UPPER RUSSIAN RIVER
AGGREGATE RESOURCES MANAGEMENT PLAN
MENDOCINO COUNTY

Prepared for
Mendocino County Water Agency

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1. EXECUTIVE SUMMARY

This document, the Upper Russian River Aggregate Resources Management Plan (RR-ARMP), was prepared by a team of consultants in cooperation with the Mendocino County Water Agency, Mendocino County Planning and Building Services Department, and the RR-ARMP Technical Advisory Committee. Funding occurred through Federal EPA 205 (j) grant funds administered by the State Water Resources Control Board. This report will serve as a planning document to guide the County of Mendocino in future river management and land use decisions in the Russian River watershed and possibly in other watersheds. This document will be presented to the Mendocino County Planning Commission and the Mendocino County Board of Supervisors for appropriate action.

The Technical Advisory Committee was charged with monitoring the progress and technical aspects of the project, making recommendations to the consultants, and establishing a Data Evaluation Team. The Data Evaluation Team is charged with reviewing the operator supplied monitoring data, evaluating the volume of material potentially available for extraction and, if extraction occurs, to verify that the Team's recommendations were fulfilled. The Implementation Plan is a mechanism to fund these and other monitoring activities.

In the interest of efficiency and cost containment, this report relies upon existing data to the extent possible, augmented with interdisciplinary field reconnaissance. This report summarizes the historic and existing river status in terms of fluvial geomorphology, fisheries, and riparian habitat conditions. Impacts of in-stream gravel extraction on rivers are reviewed and alternative aggregate sources are discussed. The Russian River aggregate market area is defined and current sources of production are identified. Market demand is analyzed through a 50-year planning horizon and methods of aggregate resource conservation are discussed. The Management Plan provides long-term guidelines to protect riverine resources and presents a series of specific recommendations to accomplish this goal.

The report recommends that any in-stream gravel extraction allowed be based upon the annual replenishment determined from field monitoring with extraction less than 50% of the annual bedload transport (which was measured at the three USGS gaging stations in Mendocino County). For planning purposes—for use during the first year after implementation of the Plan until the field monitoring data is available—the annual bedload transport rate was estimated using data supplied under contract by the US Geologic Survey (USGS) from 1992 through 1996. Based on the USGS collected field data, the estimate of average annual bedload transport from the Ukiah gaging station is 1,890 yd^3/year, 22,490 yd^3/year at the Hopland station, and 57,355 yd^3/year at the Cloverdale station. The transport rate estimated from theoretical bedload transport equations as part of this study are within the same order of magnitude. The actual replenishment rate is estimated to be approximately 50% of the transport rate, however the actual volume that replenishes bars will be determined based on the field monitoring data. The Data Evaluation Team will determine the appropriate location for extraction.

The report presents a long-term plan for management of aggregate resources that includes in-stream and off-channel recommendations. Bar skimming is recommended as the primary method of in-stream gravel extraction, with allowance for other possible techniques as recommended by the Data Evaluation Team. However, the report also recommends the eventual phase-out of in-stream mining activities. To protect riverine resources, the report describes a series of protective measures that include: establishing a redline elevation below which no extraction should occur, protection of riparian vegetation, extracting gravel from the downstream portion of the bar, and grading the slope of the bar at 2% to prevent fish entrapment.

The document also strongly recommends carrying out a monitoring plan to evaluate local and County-wide changes in channel morphology, riparian and fisheries habitat over the long term. This monitoring plan includes the following components: field surveyed channel cross sections, a longitudinal profile through the extraction zone and extending up and downstream, aerial and ground photo documentation, continued measurements of hydrology and sediment transport, and continued evaluation of fishery and riparian habitats.

Finally, the report presents a Financial Plan that can be used to generate the funds necessary to conduct the Monitoring Plan. Other bonding recommendations to prevent public cost are also discussed.

This Executive Summary was contributed by the Mendocino County Water Agency.

2. INTRODUCTION

2.1 BACKGROUND

This Aggregate Resources Management Plan for the Upper Russian River and its major tributaries in Mendocino County was prepared in cooperation with the Mendocino County Water Agency (MCWA) and the Upper Russian River Aggregate Resources Management Plan Technical Advisory Committee (TAC). The interdisciplinary consultant team that prepared the plan includes: Philip Williams & Associates, Ltd. (PWA), the prime consultant with responsibility for hydrology, hydraulics, sediment transport, and geomorphology; A. A. Rich and Associates (AARA), with responsibility for fisheries biology; Circuit Rider Productions, Inc. (CRP), with responsibility for riparian biology; Leonard Charles & Associates (LCA), with responsibility for defining how aggregate is used, identifying non-stream sources of aggregate, market area, market demand, and resource conservation; and Teresa Hughes & Associates (THA), with responsibility for development of a financial plan for monitoring activities.

The Russian River drains 503 mi^2 of the north Coast Ranges in Mendocino County, California, upstream of the Mendocino—Sonoma County line (Figure 1, Sheets 1-6). The total length of the river from its source, about 16 miles north of Ukiah to the Sonoma County line near Cloverdale, is about 44 miles. The river flows through a series of northwest trending alluvial valleys separated by narrow bedrock canyons. In Mendocino County, the major alluvial reaches are in Redwood Valley, Ukiah Valley, and Hopland (Sanel) Valley. A bedrock constriction separates Redwood Valley and Ukiah Valley, and a small bedrock constriction, informally called the Hopland Gage Constriction, separates the Ukiah Valley from the Hopland valley. The Squaw Rock constriction separates the Hopland Valley from the downstream Alexander Valley in Sonoma County.

Aggregate gravel mining has occurred throughout a large portion of the Upper Russian River Watershed. This activity began decades ago, and continues today. The goal of the Aggregate Resources Management Plan is to minimize further damage to the watershed and its resources from gravel mining. The objectives of the plan are to characterize sediment transport processes and fishery and riparian resources in the Upper Russian River and tributaries, to identify extraction methods which would minimize impacts on fishery and riparian resources, to define the market area for Russian River aggregates, to discuss aggregate production and market demand, to explain aggregate uses and specifications, and to discuss resource conservation. Recommendations in this plan are intended to minimize channel incision which causes loss of habitat, loss of the groundwater resource, undermining of bridges and buried pipelines, and streambank erosion. This plan includes monitoring recommendations and a financial plan to fund the monitoring activities. The Aggregate Resources Management Plan was prepared using available data supplemented by field reconnaissance.

Hydrologic, geomorphic, and biologic technical studies characterize sediment transport processes in the Upper Russian River system and identify significant areas of riparian and fish habitat. The potential impacts of gravel mining on the Upper Russian River and its major tributaries raise several important management issues. These include:

- The volume of gravel that may be safely extracted without causing significant geomorphic or biologic changes;

- The optimum method and location of gravel extraction and the distribution of mining activities that minimize impacts on fish and riparian habitat in the Upper Russian River and its major tributaries;

- Identification on non-stream sources of aggregate, the potential market area and demand for this aggregate, and potential aggregate resource conservation;

- Identification of monitoring activities and a financial plan to fund the recommended monitoring program.

This Aggregate Resources Management Plan for the Upper Russian River in Mendocino County is based on an understanding of the interactions between the physical and biologic processes affecting the Russian River system. The Plan provides guidelines for gravel extraction that the County can use in the long-term management of the Upper Russian River.

3. HISTORIC RIVER TRENDS

3.1 HISTORIC TRENDS IN FLUVIAL GEOMORPHOLOGY

The Russian River drains an area of 1,485 mi^2 upstream of its mouth at Jenner, California, and flows through a series of broad northwest-trending alluvial valleys separated by narrow bedrock canyons. About 20,000 years ago, during the Wisconsin glaciation, sea level was about 300 feet lower than at present, and the Russian River flowed in a deeply incised valley. As sea level rose following the glacial period, the Russian River filled its valley with gravel, sand, silt, and clay (California Department of Water Resources, 1983). In Mendocino County, northwest trending alluvial valleys are related to extensional tectonics. The alluvial deposits in these valleys are an important groundwater source and have been recently mined for aggregate.

A century of land use activities in the Russian River watershed, including in-channel gravel extraction, agriculture, grazing, timber harvest, road construction, urbanization, and the construction of dams have resulted in geomorphic and hydrologic changes. Historically, the alluvial valley bottom of the Russian River contained numerous “side channels and sloughs,” and the main channel contained riffles and numerous deep pools (California Coastal Conservancy, 1992). Historical photographs show an active channel that was close in elevation to the floodplain and had relatively low banks. Riparian habitat once extended across the broad valley. Logging, which began before 1900, may have increased the supply of sediment to the channel from hillslopes. However, this effect has been greatly overshadowed by the recent reduction in sediment supply from gravel extraction, and dam and stock pond construction. Today, the Russian River flows in an incised channel and is relatively narrow and straight.

3.1.1 Photographs

Available aerial photographs of the Russian River in Mendocino County include a partial set of the Ukiah Valley from 1952 (1 inch = 880 feet), 1957 (1 inch = 400 feet), and 1991 (1 inch = 500), and the 1993 (1 inch = 500 feet) base photographs provided for this project. Comparison of channel width between the 1950's and the 1990's show a slight narrowing of the riparian corridor related to floodplain reclamation (Florsheim and Goodwin, 1995). The aerial photographs show that the river meanders with point bars in some reaches, while it is straight with alternate bars in other reaches. The river passes through narrow bedrock gorges between Redwood Valley and Ukiah Valley, between Ukiah Valley and Hopland Valley, and between Hopland Valley and Cloverdale.

3.1.2 Longitudinal Profiles

Figure 3.1 shows a comparison of a longitudinal profile of the Russian River in Mendocino County in 1940 (COE field survey data) to 1979 (FEMA aerially surveyed water surface elevation). The actual thalweg bed elevation in 1979 is likely to be several feet lower than the water surface elevation, indicating that the estimated incision from the longitudinal profiles are a minimum value. The longitudinal profiles are not detailed enough to illustrate changes in pool depth or the relative depth between riffles and pools. However, the profiles do show a general trend of incision in the river in Mendocino County. The profile shows incision of up to 10 feet at Lake Mendocino Drive, up to 18 feet of incision between Lake Mendocino Drive and Talmage Street, and up to 10 feet of incision downstream of the Willow Rubble Dam. Near Hopland, the water surface elevation in 1979 is a few feet higher than the thalweg in 1940, suggesting that there has not been significant change in this area.

In 1989, Mendocino County conducted field surveys for a FEMA revision near the mouth of Feliz Creek (PWA, 1989; unpublished data). The longitudinal profile surveyed in 1989 shows about 5 feet of incision between 1979 and 1989 between Feliz Creek and the Highway 101 Bridge.

3.1.3 Cross-Sections

DWR (1984) conducted a three-year study on the Russian River and some tributaries in Mendocino County between 1980 and 1982 at several cross-sections (location shown in Figure 3.2). Several of these cross sections were surveyed in the same locations as prior bridge surveys and the comparison was used to indicate long-term trends. Figures 3.3 and 3.4 illustrate incision on Forsythe Creek. Table 3.1 shows changes in bed elevation and in cross-section area between Fall 1980 and Fall 1982 in several tributaries and in the main channel of the Russian River. The data show local increases in cross-section area corresponding to channel incision and widening in Dooley Creek, lower Forsythe Creek, lower Robinson Creek, and the Russian River near Highway 175 (Russ-7). DWR (1984) illustrates changes in Forsythe Creek showing almost 10 feet of widening at FOR-1 between 1980 and 1982, eight feet of incision at the Uva Drive Bridge between 1932 and 1981 (the bridge was replaced in 1990 because of scour at the bridge pier), and up to 5 feet of incision at the Highway 101 Bridge (FOR-6) between 1949 and 1981.

The Mendocino County Water Agency surveyed cross-sections in the Upper Russian River and some tributaries from 1980 to 1982 and from 1989 to 1996 (appendix A). The twelve cross-sections measured from bridges and 5 cross-sections surveyed at the Jepson Bar in 1996 illustrate changes in channel morphology and in thalweg elevation. The cross-sections illustrated in Appendix A show the short-term variation common from year to year in alluvial rivers and must be combined with the long-term data to understand longer-term river trends. The cross sections in Appendix A show some general trends. In general, the cross sections show that scour and fill in the thalweg and on and bars during the short period since 1989 has been small—usually less than a few feet. Some cross-sections showing changes since 1980 show scour (for example: West Fork Russian River at School Way Road Bridge; and at Lake Mendocino Drive Bridge). Some cross sections also show a shifting of the thalweg (for example: Forsythe Creek at Reeves Canyon Road Bridge and at the Unnamed Bridge Below Reeves Canyon Road). Other cross sections exhibit both scour and fill in the short term (for example: West Fork Russian River Moore Street Bridge at Calpella - scour from 1989 to 1991 and fill from 1991 to 1995; and Dooley Creek at the Hwy. 175 bridge - fill from 1992 to 1995 and scour from 1995 to 1996).

The flood of March 1993 tended to scour the thalweg and aggraded bars in Forsythe Creek and Dooley Creek. The largest amount of scour of the thalweg (4 feet) and the bar (9 feet) occurred in Feliz Creek at Mountain House Road (between 1980 and 1996), while the largest amount of fill on a bar 5 feet) occurred in Forsythe Creek at the Unnamed Bridge Below Reeves Canyon Road (during the 1993 flood). Little change (less than about 2 feet) occurred in the Upper Russian River at Perkins Street and Talmage Street (between 1989 and 1996). Up to 3 feet of incision has occurred at the Hwy. 175 Bridge near Hopland since 1980. Channel changes on Morrison Creek at East Road Bridge are difficult to assess because of redistribution of bed material in the channel using heavy equipment. Changes at the Jepson Bar (surveyed in 1989, 1990, and 1996 by MCWA) show scour of the thalweg at cross-sections x-s 1, and x-s 3; and aggradation in the thalweg with scour on the bar at x-s 2, x-s 4, and x-s 5 in the past 7 years (Appendix A).

3.1.4 Other Geomorphic Data

Profiles surveyed at the Ranney collector and the Sewer Treatment Plant (Figure 3.5) indicate a trend of incision over the past two and a half decades. Thalweg elevation at the Ranney Collector and at the Sewer Treatment Plant between 1970 and 1990 show incision of about 5 feet. In addition, incision and bank erosion in the Upper Russian River and tributaries were documented by DWR (1984) and in a field reconnaissance as part of this study:

Incision exposed the State Street Bridge footing on Ackerman and Hensley Creeks where remedial action included constructing grade control structures. Fish ladders were built to allow fish migration to these tributaries.

The Morrison Creek Bridge at Eastside Road was replaced due to undermining of the pier—as was the East Road Bridge in Redwood Valley (Mendocino County Water Agency, pers. comm., 1996).

A pipeline once buried 3 to 5 feet in Feliz Creek upstream of the Highway 101 bridge crossing is now exposed. Up to eight feet of bank erosion occurred between Highway 101 and the railroad crossing. A pipeline is also exposed in Dooley Creek, about 15 feet downstream of Highway 175 (Mendocino County Water Agency, pers. comm., 1996).

Bank erosion and accelerated meandering has eroded adjacent property upstream of Highway 101 on Forsythe Creek. Sand and gravel deposits are depleted above an exposed clay layer. The footings of the Reeves Canyon and Highway 101 bridges are being exposed (letter from Lisle in Appendix F, DWR, 1984) observed erosion of the clay layer suggesting that incision is continuing fairly rapidly and that the knobs and gully-like channels in the clay is easily abraded by moving bed material.

The Willow Rubble Dam was constructed by the Willow County Water District to prevent a lowering of the groundwater table as the main channel incises. The channel incised downstream of this grade control structure and it now is a barrier to fish migration.

A Redwood Valley Water District water pipeline once buried about two feet was exposed near Held Road. Accelerated bank erosion is occurring downstream of the School Way Bridge in Redwood Valley.

Clay is exposed in the bed of the main channel in the downstream portion of Redwood Valley and between Forsythe Creek and the Moore Street Bridge in Calpella.

3.2 HISTORIC TRENDS IN FISHERY RESOURCES

Sensitive management species such as the steelhead and rainbow trout, coho salmon, and tule perch have declined in the Upper Russian River during this century. However, from a scientific perspective, the fishery resources of this area are poorly understood. Numerous factors (Figure 4.19) have caused the decline in these native fish populations. However, with the exception of a few studies, most data related to the fishes of the Upper Russian River were either incidental to CFG's program to eliminate non-salmonids (begun in the early 1950's) or, related to CFG's qualitative habitat surveys, conducted from the 1950's-1970's.

The Russian River ecosystem has been completed disrupted in attempts to eradicate non-salmonid species. In the planning and execution of the eradication program, no concerns were voiced for possible endangered aquatic resources; the program was to improve steelhead trout habitat. Ironically, the non-salmonid species appear to be thriving in the system. It is commonly believed that the following factors have contributed to the decline of the fishery resources:

Construction and operation of Coyote Dam/Lake Mendocino;

Aggregate gravel mining;

Water diversions;

Logging operations;

Grazing;

Attempting to eradicate non-salmonids by chemical treatment;

Planting non-native fishes (centrarchids which prey on salmonids and other native fishes);

Planting hatchery salmonids from other watersheds;

Pollution from a variety of sources; and

Fishing.

Each of these factors has affected the Upper Russian River Drainage at one time or another. As a result, fish habitat has changed. River flow variations, high summer water temperatures, and increased siltation and poor water quality reduced fish habitat availability. Non-native fishes were introduced and native salmonid populations were replaced with hatchery stocks, thereby reducing the genetic integrity of the stocks. As a result of these factors, salmonid and tule perch populations declined, species diversity declined and, the genetic integrity of the fishery resources of the Upper Russian River was lost.

No quantitative “cause-and-effect”-type studies have been undertaken to determine how, when, how much, and for how long, each of these many factors has affected native fish production. As a "first step" towards rehabilitating the Upper Russian River, the impacts that landuse activities such as gravel mining, logging, water diversions, and dams have on fishery resources must be quantified and preventive measures taken. With these ongoing problems, a watershed approach is needed to determine the respective impacts of the various man-made perturbations to this river system, including those of gravel mining.

3.3 HISTORIC CONDITIONS IN THE RUSSIAN RIVER RIPARIAN ZONE

There is a scarcity of good baseline information on pre-settlement and early post-settlement conditions in the Russian River basin. Neither the extent, successional status or composition of floodplain vegetation; the status of water quality and fish and wildlife populations; nor the impact of Native American land use practices are known with any certainty.

Native Americans altered the landscape in the Russian River basin long before European settlement, through the practice of burning grasses in the understory of oak woodland areas to keep them relatively open and park-like. It is not known what effect, if any, this may have had on the riparian zone vegetation.

The first Europeans arrived in Sonoma and Mendocino Counties in the early 1800's. Little quantitative data exist, but travelers' diaries of the early post-settlement period describe heavily wooded floodplains, extensive freshwater marshes in some locations, an abundance of fish and shorebirds, "incredible numbers" of waterfowl, and large wildlife species—including deer, elk, pronghorn antelope, cougar, bobcat, coyote, wolf, fox, otter, black bear, and grizzly bear (Smith Consulting, 1990).

Interviews with long term residents, as well as tactical surveys conducted by the US Army Corps of Engineers in 1913, indicate that the Russian River floodplain in the upper reaches once supported gallery riparian forests, large wetlands, oxbow lakes, secondary channels and backwater sloughs. These wetland areas were said to be rich in biological diversity—supporting myriad waterfowl and acting as salmonid rearing habitat as well as refugia for fish during flood events. Deep, cold pools shaded by thick riparian growth apparently supported an abundance of salmonids (California State Coastal Conservancy, in prep). The Russian River created this diversity of habitat types by meandering freely across its floodplain. Holway (1913) reported numerous accounts of the main stem of the Russian River moving over a mile across the valley in a twenty five year period, and then returning to its original position within the next twenty years.

The majority of those interviewed stated that the river often dried up during the summer, with deep pools connected by cool underflow supporting large numbers of Steelhead and other fish. Most of the individuals interviewed referred to significantly larger numbers of waterfowl, salmonids and wildlife than are presently seen. Others felt that the wildlife numbers along the Russian remained unchanged, or in some areas, has increased.

Without a detailed assessment of flood elevations and soils, it is not possible to determine the approximate pre-settlement extent of the riparian zone. An examination of remnant stands of large riparian trees on the floodplain terrace combined with historic photos and resident interviews indicates that many areas presently in agricultural production once supported mid-aged to late successional riparian habitat merging into Valley Oak woodland.

The main stem of the Upper Russian river sustained a 30% loss of riparian vegetation between the years of 1940 and 1990, with total riparian habitat acreage being reduced from 1171 acres to 815 acres over a fifty year period (Table 3.2). Because aerial photo documentation does not exist prior to 1940 for this area, it is not possible to quantitatively assess the loss of riparian habitat since European settlement. Historic aerial photo coverage of the Upper Russian River tributaries is incomplete.

The Potter Valley project, which augments Russian River flows by diverting water from the Eel River through Lake Mendocino, has probably had a significant effect upon the extent and quality of riparian habitat by virtue of increased summer water availability and a larger low flow channel. However, no quantitative assessment of these impacts has been made.

4. EXISTING RIVER CONDITIONS

4.1 FLUVIAL GEOMORPHOLOGY

4.1.1 Hydrology

Hydrologic changes in Mendocino County in the past century include construction of the Eel River Diversion; construction of Coyote Dam which traps sediment from upstream and reduces sediment supply the downstream reaches; and numerous small stock ponds which store water and trap sediment. Since 1908, the East Fork of the Russian River in Potter Valley received water from the hydroelectric power diversion on the Eel River at the Van Arsdale Reservoir. The maximum capacity of the tunnel (which was enlarged in 1950) is 345 cfs. The diversion generally runs at full capacity during the winter and about two-thirds capacity during August and September (DWR, 1976). Between 1910 and 1968, the average discharge though the powerhouse was 199 cfs (Ritter and Brown, 1971). Before 1908, dry season flow was near zero (MCWA, pers. comm.). The increase in dry season flow affects aquatic habitat.

Coyote Dam was constructed in 1958 by the COE on the East Fork of the Russian River downstream of Potter Valley. The dam was built to decrease flooding and to increase water supply for irrigation in downstream reaches of the Russian River. Coyote Dam decreases flood peaks and increases the duration of high flows (Florsheim and Goodwin, 1995). These high flows, which fill the channel from bank to bank, may accelerate channel incision and bank erosion. Channel capacity is currently greater than it was historically due to channel incision and bank erosion.

There are three gaging stations on the Russian River in Mendocino County (West Fork Russian River near Ukiah #11461000; Russian River near Hopland #11462500; and Russian River near Cloverdale #11463000). Table 4.1 lists flood peaks for the three gaging stations. Table 4.2 summarizes the flood frequency data for the three gages.

Groundwater elevations monitored by DWR for wells near Ukiah and Hopland do not show significant changes in elevation (Florsheim and Goodwin, 1995). This is probably due to the location of these wells and their distance from the river. Local problems have occurred for individual landowners with wells near the river, since as the channel incises, the groundwater table adjacent to the river drops. For example, the Willow Water District constructed a grade control structure downstream of their wells to minimize lowering of the water table associated with incision in the Upper Russian River.

The Russian River Flood Control District currently conducts channel maintenance activities with the intent of reducing flood hazards. Maintenance activities should be evaluated by a hydrologist, biologist, and geomorphologist to ensure that the activity does not threaten riparian habitat or channel stability, and that it has a measurable effect on flood levels. For example, riparian vegetation such as willows that may slow flow velocity and raise flood peaks, also stabilizes banks and minimizes erosion and loss of land. Thus, their removal may reduce flood inundation levels, but accelerate erosion. Organic debris in the channel in some cases may cause local changes in channel pattern or cause a backwater and higher flood elevations upstream, however, organic debris is a necessary component for fish habitat. Therefore, each configuration of debris should be evaluated separately to determine its effect on the river. The effect of gravel removal to lower flood levels must also be evaluated with respect to the important role bars have in channel stability as described in Section 4.1.4. Removal of bars for flood control may destabilize the channel morphology and cause bank erosion.

4.1.2 Dominant Discharge

Channel morphology results from the interactions between flow, sediment supply, the character of sediment in transport and the bed and bank material, and vegetation. In gravel bed alluvial channels in dynamic equilibrium, the channel forming flow, or "'dominant discharge," is the flow that over time, transports the majority of the sediment and is responsible for creating and maintaining the characteristic size and shape of the channel (Wolman and Miller, 1960; Leopold *et al.*, 1964; Knighton, 1984). The floodplain is an integral part of the fluvial system and the "bankfull discharge" refers to the flow that fills the channel from bank to bank before spreading over the floodplain. In channels in dynamic equilibrium, the bankfull flow is similar to the channel forming flow and commonly has a recurrence interval of about 1.5 years in relatively humid or temperate environments (Leopold *et al.*, 1964; Leopold, 1994). In the incised Russian River, the bankfull discharge is larger than the dominant discharge.

Wolman and Miller (1960) introduced a method to determine the channel forming flow based on the magnitude and frequency of floods and sediment transport that is not dependent on morphologic indicators. In their method, the frequency of occurrence of a flow event is represented by the distribution of stream flow estimated from recorded stream flow at the gaging station. The overall work performed or the effectiveness of an event is represented as the product of the frequency of flow events and the rate of sediment transport. The rate of transport measured from USGS gaging station records is used to estimate the sediment transport rate.

Few bed material load measurements are available for the Russian River gaging stations; therefore, bedload is estimated as a percentage of the suspended load. During the periods measured at the gaging stations, bed load was about 5.3% of the suspended load at Ukiah and Hopland, and 8.7% of the suspended load at Cloverdale. The suspended load and bedload estimates are summed to provide an estimate for total load. The transport capacity equation is given as:

$$Q_s = cQ^n$$

where Q_s is the total sediment discharge in tons/day; Q is the associated discharge in cfs; and c and n are constants derived from fitting a power function to the plotted data.

Dominant discharge estimated in Florsheim and Goodwin (1995) suggests that dominant discharge for the Russian River (post-dam since 1958) at Ukiah is about 4,200 cfs (recurrence interval is 2.0 years), Hopland is about 8,400 cfs (recurrence interval is 1.7 years), and Cloverdale is about 9,300 cfs (recurrence interval is 1.3 years). An update of these data using hydrologic data from 1992 to 1995 shows that the dominant discharges are slightly higher than previously estimated. The range of flows close to the dominant discharge is responsible for creating the characteristic channel shape. Because the Russian River channel is incised, the dominant discharge is not the same as the top of bank. Rather, the elevation of the dominant discharge is only part of the way up the bank. If the sediment supply in the system remained constant over time, the river would eventually create a new channel and low floodplain system, where the floodplain would be at the elevation of the dominant discharge.

4.1.3 Channel Morphology and Geomorphic Processes

In the wide alluvial valleys of the Russian River, channel morphology adjusts to both sediment supply and the magnitude and frequency of floods. Adjustments in channel morphology maintain the dynamic balance between sediment and water flow as the fluvial system evolves in dynamic equilibrium over the long-term. Dynamic equilibrium is defined as the balance maintained by changes in flow and sediment supply around average conditions of the system as it evolves (Hack, 1960; Knighton, 1984).

Sediment from the upper portion of the watershed is transported through the river system during floods. Some of this sediment is deposited, some is scoured and some is transported through the reach to downstream reaches of the Russian River, the estuary, or the ocean. The river is in balance, when over the long term, the amount of sediment transported into a reach is the same as the amount transported out of the reach. This balance, which maintains the bedforms, is called dynamic equilibrium. When more sediment is supplied than can be transported by the river, the channel bed aggrades. When the watershed supplies less sediment than can be transported, the channel incises, bank height increases, and channel widening due to bank erosion occurs. A reduction in sediment supply, due for example to gravel extraction, can cause both rapid channel incision and channel instability. Numerous negative effects arise from rapid channel incision, including increased bank heights, bank erosion, and a lowered groundwater table. Channel incision has negative effects on riparian habitat as the groundwater table falls below the level of the plant roots and as steep streambanks, which cannot support vegetation, are eroded. Incision has economic significance because it results in land loss, scour beneath bridge piers, and increased cost of pumping groundwater from the alluvial aquifer. Gravel bars are present in incised channels (Jaeggi, 1987), however, a reduction of sediment supply can reduce the relative elevation differences between riffles and pools and thereby decrease habitat diversity.

In 1995, Philip Williams & Associates, Ltd., (PWA) surveyed a longitudinal profile and cross-sections in Redwood Valley at the Ford Gravel operation (Figures 4.1 - 4.5). Figure 4.4 shows braiding in the area where gravel has been skimmed from bars. Downstream of the mining operation the channel narrows and has incised to the clay layer there is a coarse boulder lag on top of the clay. The lack of gravel in this reach degrades fish habitat.

Clay outcrops are also present in other reaches of the West Fork of the Russian River from Redwood Valley to the confluence with the East Fork, and in tributaries such as Forsythe Creek where the channel is incised and gravel is depleted. The presence of the clay layer suggests that past incision in the river has depleted the gravel that formerly created the bed of the channel. Future replenishment of gravel from upstream reaches is limited, since there does not appear to be a large source of gravel in the incised upstream reaches, and since gravel extraction further reduces the supply.

4.1.4 Role of Bars in Gravel Bed Rivers

Bars are the dominant bedform in gravel bed streams like the Russian River. Straight reaches are characterized by alternate bars, accumulations of sediment which alternate from one bank to the other. The thalweg, or the deepest part of the channel meanders between the alternate bars. Riffles are the topographic high points in the channel and pools are the topographic low points in the channel. Pools are usually directly opposite the alternate bars, while riffles are at the cross-over points between the tail of one alternate bar and the head of the next downstream bar. The riffle is part of one continuous feature extending from the upstream bar through the downstream bar. Riffles and pools are typically spaced about 5 to 7 channel widths along the length of the channel. Other pools are associated with woody debris or bedrock outcrops and are an important component of habitat.

Meandering reaches have the same physical components as the straight reaches: riffles, pools, and bars. However, in a meandering channel, the bars form on the inside of the bend and are called point bars. Point bars are formed by the secondary flow direction set up in the meander called “helicoidal flow” or flow in a corkscrew motion. A naturally meandering channel migrates across the floodplain by eroding the outside of the bend and depositing sediment on the point bar. The bank erosion associated with meander migration is expected in dynamic equilibrium, and does not imply that the river is unstable. Accelerated erosion—that does indicate instability—may occur where the structure of the channel is disturbed by gravel extraction, where riparian vegetation is removed, or where the channel is narrowed for land reclamation.

Figure 4.6 shows a schematic diagram of alternate and point bars in a gravel bed river. Bar height depends on the width of the channel and grain size of sediment supplied by the watershed (Jaeggi, 1987). The role of bars in channel dynamics is as follows:

C Bars are sediment storage areas. The volume of sediment stored in bars depends on sediment supply from the watershed. Both scour and aggradation can occur on bars. Bars form in incised channels and provide structure necessary for aquatic habitat;

C The height and form of bars influences flow resistance and bed load transport. When bars are relatively high (with greater form roughness), flow velocity and the sediment transport rate is reduced and more sediment is deposited on bars than when bars are relatively low (for example after extraction, assuming there is no initial change in width). If the bar form is removed by extraction, velocity is locally increased, and less sediment would be deposited at flows near the dominant discharge (flows that cover the bar). Braid bars commonly form in the widened low flow channel after extraction.

