Humboldt Bay Municipal Water District

Habitat Conservation Plan For Its Mad River Operations

December 2002

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Prepared By:
Trinity Associates and
the Humboldt Bay Municipal Water District

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Executive Summary

Under Section 10 of the federal Endangered Species Act (ESA), the Humboldt Bay Municipal Water District (District) has elected to pursue an Incidental Take Permit for its Mad River activities. As required by the ESA, the District has prepared this Habitat Conservation Plan (HCP) to support issuance of this permit. The overall purpose of this effort is to describe conservation measures that the District will undertake to minimize and mitigate adverse impact to the listed species, in order to gain long-term regulatory certainty with federal agencies, such as the National Marine Fisheries Service (NMFS), the US Fish and Wildlife Service (USFWS), and other federal agencies from which the District requires permits to operate.

The District is the only water supplier in the greater Humboldt Bay area. The District sells "raw" water to industrial users on the Samoa Peninsula, and treated water on a wholesale basis to the cities of Eureka, Arcata and Blue Lake, and the Humboldt, McKinleyville, Fieldbrook, and Manila Community Services Districts. Through its Mad River operations, the District serves a population of approximately 80,000 people in the greater Humboldt Bay area, which represents roughly two-thirds of the entire county.

Four anadromous salmonid species are addressed in this HCP, as follows:

chinook salmon, coho salmon, steelhead trout, and coastal cutthroat trout.

Three of these HCP species -coho salmon, chinook salmon, and steelhead - are listed as "threatened" under the federal ESA. The California Fish and Game Commission recently determined that coho salmon warrant listing as "threatened" under the State ESA. These three species occur in the Mad River and could potentially be impacted by the District's operations. Coastal cutthroat trout are also found in the Mad River. Although they are not currently listed, they are a species of concern, and the USFWS is presently conducting a status review for this species. Therefore, they may be listed in the future. Staff from the NMFS and the USFWS concurred with the selection of these four species as the species to be addressed in this HCP.

The District's "covered activities" were identified as those activities which occur on the Mad River that could cause "take" as defined by the ESA. Ten covered activities, in which the District is currently engaged, are addressed (Section 5). Future possible activities are also identified (Section 13). The District's covered activities can be broadly categorized as: 1) flow release and management activities, 2) diversion activities in the Essex Reach of the Mad River (sub-surface via Ranney Collector system, and surface via the direct diversion facility), 3) maintenance activities, including repair of existing structures if damaged, and 4) periodic excavation and fill activities.

The District believes that the net benefits resulting from its operations are far greater than the adverse impacts associated with its operations. The net benefits are derived from the District's flow releases from Ruth Lake, especially during the critical low-flow months (summer and early fall). Before District operations, the Mad River would regularly "go dry" in the summer. Since the District began its operations, flows in the Mad River have been consistent and reliable year-round, and flow augmentation has occurred in every month except December. It is estimated that the District's operations increase aquatic habitat by approximately 450 acres during the critical low-flow months. More flow creates more aquatic and riparian habitat; therefore, the District's operations benefit the listed salmonid species, as well as other aquatic species.

However, by definition, the District's "covered activities" may cause an adverse impact on HCP species. The impacts associated with each covered activity are described, along with corresponding mitigation measures and monitoring.

Of particular interest is the retrofit project proposed for the direct diversion facility (Station 6) to mitigate and minimize adverse impacts. Operation of Station 6 is the one covered activity where a certain level of "take" is known to occur. To understand and quantify the level of take resulting from operation of Station 6, the District conducted a comprehensive fish study at that facility during 1998. The results from that study indicated that incidental take from Station 6 is very low - less than 0.2% of the estimated population of juvenile salmonids in the Mad River. With the District's proposed mitigation at Station 6, take should be further reduced. The retrofit project involves: 1) replacing a number of the existing fish screens with new screens that meet the NMFS criterion for screen mesh-size opening, 2) eliminating gaps in the subsurface portion of the structure to comply with the NMFS opening criterion, 3) retrofitting the screens such that fish are no longer lifted from the water, thereby eliminating the need for the fish bypass system, and 4) changing operations of the screens such that the new screens are fully submerged during the chinook emergence period. Following completion of the retrofit project, a comprehensive monitoring program will evaluate whether the retrofit project is successful, as compared against biological goals.

This HCP was written to coordinate with Section 7 of the ESA, to assure that the issuance of an Incidental Take Permit will not jeopardize the existence of any listed species. Section 7(a)(2) of the ESA requires that Federal agencies ensure that their actions will not likely jeopardize the continued existence of any endangered (and threatened) species, or result in the destruction or adverse modification of designated critical habitat. The District's operations do not pose jeopardy to any of the HCP species.

Retrofitting Station 6, and performing the ongoing mitigation and monitoring activities will be funded as follows:

- With respect to the Station 6 retrofit project, the District has received a $64,680 grant from the Department of Fish and Game's Salmon Recovery Program, and the Board of Directors has approved the required District cost match for this project in the FY 2002/03 budget.
- The ongoing mitigation and monitoring activities will be funded from the District's operating budget, which is established and adopted annually by the Board of Directors.

Habitat Conservation Plan

1. Introduction

The purpose of this Habitat Conservation Plan (HCP) is to provide information to the National Marine Fisheries Service (NMFS), the US Fish and Wildlife Service (USFWS), the California State Department of Fish and Game (CDFG), and other interested parties and agencies. This introduction provides an overview of the Humboldt Bay Municipal Water District (District), how the Endangered Species Act (ESA) affects the District, and how the District plans to address and comply with the Act.

1.1 Overview of the Humboldt Bay Municipal Water District

The Humboldt Bay Municipal Water District (District) was organized in 1956 under California's Municipal Water District Act. Since the early 1960s, the District has reliably supplied water to customers in the greater Humboldt Bay area of Humboldt County, California.

The District's source of supply is Ruth Lake, a 48,000 acre-feet reservoir, located approximately 85 miles upstream from the mouth of the Mad River. The District carefully plans and manages its release of water from Ruth Lake to meet its diversion requirements and its in-stream flow requirements, for the protection of fish. The District's releases from Ruth Lake provide a significant increase in flow during the Mad River's critical low-flow months, compared to naturally occurring flows (e.g. flows prior to the District). The increased flows consistently provide an increase in aquatic habitat, which in turn provides direct benefits to fish.

The District's diversion facilities are located on the Mad River at Essex, 75 miles downstream from Ruth Lake. The District diverts water at Essex for two separate systems, 1) a domestic system, which supplies treated drinking water, and 2) an industrial system, which supplies untreated "raw" water. Water for the industrial system is supplied by a surface diversion facility (Station 6). Water for the domestic system is drawn from four Ranney collectors located in the Mad River; the collectors draw water from the aquifer sixty to ninety feet below the riverbed.

The District is the only water supplier in the greater Humboldt Bay area. The District sells raw water to industrial users on the Samoa Peninsula, and treated water on a wholesale basis to the cities of Eureka, Arcata and Blue Lake, and the Humboldt, McKinleyville, Fieldbrook, and Manila Community Services Districts. Via the wholesale relationship, the District serves a population of approximately 80,000 people, or roughly two-thirds of the entire county.

1.2 Endangered Species Act

Three species of anadromous salmonids on the Mad River have been listed under the Endangered Species Act (ESA) and a fourth is under consideration.

- In 1997, the Secretary of Commerce listed coho salmon in the Southern Oregon and Northern California Evolutionary Significant Unit (ESU) as "Threatened" and subsequently designated fish-accessible reaches of the Mad River as critical habitat (50 CFR Part 226).
- In 1999, the Secretary listed chinook salmon in the California Coastal ESU as "Threatened", and designated fish-accessible reaches of the Mad River as critical habitat for the chinook as well. However, in May 2002, the critical habitat designation for chinook was vacated by a federal court ruling.
- In 2000, the Secretary listed steelhead in the Northern California ESU as "Threatened" but critical habitat has not yet been designated.
- The fourth salmonid species under consideration is the coastal cutthroat trout. The National Marine Fisheries Services (NMFS) completed a Status Review of coastal cutthroat trout, and determined that listing was not warranted in the Southern Oregon-California Coast ESU. However, in 1999, jurisdiction for coastal cutthroat trout was transferred from NMFS to the USFWS. USFWS does not utilize ESUs in its definition of a species under the ESA, and is currently undertaking a new Status Review, which is not complete at this time.

1.3 The ESA's Impact on the District

The ESA listings have numerous implications for the District. First, the ESA defines and prohibits "take" of listed species. Several of the District's Mad River activities may result in a low level of "take." Second, in conjunction with other environmental laws and regulations, the ESA has increased the cost and complexity of conducting business on the Mad River. In particular, the cost and difficulty of securing permits has increased dramatically. For example, the District must secure an Army Corps of Engineers (ACOE) permit every five years, under Section 404 of the Clean Water Act. Given the ESA listings, the ACOE must now enter into formal consultation with the NMFS and USFWS prior to issuing any permit. The Services must issue a Biological Opinion to the ACOE, determining if the District's actions pose jeopardy to the continued existence of these species, or if the actions pose a significant adverse affect on critical habitat. The District's most recent ACOE permit renewal took almost two years to complete, and significant time and effort was expended by all agencies.

1.4 Purpose of this HCP

Section 10 of the federal ESA allows for the issuance of Incidental Take Permits, which authorize a level of take associated with an otherwise lawful activity. The District has elected to pursue a fifty (50) year Incidental Take Permit for all of its Mad River activities. As required by the ESA, the District has prepared a comprehensive Habitat Conservation Plan (HCP) to support issuance of this permit. The overall purpose of this effort is to outline conservation measures that the District will undertake to minimize and mitigate adverse impact to the listed species, in order to gain long-term regulatory certainty with the federal agencies (e.g., NMFS, USFWS, and other federal agencies which issue permits, leases or exemptions to the District).

In accordance with guidance provided in NMFS' HCP Handbook (NMFS, 1996), including its five-point policy addendum (2000), the District is submitting this HCP for its Mad River activities covering coho, chinook, and steelhead. The HCP will provide the following information:

- Impacts to the listed species likely to result from the District's Mad River activities;
- Measures the District will undertake to minimize, mitigate, and monitor such impacts;
- Procedures to deal with adaptive management and changed circumstances.

The HCP will serve as the basis for issuance of an Incidental Take Permit from NMFS for coho, chinook and steelhead. Although this HCP does not seek coverage for coastal cutthroat trout, it provides information on that species to support a possible Candidate Conservation Agreement with the USFWS, given the status review in progress for that species.

2. The HCP Boundaries

The HCP Handbook discusses the merits and disadvantages of drawing an HCP boundary that is either too large or too small. If the boundary drawn is too small, the HCP may not be sufficiently comprehensive. If the boundary drawn is too large, the HCP may become too complicated, resulting in "an overextended, protracted HCP effort." The HCP boundaries described below achieve a reasonable balance, and are appropriate for the District's activities and their effect on the salmonid species addressed in this HCP.

A number of criteria were considered when selecting the boundaries of the HCP area. According to the HCP Handbook, the "HCP boundaries should encompass all areas within the applicant's project, land use area, or jurisdiction within which any permit or planned activities likely to result in incidental take are expected to occur." In addition to the Handbook's recommendations, three other criteria were considered: 1) the concept of "critical habitat," as defined in the 1973 Endangered Species Act (ESA), which includes all accessible river reaches, all substrate and adjacent riparian zones of listed species, and all areas below specific dams or longstanding, naturally impassable barriers; 2) the geographic distribution of salmonids in the Mad River; and 3) other utilized but non-contiguous areas in which the District operates, which include lands leased from the U.S. Forest Service at Ruth Lake.

For the District's Mad River operations, the HCP boundaries are described as follows:

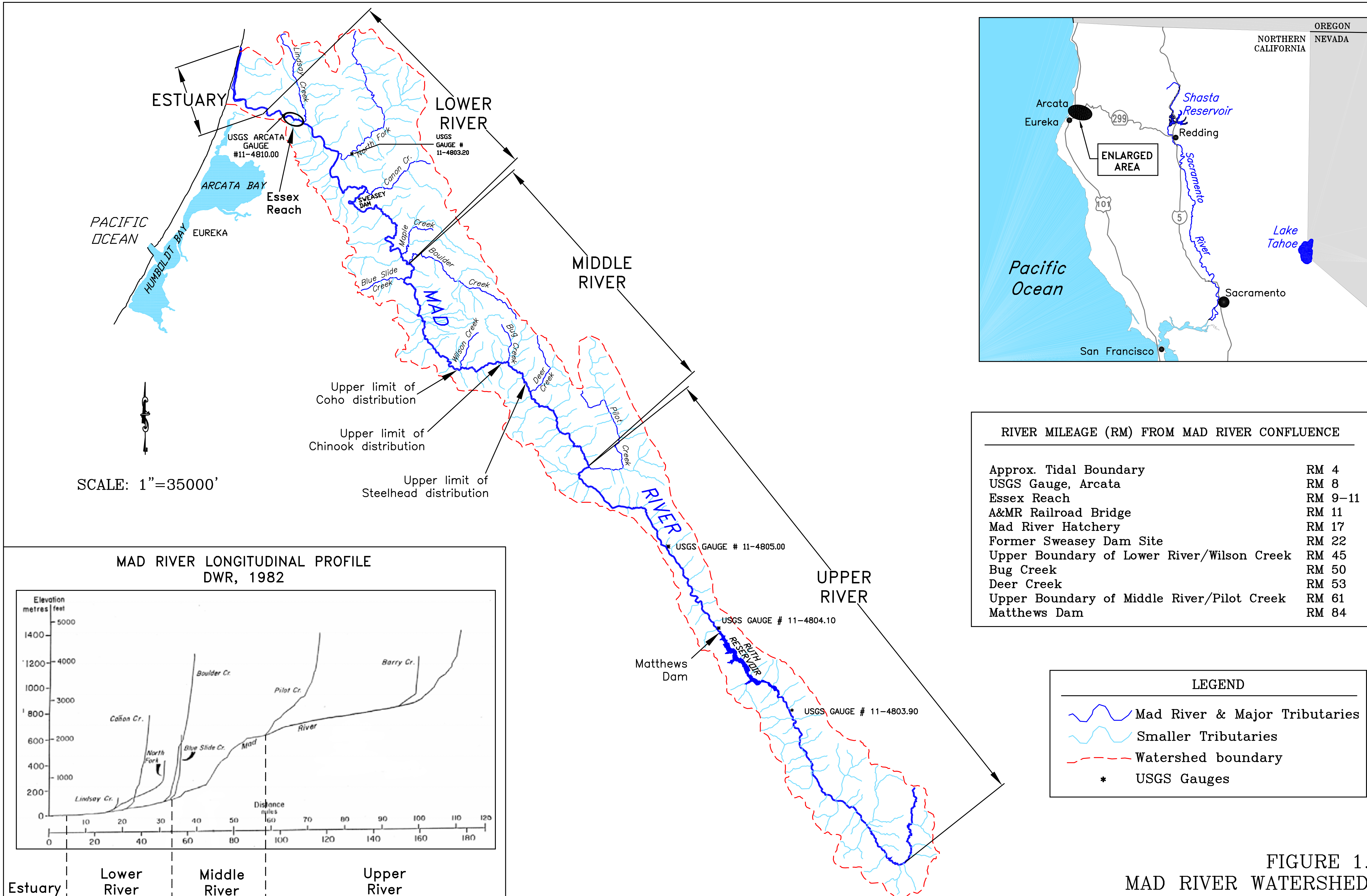
- Width: The width of the HCP area is the Mad River's bankfull channel and adjacent riparian zone.

- Upstream boundary: The HCP area's upstream boundary is defined by how far salmonids migrate up the river. For steelhead, Deer Creek (River Mile (RM) 53) usually defines the upper migration limit. However, during periods of high flow combined with geomorphic stability, steelhead may be able to migrate further upstream. Therefore, the upstream boundary of this HCP was selected at Matthews Dam (RM 84).

- Downstream boundary: The HCP area's downstream boundary is defined as the mouth of the Mad River (RM 0) because the District's activities—specifically, bypass flows below its diversions at Essex - may affect the Mad River estuary.

- Noncontiguous areas. The HCP area also includes facility and maintenance areas at Essex (owned by the District) and at Matthews Dam (leased from the Forest Service).

Refer to Figure 1, next page, for a map of the Mad River watershed which illustrates a number of features of the watershed, including the distribution limits of the salmonid species addressed in this HCP.



RIVER MILEAGE (RM) FROM MAD RIVER CONFLUENCE

Approx. Tidal Boundary	RM 4
USGS Gauge, Arcata	RM 8
Essex Reach	RM 9–11
A&MR Railroad Bridge	RM 11
Mad River Hatchery	RM 17
Former Sweasey Dam Site	RM 22
Upper Boundary of Lower River/Wilson Creek	RM 45
Bug Creek	RM 50
Deer Creek	RM 53
Upper Boundary of Middle River/Pilot Creek	RM 61
Matthews Dam	RM 84

FIGURE 1.
MAD RIVER WATERSHED

3. The Environmental Setting

Although much could be written on the Mad River environment, this plan's description will be confined to that information needed to understand the factors that directly limit the distribution or abundance of anadromous salmonids, in both space and time.

The hydrology of the Mad River is characteristic of many North Coast California streams. Storms are episodic; river stage height may fluctuate many feet from its peak storm runoff, to the baseflow stage in between storms. Most rainfall occurs in the late fall, through winter, and into the middle of spring. Snowfall occurs but its storage and melting are not considerable hydrograph components. Prior to the District's operations, in the upper river zone and below the former Sweasey Dam, the river channel would frequently "dry up" during the late summer. However, with water storage in Ruth Lake, and with bypass flows at the Essex Reach, the river flows continuously year round. Additional information about the Mad River environment is presented in Appendix A.

The two primary environmental factors limiting fish populations are the area's hydrology and its geography; therefore, the temporal and spatial aspects of each will be discussed below.

The geography of the Mad River, with respect to fish abundance and distribution, can be partitioned into four zones (Table 1, Figure 1). Anadromous fish fully occupy the two lower zones. In the middle river zone, migration barriers limit access to below Wilson Creek for coho, Bug Creek for chinook, and usually Deer Creek for steelhead. Under certain conditions, steelhead may be able to migrate further upstream and utilize the upper river zone and Pilot Creek. Therefore, the upper river zone is differentiated from the middle zone by the limited periods of time when high flows coincide with geomorphic stability, such that steelhead are able to negotiate the barriers.

Table 1. Spatial Environment – The Mad is comprised of Four Zones

Zone	Extent	Upper Extent Defined by:	Primary Fish Uses:
Estuary	RM 0 to RM 4	That portion of river that is tidally influenced	Rearing before outmigration to ocean.
Lower River (Low gradient, relatively stable morphology)	RM 4 to RM 34	The confluence of Boulder Creek. Includes Lindsay Creek; the North Fork; and Canon, Maple, and Boulder Creeks	As a "highway" to tributaries during upstream and downstream migration. Spawning and rearing of most anadromous species.
Middle River (Steep gradient, morphologically unstable)	RM 34 to RM 61	The confluence of Pilot Creek	Upstream migration barriers at RM 45, 49, and 53 stratify fish species by their ability to reach upper river. Steelhead spawning and rearing.
Upper River (Steep gradient, unstable)	Above RM 61	The Mad River watershed boundaries	Naturally of limited use by any anadromous fish due to barriers and intermittent summer flows. Since the District began operations (1962), the District has maintained summer flows.

Most of the District's operations that may impact fish occur in the Lower River zone, from RM 9 to RM 11, where the District maintains its diversion facilities. This two-mile reach, referred to as the "Essex reach," is characterized by its low gradient, high degree of confinement, sand and small gravel substrate, and lack of woody debris.

Unfortunately, the source of large woody debris, particularly from more resistant conifer species, along the lower Mad River was depleted during the 1800s. Normally large woody debris, particularly trees with their root system intact, enter the river at points where bank erosion or debris slides occur. While there is bank erosion in the Blue Lake Valley reach immediately above the Essex reach, there are virtually no large conifers remaining on the banks. Therefore, any erosion that occurs today does not provide the Essex reach with large woody debris. The Essex reach is naturally confined and has stable banks, with Cottonwoods as the main riparian overstory component. To protect the occasional large woody debris which is deposited in the Essex reach, the District does not allow the public to salvage the woody debris for firewood.

Habitat mapping indicates that the Essex Reach is primarily pool habitat (approximately 64%), which offers little shelter for fish, especially when combined with the lack of woody debris.

However, the Essex reach is a critical corridor for migration of both juveniles and adults, and also provides spawning habitat, particularly for chinook in low-water years. Refer to Appendix E-3 for detailed habitat description and mapping of this reach.

The temporal aspects of the Mad River's environmental setting are described by the interactions between hydrology and fish behavior. A particular season or time of year cannot be identified as most important to fish; life stages of fish require various flow regimes at various times (Table 2).

Table 2. Temporal Environment – Life Stages of Fish

Fish Life Cycle: Species	Months During which Life Stage Occurs	Peak During which Life Stage Occurs
Egg Incubation:		
Coho Salmon	November - May	
Chinook Salmon	November - mid-May	
Steelhead Trout	January - June	
Cutthroat Trout	Not available	
Emergence:		
Coho Salmon	Late February - mid May	
Chinook Salmon	Late February - mid May	
Steelhead Trout	May – June	
Cutthroat Trout	March – June	
Juvenile Outmigration:		
Coho Salmon	May – June	May
Chinook Salmon	April – July	June
Steelhead Trout	May – August	July
Cutthroat Trout	Not available	
Spawning Migration:		
Coho Salmon	October - February	December
Chinook Salmon	September - February	October-January
Steelhead Trout	August - April	December-January
Cutthroat Trout	August - November	September
Spawning:		
Coho Salmon	November - February	December
Chinook Salmon	November - February	December-January
Steelhead Trout	December - April	January-March
Cutthroat Trout	November - June	January

4. Species Covered in this HCP

The number of species to be covered in this HCP results from a balance between: 1) the District's need for regulatory certainty (which argues for covering more, rather than fewer, species), and 2) the regulatory agencies' need to confine the HCP to a manageable and enforceable level (which argues for fewer species.) NMFS' HCP Handbook states that the greater the number of species addressed in the HCP, the more complicated the HCP may become. This section lists species proposed to be covered, and gives the rationale for their selection.

At this time, the Secretary of Commerce has listed three anadromous salmonids species--coho salmon, chinook salmon, and steelhead--as "threatened". These three species occur in the Mad River and may be impacted by the District's operations. Coastal cutthroat trout also occur in the Mad River. Although they are not currently listed, they are undergoing a status review by the USFWS and may be listed in the future. Because coastal cutthroat trout have a similar life history to the other three listed fish, results from the District's operations and mitigation activities would likely be similar (i.e., the District would manage the cutthroat similarly as the coho, chinook, or steelhead.) Staff from the NMFS and the USFWS concurred with the selection of these four species as the species addressed in this HCP.

The HCP Handbook also suggests that the District collect and review existing information on the HCP species, focusing on the species' distribution, artificial propagation, abundance, and ecology. The Handbook recommends that research efforts should be confined to distribution or other studies that directly bear on the needs of the HCP. The District readily identified information for coho, chinook, and steelhead, but data for coastal cutthroat trout could not be found. Table 3 presents a brief summary of the data which exist for each species on the Mad River. Appendix B provides additional detail and data, including the species' evolutionary significant unit, regulatory status, life history stage, and spatial distribution.

Table 3. Available Data for Four HCP Species

Species	Designation	Years of Available Data[1]	Recent Population Estimates [1]
Coho salmon	Listed as Threatened (1997)	1971-2001 MRH. 1938-1964 Sweasey Dam. 1985-2000 Canon Cr. and North Fork Mad River	Since 1990, coho returns at the MRH ranged from 3 to 259. [2] Since 1971, numerous non-native strains of coho have been introduced to the Mad River by the MRH.
Chinook salmon	Listed as Threatened (1999)	1971-2001 MRH 1938-1964 Sweasey Dam. 1985-2000 Canon Cr. and North Fork Mad River	Since 1990, chinook returns at the MRH ranged from 1 to 67. [2]
Steelhead trout	Listed as Threatened (2000)	1971-2001 MRH. 1938-1964 Sweasey Dam. 1994-1999 summer steelhead Mad River.	Population trends complicated by two runs (winter and summer). Since 1990, steelhead returns at the MRH ranged from 915 to 11,520.
Coastal cutthroat trout	Under Status Review	Under USFWS Status Review. Previous Status Review by NMFS found little or no data.	Unknown.

(1) MRH stands for Mad River Hatchery
(2) In 1994, CDFG ceased raising coho and chinook at the Mad River Hatchery. Therefore, returning fish of these two species are voluntary, and their numbers cannot be directly compared to pre-1994 counts.

The Pacific lamprey is another species present in the Mad River, and its distribution reportedly extends as far as RM 50, which is the confluence of the Mad River and Bug Creek (CDFG Mad River Files, 1972). Although it is not listed, the USFWS has classified Pacific lamprey as a species of concern, which indicates that its long-term abundance and distribution trends are unknown. Because its abundance, distribution, and basic life history are unknown, the District would be unable to manage either its operations or mitigation activities to reduce or limit impacts. Similarly, the regulatory agencies would be unable to enforce take levels without knowing abundance and distribution. Consultation between the District and USFWS resulted in a determination to exclude the Pacific lamprey as a covered species, due to lack of life history and population data.

5. The District's Covered Activities

"Covered activities" are those activities which may result in "take," as defined by the ESA. Therefore, a District activity which may result in take (for example, operation of the fish screens at the direct diversion facility) would be a covered activity. Other activities, such as treating water for domestic use, would not be a covered activity, because water treatment does not impact nor result in take of any of the HCP species.

The HCP Handbook suggests that the applicant include "all actions within the planning area that: (1) are likely to result in incidental take; (2) are reasonably certain to occur over the life of the permit; and (3) for which the applicant has some form of control." Under these three criteria, the following lists the District's covered activities:

Current Activities which Occur on an On-going Basis:

1. Releasing flow at Matthews Dam
2. Diverting water in the Essex Reach (sub-surface via Ranney collectors and surface via direct diversion facility)
3. Bypassing flows below Essex
4. Operating the direct diversion facility (Station 6) including the fish screens
5. Dredging of forebay at Station 6
6. Maintaining adequate water surface elevation to Station 6 during low-flow months (currently done via construction of a gravel berm, but may be achieved by new grade-control structure in the future)

Current Activities which Occur only As-needed:

7. Maintaining adequate capacity in tailrace and spillway pools below Matthews Dam (by excavation if sediment, gravel or debris accumulates)
8. Gaining access to and maintaining Ranney collectors
9. Maintaining adequate flow to Station 6 (by excavation of the low-flow channel in front of Station 6 if gravel or debris accumulates)
10. Protecting banks and structures (by repairing existing rock structures and/or revetments)

The impacts associated with these activities, as well as proposed mitigation measures, are discussed in the following sections (Section 6, 7 and 8). Additionally, Appendix C contains a more detailed description of the District's Mad River activities.

6. Impacts from the District's Covered Activities

The overall effect of the District's Mad River operations is beneficial; however, each covered activity may impact the HCP species, and that impact may be beneficial or negative.

The primary beneficial activity is the District's flow releases during summer and early fall. Prior to the District's operations, flow would frequently become subsurface - that is, the river channel would completely dry up – in the late summer and fall. Releases from Ruth Lake now augment flows in 84 miles of the river, and even in drought periods, a minimum flow has consistently been maintained in the river. Flow augmentation has many beneficial effects, including expanding river habitat all the way to the mouth. It is estimated that increased flows associated with District releases provide approximately 450 acres of habitat for aquatic species during the low-flow months. Summer-run steelhead particularly benefit from this improved habitat.

To demonstrate that the District's operations have augmented flows compared to what otherwise occurred naturally, the average monthly discharge from Matthews Dam were analyzed between 1989 and 2001. Flow releases from Matthews Dam augment natural "pre-District" flows by at least one order of magnitude, during July through October, as demonstrated in Table 4.

Table 4. District's flow releases from Matthews compared to natural flow (in cfs)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
"Natural" flow above Ruth Reservoir, prior to District operations	772	622	500	250	123	59	9	1	0	5	55	320
District's releases from Matthews Dam	941	812	691	342	177	111	58	70	77	77	70	281
Net increase in flows resulting from flow releases	169	190	191	92	54	52	49	69	77	72	15	-39

Additionally, the District analyzed daily mean stream flows on the Mad River as recorded by the former United States Geological Survey (USGS) Gage Station near Forest Glen (No. 11480500), which was located approximately nine miles downstream of Matthews Dam. This station was in operation from 1953 through 1994, and therefore, recorded stream flows prior to and following the District's operation at Matthews Dam (which commenced in 1961). Table 5 presents the minimum, maximum and average daily stream flows during the low-flow months for this station.

Table 5. Daily Mean Stream Flows (cfs) during Low-flow Months (Oct. 1953 to Oct 1994)

At USGS Gage Station Near Forest Glen (located approximately 9 miles downstream of Matthews Dam)

	August			September			October			November		
Period 1 - Prior to Operation of Matthews Dam												
Year	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
1953							3	16	5	4	2330	279
1954	2	7	3	2	4	3	2	11	5	5	987	120
1955	2	5	3	1	3	2	2	5	2	3	1890	176
1956	2	5	4	2	2	2	2	1050	52	10	214	42
1957	3	7	5	2	23	4	7	1400	168	32	3350	455
1958	2	18	8	6	19	14	1	5	2	2	72	13
1959	2	2	2	2	20	7	2	9	6	2	3	2
1960	2	7	5	1	3	2	2	5	3	2	1250	117
1961	1	10	5	1	8	4	2	8	3	2	380	51
AVG	**2**	**8**	**4**	**2**	**10**	**5**	**2**	**279**	**27**	**7**	**1164**	**139**
Period 2 - After Matthews Dam in Operation												
1962	12	20	14	13	21	17	16	3840	620	217	1150	379
1963	48	135	92	118	271	220	9	213	65	29	807	362
1964	94	98	96	92	98	94	91	100	95	53	420	114
1965	45	73	53	65	73	70	69	79	76	73	425	213
1966	80	111	88	76	158	91	56	75	72	52	369	128
1967	81	121	101	99	119	111	123	269	171	70	178	122
1968	72	103	90	70	108	82	63	109	82	81	367	225
1969	73	105	95	73	119	97	95	113	109	95	206	134
1970	90	104	101	98	119	105	107	127	114	107	722	235
1971	83	100	94	95	111	100	92	141	107	102	228	122
1972	79	100	93	91	128	102	80	117	107	101	198	128
1973	83	123	95	95	118	104	102	199	111	105	3060	1262
1974	97	123	114	117	124	119	111	134	117	65	169	104
1975	70	108	88	87	108	91	87	330	117	123	620	316
1976	45	71	56	54	86	62	77	102	92	37	98	78
1977	57	81	68	14	69	56	10	51	37	9	238	44
1978	69	100	89	93	114	96	91	94	93	72	95	87
1979	93	104	98	100	102	101	45	361	94	46	1500	302
1980	88	106	96	99	106	101	96	104	99	38	100	78
1981	81	93	84	81	91	85	34	139	70	27	3000	814
1982	43	76	62	70	114	91	44	182	139	111	584	181
1983	41	137	63	70	116	87	98	143	124	147	2600	584
1984	77	93	80	83	88	86	83	94	88	94	3320	867
1985	85	96	91	90	98	95	51	121	92	40	84	63
1986	99	108	104	104	129	109	100	149	112	15	115	83
1987	90	95	93	89	97	92	87	93	90	29	87	57
1988	86	98	93	92	107	98	92	109	96	24	861	201
1989	94	104	99	83	103	98	55	231	98	55	115	90
1990	80	118	107	96	103	101	96	118	105	50	99	88
1991	94	105	99	94	102	97	34	103	88	13	86	48
1992	93	97	95	88	96	92	53	88	76	11	61	33
1993	41	43	42	42	58	52	57	64	60	59	64	61
1994	51	64	56	56	67	62	65	68	67			
AVG	**73**	**97**	**85**	**81**	**107**	**93**	**72**	**250**	**112**	**67**	**688**	**238**

All of the District's other covered activities have associated impacts – either beneficial or adverse - on the HCP species. Table 6 briefly summarizes the impacts of each activity.

The primary adverse impact associated with the District's Mad River operations results from operation of the fish screens at Station 6. To quantify the effect of the fish screens, the District conducted a comprehensive fisheries study in 1998. The results of this study indicated that less than 0.2% of the estimated juvenile fish population in the Mad River are affected by the screens. Refer to Section 7 and Appendix E-1 for additional detail about the 1998 fish study. The District will be retrofitting the Station 6 screens and operation to minimize and mitigate the adverse impacts. This retrofit project is described in Section 8.1, which follows Table 6.

Table 6. Impacts on HCP species associated with the District's Covered Activities

(Activity numbers correspond to "District's Covered Activities List" in Section 5)

District Activity (and Location)	Impact	Explanation
1. Releasing flow at Matthews Dam	Beneficial	Historically, the Mad River's upper reaches frequently went completely dry. Now, the District's releases provide a reliable and continuous flow year-round. Increased flows create approximately 450 acres of additional habitat in the summer and fall, and improve other water quality parameters such as temperature, thereby benefiting aquatic species. Ruth Lake impounds water during the first fall or winter storms; however, this likely has minimal, if any, adverse effect on downstream flows or habitat. The historical flow data indicate that operation of Matthews Dam has not reduced average flows below that which occurred naturally during September, October and November (the period during which the first storms of the season occur). As presented in Tables 4 and 5, the District's operation has significantly increased average daily flows compared to what naturally occurred. (From Table 4: Sept 77 vs. 0 cfs, October 77 vs. 5 cfs, November 70 vs. 55 cfs; and From Table 5: Sept. 93 vs. 5 cfs, October 112 vs. 27 cfs, November 112 cfs vs. 27 cfs). Matthews Dam is sited such that approximately 25 percent of runoff of Mad River lies above the dam and reservoir. Mad River's total annual discharge into the Pacific Ocean has been computed on average to slightly exceed 1,000,000 acre-feet. Consequently, approximately 250,000 acre-feet of water on average passes through the reservoir, a portion of which is impounded. The reservoir has a retention capacity of 48,000 acre-feet, which in an average year is drawn down to approximately 30,000 acre-feet. Thus, under current operational conditions during an average water year, the natural runoff above the dam is diminished by 20,000 acre-feet, which represents only 2 percent of the river's total natural runoff. On a daily basis, the runoff above the dam varies greatly, from zero surface flows (July through September) to short-term daily flows in excess of 3,000 cfs during intense late fall and winter storms. At the beginning of the fall rainfall period (normally mid to late October) the reservoir level may be twenty to twenty-five feet below the spillway. As a consequence, the majority of inflow above the dam resulting from early rain storms is impounded. During this period, however, the District's operational policy and history has been to release from 50 cfs to in excess of 100 cfs during these early storm periods. The resulting short-term impact to daily runoff resulting from impoundment from early September storms is minimal, increasing to a maximum reduction in daily flows of approximately 85% in October and 97% in November (assuming the 3,000 cfs storm event). It is important to understand these "storm" flows, under natural conditions, would not reach the Essex reach nor the estuary for 60 to 70 hours, at which time the contributing flows of the remaining drainage would significantly mitigate the flow reduction impacts.

Table 6 (Continued)		
District Activity (and Location)	**Impact**	**Explanation**
1. Releasing flow at Matthews Dam (Continued)		In terms of impacts upon water depth and wetted perimeter, a natural daily flow of 3,000 cfs would create significant short term increases in the depth and width of surface flows in the upper river reach. However, under natural conditions after heavy rainfall and the resulting storm flows ceased, the surface flow would quickly drop to levels significantly below the sustained flows now provided by the District. It is not possible to assess whether the extreme natural short-term flow variations in the upper reaches were more beneficial or detrimental to fisheries compared to the continuous, but more moderate flow conditions which now exist given the District's operation.
2. Diverting water in the Essex Reach (sub-surface via Ranney collectors and surface via direct diversion facility)	Negligible, if any	The District manages its releases from Matthews to meet its diversion requirements at Essex as well as its bypass requirements below Essex for the protection of fish (see activity 3, below). Appropriative water rights in existence at the time the District acquired its water rights permits from the State were factored in to the release requirements.
3. Bypass flows below Essex	Beneficial	The District maintains minimum bypass flows below Essex in accordance with conditions in its State Water Rights Permits for the protection of fish. Providing bypass flows that are generally greater than "naturally occurring" flows create more river and riparian habitat and aids in keeping the river mouth open.
4. Operating the direct diversion facility (Station 6) including the fish screens	Adverse	The Station 6 forebay is contiguous with the main migratory route of salmonids, and functions similarly to a natural backwater pool habitat. Salmonids (both adults and juveniles) are free to swim in or out Of the forebay and intake structure. The presence of the forebay, like a natural holding pool, does not cause salmonids to delay their migration. Avian and aquatic predators can access the forebay as they can any backwater pool habitat. The predation frequency in the forebay is not known; however there is no reason to believe it is any greater than in naturally occurring backwater pools. In 1998, the District conducted a comprehensive fish study to determine the rate of capture of salmonids at the Station 6 screens. The annual capture rates at the screens were quantified as 4 coho fry, 18 chinook fry, 15 steelhead, and 0 cutthroat juveniles. These rates are less than 0.2% of estimated population in the Mad River. (See Section 7 and Appendix E-1).
5. Dredging of forebay at Station 6	Potentially Adverse	Dredging is necessary to remove accumulated silt or debris deposited in the forebay. This activity occurs each year, but only in the winter when background turbidity in the river is very high, so there is no additional adverse turbidity effect. The frequency of dredging varies based on the frequency and severity of winter storms, but typically ranges from 2 to 5 times per month during the winter season. Fish theoretically could be injured or killed if hit with the bucket. A potential benefit of removing debris from the forebay is that a relatively simple habitat is maintained, so juvenile fish may be less likely to utilize it during low-flow periods.

Table 6 (Continued)		
District Activity (and Location)	**Impact**	**Explanation**
6. Maintaining adequate water surface elevation to Station 6 during low-flow months	Adverse	Water surface elevation must be maintained at 21 feet so the pumps operate properly. A gravel berm is constructed each year when the water surface elevation at Station 6 approaches 21 feet (generally late May or June). The berm connects the existing rock jetty, which projects from the north bank of the river, with the existing grade-control rock weir (downstream of Station 6), thereby ensuring the low-flow channel goes over the grade-control weir as opposed to around it. The berm is constructed from native gravel on the outside edge of the wetted channel, and typically occupies a footprint of approximately 0.15 acres. Turbidity may be temporarily increased above background levels, and juveniles may be injured or killed during construction of the berm. The last three years (2000–2002), a federally-licensed biologist was present during construction to protect fish. The first two years, no injuries or mortality were observed. The third year, 48 juvenile steelhead were killed when they were stranded and the pool rapidly dewatered.
7. Maintaining adequate capacity in tailrace and spillway pools below Matthews Dam	Negligible, if any	Excavation will be necessary if silt, gravel or debris accumulates in the spillway or tailrace pools. The necessity for this work generally occurs only after major storm events, and thus does not occur with great frequency – using the past as a guide, excavation of the spillway or tailrace outlets has only occurred twice in the last ten-to-fifteen years. Juvenile steelheads could be injured or killed, if they were able to navigate downstream barriers and are present at time work is done.
8. Gaining access to and maintaining Ranney collectors (which may involve building temporary gravel structures in river bed)	Negligible, if any	District personnel routinely visit the collectors to perform inspections and ongoing maintenance. To gain access to the collectors located in the river bed, District personnel use a cable car, which transports them from the bank to the collector. Periodically, the District must perform major maintenance (e.g. repair or replace pumps/motors or other heavy equipment), and to do so, a temporary gravel structure must be built for a vehicle or crane to gain access to the collector. Major maintenance does not typically occur with great frequency (in the past, between five and fifteen year intervals per collector). The District also periodically flushes the collectors and discharges water onto the dry river bed. A temporary gravel berm is constructed around the collector to contain the water. This berm creates a settling basin such that any turbidity generated by the flushing activity settles out and does not enter the wetted channel. Flushing has not occurred, and is not expected to occur, with great frequency. In the past, flushing operations have only occurred two or three times in the last 20 years. These access structures and containment berms are constructed with native river run material, outside of the wetted channel, during low-flow periods. The river bed is returned to its pre-construction condition immediately following completion of the work . Currently, the District does not need to cross the river to access any of the collectors; however should the river channel change course, stream crossings may become necessary in the future.

