Watsonville Sloughs Watershed

Resource Conservation & Enhancement Plan

prepared for

County of Santa Cruz Planning Department
*701 Ocean Street * Santa Cruz * California * 95060*

by

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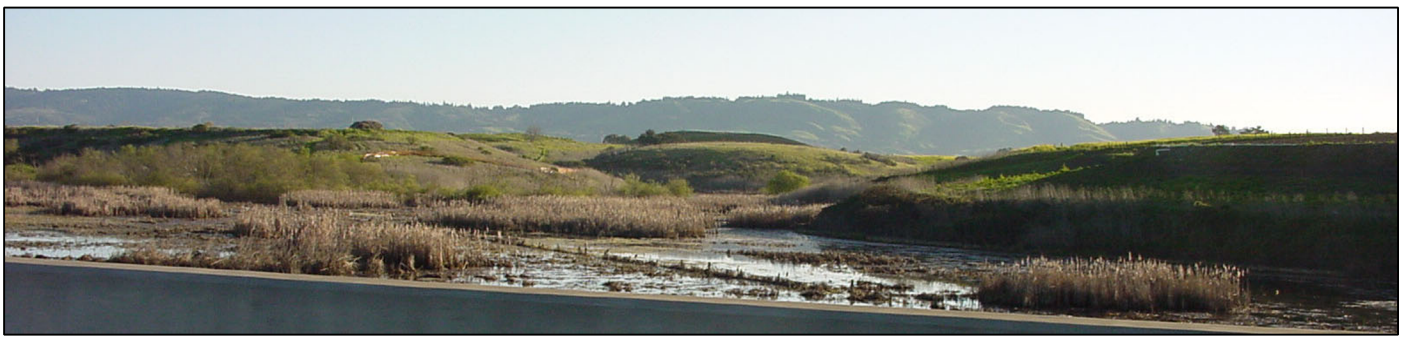

PREFACE

The WSCEP is designed to provide a future vision and a guide for many agencies, organizations and individual landowners to further the goals of conserving and restoring the diverse natural resources of the Watsonville Sloughs Watershed in concert with improving the existing economic, social and recreational activities for the community. The Plan is designed to be adaptable and flexible should important factors change in the future. The Plan supports and respects the rights of property owners and projects will only occur with the support of willing landowners and other partners.

This document identifies feasible projects that address the long-term protection and enhancement of the Watsonville Sloughs system's ecological values and the needs of agriculture and other land uses. It represents the involvement and efforts of a diverse set of numerous stakeholders who took the time to share their knowledge. The strategies and project specifics were collected from public comments received during community meetings and focused workshops convened by a steering committee and consultant team, selected to reflect a balance of the different stakeholders in the watershed. A considerable number of individual meetings were held with growers and landowners in both the lower and upper watershed to discuss wetland and resource issues and possibilities for mutually beneficial projects. All of these efforts were instrumental in refining and prioritizing the recommended projects.

Initial projects have been identified to begin implementation and demonstrate successful ways to relieve environmental stressors, buffer wetlands and sensitive areas from land use impacts, and begin the restoration of a functional ecosystem within the Sloughs.

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BACKGROUND AND INTRODUCTION

The environs of the Watsonville Sloughs are a highly valued and unique wetland resource situated adjacent to Monterey Bay within the California central coast. Six individual sloughs (Watsonville, Harkins, Struve, West Branch Struve, Gallighan, and Hanson) sustain large wetland marsh and riparian habitats for a variety of wildlife and native plants. The adjoining hillsides and upland areas contain important wildlife areas including grassland, oak woodland and chaparral habitats. Economically important agricultural production occurs throughout much of the Watsonville Sloughs Watershed.

The Sloughs have a rich history of natural resource utilization beginning with the original hunter/gatherer Native American societies. Substantial changes occurred after European settlement began in the early 1800s with widespread clearing of native vegetation and reclamation of wetlands for agriculture. This led to hydrologic changes detrimental to native plants and wildlife habitat, culminating in large losses of wetlands and native habitats during land reclamation efforts in the late 1800s and early 1900s. A marked decline in open space and habitat accelerated after World War II with an expansion of urban areas around the City of Watsonville. All of these changes fragmented the Sloughs, reduced water circulation and groundwater recharge, and introduced a number of pollutants to the waterways and remaining natural wetlands. As a result, the Watsonville Sloughs system has been listed as an impaired waterbody under the Federal Clean Water Act (Section 303d) for elevated levels of pesticides, sediment, oils and grease, metals and pathogens.

In recent years, as the drainage system constructed during the reclamation era has decayed, large areas of agricultural land have been seasonally inundated resulting in a significant loss of agricultural production. This process has been further accelerated with the accompaniment of a trend of land subsidence over large areas and urban expansion upstream adding more runoff to further tax the drainage system. Although a greater area of inundation can be viewed by some as favorable to the overall wetlands value of the Sloughs, (particularly with expanded open water habitat for winter migratory waterfowl and wetland vegetation), it has been coupled with reduced water circulation, eutrophication, and a reduction in the general biotic health of the aquatic ecosystem. In their current condition, and despite the reversion to wetlands, the natural resources of the Sloughs exist well below their potential value. Simultaneously, agricultural productivity has been adversely affected by the

same conditions. Thus, there is an opportunity to improve the natural resources of the Sloughs, while addressing the economic needs for agricultural productivity and the effects of urban expansion.

The Watsonville Sloughs Watershed Conservation and Enhancement Plan (WSCEP) specifies feasible measures that address the long-term protection and enhancement of the Watsonville Sloughs system's ecological values, and the needs of agriculture and other land uses. The WSCEP is designed to provide a future vision and a guide for many agencies, organizations and individual landowners. It is anticipated that the various entities will embark on a coordinated effort to implement the Plan and focus on priority areas. The Plan is based upon scientific, social and economic factors that have often worked at odds, but must be realigned if successful preservation and enhancement of the landscape and rural character of the Sloughs is to be realized. Most of the resource management activity now occurs in the regulatory sector, leading to a fragmented and often contentious relationship between stewardship organizations seeking resource protection and landowners. A key aim of the Plan is to find resource solutions that foster cooperation between various groups, agencies and landowners. The Plan is designed to be adaptable and flexible should important factors change in the future. Participation is on a strictly voluntary basis.

The WSCEP was prepared by a Consultant Team headed by Swanson Hydrology and Geomorphology (SH&G) under contract to the County of Santa Cruz with funding provided by the California State Coastal Conservancy and U. S. Environmental Protection Agency. The WSCEP was developed working collaboratively with numerous agencies, public interest groups and individuals with a stake in the management and protection of the Sloughs under the direction of a Steering Committee, representative of the stakeholders in the watershed.

The community and the Steering Committee identified the following goals, which are the desired outcomes of implementing the WSCEP:

- Protect and where possible restore degraded characteristics of marsh, riparian and upland habitats;
- Provide connected corridors among similar habitats as well as continuity among habitats that naturally occur in association;
- Implement projects that benefit natural resource quality while addressing social and economic needs of the community and landowners;

- Work with landowners and operators to develop mutually beneficial projects to be implemented only where the landowner is willing;
- Improve drainage and water quality in a manner that improves conditions for landowners, wildlife and water users;
- Address the needs and responsibilities of landowners in the watershed with regard to management of sensitive species;
- Look for opportunities to minimize regulatory disincentives for resource protection and enhancement on private lands;
- Establish a system whereby opportunities to acquire land can be acted upon as they arise;
- Develop public education and access improvements to enable a greater public awareness of the values of the Watsonville Sloughs for native wildlife and natural resources as well as their economic, social and recreational values.

To organize discussions of specific locations in the Watsonville Sloughs Watershed, geographic factors were used to distinguish ten specific Planning Areas, each with unique natural resource features and planning issues. In general, land use in the upper watershed is rural residential (Larkin Valley and Upper Gallighan Slough) with minor commercial agricultural land uses. The Upper Struve and Upper Watsonville Sloughs sub-watersheds are predominately urban landscapes surrounding wetlands and intervening open spaces on hillslopes; many dense commercial and industrial uses bound the Sloughs, especially along Watsonville Slough below Ford Street. The open space hilltops and upper hillslopes between Struve Slough and Watsonville Slough east of Highway 1 will become more urbanized with the completion of new housing developments within the next five years. The middle portions of Gallighan and Harkins Sloughs are highly disturbed by farms on hillslopes (fallow or under production), or other intensive uses such as landfills and transportation corridors. The lower portions of the tributary sloughs (Harkins, Struve, West Branch Struve) are generally in open space (some in public ownership) but in degraded condition (invasive vegetation and constrained hydrology). The lower watershed areas are dominated by agricultural uses on valley floors (i.e. Beach Road and Watsonville Slough below Highway 1), much of which has encroached directly into the Sloughs.

FINDINGS

An assessment of existing conditions found that present and historic land use has had a significant impact on natural resources in the watershed. In general, the impacts are conversion of land once

habitat and open space to agricultural or urban uses; water quality degraded by constrictions to water circulation, contamination from non-point source pollutants (sediments, excessive nutrients, residual DDT and other pesticides in soil from historic use and urban runoff). Vegetation resources have been degraded through land conversion, clearing practices and invasion by exotic species. The degradation of wildlife resources is related to the effects of toxic runoff, depletion of dissolved oxygen in the water column, fragmented habitat, structural barriers to wildlife movement and the presence of aggressive non-native species.

RECOMMENDATIONS

The WSCEP recommends a diverse set of projects consisting of the following five components:

- Habitat enhancement projects, such as hydrologic improvements, replacement of exotic invasive vegetation and water quality improvements;
- Land acquisition strategies, to allow for the management of areas of open space dedicated to ecosystem process and wildlife habitat;
- Coordination and improvement of regulatory process and compliance, to provide the means for landowners to have site specific requirements of sensitive resources built into the design of reliable drainage systems;
- Support and coordination with other ongoing conservation programs within the watershed to ensure communication among stewardship organizations and resource agencies, thereby fostering implementation of enhancement projects; and
- Public access and education to foster further awareness of the important natural resources of the Watsonville Sloughs system.

- Implementation of projects will only occur where there are willing landowners and will require acquisition of all applicable agency approvals.

When implemented, the recommended projects will help relieve environmental stressors; buffer wetlands and sensitive areas from land use impacts, and help restore a functional ecosystem within the Sloughs, while maintaining a viable agricultural industry.

The following are descriptions of the enhancement recommendations for each of the ten geographic planning areas in the Watsonville Sloughs Watershed.

WATSONVILLE SLOUGH

Upper Watsonville Slough

The Upper Watsonville Slough Planning Area is mostly contained within the City of Watsonville's jurisdiction and extends from its headwaters above Main Street to the low gradient drainage ditch/channel at Highway 1. The majority of the land within this Planning Area between Ford Street and Highway 1 is currently unincorporated, but area is under consideration for incorporation into the City for development with a component of expanding wetlands along the Slough.

The recommendations for the Upper Watsonville Slough Planning Area include the following projects:

- Restoration of 45 acres of wetlands formerly filled with construction debris during the 1930's. This publicly owned site is east of Ramsey Park extending from Main Street to Manabe Drive)
- Construction of a trail system through City owned parcels from Ramsey Park to Errington Road. The project will address hillslope drainage problems and include installation of urban stormwater treatments and revegetation with native plants.
- Restoration of urban wetland vegetation and hydrology from Freedom Blvd to Main Street including buffers and stormwater treatment measures.
- Restoration of 30 acres of historic wetland downstream of the westerly end of Ford Street in the event of annexation by the City of Watsonville.

Middle Watsonville Slough

The land use surrounding Middle Watsonville is predominantly agricultural lands, with a small industrial development on Lee Road. The reach of Watsonville Slough between Highway 1 and Shell Road flows through a straight ditch in the flat, northern edge of the Pajaro River floodplain. In addition to receiving agricultural runoff from the surrounding fields, Middle Watsonville Slough accepts the urban and industrial runoff from Struve Slough and the agricultural runoff from Hanson Slough.

Recommendations for Middle Watsonville Slough include:

- Reconstruction of the drainage into two separate systems: a natural wetland area and a dedicated agricultural drainage with pre-treatment measures.
- Removal of invasive, exotic vegetation from the marsh plain and adjacent upland area and revegetation with native species.

- Restructure of slough channels to obtain natural variability in pattern and depth (pools and shallows).
- Renovation of the Shell Road pumps to improve efficiency at high water stages and to allow for instantaneous, variable operation allowing water exchange during low flow freshwater periods to create transitional habitat zones.
- Securing funding to continue programs, which provide technical assistance with erosion control and other conservation practices for local landowners.

Lower Watsonville Slough

The Lower Watsonville Slough Planning Area includes the salt marsh estuary and slough channel from Shell Road to the mouth at the confluence of the Pajaro River. It includes the Pajaro Dunes development to the southwest, the agricultural lands to the east and wetland areas around Sunset State Beach.

The recommendations for Lower Watsonville Slough involve:

- Removal of exotic vegetation and revegetation with natives in existing marsh and adjacent transitional and upland areas.
- Partnership with the Friends of Pajaro Dunes and the Pajaro Dunes Homeowners Association to enhance wetland resources.
- Remove reclamation fill, berms and antiquated drainage structure to improve marsh hydrology.
- Repair and recontour the levee along the east side of the slough from Beach Road to the river mouth to enhance native vegetation and re-route agricultural drainage to pre-treatment facilities.

STRUVE SLOUGH

Upper Struve / Upper West Branch Struve Sloughs Above Highway 1

The headwaters of Struve Slough originate just south of the Watsonville Municipal Airport. The drainage area is predominantly dense urban residential and commercial development.

The recommendations for Upper Struve/Upper West Branch Struve Sloughs include:

- Renovation of hydraulic structures to restore hydrology and improve water circulation.

- Construction of trail system on City owned parcels from Pennsylvania Avenue to Highway 1 with installation of urban runoff treatment measures, removal of exotic vegetation from hillslopes and revegetation with native plants.
- Removal of reclamation fills and channels to improve water circulation with installation of ponds and meanders to diversity aquatic habitats.
- Ensure protection of uplands known as "Tar Plant Hill" located northeast of Highway 1

Lower Struve Slough / West Branch Struve Slough

This Planning Area includes the remaining portion of Struve Slough and West Branch Struve Slough downstream of Highway 1 to the confluence with Watsonville Slough just upstream of the UPRR crossing.

Recommendation for Lower Struve Slough / West Branch Struve Sloughs include:

- Restoration of channelized drainage from Lee Road to confluence with Watsonville Slough to a more natural wetland area buffered from a separate drainage system with water quality pre-treatment measures.
- Conduct selective dredging to remove remnants of reclamation activities and improve the Lee Road crossing to improve water circulation and water quality.
- Restore native vegetation cover through the removal of exotics and revegetation with appropriate native species throughout the planning area.
- Encourage the development of a management plan for the 109-acre - California Department of Fish and Game Ecological Preserve.

GALLIGHAN SLOUGH

Gallighan Slough extends from its headwaters at Highway 1 flowing down a narrow valley bounded by steep undeveloped hillslopes of dense riparian forests, then past the County landfill channelized along a main traffic corridor, and drains into Lower Harkins Slough.

The recommendations for Gallighan Slough include:

- Upgrade of the stormwater drainage system along Buena Vista Road from San Andreas Road to Highway 1 to reduce erosion and resultant sediment loading to Gallighan Slough. Requires installation of adequate culverts to pass large floods and stabilization of roadside ditches, road

cuts and road fill areas and pre-treatment facilities to remove sediment before discharge to waterways.

- Restoration of native vegetation in areas of public ownership and negotiation to expand the practice into areas of private ownership.
- Support and expand programs to encourage landowners to reduce erosion and sediment discharge from private lands through education and technical assistance.

HANSON SLOUGH

Hanson Slough drains a small basin situated between lower Harkins and lower Struve Sloughs. Harkins Slough Road traverses the upper watershed area and land use is predominately agriculture and grazing. Hanson Slough flows southward and drains into Watsonville Slough.

The recommendations for Hanson Slough include:

- Improve and expand native vegetation cover to increase abundance and diversity of plant communities and to create sediment-filtering buffers between uplands, swales and waterways.
- Develop a grazing and runoff management plan to improve water quality. The plan would include a manure management plan and grazing methods to eliminate sediment and excess nutrient delivery to the Slough.
- Restore the hydrologic function of Hanson Slough and its tributaries to reduce erosion and improve aquatic habitat and the water quality of runoff leaving the basin.

HARKINS SLOUGH

Upper Harkins Slough (Larkin Valley)

Upper Harkins Slough is the longest waterway in the Watsonville Sloughs system extending 7 miles inland through Larkin Valley. Above Highway 1 Harkins Slough flows as a stream within Larkin Valley, a narrow, linear valley surrounded by moderately steep hillslopes and tributary valleys. A significant amount of this watershed is undeveloped land providing groundwater recharge and types of wildlife habitat, relatively absent in much of the remaining areas of Watsonville Sloughs.

The recommendations for Upper Harkins Slough include:

- Establishment of a management plan to coordinate land use practices for drainage maintenance and management of riparian, wetland and sensitive species habitats. The plan

would coordinate land use activities in the upper watershed such that impacts to vegetation and wildlife resources can be minimized by the timing and methods of maintenance.

- Installation of a pilot drainage and riparian habitat restoration project to demonstrate planning, engineering, enhancement and maintenance techniques that could be applied to waterways.
- Develop a native vegetation enhancement and education program for local landowners and provide ways for grant money to be used on private land to improve native vegetation.
- Develop manure management plans for livestock or animal keeping operations to minimize entrainment of excessive nutrients into waterways and groundwater resources.

Lower Harkins Slough

Lower Harkins Slough extends from Highway 1 to the northern edge of the Pajaro Valley floodplain where it meets Watsonville Slough. The area is mostly fallow agricultural and grazing land with sparse buildings associated with present or past agricultural uses and concentrated public and private residences. Significant areas of the watershed are publicly owned, in conservation easement or not actively cultivated or grazed.

The recommendations for Lower Harkins Slough include:

- Removal of the hydraulic constriction at Harkins Slough Road by removing the road crossing or installation of an open span crossing to improve water circulation.
- Selective dredging of wetland areas to remove reclamation fills and structures and improve aquatic habitat diversity and water circulation.
- Restoration of native plant communities in the wetlands, transitional and upland areas.

BEACH ROAD DITCH

The land use surrounding Beach Road Ditch is exclusively active agricultural cultivation. On the south side of the road, Beach Road Ditch extends the length of Beach Road from Lee Road to its discharge into Lower Watsonville Slough Estuary

The recommendations for the Beach Road Ditch involve:

- Widen existing drainage ditches, plant and encourage vegetative growth within the wetlands beginning in the spring months (especially wetland vegetation capable of uptaking large amount of nutrients). Selective harvest of vegetation prior to winter storms to ensure proper flood capacity during high flows.

- Construction of pre-treatment ponds to improve water quality prior to discharge to the wetland and estuary.

The ultimate vision for the Sloughs is to improve conditions to the point where the natural ecological processes occur over a large enough area to allow them to become self-sustaining. The Sloughs' natural areas would be connected by corridors along slough and stream valleys rather than existing in isolated pockets. The connected areas would include a variety of landscape elements including wetlands on the valley floor and adjacent upland habitats, which serve a diverse assemblage of wildlife as habitat and breeding grounds. Native vegetation in the areas dedicated for natural ecosystem processes would be sustained to the point where it can out-compete exotic invasive species and maximize native wildlife habitat. For natural areas bounded by land use, pollution would be controlled within the land use either by source control to prevent pollution from entering the drainage system in the first place, or through pre-treatment, to remove as much as possible prior to discharge to natural waterways. It is this vision that will eventually lead to the creation of a vibrant and natural system that will help to nurture native plants and wildlife while enhancing the quality of life of all Pajaro Valley residents.

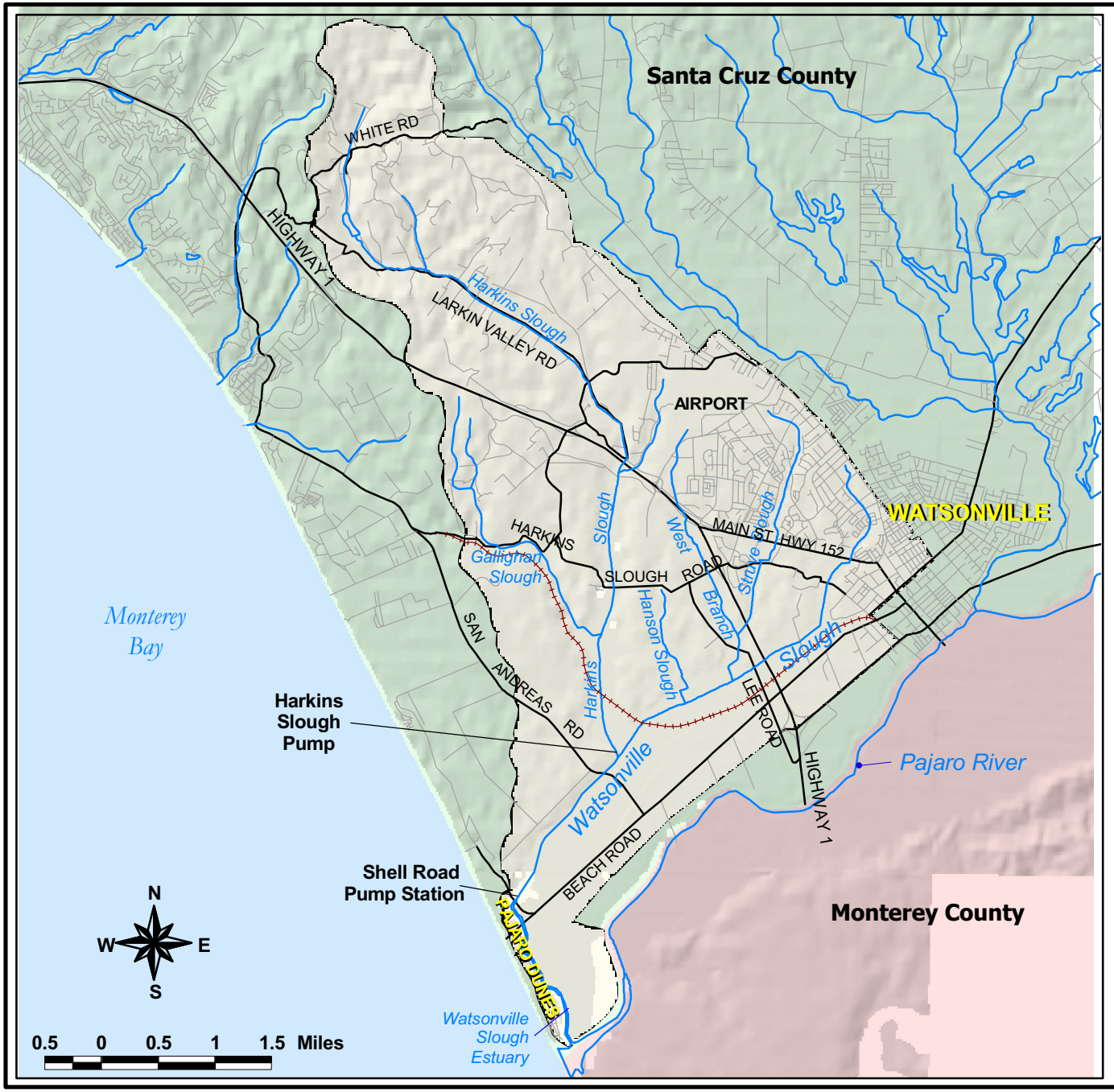
1.0 INTRODUCTION AND PROBLEM STATEMENT

The environs of the Watsonville Sloughs are a highly valued and unique wetland resource situated adjacent to Monterey Bay within the California central coast (**Figure 1-1**). Six individual sloughs (Watsonville, Harkins, Struve, West Branch Struve, Gallighan, and Hanson) sustain large wetland areas and habitats for a variety of wildlife and native plants. The adjoining hillsides, uplands and reclaimed bottomlands provide important wildlife areas, and highly productive soils support a successful agricultural economy. The Sloughs contain significant water supply resources, part of which is now being used to offset salt-contaminated coastal wells. The landscape in and around the Sloughs provides coastal scenery reminiscent of modern, historic and prehistoric times.

The Sloughs have a rich history of natural resource utilization beginning with the original hunter/gatherer Native American societies. Substantial changes occurred after European settlement began in the early 1800s with widespread clearing of native vegetation and reclamation of wetlands for agriculture. This led to hydrologic changes detrimental to native plants and wildlife habitat, culminating in large losses of wetlands and native habitats during land reclamation efforts in the late 1800s and early 1900s. A marked decline in open space and habitat accelerated after World War II with an expansion of urban areas around the City of Watsonville. All of these changes fragmented the Sloughs, reduced water circulation and groundwater recharge, and introduced a number of pollutants to the waterways and remaining natural wetlands. As a result, the Watsonville Sloughs system has been listed as an impaired waterbody under the Federal Clean Water Act (Section 303d) for elevated levels of pesticides, sediment, oils and grease, metals and pathogens.

In recent years as the drainage system constructed during the reclamation era has decayed, large areas of agricultural land have reverted back to wetlands with a significant loss of agricultural production. This process has been further accelerated with the accompaniment of a troubling trend of land subsidence over large areas and urban expansion upstream adding more runoff to further tax the system. Although reversion to wetlands can be viewed as favorable to the overall wetlands value of the Sloughs, (particularly with expanded open water habitat for winter migratory waterfowl and wetland vegetation), it has led to reduced water circulation, eutrophication, and a reduction in the general biotic health of the aquatic ecosystem. In their

Figure 1-1
Watsonville Slough Watershed Location Map



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current condition, and despite the reversion to wetlands, the natural resources of the Sloughs exist well below their potential value. Simultaneously, agricultural productivity has been adversely affected by the same conditions. Thus, there is an opportunity to improve the natural resources of the Sloughs, while addressing the economic needs for agricultural productivity and the effects of urban expansion.

This document, the Watsonville Sloughs Watershed Conservation and Enhancement Plan (WSCEP), specifies feasible measures that address the long-term protection and enhancement of the Watsonville Sloughs system's ecological values, and the needs of agriculture and other land uses. The WSCEP is designed to provide a future vision and a guide for many agencies, organizations and individual landowners. It is anticipated that the various entities will embark on a coordinated effort to implement the Plan and focus on priority areas. The Plan is based upon scientific, social and economic factors that have often worked at odds, but must be realigned if successful preservation and enhancement of the landscape and rural character of the Sloughs is to be realized. Most of the resource management activity now occurs in the regulatory sector, leading to a fragmented and often contentious relationship between organizations seeking resource protection and improvement and landowners. A key aim of the Plan is to find resource solutions that foster cooperation between various groups, agencies and landowners. The Plan is designed to be adaptable and flexible should important factors change in the future. Participation is on a strictly voluntary basis.

The WSCEP was prepared by a Consultant Team headed by Swanson Hydrology and Geomorphology (SH&G) under contract to the County of Santa Cruz with funding provided by the California State Coastal Conservancy and U. S. Environmental Protection Agency. The WSCEP was developed working collaboratively with numerous agencies, public interest groups and individuals with a stake in the management and protection of the Sloughs. The WSCEP was developed under guidance of the Watsonville Sloughs Resource Enhancement Plan Steering Committee (**Table 1-1**). The Consultant Team conducted public outreach and technical analysis and developed the plan recommendations.

Prior to performing technical analyses and developing a draft plan, the Steering Committee and Consultant Team convened a series of public meetings, including focused workshops, to integrate the community's perspectives into the planning process. The goals listed below were distilled

from those meetings. In addition to public meetings, a specific effort was made by the Consultant Team to gain insight from the landowner's perspective and to identify projects that could be mutually beneficial. The consultant's agricultural advisor (VB Agricultural Services) met individually with landowners and agricultural growers in both the lower and upper watershed to discuss wetland issues and parcel-specific possibilities for mutually beneficial resource enhancement projects.

1.1 WSCEP GOALS AND STUDY OBJECTIVES

The community and the Steering Committee identified the following goals, which are the desired outcomes of implementing the WSCEP:

- Protect and where possible restore degraded characteristics of marsh, riparian and upland habitats;
- Provide connected corridors among similar habitats as well as continuity among habitats that naturally occur in association;
- Implement projects that benefit natural resource quality while addressing social and economic needs of the community and landowners;
- Work with landowners and operators to develop mutually beneficial projects to be implemented only where the landowner is willing;
- Improve drainage and water quality in a manner that improves conditions for landowners, wildlife and water users;
- Address the needs and responsibilities of landowners in the watershed with regard to management of sensitive species;
- Look for opportunities to minimize regulatory disincentives for resource protection and enhancement on private lands;
- Establish a system whereby opportunities to acquire land can be acted upon as they arise;
- Develop public education and access improvements to enable a greater public awareness of the values of the Watsonville Sloughs for native wildlife and natural resources as well as their economic, social and recreational values.

The objectives of the research conducted in the course of preparing the WSCEP are to provide the following information:

- Develop a GIS database of the watershed in map form as a means to examine land forms, hydrology and land use and their relationship to natural resources;
- Develop a refined water quality database in order to understand drainage problems affecting land use and natural resource quality;
- Develop an understanding of social and economic conditions that lead to land use management decisions affecting natural resources, especially those of landowners;
- Identify issues related to implementing restoration projects;
- Identify projects that will achieve plan goals;
- Identify strategies for implementing enhancement projects on private and public lands;
- Develop pilot projects that demonstrate the benefits of the measures recommended in the WSCEP.

Table 1-1 Watsonville Sloughs Resource Enhancement Plan Steering Committee

Organization	Contact	Address	Phone	E-mail
County of Santa Cruz Planning Department	Donna Bradford, Resource Planner	701 Ocean St, 4th Floor Santa Cruz, CA 95060	(831) 454-7580	donna.bradford@co.santa-cruz.ca.us
City of Watsonville	Bob Geyer, Assistant Director of Public Utilities	P.O. Box 50000 Watsonville, CA 95077	(831) 728-6049	bgeyer@ci.watsonville.ca.us
Pajaro Valley Water Management Agency	Doug Coty, Watershed Program Coordinator	36 Brennan St Watsonville, CA 95076	(831)722-9292	coty@pvwma.dst.ca.us
Watsonville Wetlands Watch	Jim Van Houten	28 Arbolada Dr La Selva Beach, CA 95076	(408) 684-1861	jevan@cruzio.com
Santa Cruz County Resource Conservation District	Traci Roberts, Watsonville Sloughs Watershed Coordinator	820 Bay Avenue, Suite 107 Capitola, CA 95010	(831) 464-2950	sccrcd@cruzio.com
California State Coastal Conservancy	Patsy Heasly, Project Manager	1330 Broadway, 11th Floor Oakland, CA 94612	(510) 286-4088	paheasly@scc.ca.gov
U.S. Environmental Protection Agency, Region 9	Cheryl McGovern	75 Hawthorne St San Francisco, CA 94105	(415) 972-3415	McGovern.Cheryl@epa.gov
Santa Cruz County Farm Bureau	Dick Nutter, consultant	141 Monte Vista Ave Watsonville, CA 95076	(831) 724-1356	

2.0 SETTING

2.1 GEOGRAPHIC SETTING

The Watsonville Sloughs drain a 12,500-acre (19.5 square miles) watershed from the coastal plain and foothills of southern Santa Cruz County into Monterey Bay (Figure 1-1). The City of Watsonville lies in the southeastern portion of the watershed; the remainder of the watershed is within unincorporated Santa Cruz County. The watershed terrain is characterized by a set of southward draining valleys each with its own wetland-dominated slough that flows into Watsonville Slough.

Watsonville Slough originates in the southeastern side of the watershed within the City of Watsonville, flows westward along the northern edge of the Pajaro River floodplain, intercepting drainage from tributary sloughs before discharging into the mouth of the Pajaro River at the southwest end of the watershed. The valleys of tributary sloughs (Gallighan, Harkins, Hanson, West Branch Struve, and Struve) are entrenched within coastal terraces where the terrain is characterized by flat valley floors of marsh and riparian wetlands with steep adjacent hillsides of grasslands, oak woodland and chaparral. Harkins Slough is the longest drainage extending 7 miles inland through Larkin Valley to the headwaters situated 620 feet above sea level; Watsonville Slough flows into the Pajaro River at an elevation of 5 feet below mean sea level.

To organize discussions of specific locations in the Watsonville Sloughs Watershed, geographic factors were used to distinguish ten specific Planning Areas, each with unique natural resource features and planning issues (**Figures 2-1** and **2-2, Table 2-1**). The specifics of each Planning Area are explored in greater detail in subsequent chapters.

California State Highway 1, a north to south trending freeway, roughly divides the watershed into eastern and western halves and is a major demarcation of land use. To the west, land is generally agricultural with isolated areas of industrial uses (Lee Road) and municipal landfills (Buena Vista Road). To the east, the Sloughs are generally surrounded by urban uses, denser and industrial in the south (City of Watsonville) and rural to the north (Larkin Valley). Land coverage in most areas include marsh and riparian cover on the valley floors, and agricultural, urban, industrial and

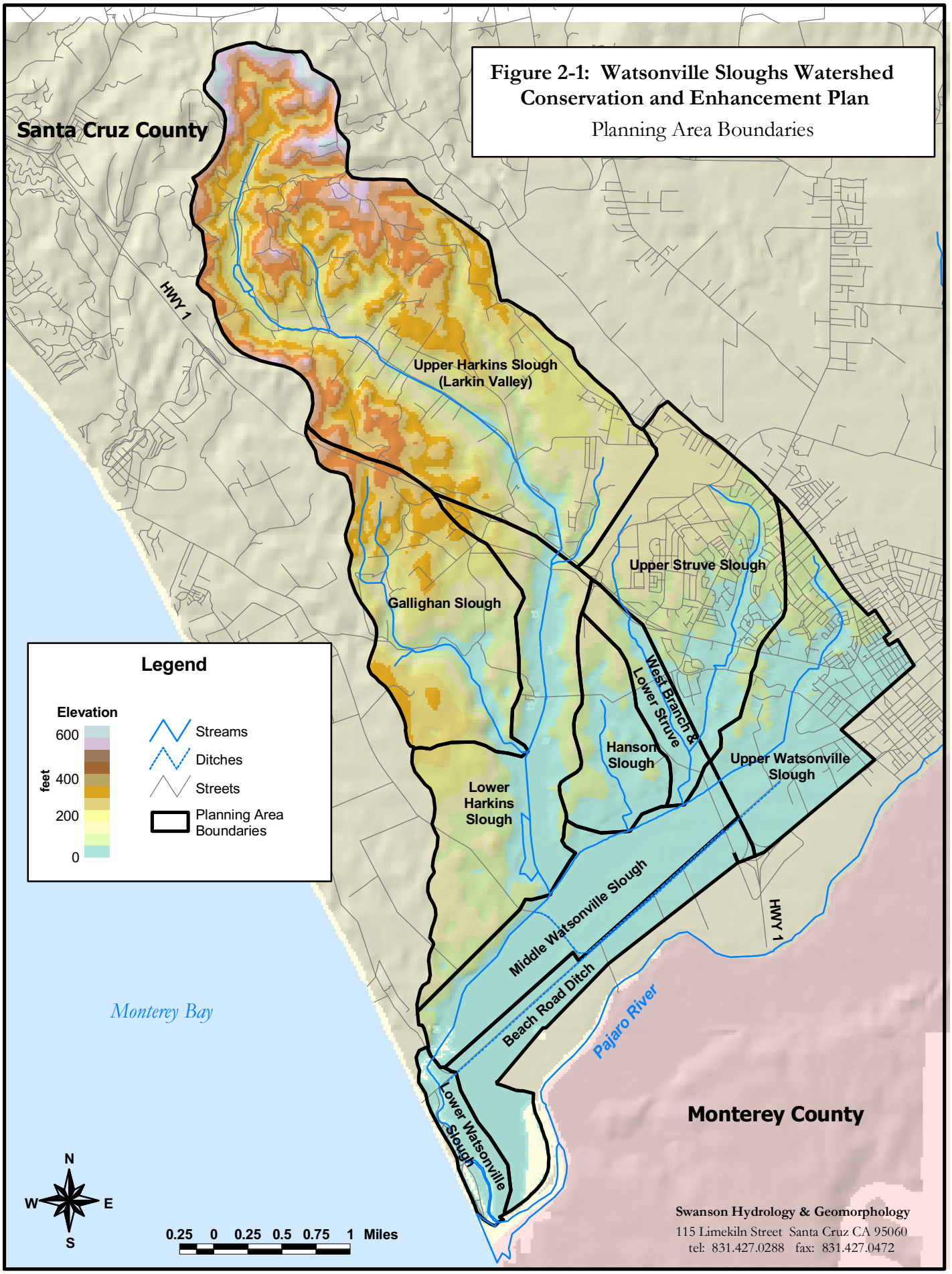
Figure 2-1: Watsonville Sloughs Watershed Conservation and Enhancement Plan
Planning Area Boundaries
Santa Cruz County
HWY 1
Upper Harkins Slough (Larkin Valley)
Gallighan Slough
Upper Struve Slough
West Branch & Lower Struve
Hanson Slough
Upper Watsonville Slough
Lower Harkins Slough
Middle Watsonville Slough
Beach Road Ditch
Pajaro River
Lower Watsonville Slough
Monterey Bay
Monterey County
Legend
Elevation
feet
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Streams
Ditches
Streets
Planning Area Boundaries
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Figure 2-2
Watsonville Slough Watershed
Legend
Streams / Sloughs
Planning Area Boundary
(interior boundary)
Watershed Boundary
(exterior planning boundary)
Scale 1:60,000 or 1 inch = 5,000 feet
Harkins Slough
LARKIN VALLEY RD
HWY 1
WATSONVILLE
Struve Slough
MAIN ST
HWY 152
HARKINS SLOUGH RD
Gallighan Slough
West Branch
Hanson Slough
Harkins Slough
Harkins Slough Pump
SAN ANDREAS RD
Watsonville Slough
LEE RD
BEACH ROAD
SANTA CRUZ COUNTY
MONTEREY COUNTY
HWY 1
Pajaro River
Shell Road Pump Station
SUNSET STATE BEACH
PAJARO DUNES
Monterey Bay
N
W
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S
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Table 2-1 Planning Areas of Watsonville Sloughs Watershed

Planning Area	Boundaries	General Hydrologic Character	General Land Use Coverages
Watsonville Slough			
Upper Watsonville Slough	Headwaters to Highway 1	Freshwater; winter runoff predominately from urban areas	Urban, industrial, agriculture, rapid urbanization
Middle Watsonville Slough	Highway 1 to Shell Road	Fresh water to brackish at lower end; seasonal freshwater runoff; runoff from urban areas upstream and adjacent agricultural lands	Predominately agriculture, short reach of industrial land between Highway 1 and 600 feet downstream of Lee Road
Lower Watsonville Slough	Shell Road to Pajaro River	Salt and brackish; freshwater inflow from winter runoff	Agriculture, public open space and private residential (Pajaro Dunes)
Struve Slough			
Upper Struve Slough and Headwaters of West Branch of Struve Slough	Headwaters of both waterways to Highway 1	Freshwater	Human modified wetlands on valley floors, open space and urban lands on hillslopes and terraces
West Branch Struve Slough and Lower Struve Slough	West Branch of Struve Slough and Struve Slough between Highway 1 and Watsonville Slough confluence	Freshwater predominately from fallow agricultural lands; urban runoff from upper Struve Slough	Predominately publicly owned wetlands and open space; proposed High School at northern end would urbanize portion of West Branch
Gallighan Slough	Headwaters to confluence with Harkins Slough	Freshwater; winter runoff from steep agricultural land, undeveloped land and municipal landfills	Mostly undeveloped open space with large areas of native vegetation, agriculture, landfills, roads and rural residential lands
Hanson Slough	Headwaters above Harkins Slough Road to confluence with Watsonville Slough	Freshwater; runoff from agricultural lands; upper watershed highly impacted by grazing	Agriculture
Harkins Slough			
Upper Harkins Slough (Larkin Valley)	Headwaters in upper Larkin Valley to Highway 1	Freshwater; runoff from rural residential lands with significant grazing areas along watercourses; minor agricultural use; some dense residential uses in lower segment	Predominately rural residential land with wetlands on and close to the floor of Larkin Valley and hillsides in predominately open space.
Lower Harkins Slough	Highway 1 to confluence with Watsonville Slough	Freshwater; runoff from rural residential land upstream in Larkin Valley and surrounding agricultural lands; tributaries to Gallighan Slough drain landfills	Predominately wetlands and oak grassland on valley floor, agriculture on hillsides; agriculture use between UPRR and confluence with Watsonville Slough
Beach Road Ditch	Along Beach Road from Lee Road to confluence with Watsonville Slough near Pajaro Dunes	Fresh to brackish water at the lower end consisting of surface runoff from agricultural lands, as well as tailwater from drain tile sumps and tributary ditches	Predominately flat agricultural lands of the lower Pajaro Valley

rural residential uses or undeveloped land on the hillsides. Land use encroaches into the valley floor wetlands to varying degrees leaving some areas wild and natural and others paved or completely clear of native vegetation. Channelization, diversion, filling of wetlands, damming and placement of culverts, pumps and tide gates have modified all of the streams and wetlands in

the watershed from their natural state.