C Bars govern low flow conditions and aquatic habitat by creating the riffle-pool structure and the low flow channel width and depth. Gravel extraction of the bar form destroys the channel structure provided by bars. Widening of the low flow channel destabilizes the channel and may lead to shallow flow, braiding, and bank erosion. The local increase in flow velocity resulting from bar removal may lead to increased velocity and erosion downstream.

C Bars and vegetation together play a role in channel stabilization. Vegetation growing at the head of the bar promotes the deposition of gravel on the bar by slowing the velocity and adds strength to the structure of the channel.

Because gravel bars form the structure necessary to stabilize the low flow channel and create the diversity of habitat necessary for aquatic habitat, impacts to aquatic and riparian will be minimized by retaining as much of the bar structure as possible during gravel extraction operations. Recommendations for in-channel gravel extraction are provided in Section 7.

4.1.5 Gravel Replenishment

Hillslope Erosion and Sediment Supply

The geomorphic processes that contribute sediment from the hillslopes to the Upper Russian River are sheet and gully erosion and landslides, or mass-movement processes. The major types of mass movement processes in the Coastal Ranges include shallow soil creep, deep creep, slump earthflow, debris flow, and debris torrents (Swanston and Swanson, 1976; Dietrich and Dunne, 1978). DWR (1984) suggested that the source of gravel to the Upper Russian River also includes stream bank erosion. Hillslope and bank erosion processes occur episodically, so that sediment transport processes in rivers are also episodic in response to watershed events.

Sediment Yield

The volume of gravel replenishment on a bar depends on geomorphic, hydrologic, and biologic processes. For example, the relationships between the slope, width, depth, particle size, flow magnitude, and vegetation and large woody debris all influence the morphology and the size of gravel bars. The watershed characteristic—sediment yield—can be used to estimate the volume of sediment supplied by upstream watershed erosion to downstream reaches. Methods to determine sediment yield are inexact and are usually taken as an estimate for planning purposes until field data can be collected. Estimates of total sediment yield include fine sediment in suspension, as well as bedload in transport that does not replenish mined bars, but is transported through the system. Therefore, gravel replenishment on bars is a percentage of the estimated sediment transport rate. A percentage of the estimate of sediment transport rate may be employed for planning purposes until direct measurement of gravel replenishment on bars are available from field survey data. Average annual replenishment is estimated to be about 50% of the bedload transport rate (Dunne *et al.*, 1981; Sonoma County Planning Department, 1994; Fugro West Inc., 1995). The 50% estimate originally suggested by Dunne *et al.* (1981) because measured data were not available has been used in Grace Harbor County, Washington in the Wynooche and Humptulips Rivers and in Snohomish County, Washington in the Pilchuck River (Collins, pers. comm., 1996). This percentage accounts for the fact that of all the gravel supplied to a reach, some is deposited on bars, while some is transported through the reach to downstream areas.

This management plan is based on replenishment volumes measured in a detailed monitoring program. However, during the first year following the adoption of the plan—before monitoring data is available—a planning estimate of the annual gravel replenishment as about 50% of the estimated annual bedload transport will be used. The prediction of a planning estimate is based on measured average annual bedload transport volumes measured at gaging stations in the main channel, and on other available data for the tributaries. Because sediment transport processes in the Upper Russian River are episodic, during wet years the river will transport more sediment than predicted, while during dry years, the river may transport little or no sediment. Thus, the planning estimate is not likely to occur in any given year and this management plan relies on measured annual replenishment determined from field monitoring after the first year. Direct measurements from field survey data (described in the monitoring section of this report) are the most accurate method of determining actual annual replenishment and are used as the basis of this plan.

Methods to estimate bedload transport rates range from detailed field measurements at the USGS gaging stations, to regional and analytical methods. Collins and Dunne (1990) describe several approaches to estimate bedload transport rates and recommend that several independent methods be used to improve the accuracy of the estimates and illustrate the possible range. Actual bedload measurements are the best method, if the period of record is long. The methods outlined in Collins and Dunne (1990) that are applied to the Upper Russian River include the following.

Field Measurements of Bedload in Transport

In 1992, the Mendocino County Water Agency provided funds for the USGS to measure bedload and suspended sediment load transport measurements at the Ukiah, Hopland, and Cloverdale gaging stations (bedload was measured in Cloverdale only in 1995). This program started field data collection that will provide valuable data over the long-term. The available bedload data for the short period of record are plotted as a rating curve on Figures 4.7 - 4.9. Figures 4.10 - 4.12 show the suspended load transport measured at the three gaging stations. The suspended sediment curves for Ukiah and Cloverdale also include data collected bu the USGS during 1964 to 1968. These sediment gaging station data should be updated as new data become available since a longer period of record is needed for the estimates of sediment transport to be statistically significant.

The average annual bedload transport rate is computed by summing the bedload transported with each daily discharge (over the post-Coyote Dam period of record) using the available gaging station records. The bedload transport estimates at the Ukiah and Hopland gaging stations are as follows:

- *Ukiah* (drainage area is 100 mi^2): 2,560 tons/year (1,890 yd^3/year; 25 tons/mi^2/year)

- *Hopland* (drainage area is 362 mi^2): 30,360 tons/year (22,490 yd^3/year; 85 tons/mi^2/year)

Because there is only one year of bedload data collected at the Cloverdale gaging station, the estimate for bedload transport at the Cloverdale station is based on the relation between suspended and bedload sediment as described in the following section.

Bedload as a Percent of Suspended Load

Bedload is a small percentage of the total sediment load of a river. Usually bedload is between 2% to 16% percent of the suspended load (Collins and Dunne, 1990). Since suspended sediment load is usually easier to measure than bedload, a proportional relationship can aid in extending data sets where only suspended load is measured. For the short period of record on the Russian River when both bedload and suspended load were measured, bedload was about 5% of the suspended load at Ukiah and Hopland and estimated as about 8% in Cloverdale. This relationship can be updated as additional sediment load measurements become available. Figure 4.9 illustrates bedload as a percent of suspended load in addition to the bedload measurement at Cloverdale:

- *Cloverdale* (drainage area is 503 mi^2): 77,430 tons/year (57,355 yd^3/year; 155 tons/mi^2/year)

Theoretical Bedload Transport Equations

The average annual bedload estimate is computed by summing the calculated bedload for the daily discharges over the gaged period of record. In this study we used several bedload and total load sediment transport equations, and the post-Coyote Dam discharge records from the USGS gaging stations at Ukiah, Hopland, and Cloverdale. Sediment transport equations are described in Vanoni, 1975. The Bagnold bedload transport equation was selected to predict average annual bedload transport rate because it approximates the measured data on the Upper Russian River more closely than other bedload transport equations (such as the Meyer Peter Muller Equation). Figure 4.13 - 4.15 illustrate the theoretical bedload transport rate compared to the measured bedload transport rate at the three USGS gaging stations. Results of the Bagnold Equation are higher than measured bedload values for Ukiah and lower for Hopland and Cloverdale as follows:

- *Ukiah*: 5,080 tons/year (3,760 yd^3/year; 50 tons/mi^2/year)

- *Hopland*: 14,700 tons/year (10,890 yd^3/year; 40 tons/mi^2/year)

- *Cloverdale*: 38,540 tons/year (28,550 yd^3/year; 80 tons/mi^2/year)

We also used the Englund and Hansen and the Brownlie equations to estimate total sediment load. Figures 4.16 - 4.18 compare the theoretical transport rates using these two equations to the measured transport rate, and shows the wide range of estimates that is common using transport equations. Results of the Englund and Hansen and the Brownlie total load transport equation are as follows:

C *Ukiah*: Englund and Hansen: 3,700 tons/year (2,740 yd^3/year; 37 tons/mi^2/year)
Brownlie: 5,760 tons/year (4,270 yd^3/year; 60 tons/mi^2/year)

C *Hopland*: Englund and Hansen: 13,470 tons/year (9,980 yd^3/year; 37 tons/mi^2/year)
Brownlie: 26,980 tons/year (19,990 yd^3/year; 75 tons/mi^2/year)

C *Cloverdale*: Englund and Hansen: 25,000 tons/year (18,520 yd^3/year; 50 tons/mi^2/year)
Brownlie: 49,490 tons/year (36,660 yd^3/year; 100 tons/mi^2/year)

Comparison with Other Coastal Basins

Bedload transport data were estimated for other nearby coastal basins including the Mad River as 309 tons/mi^2/year (Lehre, 1993), Redwood Creek as 532 tons/mi^2/year (Fugro West, 1994), and the Garcia River as 160 tons/mi^2/year (PWA, *et al.*, 1996). The best estimate for the Gualala River was 87 tons/mi^2/year (PWA, 1994). These estimates show the typical variability and range of sediment transport data.

Reservoir Sedimentation Records

Records of reservoir deposition can provide estimates of the bedload transport rate. The amount of silt deposited in Lake Mendocino (from 1959 to 1985), was measured by the Sonoma County Water Agency as 134 acre-feet/year. Fugro West (1994), provides a compilation of sedimentation rates for reservoirs in the California Coast Ranges as about 442 tons/mi^2/year. This value over estimates the actual bedload transport rate because it also includes suspended sediment deposited in the reservoir.

Sediment Budget

A sediment budget—or an accounting of the sediment inflow, change in sediment storage, and sediment outflow—is a useful way of predicting channel changes resulting from gravel extraction. If the volume of sediment that replenishes bars is larger than the extraction volume, then aggradation will occur. In contrast, if the extraction volume is larger than the replenishment rate, the incision or scour will occur. The sediment budget compares the input of sediment (input is from upstream main channel reaches, tributaries, hillslopes, and bed and bank erosion) to the output of sediment (output is the sediment that is transported out of the reach to downstream areas). The difference between the input and the output is the change in storage (aggradation or incision). There are no detailed measurements of the change in storage available for the Upper Russian River, however, field observations and available cross-sections indicate that incision and bank erosion in tributaries and in the main channel has occurred. Lacking more detailed data, the bedload input and output over the entire Upper Russian River system can be compared in a gross way as follows:

Replenishment is taken to be about 50% of the measured transport rates reported in the previous sections. Thus, we estimate the average annual bedload replenishment rates (based on measured sediment transport at gaging station records)to be about:

C 1,280 tons/year (950 yd^3/year; 13 tons/mi^2/yr) represents the bedload supply from tributaries and the main channel reach upstream of Ukiah;

- 15,180 tons/year (11,230 yd^3/year; 42 tons/mi^2/yr) represents the bedload supply from tributaries and the main channel reach upstream of Hopland (including the reach upstream of Ukiah); and

- 38,715 tons/year (28,650 yd^3/year; 78 tons/mi^2/yr) represents the bedload supply from tributaries and the main channel reach upstream of Cloverdale (including the reaches upstream of Hopland and Ukiah). This value estimates the total volume of bedload supplied by the Mendocino County portion of the Russian River system.

Replenishment and extraction estimates should be updated as additional data become available to augment the short record. Extraction rates for the entire Upper Russian River in Mendocino County were documented as 477,536 tons/yr (353,396 yd^3/year) for the period from 1950 to 1980 (DWR, 1984) and as of 1994, in-channel extraction up to 189,190 tons/year (140,000 yd^3/year) was permitted. These data, which rely only on estimates of bedload transport and extraction rates, suggest that historically more gravel has been extracted (and currently more could be extracted based on existing permits) from the Upper Russian River system than is replenished from upstream, although, the permitted volume may over estimate the actual extraction volume. If extraction continues to exceed replenishment, continued incision and bank erosion in the main channel and tributaries is expected.

The following qualitative description of bedload input and output in the main alluvial reaches and the tributaries that supply gravel in the Upper Russian River system is intended to aid in planning decisions related to gravel extraction. Table 4.3 shows the bedload transport estimated from tributaries using a regional transport estimate for Upper Russian River tributaries based on suspended sediment data (DWR, 1984). DWR suggested that bedload is 25% of the suspended load, while this study showed that bedload is about 5% of the suspended load (over the short record at Ukiah and Hopland). Estimates of bedload using both these percentages as a range are shown on Table 4.3. Replenishment is 50% of these estimated bedload transport values. These regional estimates do not reflect *actual* bedload transport in individual tributaries, and site specific bedload transport and gravel replenishment measurements should be made to verify these estimates. In the Upper Russian River, the main alluvial reaches and the tributaries that supply sediment are as follows.

Redwood Valley to Ukiah Gaging Station—including the tributaries Forsythe and York Creeks. Field observation of an exposed clay bed and gravel depletion in Forsythe Creek and in the Russian River downstream of Redwood Valley suggest that degradation rather than aggradation is occurring. The small measured gravel transport at the Ukiah gage, even during the 1995 floods, indicates that very little sediment is supplied from the West Fork of the Russian River. No sediment is supplied from the East Fork because Coyote Dam traps sediment in Lake Mendocino (except for sediment derived from bed and bank erosion). Thus, very little sediment is contributed to the Ukiah Valley from upstream as indicated by the Ukiah gaging station record.

Between the Ukiah and Hopland gaging stations—including the tributaries Hensley, Ackerman, Robinson, and Morrison Creeks. Cross-section data at the Perkins and Talmage Street Bridges show little change in bed elevation since 1989, even after the 1995 floods, and bank erosion was documented. Bedload transport through the Hopland gaging station could be supplied either from tributaries or from the bed and banks of the channel. Detailed field monitoring is needed to verify changes in bed elevation and bank erosion throughout this reach.

Between the Hopland and the Cloverdale gaging stations—including the tributaries Dooley and Feliz Creeks. Cross-section data from the Highway 175 Bridge crossing near Hopland shows incision (and narrowing) between 1980 and 1995, suggesting that sediment is supplied from the bed of the channel to downstream reaches. Detailed field monitoring is needed to verify changes in bed elevation and bank erosion throughout this reach.

4.2 EXISTING CONDITIONS: FISHERY RESOURCES

To analyze and discuss the status of the existing fishery resources in the Upper Russian River, a wide variety of sources were used, including the following: 1) the California Department of Fish and Game (CFG) files; 2) agency personnel familiar with the project area and issues; 3) relevant water quality (water temperatures, dissolved oxygen) and flow data for the Upper Russian River; 4) past and present CFG Stream Alteration Permit Applications ("1603 Permits") for in-channel projects within the project area; 5) oral histories of long-time residents in the area; 6) relevant theses from academic institutions; and, 7) AAR's extensive library, which included scientific articles on the impacts of gravel mining, sediment, water temperatures, and water quality impacts on fishes. In addition, Dr. Alice Rich made two field trips to the project area, one during the summer of 1995, and one during February 1996.

4.2.1 Fishery Requirements

Although there are numerous fish species (both native and introduced) within the Upper Russian River System (Table 4.4), the number of species (33 species from 13 families) precludes a discussion of all of them. However, some of those species have been designated species of special concern. Species of special concern are those species which have been designated as threatened, endangered, or species of special status (candidate species), by the CFG, National Marine Fisheries Service and/or the U. S. Fish and Wildlife Service. These species include the steelhead trout (*Oncorhynchus mykiss irideus*, after Behnke, 1992), the coho salmon (*Oncorhynchus kisutch*), and the Russian River tule perch (*Hysterocarpus traskii pomo*). As these are species that we know are presently at risk, and therefore, of specific management importance, this report will focus on these three species. With regard to this aggregate resources management plan, understanding the biological and physical factors which would enable the populations of the species of special concern to improve in the Upper Russian River is important for at least the following reasons:

1. Using such information, it would be possible to design gravel extraction methodologies which could minimize impacts on fishery resources;

2. Using such information, criteria could be developed which could be used as "benchmarks", to determine whether or not a particular gravel mining operation was detrimental to sensitive fish species;

3. Using the criteria, together with a long-term monitoring program, one could differentiate the impacts of gravel mining with those resulting from other land uses (water diversions, instream channelization, dams) and/or natural phenomena (floods); and,

4. Using such information, together with a long-term monitoring and rehabilitation program, it would be possible to improve conditions for the native fishes of the Upper Russian River.

To achieve these goals, life history events must be discussed in concert with key life requisites. Life requisites are those features of an organism's environment which are essential to its continued survival and reproductive success. Critical life requisite variables for fishes include:

- Appropriate water temperatures;
- Acceptable dissolved oxygen concentrations;
- Accessibility to spawning and rearing areas;
- Adequate streamflows;
- Appropriate substrate composition;
- Appropriate water depth;
- Adequate shelter or cover; and
- Abundant food.

When life requisites are not met, or are limited in some way, the fish's survival and reproductive success can be jeopardized. The factors which limit fish populations are called limiting factors. Each of the requisites vary, depending upon the season of the year and life stage of the fish. If any life stage of any species is deprived of a life requisite, the population as a whole can be negatively affected (Figure 4.19).

The sensitive fish species are particularly sensitive to environmental perturbations, and, thus, are good indicators of the relative health of the Upper Russian River Watershed. These indicator species (McCarthy and Shugart, 1990) respond to environmental perturbations more quickly than other fishes. These species are to fisheries biologists what the canary was to miners: a warning sign. The responses of these fishes to environmental changes provide a good indication of the health (or lack of it) of the watershed ecosystem, just as the condition of the canary was used to assess poor air quality conditions in mines. Thus, their health and habitat are barometers of the results of past events, as well as environmental harbingers of events to come, if we do not remedy or remove the causative agent(s).

By integrating the knowledge of what sensitive native fishes require, with that of historical and existing conditions, it can be determined if and when those requirements are being met. From this information, steps can be taken to improve conditions for the fishery resources. One method of improving conditions would be to design methodologies which could reduce the impacts of gravel mining on fishery resources. The use of these methodologies, together with a monitoring plan, and rehabilitation effort, could improve fish habitat and populations. By using life requisites as "benchmarks" for describing what the fish require and identifying limiting factors, it would be possible to understand the relative impacts of gravel operations on the fishery resources. By understanding the relative impacts of the gravel mining operations, and minimizing those impacts, the fishery resources of the Upper Russian River could be improved.

The best method for identifying the life requisites and determining whether or not these life requisites are being satisfied is to use site specific data. However, as site specific information is incomplete for all of the life stages of all of the species of management concern for the Upper Russian River, relevant data from other coastal systems was often used. And, as site specific data were not available, it is recommended that the life requisites identified in this report (Tables 4.5 - 4.8) be used as a "first cut." Once the site specific Fishery Resources Monitoring Plan (described in Section 8) is underway, the site specific requirements for each life stage of each of the species of management concern should be re-evaluated on an ongoing basis. Then, if necessary, one or more of these requirements can be modified if there is a scientific basis for such a change.

Appropriate Water Temperatures

Of all of the life stage requisites, water temperature is the most important, yet, perhaps, least understood. By contrast to us, as mammals, fishes are poikilotherms, which means that their internal body temperature varies, according to the external environment. This means that a fish has little physiological control (i.e., thermoregulation) over its body temperature; if the water is hot, the fish is hot and if the water is cold, the fish is cold. Thus, the poikilothermic fish, unlike the homeothermic mammal (which can thermo-regulate), has no physiological way to acclimate quickly to changes in water temperature. And, a fish's metabolism, which controls all aspects of its body, is directly proportional to water temperature, within certain limits. Thus, as water temperatures increase, so does the metabolic rate and the need for food. Beyond certain physiological limits, however, even an increase in food availability will not assist the fish; beyond this point, water temperature can be lethal.

Despite a fish's inability to change quickly, physiologically, they often use behavior to thermo-regulate. Salmonids can detect changes of as little as 1 degree centigrade. This is of great importance when their habitat provides more than one thermal option. For example, in a three-year Navarro River Watershed study (Rich, 1991a), juvenile coho salmon were collected in water temperatures which, based on the scientific literature, were stressful. Yet, the fish appeared to be healthy. It was surmised that there were "thermal refugia" or "cool pockets," and abundant food resources (Rich, 1991a). Other researchers have made similar conclusions (Kaya *et al.*, 1977; Keller *et al.*, 1982). Thus, within the thermocline in the pool, the cooler areas provided a refuge for the salmonids during the hot part of the day. The fish could then digest their food at physiologically-acceptable water temperatures, even though a large percentage of the pools were characterized by high water temperatures.

Chronic sublethal stressful water temperatures are usually of more importance to fishes than acute lethal temperatures. Stressful water temperatures are more common and the results less easily studied and understood than a "fish kill," resulting from lethal water temperatures. However, sublethal water temperatures can effectively block migration, reduce growth rate, create disease problems, and inhibit smoltification. Hence, it is of paramount importance that the impacts of sublethal stressful water temperatures be understood and, when possible, mitigation measures be implemented, to reduce the long-term impacts: reduced productivity within the watershed.

Water temperature standards used for selected fish species by fisheries biologists are often subject to debate. One of the primary reasons for this problem stems from the fact that it is common to base water temperature standards on selected laboratory data, rather than site specific field data for a given species. For example, water temperature requirements for salmonids, are often developed without any understanding of the physiological and/or behavioral response of the fish to changes in water temperature. Therefore, water temperature standards often do not agree with field data for a given fish species (see example on coho salmon and Appendix B in Rich (1997).

Thus, to identify appropriate water temperature requirements for fishes, it is of paramount importance to use site specific data, preferably temperature-physiology studies. The ranges of seemingly appropriate water temperatures for the species of management concern are provided in Appendix B. Based on results which were considered to be most relevant to conditions in the Upper Russian River, physiological optimal water temperature ranges are summarized in Tables 4.6 - 4.7 for the salmonid species, the most thermally intolerant of the fishes which inhabit the Russian River drainage.

Acceptable Dissolved Oxygen Concentrations

Although sensitivity of fish to low dissolved oxygen (d.o.) concentrations differs between species (salmonids are more sensitive than squawfish), the requirements (feeding, growth, reproducing) for each life stage controls the amount of oxygen needed at any given time. If these requirements are not met, the fish undergoes a stress reaction. The stress reaction influences the fish's life processes and, sometimes, whether or not the fish lives or dies. Chronic sublethal d.o. levels can result in the following impacts on salmonids: 1) cessation of immigration; 2) negative impact on swimming performance; 3) reduced growth rate; 4) reduced food consumption rate; and 5) avoidance reactions. Any of these responses can affect the fish's ability to complete its life cycle and perpetuate the species. For salmonids, d.o. concentrations should be above 7 mg/l, although at low water temperatures, 5 mg/l is probably also suitable (Tables 4.5 - 4.7).

Accessibility to Spawning and Rearing Areas

Sometimes barriers (dams, shallow riffles, waterfalls, debris jams) will delay, or even curtail migration beyond the barrier. Migration barriers may limit the success of spawning for steelhead trout and coho salmon. Longhurst (1972) noted that prior to construction of Coyote Dam, major steelhead trout spawning occurred in the main stem Russian River. Some barriers are insurmountable, but given suitable conditions (deep pools at the base of a waterfall or cascade), steelhead trout, and sometimes salmon, may be able to get past many obstacles that appear to be barriers. The best method for determining whether or not a barrier to migration exists is to obtain site specific information.

Although, the tule perch has adapted well to the varying conditions in the Russian River system, this species is on the decline. Habitat changes appear to be the major cause for this decline. Any barrier to upstream or downstream migration, either for the reproducing adults or for the newly born young, would have an adverse effect on the future of this species. Summer dams and summer roads should therefore be removed from areas where this species is known to migrate.

Adequate Streamflows

The amount of streamflow affects all life stages of salmonids and tule perch. Of the factors known to influence anadromous salmonid's ascent of creeks, streamflow connected with storm events is one of the most important. Once the fish immigrate into the Russian River drainage, there must be enough water for them to "pass over" barriers in order for the fish to reach their spawning areas. Streamflow regulates the amount of spawning area available; as flows increase (up to a point), more gravel is covered and becomes suitable for spawning. During egg incubation and fry emergence, adequate streamflows are necessary to cover the eggs and wash away excretory products. During rearing, streamflow is related to the amount of food and physical habitat available. Streamflow is also an important factor during the parr-smolt transformation and emigration of anadromous fishes. Streamflows directly affect tule perch; this species has disappeared from streams with reduced flows. The numerous flow variations which have occurred in the Upper Russian River and its tributaries, have probably detrimentally affected the Russian River tule perch, thereby reducing their population.

Appropriate Substrate Composition

Salmonids require and seek out clean (silt free) gravel (Tables 4.5-4.7). Although they will spawn and rear in embedded substrate, if nothing else is available, there is usually a reduction in survival. Successful spawning, incubation, and fry emergence depends upon the following: 1) size class composition of the substrate; 2) existing degree of embeddedness; 3) porosity of the substrate down to below the point of egg deposition in the fish's redd; and, 4) percolation rate of water through the substrate.

It is well known that sediment particle size influences the survival of salmonids. Considerable research has demonstrated that varying amounts of fines less than 3.3 mm diameter will impede the free exchange of intragravel and surface water and physically entrap fry within the redd. Increases in concentrations of fines are most injurious to salmonid habitat when the sediment source persists over a long period of time. Although, there is a great deal of variability in the results of the various studies, when fines less than 0.85 mm diameter exceeded 15%, there was a sharp drop in fry emergence and survival.

Appropriate Water Depths
Water depth is important to salmonids, particularly during the immigration and spawning season. Steelhead trout in California streams rarely chose redds which would later be exposed by receding stream levels. Preferred depths have been determined by measuring the water depth over active redds. Recommended water depths for the species of special concern are provided in Tables 4.5 - 4.7.

Adequate Shelter or Cover
Cover is an important factor in a fish's life. Cover provides protection from predators (birds, mammals, other fishes), as well as, sometimes, reduced water temperatures during hot days. Cover can be provided by overhanging vegetation, undercut banks, submerged rocks and vegetation, submerged objects such as logs, floating debris, and even turbulence and depth. Young salmonids prefer habitat characterized by abundant cover. The nearness of cover to a spawning area may be a factor in the actual selection of spawning sites; some salmonids select areas adjacent to undercut banks and overhanging vegetation. The Russian River tule perch use cover in the form of emergent aquatic plants, overhanging banks, and submerged boulders and logs. These areas are important for feeding, breeding territories, and protection of young (Reiser and Bjornn, 1979; Moyle, 1976; Giger, 1973).

Abundant Food Resources
Abundant food is particularly important to salmonids during warm summer months, when water temperature and metabolisms are high. Young salmonids require a large and constantly replenished supply of food, in order to survive and grow. Investigations of food habits of salmonids in freshwater streams demonstrate that they feed primarily on aquatic and terrestrial insects.

The tule perch is adapted for feeding on small hard-shelled invertebrates associated with the bottom, aquatic plants, and mid-water zooplankton. Food resources are of paramount importance to the tule perch; this species has disappeared from streams with reduced food availability. Any action (increased sedimentation) which results in fewer food organisms within the Russian River basin would have a long-term detrimental impact on this species.

4.2.2 Life History Information on the Species of Special Concern

Ideally, when discussing life stage periodicities and requirements, biologists use site specific data. However, most of the available studies were from the 1950's and 1960's and consisted, primarily of qualitative, rather than quantitative data (Figure 2.1). Thus, when previous biologists observed and/or collected juvenile rainbow/steelhead trout, it cannot be determined whether or not the fish was a steelhead or a rainbow trout. In many cases, biologists relied on visual observation (observing from the shore what fishes were present), rather than using collection methods (electrofishing, seining). Thus, much of the information on these species is based on information from other river systems.

Steelhead Trout
The steelhead trout is the most widespread and abundant anadromous fish species within the Russian River System. Unfortunately, however, fish stocking records demonstrated that for decades hatchery reared steelhead from within the drainage and from other drainages, and even from other states, were planted in the Russian River system. The principal sources of steelhead trout planting in recent years have been the Eel and Mad rivers. Although, the state and federal agencies' current policy is to avoid importation of exotic strains, the amount of interbreeding is unknown. However, as interbreeding hatchery (domestic) fish with wild fish results in a reduction in genetic diversity of the original wild stocks and numerous other problems (Williams *et al*., 1996; Johnsson *et al*., 1994; 1993; Flemming and

Gross, 1992; Rich, 1979), it is assumed that the long-term impact of stocking on the native steelhead trout population has been great, although the exact amount is unknown.

The steelhead trout is a polymorphic subspecies of rainbow trout. Similar to other anadromous salmonids, the steelhead trout begins life in a freshwater stream or river, rears for a period of time in fresh water, emigrates to sea for several years, and returns to its natal streams to spawn. Except for their ocean-going habits and larger spawning size, the steelhead trout is visually indistinguishable from its non-migratory counterpart, the rainbow trout. Whether or not a particular stream supports an anadromous or resident trout population appears to be the result of local adaptation to geographic location. Populations may be migratory, resident, or mixed, where the two forms presumably interbreed. Both the anadromous and resident forms may exist in the same stream, and, in some instances, may be physically discrete from one another, due to an impassable barrier to upstream migration, such as a waterfall. In these situations, steelhead trout exist below, and the resident rainbow trout exist above, the barrier (Utter *et al.*, 1980; Behnke, 1972; Needham and Gard, 1959).

Although, it is known that the steelhead population in the Russian River has declined during the past few decades, the amount of the decline is unknown. As with other salmonid river systems, few, if any, quantitative estimates of the size of the Russian River steelhead trout population have been made. In 1969, CFG estimated that there were approximately 57,000 steelhead trout which were using the drainage at that time (Vestel and Lassen, 1969); however, this estimate was not based on quantitative data. A qualitative comparison of conditions 30-40 years ago, with those of today, demonstrated that many of the creeks in the Upper Russian River which used to support steelhead trout do not support this species any longer.

Steelhead trout, as well as other anadromous salmonids, undergo the following life stages:

- Adult immigration;
- Spawning;
- Egg and Alevin incubation;
- Fry and juvenile rearing; and
- Smoltification and emigration.

A description of the timing and general biology of each of these stages is discussed below (Figure 4.20). The steelhead trout which migrate into the Russian River and most of its tributaries to spawn is referred to as the "winter run." These are steelhead trout which enter and spawn during rising stream levels during the winter and early spring months (November-April) (Withler, 1966; CFG, 1991). Most steelhead trout begin to immigrate in November, although the timing is dependent upon streamflow levels. Storm events result in streamflow changes, which cue anadromous fish immigration into the Russian River, and, eventually, into the tributaries of the Upper Russian River. Immigration of steelhead trout occurs in "waves" or pulses, coinciding with storm events, resulting in temporary high water flows (freshet conditions). Studies suggest that these freshet conditions are required to initiate both movement into a lagoon or bay, and upstream into the creeks (Shapovolov and Taft, 1954; Briggs, 1953).

The entry of steelhead trout into streams is not determined entirely by either sexual maturity or age. Although, California steelhead trout typically return to freshwater after one to two years at sea, they have a highly variable life history; some return after three or four years at sea (Shapovolov and Taft, 1954; Briggs, 1953). Steelhead trout which have spent only one year at sea, but have returned to spawn, are termed "grisle;" such males are commonly called "jacks."

After the adult steelhead trout move into a stream, they will seek out a pool or glide habitat located near the spawning area; many will "hold" in these areas for two to four weeks while their reproductive products (eggs and milt) ripen. In the Russian River drainage, most steelhead trout spawn in January and February.

