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Towards improved coastal river mouth breaching

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**TOWARDS IMPROVED
COASTAL RIVER MOUTH BREACHING**

A Thesis

Presented to

The Faculty of the Department of Environmental Studies

San Jose State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

Chris Flynn

May 1, 2002

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ABSTRACT
TOWARDS IMPROVED COASTAL RIVER MOUTH BREACHING
by Chris Flynn

Coastal river mouth breaching is the activity whereby people open up a sand bar to allow flow of coastal lagoon and river water into the ocean. The purpose of this study was to identify the goals of breaching and the compatibility of different agencies' breaching goals. This study also investigated breaching management issues, success, and effectiveness.

This research was conducted using quantitative and qualitative analysis of a survey of agency personnel involved in breaching and analysis of documents related to breaching in the Monterey Bay area. Quantitative analysis was performed using Statistical Package for Social Science software.

This thesis found that comprehensive river mouth management should be employed to plan, permit, and conduct breaching, and that coastal managers should individually evaluate river mouths and encourage natural river mouth processes prior to breaching. This study also provides a list of issues that coastal planners should consider before breaching.

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TABLE OF CONTENTS

LIST OF TABLES	viii
LIST OF FIGURES	x
Chapter	
1. INTRODUCTION	1
Background	1
Objectives	5
2. RELATED RESEARCH AND ACTIVITIES	7
General Literature Regarding Coastal River Mouth Breaching ...	7
Breaching Activities and Associated Research	9
3. METHODOLOGY	25
Study Sites	25
Study Design	26
Data Collection and Preparation	30
Data Analysis	31
4. RESULTS	33
Essential Issues to Consider When Breaching	34
Success of Breaching at Study Sites	40
Effectiveness of Breaching	46
Compatibility of Agency Goals Towards Breaching	55
Analysis of Existing Breaching Documents	59

5. DISCUSSION	68
Permit Application Preparation and Analysis	68
River Mouth and Lagoon Management and Planning	71
Recommendations	74
Contributions to the General Literature on Coastal River Mouth	
Breaching	78
Limitations of this Research	79
Research Needs	81
SELECTED REFERENCES	84
APPENDIX A: SURVEY	89
APPENDIX B: TABLES	94
APPENDIX C: FIGURES	121

LIST OF TABLES

1.	Agencies that participated in coastal river mouth breaching survey	95
2.	Statistical results of all, manager, and regulator respondents who think issues are essential	96
3.	Frequency of importance ranking for all respondents	97
4.	Frequency of importance ranking for manager respondents	98
5.	Frequency of importance ranking for regulator respondents	99
6.	Comparison of all, manager, and regulator importance rankings of essential issues based on means	100
7.	Comparison of the order that respondents considered breaching issues essential versus the order in which all potential breaching issues were ranked	101
8.	Summary of responses on success of river mouth breaching at all locations	102
9.	Success responses for the San Lorenzo River	103
10.	Success responses for the Pajaro River	104
11.	Success responses for the Carmel River	105
12.	Success responses for the Monterey Bay area	106
13.	Summary of responses for the effectiveness of all river mouth breaching methods	107
14.	Effectiveness responses for manual breaching	108
15.	Effectiveness responses for mechanized breaching	109

16. Effectiveness responses for the use of temporary water level control devices	110
17. Effectiveness responses for the use of permanent water level control devices	111
18. Effectiveness responses for natural breaching	112
19. List of agency goals provided by respondents	113
20. List of job classifications held by all respondents	114
21. Compatibility of goals towards coastal river mouth breaching	115
22. Reasons why managers and regulators think they do not have compatible goals towards river mouth breaching	116
23. Reasons why managers and regulators think they have compatible goals towards coastal river mouth breaching	117
24. List of issues pertaining to breaching at the San Lorenzo River mouth found in existing documents	118
25. List of issues pertaining to breaching at the Pajaro River mouth found in existing documents	119
26. List of issues pertaining to breaching at the Carmel River mouth found in existing documents	120

LIST OF FIGURES

1. Satellite image of the Monterey Bay area	122
2. Map of the Monterey Bay area and study site locations	123
3. USGS 7.5" quad map fo the San Lorenzo River mouth area	124
4. USGS 7.5" quad map of the Pajaro River mouth area	125
5. USGS 7.5" quad map of the Pajaro River mouth area	126
6. Lithograph of Santa Cruz and the San Lorenzo River mouth circa 1894	127
7. Aerial photo of the San Lorenzo River mouth, beach and pier	128
8. The San Lorenzo River mouth is potentially dangerous for unwary swimmers and waders	129
9. Aerial photo of the Pajaro River mouth area	130
10. The Pajaro River Mouth is adjacent to residential property and harbors a variety of wildlife	131
11. The Carmel River lagoon and bay are world renowned for their beauty	132
12. Aerial photo of the Carmel River mouth area	133
13. Sand bar blocking the Carmel River mouth with adjacent residences	134
14. Percentage of all respondents, managers, and regulators who feel issues are essential to consider when planning and conducting breaching	135
15. Manager versus regulator responses of flooding as an essential issue	136
16. Manager versus regulator responses of wildlife as an essential issue	137

17. Manager versus regulator responses of endangered species as an essential issue	138
18. Manager versus regulator responses of habitat as an essential issue	139
19. Manager versus regulator responses of public safety as an essential issue	140
20. Manager versus regulator responses of public health as an essential issue	141
21. Manager versus regulator responses of water quality as an essential issue	142
22. Manager versus regulator responses of access and recreation as an essential issue	143
23. Manager versus regulator responses of monitoring as an essential issue	144
24. Manager versus regulator responses of mitigation as an essential issue	145
25. Histogram exhibiting how all respondents, managers, and regulators rate the success of river mouth breaching at the San Lorenzo River	146
26. Histogram exhibiting how all respondents, managers, and regulators rate the success of river mouth breaching at the Pajaro River	147
27. Histogram exhibiting how all respondents, managers, and regulators rate the success of river mouth breaching at the Carmel River	148
28. Ratings by all respondents, managers, and regulators of the success of river mouth breaching in the Monterey Bay area	149
29. Ratings by all respondents, managers, and regulators of the effectiveness of manual breaching as a means of river mouth management	150
30. Ratings by all respondents, managers, and regulators of the effectiveness of mechanical breaching as a means of river mouth management	151

31. Ratings by all respondents, managers, and regulators of the effectiveness of using temporary water level control devices as a means of river mouth management	152
32. Ratings by all respondents, managers, and regulators of the effectiveness of using permanent water level control devices as a means of river mouth management	153
33. Ratings by all respondents, managers, and regulators of the effectiveness of allowing natural breaching as a means of river mouth management	154

CHAPTER 1

INTRODUCTION

Background

Coastal river mouth breaching is a statewide coastal management issue increasingly gaining attention as awareness of the sensitivity of coastal lagoon habitat rises. Despite this growing scrutiny there is a lack of understanding on how to conduct this activity in California. Those managing coastal lagoons and conducting breaching activities often are not in consensus with responsible regulatory agencies on preferred strategies for environmental management and coastal river mouth breaching activities. For the purposes of this study, coastal river mouth breaching will be defined as that process whereby people alter or bypass a river-borne or ocean deposited sand bar to allow the flow of lagoon waters into the ocean.

Current management of coastal river mouths and coastal lagoons in the Monterey Bay Area (Figure 1) includes breaching of sandbars to allow river or lagoon waters to outlet into the ocean. In some cases temporary plans are being implemented to regulate river mouth breaching. Frequently this activity is carried out as an emergency action rather than as a planned management activity. In most remaining situations the river or lagoon is allowed to breach with no human intervention. These management techniques sometimes fail to consider critical natural and human environmental factors affected by coastal river mouth breaching activity.

Historically coastal river mouth breaching has gone largely unregulated, but over the past fifteen years attention has increasingly been focused on this issue. As awareness of the fragile nature and importance of the coastal river mouth environment has grown the need for a comprehensive yet flexible approach to managing this activity has become evident. Resource managers have become aware that no single agency or entity can effectively consider all of the environmental and social issues that may come into play in the dynamic and ever changing coastal environment, and no clear criteria of how to analyze breaching exists.

Joy Chase, Coastal Program Analyst for the Central Coast District of the California Coastal Commission, noted “The nature of river mouth hydraulics, and changing human resource use affecting the dynamics of river mouths and coastal lagoons, dictates river mouth breaching practices that are open to change” (Chase 1997). She also reports that “advances in scientific knowledge, changes in citizen attitudes towards the environment, shifts in resource use or demographics, and unforeseen factors may change the environment of a river mouth, dictating flexibility in any plan for management of this process” (Chase 1997). As increased population pressure comes to bear on coastal areas and multiple coastal resource management problems occur in different combinations, a more “integrated, highly participatory management approach” to coastal management is required (Klee 1999, 47).

Since there is very little existing academic research or historical data on the issue of coastal river mouth breaching, this research will benefit many coastal resource managers, including regulatory agencies, researchers in coastal zone management, municipal and

county coastal managers, and the general public. Significantly, this information will be of immediate value to the public works departments of cities and counties in the Monterey Bay region. In addition, managers and staff from the following regulatory agencies should directly benefit from the research to be conducted: California Coastal Commission (CCC), California Department of Fish and Game (CDFG), California State Lands Commission (CSLC), California Department of Parks and Recreation (CDPR), Monterey Bay National Marine Sanctuary (MBNMS), United States Fish and Wildlife Service (USFWS), United States Environmental Protection Agency (USEPA), United States Army Corps of Engineers (USCOE), and other State and Federal agencies.

This research establishes a foundation for further research and discussion on the critical management issues of coastal river mouth breaching. This is particularly important because the coastal river mouth ecosystem supports a diversity of natural systems vital to a healthy coastal environment, and people place great economic and aesthetic value on this environment. The designation of critical habitat for endangered populations of steelhead trout, coho and chinook salmon, and tidewater goby at the San Lorenzo, Pajaro, and Carmel Rivers, and other locations in the Monterey Bay area also contributes to the importance of this work.

Improved management of coastal river mouth environments will assist in the prevention of unnecessary damage to public and private property and thereby minimize the occurrence of health and safety hazards (Otter 1998). Well planned coastal river mouth breaching may help protect coastal habitat and wildlife, encouraging the

preservation of these resources. Society will be provided with a preserved coastal environment for the benefit and enjoyment of future generations (Anderson 1997).

This research defines for the first time the major resource issues involved in river mouth breaching. It provides insight into agency attitudes towards the success of coastal river mouth breaching at the study site locations in the Monterey Bay area. This study allows coastal resource managers to see how different agencies view the effectiveness of different breaching methods, and it provides them with alternative methods of breaching that they may not have been aware of. This work may provide a valuable tool for the many agencies and interested parties who are concerned with management and regulation of natural and human coastal environmental issues regarding coastal river mouth breaching.

This research determines the essential issues that must be considered when breaching, how successful river mouth breaching is as a management technique, and if different breaching methods are effective. This research also identifies the coastal river mouth breaching goals of agencies who conduct breaching and those that regulate it, and will investigate the compatibility of those goals.

Investigation of existing research on coastal river mouth breaching reveals limited literature on the subject. What literature there is offers insight only into individual aspects of river mouth breaching or closely related coastal zone management issues. The majority of sound data on this topic is found either in the river or lagoon management plans created to cope with broader management issues at these locations, in interim plans for dealing with this issue, or in emergency breaching permits. A coastal development

permit for breaching at the Pajaro River is the only instance of a regular coastal development permit being approved for conducting coastal river mouth breaching in the Monterey Bay Region.

The scope of this research encompassed analysis of three coastal river mouth breaching sites located in the Monterey Bay region of California (Figure 2). These sites are situated at the San Lorenzo River Mouth (Figure 3), the Pajaro River Mouth (Figure 4), and the Carmel River Mouth (Figure 5). All three sites are within Santa Cruz and Monterey Counties, and border the Monterey Bay National Marine Sanctuary.

Objectives

The purpose of this study was to determine the coastal river mouth breaching goals of agencies involved in planning, conducting and regulating this activity, and to determine the compatibility of the goals of agencies that conduct versus those that regulate this activity. This study also identified issues that are essential for all of these agency personnel to consider when working on breaching projects. Ultimately, this research determined how successful these agency personnel consider breaching at the study site locations, and it ascertained the effectiveness of different breaching techniques.

The following questions are addressed by this thesis:

- 1) What are the goals that agencies have towards planning, conducting, and regulating coastal river mouth breaching?

- 2) Are the goals of agencies that conduct coastal river mouth breaching compatible with the goals of those agencies that regulate coastal river mouth breaching?
- 3) What are the essential coastal river mouth breaching issues that should be considered by agencies involved in planning, conducting, and regulating this activity?
- 4) How successful is coastal river mouth breaching at these study sites?
- 5) How effective are different methods of coastal river mouth breaching?

CHAPTER 2

RELATED RESEARCH AND ACTIVITIES

The primary focus of this chapter is to analyze and report on existing and past coastal river mouth breaching activities in the Monterey Bay region, drawing on information from a variety of primary and secondary sources. Investigation of fifteen potential study sites reveals varying levels of involvement in this issue by twenty municipal, county, state, and federal agencies. This literature review examines materials most relevant to these areas of investigation.

General Literature Regarding Coastal River Mouth Breaching

According to The Encyclopedia of Beaches and Coastal Environments coastal lagoons are “water areas separated from the sea by narrow and low lying land strips and usually differing from the sea in salinity” (Schwartz 1982, 84). Schwartz describes river mouth systems as existing in a “setting of the interface of fresh and saline waters, either on an open coast, or within a semi-enclosed body of water” (Schwartz 1982, 98). Sand bars are formed by deposition of river-born materials at the river mouth and deposition of ocean sand piled up at the river mouth by waves during the summer and fall months. This deposition is the result of low ocean wave strength, low river flow, and subsequent beach expansion (Pethick 1988). For this study, coastal river mouth breaching is defined

as the alteration or bypassing of a river-born or ocean deposited sand bar that allows the flow of lagoon waters into the ocean.

There is a distinct lack of professional or academic literature bearing directly on the topic of coastal river mouth breaching. The only article discovered with a direct reference to this activity is Experimental Opening of a Coastal California Lagoon: Effect on Bacteriological Quality of Recreational Ocean Waters (Gersburg, Matkovits, Dodge, McPherson, and Boland 1996). This article describes the water quality effects of conducting coastal river mouth breaching on surrounding surf zone waters within a four month period in 1994. The authors' conclusion, based solely on water quality effects, was that breaching was beneficial in reducing concentrated spikes of pollutants entering the ocean. They also concluded that this activity would have minimal adverse impacts on water quality in the near shore environment, and they recommended that increased surveillance of non-point pollutants be conducted.

Although the preceding article is the only one to specifically address breaching, more general works set the parameters in which to view the breaching issue. Many coastal zone experts are increasingly alarmed with the negative impact of human activities and management practices on the coastal environment. In An Introduction To Coastal Zone Management, it is noted that "human activity can interfere with the natural processes of the coast and prevent the ecosystem from maintaining the equilibrium so necessary to its continued vitality" (Beatley, Brower, and Schwab 1994, 6). These concerns are not new to coastal resource experts. In An Introduction to Coastal Geomorphology the author notes that coastal modifications can cause "enormous problems -- for their ramifications

spread widely throughout the coastal system” (Pethick 1988, 236). By its very nature, coastal river mouth breaching activities occur in particularly sensitive locations. Acting as the nexus between the saline environment of the ocean and the brackish environment of lagoon and riparian environments, coastal river mouths and their management require careful scrutiny and consideration.

Breaching Activities and Associated Research

Where breaching has been conducted and regulated there is some associated literature and research that sheds light on this practice. In June of 2001, the California Coastal Commission approved a coastal development permit application by the City of Del Mar for breaching and sand bar management at the mouth of San Dieguito Lagoon, adjacent to Del Mar Beach in San Diego County. This is the most recent example of a breaching permit being approved by the California Coastal Commission. The permit approves removal of sediment that builds up in the river mouth from sediment load transported by San Dieguito Creek, and from sand transported onshore by wave action and tidal currents during the summer and spring months (CCC 2001a).

Although this location is in Southern California, river mouth managers for the City of Del Mar must deal with issues similar to those at these the study sites within this thesis located in the Monterey Bay area. These similar issues are concerns with protection of lagoon wildlife and habitat, and maintaining acceptable lagoon and ocean water quality. Ironically one main difference at this location is that local residents, instead of expressing concerns about this lagoon flooding their property, are concerned that breaching the sand

bar may cause loss of sand downshore from the breach, possibly threatening beachfront homes. Subsequent studies by the City concluded that breaching at this location would not contribute to downshore erosion (CCC 2001a).