Several County and City of Watsonville roads provide access and form important landmark crossings over the Sloughs. Harkins Slough Road crosses Watsonville, Struve, West Branch Struve, Hanson and Harkins Sloughs in the mid-area of the watershed. Main Street in the City of Watsonville, which is also State Highway 152, crosses Struve and Watsonville Sloughs. Beach Road occurs on the Pajaro River floodplain and connects downtown Watsonville to Sunset State Beach and the Pajaro Dunes development. Lee Road is a north-south road paralleling Highway 1, crosses Struve Slough, and connects Beach Road to Harkins Slough Road. Buena Vista Road connects the mouth of Larkin Valley to Highway 1, bisects the Gallighan Slough watershed and provides access to the municipal landfill sites (County of Santa Cruz and City of Watsonville) before terminating at San Andreas Road at the western edge of the watershed. San Andreas Road connects Pajaro Valley and Beach Road to the terraces that bound the western edges of the lower Harkins and Gallighan Slough watersheds. Larkin Valley Road follows the path of upper Harkins Slough to the northern end of the watershed.

The Union Pacific Railroad crosses the lower watershed from the southeast corner at Beach Road in Watsonville to the junction of San Andreas and Buena Vista Roads at the western edge of the Gallighan Slough watershed. The railroad grade is mostly on fill with bridge and culvert crossings over Watsonville, Harkins and Gallighan Sloughs.

Santa Cruz County has designated four scenic routes in the area, including Highway 1 and portions of Beach Road, Buena Vista Drive and Shell Road. The scenic panoramas of wetland, farm fields, oak forest and maritime chaparral are outstanding.

CLIMATE AND RAINFALL

The Watsonville Sloughs Watershed experiences a Mediterranean climate. The climate of the area is extensively influenced by the presence of the Pacific Ocean, which often brings cooling fog in the spring and summer months, but also minimizes freezing days in the winter (Saah and Nahn 1989). The areas mild coastal climate and unique soils allow for year-round production of valuable row crops such as strawberries and lettuce.

Precipitation occurs as rainfall. Rainfall averages 22.6 inches per year within the City of Watsonville, the bulk of which occurs between December and February. Year-to-year variability in rainfall is substantial, ranging between only 10.66 inches in calendar year 1976 to 48.35 in 1983. Extended periods of both drought (1976-77 and 1987-1993) and wet weather (1995-98) have occurred recently and the differences in rainfall are dramatic; for example 29.93 inches fell during the three winter months of water year 1998 (Dec., Jan., Feb.) while only 1.55 inches fell in the same months of water year 1976. The maximum daily rainfall recorded was 5.93 inches on February 14, 2000. The pattern of rainfall is an important factor in plant distribution and vitality, wetlands hydroperiod and generation of erosion and sediment in the channels and throughout the watershed.

2.2 GEOLOGY, SOILS AND GEOMORPHIC PROCESSES

Historical land use spanning over the past 200 years has profoundly changed the Watsonville Sloughs Watershed. Prior to the fundamental changes that began in 1769 after European contact with the native culture, the Sloughs underwent a geological development spanning tens of thousands of years. The sum of these events has produced the landscape in evidence today. Manipulating conditions for future restoration requires a basic understanding of the history and an interpretation of the geomorphic processes of the past. The following is a brief description of the geologic and land use history relevant to the WSCEP.

The Watsonville Sloughs Watershed is situated within the tectonically active coastal plain area associated with the San Andreas Fault, a major tectonic plate boundary between the Pacific and North American Plates. The San Andreas Fault system or Complex is a series of northwest trending faults that extend from the interior of the Coast Range to the outer edges of Monterey Bay offshore and includes the San Gregorio Fault. The geologic history of California Coast Ranges, including the Santa Cruz Mountains, was initiated by the creation of the San Andreas Fault over the last 5 million years.

Uplift of the western edge of the North American plate boundary created the relief between the Santa Cruz Mountains and the shoreline, presently nearly 3,000 feet above sea level. The uplift extended high ground westward toward the coastline, exposing it to erosional forces from the ocean as well as from rainfall and runoff over the land. Over several hundred thousand years,

erosion of the land surface, deposition of alluvial deposits, continued uplift of land, and periodic inundations by the ocean left a thick deposit of sediments that now underlay the Watsonville Sloughs Watershed. These include Quaternary alluvial fan, stream, dune and estuarine deposits, and marine terrace deposits of materials ranging from gravels and unconsolidated sands (notably the Aromas Red Sands) to organic peats. **Figure 2-3** shows a geologic map of the area and the predominance of Quaternary aged units, formed over the past 2 million years. **Figure 2-4** shows a soils association map, with groupings that reflect the underlying geology.

Geomorphic processes of erosion and sediment deposition have worked over thousands of years eroding through the unconsolidated Quaternary deposits and carving the drainage network of the Sloughs visible today. The present day landscape of narrow valleys, low foothills and terraces formed over 5,000 years ago. The flat-valley floors and organic peat soils indicate that soils were formed in quiet marsh areas, with little mineral sediment input, after the valley was originally formed.

This history of geologic events and recent landscape development left a distinctive hydrologic system in the watershed, one that absorbs surface water through percolation to shallow groundwater storage in the upper watershed (perched, confined and unconfined aquifers), and then discharges through springs, seeps, hillslopes, and valley bottoms. In these niches, many endemic species developed, evolving in unique physiographic and hydrologic conditions.

The lower part of Watsonville Slough (from Highway 1 downstream) has been greatly influenced by erosion, sediment deposition and floodplain development of the Pajaro River, much of which occurred over the past 12,000 years. The development of the modern Pajaro River began over 300,000 years ago and includes the capture of the San Benito River system and erosion of the Pajaro Gap at Chittenden. However, since that time the Pajaro River has formed a broad valley floor from the Gap to the ocean (approximately 10 miles). Exposed remnant channels of the original channel have apparent meander belt widths over 1,000 feet wide. This indicates equilibrium under Holocene conditions, although it is probable that tectonic uplift and deformation of the valley floor continues.

A key factor in the more recent geologic history (last 2 million years) has been the fluctuations in sea level associated with glacial periods of the Pleistocene Epoch. These fluctuations move the

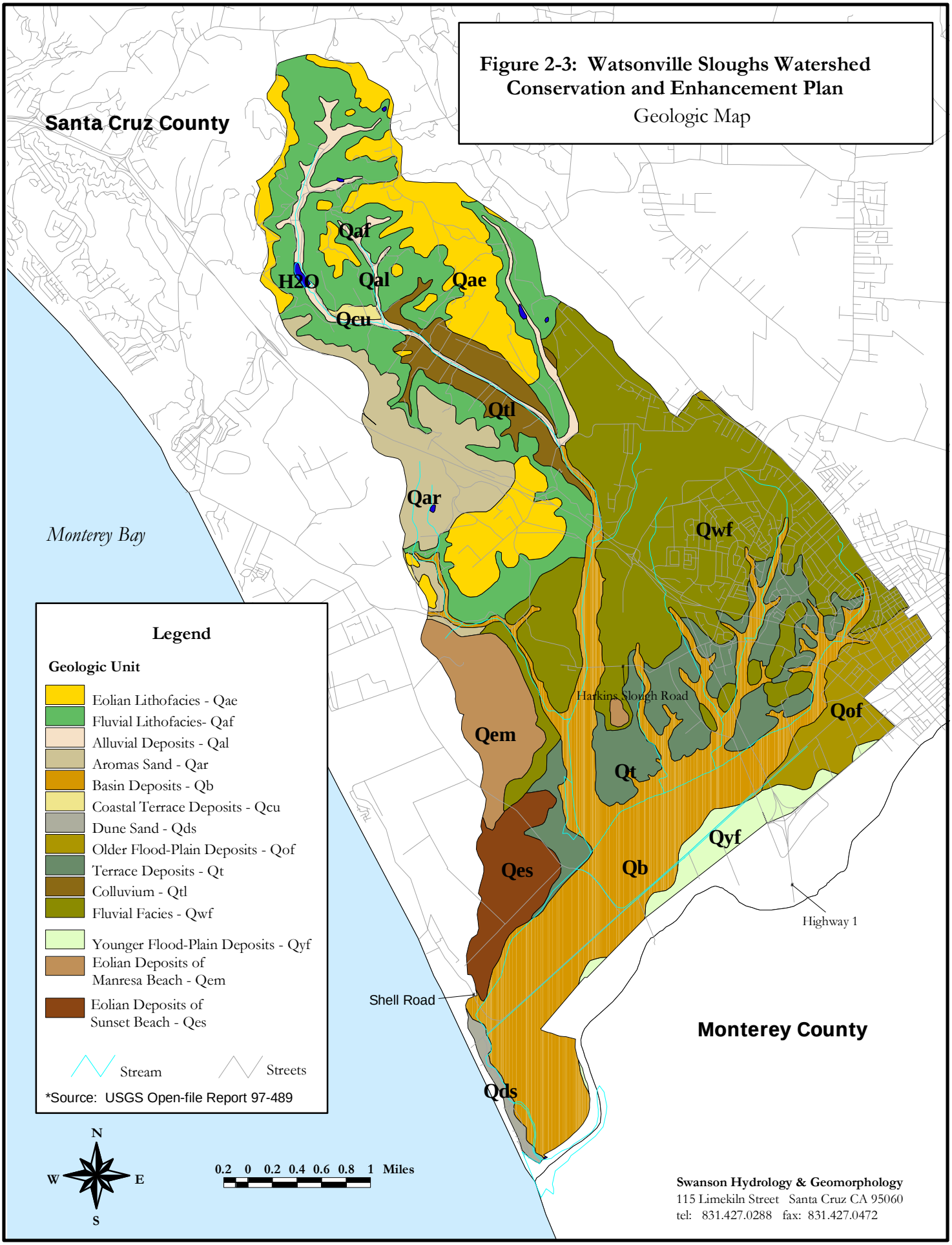
Figure 2-3: Watsonville Sloughs Watershed
Conservation and Enhancement Plan
Geologic Map
Santa Cruz County
Monterey Bay
Qaf
H2O
Qal
Qae
Qcu
Qtl
Qar
Qwf
Qem
Harkins Slough Road
Qof
Qt
Qyf
Qes
Qb
Highway 1
Shell Road
Monterey County
Qds
Legend
Geologic Unit
Eolian Lithofacies - Qae
Fluvial Lithofacies- Qaf
Alluvial Deposits - Qal
Aromas Sand - Qar
Basin Deposits - Qb
Coastal Terrace Deposits - Qcu
Dune Sand - Qds
Older Flood-Plain Deposits - Qof
Terrace Deposits - Qt
Colluvium - Qtl
Fluvial Facies - Qwf
Younger Flood-Plain Deposits - Qyf
Eolian Deposits of Manresa Beach - Qem
Eolian Deposits of Sunset Beach - Qes
Stream
Streets
*Source: USGS Open-file Report 97-489
N
W
E
S
0.2 0 0.2 0.4 0.6 0.8 1 Miles
Swanson Hydrology & Geomorphology
115 Limekiln Street Santa Cruz CA 95060
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Figure 2-3 (continued): Watsonville Sloughs Watershed Conservation and Enhancement Plan

Geologic Unit Descriptions

Qae **Eolian Lithofacies-** Moderately well sorted eolian sand. Highly variable degree of consolidation owing to differential weathering. May be as much as 200 ft thick without intervening fluvial deposits. Several sequences may be present, separated by paleosols. Upper 10 to 20 ft of each dune sequence is oxidized and relatively indurated, with all primary structures destroyed by weathering. Lower part of each dune sequence below weathering zone may be essentially unconsolidated.

Qaf **Fluvial Lithofacies-** Semiconsolidated, heterogeneous, moderately to poorly sorted silty, clay, silt, sand, and gravel. Deposited by meandering and braided streams. Includes beds of relatively well sorted gravel ranging from 10 to 20 ft thick. Clay and silty clay layers, locally as much as 2 ft thick and includes buried soils, high in expansive clays, as much as 14 ft thick.

Qal **Alluvial Deposits-** Unconsolidated, heterogeneous, moderately sorted silt and sand containing discontinuous lenses of clay and silty clay. Locally includes large amounts of gravel. May include deposits equivalent to both younger (Qyf) and older (Qof) flood-plain deposits in areas where these were not differentiated. Thickness highly variable; may be more than 100 ft thick near coast.

Qar **Aromas Sand-** Heterogeneous sequence of mainly eolian and fluvial sand, silt, clay, and gravel. Several angular unconformities present in unit, with older deposits more complexly jointed, folded, and faulted than younger deposits. Total thickness may be more than 800 ft.

Qb **Basin Deposits-** Unconsolidated, plastic, silty clay and clay rich in organic material. Locally contains interbedded thin layers of silt and silty sand. Deposited in a variety of environments including estuaries, lagoons, marsh-filled sloughs, flood basins, and lakes. Thickness highly variable; may be as much as 90 ft thick underlying some sloughs.

Qcu **Coastal Terrace Deposits-** Semiconsolidated, moderately well sorted marine sand with thin, discontinuous gravel-rich layers. May be overlain by poorly sorted fluvial and colluvial silt sand, and gravel. Thickness variable; generally less than 20 ft thick. May be relatively well indurated in upper part of weathered zone.

Qds **Dune Sand-** Unconsolidated, well-sorted, fine to medium-grained sand. Deposited as linear strip of coastal dune. May be as much as 80 ft thick.

Qof **Older Flood-Plain Deposits-** Unconsolidated, fine-grained sand, silt, and clay. More than 200 ft thick beneath parts of the Pajaro and San Lorenzo River flood plain. Lower parts of these thick fluvial aggradational deposits include large amounts of gravel, and serve a major ground-water aquifer beneath Pajaro Valley.

Qt **Terrace Deposits-** Weakly- to semi-consolidated heterogeneous deposits of moderately to poorly sorted silt, silty clay, sand, and gravel. Mostly deposited in a fluvial environment. Thickness highly variable; locally as much as 60 ft thick. Some of the deposits are relatively well indurated in upper 10 ft of weathered zone.

Qtl **Colluvium-** Unconsolidated, heterogeneous deposits of moderately to poorly sorted silt, sand, and gravel. Deposited by slope wash and mass movement. Minor fluvial reworking. Locally includes numerous landslide deposits and small alluvial fans. Contacts generally gradational. Locally grades into fluvial deposits. Generally more than 5 ft thick

Qwf **Fluvial Facies-** Semiconsolidated, moderately to poorly sorted silt, sand, silty clay, and gravel. May be more than 200 ft thick. Gravel, approximately 50 ft thick, is generally present 50 ft below surface of deposit and is both a local aquifer and significant source of gravel. Upper 5 to 15 ft of unit is moderately indurated owing to clay and iron oxide cementation in weathered zone.

Qyf **Younger Flood-Plain Deposits-** Unconsolidated, fine-grained, heterogeneous deposits of sand and silt, commonly containing relatively thin, discontinuous layers of clay. Gravel content increases toward the Santa Cruz Mountains and is locally abundant within channel and lower point-bar deposits in natural levees and channels of meandering streams. Thickness generally less than 20 ft.

Qem **Eolian Deposits of Manresa Beach-** Weakly to moderately consolidated, moderately well sorted silt and sand. Deposited in extensive coastal dune field. Overlies fluvial terrace deposits (Qwf). Locally grades conformably into underlying coastal terrace deposits (Qcu). Upper 10 to 20 ft is partially indurated owing to clay and iron oxide cementation in weathered zone. Moderate permeability and porosity except in soil zones, where generally low.

Qes **Eolian Deposits of Sunset Beach-** Weakly consolidated, well-sorted, fine- to medium-grained sand. Forms an extensive coastal dune field. Thickness ranges from 5 to 80 ft.

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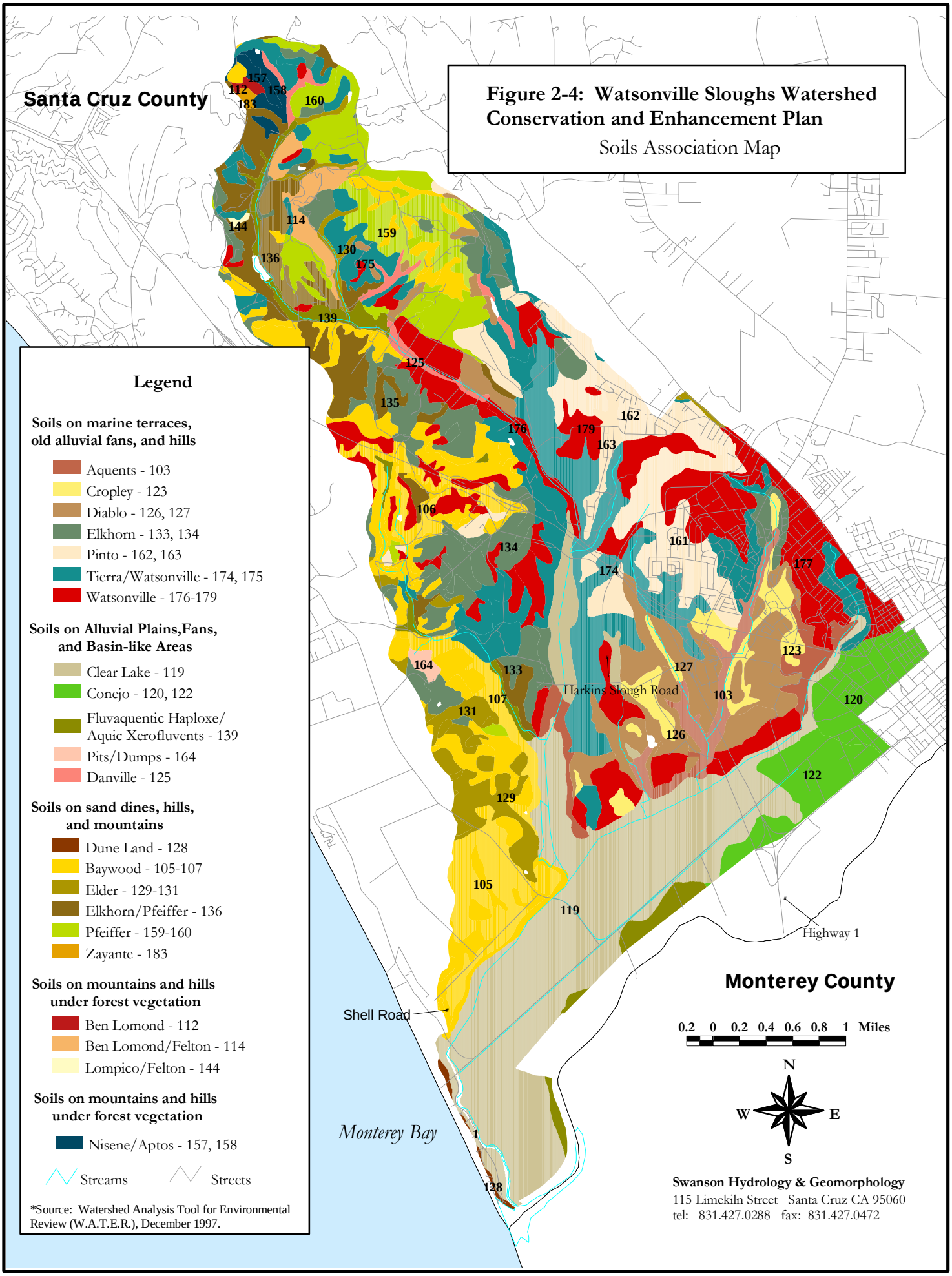
Figure 2-4: Watsonville Sloughs Watershed Conservation and Enhancement Plan
Soils Association Map
Santa Cruz County
Monterey County
Legend
Soils on marine terraces, old alluvial fans, and hills
Aquents - 103
Cropley - 123
Diablo - 126, 127
Elkhorn - 133, 134
Pinto - 162, 163
Tierra/Watsonville - 174, 175
Watsonville - 176-179
Soils on Alluvial Plains,Fans, and Basin-like Areas
Clear Lake - 119
Conejo - 120, 122
Fluvaquentic Haploxe/ Aquic Xerofluvents - 139
Pits/Dumps - 164
Danville - 125
Soils on sand dines, hills, and mountains
Dune Land - 128
Baywood - 105-107
Elder - 129-131
Elkhorn/Pfeiffer - 136
Pfeiffer - 159-160
Zayante - 183
Soils on mountains and hills under forest vegetation
Ben Lomond - 112
Ben Lomond/Felton - 114
Lompico/Felton - 144
Soils on mountains and hills under forest vegetation
Nisene/Aptos - 157, 158
Streams
Streets
*Source: Watershed Analysis Tool for Environmental Review (W.A.T.E.R.), December 1997.
Harkins Slough Road
Highway 1
Shell Road
Monterey Bay
0.2 0 0.2 0.4 0.6 0.8 1 Miles
N
W
E
S
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shoreline and coastal erosion processes faster than tectonic uplift and determine the vertical location of tidal influence. The last glacial period, which peaked around 18,000 years ago, coincided with a sea level over 300 feet lower than present and a shoreline many miles to the west of its present location. Continental glaciers melted beginning 12,000 years ago and sea level rose 300+ feet to near its present stand about 5,000 years ago. The Watsonville Sloughs Watershed was an upland terrain in the glacial periods within a much wetter climate, perhaps not unlike the Pacific Northwest of today. Beginning about 5,000 years ago, it is generally assumed that climatic conditions had become drier and close to what they are now, and "pristine" physiographic conditions existed up until the introduction of European land uses.

2.3 LAND USE HISTORY AND EFFECTS

EARLY HUMAN ACTIVITIES

Human occupancy of the Pacific Coast by Native Americans began between 8,000 to 12,000 years ago, although recent hemispheric discoveries are pushing the time back significantly. Regardless, 8,000 to 12,000 years ago would have coincided with lower sea level, and thus archeological evidence is submerged. It is believed that the subsistence living of the native Ohlones in the area depended upon the Sloughs for a variety of food and useful natural resources, such as tule and reeds for huts and basket making; extraction of these resources had little effect on the natural setting. However, it is well known that fire was used to preserve grasslands for game and this could have influenced the "pristine conditions" observed by the first European in the late 1700s. It is apparent by the descriptions of wildlife, waterfowl, abundant grasslands, water, vast riparian forests and redwood stands along the margins of the valleys, that the landscape had not been severely impacted by early human occupancy.

When Father Juan Crespi first explored the Watsonville area on October 8, 1769, he found the Pajaro River to be:

> *"… a fine little river with a fair sized bed and a great many willow trees, sycamores and other timber…and to one side to the other side of the river…a great deal of flat land…overgrown with a great deal of grass and lush plants…a very fine place for a very large mission, with a great deal of soil and water for irrigating it, and a great amount of timber."* (Paddison 1999).

Although there is not a direct description of Watsonville Sloughs in this account, it is clear that as an extension of the Pajaro Valley, the Watsonville Sloughs wetlands and grasslands were very lush and well watered, even in the late fall. The account describes abundant springs and freshwater lakes that undoubtedly are associated with springs and seeps and abundant shallow groundwater storage in the Quaternary formations. There is also reference to large redwoods occurring at low elevations along the valley fringes and headwaters.

DEVELOPMENT OF AGRICULTURE

Between this first account and the early 1800s, the most significant changes occurred with the development of the Spanish Mission culture, the elimination of Native American subsistence culture (by about the 1820s), and the introduction of European methods of grazing and crop cultivation. The first detailed map of the area's vegetation was created by the U. S. Coast and Geodetic Survey in 1853 (**Figure 2-5).** This map shows native salt marsh, grasslands, dune fields and the Pajaro River and Watsonville Slough waterways, and a significant portion of the Pajaro Valley floor in cultivation. In the late 1800's most of the lower watershed was used for cattle grazing with some vegetable crops on the valley floor. Long-time residents contend that cattle grazing (including the historic dairy/grazing operations at Harkins Slough) controlled non-native vegetation; local naturalists promote grazing as a means to remove exotic invasive vegetation species (Busch 2000). The map shows roads and a wharf near the location of Palm Beach at the end of Beach Road; agricultural products were delivered on ships probably to San Francisco. In the 1850s agriculture most likely did not have dramatic effects on the Sloughs' hydrology, although it is probable that non-native grasses and plants had begun an invasion of native plant communities, and that much of the redwoods and original wildlife had been exploited and in some cases extirpated.

By the early 1900's, the Beach Road area was switching from grazing to grains and vegetable crops. This conversion likely generated extensive reclamation efforts such as ditching and diversion to control drainage. Artesian wells used for crop irrigation are known to have existed in the lower Pajaro Valley along lower Beach Road. By the time of the first aerial photographs in 1931, the conversion of the lower half of the watershed to agriculture was nearly complete (**Figure 2-6**). Many of the farming families currently in operation adjacent to Beach Road are 2nd and 3rd generation farmers, farming the same ground their ancestors did in the early 1900's and

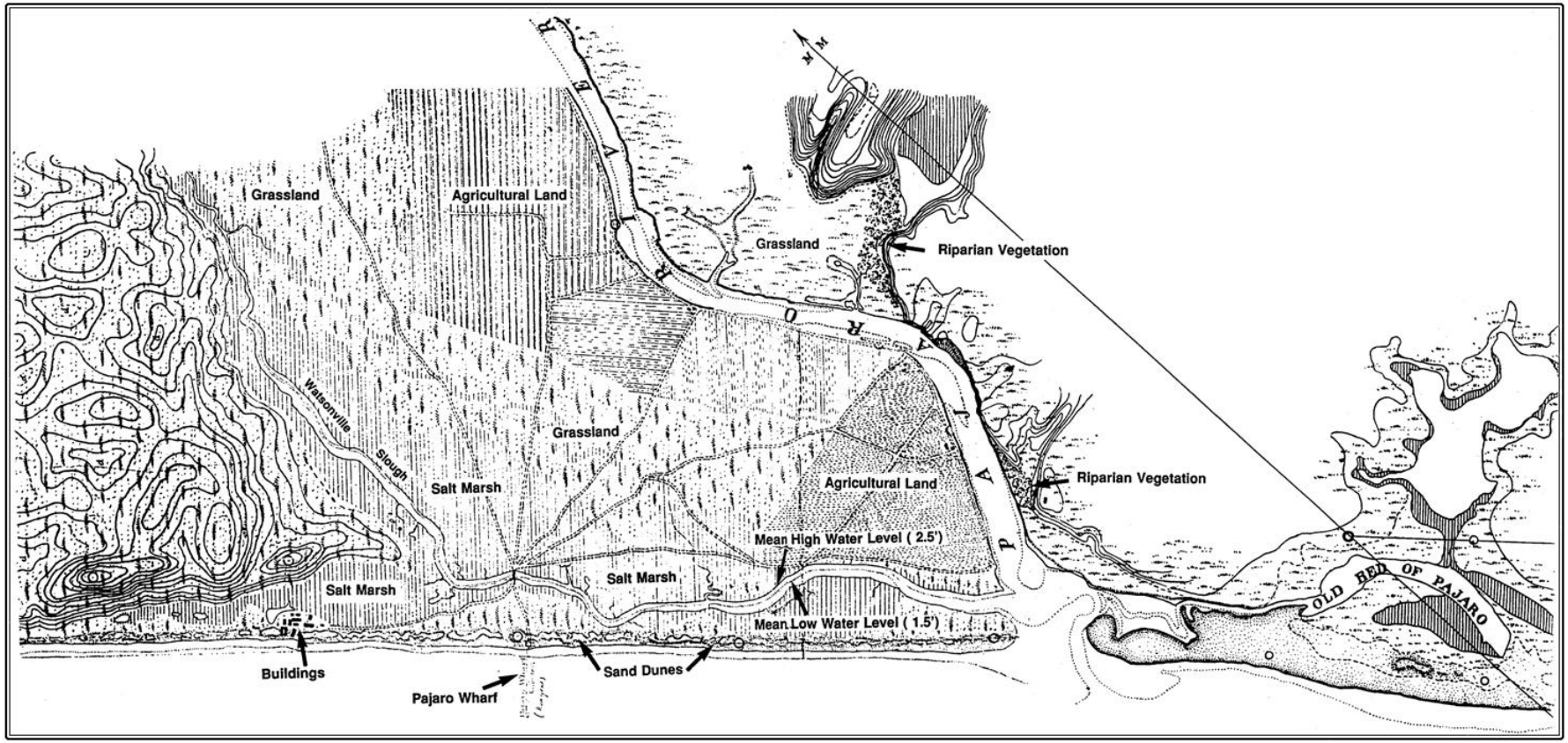

Figure 2-5: Distribution of vegetation and habitat types along the lower reaches of Watsonville Slough and the Pajaro River as mapped by the U.S. Coast and Geodetic survey of 1853.

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Figure 2-6: Aerial photograph of the lower reaches of Watsonville Slough and Pajaro River showing relic channel patterns and modifications to channel locations. *Photo taken in 1931.*

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many still farm the same crops as their ancestors. This creates a community feeling in the area that combines the financial interests of the agricultural businesses and the personal history of the residents.

An expansion of agriculture began in the late 1930s and the booming war time economy and demands for exported foodstuffs led to development of produce packing facilities and other agriculturally related businesses along Beach Road, Riverside Drive and Lee Road. Many of the road crossings and large concentrated grazing/dairy operations were already in place, however to expand crop production, waterways including the Pajaro River were confined by levees and local drainage control works. In the early 1940s, the Shell Road Pump Station and tide gates were constructed, as well as the levee that lines the left bank of Watsonville Slough from the Pajaro River to about the mid point between Shell Road and San Andreas Road; a casualty of these structures was a prominent tributary slough and extensive wetlands visible on the 1931 aerial photographs between the location of the Shell Road Pumps and Pajaro Dunes.

The 1930s and 1940s also marked the beginning of large-scale groundwater exploitation for domestic and agricultural uses, eventually leading to depletion of the shallowest aquifers first followed by deeper and deeper wells that attempted to maintain freshwater supplies for irrigation (DWR 1953). Wells as far inland as Harkins Slough have become too brackish for domestic or agricultural use due to seawater intrusion. Groundwater was over-pumped by an estimated 20,000 acre feet beyond sustained yield, leading to an extensive problem and a water supply debate that persists today.

By the late 1950's, due to advances in agriculture, drain tiling, icing of vegetables, and better seeds, pesticides and fertilizers, this area became one of the most productive in the state, growing at least 2 vegetable crops a year per acre. The postwar period saw the introduction of pesticides such as DDT and Endosulphan, chemicals since banned but still persisting in soils of the area today due to their slow rate of decay. Use of modern pesticides today is still controversial, with ongoing debates over methyl bromide for strawberry production, and efforts to forestall infestation of glassy winged sharp shooter, a carrier of Pierces Disease.

In the 1980s a boom in strawberry cultivation led to expansion of agriculture into marginal hillslope areas, especially along Struve Slough and Harkins Slough. This led to some significant

soil erosion and siltation of marsh and peat soil areas along the fringes of the valley floor. Many hillslopes now support a mix of highly productive crops including strawberries, vegetables, mushrooms, and nursery operations.

The Larkin Valley area was highly productive agricultural land with cattle grazing and un-irrigated crops such as tomatoes, beans and apricots.

Peat mining has occurred in lower Gallighan Slough (Gordon 1996) and most recently in Harkins Slough in the early 1980s. The mining left open water areas that persist today

URBAN DEVELOPMENT

The late 20th century saw surges in population and urban growth. The increase in population of Watsonville pushed its boundaries over a widespread area north and west of the original City center. Development intensified in Larkin Valley after 1950 and many parcels were subdivided for home lots supplied by groundwater wells and serviced by septic sewage systems. The use of the valley bottom for horse pasture is now a common practice by multiple rural residential landowners.

In the mid 1970s, the Pajaro Dunes development was built on the barrier beach along lower Watsonville Slough. This reduced valuable habitat areas behind the dune fields and modified the drainage of the marsh and slough. Santa Cruz County periodically breaches the sandbar that, in some years, blocks the lagoon during the summer months and floods drainage facilities, public roads, a sewage pump station and farmland.

With economic boom cycles occurring in the late 1980s and the mid to late 1990s, the City of Watsonville has expanded significantly, but is still very short on affordable housing for its working class population. Urban development east of Highway 1 has occurred at a brisk pace since the mid-1980s and includes new housing and businesses in Struve Slough and West Branch Struve Slough. Upper Watsonville Slough has been bounded by urban land for many decades, but new development off Errington Road indicates a trend of more urban development in the near future. Efforts to extend the City's boundaries west of Highway 1 have been defeated and have led to many controversies over the future of the Watsonville Sloughs, agriculture and open space.

A compromise Memorandum of Understanding (MOU) between Santa Cruz County, the City of Watsonville and the California State Coastal Commission was entered into in 2000, which enabled construction of a new high school off Harkins Slough Road between West Branch Struve Slough and Hanson Slough. As provided in the MOU the City would not pursue any annexations west of Highway 1. To ensure compliance with the MOU, Assemblyman Keeley introduced Assembly Bill No. 2144, which was signed into law in September 2000.

Action Pajaro Valley (APV), a non-profit organization, was formed to facilitate the development of a long-range plan to direct future social, economic and physical development of the Pajaro Valley. On April 9, 2002 the Watsonville City Council adopted the APV Growth Management Strategy (GMS) for future annexations east of Highway 1 for the next twenty years, including about 70 acres along Watsonville Slough east of Highway 1 and an area between the Watsonville Airport and the southern end of Larkin Valley. APV has launched a campaign to place an initiative on the November 2002 ballot to gain public approval for the GMS.

The growing population of Santa Cruz County and Watsonville has been serviced by landfills off Buena Vista Road and Gallighan Slough. A proposal by Santa Cruz County extends their landfill into adjacent agricultural land is under consideration.

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3.0 EXISTING CONDITIONS AND STRESSORS

Chapter 3 presents the scientific and planning rationale underlying the physical, biological, chemical and land use conditions that "stress" natural resources. Relieving these "stressors" is the focus of the WSCEP to ensure the future vitality of natural resources within the Watsonville Sloughs Watershed.

Chapter 3 is organized to provide a description of existing conditions followed by the identification of specific stressors on natural resources. It begins with an overview of existing land use conditions, which as described above, caused the historic degradation of natural resources and the hydrologic and geomorphic conditions that supported them. This is followed by sections describing existing conditions by scientific discipline:

- Hydrology, Geomorphology and Water Quality,
- Native Vegetation Resources,
- Wildlife Resources and Habitat, and
- Fisheries and Aquatic Habitat.