Most adult steelhead trout die after spawning, but some return to the ocean and then to the stream to spawn again; these fish are called "repeat spawners." Research on coastal streams has shown that the percentage of repeat spawners varies from three to over 50 percent of a run. Although most steelhead trout return to spawn only once, as many as five returns have been recorded, although not in recent years (Fulton, 1970; Bjornn, 1969; Withler, 1966; Shapovolov and Taft, 1954; Briggs, 1953).

Steelhead trout eggs incubate for a variable period of time (usually 30-60 days), depending upon water temperature (Leitritz and Lewis, 1980; Shapovolov and Taft, 1954). In the Upper Russian River watershed, most incubation probably occurs from January through March, although the incubation period may extend further in wet years).

The distinction between fry and juvenile is, admittedly, an arbitrary one. "Fry" status is assigned to the fish emerging from the gravel; "juvenile" status is assigned to the fish when it has reached a given length; the length differs from study to study.

Once the yolk sac is absorbed, steelhead trout fry begin to emerge from the gravel. In the Russian River, most fry emergence begins in February. After emerging from the gravel, the young fish feed and tend to congregate in schools close to shore. As the fish grow, they spread out, eat larger foods, and are thought to inhabit moderately swift portions of creeks. Most steelhead trout in the Russian River Watershed, spend from one to two years in the streams, before returning to sea (smoltification), where they spend from one to three years, before returning to freshwater to spawn. A very small percentage of fish emigrate out of California creeks during their first year (CFG, 1991; Moyle, 1976; Shapovolov and Taft, 1954; Briggs, 1953).

Smoltification, or the *parr-smolt transformation*, consists of behavioral, morphological, and biochemical changes which transform a darkly pigmented, bottom dwelling freshwater salmonid (the parr) into a pelagic silvery fish (the smolt) (Folmar and Dickhoff, 1980). During this process, salmonids emigrate from their natal streams into the sea. In the Upper Russian River drainage, smoltification and emigration probably extend from February through May. The fish then emigrate out to the Pacific Ocean.

If steelhead trout undergoing smoltification are unable to reach the Pacific Ocean, due to environmental problems (low streamflow, thermal blocks, block at the mouth of the Russian River), they revert to an immature parr-like conditions. Depending upon conditions, the trout may desmoltify and resmolt the following year, or it may die (particularly if it is a small fish).

Steelhead is proposed for listing as an endangered species and a decision will be made Augugst 7, 1997 (NMFS, pers. comm.).

Rainbow Trout

Although not sea-dwelling, the rest of the life history of the resident rainbow trout is similar to that of the steelhead trout. Most rainbow trout are spring spawners (February to June) (Figure 4.21). Most resident trout mature in their second or third year, although the time of first maturity can vary from the first to the fifth year of life; size at maturity can be 13 centimeters or larger (Moyle, 1976).

Coho Salmon

The coho salmon, which inhabit the Russian River Watershed, are within their lower geographical range; the center of abundance for this species is from Oregon to Alaska (Hart, 1973). Although, historically inhabiting the Russian River Watershed, the population of coho salmon has always been a fraction of that of the steelhead trout. However, in recent years, the population has declined precipitously, similar to the steelhead trout. Although, no reliable quantitative estimates are available, the 1969 annual run in the Russian River was estimated to be about 5,500, about a tenth of that of the steelhead trout at the time (Vestel and Lassen, 1973). In an effort to increase the run size, coho salmon from other river systems, as well as that of the Russian River, have been stocked in the Russian River and its tributaries. The primary sources of coho salmon were Pudding Creek and the Noyo River, both located within Mendocino County (CFG, 1991). Today, coho salmon occur, mainly, in the tributary streams within Sonoma County up to, and including, Dry Creek. From a review of the historical records, it was concluded that coho salmon used to inhabit many creeks in the upper sections (Upper Russian River, West Fork Russian River, Forsythe Creek drainage, Mariposa Creek) of the Upper Russian River.

Although few coho salmon have been sighted in recent years, the timing of their immigration into the Russian River is from November through January (Figure 4.22). They begin to spawn in November; peak spawning occurs from late November through January. The spawning process is similar to that previous described for steelhead trout. After spawning all of the adult salmon die (Shapovolov and Taft, 1954; CFG, 1991a).

In the Upper Russian River drainage, most coho salmon incubation occurs from December through March, although some incubation may occur as early as November and as late the beginning of April. Eggs hatch in eight to twelve weeks; fry emerge from the gravel four to ten weeks later, depending on water temperature.

Coho salmon rear throughout the year. In the Russian River, fry emergence is thought to begin in January, although most emergence probably occurs from February through April. Unlike steelhead trout juveniles, young coho salmon seek deep dark pools. In most streams, coho salmon rear for a year before emigrating. However, as evidenced from other creeks, there appears to be a general increase in the number of coho salmon which emigrate their first year (Rich, 1991a; Shapovolov and Taft, 1954; Briggs, 1953). In the Upper Russian River drainage, smoltification and emigration occur from March through June, with peak emigration during April.

Coho salmon was listed as a threatened species under federal law on October 25, 1996 for the Central California ESU (Evolutionarily Significant Unit). The agency with jurisdiction over this species is NMFS (NMFS, pers. comm.).

Russian River Tule Perch

The Russian River tule perch occurs only in the Russian River and its tributaries, from Ukiah downstream to Monte Rio and it is listed as a species of special concern in "Fish Species of Special Concern." It has been characterized as being uncommon, when compared to other native fishes (Baltz and Loudenslager, 1981; Baltz and Moyle, 1982; Moyle, 1976; Hopkirk, 1973).

The reproductive strategy of this species reflects it adaptations to the unpredictable environment of the Russian River. The Russian River tule perch mate from July through September; sperm is stored within the female until January, when fertilization occurs. During the mating season most males can be very territorial, defending areas such as under overhanging branches and plants close to shore. Young are born during May-June, when food is abundant. The entire period from March through June is a critical one for this species (Figure 4.23).

Tule perch inhabit a wide range of habitats, from sluggish turbid channels to clear, swift-flowing sections of river. They can live in fast water by residing in eddies or by staying in the slower moving backwater and edges. In most situations, they are associated with beds of emergent aquatic plants or overhanging banks. This subspecies feeds primarily on the larvae of chironomids, mayflies and blackflies, although they feed on a wide variety of bottom and plant-dwelling invertebrates. Growth is most rapid during the first eighteen months after birth (about 2-3 inches standard length); they seldom exceed about 6 inches standard length or five years of age.

4.2.3 Sensitive Habitat Areas

From a fishery resources perspective, it is not possible to differentiate sensitive from non-sensitive areas quantitative data are lacking and because of the generally poor fishery condition of the entire watershed. Two of the factors which have caused the greatest impact to fish have been the construction and operation of Coyote Dam and the introduction of non-native fishes. Thus, from a sensitivity perspective, with regard to the salmonids and the tule perch, the whole watershed needs to be rehabilitated, using a watershed-based approach. Until more studies are conducted, we can provide only a preliminary summary of the riverine areas which had, in the past, appropriate habitat for the sensitive fish species. These riverine systems are those in which steelhead/rainbow, coho salmon, and tule perch have been collected and/or observed in the past (Table 4.9). However, before implementing any rehabilitation effort for the Upper Russian River and its tributaries, further quantitative surveys are required. At this time, the primary limiting factors appear to be high water temperatures in the late spring, summer, and early fall months, and limited intermittent flows during the summer months, both of which area caused, in part, by the operation of Coyote Dam. As more studies are conducted and additional data become available, this analysis can be revised. A more detailed discussion of the history, past and current problems, and possibilities for enhancement is provided in the Status of Fishery Resources report (Rich, 1997).

Based on the review of past fishery resources surveys and documents of the Upper Russian River Watershed (see Appendix B), both water quality and physical habitat conditions for the sensitive fish species are in need of improvement. The primary limiting factors appeared to be: 1) high summer water temperatures; 2) low to non-existent summer flows; 3) migration barriers; and, 4) siltation problems due to eroded banks. Many of these factors are attributable to the construction and operation of Coyote Dam. And, as most of the information was twenty or more years old and of a qualitative nature, a more current evaluation of the drainage is warranted, particularly with regard to water temperatures and the quality and quantity of substrate in spawning and rearing areas.

4.3 EXISTING CONDITIONS: RUSSIAN RIVER RIPARIAN ZONE

4.3.1 The Riparian Zone

From an ecological perspective, the riparian zone is considered to be the area adjacent to a stream which is affected by flooding, and where direct interactions take place between the aquatic and terrestrial environments. The riparian zone does not necessarily have sharp boundaries; i.e., it is not simply a narrow strip of hydric soils and wetland plants immediately adjacent to a stream (Bayley, 1995). The riparian zone may include the following components:

C the area between the outer limit of riparian vegetation to the current boundaries of the active floodplain;

C the river channel and its associated vegetation (comprising the wetted channel, active channel, vegetated channel, channel banks, and if applicable the area from the top of the channel bank to the outer limit of riparian vegetation; and

C parts of the historical floodplain, insofar as they directly interact with the stream via sediment and nutrient inputs during major flooding events.

Riparian zones are complex transitional areas, or *ecotones*, between aquatic and fully terrestrial ecosystems. Ecological interactions in this area take place in both directions: i.e., the stream influences the adjacent land and the surrounding land influences the stream. The degree of these interactions depends partly on the local topography and hydrology and the type and height of the vegetation, and partly on the type, frequency, extent and intensity of natural and human disturbances in the system.

A landscape-ecological perspective is helpful in understanding how the relationships between riparian and fully terrestrial habitats affect plant and wildlife populations and communities in an area. The total species richness of any area bears a strong relationship to the diversity, quality, and distribution of the different habitat types present. Riparian zones in a near-natural state contain a relatively high diversity of landforms, vegetation types and successional stages that are concentrated within a small geographic area; they are especially attractive to wildlife largely because an adequate mix of habitat types, food, and shelter is consistently available even in the face of unpredictable natural disturbances such as drought, wildfires or severe floods. River drainages are also thought to have served as refuges and dispersal corridors for species responding to climate changes over evolutionary time.

Typically, the total number of plant and animal species living in riparian zone habitats is greater than in the adjacent upland habitats, and it is seasonally increased by the fact that river valleys provide one of the most important routes for the yearly migratory movements of aquatic, terrestrial and aerial animals. It is important to realize that under natural conditions most of this habitat diversity originates from, and is sustained by, the high frequency of flooding and erosive disturbance caused by the stream.

4.3.2 Riparian Habitat Values

According to A.S. Leopold and numerous other researchers, undisturbed riparian plant communities support extremely high levels of species diversity (Warner *et al.*, 1984). Half of the reptiles and three fourths of the amphibians in California are dependent upon riparian habitat. The diversity of bird species which utilize riparian habitat is unparalleled in California. Of the 502 recent native species of land mammals in California, approximately 25% are limited to, or dependent upon riparian and other wetland communities (Williams *et al.,*1984). The following are benefits provided by riparian vegetation:

C maintains cool water temperatures and high levels of dissolved oxygen by shading all or part of the stream;

C supports wildlife corridors and offers shelter and forage;

C riparian buffer strips prevent fine sediments from entering the stream (Erman, 1981);

C stabilization of banks/erosion control, preventing loss of agricultural land;

C prevents large woody debris from entering vineyards and orchards during flood peaks;

C contributes structure to streams, which provides shelter for fish and aquatic organisms (i.e., scour pools, woody debris, root mass);

C provides nutrient contributions, in the form of leaf litter and macroinvertebrates, for fish and aquatic organisms;

C standing and fallen trees and shrubs in the riparian zone hinder the flow of flood waters, substantially reducing their velocity and causing sediment to be deposited, eventually forming hummocks and terraces. Large root masses of living trees anchor the soil and reduce bank erosion. Fallen logs form dams across the channel of small streams and serve to trap sediments and to dissipate stream energy. In this way the riparian vegetation of undisturbed streams has a significant effect on physical processes such as sediment transport, channel width, and stream configuration; and

C log-and-debris dams create in-stream habitat and cover for invertebrates, fish, and other aquatic organisms. Where logs are held securely to one river bank they divert the current and cause the formation of deep scour pools and small waterfalls which increase channel roughness, dissipating the force of the water and increasing the habitat diversity for aquatic life forms. Large standing dead trees are also an important wildlife resource, providing food and habitat for many species.

4.3.3 Impacts to Riparian Habitat

The impacts to riparian habitat have been especially serious in California, where during the last century an estimated 95 percent of this type of habitat has been lost (Arnold, 1990). The alluvial areas of the riparian zone are often characterized by excellent soils and large deposits of river gravel—remnants of stream migration over time. These and other factors combine to make riparian zones economically important for agriculture and mining.

Removal of stream-side vegetation tends to increase light input, decrease the input of large organic debris, and increase sediment and nutrient inputs from the watershed. This causes water temperatures to rise and favors the growth of algae, resulting in a lowering of dissolved oxygen levels (Sparks, 1995). Although some of these changes may be beneficial to cold-water fish populations of high latitude and/or high altitude streams, they can cause severe degradation and a consequent decrease in salmonid fishes in streams of warmer climates. Reduction or loss of riparian cover reduced fish populations in some stream ecosystems by as much as 80% (Gore, 1995).

In forested areas of North America, large trees were once prevalent along almost all major rivers from the headwaters to the estuaries, but this is not true today in many areas of the contiguous United States. The significance of this major change in riparian habitat is that large standing or fallen trees were once very important for maintenance of the natural processes of both high and low-gradient streams, as well as for fish and wildlife populations. Standing and fallen trees and shrubs in the riparian zone hindered the flow of floodwater, substantially reducing their velocity and causing sediment to be deposited, eventually forming hummocks and terraces. Large root masses of living trees anchored the soil and reduced bank erosion. Fallen logs formed dams across the channel of small streams and served to trap sediments and to dissipate stream energy. In this way the riparian vegetation of undisturbed streams had a great effect on physical processes such as sediment transport, channel width, and stream configuration.

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4.3.4 Ecological Succession—Riparian Communities

An understanding of succession in riparian plant communities is critical to understanding the impacts to the riparian zone, as well as for developing management and restoration plans. Ecological succession can be described as the progressive replacement of one community by another, developing towards a more complex community structure. In each stage of riparian habitat succession, plants modify their environment, allowing invasion and eventual replacement by other plant species. Hydrologic and geomorphic processes significantly influence the distribution and survival of riparian vegetation.

Ecological succession of riparian communities along the north coastal streams of California has been well documented. The results of many studies indicate that most woody plant species on the gravel bars become established from May to July. Seeds from these species have a short viability and tend to germinate immediately after dispersal, but only in the moist, freshly deposited alluvium at the edge of the stream (McBride *et al.*, 1984; EIP Associates, 1994).

Germination, seedling establishment, and growth are correlated with sediment texture, while survival during the growing season is influenced by the depth to the water table. Sandbar willow and alders tend to establish on sediments less than 0.2 centimeters in diameter, with Fremont cottonwood and some willows establishing on sediments of 0.2 to 1 centimeter in diameter. Mulefat and other willow species tend to germinate on sediments greater than one centimeter in diameter (McBride and Strahan, 1984).

Seedling survival during the winter is affected by streamflow and sediment movement via the amount of scouring, the duration of inundation, and the age of the plants. These same factors affect saplings, but mortality rates are lower than those for seedlings. Growth to maturity is ultimately dependent on the stability of the gravel bar.

Judging by the ecological characteristics of their component species (reproductive strategies, survival, and regeneration), riparian plant communities are adapted to different levels of recurrent flood disturbance. The major natural factors controlling the community type are thought to be the availability of sufficient water in the soil to maintain the characteristic riparian species, the soil texture, and the frequency of disturbances by flooding and river channel meandering.

In the zone of seedling establishment within the stream channel, the summer drought survival of saplings and seedlings is related to the depth to the water table, and their winter survival to the duration of flooding (EIP, 1994). Pioneer, or early successional species which tend to colonize the gravel bars of the active channel include members of the willow family, alders and mulefat. These species germinate on the freshly deposited alluvium in extremely large numbers—few survive the summer drought and the winter flooding. Those that do survive will grow rapidly—up to ten feet per year—and will begin to trap sediments and build hummocks around their roots, often causing the stream to change course. As the bar builds in height and is laterally distanced from the stream channel, species which are less dependent upon direct access to groundwater begin to colonize the area.

Because species in the willow family (*Salicaceae*) tend to develop adventitious roots in response to a build-up of sediment around their trunks, they are capable of persisting in the floodplain terrace environment, provided that their roots remain tapped into the groundwater. In general, willows, alders and mulefat do not germinate on the floodplain terraces.

A "typical" point bar on Dry Creek or the Russian River has five main topographic features that support distinctive plant communities (McBride and Strahan, 1985). These are: the point bar bank (immediately adjacent to the stream), the first ridge and swale, the interior ridges and swales, the lagoon, and the base of the floodplain terrace. Gradual changes in the plant community (succession) occur on point bars as sediments are trapped by "pioneer" vegetation - mulefat, willows and cottonwoods. Ridges are formed, are built up to greater heights and eventually coalesce, with the more gravelly ridges remaining dominated by cottonwoods and willows.

Swale environments in active floodplains tend to be dominated by a mixture of Hind's walnut, box elder, coast live oak, and red willow, with walnut having the largest basal area and box elder the largest relative density. Coast live oak has a large basal area but a much lower relative density than other dominants. Reproduction in swales is dominated by box elder, although regeneration of walnut, coast live oak and Oregon ash is evident.

Active floodplain terraces may contain large individuals of both coast live oak and valley oak; however, the relative densities of these species are low compared to Hind's walnut and willows. Sandbar willow, alder, and cottonwood show significantly reduced relative densities on the floodplain terraces compared to point bars. Regeneration patterns suggest that Hind's walnut, California bay, and Oregon ash are capable of successfully establishing in this environment.

The outer banks of active floodplains show dominance by alder, cottonwood, and red willow; cottonwood and red willow are dominant where banks are in contact with the interior of point bars, and alder is dominant at the upstream and downstream ends of the point bars.

It has been suggested (McBride and Strahan, 1984) that floodplain woodlands, if left undisturbed by humans, will undergo succession to a community dominated by a mixture of Hind's walnut, box elder, oak, and bay. As the terraces continue to build in height, an increase in the more drought-tolerant species such as the oaks and bay may take place, which would come to dominate the community in higher elevations and floodplain sites most removed from the stream channel. The later stages of this successional process can be referred to as a "mature" riparian community. The term "climax" seems inappropriate for these older floodplain woodlands, since within a relatively short time the continuous migration of the stream channel will either destroy the community or will isolate it from the stream bed and the groundwater supply.

“Pioneer,” or early successional plant communities which develop on the in-channel gravel bars are characterized by low species diversity, while late successional plant communities are characterized by significant species diversity, with distinct layers of vegetation—canopy, shrub, vine and herbaceous. Although riparian habitat in the late successional stage is utilized by the greatest diversity of fauna, every habitat stage supports species which are adapted to its particular features. Especially important is the existence, at a given time, of a variety of habitat stages, age categories and land forms. This type of habitat heterogeneity has been implicated in the long term sustainability of river ecosystems (Power *et al.*, 1995).

Mature riparian plant communities, with their multi-layered habitat, may require up to one hundred years or more to develop, while the active channel habitat in the scour zone is often only a few years old. The meandering of the stream in a dynamic river ecosystem creates and destroys habitat over time. Large trees along the bank are scoured out and fall into the water, providing structure and complexity to the stream. Backwater sloughs, oxbows and floodplain wetlands contribute to the diversity of fish, wildlife and avifauna within the system.

4.3.5 Existing Riparian Habitat in the Upper Russian River

Circuit Rider Productions, Inc. (CRP) has mapped the existing extent of the riparian zone for the Upper Russian River Aggregate Resources Management Plan study area utilizing 1:6000 scale aerial photos (WAC, 1992) augmented with site specific ground reconnaissance by CRP ecologists.

The riparian zone of the Upper Russian river consists of Valley Foothill Riparian habitat, adjacent to and interacting with Riverine, Valley Oak Woodland and Montane Hardwood-Conifer habitats (California Department of Fish and Game Wildlife Habitat Relationship System (WHR).

Table 4.10 includes plant species common to the riparian zone of the Upper Russian River. Table 4.11 lists amphibians, reptiles and mammals which, according to the California Department of Fish and Game (WHR, Laudenslayer), *may* be found in the riparian zone of the Russian river. No field assessment of these species was performed as part of this plan.

Information gathered for the main stem and the tributaries within the study area included land use, land cover, canopy closure, land form, tree crown size and ground cover. These data were derived from 1:6000 scale aerial photos—no ground reconnaissance was performed. Data is summarized in Table 4.12 through Table 4.14.

Tables 4.15 through Table 4.16 contain data developed for the main stem only, north of Calpella and south of Hopland highway 101 bridge. These data were derived from aerial photos and were field corrected with ground reconnaissance by CRP ecologists. Data include successional status and average tree class size (dbh). Additional data about the riparian habitat resources of the main stem have been developed by CRP into a GIS format, and include species composition, percent cover, historic and current land use, land form and land cover (State Coastal Conservancy, in prep.). Data gathering methods and map accuracy standards are documented in Appendix C. As discussed earlier, riparian vegetation is stratified topographically according to ecological criteria such as tolerance to flooding, depth to groundwater and sediment size. Figure 4.24 depicts the expected natural riparian habitat cross-section within the Upper Russian River study area.

The majority of the remaining 2000 acres of riparian habitat within the study area exhibit low canopy closure and a diversity of land forms (Table 4.17). A significantly greater percentage of the riparian habitat is in an early to mid- successional state, with few areas characterized by late successional vegetation of significant size.

Morrison and York Creeks, and to a lesser degree Dooley and Feliz, exhibit an especially high percentage of early successional and/or unvegetated acreage within the riparian zone. Because mature riparian habitat areas support the greatest diversity of avifauna and other wildlife, this trend is problematic. Many areas that historically supported riparian habitat—probably in a mid to late successional stage—have been reclaimed for agriculture or other adjacent land uses up to the edge of the bankfull channel. Given the scour capacity of the channel, the bankfull channel of the Russian River and its tributaries often exhibit no vegetation, or vegetation in an early successional stage. Because only a few species of willow, cottonwoods, mulefat and alder are adapted to life in this scour zone, the plant species diversity within the bankfull channel area is limited.

Without a change in adjacent land uses which allow for a wider riparian corridor, given the reclamation of the majority of the historic floodplain, it is unlikely that the riparian zone within the study area will develop greater proportions of late successional or mature habitat over time. The natural trend towards development of late successional habitat may be constrained by adjacent land uses to such a degree that the system will continue to favor early successional habitat unless those constraints are removed.

Restoration of historic floodplain riparian forests would increase the diversity of habitat types within the riparian zone, and would be expected to increase the diversity and population size of the wildlife and avifauna dependent upon riparian zones.

Riparian habitat along the main stem and tributaries within the study area is presently being impacted in the following ways:

Downcutting

The main stem and many tributaries within the study area have exhibited a significant drop in the thalweg over the last 50 years. The downcutting of the bed has resulted in severe bank erosion which tends to remove the remaining mature riparian habitat at an accelerated rate. Severe downcutting of this type results in a channel which is no longer connected to the floodplain during dominant discharge events, a situation which may modify the natural patterns of seed dispersal, seedling establishment, and riparian community development, and have long term negative effects on riparian habitat sustainability (Sedell, 1984).

Downcutting may result in riparian habitat mortality as a result of lowered groundwater levels. The lowering of the groundwater table has been implicated in severe stress and up to 20% mortality of mature cottonwoods and willows on the Carmel River (MPWMD, 1996).

Downcutting of the main stem translates to the tributaries, resulting in a loss of gravels and exposure of the clay substrate in many places. In addition to the obvious problems that this phenomenon poses to spawning salmonids, seed germination and seedling establishment appear to be significantly compromised in these areas. The extent of this clay substrate phenomenon, and the degree to which riparian habitat is associated with it, needs further study.

A significant portion of the study area stream banks have erosion control features such as rip-rap, jacks or car bodies. This type of protection, in response to downcutting of the channel and severe bank erosion, may interrupt or prevent the development of riparian habitat. Table 4.16 outlines bank protection and instream data gathered by CRP in 1993 for the main stem only (State Coastal Conservancy, in prep.).

Non-native Species

There are many non-native plant species within the riparian zone of the Upper Russian River Aggregate Resources Management Plan study area. Some of them are extremely invasive, and may pose a threat to biological diversity within the basin as well as adjacent land uses. Two species, Tamarisk (*Tamarix spp.*) and Giant Reed (*Arundo donax*), are plants which utilize huge amounts of water, and may threaten the viability of adjacent agricultural operations on small tributary streams. Both of these species colonize disturbed sites such as unvegetated gravel bars and hummocks, are capable of out competing native plants, and provide limited habitat value. Giant Reed is presently found in isolated clumps throughout the study area. Tamarisk was observed only once on Parson Creek.

The Giant Reed, a native of India, has an estimated per acre evapotranspiration rate of 5.62 acre feet of water per year (Iverson, 1993), and burns "like gasoline" (Scott, 1993; Frandsen, pers. comm.). After burning, the plant readily sprouts new growth from the root crown. In an eight year period along the Santa Ana river in California, Giant Reed progressed from isolated clumps to being the only plant in the channel. It is now being sprayed aerially with herbicides multiple times per year. The only wildlife observed to utilize Giant Reed are rats (pers. comm., Gary Bell, 1996). Because Giant Reed colonizes the same substrate and elevations as riparian habitat, and (unlike riparian habitat) is fire adapted, it poses a severe threat to the sustainability of riparian vegetation, and riparian dependent species.

4.4 SUMMARY OF EXISTING RIVER CONDITIONS

Historic geomorphic and hydrologic changes in the Upper Russian River have occurred due to various land use practices in the past century such as agriculture, grazing, gravel extraction, dam construction, urbanization, and logging. Sediment is trapped behind Coyote Dam on the East Fork of the Russian River (constructed in 1958) and numerous stock ponds on smaller tributaries. Continued gravel extraction also reduces sediment supply to downstream reaches.

Evaluation of historic photographs show a narrowing of the riparian corridor related to floodplain reclamation for agriculture. Active bank erosion in some locations is causing a loss of land. A longitudinal profile surveyed in 1940 and 1979 show significant incision of up to 18 feet in the Upper Russian River. Historic cross-sections show significant incision of tributaries such as Forsythe Creek. The monitoring effort by the MCWA on the main channel and in selected tributaries provides recent data showing changes following the 1995 flood. Impacts of gravel extraction will be minimized by retaining as much of the bar form as possible during gravel extraction.

The Upper Russian River is an episodic system where short duration peak flows are relatively infrequent. The dominant discharge (channel forming flow) that transports the majority of the sediment over time recurs every 1.3 to 2 years on average. In the episodic Russian River, the dominant discharge will not occur every year.

There is a 4-year record of bedload and suspended sediment transport measurements initiated by the MCWA and the USGS in 1992. The bedload transport estimates for the short period of record are as follows: Ukiah (drainage area is 100 mi^2): 25 tons/mi^2/year (2,560 tons/year; 1,890 yd^3/year); and Hopland (drainage area is 362 mi^2): 85 tons/mi^2/year (30,360 tons/year; 22,490 yd^3/year). The bedload transport at the Cloverdale gaging station was estimated assuming that bedload transport rate for Cloverdale is 8% of the measured suspended sediment transport rate: Cloverdale (drainage area is 503 mi^2): 155 tons/mi^2/year (77,430 tons/year; 57,355 yd^3/year). The annual replenishment rate is estimated to be 50% of the transport rate.

Theoretical bedload transport equations were used as a comparison to the measured sediment transport data. Results of the Bagnold Equation are higher than measured bedload values for Ukiah and lower for Hopland and Cloverdale as follows: Ukiah: 50 tons/mi^2/year (5,080 tons/year; 3,760 yd^3/year); Hopland: 40 tons/mi^2/year (14,700 tons/year; 10,890 yd^3/year); and Cloverdale: 80 tons/mi^2/year (38,540 tons/year; 28,550 yd^3/year). These theoretical values are not as representative of bedload transport as the field measured data. This is because the theoretical values predict “potential” transport and assume that sediment supply is adequate for capacity transport to occur. Thus, the theoretical values over estimate actual transport.

A qualitative sediment budget suggests that more sediment was extracted in the past than was supplied from tributaries or upstream reaches in the 30 year period between 1950 and 1980, and that more extraction was permitted than could be replenished as of 1994. Site specific monitoring is needed to estimate tributary gravel replenishment. If extraction continues to exceed replenishment, continued incision and bank erosion in the main channel and tributaries is expected.   Continued gravel extraction may disrupt the riparian system by removing vegetation and interrupting the formation of complex instream habitat structure.

Based on the review of past surveys and documents, most of which were rather dated, both water quality (including water temperature) and physical habitat conditions for the species of special concern are in need of a great deal of improvement. The primary limiting factors appeared to be: 1) high water temperatures; 2) low to non-existent summer flows; 3) migration barriers; and, 4) siltation problems due to eroded banks. Many of these factors are attributable to the construction and operation of Coyote Dam. And, as most of the information was twenty or more years and old and of a qualitative nature, a more current evaluation of the drainage is warranted, particularly with regard to water temperatures and quality and quantity of substrate in spawning and rearing areas.

The riparian zone of the upper Russian River watershed has been reduced in size and complexity over the last 150 years by a variety of land uses. Many of the areas which historically supported floodplain wetlands and riparian forests in a mature stage have been converted to highly productive agricultural uses. The construction of Coyote Dam on the East Fork of the Russian River, and the changes in sediment transport and water flows which resulted, has presumably changed the structure of the riparian zone in the main stem and some tributaries. The significance of these changes is not well documented.

The lack of sediment supply associated with the dam, as well as removal of sediment for aggregate production, has resulted in bed downcutting in the main stem and in some tributaries. In some cases the downcutting has resulted in the removal of gravel from the bed of the stream, exposing the clay layer and reducing seedling germination and development.

In-stream removal of aggregate through bar skimming interferes with the successional processes which allow for the development of riparian vegetation. Extraction of gravel from floodplain terrace pits removes floodplain riparian vegetation which is in a mid-aged to mature state. The "capture" of floodplain terrace pits which extend below the thalweg of the river may result in rapid downcutting and loss of riparian habitat.

5. IMPACTS OF GRAVEL EXTRACTION

5.1 EFFECTS ON RIVER STABILITY

Collins and Dunne (1990) identify several potential impacts of gravel mining to fluvial environments that affect river stability, morphology, and therefore, habitat. Potential impacts of in-channel gravel extraction by skimming on channel stability include the following:

- Channel incision, or lowering of thalweg elevations. This reduces diversity of aquatic habitat by reducing the relative elevation change between pools and riffles;

- Incision or headcutting in tributaries in response to a lower base level in the main channel;

- Increased bank heights, bank erosion, and channel capacity due to channel incision;

- Threat to infrastructure such as bridges due to incision that undermines bridge piers or supports. A recent memorandum from the Federal Highway Administration and Caltrans instructs planning County agencies that in the future, the impacts of gravel extraction on existing bridges will be evaluated. Emergency bridge repair funds will be withheld or efforts may be made by the State to recover bridge repair costs from the legally responsible parties (Appendix D);

- Exposure of clay substrate layer within or below gravel deposits due to incision may remove gravel that is a necessary component of habitat. Clay is exposed in several locations in the main channel from Redwood Valley to reaches south of Calpella. Clay is also exposed on the bed of the channel in tributaries such as Forsythe Creek.