Another location that was permitted for breaching in 2001 was Soquel Creek in the City of Capitola. Capitola is interesting in that they not only conduct breaching, but also artificially block the river mouth in order to allow the lagoon to form, providing a venue for the annual Begonia festival on the lagoon (CCC 2001b).

Unlike San Dieguito Creek discussed above, the San Lorenzo, Pajaro, and Carmel Rivers, as well as many other streams and rivers in the Monterey Bay area, provide habitat, or potential habitat for winter-run chinook salmon, coho salmon, tidewater goby, and steelhead trout. Both the winter-run chinook salmon, and the tidewater goby are listed as Federal Endangered Species, while the coho salmon is currently listed as threatened under the Federal Endangered Species Act (CDFG 2001).

In 1997 the steelhead trout was protected under the Federal Endangered Species Act (CDFG 2001). The National Marine Fisheries Service classified the fish as threatened on the Central California Coast where its populations have become a small fraction of what they were in the past. The population of steelhead trout in the San Lorenzo River has decreased from approximately 20,000 in the 1960's to the range of 1,000 to 5,000 today (Smith 1997). The Carmel River also hosts a population of steelhead trout, but the lagoon is limited in providing habitat because of its shallow waters, as well as high temperature and salinity levels (Smith 1997). Efforts are underway to reintroduce a

population of steelhead to the Pajaro River by releasing steelhead smolts into the Pajaro Lagoon annually (Smith 1997).

An oblique reference to coastal river mouth breaching surfaces in The Coastal Environment: Toward Integrated Coastal and Marine Sanctuary Management (Klee 1999). This work describes the manual creation of a coastal lagoon to accommodate the annual Begonia Festival at Capitola in Santa Cruz County, California. The practice of manually creating a lagoon is the opposite activity of coastal river mouth breaching, but it does broach similar issues, and hence must be dealt with by coastal zone managers and regulators. This artificial lagoon experiences water quality problems such as high fecal coliform levels attributed to waterfowl, septic systems, and pets, as well as polluted runoff, and eutrophication (Habitat Restoration Group 1988).

Coastal river mouth breaching has received recent official scrutiny in one regional forum. In 1998, the County of San Luis Obispo had to renew that portion of its General Plan that serves as its Local Coastal Program (LCP). The resulting North Coast Area Plan Update (San Luis Obispo County 1998) contains an element specifically tailored to address those circumstances where breaching of the beach berm creates a coastal lagoon providing summer rearing habitat for juvenile steelhead trout (California Coastal Commission 1998). This element also addresses breaching as an activity requiring a permit under the authority of the CCC, CDFG, COE, MBNMS, and the RWQCB, and lists nine mandatory issues to be considered in the development of a river mouth breaching plan. These nine issues are private property flooding, public property

flooding, public safety, public health, wildlife, habitat, monitoring and mitigation, coastal access, and water quality (San Luis Obispo County 1998).

In the Monterey Bay region, as along most of the California shore, coastal river mouth breaching is primarily conducted by municipal and county governments. This is a source of concern. As stated in the 1992-94 California Sea Grant Biennial Report of Completed Projects “local governments have a natural focus on local issues” (Lester 1995, 64-65). Lester goes on to explain that movement away from the broad resource protection goals of the Coastal Act can be made worse by “lack of vigorous oversight and evaluation by the California Coastal Commission of local regulatory actions.” Despite these concerns by coastal resource experts, it should be recognized that coastal river mouth breaching is just one of local governments’ many priorities, hence time and resources spent on planning and conducting breaching must be balanced with other pressing issues.

A more deliberate and orderly approach to making decisions on coastal river mouth breaching is needed. The creation of collaborative policy initiatives established to deal with coastal river mouth breaching falls within the range of wider suggestions in the field for greater cooperation and regulation of coastal management practices. Klee notes that a “new paradigm” utilizing “Integrated Coastal Management (ICM)” was introduced in the 1980’s and should be employed to integrate economic and environmental management in protecting coastal resources (Klee 1999, 47).

Beatley, Brower, and Schwab assert “mechanisms for regional cooperation and planning in the coastal zone will, we believe, become increasingly important in the

future” (Beatley, Brower, and Schwab 1994, 195). Brindell states in A Natural Resource Policy Protocol (Brindell 1995, ix) that “a policy protocol provides proponents, opponents, and affected groups with a more reliable, fair, and predictable framework and process within which to present their information.” Such a standardized approach will result in better decision making on coastal management strategies.

In sum, river mouth management is a statewide issue and there is a long history of concern about human modifications to this environment having adverse impacts to natural and human environments. Despite a dearth of literature or direction on how to manage this activity, coastal river mouth breaching and river mouth and lagoon habitats are beginning to be managed and regulated on a regular basis. Concerns about water quality, safety, and flooding are being balanced with concerns for habitat, wildlife, and endangered species. River mouth management is becoming accepted as an integral part of managing California’s coastal resources.

Current breaching management strategies. Some local efforts have examined the management of coastal lagoon water levels, and how to conduct actual breaching activities in this environment (City of Santa Cruz 1987; Monterey County 1992; County of Santa Cruz 1992). The methods fall into three main categories: 1) no action, or natural breaching, which for the purposes of this study is defined as allowing a lagoon to breach without any immediate human efforts to make it breach at that particular time, 2) manually or mechanically open up the sand bar to allow egress of the lagoon waters and an open connection between the lagoon and the sea, and 3) installation of a temporary or

permanent water level control device to prevent lagoon waters from rising above a given level.

Additional research has been conducted on specific preferred parameters for maintaining water levels in the various lagoons. Dr. Jerry Smith spoke on the issue of lagoon habitat during an interagency meeting at the City of Santa Cruz office on river mouth breaching on August 8, 1997. He noted that for the benefit of the steelhead trout fishery in the San Lorenzo River Lagoon, it is better to maintain water at a lower level to avoid breaching and subsequent introduction of salt water than to allow higher water levels and deal with repeat breachings that result in salt water intrusion and stratified salinity conditions (Smith 1997).

Another example of parameters being set for a specific location is the proposed Breaching Protocol, Scott Creek developed to manage coastal river mouth breaching to alleviate flooding of adjacent properties at Scott Creek in Santa Cruz County (CDFG 1996). Although this breaching protocol was never adopted, it lays down location-specific parameters for high-flow (wet season) and low-flow (dry season) scenarios. These parameters are notable in that they consider tidal fluctuation in relation to the season. CDFG biologist Patricia Anderson explains that the reason these fluctuations were considered important is that the different wet and dry seasons were determined to coincide with known steelhead and salmon fishery in and out migrations specific to Scott Creek (CDFG 1996).

The most substantial data on breaching management practices being created for a specific coastal river mouth breaching location are those dictated by the 3-97-047 Pajaro

River Lagoon Sand Bar Breaching Coastal Development Permit (CDP) which was approved by the Coastal Commission on March 11, 1997 (California Coastal Commission 1997). Notable in this permit is the extensive monitoring, evaluation, and reporting required. Ongoing monitoring of water levels is required to substantiate a need to breach. Monitoring of water quality and breaching activities before, during, and after breaching is also required, and reports of this data must be submitted to the Coastal Commission after each instance of breaching. Also of note are detailed fish seining procedures required by CDFG, included as a condition for approval of this permit.

Breaching sites and issues. There are fifteen different locations in the Monterey Bay area that have had some mention in coastal river mouth breaching literature, reports, plans, or permits. The three coastal river mouth breaching locations chosen for this research at the mouths of the San Lorenzo, Pajaro, and Carmel Rivers were selected based on the historical and continuing issuance of coastal river mouth breaching permits or emergency permits for these locations, and their inclusion in draft or final coastal river lagoon management plans. These rivers also exhibit the largest cross section of coastal management issues related to breaching.

The San Lorenzo River. The San Lorenzo River is a perennial stream with low summer flows contrasted with greatly increased winter flows. Historically the San Lorenzo River had a wide floodplain and a large lagoon area (Figure 6). The lower portion of the San Lorenzo River was channeled by the construction of levees and dredging in 1958 (Figure 7). This channelization was designed to control flooding from winter storms that can result in flood peaks lasting from several hours to days.

Ever since the San Lorenzo River was confined within a channel in 1958 there has been periodic artificial and natural breaching at the mouth of the river. In the past the mouth has been breached by the City of Santa Cruz from two to four times in a summer season, with occasional winter breaching during seasons of low rainfall when the sand bar is not kept open by high river flows (City of Santa Cruz 1987). There also have been sporadic occasions when unauthorized breaching was conducted. This unauthorized breaching appears to have been done by local surfers in order to improve the waves breaking off San Lorenzo Point, or it may have been done by local residents to alleviate flooding of their properties near the Santa Cruz Beach Boardwalk parking lots that occur when the lagoon has high water levels (Hall, 2001).

With increased awareness of the importance of tidal wetlands and river mouth lagoons, the Coastal Commission began reviewing breaching of the San Lorenzo River mouth and issued a violation report for breaching without a permit in May 1987 (California Coastal Commission 1992). There may have been earlier involvement, but this is the earliest documented CCC record. Since that time there have been permitted emergency breaching, violations filed for un-permitted breaching, an accidental artificial breaching by the city, and issuance of temporary, interim, and emergency permits to allow for breaching. The last recorded instance of the San Lorenzo River being artificially breached under the auspices of an emergency permit from the CCC was in October of 1996 (California Coastal Commission 1997).

Major flooding in 1982 resulted in increased collaboration between the City of Santa Cruz and the U.S. Army Corps of Engineers on the formulation of the San Lorenzo River

Design Concept Plan (City of Santa Cruz 1987). The concept plan led to the development of a biological enhancement plan designed to maximize biological resources within the constraints of the flood control requirements. To pursue this goal the City of Santa Cruz obtained a California Coastal Conservancy Grant to prepare the San Lorenzo River Enhancement Plan (City of Santa Cruz 1987). Restoration of the lower San Lorenzo River was a primary goal of this plan.

Goals of the San Lorenzo River Enhancement Plan that are pertinent to coastal river mouth breaching include: 1) minimizing summertime flooding of poorly drained areas behind levees when the river mouth is closed by a sand bar and the lagoon levels are high, 2) control of lagoon openings to avoid instantaneous breaching causing rapid river water flow on populated beaches, and 3) installation of a water level control device to be located at the mouth of the San Lorenzo River. This device was designed to allow regulation of water levels in the San Lorenzo River Lagoon when it experienced closure due to natural damming at the mouth (City of Santa Cruz 1987).

The San Lorenzo River Lagoon attracts bathers because of its warmth relative to the adjacent ocean and the calmness of its lagoon water. This attraction may prove at times dangerous as rapidly flowing river waters or an unsupervised breach could result in a sudden change to dangerous swimming conditions in the lagoon and river mouth (Figure 8).

In 1991 a woman nearly drowned at the mouth of the San Lorenzo River during a naturally occurring breaching event. She fell in the river water that rapidly flowed from the lagoon and was swept into the adjacent surf where she nearly drowned, suffering

brain damage from this experience. The woman's family sued the City of Santa Cruz for not properly monitoring the situation. The City was not found liable in the courts because the tragic incident occurred during a natural breaching episode and not during a City breaching action. This litigation resulted in the City adopting a hands-off policy to breaching at this location.

In 1992 and 1993 the City of Santa Cruz received approval from COE, CDFG, USFWS, and CCC to construct the water level control device. In 1991 the City was granted \$200,000 in funding by the California Coastal Conservancy for construction of the water level control device. Despite this financial support the Santa Cruz Department of Public Works, concerned about litigation surrounding the near drowning in that vicinity, never proceeded with plans to build the device.

A "Criteria for Emergency Breaching of the San Lorenzo River Mouth as an Element of the Water Surface Elevation Control Project" was produced in 1992, and adopted by resolution of the City Council of the City of Santa Cruz (California Coastal Commission 1992). This plan was intended to become a part of a greater River Enhancement Plan for the San Lorenzo River in the City of Santa Cruz. Great attention was given to the various factors involved in managing water levels in the San Lorenzo River Lagoon. Despite these moves towards greater management, breaching the river mouth was still only considered as an emergency measure. Due to the litigation against the City related to the near-drowning incident, the City is still reluctant to engage in any subsequent breaching activity at this location.

Massive efforts have recently been invested in improving the San Lorenzo River levees adjacent to and upriver from the river mouth, but these efforts are ineffective near the mouth of the river because seepage from high lagoon water levels still impact some local residences (Hall 2001). It is possible that a draft lagoon management plan being developed by the City of Santa Cruz Redevelopment Agency may provide some insight into how these issues may be remedied (Myers 2001).

Current management efforts at this river mouth are limited to monitoring of natural breaching at the river mouth and water level changes in the river lagoon. Some additional monitoring should commence soon because funding has recently been obtained by the City to conduct water quality and sediment testing in the river lagoon to better understand fluctuations in oxygen levels and other factors affecting lagoon water quality (Myers 2001).

The Pajaro River. The Pajaro River drains a watershed that has been largely altered by urban development, conversion of wetlands to agricultural use, and containment of the main river within levees. The lower portion of the river has been constricted from a widely meandering course to a channeled course, except for the outlet into the ocean that meanders north to south approximately one kilometer (Figure 9). Currently there are residences adjacent to the Pajaro River Lagoon. This lagoon area and surrounding beaches and wetlands provide habitat for a variety of wildlife including the endangered least tern and tidewater goby (Figure 10) (County of Santa Cruz 1993).

The Pajaro River marks the boundary between Santa Cruz and Monterey Counties. A coastal lagoon often forms at the mouth of the Pajaro River during the summer, fall, and

winter months. Flooding occurs subsequent to rain events in the beginning of the rainy season, or in the summer months and early fall when agricultural runoff and other small water sources contribute to increased flow rates (California Coastal Commission 1997).

According to County officials, breaching activities have been ongoing at this location for many years. Coastal Commission regulatory authority was first brought into play in 1988 during a period of high lagoon water levels when an emergency CDP was obtained to conduct breaching operations. Since that time breaching has been conducted in dry season months pursuant to a County of Santa Cruz Interim Criteria Plan that includes a Memorandum of Understanding (MOU) between Santa Cruz County and the CDFG (CDFG 1997).

In 1992 the Santa Cruz County Public Works Department and the California Coastal Conservancy collaborated in producing the Pajaro River Lagoon Management Plan (County of Santa Cruz 1993). This plan provides measures to prevent flooding, manage water levels in the lagoon, and improve water quality in the lagoon and river. Disastrous flooding upstream of the lagoon in 1995 prevented implementation of these measures.

In 1996 the County applied for a Coastal Development Permit from the CCC to conduct river mouth breaching activities. Prior to this occasion, only emergency permits or MOU's of various kinds regulated coastal river mouth breaching at this location. This permit was approved on March 11, 1997 (California Coastal Commission 1997). All breaching activities conducted since that time should have been conducted under this CCC permit. This permit is notable as one of only two examples of a Coastal Development Permit that was actually approved by the Coastal Commission for coastal

river mouth breaching in the Monterey Bay region, the other permit being for breaching at Soquel Creek in the City of Capitola. This permit for breaching at the Pajaro River is not currently valid because the County does not have the necessary U.S. Army Corps of Engineers permit to conduct this activity.

The County of Santa Cruz holds, or has held, three separate permits to allow this activity. They currently have breaching authority under a Memorandum of Understanding (MOU) with the California Department of Fish and Game. They have had a section 404 streambed alteration agreement from the U.S. Army Corps of Engineers that is certified by USFWS, NMFS, and the RWQCB. This permit is currently expired but the County is in the process of renewing this permit and they hope to have it in time for use during the 2002/2003 winter season if necessary. The County currently has no specific management plan or policy that dictates how breaching of the Pajaro River and lagoon must be managed. For this reason they are relying on these permit agreements and conditions to detail how they will manage these resources (Wolcott 2001).

The County has also obtained a Coastal Development Permit from the California Coastal Commission for breaching in this area. This permit contains a condition that it is only valid so long as the CDFG MOU and COE 404 permit are valid. Since the 404 permit is not presently valid, the County is not currently permitted to breach under the Coastal Commission permit (CCC 1998). The County may request an amendment to their coastal development permit to allow it to be reactivated for a limited time period if and when they have obtained a new 404 permit from COE, or they may have to obtain a

new coastal development permit. Despite all of the efforts by the County of Santa Cruz to obtain these permits, they have not actually conducted breaching activities for six years (Wolcott 2001).

The Carmel River. The Carmel Lagoon and bay are renowned for their beauty (Figure 11). The Carmel River is primarily fed by runoff from the steep mountains in its upper watershed. The upper river flows through steep canyons, slowing and meandering in the lower reaches as it traverses the Carmel Valley en route to the ocean (Figure 12). Two small dams on the upper river have little effect on winter flows, but diversions from one dam sometimes causes the lower portion of the river to cease flowing in the summer. Flow in the river also fluctuates in response to seasonal rainfall. Flow into the lagoon normally ceases between June and August and resumes in November to January. The Carmel River lagoon differs from the other two study site locations in that the river and lagoon completely dry up during some years. Also, sudden increased flows, particularly in the beginning of the rainy season, can create rapid fill of the lagoon and cause immediate danger to adjacent development (Monterey County Department of Public Works 1992).