The scientific information is followed by descriptions of stressors within each individual geographic Planning Area described in Chapter 2 (Table 2-1).

For each of these management concerns, the Consultant Team compiled and reviewed existing information and generated new data and analyses. Chapter 3 provides an overview of the technical methods and results, and greater detail of data and interpretations for each of the disciplines is found in the Technical Appendices A-D.

3.1 OVERVIEW OF EXISTING LAND USE CONDITIONS AND IMPACTS

As discussed in Chapter 2, land use over the past 200 years has had a profound effect upon the natural resources of Watsonville Sloughs. As the changes occurred and agricultural and urban economies grew, so did the demands for increased drainage control and land reclamation (clearing, ditching, building etc.). Thus, the effect of land use on resources today involves a legacy of actions and decisions made many years ago. Removing "stressors" in some cases would

involve modification to land use cover and land management practices.

For the WSCEP, land use coverage was analyzed in a Geographic Information System (GIS) database for spatial distribution of different uses, their proximity to sensitive resource areas (i.e. wetlands, streams and sensitive vegetation and wildlife areas) and their effects upon ecosystems and natural resources in the watershed. **Table 3-1** displays the land use coverage for each Planning Area.

LAND USE STRESSORS

The following is a summary of the effects of individual land uses on natural resources and the ecosystem of the Watsonville Sloughs Watershed.

The method for deducing the impacts of past land use on natural resources involves a comparison of historic pre-disturbance conditions with present conditions. The physical conditions (hydrology, soils) support the type, health and distribution of vegetation cover and wildlife habitat. Land use alterations over the last century have negatively affected hydrology, soils or other factors, subsequently reducing the natural resource values. Some of these "legacy" changes may not be reversible (e.g. removing urban land cover or agricultural uses from former wetland areas). However, future restoration projects can focus on the modern stressors of current land uses and/or land management practices, which if corrected would improve the potential ecological health and function of the surrounding natural resources.

Table 3-2 presents the general effects each land use cover will have on water quality, hydrology, vegetation and wildlife resources. It is based upon general conclusions of technical literature and confirmed by specific data taken within the Watsonville Sloughs Watershed.

Each of the land uses and a majority of the associated stressors mentioned in **Table 3-2** are present within the Watsonville Sloughs Watershed. In general, the upper watershed is rural residential (Larkin Valley and Upper Gallighan Slough) with associated or minor commercial agricultural land uses. The Upper Struve and Upper Watsonville Sloughs subwatersheds are predominately urban landscapes surrounding wetlands and intervening open spaces on hillslopes; many dense commercial and industrial uses bound the Sloughs, especially along Watsonville

Table 3-1 Land use coverage types by Planning Area

Planning Area	Planning Area Size (acres)	Approximate Land Use Coverage Distribution (acres)						
		Urban Residential	Agricultural	Undeveloped	Rural Residential	Industrial	Commercial	Grazing
Upper Watsonville	1128	564	282	0	0	0	282	0
Middle Watsonville	1430	0	1216	0	0	214	0	0
Lower Watsonville	780	624	0	156	0	0	0	0
Upper Struve	1424	855	0	0	0	142	427	0
West Branch and Lower Struve	627	0	188	376	0	32	31	0
Gallighan Slough	2047	0	716	409	614	103	0	205
Hanson Slough	1002	0	200	401	100	0	0	301
Upper Harkins	4812	0	48	481	2887	241	0	1155
Lower Harkins	2571	0	771	1029	257	0	0	514
Beach Road Ditch	1675	0	1675	0	0	0	0	0
Totals	**17496**	**2043**	**5096**	**2852**	**3858**	**732**	**740**	**2175**

Source: Santa Cruz County GIS Database

Slough below Ford Street. The open space hilltops and upper hillslopes between Struve Slough and Watsonville Slough east of Highway 1 will become more urbanized with new development within the next five years. The middle portions of Gallighan and Harkins Sloughs are highly disturbed by farms on hillslopes (fallow or under production), or other intensive uses such as landfills or poorly constructed roads (i.e. Buena Vista Road west of Highway 1). The lower portions of the tributary sloughs (Harkins, Struve, West Branch Struve) are generally in open space (some in public ownership) but in degraded condition (invasive vegetation and constrained hydrology). The lower watershed areas are dominated by agricultural uses on valley floors (i.e. Beach Road and Watsonville Slough below Highway 1), much of which has encroached directly into the Sloughs.

The effect of land use on natural resources within each specific Planning Area is described later in this chapter.

Table 3-2 General effects of land use by type on natural resources

Land use	*Hydrology*	*Water Quality*	*Native Vegetation*	*Wildlife Resources*
Urban Residential	Increases stormwater volume and peak flow rates due to impervious surfaces. Increases downstream flooding and erosion.	Non-point source pollution discharged from urban landscapes (metals, greases and oil, nutrients).	Removes native vegetation. Places disturbance next to sensitive areas.	Displaces wildlife by removing native habitat. Introduces disturbance to adjacent sensitive areas. Aquatic ecosystems affected by runoff.
Agricultural	Alters natural hydrology to maintain drainage of land. Water table lowered due to groundwater removal. Saltwater intrusion (coastal systems).	Runoff pollution (nutrients, residual pesticides). Exposed land increases turbidity and sediment loading in waterways.	Removes native vegetation. Allows exotic species invasion of perimeter areas.	Displaces wildlife by removing native habitat. Aquatic ecosystems affected by nutrient rich runoff.
Undeveloped	Natural hydrology may be affected by upstream/downstream alterations or past land use.	Allows infiltration of runoff, vegetative uptake and soil contact to decrease contaminant loading.	Native vegetation may refuge in these areas.	Provides habitat for local wildlife. Habitat improved by corridors to connect undeveloped lands.
Rural Residential	Concentrates stormwater. Increases runoff volumes with vegetative clearing.	Leaky septic systems add nutrient runoff. Pollutant runoff from roads.	Native vegetation may remain in these areas. Development reduces or fragments vegetation.	Provides partial habitat for wildlife, especially resilient, opportunistic species.
Industrial	Concentrates stormwater flows and increases volumes. Increases downstream flooding and erosion.	Runoff pollution from industrial landscapes (metals, greases and oil, organics). Atmospheric pollution from various industrial activities.	Removes native vegetation. Minimal opportunity for any vegetative cover.	Minimal opportunity for wildlife habitat. Interrupts connectivity of habitat areas.
Commercial	Concentrates stormwater flows and increases volumes. Increases downstream flooding and erosion.	Runoff pollution from urban landscapes (metals, greases and oil, nutrients).	Removes native vegetation. Minimal opportunity for any vegetative cover.	Minimal opportunity for wildlife habitat. Interrupts connectivity of habitat areas.
Grazing	Grazing in channel decreases bank cover and increases bank erosion. Reduced cover increases erosion, runoff volume and peak flows.	Runoff pollution from livestock waste (nutrients). Channel erosion and incision leads to high sediment loads.	Native vegetation removal. Favors annual grasses and other exotic species. Removal of riparian cover. Presence of vegetation allows evapotranspiration and nutrient uptake.	Can provide habitat for local wildlife and may serve as corridors to connect undeveloped lands.

Sources: Dunne and Leopold 1978, National Research Council 1992

SURFACE WATER HYDROLOGY

The magnitude of surface flow within the Sloughs varies both seasonally and spatially. Runoff occurs in response to winter rainstorms between October and April. In general, the patterns of flow in watercourses of the headwaters are intermittent (winter rainfall runoff with late spring seasonal baseflow) or ephemeral (flows only occur shortly following rainfall events) while the waterways in the middle and lower watershed are perennial (flow all year around). **Figure 3-1** illustrates the stream characteristics and circulation ratings observed throughout the watershed.

No stream flow records exist for the Sloughs and measurement is difficult due to variable hydraulic effects of dispersed springs, dams, pumps and tidal influences. An estimated annual runoff between 3,000 and 5,000 acre feet per year (an acre foot is the volume of water covering an acre to a depth of 1 foot) discharging from the Watsonville Sloughs Watershed was made by Questa (1995) using pump records at the Shell Road pump station. Summer and fall baseflows are augmented by tailwater from agricultural lands, pumping of shallow groundwater in drain tile systems, and irrigation and septic system return flows from urban and rural areas.

The upper, headwater reaches of Upper Harkins and Gallighan Sloughs consist of steep, ephemeral reaches that transport storm runoff to perennial trunk streams that flow along narrow valley floors (i.e. Upper Harkins Slough in Larkin Valley and Gallighan Slough along Buena Vista Road). Rough estimates of flow in streams of the upper watershed are up to several hundred cubic feet per second during severe winter floods to no flow in late fall. Winter flows can cause extensive erosion in stream channels and swales.

The middle watershed area between the Pajaro River floodplain and upper Main Street (Highway 152) is characterized by perennial and seasonal marshes in flat valleys with sluggish flow circulation. The gradients in these valleys are very low, often less than 0.1%, and waterways have numerous constrictions, primarily road crossings consisting of fill and culverts that back up water in open water marshes during the winter and spring months (in some areas all year round). Seeps and springs are common along the hillslopes, as is storm runoff from the hillslopes to the marsh areas. Water levels are dictated by inflows from upstream and flow constrictions or backwater from downstream areas; these circumstances often result in the formation of seasonal lakes. Water depths can fluctuate up to 10 feet in places depending upon location and time of year.

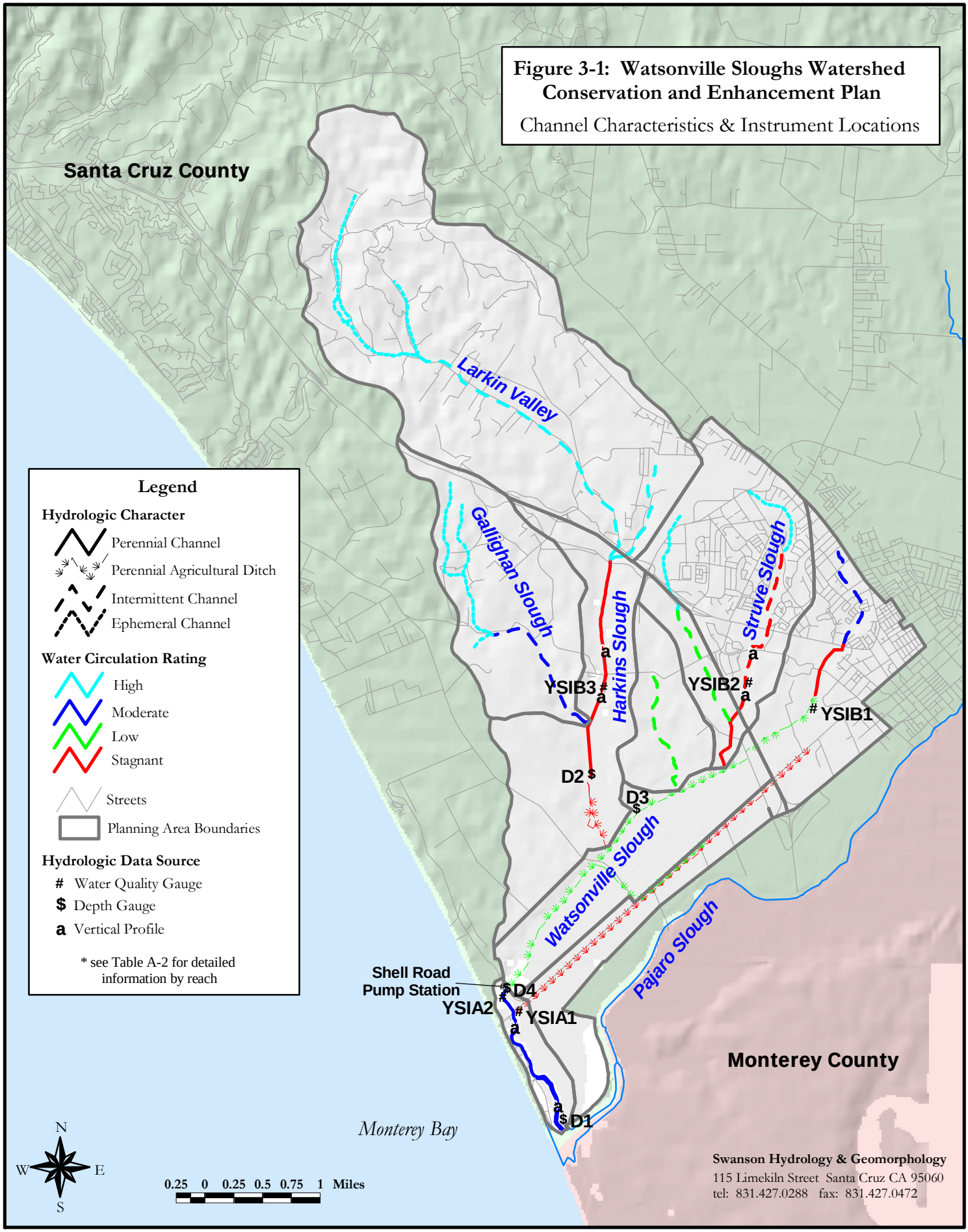
Figure 3-1: Watsonville Sloughs Watershed Conservation and Enhancement Plan
Channel Characteristics & Instrument Locations
Santa Cruz County
Larkin Valley
Calligan Slough
Harkins Slough
Struve Slough
Watsonville Slough
Pajaro Slough
YSIB3
YSIB2
YSIB1
D2
D3
D4
YSIA2
YSIA1
D1
Shell Road Pump Station
Monterey County
Monterey Bay
Legend
Hydrologic Character
Perennial Channel
Perennial Agricultural Ditch
Intermittent Channel
Ephemeral Channel
Water Circulation Rating
High
Moderate
Low
Stagnant
Streets
Planning Area Boundaries
Hydrologic Data Source
Water Quality Gauge
$ Depth Gauge
a Vertical Profile
* see Table A-2 for detailed information by reach
N
W
E
S
0.25 0 0.25 0.5 0.75 1 Miles
Swanson Hydrology & Geomorphology
115 Limekiln Street Santa Cruz CA 95060
tel: 831.427.0288 fax: 831.427.0472

In the lower watershed the Shell Road Pump Station marks the boundary of tidal influence and forms an abrupt change from freshwater upstream to seasonally salt or brackish water downstream. The original wetland hydrology above Shell Road has been modified through reclamation efforts to reduce inundation and to accommodate agriculture and other uses. Surface flow in the lower watershed occurs as perennial runoff in confined channels or drainage ditches occurring along the flat, northern edge of the Pajaro River floodplain. The gradients of Harkins and Watsonville Sloughs are less than 0.05% (or 0.05 feet per hundred feet). Drainage control structures such as the Shell Road pump and tidal dam reduce flooding of extensive former wetland areas and accommodate land development and agricultural practices in former wetland areas. Surface flows in most areas above Shell Road have sluggish to stagnant circulation. Recently, due to land subsidence and aging of drainage systems, formerly reclaimed areas have reverted back to wetlands. Some of these areas become large seasonal lakes through most of the winter rainy season and well into spring (i.e. Lower Harkins Slough, Lower Struve Slough, and Watsonville Slough between Lee Road and the UPRR crossing).

The hydrology of the Watsonville Sloughs Watershed upstream of the Shell Road Pump Station is dominated in time by seasonal rainfall and in space by the decreasing gradient and influences of human drainage modifications downstream. Seasonal rainfall occurring between November and April generates surface runoff that quickly moves from steep headwater areas, to the flat gradient valleys and waterways of the middle and lower watershed. Urbanized areas have efficient drainage systems designed to collect runoff and discharge it quickly to natural waterways; this likely increases the volume of runoff to waterways in the middle and lower watersheds. Shallow groundwater and dispersed springs extend baseflow in waterways of the lower watershed and marsh formation into the late summer, or all year round in some cases.

Downstream of Shell Road tidal dam, Watsonville Slough is influenced by tidal fluctuations that emanate from the Pacific Ocean outside of the Pajaro River mouth. Tidal fluctuations range between 0 feet when the Pajaro River mouth is closed by a sandbar (typically late summer and fall seasons) to over 7 feet when winter storm surge is added to high tides. In winter, high tides can back water up Watsonville Slough beyond the Shell Road tidal dam and inundate extensive areas of the lower Sloughs. Circulation below Shell Road is relatively high when the Pajaro River mouth is open and outgoing tides drain water from the slough out to sea. Circulation is sluggish or stagnant if the tidal range is low, or if the sandbar across the Pajaro River mouth is formed.

GROUNDWATER

Significant groundwater resources that underlie the Watsonville Sloughs Watershed provide water supply to agricultural and domestic users. There are three aquifers identified in the area. Groundwater in the lower watershed and Pajaro Valley now tap deep aquifers (600 feet below ground), but have in the past exploited from middle (250-300 feet deep) and upper level aquifers (40-60 feet deep). These aquifers are separated by less permeable layers of fine sediments that restrict downward movement of groundwater in the middle and lower reaches of the watershed. These confining layers are associated with geologic deposits formed in the quiet water environments (bays, floodplains, back dune sloughs, etc.) of the past 2 million years and generally become thinner to the east. Recharge from surface flow to the deeper aquifers is thought to occur from the Pajaro River and tributary streams along the fringes of the Pajaro Valley and upper Watsonville Slough that are underlain by permeable, coarse alluvium; the upper reaches of Larkin Valley are the only areas in the Watsonville Sloughs Watershed where it is thought to recharge deeper aquifers. In the middle and lower reaches of the watershed, low permeability layers underlie the surface watercourses and groundwater recharge is limited. The upper "shallow" aquifer is thought to be less than 40 feet deep and subject to recharge from adjacent hillslopes and side valley tributaries' streams.

Shallow perched groundwater occurs within terraces and hills that divide the Sloughs. These are not exploited for groundwater, but provide spring flow and seeps on hillsides above the valley bottoms supporting wetland plant communities.

Farmers in the lower Pajaro Valley service "drain tile" subdrain systems to collect and pump out shallow groundwater that rises during the winter months. These systems make soils productive all year round. Drain tile runoff is collected into sumps and pumped into surface ditches (such as Beach Road Ditch) before discharging into the Sloughs. Irrigation runoff and percolated rainfall are also sources collected by drain tile/sump systems and discharged into drainage ditches.

GEOMORPHOLOGY

The key management issue in the Watsonville Sloughs Watershed related to geomorphology is sediment production, transport and deposition within the waterways. Sediment is generated by erosion of exposed surface soils and in the headwater areas, on hillslopes or by erosion within the waterway (channel bank erosion). Sediment contributions within the Watsonville Sloughs Watershed were documented through examination of field conditions, geologic maps and reports, and previous studies.

Land use activities that reduce vegetation cover, expose soils or modify drainage accelerate erosion and increase sediment supply. Erosion occurs by two main processes: surface erosion, the simple removal of soil by water moving over land which creates sheet, rill and gully erosion, and landsliding or mass wasting, when large bodies of soil move en mass downslope. Landslides can be slow moving (slumps) or fast moving (debris flows) depending upon the nature of soils and underlying geologic units. While these erosional processes are natural phenomena and occur in undisturbed environments, land use activities, especially grading for roads, land clearing and drainage modifications that concentrate flow or increase runoff rates greatly accelerate erosion and sediment generation. Examples of all types of erosional features and their associated processes are visible within the Watsonville Sloughs Watershed.

As previously described, the headwater and hillslope areas in the upper Watsonville Sloughs Watershed are underlain by unconsolidated sediments of Quarternary age (less than 2 million years old). Most of these geologic units and overlying soils are highly erodible because they are coarse sand sizes and contain little clay that tends to hold soils together. Erosion from hillslopes with these materials is the main source of sediment in the upper watershed. In the lower watershed, significant erosion will occur during large runoff events on exposed agricultural lands occupying relatively steep slopes.

Sediment generated on hillslopes of the upper watershed is transported to the valley floor where the reduction of gradient and stream power will cause deposition. This leads to the formation of side valley alluvial fans and the filling of waterways such as Upper Harkins Slough or Gallighan Slough when the rate of sediment inflow exceeds the ability of the waterway to transport it. Accelerated erosion on hillslopes has been found to bury wetland soils (Struve Slough and West

Branch Struve Slough) and completely fill waterways (Gallighan Slough). Hydraulic structures, vegetation and confined channels further impede transport of sediments. The reach of Watsonville Slough between Highway 1 and Shell Road is a low gradient ditch and natural area of sediment deposition. Hanson, Upper Watsonville, Struve and Harkins Sloughs all have higher gradients during flood stage and all discharge into Watsonville Slough between Highway 1 and Shell Road. Until 1983, this reach was routinely dredged to remove accumulated sediments and maintain drainage. However, in recent years, dredging has been reduced by lack of adequate funding and regulatory restrictions.

Fine sediments (silts, fine sand, and clay) generated from eroded agricultural land and transported to the local waterways can also present issues concerning health and vitality of the Sloughs. Besides the physical impairments associated with sediment accumulation, residual pesticides (such as DDT and Endosulphan) in farmland soils are transported to waterways by soil erosion. Numerous examples are found along Watsonville Slough, Beach Road Ditch, Lower Harkins Slough, and Gallighan Slough of agricultural practices that lead to sediment runoff of contaminated soils into waterways. The sediments contributed from agricultural fields tend to be fine silts and clays, which are difficult to trap or filter once entrained in flow.

WATER CIRCULATION

The Consultant Team collected data to improve our understanding of the water circulation dynamics within the watershed. The results presented below were generated by a field survey of the location and functionality of hydraulic control structures in the watershed, direct measurements of water levels by digital recording devices, and field observations spanning the period of November 2000 through June 2001.

Figure 3-1 presents the water circulation ratings assigned to waterways within Watsonville Sloughs drainage area. Ratings of high indicate ephemeral and perennial streams that transport storm runoff and have little storage. Ratings of low or stagnant indicate little noticeable water movement and in most cases, dense algal blooms. Water circulation is minimal in low gradient areas filled with sediment and/or choked with vegetation, and drainage problems have been exacerbated by hydraulic control structures and land subsidence. **Figure 3-2** shows that inland flooding was an extensive phenomenon during the winter of 2001. **Figure 3-2** also provides the

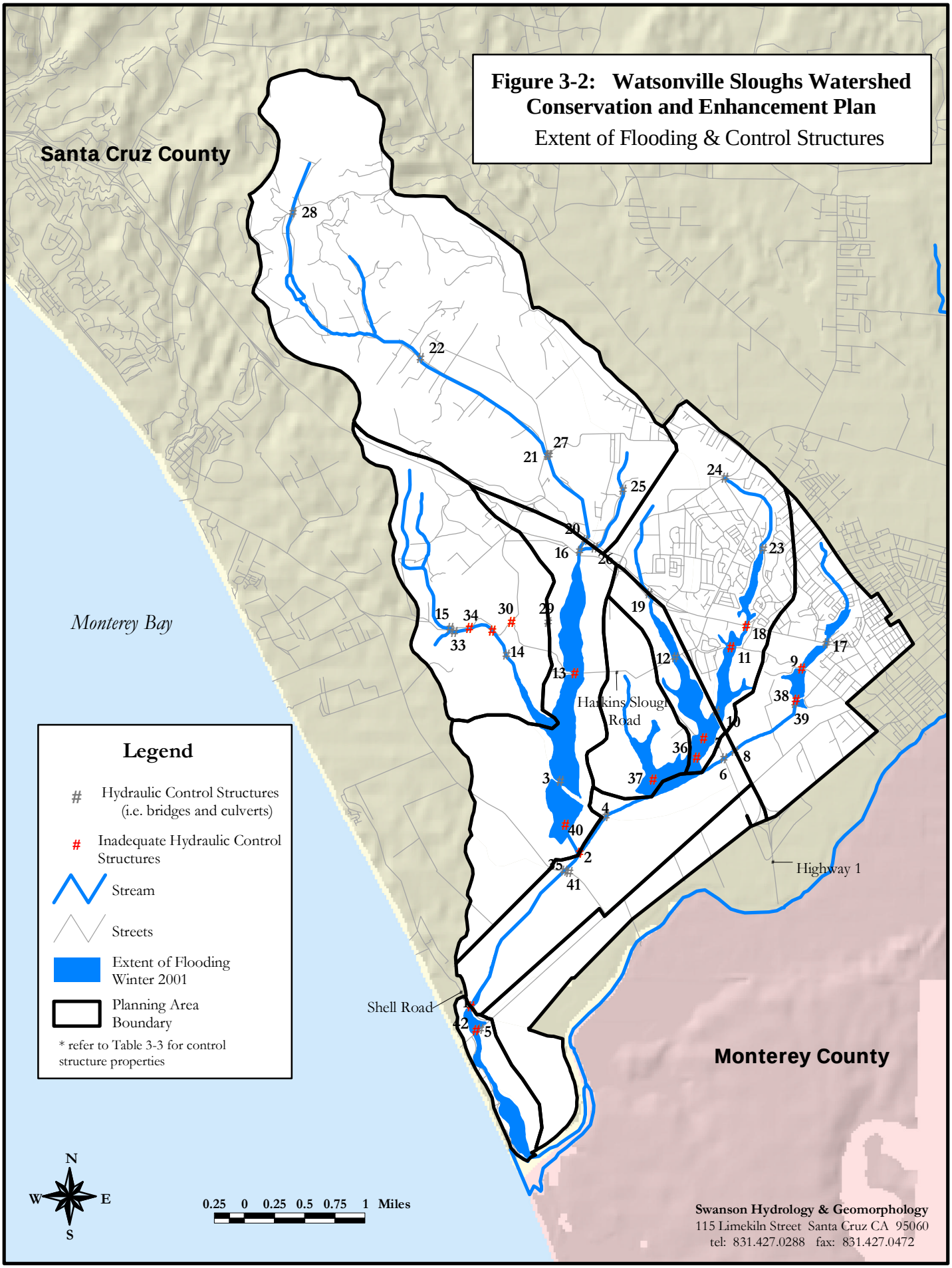
Figure 3-2: Watsonville Sloughs Watershed Conservation and Enhancement Plan
Extent of Flooding & Control Structures
Santa Cruz County
Monterey Bay
Hanklins Slough
Road
Highway 1
Shell Road
Monterey County
Legend
Hydraulic Control Structures (i.e. bridges and culverts)
Inadequate Hydraulic Control Structures
Stream
Streets
Extent of Flooding Winter 2001
Planning Area Boundary
* refer to Table 3-3 for control structure properties
N
W
E
S
0.25 0 0.25 0.5 0.75 1 Miles
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location of each of the hydraulic control structures, such as bridges, dams, pumps and levees, examined during this study. **Table 3-3** provides a detailed description of each control structure. Individual constrictions on drainage efficiency will be discussed in further detail by Planning Area at the end of this chapter.

The physical factors affecting water circulation include low gradient waterways, hydraulic control structures and potential land subsidence. The extensive seasonal lakes are in areas with low gradient waterways that have experienced a reversion to wetlands over the past 5-10 years due to decreasing efforts towards maintenance dredging. Recent subsidence of the land may have the effect of decreasing or reversing waterway gradients and further reducing the drainage efficiencies of the lower Sloughs.

The hydraulic control structures affecting waterways (**Figure 3-2** and **Table 3-3**) can significantly affect water circulation and seasonal lake formation. Some structures act as fill dams across the waterways and significantly exacerbate the winter inundation conditions. Harkins Slough Road crossings over Watsonville, Struve, and Harkins Sloughs are ideal examples. The Shell Road Pumps by design restrict tidal saltwater inflow to Middle Watsonville Slough and thus prevent circulation to the waterways above the dam. Lower Harkins Slough is seasonally lowered by pumping near its confluence with Watsonville Slough to accommodate farmland drainage for planting of spring crops.

WATER QUALITY

In the context of Watsonville Sloughs Watershed, water quality refers to the physical and chemical properties of water and its relation to the health of aquatic organisms and the health of higher organisms dependent upon aquatic productivity for food (e.g. waterfowl). All types of pollutants (i.e. trace metals, pesticides, solvents, oil, grease, nutrients, etc.) will degrade ecological health and many are toxic in excessive concentrations, but often there is little insight into how the elevated levels of pollutants affect ecosystem productivity (i.e. the number of fish or frogs for instance). Water quality data from previous studies has established that many locations in the Watsonville Sloughs Watershed are contaminated with metals, residual pesticides, grease and oil, nutrients, and sediment. It is also evident from previous data and field observations that severe impairment of basic water quality factors such as dissolved oxygen are occurring (e.g. fish

Table 3-3: Watsonville Sloughs Watershed: control structure identification, location, and rating.

Control ID	Watershed ID	Reach ID	Type and Quantity	Width (ft)	Height (ft)	Diameter (ft)	Rating	Description
1	LWS	S	pump station	NA	NA	NA	**1**	Shell Road Pump Station: eliminates tidal flushing up estuary. Stagnant water with minimal habitat value N of Pump Station
2	HSWS	P	pump station	NA	NA	NA	**1**	Harkins Slough Pump Station
3	UHS	F	Bridge	40	12	NA	4	South Pacific RR trestle above Harkins Slough; Adequate when cleared of debris; large debris pile constricting N side of control structure
4	MWS	O	2 CMP	NA	NA	5.5	4	South Pacific RR Crossing at Watsonville Slough
5	WSE	V	1 CC Tide gate	NA	NA	5.5	4	Confluence of Beach Road agricultural drainage and Watsonville Slough Estuary
6	UWS	M	2 CMP	NA	NA	4.5	4	Watsonville Slough at Lee Road; cmp half-full of sediment.
7	SS	J	culverts, road	NA	NA	NA	**1**	Struve Slough at Lee Road: Winter road closure. Road now control structure constricting flow, 2/2001 approx 150' of Rd inundated with depths up to 2.5'.
8	UWS	M	Overpass	NA	NA	NA	4	Watsonville Slough at Highway 1; overpass has no effect on drainage.
9	UWS	L	culverts, road	Innundated	Innundated	Innundated	**1**	Watsonville Slough at Harkins Slough Road: Winter road closure, Road is control structure, poor channel delineation and dense vegetation N of Harkins Slough Rd to Main St.
10	SS	J	Bridge	NA	NA	NA	4	Highway 1 at Struve Slough; overpass has sufficient clearance.
11	SS	J	2 CMP Road	Innundated	Innundated	Innundated	**1**	Harkins Slough Road at Struve Slough: Winter Road Closure, 2/2001 approx. 60' of Rd inundated with depth up to 2.5'.
12	WB	H	CMP	Inaccessable	Inaccessable	Inaccessable	5	Harkins Slough Road at West Branch, culvert clogged.
13	UHS	F	1 CB Road	6	6	NA	**1**	Harkins Slough Road at Harkins Slough. Yearly road closure. Road acting as control structure constricting flow, 2/2001 approx. 150' of Rd inundated with depths up to 2.5'.
14	GS	E	1 CMP	NA	NA	1	4	City Dump subsurface discharge point directly into Gallighan Slough
15	GS	E	1CMP	NA	NA	3	4	Buena Vista Drive at Gallighan Slough
16	UHS	F	Bridge	30	6	NA	4	Upper Harkins Slough at Ramport Rd. Confluence of LV & WMAN. Adequate when cleared of debris; all flow constricted to a width of 10.5' due to piles of debris.
17	UWS	K	2 CC	NA	NA	5.5	4	Main Street at Watsonville Slough: Extensive invasive blackberry growth at outflow of structure
18	SS	J	1 CMP	NA	NA	3	**1**	Main Street at Struve Slough, properly sized culvert, but placed at wrong elevation resulting in 3' head cut (erosion) downstream.
19	WB	G	CB	2	2	NA	4	Highway 1 at West Branch
20	LV	B	Overpass	NA	NA	NA	4	Highway 1 at Harkins Slough
21	LV	B	Bridge	7.2	18	NA	4	Buena Vista Drive at Harkins Slough
22	LV	B	CMP	NI	NI	NI	6	Larkin Valley crossing Larkin Valley Rd
23	SS	I	CMP	NI	NI	NI	6	Pennsylvania Drive at Struve Slough
24	SS	I	1 CMP	NA	NA	3.5	4	Airport Blvd. at Upper Struve Slough
25	WMAN	C	2 CC	NA	NA	3.5	4	Harkins Trib beneath Jennings Industrial Park
26	WMAN	C	1 CB	3.5	4	NA	4	Harkins Trib at Hwy 1
27	LV	B	1 CMP	3.5	5.5	NA	4	Draining S. portion of Buena Vista Rd/ Intersection of Buena Vista Rd, Larkin Valley Rd.
28	LV	A	NA	7	5	NA	4	Larkin Valley at White Rd
29	GS	E	1 CMP	NA	NA	1	6	Outfall of pumped water from County Dump property into road side ditch that eventually goes underground and surfaces at control structure 14
30	GS	E	1 CB	3	7	NA	2	Buena Vista Rd at County Dump entrance; only 1.5 ft of clearance due to siltation.
32	GS	E	1 CMP	NA	NA	3	2	Intersection of Gallighan Slough and road on dump property
33	GS	E	1 CMP	NA	NA	1	4	Culvert draining agricultural fields is perched by 4' with an extremely high sediment load in water. Simultaneous erosion and sedimentation in Buena Vista roadside ditch.
34	GS	E	1 CMP	NA	NA	2	2	Beneath Whiskey Hill Rd @ Buena Vista Rd, clogged due to high sediment load from 33
35	HSWS	Q	Bridge	35	30	NA	4	San Andreas Rd at Watsonville Slough: 25' of water clearance
36	MWS	O	2 90 turns	NA	NA	NA	**1**	2 90° turns in stream channel, high amount of sedimentation, visual high spots
37	MWS	O	3 90 turns	NA	NA	NA	**1**	3 90° turns in stream channel, high amount of sedimentation, visual high spots
38	UWS	M	2 CMP	NA	NA	3.5	3	Watsonville Slough at 356 Kearney Rd driveway. Culverts improperly placed at too high an elevation. Driveway acting as dam, creating inundation N of driveway.
39	UWS	M	Storm Drain Outlet	NA	NA	0.5	5	Stormdrain outlet discharging directly into Watsonville Slough
40	HSWS	Q	1 90 turn	NA	NA	NA	**1**	Confluence of drainage ditch West of Harkins Slough proper and Harkins Slough. High siltation, visual high spot
41	HSWS	R	Confluence	NA	NA	NA	5	Confluence of Beach Rd drainage ditch and Watsonville Slough at San Andreas Rd; no control structure.
42	WSE	V	6 CC	NA	NA	5.5	3	Beach Rd at Watsonville Slough Estuary: restrict full tidal mixing and debris preventing proper operation

*NA: Not Applicable; NI: No Information

Index of Control Structure Function

Rating	Description
1	major drainage constriction
2	clogged/ inoperable
3	inadequately sized
4	adequately sized
5	not applicable
6	no information

Index of Control Structure Types

ID	Description
CC	Concrete circular culvert
CB	Concrete box culvert
CMP	Corrogated metal pipe culvert

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kills), likely due to excessive nutrients from various land uses.

A fundamental and well-documented problem in Middle and Lower Watsonville Slough is nutrient loading from various land uses and eutrophication (Questa 1995, Hunt et al 1999, nutrient data from the County of Santa Cruz 1998, and Technical Appendix A). Eutrophication results in the loss of dissolved oxygen in the water column due to bacterial respiration of algae, whose excessive growth is stimulated by elevated nutrient levels of nitrogen and phosphorus compounds from fertilizers, septic systems and manure. Eutrophication (excessive algae production) is exacerbated by decreases in water circulation. Monbet (1992) did a comparative study of over 40 estuaries worldwide. His research found that given the same nitrate concentrations (the limiting nutrient for phytoplankton growth in estuarine systems), estuaries with greater tidal variations (circulation) would possess much lower chlorophyll levels (algae) than those experiencing less mixing.

A well-known example of eutrophication is Lake Washington in Seattle, which experienced a very rapid and dramatic shift in the summer algae levels in the 1950's in response to excessive nutrient loading from local sewage effluent. The result was the transformation of a clear, ecologically healthy lake to one experiencing blue green algae blooms, bottom water anoxia, seasonal fish kills, and widespread native species elimination at all levels of the aquatic food chain. The condition of Lake Washington has been almost completely reversed following the diversion of sewage inputs and the reduction of the nutrient inputs, which demonstrates the level of effort required to reverse this stressor.

In many of the inundated areas throughout Watsonville Sloughs the introduction of high levels of nutrients is coupled with very poor water circulation. The absence of marsh vegetation for nutrient uptake in many of these locations exacerbates the eutrophic conditions within the inland marsh areas of the Sloughs. Improved water circulation, increased wetland vegetation, and nutrient source reductions may be key strategies in future restoration efforts.

Summary of previous water quality studies

Previous water quality studies have included water, sediment and tissue sample collection in numerous locations throughout the Watsonville Sloughs Watershed. A detailed summary of previous studies' sample locations, sample collection type, collection date, and analytical

parameters investigated is presented in Technical Appendix A. Sampling and analysis for these included a range of parameters including pesticides and other organics, trace metals, nutrients and ancillary parameters. In addition, toxicity studies have been performed on transplanted bivalves and/or crustaceans to infer the ecological health of the aquatic habitat at various locations throughout the Sloughs.

The primary conclusions relevant to the WSCEP that may be drawn from the previous studies conducted in Watsonville Sloughs Watershed are:

- Trace metal and organic pesticide concentrations within the sediments of the lower Sloughs are elevated and should be monitored prior to and during any earth moving activities in areas where buried sediments may be in prolonged contact with surface waters. DDT re-suspension from buried sediments is most likely the primary concern.

- Nutrient concentrations (N, P) are extremely high in much of the Watsonville Sloughs Watershed as a result of urban runoff and agricultural practices. Stagnant waters and surface waters exposed to sunlight due to lack of vegetative cover (i.e. little circulation and warm water temperatures) exacerbate the eutrophic conditions observed in the Sloughs.

- Toxicity studies on resident crustaceans (Hunt et al 1999) illustrated that the waters within Beach Road agricultural ditch (concentrated agricultural tailings) are toxic (causing severe mortality rates) to the crustaceans following storm events that mobilize contaminated sediments into the water column.