- Local widening and flattening of the low flow channel in gravel extraction area where bar skimming occurs. This leads to braiding of the low flow channel, and increased potential for bank erosion;

- Downstream channel changes including reduced sediment supply to downstream bars, widening and flattening of low flow channel, and increased potential for braiding;

- Upstream channel changes including incision or lowering of the thalweg elevation due to headcutting upstream of the mining area;

- Removal of riparian vegetation reduces habitat and may cause channel instability and increase bank erosion;

- Incision can cause a lowering of the groundwater table in the adjacent floodplain aquifer. This may increase pumping costs for wells such as the Willow County

Water District intake and the City of Ukiah Intake, reduced aquifer storage, and could impact riparian vegetation by isolating roots above the water table;

C Degradation of habitat from the removal of the armor layer or coarse sediment from bars and release of fine material to the channel downstream.

Potential hydrologic and geomorphic impacts of floodplain pit excavation include:

C Potential for “river capture,” or the potential for river meanders to migrate, over time, through the portion of the floodplain left between the river and the pit. The potential for this to occur is greatest when the pit is close to the river, or when the pit is deeper than the river channel. If the river is diverted to the location of the extraction pit, there is the potential for rapid upstream headcutting and downstream reduction of sediment supply;

C Reduction in the filtering ability of the floodplain aquifer.

Potential impacts of “floodplain skimming,” where excavation of the floodplain takes place by creating terraces include:

C potential loss of riparian vegetation and habitat if excavation is not set back from riparian zone;

C potential loss of stability if excavation terraces are set below elevation of the dominant discharge. In the Upper Russian River, the elevation of the dominant discharge is below the top of bank (or bankfull elevation), and floodplain skimming is a viable option at present.

5.2 EFFECTS ON FISHERY RESOURCES

Gravel mining operations can impact the riparian corridor, which, in turn, may impact one or more life requisites of the fishery resources of the Upper Russian River Watershed. As previously discussed, salmonids use gravel in the following ways during critical life stages of their life cycle:

1. As a medium for spawning, incubation, and hatching of eggs;

2. As cover for young salmonids to seek shelter; and

3. As habitat for aquatic organisms, food items for young fishes.

In addition, the operations involved in gravel mining may affect the life stage requisites during one or more life stages in the life of the species of management concern. However no "cause-and-effect" type studies have been undertaken to determine the degree to which gravel mining operation results in stressful impacts on selected fishes. Thus, this section addresses potential impacts rather than known impacts, based both on studies from other areas, and professional conjecture.

Following are potential impacts of gravel extraction operations on fishery resources (Sonoma County, 1995 a, b, 1994 a, b; Yolo County Community Development, 1995; CFG, 1991; Collins and Dunne, 1990; Brookes, 1988; Martin and Platts, 1981; Bull and Scott, 1974; Vestel and Lassen, 1969):

- A reduction in salmonid spawning gravel, protective cover, and food resources, if gravel is depleted at a greater rate than it is replenished;
- Increased proportion of fine grain sizes, which can be detrimental to salmonids;
- Increased siltation, which could be detrimental to the fishery resources;
- Increased sediment input into the waterways as a result of the construction of road crossings and spur roads;
- Increased erosion and sedimentation into the creek, due to improper placement or removal of culverts in summer road crossings;
- Settling of fine-grained sediment could occur in fish food-producing areas, thereby smothering fish food organisms, if the streamflows are not adequate to move and deposit sediments to normal depositional areas;
- Increased water temperatures, eroded banks, and reduced food availability, if the riparian habitat is altered and/or destroyed;
- Decreased habitat for both fish and fish food organisms, if large woody debris and/or vegetation growing on gravel bars are removed during the annual gravel bar skimming;
- Diminished habitat quality (reduction in pool size) and quantity, if the stream bed geomorphology is altered;
- Direct kill, if any fish are present in the excavation area;
- High fish mortality (thermal stress, predation), as a result of the drying up of pools created during the gravel operations;
- Blockage of migration of salmonids and tule perch, as a result of construction of summer road crossings; and
- Reduction of large pools or deep holes, necessary for salmonids, particularly as a thermal refuge during the hot summer months, when little or no canopy is present.

5.3 EFFECTS ON RIPARIAN HABITAT

This section of the plan specifically addresses those mining impacts associated with riparian vegetation, which is critical to the long term viability of fisheries, wildlife and avifauna. At present, coho salmon are the only constituents of the riparian community of the Upper Russian River considered to be a threatened species under federal law. Coho salmon, a species dependent upon riparian habitat, was listed as threatened on October 25, 1996 for the Central California ESU (Evolutionarily Significant Unit). The agency with jurisdiction over this species is NMFS. Steelhead is proposed for listing as an endangered species and a decision will be made Augugst 7, 1997 (NMFS, pers. comm.). There are four primary ways in which gravel mining impacts the riparian habitat within the study area:

Bar skimming disturbs the existing riparian vegetation, providing opportunities for invasion by non-native species, such as Giant Reed;

Bar skimming mechanically removes habitat at the early to mid-successional stages, interrupting the natural formation of landforms which develop habitat complexity and a diversity of age classes. Depending upon the frequency at which a given bar is skimmed, the vegetation will be artificially maintained in an early successional stage, favoring those species adapted to this habitat type. Maintaining the stream side vegetation in a relatively early successional stage reduces the opportunity for shading of the stream, potentially resulting in thermal problems and a reduction in species diversity;

Downcutting of the river channel associated with gravel mining documented in the Russian River Resource Enhancement and Public Access Plan and in this study (California State Coastal Conservancy, in prep.) can increase stream velocity and bank erosion, resulting in impacts to all habitat stages. Increased velocity within the channel scours vegetation at an accelerated rate. The banks in a downcutting system become unstable as the river attempts to widen, resulting in the loss of the mature riparian habitat on the terrace. In a downcutting channel, a gradual transition zone between the terrace and instream communities is often lacking—i.e., a steep bank separates the mature terrace vegetation from the early successional stages within the active channel. In extreme situations, such as those which presently exist along the Russian River, the combination of accelerated scour in the channel and erosional pressure on the banks has resulted in areas virtually devoid of vegetation. Rapid degradation of the bed elevation can result in mature terrace riparian plants losing their connection to the groundwater (MPWMD, 1996), causing mortality and a loss of floodplain wetland features (Sparks, 1995);

In-channel mining may modify the substrate within the zone of seedling establishment, both up and downstream of the mining site. Substrate modifications of most concern are those which result in loss of gravels and exposure of the clay layer. Changes in the substrate may prevent seedling germination, or favor the development of one species over another, resulting in a change in canopy or stream-side vegetation density;

Terrace pit development impacts riparian habitat by removing vegetation—often for the long term. Pits may also constrain the channel, reducing the area in which a diversity of riparian habitat stages may develop. Depending upon the way in which the pits are designed, they may be restored to agriculture, riparian or wetland habitat. Terrace pits which have steep sides and are excavated lower than the thalweg of the stream provide little opportunity for the natural development of vegetation, and little habitat value (EIP, 1994). If a terrace pit is captured by the stream, there is the potential for significant upstream and downstream impacts to riparian habitat as the stream responds to the change in bed elevation.

6. ALTERNATIVES TO RIVER CHANNEL AND FLOODPLAIN EXTRACTION

This section addresses several topics required to prepare the Upper Russian River Aggregate Resources Management Plan including:

1. Aggregate uses and specifications;
2. Market area for aggregates from the Upper Russian River;
3. Non-stream sources of aggregates in the Upper Russian River market area;
4. Market demand for aggregates; and
5. Resource conservation strategies.

The regional location for the Upper Russian River Market Area is shown in Figure 6.1. The data reported in this section were gathered from personal interviews with staff members of Caltrans, the California Division of Mines and Geology, the Mendocino County Public Works Department, the Mendocino County Planning Department, the Mendocino County Public Health Department, the Mendocino County Water Agency, the City of Ukiah Public Works Department, the City of Willits Public Works Department, the California Mining Association, the Northern California Aggregate Association, as well as from conversations with several aggregate producers in the area. Additional data were gathered from the State of California Office of Mine Reclamation, the State of California Department of Finance Demographic Research Unit, the U.S. Bureau of Mines, and other reports.

6.1 AGGREGATE USES AND SPECIFICATIONS

This section discusses how aggregate resources are currently used in the Upper Russian River market area of Mendocino County. Aggregate uses are generally based upon the aggregate materials meeting specifications that are set by public agencies and technical organizations. Aggregate suitability and processing are discussed in order to identify how specifications and the requirements for construction use influence the production and consumption of aggregate materials in the Upper Russian River market area.

6.1.1 Aggregate Use

Aggregates are used for a wide variety of construction activities. They are a fundamental ingredient in the construction of dwellings, industrial and commercial buildings, parking lots, roads and highways, dams, bridges, railroads, schools, public utilities, and levees. Aggregates are used for decorative purposes in landscaping as well as for erosion control, fill, and other purposes.

Rock materials are used in two forms: loose and combined with binding agents. In loose form, without a binding ingredient, aggregates are used primarily as base and subbase materials for road and building construction, as backfill in culvert and pipeline trenches, and as permeable material in drain and septic systems. Railroad beds, streambank rip-rap, levees, and other types of fill also require the use of aggregates in unbound form.

For certain construction applications aggregate is mixed with binding agents. When combined with Portland Cement as concrete, aggregates are an important component in building construction, including walls, foundations, sidewalks, curbs, driveways, parking lots, city streets, bridges, and facilities for sewer and waste transport and treatment. In combination with asphalt binding, aggregates provide surfacing and structural materials for streets, roads and highways, driveways, parking lots, and roofing.

Typically, the demand for aggregate corresponds with the size of the population, although production may fluctuate from year to year in response to major construction projects. During the post-World War II period a major portion of the aggregate mined in the local counties went to highway construction. Since the completion of Highway 101 in the late 1960s, the bulk of aggregate production and use appears to have shifted to residential and related construction.

In Mendocino County, 100 percent of the state highways and 60-70 percent of the county roads are surfaced with Asphalt Concrete (AC). AC costs less than Portland Cement Concrete (PCC) and is easier to cut into if there is a need to install utilities after the road is surfaced. Curbs, sidewalks, driveways, bus parking areas, and drainage facilities are mostly made of PCC. Past trends have included reducing the AC layer and increasing the base rock layers underneath to ease utility work and maximize the amount of paved surface with limited construction funds. Further reduction in AC thickness is unlikely, but the future will probably see greater base strength to support increased traffic loads and more frequent seal coats and minor repairing to reduce the need for major repairing or reconstruction.

6.1.2 Aggregate Properties and Specifications

In order to ensure that aggregate materials possess the necessary physical properties for particular construction uses, governmental agencies and other major consumers have established specifications for aggregate quality. On the basis of standard testing procedures developed by the American Society of Testing Materials (ASTM) and the American Association of State Highway and Transportation Officials (AASHTO), these specifications have been refined over a number of years based on experience under both laboratory and field conditions. Organizations that use specifications for aggregate quality in Mendocino County are the Mendocino County Public Works Department, Public Health Department, and Building Department; the Mendocino County Water Agency; Caltrans; the Army Corps of Engineers; a variety of sanitation and school districts; various municipalities; and utilities, including Pacific Gas and Electric.

Specifications vary considerably depending upon the end product and it's intended use. However, for most specified uses, rock materials must be relatively clean and free from organic matter and deleterious substances, durable and resistant to wear, and of proper size, shape, and texture. The specifications for PCC and AC are generally the most detailed and stringent. However, rock suitable for PCC or AC may not necessarily be suitable for some other uses due to variations between aggregate specifications for different types of construction uses.

The following section describes the necessary physical properties and testing procedures used to determine aggregate performance for each major use category: PCC, AC, asphalt concrete base (ACB), road base, road subbase, various fills, and other uses. A summary of the testing requirements for these categories can be found in Table 6.1.

Portland Cement Concrete

Specifications for aggregate used in PCC are more stringent than for most other uses. In addition, the large variety of uses for concrete means that specifications vary widely. However, in most cases concrete aggregates are evaluated by characteristics such as strength, abrasion resistance or durability, chemical stability, soundness, particle size distribution, lack of organic matter and other deleterious substances, particle shape and texture, the amount of sand present as compared with clay and alkali-reactivity. There are four classes, A through D, of PCC specified by Caltrans.

Asphalt Concrete and Asphalt Concrete Base Aggregates

As with those for PCC, specifications for aggregates for AC and ACB are quite stringent. The asphalt binder is more plastic or flexible than cement binder. As a result, gradation and particle size and shape specifications for AC are different than those for PCC. In addition, a minimum percentage of crushed particles is required. However, as with PCC, durability and cleanness, or lack of fines, are required properties according to state specifications developed by Caltrans and used by most public works agencies. Caltrans specifies three types of AC, Type A or B or Open Grade, although Open Grade is not used very often.

Road Base

Specifications for aggregates used as road base generally allow an increased percentage of coarse or larger materials compared to those for AC. Base materials, with the exception of cement-treated base, support the road surface without a binding agent as in asphalt or concrete. Durability, cleanness, and structural stability are, therefore, important properties. The resistance of the material to lateral movement from vertical pressure, which is measured as the material's R-Value, is also important. The R-Value test is a general indicator of the aggregate's strength. A minimum percentage of crushed particles is also specified as with AC. Base is specified by Caltrans as Class 2 or 3. Base rock is sometimes substituted for subbase due to availability and ease of handling.

Road Subbase

Specifications for subbase aggregates are the least stringent of the four major use categories mentioned so far. Gradation requirements are less exacting, and durability testing is not required. However, since the subbase, like untreated base, must remain in place without a binder, cleanness from excess clays and resistance to lateral movement, as measured by the R-Value, are essential. The subbase must also be readily compactable and clean of organic matter. There are five classes of aggregate subbase, classes 1-5 with varying requirements for each.

Embankment Materials

Generally, the least exacting requirements apply to the materials in this category. Specifications for embankment materials, or general fill, vary considerably depending on the intended use. Many native materials used for roadfill in rural areas perform adequately while meeting minimum specifications. Embankment materials are generally required to meet gradation, compaction, and R-Value specifications.

Structural Backfill and Pipe Bedding

Structural backfill specifications have been established by both public agencies and private companies. Materials used for these purposes must be durable enough to resist breakdown and generally free from excess clays to minimize absorption of moisture and subsequent expansion. Compactibility is also a consideration. Most structure backfills must meet minimum requirements for gradation, compaction, and the equivalent amount of sand present. Structural backfill is specified by Caltrans as Type C, D, or E. Many consumers require that structure backfill aggregates meet the specifications for Class 2 aggregate base.

Pipeline bedding materials are often specified to be rounded or cubical so that pipes of vulnerable composition are not damaged by sharp fragments. Compactibility is a factor as well as chemical stability for certain uses requiring backfill or pipeline bedding.

Drain Rock

Where public sewer service is not available, the Mendocino County Public Health Department requires disposal systems with sewage leachate flowing through various aggregate materials to filter out solids, evaporate and drain off water, and facilitate bacteria decomposition. Specifications for the drain rock in septic systems are generally limited to cleanness and size gradation. The filtering system works best with mid-size range rock, Conventional leach field trenches must be filled with clean rock between 0.75 and 2.0 inches in diameter; this rock can be either round or crushed rock.

The Public Health Department permits leaching through above-grade mound systems in locations where the groundwater levels are near the surface. A mound system typically requires about 206 cubic yards of sand and gravel.

The Department is also considering permitting gravel-less systems (such as the vault system) which does not require the use of aggregate in the leach field. Such systems may be permitted only where soil conditions allow the required disposition of leachate (Ehlers, pers. comm.).

Permeable Materials

Permeable material consists of hard durable, clean, gravel or crushed stone. Permeable material is generally used when a layer of aggregate is needed that will allow a fairly large flow of water to drain from an area of excess moisture. This material has been designed as a fairly well graded material, except with few fines at the lower end of the grading curve. An aggregate graded in this manner will not become "plugged" as easily with surrounding soils and will allow water to flow through the material. Permeable material is specified by Caltrans as Class 1, including Types A and B, or Class 2. The primary difference between the various types and classes of permeable material is the gradation of the aggregate.

Rip-Rap

Rock used for slope and streambank protection must be durable, relatively non-porous, and stable after placement. Gradation specifications require large-sized rocks in most cases. Resistance to wear is tested by the durability index test, and specifications normally require approximately the same durability as road base. Rock that is porous and absorbs moisture is not suitable for this use. Rip-rap must also meet certain specifications for specific gravity, an important property in stabilizing streambanks when subjected to water flow.

Bituminous Road Seals

There are various types of road surfaces, including chip seals and slurry seals, that are directly subjected to stress from traffic and weather. As a result, specifications for these uses deal primarily with durability, moisture protection, and skid resistance. For protection from moisture, an asphaltic oil coating is applied to the aggregate. The affinity of the aggregate for the oils is determined by a "film-stripping" test. Gradation, cleanness, and particle shape are also important considerations. Skid resistance can be improved by using fractured particles.

6.1.3 Aggregate Specifications

Specifications for aggregate for particular uses are usually based on national standards and testing procedures, but often differ among agencies, depending on particular concerns and expertise. Furthermore, the establishment of material requirements for some uses often depends upon the availability of particular sources as well as the structural properties of the aggregate.

Since material requirements are often extremely significant in determining the potential sources of construction aggregate, a comparison among the requirements of several agencies will assist in understanding the constraints associated with production of aggregate materials from different sources. The standard specifications published and revised by Caltrans have been used over the years as a guide to local agencies in making their own determinations of aggregate suitability. Most specifications used by Mendocino County and local municipalities conform closely to the Caltrans standards. Table 6.2 compares the specifications of Mendocino County, the City of Ukiah, and the City of Willits, with those developed by Caltrans.

In addition to Caltrans, many other public agencies set standards for aggregate use. The Army Corps has established performance specifications for aggregate materials used in their projects that are generally more stringent than the standard Caltrans specifications. Many public works departments and water agencies adhere to the Standard Specifications for Public Works Construction designated by the American Public Works Association, the American General Contractors Association, and a cooperative committee, also known as the "green book." The County Public Health Department has specifications relating to aggregate for septic tank leach fields. There is also an ASTM regulation for sand used for leach fields from pressure distribution and mound systems.

Due to the specifications required by Caltrans and other local and federal agencies and the associated costs for maintenance, Mendocino County is fairly limited in its ability to change existing specifications for County road projects. For instance, the County must meet Caltrans specifications on State and federally funded highway projects. In addition, the increasing loads on most roads limit the possibility of reducing any of the road construction specifications.

Options for balancing the environmental and economic aspects of the use of aggregate resources relate not to modifying existing specifications, but to looking at different ways of meeting the existing specifications that allow more flexibility. Some options include recycling and reclaiming of aggregate materials and recycled materials; implementing design, bidding, testing, and inspection procedures to prevent aggregates of a higher quality than needed from being specified; and, finally, ensuring that quarry materials and recycled materials that are able to meet specifications are actually allowed and used where possible by considering the characteristics of such materials in the design of specifications. Any such changes made to Mendocino County specifications must consider the long-term effects on purchasing and maintenance costs and the continuing need to protect the health and safety of the public. In the Upper Russian River market area reclaimed aggregates are processed and sold by Ford/Parnum Paving.

6.1.4 Aggregate Suitability and Processing

Three sources of aggregate materials are present in the Upper Russian River Market Area of Mendocino County: quarries, instream gravel, and terrace gravel deposits. Rock products from each source have particular properties that determine whether they meet various performance standards, with or without additional processing. The viability of different sources for any use depends primarily on the rock itself and on the processing required to prepare the rock. Different consumer specifications and resource characteristics place different demands on material preparation, but it is possible to make generalizations about source suitability for each use category.

For most aggregate uses, rock from all of these sources requires varying amounts of processing. Depending on the site, the processing operations may include site preparation, removal of overburden, blasting excavation, crushing, screening, classifying, washing, and product batching. Other processing operations used less frequently are those associated with processing to develop specialty products and the removal of various deleterious substances.

In the past, there were low expectations regarding quarry rock's physical and economic feasibility for construction grade uses. Nonetheless, throughout the United States in areas where alluvial deposits are not readily available, hard rock sources from quarries provide aggregate materials for all construction uses. According to Caltrans, aggregate from both alluvial sources and from hard rock quarries will usually meet their specifications. The primary difference, from Caltrans' point of view, is that quarry rock is more expensive.

At this time, most of the aggregate available in the Upper Russian river market area is from quarries. The only sources of alluvial sand and gravel are those available to two operators who possess vested rights. According to SMARA (Surface Mining and Reclamation Act), a person has a vested right to continue to conduct surface mining operations without a new mining permit if the operation was legally and diligently commenced prior to January 1, 1976, and no substantial changes in operation are made. The two operations in the market area that possess vested rights are Redwood Valley Gravel (Reclamation Plan 1-91), and Ford Gravel (Reclamation Plan 1-83). Although an operation covered by a vested right does not need a permit, it must have a reclamation plan approved by the County. Thus, these operations are referred to by a reclamation plan number rather than by a permit number. Pit mining, terrace mining, and gravel bar skimming are all allowed under Ford Gravel's reclamation plan. The reclamation plan for Redwood Valley Gravel is still unfinalized but will include gravel bar skimming.

The major differences in processing requirements between quarry rock and alluvial sand and gravel are the amount of crushing and washing necessary to produce particles of the proper size and shape. Crushed rock from quarry sources that is durable enough to supply construction aggregate often must be blasted prior to extraction The nature and configuration of different materials within the quarry deposits can also affect the cost of extraction. The cost differential between using aggregate from alluvial sources versus quarry reserves also varies according to the location and the amount of transportation required to supply the aggregate material to a user. Usually, aggregate from quarries requires more processing, as well as a higher start-up investment; thus, aggregate from quarries tends to be more expensive.

Table 6.3 shows prices reported by producers for various aggregate products. In the Upper Russian River market area quarried products are not more expensive than alluvial aggregates. This is due to the restricted amount of sand and gravel available from the Upper Russian River, as well as to the competitive nature of the market area.

Despite local prices, it is more expensive to produce PCC aggregates from quarries. Additional processing is required, including: blasting operation (including materials and labor); extraction operation (including ripping and dozing); crushing operation (including sand manufacturing); washing materials; and labor (including extraction, washing, and crushing).

Crushed particles are required for some uses, such as AC and road base. As an example, "Type A" AC requires a minimum of 90 percent crushed particles. When this is the case, the crushing operation must be undertaken regardless of the source material; alluvial deposits generally require more crushing than quarry deposits for asphalt mixes. Therefore, current industry estimates place a higher cost on asphalt aggregates produced from alluvial sources. An additional cost may be incurred during production of AC from alluvial sources due to the additional cement or oil that may be required when using rounded aggregate materials. The ability of aggregate from alternative sources to meet standards of performance for particular construction applications is a matter both of its inherent physical properties (including size, shape, and strength), and the need for any additional processing. The following evaluation of the viability and suitability of aggregate from alternative sources for various uses is based on these two factors.

Portland Cement Concrete

Concrete aggregates can be produced from any of the aggregate sources discussed above if the material meets basic requirements for hardness, durability, and alkali-reactivity. The most desirable shape is spherical or roughly cubical. Quarry materials must be crushed into suitable cubical shapes. Aggregate particles that are angular require more cement to maintain the same cement/water ratio. However, with satisfactory gradation, both crushed and non-crushed aggregates generally give essentially the same strength for the same cement factor. The bond between cement paste and a given aggregate generally increases as the particles change from smooth and rounded to rough and angular. This increase in bond strength is a consideration in selecting aggregates for concrete where flexural strength is important or where high compressive strength is needed. An overabundance of rounded pieces may reduce the ability of the aggregate to interlock and thus reduce flexural strength. Generally, the angular fragments are less desirable for pumping and finishing, but this can be balanced by the addition of more cement to the mixture.

Crushed rock pieces that are flat and elongated make a concrete mix that is difficult to work and may weaken concrete. Aggregates with high percentages of flat and elongated pieces require high cement factors to produce workable and durable cement, and some specifications require that such aggregate be rejected.

Approved Sources

Aggregate for PCC to be used on State Highway projects must be from a Caltrans' approved list of aggregate sources. In the Upper Russian River market area, the list of approved sources (AB 3098 SMARA Eligible List 10/6/95) and other approved sources in Mendocino County are shown in Table 6.4.

Asphalt and Asphalt Concrete Base

Specifications for aggregate for AC and ACB can be met by all sources in the Upper Russian River market area. Primary requirements for abrasion resistance and sands equivalent can be met by each source depending on the geologic nature of individual deposits. Gradation specifications place a priority on finer-grained materials. In order for quarry operations to supply these finer materials they must "manufacture" sand by extensive crushing or import sand from another source. Certain percentages of crushed particles are also required, depending on whether Type A or Type B is specified. It may be either crushed rock from a quarry or from alluvium deposits although the amount of crushing needed varies.

Road Base

Specifications for road base can be met by all sources in the Upper Russian River market area. Requirements for gradation, sand equivalent, and R-Value are more stringent for base than for subbase. Neither these nor additional specifications for durability and particle shape place any limitations on any of the sources of supply. A small percentage of crushed fragments is usually specified to prevent shearing. This percentage is now 25 percent in Caltrans and County specifications.

Road Subbase

Specifications for road subbase can be met by all sources in the Upper Russian River market area. On-site native materials can rarely meet subbase specifications for gradation, sand equivalent, and R-Value.

Structure Backfill and Pipe Bedding

From a materials standpoint, all sources of aggregate can meet specifications for structure backfill. Native materials obtained during excavation may also be used for backfill if they meet specifications. A drawback to the use of native materials is the difficulty in locating old trenches when excavating for repairs. When rough textured or crushed particles are used for backfilling trenches, compaction is somewhat more difficult to achieve. Rounded materials will compact or settle with an application of water, while crushed rock often needs additional tamping or vibrating to meet compactibility requirements.

Due to the potential for damage to certain types of pipes from angular rock fragments, Pacific Gas and Electric and other utilities often require rounded sands for their pipe bedding. This requirement depends, however, on the composition of the pipe itself. Some pipe materials, such as concrete, are not as susceptible to damage as others. The use of a pipe casing can eliminate this problem altogether, although it can be more expensive.

Embankment Materials

Embankment materials are generally required to meet lower compaction standards. Agency specifications for sand equivalent, R-Value, and compactibility occasionally exclude the use of native fills, but most mining operations can meet material specifications for embankments.

Drain Rock

All sources of aggregate in the Russian River Market area can make specification drain rock for conventional leach fields, as particle shape is not as important a factor as cleanness and proper size gradation. However, smaller particles are discouraged, thus increasing the relative viability of quarry rock for this use. The size and shape of the sand particles is critical to the proper sewage flow and filtering operation in the mound and sand filter systems. Nearly all of the sand for these systems has come from alluvial sources in the past. Sand can be made from quarry rock, although it is more difficult and costly to make the right sizes and remove the finer and coarser materials.

Rip-Rap and Slope Protection

Instream sources cannot generally provide larger sizes of rock. Certain quarries have rock that can meet all rip-rap specifications, including durability and specific gravity. Both alluvial and quarry sources can provide sizes smaller than 3 inches to 6 inches. Quarried rock may need additional crushing as required size diminishes.

Road Surfacing

Specifications for road surfacing can be met by both alluvial and quarry sources. Crushed fragments provide more skid resistance in asphalt oil/rock coverings. However, the smaller sized particles required must be crushed extensively when obtained from most quarries.

6.2 MARKET AREA

In California, the market area for a particular aggregate source is generally considered to be the area within 25 miles of the source (Cope, Northern California Aggregate Producers Association, pers. comm.). On the basis of conversations with producers and local agency staff, the market area that includes the Upper Russian River is defined as the area from Willits south to the Sonoma County line and the area east of the coastal mountain crest to the Lake County line. This can be defined as Census Tracts 107, 108, 109, 112, 113, 114, 115, 116, 118 and block group 4 of Census Tract 106, as shown on Figure 6.2.

Due to the lack of records showing where aggregates are sold, this definition of the Upper Russian River market area is by necessity anecdotal. Aggregates are imported into the Upper Russian River market area from Shamrock Materials in Sonoma County, lava rock is imported from Lake County, and sand and gravel are imported from the Eel River in Humboldt County. In addition, Upper Russian River market area aggregate producers export aggregate to outside the Upper Russian River market area. The areas to which aggregate or aggregate products (PCC, AC, and PCC products such as septic tanks) may be exported include: other parts of Mendocino County, Lake County, Humboldt County and Sonoma County.

To establish a market area for the purpose of analysis it is necessary to make a series of assumptions as listed:

1. The amount of aggregate exported from the Upper Russian River market area to Lake County is balanced by the lava rock imported from Lake County for leach fields and landscaping and imports from the Eel River to the north.

2. Aggregate movement between Sonoma County and Mendocino County balances over the period of a few years depending on the location of Caltrans jobs.

3. Although the coastal area of Mendocino County may use a significant amount of gravel from the Upper Russian River market area if a major construction project is taking place, overall, the Mendocino coast forms a discreet market area that meets local demand from local sources.

4. Northern Aggregates, an aggregate producer located in Willits, is known to sell aggregate as far south as Sonoma County. For this reason, Census Tract 107 and block group 4 of Census Tract 106 (the Willits area), are included in the Upper Russian River market area.

These assumptions are based in part on the conversations that are summarized below:

1. Northern Aggregates operates two quarries, one outside Willits (the Harris Quarry) and one near Pieta Creek (the Pieta Quarry). Rita Santos of Northern Aggregates has stated that the company sells aggregate from the Harris Quarry into the southern part of Mendocino County and, occasionally into northern Sonoma County. She stated that the area south of the Ridgewood Summit is definitely part of their market area. Their sales into Sonoma County are not significant, but Lake County is an important part of their market area. Northern Aggregates also sells their products in coastal Mendocino County. She stated that the quarry selected to supply material for an order is dictated by the material currently stockpiled at a given quarry, as well as the location of the job. During heavy rains no material is taken from Pieta quarry as the dirt access road is not usable.

2. Hank Oberfeld of the Oberfeld Quarry in Potter Valley has stated that the market area for Russian River aggregate includes Potter Valley. He sells ninety percent of the aggregate he produces in Potter Valley. He does not supply concrete, or rock that can be used for concrete. It is his opinion that river run rock is the best material for concrete and he does not try to compete in that market. He occasionally sends material to Ukiah or Willits, but it is not a significant portion of his business.

3. According to Rick Seanor of the City of Willits Public Works Department most of the aggregate used by that department comes from Northern Aggregates. He believes the aggregate generally comes from the Harris Quarry outside Willits. Asphalt for the City of Willits is provided by Parnum Paving. Parnum Paving is located in Ukiah but has sources

of aggregate all over the County. In addition, Parnum Paving has purchased rock from Northern Aggregates and subcontracted for Northern Aggregates to crush rock for Asphalt Concrete (AC). Therefore, AC supplied by Parnum in Willits may be using locally quarried rock.