Flooding caused by high water levels in the Carmel River Lagoon has occurred for many years. Records indicate that as early as 1958 and 1962, flooding of the Carmel River Lagoon inundated surrounding residential areas. In 1982 three homes were flooded. According to the Department of Public Works, artificial breaching had been ongoing prior to these instances (Figure 13). Monterey County Department of Public Works involvement began in 1973. Breaching by County personnel is needed once or

twice in a normal year, with some years requiring three or four breachings (Monterey County Public Works Department 1992).

There have been numerous temporary agreements and plans to regulate breaching of the Carmel River Lagoon. In 1991 a document entitled Draft Interim Plan and Criteria for Breaching of the Carmel River Mouth was produced by the Monterey County Public Works Department. In 1992, another draft of the same plan was produced and implemented, but no coastal development permit was ever acquired for river mouth breaching at this location (Monterey County Department of Public Works 1992). An Army Corps of Engineers 404 permit for streambed alteration was issued in 1992 to permit “emergency” breaching of the Carmel River mouth.

The next year a Memorandum of Understanding was entered into between the California Department of Parks and Recreation and the Monterey County Department of Public Works (Monterey County Department of Public Works 1992). Subsequent emergency permits for breaching were issued by the CDFG and CCC in 1996 and 1997. A CCC staff recommendation for the California Coastal Conservancy funded Carmel River Lagoon Enhancement Plan specifically states that the 1992 draft Interim Plan and Criteria for Breaching of the Carmel River Mouth does not adequately address the issue of river mouth breaching. It also states that in future planning the Carmel River Lagoon Enhancement Plan should address the requirements to resolve ongoing issues with river mouth breaching at this location (Monterey Peninsula Regional Park District 1997).

Attempts to reach agreement on any Carmel Lagoon management plan has been hindered by an unfortunate flooding incident that occurred in January 2001 as the result

of high tides, high storm waves, and flooding of the lagoon. Monterey County became aware of potential flooding hazards to some homes in the low flood plain of the Carmel River valley adjacent to the Carmel Lagoon. The sand bar blocking the river mouth was mechanically breached but waves subsequently closed the breach and by that time, because of overtopping waves and tides, it was too dangerous for personnel to go out into the breach area. Some minor property flooding did occur to some private residences before another breach was possible (Gray 2001).

Management of the Carmel River Lagoon is under much scrutiny at the moment. There is even pending litigation from local residents who are concerned that their properties are not being adequately protected from flooding (Weeks 2001). The Monterey County Water Resources Agency submitted a coastal development permit application for breaching of the Carmel River mouth to the Coastal Commission in December 2000. This permit has not been completed and brought to hearing yet, so any findings on this application are still pending.

A draft river and lagoon management plan entitled Carmel River Lagoon: Enhancement and Management Plan: Conceptual Design Report was circulated in the fall of 1999 for review by agencies, but again no final version of this document has been adopted (Bell 2001). Despite the existence of this permit application and draft management plan there is no officially accepted plan for how to conduct breaching at the Carmel River mouth. In spite of the incomplete nature of these documents, since they are the closest example to planning documents for this location, and they are publicly available, they will be evaluated here.

CHAPTER 3

METHODOLOGY

This study of coastal river mouth breaching in the Monterey Bay region was conducted using quantitative and qualitative analysis of a survey of agency personnel involved in breaching, and analysis of existing documents related to breaching in the Monterey Bay area as well as discussions with responsible agency personnel. Quantitative analysis of survey results was performed using Statistical Package for Social Science (SPSS) software.

Study Sites

Besides their pertinent individual physical characteristics, the San Lorenzo, Pajaro, and Carmel River mouths were chosen for this research because they demonstrated both geographical and jurisdictional unity. All are located in the Monterey Bay region, and all are within the jurisdiction of a single regional office of the CCC, CDFG, USCOE, USFWS, USEPA, and RWQCB. In addition, all three locations border the Monterey Bay National Marine Sanctuary (MBNMS). These sites were also selected based on the historical and continuing issuance of coastal river mouth breaching permits or emergency permits for activities at these locations.

These locations were also good candidates for this study because they all have river and/or lagoon management plans associated with them. These plans provided good

background data on the existing environment and history of these sites. Analysis of coastal river mouth breaching activities at these locations provided a representative view of the overlapping and complex issues involved in coastal river mouth breaching.

Study Design

The methods of information gathering for this research consisted of conducting a survey of coastal zone managers, and locating and analyzing existing documentation on coastal river mouth breaching at the study sites. The survey contained both closed-end and open-end questions. Employing both of these methods allowed for a strong quantitative analysis while leaving room for the introduction of new, and perhaps vital information that would be unavailable using closed end questions (Orlich 1978). Certain assumptions were made when conducting this survey research in order to render the resulting data reliable: 1) the information provided by respondents was assumed to be accurate to the best of the knowledge of survey respondents, and 2) the researcher interpreted answers and information correctly.

The agencies participating in this survey were selected due to their prior involvement and expressed interest in conducting or regulating coastal river mouth breaching. Sixty survey participants were solicited for this study. These coastal resource managers are separated into two groups of thirty respondents for the purposes of this study.

One of these groups consists of thirty coastal resource managers who are responsible for planning and conducting breaching and river mouth management activities. For the purposes of this study that group will be referred to as “managers.” These managers

mainly consist of local City and County staff that have jurisdiction over and responsibility for the river mouths and coastal lagoons within their jurisdiction.

The other group of thirty respondents will be referred to as “regulators.” This other group consists of those resource agency staff responsible for planning, regulating, and monitoring breaching and other river mouth management activities. These regulators are representatives of regulatory agencies who have more of a regional, or even statewide responsibility for enforcing a specific law or set of laws pertaining to river mouth management than the “managers” who are focused on local management issues. These regulators are responsible for permitting breaching and river mouth management activities in the Monterey area as well as surrounding areas.

Both of these groups of respondents were identified by the inclusion of their names in plans, permits, or studies involving river mouth breaching in the Monterey Bay area, or by contacting responsible agencies and inquiring as to the staff who are directly responsible for breaching or river mouth management for the study sites within the study area. Phone calls were made to each of the involved agencies and to most of the personnel who participated in this research to ensure that the correct agency representatives were included. Table 1 displays the agencies that participated in this study.

Survey design. The survey (Appendix A) used in this research had questions designed to obtain information necessary to accomplish the objectives of this study.

Following is a list of the different survey item’s goals:

- Questions on the first page of the survey were designed to investigate what coastal river mouth managers and regulators felt are essential issues to consider when planning or conducting coastal river mouth breaching, and asked respondents to rank the importance of the issues listed. These items allowed survey respondents to indicate if an issue is essential to consider when planning or conducting breaching, to list these issues in order of importance, and to add additional issues to the table.
- Questions on the top of the second page of the survey were designed to investigate the goals of different agencies in planning, regulating, and conducting coastal river mouth breaching.
- Questions on the bottom of page 2 of the survey were designed to investigate whether coastal river mouth breaching is a successful river mouth management strategy. Survey respondents could rate how successful breaching is in meeting the goals of their agencies and could add comments to augment their evaluation.
- The questions on the third page of the survey were designed to investigate if different coastal river mouth breaching alternatives were effective in meeting their agencies goals, as well as solicit alternative methods. These questions allowed respondents to indicate how successful different methods of breaching were, add information about additional methods of breaching, and provide comments on these methods.
- The question on top of the last page of the survey was designed to investigate whether the goals of managers and regulators towards river mouth breaching were compatible, and to elicit their opinions on compatibility issues.

- The last survey question provided information on what job classification the survey respondent's hold, offering insight into the types of professionals within these agencies that were conveying their opinions on these coastal river mouth breaching issues.

Closed-end survey questions. Closed-end questions have several advantages. One is that the set of answers is uniform and presents an easy comparison between categories. Closed-end questions can also be analyzed rapidly and described in a succinct format such as a table, chart, or graph. This type of question tends to make the intent clearer so those respondents who may otherwise be unclear about their response can be enlightened as to its intent by the answer categories (Rea 1992).

Along with these advantages, closed-end questions also have some disadvantages. There is the possibility that a respondent may be unclear about a response and answer randomly to move on with the survey. This problem has been addressed by including a "don't know" category in all appropriate questions so that a respondent does not feel inclined to fill in an erroneous response. Closed-end responses limit how specific respondents may be because they are forced to respond with the closest answer instead of being allowed more precision. This problem is addressed in this study by providing a space for comments after each appropriate question. This type of venting open-end question attached to a closed-end question allows the surveyor the advantages of collecting a response to a closed-end question while capturing any additional pertinent information (Rea 1992).

Open-end survey questions. To evaluate agency goals regarding coastal river mouth breaching and the compatibility of those goals, a subjective analysis was employed on survey items 14 and 15. These questions were designed to allow for the variety of responses expected from the various agencies involved. This format does present problems because of the necessarily qualitative analysis conducted on open-end survey data (Orlich 1978). This format is also problematic in that statistical analysis of this information requires some data standardization. This process entails the interpretative, subjective, and time-consuming categorization of open-ended responses (Rea 1992). This method was deemed valid and necessary because it provided a format where agency staff can describe their agency goals, or shed light on unofficial practices and policy related to coastal river mouth breaching without being hindered by the constraints of a closed-end survey (Vilades 1982).

Data Collection and Preparation

The primary instrumentation to collect data for this research was an investigative survey (Appendix 1). Additional instrumentation used in answering the survey included mailed interview surveys, personal interviews, and telephone interviews.

Data collection was conducted in the following manner:

- 1) Telephone calls and electronically transmitted (email) communications were conducted to request participation in the survey by people responsible for conducting and regulating breaching.

- 2) Mailed letters, personal interviews, and telephone interviews were used to elicit responses from the questionnaire recipients on the remaining unanswered questions.
- 3) Multiple efforts were made to have each potential respondent complete the survey.
- 4) A letter requesting completion of unanswered responses to the questions was mailed to survey participants who did not respond in a timely manner.
- 5) If no response was forthcoming, then a follow up telephone call, electronic transmission, or letter was submitted to verify the accuracy of the information compiled during data collection.

This data collection process focused on obtaining responses to the investigative questions listed in the survey. Identical survey questions were posed to all agency participants, regardless of the manner in which they were solicited. Personal interviews, and telephone interviews were phrased in as similar a manner as possible. These steps ensured the validity, reliability, repeatability, and objectivity of this research (Orlich 1978). The identity of all respondents will be held as confidential unless permission is granted in writing to directly quote survey participants responses.

Data Analysis

The survey responses obtained from agency personnel and analysis of existing documents provided the necessary components for analysis. Data acquired from the survey was utilized to answer the five questions listed in the “Objectives” section of this thesis as completely and accurately as possible. Closed-end questions were analyzed using quantitative methods. Open-end questions were analyzed with qualitative criteria

leading to quantitative analysis where possible. Those answers that could not be qualitatively categorized were explained in accompanying text.

The quantitative data was analyzed with SPSS statistical analysis software to evaluate results of this survey. Statistical analysis included evaluation of mean, median, and standard deviation of responses. This software was also used to compare the frequency, adjusted frequency, and cumulative frequency of responses by the three groups of all respondents, managers, and regulators. Frequency plots such as histograms or bar charts were used to display the data.

These survey results were then compared with a qualitative analysis of existing plans, policies, permits and other existing documentation of the historical and current management and regulation of river mouth breaching. This qualitative assessment revealed how the results of this survey reflect the actual conduct of agencies in planning, conducting and permitting river mouth breaching at these locations.

CHAPTER 4

RESULTS

This chapter is intended to report the results of data gathering in answering the questions posed in this study. The data described here is analyzed in the conclusions and recommendations of the final chapter of this study.

A total of 60 surveys were mailed out for this study. Of that number half were sent to personnel working for agencies that plan and conduct breaching activities, referred to here as “managers”, and the other half were sent to personnel working for agencies who regulate coastal river mouth breaching, referred to here as “regulators.” Personnel from 18 different city, county, state, and federal agencies responded to the survey. A list of all the agencies with personnel that responded to this survey is located in Table 1.

A total of 47 responses to the survey were received. Of these responses 22 came from managers and 25 were completed by regulators. Details on the specific response rates to each question are included in the following text.

For the purposes of this analysis the respondents have been segregated into three groups. The first group consists of all the respondents to the survey. The second group consists of only those responses from agencies that plan and conduct breaching, or “managers.” The third group consists of those respondents representing agencies who regulate breaching activities, or “regulators.”

Twelve documents pertaining to planning, permitting, and conducting coastal river mouth breaching were analyzed to provide qualitative case studies of the study sites. Four of the documents were selected for review on each of the three study sites of the San Lorenzo River, the Pajaro River, and the Carmel River. Whenever possible agency staff responsible for planning and conducting breaching were contacted to corroborate the information found in these documents or supply additional undocumented information needed to answer the questions of this study.

Essential Issues to Consider When Breaching

To evaluate the essential issues to consider when breaching, the first page of the survey (Appendix A) contained a table listing various breaching issues and asked respondents to mark whether or not they consider those issues essential to consider when planning and conducting coastal river mouth breaching. In the same table a question was also posed asking respondents to rank those items they listed as essential in order of their importance. The final request for information in this table was for written comments on any of the information provided above. Within the context of this study, an issue is described as a coastal river mouth breaching matter or point of concern that may require management.

Essential breaching issues. All 47 respondents completed the survey request to mark which issues are essential to consider when planning and conducting breaching activities. The data from the group consisting of all respondents was first analyzed and then the data for the manager and regulator groups. Statistical analysis of the data

represented in Table 2 exhibits the frequency, and percent of responses by the group of all respondents, the group of managers, and by the group of regulators.

Figure 14 displays in graphical form the percentage of all the respondents that felt the issues provided were essential to consider when breaching. In this figure the results displayed for all respondents reflects the weighted percentage of responses in order to provide an equal representation of the sub-groups of managers and regulators. The weighted responses from all respondents resulted in listing the issues as the most essential in the descending order of: 1) flooding, 2) public safety, 3) endangered species, 4) public health, with 5) monitoring and habitat sharing equal importance, 6) wildlife, 7) water quality, 8) mitigation, and finally 9) access and recreation.

The data from the manager group in Table 2 exhibits results listing flooding and public safety as equally essential, followed by endangered species, public health, habitat and wildlife sharing equal importance. Monitoring, water quality, access and recreation, and mitigation were at the end of the list. As shown in Table 2, the group of regulators had different results. These respondents reported endangered species as the most essential item, with all of them listing this issue as essential. This is followed by flooding and monitoring ranked equally, habitat and public safety ranked equally, wildlife and public health ranked equally, mitigation and water quality ranked equally, and with access and recreation ranked the least essential.

Ranking the importance of breaching issues. Out of the forty-seven survey participants, forty-five responded to the survey question asking respondents to rank which issues are most important to consider when planning or conducting breaching.

There were twenty-one responses from personnel representing agencies that perform breaching, and twenty-one responses from personnel representing agencies that regulate breaching.

Table 3 displays the frequency of importance ranking for each issue and the mean, median, mode, and standard deviation of responses from all of the respondents. Table 4 displays the same statistics for managers, and Table 5 displays those from regulator respondents.

Table 6 provides a comparison of the importance ranking of these breaching issues by the three groups of all respondents, managers, and the regulators. The group of all respondents listed these issues in descending order of importance as: public safety, endangered species, flooding, public health, habitat, wildlife, water quality, monitoring, mitigation, and finally access and recreation.

A comparison of the order in which different groups listed breaching issues as essential, versus the order of importance ranking that the groups provided is depicted in Table 7. To more clearly depict the differences in manager and regulator responses, Figures 15 through 24 contain histograms comparing how the managers versus regulators ranked the ten individual essential issues. These histograms provide a visual depiction of the quantity of respondents that ranked each issue at different levels. These histograms also contain an overlay of a normal curve that indicates where the mean and distribution are in each data set.

The manager group listed these issues in descending order of importance as: public safety, endangered species, flooding, public health, habitat, wildlife, water quality,

monitoring, access and recreation, and mitigation. The regulator group listed these issues in descending order of importance as: endangered species, public safety, flooding, wildlife, habitat, public health, water quality, monitoring, mitigation, and access and recreation.

Survey comment results from essential issues and importance ranking. Tables 2 through 7 provide detailed statistical results of the survey regarding responses to questions about the essential issues and importance ranking of breaching issues. The following paragraphs summarize written responses that accompanied each breaching issue on the first page of the survey.

