Connectivity metric.

Table 4.10: Field Indicators of Altered Hydroperiod.

Direct Engineering Evidence	Indirect Ecological Evidence
Reduced Extent and Duration of Inundation or Saturation	
☐ Upstream spring boxes ☒ Impoundments ☒ Pumps, diversions, ditching that move water *into* the wetland OSS SITE	☐ Evidence of aquatic wildlife mortality ☐ Encroachment of terrestrial vegetation ☐ Stress or mortality of hydrophytes ☐ Compressed or reduced plant zonation
Increased Extent and Duration of Inundation or Saturation	
☒ Berms ☒ Dikes ☒ Pumps, diversions, ditching that move water *into* the wetland	☐ Late-season vitality of annual vegetation ☒ Recently drowned riparian vegetation ☒ Extensive fine-grain deposits

for 1,2,3
TOTAL
ECOSYSTEM

Depressional, Lacustrine, Playas, and Slope Wetlands: Assessment of the hydroperiod for these kinds of wetlands should be initiated with an office-based review of. Field indicators for altered hydroperiod include pumps, spring boxes, ditches, hoses and pipes, and encroachment of terrestrial vegetation (see Table 4.10 above). Tables 4.11a and 4.11b provide narratives for rating Hydroperiod for depressional, lacustrine, and seep and spring wetlands.

Table 4.11a: Rating of Hydroperiod for Depressional, Lacustrine, Playas, and Slope wetlands.

Rating	**Alternative States** **(based on Table 4.10 above)**
A	Hydroperiod of the AA is characterized by natural patterns of filling or inundation and drying or drawdown.
B	The filling or inundation patterns in the AA are of greater magnitude or duration than would be expected under natural conditions, but thereafter, the AA is subject to natural drawdown or drying.
C	Hydroperiod of the AA is characterized by natural patterns of filling or inundation, but thereafter, is subject to more rapid or extreme drawdown or drying, as compared to more natural wetlands. OR The filling or inundation patterns in the AA are of substantially lower magnitude or duration than would be expected under natural conditions, but thereafter, the AA is subject to natural drawdown or drying.
[✓ **D**]	Both the inundation and drawdown of the AA deviate from natural conditions (either increased or decreased in magnitude and/or duration).

Sa 1, 2, 3

Hydrologic Connectivity

Definition: Hydrologic Connectivity describes the ability of water to flow into or out of the wetland, or to inundate their adjacent uplands. This metric pertains only to Riverine, Estuarine, Vernal Pool Systems, individual Vernal Pools, and Playas.

This metric is scored by assessing the degree to which the hydrologic connectivity of the AA is restricted by unnatural features, such as levees and excessively high banks. These features may be restricting the hydrology of the wetland in which the AA is contained, and thus do not need to directly adjoin the AA.

Table 4.15c: Rating of Hydrologic Connectivity for Estuarine, Depressional, Lacustrine, and Slope wetlands, Playas, Individual Vernal Pools, and Vernal Pool Systems.

Rating	Alternative States
A	Rising water in the wetland that contains the AA has unrestricted access to adjacent areas, without levees or other obstructions to the lateral movement of flood waters.
[✓ **B**]	There are unnatural features such as levees or road grades that limit the amount of adjacent transition zone or the lateral movement of flood waters, relative to what is expected for the setting. But, the limitations exist for less than 50% of the boundary of wetland that contains the AA. Restrictions may be intermittent along margins of the wetland, or they may occur only along one bank or shore of the wetland. Flood flows may exceed the obstructions, but drainage back to the wetland is obstructed.
C	The amount of adjacent transition zone or the lateral movement of flood waters is limited, relative to what is expected for the setting, by unnatural features, such as levees or road grades, for 50-90% of the wetland that contains the AA. Flood flows may exceed the obstructions, but drainage back to the wetland is obstructed.
D	The amount of adjacent transition zone or the lateral movement of flood waters is limited, relative to what is expected for the setting, by unnatural features, such as levees or road grades, for more than 90% of the wetland that contains the AA.

Sn 1, 2, 3

INDIVIDUAL AREAS ARE 100% LIMITED BY DIKES BUT ORIGINALLY THE AREA WAS BLOCKED ON ONLY THE NORTH SIDE BY THE "C" DIKE. CAN BE INTERPRETED DIFFERENTLY.

Attribute 3: Physical Structure

Structural Patch Richness

Definition: Patch richness is the number of different obvious types of physical surfaces or features that may provide habitat for aquatic, wetland, or riparian species. This metric is different from topographic complexity in that it addresses the number of different patch types, whereas topographic complexity evaluates the spatial arrangement and interspersion of the types. Physical patches can be natural or unnatural.

Patch Type Definitions:

Animal mounds and burrows. Many vertebrates make mounds or holes as a consequence of their foraging, denning, predation, or other behaviors. The resulting soil disturbance helps to redistributes soil nutrients and influences plant species composition and abundance. To be considered a patch type there should be evidence that a population of burrowing animals has occupied the Assessment Area. A single burrow or mound does not constitute a patch.

Bank slumps or undercut banks in channels or along shorelines. A bank slump is a portion of a depressional, estuarine, or lacustrine bank that has broken free from the rest of the bank but has not eroded away. Undercuts are areas along the bank or shoreline of a wetland that have been excavated by waves or flowing water.

Cobble and boulders. Cobble and boulders are rocks of different size categories. The long axis of cobble ranges from about 6 cm to about 25 cm. A boulder is any rock having a long axis greater than 25 cm. Submerged cobbles and boulders provide abundant habitat for aquatic macroinvertebrates and small fish. Exposed cobbles and boulders provide roosting habitat for birds and shelter for amphibians. They contribute to patterns of shade and light and air movement near the ground surface that affect local soil moisture gradients, deposition of seeds and debris, and overall substrate complexity.

Concentric or parallel high water marks. Repeated variation in water level in a wetland can cause concentric zones in soil moisture, topographic slope, and chemistry that translate into visible zones of different vegetation types, greatly increasing overall ecological diversity. The variation in water level might be natural (e.g., seasonal) or anthropogenic.

Debris jams. A debris jam is an accumulation of drift wood and other flotage across a channel that partially or completely obstructs surface water flow.