- The Questa report (1995) conducted total water column trace metal analyses. From these results, Questa concludes that the trace metal concentrations of Cu, Pb, Ni and Zn exceed EPA water quality criteria. However, if the point of these studies is to understand the interaction and influence of these metals on the biota, Questa's data may be misinterpreted, because only the dissolved fraction of trace metal concentrations in the water column are available for biological uptake. Therefore, no clear conclusions can be made on the ecological interaction and effects of trace metal concentrations within the Watsonville Sloughs water column.

Water Quality Study conducted for the WSCEP

The focus of the 2001 studies by the WSCEP Consultant Team was to measure water quality parameters related to water circulation and the effects of nutrient loading on the biological health at the base of the food chain. The waterways in the lower watershed were the focus of measurements as they have a broad range of circulation ratings and are subject to the local and cumulative excessive nutrient loading from land uses in the watershed.

The variation of dissolved oxygen over daily and monthly time scales provides valuable preliminary data on the function of an aquatic system. A healthy aquatic system capable of supporting invertebrate and fish communities will maintain sufficient water circulation, water clarity, moderate pH, relatively low water temperatures, and dissolved oxygen (DO) levels that fluctuate around 100% saturation (atmospheric equilibrium). Locations that display chronic levels of extremely low dissolved oxygen values are most likely locations that possess compromised water quality, ecological health, and may possess decreased biological diversity and survival.

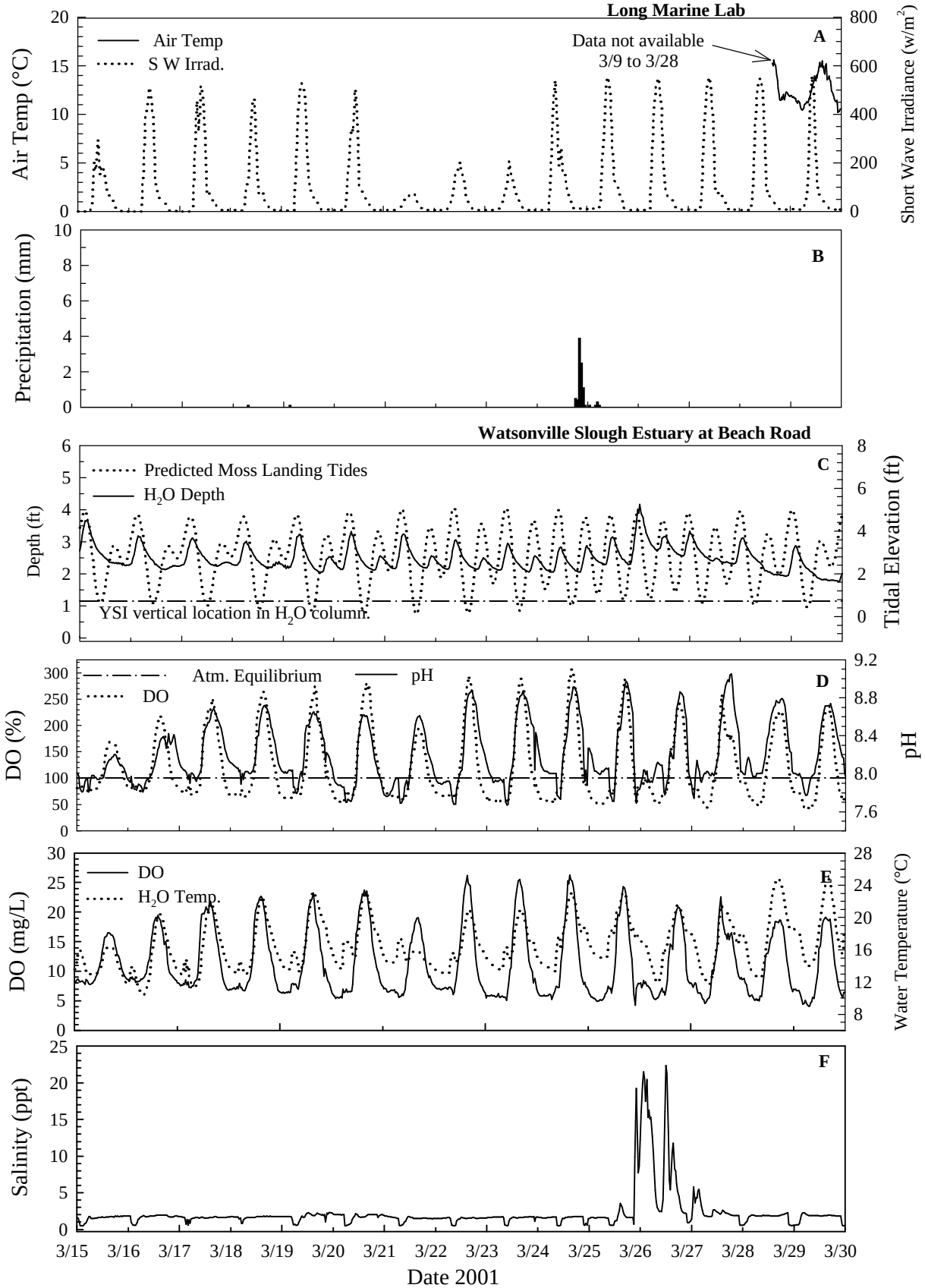
Data collection was accomplished by installing four continuous water depth recorders to document circulation, and two continuous multi-parameter water quality meters (YSIs) to measure water quality data (DO, pH, conductivity, depth, temperature, and salinity) at various locations between January and May 2001 (see Figure 3-2 for exact locations). The continuous measurements were supplemented by periodic collection of water quality data in a vertical profile at locations in Harkins, Struve and Lower Watsonville Sloughs to understand vertical variations in water quality and chemical structure.

Once collected, the data was plotted with precipitation and tidal records to document the hydrologic and water quality responses of the lower Sloughs to various physical hydrologic inputs. Continuous data collected by the recorders allows for an assessment of the stability of basic water quality parameters in the water column on short (daily) time scales and to judge the effect of stormwater runoff and tidal fluctuations on flow and water quality in individual events.

Two examples of the YSI water quality data are presented below to illustrate the interaction between nutrient loading, water circulation, and the response of daily DO values. **Figure 3-3** is continuous water quality data collected in Watsonville Slough at Beach Road (YSIA1) from

Figure 3-3: YSIA1 March 15 to March 30, 2001

Water Quality Study Results (SH&G)



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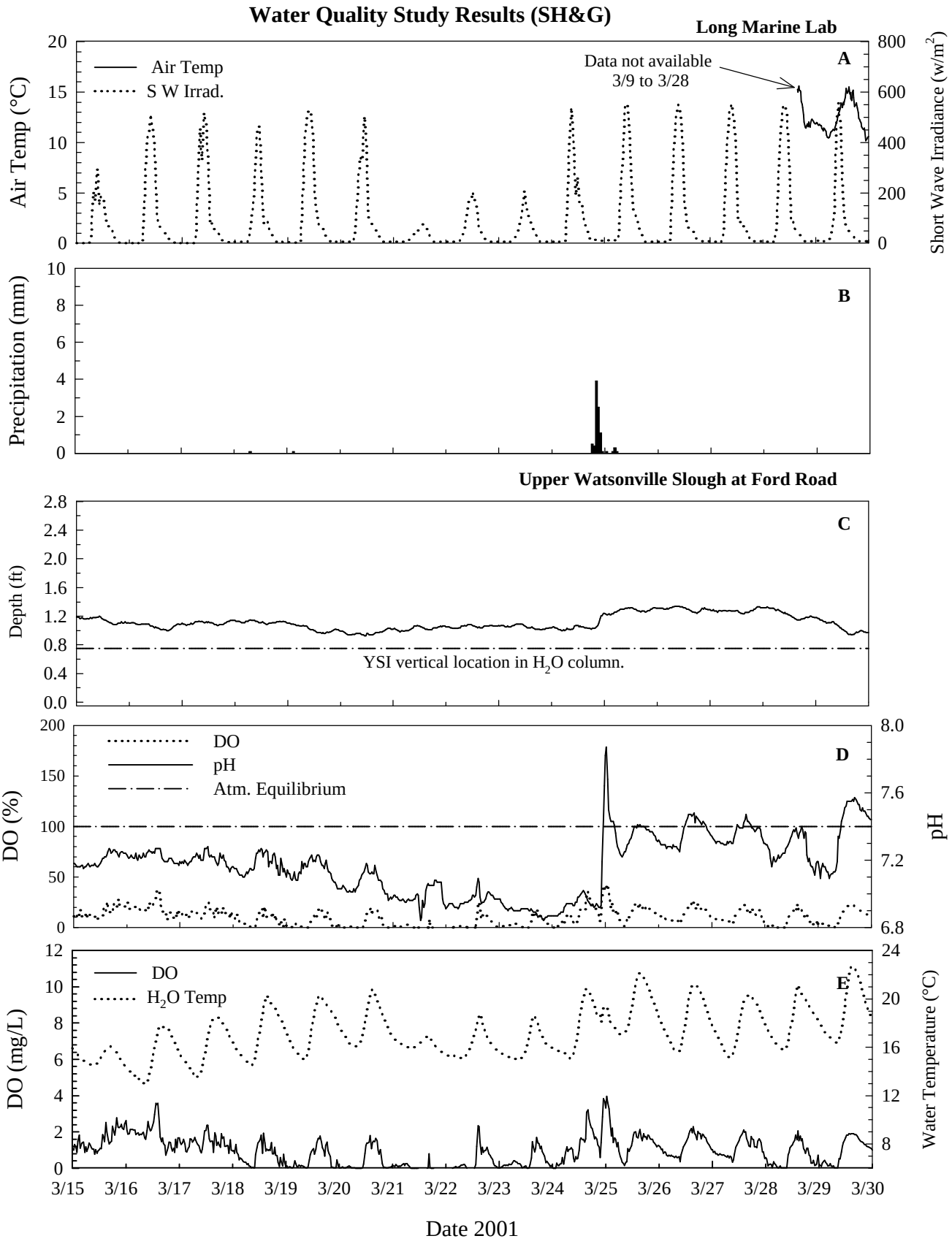
March 15 to March 30, 2001. **Figure 3-4** is the YSI data collected in Watsonville Slough at Ford Street (YSIB1) for the same time period (see **Figure 3-2** for exact instrument locations). Water data provided by the County of Santa Cruz found nitrate concentrations in March of previous years to be on the order of 0.4 mg/L near the location of YSIB1 and 75 mg/L at YSIA1. However, when comparing the DO data presented in **Figures 3-3** and **3-4**, it is apparent that even though the site at Beach Road contains three orders of magnitude more nitrate, the tidal influence on water circulation (daily depth variations) allows for the constant exchange of oxygenated waters. The DO data in **Figure 3-3** shows extreme daily variations, but water circulation prevents the system from ever going suboxic (DO values< 10%) or anoxic (DO = 0). In contrast, with the same climatic conditions, a poorly circulated water body (YSIB1) with relatively low nutrient concentrations displays a significant respiratory removal of DO and sustained suboxic waters. Approximately 500 ft. downstream of the location of the YSIB1 data collection a significant fish kill of over 30 fish was observed in late January 2001. These data support previous findings (Monbet 1992) that circulation plays a critical role in the amount of nitrate a system can tolerate before it becomes eutrophic.

An overview of the 2001 hydrologic, water circulation and water quality data collection and results are provided below:

- Land subsidence may be caused by historic shallow groundwater withdrawal, decomposition of underlying organic peat soils, and/or the sustained weight of ponded water over these areas. Land subsidence and a decaying drainage infrastructure have reduced water circulation and the conditions may worsen in years to come. Continuous water depth data and the observations of persistent ponding in Struve, Harkins and Watsonville Sloughs through the Spring of 2001 suggest an accelerated reversion of reclaimed land to wetland conditions. The best example is the seasonal lake that formed early in the winter 2000 in Lower Struve Slough between Lee Road and the UPRR crossing and then persisted well into April 2001. The inland marsh persisted two months longer than the previous winter, even with an annual precipitation totaling 15 inches less.

- It is difficult to predict whether or not the land surface has stabilized or whether subsidence may continue or increase in the future. Future restoration efforts, habitat

Figure 3-4: YSIB1 March 15 to March 30, 2001



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enhancement and drainage improvements should address the potential for significant inland storage of fresh water to remain in these areas for a number of months every year.

- Decreased water circulation and stagnant waters have had a detrimental effect on water quality. Upper Watsonville Slough, between Harkins Slough Road and Ford Road, is formerly productive farmland that reverted to wetlands in the late 1980s. The compromised DO levels measured just downstream of this inland wetland (**Figure 3-4**) indicates a compromised waterway. The observation of two separate fish kills downstream of this area following spring rainstorm events suggests that these conditions do periodically become toxic to the local inhabitants.

- Fluctuations and loss of dissolved oxygen measured in 2001 indicate stagnant water, loading of excessive nutrients from urban, rural and agricultural lands, and eutrophication in Struve, Harkins and Watsonville Sloughs above Shell Road. The measurements suggest serious impairment to the aquatic ecosystem in these areas during the winter and spring months. Because photosynthetic rates increase exponentially with water temperature, the impacts of nutrient enrichment are expected to worsen during the warmer months of late summer and fall when coupled with further declines in water circulation.

- A management conflict is apparent between increasing water circulation and reducing wetland hydroperiods. Aquatic ecosystems receiving high amount of nitrogen and phosphorus can maintain relatively low chlorophyll levels (algae) with a corresponding increase in water circulation, aeration and/or vegetation uptake. However, improving water circulation may reduce water depths of the wetlands. Unless water circulation is increased, water quality can only be improved by source reductions in nutrient loading and/or expansion of wetland vegetation in waterways for biological uptake.

VEGETATION RESOURCES

Biotic Resources Group conducted the botanical resources analysis. Study methodology included literature review, aerial photograph interpretation, and field reconnaissance surveys. The occurrence and spatial distribution of special status species was obtained from previous data.

Biotic Resources Group used aerial photo interpretation (photos dated June 2000 and October 2000) and field reconnaissance surveys to prepare a map of the principal plant communities within the watershed (**Figure 3-5**). Field surveys to document rare plant species were conducted during Spring 2001 (April-May) on publicly owned lands in the watershed. Refer to Technical Appendix B for the expanded version of this text and greater detail on vegetation descriptions and characteristics.

The Watsonville Sloughs system is recognized as the largest and most significant wetland habitat between Pescadero Marsh (San Mateo County) and Elkhorn Slough (Monterey County). The Watsonville Sloughs Watershed supports both developed and undeveloped lands and collectively supports twenty-two principal plant community types (**Table 3-4**) many of which are sensitive native communities and contain special status plant species (**Table 3-5**). This diverse assemblage of plant community types results from the variability in the watershed's topography, substrate, flooding regime, fire history, and current and past land uses as described in Chapter 2.

The upper watershed supports several sensitive upland habitats and special status plant species. These species are found to be well adapted to the Aromas red sand deposits. The central maritime chaparral and some areas of coastal live oak woodland support two rare species unique to this region of the world: Hooker's manzanita, an evergreen shrub and robust spineflower, an annual plant. The occurrence of these two species, as well as other locally unique plant species, underscores the importance of these habitats to the region's botanical diversity.

Sensitive plant communities are defined by local, State, or Federal agencies as those habitats that support special status species, provide important habitat values for wildlife, represent areas of unusual or regionally restricted habitat types, and/or provide high biological diversity. Seven of the principal plant communities on the Watsonville Sloughs Watershed lands – riparian woodland, coast live oak woodland, freshwater marsh, seasonal wetlands, coastal salt marsh, central dune scrub and central maritime chaparral – are designated as a high priority in the California Native Diversity Database (CNDDB) (CDFG 2000). This category contains native plant communities that are regarded by CDFG to have special significance under the California Environmental Quality Act (CDFG 1995a). Riparian and wetland habitats, as well as the San Andreas Live Oak Woodland and central maritime chaparral, are also considered sensitive under County of Santa Cruz Code.

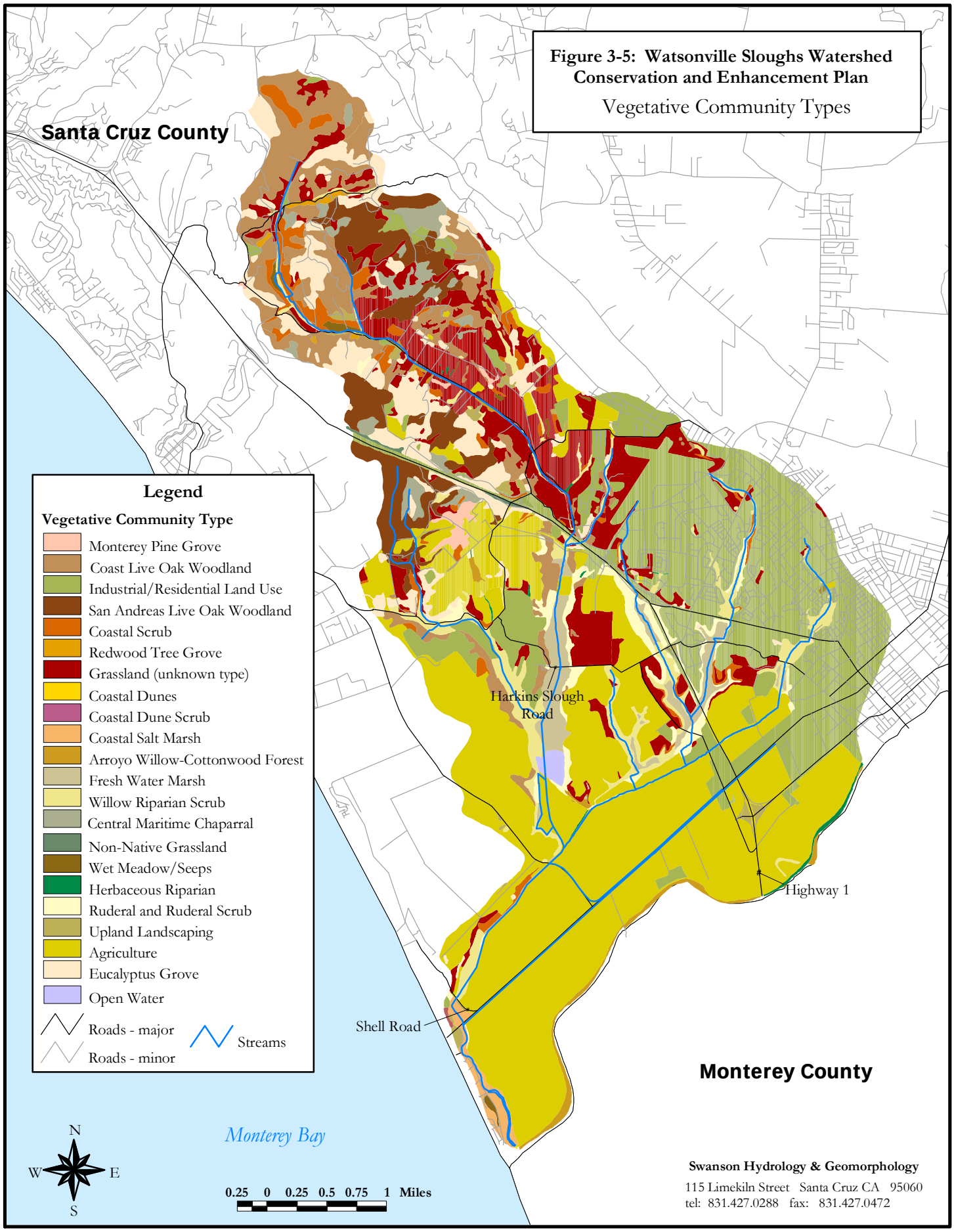
Figure 3-5: Watsonville Sloughs Watershed Conservation and Enhancement Plan
Vegetative Community Types
Santa Cruz County
Legend
Vegetative Community Type
Monterey Pine Grove
Coast Live Oak Woodland
Industrial/Residential Land Use
San Andreas Live Oak Woodland
Coastal Scrub
Redwood Tree Grove
Grassland (unknown type)
Coastal Dunes
Coastal Dune Scrub
Coastal Salt Marsh
Arroyo Willow-Cottonwood Forest
Fresh Water Marsh
Willow Riparian Scrub
Central Maritime Chaparral
Non-Native Grassland
Wet Meadow/Seeps
Herbaceous Riparian
Ruderal and Ruderal Scrub
Upland Landscaping
Agriculture
Eucalyptus Grove
Open Water
Roads - major
Roads - minor
Streams
Harkins Slough Road
Highway 1
Shell Road
Monterey County
Monterey Bay
N
W
E
S
0.25 0 0.25 0.5 0.75 1 Miles
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Table 3-4 Plant community types identified within the Watsonville Sloughs Watershed

Plant Community Type	Commonly Observed Plant Species	Acreage	Status
Coastal Dunes	Beach morning glory, sea rocket	<1	Sensitive, potential habitat for rare plants
Central Dune Scrub	Beach bur, lizard tail, bush lupine	3	Sensitive, potential habitat for rare plants
Coastal Salt Marsh	Pickleweed, jaumea, salt grass	89	Sensitive under County Code
Freshwater Marsh	Bulrush, cattail, waterweed, Pacific silverweed	269	Sensitive under County Code
Arroyo Willow – Cottonwood Riparian Forest	Willow, cottonwood, California blackberry, stinging nettle	98	Sensitive under County Code
Willow Riparian Scrub	Willow, California blackberry	505	Sensitive under County Code
Central Maritime Chaparral	Hooker's manzanita, brittle-leaved manzanita, coffee berry, buckbrush	200	Sensitive, known habitat for rare plants; "special forest" under County Code
Coast Live Oak Woodland	Coast live oak, madrone, California blackberry, coffeeberry	1067	Sensitive, potential habitat for rare plants
San Andreas Coast Live Oak Woodland	Coast live oak, madrone, California blackberry, coffeeberry, Hooker's manzanita	682	Sensitive, known habitat for rare plants; "special forest" under County Code
Grassland (unknown type) *	Wild oats, soft brome, filaree, California poppy, lupine	1520	Sensitive if providing habitat for rare plants
Native Grassland/ Coastal Terrace Prairie	California oatgrass, purple needlegrass, various wildflowers	*	Sensitive if habitat for rare plants; sensitive under County Code if in Coastal Zone
Non-Native Grassland	Wild oats, soft brome, filaree, California poppy, lupine	15	Sensitive if providing habitat for rare plants
Wet Meadow/Seeps	Rush, sedge	31	Sensitive under County Code (wetlands)
Herbaceous Riparian	Rabbitsfoot grass, rush, sedge	27	Sensitive under County Code (riparian)
Ruderal and Ruderal Scrub	Poison hemlock, wild radish, wild oats, coyote brush	276	No protective status for botanical resources
Upland Landscaping	Acacia, deodar cedar, Monterey pine, redwood	79	No protective status for botanical resources
Agriculture	Row crops	4380	No protective status for botanical resources
Eucalyptus Tree Groves	Blue gum eucalyptus, acacia, French broom	754	No protective status for botanical resources
Monterey Pine Tree Groves	Monterey Pine (non-native occurrences), French broom	52	No protective status for botanical resources
Coastal Scrub	Coyote brush, coffeeberry, poison oak	299	Sensitive if providing habitat for rare species
Redwood Tree Groves	Coast redwood, tan oak, madrone	21	No protective status for botanical resources

*Grassland types could not be differentiated through review of aerial photos.

Table 3-5 List of special status plant species known, or with potential, to occur in the Watsonville Sloughs Watershed, Santa Cruz County, California

Species	CNPS	State Status	Federal Status	Known Occurrence in Watershed?	Plant Community Type
California bottlebrush grass (*Elymus californicus)*	None	None	None	Yes	Oak Woodland
Hooker's manzanita *(Arctostaphylos hookeri*)	List 1B	None	None	Yes	Maritime Chaparral, San Andreas Live Oak Woodland
Robust spineflower *(Chorizanthe robusta var. robusta)*	List 1B	None	Endangered	Yes	Oak Woodland, Maritime Chaparral, San Andreas Live Oak Woodland
San Francisco wallflower *(Erysimum franciscanum)*	List 4	None	Species of Special Concern	No	Grassland, coastal dunes, coastal dune scrub
San Francisco popcorn flower *(Plagiobothrys diffusus)*	List 1B	Endangered	Species of Special Concern	No	Mesic grasslands
Santa Cruz Clover *(Trifolium buckwestiorum)*	List 1B	None	None	No	Mesic grasslands
Santa Cruz tarplant *(Holocarpha macradenia)*	List 1B	Endangered	Threatened	Yes	Grasslands
Kellogg's horkelia *(Horkelia cuneata ssp. sericea)*	List 1B	None	Species of Special Concern	Yes	Oak Woodland, Maritime Chaparral, San Andreas Live Oak Woodland
Small-leaved lomatium (*Lomatium parviflorum)*	List 4	None	None	Yes	Oak Woodland, San Andreas Live Oak Woodland
Santa Cruz microseris (*Microseris decipiens)*	List 4	None	Species of Special Concern	No	Oak Woodland, Grasslands
Gairdner's yampah *(Perideridia gairdneri ssp. gairdneri)*	List 4	None	Species of Special Concern	No	Oak Woodland, Grasslands
Maple-leaved checkerbloom *(Sidalcea malachroides)*	List 1B	None	None	No	Oak Woodland, Grasslands
San Francisco campion *(Silene verecunda ssp. verecunda)*	List 1B	None	Species of Special Concern	No	Oak Woodland, Grasslands
Coast wallflower (*Erysimum ammophilum*)	List 1B	None	Species of Special Concern	No	Dunes, Dune Scrub
Sand Gilia *(Gilia tenuiflora spp. arenaria)*	List 1B	None	Endangered	No	Dunes, Dune Scrub

Species	CNPS	State Status	Federal Status	Known Occurrence in Watershed?	Plant Community Type
Monterey spineflower *(Chorizanthe pungens var. pungens)*	List 1B	None	Endangered	Yes	Oak Woodland, Maritime Chaparral, San Andreas Live Oak Woodland

CNPS Status:

List 1B: These plants (predominately endemic) are rare and currently vulnerable or have a high potential for vulnerability due to limited or threatened habitat, few individuals per population, or a limited number of populations. List 1B plants meet the definitions of Section 1901, Chapter 10 of the CDF&G Code.
List 4: A watch list of plants with limited distribution in the state with low vulnerability and threat at this time. The plants are locally uncommon and should be monitored.

Riparian Forests

The riparian forests are all considered sensitive habitats according to the County of Santa Cruz and CDFG. This status is due to the value of these forests to wildlife and the relatively limited (and declining) distribution of this habitat at the local and statewide level. These habitat types are considered to be areas of high biological quality, warranting preservation and management.

Freshwater Marsh, Coastal Salt Marsh and Wet Meadow/Seeps

The wetlands within the Watsonville Sloughs complex are typical of similar areas in California. However, its relatively large size and continuity are important. Land uses have reduced the distribution and habitat quality of most wetlands in the region to fragments, and the State of California, County of Santa Cruz, CDFG and the COE consider wetlands of all types sensitive.

Central Maritime Chaparral

The central maritime chaparral is an uncommon plant community found only in Southern Santa Cruz County and Northern Monterey County. Central maritime chaparral is considered a "threatened" plant community by the California Department of Fish and Game (2000). The chaparral may also support special status species endemic to sandy soil conditions, such as robust spineflower and Hooker's manzanita. According to the CNDDB, Hooker's manzanita–dominated chaparral is more restricted in its distribution within the central maritime chaparral; this manzanita is restricted to the greater San Andreas region of Santa Cruz County and portions of north Monterey County. Due to the presence of Hooker's manzanita (and/or other rare species), the County of Santa Cruz considers this plant community a "special forest". The County's designation is intended to recognize the unique habitat qualities (including rare species) of the woodland/chaparral mosaic and limit disturbances to the habitat type through restrictions on land uses.

San Andreas Live Oak Woodland

The County of Santa Cruz considers this woodland a "special forest". This status is due to the unique habitat structure of the woodland, the presence of central maritime chaparral species within the understory, and the known or potential for the woodland mosaic to support special status plant species (i.e. Hooker's manzanita and robust spineflower). The County's designation is intended to recognize the unique habitat qualities (including rare species) of the woodland/chaparral mosaic and limit disturbances to the habitat type through restrictions on land uses.

Some of the watershed lands provide habitat for plant species of concern, including those listed by the USFWS, CDFG and/or CNPS as rare, threatened or endangered. In addition, some of the lands provide habitat for plants recognized as rare or locally unique by CDFG or CNPS.

The special status plant species known or with potential to occur in the vicinity of the watershed are listed in **Table 3-5**. Plant species of concern include those listed by either the Federal or State resource agencies as well as those identified as rare by CNPS (Skinner & Pavlik 1994). The search of the CNPS and CNDDB inventories, as well as the review of previous reports, resulted in several special status species of concern with potential to occur in the watershed area. Three of these, the robust spineflower, Monterey spineflower, and Santa Cruz tarplant are federally listed species (listed as endangered and threatened, respectively) and are known to occur in the watershed. The Santa Cruz tarplant is also listed as endangered by the State of California. The Hooker's manzanita (CNPS List 1B, no State or Federal listing) has also been documented (and was observed) in the watershed area. Special status species also occur immediately adjacent to the watershed in the Sunset State Beach area (e.g. coast wallflower, Monterey spineflower and sand gilia) and in the Ellicott pond area on San Andreas Road (e.g., Kellogg's horkelia and robust spineflower). Artist's popcorn flower (*Plagiobothrys chorianus*) is known to occur in the grasslands at Watsonville Airport.

In addition to listing at the State and Federal level or on CNPS List 1B, there are species that local botanists and local chapters of the California Native Plant Society consider to be specialty plants of the region. Such species may have limited occurrences within the Santa Cruz Mountains (locally rare), or may be endemic to the watershed land area. These plants are typically on CNPS List 4, a watch list.

WILDLIFE RESOURCES

Dana Bland of Dana Bland and Associates prepared the section on Wildlife Resources. The following is a condensed version of the Wildlife Resources Report found in Technical Appendix C. Study methodology included field reconnaissance surveys to assess current habitat values for wildlife, literature review, aerial photograph interpretation to map existing conditions for wildlife, and searches of electronic databases.

On a regional basis, the marshes of the Watsonville Sloughs Watershed are extremely important to wildlife. This area is the largest complex of freshwater marsh habitat between Pescadero Marsh to the north and Elkhorn Slough to the south (Busch 2000). The centerpiece of the Watsonville Sloughs Watershed for wildlife resources is the freshwater marsh portion of the Sloughs, and includes the marsh areas fringed by willow riparian woodland. These are the most biologically productive areas of the watershed with the highest abundance and diversity of wildlife. The marshes are important to resident wildlife and also support migrating species by providing plentiful food, cover and open water-resting areas, critical for species' success in reaching their breeding/wintering grounds. The abundant food sources within the marshes and open water areas of the Sloughs support a wide variety of wintering birds in preparation for their upcoming breeding season.

The marshes and associated grassland/scrub habitats also attract a number of foraging animals that are residents of nearby woodlands and chaparral. The Slough channels, with their adjacent riparian habitats, provide natural movement and dispersal corridors for resident wildlife. The value of contiguous habitat continues to increase as highways and urban development dissect portions of the landscape.

Special status wildlife species include candidate species for listing, those formally proposed for listing, or those listed as threatened or endangered under either state or federal endangered species laws. Species listed by the State as California as Species of Special Concern also receive special protection under CEQA review standards. Migratory birds are protected under the Migratory Bird Treaty Act and all raptor nests are protected by CDFG Code. Wildlife species identified as sensitive by the Santa Cruz Mountains Bioregional Council (1999) are also included. Wildlife species with special protected status that are known or potential inhabitants of the

Watsonville Sloughs Watershed lands are listed in **Table 3-6**. **Figure 3-6** illustrates the spatial location of the plant and wildlife species of concern identified within the Watsonville Sloughs Watershed. Refer to Technical Appendix C for a brief summary of the ecology of each species, their special status, and primary habitat requirements.

Several special status wildlife species with habitat ranges that include the Watsonville Sloughs Watershed were evaluated for their potential occurrence on site. However, the critical habitat features for these species were not found on the watershed lands to-date, and thus the following species are not presently considered potential inhabitants of the watershed lands: Common loon (expected as winter resident, but not as nesting), white-faced ibis (expected as occasional winter transients, but no breeding or rookery habitat present), Snowy plover (known to nest in dunes on beach to west of mouth of Watsonville Slough, but no habitat within the slough watershed project), California least tern (nesting only now known at south end of San Francisco Bay), long-billed curlew (nesting not known along this coast, but may be winter resident), Black tern (extirpated from breeding in the central coast), and Santa Cruz kangaroo rat (area lacks sandy soils required by this species for burrows)

The best existing conditions for wildlife diversity and abundance within the Watsonville Sloughs Watershed are currently the areas of undeveloped land or lands maintained by light grazing activities and sparsely dispersed rural residential areas. More moderate values to wildlife are currently found in sections of Harkins and Struve Sloughs where low lying areas have been gradually reverting to inland winter marshlands. The portions of Watsonville and Struve Sloughs that have been converted to exposed drainage ditches, which mainly transport urban and agricultural runoff, are most subjected to multiple impacts from urban and agricultural development.

The demands and impacts of nearby urban and agricultural land uses adversely affect the wildlife of the Watsonville Sloughs Watershed. The primary stressors on wildlife resources in the Watsonville Sloughs Watershed are:

- Draining and diverting water can leave marsh areas too dry for wintering waterfowl during critical times of year and can result in poor water circulation.

- Nutrient enrichment from urban and agricultural inputs, coupled with stagnant water, can result in extreme eutrophication of these waters. Eutrophic conditions, characterized by dense algal mats, can result in the depletion of dissolved oxygen in the water column and the die off of aquatic organisms.

- Pesticides from agricultural runoff can be toxic to local invertebrates and aquatic species and bioaccumulation up the food chain will adversely affect the higher trophic levels.

- Encroachment of urban development around the edges of the Sloughs can present barriers to wildlife movement and often leads to the proliferation of aggressive, urban tolerant, invasive wildlife species.

- Fragmented habitat areas may be too small to support wide-ranging top predators. This can lead to a rise in the number of meso-predators and increased predation pressure on smaller animals, beyond the level their population can normally sustain.

- Existing conditions in many reaches of the Sloughs pose constraints to native wildlife. Limitations include urban development, contaminants from urban and agricultural runoff, erosion and sedimentation, variable schedule of water draw downs in some slough portions, lack of adequate water circulation, structural barriers to wildlife movement, discontinuous riparian vegetation, and presence of aggressive non-native species.

Table 3-6. Special status wildlife species and their predicted occurrence in the Watsonville Sloughs Watershed, Santa Cruz County, CA.

SPECIES	STATUS[1]	HABITAT	OCCURRENCE ON SITE
Invertebrates			
Monarch butterfly *Danaus plexippus*	*	Winter roosts in Eucalyptus, pine, acacia groves protected from wind.	Potential habitat in Eucalyptus/pine groves.
Amphibians			
Santa Cruz long-toed salamander *Ambystoma macrodactylum croceum*	SE, FE	Ponds for breeding, oak woodland, coastal scrub, riparian habitats for upland refugia.	Known breeding sites include Calabasas Pond, Gillette Road pond, Buena Vista pond.
California tiger salamander *Ambystoma californiense*	FC, CSC	Vernal pools, stock ponds, natural ponds with upland grassland habitat.	Known to breed at Buena Vista pond.
California red-legged frog *Rana aurora draytonii*	FT, CSC	Riparian, marshes, estuaries and ponds.	Known to occur in West Branch Struve Slough, Hansen Slough, Harkins Slough.
Reptiles			
Southwestern pond turtle *Clemmys marmorata pallida*	FSC, CSC	Creeks and ponds.	Potential habitat in freshwater portions of Sloughs.
California horned lizard *Phrynosoma coronatum frontale*	FSC, CSC	Chaparral with loose soils.	Possible in Buena Vista area and Larkin Valley.
Black legless lizard *Anniella pulchra nigra*	CSC	Coastal dune scrub habitat.	Possible.
Birds			
Common loon *Gavia immer*	CSC		Occurs principally at Pajaro River mouth and lower Watsonville Slough.
Double-crested cormorant *Phalacrocorax auritus*	CSC	Feeds in open water habitats.	Harkins and lower Watsonville Sloughs and Pajaro River mouth.
Black-crowned night heron *Nycticorax nycticorax*	SFB	All aquatic habitats. Roosts in areas of dense willows.	Known to use Hanson and Harkins Sloughs, may use other Sloughs.
White-faced ibis *Plegadis chihi*	CSC	Fresh water and brackish marsh.	Known to winter in Hanson, Harkins, Struve and lower Watsonville Sloughs and the Pajaro River mouth.
White-tailed kite *Elanus leucurus*	FPS, SFB	Oak woodland, riparian woodland, grassland, scrub and ruderal areas.	Nesting has been documented in association with all of the Sloughs.