Comments about flooding stressed that it is only an issue if it affects life or property. Some also noted that agencies should demonstrate that flooding is imminent prior to breaching, and that flooding was most often stated as the reason that breaching was needed by agencies applying for breaching permits. Some agency personnel also pointed out that maintaining floodplain function is vital as long as it is practical, and that the main reason that flooding is an issue is because of encroachment of human structures onto the floodplain.

Comments about wildlife included contradictory notes from different respondents. One comment said that the time of year that breaching is conducted is not generally important to young wildlife; however the only other comment on this issue noted that time of year is crucial to consider prior to breaching because of the habitat and migratory needs of wildlife.

Comments on endangered species noted that planning for the gradual release of water from coastal lagoons can protect fisheries, and that adequate river flow during different seasons should be a goal of all breaching activities. It was also noted that poorly planned breaching could affect steelhead trout, and that evaluation of endangered species should take into consideration animals other than fish such as the snowy plover, red legged frog, and sand gilia. The only comment about habitat was that any planning for breaching and endangered species should take into account the entire riparian system, not just the river mouth and lagoon.

A recurring comment about public safety was that regardless of other purposes, public safety should always be the number one priority in planning and conducting breaching. This was backed up by the assertion that the agency performing breaching must demonstrate that there is a threat to public safety prior to breaching. It was also noted that water quality, currents, and uneven lagoon bottoms are potential safety hazards, and that public safety should include signs and perhaps even guards to ensure safety throughout any breaching activities. Comments on public health noted that the agency performing breaching should demonstrate that there is a threat to public health prior to breaching. It was also noted that shallow lagoons might encourage wading, that water in lagoons at river mouths can be high in e. coli bacteria, and that these waters may be a hepatitis hazard.

Water quality was mentioned as secondary to public health and safety but closely linked. Multiple comments stated that the effect of nutrient inputs on water quality should be evaluated prior to breaching. It was also noted that, depending on the location,

breaching should be evaluated as a possible discharge but the comment did not elaborate on what kind of discharge.

Regarding access and recreation, comments noted that berms across river mouths are seasonal at best, and a remark was made that access for public safety and lifeguard response should be considered prior to breaching. One respondent noted that breaching does not impact recreation; however, another stated that access across public beaches may be hampered by lagoon flooding, and that it may be in the interest of better coastal access to conduct breaching in some circumstances in order to enhance access.

Multiple comments about monitoring noted that agencies need more data on lagoon conditions before, during, and after breaching, and that there should be on-going monitoring to properly perform breaching. One respondent noted that monitoring is critical to understanding when and how to breach. Another noted that, in their opinion, monitoring is not really essential but is still required for management of other issues. There were no comments specific to mitigation.

Additional essential issues provided by respondents. Three respondents provided additional essential issues that were not listed in the survey but may serve to shed additional light on this subject. These responses exhibit the advantage of providing open-ended questions when conducting a survey on a poorly documented field such as coastal river mouth breaching. One of the respondents suggested that the safety of personnel conducting breaching activities should be considered. Another respondent noted that alternatives to both breaching and a chosen method of breaching should be

considered. Still another mentioned that the impact of breaching on aesthetics should be considered.

Another issue raised was the possibility of a contaminant release. A respondent expressed concern that releasing contaminated sediments into the ocean and resulting contaminated sediment suspension in the water column is a potential undesirable consequence of breaching. Although these issues were not provided in the survey regarding “essential items”, they will be included in Table 19 as possible issues to consider when planning, analyzing, and conducting river mouth breaching activities.

Success of Breaching at Study Sites

To investigate the question about how successful breaching at different locations is in meeting the goals of the respondent’s agencies, the second page of the survey (Appendix 1) contained a table listing the three study sites for this research. Respondents were asked to rate river mouth breaching at these locations using a number 1 through 4 to indicate their opinion of the success of river mouth breaching at meeting their agencies goals at given locations. A number 1 indicated that breaching was completely successful, 2 that breaching was partially successful, 3 that breaching was not successful, and 4 that the respondent did not know how successful breaching is at that location. An additional request for written comments was included in this table. Out of forty-seven respondents, forty-four answered these survey questions. Twenty-two of these respondents were managers and an equal number were regulators. As expected, varying

numbers of respondents answered the questions for each location. A summary of survey responses for these locations is shown in Table 8.

San Lorenzo River. As exhibited in Table 9, a total of seventeen respondents entered data for the San Lorenzo River. None of these respondents considered breaching completely successful at the San Lorenzo River, while fifteen considered breaching partially successful, and two marked breaching at this location as not successful. All eight of the manager respondents considered breaching to be partially successful at the San Lorenzo River; while seven of the regulators considered it partially successful, and two of them considered breaching not successful at that location. Figure 25 is a histogram that graphically displays how all respondents, managers, and regulators rated the success of breaching in meeting their agencies goals towards this activity at the San Lorenzo River.

In sum, this data supports the assertion that the vast majority of those personnel that know about the success of breaching at this location think that breaching is only partially successful. In chapter five there will be discussion of these results.

Pajaro River. As shown in Table 10, a total of twenty-one respondents entered data for the Pajaro River. Four of them considered breaching completely successful at meeting their agencies goals, sixteen of them considered breaching partially successful, and one of them considered breaching not successful at the Pajaro River. Four of the managers considered breaching completely successful, seven of them considered breaching partially successful, and none of them considered breaching not successful at the Pajaro River.

In contrast none of the regulators considered breaching completely successful, nine of them considered breaching partially successful, and one considered breaching not successful at meeting their agencies goals towards river mouth breaching at the Pajaro River. Figure 26 contains a histogram that graphically displays how all respondents, managers and regulators rated the success of breaching in meeting their agencies goals towards this activity at the Pajaro River.

In sum, this data shows that the vast majority thought that breaching is only partially successful at the Pajaro River mouth. It is noteworthy that none of the regulatory personnel thought that breaching at this location was completely successful while over a third of the manager respondents felt that breaching at this location is completely successful.

Carmel River. As displayed in Table 11, twenty-four respondents answered the question concerning the Carmel River. One respondent considered breaching completely successful, eighteen of them considered breaching partially successful, and five of them considered breaching not successful at this location. One of the managers considered breaching completely successful, ten of them considered it partially successful, and one of the managers considered breaching not successful at the Carmel River.

None of the regulators considered breaching completely successful, eight of them considered it partially successful, and four regulators considered breaching not successful at the Carmel River. Figure 27 contains a histogram that graphically displays how all respondents, managers and regulators rated the success of river mouth breaching in meeting their agencies goals towards this activity at the Carmel River.

In sum, this location exhibits the most negative opinion on the success of breaching of all the study sites, principally because of a large contingent of regulators who think breaching is not successful. All but two of the managers felt that breaching was partially successful while a third of the regulators felt that breaching is not successful at this site, with the other two thirds of the regulators marking breaching as partially successful. Other than the responses on the success of breaching in the Monterey Bay area, this is the only location where a manager rated current breaching practices as not successful.

Monterey Bay area. As displayed in Table 12, nineteen respondents answered the question on breaching success in the Monterey Bay Area. Only one respondent felt that breaching is completely successful in meeting their agencies goals towards breaching, sixteen felt that it is partially successful, and two felt that it is not successful. This indicates that a 90% majority of the respondents felt that throughout the Monterey Bay area breaching is only partially successful in meeting their agencies goals towards river mouth breaching. The only variation between the two groups of managers and breachers was that one manager did think breaching was completely successful and one felt that it was not successful, while none of the regulators felt that breaching in the Monterey Bay area was completely successful and one thought it was not successful.

None of the regulators felt that breaching is completely successful, nine of them considered breaching partially successful, and one felt that breaching was not successful. Figure 28 contains a histogram that graphically displays how all respondents, managers and regulators rated the success of breaching in meeting their agencies goals towards river mouth breaching in the Monterey Bay area.

In sum, this question elicited the most agreement amongst manager and regulator respondents on the success of breaching. The vast majority of respondents, sixteen out of 19 rated breaching at this location successful with one of each of the groups rating it not successful, and one manager ranking breaching in the Monterey Bay area completely successful.

Survey comments on the success of breaching. As noted above, this survey question asked respondents to provide any comments they may have on their ranking of the success of breaching at the different locations listed. These open-ended questions were solicited to allow respondents to provide additional pertinent information that was not specifically requested in the survey. Following is a summary of those comments provided by all respondents.

At the San Lorenzo River, respondents commented that the existing levee system currently provides adequate flood control. It was also noted that mechanical breaching has been successfully conducted in past years, and that on occasion breaching is sometimes done illegally by parties other than the City.

A comment was also made that the Pajaro River levee system provides flood control for the surrounding agricultural and residential areas, but not for the beach road, which is monitored by the County. One respondent noted that the County is very careful in timing breaching at this location. Other respondents had criticisms for current breaching practices at this location. One person commented that breaching is not done quickly enough as current practice seems to be that no breaching is conducted if even a small trickle of water can exit the river mouth. They noted that this may have adverse impacts

on young wildlife, particularly in nesting areas affected by the lagoon. Another respondent noted that breaching at this location is not meeting NMFS goals to protect endangered species, specifically steelhead trout, and still another said that concern for the discharge of contaminants does not appear to be integral to breaching practices at this location.

Regarding the Carmel River, a respondent commented that breaching has been successful in minimizing flooding of residences near the Carmel Lagoon, but that breaching may have adverse impacts on steelhead. A different respondent noted that threatened and endangered species are not always adequately considered, while another said that additional information is needed on the effects of breaching on the steelhead trout population, and still another noted that a past series of unpermitted breachings might have had catastrophic habitat impacts. Comments were also made that breaching is done at this location with inadequate coordination between regulatory agencies, and that coordination of breaching of the Carmel River Mouth is too often left until breaching becomes an emergency issue.

Comments on the Monterey Bay area noted that what partial success there has been in this area is limited to flood control. It was pointed out that in the absence of individual stream management plans that lay out all the requirements for breaching, some type of general protocol is needed. It was also noted that currently breaching in the Monterey Bay area is very haphazard both in terms of breaching practices and regulatory response.

In sum, these survey results exhibited consistency in the response of managers and regulators to the questions on the success of breaching at the San Lorenzo, Pajaro, and

Carmel Rivers and the Monterey Bay area. The overwhelming response from both groups is that breaching is partially successful, but there were disparities in these opinions. For the San Lorenzo River twenty-two percent of the regulators rated breaching as not successful while none of the managers did. At the Pajaro River thirty-six percent of the managers rated breaching as completely successful, while none of the regulators did. For the Carmel River thirty-three percent of the regulators rated breaching as not successful compared to only eight percent of the managers. As for the Monterey Bay area, results were almost identical with the difference being that one manager considered breaching completely successful in this area compared to no regulators making that evaluation.

Effectiveness of Breaching

To explore the question of how effective different breaching methods are in accomplishing the goals of the agencies polled in this study, the third page of the survey (Appendix A) contains a table listing five methods of breaching. Respondents were asked to rate the effectiveness of these different breaching methods in meeting the goals of their agencies towards breaching. A number one indicated that the method was completely effective in meeting their agencies goals, a two indicated that the method is partially effective, a three indicated that the method was not effective, and a number four indicated that the respondent did not know how effective that method of breaching was at meeting their agencies goals towards breaching.

An additional request for information in this table was for written comments on any of these locations or their response. Out of forty-seven respondents, forty-four answered these survey questions. Twenty-two of these respondents were managers and an equal number were regulators. As expected, varying numbers of respondents answered the questions for each location. A summary of survey responses for the effectiveness of all these locations is depicted in Table 13.

Manual breaching. In the context of this study manual breaching is considered opening up a sand bar or other barrier barring a coastal lagoon or river from releasing into the ocean using hand tools or other manual means. As shown in Table 14, a total of thirty-six of the forty-four respondents answered the question on the effectiveness of manual breaching. Two of the respondents considered manual breaching completely effective at meeting their agencies goals towards river mouth breaching, twenty-four of them considered it partially effective, and ten thought that manual breaching was not an effective method of meeting their agencies goals towards river mouth breaching.

Of the managers, none expressed the opinion that manual breaching was completely effective, twelve considered it partially effective, and five thought that manual breaching was not effective. Two of the regulators considered manual breaching completely effective, twelve thought it was partially effective, and five found manual breaching not effective. Figure 29 contains a histogram that graphically displays how all respondents, managers and regulators rated the effectiveness of manual breaching in meeting their agencies goals towards river mouth management.

In sum, there was very little variation in response between managers and regulators on this question. The only significant variation was that ten percent of the regulators rated manual breaching as completely successful in meeting their agencies river mouth management goals, while none of the managers considered it so.

Mechanical breaching. In the context of this study mechanical breaching is considered opening up a sand bar or other barrier using motorized equipment such as a backhoe, tractor, or loader. As shown in Table 15, forty-one of the forty-seven respondents answered the question on the effectiveness of mechanical breaching in meeting agencies river mouth management goals. Eleven respondents considered mechanical breaching a completely effective method, twenty-six felt that it was partially effective, and one felt it was not effective. Out of the nineteen managers who responded, six felt that this was a completely effective method of breaching, thirteen considered it partially effective and none of them thought that mechanical breaching was not effective.

Of the nineteen regulators who responded to this question, five felt that mechanical breaching was completely effective, thirteen consider it partially effective, and one found it not effective. Figure 30 contains a histogram that graphically displays how all respondents, managers and regulators rated the effectiveness of mechanical breaching in meeting their agencies river mouth management goals.

To summarize, there is little variation between manager and regulator responses on the effectiveness of mechanical breaching. The only significant variation is that five percent of the regulators, just one respondent, felt that mechanical breaching is not an effective method of meeting their agencies river mouth management goals.

Temporary water level control devices (WLCD). As depicted in Table 16, a total of twelve respondents replied to the question on the effectiveness of the use of a temporary water level control device as an effective of meeting their agencies river mouth management goals. Of these, one considered this a completely effective method of breaching, eight thought it was partially effective, and three considered it not effective. Of the managers who responded, one thought this was completely effective, three considered it partially effective, and three rated it as not effective at meeting their agencies river mouth management goals .

None of the regulator respondents considered a temporary WLCD a completely effective method, five of them thought it partially effective, and none of them considered it not effective. Figure 31 contains a histogram that graphically displays how all respondents, managers, and regulators rated the effectiveness of the use of a temporary water level control device for breaching in meeting their agencies goals towards river mouth breaching.

In sum, there was a great variation in manager versus regulator response on the effectiveness of a temporary water level control device as a means of breaching management. While the regulators were unanimous in rating this method as only partially successful, the managers were split on their opinion of this device with fourteen percent rating it completely successful, and the remainder of managers split their opinion between this device being partially successful and not successful in meeting their agencies river mouth management goals. It should be noted that there was a very low response to this question, the lowest response to any question in the survey. There also

is no known example of this type of device being utilized in this area so this data should be considered very speculative.

Permanent water level control devices (WLCD). As depicted in Table 17, a total of fifteen respondents replied to the question on the effectiveness of the use of a permanent water level control device as an effective method of meeting their agencies river mouth management goals. Of these, eight considered this a completely effective method of breaching, four thought it was partially effective, and three considered it not effective. Of the managers who responded, two thought this was a completely effective method of breaching, two considered it partially effective, and three rated it as not effective in meeting their agencies river mouth management goals.

Six of the regulator respondents considered the use of a permanent WLCD a completely effective method, two of them thought it was partially effective, and none of them considered it not effective. Figure 32 contains a histogram that graphically displays how all respondents, managers, and regulators rated the effectiveness of the use of a permanent water level control device for breaching in meeting their agencies goals towards river mouth breaching.

Again there was a great variation in manager versus regulator response on the effectiveness of a temporary water level control device as a means of breaching management. Seventy-five percent of the regulator respondents ranked this method as completely successful, with the rest of them ranking it partially successful. This compared to only twenty eight percent of the managers who thought this method of breaching management is completely successful in meeting their agencies river mouth

management goals, with another twenty-eight percent rating this method partially successful. Unlike the regulators, the largest number of managers, forty-two percent, felt that permanent water level control devices are not successful in meeting their agencies river mouth management goals. It should be noted that out of all the methods of breaching evaluated here, this method received the highest percentage of respondents ranking it as completely effective, with a total of fifty-three percent.

Natural breaching. As shown in Table 18, forty out of the forty-four respondents answered the question on the effectiveness of natural breaching in meeting their agencies river mouth management goals. Eight of the respondents considered natural breaching completely effective at this location, twenty-two of them considered it partially effective, and ten thought that natural breaching was not an effective means of breaching. Of the managers, four expressed the opinion that manual breaching was completely effective, nine considered it partially effective, and six thought that natural breaching was not effective in meeting their agencies river mouth management goals.