Hummocks or sediment mounds. Hummocks are mounds created by plants in slope wetlands, depressions, and along the banks and floodplains of fluvial and tidal systems. Hummocks are typically less than 1m high. Sediment mounds are similar to hummocks but lack plant cover.

Islands (exposed at high-water stage). An island is an area of land above the usual high water level and, at least at times, surrounded by water in a riverine, lacustrine, estuarine, or playa system. Islands differ from hummocks and other mounds by being large enough to support trees or large shrubs.

Macroalgae and algal mats. Macroalgae occurs on benthic sediments and on the water surface of all types of wetlands. Macroalgae are important primary producers, representing the base of the food web in some wetlands. Algal mats can provide abundant habitat for macro-invertebrates, amphibians, and small fishes.

Non-vegetated flats (sandflats, mudflats, gravel flats, etc.). A flat is a non-vegetated area of silt, clay, sand, shell hash, gravel, or cobble at least 10 m wide and at least 30 m long that adjoins the wetland foreshore and is a potential resting and feeding area for fishes, shorebirds, wading birds, and other waterbirds. Flats can be similar to large bars (see definitions of point bars and in-channel bars below), except that they lack the convex profile of bars and their compositional material is not as obviously sorted by size or texture.

Pannes or pools on floodplain. A panne is a shallow topographic basin lacking vegetation but existing on a well-vegetated wetland plain. Pannes fill with water at least seasonally due to overland flow. They commonly serve as foraging sites for waterbirds and as breeding sites for amphibians.

Point bars and in-channel bars. Bars are sedimentary features within intertidal and fluvial channels. They are patches of transient bedload sediment that form along the inside of meander bends or in the middle of straight channel reaches. They sometimes support vegetation. They are convex in profile and their surface material varies in size from small on top to larger along their lower margins. They can consist of any mixture of silt, sand, gravel, cobble, and boulders.

Pools in channels. Pools are areas along tidal and fluvial channels that are much deeper than the average depths of their channels and that tend to retain water longer than other areas of the channel during periods of low or no surface flow.

Riffles or rapids. Riffles and rapids are areas of relatively rapid flow and standing waves in tidal or fluvial channels. Riffles and rapids add oxygen to flowing water and provide habitat for many fish and aquatic invertebrates.

Secondary channels on floodplains or along shorelines. Channels confine riverine or estuarine flow. A channel consists of a bed and its opposing banks, plus its floodplain. Estuarine and riverine wetlands can have a primary channel that conveys most flow, and one or more secondary channels of varying sizes that convey flood flows. The systems of diverging and converging channels that characterize braided and anastomosing fluvial systems usually consist of one or more main channels plus secondary channels. Tributary channels that originate in the wetland and that only convey flow between the wetland and the primary channel are also regarded as secondary channels. For example, short tributaries that are entirely contained within the CRAM Assessment Area (AA) are regarded as secondary channels.

Shellfish beds. Oysters, clams and mussels are common bivalves that create beds on the banks and bottoms of wetland systems. Shellfish beds influence the condition of their environment by affecting flow velocities, providing substrates for plant and animal life, and playing particularly important roles in the uptake and cycling of nutrients and other water-borne materials.

Soil cracks. Repeated wetting and drying of fine grain soil that typifies some wetlands can cause the soil to crack and form deep fissures that increase the mobility of heavy metals, promote oxidation and subsidence, while also providing habitat for amphibians and macroinvertebrates. Cracks must be a minimum of 1 inch deep to qualify.

Standing snags. Tall, woody vegetation, such as trees and tall shrubs, can take many years to fall to the ground after dying. These standing "snags" they provide habitat for many species of birds and small mammals. Any standing, dead woody vegetation that is at least 3 m tall is considered a snag.

Submerged vegetation. Submerged vegetation consists of aquatic macrophytes such as *Elodea canadensis* (common elodea), and *Zostera marina* (eelgrass) that are rooted in the sub-aqueous substrate but do not usually grow high enough in the overlying water column to intercept the water surface. Submerged vegetation can strongly influence nutrient cycling while providing food and shelter for fish and other organisms.

Swales on floodplain or along shoreline. Swales are broad, elongated, vegetated, shallow depressions that can sometimes help to convey flood flows to and from vegetated marsh plains or floodplains. But, they lack obvious banks, regularly spaced deeps and shallows, or other characteristics of channels. Swales can entrap water after flood flows recede. They can act as localized recharge zones and they can sometimes receive emergent groundwater.

Variegated or crenulated foreshore. As viewed from above, the foreshore of a wetland can be mostly straight, broadly curving (i.e., arcuate), or variegated (e.g., meandering). In plan view, a variegated shoreline resembles a meandering pathway. variegated shorelines provide greater contact between water and land.

Wrackline or organic debris in channel or on floodplain. Wrack is an accumulation of natural or unnatural floating debris along the high water line of a wetland.

Structural Patch Type Worksheet for All Wetland Types, Except Vernal Pool Systems

#1

Circle each type of patch that is observed in the AA and enter the total number of observed patches in Table 4.16 below. In the case of riverine wetlands, their status as confined or non-confined must first be determined (see section 3.2.2.1).