4. Larry Wood of the City of Ukiah Public Works Department states that most of the gravel used by subcontractors on City projects comes from Ford Gravel. Asphalt Concrete comes from Parnum Paving.

5. It is the opinion of Doug Ellinger of the Mendocino County Public Works Department, and he emphasized that this was a personal opinion, that the market area for Russian River aggregates would be from Ridgewood Summit south to the County line and from half-way to the coast east to Lakeport, in Lake County. He stated that Lakeport was "hurting for gravel." He also stated that products out of Cloverdale, most particularly concrete, were used by many Public Works Department subcontractors. He stated that Ford Gravel has the only concrete plant in Ukiah, and it was not always available. In addition, for jobs near the Sonoma/Mendocino County line, the subcontractor might be out of Cloverdale and would prefer to use a familiar supplier also located in Cloverdale.

6.3 AGGREGATE PRODUCTION

Currently, in the Upper Russian River market area, the primary non-stream source of aggregate is hard rock quarries. As discussed earlier, Ford Gravel is removing some aggregates from terrace deposits. It is not known precisely how much aggregate is removed from the terrace deposits as the reporting under this reclamation plan is not broken down by source. At this time, the County has not approved any permits for terrace mining. In addition, there are no active or inactive mineral-producing mines in the County that might provide tailings that could be used as aggregate.

Table 6.5 lists aggregate producers currently operating under permit within the Upper Russian River market area or who have a permit application under consideration. The locations of these producers' aggregate sources are listed on Table 6.5 and are shown on Figure 6.3. Figure 6.3 distinguishes between types of sources: alluvial (including terrace deposits) or hard rock quarries.

6.3.1 Upper Russian River Market Area Producers

There is a shortage of records for historic production by individual producers in the Upper Russian River market area. Although, permit requirements state that producers shall submit yearly extraction figures to the County Planning Department, many do not. Ford Gravel has reported extraction for the vested right operation covered by Reclamation Plan 1-83, Northern Aggregates has reported extraction for both Harris and Pieta Quarries, and Louisiana-Pacific Corporation has submitted extraction figures for Little Eagle Rock Pit. None of the other producers in the market area have reported extraction figures to the County.

In 1994, aggregate producers in the Upper Russian River market area held permits and vested rights that allowed them to remove 565,000 yd^3 per year from hard rock quarries and 53,000 - 140,000 yd^3 from alluvial sources. This number is based on the permits issued by the Mendocino County Planning Department, it varies slightly from month to month as old permits expire and new ones are approved. Many factors influence the amount actually removed. These factors include market demand and, for the aggregate producers with instream operations, the amount of gravel that has been deposited in the stream bed over the previous winter.

Table 6.6 shows the amount of aggregate extraction allowed in the Upper Russian River market area by permit and vested right. Table 6.7 presents the extraction figures reported to the County Planning Department or to LCA by personal communication from producers. When there were no reported figures, the amount allowed by the permit was used. Table 6.7 indicates that a maximum of 354,678 yd^3 of aggregates was extracted by market area producers in 1994.

6.4 MARKET DEMAND

6.4.1 Methodology

Aggregate usage rates are influenced by a variety of factors, including population growth and major road and construction projects. The State Department of Mines and Geology has determined that population projections, combined with an assessment of past aggregate use, are the most accurate means of predicting future aggregate demand (Bob Hill, pers. comm.). This method of estimating future aggregate demand is the same method found most accurate by the preparers of the Sonoma County Aggregate Resources Management Plan. The Sonoma County ARM Plan was completed in 1994 and is the most comprehensive ARM plan currently existing in the region. It is discussed in detail later in this report. This population-based method used by the State and Sonoma County, is the method used to determine aggregate demand in this report.

6.4.2 Population

According to the last U.S. Census, the population of Mendocino County in 1990 was 80,350 people. The population of the Upper Russian River area in Mendocino County was 41,850 people or 52 percent of the County population (population counted by the U.S. Census for Census Tracts 107, 108, 109, 112, 113, 114, 115, 116, 118 and block group 4 of Census Tract 106; these tracts include, approximately, the area from Willits south to the Sonoma County line and the area east of the coastal mountain crest to the Lake County line). In 1980, the U.S. Census reported that Mendocino County had a population of 66,738 people. The population of the County as a whole grew about 20 percent during the decade. The inland population grew by about 22.5 percent, while the coastal population grew about 15.3 percent.

State Department of Finacne (demographic Research Unit) estimates that the County population as of July 1994 was 86,000 people. Table 6.8 shows their estimate of population growth for the nest 45 years (CA Department of Finacne, 1994). For Mendocino County these projections indicate a 44 percent growth in population by the year 2010 and a 118 percent growth by the year 2040. For the Upper Russian River market area these projections indicate a 50 percent growth in population by the year 2010 and a 139 percent growth in population by the year 2040. It must be remembered that these projections are just that—projections. They are based on past growth rates and assumptions about economic trends. There are many factors that could change these projections. The farther into the future the projection, the more likely the chance for inaccuracy.

Assuming the same ratio of growth as occurred between 1980 and 1990 (that is, where the inland area grew by 22.5 percent); the growth rate from 1990 to 2010 for the Upper Russian River market area would be 50 percent. At this rate, the Upper Russian River market area population could grow to 62,896 people by the year 2010. For the year 2040, the Upper Russian River market area could grow 139 percent larger than the 1990 population which would mean a population of 99,937 people.

6.4.3 Discussions of Methods of Calculating Future Demand

The following describes various methods of predicting future demand for aggregates.

Northern California Aggregate Producers Association

According to George Cope of the Northern California Aggregate Producers Association, the U.S. Bureau of Mines currently estimates a national demand of about 6.86 yd^3 of aggregate per person per year. In the Sacramento area, during the 1980s, consumption rose to 8.23 yd^3 per person. When the economy went into a slowdown, consumption dropped to 4.12 yd^3 to 5.49 yd^3 per person. According to Mr. Cope, the Northern California Aggregate Producers Association has found a projection of 6.86 yd^3 in metropolitan areas and 4.12 yd^3 to 4.80 yd^3 per person in rural areas, to be fairly accurate.

Caltrans

Caltrans is a primary consumer of aggregate in the market area. In 1994 Caltrans used 134,250 yd^3 of aggregate in Mendocino County. Of this, they estimate that 106,204 yd^3 were used on work done in the inland area of Mendocino County. George Otterbeck of Caltrans stated in a letter that "Inland, Parnum provides us with the majority of material." The amount of aggregate used by Caltrans varies depending on scheduled work projects as well as unanticipated repairs. For 1996 Caltrans has no projects scheduled for the Upper Russian River market area. There is one project scheduled for 1999, and one project scheduled for 2001 (1994 STIP, Caltrans).

Parnum Paving

Parnum Paving/Ford Gravel is the largest aggregate producer in Mendocino County. Doug McClelland of Parnum Paving estimates that the average usage in Mendocino County is 4 to 5 yd^3 per person (McClelland, pers. comm.).

Sonoma County Aggregate Resources Management Plan

In late 1994, Sonoma County adopted the *Sonoma County Aggregate Resources Management Plan*. This plan identifies current sources, production, and demand for aggregate in Sonoma County. Given the controversy over instream and terrace mining in Sonoma County, considerable time and energy went into producing this plan, and it underwent severe public scrutiny prior to adoption. As such, the Plan is considered to be "state of the art" at least as regards discussions of aggregate demand.

The Plan preparers assessed a number of methods used to determine future demand, methods that had been used in earlier plans prepared in California. The preparers concluded that the most accurate predictor of aggregate demand is total population. Other methods attempt to identify the various components of growth (road building, large development projects). These methods have proved less accurate in estimating demand than identifying a certain amount of aggregate required per capita. Thus, to estimate future demand requires calculating the per capita demand for projected populations (Sonoma County, ARM Plan, 1994, p. 3-10).

The Sonoma County ARM Plan includes three different population projections that include a range from high to moderate to low. The per capita consumption also used a range of factors. The high factor is 5.62 yd^3 per person per year which represents the actual consumption experienced between 1981 and 1990. The intermediate consumption factor is one that declines each year by the annual average rate of 0.09 yd^3 per capita. This reflects the decline in demand that occurred between 1960 and 1990 (that is, more aggregate was used per capita in 1960 than in 1990). This produces a consumption rate in 2010 of 3.74 yd^3 per person. Finally, the low consumption rate was developed to reflect a greater possible decline in per capita consumption. This factor declines by 0.19 yd^3 per year and generates a demand in the year 2010 of 1.9 yd^3 per person.

Lake County Aggregate Resource Management Plan
Lake County adopted the *Lake County Aggregate Resource Management Plan* in November, 1992. This plan used a more complex methodology of calculating future demand. The Plan estimates that demand in 1986 was 4.14 yd^3 per person. It projects this demand to decline to reach a leveling off of less than 2 yd^3 per person by the year 2000.

6.4.4 Mendocino County Demand

In 1994 Mendocino County aggregate producers reported actual extraction of 518,564 yd^3 of sand and gravel to the State Department of Conservation's Office of Mine Reclamation. When this amount is divided by a County population of 85,600, the result is a consumption rate of 6.06 yd^3 per person for the entire County. Table 6.9 shows average annual aggregate usage between the years 1990 and 1994 for the County as a whole and for the Upper Russian River market area.

If the 1994 County wide consumption rate of 6.06 yd^3 per person is multiplied by the market area population figure of 44,587 people (see Table 6.9 for the Upper Russian River market area 1994 population), an Upper Russian River market area usage figure of 270,197 yd^3 of aggregate is obtained for 1994.

It should be noted that in 1990, twenty-three mine operators in Mendocino County submitted figures to the Office of Mine Reclamation; by 1994 this figure had increased to thirty. Therefore, it is unclear if aggregate production is actually increasing or if there are simply more producers complying with the reporting requirements.

6.4.5 Future Consumption Rates

The only complete and official records available on aggregates in Mendocino County are those provided by the Office of Mine Reclamation which are shown in Table 6.9. Given the paucity of records for consumption in the Upper Russian River market area, this report assumes that future consumption will be within the range predicted for neighboring counties.

To calculate this future usage, three consumption rates will be used to establish the possible range of future demand. The high factor is based on the usage experienced by Mendocino County in 1994, when reported County wide aggregate consumption was 6.06 yd^3 per person. This figure is similar to the high usage rate of 5.62 yd^3 per person used in the Sonoma County ARM Plan. The mid-range figure is 3.74 yd^3 per person based on the Sonoma County ARM Plan projection for the year 2010. Reflecting both the Lake County ARM Plan and the Sonoma County ARM Plan, a low factor of 1.9 yd^3 per person is used. Future demand, showing these three rates, is shown in Table 6.10.

6.4.6 Summary and Discussion of Demand

Population Increase
For the year 2010 the Upper Russian River market area population is projected to increase to approximately 62,896 people. For the year 2040, the Upper Russian River market area could grow 139 percent larger than the 1990 population which would mean a population of 99,937 people.

Current Demand/Production

Aggregate supply in the Upper Russian River market area is adequate at this time. Estimated aggregate extraction (from Table 6.7) for 1994 was 354,678 yd^3. Estimated aggregate usage for 1994 (from Table 6.9) was 270,197 yd^3. Thus, current aggregate production in the market area exceeds the amount necessary to meet current demand. Due to lack of records, it is not possible to analyze aggregate production and usage by types of aggregate (sand, rock for PCC, rock for ACC, road base, rip-rap). Although overall aggregate production exceeds demand, this report cannot state with certainty that there are adequate supplies of each variety of aggregate a consumer may wish to purchase.

There are permits for a number of hard rock quarries, as well as two vested rights operations on the Russian River that remove gravel from bars and terrace deposits. The expense and difficulty of the permitting process make it likely that few small quarries will be developed in the future, and unlikely that the operators of existing small quarries will renew permits when they expire. It is likely that new quarries will be similar to the newly approved McCutchan Quarry, permitted for at least 50,000 to 75,000 yd^3 per year, and with a permit length of ten to twenty years.

A primary concern of many producers is the availability of alluvial sources of gravel. Certain types of concrete are most effectively made with gravel from streams. As Ford Gravel and Redwood Valley Gravel are the only producers currently removing gravel from the Upper Russian River, a consumer wanting instream aggregate must purchase from them, from one of the sources on the Eel River, or from Humboldt County or Sonoma County sources.

Several sources stated that highest use for river gravel is concrete, and that river gravel should be reserved for this use (Simpson, Ford, Oberfeld, McClelland, Ripple; pers. comm.). This practice is already taking place in the Upper Russian River market area. Several of the aggregate producers contacted also produce PCC (Redwood Valley Gravel, Ford Gravel, Shamrock Gravel). In general, they reserve the river gravel they produce for their own PCC production and sell little of this rock directly to the public.

Asphalt Concrete can be made from quarry rock or alluvial rock. In the Upper Russian River market area AC is provided by Parnum Paving. If Parnum Paving does not have AC available, the most likely alternative source of AC for the market area would be in northern Sonoma County.

Various people mentioned the possibility of bringing gravel in by train (Krueger, Ford, Gonzalez; pers. comm.). This is a practice that has been used for transporting sand and gravel from the Eel River in Humboldt County to Mendocino County. According to Ignacio Gonzalez of the Mendocino County Planning Department, large gravel deposits exist along the Eel River, particularly in the Garberville/Fortuna Area. The sand and gravel are loaded on to gondola cars in Humboldt County and travel south to Longvale in Mendocino County. As a primary cost of aggregate is transportation, this may become a more attractive option as the price of local aggregates increases.

Future Demand

For the year 2040, aggregate demand is estimated to be between 189,880 yd^3 and 605,618 yd^3. Currently, there are adequate aggregate resources to meet this demand. Existing permits (approved permits as of January 17 1997) and vested rights allow for the extraction of 768,000 to 855,000 yd^3 of aggregate. However, it is likely that some of these aggregate sources will be unavailable by the year 2040; some quarries may be exhausted or permits may not be renewed.

The ability to supply future demand from current permits is shown in Table 6.10. This table assumes that the operators with vested rights covered by Reclamation Plan 1-83 (Ford Gravel), and Reclamation Plan 1-91 (Redwood Valley Gravel) will still be extracting from the Russian River.

Through the year 2000, existing permits and vested rights operations are adequate to meet projected high aggregate demand in the Upper Russian River market area (314,478 yd^3). By the year 2010, existing permits and vested rights operations would be able to meet the projected low aggregate usage (119,502 yd^3) and the projected intermediate aggregate usage (235,231 yd^3), but would fall short of supplying enough aggregate to meet the projected high aggregate usage (381,150 yd^3). This assumes the quarries extract the maximum extent allowed by their permit; at this time many quarries do not report extraction of the maximum amount allowed by their permit. This also assumes that the vested rights operations covered by Reclamation Plans 1-83 and 1-91 are extracting at the highest levels estimated in this report.

By the year 2040, all current permits will have expired. It is likely that gravel will still be extracted by producers possessing vested rights. Currently, most of the gravel produced by these operations is used for in-house production of PCC, and this is likely to be the case in the future. Thus, in the absence of new permits being approved, the Upper Russian River market area would be unable to supply enough aggregate to meet local demand. However, it is likely that new quarry sources will have been developed and will be in production at that time. It is also possible that some existing quarries will have renewed their permits and will still be in operation.

Non-stream Sources

State of California mapping of aggregate resources has not been done for Mendocino County. The California Division of Mines and Geology has done extensive work on aggregate resources for the San Francisco Bay area and adjacent regions; however it has not prepared a report on aggregate resources for Mendocino County. They do plan to prepare such a report but, even when such a report does exist, it will only indicate *potential* aggregate sources. To determine the actual suitability of rock for aggregate use requires testing of the rock. This testing can be expensive and is usually done only by a party seriously interested in developing an aggregate resource (Hill, pers. comm). The best source of information on potential sources of aggregates is the aggregate producers themselves. Conversations with producers and County staff are summarized below:

1. David Ford of Redwood Valley Gravel mentioned an unused quarry called Cow Mountain Quarry on the south side of Highway 20 across from Red Rock Quarry. Mr. Ford believes this quarry ceased production due to opposition from neighbors and could potentially be reactivated. Mr. Ford also stated that there may be potential quarry sites on his own property. However, he stated that the fees involved in developing a quarry are so high that it is not worth the risk involved. His aggregate extraction in 1994 from his instream operation was 4,000 yd^3. He stated that he could easily sell 40,000 yd^3 a year if it were available to him.

2. Roger Krueger stated that Louisiana-Pacific would be interested in selling aggregates from Little Eagle Rock Pit to the public but will not currently be pursuing this option due to the time and cost involved in permitting. During 1994, Little Eagle Rock Pit was inactive.

3. Hank Oberfeld stated that his quarry contained plenty of rock, and it was his opinion that there is good rock all through Potter Valley. He stated that he has turned down work because he could not produce enough rock. He also stated that the most he has ever produced in a year is 10,000 yd^3 (his permit allows removal of 25,000 yd^3). He does not produce more because he runs a small one man operation. His current permit is up for renewal in June of 1996, and he is not sure if he will attempt to renew this permit (this permit was renewed in September of 1996 with allowed extraction of 25,000 yd^3 per year for ten years). He states that renewal of the permit will cost $20,000 and, given his age and the amount of aggregate he produces, he feels it may not be cost effective. It is his opinion, should he cease

production of aggregates in Potter Valley, his neighbors will experience an increase of approximately $5.00 per cubic yard to obtain aggregate from either Ukiah or Willits.

4. Doug McClelland, of Parnum/Ford Gravel, felt that potential aggregate sources were quite limited. It was his opinion that local geology is complex and that there is not an overabundance of suitable rock. In addition, he stated that quarry possibilities are limited by the need to find a willing landowner, to have adequate roads, and for the site to be located in an area that is not environmentally sensitive.

5. The Mendocino County Planning Department was queried as to possible locations for hard rock quarries in the Upper Russian River market area based on permits that had been denied or had expired, however no specific sites were identified by staff.

6. The Upper Russian River Gravel and Erosion Study (DWR) 1984, lists potential sources for hard rock quarries based on County records available at that time. The County Planning Department also maintains a list of existing and historic surface mining permits. Table 6.11 was compiled from these two sources. Table 6.11 lists permit applications in the market area that were denied or that have expired and do not appear to have been renewed. It is unknown what amount or quality of aggregate still exists at these locations. Also unknown are the interest that owners of the properties have in quarry operations or any environmental constraints.

Additional hard rock sources do exist in the Upper Russian River market area. The extent of these sources and the quality of the rock are not known. There may be environmental constraints that would prevent development or expansion of some sites. In addition, there is frequently opposition from neighbors to either the development of a new quarry or the reopening of a dormant quarry. Neighbors object to noise from blasting and quarry operations, as well as the traffic impacts associated with gravel trucks. Thus, even if a new quarry site is identified, it may be not be possible to extract aggregates at that location.

Can Future Demand Be Met By Non-stream Sources?

According to Table 6.10, future aggregate demand can be met by non-stream sources through the year 2000. By the year 2010 it would be possible to meet the low projected aggregate demand from existing non-stream sources but not the intermediate or the high projected aggregate demand. By the year 2040, all current permits will have expired and no aggregate would be available from existing non-stream sources. However, some gravel may be available from the terrace deposits covered by Reclamation Plan 1-83 (Ford Gravel). Once the existing permits expire, it is not possible to predict how future aggregate demand will be met. There is very little data on projected reserves at existing quarries. The location of potential quarry sites is proprietary information making it impossible to predict how many viable quarry sites exist and whether these new quarries will be able to meet future demand.

It is possible that simply renewing permits on existing quarries may be adequate to supply future aggregate demand. If additional quarries are needed, indications are that they exist, but it is unknown how many and of what quality. In addition, as mentioned above, there may be constraints on developing certain sites.

At this time, it seems unlikely that much of the future demand in the Upper Russian River market area will be met by the use of recycled products (see discussion in Section 6.5). However, the use of recycled materials, as an aggregate supplement or replacement, may become more important in the future as primary sources become limited.

Alluvial aggregate is still the preferred material for some uses. As long as alluvial sources of aggregate remain available in Sonoma County, it is likely that some consumers in the Upper Russian River market area, particularly those in the Hopland area, will choose to purchase their aggregate in Cloverdale. In addition, alluvial aggregate is currently less expensive to produce than aggregate from hard rock quarries. This may allow imported alluvial aggregate from outside the market area to be competitive with quarried products that are produced within the market area.

6.5 RESOURCE CONSERVATION

6.5.1 Recycled Aggregate

The recycling of previously used aggregate is an alternative source of supply for some uses. As the cost of aggregate rises, the use of recycled aggregate will likely rise as well. AB 939 mandates a 50 percent diversion of solid waste from landfill disposal by the year 2000. This may also encourage use of recycled aggregate. The use of recycled or alternate aggregate sources is influenced by the stringent specifications that apply to aggregates. Aggregate products are being recycled in the Upper Russian River market area. Both Parnum and Ford recycle PCC and AC. Doug McClelland of Parnum/Ford stated that they make road base from used AC and PCC, he stated that these recycled products are very popular. However, he pointed out that they are limited in the amount of recycled products they can produce by the lack of used PCC and AC available—few roads and buildings are dismantled in the Upper Russian River market area. Northern California Recycled Concrete and Products, located in Willits, intended to begin recycling aggregate products in October of 1995, (Roll, pers. comm). However, some neighbors have raised questions about having a recycling operation located in their neighborhood, and there may be issues regarding his use permit.

Caltrans is developing standard specifications to allow for recycled materials in concrete and asphalt mixes. Although Caltrans is committed to using recycled materials, at this time that commitment is limited to in-place reuse of asphalt.

Both Portland Cement Concrete and Asphalt Concrete can be recycled, however, the transportation and handling of the material adds to its cost. Processing aggregate rubble involves several steps; reinforcing bar and wire must be removed, organic substances must be removed, and large blocks must be reduced to a size that can be handled by available crushing equipment.

6.5.2 Recycled Portland Cement Concrete

Recycled or crushed concrete is a feasible source of aggregate for new concrete mixes as well as an economic reality in areas where good aggregates are scarce. The procedure for using recycled Portland Cement Concrete involves the following activities: breaking up and removing old concrete, crushing in primary and secondary crushers, removing reinforcing steel and embedded items, grading and washing, and, as a final result, stockpiling the coarse and fine aggregate.

The new concrete made from the recycled concrete generally has good workability, durability, and resistance to saturated freeze-thaw action. The compressive strength will vary with the compressive strength of the original concrete and the water-cement ratio of the new concrete. Recycled concrete is also used for lower uses such as Class III road base and trench bedding.

6.5.3 Recycled Asphalt Concrete

The use of recycled asphalt pavement, called RAP, has shown the best signs as a substitute for aggregate in the preparation of new asphalt. Caltrans is currently considering a change to their standard specification to allow recycled asphalt in AC mix. This would give batch plants an incentive to buy and use RAP. RAP is most commonly used at a percentage of about 20 to 25 percent of the aggregate in AC mixes although other percentages are used. Some areas that allow RAP in AC mixes are Santa Clara County, Orange County, and the State of Georgia which allows contractors to put down new asphalt consisting of 40 percent recycled asphalt. Frequently, recycled AC is used for lower uses such as road base.

Several processes have been developed and are now being used to recycle asphalt concrete pavements. Some of these are described below:

Cold In-Place Recycling

This process consists of pulverizing the existing bituminous surface on-site to the width and depth specified, mixing an additive with the pulverized bituminous surfacing, then spreading and compacting the mixture. This technique is suitable for the stabilization of existing bituminous surfacing.

Hot In-Place Recycling

This process heats and softens existing AC pavement to allow scarifying, or hot rotary mixing, to the depth specified, without tensile fracturing the aggregate. This process is most applicable to the rehabilitation of bituminous surfacing in the case of cracking, stripped roads, ruts and holes, loss of pavement flexibility, or degradation of aggregate gradation. Hot in-place recycling results in problems with air emissions due to the heating of the petroleum based binder in the recycled material.

Cold Planing

Cold planing involves the automatically controlled removal of pavement to a desired depth with specially designed equipment, and the restoration of the surface to a specified grade and slope free of bumps, ruts, and other imperfections, resulting in textured pavement that can be used and driven on immediately.

The selection of the type of recycling depends on the type of pavement required and the funds available. Between 1976 and 1986, approximately 21 projects conducted by Caltrans used recycled AC. As a result, two methods of mix design have been established, one for the hot central plant method using California Test 377 and the other one for the cold in-place method using California Test 378. Some of the findings of Caltrans' research are summarized here:

All methods of recycling studied are workable and may be used successfully. The method selected will depend upon the roadway condition, available materials, and funds available. The cold planing method AC surface replacement is an excellent method of removal which permits all or a portion of the AC to be recycled. With any recycled mix, the laboratory design must include comprehensive testing to establish projected performance relative to surface flushing, raveling, and stability. Recycling is particularly advantageous when only the truck lane is distressed. By milling and recycling only in the distressed lane instead of placing a thick overlay over all lanes, a considerable savings in cost can be realized.

Comparisons of hot central plant recycling, cold in-place recycling, and conventional hot overlays, reveal that a 50/50 hot recycling mix is approximately $5.00/ton less which results in a savings of about $1.00/ton for each 10 percent of RAP used. The cold recycling is about $10.00/ton less than conventional hot AC mixtures.

As mentioned above, there are some problems associated with the recycling of asphalt materials. The cleanliness of the stockpiled material is important to the quality of the new mix. In addition, some recycling methods have problems with air emissions.

6.5.4 Alternative Sources of Aggregate

Aggregate is the basic material for many construction applications. However, alternative materials exist which may be able to contribute to an overall reduction in the demand for aggregate.

Filter Fabrics

Fabric materials have been used in the construction of roads, parking lots railroad beds, and other facilities that require a stable foundation. The fabric is placed between the subsoil layer and the aggregate base, preventing the loss of aggregates into the subsoil during compaction and use. Aggregate requirements are further reduced by the fact that the uncompactible subsoils need not be replaced by compactable fill materials. Filter fabric can also be used in subsurface drains, reducing both the quantity of aggregate required within the drain and allowing use of a coarser gradation.

Native Backfill Materials

During trench excavations for subsurface drains and utility lines, imported aggregates are often used as pipe bedding and backfill. An alternative material that can be used for backfill is the originally excavated native subsoil itself. The excavated material, however, must be compactable and relatively free from excessive fines. The use of these native materials, when suitable, often offers a substantial savings in the cost of trenching operations.

Lime-Treated Subgrade

Road construction involves the placement of successive layers of subbase and base aggregates overlain by the surface course. Occasionally, depending on local soil conditions, a lime treatment can be applied to the native subsoils enabling them to perform as a subbase. In such cases, no imported subbase would be required. Generally, heavy clays can be successfully treated and used as a subbase. Lime-treated subgrades have occasionally replaced base aggregates for subdivision and parking lot projects, although this practice is seldom employed at present. The use of lime-treated subgrade is dependent on the availability of lime. In the past this availability has fluctuated rapidly, forcing contractors to rely more heavily on imported subbases.

Coastal Beach Sands

Sand is occasionally imported from nearby coastal beaches as an additive for blending with coarser materials in the production of concrete aggregates. Particle gradation specifications often allow only a small portion of beach sands to be used, however, due to their uniformity in size. Issues related to beach sands extraction include the preservation of dune grasses and other habitats, maintenance of beach replenishment, potential impacts on coastal recreation opportunities, and scenic and visual conditions. An important consideration in the use of these materials is the haul distance required to deliver them to processing facilities and the resultant coat increase in the price of concrete aggregates.

Tailings From Industrial and Other Mining Operations

The U.S. Bureau of Mines, in its Mineral Commodity Profile Series (MCP-17: Stone, 1978) mentions that iron-blast furnace slag is a material competitive with rock products for many specifications. Air cooled blast furnace slag currently provides aggregate for PCC mixes in other sections of the country (Portland Cement Association, 1988, *Design and Control of Concrete Mixes*). However the lack of these metal processing wastes in Mendocino County renders their use unlikely. Lightweight aggregates, such as cinder, pumice, or processed shale and limestone can also be used as substitute for aggregate in those areas where they are available. Tailings from mines are another potential source of aggregate but these are not available in Mendocino County, (Gonzalez, pers. comm).

Recycled Glass
Crushed glass is a new substitute for base rock that is being explored although no test results are available as of yet. In addition glass (cullet) can be used as a supplement for aggregate in variety of products discussed below.

Glasphalt
In 1970, Caltrans conducted studies using cullet as a partial substitute for aggregate in the production of asphalt. The resulting substance is known as glasphalt. The results of the Caltrans studies were disappointing. The glasphalt surface raveled and stripped, meaning pieces of cullet began to separate from the road surface. As recently as 1990, Caltrans said that speed limitation, raveling and the cost of substituting glass prevented their department from making use of glasphalt.

Brick
Research conducted prior to 1973 by the U.S. Bureau of Mines, Ceramic Research Lab, revealed that bricks made with 10 percent or more cullet are stronger, resist absorption of water, and fire in half the time of regular bricks made with aggregate.

Building Blocks—Cement
Cement blocks made with an undisclosed portion of cullet were tested in 1981 and found economically feasible. Performance met specifications for similar construction materials.

Cement
Ground glass can act as a synthetic pozzuolana, a siliceous and aluminous substance that reacts chemically with calcium hydroxide at ordinary temperatures in the presence of moisture to form a cement-like material. There is a possibility that cullet could potentially replace cement in concrete and improve its properties (see Building Blocks—Cement).

Concrete
When cullet is added to the matrix, it is called glascrete. The American Society of Testing and Materials showed in 1977 that direct use of cullet in concrete results in the same standard of performance as conventional concrete. However, Dr. Eugene Tseng, a noted cullet products expert, cautions about glass silicea expansion.

Although the technological feasibility of using glass or foamed glass in concrete has been shown by at least three research groups and one manufacturer, the cost of cullet ($40-$80/ton) as a substitute for sand or gravel ($10 to $15/ton) may present an economic barrier to its present use. This economic constraint may apply to most use of cullet as a replacement or supplement for aggregate.

6.5.5 Other Recycling Sources

The City of Santa Barbara has tried using crushed alabaster/porcelain toilets for AC aggregate. There have been varied results from using recycled rubber from ground up tires with an additive binder in AC mixtures. Problems with the rubber mixes have included wear and tear, recycling, and potential toxic problems. According to Karen Calvert, the Press Democrat has reported tires used in this type of application smoking. The article she cites did not explain whether friction of spontaneous combustion of another sort was the cause.

The need statewide to reduce solid waste may stimulate the development of additional replacements for aggregate.

7. MANAGEMENT PLAN

7.1 LONG-TERM MANAGEMENT GUIDELINES

Long-term gravel management guidelines are intended to address the following issues identified by the TAC for the Russian River Aggregate Resources Management Plan:

- Minimize impacts to fish and wildlife habitat and riparian resources in the Upper Russian River and tributaries;
- Minimize local, upstream, and downstream impacts to channel stability;
- Determine the volume of gravel that may be safely extracted without causing significant geomorphic or biologic changes; and
- Determine the optimum method and location of gravel extraction and the distribution of mining activities that will minimize impacts on riparian habitat in the Upper Russian River and tributaries.