Four of the regulators considered manual breaching completely effective, thirteen thought it was partially effective, and four found natural breaching not effective. Figure 33 contains a histogram that graphically displays how all respondents, managers, and regulators rated the effectiveness of natural breaching in meeting their agencies goals towards river mouth breaching.

The effectiveness of this method earned a mixed review from both managers and regulators. The majority of both groups, forty-seven percent of the managers and sixty-one percent of the regulators, felt that natural breaching is partially effective in meeting

their agencies river mouth management goals. There was a slight variation in the split of the remaining respondents with twenty-one percent of the managers considering this method completely effective and the other thirty-one percent considering it not effective. The remaining regulators were split evenly with nineteen percent responding that this method is effective and another nineteen percent responding that it is not effective in meeting their agencies river mouth management goals.

In sum, there are some large variations in opinion both in differences between the survey groups, and agreement amongst the groups on the effectiveness of these five methods of breaching management. Overall the use of a permanent water level control device received the highest cumulative percentage, fifty three percent, of respondents ranking it as completely effective. There was a noticeable difference between the manager and regulator views on this method with regulators preferring this method, but managers preferring mechanical breaching.

Survey comments on the effectiveness of various breaching methods. As noted above, the survey requested that respondents add any comments they may have on their rating of the effectiveness of the various breaching methods provided.

Some of the comments on manual breaching acknowledged the limitations of this method. According to these respondents, manual breaching can be slow or ineffective depending on the volume of berm that needs to be removed to open a channel, and sometimes a sand berm and river mouth area are far too wide to even consider manual breaching. Another constraint cited was that this method can be time consuming, and it is even possible that a manual breach could get out of control. Some positive comments

on this method of breaching were that manual breaching can be done after initial mechanized breaching to fine-tune the breach. It was also noted that since this method is less intrusive it can take into account the location of endangered species and possibly avoid or reduce the impact to them or their habitat.

A cautionary note on mechanical breaching warned that once the river channel is breached it might rapidly erode sand, potentially trapping an inexperienced machine operator. Another respondent noted that breaching may entirely empty the Carmel River Lagoon before juvenile fish are prepared to leave, and that lower water levels also reduce the amount of deep water habitat for aquatic species. However, more positive comments noted that mechanical breaching can be effective if done correctly, and if resources are kept at hand to close the breach if necessary.

Comments on the use of temporary water level control devices noted that this method can facilitate flow with minimal staff, but it is only effective if the control device is designed for the appropriate water volume to be encountered. Another respondent stated that the use of this method is preferred to episodic breaches because it provides better habitat protection.

Pertaining to the use of permanent water level control devices, comments indicated this method is only effective at the appropriate water volumes, and flow rates may potentially exceed the tolerance of a permanent device. They also noted that in some locations there is no feasible site for pumps, check dams, or other design features that may be necessary for a permanent structure of this nature. Some positive comments

pointed out that since the use of a permanent water control device allows maximum flexibility for managing flows to the sea, it might also be preferable in protecting habitat.

By far the predominant comment on natural breaching is that this is the preferable method of breaching whenever possible. Six respondents made this comment. There were, however, some qualifications included with this statement. It was pointed out that there may be competing regulatory issues regarding taking no action and allowing a natural breach to occur. It was also noted that natural breaching would probably take a back seat to human induced breaching methods as long as people develop on the adjacent floodplains, or negatively impact the water quality of the lagoon.

Several limitations on natural breaching that were raised pointed out that if a lagoon breaches too early it could re-form in a poor location. Another comment was made that flooding problems may also occur because of sand bar elevation changes. A respondent also commented that there could be problems with deposits of kelp and other materials that decompose in the lagoon causing anaerobic conditions. One respondent categorically stated that natural breaching is unsuccessful because of flooding, public safety, and public health issues.

Additional methods of river mouth breaching. Only one respondent offered an additional method of river mouth breaching that was not included in the survey. They noted that part of the Carmel River breaching issue is a result of upstream dam release of water. They contended that upstream discharges could be considered a method of breaching control because the amount of dam flow volume released can often determine whether a “natural” breach will occur. They also pointed out that the decision could be

made to impound water behind a dam allowing a low-volume release over a period of time as opposed to allowing a sudden, rapid release of water that can cause a controlled breach.

Compatibility of Agency Goals Towards Coastal River Mouth Breaching

Two different questions were posed in the survey to investigate the question on what the goals of agencies responsible for breaching and regulating are and if those goals are compatible (Appendix 1). Further insight into the compatibility of agency goals will utilize information from some of the other questions in this survey. That data and its ramifications are addressed in the discussion section of this study. Agency goals are differentiated from essential issues discussed earlier in that the goals represent agencies objectives or desired end in management policy aimed at addressing an issue. An essential issue, on the other hand, is the point or matter in question for which a goal is intended to resolve.

Agency goals. To determine the goals of agencies involved in planning and conducting coastal river mouth breaching, and the goals of the agencies that regulate breaching, the second page of the survey asked the respondents to list their agencies goals regarding river mouth breaching. Table 19 provides a listing of all the agency goals provided by respondents and the frequency of those responses.

Thirty-four of the forty-seven respondents answered this question. Eighteen of the managers responded and sixteen regulators answered this question with varying degrees of detail. These respondents provided ninety-four individual responses in twenty agency

goal categories. A remarkable difference was noted in the response of managers versus regulators on the issue of flooding. Eight of the managers marked prevention of flooding as an agency goal, whereas only one of the regulators marked prevention of flooding as their agencies goal towards breaching. A similarity of response was notable from managers and regulators regarding those agency goals pertaining to public safety, public health, and promoting natural breaching.

The eighteen managers that answered this question provided thirty-four individual responses in twelve different goal categories. A greater emphasis was placed by manager respondents on agency goals pertaining to monitoring, protecting worker safety, and allowing the continued operation of reservoirs.

The sixteen regulators who answered this question gave a total of sixty responses in nineteen different agency goal categories. Regulator respondents placed greater emphasis on those agency goals that pertain to wildlife, endangered species, habitat, water quality, public access, mitigation, alternatives analysis, and proper regulatory clearance for breaching activities.

Compatibility of manager and regulator goals towards breaching. In order to determine if the goals of agencies who plan and conduct breaching and those who regulate this activity are compatible, the survey (Appendix A) asked respondents to indicate if they felt that their goals were compatible, and to explain why they held this position. A list of the positions held by all respondents is shown in Table 20.

A total of thirty-three of the forty-seven respondents addressed the question on the compatibility of manager versus regulator compatibility. Table 21 displays the

responses to this question. Of all thirty-three respondents, twenty-four had a negative response to this question indicating that they felt the goals of breaching and regulating agencies are not compatible regarding coastal river mouth breaching. Eight of these respondents that answered negatively qualified their remarks by noting they did not feel this was always the case, but that the goals of these agencies were more often not compatible than compatible. The other nine respondents made positive comments that they felt manager and regulator goals towards breaching are compatible. Eight of these respondents qualified their responses by noting that they did not feel that the goals of managers and regulators was always compatible, but that they were more often compatible than not compatible.

In summary, if we group these responses into negative, qualified, and positive responses there are sixteen negative responses, sixteen qualified responses, and one positive response, with the qualified responses split evenly between negatives and positives.

In response to the request to explain why respondents felt that the goals of managers and regulators were compatible or not, there were seventy replies made in nineteen different goal categories. The seventeen respondents who felt the goals of managers and regulators towards breaching are compatible provided fifteen replies in six goal categories. These respondents felt that the agencies goals were compatible regarding flooding, property protection, wildlife, endangered species, and habitat and water quality.

The reasons why respondents felt that these goals were incompatible are listed in Table 22, and the reasons why respondents thought their goals were compatible are listed

in Table 23. The fourteen managers and ten regulators who replied negatively made fifty-five comments in thirteen different goal categories. These respondents felt that goals of managers and regulators are not compatible because managers place greater emphasis on flood control, protecting property, public safety, public health, and public access. This group also felt that the goals of managers and regulators are not compatible because regulators place greater emphasis on wildlife, endangered species, habitat, monitoring, the natural environment as a whole, and are narrowly focused upon their singular agency responsibilities at the expense of other management issues.

Comments provided by respondents about agency goals and their compatibility.

Some of the respondents commented about issues that were not readily integrated into the specific categories of reasons for compatibility or incompatibility listed in Tables 22, and 23 respectively. The following issues are more general comments not aimed at specific reasons or issues that cause these circumstances.

Some of these respondents commented that breaching is often conducted as an emergency measure. One noted that environmental issues might not be adequately considered by a public works agency when rising water is at or near flood stage during an unanticipated event. Another expressed the opinion that in most cases, breaching occurs as a last effort in the management process. Regulators only come into this situation after the fact, and have little power to impact actual breaching. According to another respondent, once breaching has occurred, there is little that agencies can do to improve management of breaching.

Many of the respondents commented that greater coordination is needed among all of the agencies involved in planning, conducting, and regulating coastal river mouth breaching. It was noted that even regulatory agencies with similar mandates might have widely different opinions on any particular breaching issue at a given location. Others noted that planning, development of consistent goals, individual management plans, and a general breaching protocol would provide for consistent permitting and avoidance of the delays that cause breaching to be dealt with as an emergency. Others noted that the problem is not so much incompatible goals as different prioritization of goals.

Still other respondents expressed a need for more funding and study of this issue to better understand how to balance the many issues at stake when breaching. Adequate funding for river mouth management programs within local agencies was noted as a need as well as additional resources and guidance from regulatory agencies concerning the specific regulatory requirements for the coastal river mouth environment. Finally, guidance in dealing with endangered species and the role of lagoons as rearing habitats was requested by one regulator.

Analysis of Existing Breaching Documents

Because there are so few examples of academic or professional articles addressing the issue of coastal river mouth breaching, the best source of information for planning and conducting this activity are the planning documents, policies, permits, and other associated sources of information on breaching as it pertains to these study sites.

Another source of information that helped confirm the current status of information on

this topic is the agency personnel who are responsible for planning, conducting and regulating breaching in the study site jurisdictions.

The following analysis of existing agency documents that address coastal river mouth breaching included investigation of how the ten basic breaching issues investigated on page one of the survey are dealt with. This analysis has also attempted to determine whether the goals of managers and regulators are compatible towards river mouth breaching, the extent of breaching success at these locations, and whether there is indication of the effectiveness of any particular method of river mouth breaching at the three study sites or in the Monterey Bay area.

The nature of these documents does not allow for analysis of the success of breaching, or the compatibility of manager and regulator goals towards breaching. In some other documents it is possible to evaluate methods of breaching that are considered effective, agency goals, or the issues that are considered important to the agencies that produced the documents, but in others this is not possible. Therefore in the following analysis of existing documents only those items that can clearly demonstrate data pertinent to the objectives of this study will be addressed and discussed.

It should be noted that since the format and purpose of these documents were for management of breaching activities and not intended to answer these specific questions they may, or may not, provide answers to the questions posed by this research. For example, a staff report by one agency is unlikely to reflect that agencies collective view on river mouth management, but rather addresses specific issues in the context of the individual project that is being analyzed. Such a staff report also cannot be construed to

represent the views of any other agency towards that location or issue as it would have been written solely for the purposes of the parent agency.

Analysis of documents and agency staff consultation on the San Lorenzo River mouth. The San Lorenzo River Mouth is unique since in 1992 the City of Santa Cruz officially adopted a policy of not artificially breaching the river mouth, thereby allowing natural conditions to prevail. Because of this official no breaching policy, all of the documents directly related to breaching precede that date.

There is a new draft document entitled “Lower San Lorenzo River and Lagoon Management Plan” currently being developed by the City of Santa Cruz Redevelopment Agency. When completed this document may be used to direct the City’s management of the San Lorenzo River and lagoon. This document will undergo review by a City designated San Lorenzo River Task Force. It will then be reviewed and edited per outside agency personnel, and adoption by the Santa Cruz City Council, at which time an environmental document to validate its use will be conducted and it will be made available to the public (Meyers 2001).

The issues that were considered in all of the four documents analyzed for this location are displayed in Table 24. The first document for analysis in this work is a California Coastal Commission staff report written in March, 1992 presenting the Commission’s findings on coastal development permit application #3-92-15 submitted by the City of Santa Cruz for installation of a water level control device at the mouth of the San Lorenzo River. The City’s goals in proposing this device included prevention of flooding and the protection of marine resources, notably maintaining acceptable steelhead

trout habitat. The Coastal Commission's recommendations on this permit application signify the Commission's interest in controlling flooding, protecting lagoon habitat, monitoring of breaching, public safety, and proper permitting by the U.S. Army Corps of Engineers (CCC 1992).

The proposal of a water level control device at this location indicates that the parties involved felt that this method of river mouth management would be at least partially successful in meeting the needs of river mouth managers at this location. Since this proposed water level control device had not been implemented yet, the real effectiveness of this method of managing the lagoon water level is unknown. Despite this, the City of Santa Cruz and the Coastal Conservancy were optimistic that this method of breaching would prove effective. The historical method of conducting mechanical breaching at the San Lorenzo River Mouth was deemed not effective in this document by both the City and the Coastal Commission (CCC 1992).

The second document analyzed here is titled "Criteria for breaching of the San Lorenzo River mouth as an element of the water surface elevation control project." It was written just prior to the City adopting their policy of not breaching at this location, thereby allowing natural breaching processes to prevail (City of Santa Cruz Department of Public Works 1987). The breaching goals of the City as represented in this work include control of flooding, protecting public safety, public health, habitat, water quality, and monitoring water levels in the lagoon (City of Santa Cruz 1992).

The third document analyzed is a U.S. Army Corps of Engineers permit for installation of the water level control device at the mouth of the San Lorenzo River. The

breaching goals detailed in this document include flood control, monitoring, maintaining water quality, habitat protection, and appropriate permitting by USFWS and CDFG (USCOE 1992).

The fourth document analyzed is an emergency permit issued by the California Coastal Commission in November of 1992. This permit was issued for emergency breaching of the San Lorenzo River mouth and subsequent plugging of the breach with sand. The goals of breaching presented in this document are to prevent street flooding, and to protect public health, property, and public services. It also stresses the need for breaching to maintain water oxygen levels for protection of wildlife.

The City of Santa Cruz is drafting a planning document that deals directly with management of the San Lorenzo River Lagoon and river mouth. Unfortunately since this document has not been completed and it is not available to the public, it cannot be analyzed in this study. When this document is released it should shed additional light on the management of river mouth breaching at this location (Hall 2001).

Analysis of documents and agency staff consultation on the Pajaro River mouth.

The Pajaro River mouth is the only study site that has at one time had all of the resource agency permits necessary to conduct breaching operations. Despite this, Santa Cruz County does not currently have the proper permits to conduct breaching activities at the Pajaro River Mouth.

The issues that were considered in all of the four documents analyzed for this location are displayed in Table 25. The first document analyzed here is the 'interim criteria' plan for emergency breaching of the Pajaro River Mouth (effective April 10, 1992). The

goals expressed in these criteria are to prevent flooding of streets and utilities affected by formation of the Pajaro Lagoon in order to protect public safety and health, and to maintain access on roads affected by high water levels (County of Santa Cruz 1992).

The second document analyzed is the Pajaro River Lagoon Management Plan, produced in 1993 for the County of Santa Cruz. The County is not currently using this plan. They follow the coastal development permit that they obtained in 1998 to manage river mouth breaching. A list of the breaching issues raised in this document is shown in Table 25 (Wolcott 2001).

This management document contains goals formulated to plan management of the Pajaro River Lagoon. These include minimizing flooding, maintaining water quality, improving management of water levels in the lagoon, enhancing and protecting aquatic habitat, and protecting public health and safety. Some other goals inherent in this plan are to comply with the regulatory requirements of all concerned agencies, to recognize environmental resources that require consideration in the lagoon management plan and design enhancement plan, and to maximize acquisition of available funding from outside agencies (County of Santa Cruz 1993).

This plan describes breaching of the sand bar as only partially successful because existing breaching practices were not adequately addressing all of the breaching issues at this location. At the time this document was released, breaching had already been conducted by mechanical means. This method was found to be only partially effective because there were times of the year when it was unsafe to breach because high surf conditions endangered equipment and operators. Mechanical breaching was the only

method of breaching at the Pajaro River Mouth mentioned in this plan (County of Santa Cruz 1993).

The third document analyzed is a 1601 Streambed Alteration Permit, referred to as a Memorandum of Understanding, originally issued by the California Department of Fish and Game to the County of Santa Cruz for breaching of the Pajaro River Mouth in 1993. This document was rewritten in 1997 and approved again by the CDFG in 1997. The goals of breaching as described in this document are to prevent flooding, and monitor and control lagoon water levels (CDFG 1997).