Table 6 (Continued)		
District Activity (and Location)	**Impact**	**Explanation**
9. Maintaining adequate flow to Station 6	Negative	Modest excavation of the low-flow channel in front of the Station 6 inlet is necessary to remove accumulated gravel/debris. Accumulated gravel must be removed before a permanent bar forms which blocks the entrance to the forebay. When the District excavates, it is through the aggraded bed (e.g. the accumulated gravel) in order to relocate the thalweg in closer proximity to the forebay entrance. The overall bed elevation and slope of the channel are not altered. There is no headwall created, as would occur from in-channel pit mining. The up and down-river riffles are still the hydraulic controls that maintain the overall slope through this reach. This work is necessary to ensure flow from the low-flow channel can freely enter Station 6. The excavated area depends on the extent of accumulation and the location of the low-flow channel in relation to the Station 6 entrance; however a typical area is only 0.1 to 0.2 acres. Turbidity may be temporarily increased above background levels, and juveniles could be injured or killed during excavation work.
10. Protecting banks and structures (by maintaining or repairing existing rock structures or revetments) in the Essex Reach, and in the tailrace outlet and plunge pool downstream of Matthews Dam	Negligible	Several rock structures exist in the Essex reach. Examples of such structures include: revetment which protects the collectors and underground pipelines out to the collectors; a rock jetty (which projects from the north bank just upstream of Station 6), a grade-control weir just downstream of Station 6; and rock slope protection along the banks. Rock slope protection also exists just downstream of Matthews Dam around the plunge pool and tailrace outlets. The District must maintain these structures and make repairs if they are degraded or damaged. Minor, short-term impacts to riparian vegetation could occur, and juveniles could theoretically be killed during the placement of rock. Since this activity is generally in response to storms or other significant events which cause degradation or damage, this work is not expected to occur very frequently.

7. Quantifying Impacts from the District's Covered Activities

On the Mad River, naturally reproducing population estimates for chinook, coho, steelhead, and cutthroat are unknown. Although coho, chinook, and steelhead adult returns have been counted at the Mad River Hatchery since 1971, the hatchery counts represent just a very small fraction of the total salmonid population in the river system.

Quantifying the level of "take" for many of the District's covered activities is not possible. For example, many of the District's activities involve work in the Mad River channel (e.g. dredging/excavation, building the low-flow berm, etc.). Impacts resulting from such work depend on conditions present at the time the work occurs. Quantifying potential impacts associated with work in the channel would require knowing the population of a species, knowing their distribution within the river, and knowing the specific response fish in the area will have to the District's work. Where quantification of take is not possible, the HCP describes the spatial and temporal characteristics of the activity and its potential effects on habitat.

The District's flow management (e.g. releases and diversions) are also covered activities for which "take" is not specifically quantified. There is likely no "take" whatsoever resulting from the District's flow management. In fact, the District's flow releases increase aquatic habitat, especially in the low-flow months, thereby providing a net benefit to aquatic species.

One activity for which quantification is possible is operation of the District's direct diversion facility (Station 6), and more specifically, operation of the fish screens. This quantification is based on the following information gained during prior fishery studies:

- In June 1977, the USFWS California Cooperative Fishery Research Unit, at Humboldt State University, conducted a fish behavior study to evaluate the District's newly installed fish return system. The study consisted of introducing the 2,000 chinook fingerlings into the forebay and running the screens for 30 minutes. "At the end of the 30 minute test no fish had gone through the screen by-pass system. We then observed most of the fish swimming in a school in the forebay area apparently without regard for the small attraction current towards the diversion pumps" (USFWS, 1977). (Refer to Appendix E-2.)

- The District conducted a comprehensive fisheries study in 1998 to quantify the effect of the fish screens at Station 6. The resulting annual capture rates at the screens were very low - 4 coho fry, 18 chinook fry, 15 steelhead, and 0 cutthroat juveniles (Refer to Appendix E-1). These rates are less than 0.2% of the estimated populations in the Mad River. (See Table 7 below.)

- During the District's 1998 fish study, a known number of yearling steelhead was released from the hatchery. Because these fish were marked, biologists could establish the percentages of the released steelhead that were captured by the operation of Station 6. The take of the marked steelhead yearlings was 15 fish of 247,000 released (0.006%).

To quantify the impacts associated with operation of Station 6, and to put this impact in context, capture rates from the 1998 fisheries study were used in conjunction with a conservative estimate of population for each species in the Mad River system (Table 7) . The population estimates are based on a *very* conservative assumption that only 10 redds of each species are present in the entire Mad River system, and data strongly suggests that many more than 10 redds are present.

Table 7. Quantification of Impacts at Station 6

Methodology	Coho	Chinook	Steelhead	Explanation
The average number of eggs per redd is known	1,700 eggs	3,500 eggs	5,000 eggs	Data from Mad River Hatchery
Assume fish build just 10 redds per year in the Mad River and its tributaries	17,000 eggs	35,000 eggs	50,000 eggs	Although Mad River redd surveys have not been formally performed and documented, evidence suggests that many more than just 10 redds would be built (likely hundreds are built per season)
The egg-to-fry survival rates are estimated based on study finding	75% survival	30% survival	75% survival	The 75% survival rate for Coho based on work by Shapovalov and Taft, 1954, and Briggs, 1953. Steelhead egg to fry survival rates assumed to be similar to coho.
The number of fry are then estimated	17,000 x 0.75 = 12,750 fry	35,000 x 0.30 = 10,500 fry	50,000 x 0.75 = 37,500 fry	Multiply number of eggs by survival rate
Annual capture rate by the screens at Station 6 from the 1998 fish study	4 fry per year	18 fry per year	15 fry per year	Annual capture rate by screens based on the monthly capture rate observed during 1998 fish study
Percentage of fish caught by screens, assuming just 10 redds in Mad River	(4 / 12,750) = 0.03%	(18 / 10,500) = 0.17%	(15 / 37,500) = 0.04%	These percentages represent the incidental take from Pump Station 6, operating prior to any mitigation measures or retrofitting.

Based on the foregoing, “take” estimates at Station 6 are less than 0.2% for any of the three HCP species. (Cutthroat trout take could not be quantified because no cutthroat were captured in the 1998 fisheries study.) As noted previously, a conservative assumption in deriving this estimate is that just 10 redds of each species are in the Mad River and its tributaries (second row of Table 7). Surveys conducted by CDFG biologist indicate that many more - perhaps hundreds - of redds are built by fish in the Mad River and its tributaries (Table 8).

Table 8. Average spawning escapement of Mad River chinook female salmon

(“Escapement” refers to female salmon “escaping” from the ocean, and returning to the river)

Source And Location	Number Spawning Chinook (either sex)
Mad River Hatchery (1989 to 1994)	136
Mad River Spawning Survey (1994 to 2000)	64
Canon Creek Index Spawning Surveys (1985 to 2001)	128
North Fork Index Spawning Surveys (1985 to 2001)	164
TOTAL/2 (assuming 50% are females)	**492 divided by 2 = 246**

The estimate of spawning female chinook salmon (246) is derived from three sources: 1) limited spawning surveys by CDFG on the Mad River; 2) Mad River Hatchery counts; and 3) spawning surveys by a local biologist on Canon Creek and the North Fork Mad River (personal communication, Larry Preston, CDFG 2002). Assuming only 10 redds results in a conservative estimate of take. If a greater number of redds were assumed, the denominators in the fractions in row 6 of Table 7 would be greater; and therefore, the percentage of fish caught by the screens would be even less.

8. Mitigation Measures and Monitoring

The District's covered activities, by definition, may result in take of the HCP species. However, the level of take can be limited and reduced by mitigation measures. This section describes the mitigation measures that are proposed by the District. To determine the effectiveness of the mitigation measures, the District also proposes monitoring. Finally, in order to compare the monitoring results against some benchmark or standard, biological goals have been developed as follows:

- For activities relating to flow and diversions (Activities 1 through 3: Releasing flow at Matthews Dam, Diverting water in the Essex reach, and Bypass flows below Essex), the biological goal is that the river will be watered at all times, and in-stream flows will always be maintained in accordance with the flow and bypass conditions in the District's State Water Rights Permits.

- For activity 4, operating the direct diversion facility, the biological goal is that the level of take at Station 6 not exceed 3% to 5% of the juvenile salmonid population exposed to the screens for a given year class. (See Section 8.2.c for additional details regarding this goal).

- For all other activities (e.g. activities 5 through 10), the biological goal is to minimize "take" of the covered species, and furthermore to minimize adverse impacts to their habitat.

The mitigation measures and monitoring are summarized for each covered activity in Table 9. Sections 8.1 and 8.2, which follow, explain the mitigation and monitoring program for certain activities in greater detail.

Table 9. Mitigation and Monitoring for Covered Activities

District Activity	Potential Impacts, Mitigation and Monitoring
1. Releasing flow at Matthews Dam	Potential Impacts: Take resulting from no flow releases to river, or from rapidly changing flows in a very short time period (e.g. "ramping") Mitigation: Provide flows sufficient to maintain a 5 cfs minimum at all times below the dam. During low-flow times of the year (defined for this purpose as 100 cfs or less), if the District plans to reduce its releases at one time by more than 25%, it shall do so in gradual increments over a 24-hour period to ensure no stranding will result. Monitoring: Daily flow records for releases from Matthews Dam shall be maintained by District.

Table 9 (Continued)	
District Activity	**Potential Impacts, Mitigation and Monitoring**
2. Diverting water in the Essex Reach (sub-surface via Ranney collectors and surface via direct diversion facility)	Potential Impacts: Decreasing flow in river below Essex, potentially causing habitat loss Mitigation: The District will provide sufficient flows to maintain habitat, in accordance with requirements in District's State Water Rights Permits. Monitoring: On a daily basis, the District plans and executes its flow releases to satisfy all downstream requirements (e.g. diversion and bypass below Essex). On a daily basis, the District also monitors the actual flow below Essex to ensure its bypass flow requirements are met (based on daily flow data from the USGS gage station on the Mad River downstream of Essex near the Highway 299 bridge).
3. Bypass flows below Essex	Potential Impact: Decreasing flow below Essex, potentially causing habitat loss. Mitigation: The District will release sufficient water from Matthews Dam to accommodate its downstream diversion requirements, and to maintain the in-stream flow requirements below Essex in accordance with conditions in the District's State Water Rights Permits. It is important to note that the District could be out of compliance with respect to the downstream flow requirements for up to 72 hours following issuance of a USGS "correction factor" which affects the resulting flow measurement at a USGS gage station on the Mad River (See Section 8.2.a and Appendix C for more details). USGS provides the District with a copy of the gage station correction factor right after they establish one. The District shall immediately increase its release from Matthews if a shortfall in the required bypass flow below Essex occurs following receipt of such correction factor. Monitoring: On a daily basis, the District plans and executes its flow releases to satisfy all downstream requirements (e.g diversion and bypass below Essex). On a daily basis, the District also monitors the actual flow below Essex to ensure its bypass flow requirements are met (based on daily flow data from the USGS gage station on the Mad River downstream of Essex near the Highway 299 bridge).
4. Operating the direct diversion facility (Station 6) including the fish screens	Potential Impacts: Take resulting from operation of the fish screens (impingement or removal via the buckets attached to the screen face) Mitigation: The District will be retrofitting the Station 6 screens to minimize take. The retrofit project is described in detail in Section 8.1. Monitoring: The District will conduct comprehensive monitoring after the Station 6 screens are retrofitted. The monitoring is described in detail in Section 8.2.c.
5. Dredging of forebay at Station 6	Potential Impact: Take could occur if the clamshell bucket or excavator happens to strike or capture fish which happen to be in the forebay at the time of this work. This activity only occurs in the winter when background turbidity in the river is very high, so additional adverse turbidity effects will not occur. Mitigation: District personnel will strike the top of the water with the bucket prior to starting the dredging in an attempt to "scare away" any fish which may be present. Monitoring: District personnel will visually monitor as work proceeds.

Table 9 (Continued)	
District Activity	**Potential Impacts, Mitigation and Monitoring**
6. Maintaining adequate water surface elevation to Station 6 during low-flow months	Potential Impacts: Take could occur if fish are killed or injured during construction of the low-flow berm. Turbidity may increase for a short period of time just downstream of Station 6. Mitigation: a) Measures to minimize adverse impacts to habitat: The berm will be constructed such that it occupies the minimum possible area of the low-flow channel. Work will occur in a timely manner to minimize turbidity disturbances (e.g. berm will generally be constructed in less than 6-to-8 hours). The Station 6 pumps will be run to draw as much turbid water into the forebay as possible. Any additional techniques known to the District, and suitable for this work, shall be employed to further minimize turbidity effects. The District shall exercise every reasonable precaution to protect the stream from fuel or oil spills. Equipment fueling shall not occur within the bankfull channel. All equipment shall be pressure washed and inspected for leaks prior to entering the river bed. Spill containment kits shall be readily available at the work site. b) Measures to minimize take: Prior to commencing construction of the berm, a fisheries biologist will inspect the area and determine to what extent juvenile salmonids are present. The biologist, in consultation with the District, will determine if any mitigation measures, over and above the following, are warranted based on the conditions present at the time. During construction, the fisheries biologist shall disperse fish by wading the river ahead of the heavy equipment. Additional personnel shall be available to rescue fish if they become stranded in a pool. c) Longer-term Mitigation: Construction of the gravel berm has been required since 1992 to maintain adequate water surface elevation to Station 6 during the low-flow months (given the long-term bed degradation which has occurred in the Mad River). At this time, there is no reason to believe the bed elevation will aggrade and return to its prior elevation. Therefore, the District will likely have to address low water surface elevations during the low-flow months over the foreseeable future. The District shall initiate a study to determine if a more permanent solution is feasible to provide the necessary water-surface elevation during the low-flow months. This study shall include an assessment of the geomorphic conditions at the site, engineering considerations, including navigability, and biological considerations, which shall be developed in consultation with NMFS and CDFG. The study shall identify feasible alternatives and shall recommend the preferred alternative. The District shall complete this study within 3 years after obtaining an Incidental Take Permit from NMFS. Via the adaptive management process of this HCP, the District, in consultation with NMFS, shall pursue a more permanent solution if a feasible alternative exists (feasible from engineering, operational and biological perspectives). Monitoring: The fisheries biologist shall provide a report to the District documenting the presence or absence of fish, and whether any injury or mortality occurred. The biologist will recommend additional mitigation, if warranted. The District shall provide pre- and post-construction photographs.

Table 9 (Continued)	
District Activity	**Potential Impacts, Mitigation and Monitoring**
7. Maintaining adequate capacity in tailrace and spillway pools below Matthews Dam	Potential Impact: Take could occur during excavation (if juvenile steelhead are able to navigate the downstream natural barriers and are present in the plunge pool or tailrace outlet at the time when work is being done). Turbidity may increase for a short period of time in the vicinity of the plunge pool or tailrace outlets. Mitigation: a) Measures to minimize adverse impacts to habitat: Work will occur in a timely manner such that turbidity disturbance are minimized. The District shall exercise every reasonable precaution to protect the stream from fuel or oil spills. Equipment fueling shall not occur within the bankfull channel. All equipment shall be pressure washed and inspected for leaks prior to entering the wetted channel bed. Spill containment kits shall be readily available at the work site. b) Measures to minimize take: Prior to commencing work, District personnel shall inspect the area. If fish are present, District personnel will wade the water ahead of heavy equipment to disperse the fish. Monitoring: The District shall monitor work and provide pre- and post-construction photographs.
8. Gaining access to and maintaining Ranney collectors (which may involve building temporary gravel structures in river bed)	Potential Impacts: Take should not result from this activity. Temporary gravel structures are constructed on the dry river bed near the collectors during low-flow conditions (unless an emergency or unforeseen condition otherwise warrants). The river bed is returned to its pre-construction condition. At this time, the District is able to access all collectors from the dry river bed, so channel crossings are not necessary. If channel conditions change over the term of the HCP, the District may need to cross the wetted channel. Mitigation: The District shall exercise every reasonable precaution to protect the stream bed from fuel or oil spills. Equipment fueling shall not occur within the bankfull channel. All equipment shall be pressure washed and inspected for leaks prior to entering the channel bed. Spill containment kits shall be readily available at the work site. If channel crossings become necessary in the future, temporary crossings shall be installed and removed during the period of June 15th to September 15th. A fisheries biologist shall wade the stream ahead of heavy equipment crossing the wetted channel to disperse any juvenile salmonids that may be present. With respect to construction of a containment berm associated with collector flushing, this work shall be completed prior to September 15th each year. Monitoring: District personnel or the fisheries biologist shall monitor work and provide pre- and post- construction photographs.

Table 9 (Continued)	
District Activity	**Potential Impacts, Mitigation and Monitoring**
9. Maintaining adequate flow to Station 6 (by excavating aggraded material in low-flow channel)	Potential Impacts: Take could occur if fish are killed or injured during excavation of the low-flow channel. Turbidity may increase for a short period of time in the vicinity of Station 6. Mitigation: a) Measures to minimize adverse impacts to habitat: The excavation shall be done in such a manner that it occupies the minimum possible area of the low-flow channel. Work shall occur in a timely manner to minimize turbidity disturbances (e.g. generally less than 4-to-6 hours). The Station 6 pumps will be run to draw as much turbid water into the forebay as possible. Any additional techniques known to the District, and suitable for this work, shall be employed to further minimize turbidity effects. The District shall exercise every reasonable precaution to protect the stream from fuel or oil spills. Equipment fueling shall not occur within the bankfull channel. All equipment shall be pressure washed and inspected for leaks prior to entering the river bed. Spill containment kits shall be readily available at the work site. b) Measures to minimize take: During excavation, a fisheries biologist shall disperse fish by wading the river ahead of the heavy equipment. Monitoring: The fisheries biologist shall monitor work and record whether any injury or mortality occurred. The District shall provide pre- and post-construction photographs.
10. Protecting banks and structures (by maintaining or repairing existing rock structures or revetments)	Potential Impacts: Short-term impacts to riparian vegetation could occur, and juveniles could theoretically be killed during the placement of rock. Since this activity is in response to storms or other significant events which cause damage, this work is not expected to occur at all frequently. Mitigation: a) Measures to minimize adverse impacts to habitat: Placement of rock structures shall be done in such a manner that it occupies the minimum possible area of the low-flow channel, and minimizes adverse impacts to riparian vegetation. The District shall exercise every reasonable precaution to protect the stream from fuel or oil spills. Equipment fueling shall not occur within the bankfull channel. All equipment shall be pressure washed and inspected for leaks prior to entering the river bed. Spill containment kits shall be readily available at the work site. b) Measures to minimize take: If any rock placement occurs in the wetted channel, District personnel or a fisheries biologist shall be present to disperse fish by wading the river ahead of the heavy equipment which is placing rock. Monitoring: District personnel or the fisheries biologist shall monitor work and provide pre- and post- construction photographs.

8.1 Mitigation for Operation of Direct Diversion Facility (Activity 4)

As discussed previously, the District conducted a comprehensive fishery study at Station 6 in 1998. This study determined that a negligible number of salmonid juveniles were captured at the screens - on an annual basis, just 4 coho salmon fry, 18 chinook fry, 15 steelhead smolts, and zero coastal cutthroat. During the 1998 study, a "mark-recapture" evaluation of hatchery released (247,000) steelhead was also conducted, with just 14 fish (0.006%) being captured in the District's screens. (Refer to Appendix E-1 for a detailed discussion of the 1998 study.)

Despite the favorable results from the 1998 fish study, NMFS staff expressed concern that emerging chinook fry could be caught in the existing vertical traveling screens at Station 6, given that the facility meets most, but not all, of NMFS' new (1997) fish screen criteria. The facility does not meet the following criteria:

- Screen mesh openings are 3/16" rather than 3/32"
- Seals on the screen structure perimeter may exceed 3/32"
- Intake structure does not accommodate sweeping flows across screen face.

NMFS staff requested that the District make this facility "fish tight" and the District responded by proposing a retrofit of Station 6. The retrofit is proposed to occur in two phases. First, 20 new screen panels with 3/32" mesh openings will be installed to prevent entrainment at one of the two identical intake structures of Station 6. Second, the traveling screens will be reprogrammed such that the new screens, when not in operation, will remain submerged during the period of chinook emergence (generally March through May). Third, seals at the bottom and sides of the screen structure will be installed to ensure a minimum opening of less than 3/32" And fourth, the existing troughs on the screens will be removed and replaced with debris "rakes". By removing the troughs, fish will no longer be lifted out of the water, thereby eliminating the need for the fish bypass system. If the retrofit on the first intake structure does not cause any significant problems (operationally or biologically), the District will then complete the same retrofit on the second intake structure.

NMFS and CDFG staff concur with the retrofit project at Station 6. However, due to the lack of sweep velocities, NMFS expressed concern that the decreased screen mesh size could theoretically cause fish impingement at the screens.

The District has addressed this potential issue in two ways. First, the District has computed velocities in accordance with the NMFS' 1997 fish screen criteria. The velocity computations were done using the most conservative assumptions possible (thereby, yielding the highest possible approach velocity). The results are as follows:

> "NMFS has established 0.33 feet per second (fps) as the maximum approach velocity for fry-sized salmonids at a direct diversion facility located on a river, and 0.40 fps for a canal. Approach velocities at the Station 6 screens are below the new criteria established by NMFS. At the maximum design pumping rate of 60 MGD, and under the lowest historical water surface elevation ever experienced (20.7 feet), the approach velocity 3-inches from the screen face is only 0.30 fps. (It should be noted that the lowest possible water surface elevation is now approximately 21.5 feet given the addition of the grade control weir downstream.) The maximum approach velocity at the current pumping rate of 18 MGD is just 0.09 fps. Therefore, under all possible operating conditions, the approach velocities at the Station 6 screens are below the NMFS criteria for both a canal structure and an in-river structure.
>
> Additionally, at the request of NMFS staff, the District computed velocities at other locations in the forebay. At the maximum pumping rate of 60 MGD, and the existing low-flow water stage height of 21.5 feet (lowest possible with downstream grade control weir), the flow velocities at various Station 6 locations are as follows (Table 10)." (John Winzler, District Engineer)

Table 10. Station 6 Approach Velocities

Location at Intake Structure	**Estimated Velocity at 60 MGD (fps)**	**NMFS' Velocity Criterion (fps)**
Forebay shear wall (ungated)	0.13	0.4
Forebay shear wall (6 open gates)	0.39	0.4
Trash rack screens	0.34	0.4
Roller gate opening	0.30	0.4
3" in front of screens	0.29	0.4

Second, the District proposes a comprehensive multi-year monitoring program to document the effectiveness of the Station 6 retrofit, and to quantify impingement of juvenile salmonids, if such occurs. (See Section 8.2.c for detailed discussion of the Station 6 monitoring program.)

8.2 Monitoring Program

Table 9 summarized the monitoring proposal for each covered activity. This section describes the monitoring program in greater detail for groupings of similar activities as follows: 8.2.a) flow release and bypass (activities 1 through 3), 8.2.b) work in the channel such as excavation, fill, or repair of structures (activities 5 through 10), and 8.2.c) Station 6 operation after the retrofit project is completed (activity 4).

8.2.a) Monitoring Associated with Flow Releases and Bypass Activities (Activities 1-3)

The District carefully plans and manages its water releases from Matthews Dam on a daily basis to assure sufficient water is available year round for the District's downstream diversions, and for the minimum bypass flows as required in the District's State Water Rights Permits for the protection and preservation of fish. The District has the ability to accurately predict its diversion requirements based on known customer demands. The District also has the ability to calculate natural flow in the Mad River below Essex using flow data which available at several locations (inflow into Ruth Lake, releases from Matthews Dam into the Mad River below the dam, and flow at the U.S. Geological Survey (USGS) gage station downstream of Essex). Therefore, the District is able to accurately establish its required releases to meet both its downstream diversion requirements and the minimum bypass flow requirements below Essex.

In establishing its release requirements, the District uses daily flow data recorded at a particular time of the day. This data is directly measured at Matthews Dam or obtained from USGS for its gage stations on the Mad River. It is important to note that the data published by USGS after-the-fact will invariably differ from the USGS "provisional" data used by the District on a daily basis for its operational planning. First, the USGS published data represents a daily mean flow (versus flow at a particular time of the day which is used for operational planning). Furthermore, the USGS published data may incorporate "corrections" which have been applied retroactively to their original "provisional" data. Because river cross sections change, the USGS periodically establishes a "shift" at a particular station to provide a more accurate representation of the flow. A "shift", if established, is applied to the staff gage reading, and the adjusted gage height reading is then used to determine the discharge from the USGS rating table.

USGS' policy is to establish a "shift" (also known as a correction factor) if the discharge measurements taken in the field differ from the rating table results by 6% or more.

If the District receives a correction factor from USGS and determines that the bypass flow downstream of Essex no longer meets the minimum requirements, the District will immediately increase its release from Ruth. It is important to note though that it takes approximately 72 hours for the increased flows to reach Essex and the downstream USGS gage station near the Highway 299 bridge in Arcata. Therefore, the District could be out of compliance with respect to the minimum bypass flows below Essex for a period of up to three days following receipt of a new USGS correction factor. Based on the foregoing, the District cannot be held accountable for lack of compliance of the minimum bypass flows below Essex within the first 72 hours after a new correction factor is received from USGS.

As part of its monitoring program, the District will submit the following data to NMFS (and USFWS if a CCA is pursued):

- Daily discharge data from Matthews Dam
- Daily diversions at Essex;
- Daily calculation of natural flow below Essex;
- Daily discharge data from USGS station downstream of Essex;
- A statement as to whether or not the District satisfied its bypass flow requirements;
- Copies of correction factors received from the USGS, with a statement documenting whether the correction factor affected the District's ability to meet its minimum bypass requirements, and if so, whether the District increased its releases from Ruth Lake.

8.2.b) Monitoring Associated with Work in the Channel (Activities 5 – 10)

Excavation and fill occur in several of the District's covered activities. These activities shall be done in such a manner that they occupy the minimum possible area of the low-flow channel. Work shall occur in a timely manner to minimize turbidity disturbances. Except for the forebay dredging, which occurs throughout the high flow season, these activities are normally completed in a single day. For work done in the vicinity of Station 6, the Station 6 pumps will be run to draw as much turbid water into the forebay as possible. Any additional techniques known to the District, and suitable for the particular work, shall be employed to further minimize turbidity effects. The District shall exercise every reasonable precaution to protect the stream from fuel or oil spills. Equipment fueling shall not occur within the bankfull channel. All equipment shall be pressure washed and inspected for leaks prior to entering the river bed. Spill containment kits shall be readily available at the work site.

Biologists or District staff shall record the presence or absence of fish in each area before and during construction. They will attempt to disperse fish from the area of work, and they will also record any incidence of injury or mortality as a result of the District activity. The District will establish photographic control point(s) that will provide a complete visual record of the areas pre- and post-construction. The District will report any documented injury or mortality.

8.2.c) Monitoring Associated with Direct Diversion Facility, Station 6 (Activity 4)

Section 8.1 described the retrofit project at Station 6 designed to make the facility "fish tight." Following completion of this project, the District will implement a comprehensive monitoring program at Station 6 to evaluate whether juvenile salmonids are impinged on the new screens given the increased velocity through the screens due to the smaller screen mesh size. Upon completion of the monitoring program, a determination will be made as to whether the retrofitted screens meet the biological goal established for the facility.

<u>Station 6 Monitoring: Issue Discussion</u>

Prior to discussing the specific components of the monitoring program, several important issues need to be addressed. First, how should the biological goal be established to ensure protection of the listed species? Second, how can the level of take which occurs at Station 6 be put into the appropriate context? In particular, how can a determination be made as to whether the biological goal has been achieved given the lack of population data for any of the listed species on the Mad River or in their ESUs?

Federal regulations provide some guidance as to how to address these issues. In 1979, the ESA was amended to reduce the Services substantive obligation under the ESA from insuring that an action "does not jeopardize" listed species or adversely modify critical habitat, to insuring that the action "is not likely to jeopardize" such species or critical habitat. In authorizing this amendment, Congress understood and expressly provided that consultation and the resultant biological opinion be based on the "best scientific and commercial data available." This change was intended to make the process more flexible and establish a reasonable information standard. Federal regulations also state that the Services, in formulating their biological opinion, must provide the "benefit of the doubt" to the species concerned. Based on the regulations, two principles emerge which will guide development of the monitoring program. The guiding principles are as follows:

1) A *conservative* biological goal will be established to ensure the Services' can render a biological opinion which provides the "benefit of the doubt" to the species; and

2) The best *available* scientific and commercial data will be used in the monitoring program and in the evaluation of whether the biological goal has been achieved.

Based on the forgoing principles, a biological goal has been established that the level of take at Station 6 not exceed 3% to 5% of the juvenile salmonid population exposed to the screens for a given year class. Exposure is defined as those fish that enter the forebay and are potentially influenced by the flow approaching the screens (e.g. they could be impinged on the screen face). This goal is a conservative goal that provides the "benefit of doubt to the species." If achieved, it will ensure that the level of take at Station 6 will not significantly impair the recovery of the Mad River stocks of the listed species, and therefore, "is not likely to pose jeopardy to the listed species."

The biological goal is applicable to all of the juvenile salmonid species covered in this HCP (coho, chinook, and steelhead) [(1)], and data will be collected for all covered species during the monitoring program. However, young-of-the-year chinook [(2)] will be used as an "indicator" species to assess whether the retrofitted screens meet the biological goal. Chinook often spawn in the mainstem of the lower Mad River, particularly during low-flow years, and emergent chinook fry generally move downriver immediately. Therefore, they are most vulnerable to impingement if exposed to the Station 6 screens due to their small size. Conversely, coho and steelhead generally rear for a year prior to out-migration, and thus are not as vulnerable to impingement at Station 6 given their larger size. Given the life cycle differences, young-of-the-year chinook (an "indicator" species) will be used to assess if impingement is a problem with the retrofitted screens.

A key challenge in assessing whether the biological goal has been met is determining the juvenile chinook population which is exposed to the Station 6 screens. The young-of the-year chinook population in the lower Mad River is not known, let alone the juvenile population actually exposed to the screens. An estimate of the young-of-the-year population could be derived from spawning data, however, the distribution and

[(1)] During the monitoring program, data will also be collected on cutthroat trout given their similar life stage cycle
[(2)] Young-of-the-year refers to salmonids which are less than one year old, which is the age class of greatest concern for impingement.

abundance of chinook salmon spawning in the lower Mad River is also not known. Furthermore, the distribution and abundance of chinook spawning in the lower Mad River can vary greatly from year to year based on flow conditions and the population of returning spawners. And finally, the number of emergent fry depends on the fecundity of females and the rate of survival from egg to fry.

Normally, chinook begin entering the Mad River in September, with spawning beginning in the mainstem during October. In early winter following storm runoff, another run of chinook may enter the river and move up into the tributaries to spawn in December or later. Redd survival in the confined reach near Essex is normally poor due to winter and spring runoff which scours the bed. However, spawning in large numbers can occur in the lower Mad River in years when low flow conditions prevail into the fall combined with a large spawning escapement. These conditions occurred in 2000 when CDFG observed 155 chinook redds between the Mad River Hatchery and the Highway 101 Bridge (Larry Preston, CDFG, personal communication, 2002) . However, in the three-year period 1996 through 1998, no redds were observed in the same area.

Given the inherent uncertainty in the abundance and distribution of young-of-the-year chinook in the lower Mad River, plus the inherent uncertainty in the juvenile chinook population exposed to the screens, the District, in consultation with NMFS, has developed a multi-phase monitoring program, using the best available data, to assess whether the biological goal is achieved. Each phase of the three-phase monitoring program is outlined below

Phase 1 Monitoring

A conservative "threshold" of juvenile take at Station 6 is established during Phase 1 to assess whether the biological goal is achieved. This conservative threshold is that the level of take of juvenile chinook at Station 6 shall not exceed 1% of the juvenile chinook population exposed to the screens for a given year class. During Phase 1, the population exposed to the screens is assumed to be 25% of the juvenile chinook population in the entire Mad River system, given the best available population data which exists for the Mad River at this time. (Note - the 25% assumption is explained later). After the retrofit project has been completed, the District will commence a three-year monitoring study to measure the impingement at the Station 6 screens at the time when young-of-the-year chinook may be present. If the measured impingement is less than the conservative threshold, a finding will be made that the biological goal at Station 6 has been achieved and additional monitoring will not be necessary (unless certain conditions at Station 6 change in the future). However, if the impingement exceeds the conservative threshold, then the District will proceed with Phase 2 of the monitoring program.

The purpose of Phase 1 monitoring is to determine whether take at Station 6 warrants further monitoring and assessment. The conservative threshold is intended to be lower than the biological goal, and if not exceeded, gives confidence that Station 6 is not likely to impair recovery of the listed salmonid populations in the Mad River. If the conservative threshold is exceeded, it only implies that further data collection and assessment is warranted. The Phase 1 program details are outlined below.

- Overview of Methodology to Estimate Population Exposed to the Screens - As noted above, the distribution and abundance of chinook salmon spawning in the Mad River is not known and can vary greatly. Comprehensive spawning surveys of the Mad River and its tributaries have not been conducted. However, since 1985, spawning surveys have consistently been conducted in Canon Creek and in the North Fork of Mad River. Data collected over nearly two decades covers drought and flood periods, and for that reason is useful in illustrating trends in spawning escapement to these tributaries and possibly the Mad River as a whole. Area biologists believe that the populations observed at these two streams are but a fraction of the total population returning to the Mad River. (Personal Communication: Dennis Halligan, NRM, Larry Preston, CDFG, Terry Roelofs, Humboldt State University, and Bill Trush, McBain & Trush/HSU, 2002) Chinook can access at least 45 miles of the mainstem of the Mad River below the confluence with Wilson Creek, and spawning is known to occur in the mainstem.

  At this time, spawning escapement data from Canon Creek and North Fork Mad River is the best available to estimate the total population of adult chinook returning to the Mad River to spawn, and as such, will be used to develop an estimate of the juvenile population exposed to the screens during Phase 1. The spawning escapement data from 1985 through 2002 for Canon and North Fork Mad River is presented in Table 11. This historical data will be used to describe the methodology which will be used to determine whether the conservative threshold established for the Phase 1 monitoring is achieved.

Columns B and C of Table 11 present the annual spawning escapement data collected by CDFG and Simpson Resources on Canon Creek and the North Fork Mad River. According to CDFG, the data are actual survey counts and should be considered the minimum possible escapement from Canon and North Fork, and thus represent a conservative estimate of the actual spawning escapement. An estimate of the number of emergent fry associated with the spawning escapement from Canon and North Fork is presented in column G. This estimate is based on assumptions that half of the fish run is female (column D), fecundity of Mad River chinook is 3,500 eggs (column E), and the egg-to-fry survival rate is 18% (column F). Literature suggests that egg-to-fry survival rates typically range from 5% to 30% (Healy 1991). An 18% egg-to-fry survival rate was chosen as an average rate to derive young-of-the-year abundance. As noted above, the spawning escapement from Canon and North Fork represents only a small fraction of the spawning escapement which occurs in the Mad River system. Canon and North Fork Mad River combined represent 32% of the total watershed area accessible to chinook salmon up to Wilson Creek. Therefore, the spawning escapement data from Canon and North Fork have been extrapolated to the Mad River system where chinook may spawn (column H). The specific assumptions and references used to develop the chinook emergent fry estimates are noted at the end of the table.

As shown in Column H, the average number of emergent fry in the Mad River system between 1985 and 2002, given the assumptions noted above, is 287,766. This represents a reasonable estimate of the young-of-the-year chinook population for the Mad River system over time. It should be noted that the estimate of young-of-the-year chinook population for 2000-01 using the Canon and North Fork data extrapolated to the Mad River system is 266,766; however, CDFG estimated the young-of-the-year chinook population to be 954,027 that year based on their Steelhead Research and Monitoring Program. (Reference: Project 2a3. Juvenile Steelhead Downstream Migration Study in the Mad River, Humboldt County, California – Spring 2001. State of CA Dept. of Fish and Game, Page 52). Therefore, the estimate of the young-of-the-year chinook population in the Mad River using the Canon and North Fork data appears to be extremely conservative, at least for that year.

Given the estimate of the young-of-the-year chinook population in the Mad River system (column H), an estimate of the juvenile chinook population exposed to the Station 6 screens is established. NMFS suggested an assumption that 50% of the young-of-the year chinook population migrate downstream along the edge of the channel, and that 25% of the juvenile population may enter the forebay and are exposed to the Station 6 screens (since half are presumed to migrate on each edge). As shown in Column I, 25% of the average population is 71,941.

As introduced above, a conservative threshold has been established for the monitoring program that take of juvenile salmonids shall be less than 1% of the juvenile salmonid population exposed to the screens for a given year class. This 1% threshold equates to 719 young-of-the year chinook based on the Canon and North Fork spawning escapement data from 1985 to 2002 (column J).

During Phase 1 of the monitoring study, the determination of whether the 1% conservative threshold has been met will be based on an estimate of the young-of-the-year population exposed to the screens, developed in accordance with the methodology above, but utilizing the actual spawning escapement data from Canon and North Fork each year.

Table 11 - Methodology to Determine Take Threshold during Phase 1 Monitoring

(Based on Spawning Escapement Survey Data of Index reaches of Canon Creek and North Fork Mad River)

A	B	C	D	E	F	G	H	I	J	K
	Spawning Escapement				Egg-Fry	Emergent Fry	Emergent Fry	Exposed	1%	3%
Year	Canon	No. Fork	Females	Fecundity	Survival Rate	(Canon & No. Fork)	(Mad River System)	To Screens	Threshold	Threshold
1985-86	514	364	439	3,500	0.18	276,570	864,281	216,070	2,161	6,482
1986-87	90	212	151	3,500	0.18	95,130	297,281	74,320	743	2,230
1987-88	117	200	159	3,500	0.18	99,855	312,047	78,012	780	2,340
1988-89	69	238	154	3,500	0.18	96,705	302,203	75,551	756	2,267
1989-90	9	33	21	3,500	0.18	13,230	41,344	10,336	103	310
1990-91	0	2	1	3,500	0.18	630	1,969	492	5	15
1992-93	57	153	105	3,500	0.18	66,150	206,719	51,680	517	1,550
1993-94	20	22	21	3,500	0.18	13,230	41,344	10,336	103	310
1994-95	32	6	19	3,500	0.18	11,970	37,406	9,352	94	281
1996-97	129	553	341	3,500	0.18	214,830	671,344	167,836	1,678	5,035
1997-98	53	84	69	3,500	0.18	43,155	134,859	33,715	337	1,011
1998-99	66	52	59	3,500	0.18	37,170	116,156	29,039	290	871
1999-00	162	64	113	3,500	0.18	71,190	222,469	55,617	556	1,669
2000-01	79	192	136	3,500	0.18	85,365	266,766	66,691	667	2,001
2001-02	530	283	407	3,500	0.18	256,095	800,297	200,074	2,001	6,002
AVERAGE	**128**	**164**	**146**			**92,085**	**287,766**	**71,941**	**719**	**2,158**

Notes:

(B)&(C) Spawning Escapement data for Canon Creek & No. Fork Mad River from CDFG for 1985-2001 (Larry Preston 2002), and for 2001-02 from Simpson Resource Co. (Brian Michaels 2002). The average spawning escapement observed in index reaches on Canon & No. Fork is a total of 292 fish (128+164).