STRUCTURAL PATCH TYPE (check for presence)	Riverine (Non-confined)	Riverine (Confined)	All Estuarine	**Depressional**	Slope Wetlands	Lacustrine	Individual Vernal Pools	Playas
Minimum Patch Size	3 m^2	3 m^2	3 m^2	**3 m^2**	1 m^2	3 m^2	1 m^2	3 m^2
Secondary channels on floodplains or along shorelines	1	0	1	**0**	1	1	0	1
Swales on floodplain or along shoreline	1	0	0	**1**	1	1	1	1
Pannes or pools on floodplain	1	0	1	**0**	1	1	1	1
Vegetated islands (mostly above high-water)	1	0	0	**1**	0	[✓ 1]	1	1
Pools or depressions in channels (wet or dry channels)	1	1	1	**0**	0	0	0	0
Riffles or rapids (wet channel) or planar bed (dry channel)	1	1	0	**0**	0	0	0	0
Non-vegetated flats or bare ground (sandflats, mudflats, gravel flats, etc.)	0	0	1	**1**	1	1	1	1
Point bars and in-channel bars	1	1	1	**0**	0	0	0	0
Debris jams	1	1	1	**0**	0	1	0	0
Abundant wrackline or organic debris in channel, on floodplain, or across depressional wetland plain	1	1	1	**1**	0	1	0	0
Plant hummocks and/or sediment mounds	1	1	1	**1**	1	1	1	1
Bank slumps or undercut banks in channels or along shoreline	1	1	1	**1**	0	1	0	0
Variegated, convoluted, or crenulated foreshore (instead of broadly arcuate or mostly straight)	1	1	0	**1**	0	1	0	0
Animal mounds and burrows	0	0	1	**1**	1	0	1	1
Standing snags (at least 3 m tall)	1	1	1	**1**	1	1	0	0
Filamentous macroalgae or algal mats	1	1	1	**1**	1	[✓ 1]	1	1
Shellfish beds	0	0	1	**0**	0	1	0	0
Concentric or parallel high water marks	0	0	0	**1**	1	1	1	1
Soil cracks	0	0	1	**1**	0	1	1	1
Cobble and/or Boulders	1	1	0	**0**	1	1	1	0
Submerged vegetation	1	0	1	**1**	0	[✓ 1]	0	0
Total Possible	16	11	15	**13**	10	16	10	10
No. Observed Patch Types (enter here and use in Table 4.16 below)						3		

#2

Structural Patch Type Worksheet for All Wetland Types, Except Vernal Pool Systems

Circle each type of patch that is observed in the AA and enter the total number of observed patches in Table 4.16 below. In the case of riverine wetlands, their status as confined or non-confined must first be determined (see section 3.2.2.1).

STRUCTURAL PATCH TYPE (check for presence)	Riverine (Non-confined)	Riverine (Confined)	All Estuarine	**Depressional**	Slope Wetlands	Lacustrine	Individual Vernal Pools	Playas
Minimum Patch Size	3 m^2	3 m^2	3 m^2	**3 m^2**	1 m^2	3 m^2	1 m^2	3 m^2
Secondary channels on floodplains or along shorelines	1	0	1	**0**	1	1	0	1
Swales on floodplain or along shoreline	1	0	0	**1**	1	1	1	1
Pannes or pools on floodplain	1	0	1	**0**	1	1	1	1
Vegetated islands (mostly above high-water)	1	0	0	**1**	0	0	1	1
Pools or depressions in channels (wet or dry channels)	1	1	1	**0**	0	0	0	0
Riffles or rapids (wet channel) or planar bed (dry channel)	1	1	0	**0**	0	0	0	0
Non-vegetated flats or bare ground (sandflats, mudflats, gravel flats, etc.)	0	0	1	**1**	1	1	1	1
Point bars and in-channel bars	1	1	1	**0**	0	0	0	0
Debris jams	1	1	1	**0**	0	1	0	0
Abundant wrackline or organic debris in channel, on floodplain, or across depressional wetland plain	1	1	1	**1**	0	1	0	0
Plant hummocks and/or sediment mounds	1	1	1	**1**	1	[✓ 1]	1	1
Bank slumps or undercut banks in channels or along shoreline	1	1	1	**1**	0	1	0	0
Variegated, convoluted, or crenulated foreshore (instead of broadly arcuate or mostly straight)	1	1	0	**1**	0	1	0	0
Animal mounds and burrows	0	0	1	**1**	1	0	1	1
Standing snags (at least 3 m tall)	1	1	1	**1**	1	1	0	0
Filamentous macroalgae or algal mats	1	1	1	**1**	1	[✓ 1]	1	1
Shellfish beds	0	0	1	**0**	0	1	0	0
Concentric or parallel high water marks	0	0	0	**1**	1	1	1	1
Soil cracks	0	0	1	**1**	0	1	1	1
Cobble and/or Boulders	1	1	0	**0**	1	1	1	0
Submerged vegetation	1	0	1	**1**	0	[✓ 1]	0	0
Total Possible	16	11	15	**13**	10	16	10	10
No. Observed Patch Types (enter here and use in Table 4.16 below)						3		

Structural Patch Type Worksheet for All Wetland Types, Except Vernal Pool Systems #3

Circle each type of patch that is observed in the AA and enter the total number of observed patches in Table 4.16 below. In the case of riverine wetlands, their status as confined or non-confined must first be determined (see section 3.2.2.1).

STRUCTURAL PATCH TYPE (check for presence)	Riverine (Non-confined)	Riverine (Confined)	All Estuarine	**Depressional**	Slope Wetlands	Lacustrine	Individual Vernal Pools	Playas
Minimum Patch Size	3 m^2	3 m^2	3 m^2	**3 m^2**	1 m^2	3 m^2	1 m^2	3 m^2
Secondary channels on floodplains or along shorelines	1	0	1	**0**	1	1	0	1
Swales on floodplain or along shoreline	1	0	0	**1**	1	1	1	1
Pannes or pools on floodplain	1	0	1	**0**	1	1	1	1
Vegetated islands (mostly above high-water)	1	0	0	**1**	0	0	1	1
Pools or depressions in channels (wet or dry channels)	1	1	1	**0**	0	0	0	0
Riffles or rapids (wet channel) or planar bed (dry channel)	1	1	0	**0**	0	0	0	0
Non-vegetated flats or bare ground (sandflats, mudflats, gravel flats, etc.)	0	0	1	**1**	1	[✓ 1]	1	1
Point bars and in-channel bars	1	1	1	**0**	0	0	0	0
Debris jams	1	1	1	**0**	0	1	0	0
Abundant wrackline or organic debris in channel, on floodplain, or across depressional wetland plain	1	1	1	**1**	0	1	0	0
Plant hummocks and/or sediment mounds	1	1	1	**1**	1	1	1	1
Bank slumps or undercut banks in channels or along shoreline	1	1	1	**1**	0	1	0	0
Variegated, convoluted, or crenulated foreshore (instead of broadly arcuate or mostly straight)	1	1	0	**1**	0	[✓ 1]	0	0
Animal mounds and burrows	0	0	1	**1**	1	0	1	1
Standing snags (at least 3 m tall)	1	1	1	**1**	1	1	0	0
Filamentous macroalgae or algal mats	1	1	1	**1**	1	[✓ 1]	1	1
Shellfish beds	0	0	1	**0**	0	1	0	0
Concentric or parallel high water marks	0	0	0	**1**	1	1	1	1
Soil cracks	0	0	1	**1**	0	1	1	1
Cobble and/or Boulders	1	1	0	**0**	1	1	1	0
Submerged vegetation	1	0	1	**1**	0	1	0	0
Total Possible	16	11	15	**13**	10	16	10	10
No. Observed Patch Types (enter here and use in Table 4.16 below)						3		

Table 4.16: Rating of Structural Patch Richness (based on results from worksheets).