The fourth document analyzed is a staff report prepared by the California Coastal Commission to present their findings and recommendations on coastal development permit application #3-97-047. This report was subsequently approved as recommended by the Commission staff. A list of all the issues broached in this document is also displayed in Table 25. According to this document the goals of breaching are flood control, protection of endangered species, habitat, and wildlife, maintaining access on adjacent roads, and protection of public health and safety (CCC 1998).

The depth of coordination necessary to produce this coastal development permit application seems to indicate excellent communication and coordination between Commission and County staff, but does not provide clear indication on the compatibility of agency goals towards breaching at this location (CCC 1998).

Analysis of documents and agency staff consultation on the Carmel River mouth.

Table 26 lists the breaching issues dealt with in the following existing documents on Carmel River mouth management. The first document from this location analyzed was

the Interim Plan and Criteria for Emergency Breaching of the Carmel River Mouth produced in 1992 by the Monterey County Department of Public Works. This interim plan presents the goals of breaching at this location as prevention of flooding, guarding public safety and health, and the protection of endangered species, habitat, and wildlife (County of Santa Cruz 1992).

Although this work does not specifically state that breaching is successful at this location, they detail it in a manner that implies it is at least partially successful. Mechanical breaching is the only method mentioned in this document and the detail afforded in discussing this method implies that the County believes that mechanical breaching is at least partially effective in meeting their goals towards coastal river mouth breaching (County of Santa Cruz 1992).

The second document analyzed is a California Department of Fish and Game 1601 Streambed Alteration agreement referred to as a Memorandum of Understanding. There were CDFG 1601 permits that preceded this one, but their contents were so similar in nature that evaluation of this one document will include all of the information that was included in the earlier permits. The goals that are represented in this document include prevention of flooding and protection of endangered species and habitat (CDFG 1997).

The third document analyzed is the “Carmel River Lagoon: Enhancement and Management Plan: Conceptual Design Report,” produced for the Monterey Peninsula Regional Park District, California Coastal Conservancy, and California Department of Parks and Recreation by a private consultant. The goals of this document with respect to coastal river mouth breaching include management of flooding and water levels in the

lagoon, and protection of wildlife, endangered species, and habitat. Other goals include safeguarding public health and safety, guarding water quality, maintaining public access and recreation, and providing monitoring and mitigation of breaching activities (MPRPD 1999).

This work does describe mechanical breaching as the most effective possible option for this location. There are qualifications to this assertion though, so mechanical breaching can be best evaluated at this location as partially successful. Natural breaching is seen as the preferable option if possible, but is seen as only partially effective in that it still allows flooding. Some unauthorized manual breaching is conducted at this location, but it is also seen as only partially effective in meeting all of the goals of breaching at this location (MRPD 1999).

The fourth document is a coastal development permit application for breaching of the Carmel River lagoon sand bar submitted to the California Coastal Commission by the Monterey County Water Resources Agency in December, 2000. The County of Santa Cruz' goals in breaching at this location are presented as prevention of flooding, protection of public safety and health, protection and enhancement of wildlife, endangered species, and habitat, and protection of access and recreation. Attached to this permit application are the three Carmel River Mouth documents listed above, so the contents of those documents may be considered to apply to this one as well.

CHAPTER 5

DISCUSSION

This chapter will analyze and discuss the implications of the data results from surveys and literature presented in Chapter 4. This chapter analyzes how this information may be of use to those involved in river mouth management, and it considers the implications of how this research may assist coastal river mouth managers improve their permitting and planning of coastal river mouth breaching activities. Coupled with this analysis is discussion of the implications of these findings on river mouth breaching at the individual study sites and some general recommendations for improving coastal river mouth breaching practices. This chapter also describes how these results contribute to the general literature on coastal river mouth breaching, the limitations of this research, and suggestions for further research in the field.

Permit Application Preparation and Analysis

Throughout this research it has been noted that there is a lack of proper permitting for river mouth breaching activities. This is symptomatic of the reluctant manner in which river mouth managers and regulators have been involved in the planning and management of breaching activities. Some related, ongoing problems include a lack of regular breaching permits, repeated use of emergency permits in situations that may not

be applicable, and repeated filing of violations with no measures implemented to uphold the violation charges.

The data that has been produced in this research may prove of equal use to managers and regulators in processing agency river mouth breaching permits. Since all three of the study sites are currently lacking the proper permits to conduct breaching activities, the following descriptions of the uses of this data in properly permitting breaching activities can be applied to all three sites.

It is important in applying for or analyzing a coastal river mouth breaching permit to understand the basic resource management issues and goals driving the proposed action and its regulation. The results shown in Tables 7 and 19 demonstrate that managers and regulators place different emphasis on the importance of breaching issues and that they have different goals towards breaching. This information may prove useful in allowing analysts and planners to consider major issues and goals, and may help ensure that they do not overlook something vital in a permit application, permit analysis, and subsequent issuance of a breaching permit.

Agencies regulating breaching appear to encourage proper permitting without applying undue pressures on the agencies responsible for performing breaching. This could be construed as reasonable given the manager's option of refusing to do anything to manage breaching as has been the case at the San Lorenzo River for almost ten years. It also may reflect the regulators' reluctance to commit greater resources to an issue that has not received widespread attention compared to other immediately pressing concerns. Despite this situation the findings on how the respondents rated the overall success of

current breaching, as shown in Tables 8-11, demonstrate that breaching is perceived as only partially successful at all of these study sites. This information alerts managers and regulators involved in the permitting process that additional efforts are necessary to improve current breaching practices.

Tables 13 through 18 exhibit that there was a large variation between the responses of managers and regulators on the effectiveness of various breaching methods. Table 17 shows that of all the methods analyzed in the survey, the only method preferred by a majority of respondents was the use of a permanent water level control device. However, that method also showed the most polarization between regulators who all thought it effective, and managers who almost all did not.

These findings may help explain why there appears to be a lot of inertia behind maintaining current breaching practices. Managers of the San Lorenzo River have declined to take any actions to manage breaching activity despite the preference expressed by regulators that the water level control device originally recommended over ten years ago be implemented. At the Carmel River managers have not considered the option of installing a permanent water level control device despite the above-mentioned finding that regulators approve of this option. This same option may not be as feasible at the Pajaro River because of different environmental conditions, but nonetheless this work reveals that not all of the parties involved in managing that river mouth are completely satisfied with current management practices at that location and that further efforts towards improving breaching are needed.

Another possible benefit of this research is that it provides managers and regulators with additional information with which to perform alternatives analysis when preparing and analyzing coastal river mouth breaching permit applications. Balancing the essential breaching issues provided by this work could be combined with analysis of the possible use of the different methods of breaching provided here. Innovative consideration of these issues may lead to new practices of using different breaching methods at different times to address specific circumstances. Utilizing the tools provided by this research may help inform both managers and regulators of the basic methods of breaching that have been considered in this area. It could also help these personnel in identifying the methods appropriate to their proposed breaching location.

River Mouth and Lagoon Management and Planning

None of the coastal river mouth breaching sites studied in this research has a current, approved river mouth or lagoon management plan for breaching activities. A draft management plan is currently being produced for the San Lorenzo River, and a draft management plan was once produced for the Pajaro River but never finalized. Likewise at the Carmel River a draft management plan was produced and circulated for comments but it has yet to be finalized and adopted. This inability to complete a management plan may be indicative of the complications river mouth managers and regulators face when attempting to gain consensus on the management of coastal lagoons and river mouths.

The results in Tables 2 through 7 show that managers and regulators expressed no difference in their listing of essential issues, and very little difference in their ranking of

the importance of these same breaching issues. Managers may be able to use the data provided in this research to evaluate the breaching issues that they are addressing with draft river mouth and lagoon management plans, and consider additional issues they may not have previously analyzed. Consideration of these issues and coordination on their management may help avoid unnecessary disagreement on the content of a management plan and a delay in its approval and implementation.

Table 19 shows that managers and regulators rate their agencies' goals towards breaching quite differently. Perhaps most notable is the finding that most of the managers marked prevention of flooding as an agency goal whereas only one of the regulators marked it so. Evaluation of the discrepancies between manager and regulator goals towards breaching shown in Table 19 may provide those planning coastal river mouth breaching with insight as to why they have difficulty reaching agreement on how to manage breaching. This finding is compounded by the survey result that these two groups consider their respective group's goals towards breaching as incompatible. This information and the supporting data may prove of use to coastal managers and regulators when they are attempting to draft and finalize lagoon or river mouth management plans.

The findings of this research as shown in Table 13 through 17 indicate that river and lagoon management plans should include consideration of the use alternative methods of breaching. It is appears that using multiple methods of breaching to cope with changing circumstances at individual sites may also be prudent. This would allow for flexibility in balancing fluctuations in resources, such as fish migration or nesting seasons that may

make one method of breaching acceptable during one season or month, and not acceptable during another.

As shown in Table 8 managers and regulators exhibited similar views that current breaching practices are only partially successful in meeting their agencies goals towards river mouth breaching at the study sites and in the Monterey Bay area. Those planning the management of these resources may want to take into account this tepid support of current breaching management, and consider incorporating alternative methods of river and lagoon management.

At the San Lorenzo River there is currently a river mouth and lagoon plan under consideration. The finding shown in Table 9 that the vast majority of respondents deemed breaching only partially successful at the San Lorenzo River should be considered when evaluating alternatives to breaching at this location. One option may include reconsidering implementation of the Water Level Control Device that was originally planned in the “San Lorenzo River Lagoon Enhancement Plan” adopted by the Santa Cruz City Council in 1992.

At the Pajaro River they have not worked toward the development of a river mouth or lagoon plan since 1992. Even that plan was never officially adopted so in effect no comprehensive analysis of river mouth management at this location has been completed. Table 10 shows that a similar majority of respondents evaluated breaching as only partially successful at this location, suggesting that efforts to develop and implement a management plan for this location is also needed.

A draft “Carmel River Lagoon: Enhancement and Management Plan: Conceptual Design Report” was originally circulated in the fall of 1999 for review by agencies, but this draft plan has never been finalized. Since this plan is comparatively well developed it could be used as a basis for further alternatives analysis in developing a California Environmental Quality Act environmental impact report, or in preparing a river mouth breaching permit application. The survey results in Table 11 show that, as with the other locations, the majority of respondents thought that breaching at the Carmel River is also only partially successful. Carmel River managers may be able to use this research data to better understand the attitudes of managers and regulators towards their respective goals in managing these, as well as the many other affected resources described in this research.

Recommendations

River mouth managers are not obtaining the proper permits for conducting breaching activities. This situation is common to the study sites, and throughout the region and state. There is unauthorized breaching occurring regularly, conducted both by those responsible for these resources and by independent parties concerned about one or more of the issues resulting from high lagoon levels. It has become common practice for both managers and regulatory agencies to accept the use of emergency permits for breaching even though they may be inappropriate. These parties should make the commitment of resources necessary to apply for, process, and, if possible, issue the permits required to conduct river mouth breaching.

There is a lack of collaboration and communication between the various regulatory agencies towards resolving their conflicting needs regarding breaching. It is extremely difficult for managers to obtain permits when they are forced to try and meet the demands of unrelated agencies that have different goals and requirements regarding the practice of breaching and river and lagoon management. There should be a regional collaboration forum including all of the interested parties from local, state, and federal agencies, as well as non-profits or individuals, organized on a periodic basis to ensure that information and techniques about breaching activities within this region are well known to all of the stakeholders. A main goal of such a forum should be to collaborate on developing mutually acceptable policies towards planning and conducting river mouth breaching. This type of coordination may require greater dedication of staff resources than is currently devoted to regulating and managing these resources. Dedicating staff resources specifically to address river mouth and lagoon management should be addressed at a statewide and regional basis.

There are currently no accepted coastal river mouth or lagoon management plans for any of the study sites investigated in this research. Managers and regulators should collaborate in developing and finalizing management plans for coastal river mouths and lagoons. Completed management plans would prove helpful in documenting past attempts to manage complex river mouth and lagoon issues and may provide information to future planners as to why different management methods were or were not accepted in the past. Finalized river mouth or lagoon management plans may also serve as a strong

basis for completing necessary CEQA documents and to justify preferred alternatives in breaching permit applications.

Those responsible for producing environmental documents to comply with the California Environmental Quality Act regarding coastal river mouth breaching activities have chosen not to produce full environmental impact reports. It is possible that by producing a full environmental impact report for river mouth breaching activities that the reports and communication between agencies necessary to produce such a document could help in coming to agreement on preferable breaching methods for an individual location. Responsible manager agencies should consider producing a full environmental impact report as a way to gain the knowledge and multi-agency concurrence necessary to satisfy all of the permitting agencies and obtain the proper permits to proceed with this activity. Permitting agencies should look closely at current environmental documentation for river mouth breaching to ensure that it is adequate to satisfy the requirements of the California Environmental Quality Act.

There should be more comparative research of this nature to investigate individual resource issues that occur when managing coastal lagoon resources. There are encouraging studies currently underway on water quality conditions in the San Lorenzo River and their impacts in the river and lagoon. More of this should be done to evaluate environmental conditions for biological, water quality, hydrological, and other resources to make evaluation of breaching more comprehensive.

Coastal planners should consider the list of breaching issues and goals shown in Tables 7 and 19 when evaluating possible breaching impacts and the varying goals of the

agencies involved in breaching. These lists may also prove helpful to those developing river mouth and lagoon management plans and should be considered when drafting or reviewing such a document.

This research has shown that the majority of breaching is currently conducted using mechanical breaching techniques with occasional manual breaching. The alternate methods examined in this research should be considered when planning breaching activities. Thought should also be given to alternating techniques during different seasons to address different resource issues.

Coastal resource managers should consider natural breaching as a possible method of managing river mouths or as part of a comprehensive flexible plan for breaching with different methods as a way of accommodating the dynamic river mouth and lagoon environment. In the analysis of the effectiveness of breaching methods there was no unanimous consensus on a most effective method of breaching. However, promoting natural breaching was listed as the number one goal of all respondent's agencies towards river mouth breaching in the survey. This may indicate that natural breaching, though not considered a preferred method in the analysis of the effectiveness of breaching, still provides overall benefits that extend beyond immediate breaching activities.

Each river mouth has unique characteristics that dictate individual consideration of impacts not seen in other locations. This study has revealed that in some cases consideration of the impacts of upstream water management practices on coastal river lagoons or possible ways to avoid physical manipulation of the river mouth in lieu of upstream water management practices should be considered in planning river mouth

management and breaching activities. In addition, the issue of worker safety that was introduced as a potential breaching issue should be considered, along with the possibility of including habitat restoration in river mouth planning and management.

Contributions to the General Literature on Coastal River Mouth Breaching

This research contributes to the general literature on coastal river mouth breaching by providing tools for the agencies and interested parties concerned with management and regulation of issues involved in coastal river mouth breaching. Investigation of existing research on coastal river mouth breaching has revealed a limited quantity of literature on the subject. As related in this study, what literature there is offers insight only into individual aspects of river mouth breaching or related coastal management issues.

This work contributes to the general literature on coastal river mouth breaching by providing a definition for this activity, and defining the major environmental resource issues involved in river mouth breaching. It also identifies the coastal river mouth breaching goals of agencies that manage and regulate breaching, and describes how those agencies view the compatibility of their respective goals towards this activity.

This study also contributes to the literature on coastal river mouth breaching by providing the first formal attempt to evaluate breaching as a regional management issue rather than solely on the basis of individual location. Perhaps equally important as any one of these individual contributions, all of these additions to coastal river mouth breaching literature establish a basis of comparison for further study and analysis in the general literature on coastal river mouth breaching.

Limitations of This Research

This research was not designed to provide specific guidance on how coastal river mouth breaching should be conducted. It is simply intended as a guide for beginning the in-depth analysis required to analyze and plan for the coastal river mouth management needs of an individual location. Each coastal river mouth and coastal lagoon will require individual evaluation in order to effectively design optimal river mouth management strategies for that specific location. Since different locations are likely to have different resource issues, it is expected that an issue analysis based solely on this study will lack some of the information requisite to a thorough analysis for a specific locale.

Qualitative analysis of existing documents in this work was limited by the nature of the existing documents available. Since the purpose and format of these existing documents was for management of breaching activities, application for permits, or permitting, they did not always allow analysis of the success of breaching, or the compatibility of manager and regulator goals towards breaching. In some of the documents it was possible to evaluate the success of breaching, the effectiveness of breaching methods, agency goals towards breaching, or the issues that are considered important to the agencies that produced the documents, but in other documents this was not possible.

This work suffered not only from a lack of existing professional and academic literature on the subject matter, but also from a lack of approved and implemented management plans or documentation on the planning and conduct of river mouth and lagoon management, breaching, and associated activities. It appears that with limited

time and resources agencies responsible for breaching have had few resources to commit to planning breaching activities and lagoon management.