(D) Estimated number of females assumed to be 50% of the average escapement from Canon and North Fork for a given year.

(E) Estimated fecundity based on average number of eggs per female Chinook returning to Mad River Hatchery through 1994 (CDFG-MRH Heartright, 1999)

(F) Egg-to-fry survival rates vary from 5%-30% per Life History of Chinook Salmon (M.C. Healy, 1991, Pacific Salmon Histories ed. by C.Groot & L.Margolis). The average survival rate of 18% assumed.

(G) Estimate of emergent fry given the estimated females, fecundity rate, and egg-to-fry survival rates (e.g. G=DxExF)

(H) Utilizing a unit area extrapolation (from CALWATER Planning Watershed Units, CA Rivers Assessment, Teale Data Center & CDFG, 1995), the combined watersheds of Canon Creek and North Fork represent 32% of the Mad River watershed up through Wilson Creek, the upper limit of chinook distribution.

(I) Fish exposed to the Station 6 screens assumed to be 25% of estimated fry population (NMFS - Sam Flanagan, 2002)

(J) Resulting calculation of 1% of the assumed population exposed to the screens (e.g. 1% of column I).

(K) Resulting calculation of 3% of the assumed population exposed to the screens (e.g. 3% of column I).

- Station 6 Monitoring - After the screen retrofit project is completed, the District will conduct a monitoring study at Station 6 for three consecutive years throughout the period that the majority of chinook are emerging and migrating (typically from March through May). The monitoring period will begin March 1 and continue through May 31. After May 31, monitoring may end if no juvenile chinook are captured in any consecutive seven day period. The monitoring period may be adjusted by notification from CDFG or NMFS as new information relevant to chinook emergence or out-migration becomes available.

  As in the District's 1998 Station 6 fish study (Appendix E-1), a McBain ramp fish trap will be placed in a bypass trough to capture fish washed from the screens. Fish may either become impinged on the screen face or be collected and lifted from the water by a debris trough, which will be attached to one screen panel. The screens generally run for only 20 minutes every 96 hours. However, during this monitoring study, the screens will be run for 30 minutes every 24 hours to document young-of-the-year chinook mortality. Any young-on-the-year chinook that are impinged on the screen panels, or any "floaters" which may drift into the intake structure, during the previous 24-hour period will be collected when the screens are run.

  During the monitoring study, the District will divert the maximum rate possible from a single intake structure at Station 6. Since each intake structure is identical, the maximum rate from one intake structure will be multiplied by two to establish the total Station 6 flow rate at which the monitoring was conducted. (For example, if the District is able to achieve 22 MGD from one intake, the total rate established for the Station 6 monitoring study will be 44 MGD.)

Phase 1 monitoring shall be reinitiated during the 50-year period covered by the Incidental Take Permit if any of the following conditions occur:

- The District's maximum diversion rate increases beyond that which is achieved during the monitoring study (say from the 44 MGD example above to 50 or 60 MGD), or some other change is made that increases the velocity through the screens; or
- A change occurs in the mainstem channel such that flow is actually directed into the forebay (versus the forebay acting as a backwater pool on the outside of the meander, as is currently the case).

Phase 1 Evaluation - Each year, the District will obtain the spawning escapement data from Canon and North Fork from either CDFG or Simpson Resources Co. From these data, the District will develop an estimate of the young-of-year chinook population exposed to the Station 6 screens in the subsequent year during emergence and migration, in accordance with the methodology outlined above ("Overview of Methodology to Estimate Population Exposed to the Screens" subsection). If CDFG nor Simpson Resources plan to collect chinook spawning escapement data on Canon or North Fork during Phase 1, then the District will make every reasonable effort to collect such data on its own. (3) If for any reason no data are collected in a given year, NMFS and the District will develop an alternative method for estimating population abundance for that year, including using the long-term average spawning escapement data from Canon and North Fork (e.g. 1985 through most current year available).

Phase 1 monitoring is planned to proceed for three years. However, NMFS may allow a continuation of Phase 1 beyond three years if low escapement or

(3) The District's ability to collect spawning escapement data on Canon Creek and North Fork is conditioned upon Simpson Resources granting permission to the District to access said locations.

poor survey conditions exist in the Mad River at any time during Phase 1, or if any other extenuating circumstance warrants an extension.

Upon conclusion of Phase 1 monitoring, a determination will be made as to whether the level of take of juvenile salmonids at Station 6 exceeds on average 1% of the juvenile population exposed to the screens for a given year class, given the chinook spawning escapement data from Canon Creek and North Fork extrapolated to the Mad River system. If the measured rate of impingement is less than the 1% conservative threshold, a finding will be made that the biological goal at Station 6 has been achieved and additional monitoring and mitigation will not be necessary. However, if the measured rate of impingement exceeds the 1% threshold, then the District will proceed with Phase 2 of the monitoring program.

If in any year of Phase 1, the measured impingement is greater than 3% of the estimated population exposed to the screens, then the District shall proceed to Phase 2 of the monitoring program. NMFS may grant an exemption to this requirement based on low escapement, poor survey conditions, or other extenuating circumstances.

Phase 2 Monitoring

- Station 6 Monitoring Study - The District shall continue the monitoring study for three additional years to measure impingement of young-of-the-year chinook at the Station 6 screens. The study will be conducted in the manner described in Phase 1, and the District will continue to report the results of the monitoring study to NMFS on an annual basis.

- Population Data – The District will initiate an effort to establish a better estimate of the young-of-the-year chinook population exposed to the Station 6 screens. To accomplish this objective, the District will compile data from other monitoring efforts that may be underway in the watershed, and/or initiate its own data collection effort. At a minimum, the District shall compile or collect spawning escapement data on index reaches of Canon Creek, the North Fork Mad River, and the lower reach of the mainstem Mad River. The District may compile or collect additional data, at its discretion, to further improve upon the population estimate. The District may also conduct additional research/studies to improve upon any of the assumptions factoring into the estimate of the juvenile population exposed to the screens.

Following compilation or collection of additional population data, the District shall prepare and submit to NMFS a revised estimate of the young-of-the year chinook population exposed to the Station 6 screens, and the basis upon which the estimate was derived. NMFS will review the submission and make a finding on its completeness and the assumptions used.

- Phase 2 Evaluation - The take threshold in Phase 2 has been established at the lower end of the 3%-5% biological goal (e.g. that take of juvenile salmonids not exceed 3% of the juvenile population exposed to the screens for a given year class). The evaluation as to whether this goal has been met will be based on the improved population data collected each year during Phase 2.

  The Phase 2 monitoring is planned to proceed for three years. However, as in Phase 1, NMFS may allow a continuation of Phase 2 beyond three years if low escapement or poor survey conditions exist in the Mad River at any time during Phase 2, or if any other extenuating circumstance warrants an extension.

  Upon conclusion of Phase 2 monitoring, a determination will be made as to whether the level of take of juvenile salmonids at Station 6 exceeds on average 3% of the juvenile population exposed to the screens for a given year class. If the measured rate of impingement is less than the 3% threshold, a finding will be made that the biological goal at Station 6 has been achieved and additional monitoring and mitigation will not be necessary. However, if the measured rate of impingement exceeds the 3% threshold, then the District will proceed with Phase 3 of the monitoring program.

If in any year of Phase 2, the measured impingement is greater than 5% of the estimated population exposed to the screens, then the District shall proceed to Phase 3 of the monitoring program. NMFS may grant an exemption to this requirement based on low escapement, poor survey conditions, or other extenuating circumstances.

Phase 3 Monitoring

When Phase 3 is triggered, the District will initiate the adaptive management provision of this HCP for Station 6. Via the adaptive management process, the District will make additional retrofits to Station 6, or changes in its operation, in an effort to meet the biological goal. The following summarizes the process and timetable for Phase 3 actions. Additional actions and timetables may be mutually agreed to by the District and NMFS during the adaptive management process.

The District shall identify and assess alternatives to retrofit or modify the Station 6 facility or its operation, within six months after Phase 3 is initiated. Following completion of this assessment, the District shall submit to NMFS its recommendation for modifying the facility or operations, along with a schedule by which the changes will be implemented. Within three months, NMFS shall provide comments to the District on the recommended changes. Pending concurrence from NMFS, the District shall implement the recommended changes within the agreed upon timeframe. (Note – The implementation schedule may be influenced by regulatory agency approvals, permit acquisition, or CEQA compliance) During Phase 3, monitoring, as outlined in Phase 2, shall continue if NMFS determines that such information is warranted.

Following implementation of the changes at Station 6, the District will implement three successive years of monitoring to assess whether the biological goal is achieved. As provided in Phases 1 and 2, NMFS may allow a continuation of the Phase 3 monitoring beyond three years if low escapement or poor survey conditions exist in the Mad River during Phase 3, or if any other extenuating circumstance warrants an extension.

Upon conclusion of Phase 3 monitoring, a final determination will be made by NMFS as to whether the biological goal has been achieved (e.g. that the level of take at Station 6 not exceed 3% to 5% of the juvenile population exposed to the screens for a given year class.) If the measured rate of impingement is less than the lower-end of the goal (e.g. the 3% threshold), a finding will be made that the biological goal at Station 6 has been achieved, and additional monitoring and mitigation will not be necessary. However, if the measured rate of impingement exceeds the 3% lower-end threshold, the District will continue to modify Station 6 with reasonable alternatives through the process described above, until the take level does not exceed the 3% threshold. If the District has exhausted all identified reasonable alternatives to modify Station 6 in an attempt to meet the 3% threshold, then one of the following outcomes will result:

- NMFS may find the biological goal has been achieved if: 1) the District has implemented all feasible and reasonable facility retrofits/operational modifications, and 2) the District has achieved a level of take of juvenile salmonids less than 5% of the juvenile population exposed to the screens for a given year class (e.g. the upper-end of the biological goal).
- If NMFS determines that the District has not implemented all feasible and reasonable facility retrofits/operational modifications in an attempt to meet the biological goal, or if the level of juvenile take exceeds 5% of the juvenile population exposed to the screens for a given year class, then NMFS shall exercise its authority to suspend incidental take authorization for the Station 6 direct diversion in accordance with Federal Regulations (50 CFR 13.27). NMFS shall only suspend permit authorization relating

to operation of Station 6. All other activities and privileges afforded by the Incidental Take Permit shall remain in effect. This suspension shall remain in effect until such time as an acceptable alternative has been implemented at Station 6 which meets the biological goal.

9. Annual Reporting

The District shall submit an annual report to NMFS by February 28th each year outlining which of the covered activities occurred in the preceding calendar year. The purpose of the report is to document compliance with the terms and conditions of the HCP, and to document if any take occurred. The report shall also address progress made with respect to the Station 6 retrofit project and associated monitoring, and progress on the study to address a more permanent grade control structure in the Essex Reach.

10. Analysis of Alternatives to the District's Activities

Covered activities were listed in Section 5 of this HCP; their impacts and associated mitigation measures, monitoring plans, and goals were described in subsequent sections. The current level of incidental take is low relative to estimates of HCP species' populations. Once mitigation measures are in place, take will be lower still. However, the HCP Handbook suggests that alternatives to the proposed activities be explored, to assure agencies and the public that all reasonable choices were considered. Two alternatives were considered. They were:

Alternative 1. "No-Action" Because the District's current activities already exist and are on-going, "no action" means the District operates as it currently does. For example, fish screens would not be replaced nor other mitigation implemented. This No-Action alternative was dismissed because it does not minimize take of HCP species, and it could expose the District to enforcement actions by federal or state agencies for noncompliance with the ESA.

Alternative 2. Limit Diversion from Ranney Collectors Only. This alternative is infeasible because the Ranney collectors' yields are too low. During the 1960s and 1970s, the District supplied both municipal and industrial water users through the Ranney collectors. However, in the 1970s, the Ranney collectors alone were incapable of delivering the water needed by the industrial and domestic water customers, so the District constructed its surface diversion station. If the District eliminated its Mad River surface diversion station, in favor of the Ranney collectors as sole sources, based on previous experience, the District would be unable to meet the water needs of the Humboldt Bay Region. Therefore, the present use of the Ranney collectors as a sole source of wholesale water is not a feasible alternative.

11. Adaptive Management and this HCP

Section 8 described the biological goals, mitigation and monitoring measures associated with each of the District's covered activities. Adaptive management is an iterative process of evaluating the effectiveness of the mitigation measures. An iterative process is required because how any ecosystem responds to mitigation measures is inherently variable and sometimes unpredictable. An adaptive management process attempts to produce the most effective mitigation measures, given the inherent uncertainty in ecosystems. If over the course of this HCP, the District finds that a mitigation measure is not effective at reaching the biological goal, the District shall pursue alternative mitigation in an attempt to meet the biological goal.

Fortunately, the degree of uncertainty associated with the District's activities and mitigation measures is relatively small. Of the 10 covered activities in which the District is currently engaged, the only ones with inherent uncertainty are Station 6 following the screen retrofit project, and construction of the low-flow berm. If the mitigation measures associated with these activities need to be improved to meet the biological goal, the District, in consultation with NMFS (and other agencies as appropriate) shall pursue additional mitigation measures, as follows:

Activity 4 – Operating the Direct Diversion Facility: The District shall identify and assess alternatives to further retrofit or modify the Station 6 facility or its operation, and shall implement additional changes (per process and schedule outlined in Phase 3 of Station 6 monitoring program, above).

Activity 6 – Maintaining adequate water surface elevation to Station 6 during low-flow months: The District shall initiate a study to determine if a more permanent solution is feasible to provide the necessary water-surface elevation during the low-flow months. This study shall include an assessment of the geomorphic conditions at the site, engineering considerations, including navigability, and biological considerations (which shall be developed in consultation with NMFS and CDFG). The study shall identify feasible alternatives and shall recommend the preferred alternative. If the District recommends an alternative to the gravel berm, NMFS shall make a finding that adverse impacts associated with the proposed alternative are less than the impacts resulting from construction of the gravel berm (and therefore are less than what NMFS' authorized in the Incidental Take Permit). The District shall complete this study within three years of obtaining an Incidental Take Permit from NMFS. The District shall implement a more permanent solution if one is determined to be feasible with less adverse biological impact, and if NMFS makes the finding noted above.

12. Coordination of this HCP with Section 7 of the ESA

The primary purpose of coordinating this HCP with Section 7 of the ESA is to assure that the issuance of an Incidental Take Permit will not jeopardize the existence of any listed species. Section 7(a)(2) of the ESA requires that Federal agencies ensure that their actions will not likely jeopardize the continued existence of any endangered and threatened species, nor result in the destruction or adverse modification of designated critical habitat. ESA Section 7 also requires that the District describe any "jeopardy" through indirect, direct, and cumulative effects on listed species and their critical habitat.

Indirect and cumulative effects are factors to consider when determining whether an activity presents jeopardy to a listed species. Indirect effects may occur in three ways: 1) to HCP species inside the HCP area, 2) to HCP species outside the HCP area, or 3) to non-HCP species inside the HCP area. Cumulative effects are those that occur in an additive or synergistic fashion, over space and time.

One listed species outside of the HCP boundaries, but unlikely impacted by District activities, is the bald eagle, a federally protected species. The bald eagle has been observed nesting near Ruth Lake; however, the District conducts no activities that would disrupt the nest's use, or the bird's forage behavior. Since 1962, the water stage fluctuations of Ruth Lake have not appeared to affect the bald eagle's nesting. Flow augmentation from Matthews Dam has likely increased riparian and aquatic forage area for the eagle, which would be a benefit. Another listed species, the snowy plover, nests in coastal dune areas near the mouth of the Mad River, but the District's activities do not involve or affect coastal dune habitat. Lastly, USFWS has determined that the Tidewater goby, another listed species, does not occur in the Mad River.

One species that occurs inside the HCP boundaries, but is not covered in this HCP, is the Pacific lamprey, which USFWS considers a species of concern. This designation does not confer any special status under the ESA. The USFWS has also accepted a petition to list green sturgeon, which historically may have entered the lower reaches of the HCP area. Consultation with USFWS determined that insufficient data on these species exist to warrant consideration in this HCP. Other protected species present in the plan area are the Northwestern Pond turtle, the Northern Red-legged frog, and the Foothill Yellow-Legged frog. Because these species utilize the aquatic and riparian HCP areas, the District's flow augmentation would likely benefit these species. No federally listed plants are within the HCP boundary.

13. Potential Future Activities in Response to Changed Circumstances

The District may need to pursue additional activities over the course of the HCP planning horizon (e.g. 50 years) due to changed circumstances. Possible future activities could result in adverse impacts to critical habitat and/or incidental take. The possible future activities, that the District has been able to contemplate at this time, include:

11. Restoration of channel capacity below Matthews Dam - On the left bank of the canyon immediately below the dam, an active slide could introduce a sudden load of coarse sediment and large woody debris. If the river then moved toward the right bank, water surface elevation would rise. Backwater flooding of the hydro-plant could occur, which would compromise that facility and potentially the dam. Under such circumstances, the District would need to reduce stage height by excavating the channel where the deposition occurred, and/or increase the channel cross sectional area. Turbidity may be temporarily increased above background levels, and juvenile steelheads (if able to navigate downstream natural barriers and are present) could be injured or killed during dredging/excavation work.

12. Repairing, rehabilitating or replacing water lines in the riverbed – The District's domestic system has five 24-inch diameter pipelines which run under the river bed connecting each collector to a common header on the south bank of the river. The District's industrial system has a 51-inch diameter pipeline which crosses under the river twice between Station 6 and the Highway 299 bridge. Over the term of this HCP these line may need to be repaired, rehabilitated or replaced. If so, such work would involve excavation (to a depth of approximately 14 to 19 feet) below the gravel surface, installing steel piling under the pipeline (if deemed necessary), encasing the pipe with reinforced concrete, and replacing the excavated material back to original elevation. Where construction could not be performed in an above-ground gravel environment, the river would have to be diverted into a temporary adjacent channel. Work would generally be contained to less than 100 feet of total channel length. The diversion of the wetted channel, if necessary, could be implemented by use of temporary fabri-dams, thereby minimizing turbidity effects. Take could occur if fish are killed or injured during construction. Turbidity would likely increase for a short period of time in the vicinity of construction, and riparian vegetation could be affected.

13. Construction of Additional Grade Control Structures in the Essex Reach - For proper operation of Station 6, the river's water surface elevation must be a minimum of 21 feet msl. The existing grade control weir was constructed in 1991. If river degradation continues in the Essex reach, the District may need to further stabilize the river's water surface elevation, by constructing a series of weirs down-river. Take could occur if fish are killed or injured during construction. Turbidity would likely increase for a short period of time in the vicinity of construction, and riparian vegetation could be affected.

Although the District has attempted to describe the possible future activities and briefly note their impacts, additional evaluation will be necessary if and when these activities become necessary. One of the following processes will be employed to accomplish this:

If a "changed circumstance" results in a proposed activity which requires a federal action (e.g. an Army Corps of Engineer's permit), the related ESA Section 7 process will be utilized to address the impacts and provide the District incidental take protection. The District will obtain technical assistance regarding such activities from NMFS in advance of the Section 7 consultation to ensure the proposed activity minimizes and mitigates impacts to HCP covered species to the maximum extent practicable.

If a "changed circumstance" results in a proposed activity which does not require a federal action, this HCP and associated Incidental Take Permit will cover the activity contingent upon the following being satisfied:

1. The District has notified NMFS of the changed circumstance.
2. The District has obtained technical assistance from NMFS for the purpose of developing actions to address the changed circumstance.
3. The District has provided NMFS with the following material:
   - a description of the proposed activity;
   - an evaluation of the potential effects of the proposed activity on HCP covered species and critical habitat; and
   - a determination whether HCP covered species or critical habitat are likely to be adversely affected by the proposed activity.
4. NMFS has provided to the District a finding that the proposed activity:
   - minimizes and mitigates impacts to HCP covered species and critical habitat to the maximum extent practicable;
   - will not appreciably reduce the likelihood of both the survival and recovery of HCP covered species in the wild; and
   - will not destroy or adversely modify HCP covered critical habitat.

14. Funding

A Habitat Conservation Plan is just a document; the Plan's activities require funding to become reality. This section will describe the estimated cost and necessary funding to implement the HCP mitigation measures and monitoring plan. The District will fund the implementation of the HCP from two sources:

1. Grant Funding - The District has received a grant totaling $64,680 from CDFG's Salmon Recovery Program, in order to complete the Station 6 retrofit project. The District's Board of Directors has approved the use of matching funds as required by the CDFG grant agreement.

2. Annual District Budget - All other covered activities, and their associated mitigation measures and monitoring, will be funded from the District's operating budget, which is established and adopted each year by the Board of Directors.

15. References

A thorough bibliography of work on the Mad River system was compiled during the research for this HCP (Appendix F). References cited in the HCP report text are listed here.

California Department of Fish and Game, 1972. Mill Creek field notes, 5/1/72. Eureka, California.

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US Fish and Wildlife Service, 1977. Fish Behavior Study Evaluating the Fish Return System, Humboldt Bay Municipal Water District. June 1977. USFWS California Cooperative Fishery Research Unit, Humboldt State University, Arcata, California.

Shapovalov and Taft, 1954. The life histories of the steelhead rainbow trout and silver salmon with special reference to Waddell Creek, California, and recommendations regarding their management. California Dept. of Fish and Game, Bulletin 98:375p (Shapovalov and Taft found that under favorable conditions 65-85% of the eggs will survive to emergence)

J.C. Briggs, 1953. The behavior and reproduction of salmonid fishes in a small coastal stream. California Dept, of Fish and Game, Bulletin 94:62p (Briggs examined 22 California Coho Redds and found that the average egg-to-fry survival was 74.3%)

Humboldt Bay Municipal Water District

Habitat Conservation Plan

Appendix A

Mad River Environment

Overview of the Mad River

The Mad River is one of the many river systems in the Evolutionary Significant Units (ESU), which have been listed under the ESA. However, its contribution to the overall abundance of listed species is limited by natural constraints.

The Mad River watershed drains an area of approximately 500 square miles; the basin is 100 miles in length, averages six miles wide, and is bounded by parallel ridges of the Coast Range. Ridge elevations are 3,000 feet on the west and 5,000 feet on the east; water flows northwest from the headwaters in Trinity County to the river's mouth northwest of Arcata in Humboldt County.

Geomorphically, and for purposes of anadromous salmonid distribution, the Mad River can be stratified into four distinct zones. (Refer to Figure 1 in the HCP main body). Anadromous salmonids fully occupy the estuary and lower river zone and its tributaries up to River Mile (RM) 34; the middle river zone from RM 34 to 61 can be characterized as a geologically unstable and steep (between Wilson Creek RM 45.5 and Bug Creek RM 49, the river drops 600 feet in elevation). In the middle river zone, depending on local conditions and flow, the boulder canyon contains barriers at RM 45, 49, and 53. These barriers prevent anadromous salmonid migration to the upper river zone, which starts above RM 61. Under natural conditions, this zone often had no flow in August or September.

Six tributaries of the Mad River are fish-producing streams:
(Refer to Figure 1 in main body of HCP)

- RM 10.8 Lindsay Creek, drainage area 17 square miles;
- RM 14.8 North Fork, drainage area 50 square miles;
- RM 20.6 Canon Creek, drainage area 16 square miles;
- RM 32.1 Maple Creek, drainage area 17 square miles;
- RM 33.4 Boulder Creek, drainage area 19 square miles;
- RM 60.7 Pilot Creek, drainage area 40 square miles
  (This creek is accessible to steelhead only if barriers below on the Mad River are passable).

The watershed's precipitation is affected by its proximity to the Pacific Ocean and its altitude, with annual average precipitation of 40 inches in the lower zone, and an average of 80 inches in the middle zone. Snow is common above 4,000 feet on the eastern ridgeline, with average annual snowfall of one to five feet. The Mad River has two distinct seasons (dry and wet), and from June through October, coastal fog moderates ambient air and water temperatures in the lower zone. (See Figure 1, Isothetyal Map)

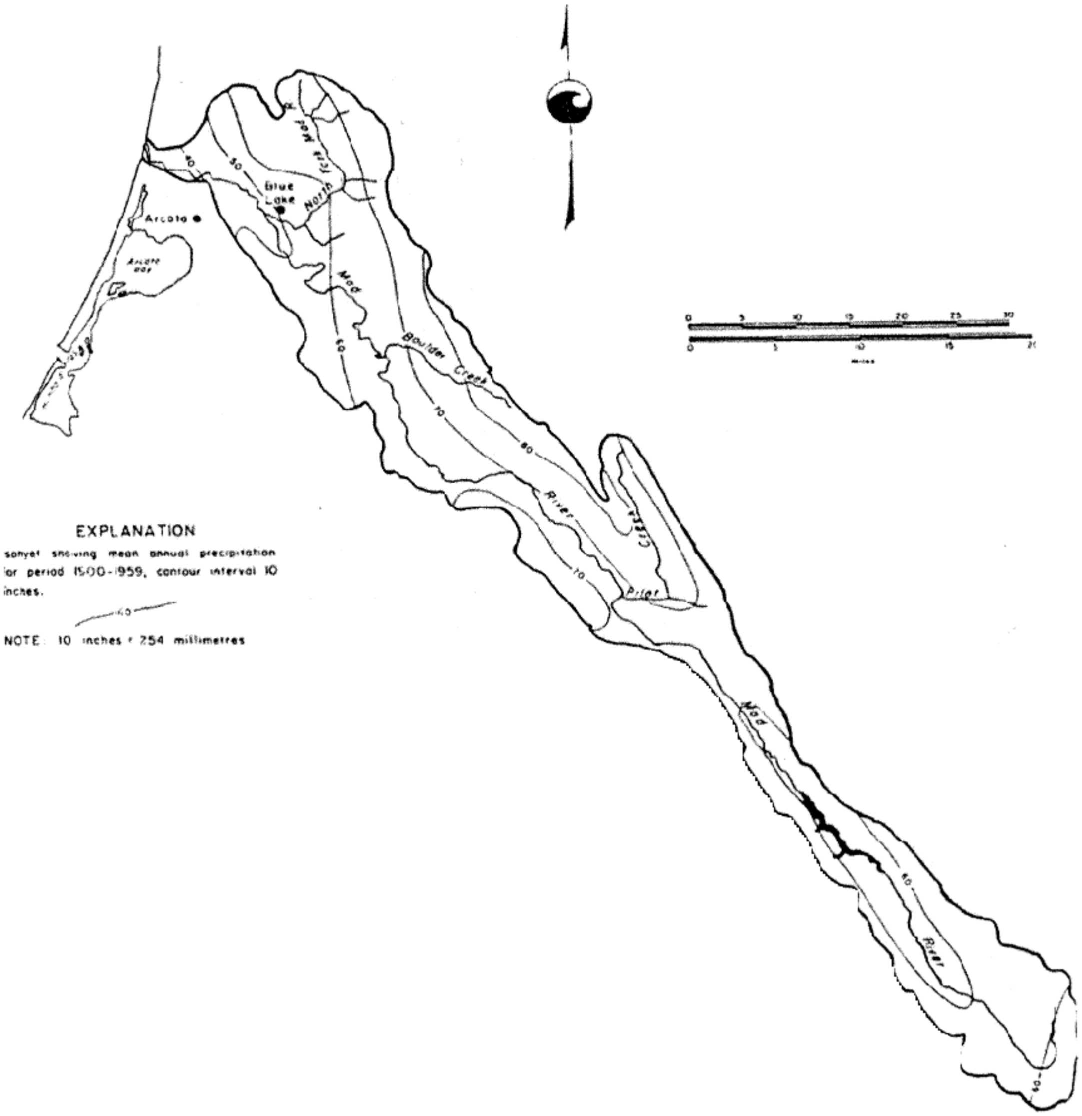

Figure 1 Isothetyal map of the Mad River basin (Department of Water Resources, 1982).

The annual average water yield from the Mad River is approximately 1 million-acre feet. Natural flow in the Mad River varies greatly; eighty-five percent of the water yield or discharge occurs from November through March. Severe storms periodically cause wide spread flooding and channel adjustments.

Historically, the lower Mad River would flood through multiple floodplain/slough channels to Humboldt Bay. As a result, the Mad River infrequently flushed its estuary of accumulated sediments, and according to historical accounts from 1870 to 1915, the mouth of the Mad River was often closed during the low flow period of October, November, December. Local fishermen would artificially breach the sand bar, primarily to allow salmon to migrate into the river. Since the early 1900s, the lower Mad River has been channelized and straightened; its overflow channels have been sealed, its banks armored, and now most moderate floods remain confined in the lower Mad River channel (Scalici 1993). Degradation of the lower Mad River is one consequence of concentrating flood flows in the main channel. Also, its tidal prism and estuary have expanded, and currently the lower 4.4 miles of the Mad River, up to Highway 101, are tidally influenced. From 1975 to 1998, the mouth of the Mad River migrated north along the coastal bluffs, greatly elongating its estuary area, but in 1998, the mouth began to return south, reducing its estuary area. The estuary and the tidal portion of the Mad River lack adjoining tidelands or tidal sloughs, which serve as important rearing habitat for anadromous salmonids, particularly for chinook salmon.

Under natural conditions, the Mad River was perennial up to the confluence with Pilot Creek (RM 61), but above this point, flow was intermittent particularly in August and September. The eastern slope in the middle zone receives the greatest amount of precipitation (annual average of 80 inches) which greatly affects the Mad River’s aquatic environment. The middle zone is predominately composed of Francisican Melange, and the combination of high precipitation and very unstable slopes results in the zone contributing high volumes of sediment in the Mad River. Erosion of the riverbed and bank, and the transport of suspended sediment, occurs during bankfull discharges. In the middle zone, high flows erode the toes of slides leading to continual upslope failures, which convey more sediment and boulders to the channel below. These landslides have extended from the river to the ridgeline, encompassing several hundred acres. The boulder reach near Bug Creek is an example of these conditions, which create barriers to salmonid migration.

Figure 2 – Bug Creek Barrier

Suspended sediment is a significant water quality issue in the Mad River, which has been listed by the Environmental Protection Agency as sediment (turbidity) impaired. The Mad River basin is one of several in northern coastal California, where suspended sediment is of 5 to 50 times that of comparably sized streams in the United States.

The quality and availability of coho and chinook rearing habitat in the mainstem or in the estuary is poor or lacking entirely. The boulder-cobble middle zone of the main stem and the tributaries, provide higher quality steelhead rearing habitat. Of the six major tributaries and the main stem, Lindsay Creek is the primary spawning and rearing habitat for coho and coastal cutthroat trout.

In summary, the environmental conditions which have affected the distribution and abundance of Mad River anadromous salmonids are as follows:

- Historically, the mouth closed during low flow conditions. Presently, the mouth remains open, although adults migrating upriver still wait for the first fall freshets to enter the river.
- Historically, the lower 61 miles of the river were naturally perennial; the reaches above RM 61 were naturally intermittent.
- The estuary and tidal reach of the river exhibit limited structural diversity such as adjoining tidelands or tidal sloughs. Valuable rearing habitat is limited, particularly for chinook juveniles.
- The mainstem also exhibits limited structural diversity which is normally provided by large woody debris, and as a result, rearing habitat is limited.
- The middle zone (RM 34-61) is a major source of sediment that affects the quality of aquatic habitat down river.
- Natural barriers exist which prevent anadromous salmonid migration to the upper river zone. Only the lower 45 to 53 miles of the mainstem are accessible to adult coho and chinook salmonids migrating upriver. Steelhead occasionally spawn in the upper zone if flow conditions and the boulder reach configuration are conducive.
- The quality and availability of coho and chinook rearing habitat in the mainstem or in the estuary is poor or lacking entirely. The boulder-cobble middle zone of the main stem and the tributaries provide higher quality steelhead rearing habitat. The primary tributaries are also limited in the amount of habitat they provide. Lindsay Creek is the primary spawning and rearing area for coho salmon and coastal cutthroat trout.

Overview of Essex Reach

The District's diversions, infrastructure, and maintenance activities are concentrated in the Essex reach of the lower Mad River; therefore, this reach is described in greater detail.

The District's diversion facilities are located in the Essex reach of the Mad River. This reach, from RM 8.8 to 10.7, is a low gradient, confined segment of the Mad River. Typical of lower river reaches with low gradients, pools dominate the Essex reach with an abundance of fine sediment and few riffles. The Essex reach area is composed of 64% pools, 11% riffles, 22% runs or glides and 3% backwater pools. (Figure 3).

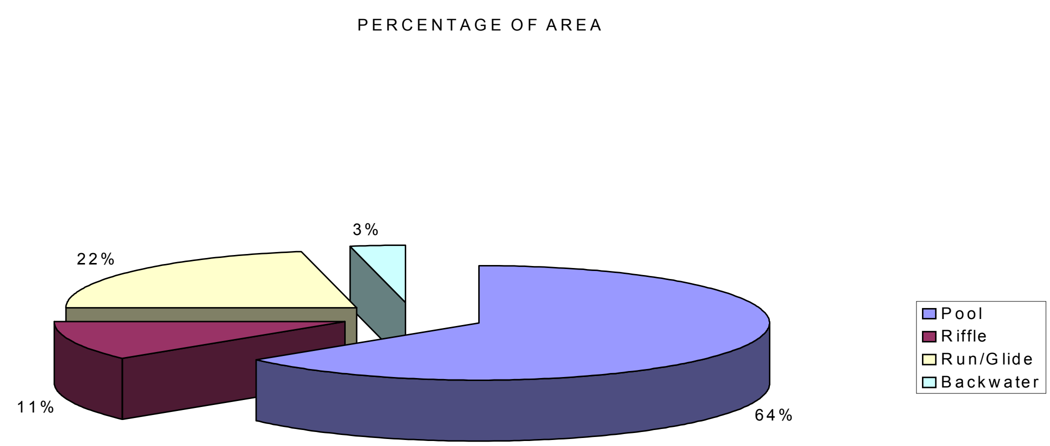

Figure 3 - Percentage of habitat types by area in the Essex Reach (RM 8.8 to 10.7)

Most of the pools are lateral scour pools along bedrock on the outside of meanders, with very little shelter for fish. The substrate throughout this reach is characterized by sand and small gravel, which can cause poor production of food organisms for juvenile salmonids, poor spawning, low egg survival rates, and poor over-wintering cobble habitat for juveniles. Large woody debris is noticeably missing in this section of the Mad River. Large wood is an important shelter element for coho juveniles, and the lack of it reduces the quality of available habitat.

According to the District's Engineer, the bed of the Mad River has degraded significantly in the Essex reach (an estimated 6 to 10 feet) since the District installed its Ranney collectors in 1962. By 1991, bed degradation had reached a critical level and the District had to install a rock grade control structure, in order to maintain the minimum water elevation necessary to operate its surface diversion facility. Since 1992, the District has established and maintained eight cross sections to monitor changes in bed and water surface elevations in the Essex reach. These cross sections document that varying annual degradation of the channel has occurred through 1997 with some slight aggradation thereafter.

Because the District controls access to the area and owns most of the Essex reach, the riparian habitat has been largely protected from disturbances. The riparian habitat in the Essex reach is stratified by successional zones beginning with herbaceous vegetation at the back edge of gravel bars; farther from the water, woody vegetation is composed of mostly Coyote bush and Arroyo willow. The woody vegetation increases in density with distance from the water, progressing into the beginnings of a riparian forest of black cottonwood and red alder. The riparian forest also increases in density farther from the water.

Humboldt Bay Municipal Water District

Habitat Conservation Plan

Appendix B

Collection of Salmonid Data for the Mad River

Coho, chinook, steelhead, and coastal cutthroat trout do not have access to the entire Mad River basin due to natural barriers. The Mad River mainstem and its tributaries from the mouth to just beyond Blue Slide Creek (River Mile (RM) 35) are the primary regions used by coho and chinook salmon. An unstable, steep, boulder-dominated middle reach, approximately 30 miles in length, separates the lower Mad River from the equally low gradient upper Mad River near the Humboldt-Trinity County line. The upper limit for steelhead migration is between Wilson Creek (RM 45) to near Deer Creek (RM 53). In 1981, CDFG and Six Rivers National Forest personnel attempted to modify the principal barrier on the Mad River below Deer Creek, yet due to the changing configuration of the riverbed in this cascade reach, it remains a barrier to migrating steelhead. The North Fork Mad River also has a natural migration barrier approximately 5 miles from its confluence with the Mad River. (Refer to Figure1, Watershed Map, in main body of HCP).

Historically, American settlers along the Mad River created the first significant declines in salmon and steelhead. Historic salmon runs in the Mad River included pink or humpback, king, silver and steelhead (Arcata Union Sept. 6, 1928). In years of low flow, large numbers of salmon would be speared at the entrance of the Mad River (Arcata Union 1896). Commercial fishermen used seine nets, gill nets, and later, trolling. Seining was banned on the Mad River in 1913, but gill netting was still legal (in season). The salmon and steelhead on the Mad River have never fully recovered from over harvesting during the last half of the 1800s. The abundance of coho salmon in the first half of the 1900s has been estimated at 2,500; chinook salmon at 10,000, and steelhead at 6,000. Although fish may have begun to recover from the over harvest of the last century, that recovery was slowed significantly by two floods on the Mad River in 1953 and 1955. Fish counts for coho salmon declined 91 percent to an average of 37 fish; chinook salmon declined 76 percent to an average of 325 fish; and steelhead declined 64 percent to an average of 1,556 fish. Compounding the impact of these earlier floods was the impact of the 1964 flood. Since fish counts ceased at Sweasey Dam in 1964, the impacts of the 1964 flood could not be quantified. *(Note – Sweasey Dam was the first water impoundment structure on the Mad River. It had a storage capacity of 2,000 acre-feet, but completely filled with sediment by 1955. It was located 22 miles from the mouth of the Mad River, and was in operation from 1938 to 1962. It was removed in 1970).*

Non-native salmon and steelhead were introduced in the early 1900s. In 1912, approximately 100,000 salmon fry were annually stocked from Price Creek Hatchery on the Eel River, into the Mad River. In 1917, as many as 500,000 Quinnat salmon from the State Hatchery near Fort Seward, and 250,000 steelhead were stocked in the Mad River. This practice of stocking salmon in the Mad River continued at least through 1925 (Arcata Union 1913, 1917, and 1925).

Beginning in 1957, California Department of Fish and Game (CDFG) "enhanced" the salmonid population with non-native salmonids. The Mad River Hatchery is the only one out of nine state hatcheries for which the purpose is "enhancement" rather than mitigation. However, the Mad River Hatchery currently raises only steelhead trout, which are marked for identification, to enhance the local sport fishery.

Since 1990, the return of steelhead to the Mad River Hatchery has increased 165%, while the return of adult coho and chinook salmon has declined significantly. Coho have declined 89% and chinook 91%. Since 1990, based on Brown's (1994) estimate of the ratio of hatchery (44%) to "naturalized" fish (66%), the total run of coho salmon in the Mad River could average as low as 134 adults, of which 59 returned are hatchery and 75 are "naturalized". Information on each of the salmonid species follows.

Coho salmon (Oncorhynchus kisutch)

Evolutionary Significant Unit: Southern Oregon-Northern California Coasts

Regulatory Status: Listed as Threatened in 1997, critical habitat designated in 1999.