Rating	Confined Riverine, Playas, Springs & Seeps, Individual Vernal Pools	**Vernal ,Pool Systems and Depressional**	Estuarine	Non-confined Riverine, Lacustrine
A	≥ 8	**≥ 11**	≥ 11	≥ 12
B	6 – 7	**8 – 10**	8 – 10	9 – 11
C	4 – 5	**5 – 7**	6 – 7	6 – 8
[✓ **D**]	≤ 3	**≤ 4**	≤ 5	[✓ ≤ 5]

Sn 1,2,3

Topographic Complexity

Definition: Topographic complexity refers to the variety of elevations within a wetland due to physical, abiotic features and elevations gradients.

Table 4.17: Typical indicators of Macro- and Micro-topographic Complexity for each wetland type.

Type	**Examples of Topographic Features**
Depressional and Playas	**pools, islands, bars, mounds or hummocks, variegated shorelines, soil cracks, partially buried debris, plant hummocks, livestock tracks**
Estuarine	channels large and small, islands, bars, pannes, potholes, natural levees, shellfish beds, hummocks, slump blocks, first-order tidal creeks, soil cracks, partially buried debris, plant hummocks
Lacustrine	islands, bars, boulders, cliffs, benches, variegated shorelines, cobble, boulders, partially buried debris, plant hummocks
Riverine	pools, runs, glides, pits, ponds, hummocks, bars, debris jams, cobble, boulders, slump blocks, tree-fall holes, plant hummocks
Slope Wetlands	pools, runnels, plant hummocks, burrows, plant hummocks, cobbles, boulders, partially buried debris, cattle or sheep tracks
Vernal Pools and Pool Systems	soil cracks, "mima-mounds," rivulets between pools or along swales, cobble, plant hummocks, cattle or sheep tracks

Figure 4.6: Scale-independent schematic profiles of Topographic Complexity.
Each profile A-D represents one-half of a characteristic cross-section through an AA. The right end of each profile represents either the buffer along the backshore of the wetland encompassing the AA, or, if the AA is not contiguous with the buffer, then the right end of each profile represents the edge of the AA.

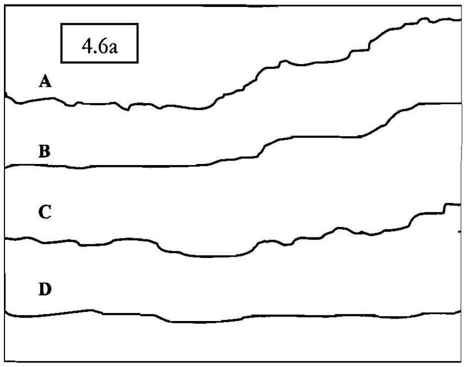


Table 4.18a: Rating of Topographic Complexity for Depressional Wetlands, Playas, Individual Vernal Pools, and Slope Wetlands.

Rating	Alternative States (based on diagrams in Figure 4.6 above)
A	AA as viewed along a typical cross-section has at least two benches or breaks in slope, and each of these benches, plus the slopes between them contain physical patch types or features that contribute to abundant micro-topographic relief or variability as illustrated in profile A of Figure 4.6a.
B	AA has at least two benches or breaks in slope above the middle area or bottom zone of the AA, but these benches and slopes mostly lack abundant micro-topographic relief. The AA resembles profile B of Figure 4.6a.
C	AA lacks any obvious break in slope or bench, and is best characterized has a single slope that has at least a moderate amount of micro-topographic complexity, as illustrated in profile C of Figure 4.6a.
[✓ D]	AA has a single, uniform slope with little or no micro-topographic complexity, as illustrated in profile D of Figure 4.6a.

Attribute 4: Biotic Structure

Plant Community Metric

Definition: The Plant Community Metric is composed of three submetrics for each wetland type. Two of these sub-metrics, Number of Co-dominant Plants and Percent Invasion, are common to all wetland types. For all wetlands except Vernal Pools and Vernal Pool Systems, the Number of Plant Layers as defined for CRAM is also assessed. For Vernal Pools and Pool Systems, the Number of Plant layers submetric is replaced by the Native Species Richness submetric. A thorough reconnaissance of an AA is required to assess its condition using these submetrics. The assessment for each submetric is guided by a set of Plant Community Worksheets. The Plant Community metric is calculated based on these worksheets.

A "plant" is defined as an individual of any species of tree, shrub, herb/forb, moss, fern, emergent, submerged, submergent or floating macrophyte, including non-native (exotic) plant species. For the purposes of CRAM, a plant "layer" is a stratum of vegetation indicated by a discreet canopy at a specified height that comprises at least 5% of the area of the AA where the layer is expected.

Non-native species owe their occurrence in California to the actions of people since shortly before Euroamerican contact. "Invasive" species are non-native species that tend to dominate one or more plant layers within an AA. CRAM uses the California Invasive Plant Council (Cal-IPC) list to determine the invasive status of plants, with augmentation by regional experts.

Number of Plant Layers Present

To be counted in CRAM, a layer must cover at least 5% of *the portion of the AA that is suitable for the layer.* This would be the littoral zone of lakes and depressional wetlands for the one aquatic layer, called "floating." The "short," "medium," and "tall" layers might be found throughout the non-aquatic areas of each wetland class, except in areas of exposed bedrock, mudflat, beaches, active point bars, etc. The "very tall" layer is usually expected to occur along the backshore, except in forested wetlands.

It is essential that the layers be identified by the actual plant heights (i.e., the approximate maximum heights) of plant species in the AA, regardless of the growth potential of the species. For example, a young sapling redwood between 0.5 m and 0.75 m tall would belong to the "medium" layer, even though in the future the same individual redwood might belong to the "very tall" layer. Some species might belong to multiple plant layers. For example, groves of red alders of all different ages and heights might collectively represent all four non-aquatic layers in a riverine AA. Riparian vines, such as wild grape, might also dominate all of the non-aquatic layers.