The existing conditions in the Upper Russian River and tributaries suggest that the main channel and the tributaries have incised significantly over the past century as sediment supply has decreased. Bank erosion and loss of riparian vegetation continue to be significant problems throughout the system. Further incision and secondary geomorphic, hydrologic, and biologic impacts could result from continued gravel extraction. The management guidelines described in this section will minimize the impacts of both in-channel and floodplain (off-channel) gravel extraction, however impacts due to past practices are likely to persist.

All instream gravel mining methods effect channel stability, riparian habitat, and fish, primarily through channel destabilization, substrate modification and direct loss of riparian vegetation. The best way to reduce these impacts to channel stability and habitat is to minimize or cease instream mining. However, cessation of gravel mining activities may present economic or legal constraints (with vested rights). With these constraints, gravel mining could proceed under a gradual but structured phaseout (except for vested rights) provided that proper safeguards are employed to ensure the biological integrity of the stream, including its salmonid resources.

Selection of a schedule for such a phase-out would rest with the Data Evaluation Team or with the CDFG which is currently implementing site specific recommendations based on a system-wide evaluation. A suggested phaseout might span a period of up to 20 years. Detailed monitoring of changes in the river resulting from gravel extraction (described in Section 8) is critical in determining the effect of mining and the appropriate time-frame for phasing out extraction activities.

Impacts of in-channel gravel extraction are the greatest at the bar where gravel is extracted, but also extend upstream and downstream. The long-term management strategy that would provide the most protection for channel stability and for fish, wildlife, and riparian resources would be to phase out in-stream and floodplain extraction over a period of time. For example, if a planning period of up to 20 years was designated, other aggregate sources—such as quarries—could be located and developed to replace in-stream and floodplain gravel as a resource. During the period when in-channel and floodplain extraction is permitted, the following guidelines should be followed to minimize impacts to the Upper Russian River and tributaries. The Management Plan is intended to provide flexibility to the Data Evaluation Team so that if, in the future, the river shows trends of incision or degradation, or if steelhead are listed as endangered in addition to the recent listing of coho, extraction could be limited. At present, the Data Evaluation Team should take direction from NMFS as to the effects of the listings on management of gravel extraction.

7.1.1 In-channel Mining Recommendations

Permit Mining Volume Based on Measured Annual Replenishment

In the first year following adoption of the gravel management plan, a volume equal to the estimated annual replenishment could be extracted from the Upper Russian River and selected tributaries. The estimated transport rate is about 2,560 tons/year (1,890 yd^3/year) at Ukiah, 30,360 tons/year (22,490 yd^3/year) at Hopland, and 77,430 tons/year (57,355 yd^3/year) at Cloverdale. The estimates for tributaries are reported in Table 4.3. The estimated replenishment rate is 50% of the transport rate. These replenishment estimates would be used for one year only, after which time the ***actual*** replenishment volume would be measured from the monitoring data collected as part of the Monitoring Plan described in Section 8. Replenishment (up to the elevation of the 1995 channel configuration) would need to occur before subsequent extraction could take place.

The concept of annual replenishment takes into account the episodic nature of sediment transport in the Upper Russian River. For example, during wet periods with high stream flows, and a high contribution of sediment from hillslopes and tributaries, monitoring data would show that gravel bars replenished quickly. During drought periods with low streamflow, and little sediment supply or transport, monitoring data would likely show that bars were replenished at a slower rate. Use of field monitoring data is essential in measuring when actual replenishment occurs. Use of the concept of annual replenishment protects long-term channel stability and aquatic and riparian habitat by extracting a volume sustainable by watershed processes.

The current direction of CDFG policy is to maintain existing channel morphology unless specific improvements are intended (Heise, pers. comm., 1995). Extraction methodology is to be tailored to the morphology of each site. Monitoring is a crucial element of this process. In addition to local monitoring for replenishment at specific mining sites, monitoring of the entire reach from Redwood Valley to the County line will provide information on the cumulative response of the system to gravel extraction. Because the elevation of the bed of the channel is variable from year to year, a reach-based approach to monitoring will provide a larger context for site specific changes. If monitoring data show that there is a reach-scale trend of bed lowering (on bars or in the thalweg) the Data Evaluation Team could limit extraction.

It is important for the County and the Data Evaluation Team to develop a system to allocate the total estimated annual replenishment between all of the operators (and individuals extracting their one-time 1,000 yd^3) on the Upper Russian River.

Establish an Absolute Elevation below Which No Extraction May Occur

The absolute elevation below which no mining could occur would be surveyed on a site specific basis. A "redline" elevation tied to NGVD or NAVD should be established below which mining may not take place, in order to avoid impacts to structures such as bridges and to avoid vegetation impacts associated with downcutting due to excess removal of sediment. A redline elevation should be at least one foot above the low flow water surface elevation (at the edge of the bar closest to the low flow channel) during the first year following adoption of the gravel management plan (assuming that this will occur in 1996). A one-foot minimum elevation as a buffer with a 4% grade toward the bank or a two-foot minimum elevation with a 2% grade is consistent with that recommended by the National Marine Fisheries Service (NMFS). The Data Evaluation Team should aid in defining the grade and elevation of the redline at specific sites with the intent of retaining the structure of the low flow channel and bar.

Limit In-channel Extraction Methods to "Bar Skimming" or an Alternative Method Recommended by the Data Evaluation Team

If mining is limited to the downstream end of the bar with a riparian buffer on both the channel and hillslope (or floodplain) side, bar skimming would minimize impacts. Other methods such as excavation of trenches or pools in the low flow channel lower the local base level, and maximize upstream (headcutting and incision) and downstream (widening and braiding) impacts. In addition, direct disturbance of the substrate in the low flow channel should be avoided. In the future, the Data Evaluation Team should have flexibility to decide on the most appropriate method to enhance habitat on a site specific basis.

Trenching on bars may be beneficial in the future for the Russian River if it becomes severely aggraded, flat, shallow, and braided and has few invertebrates. The department of Fish and Game should be consulted in order to determine if the Russian River meets these conditions in the future. Trenching of bars may initially impact a smaller area of riparian habitat than skimming—as a result of excavating deeper rather than shallow skimming of a large area. However, over the long-term, the upstream and downstream effects of a trench on the bar or in the channel may offset any short-term benefit derived from this method. Deep in-channel trenching to create pools for fish habitat has the following negative effects:

C excavated pools are a short-term morphologic feature that will fill in during subsequent floods. Thus, in order to create a permanent pool, long-term maintenance would be required. Natural pools in the gravel bed rivers are maintained without excavation in association with large woody debris or as a result of geomorphic processes that create pools spaced approximately 5-7 channel widths apart in alluvial channels. However, artificially constructed pools not associated with these hydraulic factors would not be permanent features;

C an excavated pool (or larger in-stream pit) acts as a local base level, and can cause upstream and downstream incision as the channel re-establishes its gradient (Sandecki, 1989; Collins and Dunne, 1990). Incision is a negative effect of trenching that may result in increased bank erosion and loss of habitat;

C in-channel excavation of pools would most likely take place in summer after June 15—after the need for spawning habitat has passed. Subsequent winter flows may re-fill the pool before it can be used by fish in the following season.

Any future trenching within one mile upstream of downstream of a State Highway Bridge should have Caltrans Concurrence prior to excavation using this method.

Grade Slope of Excavated Bar to Prevent Fish Entrapment

Excavation on bars by gravel skimming would have a 2% to 4% slope toward the bank. After extraction, gravel bars must be left void of isolated pockets or holes (Macedo, 1995).

Extract Gravel from the Downstream Portion of the Bar

Retaining the upstream one to two thirds of the bar and riparian vegetation while excavating from the downstream third of the bar is accepted as a method to promote channel stability and protect the narrow width of the low flow channel necessary for fish. Gravel would be redeposited in the excavated downstream one to two thirds of the bar (or downstream of the widest point of the bar) where an eddy would form during sediment transporting flows. In contrast, if excavation occurs on the entire bar after removing existing riparian vegetation, there is a greater potential for widening and braiding of the low flow channel. Retaining the riparian habitat on the upstream portion of the bar will allow the vegetation to act as a seed source for the lower half of the bar and areas donwstream. This concept has been employed in the Sonoma County

Aggregate Resources Management Plan for the Russian River (PWA, 1994a) and the Garcia River Gravel Management Plan (PWA *et al.*, 1996) and is recommended by the California State Department of Mines and Geology (Sandecki, 1995), and the California Department of Fish and Game (Macedo, 1995).

Concentrate Activities to Minimize Disturbance

In-channel extraction activities should be concentrated or localized to a few bars rather than spread out over many bars. For example, vested rights exist in Redwood Valley. Future mining should be concentrated at the existing site, rather than expanding upstream or downstream. This localization of extraction will minimize the area of disturbance of upstream and downstream effects. Skimming decreases habitat and species diversity—these effects should not be expanded over a large portion of the study area.

Review Cumulative Effects of Gravel Extraction

The cumulative impact of all mining proposals should be reviewed on an annual basis to determine if there are potential cumulative riverine effects and to ensure that permits are distributed in a manner that minimizes long-term impacts and inequities in permits between adjacent mining operations.

Establish a Long-term Monitoring Program

Monitoring of changes in bed elevation and channel morphology, and aquatic and riparian habitat upstream and downstream of the extraction would identify any impacts of gravel extraction to biologic resources. Long-term data collected over a period of decades as gravel extraction occurs will provide data to use in determining trends. A recommended monitoring plan is described in Section 8.

Evaluate Need for In-channel Reclamation on an Annual Basis

Currently, in-channel re-vegetation is not recommended, provided that skimming operations follow recommendations for a 2% to 4% slope (from bank to low flow channel edge) on the downstream third of the bar without depressions that could trap fish. Vegetation is likely to re-establish itself without human intervention. If monitoring data show that the main low flow channel does become temperature limited, excavation of back bar pools are recommended. If monitoring data show that bank stability is disturbed by mining operations, grading banks to a stable slope (at least 3:1) and planting native vegetation is recommended. Revegetation with native species should be planted adjacent to access roads in the riparian zone to act as a buffer and to retain fine sediment. Retention of all naturally recruited woody debris should be encouraged.

Native plants for re-vegetation should be propagated only from seeds and cuttings collected from within the Upper Russian River basin, and preferably from within five miles of the re-vegetation site. This will ensure the genetic appropriateness of the nursery stock, and will result in higher success rates. An experienced restoration ecologist should be consulted for appropriate site design based on the ecological criteria for each riparian species (for example: moisture, slope, and exposure requirements).

Minimize Activities That Release Fine Sediment to the River

No washing, crushing, screening, stockpiling, or plant operations should occur at or below the streams "average high water elevation," or in the Russian River, the top of bank (Macedo, 1995). These activities have the potential to release fine sediment into the stream, degrading salmonid habitat conditions. The Regional Water Quality Control Board (RWQCB) currently regulates fine sediment releases to the river from gravel processing through its waste discharge requirements. Gravel mining and processing applicants should notify the RWQCB if waste discharge requirements are applicable to their operation.

Retain Vegetation Buffer at Edge of Water and Against Bank

Riparian vegetation performs several functions essential to the proper maintenance of geomorphic and biological processes in rivers. It shields banks and bars from erosion. Additionally, riparian vegetation, including roots and downed trees, serves as cover for salmonids, provides a food source, works as a filter against sediment inputs, and aids in nutrient cycling. More broadly, the riparian zone is necessary to the integrity of the ecosystem providing habitat for invertebrates, birds, and other wildlife. CDFG frequently suggests a buffer of 100 feet back from the top of bank of the channel (Cox, pers. comm., 1995).

Avoid Dry Road Crossings

Dry road crossings disrupt the substrate and can result in direct mortality or increased predation opportunity of fry. The preferred type of crossing is the free-span seasonal bridge (Macedo, 1996). This type of crossing protects the upstream habitat as well as improving river conditions for reaction. If dry crossings are unavoidable, they should not be placed in the channel prior to June 15, and should be removed by October 15 so that they do not interfere with incubating or migrating salmonids. The number of crossings should be kept to a minimum. Placement of crossings should also take into account the damage which might occur to riparian vegetation. Roads should lead directly to the crossings and not long distances through the riparian corridor. Placement of any road crossing should be done with the approval of the Data Evaluation Team. Any structure placed across a river or recreationally navigable stream should be designed and installed so as to provide sufficient overhead clearance to allow unobstructed and safe passage for small recreational craft (California State Lands Commission, pers. comm., 1996).

Limit In-channel Operations to the Period Between June 15 and October 15

Gravel extraction for outside this window may interfere with salmonid incubation and migration. The hatching period for late steelhead spawners may extend for 40-50 days. Therefore, the June 15 start date is necessary to protect eggs laid from late April to May.

An Annual Status and Trends Report Should Be Produced by the County, the Data Evaluation Team or Agent of the County

This report should review permitted extraction quantities in light of results of the monitoring program, or as improved estimates of replenishment become available. The report should document changes in bed elevation, channel morphology, and aquatic and riparian habitat on the Upper Russian River and in the tributaries with gravel extraction. The report should also include a record of gravel extraction volumes permitted, and where gravel was excavated. Finally, recommendations for reclamation, if needed should be documented.

7.1.2 Floodplain (Off-Channel) Extraction Recommendations

Floodplain Gravel Extraction Should Be Set Back from the Main Channel

In a dynamic alluvial system, it is not uncommon for meanders to migrate across a floodplain. In areas where gravel extraction occurs on floodplains or terraces, there is a potential for the river channel to migrate toward the pit. If the river erodes through the area left between the excavated pit and the river, there is a potential for "river capture," a situation where the low flow channel is diverted though the pit. In Upper Russian River, a setback of at least 1000 feet (the approximate meander wave height) is recommended in the main channel and a set back of at least 400 feet is recommended for the tributaries to minimize the potential for river capture. In order to avoid river capture, excavation pits should set back from the river to provide a buffer, and should be designed to withstand the 100-year flood (CDFG, 1993b). Adequate buffer widths and reduced pit slope gradients are preferred over engineered structures which require maintenance in perpetuity (OMR, pers. comm., 1996). Hydraulic, geomorphic, and geotechnical studies should be conducted prior to design and construction of the pit and levee. Guidelines for levee construction can be found in the COE Engineering Manual EM 1110-2-1913 (Gahagan and Bryant, pers. comm., 1995).

In addition to river capture, extraction pits create the possibility of stranding fish. To avoid this impact, CDFG (1993) requires that all off-channel mining be conducted above the 25-year floodplain. NMFS prefers 100-year isolation to minimize fish entrapment.

The Maximum Depth of Floodplain Gravel Extraction Should Remain above the Channel Thalweg

Floodplain gravel pits should not be excavated below the elevation of the thalweg in the adjacent channel. This will minimize the impacts of potential river capture by limiting the potential for headcutting and the potential of the pit to trap sediment. A shallow excavation (above the water table) would provide a depression that would fill with water part of the year, and develop seasonal wetland habitat. Excavation below the water table would provide deep water habitat.

Side Slopes of Floodplain Excavation Should Range from 3:1 to 10:1

Side slopes of a floodplain pit should be graded to a slope that ranges from 3:1 to 10:1. This will allow for a range of vegetation from wetland to upland. Steep side slopes excavated in floodplain pits on other systems have not been successfully reclaimed, since it is difficult for vegetation to become established. Terrace pits should be designed with a large percentage of edge habitat with a low gradient which will naturally sustain vegetation at a variety of water levels. Pit margins should be reclaimed with riparian buffer zones of fifty feet surrounding them. Islands should be incorporated into the reclaimed pits as waterfowl refugia. Pits should be designed with input from the Mosquito Abatement District.

Place Stockpiled Topsoil above the 25-year Floodplain

Stockpiled topsoil can introduce a large supply of fines to the river during a flood event and degrade salmonid habitat. The CDFG (1993b) considers storage above the 25-year flood inundation level sufficient to minimize this risk.

Floodplain Skimming Should Be Considered If Future Channel Incision Deepens the Low Flow Channel

If monitoring data show that the Upper Russian River channel incises significantly due to a reduced sediment supply from upstream, floodplain skimming, or excavation of a new floodplain at the elevation of the dominant discharge could be initiated. Future incision is possible since improved timber harvest practices will reduce sediment supply in the future. In an incised channel, floodplain skimming could re-establish the historic relationship between the river channel and the floodplain. One-time extraction from a floodplain or terrace should be evaluated relative to the potential long-term value of that area for sustainable agriculture or wildlife values as a future option.

Floodplain Pits Should Be Restored to Wetland Habitat or Reclaimed for Agriculture

There are very few examples of successfully restored or reclaimed gravel extraction pits on other river systems with gravel extraction. The key to over coming barriers to successful restoration or reclamation is to conserve or import adequate material to re-fill the pit, while ensuring that pit margins are graded to allow for development of significant wetland and emergent vegetation.

A Plan Must Be Submitted Which Accounts for Long-term Liability

Floodplain and terrace gravel extraction pits have impacts which extend far beyond the life of a gravel operators involvement with an operation. If liability for these impacts is not adequately covered, the burden falls upon the general public. Thus, it is necessary that a plan be provided to cover financial liability for any reasonably foreseeable impacts.

Establish a Long-term Monitoring Program

A long-term monitoring program should provide data illustrating any impacts to river stability, groundwater, fisheries, and riparian vegetation. The monitoring program should assess the success of any reclamation or restoration attempted.

An Annual Status and Trends Report Should Be Produced by the County, the Data Evaluation Team or Agent of the County

The status and trends report described previously should include a section on the hydrologic and biologic components of floodplain pit reclamation.

7.1.3 Other Recommendations

Reward Operators That Follow the Permit Process

County Agencies should purchase gravel from operators or producers that have permitted operations.

Facilitate Permit Process

The Mendocino County lead permitting agency should encourage participation in the existing structure offered by the COE: the inter-agency meeting held once a month in San Francisco, or in a similar inter-agency meeting held in Ukiah. This meeting can facilitate permit process for individuals requesting permits to extract gravel by identifying issues early in the process, by initiation of a resolution process, and by offering informal non-binding decisions prior to submission of the permit application.

Require Consistent Reclamation Plans

In addition to the statutory and regulatory reclamation plan requirements defined in the Public Resources Code (PRC) and the California Code of Regulations (CCR), in-channel reclamation plans should include:

C a baseline survey (assuming the 1995 elevation is the baseline) consisting of existing condition cross-section data in a format compatible with the MCWA data archive so that all the reclamation plan data for the river is comparable. Cross-sections must be surveyed between two monumented endpoints set back from the top of bank, and elevations should be referenced to NGVD;

C the proposed mining cross-section data should be plotted over the baseline data to illustrate the vertical extent of the proposed excavation;

C the cross-section of the replenished bar should be the same as the baseline data (assuming the 1995 cross-section is the baseline). This illustrates that the bar elevation after the bar is replenished will be the same as the bar before gravel extraction;

C a planimetric map showing the aerial extent of the excavation and extent of the riparian buffers;

C a planting plan for any areas such as roads that need to be restored;

C a baseline fishery resources survey consisting of the components of Phase I of the Fishery Resources Monitoring Plan. This will integrate the fishery resources-related studies/analysis into the aggregate management plan <u>at the onset</u>;
C a monitoring plan;

- financial assurance for monitoring and reclamation activities.

In accordance with the Surface Mining and Reclamation Act of 1975, the State Geologist will provide technical assistance to the lead agency staff in the review of reclamation issues (Sandecki, 1989).

An alternative use of reclamation or mitigation funds is to purchase easements on terrace lands rather than re-vegetation of active channel species, which quickly regenerate naturally. The riparian zone within the study area has been constrained by adjacent land uses, resulting in the reduction of diverse habitat stages. This form of reclamation or mitigation would result in a wider riverine corridor, allowing for the development of a diversity of habitat stages which would benefit fish and wildlife.

7.2 APPROPRIATE EXTRACTION METHODS

The following guidelines are for appropriate in-channel extraction methods:

- the total volume of material which can be mined in the Upper Russian River and tributaries in any given year may not exceed the actual annual replenishment. The actual replenishment will be measured from monitoring data;
- mine on lower 2/3 of bar only (or downstream of the widest point on the bar) to keep structure of channel intact and to enhance stability. Retention of vegetation on the upstream portion of the bar will provide a seed and propagule source for development of new habitat.
- maintain buffer between river and extraction to provide shade that lowers water temperatures to protect margin of channel where small fish swim. Maintain buffer between bank and bar to minimize bank erosion;
- require one foot vertical distance above the low flow water surface at time of extraction to aid in maintaining the structure of the bar, to enhance stability and to maintain elevation above an established "redline";
- maintain a 2% grade sloping from bank toward low flow channel and graded smoothly to prevent holes or irregularities that may trap fish;
- do not disturb low flow channel important for fish and other aquatic habitat;
- extract only between June 15 and October 15 to protect fish during sensitive life stages.

The following guidelines are for appropriate floodplain or terrace extraction methods:

- setback excavation pits at least 1,000 feet from the main channel (measured from the top of bank) or above the 25-year flood inundation level to avoid river capture and fish entrapment, and encroachment into the riparian zone;
- extraction depths should not exceed that of the river channel thalweg in the same cross-section to avoid creating a sediment trap if the river is captured by the pit;

- side slopes of floodplain excavation should range from 3:1 to 10:1 to enhance reclamation and natural regeneration of wetland habitat;
- place stockpiled topsoil above the 25-year floodplain to avoid erosion of the stockpiled material and contribution of fine sediment to the river.

The opportunity for off site quarry development is examined in Section 6.

7.3 APPROPRIATE EXTRACTION SITES

Appropriate extraction sites are locations chosen based knowledge of the local rate of aggradation or scour, a site specific determination of channel stability and bank erosion and evaluation of riparian resources. Site-specific evaluation is needed to evaluate each proposed operation to minimize disturbance and maximize stability of channel. In-channel extraction sites should be located where the channel loses gradient or increases in width, and deposition occurs unrelated to regular bar-pool spacing in channel. Particular sites may include sites upstream of a bedrock constriction or backwater, or at deltas created near confluences. Because existing mining operations have already disturbed fish and riparian habitat, in-channel operations should be limited to the existing vested sites, rather than disturbing new areas. Other potential sites could include bars where landowners can show that aggradation on a bar causes a problem such as bank erosion or flooding. In order to assess if aggradation on bars is a problem, the Data Evaluation Team should evaluate data and be able to specifically show that bank erosion was caused by bar aggradation (and not by narrowing of the channel, removal of riparian vegetation, or other bank disturbances). Over time, as off-channel or quarry sites are developed, these in-channel sites could be phased out.

SMARA section 2770.5 states that if mining is proposed within one mile of any state highway bridge, Caltrans must be notified and given the opportunity to comment on the proposal. This is especially important in light of the memorandum circulated by the FHWA and Caltrans (Appendix D) that suggest that the County will be liable for bridge repairs that result from incision related to gravel extraction.

8. MONITORING PLAN FOR UPPER RUSSIAN RIVER AGGREGATE RESOURCES MANAGEMENT PLAN

The following monitoring recommendations are intended to be consistent with monitoring requirements currently being developed by the Corps of Engineers, the Department of Conservation, and other nearby Counties dealing with similar issues such as Humboldt County (1996) and Sonoma County Planning Department (1994). Appendix E provides the Draft Instream Monitoring Guidelines developed by the Resources Agency (1996). These guidelines may be the minimum required by State agencies for all permitted operations in the future. However, the County may require more detailed monitoring data in order to meet the goal of maintaining channel stability and minimizing impacts to fisheries and riparian resources in the Upper Russian River.

Monitoring will provide data to evaluate the local upstream and downstream effects of gravel extraction activities, and long-term changes over the scale of the reach from Redwood Valley to the boarder with Sonoma County. Analysis and interpretation of the monitoring data should remain the task of the impartial professionals in each discipline, such as exists on the Data Evaluation Team. Agencies suggested for the Data Evaluation Team at the November 26, 1996 TAC Meeting were the Mendocino County Water Agency, the Mendocino County Planning and Building Services Department, the California Department of Fish and Game, the Russian River Flood Control and Water Conservation Improvement District, and State Mines and Geology Office of Mine Reclamation. The Data Evaluation Team should evaluate the monitoring plan each year to ensure that it answers the relevant questions. The data collected to monitor hydrology, geomorphology, fishery, and riparian biology should be integrated to maximize efficiency, and reduce the cost and effort associated with the monitoring plan. A brief status and trends report summarizing the annual results of the physical and biological monitoring should document the evolution of the sites over time, and the cumulative effects of gravel extraction. The summary should also recommend any channel maintenance or modification of extraction rates needed to minimize impacts of extraction and to review the appropriateness and detail of the monitoring plan. Funding for monitoring and analysis will be provided by the operator requesting the permit (local scale) and coordinated by the Data Evaluation Team (reach scale) as discussed in the Financial Plan (Section 9). Monitoring should be managed by professionals trained in the use of the accepted techniques. However, the general public may assist in these activities provided they are trained or overseen by experienced professionals.

8.1 MONITORING GRAVEL REPLENISHMENT, GEOMORPHOLOGY, AND HYDROLOGY

Physical monitoring requirements of gravel extraction activities should include surveyed channel cross-sections, longitudinal profiles, bed material measurements, geomorphic maps, and discharge and sediment transport measurements. The physical data will illustrate bar replenishment and any changes in channel morphology, bank erosion, or particle size. In addition to local monitoring for replenishment at specific mining sites, monitoring of the Upper Russian River from Redwood Valley to the County line and the tributaries where mining occurs will provide information on the cumulative response of the system to gravel extraction. For example, it is important for downstream bars to receive sufficient gravel to maintain riparian structure and channel stability. Because the elevation of the bed of the channel is variable from year to year, a reach-based approach to monitoring will provide a larger context for site specific changes. If long-term monitoring data show that there is a reach-scale trend of bed lowering (on bars or in the thalweg) the Data Evaluation Team could limit extraction.

Cross-sections
Surveyed channel cross-sections should be located at permanently monumented sites upstream, downstream and within the extraction area. Cross-sections intended to show reach-scale changes in the Upper Russian River system should be consistently located over geomorphic features such as at the head of riffles, across the deepest part of pools, or across particular types of channel bars. Cross-section spacing should be frequent enough to define the morphology of the river channel. Cross-section data should be surveyed in late spring or early summer, to evaluate changes that may occur during the wet season. Cross-section data should be collected over the Upper Russian River Reach, in tributaries where mining occurs, and locally upstream, downstream, and within each mining site:

- *Reach Scale Cross-sections:* one long-term monitoring set to include the cross-sections already surveyed by the Mendocino County Water Agency to illustrate long-term changes over the scale of the reach from Redwood Valley to the County line. Cross-sections surveyed by other government agencies should be incorporated into this program. Data sources for the Russian River include Caltrans (for 101 Highway bridge crossings on tributaries and on the main channel) and the USGS at the gaging stations. Additional cross-sections could be added to the set to aid in answering specific questions that arise. Cross-section spacing should range from about 1,000 to 5,000 feet in the main channel, and about every 200- 500 feet in tributaries depending on the local channel morphology. It is advantageous to locate new cross-sections at the head (upstream end) of riffles, where changes in bed elevation are most likely representative of larger scale trends. This long-term monitoring data should be collected and analyzed even if no mining occurs in order to understand the trends of the river;

- *Local Cross-sections:* one set of cross-sections at each extraction site to illustrate local changes related to specific in-channel extraction activities. Cross-sections should illustrate the upstream, mid-, and downstream portion of the channel bar being excavated, and at least one cross-section upstream and one cross-section downstream of the bar. Thus, at least five cross-sections should be located at every extraction site to illustrate local changes.

Caltrans recommends that three cross sections at the 101 Bridge be surveyed annually by the operators. One cross section should be surveyed at the upstream face of the bridge, one should be surveyed about one bridge length upstream and downstream of the bridge. A copy of the cross section should be sent to the Caltrans Transportation Planning Office in Eureka for review and comment before new permits for extraction are authorized by Mendocino County(Caltrans, pers. comm., 1996).

Cross-sections should be oriented perpendicular to the channel, extend from the top of bank to the opposite top of bank, and show the morphology of the channel (including the portion below the water surface). Survey notes should describe geomorphic features including top and base of bank, edges and top of bars, thalweg (the deepest part of the channel), and sediment characteristics. All cross-section elevations should be tied into a benchmark referenced to NGVD (National Geodetic Vertical Datum of 1929) or NAVD (North American Vertical Datum of 1988). By standardizing the horizontal and vertical reference datums, data can be used in a watershed data base, or GIS which could be used to address issues related to river stability, flood control, bed load transport, and the cumulative effects of gravel extraction. These data will be utilized in future management decisions by the Data Evaluation Team. A standard format for recording cross-section data should be provided to operators by the County to ensure that cross-section data are repeatable, and usable as part of the long-term record.

Monitoring of bed elevations will allow for quantitative documentation of long-term river trends, and evaluation by the Data Evaluation Team of the potential impacts to aquatic habitat. Scour chains may be used in addition to cross-sections to document changes in bed elevation. Scour chains should be placed on a bar, and the location should be mapped and described in field notes, to aid in data recovery.

Longitudinal Profile
A longitudinal profile should extend through a reach extending from upstream of the project area to downstream of the project area. Profile points should be surveyed in the thalweg, and be detailed enough to illustrate the channel morphology (riffle-pool sequences). Distance measurements should be based on River Mile upstream of the ocean, or continue to a permanent or reproducible location marker such as a bridge. Distance should be measured along the centerline of the channel (not the meandering low flow channel). Profile elevations should referenced to NGVD or NAVD.

Geomorphic Maps
Geomorphic maps may be constructed using a tape and compass for the project reaches to illustrate channel morphology. Maps should illustrate bed and bank characteristics of the channel and particle size.

Photo-Documentation
Photographs of the project sites should be taken prior to excavation to document the baseline conditions, and again during each monitoring session. Aerial photos should be taken twice a year (spring and fall) at a scale of 1:6,000 (1" = 500') or larger. Local field photographic station locations should be mapped on the geomorphic map and staked in the field in order to establish permanent photo stations.

Hydrology and Sediment Transport
Discharge and bed material measurements including suspended and bedload transport measurements taken by the USGS at the West Fork Russian River near Ukiah (#11461000), the Russian River near Hopland (#11462500), and the Russian River near Cloverdale (#1143000) gaging stations should continue in order to provide a statistically significant data base. Long-term data taken over a range of flows will add to our knowledge of river processes and aid in objectively evaluating the long-term trends in the river.

Groundwater Level
At least one groundwater level monitoring well should be established adjacent to each off-channel floodplain excavation to record changes in ground water levels. The wells should be installed between 25 and 50 feet from the edge of the pit (on the side away from the river). Groundwater table elevation measurements should be taken monthly.

8.1.1 Terrace Pit Extraction

Photo documentation
Aerial photographs of the river should be flown in spring before gravel extraction and in fall after the extraction activity to aid the County in assessing channel stability and determining if there have been any erosion changes in the bank between the river and the terrace pit.

Bathymetry Survey
A bathymetric survey (using an echo sounder) should be taken across each actively mined terrace pit to ensure that the elevation of the deepest part of the pit is not lower than the elevation of the adjacent river.