SPECIES	STATUS[1]	HABITAT	OCCURRENCE ON SITE
Osprey *Pandion haliaetus*	CSC	Nests in top of tall trees near creeks or lakes. Forages over open water habitat.	Most frequently reported from the Pajaro River mouth, lower Watsonville and Harkins Sloughs.
Northern harrier *Circus cyaneus*	CSC	Nests on ground in grassland or open scrub. Occurs in various open habitats.	Possible nesting along Sloughs. Found throughout the area in suitable habitat.
Cooper's hawk *Accipiter cooperii*	CSC	Oak woodland, riparian.	Potential nesting habitat in oak woodlands and riparian forests along Sloughs.
Sharp-shinned hawk *Accipter striatus*	CSC	Riparian or oak woodland. Nests in coniferous forests.	Nesting unlikely; potential wintering habitat along Sloughs
Ferruginous hawk *Buteo regalis*	CSC	Favors grassland and other open habitat between the Sloughs.	Known to winter in Hanson Slough, may use other Sloughs.
Golden eagle *Aquila chrysaetos*	CSC	Nests in oak savannah, oak woodland. Foraging activity is focused on grasslands.	Nesting unlikely; most frequently seen around Harkins Slough and inland of Highway 1 near Struve and Watsonville Sloughs.
Merlin *Falco columbarius*	CSC	Winters in central California in variety of habitats.	Known to winter along Sloughs; uses all of the Sloughs.
Prairie falcon *Falco mexicanus*	CSC	Nests on tall cliffs (80-100 ft) or in crevices or ledges on the cliffs; forages very long distances.	Known to winter in Hanson Slough, may use other Sloughs; no nesting habitat in watershed area.
Peregrine Falcon *Falco peregrinus*	SE	Nests on shelves of tall cliffs; winters in areas where prey of waterfowl and other small birds is abundant.	No nesting habitat; wintering habitat along Sloughs. Seen most frequently at Pajaro River mouth, Harkins and lower Watsonville Sloughs.
Long-billed curlew *Numenius americanus*	CSC		Known to winter in Hanson Slough, may use other Sloughs.
Black tern *Childonias niger*	CSC		Known to winter in Hanson Slough, may use other Sloughs.
California gull *Larus californicus*	CSC	Uses wetland and agricultural habitats.	Concentrations gather at the landfills, Harkins Slough and Pajaro River mouth.
Short-eared owl *Asio flammeus*	CSC	Grassland and wetland habitats.	Known to winter in uplands near Harkins, Hanson, Struve, and West Struve Sloughs.
Burrowing owl *Athene cunicularia hypugea*	CSC, SFB	Grasslands with burrows.	Probably extirpated. Most recent records from uplands between Harkins and West Struve Sloughs.
Western kingbird *Tyrannus verticalis*	SFB	Open grasslands with scattered trees (e.g. oak savannah).	Probably extirpated.

SPECIES	STATUS[1]	HABITAT	OCCURRENCE ON SITE
Loggerhead shrike *Lanius ludovicianus*	FSC, CSC	Open habitats with scattered shrubs, tree, lookout posts.	Possible nesting in scrub habitats adjacent to Sloughs.
California horned lark *Eremophila alpestris actia*	CSC	Open grasslands with short vegetation.	Probably extirpated.
Saltmarsh common yellowthroat *Geothlypis trichas sinuosa*	CSC		Known to winter in Hanson Slough, may use other Sloughs.
Yellow warbler *Dendroica petechia brewsteri*	CSC	Riparian habitats with dense willows, cottonwoods.	Nesting at Harkins and Hanson Sloughs. Probably extirpated. Currently migrant only.
Yellow-breasted chat *Icteria virens*	CSC	Nests in riparian habitats with dense willows, cottonwoods.	Migrant only?
Tricolored blackbird *Agelaius tricolor*	CSC	Nest in freshwater marshes with dense tules, cattails. Grasslands used for foraging.	Historically occurred in Harkins, Hanson, and West Branch Struve Slough.
Mammals			
Yuma myotis *Myotis yumanensis*	FSC, CSC	Open forests and woodlands with water nearby; roosts in buildings, caves, crevices.	Possible.
Western red bat *Lasiurus blossevilli*	SFB	Foliage roosting bat, uses cottonwoods and willows.	Possible.
Townsend's western big-eared bat *Corynorhinus townsendii townsendii*	FSC, CSC	Wide variety of habitats; roosts in caves, tunnels, mines, and buildings.	Possible.
San Francisco dusky-footed woodrat *Neotoma fuscipes annectens*	FSC, CSC	Riparian and oak woodlands.	Probable inhabitant of woodlands.

[1] Key to status:

FC = Federal candidate for listing as endangered
FE = Federally listed as endangered species
FT = Federally listed as threatened species
FSC = Federal species of special concern
SE = State listed as endangered species
CSC = California species of special concern
SFB = Sensitive Fauna in the Santa Cruz Mountain Bioregion
* = Locally unique species in Santa Cruz County LCP

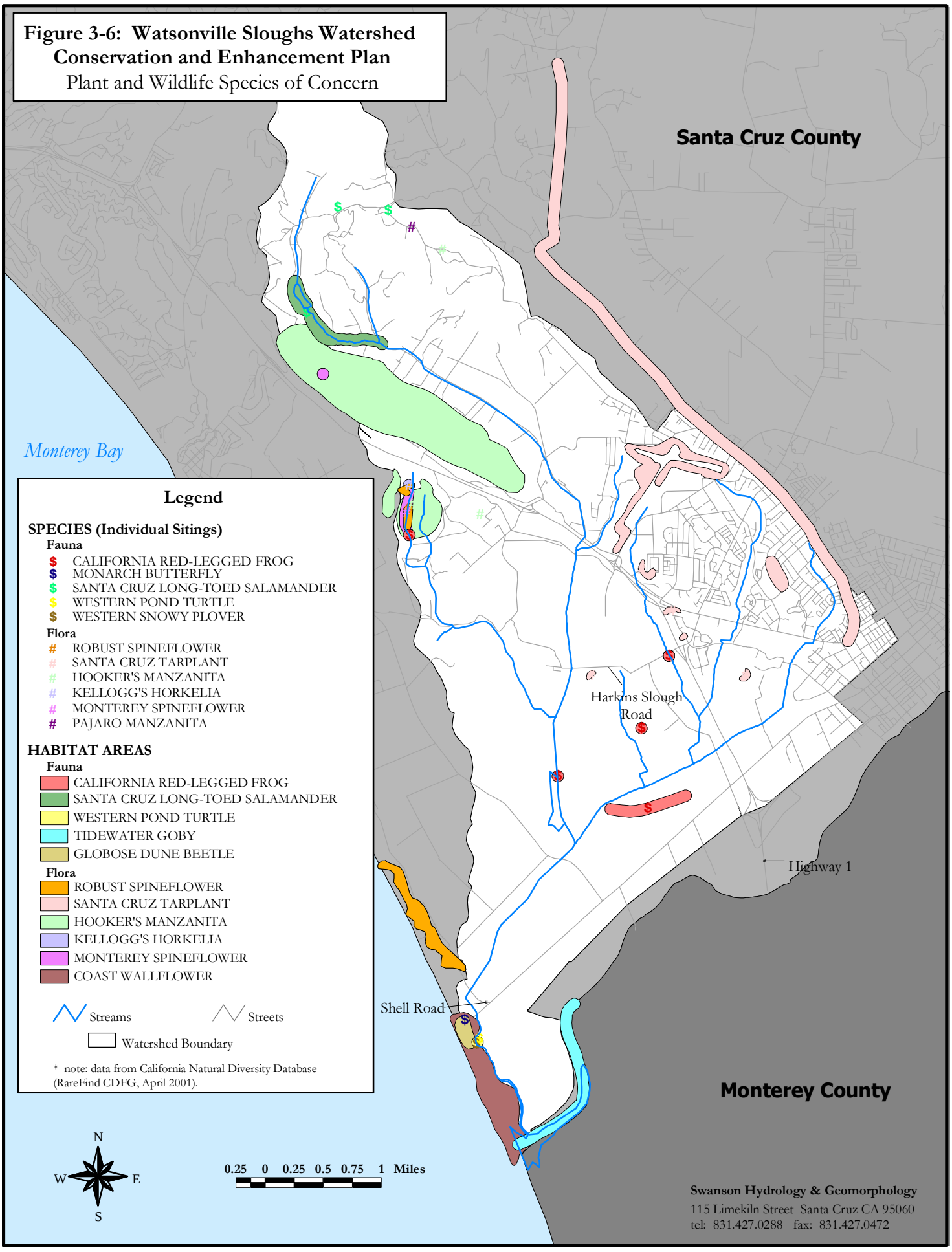
Figure 3-6: Watsonville Sloughs Watershed Conservation and Enhancement Plan
Plant and Wildlife Species of Concern
Santa Cruz County
Monterey Bay
Harkins Slough Road
Highway 1
Shell Road
Monterey County
Legend
SPECIES (Individual Sitings)
Fauna
$ CALIFORNIA RED-LEGGED FROG
$ MONARCH BUTTERFLY
$ SANTA CRUZ LONG-TOED SALAMANDER
$ WESTERN POND TURTLE
$ WESTERN SNOWY PLOVER
Flora
ROBUST SPINEFLOWER
SANTA CRUZ TARPLANT
HOOKER'S MANZANITA
KELLOGG'S HORKELIA
MONTEREY SPINEFLOWER
PAJARO MANZANITA
HABITAT AREAS
Fauna
CALIFORNIA RED-LEGGED FROG
SANTA CRUZ LONG-TOED SALAMANDER
WESTERN POND TURTLE
TIDEWATER GOBY
GLOBOSE DUNE BEETLE
Flora
ROBUST SPINEFLOWER
SANTA CRUZ TARPLANT
HOOKER'S MANZANITA
KELLOGG'S HORKELIA
MONTEREY SPINEFLOWER
COAST WALLFLOWER
Streams
Streets
Watershed Boundary
* note: data from California Natural Diversity Database (RareFind CDFG, April 2001).
N
W
E
S
0.25 0 0.25 0.5 0.75 1 Miles
Swanson Hydrology & Geomorphology
115 Limekiln Street Santa Cruz CA 95060
tel: 831.427.0288 fax: 831.427.0472

BIRD RESOURCES

David Suddjian of Suddjian Biological Consulting Services prepared an assessment of the bird resources of the Watsonville Sloughs Watershed. The complete version of the assessment, including a discussion of population trends and changing patterns of bird use and the comprehensive listing of bird species known to have occurred in the study area is contained in Technical Appendix G. The assessment was based on existing information including: species files and other archived data maintained by the Santa Cruz Bird Club since 1974, data from the Santa Cruz County Breeding Bird Atlas Project (1987-1993), various published and unpublished summaries in a library of Santa Cruz avifauna, which have been developed by the bird club, data from portions of the Moss Landing Christmas Bird Count covering the Sloughs, and bird studies personally conducted in the study area from 1986 to the present by Suddjian.

The following information from the assessment was made available too late to integrate into the technical analyses used to develop the WSCEP. However, the information is important enough to include here and as a technical appendix.

Within the context of Santa Cruz County, the varied wetlands and open water habitats of the Sloughs support significant numbers of migratory and wintering waterbirds. Numbers of winter waterfowl in the Sloughs are usually second in the county only to those using College Lake, and in some years the Sloughs rank first in numbers of ducks. The wetlands host large portions of the county's breeding populations of several nesting waterbirds. The grassland habitats and other open areas on the uplands between the Sloughs are highly important for migratory and wintering raptors. Several breeding species associated with grasslands were principally found in the Pajaro Valley only in the lands around the Sloughs. Unfortunately, there has been a significant decline in populations of many grassland birds in the slough system over the last few decades due to habitat loss and degradation. A third habitat of high importance for birds is deciduous riparian forest and woodland associated with the Sloughs. Riparian habitat is widely recognized for its high abundance and species richness of birds and, especially, its value for breeding landbirds and as a "stop over" for migratory landbirds.

Freshwater Wetlands

A broad range of microhabitats are found within the freshwater wetlands of the Sloughs,

including: open water areas ranging in size from many acres to small fractions of an acre, seasonally exposed mudflats along the margins of open water areas, and areas dominated by various types of emergent wetland vegetation. The seasonal pattern of winter flooding and dry season draw down is a critical feature for the birds, providing different habitat conditions in different seasons and increasing the productivity of aquatic habitats for foraging birds.

Freshwater wetland areas currently of the greatest importance for birds are: (1) Harkins Slough from downstream of Ranport Road to a short ways downstream of Harkins Slough Road, (2) Anderson Peat Ponds, (3) Watsonville Slough near the mouth of Struve Slough, (4) Watsonville Slough near Ford Road, (5) West Branch Struve Slough, and (6) East Struve Slough from its mouth to Harkins Slough Road.

Brackish Wetlands of Lower Watsonville Slough and the Pajaro River mouth

The lower reach of Watsonville Slough (downstream of Shell Road) and the adjacent Pajaro River mouth are a distinctive part of the slough system with regard to birds. These areas are linked to the more inland parts of the slough system by the waters of Watsonville Slough, and there is some degree of bird movement between the coastal and inland parts of the system. However, the segment of Watsonville Slough between Shell Road and Harkins Slough is of low value for birds with little wetland habitat, and the intervening distance of over 2 kilometers leaves the coastal and inland parts of the slough system physically separated from each other for most bird species.

The coastal location of lower Watsonville Slough and the Pajaro River mouth and their brackish water habitats attract a unique set of waterbirds. The brackish wetlands along Watsonville Slough are the most extensive area of this habitat available for birds in Santa Cruz County. The slough and wetlands sometimes provide important exposed mudflats that may be used by many shorebirds, but amounts of exposed mudflats are highly variable, depending on tides, levels of flow in the Pajaro River, and varying degrees of exchange of water flowing across the beach. The sand flats along the margins of the river lagoon are similarly important for shorebirds. The margins of lower Watsonville Slough and the Pajaro River lagoon are important for nesting Black-necked Stilt and American Avocet.

Grassland

The grasslands and other open areas without active agricultural activity are of critical importance for the birds of the Sloughs. Few such areas remain available for birds in the lowlands of the Pajaro Valley, where most grasslands have been replaced by row crops or orchards. Grasslands near wetlands are especially rare. The grasslands and other open upland habitats attract birds that add greatly to the diversity of species using the slough system. Indeed, the resources of both the inter-slough upland habitats and adjacent slough wetlands come together in a synergistic relationship that greatly enhances the habitat value and utilization of both areas by birds. The importance of this integral relationship cannot be overstated, as it is key to sustaining the avian richness and full ecological functions of the slough system.

Grassland areas presently of the greatest importance for birds include areas along the east side of Harkins Slough, areas around West Branch Struve Slough, and areas near East Struve and Watsonville Sloughs, inland of Highway 1. The area inland of Highway 1 recently supported the most extensive grassland communities, but much land there has been (and continues to be) converted to development.

Deciduous Riparian Forest

Deciduous riparian forest provides valuable habitat for riparian-associated birds, and also is used by many wetland birds for roosting and nesting. The deciduous foliage supports large prey populations of insects and other invertebrates. The dense growth of the vegetation provides excellent cover and many nesting opportunities. Snag features provided by dead trees or large dead limbs are important perches for raptors, herons and egrets, and nest sites for cavity nesting birds. In general, the larger, more extensive stands of willows are more important for birds than small or isolated patches, although even the small patches provide valuable structural diversity and cover in the Sloughs.

Of the large willow stands, those at Harkins Slough (both downstream of Harkins Slough Road and downstream of Ranport Road), Hanson Slough, and at upper Watsonville Slough (between Freedom Boulevard and Ford Road) are of the greatest value within the study area. To some degree, potential bird use of the riparian forest in the area is somewhat limited by its fairly simple structure (dominated mostly by willows, lacking a tall over story), and the seasonal flooding that persists in many areas well into the nesting season.

Coast Live Oak Woodland

Coast live oak woodland is fairly limited in extent near the Sloughs themselves, but occurs extensively in parts of the upper watershed. Its overall habitat values are similar to those described for the riparian forest. Large live oaks are especially favored as nest and perch sites for raptors, and snag features that commonly occur are critical resources for cavity nesting species. Acorns are an important food for some birds, especially jays, Acorn Woodpecker, Varied Thrush and Band-tailed Pigeon. Oaks often host large populations of insects and other invertebrates and so are important for migratory landbirds in the spring and fall.

It achieves its highest value in parts of the upper watershed where it occurs in fairly extensive stands with variably dense undergrowth of blackberry, poison oak and coffeeberry. The smaller stands adjacent to the Sloughs are used especially by raptors for roost, perch and nest sites.

FISHERIES AND AQUATIC RESOURCES

Jeff Hagar of Hagar Associates, fisheries biologist, completed the fisheries assessment for the WSCEP. The assessment consisted of a literature review of previous reports and publications conducted on the Central California Coast and a preliminary reconnaissance level fish species assessment. California streams typically have associations or zones of fish that change from the headwaters down into the lower reaches in a fairly consistent pattern throughout the Central Valley and also in many central coast streams (Murphy 1948, Moyle 1976). Although not perfectly consistent, these observations are helpful for organization. A more complete description of the fisheries data can be found in Technical Appendix D.

The upper watershed streams of Watsonville Sloughs Watershed (Larkin Valley Creek, Gallighan Slough, Upper West Branch Struve Slough, and Upper Struve Slough) are hydrologically part of the Pajaro River system and affiliated with the fish communities of other tributaries of Monterey Bay, including the San Lorenzo River system, Elkhorn Slough, and the Salinas River (Snyder 1912; Murphy 1948; Shepard and Emery 1941, cited in Murphy 1948). Freshwater fishes in streams tributary to Monterey Bay include many of the same species found in the Sacramento and San Joaquin River systems and are likely derived from Central Valley populations through geologic and climatic events that connected San Francisco Bay drainages with Monterey Bay drainages (Snyder 1912, Murphy 1948). It is likely that Central Valley species moved freely through the area now covered by San Francisco Bay, either when sea levels were lower in the

geologic past or during periods of flood when the surface waters of the Bay became fresh. The Coyote Creek drainage has transitioned over geologic time from draining to San Francisco Bay to draining currently to the Pajaro River system, thus providing a potential route for fish transfer between the two basins (Branner 1907 cited in Snyder 1912, Murphy 1948).

In typical headwater streams the gradient is high (3 foot drop or more in elevation over 1000 foot length of stream), water is usually clear, streams are well-shaded with relatively cold temperature (seldom exceeding 21°C) and saturated with oxygen, and the substrate is dominated by bedrock. Headwater reaches are typically dominated by rainbow trout. Sculpin, speckled dace, Sacramento sucker, and California roach may occur with trout in some areas. The lower extent of trout distribution is regulated largely by water temperature. At warm mid-gradient sites rainbow trout are replaced by pike minnow and the two species only overlap as juveniles in faster flowing riffle and run habitat (Smith 1982). In coastal streams there may be a distinction between a resident trout zone, which occurs above barriers to migration of anadromous fish, and an anadromous fish zone that supports migratory steelhead, lamprey, and possibly Coho or Chinook salmon. In some coastal streams the anadromous zone may extend downstream to reaches with tidal influence.

Lower gradient, warmer water stream sections with large pools that remain over the dry season support Sacramento sucker, Sacramento pikeminnow (squawfish), and hardhead (hardhead are not present in Monterey Bay tributaries). Young of all these species tend to occur higher in the watershed and gradually move to downstream reaches as they mature and grow larger. Although sucker and pikeminnow are usually dominant, other species such as tule perch, roach, prickly sculpin, speckled dace, and trout may also occur. Summer water temperatures in these streams usually exceed 20°C and may fluctuate during the day; however, under conditions of augmented flow, such as dam releases, trout may be able use warm water habitats where high summer flows provide fast-water feeding habitat (Smith and Li 1983). Higher flows can result in an increase in drift of aquatic invertebrates used by trout for food. At high rates of food consumption, trout can sustain the higher metabolic rate required in warmer water. Therefore, under augmented flow conditions trout can occupy warmer habitats than may otherwise be possible (Smith and Li 1983).

In the lowest gradient reaches where streams form deep channels with sluggish currents, native fishes may include a mixture of freshwater fish, anadromous fish, and estuarine or marine

species. This could include blackfish, hitch, splittail (not present in Monterey Bay tributaries), squawfish, and suckers as well as a number of introduced species. In larger rivers, anadromous species such as salmon, steelhead, lamprey, and sturgeon pass through these reaches on migrations and may spend variable amounts of time there.

The Watsonville Sloughs' aquatic habitat conditions substantially deviate from an idealized conception of a typical watershed. Stream type aquatic habitat in the Watsonville Sloughs Watershed is limited by the watershed's small size, low elevation, and relatively low gradient. Most tributary streams are dry by early summer. Steelhead and coldwater trout may have historically been present in Larkin Valley, but the habitat does not presently exist in sufficient abundance to support this species. The headwaters of the Sloughs provide habitat more typical of the warm, small tributary type that would be expected to support California roach with prickly sculpin and stickleback also potentially present. Introduced exotic species such as mosquitofish (*Gambusia*) and green sunfish may be present also, particularly in lower gradient, less swiftly flowing sections.

Aquatic habitats within the greater Watsonville Sloughs System can be classified as predominantly flowing water or stream habitats (also termed riverine or lentic), standing freshwater lake or marsh habitats (also termed lacustrine or lotic), or estuarine habitats (**Table 3-7**). These habitat classifications are useful in understanding the occurrence and distribution of fish species within the slough system.

Records of collections in the Watsonville Sloughs Watershed are limited but collections from other Monterey Bay tributaries provide an indication of species that could occur in the area. There are three fish species that have historically occupied the Watsonville Sloughs and are currently listed as either Federal or State Endangered Species. They include the Tidewater Goby, the Steelhead Salmon and the Coho Salmon. The Shell Road Pump Station poses a significant barrier for the inland migration of these species, which may have historically occupied the upper portions of Watsonville Slough prior to development and channel alterations.

Tidewater Goby

Tidewater gobies (*Eucyclogobius newberryi*) have been reported most recently in Smith (1993) from both the Pajaro River Lagoon and the lower reach of Watsonville Slough. The tidewater goby is listed under the Federal Endangered Species Act as an endangered species but has

recently been proposed for de-listing. The USFWS has determined that north of Orange County there are more populations than were known at the time of the listing, that the threats to those populations are less severe than previously believed, and that the tidewater goby has a greater ability than was known in 1994 to re-colonize habitats from which it is temporarily absent. The proposal would remove the northern populations of the tidewater goby from protection under the Act (Federal Register: June 24, 1999; Volume 64, Number 121). Tidewater goby is also listed as a California Special Concern species.

Table 3-7 Aquatic habitats of the Watsonville Sloughs Watershed

STREAM REACH	HABITAT TYPE	EXPECTED FISH COMMUNITY TYPE
Watsonville Slough		
Upper Watsonville Slough	Headwaters: Perennial Stream	Small warm headwater; exotics or no fish
	Mid-segment: Seasonal Lake/Marsh	Low gradient native species and introduced exotics
	Lower Segment: Modified Drainage Channel	Small warm headwater; exotics or no fish
Middle Watsonville Slough	Modified Drainage Channel	Low gradient native species and introduced exotics
Lower Watsonville Slough	Estuarine	Marine/estuarine
Struve Slough		
Upper Struve Slough	Intermittent Stream	Small warm headwater; exotics or no fish
Lower Struve Slough	Seasonal Lake/Marsh	Low gradient native species and introduced exotics
West Branch Struve Slough	Intermittent Stream	Small warm headwater; exotics or no fish
Gallighan Slough	Intermittent Stream	Small warm headwater; exotics or no fish
Hanson Slough	Upper: Intermittent Stream Lower: Seasonal Lake/Marsh	Low gradient native species and introduced exotics
Harkins Slough		
Upper Harkins Slough and Tributaries (Larkin Valley)	Upper: Ephemeral Stream Lower: Intermittent Stream	Small warm headwater; exotics or no fish
Lower Harkins Slough	Seasonal Lake/Marsh	Low gradient native species and introduced exotics
Beach Road Ditch	Modified Drainage Channel	Small warm headwater; exotics or no fish

Steelhead

Steelhead (*Oncorhynchus mykiss*) are not expected in upper reaches of the Watsonville Sloughs Watershed but smolts from the Pajaro River may spend brief periods of time in the estuary

feeding before entering the ocean (The Habitat Restoration Group 1997). Adults may also enter the lower estuarine reach of Watsonville Slough from the Pajaro River to feed. Steelhead populations in the Pajaro River basin use Salsipuedes Creek, Corralitos Creek, Uvas Creek, and Llagas Creek for spawning and rearing. Smith (1993) found a few steelhead in the Pajaro Lagoon in August 1991 that he identified as holdover hatchery smolts. The Pajaro River and Watsonville Slough are also within the critical habitat designation for steelhead under the Federal Endangered Species Act (FESA). Southern steelhead (south of San Francisco Bay) are a California Special Concern species.

Coho Salmon

South of San Francisco Bay, Coho salmon (*Oncorhynchus kisutch*) are currently known to have spawning populations in only Waddell Creek and Scott Creek. Smith found a single adult Coho salmon in the Pajaro Lagoon in August 1991 that he believed entered the estuary to feed on abundant herring and topsmelt (Smith 1993). Such fish could presumably also enter the lower reach of Watsonville Slough. The Pajaro River and Watsonville Slough are not within critical habitat designated for the Central California Coho ESU (Federal Register: May 5, 1999; Vol. 64, No. 86) and therefore are not subject to habitat modification provisions of the ESA.

Fish Survey Results

No previous fish surveys have been performed in the freshwater reaches of Watsonville Slough, upstream of the estuary. Therefore to complement the literature search, Hagar and Associates conduct a limited fish survey in June 2001. Preliminary, reconnaissance level assessment of presence and distribution of fish species was conducted by visual observation and sampling in Harkins Slough (upstream of the UPRR crossing) and Struve Slough by dip-net, minnow trap, or hoop trap. Based on the limited sampling completed to date, fish species occurrence in the Sloughs is consistent with expectations. Sacramento blackfish, stickleback, carp, *Gambusia*, and black crappie were captured in Harkins Slough. *Gambusia*, stickleback, and prickly sculpin were observed in visual surveys of Larkin Creek from Harkins Slough upstream to about Windsong Way. Larkin Creek was dry from Senda Ladera Drive upstream. Only stickleback were captured in Struve Slough though sampling was limited to dip-netting. Further sampling is required to develop a complete data set of existing fisheries resources.

3.2 CONDITIONS AND STRESSORS BY PLANNING AREA

A description of the conditions and stressors are presented below for each Planning Area presented in Table 2-1. In this section the cumulative effects of land use, hydrologic constraints, water quality impairments, vegetation conditions, and wildlife and fisheries habitats are prioritized to illuminate the main issues associated with each location.

WATSONVILLE SLOUGH

Upper Watsonville Slough

The Upper Watsonville Slough Planning Area is mostly contained within the City of Watsonville's jurisdiction and extends from its headwaters above Main Street to the low gradient drainage ditch/channel at Highway 1 (**Figure 3-7**). The majority of the land within this Planning Area between Ford Street and Highway 1 is currently unincorporated. In a separate planning process now underway, this area is under consideration for incorporation into the City for development with a component of expanding wetlands along the Slough.

The drainage area of Upper Watsonville Slough is predominately urban cover with residential and commercial uses above and below Main Street becoming industrial and agricultural land use in the lower reaches below Ford Street. Above Harkins Slough Road the Slough area is a confined, overgrown channel approximately 6 feet wide. Below Harkins Slough Road the channel widens considerably during the winter months and contains potentially good quality wetlands and habitat. The private crossing near Ford Street is a major hydraulic constriction of road fill with an improperly placed culvert (control structure # 38, Table 3-3). Below Ford Street, the Slough is confined to an exposed earthen ditch approximately 8 feet wide and bounded by agricultural land with industrial uses in the surrounding area. A key exception is the residential apartments built in 1999 on the north side of Errington Road, the beginning of more residential developments planned along the north side of the Slough up to Main Street. Errington Road will eventually be connected to Main Street to the north by the Ohlone Parkway. The breakdown of land use distributions is shown in Table 3-1.

The hydrology of Upper Watsonville Slough is characterized by perennial wetlands with open water between Main Street and Ford Street and perennial flow in the agricultural ditch extending from Ford Street to Highway 1. Winter storm runoff to the Sloughs emanates through storm


Legend
Streams / Sloughs
Planning Area Boundary
(interior boundary)
Watershed Boundary
(exterior planning boundary)
Scale 1:18,000 or 1 inch = 1,500 feet
Figure 3-7
Upper Watsonville Slough
WATSONVILLE
Struve Slough
GREEN VALLEY RD
MAIN STREET HWY 152
HARKINS SLOUGH RD
Watsonville Slough
FORD ST
LEE RD
HWY 1
ERRINGTON ROAD
BEACH ROAD
Pajaro River
N
W
E
S
Swanson Hydrology & Geomorphology
115 Limekiln Street ◆ Santa Cruz, CA ◆ 95060
tel: 831.427.0288 ◆ fax: 831.427.0472

drains from the surrounding urban and industrial areas situated on alluvial terraces 10 to 25 feet above the Slough, or the floodplain of the Pajaro River. Agricultural areas below Ford Street and extending to the south side of Beach Road drain into the Slough through ditches or dispersed runoff from agricultural fields. A drainage ditch servicing much of the agricultural land south of Beach Road discharges into the Slough just above Highway 1.

Water circulation is generally low to stagnant through the Upper Watsonville Slough Planning Area, in large part due to fill placement in wetlands for road crossings (e.g. Main Street, Harkins Slough Road and Ford Street). The historic dumping of fill at a City landfill between Harkins Slough Road and Main Street has also resulted in channel constrictions during the high flow months. The City of Watsonville is planning the replacement of the existing Harkins Slough Road fill and culvert crossing with a pier supported, open span structure which will reduce backwater and winter flooding; the City has also applied for grant money to remove the fill at the old dump and restore wetlands. The Slough between Ford Street and Highway 1 was dredged in Fall of 2000 by the private landowner. Topographic surveys of this area revealed the ground surrounding the Slough rises between Ford Street and Lee Road; this indicates that the Slough may have been historically diverted from its natural path to the south and the Pajaro River to the west to connect with Struve Slough below Lee Road. There is also evidence of land subsidence near Ford Street as a private drive had to be raised 3.0 feet in recent years. In addition, winter wetlands have recently been occupying areas historically in year- round agricultural production. Despite the dredging in 2000, the first to occur since 1983, drainage conditions in the agricultural lands surrounding the Slough below Ford Street continue to decay.

There is evidence of nutrient and pollutant loading of metals, greases and oils, and pesticides from surrounding urban and residential land uses (Questa 1995). Water quality data collected in 2001 from just downstream of the Ford Road crossing illustrated alarmingly low DO levels in the relatively wet, cool months of March (see Figure 3-4). The Consultant Team observed a fish kill of 30+ fish in this area on January 24, 2001. While the low DO levels may not be the direct cause of the fish kill, these results do provide further evidence that waters in this area of Watsonville Slough are extremely impaired and not ecologically sustainable in their current state.

The vegetation cover for Upper Watsonville Slough is presented in Figure 3-5. The highest quality wetlands are located between Main Street and Ford Street and consist of emergent marsh,

open water and willow riparian forest. The hillslopes are in a generally degraded condition throughout, however the hillslope along Ramsey Park has native oak woodlands of good quality. In other open space areas on hillslopes above and below Main Street invasive exotic species, mainly annual grasses, Himalayan blackberry and hemlock, dominate vegetation. Native vegetation cover is absent in the surrounding urban and industrial lands, as well as the active agricultural fields below Ford Street. Areas of recent and historic fill placement (the old City of Watsonville dump above Harkins Slough Road, the recently placed fill below Ford Street) are havens for exotic vegetation. A storm water detention pond located within the apartment development near the Slough crossing of Errington Road is an example of an artificial wetland supporting native wetland vegetation.

The wildlife and fisheries resources are limited within Upper Watsonville Slough due to encroachment of urban and agricultural uses. There are areas of good songbird and waterfowl habitat between Ford Street and Main Street. Raptors and herons are found in eucalyptus groves upstream of Ford Street. Warm water fish and bullfrogs were observed residing in both wetlands and in the reaches of drainage ditch along agricultural lands near Errington Road.

The main stressors for the Upper Watsonville Slough Planning Area are:

- Land use is extensively urban and industrial, posing limitations on habitat enhancement.
- Water circulation is constricted by hydraulic structures at Main Street, Harkins Slough Road and Ford Street and the flat channel gradient downstream of Main Street.
- Water quality conditions are degraded by poor circulation, nutrient input, urban and agricultural pollution, and the lack of riparian or wetland vegetation within the Slough downstream of Ford Street.
- Vegetation resources are degraded due to loss of areas to urban cover and agricultural uses, invasion of exotic species, and clearing of vegetation associated with maintenance of former wetland areas and waterways.

- Wildlife resources are limited by urban land use cover, agricultural land uses, poor water quality, invasive exotic species (e.g. bullfrog) and lack of native vegetation cover for forage and habitat.

Middle Watsonville Slough

The land use surrounding Middle Watsonville (**Figure 3-8**) is predominantly agricultural lands, with a small industrial development on Lee Road. The reach of Watsonville Slough between Highway 1 and Shell Road flows through a straight ditch in the flat, northern edge of the Pajaro River floodplain. In addition to receiving agricultural tailing from the surrounding fields, Middle Watsonville Slough accepts the urban and industrial runoff from Struve Slough and the agricultural runoff from Hanson Slough (**Figure 3-8**).

Areas to the north of Middle Watsonville Slough experienced extensive winter inundation in 2001, including sustained flooding of a significant portion of active agricultural land just upstream of the confluence of Struve and Watsonville Sloughs (see Figure 3-2). A continuous depth gage (D#2) located at the intersection of Watsonville Slough and UPRR Trestle displayed a very slow drainage rate of the upland flooded areas. Using the change in depth at this site from April 1st through May 31st, 2001 the water depth decreased an average of <0.1 inches/day, even though a significant amount of water still remained in upstream areas, including Struve Slough.

The Middle Watsonville Slough was historically a winter-inundated floodplain of the Pajaro River. From the 1900's drainage of these lands has been maintained by channel dredging. In 1983 the dredging maintenance was reduced and the wetland hydrology and vegetation slowly returned. The Slough now contains some cattail growth on the channel bed, indicating a significant loss of flow depth and hydraulic capacity.

The hydrologic end member of the Middle Watsonville Slough is controlled by the County-maintained tidal dam and pump station at Shell Road. The Shell Road pump station consists of a concrete tidal dam and pump structure built in the 1940s to block saltwater and tidal flows. The tidal dam forms an abrupt hydrologic boundary between saltwater from the ocean and fresh water flowing from the upper watershed areas. The Watsonville Slough channel is highly modified (straighter and deeper than natural) in this reach and bounded by fallow and active cropland, riparian forest and degraded marsh plain areas. A levee built in the 1940s as part of the Shell

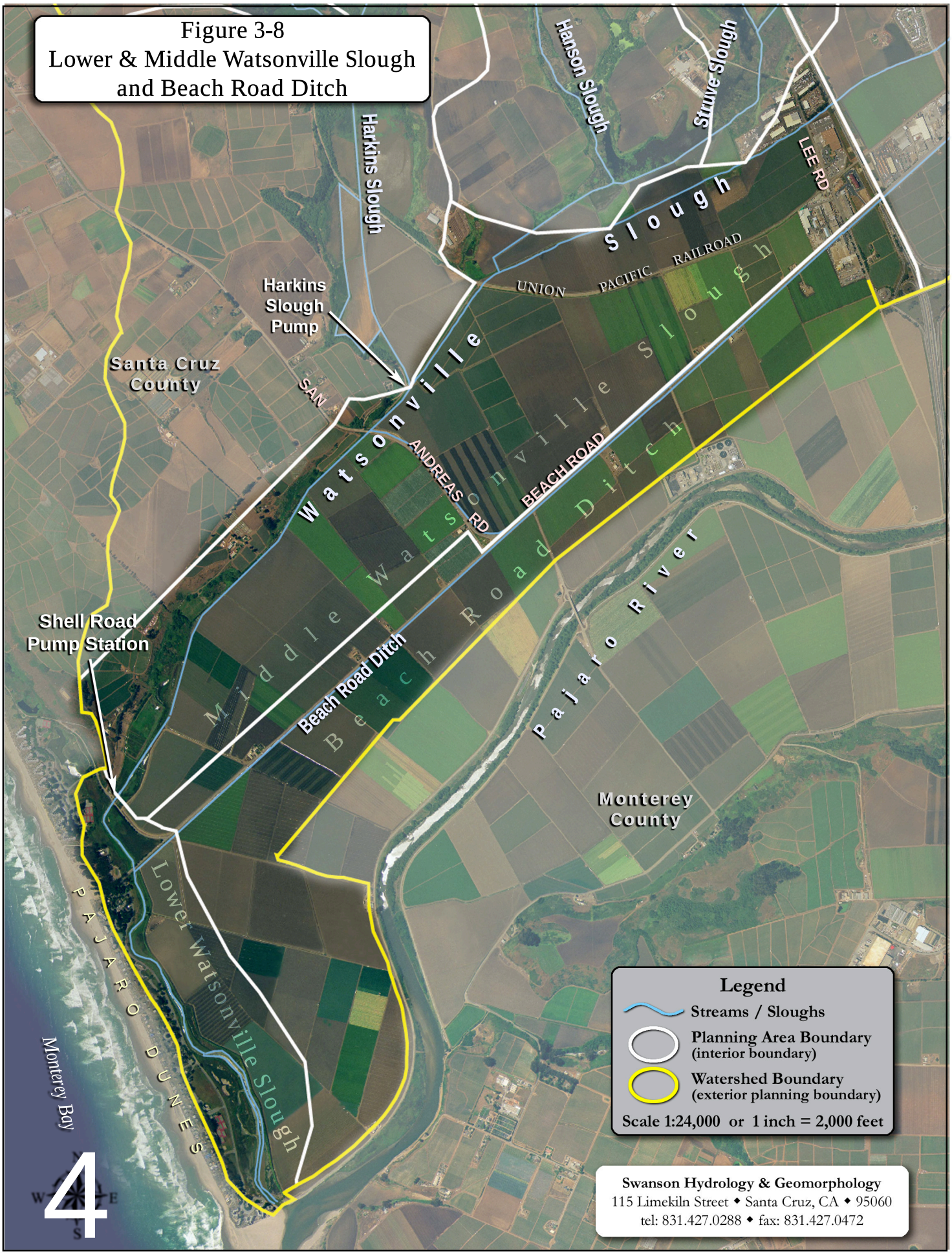
Figure 3-8
Lower & Middle Watsonville Slough
and Beach Road Ditch
Harkins Slough
Hanson Slough
Struve Slough
LEE RD
Slough
UNION PACIFIC RAILROAD
Harkins Slough Pump
Santa Cruz County
SAN
Watsonville Slough
ANDREAS RD
BEACH ROAD
Watsonville Slough
Ditch
Shell Road Pump Station
Middle Watsonville Slough
Beach Road Ditch
Beach Road
Pajaro River
Monterey County
Lower Watsonville Slough
PAJARO DUNES
Monterey Bay
Legend
Streams / Sloughs
Planning Area Boundary
(interior boundary)
Watershed Boundary
(exterior planning boundary)
Scale 1:24,000 or 1 inch = 2,000 feet
Swanson Hydrology & Geomorphology
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tel: 831.427.0288 ◆ fax: 831.427.0472
4

Road tidal dam system extends from the south side of the slough to the Pajaro River Levee (between San Andreas Road and Shell Road).