Layer definitions:

Floating Layer. This layer includes rooted aquatic macrophytes such as *Ruppia cirrhosa* (ditchgrass), *Ranunculus aquatilis* (water buttercup), and *Potamogeton foliosus* (leafy pondweed) that create floating or buoyant canopies at or near the water surface that shade the water column. This layer also includes non-rooted aquatic plants such as *Lemna* spp. (duckweed) and *Eichhornia crassipes* (water hyacinth) that form floating canopies.

Short Vegetation. This layer varies in maximum height among the wetland types, but is never taller than 50 cm. It includes small emergent vegetation and plants. It can include young forms of species that grow taller. Vegetation that is naturally short in its mature stage includes *Rorippa nasturtium-aquaticum* (watercress), small Isoetes (quillworts*), Distichlis spicata* (saltgrass), *Jaumea carnosa* (jaumea), *Ranunculus flamula* (creeping buttercup), *Alisma* spp. (water plantain), *Sparganium* (burweeds), and *Sagitaria* spp. (arrowhead).

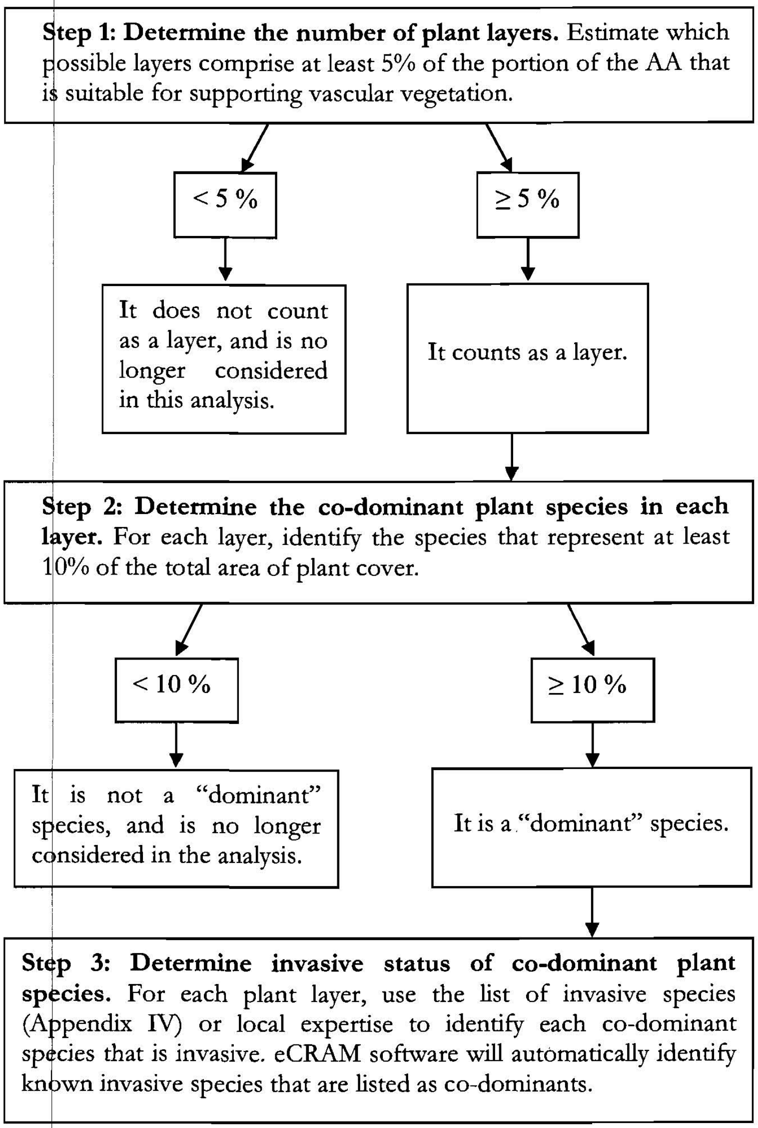
Medium Vegetation. This layer never exceeds 75 cm in height. It commonly includes emergent vegetation such *Salicornia virginica* (pickleweed), *Atriplex* spp. (saltbush), rushes (*Juncus* spp.), and *Rumex crispus* (curly dock).

Tall Vegetation. This layer never exceeds 1.5 m in height. It usually includes the tallest emergent vegetation and the larger shrubs. Examples include *Typha latifolia* (broad-leaved cattail), *Scirpus californicus* (bulrush), *Rubus ursinus* (California blackberry), and *Baccharis piluaris* (coyote brush).

Very Tall Vegetation. This layer is reserved for shrubs, vines, and trees that are taller than 1.5 m. Examples include *Plantanus racemosa* (western sycamore), *Populus fremontii* (Fremont cottonwood), *Alnus rubra* (red alder), *Sambucus mexicanus* (Blue elderberry), and *Corylus californicus* (hazelnut).

Standing (upright) dead or senescent vegetation from the previous growing season can be used in addition to live vegetation to assess the number of plant layers present. However, the lengths of prostrate stems or shoots are disregarded. In other words, fallen vegetation should not be "held up" to determine the plant layer to which it belongs. The number of plant layers must be determined based on the way the vegetation presents itself in the field.

Appendix I: Flow Chart to Determine Plant Dominance



Step 1: Determine the number of plant layers. Estimate which possible layers comprise at least 5% of the portion of the AA that is suitable for supporting vascular vegetation.

It does not count as a layer, and is no longer considered in this analysis.

It counts as a layer.

Step 2: Determine the co-dominant plant species in each layer. For each layer, identify the species that represent at least 10% of the total area of plant cover.

It is not a "dominant" species, and is no longer considered in the analysis.

It is a "dominant" species.

Step 3: Determine invasive status of co-dominant plant species. For each plant layer, use the list of invasive species (Appendix IV) or local expertise to identify each co-dominant species that is invasive. eCRAM software will automatically identify known invasive species that are listed as co-dominants.