Life History Periods:

Egg Incubation/Sac Fry:	October-mid. May
Fry Emergence:	Late February-late June
Juvenile Rearing:	Year-round
Juvenile Outmigration:	May to mid-July (Peak, May)
Adult Migration:	October-February (Peak mid-November to mid-December)
Spawning:	November-February (Peak early December)

Distribution: Coho salmon distribution can be described temporally and spatially. The temporal distribution of coho varies with rainfall and runoff. Coho begin moving upstream to spawn when heavy autumn rains increase the Mad River's flow. Sudden drops in stream flow can check their migration; these drops often occur after a heavy rainstorm has passed. When another storm causes stream stage height to rise again, the coho continue their up migration. Adult coho up migration peaks during mid-November to mid-December.

The "lower" forty five miles of the Mad River, up to Wilson Creek, are accessible to adult coho salmon migrating upriver to spawn. Lindsay Creek and its tributaries are regarded as the most important coho salmon watershed in the Mad River system. Coho have been observed in Mill Creek, Warren Creek, Hall Creek, Leggit Creek, Powers Creek, Quarry Creek, the North Fork Mad River, Maple Creek, and the Mad River main stem.

Artificial Propagation: The abundance of coho salmon following the floods of 1953 and 1955 declined to an average of just 37 fish/year passing Sweasey Dam. In response, in 1957, CDFG began its "enhancement" stocking program for coho salmon using stock from the Quilcene and Klaskanine Rivers in Oregon. Annual plantings of 40,000 to 75,000 since 1957 resulted in higher returns (average of 1,137 fish) for the period from 1959 to 1964 at Sweasey Dam (CDFG 1968). Adult coho salmon returns to CDFG's Mad River Hatchery from 1971 to 1989 averaged 525 fish; but since 1990, coho returns averaged 59 fish, an 89 percent decline. (Refer to Table 2, page 6).

The Mad River Hatchery has stocked the river with non-native fish 18 times since 1970 (CDFG 1994). Coho salmon stocks that have been used by Mad River Hatchery are:

- Central California Coast ESU- Warm Springs, Noyo River
- S. Oregon/N. Calif. Coast ESU- Humboldt State University, Mad River, Prairie Creek, Trinity River, Iron Gate
- Oregon Coast ESU-Alsea/Fall Creek, Trask
- Lower Columbia River. Southwest Coast Washington ESU-Klaskanine, Sandy
- Puget Sound/Strait of Georgia ESU-Skagit, Green River, Minter Creek
- Other- Silverado" (Weitkamp, 1995).

Abundance: By the 1950s, the Mad River's native coho population was estimated to be between 2,500 to 3,000 fish (CDWR 1965). In response to CDFG's enhancement program described above, counts of coho salmon at Sweasey Dam increased a dramatic 3,000 percent, averaging 1,138 fish from 1959 to 1964 (see Table 1). Unfortunately, as a result of CDFG's past stocking and hatchery program, Mad River coho salmon are considered one of the most genetically diverse in the State, dominated by non-native populations (CDFG 1994).

Table 1. Sweasey Dam coho salmon counts (CDFG 1968)

YEAR	NUMBER OF FISH	YEAR	NUMBER OF FISH
1938	498	1952	72
1939	725	1953	91
1940		1954	59
1941	308	1955	2
1942	378	1956	21
1943	259	1957	11
1944	NA	1958	3
1945	NA	1959	541
1946	415	1960	244
1947	NA	1961	710
1948	515	1962	3580
1949	512	1963	1419
1950	147	1964	332
1951	414	AVERAGE	474

In 1958, DWR assumed that the number of fish migrating above Sweasey Dam represented approximately 16% of the total Mad River population. Most coho salmon utilized the lower 22 miles of the Mad River and its tributaries, such as Lindsay Creek. For the pre-flood period of 1938 through 1951, an average of 396 coho salmon migrated past Sweasey Dam. Using DWR's 16% assumption, the average run for the entire Mad River could have been 2,475 fish.

Following the major floods of 1953 and 1955, the naturally reproducing coho salmon passing Sweasey Dam dropped to an average of 37 fish, indicating that the total run for the Mad River could have dropped to 231 fish, a 91 percent decline. The first returns of non-native coho salmon stocks planted in 1957 would have returned in 1959. However, since that time, the proportion of naturally producing coho salmon run is unknown. One estimate is that the Mad River coho salmon run is made up of 56% "naturalized" adults and 44% hatchery adults (Brown 1994). Since 1990, on average 65 coho adults have returned to CDFG's Mad River Hatchery. Using Brown's assumption of the ratio of naturalized to hatchery fish, the naturalized run of coho salmon in the Mad River averages 83 adults.

Fish counts on the mainstem have not been conducted since 1970 when Sweasey dam was removed. Whether salmon are utilizing the mainstem area above the former location of Sweasey Dam is unknown. Since 1964, the only fish counts for coho salmon are: 1) those at Mad River Hatchery (Table 2), and 2) at Canon Creek and the North Fork Mad River (Table 3). Adult coho salmon returns to Mad River Hatchery from 1971 to 1989 averaged 525 fish. Since 1990, hatchery staff counted an average, of 56 fish, an 89 percent decline.

Table 2. Adult coho salmon returns to CDFG's Mad River Hatchery (Barngrover 1994, Heartright 2002)

YEAR	MALES	FEMALES	GRILSE	TOTAL
1971	90	178	69	337
1972	105	130	231	466
1973	105	176	46	327
1974	67	74	19	160
1975	167	339	1597	2103
1976	88	129	976	1193
1977	163	290	195	648
1978	42	31	524	597
1979	39	90	223	352
1980	56	106	341	503
1981	16	62	57	135
1982	73	76	473	622
1983	11	11	65	87
1984	12	8	4	24
1985	24	14	7	45
1986	29	30	265	324
1987	94	126	733	953
1988	93	161	591	845
1989	18	17	221	256
1990	17	27	48	92
1991	6	13	18	37
1992	24	32	11	67
1993	15	18	6	39
1994	46	23	5	74
1995	7	5	0	12
1996	58	47	154	259
1997	9	30	1	40
1998	7	5	1	13
1999	8	7	5	20
2000	12	5	0	17
2001	2	1	0	3
AVERAGE	48	73	222	343

Table 3. Numbers of coho salmon surveyed in index reaches on Canon Creek and North Fork Mad River (CDFG 2000)

YEAR	CANON CREEK	NORTH FORK MAD RIVER
1985-86	14	1
1986-87	3	88
1987-88	19	25
1988-89	7	15
1989-90	9	5
1990-91	4	0
1991-92	--	--
1992-93	1	0
1993-94	0	0
1994-95	2	0
1995-96	4	--
1996-97	5	0
1997-98	0	0
1998-99	0	0
1999-2000	1	0
AVERAGE	5	9

Chinook salmon (Oncorhynchus tshawytscha)
Evolutionary Significant Unit: California Coastal

Regulatory Status: Listed as Threatened in 1999, and critical habitat designated in 2000. The critical habitat designation for chinook was vacated by a descent decree issued by a Federal Court in May 2002.

Life History Periods:

Egg Incubation/Sac Fry:	November-mid. May
Emergence:	late February-early May
Juvenile Outmigration:	April-July (Peak early to mid-June)
Adult Migration:	September-February (Peak November)_
Spawning:	November-February (Peak December- mid January)

In the 1993 "Humboldt County Programmatic Environmental Impact Report On Gravel Removal From The Lower Mad River" chinook life history is described. The chinook salmon of the Mad River exhibit the "ocean-type" behaviors defined by Healey (1991) because these populations migrate to sea during their first year of life, (normally within three months after emergence from the spawning gravel) spend most of their ocean life in coastal waters, and return to their natal river in the fall, a few days or weeks before spawning. Annual peak downstream migration, in the river and entering the estuary, occurs at the same time, indicating Mad River juvenile chinook spend little time rearing in the lower mainstem.

Distribution: Before Sweasey Dam was removed, most chinook and coho salmon spawned below the dam while steelhead spawned above it (CDFG, 1957). Ridenhour (1961) found that the most important spawning area was from Highway 299 to Sweasey Dam, including the North Fork and Canon Creek. Ridenhour also observed three natural barriers to Chinook salmon migration; one was located below Bug Creek (RM 49.6), another was located two miles below Bug Creek, and the third located one half mile above Showers Creek (RM 54.4). The barrier one half mile below Bug Creek terminated in a 25-foot fall. It is the upper limit of anadromous fish migration on the Mad River, and is the reason no fish access facilities were required at Matthews Dam (CDWR 1965, and ACOE 1968).

Artificial Propagation: The CDFG has operated a hatchery on the Mad River for the enhancement of chinook salmon since 1970 (see Table 4). Since 1995, the Mad River Hatchery no longer collects chinook salmon. The number of returning fish tallied after this date are volunteers.

Table 4. Numbers of chinook salmon returning to CDFG Mad River Hatchery (Barngrover 1994, Heartright 1999)

YEAR	MALES	FEMALES	GRILSE	TOTAL
1971	60	178	85	323
1972	241	415	380	1036
1973	337	53	105	495
1974	110	71	50	231
1975	53	41	184	278
1976	323	155	183	661
1977	95	68	87	250
1978	37	19	190	246
1979	51	77	17	145
1980	26	40	20	86
1981	32	6	213	251
1982	257	391	252	900
1983	119	194	124	437
1984	21	13	48	82
1985	149	28	98	275
1986	106	121	72	299
1987	253	315	278	846
1988	49	110	83	242
1989	10	19	17	46
1990	0	0	1	1
1991	2	4	4	10
1992	13	12	2	27
1993	2	5	4	11
1994	27	35	5	67
1995	16	6	34	56
1996	24	18	22	64
1997	3	1	3	7
1998	17	12	11	40
1999	20	5	25	50
2000	9	2	0	11
2001	26	26	0	52
AVERAGE	80	79	84	243

Abundance:

In 1958, the California Department of Water Resources (DWR) and the CDFG reported,

> *"During two recent years, 1952 and 1954, the Department of Fish and Game conducted tagging and recovery programs to estimate the size of the king salmon runs. In 1952, when 401 king salmon passed over Sweasey Dam, it was estimated that 5,120 spawned downstream from the dam, and that anglers in the river below the dam took 800. In 1954, when 403 king salmon passed Sweasey Dam, an estimated 3,266 fish spawned downstream from the dam, and the angler catch was estimated to be 238 fish. Using an average of 4,000 fish spawning below Sweasey Dam, and 1,174 fish spawning above the dam, it is estimated that on the average, about 5,175 king salmon spawn in the Mad River" (CDWR-CDFG 1958).*

The mainstem of the Mad River has been considered to be the primary area of importance for the propagation of chinook salmon (Ridenhour (1961). The historic estimates of chinook salmon abundance in the Mad River can be based on commercial salmon shipping reports in the Arcata Union. Ridenhour (1961) estimated that the total run was 10,000 plus the sport catch and spawning escapement. In 1958, CDFG ran tagging and recovery programs and estimated the total chinook salmon run at 5,175.

Of the 5,175 total, CDFG in 1958 estimated that 23 percent of the chinook spawned above Sweasey Dam and the remaining 4,000 spawned below. During the pre-flood period of 1938 through 1952, an average of 1,329 chinook salmon migrated past Sweasey Dam (see Table 5). Based on DWR's distribution estimate, the average run for the Mad River during this period would have been approximately 5,778 adults. Following a flood in 1953, an average of 325 naturally reproducing chinook salmon passed Sweasey Dam. The total run, based on DWR's distribution estimate, would have declined to 1,413 fish, a 76 percent reduction. Similar to chinook and coho estimates, the impact of the 1964 flood on the abundance chinook salmon cannot be assessed, because Sweasey Dam fish counts ceased in 1964.

Table 5 Number of chinook salmon counted at Sweasey Dam from 1938 to 1964 (CDFG 1968)

YEAR	NUMBER OF FISH		YEAR	NUMBER OF FISH
1938	1273		1952	401
1939	1257		1953	853
1940	1293		1954	403
1941	3139		1955	390
1942	1676		1956	129
1943	1236		1957	494
1944	-		1958	478
1945	-		1959	19
1946	1181		1960	55
1947	717		1961	40
1948	672		1962	238
1949	484		1963	232
1950	1505		1964	492
1951	1519		AVERAGE	807

When Sweasey Dam was removed in 1970, the impacts on chinook were similar to that of coho. Fish counts on the mainstem have not been conducted since, so once again, it is unknown whether chinook are utilizing the mainstem area above the former location of Sweasey Dam. Since 1964, the only fish counts for chinook salmon are: 1) those at Mad River Hatchery, which began in 1971 (Table 4), and 2) those in index reaches of Canon Creek and the North Fork Mad River (Table 6). Adult chinook salmon returns to Mad River Hatchery from 1971 to 1989 averaged 375 fish. Since 1990, hatchery staff counted an average of 33 fish, a 91 percent decline.

Table 6. Numbers of chinook counted in index reaches of Canon Creek and North Fork Mad River (CDFG 2000)

YEAR	CANON CREEK	NORTH FORK MAD RIVER
1985-86	514	364
1986-87	90	212
1987-88	117	200
1988-89	69	238
1989-90	9	33
1990-91	0	2
1991-92	2	--
1992-93	57	153
1993-94	20	22
1994-95	32	6
1995-96	93	--
1996-97	129	553
1997-98	53	84
1998-99	66	52
1999-2000	162	64
2000-2001	79	192
AVERAGE	**93**	**155**

Steelhead trout (Oncorhynchus mykiss)

Evolutionary Significant Unit: Northern California

Regulatory Status: Listed as Threatened in 2000. The critical habitat designation for steelhead is still under consideration.

Life History Periods:

Egg Incubation/Sac Fry:	January-June
Emergence:	May-June
Juvenile Outmigration:	May-August (Peak, July)
Winter Run Migration:	mid-August to mid-April (Peak, December-February)
Summer Run Migration:	mid-March to mid-July
Spawning:	late-December-mid. April (Peak, mid-January to mid-March)

In the 1993 "Humboldt County Programmatic Environmental Impact Report On Gravel Removal From The Lower Mad River" steelhead life history is described.

> *"Boydstun (1974) reported earlier downstream trapping at Sweasey Dam by CDFG documented most age classes were migrating from May 1 through August, peaking in July. Adult winter Steelhead can enter the Mad River at the same time as Chinook salmon (late August), though most of the run enters later in the winter. For example, Bailey (1953) seined 252 Chinook salmon and four Steelhead in the Bugenig and Carson holes from October 10 to November 1952. Peak migration usually occurs from December to late February, overlapping the Coho runs more than Chinook runs. Spawning can occur from late-December to mid-April, depending on annual flows".*

Life History: An overview of steelhead life history was provided by Busby in 1996, during NMFS's status review of steelhead.

> *"Unlike the coastal/inland groups, summer and winter Steelhead co-occur in several river basins, primarily within the range of the coastal Steelhead group. The few genetic analyses that have considered this issue indicate that summer and winter Steelhead from the same river basin are more genetically similar to each other than to the same run type in another river basin. This indicates that all summer Steelhead, for example, are not descended and distributed from one ancestral source and, therefore, are not a monophyletic unit" (Busby 1996).*
>
> *"Half-pounders are only reported in the literature from a small geographic region in southern Oregon and northern California. However, genetic data do not show a particularly strong affinity among rivers having half-pounders; rather, the affinities are geographic, including streams both with and without half-pounders" (Busby 1996).*

Steelhead of the northern Coastal California ESU exhibit more flexible life history strategies than steelhead of other Pacific Coast ESU's, and than chinook and coho salmon (Trush 1993). Steelhead half-pounders have been reported in the Mad River (Snyder 1925, Kesner and Barnhart 1972, Everest 1973, Barnhart 1986 in Trush 1993). In 1974, Boydstun reported that an early winter stock was also present in the Mad River, but in low numbers. A significant run of summer steelhead, averaging 374 fish, has been inventoried since 1994 (CDFG-Preston 1999).

Distribution: A natural barrier about one-half mile below Bug Creek has a 25-foot fall at its head, and has been the historic upper limit for anadromous salmonids. A second natural barrier is found five miles up the North Fork Mad River (CDWR-CDFG 1958). The bulk of the steelhead run in the Mad River is believed to have spawned above Sweasey Dam (CDWR-CDFG 1958, DWR 1965). In 1981, Six Rivers National Forest and CDFG modified the barrier just below Bug Creek. Since 1982, some summer steelhead negotiated the barrier below Deer Creek, but only during sufficient physical conditions in this cascade region of the Mad River inner gorge.

A boulder falls below Deer Creek also appears to be a selective barrier (CDFG-L.Preston 1999, 2002). While large numbers of summer steelhead have been counted below Deer Creek, over the last three years, a declining number of steelhead have been able to negotiate this barrier. In 1998, only four fish were observed in the upper Mad River, where Six Rivers National Forest maintains its index reach. The unstable geology from Wilson Creek through to Showers Creek makes fish passage uncertain, in any given year, depending on channel and flow conditions.

Artificial Propagation: The Mad River has a long history of receiving non-native steelhead stocks. As early as 1917, 250,000 steelhead from Price Creek Hatchery on the Eel River were planted on a regular basis (Arcata Union 1917). Winter steelhead were established at the Mad River Hatchery with eggs from Van Arsdale Fisheries Station on the Eel River and San Lorenzo River (Cramer et al. 1995). Since 1971, the Mad River Hatchery has been the primary steelhead hatchery in this ESU, which CDFG operates to "enhance" steelhead stocks (CDFG, McEwan and Jackson 1996). From 1971 to 1989, adult steelhead returns to Mad River Hatchery have averaged 1970 fish; since 1990 hatchery staff counted an average of 5,213 fish, a 165% increase.

Table 7. Steelhead stocks released into the Mad River by the Hatchery (CDFG 1994)

RUN	RELEASED STOCK	PERIOD OF RECORD	TOTAL STEELHEAD RELEASED
Summer	Skamania	1972-81	349,880
Summer	Mad River	1968-91	909,311
Winter	Eel River	1972-74	292,210
Winter	Mad River	1968-91	3,986,235
Winter	Mad River (fry)	1982-85	720,330
Winter	Russian River	1989-90	22,320
Winter	Russian River (fry)	1989	64,180
Winter	San Lorenzo River	1973	100,800

Summer steelhead were established at the Mad River Hatchery from Skamania stock, but CDFG terminated its summer steelhead program in 1995. Approximately 233,000 juvenile steelhead of various stock origins are released annually into Mad River (CDFG 1994).

Table 8. Numbers of steelhead counted at the Mad River Hatchery (Barngrover 1990, Heartright 2002)

YEAR	ADULTS		YEAR	ADULTS
1971	42		1987	4303
1972	52		1988	2529
1973	2872		1989	1027
1974	2138		1990	915
1975	190		1991	3463
1976	658		1992	7497
1977	1317		1993	5591
1978	2190		1994	11118
1979	1411		1995	11520
1980	730		1996	8713
1981	442		1997	1807
1982	1087		1998	2371
1983	838		1999	3085
1984			2000	1399
1985	753		2001	5075
1986	13833		AVERAGE	3225

Significant predation of hatchery steelhead trout yearlings occurs when the CDFG Mad River Hatchery releases its stock. Flocks of cormorants have been observed below the hatchery, following and preying on the newly released fish in the spring.

Abundance:

According to NMFS's Biological Review Team, steelhead abundance estimates are uncertain. First, steelhead run sizes throughout the ESU are unknown, and estimates were based largely on evidence of habitat degradation and the few dam counts and survey index estimates of stock trends in the region. Second, the genetic heritage of the natural winter steelhead population in the Mad River is uncertain.

In the 1940s, historical abundance of steelhead was estimated at 3,800 (Murphy and Shapovalov 1951). In the 1960s, steelhead counts ranged from as low as 2,000 to 6,000 (CDWR 1965, CDFG 1966, and McEwan 1996). From 1938 to 1954, Sweasey dam steelhead counts averaged 4,230 fish; following the 1953 flood, the average count declined 59 percent to 1,741 fish (see Table 9).

Table 9. Sweasey Dam steelhead Counts (*no counts taken in 1944, and 1945, CDFG 1968)

YEAR	NUMBER OF FISH		YEAR	NUMBER OF FISH
1938	3110		1952	5613
1939	3118		1953	2943
1940	5706		1954	2390
1941	4583		1955	148
1942	6650		1956	2717
1943	4921		1957	1957
1944	-		1958	1780
1945	-		1959	1376
1946	5106		1960	1343
1947	3582		1961	1985
1948	3139		1962	1708
1949	4074		1963	2178
1950	4430		1964	373
1951	5543		AVERAGE	3218

From 1994 to 1998, annual summer steelhead have been surveyed from Matthews Dam to Highway 101 by a cooperative multi-party review team (California Trout, CDFG, USFS, Simpson Timber Co., Gravel Operator's consultant NRM Inc.), (and HBMWD in 1995) (see Table 10). Surveyors make direct observation population estimates of all adults greater than 16 inches, and "half-pounder" adults less than 16 inches. In 1999, surveyors counted the fewest summer steelhead (82) since complete river counts began in 1994. The 1999 count was 119 adult fish lower than the 1998 count, or less than one quarter of the population for the years 1994 to 1998 (L.Preston 2002).

Table 10. Number of Mad River summer steelhead and "half-pounders" 1994 to 2001 (CDFG-L.Preston 2002)

YEAR	ADULTS	½ POUNDERS
1994	287	172
1995	569	21
1996	515	26
1997	284	12
1998	201	20
1999	82	19
2000	N/A	N/A
2001	N/A	N/A
AVERAGE	323	45

Coastal cutthroat trout (Oncorhynchus clarki clarki)

Evolutionary Significant Unit: Southern Oregon and California Coasts

Regulatory Status: In 1999, NMFS determined that listing was not warranted in the Southern Oregon and California Coasts ESU (Johnson 1999). During the same year, the USFWS assumed jurisdiction for coastal cutthroat trout, and they are presently conducting a status review. Unlike NMFS, USF&WS does not utilize ESUs in the definition of a species under the ESA.

Life History Periods:

Emergence:	March-June
Juvenile Outmigration:	March-June (Peak April)
Adult Spawning Migration:	August-November (Peak September)
Spawning:	November-June (Peak January)

Distribution:

Coastal cutthroat trout require small, low gradient streams and estuarine habitats, such as Lindsay Creek on the lower Mad River and the North Fork of the Mad River (Moyle 1989, ACOE 1973).

Artificial Propagation:

No information specific to the Mad River was presented in the Status Review Report (Johnson 1999).

Abundance:

No information specific to the Mad River was presented in the NMFS Status Review Report (Johnson 1999).

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Humboldt Bay Municipal Water District

Habitat Conservation Plan

Appendix C

District's Mad River Operations

Introduction

The District provides water on a wholesale basis to municipal and industrial customers in the Humboldt Bay area, and also to a number of retail customers. The District's wholesale municipal customers include the Cities of Arcata, Blue Lake and Eureka, and the Humboldt, McKinleyville, Manila and Fieldbrook Community Services District. Via the wholesale relationship, the District serves a population of approximately 80,000 in the greater Humboldt Bay area. The District's industrial customer(s) are located on the Samoa Peninsula.

Two delivery systems convey water from the Essex facilities to the District's wholesale customers - one for domestic use and one for industrial use.

The District's domestic system at Essex is comprised of 24" pipelines from the five Ranney collectors, which lie beneath the riverbed. They connect each collector to a main transmission line that is parallel to the south bank of the Mad River. The mainline increases in diameter as it travels downriver from 24" to 51". Water for the domestic system is chlorinated at Essex and then pumped to the District's treatment plant, located at Korblex. From Korblex, the District supplies water on a gravity basis to its seven wholesale municipal customers.

Just downstream of Station 6, the District's industrial water line crosses the Mad River (about 10 feet below the channel bed) to the north bank, and then proceeds downriver. Just above the Highway 299 bridge, the line crosses beneath the Mad River again back to the south bank. The industrial line then proceeds through Arcata and down the Samoa Peninsula.

The District's operations and maintenance activities that are within the HCP planning area were introduced in the main body of the HCP in Section 5. These activities, which are discussed in greater detail in this appendix, are as follows:

Current Activities Which Occur on an Ongoing Basis: These activities include: releasing flow at Matthews Dam; diverting flow in the Essex Reach (subsurface via Ranney collectors and surface via direct diversion facility); bypassing flow below Essex; operating the direct diversion facility (Station 6) including the fish screens; dredging the forebay in front of Station 6; and maintaining adequate water surface elevation to Station 6 during the low-flow months.

Current Activities Which Occur Only As-needed: These activities include: maintaining adequate capacity in tailrace and spillway pools below Matthews Dam (by excavation if sediment, gravel or debris accumulates); gaining access to and maintaining Ranney collectors; maintaining adequate flow to Station 6 (by dredging/excavation of the low-flow channel in front of Station 6 if gravel or debris accumulates); and protecting banks and structures (by repairing/installing rock structures or revetment).

Possible Future Activities: The District will likely need to pursue a number of new projects or activities over the course of the HCP planning horizon (50 years). Possible future activities include: restoring channel capacity below Matthews Dam (if impeded by material resulting from landslide, or other significant deposition); repairing, rehabilitating, or replacing water lines in the riverbed in the Essex reach; and constructing additional grade control structures in the Essex Reach.

Current Activities Which Occur on an Ongoing Basis

1. Releasing flow at Matthews Dam

Introduction

Completed in 1961, R.W. Matthews Dam is a 172-foot earth filled dam located at River Mile 84 on the Mad River (see photo below). The dam impounds runoff from approximately 121 square miles, or 25% of the Mad River basin, and thereby forms Ruth Lake. Ruth Lake stores surplus water for release to the Mad River during natural low-flow periods. The capacity of Ruth Lake is approximately 48,000 acre-feet. It is designed to supply a "safe yield" of 75 million gallons per day (MGD) average annual diversion at Essex, and to meet minimum bypass flow requirements which have been established for the protection and preservation of fish.

Water passes uncontrolled over the dam's spillway when water surface in Ruth Lake has reached an elevation of 2,654 feet. A 42-inch diameter penstock discharges water from Ruth Lake to the Mad River, which is then conveyed for 75 miles down river to Essex.

In 1981, the Federal Energy Regulatory Commission (FERC) granted Exemption No. 3430 for a 2 MW hydroelectric plant at Matthews Dam. The District has a contract to sell "as available" energy and capacity to PG&E. The District does not operate the plant as an electric "peaking" facility, nor does the District "ramp" its flow releases (e.g. change dramatically in a short period of time in response to power needs). Power production is incidental to water released for the District's water supply function.

Matthews Dam and Ruth Lake

Flow Requirements for the Protection of Fish

The State Water Rights Board (SWRB) and California Department of Fish and Game (CDFG) stipulated minimum flow requirements below Matthews Dam and below the Essex diversions for the protection and preservation of fish. The stipulated minimum flows are as follows:

a) The District shall release a minimum flow of five cubic feet per second into the natural stream bed of Mad River immediately below Ruth Dam (now known as Matthews Dam).

b) The District shall bypass or release into the natural streambed of the Mad River immediately below the Essex diversion the following minimum flows or the natural flow of the Mad River as regulated by diversions now in existence, whichever is less:

- October 1 through October 15 30 cfs
- October 16 through October 31 50 cfs
- November 1 through June 30 75 cfs
- July 1 through July 31 50 cfs
- August 1 through August 31 40 cfs
- September 1 through September 30 30 cfs

District Management of Flow Releases

The District carefully plans and manages its water releases from Matthews Dam on a daily basis to ensure sufficient water is available year round for the District's downstream diversion requirements and minimum bypass flow requirements below Essex. Additionally, the District accounts for other factors, such as evaporative losses, in determining the amount of water it must release.

The District has the ability to accurately plan its diversion requirements based on known customer demands. The District is able to monitor wholesale customer usage on a real-time basis given the District's SCADA system (Supervisory Control and Data Acquisition). The District also has the ability to calculate natural flow in the Mad River below Essex on a daily basis. Natural flow is defined as follows:

Essex Diversion + Flow Below Essex + Inflow into Ruth at Zenia – Flow Release at Matthews Dam

Natural flow is calculated on a daily basis using daily flow data from the U.S. Geological Survey (USGS) gage stations. USGS gage stations currently exist at three locations on the Mad River – near Zenia which measures the inflow into Ruth Lake, immediately downstream of Matthews Dam which measures the flow release from Matthews Dam, and just downstream of the Essex diversion near the Highway 299 bridge over-crossing. The District is currently engaged in a project with the USGS to improve the accuracy of flow measurement on the Mad River just below Matthews Dam. The District is installing a USGS-approved flow meter which will measure water flowing through the penstock. The District is also developing rating tables which will be used to calculate the volume of water that flows over the ungated spillway during the winter season, and the volume of water which may occasionally flow through the 10-inch "bypass" pipe (which is used to provide discharge to the river if the penstock is temporarily out of service). The sum of the flow through the penstock, over the spillway, and through the bypass pipe is the total flow released into the Mad River below Matthews Dam. The District will continue its cooperative relationship with the USGS, who will periodically validate the improved flow measurement techniques, and will continue to make the resulting flow data available to the public.

As noted above, the District uses USGS flow data during its daily planning process. It is important to note that the USGS data used by the District in its daily planning process will invariably differ from that which USGS later publishes for two reasons. First, the USGS published data represent daily mean discharge, yet the District uses USGS flow data for a particular time of the day (generally seven or eight in the morning). Furthermore, the USGS published data may incorporate after-the-fact adjustments based on "corrections" they believe should have been applied for a certain period of time. These adjustments are incorporated into their final daily mean flow records as published in their annual Water Resources reports.

USGS staff visit the gage stations on the Mad River on a regular basis to assess whether an adjustment to the staff gage height (e.g. "correction factor") is warranted to provide more accurate flow measurement. If USGS establishes a "correction factor" for a station on the Mad River, they provide it to the District in a timely manner. If the District receives a correction factor from USGS and determines that the flow downstream of Essex no longer meets the minimum bypass requirements, the District will increase its release from Matthews Dam. It is important to note that it takes approximately 72 hours for the increased flows to reach Essex. Therefore, the District could be out of compliance with respect to the minimum bypass flows below Essex for a period of up to three days following receipt of a new USGS correction factor.

During technical consultation with NMFS on this HCP, NMFS staff inquired how this process works and how many correction factors had been received from USGS in the recent past. Table 1 presents daily flow data downstream of Essex associated with the most recent USGS correction factors at their gage station near the Highway 299 crossing. The new correction factors are highlighted. The table presents flow for the day preceding, the day of, and the day following receipt of a new USGS correction factor, as well as the resulting natural flow.

Table 1 – USGS "Correction Factors" at Highway 299 Gage Station (May 2001 – Oct. 2002)

	Staff Gage Height (feet)	Corresponding Flow on USGS Rating Table (cfs)	Correction Factor (feet)	Adjusted Staff Gage Height (feet)	Adjusted Flow from USGS Rating Table (cfs)	Natural Flow (cfs)	Compliance with Bypass Flow Requirements? (yes/no)
5/14/01	4.74	127.7	0.15	4.89	159.5	174.9	yes
5/15/01	4.93	165.8	0.27	5.20	232.5	250.0	yes
5/16/01	5.57	354.2	0.27	5.84	459.9	482.4	yes
6/13/01	4.22	42.9	0.27	4.49	82.5	86.8	yes
6/14/01	4.21	41.7	0.20	4.41	69.4	72.5	no - 3.1 cfs short
6/15/01	4.19	39.3	0.20	4.39	66.4	55.4	yes
6/16/01	4.13	32.9	0.20	4.33	57.6	47.4	yes
7/8/01	4.10	30.0	0.20	4.30	53.5	40.3	yes
7/9/01	4.05	25.2	0.15	4.20	40.9	26.3	yes
7/10/01	4.07	27.0	0.15	4.22	43.2	27.1	yes
7/26/01	3.86	10.0	0.15	4.01	21.5	26.8	no - 5.3 cfs short
7/27/01	3.87	10.5	0.09	3.96	17.4	18.4	no - 1.0 cfs short
7/28/01	3.90	12.5	0.09	3.99	19.9	20.5	no - 0.6 cfs short
7/29/01	3.90	12.5	0.09	3.99	19.9	20.9	no - 1.0 cfs short
7/30/01	3.91	13.1	0.09	4.00	20.7	17.7	yes
8/30/01	3.98	18.9	0.09	4.07	27.0	13.0	yes
8/31/02	3.94	15.2	0.08	4.02	22.4	7.9	yes
9/1/01	3.97	17.9	0.08	4.05	25.1	13.6	yes
				0.00			
11/7/01	4.10	30.0	0.08	4.18	38.5	19.7	yes
11/8/01	4.10	30.0	0.11	4.21	42.0	7.9	yes
11/9/01	4.10	30.0	0.11	4.21	42.0	6.8	yes
2/5/02	7.11	1258.0	0.11	7.22	1344.9	1257.5	yes
2/6/02	7.06	1216.0	-0.17	6.89	1081.6	985.9	yes
2/7/02	7.08	1216.0	-0.17	6.91	1095.6	1091.4	yes
2/8/02	10.01	5017.0	-0.17	9.84	4734.2	4811.3	yes
2/9/02	9.60	4317.0	0.22	9.82	4699.3	4521.3	yes
2/21/02	11.22	7439.0	0.22	11.44	7885.3	7413.0	yes
2/22/02	9.67	4432.0	0.34	10.01	5035.2	4674.2	yes
2/23/02	9.23	3723.0	0.34	9.57	4273.2	5123.7	yes
3/6/02	7.12	1266.0	0.34	7.46	1557.2	1509.2	yes
3/7/02	7.69	1777.0	-0.13	7.56	1650.8	1731.5	yes
3/8/02	7.72	1806.0	-0.13	7.59	1679.4	1622.3	yes

Table 1 (Continued)

	Staff Gage Height (feet)	Corresponding Flow on USGS Rating Table (cfs)	Correction Factor (feet)	Adjusted Staff Gage Height (feet)	Adjusted Flow from USGS Rating Table (cfs)	Natural Flow (cfs)	Compliance with Bypass Flow Requirements? (yes/no)
4/1/02	6.84	1043.0	-0.13	6.71	951.9	852.7	yes
4/2/02	6.75	977.4	-0.24	6.51	819.2	866.7	yes
4/3/02	6.46	786.0	-0.24	6.22	647.8	689.7	yes
5/1/02	6.26	667.3	-0.24	6.02	543.8	579.1	yes
5/2/02	6.17	617.7	-0.16	6.01	538.9	550.3	yes
5/3/02	6.06	560.8	-0.16	5.90	486.8	498.6	yes
5/8/02	5.76	423.7	-0.16	5.60	361.9	376.5	yes
5/9/02	5.73	411.7	-0.14	5.59	358.2	374.2	yes
5/10/02	5.68	392.8	-0.14	5.54	339.9	154.7	yes
5/28/02	5.33	273.8	-0.14	5.19	229.8	252.3	yes
5/29/02	5.36	282.7	-0.47	4.89	159.5	179.8	yes
5/30/02	5.31	267.9	-0.47	4.84	149.9	198.6	yes
7/14/02	4.81	141.9	-0.47	4.34	59.0	57.4	yes
7/15/02	4.76	131.7	-0.70	4.06	26.1	16.0	yes
7/16/02	4.79	137.9	-0.70	4.09	29.0	-4.6	yes
7/19/02	4.88	155.8	-0.70	4.18	38.5	21.4	yes
7/20/02	4.87	153.8	-0.65	4.22	43.2	32.0	yes
7/21/02	4.87	153.8	-0.65	4.22	43.2	31.5	yes
8/7/02	4.82	143.8	-0.65	4.17	37.4	10.4	yes
8/8/02	4.80	140.0	-0.66	4.14	34.1	8.9	yes
8/9/02	4.82	143.8	-0.66	4.16	36.3	9.0	yes
9/5/02	4.72	123.8	-0.66	4.06	26.1	8.2	yes
9/6/02	4.70	120.0	-0.70	4.00	20.7	6.2	yes
9/7/02	4.80	140.0	-0.70	4.10	30.0	16.6	yes
9/25/02	4.82	143.8	-0.70	4.12	32.0	14.8	yes
9/26/02	4.78	135.8	-0.74	4.04	24.2	7.5	yes
9/27/02	4.80	140.0	-0.74	4.06	26.1	8.3	yes
10/24/02	4.87	153.8	-0.74	4.13	33.1	9.9	yes
10/25/02	4.85	149.8	-0.71	4.14	34.1	16.5	yes
10/26/02	4.86	151.8	-0.71	4.15	35.2	20.0	yes

The District's flow releases have augmented flows compared to what otherwise occurred naturally.

The District analyzed average monthly flow releases from Matthews Dam between 1989 and 2001. The average monthly flow release from Matthews Dam has augmented natural "pre-District" flows by at least one order of magnitude during the low-flow months. Table 2 presents this monthly flow data. Flow augmentation has many beneficial effects, including expanding river habitat for the benefit of aquatic species.

Table 2. District's flow releases from Matthews compared to natural flow (in cfs)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
"Natural" flow above Ruth Reservoir, prior to District operations	772	622	500	250	123	59	9	1	0	5	55	320
District's releases from Matthews Dam	941	812	691	342	177	111	58	70	77	77	70	281
Net increase in flows resulting from flow releases	169	190	191	92	54	52	49	69	77	72	15	-39

Additionally, the District analyzed daily flow data for the USGS gage station near Forest Glen (No. 11480500) which was located approximately nine miles downstream of Matthews Dam. This station operated between 1953 and 1994, and thus recorded flows prior to and following construction of Matthews Dam. The daily mean flows recorded at this station significantly increased during the low-flow months after the District's operation commenced in 1961. Table 3 presents the minimum, maximum and average daily stream flows during the low-flow months of the year at the USGS gage station near Forest Glen for 1953 through 1994.

Table 3. Daily Mean Stream Flows (cfs) during Low-flow Months (1953 to 1994)
At USGS Gage Station Near Forest Glen (located approximately 9 miles downstream of Matthews Dam)

Period 1 - Prior to Operation of Matthews Dam												
	August			September			October			November		
Year	Min	Max	Avg	Min	Max	Avg.	Min	Max	Avg.	Min	Max	Avg.
1953							3	16	5	4	2330	279
1954	2	7	3	2	4	3	2	11	5	5	987	120
1955	2	5	3	1	3	2	2	5	2	3	1890	176
1956	2	5	4	2	2	2	2	1050	52	10	214	42
1957	3	7	5	2	23	4	7	1400	168	32	3350	455
1958	2	18	8	6	19	14	1	5	2	2	72	13
1959	2	2	2	2	20	7	2	9	6	2	3	2
1960	2	7	5	1	3	2	2	5	3	2	1250	117
1961	1	10	5	1	8	4	2	8	3	2	380	51
AVG	2	8	4	2	10	5	2	279	27	7	1164	139
Period 2 - After Matthews Dam in Operation												
1962	12	20	14	13	21	17	16	3840	620	217	1150	379
1963	48	135	92	118	271	220	9	213	65	29	807	362
1964	94	98	96	92	98	94	91	100	95	53	420	114
1965	45	73	53	65	73	70	69	79	76	73	425	213
1966	80	111	88	76	158	91	56	75	72	52	369	128
1967	81	121	101	99	119	111	123	269	171	70	178	122
1968	72	103	90	70	108	82	63	109	82	81	367	225
1969	73	105	95	73	119	97	95	113	109	95	206	134
1970	90	104	101	98	119	105	107	127	114	107	722	235
1971	83	100	94	95	111	100	92	141	107	102	228	122
1972	79	100	93	91	128	102	80	117	107	101	198	128
1973	83	123	95	95	118	104	102	199	111	105	3060	1262
1974	97	123	114	117	124	119	111	134	117	65	169	104
1975	70	108	88	87	108	91	87	330	117	123	620	316
1976	45	71	56	54	86	62	77	102	92	37	98	78
1977	57	81	68	14	69	56	10	51	37	9	238	44
1978	69	100	89	93	114	96	91	94	93	72	95	87
1979	93	104	98	100	102	101	45	361	94	46	1500	302
1980	88	106	96	99	106	101	96	104	99	38	100	78
1981	81	93	84	81	91	85	34	139	70	27	3000	814
1982	43	76	62	70	114	91	44	182	139	111	584	181
1983	41	137	63	70	116	87	98	143	124	147	2600	584
1984	77	93	80	83	88	86	83	94	88	94	3320	867
1985	85	96	91	90	98	95	51	121	92	40	84	63
1986	99	108	104	104	129	109	100	149	112	15	115	83
1987	90	95	93	89	97	92	87	93	90	29	87	57
1988	86	98	93	92	107	98	92	109	96	24	861	201
1989	94	104	99	83	103	98	55	231	98	55	115	90
1990	80	118	107	96	103	101	96	118	105	50	99	88
1991	94	105	99	94	102	97	34	103	88	13	86	48
1992	93	97	95	88	96	92	53	88	76	11	61	33
1993	41	43	42	42	58	52	57	64	60	59	64	61
1994	51	64	56	56	67	62	65	68	67			
AVG	73	97	85	81	107	93	72	250	112	67	688	238

2. Diverting Water in the Essex Reach

Sub-surface Diversion via Ranney Collectors

The District constructed five Ranney collectors in the Essex Reach (RM 9.14 to 10.76) to deliver water on a wholesale basis to its domestic and industrial customers. During the initial development phase, the District completed construction of four Ranney collectors (numbers 1 & 1A, 2, 3, and 4). Upon completion, the District found it was unable to meet the water demands of both its municipal customers and industrial customers (e.g. two pulp mills who had contracted for 60 MGD. In 1965, the District began construction of Collector #5. The District then proceeded to convert Collectors #3, #4 and #5 for industrial water delivery, with the addition of upper laterals. Collector #3 was converted to a direct diversion facility, with a pre-settling pond, trash rack, traveling water fish-debris screen, and low-flow weir. However, Collector #3 did not meet required design criteria, and was inadequate as a permanent direct diversion facility. The District later determined that a new direct river diversion facility was required if it was to reliably meet the industrial water needs of 60 MGD.