8.2 MONITORING FISHERY RESOURCES

8.2.1 Overall Approach

Due to the lack of recent quantitative fishery resources surveys in the Upper Russian River drainage (with the exception of Pieta Creek and Ackerman Creek) before one can monitor the impacts of gravel mining on the fishery resources, surveys need to be undertaken to identify which creeks to monitor. Although, historically, salmonids inhabited both the Upper Russian River and its tributaries and tule perch inhabited many more areas than they do today, existing, or baseline, conditions are unknown for most of the watershed. And, time and financial resources would preclude monitoring the existing conditions of every mile of every stream within the Upper Russian River drainage. Therefore, we propose a Monitoring Plan with the following Phases:

Phase I:

Identify "priority creeks" to monitor, conduct habitat, water temperature, and population surveys of the Upper Russian River and its tributaries in which salmonids and tule perch have been collected and/or observed; and

Identify rehabilitation measures which could be implemented.

Phase II:

Implement rehabilitation measures; and

Monitor fishery resources conditions.

Phase III:

Reassess the monitoring plan;

Identify rehabilitation measures.

Phase IV:

Continued implementation of rehabilitation measures;

Continued monitoring of fishery resources.

To monitor the impacts of gravel mining on the fishes of the Upper Russian River drainage, one needs to identify "cause-and-effect" relationships within the watershed. In other words, what environmental factors and processes are affected by gravel mining and how do these factors affect the fishery resources? However, as gravel mining has been only one of a variety of factors (construction and operation of Coyote Dam/Mendocino Lake, logging, grazing, natural geology and hydrology of the area, water diversions, planting of non-native fishes) which have shaped the watershed, and hence its fish assemblages, one needs to design a monitoring scheme which would differentiate these factors. As it would be highly impractical to monitor all the creeks, the monitoring approach we suggest would be to divide the watershed into the broad components (land use history, soil type, hydrology, geology) which ultimately affect biological resources. The intent of the monitoring design would be to incorporate these components into a scheme which would provide cause-and-effect relationships, first in a broad context and, second, in the specific context of impacts of gravel mining on the fishery resources.

We propose a stratified classification scheme to monitor the impacts of gravel mining on fishery resources. The stratification criteria would need to be agreed upon by the various parties involved in this project (both consultants and agency personnel). Possible criteria (the "causes" of environmental change) could consist of the following:

- Land use history (mining, logging, agriculture, dam construction, water diversions);

- Geology (Franciscan Melange, Franciscan Complex-Coastal Belt, others)—would affect erosion potential, soil type, other factors;

- Soil type (would affect riparian species and erosion potential);

- Hydrology (stream order, for example, affects fish species diversity); and

- Direction, or aspect of stream (sun would affect water temperature, which, in turn, impacts fishes).

Because it is assumed that non-native fish species have been introduced into the entire Upper Russian River drainage, it is not be possible to use any of the streams as "control" or "reference" streams, from the perspective of a "historical stream.” The approach would be to proceed sequentially, from the watershed, down to specific mining operations. Within each of the land use categories, there might be further classification. For example, within the "mining category", some mining techniques could result in more of an impact than others. Similarly, with logging history, there are types of logging (the "skidding" which occurred during the 1950's and 1960's had more of an impact on the land and aquatic systems than some of the more recent logging (since the 1973 Forest Practices Act) activities.

From a fishery resources perspective, the land use/land form (causes for change in fish populations) include the factors listed previously. The types of information which would need to be collected for the monitoring effort would include the following:

- Fish habitat (types and sizes of habitats, substrate, cover types, stream flows, existence of migration barriers, existence of spawning gravel);

- Fish populations (including species diversity, fish growth, fish ages);

- Water Temperatures (24-hour thermal recorders) in selected sections of streams;

- General water quality (dissolved oxygen, presence of any pollutants) conditions;

- Sediment-related information (McNeil sampling in and around spawning redds, water turbidity measurements during winter) upstream and downstream of selected gravel operations; and

- Food resources.

It is anticipated that some of the information required for monitoring other aspects of the drainage (hydrology, riparian vegetation, sedimentation) could be integrated with that of the fishery resources monitoring. For example, if riparian vegetation is mapped and photographed, this information is important from the standpoint of both protection and shade (reduced water temperatures) for fishes. Similarly, hydrologic changes which would affect pool structure or riffle habitat would affect fishes. Thus, the information for each of the scientific disciplines should be integrated to maximize efficiency and reduce effort, and, hence, costs, to the Monitoring Project.

As part of this process, some assumptions will be necessary. For example, we may assume at the onset that water temperatures and streamflows are limiting for all the creeks. Or, we may assume that the optimal water temperature range for steelhead trout rearing is 55-60 °F for all of the creeks. However, as the monitoring proceeds, and new data are collected, these assumptions may prove to be incorrect. If, for example, a stream contained abundant food organisms, a water temperature above 60 °F might be optimal for rearing steelhead trout. Or, if an underground spring were present which kept a creek cool, and abundant fish food organisms were present, then neither low streamflow nor water temperature might present a problem for salmonids. In summary, the monitoring effort could be refined by the data evaluation team, as knowledge of the Upper Russian River increases.

Some of the data collected in the hydrology, geomorphology, and riparian resources portions of the monitoring plan should be integrated with that of the fisheries monitoring. For example, if riparian vegetation is mapped and photographed, this information is important from the standpoint of both protection and shade (reduced water temperatures) for fishes. Similarly, hydrologic changes would affect pool structure or riffle habitat would effect fishes.

Fish habitat components such as the type and size of habitat, substrate, existence of gravel, cover type, stream flow, and existence of migration barriers should be evaluated at sampling sites;

Fish population including species diversity, fish growth, and fish ages should be monitored at sampling sites;

Water temperature should be measured using 24-hour thermal recorders in selected sections of the river;

General water quality should be measured including dissolved oxygen and the presence of any pollutants;

Sediment data should be collected using a McNeill sampler in and around spawning redds. Water turbidity measurements should be made in winter; and

An evaluation of food resources should be made at sampling sites.

To monitor the cause and effect relationship between gravel mining and the fish resource of the Upper Russian River and Tributaries, the fish monitoring needs to occur on the scale of the watershed over the long-term. This will help separate the effects of gravel extraction from the effects of other watershed land uses such as the operation of Coyote Dam, logging, grazing, water diversions, planting of non-native fishes, and natural variations in the geology and hydrology of the area. The intent of the monitoring design would be to incorporate these components into a scheme which could provide cause and effect relationships, in the broad and specific context of the impacts of gravel mining on fishery resources.

8.3 MONITORING RIPARIAN HABITAT

Substrate Changes

Changes in the substrate—notably a progression from gravel to clay—should be closely monitored. Baseline data gathering on reaches with clay substrate should be performed, and the results mapped. A yearly assessment and mapping of the extent of clay substrate will help to determine the rate of progression of this problem, Those reaches with no gravel substrate remaining should be carefully monitored for vegetation establishment.

Cross-sections

Yearly cross-section surveys of riparian vegetation—both in channel and on the floodplain—are necessary to document changes in vegetation due to gravel extraction. Vegetation surveys should be performed at the same locations as geomorphic cross-sections, and should depict species according to elevation.

Groundwater Impacts on Riparian Vegetation

Mature riparian habitat on the floodplain should be monitored yearly for water stress and mortality due to a drop in groundwater associated with channel incision. Data regarding the extent and seriousness of this phenomenon should be summarized and mapped.

Non-Native Vegetation

The extent of non-native vegetation, specifically giant reed (Arundo Donax) should be monitored for those sites which are directly or indirectly disturbed by gravel extraction activities. The spread of the giant reed should be monitored on a yearly basis, and the infestations mapped.

8.4 MONITORING RECLAMATION ACTIVITIES

The purpose of monitoring reclamation plans is to ensure consistency and compliance with the PRC and CCR. In accordance with the Surface Mining and Reclamation Act of 1975, the State Geologist will provide technical assistance to the lead agency staff in the review of reclamation issues (Sandecki, 1989). The monitoring plan for reclamation should include:

- a baseline survey consisting of existing condition cross-section data in a format compatible with the MCWA data archive so that all the reclamation plan data for the river is comparable. Cross-sections should be surveyed as described in Section 8.1;

- cross-section data showing that the post-replenishment bar elevation is the same as the bar elevation before gravel extraction;

- a geomorphic map showing the aerial extent of excavation and extent of riparian buffers;

- vegetation transacts showing success of mitigation or reclamation planting, and indicating a planting plan for any areas such as roads that need to be restored.

8.5 ANNUAL STATUS AND TRENDS REPORT

An annual status and trends report to summarize existing condition and trends of river should be produced by the County (or agent of the County). This report should review permitted extraction quantities in light of results of the monitoring program, or as improved estimates of replenishment become available. The report should document changes in bed elevation, channel morphology, and aquatic and riparian habitat on the Upper Russian River and in the designated tributaries. The report should also include a record of gravel extraction volumes permitted, and where gravel was excavated. Finally, recommendations for reclamation, should be documented.

9. FINANCIAL PLAN

9.1 INTRODUCTION

This Financial Plan addresses several issues regarding the funding and implementation of the Upper Russian River Gravel Management Plan. The issues addressed are:

P Financial Assurance for Monitoring;
P Financial Assurance for Reclamation;
P Tonnage Charges/Excavation Verification System;
P Aggregate Truck Manifest System;
P Bridge Replacement Bonding; and
P Pit Capture Bonding.

Information for the Financial Plan was gathered through conversation with State and County agencies as well as with private industry parties. Conversations were held with staff members of Yolo County, Sonoma County, Shasta County, Tehama County, the Federal Highway Administration, and the Department of Conservation. Additional documentation for this report was provided by EnviroMine, an environmental and mine permitting services organization located in San Diego, California.

9.2 FINANCIAL ASSURANCE FOR MONITORING

In the State of California, there is no overall law that shows how a mining operation is to conduct its monitoring system. Although each County is obligated to follow certain guidelines set by the Surface Mining and Reclamation Act of 1975 (SMARA), each County is basically on its own.

9.2.1 Mining Inspections

Counties are obligated to conduct inspections of mining operations no less than once a calendar year, and must inspect a mining operation within 6 months of its reclamation plan being approved. The mining operation is solely responsible for the cost of the inspection according to SMARA, but some counties charge no fee for this, Tehama County being one of them. The County is responsible for sending the operation written notice of the pending inspection within 30 days of conducting it.

9.2.2 Violation of the Reclamation Plan

In the case that the mining operation is in violation of any part of the its reclamation plan, the County must specify the violation in writing.

1. The mining operation has 30 days from there to come into compliance with its reclamation plan, if it fails to comply, the County has the right to halt its activities.

2. The County must put into writing all aspects of the violation, taking into account any and all good faith attempts to rectify the problem on the mining operator's part.

3. In failing to comply the mining operator is subject to be fined a maximum penalty of no more than $5,000 per day.

4. In assessing the amount that the penalty shall be set at, the County must take into account the nature, circumstances and gravity of the violation, before placing a penalty of some financial amount.

9.2.3 20-year Reclamation Plan

Many counties require their mining operations to set their reclamation plan for a 20 year period. Allowing counties to insure that all environmental needs are being met by the mining operators. Counties can study the effects that a particular mining operation is having on the channel morphology, verify that the depth at which gravel is being excavated is not unsettling the vegetation. Allowing the County to focus on the effects that the mining operation is having over the entire environment over an extended period to ensure that no damaging effects can occur. In the event that there is damage, it can be recognized and rectified before causing further long lasting damage.

9.3 FINANCIAL ASSURANCE FOR RECLAMATION

Permits for mining operations are awarded on an financial assurance by the state. The proposed mining operation must provide the County with its estimated costs for a reclamation plan. The reclamation plan describe the project and address all potential hindrances. All documentation for the reclamation plan must comply to the Surface Mining and Reclamation Act of 1975 (SMARA). The County requires the mining operation to provide the following information:

1. The name and address of the surface mining operator and the names and addresses of any persons designated by the operator as an agent for the service of process.

2. The anticipated quantity, the type of minerals for which the surface mining operation is to be conducted.

3. The proposed dates for the initiation and termination of surface mining operation.

4. The maximum anticipated depth of the surface mining operation.

5. The size and legal description of the lands effected by the surface mining operation.

6. A description of and a plan for the type of surface mining operation to be employed, and a schedule that will provide for the completion of the surface mining on each segment of the mined lands so that reclamation can be initiated at the earliest possible time on those portions of the mined lands that will not be subject to further disturbance by the surface mining operation.

7. A description of the proposed use or potential uses for the mined lands after reclamation.

8. A description of the manner in which reclamation, adequate for the proposed use or potential uses will be accomplished, including: a) a description of the manner in which contaminants will be controlled, and mining waste will be disposed; and b) a description of the manner in which affected

stream bed channels and streambanks will be rehabilitated to a condition minimizing erosion and sediment will occur.

9. An assessment of the effect that implementation of the reclamation plan on future mining in the area.

10. A statement that the person submitting the reclamation plan accepts responsibility for reclaiming the mined lands in accordance with the reclamation plan.

11. Any other information which the County may require by ordinance.

The State charges no fee for processing the reclamation plan. The individual counties, however, do charge. Their fees vary widely, with many counties in the state charging no fees. The state average is $850.00.

The County then requires the mining operation to acquire financial assurance for the mining operation. The financial assurance may take the form of a surety bond, irrevocable letters of credit, trust funds, or other forms of financial assurance. The amount of the financial assurance is based on the individual needs of the site and vary widely. The financial assurance remains in effect for the duration of the mining operation. At the end of each calendar year or the anniversary date of the reclamation plan (whichever date the County sets forth), the financial assurance is examined and considered for readjustment, based on the needs of that particular year. The mining operators have the option, however, of bonding one particular spot of land, instead of the all of the entire site, therefore providing bonding for only the portion of land in use. For example, if 50 acres have been acquired, but only 10 acres are to be used for that calendar year, the operator is only required to assure only 10 acres.

Of the four counties studied in this plan costs for implementing a reclamation plan varied widely, demonstrating the different standards in the state.

County	**Fees**
Yolo County	$25,000 per site (highest in state)
Tehama County	None
Sonoma County	$7,000 per site (second highest in state)
Shasta County	$2,000 per site
State Average	$850 per site

The current cost of implementing a reclamation plan in Mendocino County ranges between $200-250 per site (EnviroMINE, 1995), an increase from $150 per site in 1994. These costs cover all annual compliance inspection fees. Mendocino County does not currently charge for a financial assurance review. Besides these charges, mining operators are required to pay the following State agency fees:

State Agency	**Fees**
California Coastal Commission	$600
State Coastal Conservancy	None
Department of Conservation/ State Mining & Geology Board	None
Department of Conservation/Office of Mine Reporting and Reclamation	$500
U.S. Corps of Engineers	$100 for individual commercial/industrial permit
Department of Fish & Game	$530 for commercial operations; $850 for review of Environmental Impact Report; $1,250 for review of Negative Reclamation

State Lands Commission	$25 non-refundable filing fee; $825 processing deposit
Department of Transportation	None
The Reclamation Board	None
State Water Resources Control Board and Regional Water Quality Control Board	$1,000/acre of fill up to $10,000 maximum for both 401 certification and report of waste discharge.

In the case where the mining operation is incapable of performing in accordance to the its reclamation plan (bankruptcy, bad credit) the County is obligated to notify the operator that the County is prepared to forfeit the financial assurance and to specify the reasons why. The mining operation has 60 days from the notice to fulfill its reclamation plan. If it cannot, the County then claims the money and is obligated to the state to finish the operation in full accordance to the reclamation plan worked out with the mining operation. At no time, however, can the reclaimed money be used by the County for any other purpose than for the reclamation plan. Any fees above those required to fulfill the reclamation plan, above what was financially assured, the mining operation must reimburse the County.

9.4 TONNAGE CHARGES/EXCAVATION VERIFICATION SYSTEM

At the end of each calendar year, or on the anniversary date of the mining reclamation, as set by the County, a mining operation must report on the tonnage excavated over the last year. Among other things (proof of the of reclamation approval, use permit, address) the mining operation must provide the following information regarding excavation, according to SMARA regulations:

- The total acreage of land newly disturbed by the mining operation during the previous calendar year.

- The approximate total of disturbed acreage reclaimed during the previous calendar year.
- The approximate total unreclaimed disturbed acreage remaining as of the end of the calendar year.

- The total production of each mineral commodity produced during the previous year.

According to SMARA regulations, the County can charge no more than $2,000 (excavation of more than 100,000 tons) for its reporting fees per site, and no less than $50 (for up to and including 100 tons). Additionally, as of 1994-95, a County can collect no more than $1 million in reporting fees from all of its combined mining operations. If they collect more, the County is under obligation from the state to adjust their reporting fees to comply with the state's limitations. In the event that a mining operation is late in paying their reporting fees, the County may charge them no less than $100 or 10% of the reporting fee due to the County, whichever is greater. In addition to the regulated state costs and procedures, each County has a different method of collecting fees and verifying the tonnages excavated by its mining operations.

Sonoma County
Requires each mining operator to provide the County with their yearly excavation totals, as required by SMARA regulations, but also charges 0.20 per ton for quarry operations, 0.25 per ton for instream mining operations. In addition, Sonoma County charges a fee based on the administration time spent on an operation – the number of phone calls accepted, the number of issues addressed and man-hours needed on an individual mining operation. This fee is charged on a percentage basis at the end of each year and charged to the operator.

Tehama County
Obtains its annual excavation figures by doing cross-sections. At the beginning of each year the County, along with the mining operators, survey the depths of the site, before excavation commences. At year's end, the process is repeated in order to measure the change in the depths that have taken place over the past year. This depth figure is used to illustrate the amount excavated from the site as well as surveying the impacts that the mining operation is having on the surrounding environment. Outside of this, all annual inspection costs are taken up by the County at no charge to the operator.

Yolo County
Requires each mining operation to report their tonnage annually, but no charges no fees. There is no charge for site inspections. At one time the County charged the operators 0.2 per ton, but discontinued the practice in 1994. The County currently charges the operators a fee based on the County's estimated administrative costs from the year. At the end of the year the County presents its fees to the mining operators, who are allowed to verify the list for items that they don't feel they need to be charged for. The County and operator then negotiate a fair price that the mining operator shall pay. Operators must pay a $500 site inspection fee as well as .10/ton for a habitat conversion fund.

Shasta County
Collects its tonnage reports at the end of each calendar year. It bases its tonnage extraction charges on those set by SMARA, which incorporates a sliding scale into its figures. For example, while the County charges an annual flat fee of $500 for its active mining report charges, and $250 for its idle mining reporting charges, Shasta County has set up a sliding scale for its production costs. Instead of setting a certain cost per ton extracted, they charge based on a scale – $50 for up to and including 100 tons, $5,000 for excavations of more than 100,000 tons. These charges also take care of all administrative fees as well as site inspections by the County.

9.4.1 Recommendation for Tonnage Charge and Excavation Verification Fee

When looking at instream mining monitoring , other factors must be reviewed besides gravel extraction (the effects of the mining operation can impact channel morphology, the biology of the stream, fish spawning habitats). Therefore, it is in the best interest of a County to develop a method of collecting funds that will address the multiple issues in order to create an effective excavation verification system.

A cross-sectioning procedure can be put into place, thereby creating a more accurate data base by which a County can evaluate the impact of an instream mining operation on the County. Cross-sections should be conducted more off-site than on-site and analyze the effects of instream mining on the surrounding areas as well as the channel.

If historic data is available on an individual creek, it should be used as a point of reference. New historical data should be created as well, allowing for a tracking system to be created for all new mining operations. For instance, if a creek has a history of instream mining, but has sustained little damage, that should be taken into consideration when considering adding a new operation to a location. In the event where over-mining has occurred, and environmental and structural damage has occurred, a County may want to rethink placing a new mining operation into the County.

A further suggestion would be one based on the fees charged by the County in regards to excavation. A system, loosely modeled after SMARA's annual extraction reporting fee requirements, whereby a mining operation was to pay its tonnage fees proportional to the amount excavated would be exceedingly beneficial to both County and miner. If the County were to take into account the size and scope of the operation and charge its tonnage fees accordingly, perhaps on more of a sliding scale basis, the needs of both parties may be better served.

In this way, a smaller mining operation would not be obligated to pay the same costs as a larger operation, while the County would now be able to collect fees that would be more in proportion to the scale of the project. For example, a mining operation that reports annual extraction levels of over 100,000 tons could be charged $1 per ton, while a smaller operator, extracting under 25,000 would be charged 35 cents per ton. These fees could in turn be used to fund improved monitoring systems.

9.5 AGGREGATE TRUCK MANIFEST SYSTEM

In discussions with mining operators, as well as various counties, it became clear that a verification system for monitoring the amounts extracted from mining operations can be established in ways that benefit both the County's and the operator's needs.

Since most mining operations do not retain their own fleet of excavation trucks, they must hire out for hauling services. What this enables them to do is to maintain a continuous and accurate count of the tonnage extracted from each site, since the trucking services must keep an accurate track of each payload hauled. With this information, a mining operation can compare the payload figures with the tonnage figures and arrive at an accurate daily count, two or three trucks per day being average. At year's end, the mine operator can take these figures to the County with surety of its accuracy due to the double check system that the payload figures that the trucking operators provide them.

Counties, in turn, have set out to find ways to meet the trucking needs of the mining operators, while also accounting for the potential damage these needs may cause. Sonoma County has developed a detailed system to address this.

Sonoma County

Sonoma County has established its own system by which they tax the trucks doing the extraction work, the revenue going toward road work as well as toward any damage that a mining operation in the County may incur. The fee is based on estimates of traffic that will be generated by a mining project. A 5 axle truck, for example, with an $1,000,000 value, would be required to pay a registration fee of approximately $3,450. Trucks also must pay a 0.16 cent excise tax on each gallon of gas. If the truck averaged 100,000 miles per year and about 4 miles per gallon , the annual fuel tax would amount to $4,000. The State collects the fuel taxes and registration fees and returns 58% back to the County and city road funds. In the above sample, the 58% refund to the County would equal $4,321 being returned to the County and city funds.

Additionally, all mining operations in Sonoma County are required to pay a yearly mitigation fee which is to be held in a special County fund which may be used to pay for mitigation of off-site impacts arising from industry operations. The collected amount has averaged out to a figure of $56,143 or 1.12 cents per ton annually. Sonoma County's example illustrates how a County can collect fees from a mining operation to in order to mitigate any further problems that a mining operation may cause in terms of damage done to structures, vegetation, channel morphology.

By charging a fee based on the estimated truck traffic generated by a project, as well as collecting a excise tax based on each gallon, the County can begin to meet its needs as far as its off-site impacts are concerned. As a condition of permit approval, a County may want to require a mining operation to install turn lanes, aprons, and other improvements to site entrances. With these measures taken care of beforehand, coupled with the fees for collected for the possibility of future off-site impacts, the County can be in a strong position to mitigate any future problems.

9.6 BRIDGE REPLACEMENT BONDING

In a notification sent to the Department of Transportation from Region 9, Federal Highway Administration (FHWA) the FHWA stated its concerns regarding the effects of instream mining activities on bridges. The notification cited a total 17 bridge failures in the 1995 storms, with several of these failures attributed to aggregate mining. The estimated value of bridges susceptible to mining-related failures for repairs from substructure damage is $31 million, and for replacement approximately $100 million.

According to FWHA guidelines, legally responsible parties are responsible for maintaining their sites, and FHWA has no responsibility for funding actions that were incurred by irresponsible behavior. FWHA warns that a loss of Federal Emergency Relief (ER) Funds could occur if steps are not taken to curb the effects of aggregate mining on bridges.

Cache Creek, Yolo County

One of the significant bridge failures cited in the notification occurred in Yolo County, at the Capay Bridge over Cache Creek, Yolo County. In discussions with David Morrison, Yolo County Planning Department, he acknowledged the effects of instream mining on the failure of the Capay Bridge, but expressed that there were other significant factors that had to be looked into when considering the effects of instream mining on bridges. Over the years many factors may have contributed to the Capay Bridge's failure. The creek has become narrower, faster, deeper and carrying more water than it did a century ago. As the creek narrows, the speed of the water becomes faster, increasing the capacity for erosion. Historically, its width at some reaches stood at 5,000 acres, today it stands at just under 1,600 acres. The creek experiences canals being cut into it, diverting water from the creek for irrigation purposes, thereby preventing the natural flow of the creek and causes its channel to become unstable. The increased stress within the channel has stripped riparian vegetation from the stream bed, which has led to further destabilization. As a result the stream bed has lowered 25 feet in some reaches. Not surprisingly, the structure of Cache Creek is out of balance with the flows and sediment loads that it presently carries.

The bridge itself was built in two phases – the first phase being built in 1917, the second being built during the 1940's. It was designed to accommodate water that flowed horizontally, in a natural path. As a result of mining activity over the years a gravel barge built up along the creek causing the water to flow incorrectly, at angles that the bridge was not designed to withstand, resulting in the bridge's eventual failure. Overall, the estimated cost to repair the bridge will be $2.2 million.

Cottonwood Creek, Shasta County

Another site of significance, although not mentioned in the FHWA notification, is Cottonwood Creek in Shasta County. Currently, three bridges cross the creek – Interstate 5, Southern Pacific Railroad, and Highway 99. A fourth bridge is under construction. Two mining operations, Xtra Power (west of the bridges) and Anderson Cotton Concrete Products (east of the bridges), work on either end of the creek.

Several of the bridges crossing Cottonwod Creek are threatened by channel incision. Caltrans contends that the aggregate extraction activity causes damage to the bridges and has documented that the river bed has degraded significantly since the Route 5 bridge was constructed in 1964. Route 5 bridge piers are undermined, as are bridge piers on County bridges immediately donwstream, since aggregate extraction is in excess of replenishment (Caltrans, pers. comm., 1996). Caltrans suggests that it is the mining operators responsibility to minimize their mining activities so as not to over-mine and cause channel incision, thereby weakening bridge foundations. The mining operators counter this claim by saying that Caltrans has failed to maintain the bridge abutments. Caltrans acknowledges the need for bridge inspections (they currently inspect bridges biennially) but feels that inspection itself is no guarantee against bridge failure from undercutting of piers.

9.6.1 Recommendation for Bridge Replacement Bonding

When considering issuing an adequate bond for bridge replacement it becomes clear that many factors must be considered when issuing such a bond. While the effects of instream mining certainly contributes to the occurrence of bridge failures, historical factors play a key role as well.

A system of annual inspections should be established to help alleviate the potential of bridge failure. The age and condition of the bridge should come into question. The Capay Bridge, for example, was 89-years old and not designed for the conditions that it found itself in. Also, the condition of the creek that the bridge runs over should be taken into consideration, with a series of questions being asked: How fast is the creek running? Is it running at the same speed as it was when the bridge was originally built? Has the channel narrowed? Has it become unstable enough to cause concern? Have the bridges abutments been maintained and cleaned on a regular basis? These questions and many others should be taken into consideration when inspections take place and bond measures are considered.

The bonds themselves should be applied on site specific basis. Given the specifics of the individual site, what costs and measures would be required to prevent bridge failure. Costs for materials, labor and equipment to repair or rebuild should be built into the bond. Additionally, a specified percentage should be incorporated into the bond to address administrative costs. These administrative costs should be based not on the salaries paid to the County employees, but on the estimated that a contractor would charge to provide the same work. In this case a County would recoup the true market value of their labor.

9.6.2 Pit Capture Bond

The potential for pit capture is greatest when aggregate mining operations are held too close to the river or the excavation pit is deeper than the river channel. Under these circumstances, great damage can be done to County land and measures must be put in place to reduce the chances of this possibility of occurring.

Cottonwood Creek, Shasta County

In speaking with Bill Walker of Shasta County he explained how Cottonwood Creek had broken through a berm at the east end of the creek during the 1994-95 storms. As a result of the continuous downpour the creek had overflowed and had poured into two ponds, belonging to the Black Land #1 mining operation, that run parallel to the creek. Over time, as the storm subsided, the water receded back to its normal level.

Since the overflow had occurred in the creek's floodplain, which serves as a wildlife habitat, no damage was incurred that required funds to repair. In the event, however, that the pit capture had caused damage to a road, a bridge abutment or any other type of structure, the aggregate operator would be held responsible.

In response to this, one mining operation has stated in its reclamation plan that it intends to build a tie-dike at its aggregate site as a means to halt the meandering of the creek. Shasta County is strongly considering making such measures mandatory for all aggregate miners requesting a use permit.

Sonoma County

Sonoma County has adopted a “Flood Protection Program.” The program was established to provide levee maintenance between existing terrace pits and the river channel in order to help reduce the chances of flood damage and pit capture. Many existing mining operations in the County are located close to the bank of the Russian River. As a result of this, Sonoma now requires all new mining operations to be located at least 450 feet from the river, effectively minimizing the chances of pit capture.

For older, established mining operations which are located within 450 feet of the river and are seeking approval for new or revised reclamation plans, Sonoma County is now adopting new measures to assure itself against the effects of flood damage or pit capture. They are now requiring that each operation show proof of adequate funding arrangements to maintain and repair river bank and shoreline facilities for a 20-year period.

9.6.3 Recommendation for Pit Capture Bond

In securing an adequate bond aimed at the prevention of pit capture certain aims must be properly addressed. By attaching a flat fee to the bond a County may very well find itself in a situation where the required sum may not meet the demand of the situation at hand. For example, if a bond were to be set at $5,000, but the actual damage that the operator is responsible for is three times that amount, the County would have no legal means of obtaining the difference in cost, and would have to make it up themselves.

Furthermore, by structuring the bond on a site specific basis the County could work with the permit holder to assess the potential risk and set a bond price accordingly. They would also assess the necessity, costs for labor, material and equipment which would fall under the envelope of the bond. A percentage would also be attached for administrative costs.

One possible measure that all counties may take into consideration would be to incorporate into their permit requirements some form of safety measure to halt the potential for river meandering into the floodplain and causing damage to structures.

10. CONCLUSIONS

This gravel management plan for the Upper Russian River is based on an evaluation of the historic and existing geomorphic, hydrologic, and biologic conditions of the system, as well as an analysis of aggregate production, demand, use, specifications, conservation, and reuse. The plan includes a monitoring plan and a financial Plan to fund monitoring activities. The following conclusions are based on a review of available data, field reconnaissance and discussions with numerous agency staff.

Coyote Dam forms Lake Mendocino on the East Fork of the Russian River and traps sediment from upstream reaches in Potter Valley, reduces sediment supply to downstream reaches, and changes the hydrologic regime of the river. The major tributaries to the Russian River in Mendocino County include Forsythe Creek which joins the Russian River north of Calpella; York Creek, Hensley Creek, Ackerman Creek, Robinson Creek, and Feliz Creek which drain the western side of the watershed; and Dooley Creek and Morrison Creek, which drain the eastern side of the watershed.

The Russian River and its tributaries have experienced significant incision of up to 18 feet of incision in some locations in Mendocino County in the past century. Tributaries have incised to meet the lower base level of the main stem of the Russian River. Various structures such as the Willow Rubble Dam on the main channel was constructed by the Willow County Water District to prevent the lowering of the groundwater table expected as the river incised. Grade control structures on Ackerman and Hensley Creeks were constructed to protect highway bridge.