Plant Community Metric Worksheet 1 of 8: Plant layer heights for all wetland types. # 1

Wetland Type	Plant Layers				
	Aquatic	Semi-aquatic and Riparian			
	Floating	Short	Medium	Tall	Very Tall
Perennial Saline Estuarine	On Water Surface	<0.3 m	0.3 – 0.75 m	0.75 – 1.5 m	>1.5 m
Perennial Non-saline Estuarine, Seasonal Estuarine	On Water Surface	<0.3 m	0.3 – 0.75 m	0.75 – 1.5 m	>1.5 m
Lacustrine, Depressional and Non-confined Riverine	**On Water Surface** 0	0 **<0.5 m**	5 SP + 1 INVASIVE **0.5 – 1.5 m**	2 **1.5 - 3.0 m**	0 **>3.0 m**
Slope	NA	<0.3 m	0.3 – 0.75 m	0.75 – 1.5 m	>1.5 m
Confined Riverine	NA	<0.5 m	0.5 – 1.5 m	1.5 – 3.0 m	>3.0 m

Number of Co-dominant Species

For each plant layer in the AA, all species represented by living vegetation that comprises at least 10% relative cover within the layer are considered to be dominant. Only living vegetation in growth position is considered in this metric. Dead or senescent vegetation is disregarded.

Percent Invasion

The number of invasive co-dominant species for all plant layers combined is assessed as a percentage of the total number of co-dominants, based on the results of the Number of Co-dominant Species sub-metric. The invasive status for many California wetland and riparian plant species is based on the Cal-IPC list (Appendix IV). However, the best professional judgment of local experts may be used instead to determine whether or not a co-dominant species is invasive.

Plant Community Metric Worksheet 1 of 8: Plant layer heights for all wetland types. #2

Wetland Type	Plant Layers				
	Aquatic	Semi-aquatic and Riparian			
	Floating	Short	Medium	Tall	Very Tall
Perennial Saline Estuarine	On Water Surface	<0.3 m	0.3 – 0.75 m	0.75 – 1.5 m	>1.5 m
Perennial Non-saline Estuarine, Seasonal Estuarine	On Water Surface	<0.3 m	0.3 – 0.75 m	[✓ 0.75 – 1.5 m] 2 SP	>1.5 m
Lacustrine, Depressional and Non-confined Riverine	**On Water Surface**	**<0.5 m**	**0.5 – 1.5 m**	**1.5 - 3.0 m**	**>3.0 m**
Slope	NA	<0.3 m	0.3 – 0.75 m	0.75 – 1.5 m	>1.5 m
Confined Riverine	NA	<0.5 m	0.5 – 1.5 m	1.5 – 3.0 m	>3.0 m

Number of Co-dominant Species

For each plant layer in the AA, all species represented by living vegetation that comprises at least 10% relative cover within the layer are considered to be dominant. Only living vegetation in growth position is considered in this metric. Dead or senescent vegetation is disregarded.

Percent Invasion

The number of invasive co-dominant species for all plant layers combined is assessed as a percentage of the total number of co-dominants, based on the results of the Number of Co-dominant Species sub-metric. The invasive status for many California wetland and riparian plant species is based on the Cal-IPC list (Appendix IV). However, the best professional judgment of local experts may be used instead to determine whether or not a co-dominant species is invasive.

Plant Community Metric Worksheet 1 of 8: Plant layer heights for all wetland types. #3

Wetland Type	Plant Layers				
	Aquatic	Semi-aquatic and Riparian			
	Floating	Short	Medium	Tall	Very Tall
Perennial Saline Estuarine	On Water Surface	<0.3 m	0.3 – 0.75 m	0.75 – 1.5 m	>1.5 m
Perennial Non-saline Estuarine, Seasonal Estuarine	On Water Surface	<0.3 m	0.3 – 0.75 m	0.75 – 1.5 m	>1.5 m
Lacustrine, Depressional and Non-confined Riverine	**On Water Surface** 0	**<0.5 m** 0	**0.5 – 1.5 m** 0	**1.5 - 3.0 m** 0	**>3.0 m** 0
Slope	NA	<0.3 m	0.3 – 0.75 m	0.75 – 1.5 m	>1.5 m
Confined Riverine	NA	<0.5 m	0.5 – 1.5 m	1.5 – 3.0 m	>3.0 m

Number of Co-dominant Species

For each plant layer in the AA, all species represented by living vegetation that comprises at least 10% relative cover within the layer are considered to be dominant. Only living vegetation in growth position is considered in this metric. Dead or senescent vegetation is disregarded.

Percent Invasion

The number of invasive co-dominant species for all plant layers combined is assessed as a percentage of the total number of co-dominants, based on the results of the Number of Co-dominant Species sub-metric. The invasive status for many California wetland and riparian plant species is based on the Cal-IPC list (Appendix IV). However, the best professional judgment of local experts may be used instead to determine whether or not a co-dominant species is invasive.

2

Plant Community Metric Worksheet 2 of 8: Co-dominant species richness for all wetland types, except Confined Riverine, Slope wetlands, Vernal Pools, and Playas

(A dominant species represents ≥10% *relative* cover)

Note: Plant species should only be counted once when calculating the Number of Co-dominant Species and Percent Invasion metric scores.

Floating or Canopy-forming	**Invasive?**	**Short**	**Invasive?**
Medium	**Invasive?**	**Tall**	**Invasive?**
		TYPHA	NO
		SCIRPUS	NO
Very Tall	**Invasive?**		
		Total number of co-dominant species for all layers combined (enter here and use in Table 4.19)	2
		Percent Invasion (enter here and use in Table 4.19)	0

Table 4.19: Ratings for submetrics of Plant Community Metric.

Rating	Number of Plant Layers Present	Number of Co-dominant Species	Percent Invasion
	Lacustrine, Depressional and Non-confined Riverine Wetlands		
A	4 – 5	≥ 12	[✓ 0 – 15%]
B	3	9 – 11	16 – 30%
C	[✓ 1 – 2]	6 – 8	31 – 45%
D	0	[✓ 0 – 5]	46 – 100%

Plant Community Metric Worksheet 2 of 8: Co-dominant species richness for all wetland types, except Confined Riverine, Slope wetlands, Vernal Pools, and Playas

(A dominant species represents ≥10% *relative* cover)

1

Note: Plant species should only be counted once when calculating the Number of Co-dominant Species and Percent Invasion metric scores.