Each Ranney collector houses two or three large electric-driven pumps and associated equipment. The collectors draw water from the aquifer via lateral pipes located 60 to 90 feet beneath the bed of the river. This water is then treated in accordance with standards set by the California Department of Health Services, and delivered to the District's municipal customers.

Currently, collectors 1, 1A, 2, 3 and 4 are in operation and provide domestic water for municipal purposes. Station 5 is currently not in service.

Ranney Collector

Surface Diversion via Direct Diversion Facility

In 1976, a new direct diversion facility was constructed (Station 6) to deliver 60 MGD to the District's industrial customers. Station 6 is comprised of a forebay, which is directly adjacent to the Mad River and extends transverse to the direction of flow, and a concrete pumping structure. This facility and its operation are described in greater detail under Activity 4 later in this appendix.

Electric-Driven Pump Motors at Direct Diversion Facility

Impacts of Diversion on River Stage Elevation

During technical consultation with NMFS on this HCP, NMFS staff questioned to what extent the District's diversion operations (and in particular, the direct diversion facility) has on river stage height. The District's diversion operations do not adversely affect downstream habitat nor cause stranding.

It is important to understand the channel configuration in the vicinity of the direct diversion facility. During low-flow conditions, the existing permanent rock weir, temporary gravel berm and rock jetty (which together control the water surface elevation to the diversion facility) also create a reservoir of water above the rock weir amounting to 20-25 acre feet of storage and extending 800 to 1000 feet upstream of the weir. This impounded water volume has a tremendous modulating effect upon flow changes below the rock weir in response to changes in diversion rates. As a result, changes in water depth and surface width resulting from changes in the District's diversion rate occurs over many hours.

To help demonstrate this, the District analyzed actual diversion and river stage elevation data based on recent diversion rates. Additionally, the District performed a hydraulic analysis to estimate changes in water depth and surface width based on the maximum change possible in the diversion rate at the direct diversion facility (e.g. 0 to 60 MGD). The results of these analyses are discussed separately below.

First, with respect to current operations, it is helpful to understand how the direct diversion facility (Station 6) operates. The direct diversion facility pumps water into a 1 million gallon (MG) reservoir located on the Samoa Peninsula near the existing industrial customer (e.g. the Samoa Pacific Cellulose pulp mill, formerly Louisiana Pacific). This reservoir, in turn, supplies water to the pulp mill as needed. The Station 6 pumps operate when the water in the 1 MG tank reaches an established set point, thereby refilling the reservoir. The following graph depicts a fairly typical elevation profile in the industrial water reservoir over a 24-hour period. The Station 6 pumps are operating at times when the elevation in the industrial water reservoir is increasing.

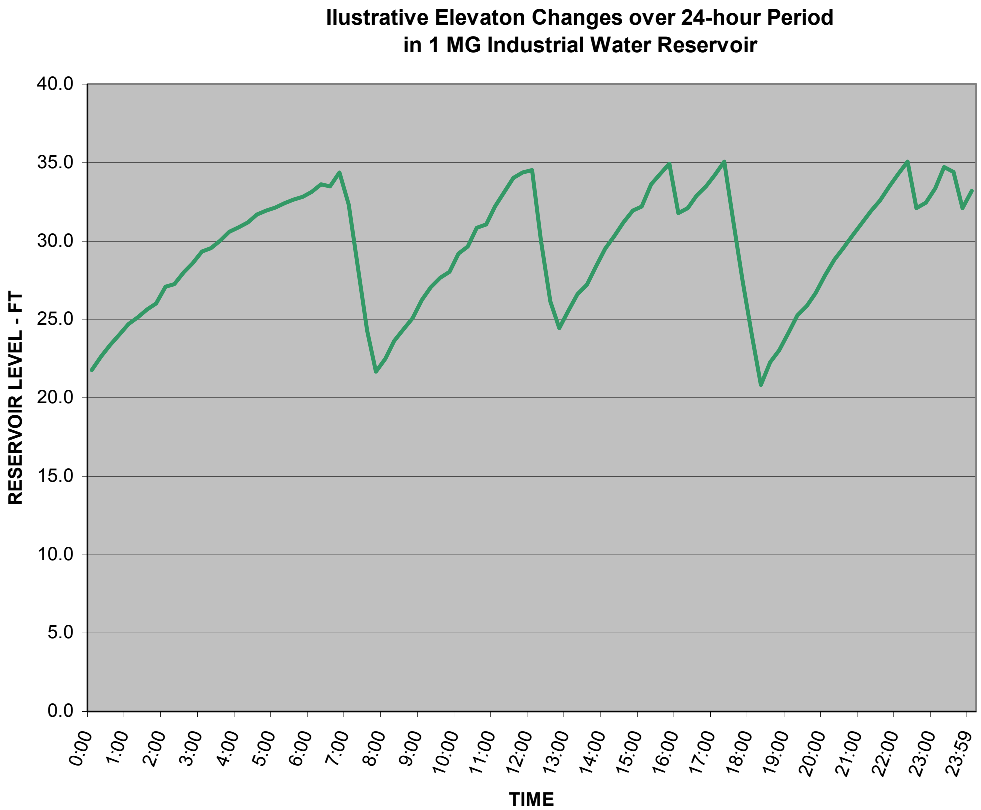


Table 4 presents diversion rates, and corresponding river elevations at Station 6 and downstream at the USGS Highway 299 gage, over a 24-hour period for a representative summer-time day and winter-time day (which were selected at random from 2002). For the summer-time day (which is the period of greater interest on the river), the minimum and maximum diversion rates at the direct diversion facility ranged from 6.2 MGD to 21.1 MGD, as noted by the shaded cells. Despite a wide variation in the diversion rates, the resulting change in river stage at Station 6 and also at the USGS Highway 299 gage is less than one-tenth of one foot over the 24-hour period.

Table 4. Hourly Diversion Rates and River Stage
(for Illustrative Summer and Winter Day from 2002)

	Winter-time Day (1/16/02)					Summer-time Day (6/13/02)				
TIME	Domestic System Diversion (MGD)	Industrial System Diversion (MGD)	Total Essex Diversion (CFS)	River Stage at Station 6 (FT)	USGS Gage (at Hwy 299) (FT)	Domestic System Diversion (MGD)	Industrial System Diversion (MGD)	Total Essex Diversion (CFS)	River Stage at Station 6 (FT)	USGS Gage (at Hwy 299) (FT)
0:00	5.9	15.5	33.3	22.3	7.48	12.0	15.4	42.4	21.1	5.08
1:00	6.2	14.9	32.7	22.3	7.45	12.0	15.4	42.4	21.1	5.10
2:00	6.2	15.3	33.3	22.2	7.48	12.0	15.5	42.6	21.1	5.10
3:00	6.2	14.6	32.2	22.2	7.48	12.0	15.2	42.2	21.1	5.11
4:00	6.2	14.6	32.3	22.2	7.48	12.0	15.2	42.1	21.1	5.11
5:00	6.2	14.9	32.7	22.2	7.47	12.0	15.2	42.2	21.1	5.11
6:00	6.3	14.1	31.5	22.2	7.49	12.0	19.8	49.3	21.1	5.09
7:00	6.3	0.0	9.7	22.3	7.49	17.0	6.2	36.0	21.1	5.09
8:00	11.1	15.3	41.0	22.2	7.40	16.9	16.8	52.4	21.1	5.09
9:00	16.0	15.7	49.1	22.2	7.44	16.9	14.0	47.8	21.1	5.10
10:00	15.9	15.1	48.1	22.2	7.43	16.9	17.1	52.7	21.1	5.08
11:00	6.9	13.6	31.8	22.2	7.40	11.8	16.3	43.6	21.1	5.07
12:00	6.2	0.0	9.7	22.3	7.40	0.0	6.7	10.4	21.2	5.10
13:00	6.2	18.7	38.6	22.2	7.38	0.0	15.1	23.4	21.1	5.15
14:00	12.3	18.3	47.4	22.2	7.41	0.0	20.1	31.1	21.1	5.12
15:00	0.0	17.7	27.4	22.2	7.38	0.0	20.1	31.1	21.1	5.12
16:00	6.3	0.0	9.7	22.2	7.38	3.8	19.8	36.6	21.1	5.13
17:00	12.4	8.7	32.6	22.2	7.33	12.1	20.0	49.9	21.1	5.12
18:00	12.3	0.0	19.1	22.2	7.40	11.8	19.7	48.9	21.1	5.11
19:00	12.3	21.1	51.8	22.1	7.39	17.4	19.8	57.6	21.1	5.11
20:00	12.3	20.3	50.5	22.1	7.35	17.0	19.5	56.5	21.1	5.09
21:00	12.4	19.4	49.2	22.1	7.39	17.0	19.2	56.2	21.1	5.09
22:00	6.2	19.0	39.0	22.1	7.33	16.9	19.0	55.7	21.1	5.09
23:00	6.2	8.9	23.3	22.1	7.34	17.0	20.1	57.6	21.1	5.08
23:59	6.2	14.3	31.8	22.1	7.37	16.9	20.1	57.4	21.1	5.08

Additionally, the District reviewed its most recent operational data to determine the maximum change in pumping rate at the direct diversion facility over a short-period of time. On July 31, 2002, the pulp mill experienced some problems. Between noon and two-thirty p.m., the diversion rates at the direct diversion facility changed four discrete times as follows: 1) from approximately 16 MGD down to zero, 2) from zero to 15 MGD, 3) from 15 MGD back to zero, and 4) from zero up to 20 MGD. These changes in diversion rates were in essence instantaneous. During this event, the corresponding change in river stage elevation at Station 6 was 20.99 feet to 20.82 feet, which is less than two-tenths of one foot.

As introduced above, the District also performed a hydraulic analysis to estimate the impacts below the diversion facility which would result from modifying diversion rates using three current operational scenarios and two hypothetical operational scenarios (up to an including the maximum possible diversion rate). The current scenarios utilize actual flow and diversion conditions from September 13, 2000 since the actual channel conditions at two cross sections below the Essex diversion facilities were known that day (based on the cross sectional survey completed by Winzler & Kelly Consulting Engineers for the District). The current scenarios and two hypothetical scenarios are summarized as follows:

Current Operations:

Scenario 1: Normal summer/fall diversion conditions, i.e. – 41.1 cfs diversion to municipal and industrial customers.

Scenario 2: Immediate cessation of industrial water diversion, i.e. – 13.3 cfs diversion to municipal customers only, thereby adding 27.8 cfs to downstream flows.

Scenario 3: Assumed power outage with immediate cessation of all deliveries i.e. – 41.1 cfs added to downstream flows.

Hypothetical Operations:

Scenario 4: Maximum industrial and domestic capacity of 116 cfs is in use (93 cfs industrial and 23 cfs domestic), and then industrial demand immediately terminates – i.e., 93 cfs is added to downstream flow.

Scenario 5: Maximum industrial and domestic capacity is in use (116 cfs) and loss of power causes immediate termination of all delivery - i.e., 116 cfs is added to downstream flow.

The five scenarios are applied to known diversions and river hydraulic conditions existing at two river channel cross sections (called Sections 1 and 2) which are located downstream of the Essex diversion facilities. Section 1 is approximately 400 feet wide with bank elevations of 27.8 feet and 41.3 feet. The channel floor has a low-flow channel against the north bank that is approximately 4 feet deep and 50 feet wide with a thalwag elevation of 13.2 feet, and a secondary low-flow channel near the south bank with a thalwag elevation of 15.3 feet. On the survey date (9/13/2000), the water surface elevation at Section 1 was observed in the low-flow channel at elevation 14.8 feet, and in the secondary channel at elevation 16.4 Section 2 is approximately 250 feet wide with bank elevations of 34.2 feet and 27.0 feet. The channel floor has a low-flow channel against the south bank that is approximately 12 feet deep and 210 feet wide with a thalwag elevation of 14.8 feet, and a secondary low-flow channel near the north bank with a thalwag elevation of 19.0 feet. On the survey date, the water surface elevation at Section 2 was observed in the low-flow channel at elevation 18.2 feet, and there was no flow in the secondary channel.

A hydraulic analysis of the various flow characteristics was performed of each cross section. The computer software program used was Flowmaster, Version 6.1, as developed by Haested. Flowmaster computes water surface profiles for regular and irregular shaped channel cross sections using Manning's equation. The water surface profile can be translated into water depths and change in top width of the water surface at the known river cross sections. Table 5 presents the results from this hydraulic analysis for each scenario at the two cross sections.

Table 5. Channel Changes Below Essex based on Results of Hydraulic Analysis

River Cross-Section Number	Changing Conditions Scenario	Increase in Flow rate (cfs)	Change in Water Depth (feet)	Change in Water Surface Width (feet)*
1	2	27.8	0.2	1.7
1	3	41.1	0.4	2.8
1	4	93.0	0.9	14.4
1	5	116.0	1.0	19.4
2	2	27.8	0.1	2.7
2	3	41.1	0.2	4.0
2	4	93.0	0.4	8.1
2	5	116.0	0.5	9.6

* Because of the flat slopes of the gravel bars in the areas of the cross-sections, change in top width of the actual river surface width is equivalent to change in wetted perimeter.

As illustrated in Table 5, the maximum change in water depth for Sections 1 and 2 was 1.0 feet and 0.5 feet, respectively, resulting from Scenario 5, the worst case flow rate change. Similarly, Scenario 5 resulted in the maximum change in top water surface width for Sections 1 and 2 of 19.4 feet and 9.6 feet, respectively.

As introduced previously, the existing permanent rock dike, temporary gravel berm and rock weir (which together control the water surface to the surface diversion facilities) also create a reservoir or water impound area above the rock weir amounting to 20-25 acre feet of storage, and extending 800 to 1000 feet upstream of the weir. This impounded water volume has a modulating effect upon flow changes below the rock weir. Therefore, any change in water depth or surface width resulting from changes in diversion rates will occur over many hours, as observed by and attested to by District personnel.

3. Bypassing Flows Below Essex

The District maintains bypass flows below Essex in accordance with conditions in its State Water Rights Permits. Management of flow releases, including the minimum bypass requirements, were discussed in detail above under Activity 1. During technical consultation with NMFS on this HCP, NMFS staff requested that the District provide a summary of its bypass flows below Essex for the recent past. Figures 1.1 through 1.12 (at the end of this appendix) present daily flow records for each water year between 1989 and 2001. These figures present natural discharge, discharge above Essex, and discharge below Essex (e.g. the bypass flow) over a range of water year conditions (wet, normal, dry). As can be seen, but for a very few instances, the bypass flows below Essex are greater than the natural flows which would otherwise exist in the Mad River, especially during the critical low-flow months in the late summer and fall.

4. Operating the direct diversion facility, including the fish screens

In 1976, a new direct diversion facility was constructed (Station 6) to deliver 60 MGD to the District's industrial customers. Station 6 is comprised of a forebay, which is directly adjacent to the Mad River and extends transverse to the direction of flow, and a concrete pumping structure. A shear wall of removable concrete panels across the entrance of the forebay reduces the amount of debris entering during high flows. Cellular steel sheet pile structures make up the forebay sidewalls. The forebay shape is trapezoidal, 90 feet wide at the riverbank, and tapering to 36 feet wide, in front of the trash racks at the back of the forebay. The forebay is approximately 90 feet long, from the shear wall in front at the river to the trash racks in the back. Within the forebay and approach chambers to the fish screens, no undesirable hydraulic effects (i.e., eddies or stagnant flow zones) exist which would delay, confine, or injure fish.

The concrete intake structure is divided into two equivalent "pumping cells," each one housing three-large electric-driven motors. Each cell is protected by a composite inclined trash rack at the entrance to the structure. The trash racks remove woody debris that ends up in the forebay. The trash racks are made of vertical steel bars spaced two inches apart; their function is to catch floating debris and prevent fish larger than two inches in body width from entering. A mechanical, motor driven trash rake cleans the racks, which is activated manually. The trash rake brings all trash and debris to the pump deck surface for disposal.

Each cell also has a mechanically operated fish screen located approximately 12 feet in front of the pumps. The fish screens are vertical traveling Rex "four post type" screens. The screen, including the structural framing system, completely fills the opening between the concrete sidewalls and is further "guarded" along both sides by redwood 2" x 4" sealing strips, connected directly to the concrete sidewalls. At the bottom of the screen, a steel boot plate reduces any opening at the screen bottom to less than 3/8". The rotation direction of the screen and fish buckets is toward the face of the screen, creating a water movement away from the screen at this point. Each of the two fish screens is 13 feet-2 inches wide (frame to frame) and articulated at 2-foot vertical intervals. The screen material is Type 304 stainless steel wire cloth with 3/16" square opening.

The frequency of screen runs is determined by the debris present in the water. Normally the screens are set to run for 20 minutes every 96 hours; however, the frequency may increase when the river is over 23.0 feet, or the turbidity is over 30 NTU. The screens also activate automatically if head loss is too high.

The fish bypass system begins with the fish baskets/troughs attached to the vertical traveling screens. When the screens are in operation, small organic debris or juvenile fish within 4.5 inches of the screen face will be lifted out of the water column, by one of the 58 troughs, which are attached to the screens at two-foot intervals. The troughs are made of carbon steel (12' l x 2.5" d x 2.5" to 4.5" wide), and are capable of holding water to support fish. As the troughs pass over the head sprockets, fish slide onto a wire screen where a low-pressure spray directs them to a fiberglass trough. Debris generally remains matted on the basket panels and is removed by a high-pressure spray, which blasts debris into a debris trough located immediately below the fish trough. A low pressure flushing flow runs twenty minutes after the screen has stopped operating, to guide the fish back to the river. The fish bypass system is approximately 390 feet long, and descends approximately 40 feet. Fish are returned to the Mad River below a boulder grade control structure, into a flatwater habitat reach.

<u>Compliance with NMFS Fish Screen Criteria</u>

Station 6 was designed in accordance with CDFG's fish screen criteria in 1975. Station 6 was a "state of the art" diversion and screening facility for its time. More recently, NMFS (1997) and CDFG (1999) have adopted updated fish screen criteria applicable for new facilities. Station 6 is able to meet the primary goal established for new facilities – that is to not separate anadromous salmonids from their main migratory route. The forebay basin at Station 6 functions like a backwater pool or off-channel slough. Anadromous salmonids of all age classes that enter the forebay basin are never segregated from their migratory route in the main channel, nor are they prevented from freely swimming out of the facility. The forebay basin provides a slack water environment that allows suspended sediment to settle, and provides low velocity, deep-water habitat for migrating salmonids. Furthermore, Station 6 currently meets all but two of NMFS screen criteria for new facilities, including arguably the most important criterion – that is approach velocity. Refer to Appendix D for a comprehensive evaluation of how the District's fish screens meet NMFS' 1997 Fish Screening Criteria for Anadramous Salmonids.

During the technical consultation with NMFS in 2000, the District agreed to make Station 6 "fish tight" by complying with NMFS' 3/32-inch screen size opening criterion. The District also agreed to remove the existing buckets on the fish screens and replace them with rakes, thereby eliminating the possibility of lifting fish out of the water. This in turn eliminates the need for the fish return system, which does not meet current standards. Additionally, the District will be conducting a comprehensive monitoring program after the Station 6 retrofit project is complete. The Station 6 retrofit project, plus the monitoring program, are outlined in greater detail in the main body of the District's HCP.

5. Dredging the forebay at Station 6

The District performs dredging/excavation each winter to remove accumulated sediment.
The Mad River experiences highly varying water surface elevations; stage height can vary by over 20 feet. The Mad River also experiences high sediment and debris load in the winter. Therefore, a principal design criterion of Station 6 was mechanical removal of accumulated silt and gravel in the forebay to protect the pumps. The District must dredge the forebay after high flow events deposit large amounts of silt and gravel. The frequency of dredging depends on the severity of winter storms but generally varies between 2 and 5 times per month. Either a crane with a clamshell bucket, or an excavator, is used to dredge the forebay to a depth of 10 to 12 feet msl. The crane or excavator is also used, as needed, to clear the channel in front of the forebay, maintaining a continuous water flow in the forebay and the low flow channel of the river.

6. Maintaining adequate water surface elevation to Station 6 during low-flow months

From 1976 to 1991, channel conditions in the Mad River allowed the District to operate Station 6 (the direct diversion facility) without any grade or water stage control. However, the bed of the Mad River has degraded over time. In the late 1980's the riverbed near Station 6 was approaching an elevation at which the pumps would vortex and no longer operate. Therefore, in 1991, the District installed two rock structures as a means of controlling water surface elevation – a jetty and a weir. The rock jetty, which projects from the north bank of the river, directs the flow toward Station 6. The weir, located 190 feet downriver of Station 6, controls the water surface elevation at Station 6 at approximately 21.5 feet mean sea level (msl). This grade control system ensures sufficient water surface elevation at Station 6 during the low flow months.

When runoff declines in late spring and water stage is close to 21 feet msl, the District constructs a berm connecting the rock jetty to the grade control weir downstream. The berm does not divert water into Station 6, rather it ensures water passes over the weir during the low flow months (as opposed to going around it), thereby ensuring adequate water surface elevation at Station 6. The District currently constructs the berm from river-run gravel, derived either from a point bar downstream near the north bank or from the dredging/excavation of the low-flow channel in front of Station 6. The exact location and length of the berm may vary based on channel conditions, but fill is limited to that necessary to connect the rock jetty with the weir. The berm is approximately 350 feet in length, by 20 feet wide, by 3-4 feet high. Therefore, the footprint covers approximately 0.15 acres.

Berm During Construction
(with federally-licensed biologist in the river protecting fish)

Completed Berm
(connecting to the downstream grade-control weir, pictured)

The District has evaluated the use of bladders as an alternative to construction of the gravel berm. Bladders were determined to not be a feasible alternative for a variety of reasons. First, there is no way to install and secure bladders given the existing channel configuration and rock structures at each end (the jetty and weir) absent installation of some permanent concrete structure to which the bladders could be attached. More importantly, there is no way to install and remove bladders safely each season. The Mad River water surface elevation can change very rapidly and dramatically in response to storm events. To ensure worker safety, the District would require the bladder to be removed prior to the first significant storms, and the necessary water surface elevation to Station 6 would then not be maintained. If the District waited until after the first storm events (such that the necessary water surface elevation is maintained), the District could not safely remove the bladders, and they potentially could be washed away causing injury or damage down stream.

As discussed in the main body of the HCP, the District will initiate a study to determine if a more permanent solution is available to provide the necessary water-surface elevation.

Current Activities Which Occur Only As-needed

7. Maintaining adequate capacity in tailrace and spillway pools below Matthews

Erosion, resulting from high water events passing over the spillway, periodically results in deposition of material in the plunge pool or tailrace channel outlet (the confluence with the Mad River).

In the tailrace channel, aggraded material collects which, in turn, may increase water surface elevation in the tailrace pool. This elevated water surface could result in accelerated bank erosion that threatens the dam face, the hydroelectric facility, or the County road located on the right bank. Aggradations in the past have partially or completely closed off the tailrace channel.

At the spillway plunge pool, riprap encased in concrete has been applied on the left bank. This riprap should stabilize the bank and minimize erosion. However, erosion during high discharge events may still occur. Additionally, course sediment derived from the steep talus slope on the right (east) bank of the spillway may be deposited in the spillway plunge pool.

On an as-needed basis, the District must remove this aggraded material and sediment from the tailrace channel and spillway plunge pool. The tailrace channel, subject to siltation and gravel deposits, covers an area approximately 30 feet by 80 feet (0.05 acres). The spillway plunge pool, subject to siltation and gravel deposits, covers an area approximately 40 feet by 100 feet (0.09 acres).

8. Gaining access to and maintaining Ranney Collectors

District personnel routinely visit the collectors to perform inspections and ongoing maintenance. To gain access to the collectors located in the river bed, District personnel are transported in an above-ground cable car. The District must occasionally perform major maintenance at the collectors, including repair or installation of new pumps, motors, or other heavy equipment. A crane will usually be required for the major maintenance, and if so, temporary access structures must be constructed to allow the crane to access equipment on collectors decks.

The temporary access structures to Collectors 1, 2 or 4 are constructed by pushing native river run materials with a backhoe, front end-loader, or tractor. The structures will normally be constructed on the exposed riverbed outside of the wetted channel, during the low-flow period. Under emergency conditions, the District may need to gain access during the higher flow months, and thereby work in the wetted channel. The river bed will be returned to its pre-construction condition upon completion. Two types of temporary access structures exist - roads and ramps - as follows:

- The temporary roads utilizes a maximum of 2,000 to 3,000 cubic yards of material. The temporary road entrances, from the top of bank to the exposed bed of the river, have been previously established at each of Station.
- The ramps are 3 to 4 feet above the exposed riverbed elevation, covering an area approximately 40' by 40' adjacent to the Ranney collector. The ramps range in length from 75' to 200' and height from 10' to 20', depending on the channel topography. The ramp also includes a flattened 25' by 25' area on the top for the crane to set.

Currently, the District does not need to cross the wetted channel to access any of the collectors to perform its maintenance. However, should the river channel change in relation to the collector structures, channel crossings may become necessary in the future.

Occasionally, the District must flush its collectors of accumulated sediment or conduct performance tests. Construction of a temporary berm is necessary to control the run-off generated from these activities. The berm is constructed by pushing riverbed material 3' to 4' high around a portion of the collector. The length and exact configuration depend on the edge of the low-flow water in relation to the collector and the area of discharge. The berm would be constructed away from the low-flow channel, and would not create any pits or pools. Water discharged from the collector would be contained to allow any sedimentation or turbidity to settle out. The water would then percolate into the riverbed, or be allowed to flow back into the river channel through some form of turbidity control (e.g. silt curtains or screens). The berm would be regraded to the original channel bed topography when the activity is complete.

9. Maintaining adequate flow to direct diversion facility (Station 6)

Each year, the District must assess changes to channel morphology in front of Station 6. Depending on the magnitude and duration of winter floods, coarse sediment can accumulate behind the rock weir downriver of Station 6. If aggradation threatens to block the forebay and limit exchange of water with the low-flow channel, excavation of aggraded material may be necessary. This gravel must be removed before it causes a bar to form, which can block the entrance to the forebay, and cause the thalweg to shift to the center of the channel. When the District excavates, it is through the aggraded bed (e.g. the accumulated gravel) in order to relocate the thalwag in closer proximity to the forebay entrance. The overall bed elevation and slope of the channel are not altered. There is no headwall created, as would occur from in-channel pit mining. The up and down-river riffles are still the hydraulic controls that maintain the overall slope through this reach.

The configuration and extent of the excavation required varies depending on the amount of material which has aggraded in front of Station 6, and the location of the aggraded material in relation to the low-flow channel of the river. Excavations have typically been approximately 250 – 500 feet by 20 feet (0.11 – 0.23 acres). The sediment removed during dredging is removed or utilized in the construction of the low flow berm each year to minimize excavation of the adjoining gravel bar.

10. Repair of Rock Structures and Revetment

The District has little control over factors that cause degradation or that damage its infrastructure. Existing rock structures and revetments need to be maintained, and rehabilitated or repaired if damaged. Stationary rock structures that are part of the District's facilities include: a grade control weir below Station 6; a rock jetty which projects from the north bank just upstream of Station 6, three wing jetties on the north bank near Station 1; and rock structures protecting the in-river collectors or domestic lines. Existing rock revetments are located in the plunge pool and tailrace outlet below Matthews Dam, and at various locations in the Essex Reach on both banks of the river from Collector 3 to above the Highway 299 bridge. The revetments vary in length from 100 to 800 feet and consist of ¼ ton to 4 ton rocks. The toe trenches or keys into gravel substrate for these revetments encumber a footprint of approximately 0.75 acres in total. Figure 2 at the end of this appendix show the approximate location of rip rap and rock structures in the Essex reach.

Possible Future Activities

The District may need to pursue a number of new projects or activities over the course of the HCP planning horizon which is 50 years. Potential future activities contemplated at this time are as follows:

11. Restoring channel capacity below Matthews Dam

The river channel below Matthews Dam could become partially or totally blocked if a landslide occurred downstream of the dam. Such an event could seriously threaten the safety and integrity of the dam and powerhouse. Excavation of material in the channel below Matthews Dam would be necessary if the channel was impeded by material from a landslide or other significant deposition.

12. Repairing, rehabilitating or replacing water lines in the riverbed in Essex Reach

The District's domestic system has five 24-inch diameter pipelines which run under the river bed connecting each collector to a common pipeline header on the south bank of the river. The District's industrial system has a 51-inch diameter pipeline which crosses under the river twice between Station 6 and the Highway 299 bridge. Over the term of this HCP (e.g. 50 years), these line may need to be repaired, rehabilitated or replaced. Such work would involve excavation (to a depth of approximately 14 to 19 feet) below the gravel surface, installing steel piling under the pipeline (if deemed necessary), encasing the pipe with reinforced concrete, and replacing the excavated material back to original elevation. Where construction could not be performed in an above-ground gravel environment, the river would have to be diverted into a temporary adjacent channel.

13. Constructing additional grade control structures in the Essex Reach

From 1976 to 1991, channel conditions in the Mad River allowed the District to operate the direct diversion facility without any grade or water stage control. However, the bed of the Mad River has degraded over time. In the late 1980's the riverbed near Station 6 was approaching an elevation at which the pumps would vortex and no longer operate. Therefore, in 1991, the District installed two rock structures as a means of controlling water surface elevation – a jetty and a weir. The rock jetty, which projects from the north bank of the river, directs the flow toward Station 6. The weir, located 190 feet downriver of Station 6, controls the water surface elevation at Station 6 at approximately 21.5 feet mean sea level (msl). This grade control system ensures sufficient water surface elevation at Station 6 during the low flow months. If the riverbed continues to degrade, additional grade-control structure(s) may be required over the 50 year term of the HCP.

Figure 1.1
Mad River
10/1/1989 to 9/30/1990 Comparison of Natural Flow
To Discharge Above and Below HBMWD's Essex Diversion

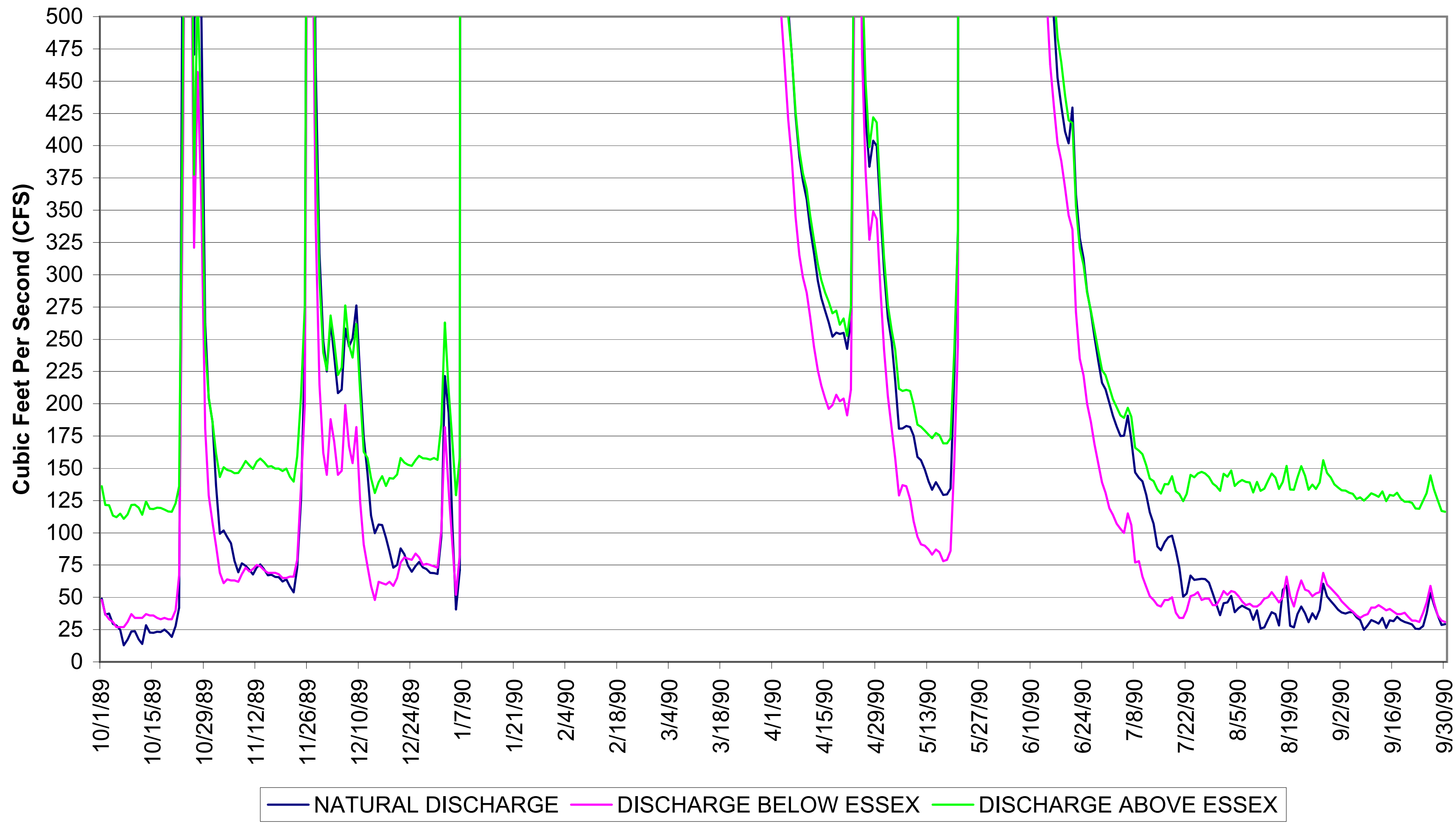


Figure 1.2
Mad River
10/1/1990 to 9/30/1991 Comparison of Natural Flow
To Discharge Above and Below HBMWD's Essex Diversion

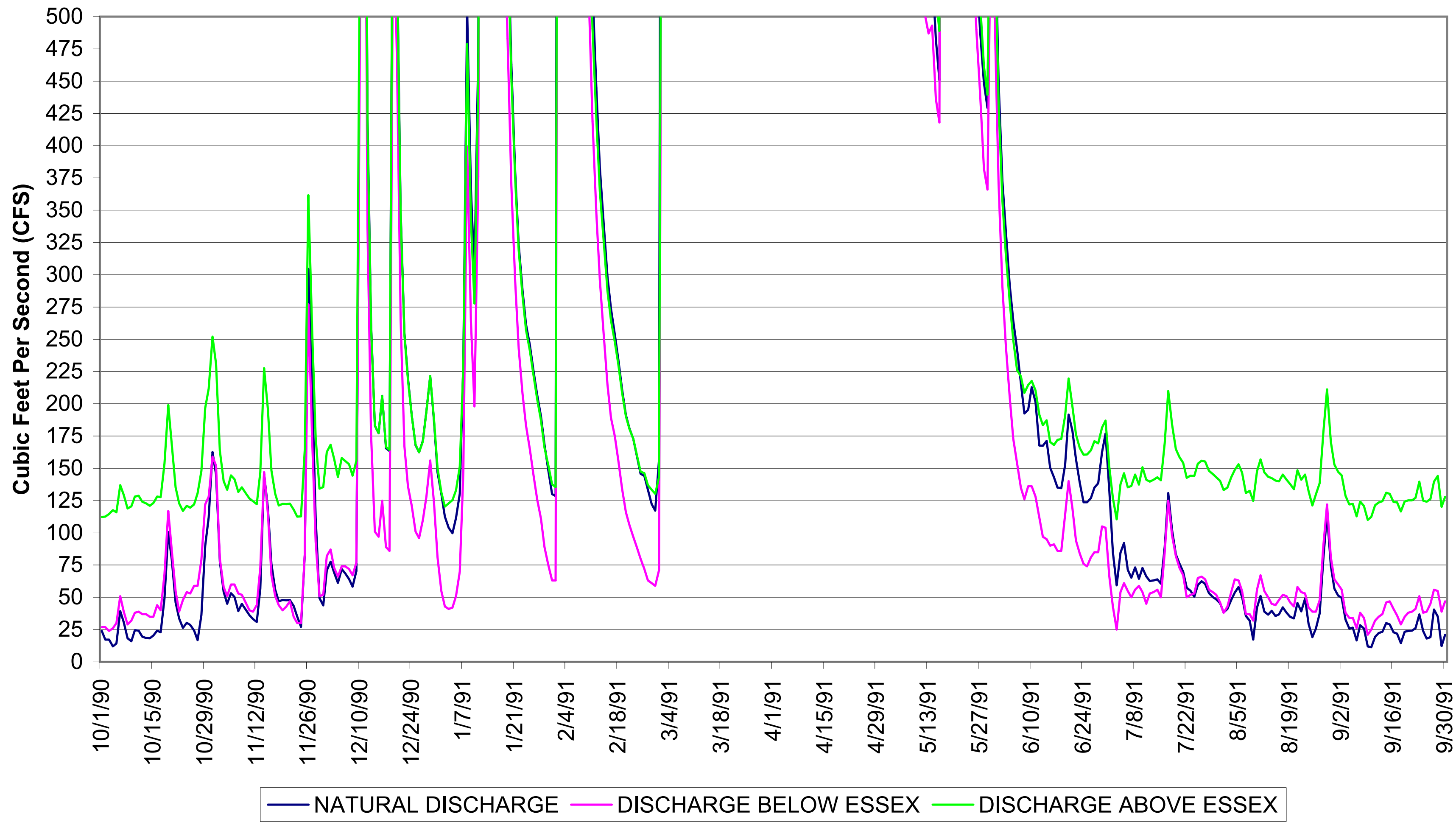


Figure 1.3
Mad River
10/1/1991 to 9/30/1992 Comparison of Natural Flow
To Discharge Above and Below HBMWD's Essex Diversion