The vegetation resources within this Planning Area are minimal, due to the extensive development of agricultural and some industrial lands. The very poor drainage and high nutrient loading has resulted in extremely eutrophic waters within this portion of the Slough. The visual degradation of this system is apparent by the lack of any riparian vegetation and dense algal blooms within the channel reaches. Both the wildlife and aquatic habitat value in this area are highly degraded.

The main stressors in Middle Watsonville Slough are:

- Land use encroachment constricts the Slough to a drainage ditch in most areas, limiting habitat values and introducing pollutants (sediment, nutrients and urban runoff).
- Water circulation is low due to flat channel gradient, hydraulic constrictions such as the Shell Road Pump and reaches choked with sediment.
- Extreme nutrient and other contaminant loading from both surrounding and upstream land uses significantly degrade water quality and limit aquatic habitat quality.
- Native vegetation is limited to small pockets mixed with exotic species and surrounded in many locations by barren land.
- The aquatic habitats for invertebrates and fish are compromised as a result of the poor water quality and vegetative conditions.
- The productivity of agricultural land adjoining this reach is degraded by saturated soils and the overall failure of the drainage system.

Lower Watsonville Slough

The Lower Watsonville Slough Planning Area (**Figure 3-8**) includes the salt marsh estuary and slough channel from Shell Road to the mouth at the confluence of the Pajaro River. It includes

the Pajaro Dunes development to the southwest, the agricultural lands to the east and wetland areas around Sunset State Beach. Watsonville Slough flows along the east side of the development, where roads and manicured landscaping encroach into the back beach marsh plain and lagoon area. The Pajaro Dunes development contains a complex of roads and housing covering the landside of the barrier beach that extends across the mouth of the Pajaro River. The major road crossings include Beach Road and Shell Road; the main access road to Pajaro Dunes, Rio Boca Road, parallels the Slough from Beach Road to the mouth. The east side of the estuary is confined by a levee that extends from Beach Road to the Pajaro River, which provides flood protection for the neighboring agricultural fields. Beach Road is a multi-culvert fill structure that does not appear to be a significant barrier to stream flow or aquatic organisms. In contrast, the multi-culvert structure at Shell Road has flap gates that act as a tidal dam, and a pump station, which together form a significant hydraulic and aquatic migration barrier. The estuarine environment of Watsonville Slough is now limited to this reach due to the successful prevention of saltwater migration inland beyond the Shell Road Pump Station.

The hydrology of Lower Watsonville Slough is characterized by tidal fluctuations when the mouth of the Pajaro River is open, typically early winter through mid to late summer, and backwater when the River mouth is allowed to remain closed. Periodically in the late summer and fall months, the Pajaro River mouth closes and water levels become relatively static and dominated by freshwater inflow. Until the sandbar blocking the Pajaro River mouth is breached by overtopping flows of the Pajaro River, the runoff from the earliest fall rainstorms may collect behind the sandbar and cause flooding in the lower valley. This situation may necessitate artificial breaching by Santa Cruz County.

Freshwater inflows from upstream during winter runoff sustain freshwater conditions at Beach Road, but water depths are significantly influenced by tidal elevations. The tidal range varies between less than 2.0 feet for neap conditions to over 6 feet during spring tides. A significant rainstorm can add several feet to normally predicted water depths within the estuary (see Technical Appendix A). In the summer months when the lagoon is open to the ocean, the salinity at Beach Road may increase as fresh water inflows become limited. The depth and salinity data presented in Figure 3-3 and collected at Watsonville Slough at Beach Road show the interactive effects of tides and freshwater inflows on the water levels in mid-March 2001.

Hunt et al (1999) found a significant toxic response of crustaceans when transplanted into waters containing concentrated agricultural drainage (Beach Road Ditch). The highest mortality rates were recorded following a storm event, which mixes the contaminated sediments throughout the water column. The Lower Watsonville Slough Estuary receives all of the runoff from the entire Watsonville Sloughs Watershed, including the untreated concentrated agricultural drainage from the Beach Road Ditch.

The coastal salt marsh is a biologically productive habitat, and consequently, a wide variety of wildlife species utilize this habitat type. Snakes hunt for small mammals at the edges of salt marsh, shorebirds forage for invertebrates in the exposed mud of the salt marsh at low tide, herons and egrets forage for fish in the channels, secretive rails may inhabit the denser stands of salt grass, and raccoons may hunt along the shorelines at night. The overall value to wildlife of the coastal salt marsh of Watsonville Slough Estuary is adversely affected by pesticide runoff from adjacent agricultural lands, reducing the invertebrate fauna on which many vertebrates forage. The narrow width of the vegetated channel also places a constraint on the available habitat within the estuarine portion of the watershed.

The wildlife that inhabit the coastal dune scrub are able to tolerate the arid climate, sandy soil and salt spray. Common species such as white-crowned sparrow (Zonotrichia leucophrys) and deer mouse (Peromyscus maniculatus) may forage for seeds in this habitat, Anna's hummingbird (Calypte anna) may find nectar on some plants, and western fence lizard (Sceloporus occidentalis) may forage on insects.

Estuarine aquatic habitat is limited to the reach of Watsonville Slough downstream of the Shell Road Pump Station. This reach is a tributary arm of the Pajaro River lagoon and supports water quality conditions and fish populations typical of the larger lagoon environment. Smith (1993) found twenty-five species of fish in the Pajaro River lagoon of which nine were found in Watsonville Slough between Shell Road and the confluence with the lagoon. None of the species encountered by Smith are freshwater species. Threespine stickleback, arrow goby, and tidewater goby are resident estuarine species. All others are marine species that use the lagoon and lower Watsonville Slough for spawning, juvenile rearing, or feeding. The reach is influenced by tidal circulation as well as freshwater inflows from upper watershed areas. Tide gates at Shell Road prevent upstream circulation of estuarine waters or upstream movement of estuarine fish. All

aquatic habitats upstream of the Shell Road tide gate and pump are freshwater.

The main stressors for Lower Watsonville Slough are:

- Salt-marsh habitat is degraded due to reclamation. The extent of the salt marsh is confined by Pajaro Dunes development to the west, the flood control levee to the east, and the Shell Road Pump Station inland.

- The Shell Road Pump Station has abruptly eliminated the natural brackish transition. This barrier also prevents and limits the inland migration of aquatic flora and fauna.

- Concentrated agricultural runoff is discharged directly into the Slough from Beach Road Ditch and at the Shell Road Pump. This increases nutrient delivery, increases algal production and reduces dissolved oxygen concentrations, especially during periods when the lagoon mouth is closed.

- The polluted estuarine waters of Watsonville Slough will expose Federal and State listed anadromous fish to potentially toxic waters and reduces invertebrate, prey fauna.

- The quality of native plant communities and wildlife habitat is degraded by exotic, invasive vegetation and the fill and structural remains of past dredging and reclamation attempts.

STRUVE SLOUGH

Upper Struve Slough

The headwaters of Struve Slough originate just south of the Watsonville Municipal Airport. The drainage area of Upper Struve Slough is predominantly dense urban residential development (**Figure 3-9**). Associated with urban land use is artificial landscaping, road networks, and encroachment on the drainage way.

Extending from the headwaters to Green Valley Road, Upper Struve Slough is confined in a relatively small channel (approximately 3 ft deep and 5 ft wide) and densely overgrown with blackberries. The area between Green Valley Road and Main Street serves as winter water


Figure 3-9
Upper Struve Slough & Upper West Branch &
West Branch Struve Slough & Lower Struve
N
W
E
S
West Branch Struve Slough
WATSONVILLE
Harkins Slough
GREEN VALLEY RD
Struve Slough
MAIN STREET
HWY 1
HWY 152
HARKINS SLOUGH RD
West Branch Struve Slough
Hanson Slough
Watsonville Slough
Legend
Streams / Sloughs
Planning Area Boundary
(interior boundary)
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storage, forming an inland freshwater marsh in the winter and spring months. The winter inundation in this area is due to the improper culvert placement beneath Main Street (control structure #18, Table 3-3). The 3-foot deep headcut observed at the outlet of the culvert, west of Main Street, suggests that the culvert was placed at too high of an elevation.

Wildlife use of the landscaping plants is expected to be low because many are non-native plants not frequented by native wildlife species. Most are single shrubs or trees interspersed among an otherwise urbanized or developed area, providing little vegetative cover for wildlife. Urban adapted species such as scrub jay (*Aphelocoma coerulescens*) and European starling (*Sturnus vulgaris*) may use the landscaped areas as perches and these, as well as other birds, may occasionally forage on berries or nectar of some plants.

The main stressors on Upper Struve Slough are:

- Extensive urban development encroaching into wetlands and hillslopes removes areas for native plant communities and wildlife habitat and brings pollution sources close to sensitive areas.

- Poor drainage in the slough between Pennsylvania Drive and Main Street results in poor water circulation.

- Water quality in the slough is influenced by urban runoff and non-point source pollution.

- The removal of native vegetation and wildlife habitat is compounded by expansion of urban tolerant wildlife species such as raccoons, opossum, and starlings.

Lower Struve Slough / West Branch Struve Slough

Struve Slough and the West Branch of Struve Slough drain predominately urban lands of the City of Watsonville with their headwaters originating north of Highway 152 (Main Street). Lower Struve extends from Main Street to its confluence with Watsonville Slough (**Figure 3-9**). West Branch Struve Slough originates at the Watsonville Municipal Airport. Most of the hilltops within the drainage area have been recently converted to commercial and residential urban land. A mushroom factory is situated on the hilltop above the west side of Struve Slough and the

confluence with the Watsonville Slough at Lee Road. An unnamed tributary originates along the west side of Highway 1 at the Main Street/Highway 152 interchange and will be near the site of a proposed high school off Harkins Slough Road. This tributary is the north end of a large area of public ownership that extends to Lee Road. As the high school project moves ahead, this area will experience profound changes as the development of bridges and other infrastructure occur. Proposals to the Local Agency Formation Commission (LAFCO) to extend urban land west of Highway 1 have been highly contested and defeated over the past 10 years. A Memorandum of Understanding with the City of Watsonville, County of Santa Cruz and California Coastal Commission was entered into as part of the agreement to allow the new high school to be built on the City of Watsonville's coastal zone area west of Highway 1. The MOU contains provisions that establish barriers to any further development west of Highway 1.

The three branches of Struve Slough (Struve, West Branch Struve, and unnamed tributary) converge above Lee Road. From Main Street to Lee Road, Struve Slough is densely vegetated and contains a significant amount of freshwater marsh habitat in the winter and spring. The extent of the marsh is bound by hillslopes that are occupied by a combination of grasslands, agricultural fields and commercial developments. West Branch Struve Slough extending from Highway 1 to its confluence with Struve Slough above Lee Road is undeveloped State-owned land. The valley is filled with extensive freshwater marsh vegetation and habitat and the hillslopes are currently undeveloped grasslands.

The hydraulics of waterways in the Struve Slough system are highly influenced by road fill crossings and hydraulic structures associated with hilltop urban drainage systems. These structures tend to detain runoff and spring water and maintain perennial ponds and emergent marshes. The fill crossing at Lee Road further exacerbates the drainage inefficiencies of the upland areas (control structure #7, Table 3-3) and is often submerged in the winter months. Struve Slough flows in a ditch and marsh system along the north edge of the Pajaro Valley, paralleling Watsonville Slough to the south. Struve Slough picks up the Hanson Slough drainage in an area of ponded marsh with riparian woodland abutting the hillslopes to the north and flows into an earthen ditch before entering into a similar ditch of Watsonville Slough just upstream of the railroad crossing. The combination of ineffective drainage control structures (#7, #11) and the potential for significant land subsidence may make future drainage of these areas following storm events extremely difficult.

Similar to Upper Watsonville Slough, Struve Slough receives a significant amount of urban runoff from the surrounding city of Watsonville. However, unlike Upper Watsonville, Struve Slough contains a significant amount of cattails, wetland vegetation, and bird life. Water quality data collected in the open water east of Highway 1 indicated extremely low bottom water DO levels and visual observations showed extreme algal growth and decay. Visually, the habitat value in Struve Slough is significantly greater than that of Upper Watsonville, and efforts to decrease pollutant runoff from urban areas will have a positive effect on its recovery to a healthy ecosystem.

Below Harkins Slough Road and extending to the confluence of Struve and Watsonville Sloughs, a substantial seasonal marsh develops in the winter months. This area is dominated by freshwater marsh vegetation, intermingled with willow riparian woodland and upland grassland. This habitat is likely to support species such as stickleback, hitch, blackfish, and possibly Sacramento sucker, although sucker would need access to stream habitats to complete spawning. All of these species can tolerate warm temperatures, low dissolved oxygen levels, and tend to prefer habitats with less current. They can also (with the exception of the sucker) complete their reproductive cycle in lotic habitats. In addition, the warmer, ponded water habitats of the Sloughs would provide suitable habitat for introduced exotic species such as carp, mosquitofish, catfish, and members of the sunfish family, such as green sunfish.

The main stressors in the Lower Struve/ West Branch Struve Sloughs Planning Area are:

- Extensive urban and commercial development from upstream areas transports pollutants to aquatic habitats in Lower Struve and West Branch Struve Sloughs.

- Water quality is affected by runoff and intermixing with agricultural drainage, especially by recently cultivated agricultural fields of the lower reaches of the Planning Area.

- Harkins Slough and Lee Roads are hydraulic barriers that reduce water circulation and affect water quality.

- Land subsidence within the lower reaches present challenges to providing future drainage for agriculture.

- Native vegetation cover in wetlands, transitional areas and uplands is degraded by invasive exotic species and the remnants of past agricultural and reclamation activities.

- Wildlife habitat is compromised by exotic vegetation cover and poor water quality from low circulation and pollutant loading.

GALLIGHAN SLOUGH

The headwaters of Gallighan Slough (**Figure 3-10**) originate at the southwest side of Highway 1, flowing down a narrow valley bounded by steep hillslopes and small tributary valleys. The headwaters of Gallighan Slough may contain light grazing and sparse rural residential development, but the majority of the drainage area is undeveloped lands with dense riparian forest areas. The reach along Buena Vista Road is severely affected by the amount of sediment eroding from hilltop strawberry fields during high winter runoffs (control structure #33, Table 3-3). The roadside ditch appears to be continually overwhelmed with sediment and episodic flooding of Buena Vista Road at Whiskey Hill Road occurs due to the burial of the road crossing culvert (control structure #34, Table 3-3). At Buena Vista Road, Gallighan Slough becomes a maintained roadside drainage ditch. This reach receives a significant amount of agricultural runoff from the hillslopes to the southwest of Buena Vista Road. The hydrology of Gallighan Slough is ephemeral. It is also affected by road drainage and sedimentation from cropland and eroding road cuts. At the Santa Cruz County Buena Vista Landfill, Gallighan Slough flows between active landfills receiving all of the storm water runoff from the dump. Gallighan Slough joins Harkins Slough below Harkins Slough Road.

The most prominent water quality issues affecting Gallighan Slough are the presence of and storm runoff from two landfills within its watershed; the County of Santa Cruz Landfill on Buena Vista Road and the City Municipal Landfill off of San Andreas Road. The types of pollutants associated with landfill runoff could range from hydrocarbons to heavy metals, organics and sediment.


Figure 3-10
Gallighan Slough
TRABING RD
HWY 1
FIESTA WAY
Harkins Slough
LARKIN VALLEY RD
Gallighan
RANPORT RD
BUENA VISTA RD
Harkins Slough
County Landfill
BUENA VISTA RD
County Landfill
City Landfill
Slough
HARKINS SLOUGH RD
SAN ANDREAS RD
UNION PACIFIC RAILROAD
Legend
Streams / Sloughs
Planning Area Boundary
(interior boundary)
Watershed Boundary
(exterior planning boundary)
Scale 1:18,000 or 1 inch = 1,500 feet
N
W
E
S
Swanson Hydrology & Geomorphology
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The upper watershed lands in Gallighan Slough support a mosaic of woodland vegetation. Dominant plant community types include coast live oak woodland, central maritime chaparral and coastal scrub. Riparian woodland occurs along the several creeks that traverse this foothill and steeper terrain. The upper watershed (above Buena Vista Road) does provide a section of wildlife habitat for foragers and grazers.

The main stressors in Gallighan Slough are:

- High sediment loads eroding from agricultural fields, roads and some surrounding areas.
- High sediment loads from poorly designed and maintained road and drainage ditch along Buena Vista Road from San Andreas to County landfill.
- Native vegetation impacted by cleared land and roads and degraded lands.
- Wildlife habitat fragmented by roads and cleared areas. Aquatic habitat affected by excessive sediment input and by migratory barriers.

HANSON SLOUGH

Hanson Slough (**Figure 3-11**) drains a small basin mostly situated south of Harkins Slough Road, west of Lee Road, and south of Harkins Slough. The headwaters originate above Harkins Slough Road, in a hilly area highly impacted by cattle grazing operations. Below Harkins Slough Road, Hanson Slough flows within a willow riparian corridor bounded by hillslope cropland. This was the site of a water quality improvement project completed by the Watershed Institute of California State University Monterey Bay using willows to filter runoff and sediment flowing off crop fields. Hanson Slough flows southward and drains into Watsonville Slough.

The middle and lower portion of the Hanson Slough watershed is intermingled with willow riparian woodland and upland grassland. The Lower Struve Slough inland marsh extends to the confluence of Hanson and Struve Slough during the winter and spring and is dominated by freshwater marsh vegetation.


Figure 3-11
Hanson Slough
Legend
Streams / Sloughs
Planning Area Boundary
(interior boundary)
Watershed Boundary
(exterior planning boundary)
Scale 1:18,000 or 1 inch = 1,500 feet
WATSONVILLE
HWY 1
GREEN VALLEY RD
Struve Slough
MAIN STREET
HWY 152
BUENA VISTA RD
Harkins Slough
West Branch Struve Slough
HARKINS SLOUGH RD
LEE RD
Hanson Slough
Gallighan Slough
Harkins Slough
Struve Slough
Slough
Watsonville
HWY 1
UNION PACIFIC RAILROAD
BEACH ROAD
N
W
E
S
Swanson Hydrology & Geomorphology
115 Limekiln Street ◆ Santa Cruz, CA ◆ 95060
tel: 831.427.0288 ◆ fax: 831.427.0472

The main stressors of Hanson Slough are:

- Water quality is degraded by land uses including the intensive grazing operations in the upper watershed exposing soils to surface erosion, removal of native vegetation cover, and compaction of soils within the waterway.

- Animal waste deposited directly into the waterway contributes to the nutrient contamination of the Sloughs.

- Despite some patches of riparian forest along the waterway, native vegetation cover is sparse in the upper watershed and areas below Harkins Slough Road, decreasing overall diversity and abundance.

- Wildlife habitat is limited and degraded by present land uses, a lack of native vegetation cover and apparent degraded water quality.

HARKINS SLOUGH

Upper Harkins Slough (Larkin Valley)

Upper Harkins Slough is the longest waterway in the Watsonville Sloughs system extending 7 miles inland through Larkin Valley. In the upper watershed area above Highway 1 (**Figure 3-12**) Harkins Slough flows as a stream within Larkin Valley, a narrow, linear valley surrounded by moderately steep hillslopes and tributary valleys. A significant amount of this watershed is undeveloped land providing groundwater recharge and portions of wildlife habitat, relatively absent in much of the remaining areas of Watsonville Sloughs. Land use consists of rural residential development with a significant area of horse stables and grazing use. The greatest impact is grazing on the unprotected channels of the Slough exposed within grazing lands. Landslides and seeps are common on the hillslopes as underlying soils are moderate to highly erodible and structurally weak.

The headwaters of Harkins Slough are ephemeral streams, transporting water to the lower elevations following large precipitation events. As the stream continues down Larkin Valley, Harkins Slough becomes an intermittent small creek channel along Larkin Valley Road, dissected by numerous private property lines situated perpendicular to the waterway. Often times there is

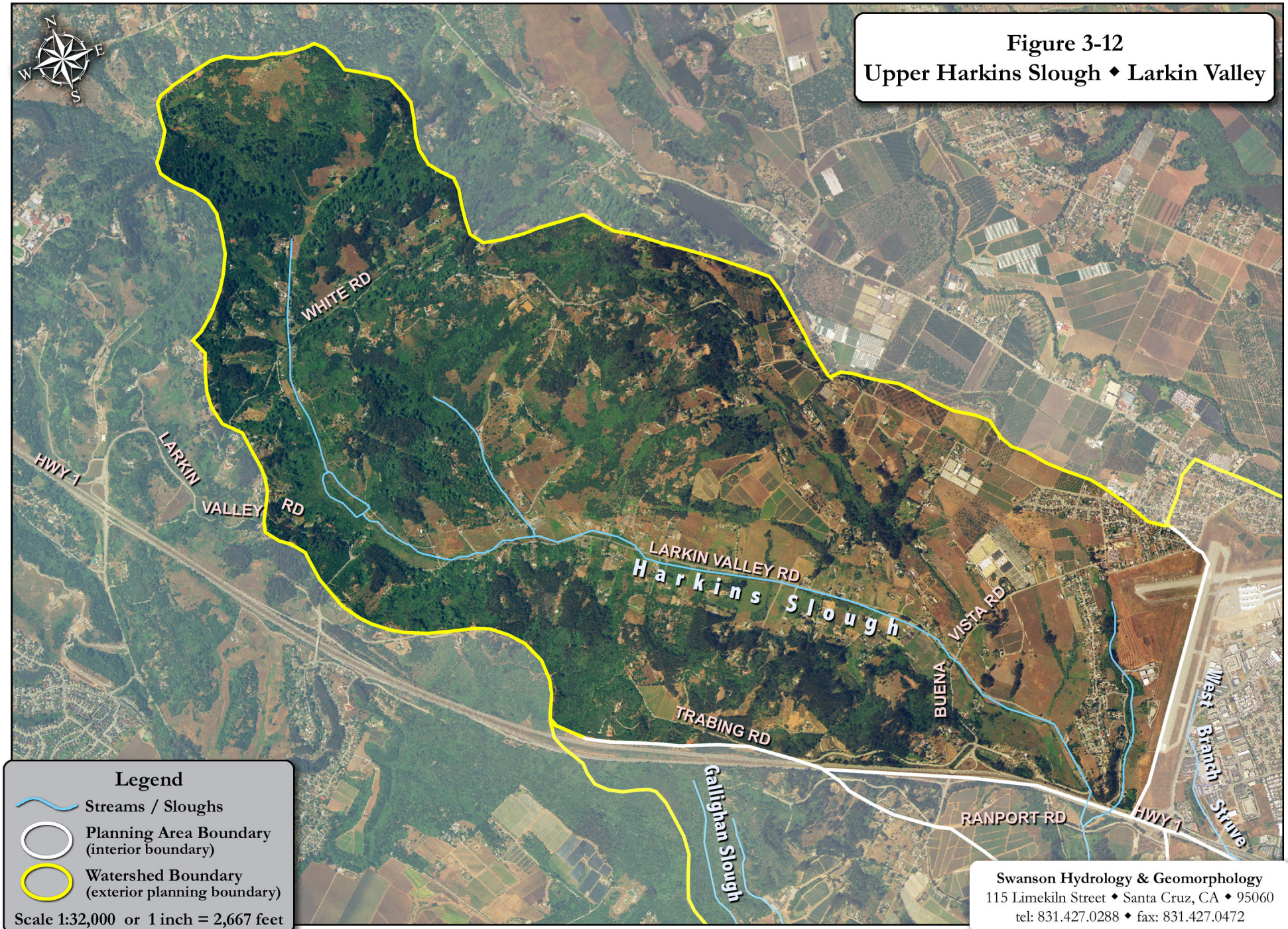
Figure 3-12
Upper Harkins Slough ◆ Larkin Valley
N
E
S
W
WHITE RD
HWY 1
LARKIN VALLEY RD
LARKIN VALLEY RD
Harkins Slough
VISTA RD
BUENA
TRABING RD
Gallighan Slough
RANPORT RD
HWY 1
West Branch Struve
Legend
Streams / Sloughs
Planning Area Boundary
(interior boundary)
Watershed Boundary
(exterior planning boundary)
Scale 1:32,000 or 1 inch = 2,667 feet
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water below Buena Vista Road Crossing all year round.

There are two main water quality issues associated with Upper Harkins Slough. The first is the domestic sewage predominately handled by septic systems. Leaky septic systems can be a chronic source of nutrients to the groundwater and local waterways. The second is channel erosion within exposed reaches accessible to livestock. Simple efforts can protect the stream from livestock destruction and improve aquatic habitat by the rejuvenation of riparian cover.

The upper watershed lands in Upper Harkins Slough support a mosaic of woodland vegetation. Dominant plant community types include coast live oak woodland, central maritime chaparral and coastal scrub. Riparian woodland occurs along the several creeks that traverse this foothill and steeper terrain. Since the turn of the century, land use changes have altered large expanses of the historic oak and chaparral landscape. These trees now form dense groves throughout the upper watershed. Rural residential and agricultural activities as well as public facilities (i.e., roadways) have altered the historic (pre-European) distribution of both the woodlands and grasslands within the upper watershed. This has occurred through the planting of non-native trees, most notably blue gum eucalyptus and Monterey pine, by the direct alteration of habitat, and through indirect means (i.e. relocation, filling or other alterations of natural drainage features). As a result of these human activities, the upper watershed supports numerous non-native plant species, including some species that are considered to be invasive pests. The riparian corridor ranges from densely vegetated and relatively undisturbed to a highly modified channel, cleared of vegetation and functioning as a roadside ditch.

The sparse riparian corridors still remaining in Watsonville Sloughs Watershed are most prominent in the Upper Harkins sub-watershed. Riparian habitat is one of the highest valued habitats for wildlife species diversity and abundance in California. Factors that contribute to the high wildlife value include seasonal presence of surface water, variety of niches provided by the high structural complexity of the habitat, and abundance of plant growth. Riparian habitat along the Sloughs may be used by a diversity of wildlife species for food, water, escape cover, nesting, and thermal cover. The willow thickets along the Sloughs also provide a buffer for wildlife from adjacent urban and agricultural uses

The historic fisheries habitat in this area has been greatly affected by channel alteration, land use

and physical barriers existing in the lower watersheds. Smaller tributary intermittent streams may be able to sustain trout, but California roach may be the primary year-round resident. Roach can survive in very small streams including intermittent reaches where only isolated pools remain during the dry season. Historically, other species may use these streams in the spring for spawning.

The main stressors for Upper Harkins Slough are:

- The riparian habitat and wetlands along the Slough have many reaches that have been exposed by land clearing and/or erosion leaving a roadside ditch or an unprotected channel within grazing lands. These degraded reaches fragment valuable areas of riparian vegetation and aquatic habitat. In addition, channel erosion produces sediment during high flows.

- Leaky septic systems and livestock manure are chronic sources of nutrients to the groundwater and waterways.

- Erosion occurring in cleared areas or disturbed by grazing or development contribute an excessive sediment supply to local and downstream reaches. This reduces aquatic habitat quality and clogs waterways, causing flooding.

Lower Harkins Slough

Development in Lower Harkins Slough consists of sparse buildings associated with present or past agricultural uses (cattle grazing and dairy operations), and concentrated public and private residences (**Figure 3-13**). Most of the parcels in this area are relatively large (fifty to several hundred acres). The land uses within the contributing watersheds present greater impacts to the Lower Harkins Slough than the immediately surrounding lands. For example, large amounts of sediment have been transported from Larkin Valley and deposited in Lower Harkins Slough, and the landfill runoff from Gallighan Slough is ultimately transported to the inland marsh within Lower Harkins Slough.

Harkins Slough flows under Highway 1 as a riparian forest-lined creek channel at Rampart Road before opening into the low gradient, perennially open water slough that is visible along Harkins

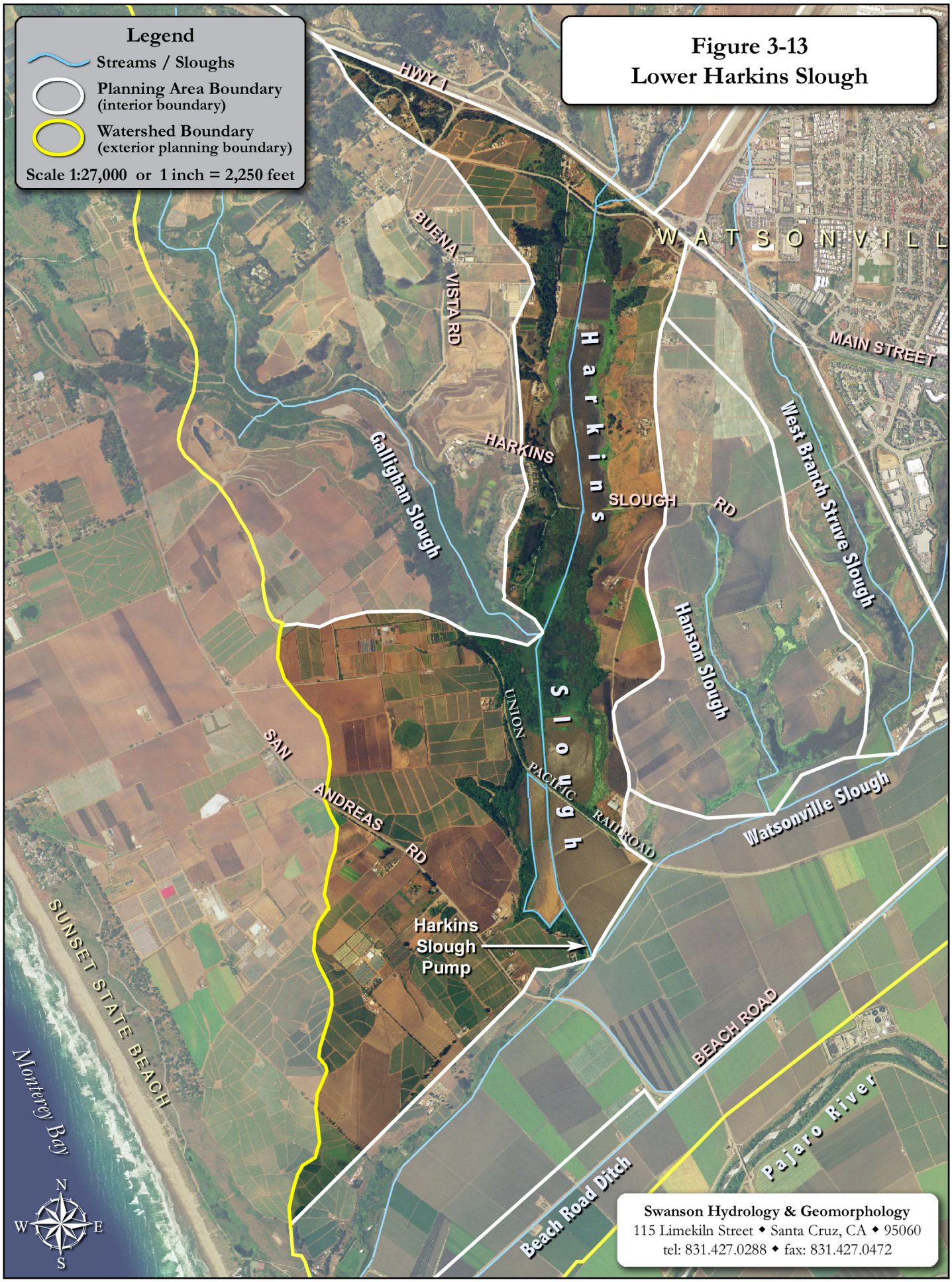
Figure 3-13
Lower Harkins Slough
Legend
Streams / Sloughs
Planning Area Boundary
(interior boundary)
Watershed Boundary
(exterior planning boundary)
Scale 1:27,000 or 1 inch = 2,250 feet
HWY 1
BUENA VISTA RD
WATSONVILLE
MAIN STREET
Harkins Slough
HARKINS SLOUGH RD
Gallighan Slough
West Branch Struve Slough
Hanson Slough
UNION PACIFIC RAILROAD
SAN ANDREAS RD
Watsonville Slough
Harkins Slough Pump
SUNSET STATE BEACH
Monterey Bay
BEACH ROAD
Pajaro River
Beach Road Ditch
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Slough Road. The hillsides bordering Harkins Slough are predominantly oak woodland habitat. The valley floor is underlain by peat soils, a deep accumulation of predominately organic matter (marsh vegetation). The peat was mined as recently as the 1980s leaving 6-9 ft deep ponds just above the Union Pacific Railroad Crossing (UPRR). The peat soils underlying the valley floor are prone to subsidence as evidenced by the Harkins Slough Road crossing, which has recently been submerged as an extensive inland marsh for much of the past three to five years. The hillslopes bounding the Harkins Slough freshwater marsh have visible landslides and potential abrupt breaks in slope, which may be attributable to land fissures associated with land subsidence within the Slough.

Lower Harkins Slough merges into Watsonville Slough below the UPRR crossing, a structure of fill that spans the valley floor. Grassy hillslopes and areas under intensive strawberry production drain onto side valley alluvial fans. Below the UPRR crossing, Harkins Slough flows in an earthen ditch bounded by agricultural lands. In the winter of 2001 the majority of these fields were flooded until late April (see Figure 3-2). The Harkins Slough valley ends where it meets Watsonville Slough on the north edge of the Pajaro Valley floodplain.

At the confluence with Watsonville Slough, Harkins Slough is hydraulically controlled by a concrete weir and pump system that has been historically operated for flood control. A water diversion project was completed in Winter 2001 by the Pajaro Valley Water Management Agency (PVWMA) to pump surface water from Harkins Slough to a groundwater recharge basin and production field located in the uplands to the west. The water rights permits allow water to be diverted only during flood season and monitoring is to be established by permit approval conditions to determine the impact of its operations. The groundwater produced from this field will be allocated to farms in the lower Pajaro Valley to replace supply wells impacted by seawater intrusion.

The progressive increase in the winter water retention within Lower Harkins Slough is due to structures constricting drainage, potential land subsidence, and the presence of relatively impermeable clay soils. The main drainage constrictions include Harkins Slough Road, the UPRR, a large sediment and debris pile on the upstream side of the UPRR trestle, and the elevation difference between Lower Harkins Slough and Watsonville Slough at the confluence.

The freshwater marshes and ponds of Harkins Slough provide important foraging and breeding areas for a variety of wildlife species. The presence of wetland plants such as cattails, bulrush, and willows directly increase the wildlife value of the marsh. Wetland vegetation provides cover, breeding sites and a food base of a diversified aquatic invertebrate fauna, the basis of many food webs. The Slough provides important wintering (Busch 1986) and breeding habitat (Busch 1985) for a number of waterfowl. The abundance of waterfowl attracts predators such as hawks and falcons. Wildlife from adjacent upland habitats are attracted to the marsh areas for drinking water and foraging opportunities. The wildlife value of the freshwater marsh habitats can be impaired by periods of oxygen depletion, artificial lowering of water levels by pumping, the build-up of pesticides that may limit invertebrate fauna, and the presence of non-native predator species. The overall health of the Slough is constrained by the close proximity to urban and agricultural development.

The wildlife value of oak woodland varies with the degree of canopy cover and the density and diversity of understory plants. Acorns from oaks provide important food resources for many wildlife species and natural cavities in the oaks provide nesting opportunities for some birds and mammals. Snags are an important component of oak woodlands for some wildlife, such as woodpeckers, which excavate nests in snags and holes for storing acorns. Downed decaying logs and limbs add to the structural complexity of the habitat and are an important cover, nesting, roosting, and foraging substrate for species, such as newts, which are attracted to the moist microclimate and invertebrate food supply. The denser oak woodlands also provide escape cover during the day for species such as deer.

The most extensive open water habitat is found in Harkins Slough. Some parts of Harkins Slough reach depths of nine feet or more and exposure to coastal breezes can result in increased dissolved oxygen levels mixing all the way to the bottom waters due to wind stress alone. In contrast, much of the other slough habitat, such as in Struve Slough, consists of predominantly 1-3 foot water depths dominated by abundant growths of algae and aquatic plants with very little open water habitat. Fish life in these shallower more vegetated habitats is likely limited to species such as stickleback and *Gambusia*.

The main stressors in Lower Harkins Slough are:

- Lower Harkins Slough receives contaminants generated in the upper watersheds of Larkin Valley and Gallighan Slough. The main pollutant types are sediment from roads and agriculture, nutrients from septic systems, livestock manure and fertilizer, and a variety of pollutants from landfill runoff.

- Poor water circulation and the progressive expansion of seasonal lakes is due to the combined effects of hydraulic constrictions (UPRR, Harkins Slough Road and Highway 1), sedimentation, and land subsidence. Winter inundation of recently cultivated agricultural fields will decrease the water quality of overlying waters.

- Vegetation resources in the wetlands, transitional areas and uplands are degraded by land use leaving clear and degraded conditions and areas dominated by exotic invasive species.