This research was limited to the study sites that are included in this work and may have restricted applicability outside of the Monterey Bay area. When considered in a statewide, national, or international context, this information, though valuable, will in no way be comprehensive as it lacks the depth and complexity required for application to a larger forum.

It seems that when government resources and funding have been made available for study of coastal rivers, a lesser amount of study was conducted on the management of the associated river mouth and lagoon system and even less on management of river mouth breaching. Since this is the first comprehensive regional work on this subject, the topics covered will doubtless be expanded on in the future. It is hoped that later researchers can collect additional detailed information on the individual and collective issues that need to be dealt with in coastal river mouth management and expand the scope of these studies to the statewide or even national level.

There are some inherent problems with using a survey to collect data. As with any survey it was not possible to contact all of the potential respondents. Some of the personnel with direct knowledge and responsibility for management of coastal river mouth breaching were apparently too busy to respond to part or all of this survey. The qualitative analysis conducted here was necessarily subjective, and despite the best efforts of the researcher may have been biased or misinterpreted.

It should be considered when reviewing this data that some of the questions obtained a smaller response rate than others. There was a lower response rate on the question about the success of breaching at the San Lorenzo River, where only 17 of the 47 respondents answered the question. There was also a lower response on the questions about the effectiveness of different breaching methods as they pertained to the use of a temporary and permanent water level control devices, which obtained a response of twelve, and fifteen respondents respectively from the forty-seven survey participants.

Research Needs

It is recommended that in the future researchers should focus on exploring the details of some of the individual issues that were reviewed in this work as they relate to coastal river mouth breaching. In particular, analysis of endangered species, wildlife, habitat and satisfying the legal requirements of managing these resources would be very helpful to the coastal zone managers who work on this subject.

The manner in which increased collaboration between all of the parties involved in coastal river mouth breaching in this area points to a need to refine how this could be accomplished. The dynamics of collaboration between these agencies as it relates to river mouth management in this area would be a valuable area of research.

Research into the occurrence and management of coastal river mouth breaching reveals many locations of concern in Santa Cruz and Monterey Counties. Scott Creek, Waddell Creek, Natural Bridges Lagoon, Corcoran Lagoon, Soquel Creek Lagoon , Schwan Lake Lagoon, Younger Lagoon, Neary Lagoon, Salinas River, and the Sand City

Culvert were all found to have had some type of breaching-related activity, or scrutiny by resource agencies in the past. Much of this information was obtained through personal conversations because written or historical data is sparse. A long-term plan to collect data on coastal river mouth breaching in the Monterey Bay area would be necessary to extend research into the locations listed here.

This research also disclosed evidence of coastal river mouth breaching activities outside of the Monterey Bay area at Elk Creek in Del Norte County, the Russian River in Sonoma County, Pescadero Creek and Pomponio Creek in San Mateo County, Pismo and Arroyo Grande Creeks in San Luis Obispo County, Malibu Creek in Los Angeles County, Aliso Creek and San Mateo Creek in Orange County, and San Dieguito Creek, San Elijo Creek, and Buena Vista Lagoons in San Diego County. Academic or professional articles or research on the specifics of breaching at these locations currently do not exist.

Research into the statewide occurrence of river mouth breaching and how it is conducted is sorely needed. Information detailing the impact of past breaching activities on the natural and human environment is essential to begin evaluation of the effects of coastal river mouth breaching activities in various environments. Further research into national and international standards and practices for coastal river mouth breaching is also needed. Combined efforts of coastal zone managers in defining their strategies for management of this activity would improve the effectiveness of regulating these issues.

River mouth managers have claimed that their river mouth breaching activities are exempt from the California Environmental Quality Act because breaching activities are

an on-going maintenance activity that has been conducted since well before the implementation of this law (California Coastal Commission 1998). Further research is needed to evaluate the validity of conducting coastal river mouth breaching as statutorily exempt from California Environmental Quality Act authority as an on-going maintenance activity. Most coastal river mouth breaching conducted under a permit from agencies has involved issuance of an emergency permit, or operation under an interim criteria (agreement), or a memorandum of understanding. Research is also needed on the legitimacy of using emergency permits or these other policy tools to conduct coastal river mouth breaching or related activities.

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APPENDIX A

SURVEY

Appendix E - Investigative Survey

Please answer the following questions as directed. If you need additional room for comments please write them on the back of the page.

In column A of the following table please review the list of issues to consider when planning or conducting coastal river mouth breaching. If you feel that there are any other pertinent issues that should be included please add them to column A and include them in the following steps.

In column B please mark an "X" next to all issues that you feel are essential to consider when planning or conducting breaching.

In Column C please rank by number these issues in order of their importance with # 1 being the most important issue.

In Column D please write any comments you may have about these issues.

A CRMB Issues	B Essential	C Importance	D Comments
Flooding			
Wildlife			
Endangered Species (steelhead, coho and chinook salmon, tidewater goby)			
Habitat			
Public Safety			
Public Health			
Water Quality			
Access/Recreation			
Monitoring			
Mitigation			

What are your agencies goals regarding coastal river mouth breaching?

Please review the locations listed in column A of the table below.

In column B please use the following rating system to rate the success of current breaching practices in meeting the goals of your agency.

Completely Successful 1
 Partially Successful 2
 Not Successful 3
 Don't Know 4

In column C please provide any comments you may have on your rating or on success of breaching at meeting the goals of your agency. If you need additional room for your comments please write them on the back of this page.

A Location	B Rating (1,2,3,or 4)	C Comments
<u>San Lorenzo River</u>		
Pajaro River		
Carmel River		
Monterey Bay Area		

Column A of the following table lists various methods of managing river mouths and breaching. If you know of any additional methods of managing river mouths please add them to column A and include them in the following steps.

In column B please rate the effectiveness of various breaching methods in meeting the goals of your agency. Please use the following rating system:

Completely Effective	1
Partially Effective	2
Not Effective	3
Don't Know	4

In column C please provide any comments you have on your rating or on the effectiveness of the methods listed in meeting the goals of your agency. If you need additional room for your comments please write them on the back of this page..

A	B	C
Breaching method	1, 2, 3, or 4	Comments
Manual Breaching		
Mechanized Breaching		
Temporary Water Level Control Device		
Permanent Water Level Control Device		
Natural, or Un-controlled Breaching		

Do you feel that those agencies conducting coastal river mouth breaching and those regulating it have compatible goals regarding this activity and why?

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

What is your job classification with your agency?

APPENDIX B**TABLES**

TABLE 1

**AGENCIES THAT PARTICIPATED IN COASTAL RIVER MOUTH BREACHING
SURVEY**

Managing Agencies	Regulating Agencies
City of Santa Cruz	California Coastal Commission
City of Carmel by the Sea	California Department of Fish and Game
City of Watsonville	Regional Water Quality Control Board
Santa Cruz County	State Water Resources Control Board
County of Monterey	State Lands Commission
Monterey Peninsula Water Management District	US Army Corps of Engineers
Monterey County Water Resources Agency	US Fish and Wildlife Service
California Department of Transportation	Monterey Bay National Marine Sanctuary
California Department of Parks and Recreation	National Marine Fisheries Service

TABLE 2

**STATISTICAL RESULTS OF ALL, MANAGER, AND REGULATOR
RESPONDENTS WHO THINK ISSUES ARE ESSENTIAL**

Issue	All Frequency	All Percent	Manager Frequency	Manager Percent	Regulator Frequency	Regulator Percent
Flooding	45	95.7	21	95.5	25	100.0
Public Safety	44	93.6	21	95.5	24	96.0
ESA*	44	93.6	19	86.4	24	96.0
Public Health	38	80.9	16	72.7	23	92.0
Habitat	37	78.7	14	63.6	23	92.0
Monitoring	37	78.7	14	63.6	22	88.0
Wildlife	36	76.6	13	59.1	22	88.0
Water Quality	32	68.1	12	54.5	20	80.0
Mitigation	29	61.7	10	45.5	20	80.0
AccRec**	24	51.1	9	40.9	14	56.0

Non-responses = 13

* Endangered Species

** Access and Recreation

TABLE 3
FREQUENCY OF IMPORTANCE RANKING FOR ALL RESPONDENTS

Rank	Flooding	Wild- life	Endangered Species	Habitat	Public Safety	Public Health	Water Quality	Access & Rec.	Monitoring	Mitigation
1	7		13	1	18	2				
2	7	3	6	6	10	8	2			
3	12	6	11	1	3	3	6			
4	5	8	7	6	2	6	3		3	2
5	1	7	3	9	6	7	5	1	1	2
6	2	7		10		6	14		3	
7	7	8	1	7	1	6	3		7	2
8	1	2	1	1	1	3	5	7	18	4
9		1		1	1	1	3	12	9	14
10							1	22	1	18
Total	42	42	42	42	42	42	42	42	42	42
Mean	3.60	5.10	2.76	5.02	2.60	4.69	5.74	9.26	7.60	8.81
Median	3.00	5.00	3.00	5.00	2.00	5.00	6.00	10.0	8.00	9.00
Mode	3	4*	1	6	1	2	6	10	8	10
Std. Dev	2.12	1.79	1.68	1.87	2.08	2.16	2.01	1.01	1.42	1.64

* Multiple modes exist. The smallest mode is shown.

TABLE 4
FREQUENCY OF IMPORTANCE RANKING FOR MANAGER RESPONDENTS

Rank	Flooding	Wild-life	Endangered Species	Habitat	Public Safety	Public Health	Water Quality	Access & Rec.	Monitoring	Mitigation
1	2		4		13	2				
2	4		4	2	7	4				
3	11	2	5		1		2			
4	2	2	7	2		3	3		1	1
5		5	1	4		5	4	1	1	
6		3		9		4	5			
7	1	8		3		1	2		5	1
8	1	1		1		2	3	2	8	3
9							2	11	5	3
10							2	7	1	13
Total	21	21	21	21	21	21	21	21	21	21
Mean	3.14	5.76	2.86	5.48	1.43	4.48	5.90	9.05	7.76	9.14
Median	3.00	6.00	3.00	6.00	1.00	5.00	6.00	9.00	8.00	10.0
Mode	3	7	4	6	1	5	6	9	8	10
Std Dev	1.65	1.45	1.24	1.50	.60	2.14	1.81	1.12	1.37	1.49

TABLE 5

FREQUENCY OF IMPORTANCE RANKING FOR REGULATOR RESPONDENTS

Rank	Flooding	Wild-life	Endangered Species	Habitat	Public Safety	Public Health	Water Quality	Access & Rec.	Monitoring	Mitigation
1	5		9	1	5					
2	3	3	2	4	3	4	2			
3	1	4	6	1	2	3	4			
4	3	6		4	2	3		2		1
5	1	2	2	5	6	2	1			2
6	2	4		1		2	9	3		
7	6		1	4	1	5	1	2		1
8		1	1		1	1	2	5	10	1
9		1		1	1	1	1	1	4	11
10							1	15		5
Total	21	21	21	21	21	21	21	21	21	21
Mean	4.04	4.42	2.67	4.57	3.57	4.81	5.14	9.33	7.09	8.10
Median	4.00	4.00	2.00	5.00	4.00	5.00	6.00	10.0	8.00	9.00
Mode	7	4	1	5	5	7	6	10	8	9
Std Dev	2.46	1.89	2.06	2.11	2.39	2.21	2.23	0.87	1.47	1.75

TABLE 6

COMPARISON OF ALL, MANAGER, AND REGULATOR IMPORTANCE RANKINGS OF
BREACHING ISSUES BASED ON MEANS*

All Respondents	Mean	Managers	Mean	Regulators	Mean
Public Safety	2.60	Public Safety	1.43	Endangered Species	2.67
Endangered Species	2.76	Endangered Species	2.86	Public Safety	3.76
Flooding	3.60	Flooding	3.14	Flooding	4.05
Public Health	4.69	Public Health	4.48	Wildlife	4.43
Habitat	5.02	Habitat	5.48	Habitat	4.57
Wildlife	5.10	Wildlife	5.76	Public Health	4.90
Water Quality	5.74	Water Quality	5.90	Water Quality	5.57
Monitoring	7.60	Monitoring	7.76	Monitoring	7.43
Mitigation	8.81	Access and Recreation	9.05	Mitigation	8.48
Access and Recreation	9.26	Mitigation	9.14	Access and Recreation	9.48

* Issues ranked as most essential possess the lowest means.

TABLE 7

COMPARISON OF THE ORDER THAT RESPONDENTS CONSIDERED BREACHING ISSUES ESSENTIAL
VERSUS THE ORDER IN WHICH ALL POTENTIAL BREACHING ISSUES WERE RANKED

All Respondents		Managers		Regulators	
<u>Essential</u>	<u>Ranked</u>	<u>Essential</u>	<u>Ranked</u>	<u>Essential</u>	<u>Ranked</u>
Flooding	Public Safety	Flooding	Public Safety	ESA *	ESA *
Public Safety	ESA *	Public Safety	ESA *	Monitoring	Public Safety
ESA *	Flooding	Public Health	Flooding	Flooding	Flooding
Public Health	Public Health	ESA *	Public Health	Habitat	Wildlife
Monitoring	Habitat	Habitat	Habitat	Public Safety	Habitat
Habitat	Wildlife	Wildlife	Wildlife	Public Health	Public Health
Wildlife	Water Quality	Monitoring	Water Quality	Wildlife	Water Quality
Water Quality	Monitoring	Water Quality	Monitoring	Water Quality	Monitoring
Mitigation	Mitigation	Access & Rec	Access & Rec	Mitigation	Mitigation
Access & Rec	Access & Rec	Mitigation	Mitigation	Access & Rec	Access & Rec

* ESA = Endangered Species

TABLE 8

**SUMMARY OF RESPONSES ON THE SUCCESS OF RIVER MOUTH BREACHING
AT ALL LOCATIONS***

	San Lorenzo River	Pajaro River	Carmel River	Monterey Bay Area
Total Responses	44	44	44	44
Mean	2.12	1.86	2.17	2.05
Median	2.00	2.00	2.00	2.00
Mode	2.0	2.0	2.0	2.0
Standard Deviation	.332	.478	.482	.405
T-Test comparison of Managers vs. Regulators	-1.00	-1.00	-1.58	-1.633

* values of 1=completely successful, 2=partially successful, and 3=not successful.

TABLE 9
SUCCESS RESPONSES FOR THE SAN LORENZO RIVER

	Frequency	Percent	Valid Percent*	Cumulative Percent
All Respondents				
Completely Successful	0	0	0	0
Partially Successful	15	34.1	88.2	88.2
Not Successful	2	4.5	11.8	100.0
Don't Know	27	61.4	--	--
Managers				
Completely Successful	0	0	0	0
Partially Successful	8	36.4	100.0	100.0
Not Successful	--	--	--	--
Don't Know	14	63.6	--	--
Regulators				
Completely Successful	0	0	0	0
Partially Successful	7	31.8	77.8	77.8
Not Successful	2	9.1	22.2	100.0
Don't Know	13	59.1	--	--

* Valid percent excludes respondents who answered with "don't know."

TABLE 10
SUCCESS RESPONSES FOR THE PAJARO RIVER

	Frequency	Percent	Valid Percent*	Cumulative Percent
All Respondents				
Completely Successful	4	9.1	19.0	19.0
Partially Successful	16	36.4	76.2	95.2
Not Successful	1	2.3	4.8	100.0
Don't Know	23	52.3	--	--
Managers				
Completely Successful	4	18.2	36.4	36.4
Partially Successful	7	31.8	63.6	100.0
Not Successful	0	0	0	0
Don't Know	11	50.0	--	--
Regulators				
Completely Successful	0	0	0	0
Partially Successful	9	40.9	90.0	90.0
Not Successful	1	4.5	10.0	100.0
Don't Know	12	--	--	--

* Valid percent excludes respondents who answered with "don't know."

TABLE 11
SUCCESS RESPONSES FOR THE CARMEL RIVER

	Frequency	Percent	Valid Percent*	Cumulative Percent
All Respondents				
Completely Successful	1	2.3	4.2	4.2
Partially Successful	18	40.9	75.0	79.2
Not Successful	5	11.4	20.8	100.0
Don't Know	20	45.5	--	--
Managers				
Completely Successful	1	4.5	8.3	8.3
Partially Successful	10	45.5	83.3	91.7
Not Successful	1	4.5	8.3	100.0
Don't Know	10	45.5	--	--
Regulators				
Completely Successful	0	0	0	0
Partially Successful	8	36.4	66.7	66.7
Not Successful	4	18.2	33.3	100.0
Don't Know	10	45.5	--	--

* Valid percent excludes respondents who answered with "don't know."