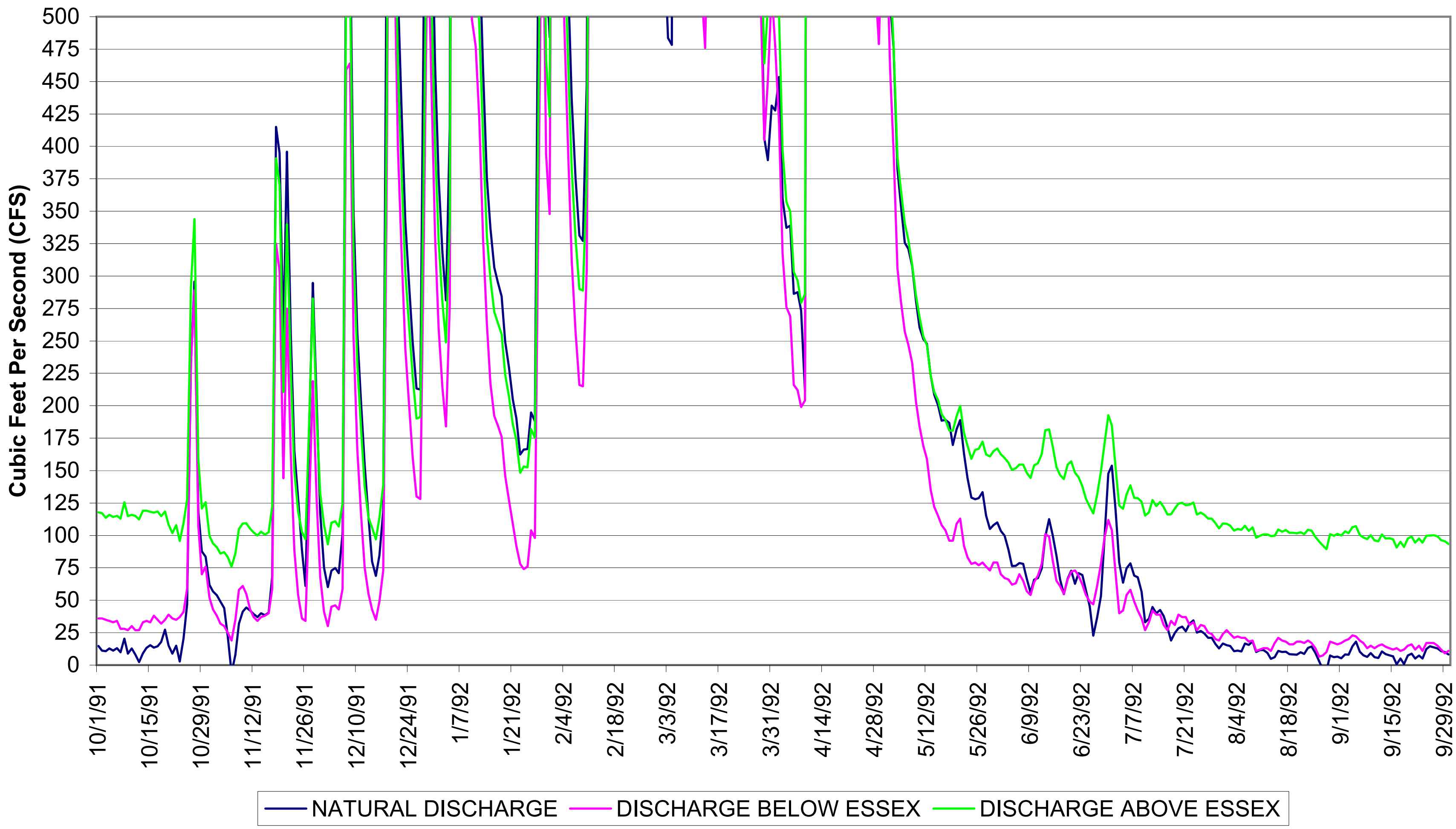


Figure 1.4
Mad River
10/1/1992 to 9/30/1993 Comparison of Natural Flow
To Discharge Above and Below HBMWD's Essex Diversion

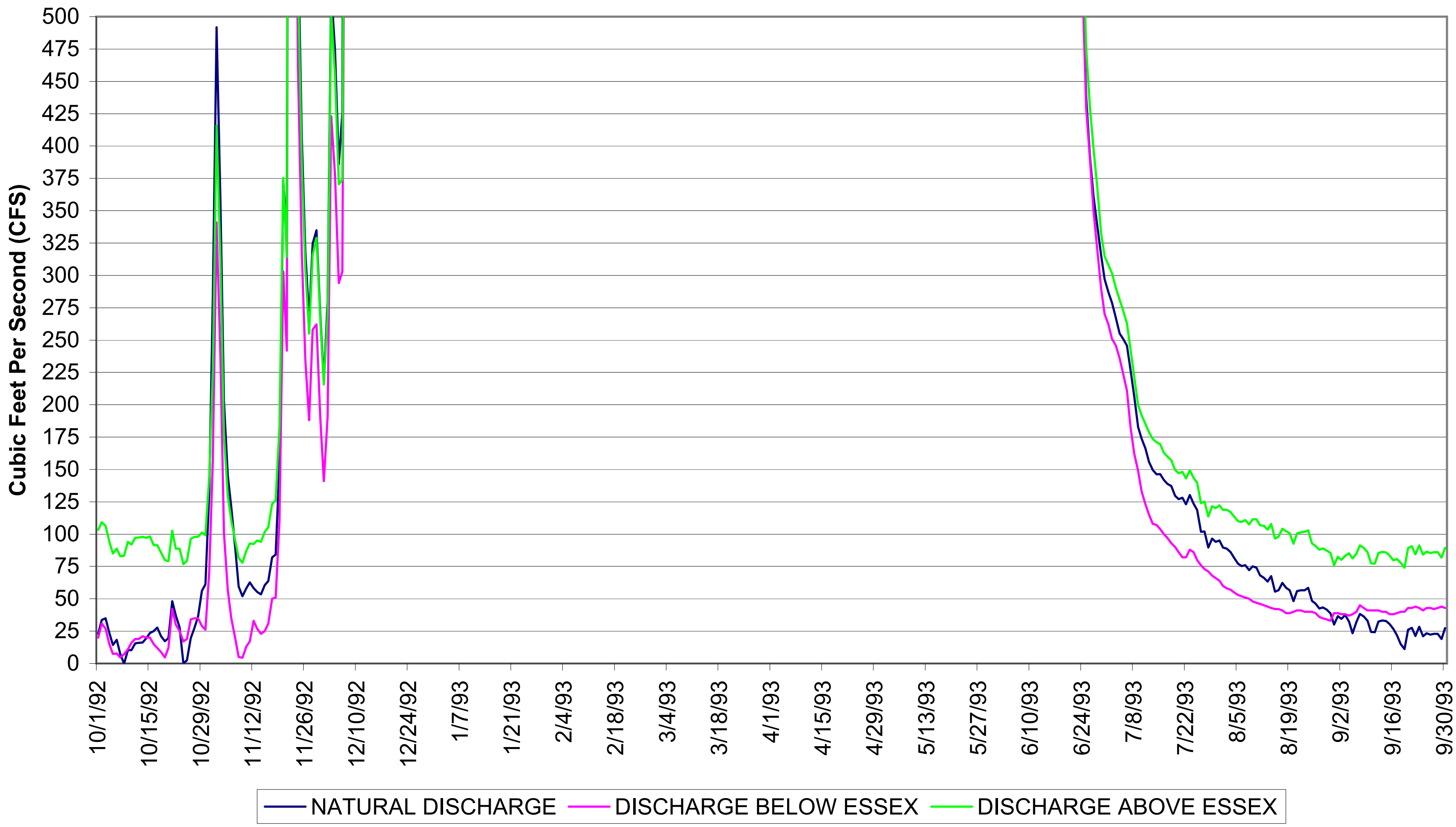


Figure 1.5
Mad River
10/1/1993 to 9/30/1994 Comparison of Natural Flow
To Discharge Above and Below HBMWD's Essex Diversion

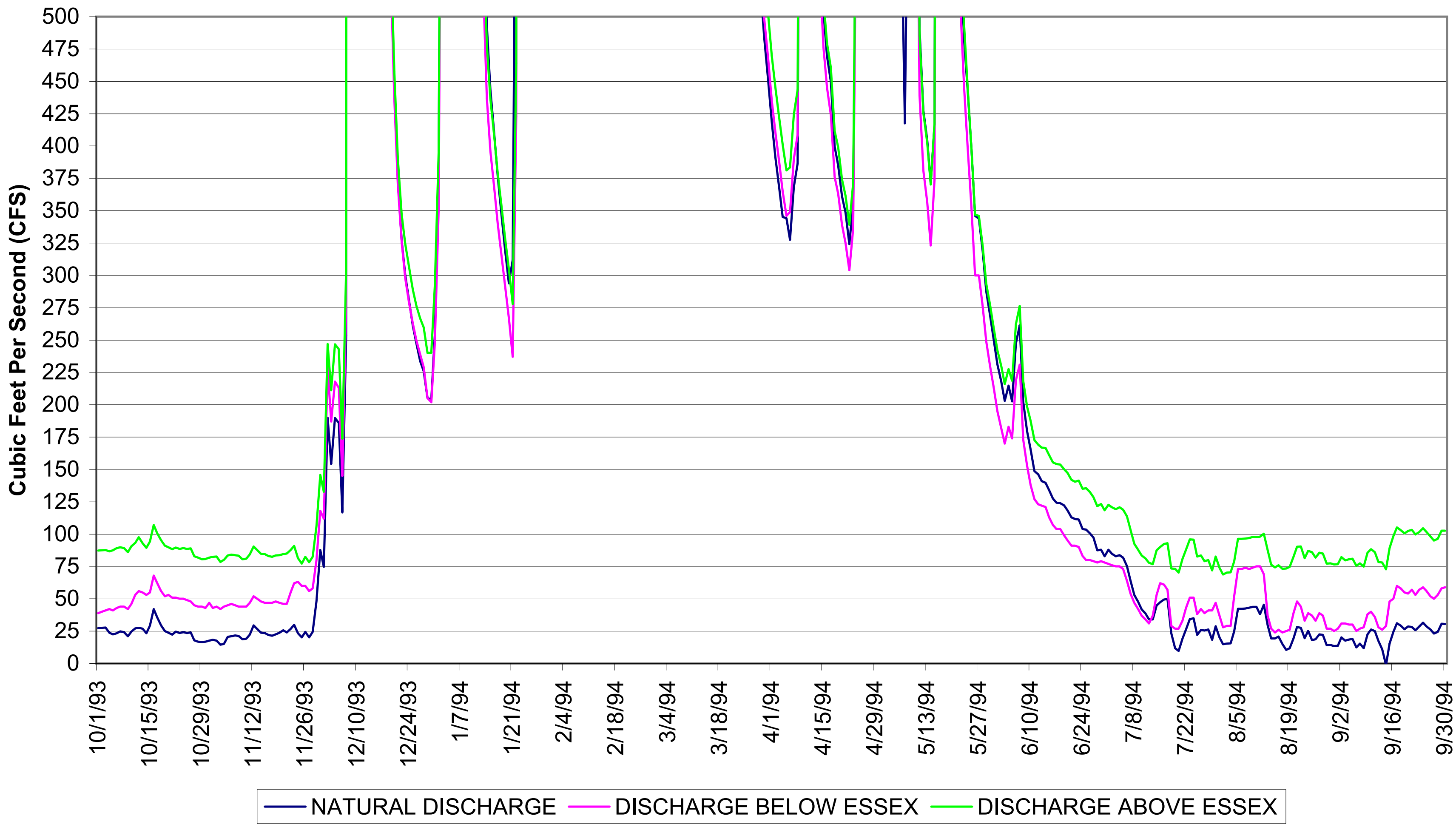


Figure 1.6
Mad River
10/1/1994 to 9/30/1995 Comparison of Natural Flow
To Discharge Above and Below HBMWD's Essex Diversion

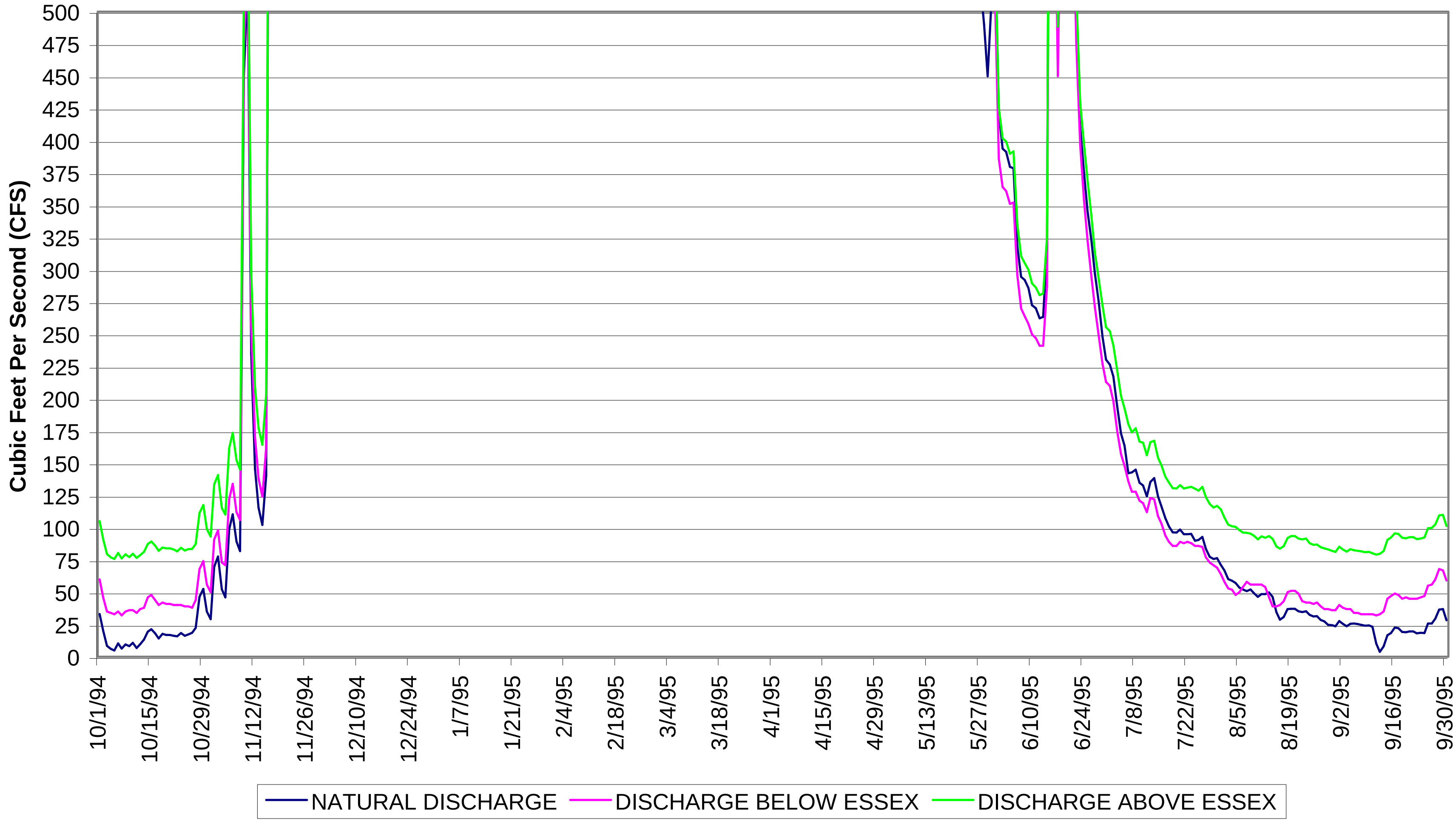


Figure 1.7
Mad River
10/1/1995 to 9/30/1996 Comparison of Natural Flow
To Discharge Above and Below HBMWD's Essex Diversion

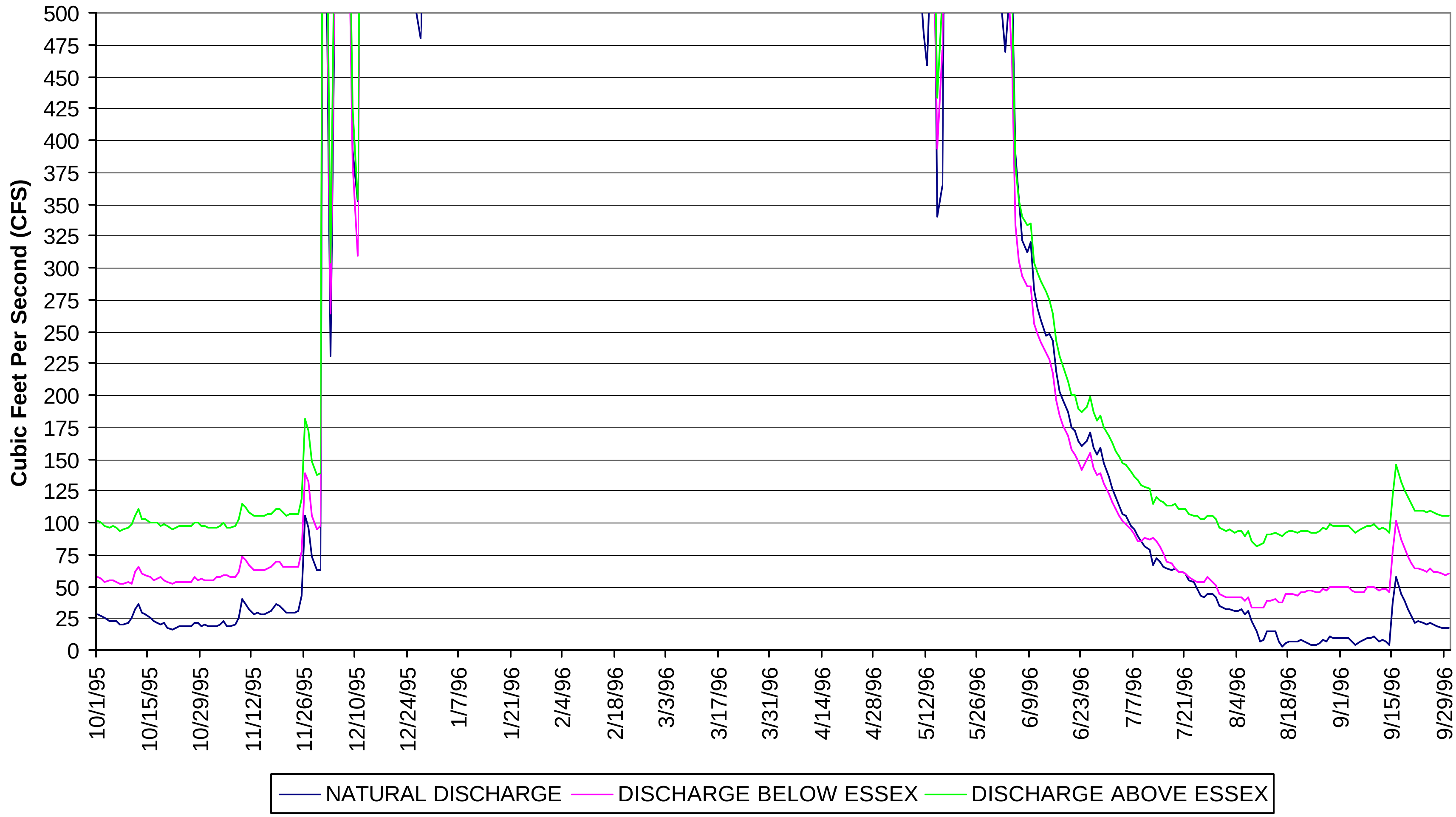


Figure 1.8
Mad River
10/1/1996 to 9/30/1997 Comparison of Natural Flow
To Discharge Above and Below HBMWD's Essex Diversion

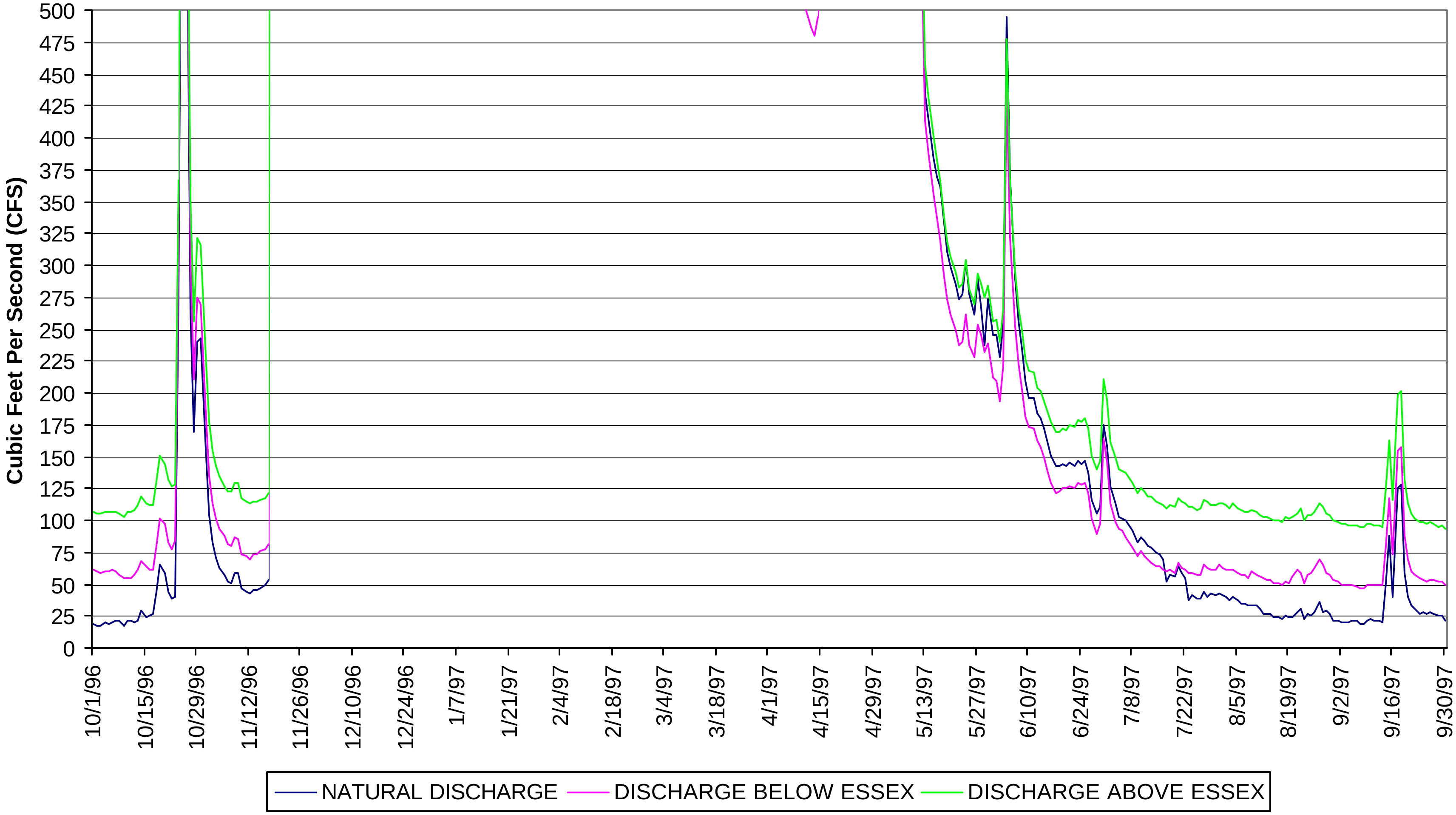


Figure 1.9
Mad River
10/1/1997 to 9/30/1998 Comparison of Natural Flow
To Discharge Above and Below HBMWD's Essex Diversion

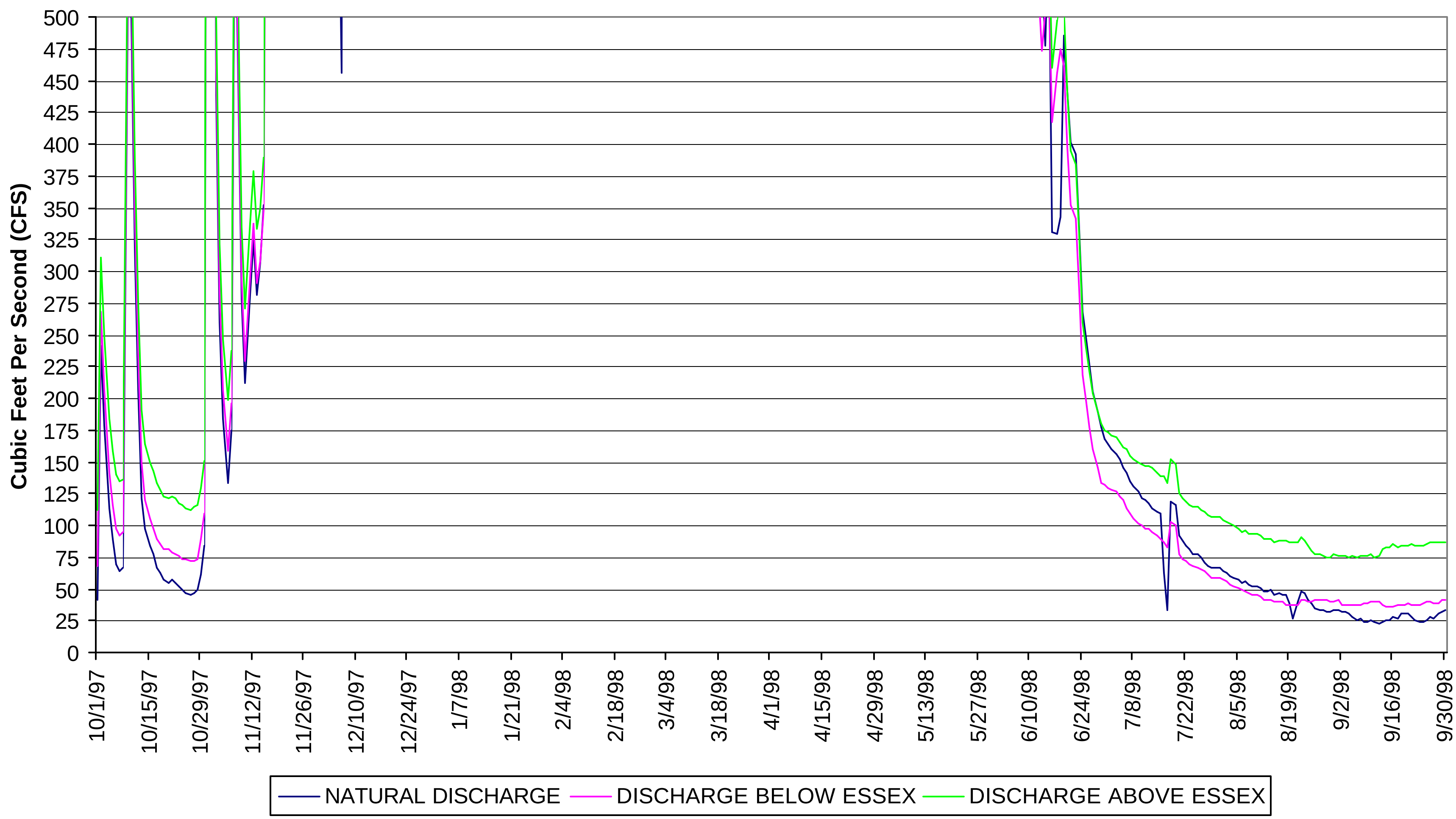


Figure 1.10
Mad River
10/1/1998 to 9/30/1999 Comparison of Natural Flow
To Discharge Above and Below HBMWD's Essex Diversion

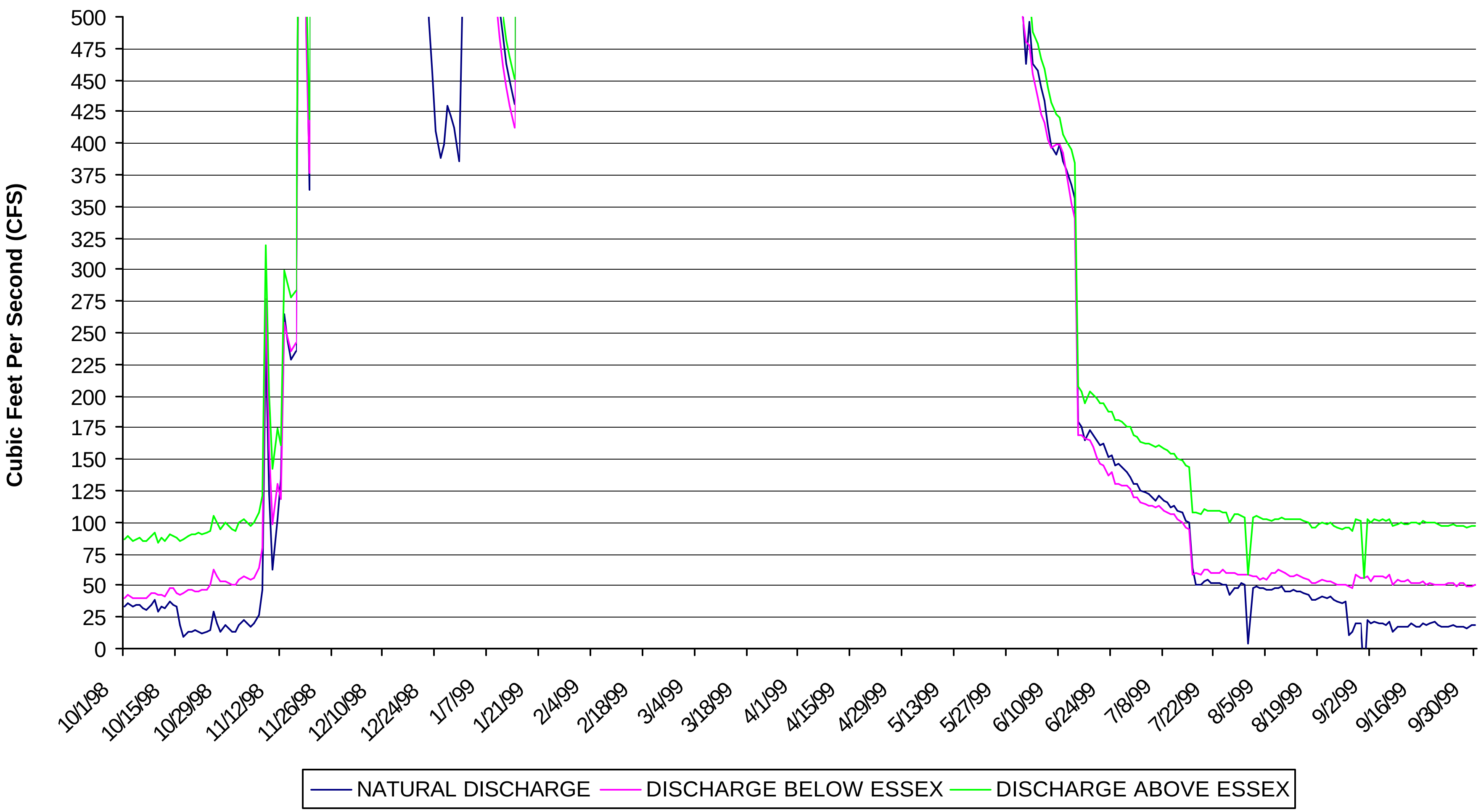


Figure 1.11
Mad River
10/1/1999 to 9/30/2000 Comparison of Natural Flow
To Discharge Above and Below HBMWD's Essex Diversion

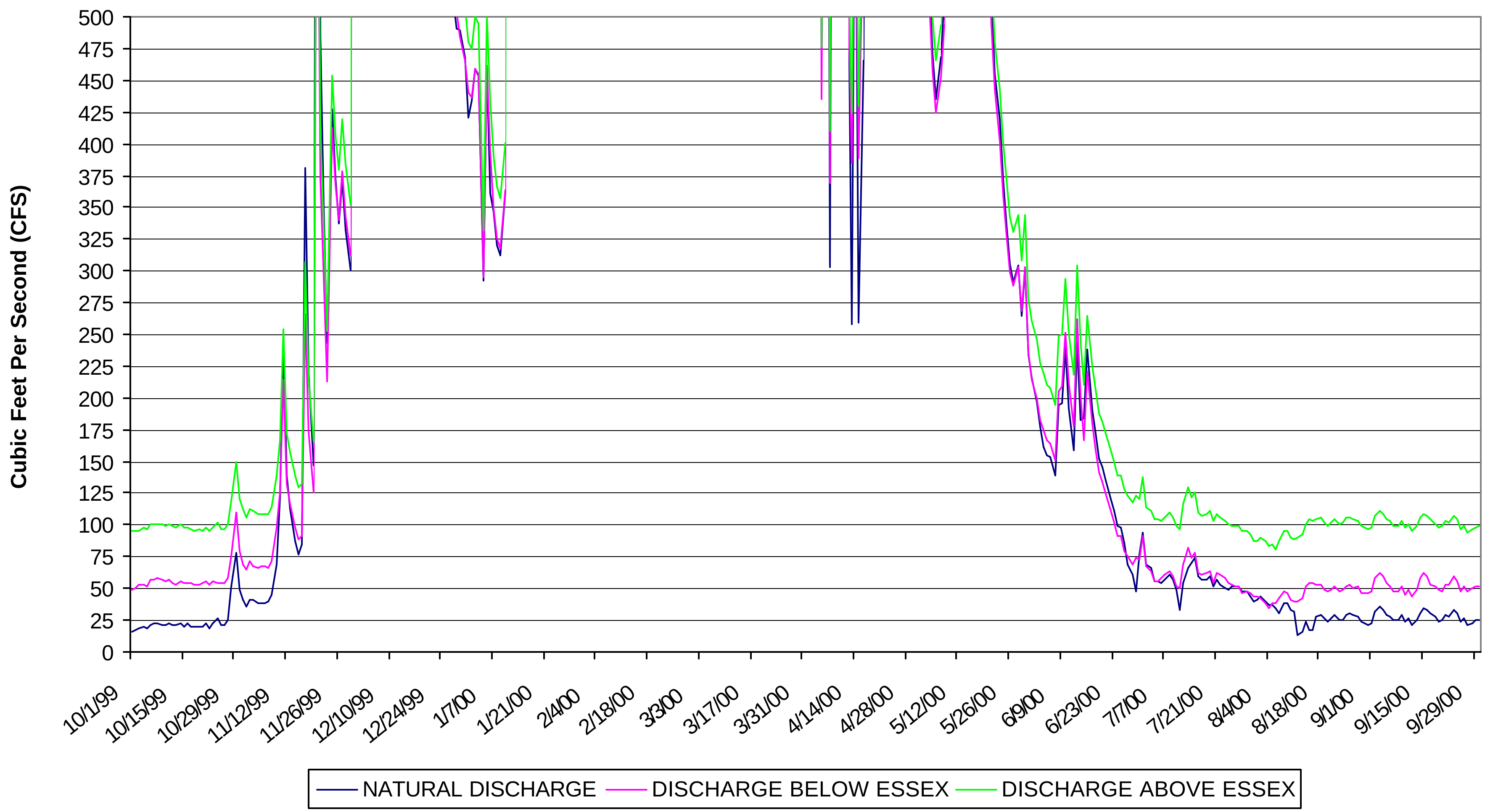
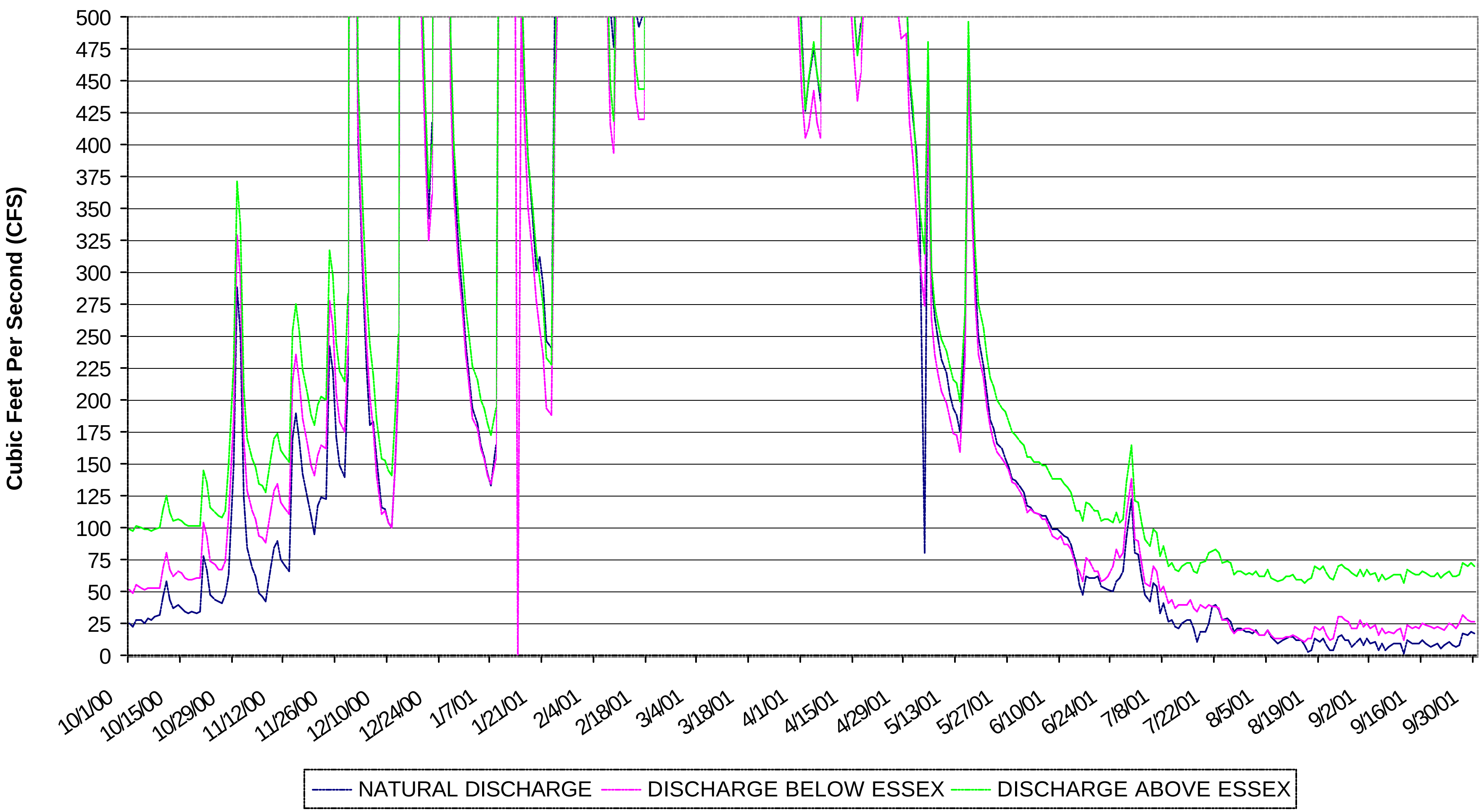


Figure 1.12
Mad River
10/1/2000 to 9/30/2001 Comparison of Natural Flow
To Discharge Above and Below HBMWD's Essex Diversion



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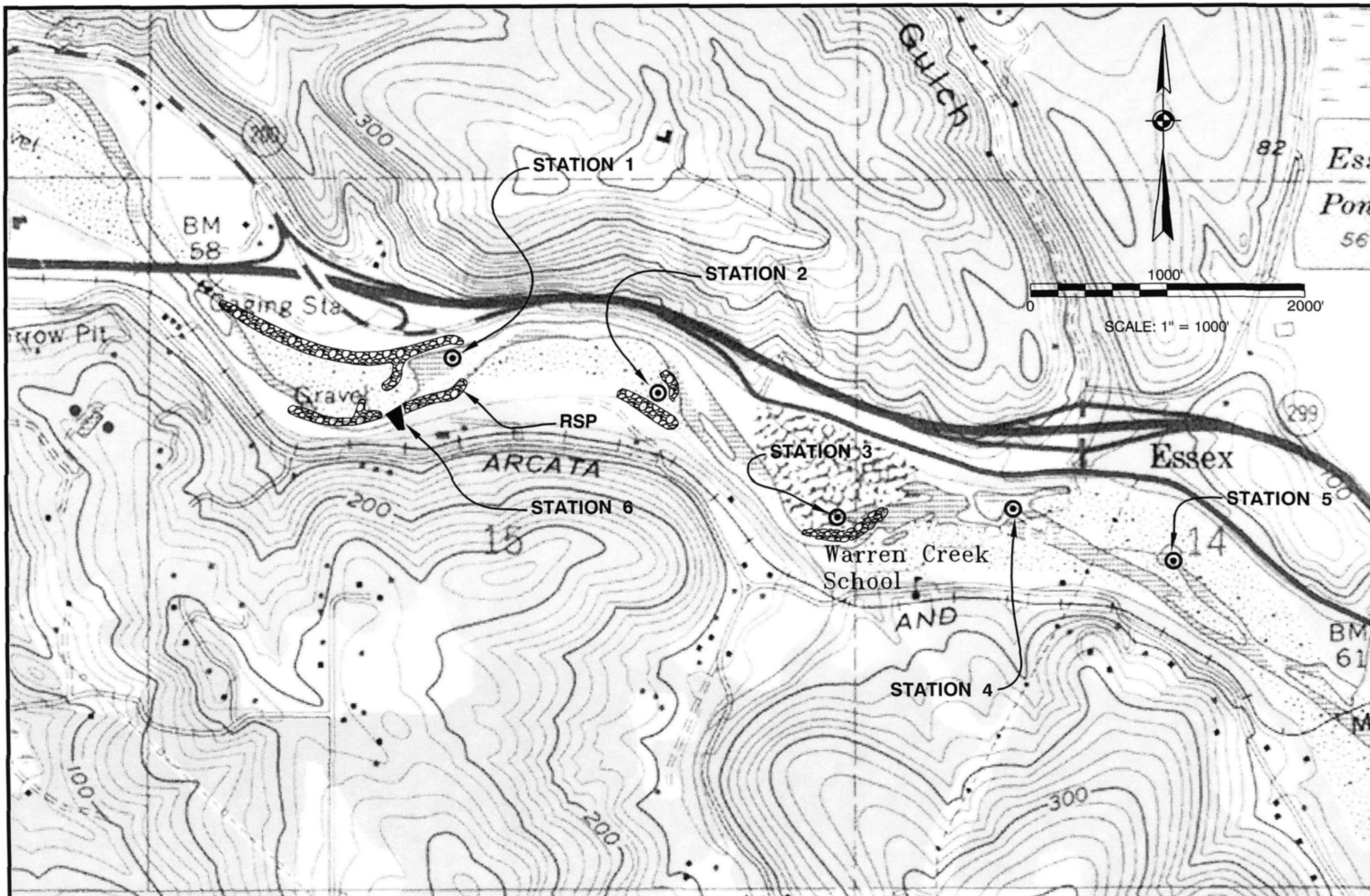

LOCATION OF RIP RAP AND ROCK STRUCTURE AREAS

FIGURE 2

WINZLER & KELLY

Humboldt Bay Municipal Water District

Habitat Conservation Plan

Appendix D

Evaluation of the Conformity of Station 6 with NMFS' 1997 Fish Screening Criteria For Anadromous Salmonids

TABLE OF CONTENTS

1.0 INTRODUCTION

The Humboldt Bay Municipal Water District (District) pumps untreated surface water from the lower Mad River at its Hilfiker Pump Station 6. Station 6 was built in 1976, and was designed to provide up to 60 million gallons per day to its industrial customers. Station 6 contains a forebay, intake structure, and a fish bypass system; the latter is comprised of vertical traveling "Rex" screens and a fish return system.