Floating or Canopy-forming	Invasive?	Short	Invasive?
		ACROPTILON REPENS	YES
		DISTCHLIS SPICATA	NO
Medium	**Invasive?**	**Tall**	**Invasive?**
POLYGONUM LAPATHIFOLIUM	NO		
ASCLEPIAS FASCICULATA	NO		
OREGONANA	NO		
URTICA HOLOSERICEA	NO		
Very Tall	**Invasive?**		
		Total number of co-dominant species for all layers combined (enter here and use in Table 4.19)	6
		Percent Invasion (enter here and use in Table 4.19)	20%

Table 4.19: Ratings for submetrics of Plant Community Metric.

Rating	Number of Plant Layers Present	Number of Co-dominant Species	Percent Invasion
	Lacustrine, Depressional and Non-confined Riverine Wetlands		
A	4 – 5	≥ 12	0 – 15%
B	3	9 – 11	[✓ 16 – 30%]
C	[✓ 1 – 2]	[✓ 6 – 8]	31 – 45%
D	0	0 – 5	46 – 100%

(A dominant species represents ≥10% *relative* cover)

#2

Note: Plant species should only be counted once when calculating the Number of Co-dominant Species and Percent Invasion metric scores.

Floating or Canopy-forming	**Invasive?**	**Short**	**Invasive?**
Medium	**Invasive?**	**Tall**	**Invasive?**
		TYPHA	0
		SCIRPUS	0
Very Tall	**Invasive?**		
		Total number of co-dominant species for all layers combined (enter here and use in Table 4.19)	2
		Percent Invasion (enter here and use in Table 4.19)	0

Table 4.19: Ratings for submetrics of Plant Community Metric.

Rating	Number of Plant Layers Present	Number of Co-dominant Species	Percent Invasion
	1 (Tall) C	2 D	0 A

3

Plant Community Metric Worksheet 2 of 8: Co-dominant species richness for all wetland types, except Confined Riverine, Slope wetlands, Vernal Pools, and Playas

(A dominant species represents ≥10% *relative* cover)

Note: Plant species should only be counted once when calculating the Number of Co-dominant Species and Percent Invasion metric scores.

Floating or Canopy-forming	Invasive?	Short	Invasive?
NOT VEGETATED WITH AQUATICS			
OCCASIONAL ANNUAL WEED IN DAMP SOIL			
DURING DRYING PERIOD			
Medium	**Invasive?**	**Tall**	**Invasive?**
Very Tall	**Invasive?**		
		Total number of co-dominant species for all layers combined (enter here and use in Table 4.19)	0
		Percent Invasion (enter here and use in Table 4.19)	0

Table 4.19: Ratings for submetrics of Plant Community Metric.

Rating	Number of Plant Layers Present	Number of Co-dominant Species	Percent Invasion
		Lacustrine, Depressional and Non-confined Riverine Wetlands	
A	4 – 5	≥ 12	[✓ 0 – 15%]
B	3	9 – 11	16 – 30%
C	1 – 2	6 – 8	31 – 45%
D	[✓ 0]	[✓ 0 – 5]	46 – 100%

Horizontal Interspersion and Zonation

Definition: Horizontal biotic structure refers to the variety and interspersion of plant "zones." Plant zones are plant monocultures or obvious multi-species association that are arrayed along gradients of elevation, moisture, or other environmental factors that seem to affect the plant community organization in plan view. Interspersion is essentially a measure of the number of distinct plant zones and the amount of edge between them.

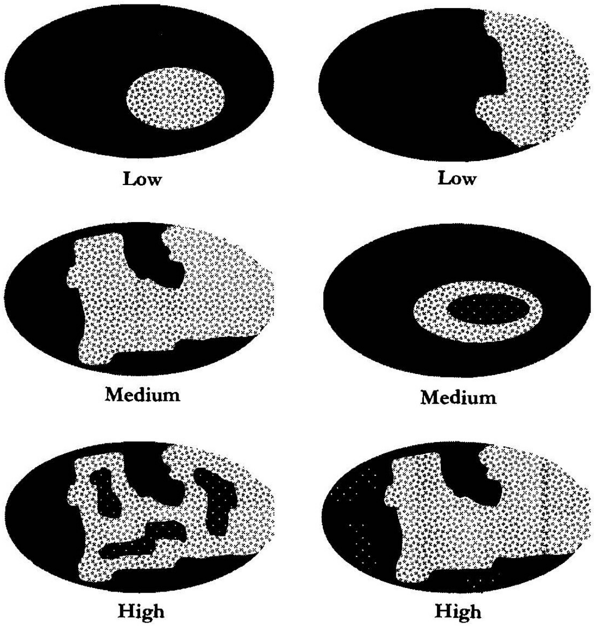
Table 4.20a: Rating of Horizontal Interspersion of Plant Zones for all AAs except Riverine and Vernal Pool Systems.

Rating	Alternative States (based on Figures 4.7, 4.8, and 4.10)
[✓ A]	AA has a high degree of plan-view interspersion.
B	AA has a moderate degree of plan-view interspersion.
C	AA has a low degree of plan-view interspersion.
D	AA has essentially no plan-view interspersion.

FOR 1,2,3

Note: When using this metric, it is helpful to assign names of plant species or associations of species to the colored patches in Figure 4.10.

Figure 4.7: Diagram of the degrees of interspersion of plant zones for Lacustrine, Depressional, Playas, and Slope wetlands. Hatching patterns represent plant zones (adapted from Mack 2001). Each zone must comprise at least 5% of the AA.