- Wildlife and fisheries are limited by poor water circulation, lack of native vegetation cover and migration barriers at road crossings (UPRR, Harkins Slough Road, Ranport Road and Highway 1 culverts).

BEACH ROAD DITCH

The land use surround Beach Road Ditch (**Figure 3-8**) is exclusively active agricultural field cultivation. On the south side of the road, Beach Road Ditch extends the length of Beach Road from Lee Road to its discharge into Lower Watsonville Slough estuary. On the north side of the road, waters from Lee Road head north at San Andreas Road and discharge directly to Watsonville Slough at San Andreas Road during high flows. During the drier months the drainage on the north side appears to evaporate or infiltrate rather than reaching the Slough waters directly.

The principal purpose of the ditch is to accept nearby agricultural drain tile runoff and transport the waters to the Slough. The toxicity study performed by Hunt et al (1999) in the Beach Road Ditch illustrated high mortality rates of transplanted crustaceans. Visual observations confirm that

the exposed drainage ditch does not contain any valuable vegetative or aquatic habitat.

Extensive and continuous groundwater withdrawal has created an inland migration of saltwater intrusion. Information from Pajaro Valley Management personnel indicates that saltwater has been detected in deep groundwater wells (over 400 ft bgs) beneath Watsonville Slough at the UPRR trestle. This location is over 2 miles inland from the Pacific Ocean.

The agricultural lands in the watershed provide limited habitat for native wildlife. The disking of the soil for row crops reduces habitat for ground burrowing animals and the application of pesticides may reduce the invertebrate fauna upon which several types of wildlife depend for forage. Agricultural fields also often attract non-native wildlife such as European starling (*Sturnus vulgaris*), Norway rat (*Rattus norvegicus*), and feral pigs (*Sus scrofa*).

The main stressors present in the Beach Road Ditch are:

- The economic value of the productive agricultural lands surrounding this reach is high.
- Concentrated, untreated, and potentially toxic agricultural drainage is eventually released into Watsonville Slough at two specific locations.
- Saltwater intrusion continues due to groundwater overdraft to meet irrigation needs.
- Wildlife and aquatic habitat is relatively non-existent.

3.3 PUBLIC ACCESS AND RECREATION

Public access and recreation in the Watsonville Sloughs Watershed is presently very limited (**Figure 3-14**). The areas of Larkin Valley, Watsonville Slough, and Harkins Slough are mostly private lands with no public access. There are extensive informal access points, most of which can only be accessed by trespassing through private land. The main points of access are in the Union Pacific Railroad corridor that runs from Lee Road across Watsonville Slough and northward across Harkins Slough through Gallighan Slough. Foot traffic and motor vehicles have been observed along this area, some accessing the railroad from private agricultural roads off

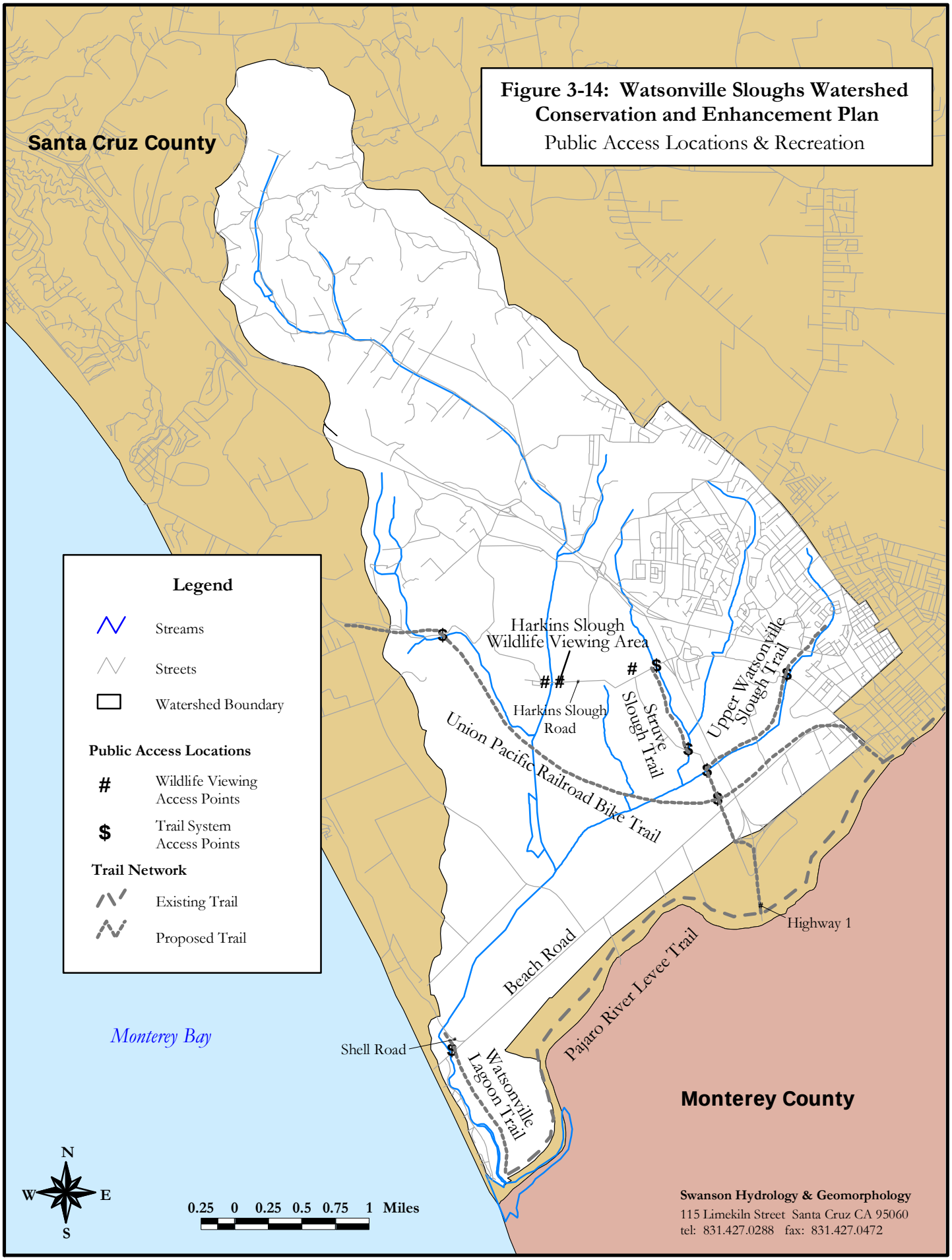
Figure 3-14: Watsonville Sloughs Watershed Conservation and Enhancement Plan
Public Access Locations & Recreation
Santa Cruz County
Legend
Streams
Streets
Watershed Boundary
Public Access Locations
Wildlife Viewing Access Points
$ Trail System Access Points
Trail Network
Existing Trail
Proposed Trail
Harkins Slough Wildlife Viewing Area
Harkins Slough Road
Struve Slough Trail
Upper Watsonville Slough Trail
Union Pacific Railroad Bike Trail
Highway 1
Beach Road
Pajaro River Levee Trail
Shell Road
Watsonville Lagoon Trail
Monterey Bay
Monterey County
N
W
E
S
0.25 0 0.25 0.5 0.75 1 Miles
Swanson Hydrology & Geomorphology
115 Limekiln Street Santa Cruz CA 95060
tel: 831.427.0288 fax: 831.427.0472

Beach Road. Fishing off the railroad bridge at Harkins Slough is a common recreational activity.

The flooded and closed Harkins Slough Road crossing over Harkins Slough from the west side (Buena Vista Road) is a common public access point for novice and expert bird watchers and nature artists. This area can also be accessed from the east or Watsonville side, as well. This area allows visitors access to the valley bottom from the hilltops and is a good location to see raptors and waterfowl. It has also become the site of increased graffiti tagging activities. Informal access also occurs at Struve Slough at Lee Road, although it is limited as the road is open at times for traffic. This area north to Harkins Slough Road is publicly owned and connects to the site where the new high school is to be built. There are provisions in the High School Plan for access and nature education in the Sloughs. There is public access to the segment of Lower Watsonville Slough between Beach Road and Shell Road on California State Parks Lands. There are no formal trails or access points in the marsh area. However, it is accessible to residents within the Pajaro Dunes development.

The mouth of Watsonville Slough is accessible by foot or bicycle along the maintenance road on the crown of the left bank (north side) of the Pajaro River levee. The levee trail extends to Murphy Crossing (10 miles east) and is broken at the Salsipuedes Creek crossing. Although the use of the levee trail is not officially condoned, it is extensively used. The levee trail is not accessible west of Thurwachter Road.

The City of Watsonville owns large areas of Upper Watsonville Slough from a point above Main Street at Highway 152 to Ford Street, as well as a good portion of Struve Slough between Highway 1 and Green Valley Road. Much of the access there is trespassing and some areas are reported to be used for illicit activities.

FUTURE PLANS FOR PUBLIC ACCESS TRAILS

Santa Cruz County Transportation Commission is planning a 31-mile bicycle path corridor from Watsonville to Davenport along the Union Pacific Railroad corridor, which ends at Beach Road (http://www.sccrtc.org/factsht.html). A master plan is being developed to determine the cost of the path and the feasibility of crossing 37 bridges. The present cost estimate for construction is $25 million, excluding easement acquisition.

The City of Watsonville has prepared a Trails Master Plan for City-owned property in Struve and Watsonville Sloughs from above Main Street to Highway 1 (see Technical Appendix H). The plan includes trail alignments and engineering details that will allow the City to move forward with plans preparation, bidding and construction. The proposed trail system occurs along the hillslopes below the urban area hilltops and above the wetlands areas in the valley bottoms. The trails will have different uses from walking paths to disabled access and perhaps bicycle access. There are opportunities for viewpoints, interpretative signs and parking. The trails could eventually tie into the planned County bike path corridor described above. Implementation of the trails projects allows for integration of vegetation and wetlands enhancement projects since equipment, construction and maintenance access will be developed. The City anticipates construction over the next 5 years and City funds have been allocated for some of the necessary funding.

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4.0 RECOMMENDED CONSERVATION AND ENHANCEMENT PLAN

4.1 INTRODUCTION

The main strategy for success of the WSCEP program is to carry out resource enhancement projects that meet the pressing needs of natural resources while addressing and in some cases improving social and economic conditions for the local community. An initial set of recommended demonstration projects should show the community how an optimized planning process works to improve the Sloughs and minimize conflicts between land use and natural resources. The optimized planning process will simultaneously address the environmental needs of the Sloughs, the needs of private landowners, the economic needs of agriculture, the regulatory policies of resources agencies, and the requirements of grant and local government funding agencies. The strategy is to apply new planning and scientific information to land use as a means to identify projects that gain support from landowners and funding agencies, then implement them to demonstrate success. After the experience of demonstration projects, it is anticipated that the momentum of each success will build further progress, more projects and more success. The momentum to implement projects will be gained as support from landowners and the local community increases and conditions are measurably improved. In the end, the vision for the Sloughs with full implementation of the WSCEP is one where the quality of wildlife habitats, water, and the visual qualities of the Sloughs are appreciated and protected by the community.

The ultimate vision for the Sloughs is to improve conditions to the point where the natural ecological processes occur over a large enough area to allow them to become self-sustaining. The Sloughs' natural areas would be connected by corridors along slough and stream valleys rather than existing in isolated pockets. The connected areas would include a variety of landscape elements including wetlands on the valley floor and whole hillsides and hilltops, which serve many types of wildlife as habitat and breeding grounds. Native vegetation in the areas dedicated for natural ecosystem processes would be sustained to the point where it can out-compete exotic invasive species and maximize native wildlife habitat. For natural areas bounded by land use, the ultimate vision is that pollution is controlled within the land use either by source control to prevent pollution from entering the drainage system in the first place, or through pre-treatment, to remove as much as possible prior to discharge to natural waterways.

This Chapter describes the recommendations of the WSCEP and the recommended program for achieving the WSCEP goals stated in Chapter 1 and the vision outlined above. The recommendations are designed to reduce stressors identified as compromising the quality and vitality of natural resources in the Watsonville Sloughs Watershed. The program consists of five components:

- Habitat enhancement projects,
- Land acquisition strategies,
- Coordination and improvement of regulatory process and compliance,
- Support and coordination with other ongoing conservation programs, and
- Public access and education.

IMPLEMENT HABITAT ENHANCEMENT PROJECTS

Hydrologic Enhancement of Wetlands

The WSCEP recommendations include a diverse set of projects to be carried out with willing landowners. The projects include actions designed to reverse reclamation era actions that drained wetlands and modified their hydrology, including removal of fill and retrofits of pumps and drainage ditches. The deterioration of drainage systems has stagnated water circulation in wetlands systems and has become a threat to the integrity of agricultural lands. Many drainage systems were originally designed to be continuously maintained by dredging, a practice that is inefficient given funding and regulatory constraints. New drainage control facilities hold the opportunity to separate wetland habitat areas from the drainage system that services the agricultural fields, thereby improving agricultural land productivity, water quality and habitat function. Renovation of the Shell Road Pumps will benefit ecosystem conditions by improving water circulation and migratory pathways for aquatic species in Middle Watsonville Slough, and drainage conditions for farmers whose lands bound that reach.

Replacement of Exotic Invasive Vegetation

The potential habitat values of many areas in Watsonville Sloughs Watershed are being compromised by the extensive presence of exotic/invasive vegetation. A major initiative to replace exotic invasive plant species is needed to realize the habitat potential of the Sloughs, from hilltop to wetland. The WSCEP features these projects throughout the watershed. They are

critical to expanding and improving native wildlife habitat.

Water Quality Improvement

The WSCEP recognizes that the relationship of land use to natural habitats in the slough system needs to be defined to buffer habitat areas from polluted runoff. There are many serious pollution problems in the Watsonville Sloughs Watershed, most notably the excessive input of nutrients into waterways and the resulting eutrophication (loss of dissolved oxygen due to the overproduction of algae stimulated by excessive nutrients). The WSCEP recommendations include projects that separate and treat agricultural and urban runoff before it is discharged into natural waterways and habitats. It also provides the physical separation necessary to protect wetlands and adjacent habitats from disturbance.

LAND ACQUISITION STRATEGIES

The WSCEP provides direction for resource agencies and private non-profit groups for their land acquisition programs to direct conservation efforts to areas where it increases resource values the greatest amount per dollar spent. The WSCEP designates priority areas for acquisition based upon the goal to re-establish ecosystem food webs and to connect existing but isolated publicly owned habitat areas and establish migration corridors. The WSCEP provides mechanisms to be used during enhancement project planning to define appropriate lines between lands dedicated to resource management and conservation and lands dedicated to land use (agricultural or urban). There are several restoration opportunities available, however acquisition can only occur where there are willing sellers.

IMPROVEMENTS IN REGULATORY COMPLIANCE

The wetlands and other lands in the Watsonville Sloughs Watershed fall under a host of regulations of a number of agencies. Many conflicts occur between landowners and regulators in Santa Cruz County and state and federal agencies. Most of the conflicts revolve around endangered or sensitive species habitat and land use. The problems for landowners have been exacerbated as drainage systems have deteriorated. Other regulatory concerns are related to water quality problems and impending Total Maximum Daily Loads (TMDL) regulation.

The WSCEP should help reduce regulatory violations by providing the means for landowners to

have site specific requirements of sensitive resources built into the design of reliable drainage systems. Using site specific habitat requirements as a part of enhancement project design rather than as an afterthought of mitigation, landowners should be able to work within the rules that prevent harm to water quality and wildlife habitat. For example, certain areas known to be critical for wildlife breeding success could have seasonal guidelines established to alleviate impacts to wildlife and to the landowner who faces fines and expensive remediation. There is a substantial opportunity to implement WSCEP recommended projects that would improve drainage and reduce erosion on private lands while simultaneously benefiting wildlife and water quality. The WSCEP provides the missing factor for success: a science-based planning process to incorporate wildlife habitat and seasonal usage with the activities of landowners. This plan can provide the best information to landowner and regulatory agencies to identify management practices and projects that prevent or solve expensive conflicts.

The U.S. Fish and Wildlife Service's "Safe Harbors" program for endangered species may be applied to the Watsonville Sloughs Watershed to define habitat areas and to allow for potentially conflicting land use activities. The main requirement of Safe Harbors is that a specific management plan be implemented which will result in a net improvement in habitat and population of an endangered species. Once in place, a "Safe Harbors" contract would allow for "incidental take" of endangered species habitat in areas designated for specific land use activity. The Santa Cruz County Resource Conservation District has received a grant from the USFWS to conduct a pilot "Safe Harbors" project in the Watsonville Sloughs Watershed.

SUPPORT AND COORDINATE WSCEP WITH OTHER ONGOING CONSERVATION PROGRAMS

Implementation of the WSCEP will largely occur through existing organizations (non-profit, governmental and non-governmental agencies) already involved in resource conservation work in the Watsonville Sloughs Watershed. These groups and their specific programs include:

- The Santa Cruz County Resource Conservation District's Watsonville Sloughs Watershed Coordinator program and the Monterey Bay Wetlands Project,
- Local conservation organizations working to protect and restore habitat in the slough watershed,
- The City of Watsonville wetlands conservation and public trails program,

- The Coalition of Central Coast County Farm Bureaus Agricultural Water Quality Program to improve water quality discharge to the Monterey Bay Marine Sanctuary,
- The University of California at Santa Cruz research into nitrate discharge in the Pajaro Valley and efforts to reduce it through targeted reduced fertilizer applications,
- The County of Santa Cruz resource planning efforts, which include overseeing the preparation of the WSCEP, and
- The Pajaro Valley Water Management Agency water resources development projects on Harkins Slough.

All of these organizations are involved in efforts with private and public landowners to reduce pollution in the Sloughs through reduction in non-point source inputs from urban, agricultural and industrial areas. It is envisioned that the WSCEP will provide a common direction for resource agencies and conservation organizations and landowners.

PUBLIC ACCESS AND EDUCATION

Public understanding of the Watsonville Sloughs ecosystem as a community asset is on the rise. To foster further awareness, the WSCEP and local agencies have identified a trails system to improve access for passive recreation and environmental education. The Watsonville Sloughs trail system listed in the enhancement projects below is being undertaken by the City of Watsonville. The Trail system can also be a key link to future non-automobile transportation as part of regional trail systems.

Public understanding of the Sloughs' natural resources can be achieved through ongoing coordination with public schools in the Pajaro Valley area and through interpretative programs, which can be expanded through improved public access. There is interest and opportunities to develop an interpretive center for Native American Culture and its important relationship with the Slough ecosystem. The Pajaro Valley Unified School District and the Watsonville Wetlands Watch are currently planning for the proposed Watsonville Sloughs Resource Education Center at the planned new high school off Harkins Slough Road, including development of wetlands science curriculum.

Another avenue of public education involves landowners who become part of an enhancement project planning process. Problem identification workshops were conducted in 2000 as a part of

the WSCEP development process. Landowners expressed the desire to become involved in development of projects and management plans to address resource and regulatory problems on their lands or in their community. This landowner involvement will involve "fact finding" and educational workshops as part of the planning process in order to gain support for specific projects. Similarly, public interest groups were involved in the development of the WSCEP and will likely become participants in enhancement project planning workshops.

4.2 RECOMMENDED ENHANCEMENT PROJECTS

When implemented, the recommended habitat enhancement projects will help relieve environmental stressors, buffer wetlands and sensitive areas from land use impacts, and help restore a functional ecosystem within the Sloughs. The habitat enhancement projects are designed to accomplish much of the five plan components described above.

The following are descriptions of the habitat enhancement recommendations for each geographic region in the Watsonville Sloughs Watershed. The recommendations were converted into specific projects displayed at the end of this section in **Table 4-1**. The environmental stressors described by geographic area in Chapter 3 are displayed in **Table 4-2** with the corresponding habitat enhancement project(s) designed to reduce stressors.

UPPER WATSONVILLE SLOUGH

The Upper Watsonville Slough Planning Area is mostly contained within the City of Watsonville's jurisdiction and extends from its headwaters above Main Street to the low gradient drainage ditch/channel at Highway 1. The lower portion of the Slough below Ford Street is under consideration by the City of Watsonville for expansion of wetlands and development of adjacent land.

The recommendations for Upper Watsonville Slough include the following elements:

- Enhance degraded historic wetland areas upstream of the westerly end of Ford Street by removal of fill, most notably in the old City of Watsonville Dump, and removal of hydraulic constrictions at Manabe Driveway. It is assumed that the Harkins Slough Road Crossing would be replaced with a less constricted structure under separate plans by the City of Watsonville and that wetlands downstream of the westerly end of Ford Street

would be restored under development and annexation plans now under consideration by the City of Watsonville.

- Selectively enhance freshwater marsh areas and the Slough channel to improve water circulation, remove remnants of reclamation, stabilize channel banks and improve hydrologic conditions for native vegetation communities.
- Revegetate the areas between the freshwater wetlands and riparian areas with native plant communities in transitional and upland settings. This would create fully native plant communities from the edges of wetlands up hillslopes to the hilltops of urban cover.
- Rehabilitate areas on hillslopes covered in fill or trash to support native vegetation.
- Install stormwater treatment facilities at the major outfalls draining urban areas in order to remove pollutants.

MIDDLE WATSONVILLE SLOUGH

Middle Watsonville Slough extends from the Shell Road Pump to Highway 1. It is surrounded by predominantly agricultural lands, with a small industrial development on Lee Road. The Slough is generally a straight ditch in the flat, northern edge of the Pajaro River floodplain

The recommendations for Middle Watsonville Slough include the following elements:

- Reconstruct the Slough and agricultural drainage system into two separate channels: a dedicated agricultural drainage ditch and a protected waterway (**Figure 4-1**). This treatment would be used from Lee Road to the existing levee along the south side of the slough between San Andreas Road and Shell Road. The agricultural drainage system would include pre-treatment wetlands to remove nutrients prior to discharge to the protected waterway of the Slough. The new system could include an expanded marsh plain with the protected waterway. The specific design would depend upon the hydraulic criteria for the ditch and land availability (which would be subject to negotiation with multiple landowners).
- Enhance areas of degraded native vegetation with the removal of exotic species and by regrading land to remove fill and remnants of reclamation. Revegetate new marsh areas, interior levee slopes and the hillslope rising to the north with native transitional and upland species.
- Restructure the slough channel to obtain natural variability in pattern and depth (pools and shallows). Excavate the marsh plain to create backwater channels and variable

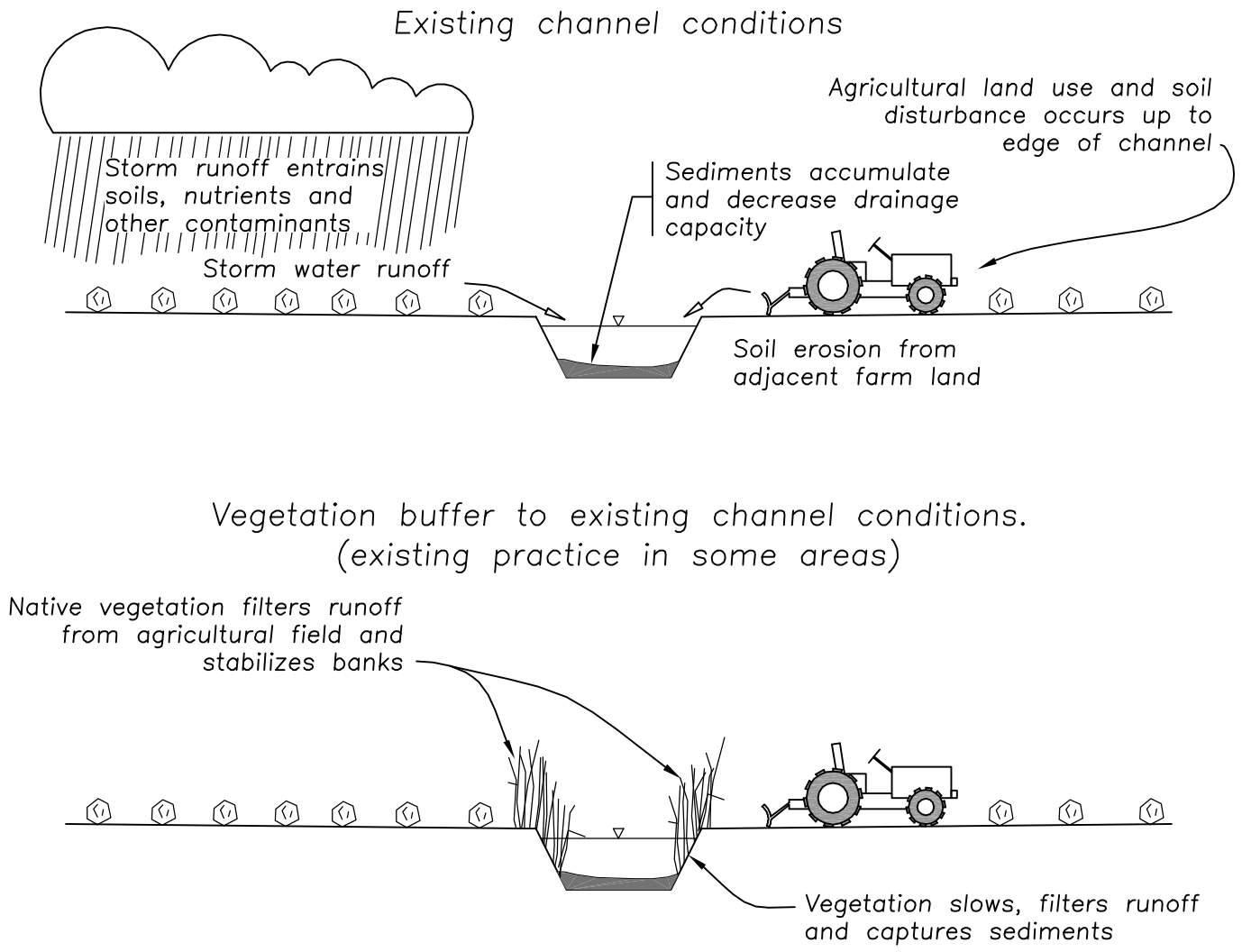

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Figure 4-1: Schematic drawing of Potential drainage system Improvements in agricultural areas for Middle and Upper reaches of Watsonville and Lower Harkins Sloughs.

topography to support a range of vegetation from freshwater marsh and riparian forest to transitional and upland species.

- Renovate the Shell Pump Station to improve its potential for preventing incursion of saltwater. The renovations would allow for a higher pump capacity and instantaneous, variable operation of gates and pumps that allow exchange during periods of excess freshwater, but provide flood protection when saltwater and/or high tidal stages are present.

LOWER WATSONVILLE SLOUGH

The Lower Watsonville Slough is the reach below the Shell Road Pump and includes the Pajaro Dunes development below Shell Road, the levee/drainage pump system on the east side of Watsonville Slough from Beach Road to the mouth, and the publicly owned land between Sunset Beach and Beach Road.

The recommendations for Lower Watsonville Slough would involve implementing enhancement projects including:

- Remove exotic vegetation cover and plant native vegetation in existing marsh and adjacent transition and upland areas, as well as on the levee along the eastern side of the Slough.
- Work with Pajaro Dunes development to manage marsh areas between the access road and Slough to enhance resources.
- Remove fill berms and antiquated drainage structures throughout the wetlands to improve marsh hydrology for native vegetation. Create islands for waterfowl refugia.
- Re-contour and construct the levee along the east side of the slough from Beach Road to the mouth to develop more favorable terrain for native vegetation. Revegetate levee with native species and re-route agricultural drainage to pre-treatment wetland. Construct trail on top of levee to connect Pajaro River levee trail to Beach Road.

UPPER STRUVE/UPPER WEST BRANCH STRUVE SLOUGHS ABOVE HIGHWAY 1

The headwaters of Struve Slough and West Branch Struve Slough originate just south of the Watsonville Municipal Airport and extend to Highway 1. The drainage area is predominantly dense urban residential and commercial development on hilltops and hillslopes, with open space

and wetland areas increasing in width and area towards Highway 1.

The recommendations for Upper Struve/Upper West Branch Struve Sloughs include the following elements:

- Remove or modify hydraulic structures to restore pre-reclamation hydrology and improve water circulation including the Main Street crossing. The City of Watsonville is planning the replacement of the Harkins Slough Road crossing with a span structure.
- Restore native vegetation communities through the removal of exotic vegetation and the planting of degraded wetlands and hillslope areas with native plants. Existing urban runoff pre-treatment basins could be modified to enhance hydrology and soil conditions for native plant communities.
- Conduct selective dredging to create ponds and improve water circulation, to remove remnants of reclamation and to diversify aquatic habitats.
- Add urban stormwater runoff pre-treatment systems at drainage outfalls where they do not currently exist. These could be created wetlands or a combination of catch basins, detention structures and filters. The precise design would depend upon many engineering factors, but this recommendation assumes the need to improve urban runoff quality will be realized.

LOWER STRUVE/WEST BRANCH STRUVE SLOUGHS

This Planning Area includes all of Struve Slough and West Branch Struve Slough downstream of Highway 1 to its confluence with Watsonville Slough just upstream of the UPRR crossing. The recommendations for Lower Struve/West Branch Struve Sloughs would involve implementing enhancement projects including:

- Restore native vegetation cover in all areas by removing exotics, improving hydrology and soil conditions in degraded areas and planting appropriate native species. This would occur over the entire Planning Area, much of which is publicly owned.
- Improve the Lee Road crossing by replacing with a span structure to improve water circulation. Conduct selective dredging to remove remnants of reclamation activities and to improve water circulation and water quality.
- The lower reach of Struve Slough and its confluence with Watsonville Slough between Lee Road and the UPRR crossing would be reconfigured to reconstruct the decaying

drainage system and restore the marsh plain. The precise plan would depend on consultation with private landowners and growers, but would include the improvements described in the Middle Watsonville Slough Planning Area.

GALLIGHAN SLOUGH

Gallighan Slough extends from its headwaters at Highway 1 to Harkins Slough. The Slough flows through the middle of the watershed past the County landfill and then enters Lower Harkins Slough below the Harkins Slough Road crossing. The recommendations for Gallighan Slough include the following elements:

- Upgrade the stormwater drainage system along Buena Vista Road from San Andreas Road to Highway 1 to reduce erosion and sediment supply to Gallighan Slough. Install adequate culverts to pass large floods and stabilize roadside ditches, road cuts and road fill areas with riprap and/or native vegetation if feasible. Use pre-treatment facilities to remove sediment before discharge to waterways.
- Restore native vegetation habitat in areas of public ownership and negotiate to expand into areas of private ownership. Ensure that the final disposition of the landfills is to restore native vegetation appropriate to its location in the landscape.
- Expand programs to encourage landowners to reduce erosion and sediment discharge from private lands through education and by providing technical assistance.

HANSON SLOUGH

Hanson Slough drains a relatively small basin situated between Lower Harkins and Lower Struve Sloughs. Harkins Slough Road transverses the upper watershed area and land use is predominately agriculture and grazing. The drainage originates above Harkins Slough Road and flows to Watsonville Slough.

The recommendations for Hanson Slough include the following elements:

- Improve and expand native vegetation cover to increase abundance and diversity of plant communities, and also as a means to create sediment-filtering buffers along waterways (an expansion of the Watershed Institute's riparian restoration and water quality project).

The area converted to native plant communities would be determined through consultations with landowners.

- Develop a grazing and runoff management plan to improve water quality. The plan would include a manure management plan and grazing methods to eliminate sediment and nutrient pollution delivered to the waterway.
- Restore the hydrologic function of Hanson Slough and its tributaries to reduce erosion and improve aquatic habitat and the water quality of runoff leaving the basin.

UPPER HARKINS SLOUGH (LARKIN VALLEY)

Upper Harkins Slough is the longest waterway in the Watsonville Sloughs system extending from Highway 1 seven miles inland through Larkin Valley. In the upper watershed area above Highway 1 (Figure 3-12) Harkins Slough flows as a stream within Larkin Valley, a narrow, linear valley surrounded by moderately steep hillslopes and tributary valleys. A significant amount of this watershed is undeveloped land providing groundwater recharge, relatively absent in much of the remaining areas of Watsonville Sloughs Watershed.

The WSCEP recognizes a need to coordinate the activities and desires of the multiple landowners in the Larkin Valley area. The specific information needed is not available. The overall aim of the recommendations is to decrease erosion and entrainment of nutrients from unmanaged manure and septic systems and includes the following elements as next steps:

- Establish a Management Plan to coordinate land use practices in Upper Harkins Slough for drainage maintenance and management of riparian, wetlands and sensitive species habitats. The Plan would coordinate land use activities on multiple properties such that impacts to vegetation and wildlife resources can be minimized by the timing and methods of maintenance.
- Conduct a pilot drainage improvement project to demonstrate planning, engineering, resource enhancement and maintenance techniques that could be applied to waterways.
- Develop a native vegetation enhancement and education program for local landowners to improve native vegetation stands. Provide ways for grant money to be used on private land to improve native vegetation.
- Develop manure management plans for livestock operations to minimize entrainment of nutrients into waterways.

- Develop a plan to upgrade deficient septic systems.

LOWER HARKINS SLOUGH

Lower Harkins Slough extends from Highway 1 to the northern edge of the Pajaro Valley floodplain where it meets Watsonville Slough. The area is mostly fallow agricultural and grazing land with sparse buildings associated with present or past agricultural uses (cattle grazing and dairy operations) and concentrated public and private residences. Significant areas of the adjoining hillslopes are publicly owned, in conservation easement, or not actively cultivated or grazed.

The areas of Lower Harkins Slough and West Branch Struve Slough linked via a restored Middle Watsonville Slough represents the best area for a large contiguous wetland ecosystem restoration and should be considered a priority. Much of the land on the valley floor is in wetlands and/or under public ownership.

The recommendations for Lower Harkins Slough include the following elements:

- Remove the hydraulic constriction at Harkins Slough Road by removing the crossing or installing an open span crossing to improve water circulation.
- Selectively dredge wetland areas to remove reclamation era fill and structures and to improve aquatic habitat diversity and water circulation.
- Enhance native vegetation in available areas (public lands and those subject to consultation with private landowners). Restore native plant communities in the wetlands, transitional areas and uplands.

BEACH ROAD DITCH

The land use surrounding Beach Road Ditch is exclusively active agricultural cultivation. On the south side of the road, Beach Road Ditch extends the length of Beach Road from Lee Road to its discharge into Lower Watsonville Slough estuary.

The recommendations for the Beach Road Ditch involve the following elements:

- Widen existing agricultural drainage ditches.

- Plant and encourage vegetative growth within the wetlands beginning in the spring months, especially wetland vegetation capable of uptaking large amount of nutrients, such as bulrush and cattails. Prior to winter storms, selectively harvest a portion of the vegetation to ensure proper flood capacity during high flows and minimal vegetation growing periods (winter).
- Provide a pre-treatment pond prior to discharge into estuary.

Table 4-1 shows a matrix of the recommended projects, which includes the following actions applied to specific sites within each Planning Area:

- Remove fill from wetlands and restore wetland hydrology, soils and vegetation.
- Install Erosion and Drainage Control Facilities to reduce sediment generation.
- Remove exotic vegetation and restore native plant communities.
- Install drainage facilities to separate agricultural runoff from wetland areas.
- Modify flood control pump stations to improve aquatic habitat and water circulation.
- Establish buffers between agricultural areas and waterways to reduce pollution discharge.
- Install urban and agriculture runoff treatment facilities to improve water quality discharged to wetlands.
- Create treatment wetlands for improving water quality discharged to natural sloughs.
- Improve roadside drainage systems in order to reduce sediment generation and to reduce concentrated peak flows.
- Create trails, viewpoints and other recreational and education opportunities.

The recommended projects shown in **Table 4-1** are described in conceptual form. Implementation of projects will depend upon the availability of funding and interested landowners. Further refinement of project details will be developed in collaboration with landowners. For some projects, there is also a need to develop master plans to work up specific engineering, regulatory and other planning details prior to development of construction plans and specifications. Several of these projects have reached a level of development where their implementation has either begun or could occur quickly. **Table 4-1** does not represent an all-inclusive set of recommended projects and will change over time as projects are implemented, as new projects and programs are identified, additional input is received and new opportunities arise.

WATSONVILLE SLOUGHS WATERSHED CONSERVATION AND ENHANCEMENT PLAN

TABLE 4.1

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High = Over $400,000

This matrix is a dynamic document that will change over time as projects ripen, costs become known, and land and funding become available.