In 1997, the Southwest Region of NMFS published Fish Screening Criteria for Anadromous Salmonids that are applicable for new facilities. In 1999, the District completed an evaluation which examined the extent to which Station 6 complies with NMFS' 1997 guidelines for new facilities. Subsequently, the District updated portions of the evaluation based on the discussions which occurred with NMFS staff during the technical consultation phase of the District's HCP process.

This report has been prepared in a question–answer format, addressing each criterion presented in NMFS' 1997 guidelines. All calculations and Station 6 design details were provided by John Winzler, District Engineer, and also Professional Engineer of record for the 1975 facility design. Input provided by others are referenced herein.

2.0 BACKGROUND

A brief summary of Hilfiker Pumping Station 6 is provided below by John Winzler.

"Major considerations for design and selection of the type and site for a direct river diversion on the Mad River include:

- *The extreme variation in river flow and river elevation experienced during seasonal changes in runoff in the river basin.*
- *The copious silt and gravel suspensions transported by the river during high water and resultant extensive sediment depositions.*
- *Protection and preservation of the fishery as it applies to the anadromous fish runs and their spawning cycles.*

It is evident that any diversion facility on the Mad River will have to be constructed so as to allow for the continued mechanical removal of silt and gravel within the diversion channelization and structure itself; some type of pre sedimentation for the coarser sands and gravel is required."

3.0 GENERAL CONSIDERATIONS

What is the swimming ability of fish present at the pumping facility?

Anadromous salmonid fry are present at Station 6. Fry will have the least developed swimming ability of any other salmonid life stage of present at Station 6. In studying the effects of culverts on the migration of salmonids, researchers have found that salmonid fry are capable of swimming against velocities up to 2.0 fps (personal communication, William Trush, 1999).

What time of year are fish present at the pumping facility?

For anadromous salmonid fry in the Mad River, the critical time period is March through July; for smolt outmigration, it is April through August. The critical adult migration occurs from October through February, and for spawning, the critical period is from December through March.

What has been the historic rate of diversion at the pumping facility?

Station 6 is designed to deliver is 60 MGD (93 cfs). Its actual achieved maximum diversion was in the 1980's, at 42 MGD (65 cfs); and for the last five years, the diversions have been reduced to approximately 18 MGD (30 cfs).

What are the behavioral responses of those fish present at the pumping facility?

The effect of Station 6 on the behavior of anadromous salmonid juveniles was investigated in comprehensive fish studies conducted in 1998 and 1977. (Refer to Appendices E-1 and E-2, respectively). The studies found that juvenile anadromous salmonids were free to enter and leave the forebay at all times during all flow conditions, and also that capture rates at Station 6 were extremely low.

4.0 STATION 6 EVALUATION vs. NMFS CRITERIA

Is Station 6 Pumping facility a functional design that reflects NMFS design criteria: define type, location, method of operation, and other important characteristics of the fish screen facility? Hydraulic information should include: hydraulic capacity, expected water surface elevations, and flows through various areas of the structures.

4.1 Direct Diversion Design Criteria

Station 6's pumping facilities was designed in 1975. It is comprised of a steel sheet pile forebay, which is directly adjacent to the Mad River and extends transverse to the direction of flow, and a concrete pumping structure with three pumps in each compartment. The concrete intake structure is basically divided into two equal pumping "cells", with both cells being protected with a composite inclined trash rack at the entrance to the structure. Each pumping cell has a vertical mechanically operated fish screen located approximately 12 feet in front of the pump impellers. The cells have sloping floors from the trash rack (which is approximately 12 feet in front of the fish screen) which creates 5 feet of additional depth of water at the screens and pumps.

Station 6 is designed to accommodate a maximum average daily pumping rate of 60 million gallons per day (MGD), or approximately 93 cubic feet per second (cfs).

4.2 Forebay

The forebay is trapezoidal in shape, varying in dimension from over 90 feet in width at the entrance (i.e., confluence with Mad River) to approximately 36 feet in width, in front of the trash racks at the concrete pumping structure. The forebay is approximately 90 feet long, at its center, from the river to the trash racks. The elevation of the forebay entrance was designed to be elevation 13'+/-, i.e., similar to the elevation of the thalweg of the Mad River, adjacent to the forebay.

A 30 ton crane is used to dredge the forebay. Dredging is required after high river events in which large amounts of silt and gravel settle out in front and within the forebay. The forebay is normally dredged to a depth of 10 to 12 feet.

Approach velocity into the forebay is controlled by a shear wall which has multiple movable concrete gate sections (4'x10'). These gate sections control the inlet area into the forebay, and, as a consequence, effect the inlet velocity. The District maintains sufficient openings in the shear wall to provide entrance velocities below 0.40 fps. The current delivery rate of 18 MGD creates velocities of only 0.04 fps at the forebay entrance with all gates open. At the maximum pumping rate of 60 MGD, and the lowest possible water stage height of 21.5 feet (given the grade control weir downstream), the total "ungated" area of the forebay entrance would create an inflow velocity of 0.13 fps. To meet NMFS' 0.4 fps entrance velocity criterion at the maximum pumping rate of 60 MGD, the District will maintain a minimum of 233 feet of gate opening (i.e., via removal of 6 concrete gates from the shear wall).

4.3 Fish Screens

The fish screens are two Rex "four post type" screens furnished by Envirex. The basic horizontal opening to accommodate each screen is 13'-4" clear, concrete sidewall to concrete sidewall. The fish screen, including the structural framing system completely fulfills the opening and is further "guarded" against unprotected vertical open space along both sides of the screen by redwood 2 x 4 sealing strips directly connected to the concrete sidewalls.

At the bottom of the screen, a steel bottom boot plate reduces any unprotected opening at the screen bottom to less than 3/8" and the direction of the rotating screen and fish bucket is toward the face of the screen creating, if anything, creating a movement of water away from the screen at this point.

Each of the two fish screens is basically 13'-2" wide (frame to frame) and articulated at 2' vertical intervals. The screen material is Type 304 stainless steel wire cloth with 3/16" square opening. The screen material provides an excess of 37 percent open area.

NMFS has established 0.33 feet per second (fps) as the maximum approach velocity for fry-sized salmonids at a direct diversion facility located on a river, and 0.40 fps for a canal. Station 6 is akin to a canal so the more relevant criterion is 0.40 fps. Approach velocities at the Station 6 screens are below the new criteria established by NMFS. At the maximum design pumping rate of 60 MGD, and under the lowest historical water surface elevation ever experienced (20.7 feet), the approach velocity at the screens is only 0.30 fps. (It should be noted that the lowest possible water surface elevation is now approximately 21.5 feet given the addition of the grade control weir downstream.) The maximum approach velocity at the historical maximum delivery rate of 42 MGD is only 0.20 fps, and at the current pumping rate of 18 MGD, the maximum velocity is just 0.09 fps. Therefore, under all possible operating conditions, the approach velocities at the Station 6 screens are below the NMFS criteria for both a canal structure and an in-river structure .

The timing, frequency, and duration that the screens are run are dependent on water quality conditions. The normal run time of the screens is 20 minutes every 96 hours. During periods of high water discharge, particularly the first overbank flows of the season, high concentrations of sediment and organic debris are common, resulting in more frequent screen run times. Algae build-up on the screens in the summer may also trigger more frequent run times to reduce head loss.

4.4 Screen Criteria for Juvenile Salmonids

Where installation of fish screens at the diversion entrance is undesirable or impractical, the screens may be installed at a suitable location downstream of the canal [Forebay] entrance. (NMFS, 1997)

Do physical factors at the Station 6 Pumping facility preclude screen construction at the diversion entrance such as excess river gradient, potential for damage by large debris, and potential for heavy sedimentation?

It would be our opinion (i.e., Winzler & Kelly, Consulting Engineers) that a screen at the forebay entrance could not be maintained because of the heavy bed load of large gravel that is moved through the river system in the vicinity of the Diversion Facilities and the preponderance of large debris and heavy drift which accompany each high river occasion. The District, initially, attempted to operate the Diversion Facilities with only a log boom across the entrance to deter debris and drift from entering the forebay. This proved entirely impractical as the forebay became a depository of logs, stumps, limbs and other woody debris, as well as the fact that accelerated siltation occurred within the forebay as a result of extensive deposits of heavy gravel. Ultimately, to mitigate this problem, a removable concrete gating system was installed across the forebay entrance, which acts as a shear in terms of deflecting debris and gravel, and yet provides adequate open area for water entry into the forebay."

4.5 Structure Placement

For on-river screens, it is preferable to keep the fish in the main channel rather than put them through intermediate bypasses. (NMFS, 1997)

Does Station 6 pumping facility and its screen placement function the same as an "on-river" screen, to keep the fish in the main channel rather than put them through intermediate bypasses?

Station 6 does not divert the Mad River into a "canal" like structure. Rather, the position of Station 6 in relation to the Mad River is analogous to a "backwater" or "lateral pool" habitat. The District's facility is built into the left bank (looking downriver) of the Mad River. Fish that enter the forebay are not physically removed from the main channel, nor are they prevented from freely swimming out of the facility into the main flow of the river. The screen placement does not put fish through any intermediate bypass. The screens function as the interior third wall to the backwater environment created by the forebay walls. When the screens are not in motion, fish can either continue to occupy the forebay, or can swim back out into the Mad River.

4.6 Approach Velocity

Approach Velocity is the water velocity vector component perpendicular to the screen face. Approach velocity shall be measured approximately three inches in front of the screen surface. If a biological justification cannot demonstrate the absence of fry-sized (less than 2.36" (60 mm) in length) salmonids in the vicinity of the screen, fry will be assumed present and the following criteria apply: (NMFS, 1997)

4.6.1 Fry Criteria

Design approach velocity shall not exceed:
Streams and Rivers:-------------------- 0.33 feet per second
Canals: ---------------------------------- 0.40 feet per second

4.6.2 Fingerling Criteria-2.36" (60 mm) and longer

Design approach velocity shall not exceed:
All locations:---------------------------- 0.8 feet per second

Does the approach velocity at Station 6's fish screen, measured approximately three inches in front of the screen surface exceed 0.40 feet per second?

An important factor in calculating the approach velocity is the water surface elevation at the screen face. The initial design criteria for Station 6 assumed that the low water surface elevation in the forebay and at the fish screens would be maintained at or above 21.0 feet mean sea level (msl). Actual operational experience has shown that the lowest historical water surface elevation ever encountered was 20.7 feet. The velocity calculations at the fish screens have been computed on the basis of this lowest historical water surface elevation of 20.7 feet. It should be noted that installation of the grade control weir downstream of Station 6 allows the District to control the water surface elevation at approximately 21.5 feet now. Therefore, using the 20.7' surface elevation to compute velocities at the screen face is a *very* conservative assumption.

The calculated approach velocity, 3-inches in front of the screen face, under existing conditions (i.e., delivery of 18 MGD) is 0.09 feet per second, significantly below the allowed criterion of 0.40 for canals, which Station 6 is akin to. At the maximum design pumping capacity of 60 MGD, the calculated approach velocity 3-inches from the screen face is 0.30 fps, again well below the allowed criterion of 0.40 fps for canals, and also below the 0.33 fps criterion for rivers.

What is the total submerged screen area (excluding area of structural components) calculated by dividing the maximum diverted flow by the allowable approach velocity?

The total submerged unencumbered screen area at the current controlled low water surface elevation of 21.5 feet msl is 240.4 square feet. The *required* submerged screen area under the maximum design pumping rate of 60 MGD, at the allowed approach velocity of 0.40 fps and3-inches in front of the screen face, would be 232.1 square feet. Thus, the available submerged screen area meets NMFS requirements under all possible flow conditions.

Does the screen design provide for uniform flow distribution over the surface of the screen, thereby minimizing approach velocity?

"In-situ velocity tests have never been performed, however, it is our opinion (i.e., Winzler & Kelly, Consulting Engineers) that the uniformity of the approach chambers would create a laminar or uniform flow condition approaching the screens, and this uniform flow would be distributed equally over the screen surface, precluding the occurrence of localized accelerated approach velocities."

4.7 Sweeping Velocity

Sweeping Velocity is the water velocity vector component parallel and adjacent to the screen face. Sweeping Velocity shall be greater than approach velocity. (NMFS, 1997)

Is the sweeping velocity greater than approach velocity?

The District's intake structure does not create sweeping velocities. Since the screens are installed at right angles to the direction of flow, sweeping velocities do not exist at the screen or within the diversion chambers.

4.8 Screen Face Material

Does the woven wire: screen openings exceed 3/32 inches (2.38 mm), measured diagonally (e.g.: 6-14 mesh)?

Openings currently measure 8/32" diagonally. (See addendum, page 17. The District will be retrofitting Station 6 to meet NMFS' 3/32-inch criterion).

Does the screen material provide a minimum of 27% open area?

The screen material is Type 304 stainless steel wire screen cloth with 3/16" clear square openings, providing an open area of 37 % of the total screen surface area.

Is Station # 6's fish screen material corrosion resistant and sufficiently durable to maintain a smooth and uniform surface with long term use?

As noted herein before, the screen material is stainless steel and consequently is corrosion resistant and thus provides a long-term smooth and durable surface.

4.9 Civil Works and Structural Features

Is the face of the screen surface flush with any adjacent screen bay, pier noses, and walls, allowing fish unimpeded movement parallel to the screen face and ready access to bypass routes?

The basic horizontal opening to accommodate each screen is 13'-4" clear, concrete sidewall to concrete sidewall. The fish screen, including the structural framing system completely fulfills the opening and is further "guarded" against unprotected vertical open space along both sides of the screen by redwood 2 x 4 sealing strips directly connected to the concrete sidewalls.

At the bottom of the screen, a steel bottom boot plate reduces any unprotected opening at the screen bottom to less than 3/8" and the direction of the rotating screen and fish bucket is toward the face of the screen creating, if anything, a movement of water away from the screen at this point.

Does Station 6 pumping facility provide structural features to protect the integrity of the fish screens from large debris? Trash racks, log booms, sediment sluices, or other measures may be needed.

The District's Pump Station 6 facility has the following structure in front of the vertical traveling Rex screens; forebay gates, trash racks, and the gated rear wall of the forebay. The Forebay gates are 126 feet, the trash racks 36 feet, and gated rear forebay wall is 12 feet in front of the vertical traveling Rex screens.

Does the civil works design eliminate undesirable hydraulic effects (e.g.-eddies, stagnant flows zones) that may delay or injure fish, or provide predator opportunities?

There are no identifiable undesirable hydraulic effects within the forebay and approach chambers to the fish screens (i.e., eddies or stagnant flow zones) which would delay, confine or injure fish. The very fact that the forebay provides a deeper, slow moving water area for fish to enter and rest before moving on down or up stream, may encourage the presence of predators, however, the visual presence of such predators (i.e., kingfishers and river otter) seems no more prevalent in the forebay than in the adjacent river.

4.10 Juvenile Bypass System Layout

Juvenile bypass systems are water channels which transport juvenile fish from the face of a screen to a relatively safe location in the main migratory route of the river or stream. Juvenile bypass systems are necessary for screens located in canals because anadromous fish must be routed back to their main migratory route. For other screen locations and configurations, NMFS accepts the option which, in its judgment, provides the highest degree of fish protection given existing site and project constraints. (NMFS, 1997)

Does the fish bypass system transport juvenile fish from the face of a screen to a relatively safe location in the main migratory route of the river or stream?

The District's Pump Station 6 facility is not located or configured as a "canal", but more as a backwater pool or off-channel slough habitat. Fish are never segregated from their main migratory route or prevented from swimming freely in or out of the pumping facility. The pumping facility provides a slack water environment for settling of suspended sediment, and a low velocity deep water habitat for migrating salmonids.

The fish bypass system begins with the troughs attached to the vertical traveling screens. Juvenile fish are transported, through a series of flumes and conduits back to the Mad River, where they exit below a rock weir into a flatwater habitat.

Does the screen and bypass system work in tandem to move out-migrating salmonids to the bypass outfall with minimum injury or delay?

When the screens are in motion the bypass system is also functioning. Water continues to flow through the bypass system for twenty minutes after the screens have been shut off. The District has modified its fish bypass facility, to reduce the rate of fish mortality in response to findings from the 1998 Fishery Study at Station 6.

Are all components of the bypass system, from entrance to outfall, of sufficient hydraulic capacity to minimize the potential for debris blockage?

Yes. Debris is dislodged from the vertical traveling Rex water screens by low and high pressure Rex spray nozzles. The screens, debris is washed into a refuse trough and conveyed by water through a steel debris grate and into to a concrete containment basin. Water from the refuse troughs joins the water in the fish bypass in the concrete basin. Water and fish in the bypass system join surface runoff in a 48 inch steel corrugated culvert that empties into a 30 inch culvert to exit at the outfall. While debris is effectively removed from the fish bypass system, debris could be re-introduced into the bypass system from surface runoff flowing into the 48 inch culvert and then to the 30 inch culvert.

Is access provided at locations in the bypass system where debris accumulation may occur?

Yes. Regular inspections occur at debris rack at the exit of the refuse trough located in the concrete containment basin, and at the clean-out basin. A trash bin is always in place to collect debris from the refuse trough. Access is provided at the clean-out basin for personnel and equipment as needed.

The screen civil works floor shall allow fish to be routed to the river safely in the event the canal is dewatered.

The screen civil works are not located in a canal, but within the intake structure behind the rear wall of the Forebay. The rear wall has a full length opening of 13’4”; it is gated and capable of being sealed off. Two parallel intake chambers operate separately from each other. One chamber can be dewatered while the other continues to function. The floor of the chamber is at 8 feet msl, which is below the Mad River’s thalweg bed elevation. These chambers are dewatered once a year to allow for an inspection of the screens and their maintenance.

4.10.1 Bypass Entrance

Is the bypass entrance provided with an independent flow control, acceptable to NMFS?

Flow control in the fish troughs and therefore through out the bypass system is programmed for 60 GPM, and is capable of manual control.

Is the bypass entrance velocity equal or exceed the maximum velocity vector resultant along the screen, upstream of the entrance?

The maximum approach velocity of 0.30 fps, 3 inches in front of the screens, is achieved during maximum pumping rates of 60 MGD. The velocity in the fish trough is up to 10 fps.

4.10.2 Bypass Conduit Design

Does the bypass facility provide smooth interior pipe surfaces and conduit joints to minimize turbulence, debris accumulation, and the risk of injury to juvenile fish?

No, the interiors of some of the conduit pipes are corrugated, and there are 90 degree turns in the bypass system. During the 1998 fish study, biologists observed that the 30 inch x 220 foot steel corrugated culvert did not convey all of its water to the outfall. The biologists observed a loss of fish, specifically when fish were placed into the entrance of the 220 foot culvert. Opening(s) in the culvert may have allowed fish to be lost in transport through the culvert. In response, the District has repaired this culvert to prevent any further loss of water or fish.

Does the bypass system cause fish to free-fall?

Yes, fish can free-fall 2' from the face of the screens into either the fish or refuse troughs. One other point with a free-fall of 8 inches is located at the outlets of the two troughs into the concrete containment basin. Depending on river stage, the outfall from the 30" culvert discharges directly into the river through a flexible 12 inch conduit.

Does the bypass system pump fish within the system?

No.

Is the pressure in the bypass pipe equal to or above atmospheric pressure?

As the various segments of pipe in the fish bypass system are always exposed to the atmosphere in terms of entry characteristics, manhole junctions and ultimate termination of flow, the pressure in the piping system is always equal to atmospheric pressure.

Does the bypass system contain extreme bends in the pipe layout that may cause, excessive physical contact between small fish and hard surfaces and result in debris clogging. Is the bypass pipe centerline radius of curvature (R/D) 5 or greater? Greater R/D may be required if supercritical velocities exist.

The bypass piping involves several varying types of hydraulic structures, including a segment of half-round flume which collects any fish brought to the pump deck level by the screen buckets; the fish are conveyed by the flume to a containment structure; thence through varying piping systems to the river. The pipe layout should not cause excessive physical contact between small fish and hard surfaces, nor would the layout create issues of debris clogging.

Is Station # 6 bypass system designed for bypass pipes or open channels to minimize debris clogging and sediment deposition and to facilitate cleaning?

The bypass piping system was designed and constructed in a manner to facilitate easy access for purposes of debris and sediment removal and/or other cleaning and maintenance issues.

Are the bypass system conduit pipes 24 inches (0.610m) or greater in diameter?

No, approximately 21% of the conduit length in the bypass system is less than 24” in diameter.

BYPASS SEGMENT	LENGTH	DEPTH	WIDTH
Fish Trough	56 feet	1 foot	2 feet
Refuse Trough	56 feet	1 foot	2 feet
Settling Basin	8 feet	3 feet	4 feet
Steel Trough	11 feet	1 foot	1.75 feet
Steel Pipe	73 feet	N/A	0.75 foot-diameter
Steel Culvert	46 feet	N/A	4 feet-diameter
Steel Trough	8 feet	1.3 feet	4 feet tapering to 2.5 feet
Steel Culvert	220 feet	N/A	2.5 feet-diameter
Flex Pipe	30 feet	N/A	1 foot-diameter

Does the bypass system conduit pipes achieve a velocity of 2.0 fps (0610 mps) or greater?

Yes, up to 10.0 fps. Field tests performed in various reaches of the bypass conduit piping system illustrate that the velocity of flow within the system exceeds 2.0 fps.

Does the bypass system contain any closure valves?

Yes, one 8” valve.

Is the depth of flow in the bypass conduit at least 0.75 ft. (0.23m) or greater?

No, the flow depth varies, although it averages 2 inches to 3 inches through most of the conduits in the bypass system. During periods of high surface runoff, the 48” and 30” culverts may have greater flow depths because they convey both runoff and bypass flow.

Are there any hydraulic jumps within the bypass system?

There are no instances or circumstances that create hydraulic jumps within the bypass system.

4.10.3 Bypass Outfall

Are ambient river velocities at the bypass outfall greater than 4.0 fps(1.2 mps)?

No, velocities of 4.0 fps should only occur during flood flows.

Is the bypass outfall located and designed to minimize avian and aquatic predation in an area free of eddies, reverse flow, or known predator habitat?

The outfall is located below the District's grade control weir, beyond its bubble cover where larger fish could be holding, in an area characterized as flatwater run habitat.

Is there sufficient depth at the bypass outfall(depending on the impact velocity and quantity of bypass flow) to avoid fish injuries at all river and bypass flows?

During low flow conditions, water depth would average 1.5 feet to 2.5 feet. During normal high water events the depth would increase to 3 feet to 5 feet.

Does impact velocity (including vertical and horizontal components) exceed 25.0 fps (7.6 mps)?

The manner in which the exit flow to the river is controlled is such that in no instances does the impact velocity of bypass water entering the river approach or exceed 25.0 fps.

Is the bypass outfall designed to avoid adult fish attraction or injuries to jumping fish?

No, deep water habitat is created where adult anadromous salmonids will hold at the outfall location. The outfall does not create a situation that would attract jumping fish.

4.11 Operation and Maintenance

Can the fish screens be automatically cleaned as frequently as necessary to prevent accumulation of debris?

Yes, the screens can be triggered to run at any specified head loss.

The Rex Traveling Screens are checked on a daily basis by operators. A monthly inspection is made on chains, running gear, fish buckets and rotating parts. An annual dewatering is done to inspect total screen assembly and frames.

Does the open channel intake include a trash rack in the screen facility design which can be kept free of debris?

Dual trash racks are present at the entry to the intake structure's concrete floor (elevation 13') up to the concrete pump deck (elevation 55'); and are sloped in the direction of flow.

A mechanical, motor-driven trash rake provides a means of rack cleaning, which is activated manually. A headloss alarm will alert operators of abnormal debris buildup. The trash rake brings all trash and debris to the pump deck surface for disposal.

Is the head differential to trigger screen cleaning for intermittent type system a maximum of 0.1 feet (0.03m)?

No, the current setting for head loss trigger of the screens is set at 0.5 feet.

The timing, frequency, and duration that the screens are run are dependent on water quality conditions. During periods of high water discharge particularly the first overbank flows of the season high concentrations of organic debris are common, as well as a high suspended sediment load. Conversely, during low flow conditions in the summer, algae build-up on the screens may trigger the running of the screens, to reduce head loss.

"The following is a basic criteria for setting the screen run times. These criteria may vary due to the conditions of several variables in the river. A brief explanation is that if the river rises and drops quickly within a few days no change in the run time may be necessary or if the turbidity does the same again, no change would be needed. The normal run time on the screens is set for every 96 hours. A change of time may occur when the river is over 23.0 feet. The time that is set may vary from every 4 hours, above the normal of every 96 hours. Also it should be mentioned that the screens run on a headloss situation when they occur." (H. Shamps, HBMWD, personal communications 1997)

"The Rex Traveling screens are programmed to run 20 minutes with a 20 minute delay between screen #1 and #2. The screens will also activate automatically on a headloss programmed at 6 inches. The frequency of screen runs is programmed by operations and is generally determined by the debris present in the water. During abnormally high river events it could be programmed for every 2 hours. The screens can be run manually from the pump station bypassing the automatic control." (HBMWD, Pump Station 6 Fish Bypass System, Correspondence D. Stoveland, 9/30/97)

Screen and bypass facilities shall be evaluated for biological effectiveness and to verify that hydraulic design objectives are achieved.

In 1977, the District cooperated in a fish study, and in 1998, the District conducted a comprehensive fishery studies at Station 6. The results from both studies were very favorable and confirm that the hydraulic and biological objectives at this facility have been met. (Refer to Appendices E-1 and E-2)

5.0 CONCLUSIONS

In 1998, the District's fish study found that a negligible number of salmonid juveniles were caught in its screens. While the District's screens exceed NMFS's guideline of a maximum diagonal screen opening of 3/32 inch, the results of the 1998 study indicate that operation of the fish screens at Station 6 on an annual basis capture, just 4 coho salmon fry, 18 chinook fry, 15 steelhead smolts, and zero coastal cutthroat. During the 1998 study there was also an opportunity to conduct a "mark-recapture" study of hatchery released (247,000) steelhead, with just 14 fish (0.006%) being captured in the District's screens. (Refer to Appendix E-1)

Anadromous salmonids, particularly adults migrating, can be attracted to the forebay of Station 6. The forebay is contiguous with the main migratory route of these fish, and functions similarly to natural backwater pool habitats. Adult salmonids as well as juveniles are free to swim in or out of the forebay and intake structure. The presence of the forebay, like a natural holding pool, does not cause anadromous salmonids to delay their migration. Avian and aquatic predators can access the forebay as they can access any backwater pool habitat; it is not known if the predation frequency is greater than in other similar habitat in the lower Mad River. Adult anadromous salmonids cannot gain access beyond the trash racks. Juvenile salmonids can, but whether they are drawn to the screens during normal foraging activities is unknown. The conclusion of the 1977 fish study was that they were not. Under the maximum pumping capacity at the screen face the approach velocity is a fraction of the swimming ability of even juvenile salmonids.

6.0 Addendum

During the technical consultation with NMFS on the District's HCP, the District agreed to make Station 6 "fish tight" by complying with NMFS' 3/32-inch screen size opening criterion. The District also agreed to remove the existing buckets on the fish screens and replace them with rakes, thereby eliminating the possibility of lifting fish out of the water. This in turn eliminates the need for the fish return system, which does not meet current standards. Additionally, the District agreed to conduct a comprehensive monitoring program after the Station 6 retrofit project is complete. The Station 6 retrofit project plus the monitoring program are outlined in greater detail in the main body of the District's HCP.

Humboldt Bay Municipal Water District

Habitat Conservation Plan

Appendix E Contains three Fish Study Reports as follows:

Appendix E-1: **Fishery Study at Humboldt Bay Municipal Water District's Hilfiker Pump Station 6 Fish Screen & Bypass System (Trinity Associates, March 1999)**

Appendix E-2: **1977 Fishery Study at Station 6 (synopsis of R. Barnhart's 1977 study prepared by Trinity Associates, 2002)**

Appendix E-3: **A Fishery Study of the Lower Mad River: Fish Habitat Mapping, Direct Observation, and Migration Barrier Evaluation (Trinity Associates, May 1995)**

Humboldt Bay Municipal Water District
Habitat Conservation Plan

Appendix E-1

Fishery Study at Humboldt Bay Municipal Water District's Hilfiker Pump Station 6 Fish Screen & Bypass System

Prepared for
Humboldt Bay Municipal Water District
Prepared by
Trinity Associates
March 1999

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1.0 INTRODUCTION

In 1998, Trinity Associates conducted a three-phase fishery study at the Hilfiker Pump Station 6, a direct diversion facility. The purpose of phase one (a pilot fishery study) was to determine if the vertical traveling "Rex" fish screens were capturing anadromous salmonids. The second phase of the fishery study quantified the number of juvenile anadromous salmonids entrained by the fish bypass system. The purpose of third phase was to quantify the survival rate of juvenile anadromous salmonids in the fish bypass system.

The fishery study was conducted by Aldaron Laird, Environmental Planner/Project Manager from Trinity Associates; Dr. Bill Trush, senior fish biologist of McBain and Trush; Ross Taylor, fish biologist; and Dennis Halligan, fish biologist of Natural Resources Management (NRM) Corporation. Dennis Halligan, the Federal Section 10(b) permit holder, and field technicians from NRM CORP, conducted daily fish trapping at Station 6 daily.

2.0 PHASE 1 PILOT STUDY (March 13 to March 27, 1998)

The primary objective of the pilot study was to determine if two vertical traveling Rex screens at Station 6 were in fact capturing wild anadromous salmonids, during natural spring flows. The pilot study involved running a McBain ramp trap twice a day, for ten consecutive days. The length of each sampling period was consistent with the Station 6's normal operating procedures. Sampling was conducted during five sampling periods to determine if more fish were trapped in the pumps and screens, during different times of the day.

Trapping also allowed the fish biologist to identify the fish species captured, and to determine whether certain times of day and/or flow conditions influenced the fish capture rate. The pilot study results would be used to develop recommendations on sampling frequency and timing, for the subsequent second phase fishery study.

Fortuitously, the start of the pilot study occurred three days prior to the first release of marked fish from CDFG's Mad River Hatchery. On March 15th, 77,000 yearling steelhead, all with clipped adipose fins were released from the hatchery, approximately five miles upstream of Station 6's forebay. These marked fish facilitated a "mark-recapture" study, with a known number of fish moving down river, under natural spring flow conditions, past Station 6's forebay.

The sampling period for the pilot study was extended to March 27th, in order to run the screens during a moderately sized storm event. Between March 22nd and 25th, approximately 3.5 inches of rain fell in the Eureka area. There was considerable snowmelt at higher elevations, which contributed to a stage height increase in the Mad River. Sampling occurred once per day during the storm, and continued as the Mad River's stage height dropped.

2.1 Results

The pilot study sampling confirmed that a negligible number of anadromous fish were being captured by the vertical traveling “Rex” screens and transported through the bypass system (Table 1).

Table 1. Anadromous Salmonids Caught during the Pilot Study at the District’s Direct Diversion Station 6, March 13-27, 1998.

SPECIES	Number Caught in Pilot Study	Between Midnight and 7 AM	Between 7 AM and Noon	Between Noon and 6 PM	Between 6 PM and Midnight
Coho salmon	0	0	0	0	0
Chinook salmon	21	1	10	1	9
Steelhead trout	3	0	1	2	0
Cutthroat trout	0	0	0	0	0

No coho salmon or coastal cutthroat trout were captured during the pilot study phase, even though they are common in the lower Mad River during the period of spring out-migration. Capture rates were calculated by dividing the measured capture (numbers of fish captured in bypass troughs) by the measured effort (time that screens were run). Thus, the units to describe the capture rate were “number of fish per hour”. There were 24 sampling periods during the pilot phase of the fish study, resulting in the following capture rates:

- Coho salmon-- 0.00 fish per hour
- Chinook salmon-- 1.31 fish per hour
- Steelhead trout -- 0.06 fish per hour

During the March 22nd to March 25th storm, there were 5 sampling periods. Stage height had no effect on the capture rates of coho salmon or steelhead, but stage height did appear to influence the capture rate of chinook salmon.

- Coho salmon-- 0.0 fish per hour
- Chinook salmon-- 4.5 fish per hour
- Steelhead trout -- 0.0 fish per hour

During the pilot study, only two marked steelhead were captured in the vertical traveling "Rex" screens, after the CDFG released 77,000 steelhead from the Mad River Hatchery. The pilot study confirmed several important factors to consider while conducting the second phase of the fishery study:

- The vertical traveling screens capture fish, including juvenile salmonids.
- Capture rates were fairly similar between sampling periods.
- The March 22nd-25th storm sampling period between 7 AM and 12 noon had the highest "salmonid per sample" at 1.0 salmonids/sample.
- Capture rates of all fish species were greater during the March 22nd – 25th storm, especially during the rising limb of the storm hydrograph.
- The results of the pilot study established early morning, after 7 AM, as the most productive time to sample the screens. The results also indicated that some sampling should occur at night, as flow drops and turbidity decreases. Further, sampling should occur during any future storm events that cause an increase in stage height.

3.0 PHASE II FISH STUDY (March 28 to September 30,1998)

The second phase of the fish study ran from March 28th to September 30th, 1998. The objectives of the phase II study expanded on those of the pilot study, to include:

- Identify and enumerate the different species of fish captured by the revolving Rex traveling screens.
- Document the number of fish captured per sampling effort during the study period of March through September.
- Determine the extent of mortality of fish captured.

Monthly capture rates (number of fish/hour) for the various species of anadromous fish caught were calculated by dividing the number of fish caught by the amount of time the screens operated. These capture rates will facilitate quantifying the level of incidental take from the operation of the vertical traveling "Rex" screens at Station 6.

The two vertical traveling "Rex" screens were run daily, starting March 13, 1998 in Phase I, and ending with Phase II in September 30, 1998. Typically, each screen was operated for 20 minutes, for a total of 40 minutes of trapping effort per visit. From March through September, the total time that the screens were operated for the trapping project ranged from a high of 22 hours per month in the spring to 18 hours per month by fall. The normal run time duration is 5 hours per month.

Out-migrating juvenile anadromous salmonids comprised a minority of the total fish captured during the study: 74 of 1,176 fish, or 6.3%. Most of the salmonids were captured in March and April: 56 out of 74, or 76% (Table 2). Twenty-two of the 42 chinook salmon handled (52.4%) were captured during the moderate storm event between March 22nd to 25th. The juvenile chinook captured ranged from 29 to 61 mm in fork length (with a mean of 41.6 mm), suggesting that they were smaller, early out-migrants (and weaker swimmers). The literature reports mean fork lengths of out-migrant fall chinook juveniles averaging 52 to 72 mm (Healey 1991).

Fifty percent of the 28 steelhead trapped were marked fish released from CDFG's Mad River Hatchery. Of these 14 clipped fish, 11 were captured in April. During spring 1998, the hatchery released a total of 247,000 marked steelhead, including the initially released 77,000 marked fish, three days after the pilot study began (March 15, 1998). The remaining marked steelhead were released on March 24th (74,000 fish) and April 2nd (96,000 fish). The capture rate of marked steelhead in the vertical traveling "Rex" screens at Station 6 was minimal ($14 \div 247{,}000 = 0.000057$ or less than 0.006%), which assumes all marked fish passed the Station 6 facilities. Because of the high number of avian predators observed along the lower Mad River after the steelhead releases, fewer than 247,000 marked steelhead are likely to have passed the forebay. However, even assuming an unlikely mortality of 50% of the hatchery steelhead prior to reaching the forebay, the vertical traveling "Rex" screens capture rate would still be minor ($14 \div 123{,}500 = 0.00011$ or less than 1/100%).