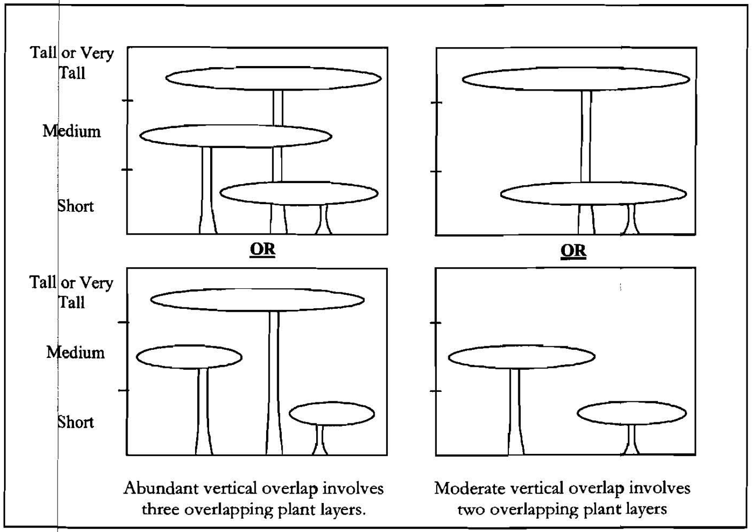
Low Low

Medium Medium

High High

Vertical Biotic Structure

Definition: The vertical component of biotic structure consists of the interspersion and complexity of plant layers. The same plant layers used to assess the Plant Community Composition Metrics (see Section 4.4.2) are used to assess Vertical Biotic Structure. To be counted in CRAM, a layer must cover at least 5% of the portion of the AA that is suitable for the layer. This metric does not pertain to Vernal Pools, Vernal Pool Systems, or Playas.



Abundant vertical overlap involves three overlapping plant layers.

Moderate vertical overlap involves two overlapping plant layers

Figure 4.11: Schematic diagrams of vertical interspersion of plant layers for Riverine AAs and for Depressional and Lacustrine AAs having Tall or Very Tall plant layers.

Table 4.21: Rating of Vertical Biotic Structure for Riverine AAs and for Lacustrine and Depressional AAs supporting Tall or Very Tall plant layers (see Figure 4.11).

Rating	Alternative States
A	More than 50% of the vegetated area of the AA supports abundant overlap of plant layers (see Figures 4.11).
B	More than 50% of the area supports at least moderate overlap of plant layers.
C	25–50% of the vegetated AA supports at least moderate overlap of plant layers, **or** three plant layers are well represented in the AA but there is little to no overlap.
[✓ **D**]	Less than 25% of the vegetated AA supports moderate overlap of plant layers, **or** two layers are well represented with little overlap, **or** AA is sparsely vegetated overall.

FoR 1,

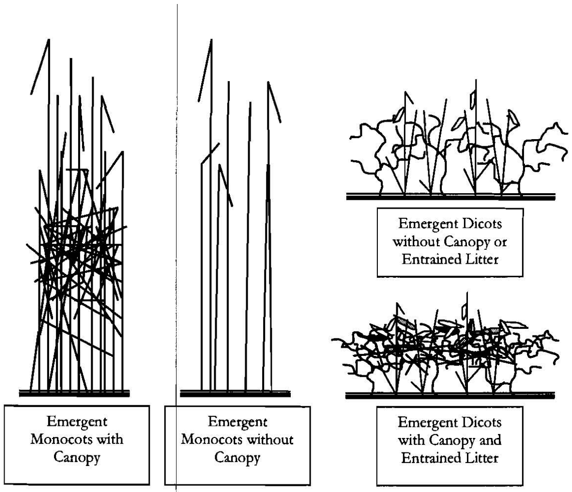


Figure 4.12: Schematic diagrams of plant canopies and entrained litter used to assess Vertical Biotic Structure in all Estuarine wetlands, or in Depressional and Lacustrine wetlands dominated by emergent monocots or lacking Tall and Very Tall plant layers.

Table 4.22: Rating of Vertical Biotic Structure for wetlands dominated by emergent monocots or lacking Tall and Very Tall plant layers, especially Estuarine saline wetlands (see Figure 4.12).

Rating	Alternative States
A	Most of the vegetated plain of the AA has a dense canopy of living vegetation or entrained litter or detritus forming a "ceiling" of cover 10-20 cm of above the wetland surface that shades the surface and can provide abundant cover for wildlife.
B	Less than half of the vegetated plain of the AA has a dense canopy of vegetation or entrained litter as described in "A" above; OR Most of the vegetated plain has a dense canopy but the ceiling it forms is much less than 10-20 cm above the ground surface.
C	Less than half of the vegetated plain of the AA has a dense canopy of vegetation or entrained litter AND the ceiling it forms is much less than 10-20 cm above the ground surface.
[✓ D]	Most of the AA lacks a dense canopy of living vegetation or entrained litter or detritus.

for 1,2,3

Guidelines to Complete the Stressor Checklists

Definition: A stressor, as defined for the purposes of the CRAM, is an anthropogenic perturbation within a wetland or its environmental setting that is likely to negatively impact the condition and function of the CRAM Assessment Area (AA). A disturbance is a natural phenomenon that affects the AA.

There are four underlying assumptions of the Stressor Checklist: (1) deviation from the best achievable condition can be explained by a single stressor or multiple stressors acting on the wetland; (2) increasing the number of stressors acting on the wetland causes a decline in its condition (there is no assumption as to whether this decline is additive (linear), multiplicative, or is best represented by some other non-linear mode); (3) increasing either the intensity or the proximity of the stressor results in a greater decline in condition; and (4) continuous or chronic stress increases the decline in condition.

The process to identify stressors is the same for all wetland types. For each CRAM attribute, a variety of possible stressors are listed. Their presence and likelihood of significantly affecting the AA are recorded in the Stressor Checklist Worksheet. For the Hydrology, Physical Structure, and Biotic Structure attributes, the focus is on stressors operating within the AA or within 50 m of the AA. For the Buffer and Landscape Context attribute, the focus is on stressors operating within 500 m of the AA. More distant stressors that have obvious, direct, controlling influences on the AA can also be noted.

Table 5.1: Wetland disturbances and conversions.

FOR 1,2,3

Has a major disturbance occurred at this wetland?	Yes	[✓ No]		
If yes, was it a flood, fire, landslide, or other?	flood	fire	landslide	other
If yes, then how severe is the disturbance?	likely to affect site next 5 or more years	likely to affect site next 3-5 years	likely to affect site next 1-2 years	
Has this wetland been converted from another type? If yes, then what was the previous type?	[✓ depressional]	vernal pool	vernal pool system	
	non-confined riverine	confined riverine	seasonal estuarine	
	perennial saline estuarine	perennial non-saline estuarine	wet meadow	
	lacustrine	seep or spring	playa	

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