TABLE 12
SUCCESS RESPONSES FOR THE MONTEREY BAY AREA

	Frequency	Percent	Valid Percent*	Cumulative Percent
All Respondents				
Completely Successful	1	2.3	5.3	5.3
Partially Successful	16	36.4	84.2	89.5
Not Successful	2	4.5	10.5	100.0
Don't Know	25	56.8	--	--
Managers				
Completely Successful	1	4.5	11.1	11.1
Partially Successful	7	31.8	77.8	88.9
Not Successful	1	4.5	11.1	100.0
Don't Know	13	59.1	--	--
Regulators				
Completely Successful	0	0	0	0
Partially Successful	9	41.0	90	90
Not Successful	1	4.5	10	100.0
Don't Know	12	54.5	--	--

* Valid percent excludes respondents who answered with "don't know."

TABLE 13

SUMMARY OF RESPONSES FOR THE EFFECTIVENESS OF ALL RIVER MOUTH BREACHING METHODS*

	Manual	Mechanized	Temporary WLCD	Permanent WLCD	Natural
Total Responses	44	44	44	44	44
Mean	2.22	1.74	2.17	1.67	2.05
Median	2.00	2.00	2.00	1.00	2.00
Mode	2	2	2	1	2
Standard Deviation	.54	.50	.58	.82	.68
T-Test comparison of Breachers vs. Regulators	.899	-.808	1.00	3.00	.825

* values of 1=effective, 2=partially effective, and 3=not effective are applied.

TABLE 14
EFFECTIVENESS RESPONSES FOR MANUAL BREACHING

	Frequency	Percent	Valid Percent*	Cumulative Percent
All Respondents				
Completely Effective	2	4.5	5.6	5.6
Partially Effective	24	54.5	66.7	72.2
Not Effective	10	22.7	27.8	100.0
Don't Know	8	18.2	--	--
Managers				
Completely Effective	0	0	0	0
Partially Effective	12	54.5	70.6	70.6
Not Effective	5	22.7	29.4	100.0
Don't Know	5	77.3	--	--
Regulators				
Completely Effective	2	9.1	10.5	10.5
Partially Effective	12	54.5	63.2	73.7
Not Effective	5	22.7	26.3	100.0
Don't Know	3	13.6	--	--

* Valid percent excludes respondents who answered with "don't know."

TABLE 15

EFFECTIVENESS RESPONSES FOR MECHANICAL BREACHING

	Frequency	Percent	Valid Percent*	Cumulative Percent
All Respondents				
Completely Effective	11	25.0	28.9	28.9
Partially Effective	26	59.1	68.4	97.4
Not Effective	1	2.3	2.6	100.0
Don't Know	6	13.6	--	--
Managers				
Completely Effective	6	27.3	31.6	31.6
Partially Effective	13	59.1	68.4	100.0
Not Effective	0	0	0	--
Don't Know	3	13.6	--	--
Regulators				
Completely Effective	5	22.7	26.3	26.3
Partially Effective	13	59.1	68.4	94.7
Not Effective	1	4.5	5.3	100.0
Don't Know	3	13.6	--	--

* Valid percent excludes respondents who answered with "don't know."

TABLE 16

**EFFECTIVENESS RESPONSES FOR THE USE OF TEMPORARY
WATER LEVEL CONTROL DEVICES**

	Frequency	Percent	Valid Percent*	Cumulative Percent
All Respondents				
Completely Effective	1	2.3	8.3	8.3
Partially Effective	8	18.2	66.7	75.0
Not Effective	3	6.8	25.0	100.0
Don't Know	32	25.0	--	--
Managers				
Completely Effective	1	4.5	14.3	14.3
Partially Effective	3	13.6	42.9	57.1
Not Effective	3	13.6	42.9	100.0
Don't Know	15	68.2	--	--
Regulators				
Completely Effective	0	0	0	0
Partially Effective	5	22.7	100.0	100.0
Not Effective	0	0	--	--
Don't Know	17	77.3	--	--

* Valid percent excludes respondents who answered with "don't know."

TABLE 17

**EFFECTIVENESS RESPONSES FOR THE USE OF PERMANENT
WATER LEVEL CONTROL DEVICES**

	Frequency	Percent	Valid Percent*	Cumulative Percent
All Respondents				
Completely Effective	8	18.2	53.3	53.3
Partially Effective	4	9.1	26.7	80.0
Not Effective	3	6.8	20.0	100.0
Don't Know	29	65.9	--	--
Managers				
Completely Effective	2	9.1	28.6	28.6
Partially Effective	2	9.1	28.6	57.2
Not Effective	3	13.6	42.9	100.0
Don't Know	15	68.2	--	--
Regulators				
Completely Effective	6	27.3	75.0	75.0
Partially Effective	2	9.1	25.0	100.0
Not Effective	0	--	--	--
Don't Know	14	63.6	--	--

* Valid percent excludes respondents who answered with "don't know."

TABLE 18
EFFECTIVENESS RESPONSES FOR NATURAL BREACHING

	Frequency	Percent	Valid Percent*	Cumulative Percent
All Respondents				
Completely Effective	8	18.2	20.0	20.0
Partially Effective	22	50.0	55.0	75.0
Not Effective	10	22.7	25.0	100.0
Don't Know	4	9.1	--	--
Managers				
Completely Effective	4	18.2	21.1	21.1
Partially Effective	9	40.9	47.4	68.4
Not Effective	6	27.3	31.6	100.0
Don't Know	3	13.6	--	--
Regulators				
Completely Effective	4	18.2	19.0	19.0
Partially Effective	13	59.1	61.9	81.0
Not Effective	4	18.2	19.0	100.0
Don't Know	1	4.5	--	--

* Valid percent excludes respondents who answered with "don't know."

TABLE 19

LIST OF AGENCY GOALS PROVIDED BY RESPONDENTS

Agency Goals	Managers	Regulators	Total
Promote natural breaching process	7	5	12
Ensure proper regulatory clearance	1	10	11
Prevent flooding	8	1	9
Protect lagoon habitat	2	6	8
Protect endangered species	1	6	7
Protect steelhead habitat	2	4	6
Protect public health	3	3	6
Educate public on steelhead trout habitat needs	2	3	6
Promote habitat restoration	0	4	4
Protect public safety	2	2	4
Restore water quality	0	4	4
Monitor breaching activities	3	1	4
Protect property	2	1	3
Protect marine habitat	0	3	3
Protect water quality	0	2	2
Protect public access	0	2	2
Mitigate for breaching impacts	0	1	1
Explore alternatives to breaching methods	0	1	1
Protect worker safety	0	1	1
Allow continued operation of reservoirs	1	0	0
Total responses	34	60	94

TABLE 20

LIST OF JOB CLASSIFICATIONS HELD BY ALL RESPONDENTS

Managers	Regulators
Water Resources Engineer	Engineer
Resource Planner	Environmental Planner
Environmental Planner	Coastal Program Analyst
Superintendent	Structural Engineer
Planner	Deputy Field Supervisor
Resource Planner	Sanctuary Enforcement Officer
Assistant Public Works Director	Environmental Specialist
Environmental Manager	Community Manager
Assistant Director of Public Works	Environmental Specialist, Area Recovery
Senior Environmental Planner	Coordinator
Resource Planner	Environmental Specialist
Public Works Operations Manager	Coastal Planner
Superintendent of Parks	Water Quality Specialist
Marine Safety Supervisor	Research Coordinator
Administrative Analyst	Research Specialist
Director of Public Works and Utilities	Enforcement Supervisor
Environmental Planner	Engineer
Resource Analyst	Environmental Specialist
Emergency Services Mngr	Water Quality Engineer
Senior Environmental Planner	Road Maintenance Superintendent
Senior Transportation Engineer	Environmental Specialist
Public Works Director	Coastal Planner
Chief Engineer of Operations & Maintenance	Soils Engineer / Geologist
	Regional Manager
	Senior Biologist

TABLE 21
COMPATIBILITY OF GOALS TOWARDS COASTAL RIVER MOUTH BREACHING

Nature of Response	All Respondents		Managers		Regulators	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Negative	16	34.04	11	50.0	5	20.00
Qualified Negative	8	17.02	3	13.64	5	20.00
Positive	1	2.13	--	--	1	4.00
Qualified Positive	8	17.02	4	18.18	4	16.00
No Response	14	29.78	4	18.18	10	40.00
Totals	47	100	22	100	25	100

TABLE 22

**REASONS WHY MANAGERS AND REGULATORS THINK THEY DO NOT HAVE COMPATIBLE GOALS
TOWARDS COASTAL RIVER MOUTH BREACHING**

Reason	Total	Managers	Regulators
Breachers place greater emphasis on flood control	12	8	4
Breachers place greater emphasis on protecting property	4	3	1
Regulators place greater emphasis on wildlife	1	--	1
Regulators place greater emphasis on endangered species protection	8	5	3
Regulators place greater emphasis on habitat protection	7	5	2
Breachers place greater emphasis on public safety	7	5	2
Breachers place greater emphasis on public health	3	3	--
Breachers place greater emphasis on protecting public access	3	2	1
Regulators place greater emphasis on monitoring	2	2	--
Regulators are narrowly focused on their agencies' singular responsibility	2	2	--
Agencies have conflicting goals about the same individual resource issue	1	1	--
Regulators place greater emphasis on retaining a natural environment	1	1	--
Poor coordination between agencies on breaching matters	4	3	1
Total	55	40	15

TABLE 23

REASONS WHY MANAGERS AND REGULATORS THINK THEY HAVE COMPATIBLE GOALS
TOWARDS COASTAL RIVER MOUTH BREACHING

Reason	Total	Managers	Regulators
Prevent flooding	5	1	4
Protect property	3	1	2
Protect wildlife	2	1	1
Protect endangered species	1	1	--
Protect lagoon habitat	2	1	1
Protect water quality	2	1	1
Total	15	6	9

TABLE 24

LIST OF ISSUES PERTAINING TO COASTAL RIVER MOUTH BREACHING AT THE
SAN LORENZO RIVER MOUTH FOUND IN EXISTING DOCUMENTS

Essential Issues	Coastal Commission Staff Report	Criteria for Emergency Breaching	U.S. Army Corps Permit for a Water Level Control Device	Coastal Commission Emergency Permit
Flooding	X*	X	X	X
Wildlife	X			X
Endangered Species				
Habitat	X	X	X	
Public Safety	X	X		X
Public Health	X	X		X
Water Quality		X	X	
Access/Recreation				
Monitoring	X	X	X	
Mitigation				

* Issues marked with an X were found to be treated as essential in the document indicated.

TABLE 25

LIST OF ISSUES PERTAINING TO COASTAL RIVER MOUTH BREACHING AT THE
PAJARO RIVER MOUTH FOUND IN EXISTING DOCUMENTS

Essential Issues	Interim Criteria for Emergency Breaching	Pajaro River Lagoon Management Plan	CDFG Memorandum of Understanding	Coastal Commission Staff Report
Flooding	X*	X	X	X
Wildlife	X	X		X
Endangered Species	X			X
Habitat	X	X		X
Public Safety	X	X	X	X
Public Health	X	X	X	X
Water Quality		X		X
Access/Recreation	X	X	X	X
Monitoring	X	X	X	X
Mitigation				X

* Issues marked with an X were found to be treated as essential in the document indicated.

TABLE 26

LIST OF ISSUES PERTAINING TO COASTAL RIVER MOUTH BREACHING AT THE
CARMEL RIVER MOUTH FOUND IN EXISTING DOCUMENTS

Essential Issues	Criteria for Emergency Breaching	CDFG 1601 Permit	Carmel River Lagoon Enhancement Plan	Coastal Development Permit Application
Flooding	X*	X	X	X
Wildlife	X	X	X	X
Endangered Species	X	X	X	X
Habitat	X	X	X	X
Public Safety	X		X	X
Public Health	X		X	X
Water Quality		X	X	X
Access/Recreation			X	X
Monitoring	X		X	X
Mitigation			X	X

*Issues marked with an X were found to be treated as essential in the document indicated.

APPENDIX C

FIGURES

FIGURE 1
SATELLITE IMAGE OF THE MONTEREY BAY

Source: NASA Applied Sciences Information Branch, 1999. Modified by author.

FIGURE 2
MAP OF THE MONTEREY BAY AREA AND STUDY SITE LOCATIONS

Source: California Coastal Commission, ReCAP Pilot Project Preliminary Findings and Recommendations: Monterey Bay Region 1994, p. 20. Digital modifications by author.

FIGURE 3

USGS 7.5" QUAD MAP OF THE SAN LORENZO RIVER MOUTH AREA

Scale: 1:12,000

Source: USGS 7.5 minute series, Santa Cruz Quadrangle 1954, revised 1994. Digital modifications by author.

FIGURE 4

USGS 7.5" QUAD MAP OF THE PAJARO RIVER MOUTH AREA

Source: USGS 7.5 minute series, Moss Landing Quadrangle 1954, revised 1994. Digital modifications by author.

FIGURE 5

USGS 7.5" QUAD MAP OF THE CARMEL RIVER MOUTH AREA

Source: USGS 7.5 minute series, Monterey Quadrangle 1954, revised 1994, digital modifications by author.

FIGURE 6

LITHOGRAPH OF SANTA CRUZ AND THE SAN LORENZO RIVER MOUTH CIRCA 1894

Source: A.L. Bancroft & Company, 1894. Courtesy of the Santa Cruz Museum of Art and History Archives.
Digital modifications by author.

FIGURE 7

AERIAL PHOTO OF THE SAN LORENZO RIVER MOUTH, BEACH AND PIER

Source: Dave Francis, Cruzio.com, 2000.

FIGURE 8

THE SAN LORENZO RIVER MOUTH IS POTENTIALLY DANGEROUS FOR
UNWARY SWIMMERS AND WADERS

FIGURE 10

THE PAJARO RIVER MOUTH IS ADJACENT TO RESIDENTIAL PROPERTY AND
HARBORS A VARIETY OF WILDLIFE

FIGURE 12

AERIAL PHOTO OF THE CARMEL RIVER MOUTH AREA

Source: California Coastal Commission, Aerial photograph # 111-5, 1994.

FIGURE 14

PERCENTAGE OF ALL* RESPONDENTS, BREACHERS, AND REGULATORS WHO FEEL ISSUES ARE ESSENTIAL TO CONSIDER WHEN PLANNING AND CONDUCTING BREACHING

* "All" percentages are weighted to provide equal representation of managers and regulators despite their different response rates to the survey.

FIGURE 16

MANAGER VERSUS REGULATOR RESPONSES OF WILDLIFE AS AN ESSENTIAL ISSUE

FIGURE 18

MANAGER VERSUS REGULATOR RESPONSES OF HABITAT AS AN ESSENTIAL ISSUE

FIGURE 19
MANAGER VERSUS REGULATOR RESPONSES OF PUBLIC SAFETY AS AN ESSENTIAL ISSUE

FIGURE 20
MANAGER VERSUS REGULATOR RESPONSES OF PUBLIC HEALTH AS AN ESSENTIAL ISSUE

FIGURE 22
MANAGER VERSUS REGULATOR RESPONSES OF ACCESS AND RECREATION AS AN ESSENTIAL ISSUE

FIGURE 23
MANAGER VERSUS REGULATOR RESPONSES OF MONITORING AS AN ESSENTIAL ISSUE

FIGURE 24
MANAGER VERSUS REGULATOR RESPONSES OF MITIGATION AS AN ESSENTIAL ISSUE

FIGURE 25
RATINGS BY ALL RESPONDENTS, MANAGERS, AND REGULATORS OF THE
SUCCESS OF RIVER MOUTH BREACHING AT THE SAN LORENZO RIVER*

* Y axis depicts valid percent of responses to each category.

FIGURE 26

**RATINGS BY ALL RESPONDENTS, MANAGERS, AND REGULATORS OF THE
SUCCESS OF RIVER MOUTH BREACHING AT THE PAJARO RIVER***

FIGURE 27

RATINGS BY ALL RESPONDENTS, MANAGERS, AND REGULATORS OF THE
SUCCESS OF RIVER MOUTH BREACHING AT THE CARMEL RIVER*

* Y axis depicts valid percent of responses to each category.

FIGURE 28
RATINGS BY ALL RESPONDENTS, MANAGERS, AND REGULATORS OF THE
SUCCESS OF RIVER MOUTH BREACHING IN THE MONTEREY BAY AREA*

* Y axis depicts valid percent of responses to each category.

FIGURE 29
RATINGS BY ALL RESPONDENTS, MANAGERS, AND REGULATORS OF THE
EFFECTIVENESS OF MANUAL BREACHING AS A MEANS OF RIVER MOUTH MANAGEMENT*

* Y axis depicts valid percent of responses to each category.

FIGURE 31

RATINGS BY ALL RESPONDENTS, MANAGERS, AND REGULATORS OF THE EFFECTIVENESS OF USING
TEMPORARY WATER LEVEL CONTROL DEVICES AS A MEANS OF RIVER MOUTH BREACHING*

* Y axis depicts valid percent of responses to each category.