No coho salmon smolts or coastal cutthroat trout (any age class) were captured during the trapping project, even though the forebay at Station 6 is located directly downstream from Lindsay Creek, a major producer of coho salmon and coastal cutthroat trout in the Mad River basin. The eight coho salmon captured were young-of-the-year, ranging from 49 to 74 mm in fork length.

Table 2. Monthly capture (numbers of fish), by species of anadromous salmonids at the vertical traveling "Rex" screens at Station 6, March 13 – September 30, 1998.

Month	Screen Time (hours)	Chinook Salmon	Coho Salmon	Steelhead Trout	Cutthroat Trout
March	22.00	27	0	4	0
April	20.00	13	1	17	0
May	20.66	2	3	1	0
June	19.66	1	2	0	0
July	18.33	1	2	2	0
August	19.33	0	0	3	0
September	17.65	0	0	1	0
Total	**137.63**	**44**	**8**	**28**	**0**

Capture rates were calculated by dividing the measured capture (numbers of fish captured in bypass troughs) by the measured effort (time that screens were run). Thus, the units to describe the capture rate were "number of fish per hour" (Table 3). Because juvenile salmonids migrate seasonally, capture rates were calculated for each month. March and April were the peak months of capture chinook salmon (90.9%) and steelhead (75.0%). The peak months of capture for coho salmon was May, June and July (87.5%).

Chinook salmon had the highest monthly capture rate of 1.23 fish/hour in March, steelhead's highest monthly capture rate was 0.85 fish/hour in April however the majority of these fish were hatchery releases, and coho's highest capture rate was 0.15 fish/hour in May (Table 3).

Table 3. Capture Rate (# of fish per hour of screen run time), by anadromous salmonid species and month, in the vertical traveling "Rex" screens at Station 6, March 13 – September 30, 1998)

Month	Chinook Salmon	Coho Salmon	Steelhead Trout	Cutthroat Trout
March	1.23	0	0.18	0
April	0.65	0.05	0.85	0
May	0.10	0.15	0.05	0
June	0.05	0.10	0	0
July	0.05	0.11	0.11	0
August	0	0	0.16	0
September	0	0	0.06	0
Total Catch	**44**	**8**	**28**	**0**
Average Capture Rate	**0.32**	**0.06**	**0.20**	**0**

One major change in stage height occurred, between March 22nd and 25th when 3.5 inches of rain fell in Eureka, during the trapping project. Higher elevation areas experienced more rain, in addition to snowmelt (4. 5 inches of rain was recorded at Ruth Reservoir). Stage height increased from 21.9 feet at 10:00 PM on March 21st to 28.7 feet at 11:30 PM on March 22nd. By April 2nd , the stage height decreased to 23.1 feet, dropping at a slow, steady rate.

During the entire fish study, 44 juvenile chinook salmon were captured. The mortality rate for juvenile chinook salmon during the fish study was 35.7%. The mortality rate for young-of-the-year coho salmon was similar to chinook salmon (three mortalities out of eight fish, or 37.5%). The mortality rate for steelhead trout was 7 out of 28 fish (25%).

Despite running the screens 3.5 to 4.5 times longer than is normal, only 80 fish were captured during the total duration of the seven-month study. At Station 6 the location and backwater configuration of the forebay probably reduces the number of juvenile salmonids entering the forebay. In larger rivers, juvenile chinook salmon tend to migrate along the rivers' slower, shallower edges (Healey and Jordan 1982). Station 6's forebay is located on the outside of a river bend; the shallower, low velocity margin is located on the inside of the river bend (opposite the forebay location).

The configuration of the forebay creates a backwater area, which is most likely not utilized heavily by out-migrating salmonids. The low velocities through the screens created by the pumps, and the slow movement of the vertical traveling Rex screens, allow juvenile salmonids ample opportunity to avoid the troughs at the base of each screen section.

The extremely low numbers of salmonids trapped are apparent when one considers that only 14 marked hatchery steelhead out of 247,000 were collected in the bypass troughs. Also, one can assume that many chinook migrated past Station 6's forebay between March and June of 1998, yet only 44 were caught in the bypass system. The lack of trapped coho salmon smolts is another indication that out-migrating salmonids either avoid the screens, or fail to enter the forebay.

4.0 PHASE III FISH STUDY (September 2, 1998)

The purpose of this study was to observe the passage of "young of the year" steelhead through the fish bypass system at Station 6. In order to return to the Mad River, all fish captured in the vertical traveling "Rex" screens must travel through the fish bypass system. Hatchery reared "young of the year" steelhead are assumed to behave the same as wild fish entering the system from the lower Mad River. On September 2, 1998, Station 6 fish bypass system was tested. Dennis Halligan, fish biologist, and Andrew Jensen of NRM Corporation conducted the test, with assistance from Aldaron Laird, from Trinity Associates.

To test the ability of the fish bypass system to transport fish safely to the Mad River, a three-stage study was conducted. In each stage, a fish net was put in place at the outlet of whatever reach was to be tested. The screens at Station 6 would then be turned on, thus releasing the normal volume of water through the fish bypass system. Ten fish were then placed into each of the three stages of the fish bypass system. After approximately 5 minutes, the screens were turned off, reducing the volume of water by roughly half. All fish were inspected for scale and fin damage, and then released into the Station 6 forebay.

Sixty healthy "young of the year" steelhead were obtained from the Mad River Hatchery. The healthy fish were transported to Station 6 and exhibited vigorous swimming behavior before the tests. The fish used in the study ranged in length from 65 to 100 mm. Of the thirty fish released, sixteen were recaptured in the three stages; and fourteen were not (Table 4).

Table 4 Fish bypass system, fish transport mortality study

STAGE NUMBER	SEGMENT NUMBER	FISH RELEASED	FISH RECOVERED	FISH NOT-RECOVERED
STAGE 1	1 TO 8	10	7	30%
STAGE 1	10	10	4	60%
STAGE 3	1 TO 10	10	5	50%
SUBTOTAL		30	16	47%
FLUSHING	1 TO 10	0	2	N/A
TOTAL		30	18	40%

The fish bypass system was separated into 10 segments. At stage 1, a net was placed after segment 8; at stage 2, a net was placed after segment 10; and, at stage 3, a net was placed after segment 10. After checking all nets, fourteen fish were missing. By increasing flow, attempts were made to recover the fourteen fish. Two more fish were recaptured in nets. Six more fish were netted in the open-air clean-out basin. Six fish were unaccounted for and may have escaped in Segment 10, a 220-foot culvert, which was observed to leak.

"Young of the year" steelhead entering the fish bypass system appear to move in greater numbers after the fish screens stop, during the declining limb of a water release. "Young of the year" steelhead became stranded in Segment 3, the concrete basin. At the base of the hydraulic trash grate lift a depression in the Concrete Basin, creates an area of lower velocities during normal water release. The basin's depression holds sufficient water so that a few fish can remain, once the basin becomes dry.

A significant leak was observed in Segment 10 a 220 foot x 30-inch culvert. When the screens are turned off, water volume is reduced by approximately half. When the shut-off valve stops all water from entering the fish bypass system, water ceases to flow in Segment 10, the 220 foot x 30 inch Culvert; however, water continues to exit from the rip rap below the Segment 10, 220 foot x 30 inch Culvert outlet, for a few more minutes.

Six fish recaptured had suffered scale damage during passage through the Fish Bypass System covering approximately 20% of their body. The remaining eighteen fish recaptured were observed to not exhibit any scale or fin damage.

"Young of the year" Steelhead Trout moving through the Fish Bypass system were detained in two locations Segment 3, Concrete Basin, and Segment 9, Open Air Clean-out Basin. Mortality of "young of the year" Steelhead Trout could occur at these two locations.

The District in response to the findings of this study, has modified the fish bypass system to eliminate impacts to fish at; the concrete basin that had a depression which could trap fish, the open-air clean-out basin which also could trap fish has been removed from the bypass system, and the openings in the bottom of the 220 foot culvert have been sealed.

5.0 CALCULATION OF ANTICIPATED TAKE LEVELS

Vertical Traveling Rex Screens

The 1998 fish study at Hilfiker Pump Station 6 documented monthly capture rates for chinook salmon, coho salmon and steelhead, by dividing the number of fish caught by the amount of time the screens operated (number of fish/hour). During the fish study, from March through September, the screens were run more frequently, every 24 hours instead of every 96 hours. Most (76%) of the salmonids were captured in March and April, during a moderate storm event. Because juvenile salmonids out-migrate seasonally, capture rates were calculated for each month. March and April were the peak months of capture for chinook salmon (90.9%) and steelhead (75%); and coho salmon capture peaked in May, June and July (87.5%). The highest capture rate for chinook salmon was 1.23 fish/hour in March, for coho salmon, it was 0.15 fish/hour in May, and for steelhead the highest capture rate was 0.85 fish/hour in April. No coastal cutthroat trout were captured during the fish study.

The 1998 fish study found that 50% of the 28 trapped steelhead were marked fish released from CDFG's Mad River Hatchery. The capture rate of marked yearling steelhead in the Station 6 screens was low (14 ÷ 247,000 = 0.000057 or less than 0.006%), assuming all marked fish passed the Station 6 facilities. Because a high number of avian predators were observed along the lower Mad River after the steelhead releases fewer than 247,000 marked steelhead passed the forebay. However, even assuming an unlikely mortality of 50% of the hatchery steelhead prior to reaching the forebay, the screens capture rate would still be low (14 ÷ 123,500 = 0.011 or less than 1/100%).

The District normally runs its screens every 96 hours, 20 minutes for each screen, for a total run time of just 5 hours/month. During the 1998 study the normal run time for the screens was increased (Table 2) from 5 hours to 17-22 hours per month. At the highest monthly capture rate measured for each species, the District's normal operation of its screens (approximately 5 hours run time per month) would amount to a yearly incidental take of just 134 individual animals (9 coho salmon, 74 chinook salmon, and 51 steelhead) (Table 5).

Table 5. Comparison of actual monthly capture rates versus maximum monthly capture rates. The maximum was calculated by taking the maximum monthly capture which actually occurred and assuming that maximum rate occurred each month between October and February (based on normal screen run time of 5 hours per month).

Capture Rate	Coho Salmon	Chinook Salmon	Steelhead Trout	Cutthroat Trout
Maximum Capture Rate	9	74	51	0
Monthly Capture Rate	4	18	15	0

Calculating incidental take under normal screen run time of 5 hours, and using actual monthly capture rates scientist measured (extrapolating for the months of October through February) the yearly take is reduced from 134 to just 37 individuals (4 Coho salmon, 18 Chinook salmon, and 15 Steelhead).

Table 6. Capture Rate Measured (# of Fish Per Hour of Screen Run Time), Times Normal Monthly Screen Run Time of Five Hours, Based on 1998 Hilfiker Pump Station Fish Study

Month	**Coho Salmon**	**Chinook Salmon**	**Steelhead Trout**
January	0	0	*0.06 yields 0.3 fish*
February	0	*0.65 yields 3.25 fish*	*0.06 yields 0.3 fish*
March	0	1.23 yields 6.15 fish	0.18 yields 0.9 fish
April	*0.05 yields* 0.25 fish	0.65 yields 3.25 fish	0.85 yields 4.25 fish
May	*0.15 yields* 0.75 fish	0.10 yields 0.5 fish	0.05 yields 0.25 fish
June	*0.10 yields* 0.5 fish	0.05 yields 0.25 fish	0
July	*0.11 yields* 0.55 fish	0.05 yields 0.25 fish	0.11 yields 0.55 fish
August	0	0	0.16 yields 0.8 fish
September	0	0	0.06 yields 0.8 fish
October	0	0	*0.06 yields 0.3 fish*
November	0	0	*0.06 yields 0.3 fish*
December	0	0	*0.06 yields 0.3 fish*
Total	**4 fish**	**18 fish**	**15 fish**

The levels of incidental take per year, calculated for the District's Hilfiker Pump Station 6 screens, ranges from; 4 to maximum of 9 coho salmon, 18 to maximum of 74 chinook salmon, and 15 to maximum of 51 steelhead. In the case of steelhead based on the 1998 study, 7 to 25 taken would be of hatchery origin.

Humboldt Bay Municipal Water District

Habitat Conservation Plan

Appendix E-2

1977 Fishery Study at Station 6

**(synopsis of R. Barnhart's 1977 study
prepared by Trinity Associates, 2002)**

The United States Fish & Wildlife California Cooperative Fishery Research Unit, at Humboldt State University, conducted a fish behavior study on June 1, 1977, to evaluate HBMWD's two new fish return systems. The two fish return systems were: 1) a screen bypass, and 2) a pump bypass. The pump bypass system is no longer used or operable at this time, and will not be discussed further. The fish study used 6,000 Mad River hatchery reared chinook salmon smolts, 3-5 inches in length. In 1977, the District was diverting 43.7% (89 cfs) of the flow in the lower Mad River; water stage in the forebay was 21.4', and the flow at the USGS Arcata stream gauge was 98.8 cfs.

The first test run consisted of introducing 2,000 fish into the forebay and running the screens for 30 minutes. "At the end of the 30 minute test no fish had gone through the screen By-Pass system. We then observed most of the fish swimming in a school in the forebay area apparently without regard for the small attraction current towards the diversion pumps" (Barnhart, 1977).

Because fish were not attracted to the screens or pumps in the first test run a decision was made to run a second test run and introduce another 2,000 fish 15' in front of the pumps (approximately 2 feet in front of the running screens), by dropping them 40' down the "well" (the intake Structure chamber behind rear gated wall of the forebay). The screens were run for 30 minutes. Fish entering the bypass system were netted at the outlet. One hundred and eighty eight live and 30 dead fish were recovered.

The 1977 study concluded that most of the mortality measured resulted from handling during transit from the hatchery to Pump Station 6. "Many moralities were observed in the water-filled holding channels on the vertical traveling screens shortly after the screens had emerged from the water. These fish began appearing in the screen channels about 10 minutes after they had been dropped down the well. Dead fish exhibited no evidence of body damage due to impingement on the screens"(USFWS, 1977). Of 2,000 fish introduced in the second test run when the bypass screens were running, 218 fish (5.5%) went through the screen bypass system, 30 were dead (13.8%).

In the 1977 study, fish in the "fish baskets/troughs" did not always get washed into the fish trough but ended up in the "refuse" trough. The author concluded..."it is also apparent that the pulling or attracting power of the current from the forebay to the diversion pump area is negligible. Healthy fish should be able to maintain their position in the forebay area without difficulty. At low flow conditions (less than 100 cfs) when most of the river flow would be diverted through the pumps the situation would be changed and most fish might be forced to travel through the fish by-pass systems. During average run-off years, however, low flow conditions occur after the peak of downstream fish migration"(USFWS, 1977).

Reference

California Cooperative Fishery Research Unit "Test Of Fish By-Pass Facilities, Essex Pump Station, Mad River, Ca., Research Report 77-1, USFWS, R. Barnhart, 1977

Appendix E – 3

A Fishery Study of the Lower Mad River: Fish Habitat Mapping, Direct Observation, and Migration Barrier Evaluation

Prepared for
Humboldt Bay Municipal Water District
Prepared by
Trinity Associates

May 1995

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1.0 INTRODUCTION

The Mad River, Humboldt County, supports as many as four runs of steelhead (*Oncorhynchus mykiss*), several runs of chinook salmon (*O. tschawytsha*), coho salmon (*O. kisutch*), and coastal cutthroat (*Salmo clarkii*). All are anadromous, migrating between freshwater spawning areas and the Pacific Ocean during their life cycle. The lower portion of the Mad River functions thus mostly as a migration route for the adults on their upstream spawning runs and for smolting juveniles downstream on the way from their freshwater rearing areas to the ocean.

The Humboldt Bay Municipal Water District (HBMWD) operates and maintains five Ranney wells and a surface water collector on the Mad River between the Highway 299 Bridge and the Arcata and Mad River Railroad (A&MR) bridge. HBMWD and the US Geological Survey (USGS) have both installed grade control structures, which affect water surface elevation, velocity and depth, which in turn affect fish migration. In order to assess fish usage and habitat conditions of this reach, HBMWD secured the services of Trinity Associates (TA) to: 1) conduct an inventory of the physical fish habitat; 2) determine habitat use by salmonids during the fall, 1994 by direct observation with mask and snorkel, and; 3) analyze two boulder grade control weirs to determine whether they were migration barriers (see Habitat Map).

2.0 LIFE HISTORY

Habitat use by anadromous salmonids is characterized by constant change throughout their complex life cycles. As a result, population estimates for a particular section of stream offer only a temporary snapshot of a fishery during one stage of its life. For the Mad River, four salmonid species each have their own habitat requirements and survival rates for their different life stages. This complexity demands that fishery manager's focus on managing physical habitat rather than numbers of fish.

General descriptions of freshwater habitat use by anadromous salmonids must include: upstream spawning migration, adult holding and spawning, juvenile (summer and winter) rearing, and downstream migration to the ocean (smolting). All Mad River adult salmonids require adequate water flow to negotiate potential barriers during upstream migration from the ocean. Most adults move upstream during the fall, after the first rains, and through the winter. They look to hold in pools and runs with good cover or depth, which adjoin good spawning habitat. The latter is usually characterized by shallow, swift glide areas between a pool and a riffle, with a substrate of large gravel and small cobble in which eggs are buried, and preferably devoid of large amounts of sand, which can suffocate the incubating eggs. An exception, the native summer steelhead migrate in the spring to holding pools high in the system, taking advantage of areas which the fall/winter fish can't reach for lack of time. After spawning, chinook and coho adults die, but steelhead and cutthroat adults may head back to the ocean to return the following season to spawn again.

All salmonids hatch from eggs buried under gravel and emerge through the gravel to rear for a time in freshwater. During this early stage, salmonid fry use the slow velocity margins of pools where small food items drift slowly past and where the small fish aren't swept downstream. Overhanging vegetation or clean gravel substrate provides protection from bird predation. Chinook salmon juveniles spend only a few months in freshwater before moving downstream in the early summer of their first year to the lower sections of rivers and estuaries to rear before entering the ocean. On the other hand, coho salmon generally spend one year and steelhead and coastal cutthroat trout spend at least one or more years rearing in freshwater before they smolt. As such, quality freshwater rearing habitat takes on more importance for these species, both during the summer and winter seasons. Coho juveniles prefer deep pools with large woody debris while rearing steelhead tend towards pools and runs (even riffles) characterized by boulders and bedrock and use clean cobble substrate to dive into for protection from high winter flows.

Once the juveniles reach a particular size, different for each species, they go through gradual external and internal changes to a form better suited to life in a saltwater environment. During this smolting process, the fish migrate downstream usually during the spring and early summer before flows are too reduced. Habitat requirements during this migration are adequate flow and shelter from predation.

3.0 METHODS

3.1 Habitat Typing

The above discussion illustrates how a population estimate for a stream reach can reveal only a small and temporary picture of the salmonid use. Fisheries managers, recognizing the complex task to monitor salmonids, have opted to focus on physical fish habitat, which is not as temporal as fish populations. Fish habitat typing provides a cost-effective framework for fish management and as such has become an important fisheries tool.

The habitat survey method used here is consistent with the methods adopted by the California Department of Fish and Game (CDFG) (CDFG 1995) and the U.S. Forest Service for managing anadromous salmonids. The method produces a 100% description of a stream's physical fish habitat at one of three levels: micro, meso or macro-habitat. Micro-habitat typing usually targets a particular life stage (such as summer rearing) and flow (summer base flow) and separates the stream into small habitat units. Micro-habitat typing is useful for project level stream restoration design and monitoring. Macro-habitat typing, used in this project, takes a broader perspective separating the river into habitat types, which are maintained regardless of discharge, often lumping several small pools at low flow into one large pool as it would function at a higher winter flow.

On October 3, 1994, beginning at the downstream end of the study reach, the Highway 299 Bridge, Trinity Associates characterized each habitat unit within the flowing, wetted channel as one of five types: pool, riffle, run/glide, cascade or backwater. For each unit, we measured the length and width in feet with a 200' reel tape and the average and maximum depth in tenths of feet with a stadia rod. We also identified the amount and quality of fish shelter useful to adult and juvenile salmonids. For pools and runs, we also measured the maximum depth at the crest of the pool tail (downstream end). This is subtracted from the maximum or average pool depth to determine the residual pool depth, either of which are useful to monitor bed changes independent of discharge (Lisle 1987).

3.2 Direct Observation

During the habitat inventory on October 3 and 4, direct observations for the presence or absence of salmonids were made with mask and snorkel in each of the pools and runs. The species and the approximate size and number of the observed fish were recorded. Trinity Associates planned to continue direct observation throughout the fall to determine usage of the reach as a migration route. Instead, we found that a fish ecology class at Humboldt State University under the direction of Dr. William Trush was diving several reaches of the lower Mad River each week. Rather than duplicating their effort, we met and worked with the students covering the HBMWD reach to verify their fish identification and diving skills. We present their preliminary results here, recognizing that the students for a future report are synthesizing the overall class results.

3.3 Migration Barrier Analysis

Two grade control structures (boulder weirs) within the reach were analyzed to determine whether they were fish migration barriers at low summer flows. One is a high gradient boulder riffle just upstream of the Highway 299 bridge apparently placed by the US Geological Survey (USGS) as a datum control for their gauging station (Trinity Associates 1994). The second is a boulder weir further upstream and constructed by HBMWD to back-flood the forebay on Pump Station 6. For each grade control structure, the main thread of attractant flow was first identified and then measured for water depths and velocities. Where a jump appeared necessary for upstream fish migration, vertical distance and maximum depths of the starting and ending pools were measured. Measurements were then compared to velocity criteria reported by Orsborne (1985) for sustained swimming, prolonged, and burst speeds of the different fish species to determine whether or not they were barriers.

4.0 RESULTS

4.1 Habitat Typing

The results of the habitat inventory are presented in Table 1 and on Figure 1 habitat map. This reach of the Mad River was typical of the lower reach of rivers with a low gradient, dominated by pools with an abundance of fine sediment and few riffles. The area of each habitat unit was calculated by multiplying the average width by the average length and for the area surveyed, 64% were pools, 11% riffles, and 22% runs or glides and 3% backwater pools (Figure 1). Most of the pools were lateral scour pools along bedrock or boulders with very little shelter for adults or juveniles. The exceptions to this were the two pools under the bridges (units # 1 and 34), where small boulders and the bridge footings themselves provided some shelter. Residual pool depths are reported on the habitat map (Residual Average Depth) and on Table 1 (Residual Average and Residual Maximum Depths) for future monitoring purposes.

The substrate throughout the reach was characterized by sand and small gravel. This dominance of fine sediment is consistent with: poor production of food organisms for juvenile salmonids; poor spawning due to low egg survival rates; and poor over wintering cobble habitat for juveniles.

There was a notable lack of large woody debris (LWD) in this section of the Mad River. Downriver of Highway 299, LWD is fairly common as shelter and as a structural element for pools, and in upriver areas there is frequently after large storms a great deal of LWD left on the river bars. Large wood is an important shelter element for coho salmon juveniles and the lack of it reduces the quality of available habitat.

4.2 Direct Observation

On October 3 and 4, 1994, we observed very few salmonids in the study reach. The only adults we observed were in the two bridge pools (units #1 and #34). No attempt to count the fish was made but each contained more than 10 steelhead half-pounders. These fish have spent less than one year in the ocean when they enter the river as immature adults. They do not spawn but remain in the lower part of the river a few months before they return downstream to the ocean to spend another year before their actual spawning run. The scarcity of shelter resulted in very few juveniles found- a few young-of-the-year (0+) and one year old (1+) steelhead in the pool below the weir and in some backwater areas.

Table 1. Habitat inventory for the Mad River between Highway 299 and the A&MR Railroad trestle on October 3, 1994

		AVERAGE			MAX	RES.AVG.	RES.MAX		
UNIT #	HABITAT TYPE	LENGTH	WIDTH	DEPTH	DEPTH	DEPTH	DEPTH	SHELTER	NOTES
1	POOL	275	75	2	3.3	1.3	2.6	Boulders	Hwy.299 pool. Observed ~20 SH half-pounders, otter on right bank (RB)
2	HI GRADE RIFFLE	50	44	1.3	2.3			Boulders	Good, deep channel for upstream passsage. Max. velocities 2.0, 2.7 fps
3	RIFFLE	167	40	0.8				Gravel	Staff gage @ 2.98'. Top of riffle very shallow, .5' with velocity 1.8 fps
4	BACKWATER	200	50	2.4	3.5			Boulders	
5	POOL	575	72	1.4	1.8	0.4	0.8	None	
6	RIFFLE	52	60	0.7	0.7			None	
7	POOL	194	46	1.6	1.6	0.2	0.2	None	
8	RIFFLE	171	42	0.6	0.6			None	Top of riffle shallow, .45'
9	POOL	250	60	4.5	13	3.6	12.1	Depth	Deep but not very good cover,
10	POOL	490	70	2.2	3.5	1.3	2.6	Bdrk, bldrs	Some 0+, 1+ SH near weir
11	WEIR	20	43	0.5				Boulders	2.5-3' drop, Velocities in chute: 1.6, 2.9, 1.5, 2.9, 5.3, 5.6 fps. Passable
12	BACKWATER	161	49	2.5	5.8			Boulders	
13	POOL	220	190	2.3	4.5	1.3	3.5	Forebay	Dam pool behind weir
14	GLIDE	253	100	0.6				None	
15	POOL	775	76	3	10	1.8	8.8	Bdrk, depth	
16	GLIDE	315	151	0.5				None	
17	POOL	870	105	2.4	4.7	1.4	3.7	Boulders	No fish or cover
18	RUN	640	35	1.5				Bdrk, bldrs	#15-18 one corner pool at high flows with very little shelter
19	RIFFLE	110	60	0.4				Boulders	
20	POOL	324	58	2.3	3.7	1.5	2.9	Boulders	
21	RIFFLE	70	50	0.7				None	
22	POOL	570	60	2.9	4.8	1.9	3.8	Bedrock	Big bedrock pool with some shelter near LB but no fish
23	RIFFLE	135	70	0.7				None	
24	POOL	200	56	1.6	3.5	0.6	2.5	Boulder weir	
25	RIFFLE	268	40	0.7				Boulders	Secondary backwater channel adjacent but barely flowing
26	BACKWATER	122	42	2.7	4.7	1.7	3.7	Boulders	
27	BACKWATER	79	93	4.9	6.8	3.9	5.8	Depth	Mouth of Warren Creek, some 0+ salmonids
28	GLIDE	662	150	1.3				None	
29	POOL	862	90	3	6	1.6	4.6	Bedrock	
30	RIFFLE	170	100	0.6				None	
31	POOL	940	100	2.1	3.5	1.1	2.5	Bedrock	
32	RIFFLE	357	48	0.7				None	
33	POOL	360	70	2.6	6	1.6	5	Footing	Foot of RR trestle good shelter under footing, ~20 half-pounder SH
34	RIFFLE	185	65	0.7				None	

We compiled the diving results from the HSU student project to show changes in the usage of habitat between September 23 and November 3, 1994 (Table 2). Water temperatures ranged from 60-67 degrees Fahrenheit, suitable for salmonid rearing. Four age classes were distinguished for steelhead in the student counts: 0+ and 1+ juveniles, half-pounders (HP) and adults (AD) and for chinook salmon (KS) just adults (AD) were observed. The students typed and numbered habitat units differently than we, but since Trinity Associates supplied them with the aerial photos they used, we were able to correspond their field observations to our habitat units. One student group reported the steelhead juveniles as 0+/1+ for the youngest and 2+ for the next size class. We took the liberty of reporting them as 0+ and 1+ respectively in Table 2. Numbers in Table 2 are not population estimates but are indicators of presence and general abundance.

Table 2. Direct observation of salmonids on the Mad River between Highway 299 and the A&MR Railroad trestle.

		9/23/94 (HSU)					9/30/94 (HSU)					10/3/94 (TA)					10/7/94 (HSU)					10/15/94 (HSU)					10/22/94 (HSU)					10/31/94 (HSU)					11/3/94 (HSU)				
		STEELHEAD				KS	STEELHEAD				KS	STEELHEAD				KS	STEELHEAD				KS	STEELHEAD				KS	STEELHEAD				KS	STEELHEAD				KS	STEELHEAD				KS
		0+	1+	HP	AD	AD	0+	1+	HP	AD	AD	0+	1+	HP	AD	AD	0+	1+	HP	AD	AD	0+	1+	HP	AD	AD	0+	1+	HP	AD	AD	0+	1+	HP	AD	AD	0+	1+	HP	AD	AD
1	POOL													~20			58	7	34			42		12	1	1	38	14	25			52	13	15		1	(1 Chum salmon)				
2	HG RIFFLE																																								
3	RIFFLE																23																								
4	BACKWATER																																								
5	POOL																4					6				1															
6	RIFFLE																3							1																	
7	POOL																																								
8	RIFFLE																																								
9	POOL																									1										1					
10	POOL						13					>10	>3				36	4				28	2				15					18	1								
11	WEIR																																								
12	BACKWATER																																								
13	POOL																3					2																			
14	GLIDE																1																								
15	POOL						30										37	1				33	3				35	2				28									
16	GLIDE																																								
17	POOL																																								
18	RUN						35	1									78	2									36	1													
19	RIFFLE																																								
20	POOL						2										15	2									3														
21	RIFFLE																																								
22	POOL																2																								
23	RIFFLE				2												4																								
24	POOL																																								
25	RIFFLE																																								
26	BACKWATER																																								
27	BACKWATER																																								
28	GLIDE																																								
29	POOL																																								
30	RIFFLE																																								
31	POOL																																								
32	RIFFLE																																								
33	POOL								24					~20				10	32		2			20		1												1	2	4	17
34	RIFFLE																																								

The habitat throughout this reach appears to get little summer use by rearing salmonid juveniles. According to these data, steelhead juveniles predominantly used Units # 1,10, 15, 18, and 34, most of which are pools with medium to good shelter. Steelhead half-pounders were holding in the two bridge pools (# 1 and 34) through most of October. Besides occasional sightings, adult steelhead and chinook salmon were not using the reach until early November, after the first of the fall rains. Once the rains started, the river became turbid making further direct observation impractical.

In the reach downstream of the Highway 299 bridge, another of the HSU student groups observed many more steelhead half-pounders and adults and chinook adults than those observed in the HBMWD reach. The lower reach is more confined and the pools are deeper and contain much more shelter than the HBMWD's middle reach.

4.3 Migration Barrier Analysis

Physical barriers to upstream fish migration can consist of either velocity chutes, differential elevations, shallow water depths or combinations of these. If an adult salmonid is forced to jump an obstacle, they generally need to jump from a pool at least 1.25 times deeper than the height of the obstacle.

A high grade boulder riffle formed by the USGS gauging station grade control weir just upstream of the Highway 299 bridge (unit #2) was assessed to determine if it posed a migration barrier to adult or juvenile fish at minimum summer discharge. The riffle drops 3-4 feet over it's 50' length at a slope >4% and has several main flow channels. We measured depths and velocities through the main channels to determine whether adult salmonids could successfully negotiate their way upstream at this discharge. Average depths were 1.5'-2' and velocities were all less than 3 feet per second (fps), both parameters well within the capabilities of migrating adults (Figure 2 and Orsborn 1985).

The boulder weir built by HBMWD to back-flood the forebay was also analyzed for fish passage at this discharge. The weir was built of small to medium boulders and at low flow, water dropped 2.5'-3' over the weir's 20' length. The pool below averaged <2' deep with no deep spots near the weir from which to jump. The depth over the weir averaged <1' deep through the boulders except in a few deeper channels. Velocity measurements in the most likely access channel ranged from a low of 1.5 fps to a maximum of 5.6 fps with average depths >1'. Although fast, these upper velocities are below the "burst" speed and the "prolonged" speed of anadromous salmonids (Figure 2 and Orsborn 1985).

5.0 CONCLUSIONS

The middle section of the lower Mad River between the two bridges provides little summer rearing habitat for juvenile salmonids. Shelter is limited to boulders and bedrock in a few areas with much of the substrate embedded with fine gravel and sand. The lack of large woody debris or clean cobble in the reach limits rearing by coho salmon or steelhead juveniles during the summer and probably the winter.

Adult salmonids find little holding or spawning habitat within the reach because of the lack of shelter and clean gravels. Holding habitat for adult salmonids is limited to the pools under the two bridges. Observation of the pools downstream of Highway 299 indicate that by early October, salmonid adults are in the lower river awaiting higher discharges associated with the fall rains for their spawning migrations. By contrast, the HBMWD reach held only steelhead half-pounders during the same period.

The habitat value for the middle reach for juveniles and adults could be increased with addition of large woody debris, particularly for coho salmon. We suspect that one reason for the lack of wood is that after high flows leave material perched on upstream river bars out of the low flow channel, local citizens salvage this material for firewood, etc. without realizing the value it might have as future downstream fish shelter and structure for pools. We would recommend that efforts be made to prevent salvage of this LWD material.

Neither the USGS boulder area near Highway 299 or the HBMWD weir appear to function as upstream or downstream migration barriers at low flows. Riffles between the two boulder areas may be more limiting to migration due to their shallow depth. But once the first fall rains occur, the discharge increases which triggers the spawning migration instincts in the salmonids at the same time it increases the water depth.

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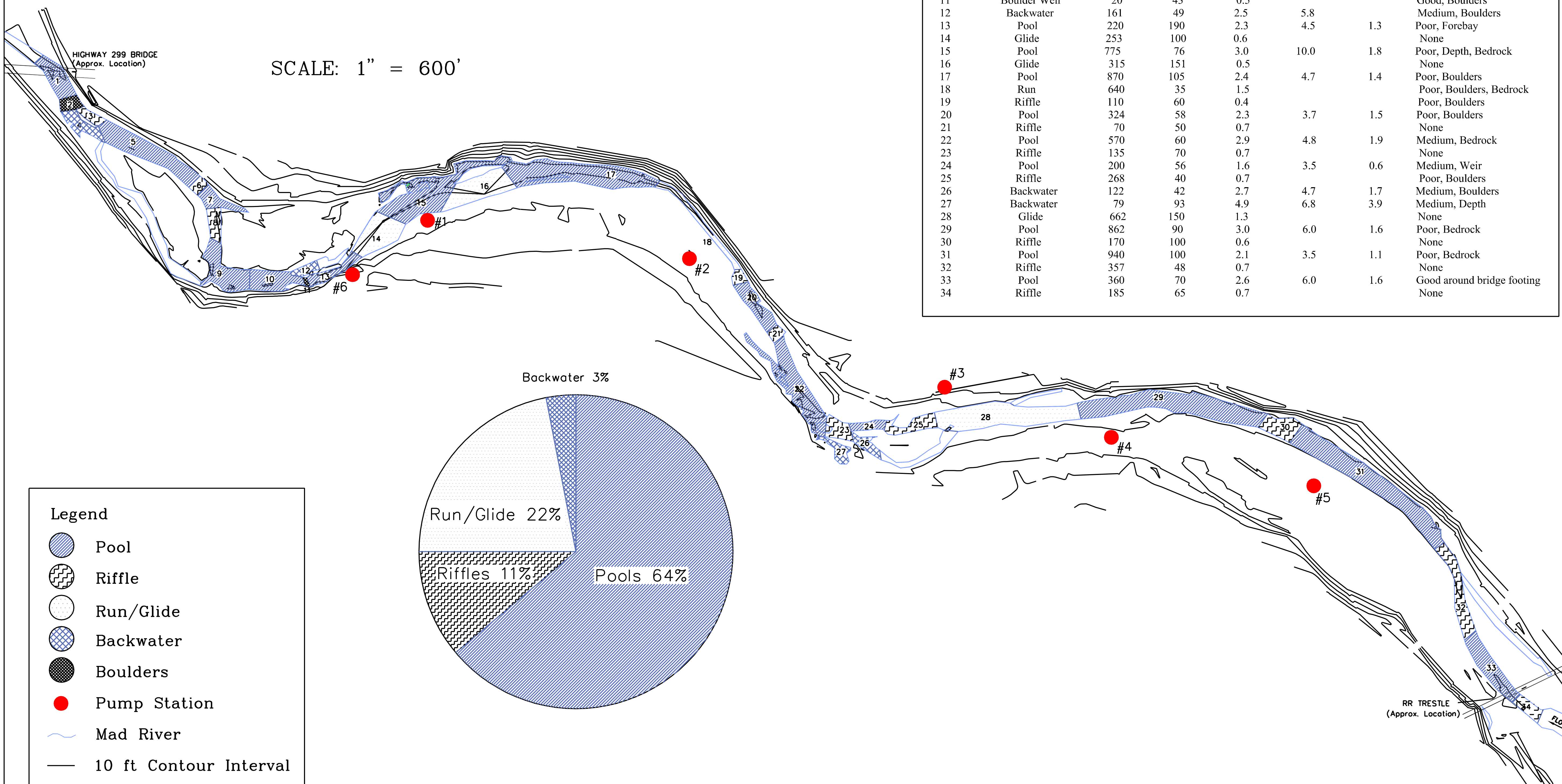
LOWER MAD RIVER

From Highway 299 Bridge to Railroad Trestle

Fish Habitat Types

SCALE: 1" = 600'



Legend

- Pool
- Riffle
- Run/Glide
- Backwater
- Boulders
- Pump Station
- Mad River
- 10 ft Contour Interval

Mad River Salmonid Habitat Types, October 4, 1994

UNIT#	HABITAT TYPE	AVERAGE LENGTH	AVERAGE WIDTH	AVERAGE DEPTH	MAXIMUM DEPTH	RESIDUAL DEPTH	COVER QUALITY AND TYPE
1	Pool	275	75	2.0	3.3	1.3	Good, Boulders
2	High Gradient Riffle	50	44	1.3	2.3		Good, Boulders
3	Riffle	167	40	0.8			Medium, Gravel
4	Backwater	200	50	2.4	3.5		Medium, Boulders
5	Pool	575	72	1.4	1.8	0.4	None
6	Riffle	52	60	0.7	0.7		None
7	Pool	194	46	1.6	1.6	0.2	None
8	Riffle	171	42	0.6	0.6		None
9	Pool	250	60	4.5	13.0	3.6	Poor, Depth
10	Pool	490	70	2.2	3.5	1.3	Medium, Bedrock, Boulders
11	Boulder Weir	20	43	0.5			Good, Boulders
12	Backwater	161	49	2.5	5.8		Medium, Boulders
13	Pool	220	190	2.3	4.5	1.3	Poor, Forebay
14	Glide	253	100	0.6			None
15	Pool	775	76	3.0	10.0	1.8	Poor, Depth, Bedrock
16	Glide	315	151	0.5			None
17	Pool	870	105	2.4	4.7	1.4	Poor, Boulders
18	Run	640	35	1.5			Poor, Boulders, Bedrock
19	Riffle	110	60	0.4			Poor, Boulders
20	Pool	324	58	2.3	3.7	1.5	Poor, Boulders
21	Riffle	70	50	0.7			None
22	Pool	570	60	2.9	4.8	1.9	Medium, Bedrock
23	Riffle	135	70	0.7			None
24	Pool	200	56	1.6	3.5	0.6	Medium, Weir
25	Riffle	268	40	0.7			Poor, Boulders
26	Backwater	122	42	2.7	4.7	1.7	Medium, Boulders
27	Backwater	79	93	4.9	6.8	3.9	Medium, Depth
28	Glide	662	150	1.3			None
29	Pool	862	90	3.0	6.0	1.6	Poor, Bedrock
30	Riffle	170	100	0.6			None
31	Pool	940	100	2.1	3.5	1.1	Poor, Bedrock
32	Riffle	357	48	0.7			None
33	Pool	360	70	2.6	6.0	1.6	Good around bridge footing
34	Riffle	185	65	0.7			None

Humboldt Bay Municipal Water District

Habitat Conservation Plan

Appendix F

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