Planning Area	Project Code	Project Name	Project Area	Anticipated Project Partners (LeadAgency in BOLD)	Description (number of acres to be treated)	Estimated Cost	Projected Funding Date
Watershed Wide	WSW-1	Erosion Control & Habitat Restoration	Watershed wide	Resource Conservation District	Central Monterey Bay Wetlands Project - Work with landowners to facilitate adoption of erosion control practices, repair gully sites to protect water quality. Extent estimated at 8300 acres (13.0 sq miles)	medium to high	Begun 1999. Ongoing pending future funding
	WSW-2	Permit Coordination Program	Watershed wide	**Resource Conservation District,** Santa Cruz County, Natural Resource Conservation Service	Facilitate restoration demonstration projects using permit coordination or safe harbor agreements and conduct long term monitoring. Extent affected by permit issues estimated at 6200 acres (9.7 sq miles)	medium to high	Pending funding - Summer 2002
	WSW-3	Non-native invasive plant eradication	Watershed wide	Resource Conservation District	Non-native, noxious weed eradication replacement with native vegetation	low, on a per projec basis	Ongoing
	WSW-4	Habitat Protection	Watershed wide	Resource Conservation District, Santa Cruz County	Installation of wetland buffers & setbacks. Extent estimated at 904 acres (1.4 sq miles)	medium	
	WSW-5	Farm Bureau Agricultural Water Quality Program	Watershed wide	**Santa Cruz County Farm Bureau** RWQCB, U.C. Cooperative Extension, landowners, farm managers	Implements Monterey Bay Sancuary Water Quality Protection Plan's Agricultural Action Plan; establishes local watershed working groups to develop and implement water quality improvement plans	Low to medium	Began in 2000; additional funding needed to support the County Program Coordinator position and for water quality moitoring materials and analysis
Upper Watsonville Slough	UW-1	Wetlands Restoration, Site A	1930's City dump site (east of Ramsey Park (from Main St. to Manabe Drive)	**City of Watsonville**	Remove fill from 45 acres, restore to wetland; reveg slopes; install urban stormwater runoff treatments	high	Prop13 preproposal submitted, if successful funds avail 10/2003
	UW-2	Upper Watsonville Slough, Trails Master Plan	Main Street to Errington Road	**City of Watsonville**	Correct Drainage Problems on Hillslopes; install urban stormwate runoff treatments; construct trail system from Ramsy Park to Errington Road; revegetate slopes	medium	2004
Headwaters: Freedom Blvd to Hwy 1 See Figure 3-7	UW-3	M&F Farms - Wetland Restoration Project	Manabe Drive to Highway 1	**City of Watsonville,** County of Santa Cruz	Restore approx. 30 acres of wetlands; improve slough corridor to Hwy 1; revegetate with natives; install urban runoff; treatments; install trail system	medium	Project linked to future annexation proposal, possibly 2004, Funding from development fees
	UW-4	Urban Wetland Enhancement	Freedom Blvd to Main Street	**City of Watsonville**	Restore wetland vegetation and hydrology along 5,000 linear feet; buffer urban uses and stormwater runoff on 68 acres	medium	Unknown
Middle Watsonville Slough	MW-1	Middle Watsonville Slough Drainage and Wetlands Enhancement Plan	Highway 1 to San Andreas Road	SCC Resource Conservation District,**Santa Cruz County,** City of Watsonville, Land Trust of Santa Cruz County	Construct berm to separate ag. drainage from protected waterwa expand and restore freshwater wetlands and adjacent uplands to the north; reestablish native vegetation along 9400 linear feet; install urban and agricultural stormwater runoff and ag tailwater treatments; establish authorities for maintenance; provide erosion control technical assistance on private lands	high	Prop 13 preproposal submitted for funding, if successful, funds avail. 10/2003, Needs engineering feasibility study including geotech and hydrologic study
	MW-1.5	Middle Watsonville Slough Drainage and Wetlands Enhancement Plan	San Andreas Road to Shell Road	SCC Resource Conservation District,**Santa Cruz County,** Land Trust of Santa Cruz County	Construct berm to separate ag. drainage from protected waterwa expand and restore freshwater wetlands and adjacent uplands to the north; reestablish native vegetation along 7300 linear feet; install urban stormwater runoff treatments; establish authorities for maintenance; provide erosion control technical assistance on private lands	high	Needs engineering feasibility study including geotech and hydrologic study
Hwy 1 to Shell Road, See Figure 3-8	MW-2	Shell Road Pump Retrofit Project	Shell Road Pump Station	Santa Cruz County PublicWorks	Renovate pumps to prevent leaking of saltwater; improve efficiency at high stage and to allow for instantaneous,variable operation allowing water exchange during freshwater periods to create transitional habitat zones	high	2004 pending design report for Middle WS
	MW-3	Shell Road Wetland Enhancement Project	Fallow area between bluff and Watsonville Slough	Resource Conservation District	Remove exotic vegetation; regrade to restore hydrology; revegetate with natives on 12 acres; buffer adjacent land uses; work with landowners to explore conservation easement	medium	2004 pending consultation and planning with landowners
	MW-4	Middle Watsonville Slough Hillslope Enhancement Project	Hillslopes along the north side of Watsonville Slough from Shell Rd to Lee Road	Resource Conservation District	Install agricultural management measures; remove exotic vegetation; replace with natives on 49 acres; develop and implement Conservation Plans	low	2004 pending consultant with landowners, SCCRCD funding for vegetation management, pending ($50-$100,000)

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Cost Estimates: Low = less than $150,000
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This matrix is a dynamic document that will change over time as projects ripen, costs become known, and land and funding become available.

Planning Area	Project Code	Project Name	Project Area	Anticipated Project Partners (LeadAgency in BOLD)	Description (number of acres to be treated)	Estimated Cost	Projected Funding Date
Lower Watsonville Slough Shell Road to Pajaro River	LW-1	Palm Beach Wetland Enhancement Project	Marsh area between Shell Road and Palm Beach parking lot	Resource Conservation District, Santa Cruz County, **CA Dept Parks & Recreation**	Remove reclamation berms; remove exotic vegetation and revegetate with natives on 4 acres	Low	2004
	LW-2	Lower Watsonville Slough Levee and Marsh Habitat Enhancement	Levee and marsh east of the estuary from Beach Road south to the mouth of the Pajaro River	Resource Conservation District, Santa Cruz County, Friends of Pajaro Dunes	Regrade levee; modify Ag. drainage system along 6230 feet; remove fill to restore marsh hydrology for 19 acres; revegetate levee to slough with natives.	Medium	2003 pending landowner consultation
	LW-3	Pajaro Dunes Marsh Enhancement Project	From the center of the estuary to Rio Boca Road	**Pajaro Dunes H.O. Assn,** Resource Conservation District, Friends of Pajaro Dunes	Remove reclamation fill to restore hydrology; revegetate with natives on 32 acres	Low to medium	2003 - 2006 pending consultation with landowners and Homeowners Association
	LW-4	Shorebirds Lagoon Enhancement	Shorebirds Lagoon at Pajaro Dunes	**Pajaro Dunes North H.O. Assn.,** Friends of Pajaro Dunes	Remove exotic vegetation; revegetate with natives on 5 acres		
	LW-5	Pajaro Dunes	Lot next to PD firestation	**Pajaro Dunes North H.O. Assn.,** Friends of Pajaro Dunes	Lot (wetland restoration on <0.5 acres)		
	LW-6	Pajaro Dunes	Wetland swale restoration	**Pajaro Dunes H.O. Assn,** Friends of Pajaro Dunes	Removal of underutilized parking area at Avocet Circle and Plover Circle; restore original wetland swale on <0.5 acres		
	LW-7	Sunset Beach wetland Restoration	Upper lagoon North of Pajaro Dunes	State Parks	Remove exotic vegetation; excavate 1000 cu yds for dune erosion repair		
Hanson Slough, Entire reach, See Figure 3-11	HS-1	Hanson Slough Water Quality and Habitat Enhancement	Uplands, swales and waterways of Hanson Slough	Santa Cruz Resource Conservation District Affected landowners and managers, Open Space Alliance	Develop buffers between uplands, swales and waterways; revegetate to natives to 55 acres; construct channel imrpovement to reduce erosion; develop grazing management plan for uplands	medium	2003-? pending landowner consultations
Lower Harkins Slough From Hwy. 1 to confluence with Watsonville Slough, See Figure 3-13	LHK-1	Lower Harkins Slough Wetlands Enhancement Phase 1	Harkins Slough from confluence at Watsonville Slough upstream to UPRR crossing	Resource Conservation District, Santa Cruz County, PVWMA, Land Trust of Santa Cruz County	Protect waterway along 7070 linear feet; retrofit Ag drainage system; restore marsh in waterway and uplands	high	2003-05 pending landowner consultation
	LHK-2	Lower Harkins Slough Wetlands Enhancement Phase 2	Middle of Harkins Slough from UPRR to Highway 1	Resource Conservation District, **US FWS and CDFG,** Farm Services Agency, Open Space Alliance	Acquire Marsh (236 acres)and uplands (199 acres) areas; restore marsh hydrology in waterway; remove exotic vegetation; revegetate with natives	high	2003-05 pending landowner consultations
	LHK-3	Harkins Slough Road Closure	Harkins Slough Road	**SC County Public Works**, Open Space Alliance	Rebuild or remove Harkins Slough Road to reduce hydraulic obstruction	medium	
Upper Harkins Slough Entire subwatershed - Larkin Valley, See Figure 3-12	UHK-1	Upper Harkins Slough Habitat and Drainage Master Plan	Harkins Slough from Highway 1 to headwaters	Resource Conservation District, **Santa Cruz County**	Develop management plan to reconcile drainage and erosion problems with regulatory issues; develop master project plan	medium	2002-2003 pending funding
	UHK-2	Upper Harkins Slough Drainage and Erosion Demonstration Project	Corner of Senda Ladera and Larkin Valley Road	Resource Conservation District, Santa Cruz County, **Property Owner**	Plan and construct drainage and erosion control demonstration project for 9-acre equestrian property	low	2002-2003 pending landowner consultation and funding
	UHK-3	Larkin Valley Manure Management Plan	Harkins Slough Highway 1 to headwaters	**Santa Cruz County Resource Conservation District**	Develop landowner education project for manure management to prevent nutirent runoff to Harkins Slough	low	2003
	UHK-4	Larkin Valley Septic System Retrofit Project	Harkins Slough Highway 1 to headwaters	**Santa Cruz County**	Develop a plan to upgrade septic systems or tie into municiple system in order to reduce nutirent input to Slough	low	2004
West Branch and Lower Struve Slough Entire reach of West Branch and Struve Slough between Hwy 1 and confluence with Watsonville Slough, See Figure 3-9	LS-1	Lower Struve Slough Habitat Enhancement Project	Marsh to Hilltops from below Lee Road Crossing to Highway 1	**Dept. of Fish and Game,** Resource Conservation District, Watsonville Wetlands Watch	Remove reclamation fill and channels; restore wetland hydrology on 101 acres; remove exotic vegetation from marsh and hillslope areas; revegetate with natives; buffer industrial land & runoff from marsh on 108 acres	medium to high	dependent upon CDFG funding and planning schedule
	LS-2	Lee Road crossing Retrofit	Lee Road Crossing over Struve Slough	**Santa CruzCounty**	Rebuild or remove Lee Road to reduce hydraulic obstruction	medium	2003
	LS-3	Wetlands Education Resource Center	Site at New Millennium High School	Pajaro Valley Unified School District, **City of Watsonville,** Watsonville Wetlands Watch	Establish the Wetlands Education Resource Center	medium to high, $400k	2004
	LS-4	Tar Plant Hill	Tar Plant Hill - northeast of Hwy 1	**Watsonville Wetlands Watch**	Ensure protection of Tar Plant Hill	medium to high	2002 - 2003
	LS-5	CDFG Watsonville Slough Ecological Reserve Management Plan	CDFG Ecological Preserve along West Branch and Lower Struve Slough 109 acres	**California Department of Fish and Game**	Develop management plan to define projects to maximize natural reousrces in the WSER		

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Planning Area	Project Code	Project Name	Project Area	Anticipated Project Partners (LeadAgency in BOLD)	Description (number of acres to be treated)	Estimated Cost	Projected Funding Date
Upper Struve Slough Headwaters to Hwy 1, See Figure 3-9	US-1	Struve Slough Trail Project Phase 1	Struve Slough from Pennsylvania Ave. to Main Street	**City of Watsonville**	Construct trail along 3900 linear feet; install urban runoff treatment measures; remove exotic vegetation from hillslopes and revegetate with natives on 5.5 acres (60 ft buffer)	low	2002
	US-2	Struve Slough Trail Project Phase 2	Struve Slough from Main Street to Highway 1	**City of Watsonville**	Construct trail system on hillslopes along both sides of slough along 13600 linear feet; install urban runoff treatment measures; remove exotic vegetation from hillslopes and revegetate with natives on 19 acres (60 ft buffer)	medium	2003
	US-3	Struve Slough Wetlands Enhancement Project	Headwaters of Struve Slough to Highway 1	**City of Watsonville** Resource Conservation District, Community Alliance of Family Farmers, Watsonville Wetlands Watch	Remove reclamation fill and channels; construct ponds to restore hydrology on 69 acres of wetalnds; remove exotic vegetation from 57 acres of hillslopes; revegetate with natives	medium	2004
Gallighan Slough Entire subwatershed, See Figure 3-10	GS-1	Buena Vista Road Erosion Control Project	Buena Vista Road from Hacienda to San Andreas Road	**SC County Public Works,** Resource Conservation District	Construct drainage improvements to reduce gully erosion; work with adjacent landowners to rectify discharge form private lands; examine drainage around County landfill. Extent: 1370 acres (entire planning area)	medium	2004
	GS-2	Gallighan Slough Hydrologic Enhancement Project	Gallighan Slough from Harkins Slough to San Andreas Road	Resource Conservation District, Santa Cruz County	Restore Gallighan Slough through 5400 linear feet of channel reconstruction, removal of spoils; revegetate with natives	medium	2004 dependent upon landowner consultantions
	GS-3	Gallighan Slough Hillslope Habitat Enhancement Project	Gallighan Slough Watershed	Resource Conservation District	Install erosion control management measures; remove exotics and revegetate with natives. Extent: 1370 acres (entire planning area)	medium	2004 phased dependent upon landowner consultations
	GS-4	Buena Vista Acquistion Project	Upper Gallighan Slough Watershed	Trust for Public Lands, Dept of Fish and Game	Acquire 289 acres of Maritime Chapparrel and Buena Vista Pond	high	
Beach Road Ditch	BR-1	Beach Road Ditch Water Quality Improvement Project	Beach Road corridor from the Watsonville City limits to Palm Beach	Resource Conservation District,**SC County Public Works**	Construct treatment wetland corridor along 15,000 linear feet (2.8 miles) of Beach Rd and improve drainage system from adjacent farms	high	2004 phased dependent upon landowner consultations

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4.3 INITIAL HABITAT ENHANCEMENT PROJECTS

Five projects were selected for further detailed conceptual design within the WSCEP planning process. The criteria used to select these included:

- The project is feasible to construct.
- The project is within the list of recommended WSCEP projects or is similar and will help achieve the goals of the WSCEP.
- Landowners have expressed a willingness to participate.
- There are project proponents to secure funding, handle contracting for design, environmental review (CEQA) and permitting, and construction.
- The project provides demonstration or educational values.

The following five projects have been identified as priority projects:

1. Planning and Engineering Feasibility Assessment for the Enhancement of Watsonville Slough between Highway 1 and Shell Road
2. Upper Harkins Slough Riparian Habitat and Drainage Management Plan (lead: Santa Cruz County Planning Department)
3. Conceptual Stream Stabilization Plan for Jones/Lees Property (lead: Santa Cruz County Planning Department and Lees)
4. Watsonville Sloughs Trails Master Plan (lead: City of Watsonville)
5. City of Watsonville Wetlands Restoration Project (lead: City of Watsonville)

PLANNING AND ENGINEERING FEASIBILITY ASSESSMENT FOR THE ENHANCEMENT OF WATSONVILLE SLOUGH BETWEEN HIGHWAY 1 AND SHELL ROAD

The Middle Watsonville Slough has three major projects, identified in **Table 4-1** as MW-1, MW-1.5 and MW- 2 that are ready for more detailed engineering design. This project has multiple landowners interested in re-designing and operating the present Watsonville Slough drainage system between Lee Road and Shell Road and includes renovation of the Shell Road Pumps. The project would ultimately buffer 16,700 feet (3.2 miles) of waterway between Highway 1 and

Shell Road from agricultural runoff. Conceptual cross section drawings of various settings and scenarios are presented in **Figure 4-1**.

The next step in this project is to develop a planning and engineering feasibility study and engage the landowners, the local drainage agency and resource agencies in the development of the specific design of the project as well as long-term maintenance and permitting requirements. There is a need to develop basic performance criteria for the project (channel capacity, wetland restoration design, drainage facilities, etc.). The hydrology of Watsonville Slough needs to be further quantified in order to set design flows for the project. Several aspects of the project require information regarding geotechnical properties of soils.

The proposed scope of work is presented in detail in Technical Appendix I.

UPPER HARKINS SLOUGH RIPARIAN HABITAT AND DRAINAGE MANAGEMENT PLAN

The juxtaposition of land uses and the presence of endangered and sensitive species habitats in Upper Harkins Slough have created significant challenges for effective resource management. Future development may create further problems and perhaps some opportunities to resolve resource management conflicts. The WSCEP proposes development of a management plan directed at the unique issues and problems of Larkin Valley as a high priority. The management planning process will develop information needed to find solutions to resource management problems. The management plan will allow for development of effective projects and maintenance measures to prevent erosion and reduce flooding. It will also emphasize public education regarding manure management to help reduce nutrient loading and pollution. A scope of work for the development of the plan is included in Technical Appendix J.

CONCEPTUAL STREAM STABILIZATION PLAN FOR JONES/LEES PROPERTY

Upper Harkins Slough (also called Larkin Valley Creek) flows through the Lees property, which is situated at the northern end of Larkin Valley. High runoff in 1998 eroded the Harkins Slough channel from a former grassy swale into a deep gully that continues to erode and supply excessive sediment loads downstream. The gully has reduced the productivity of the horse pasture and access across the gully for horses is difficult. A second gully has formed on the same property

since 2000 and is releasing excessive sediment.

The proposed project is to stabilize the gullies into properly sized channels, revegetate them with native species, and manage them as riparian wetland areas buffered from land uses. The project will include development of a maintenance and operations agreement with the landowner to allow use of the land but prevent conflicts with sensitive resources. The Jones/Lees property erosion control plan is presented in Technical Appendix K.

WATSONVILLE SLOUGHS TRAIL MASTER PLAN

The City of Watsonville has prepared a trail master plan to develop a walking trail system from Upper Watsonville and Struve Sloughs to the vicinity of Highway 1. The proposed trails are sited on land owned by the City and within City limits. The City's project includes removal of invasive vegetation and replacement with native species. The Trails Master Plan is currently undergoing environmental review and is included in the WSCEP as Technical Appendix H.

CITY OF WATSONVILLE WETLANDS RESTORATION PROJECT

The City of Watsonville has identified a wetlands restoration project in Upper Watsonville Slough just north of the Harkins Slough Road Crossing and east of Ramsey Park. The project involves removal of fill from a 45-acre wetland area, restoration of original topography, and revegetation with appropriate native species. The City has applied for grant funding to the Regional Water Quality Control Board. Further details of the conceptual plan are found in Technical Appendix L.

Table 4-2 presents an analysis of the anticipated benefits of the recommended projects by Planning Area in terms of relief of stressors. In general, there is a potentially considerable improvement in conditions for natural resources. However, the degree of urbanization and development in the watershed precludes full elimination, except potentially in some isolated areas. The objective should be to minimize land use impacts, and this will take an ongoing effort.

Table 4-2: Relation of Recommended Projects to Environmental Stressors

Planning Area and Stressors	Management Recommendations
KEY→	See Table 4-1 for details
Upper Watsonville Slough	
Surrounding land use is extensively urban and industrial, posing limitations on habitat enhancement.	WSW (all) UW (all)
Water circulation is constricted by hydraulic structures at Main Street, Harkins Slough Road and Ford Street and the flat channel gradient downstream of Main Street.	UW-3
Water quality conditions are degraded by poor circulation, nutrient input, urban and agricultural pollution, and the lack of riparian or wetland vegetation within the Slough downstream of Ford Street.	UW-1,3,4
Vegetation resources are degraded due to loss of area to urban cover and agricultural uses, invasion of exotic species, and clearing of vegetation associated with maintenance of former wetland areas and waterways.	UW-1,2,4 WSW-3
Wildlife resources are limited by urban land use cover, cleared agricultural land, poor water quality, invasive exotic species (e.g. bullfrog), and lack of native vegetation cover for forage and habitat.	UW (all) WSW-3,4
Middle Watsonville Slough	
Land use encroachment constricts the Slough to a drainage ditch in most areas, limiting habitat and introducing pollutants (sediment, nutrients and urban runoff).	MW (all) WSW-1,3,4
Water circulation is poor due to flat channel gradient and hydraulic constrictions such as the Shell Road Pump and reaches, which are choked with sediment.	MW-1,1.5,2
Nutrient and other contaminant loading from both surrounding and upstream land uses significantly degrade water quality and limit aquatic habitat quality.	MW-1,1.5,2 WSW-1,4
Native vegetation is limited to small pockets mixed with exotic species.	MW-1,1.5,3,4 WSW-1,3
The aquatic habitats for invertebrates and fish are compromised as a result of poor water quality and vegetative conditions.	MW-1,1.5 WSW-1,4
Lower Watsonville Slough	
Reclamation has degraded salt marsh habitat. The extent of the salt marsh is confined by Pajaro Dunes development to the west, the flood control levee to the east, and the Shell Road Pump Station inland.	MW-3 LW-(all)
The Shell Road Pump Station has abruptly eliminated the natural brackish transition. This barrier also prevents and limits the inland migration of aquatic flora and fauna.	MW-2
Concentrated agricultural runoff is discharged directly into the Slough from Beach Road Ditch and at the Shell Road Pump Station. This increases nutrient delivery and algal production and reduces dissolved oxygen concentrations, especially during periods when the lagoon mouth is closed.	MW-1.5 (benefits at Shell Road, but not Beach Road)

Planning Area and Stressors	Management Recommendations
KEY→	See Table 4-1 for details
The polluted estuarine waters of Watsonville Slough exposes Federal and State listed anadromous fish to potentially toxic waters.	All measures involving control of soil erosion urban and agricultural runoff. WSW-(all)
The quality of native plant communities and wildlife habitat is degraded by exotic, invasive vegetation and the fill and structural remains of past dredging and reclamation attempts.	LW-(all) WSW-1,3,5
Upper Struve Slough	
Poor drainage in the Sloughs between Pennsylvania Drive and Main Street results in poor water circulation.	US-3
Water quality in the Sloughs is influenced by urban runoff and non-point source pollution.	US-3 WSW-1,4
The removal of native vegetation and wildlife habitat is compounded by expansion of urban tolerant wildlife species such as raccoons, opossum, starlings, and domestic cats.	US-(all) WSW-3,4
Lower Struve/ West Branch Struve Sloughs	
Extensive urban and commercial development from upstream areas transports pollutants to aquatic habitats in Lower Struve and West Branch Struve Sloughs.	US-(all) WSW-1,4
Water quality is affected by runoff and intermixing with agricultural drainage, especially by recently cultivated agricultural fields of the lower reaches of the Planning Area.	LS-1 WSW-1,4
Harkins Slough Road and Lee Road are hydraulic barriers that reduce water circulation and affect water quality.	LS-2 Harkins Sl. Bridge project (City of Watsonville
Land subsidence within the lower reaches present challenges to providing future drainage for agriculture.	0
Native vegetation cover in wetlands, transitional areas and uplands is degraded by invasive exotic species and the remnants of past agricultural and reclamation activities.	LS-1 WSW-3,4
Wildlife habitat is compromised by exotic vegetation cover and poor water quality from low circulation and pollutant loading.	LS-1 WSW-3,4
Gallighan Slough	
High sediment loads originate from eroding agricultural fields, roads and some surrounding areas.	GS-(all) WSW-1
High sediment loads enter the slough from poorly designed and maintained road and drainage ditches along Buena Vista Road from San Andreas Road to the County Landfill.	GS-1,3 WSW-1
Native vegetation is impacted by cleared land and roads and degraded lands.	GS-3 WSW-3
Wildlife habitat has been fragmented by roads and cleared areas. Excessive sediment input and migratory barriers affect aquatic habitat.	GS-(all) WSW-4
Hanson Slough	
Water quality is degraded by land uses including the intensive grazing operations in the upper watershed exposing soils to nitrate loading, surface erosion, removal of native vegetation cover, and compacting of soils within the waterway	HS-1

Planning Area and Stressors	Management Recommendations
KEY→	See Table 4-1 for details
Upper Harkins Slough	
High animal waste concentration carried into the waterway contributes to the nutrient contamination of the Slough.	UHK-1 WSW-4
Despite some patches of riparian forest along the waterway, native vegetation cover is sparse in the upper watershed and areas below Harkins Slough Road, decreasing overall diversity and abundance.	UHK-1
Wildlife habitat is limited and degraded by present land uses, a lack of native vegetation cover and apparent degraded water quality.	UHK-1
The riparian habitat and wetlands along many reaches of the Slough have been exposed by land clearing and/or erosion. These degraded reaches fragment valuable areas of riparian vegetation and aquatic habitat. In addition, channel erosion produces sediment during high flows.	UHK-1 WSW-1
Leaky septic systems and livestock manure are chronic sources of nutrients to the groundwater and waterways.	UHK-1 WSW-4
Erosion occurring in cleared areas or areas disturbed by grazing or development contribute an excessive sediment supply to local and downstream reaches. This reduces aquatic habitat quality and clogs waterways causing flooding.	UHK-1 WSW-1
Lower Harkins Slough	
Lower Harkins Slough receives contaminants generated in the upper watersheds of Larkin Valley and Gallighan Slough. The main pollutant types are sediment from roads and agriculture, nutrients from septic systems, livestock manure and fertilizer, and a variety of pollutants from landfill runoff.	GS-(all) UHK-1 LHK-1,2 WSW-1,4
Poor water circulation and the progressive expansion of seasonal lakes are due to the combined effects of hydraulic constrictions (UPRR, Harkins Slough Road and Highway 1) and land subsidence. Winter inundation of recently cultivated agricultural fields will decrease the water quality of overlying waters.	LHK-3
Vegetation resources in the wetlands, transitional areas and uplands are degraded by land uses that leave degraded conditions and result in large areas dominated by exotic invasive species.	LHK-1,2 WSW-1,3,4
Terrestrial and aquatic wildlife are limited by poor water circulation, lack of native vegetation cover and migration barriers at road crossings (UPRR, Harkins Slough Road, Ranport Road and Highway 1 culverts).	LHK-3
Beach Road Ditch	
Concentrated, untreated, and potentially toxic agricultural drainage is eventually released into Watsonville Slough at two specific locations.	BR-1
Wildlife and aquatic habitat is relatively non-existent.	BR-1

4.4 LAND ACQUISITION STRATEGY

Making land available for resource management and conservation may involve many instruments including acquiring fee title, conservation easements, or acquisition and sell back with easements and/or restrictions. All land acquisition recommendations assume that such acquisitions involve only willing landowners.

The realization of full ecosystem restoration would require an extensive area of open space dedicated to ecosystem process and wildlife habitat. Accomplishment of this would undoubtedly involve incremental steps over a long period of time through the work of conservation organizations with willing landowners. There is a substantial opportunity to create a large open space area west of Highway 1 by connecting the publicly owned lands of West Branch Struve Slough with the publicly owned lands in Harkins Slough via a restored Middle Watsonville Slough. This would include the valley floor of Harkins Slough and the hillslopes and hilltops east of Harkins Slough, north of Middle Watsonville Slough and ultimately connect to Ellicott Slough National Wildlife Refuge located adjacent to the western edge of the Watsonville Sloughs Watershed.

The WSCEP recommendations for land acquisition are to acquire lands that:

- Protect, and where possible, restore high quality habitat such as marsh, riparian, grasslands, maritime chaparral and oak woodlands.
- Protect existing high quality habitat.
- Provide connected corridors among similar habitats as well as continuity among habitats that naturally occur in association.
- Demonstrate compatibility of habitat enhancement and agriculture or other land uses.

Specifically the acquisition needs by habitat type are:

- Preserve the existing expanse of maritime chaparral occurring south of Highway 1 and between upper areas of Gallighan Slough and Ellicott NWR.
- Restore riparian and wetland on valley floor areas linking Upper Harkins Slough to Lower Harkins Slough to Watsonville Slough.
- Restore wetlands and riparian areas within and grasslands surrounding Hanson Slough.

- Preserve the varied grasslands and oak woodland habitats occurring in the intervening hillslopes between the valley floors of West Branch Struve Slough and Gallighan Slough.
- Create riparian buffer areas along all riparian corridors in the watershed.
- Create buffer areas adjacent to all marsh areas within the watershed.

4.5 WATERSHED-WIDE WATER POLLUTION PREVENTION AND CONSERVATION STRATEGY

The WSCEP has a focused effort to solve water pollution problems primarily through implementation of enhancement projects. Many water pollution discharge problems result from a lack of buffer space between pollution sources and receiving waters. The following is a general discussion of water pollution problems and generalized approaches that should be implemented by organizations and landowners in the watershed.

POLLUTION FROM URBAN STORMWATER RUNOFF

The main urban and industrial pollution problems are metals, oils and greases, pesticides from domestic sources, and nutrients. Where urban or industrial areas bound the Sloughs, the WSCEP recommends control of pollution sources. It also recommends installation of stormwater pre-treatment facilities that are effective and economical to maintain. The best control method is not to allow pollutants into the storm drain system from the start, and this requires public education and enforcement of pollution laws through discharge permitting. Once entrained in stormwater, there are a number of discharge pre-treatment methods such as retention basins, pre-treatment wetlands and active treatment (routing to active treatment facilities). Some of these facilities have been installed within the commercial areas of Watsonville, however it unknown how well they function. The WSCEP provides projects to upgrade existing stormwater treatment facilities and construct new ones.

POLLUTION FROM RURAL RESIDENTIAL AREAS

Pollution from rural residential lands primarily in Larkin Valley (Upper Harkins Slough) is a major concern with regard to discharge of sediment and nutrients to the Sloughs. The nutrients are from livestock manure and domestic septic systems entrained in stormwater runoff and

shallow groundwater. Excessive sediment discharge results from poor road drainage, overgrazing, a lack of stabilizing vegetation along channels in some locations, and recent channel instability resulting from geomorphic processes. New development has created new drainage problems and erosion hazards that have a cumulative effect as well.

The WSCEP proposes the development of a site-specific management plan for Upper Harkins Slough in Larkin Valley in order to address landowner and agency concerns and to develop community based solutions.

POLLUTION FROM AGRICULTURAL LANDS

Potential pollution problems from agricultural lands include sediment and nutrients. Much of the problem results from a lack of buffer space and stabilizing vegetation between the Sloughs and agricultural lands and the fact that the waterways are used as agricultural drains.

The WSCEP enhancement projects will address this issue by reconstructing drainage systems that separate agricultural runoff from the natural waterway and constructing treatment ponds and wetlands.

USE OF BUFFERS BETWEEN LAND USES AND WETLANDS

Preservation of buffer land between land uses and natural areas is an essential component of WSCEP recommended projects. Wetland areas on the valley floor are bounded by transitional seasonal wetlands and upland hillslopes that provide wildlife cover and areas to forage and nest. It is anticipated that many areas east of Highway 1 will be subject to development and conversion of rural land to urban uses to provide needed housing (i.e. Buena Vista Annexation). Through implementation of the WSCEP projects, it is hoped that cooperative efforts of agencies and landowners will result in the preservation and enhancement of significant areas between the valley floor wetland/riparian habitats and developed areas. Existing zoning and other ordinances, as well as federal regulations protecting endangered species, have considerable influence on these decisions. However, the WSCEP seeks to find solutions that meet multiple needs without regulatory actions and perhaps provide solutions, such as “Safe Harbors” agreements that enhance wildlife and help landowners. It is noteworthy that the City of Watsonville is developing management measures for many wetland and hillslope lands, including native vegetation

conversion projects, wetland restoration projects, and stormwater improvements.

4.6 IMPLEMENTATION AND FUNDING STRATEGY

The following implementation strategies are designed to encourage agencies and landowners in the development and implementation of WSCEP projects.

DEVELOP AND IMPLEMENT ENHANCEMENT PROJECTS WITH WILLING LANDOWNERS AND AN APPROPRIATE LEAD ORGANIZATION (AGENCY OR NON-PROFIT)

Many funding agencies require a governmental agency and/or non-profit organization to manage grant funding and project implementation. Most commonly, the proposed WSCEP resource enhancement projects will require a non-profit or governmental lead agency working with a willing landowner, coordinating project implementation, and handling contracts, grants, and environmental review.

DEMONSTRATE SUCCESS THROUGH IMPLEMENTATION OF PILOT PROJECTS SUCH AS THE PRIORITY PROJECTS DESCRIBED ABOVE IN ORDER TO EXPAND PARTICIPATION IN RESOURCE ENHANCEMENT PROJECTS

Implementation of initial projects will demonstrate how projects incorporate multiple objectives (e.g. habitat requirements of wildlife, uses desired by landowners). The five WSCEP initial projects described above are targeted to achieve results in a variety of settings with different issues and stakeholder groups. Success of the initial projects should attract greater interest in other projects by private landowners and will help define the planning process for obtaining permits and regulatory approval. They will also demonstrate the valuable role of scientific and engineering data in designing an "optimum" project that meets the needs of landowners and other stakeholders.

DIRECT RESOURCE, REGULATORY AND FUNDING AGENCIES TOWARDS ACHIEVING THE WSCEP GOALS AND INTEGRATE WSCEP RECOMMENDATIONS INTO PERMITTING AND ENVIRONMENTAL REVIEW

The involvement of regulatory agencies in the development of WSCEP and their future involvement as stakeholders in science-based planning and engineering studies should help resolve specific resource management and regulatory issues. In the case of the agricultural and rural residential community, the WSCEP can help define and resolve endangered species management issues and perhaps implement "Safe Harbors" agreements that allow for incidental take when an overall management strategy is in place. Development of new habitat areas and enhancement of existing areas can aid in offsetting the impacts of activities related to drainage and land use in and near sensitive resources. Implementation of the WSCEP watershed-wide should help coordinate and streamline regulatory process.

ENCOURAGE COORDINATION OF IMPORTANT LAND USE PROJECTS IN THE PLANNING AREAS WITH WSCEP RECOMMENDATIONS

Several other important projects are underway in the Watsonville Sloughs Watershed that should integrate the WSCEP into their planning and design process:

- Construction of third Watsonville high school.
- Bridge replacements along Harkins Slough Road.
- Renovation of the Redman House and surrounding fields as the Pajaro Valley Agricultural History and Education Center.
- Establishment of an Ohlone Village.
- Establishment of an Environmental Studies Center.
- The proposed Buena Vista Annexation.
- Pajaro Valley Water Management Agency Water Supply Projects.

The following provides guidance for consistency with WSCEP goals:

- Site stormwater systems should be designed to have minimum impact on water quality. This would include effective source control to prevent fertilizers and pesticides from

entering the Sloughs and using permeable pavements, active treatment systems and passive systems involving use of native vegetation buffers.

- Adequate physical buffers should be incorporated to create sufficient room for transitional habitats on hillslopes above wetlands.
- Site-specific conditions should be integrated into designs for road improvements. In some cases it would be beneficial to replace minimal culverts with open span bridges and allow for free-flowing conditions, whereas in other cases, removal of culverts and fill could reduce wetland hydroperiod and cause an impact. It may be desirable to install gates or weirs that can be adjusted to develop optimum flow.
- Siting of structures should not exacerbate erosion of unstable slopes or increase erosion and should avoid fragmentation of habitats.

COORDINATE EFFORTS OF CONSERVATION ORGANIZATIONS TO WORK ON PRIORITIES FOR LAND ACQUISITION AND TO PARTICIPATE IN PROJECTS AS OUTLINED IN THE WSCEP

A Stewardship Committee has been formed to encourage coordination among conservation efforts within the watershed. The Committee will meet on a regular basis. An important role of the Stewardship Committee and the coordination meetings is to ensure communication among stewardship organizations and agencies. A list of partnering agencies and organizations is included below. Periodic meetings between resource managers and resource organizations will help coordinate future activities and help update the WSCEP. The following is a list of agencies.

- County of Santa Cruz
- City of Watsonville
- California Department of Fish and Game
- California State Coastal Conservancy
- U.S. Department of Interior Fish and Wildlife Service
- U.S. Department of Agriculture Natural Resources Conservation Service
- U.S. Environmental Protection Agency
- Santa Cruz County Resource Conservation District

The following agencies and non-profit organizations are among those who have expressed interested in taking an active role in plan implementation:

- Land Trust of Santa Cruz County
- Coastal Watershed Council
- Community Action Board of Santa Cruz County
- Open Space Alliance
- Santa Cruz County Farm Bureau
- Watsonville Wetlands Watch
- American Farmland Trust
- Association of Monterey Bay Area Governments (AMBAG)
- Friends of Pajaro Dunes
- Trust for Public Land
- Community Alliance with Family Farmers

The following is provided as general information on what is entailed in implementing an enhancement project.

Scientific justification for project

The project must have demonstrable biological and/or water quality benefits that meet the overall program goals and strategies. These benefits must be demonstrable using current accepted scientific and engineering practices. The project must be feasible from a construction, implementation, management, operations, and maintenance standpoint.

Landowner cooperation and land availability

Each project must have the cooperation of landowners whose lands are involved or affected. The land proposed for enhancement must be available for dedication to natural resource management by fee-title or conservation easement. In some cases, specific grant funding sources require protection of restored habitat in perpetuity. There may be operations, monitoring and maintenance requirements for projects that require access through private lands and maintenance resource requirements that highlight the need for cooperation.

CEQA and regulatory compliance and permitting

All projects undertaken must meet conditions of the California Environmental Quality Act

(CEQA) and in some cases the National Environmental Protection Act (NEPA). Some project may require permits from resource agencies such as California Department of Fish and Game, the U.S. Army Corps of Engineers, National Marine Fisheries Service, Regional Water Quality Control Board, County of Santa Cruz, Coastal Commission or U.S. Fish and Wildlife Service. The projects must have sufficient planning, engineering and scientific detail so that permitting applications and packages can be compiled and reviewed. Each project needs a project proponent and a lead agency responsible and accountable for seeing that the project is carried out as permitted and maintained, and to conduct any required monitoring and complete any remedial measures.

Funding

Most projects require funding and many will require multiple funding sources and implementation partners. The watershed plan will provide a vehicle for attracting funding to acquire land and conservation easements and to construct enhancement projects. As with regulatory compliance, many funding programs have specific requirements with regard to administration of the grant money and contracts to carry out the project.

Cooperation and coordination between funders, regulators and implementing organizations

It is anticipated that a number of organizations and landowners will be involved in implementing a watershed plan. There is a need to follow a planning process that allows project proponents to design a project and then develop and transmit information to funding and regulatory agencies.