The dominant discharge (channel forming flow in the Upper Russian River has a recurrence interval that ranges between 1.3 and 2-years. In a California fluvial system where flood events are episodic, gravel extracted from bars will not be replenished every year.

This Aggregate Resources Management Plan is based on the actual gravel replenishment to be measured from field monitoring data. This plan is not based on estimated bedload transport rates, except in the first year, before monitoring data is available. During the first year after the plan is adopted, replenishment is estimated to be about 50% of the measured transport rates. The average annual bedload replenishment rates (based on measured sediment transport at the gaging stations) are:

C Ukiah gage: 1,280 tons/year (950 yd^3/year; 13 tons/mi^2/yr);
C Hopland gage: 15,180 tons/year (11,230 yd^3/year; 42 tons/mi^2/yr);
C Cloverdale gage: 38,715 tons/year (28,650 yd^3/year; 78 tons/mi^2/yr.

After the first year, when monitoring data is available, the actual replenishment will be measured in the field, and the above estimates will no longer be used.

Bedload transport rates were estimated using measured field data from the Ukiah, and Hopland gaging stations. The bedload transport at the Cloverdale gaging station was estimated assuming that bedload transport rate for Cloverdale is 8% of the measured suspended sediment transport rate. The measured bedload transport for the short period of record is as follows:

C Ukiah (drainage area is 100 mi^2): 2,560 tons/year (1,890 yd^3/year; 25 tons/mi^2/year);
C Hopland (drainage area is 362 mi^2): 30,360 tons/year (22,490 yd^3/year; 85 tons/mi^2/year).

C Cloverdale (drainage area is 503 mi^2): 77,430 tons/year (57,355 yd^3/year; 155 tons/mi^2/year).

Theoretical bedload transport equations were used as a comparison to the measured sediment transport data. Results of the Bagnold Equation are higher than measured bedload values for Ukiah and lower for Hopland and Cloverdale as follows:

C Ukiah: 5,080 tons/year (3,760 yd^3/year; 50 tons/mi^2/year)
C Hopland: 14,700 tons/year (10,890 yd^3/year; 40 tons/mi^2/year)
C Cloverdale: 38,540 tons/year (28,550 yd^3/year; 80 tons/mi^2/year).

A qualitative sediment budget suggests that more sediment was extracted in the past than was supplied from tributaries or upstream reaches. Site specific monitoring data are needed to estimate tributary gravel replenishment. If extraction continues to exceed replenishment, continued incision and bank erosion in the main channel and tributaries is expected.

Three sensitive fish species were: the steelhead trout (and its resident counterpart, the rainbow trout), coho salmon and, the Russian River tule perch. Current populations of these species are very low, compared to historical conditions. The following factors have contributed to the decline of the fishery resources: 1) construction and operation of Coyote Dam/Mendocino Lake; 2) aggregate gravel mining; 3) water diversions; 4) logging operations; 5) grazing; 6) attempting to eradicate non-salmonids by chemical treatment; 7) planting non-native fishes (centrarchids); 8) planting hatchery salmonids; and, 9) pollution from a variety of sources.

Each of these factors has affected the Upper Russian River drainage at one time or another. As a result, fish habitat availability decreased, as river flows changed, water temperatures increased, and siltation increased. In addition, non-native fishes were introduced and native salmonid populations were replaced with hatchery stocks thereby introducing the genetic integrity of the stocks. As a result of these factors, salmonid and tule perch populations declined, species diversity declined and, the genetic integrity of the fishery resources of the Upper Russian River was lost.

No quantitative "cause-and-effect" type studies have been undertaken to determine how, when, how much, and for how long, each of these many factors have affected native fish production. Thus, populations of fishes continue to decline to the point that, for some species, extinction may be on the horizon, long before we have all concluded that we, as a species, are culpable for the decline in these resources. As a "first step" towards rehabilitating the Upper Russian River, the impacts that land uses such as dams, water diversions, gravel mining, logging and grazing have on fishery resources must be quantified and preventive measures taken.

Based on the review of past surveys and documents, most of which were dated, both water quality and physical habitat conditions for the *species of management concern* are in need of a great deal of improvement. The primary limiting factors appeared to be: 1) high summer water temperatures; 2) low to non-existent summer flows; 3) migration barriers; and, 4) siltation problems due to eroded banks. However, most of the information was twenty or more years old and of a qualitative nature. Therefore, to understand the degree to which gravel mining affects fishery resources, a more current evaluation of the drainage is warranted, particularly with regard to water temperatures and the quality and quantity of substrate in spawning and rearing areas.

Gravel mining operations can impact the riparian corridor, which, in turn, may impact one or more *life requisites* of the fishery resources of the Upper Russian River Watershed. As previously discussed, salmonids use gravel in the following ways during critical life stages of their life cycle: 1) as a medium for spawning, incubation, and hatching of eggs; 2) as cover for young salmonids to seek shelter; and, 3) as habitat for aquatic organisms, food items for young fishes. The operations involved in gravel mining, itself, may affect the life stage requisites during one or more life stages of sensitive fish species. However no "cause-and-effect" type studies have been undertaken to determine the degree to which a gravel mining operation results in stressful impacts on selected fishes.

The potential impacts of gravel extraction operations on fishery resources include: 1) reduction in salmonid spawning gravel, protective cover, and food resources, if gravel is depleted at a greater rate than it is replenished; 2) increased siltation, which could be detrimental to the fishery resources; 3) increased sediment input into the waterway as a result of the construction of road crossings and spur roads; 4) increased erosion and sedimentation into the creek, due to improper placement or removal of culverts in summer road crossings; 5) settling of fine-grained sediment could occur in fish food-producing areas, thereby smothering fish food organisms, if the streamflows are not adequate to move and deposit sediments to normal depositional areas; 6) increased water temperatures, eroded banks, and reduced food availability, if the riparian habitat is altered and/or destroyed; 7)decreased habitat for both fish and fish food organisms, if large woody debris and/or vegetation growing on gravel bars are removed during the annual gravel bar skimming; 8) diminished habitat quality (reduction in pool size) and quantity, if the stream bed geomorphology is altered; 9) direct kill, if any fish are present in the construction area; 10) high fish mortality (thermal stress, predation), as a result of the drying up of any pools which had created during the gravel operations; 11) blockage of migration of salmonids and tule perch, as a result of Construction of summer road crossings; and, 12) reduction of large pools or deep holes, so necessary for salmonids, particularly as a thermal refuge during the hot summer months, when little or no canopy is present.

Methods for reducing the potential impacts of gravel extraction on fishery resources habitat and populations in the Upper Russian River watershed include: 1) the "work window" for gravel mining operations should be from June 15 - October 15 to minimize impacts on sensitive life stages; 2) stream crossings should be removed by October 15, unless an extension is granted; 3) gravel bar skimming should be limited to the downstream portion of the bar; 4) gravel extraction should be conducted when the stream channel is dry; 5) following extraction, gravel bars should be left void of isolated pockets or holes and have a minimum bank exposure of one foot and a minimum bar slope of two percent; 6) summer dams and summer roads should be removed from areas where tule perch are known to migrate; and, 7) a long-term Fishery Resources Monitoring Plan, including water quality sampling, should be implemented.

The riparian zone of the Upper Russian River has been impacted by a variety of land uses since the 1800's. Logging, urbanization, agricultural reclamation of the floodplain and gravel mining have resulted in a reduction in the total extent of riparian habitat; an interruption in connectivity between the riparian zone and adjacent upland habitat; a reduction in the diversity of habitat types and age categories within the riparian zone; a relatively greater proportion of young, or early successional habitat, within the riparian zone due to the removal of older floodplain stands; and a reduction in the ability of the system to contribute large woody debris from the adjacent riparian zone due to reclamation of late successional habitat areas and increased erosive force on those areas which do exist. These modifications to the riparian zone have an impact on the ability of the Upper Russian River ecosystem to sustain historic levels of fish and wildlife.

Although many riparian impacts stem from historic land use, those and uses which persist —such as gravel mining—may need to be modified in order to allow for reclamation of fish and wildlife habitat. Current mining practices can result in removal of riparian vegetation every few years through bar skimming. If vegetation is not allowed to develop, and bars are not allowed to build up in elevation, early successional vegetation will not develop into mid and late successional stands. The removal of gravel and vegetation from the channel may encourage lateral erosion, resulting in the accelerated removal of mature habitat which exists adjacent to the channel.

Terrace pit development will result in direct removal of riparian habitat, and if a pit is captured, could result in additional erosion of habitat up and downstream of the pit capture site. There is an opportunity for creation of floodplain wetland habitat during the pit reclamation process. In order to maximize this reclamation technique, the pit margins would need to be graded to the lowest possible slope to encourage development of a diversity of wetland emergent species (10:1 to 3;1). Additionally, the pit bottom should not be excavated below the thalweg of the river—both to protect from pit capture and to allow for wetland productivity.

Modification of existing and proposed land use practices to allow for natural, uninterrupted regeneration of riparian habitat both in the active channel and on the floodplain is likely to result in higher fish and wildlife values over time. Removal of vegetation should be isolated to specific areas, and if possible, should be performed in such a way as to allow for habitat succession over the long-term. Gravel removal plans should take into account the potential impacts to up and downstream riparian habitat areas.

The market area for aggregates from the upper Russian River (the Upper Russian River market area) is defined as the area from Willits south to the Sonoma County line, and the area east of the coastal mountain crest to the Lake County line. Currently, aggregate supply in this area is adequate to meet local demand. Nonetheless, aggregate from other areas is imported into the Upper Russian River market area, and aggregates from this market area are exported to Sonoma County, Lake County and other parts of Mendocino County.

In the Upper Russian River market area, aggregates are produced from instream sources, terrace pits, and hard rock quarries. Permits active in 1994 allowed for the extraction of 618,000 to 705,000 yd^3 of gravel per year. Of this amount, 565,000 yd^3 may be extracted from rock quarries and 53,000 to 140,000 yd^3 from instream sources. Aggregate production in the Upper Russian River market area for 1994 is estimated at to be as much as 354,678 yd^3. This report estimates that the population of the Upper Russian River market area used 270,197 yd^3 of aggregate in 1994.

Existing permits and vested rights operations can meet projected aggregate demand at least through the year 2000 and can meet low and intermediate usage demand through the year 2010. Future aggregate demand and supply are summarized in Tables 6.9 and 6.10 from the section on market demand. Demand for the year 2010 at the high end of the projected usage range cannot be met by existing permitted quarries and existing vested rights. Whether demand for the year 2040 can be met is unknown since all permits will expire before that date. Once existing permits expire, it is unknown how future aggregate demand will be met. Some aggregate may still be extracted by the operations that possess vested rights. However, aggregate from the two operations with vested rights will not be sufficient to meet future aggregate demand.

Official mapping of aggregate resources has not been done for Mendocino County. It is likely that potential hard rock quarries exist in the Upper Russian River Market Area in addition to the quarries currently being operated. However, the locations of such sources have not been mapped or reported. The information is known to operators and landowners; it is proprietary and is not available to the public.

There are insufficient data on the projected reserves at existing quarries and the possible locations of new quarries to judge whether there will be adequate future supplies to meet projected demand. It is possible that simply renewing existing permits may be adequate to meet the demand. If additional quarries are needed, it is possible that adequate sources exist. However, it is unknown how many potential quarries exist nor the quality of aggregate in those sources. It is unknown whether these sources can be developed given environmental and sociocultural constraints.

The use of recycled aggregate materials or alternate aggregate materials is the most effective way of conserving existing aggregate resources. The use of recycled or alternate aggregate sources is influenced by the stringent specifications that apply to aggregates. Caltrans is developing standard specifications to allow for recycled materials in concrete and asphalt mixes. As the cost of aggregate rises, the use of recycled aggregate will likely rise as well. AB 939 mandates a 50 percent diversion of solid waste from landfill disposal by the year 2000. This need statewide to reduce solid waste may stimulate the development of additional replacements for aggregate. Aggregates are recycled in the Upper Russian River market area, but these recycled aggregates do not have a significant impact on the market at this time.

Aggregates are used for construction, roads, and for decorative purposes. In this section of the report aggregate characteristics and testing requirements are discussed, along with the appropriate uses for various types of aggregate. Aggregate specifications are explained; specifications used by Mendocino County, the City of Willits and the City of Ukiah conform to the Caltrans standards. Aggregate suitability and processing are discussed as are the different processing requirements for instream and quarry aggregates. While instream sources are preferable for certain uses, all types of demand can be met through aggregate derived from hard rock quarries.

In channel mining recommendations are based on the following concepts:

- Permit mining volume based on measured annual replenishment;
- Establish an absolute elevation below which no extraction may occur;
- Limit in-channel mining methods to bar skimming or other methods recommended by the Data Evaluation Team to enhance habitat;
- Grade slope of excavated bar to prevent fish entrapment and reconnect side channels to the main channel or rescue fish if stranding occurs;
- Extract gravel from the downstream portion of the bar;
- Concentrate in-channel activities to minimize area of disturbance;
- Review cumulative effects of gravel extraction;
- Maintain flood capacity;
- Establish a long-term monitoring program;
- Evaluate need for in-channel reclamation on an annual basis;
- Minimize activities that release fine sediment to the river;
- Retain riparian buffer at edge of water and against bank;
- Avoid dry road crossings;
- Limit in-channel operation to the period between June 15 and October 15; and
- An annual status and trends should be produced by the Data Evaluation Team.

Floodplain or terrace (off channel) mining recommendations are based on the following concepts:

- Floodplain gravel extraction should be set back from the main channel;
- The maximum depth of floodplain gravel extraction should remain above the channel thalweg;
- Side slopes of floodplain excavation should range from 3: to 10:1;
- Place stockpiled topsoil above the 25-year floodplain;
- Floodplain skimming should be considered if future channel incision deepens the low flow channel;
- Floodplain pits should be restored to wetland habitat or reclaimed for agriculture;
- A plan must be submitted that accounts for long-term liability;
- A long-term monitoring program should be established;

- An annual status and trends report should be produced by the Data Evaluation Team.

Other recommendations include:
- Reward operators that follow the permit process;
- Facilitate the permit process;
- Require consistent reclamation plans.

The monitoring plan includes recommendations for evaluating gravel replenishment, geomorphology, and hydrology, fisheries and riparian habitat. Monitoring activities should include field surveyed channel cross-sections, a longitudinal profile, construction of geomorphic maps, aerial photo and ground photo documentation, continued measurements of hydrology and sediment transport, an evaluation of the extent and quality of riparian vegetation and a fishery resources habitat and population assessment.

The Financial Plan includes a discussion of measures that can be used to generate the funds necessary to conduct the Monitoring Plan. Other bonding recommendations to minimize cost to the public are also discussed.

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Cope, George	Northern California Aggregate Producers Association
Creason, Kathleen	California Mining Association
Downey, Cameron	California Department of Conservation, Office of Mine Reclamation
Ehlers, Jim	Mendocino County Public Health Department
Falleri, Allan	Mendocino County Planning Department
Farr, Leif	Mendocino County Planning Department
Ford, David	Redwood Valley Gravel
Gaiser, Bob	Sonoma County Planning Department
Gonzalez, Ignacio	Mendocino County Planning Department
Hill, Bob	California Department Of Mines and Geology
Jackson, Dennis	Mendocino County Water Agency
Lagomarsino, Adele	Dept. of Conservation, Office of Mine Reclamation
McLelland, Doug	Parnum Paving
Newton, Dave	Stagecoach Village
Oberfeld, Hank	Oberfeld Quarry
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Otterbeck, George	Caltrans, District 1, Construction
Ripple, Dave	Shamrock Materials, Inc.
Roll, Mark	Northern California Recycled Concrete and Products
Santos, Rita	Northern Aggregates
Seanor, Rick	City of Willits, Department of Public Works
Shott, Tom	Natural Resource Conservation Department, USDA
Simpson, Gregg	Gregg Simpson Trucking
Slota, Dennis	Mendocino County Water Agency
Strahan, Tim	Caltrans, District 1, Program Management
Townsend, Pam	Mendocino County Planning Department
Welgoss, Bill	Pit & Quarry Magazine
Wood, Larry	City of Ukiah Public Works Department

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PERSONS CONTACTED FOR FINANCIAL PLAN

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Dupras, Don	Department of Conversation, Office of Mine Reclamation
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McClellan, Doug	Parnum Paving
Morrison, David	Yolo County Planning Department
Rush, Andrew	Department of Conversation, Office of Mine Reclamation
Stoufer, John	Tehama County Planning Department

APPENDIX A

Geomorphic Cross-section Data

Upper Russian River Aggregate Resources Management Plan
Philip Williams & Associates, Ltd.

APPENDIX B

Schematic Depictions of Current Knowledge of the Effects of Water Temperature on Relevant Salmonid Species

and

Status of Existing Fishery Resources in the Upper Russian River Watershed - Summary

Upper Russian River Aggregate Resources Management Plan
A. A. Rich Associates

APPENDIX C

Riparian Data Gathering Methods and Map Accuracy

Upper Russian River Aggregate Resources Management Plan
Circuit Rider Productions, Inc.
(Revised January 30, 1996)

DATA DICTIONARY:
ITEM DEFINITIONS AND EXPLANATORY NOTES FOR THE UPPER RUSSIAN RIVER AGGREGATE RESOURCES MANAGEMENT PLAN DATABASES

I. INTRODUCTION:

The purpose of this data dictionary is to document the contents of the attribute database that was developed for the Upper Russian River Aggregate Resources Management Plan, including information on data set file names, item names in each database file, item definitions, data sources, and codes. Since a data dictionary must change and grow along with the database itself, the code changes that are inevitable in any on-going project have also been recorded here.

The database filename consists of abbreviations referring to the study area (initials), the County, the type of data, the decade the aerial photography was produced, and a filename extension designating the file format. For example, RRME9HAB.xls is the name of the file containing habitat data for the Russian River study area, in Mendocino County, based on 1992 aerial photos, and stored in Excel 3.0 spreadsheet format.

Each individual map polygon or sub-polygon in the database was assigned a composite ID (also Acad_text) number derived by summing up the values of the codes for Bank, Reach and Polygon, as given below. For example, the ID number **8123.1** designates a specific polygon in the Feliz Creek Reach on the Right bank with a Polygon Number 23, and a Subpolygon .1.

BANK
Code 7000 = Mid-Channel
Code 8000 = Right Bank (facing downstream).
Code 9000 = Left Bank (facing downstream).

REACH
Code 000 = York Creek
Code 100 = Feliz Creek
Code 200 = Dooley Creek
Code 300 = Russian River, south of Hopland Hwy. 101 bridge
Code 400 = Morrison Creek
Code 500 = Ackerman Creek
Code 600 = Hensley Creek
Code 700 = Forsythe Creek
Code 800 = Robinson Creek
Code 900 = Russian River, north of Calpella
Code 9150000 = Russian River, from Hopland Hwy. 101 bridge north to Calpella

POLYGON
The identification code for an individual polygon is a whole number having from one to two digits within the range 1 to 99, inclusive.

SUB-POLYGON
Some polygons have been divided by a river mile marker into two or more parts. The sub-units of such a polygon are designated by decimal numbers.

A "missing data" code of either "xxxx" (for text fields) or "9999" (for numerical fields) was assigned when data for a given map polygon was unavailable, in order to differentiate such cases from legitimate "blank" fields in the database.

II. RIPARIAN VEGETATION AND LANDUSE DATABASES

Item list: Acad_Text\USGS_Quad\Aerial_#\Reach\Poly\Bank\Area_meter\Area_Ac\LandUse\LandCover\WHR\CNDDB\LandForm\Canopy_Closure\Ground_Coverage\Crown_Sz\Av_DBH

Item (1). Item Name: ACAD_TEXT\Data Type: Number

A numerical field containing the unique user-assigned identification number for each map polygon (it was called ACAD_TEXT for reasons having to do with the ArcCAD GIS program). This item serves as the principal "key" for sorting database records and relating them to the map polygons. Due to additions and deletions of polygons during the map editing process, these ID numbers were not necessarily sequential.

Item (2). Item Name: USGS_Quad\Data Type: Character

U. S. Geological Survey, 7.5 Minute Series Topographic Quadrangle names.

Item (3). Item Name: Aerial_#\Data Type: Character

Mendocino County, 1992 Aerial Photo Number, WAC Corporation, Eugene, Oregon. Aerial photo copy enlargements at 1:6000 scale, (original scale 1:31,680).

Item (4). Item Name: AREA_Meter\Data Type: Number

The area of a given polygon in square meters as calculated by AutoCad.

Item (5). Item Name: AREA_AC\Data Type: Number

The area of a given polygon in acres. Area_Ac is the result of multiplying the area in square meters (as calculated by AutoCad) by a conversion factor of 0.000247.

Item (6). Item Name: LANDUSE\Data Type: Character

Item (7). Item Name: LANDCOVER\Data Type: Character

Code A (Land Use) = Agricultural Land

Code R (Land Use) = Rural Residential, Rural Public Facilities (e.g.,schools), Rural Commercial Land, or Rural Golf Courses and other landscaped areas with 10-75% tree and/or grass cover.

Code O (Land Use) = Open Land (mainly unvegetated land that is not presently in agricultural, industrial, residential, commercial, transportation, or urban use, with <10% cover by herbs, shrubs, and/or trees).

Code h (Land Cover) = areas (other than gravel bars or gravel pit margins) in which open condition is clearly the result of recent human disturbance by cutting, bulldozing, heavy vehicle traffic, etc.

Code sc (Land Cover) = a gravel bar which has recently been "scraped" or "skimmed" to obtain aggregate.

Code N (Land Use) = Non-Cultivated Vegetated Land (cultural, semi-natural, or natural vegetation with >10% cover by herbs, shrubs, and/or trees).

Code fs (Land Cover) = Forbs and Shrubs predominate, although scattered small trees may be present. Use of this category is restricted to relatively early successional vegetation in habitats normally dominated by trees.

Code ow (Land Cover) = Oak/Hardwood Woodland or Forest (may include all oak species found in study area).

Code rf (Land Cover) = Riparian Forest, Woodland, and/or Scrub.

Item (8). Item Name: WHR\Data Type: Character

Item (9). Item Name: CNDDB\Data Type: Number

The California Natural Diversity Data Base (CNDDB) and the Wildlife Habitat Relationships (WHR) system are used by the Department of Fish and Game to classify vegetation communities and wildlife habitats throughout the state (see Airola 1988; Holland 1986; Mayer and Laudenslayer 1988). In the present study, CRP used both of these systems to classify polygons, in addition to the land use/land cover classification scheme presented above. The approximate correspondences among these three classification systems is given in the following table, for those land cover units that may occur in the study area:

Land Cover Units Used in this Study, and Their Approximate Correspondence to Units in the WHR Habitat Type and CNDDB Natural Community Type Classification Systems[1]

Land Cover Units Used In This Study	WHR Codes	WHR Habitats	CNDDB Codes
Riparian Forest and/or Scrub[4]	VRI	Valley-Foothill Riparian	61400
" " " "	"	" " "	63400
Oak/Hardwood Woodland[5]	(No General Oak Habitat Classification)		71100
Orchard or Vineyard	OVN	Orchard or Vineyard	None

Notes: [1]CNDDB codes are generally based on R. F. Holland (1986), and R. F. Holland's WHR-CNDDB correlations in the "Crosswalk Table" on pp. 23-39 in Mayer and Laudenslayer (1988). WHR Habitat names and codes are those listed in Mayer and Laudenslayer (1988) and the California Department of Fish and Game's WHR Computer Database (version 5.0). Since the intention of the WHR system is to classify major vegetative complexes at a scale sufficient to predict wildlife habitat relationships, most of its categories are at the association level of a vegetation classification or higher. A WHR habitat is generally broader than a "natural Community" type in the CNDDB system; a WHR habitat often encompasses more than one CNDDB community type.

Where disturbance has removed a pre-existing tree cover and tree species have not yet re-colonized a site to any significant degree, the WHR system allows the coding of such units as the "seedling stage" of a tree-dominated habitat. In this project we preferred not to make assumptions regarding potential vegetation development; all such units were coded on the basis of their presently existing cover (e.g., "Open", "Grassland", or "Forbs and Shrubs").

[3]All Grassland/Savanna cover units were assumed to be WHR Annual Grassland, unless determined by

ground truth to be Perennial Grassland.

[4] In the CNDDB system, Riparian Forest is 61400 and Riparian Scrub is 63400, but only the 61400 code was used here.

[5] "Oak/Hardwood Woodlands" in this geographic area are very variable in composition and structure. The CNDDB code 71100 refers to all vegetation types dominated by oaks and other hardwoods, but unfortunately the WHR system does not contain a comparably general designation. The WHR code VOW (Valley Oak Woodland) was therefore used to represent all oak woodlands in the lower-elevation parts of the study area and COW (Coastal Oak Woodland) was used for all hillside oak woodlands, since those appeared to be the most common types. However, in any area where ground-truth data was not obtained it should be realized that stands labeled VOW or COW may actually comprise some of the other oak-and hardwood-dominated types listed in this table.

Item (10). Item Name: LANDFORM\Data Type: Character Main Stem River Channel

Code I = Immediate Bank: a narrow bank which makes an abrupt transition between the wetted channel and the upper terrace, with no intervening in-channel terrace or gravel bar.

Code Tc = In-Channel Terrace: areas of intermediate elevation located between a gravel bar and the outer channel bank/upper terrrace. In-channel terraces may be in various stages of hummock formation, or they may be more-or-less level if the hummocks have already coalesced.

Code P = Point Bar or Alternate Bar: gravel bars formed at bends in a stream's thalweg that follow bends in the stream channel are called point bars; bars formed where there is a meandering thalweg within a straight stream channel are called alternate bars. There is a gradation between the two types of bars which often makes them difficult to distinguish; they are therefore lumped together here.

Code Wc = Wetted channel: that portion of the river's main channel (or a back channel connected to the main channel) in which surface water is visible.

Code M = Mid-Channel Island, or emergent "riffle bar".

Item (11). Item Name: CANOPY_CLOSURE\Data Type: Character Canopy closure as estimated from ground-truthing or aerial photos ("Photo-Closure") was classified into three categories:

Code L = Low; from "10"% (i.e., 5-15%) up to "40"% (i.e., 35-45%)
Code M = Medium; from > "40"% up to "70"% (i.e., 65-75%)
Code H = High; from > "70"% up to 100%

Note: The standard WHR system uses four classes for percent canopy closure (i.e., 10-24%, 25-39%, 40-59%, 60-100%). In the present project it was not feasible to distinguish such narrowly-defined categories because of the less-than-optimum quality of the available aerial photos; we therefore used the three broad classes defined above. In effect our scheme combined the first two WHR categories ("Sparse" and "Open") into a single class, while retaining classes similar to the WHR's "Moderate" and "Dense" categories.

Note: Our class boundaries for percent canopy closure were deliberately "fuzzy"; instead of a class boundary being a single percentage value, our threshold criteria spanned a range of values. The dividing line between canopy closure classes was drawn by eye where there was a "noticeable change" in canopy density that fell within these ranges on the photos; the actual location of the line was therefore a matter of the judgement of the photo-interpreter. According to Thompson (1987) a similar procedure is used by USGS to produce vegetation cover information on 7.5 minute quad maps.

Item (12). Item Name: GROUND_COVER\Data Type: Character
A rough visual estimate of the percentage of ground surface within the entire polygon covered by vegetation of any type. Codes and categories for cover followed Northen's terminology (Northen 1991; 1992):

Code u = "unvegetated" (<10% cover)
Code s = "sparsely vegetated" (11% - 50% cover)
Code c = "well vegetated" (> 50% cover)

Item (13). Item Name: CROWN_SIZE\Data Type: Character
We used 1:2,400-scale aerial photos and ground-truthing to classify vegetation in terms of the average crown diameter of overstory trees. However, we modified the criteria of the WHR system (Mayer and Laudenslayer 1988) by dropping the "multi-layered" class (because it combines layering and cover criteria rather than just tree size), and lumping the remaining five WHR classes into three categories, as follows:

Code A = Seedling to Sapling size (<15'; WHR codes 1 and 2)
Code B = Pole to Small size (15'-45'; WHR codes 3 and 4)
Code C = Medium to Large size (>45'; WHR code 5)

The use of these three broad size classes was a deliberate tradeoff, intended to improve the classification accuracy by accepting some loss of precision.

Note: The WHR system assumes that there is a consistent relationship between crown diameter and dbh which can be applied to all species of conifers on the one hand and all species of hardwoods on the other. No doubt this is an over-simplification, but it enables the user of the WHR system to obtain a rough estimate of average tree dbh from aerial photos in areas or time periods for which ground truth data may be unavailable.

The table below gives the correspondences among size class, conifer crown diameter, hardwood crown diameter, and dbh class that are assumed in the WHR system (Mayer and Laudenslayer 1988). Also shown are the actual sizes of tree crown images as they appear on aerial photos at the scales which were used in this project:

WHR Code	WHR Size Class	WHR Conifer Crown Diam.	WHR Hardwood Crown Diam.	WHR dbh Class	Hdwood Crown Diam. on 1:6,000 Aerial Photos	Hdwood Crown Diam. on 1:2,400 Aerial Photos
1	Seedling	n/a	n/a	< 1"	n/a	n/a
2	Sapling	n/a	< 15'	1-6"	< 0.8 mm	< 1.9 mm
3	Pole	< 12'	15-30'	6-11"	0.8 - 1.5 mm	1.9 - 3.8 mm
4	Small	12-24'	30-45'	11-24"	1.5 - 2.3 mm	3.8 - 5.7 mm
5	Med/Large	> 24'	> 45'	> 24"	> 2.3 mm	> 5.7 mm

Note: The structural condition of an entire stand, i.e., its particular combination of average tree size and canopy closure, is called the "habitat stage" in WHR terminology. A concept similar to that of the WHR habitat stage (albeit at a coarser resolution) can be expressed in our system by combining the codes for our three crown size classes with the codes for our three canopy closure classes.

For example, in our terminology the single habitat stage "BL" (consisting of "Pole to Small" size class trees with "Low" canopy closure) could include up to four of the WHR habitat stages: Pole/Sparse (3S), Pole/Open (3P), Small/Sparse (4S), and Small/Open (4P).

Item (14). Item Name: AV_DBH\Field Width: 10\Data Type: Character
A rough visual estimate (in inches) of the diameter class at breast height for the "average" or "typical" size of tree within the entire polygon. Used for tree-dominated and mixed vegetation types only; not used for polygons with <10% cover. This information is available only in area of project covered by the Russian River Resource Enhancement Plan, which includes the Russian River mainstem from the Hopland 101 bridge north to the Redwood Valley.

Code A = Seedling to Sapling size (<1"-6"; WHR codes 1 and 2)
Code B = Pole to Small size (7"-24"; WHR codes 3 and 4)
Code C = Medium to Large size (>24"; WHR code 5)

Note: On our field sheets the "Size" category originally contained dbh size class information according to the standard WHR definitions (Mayer and Laudenslayer 1988). We subsequently modified our classification by lumping the five WHR size classes into the above three categories, and changing the name of this item to Av_dbh. Av_dbh differs from Item 2 above (N_Size_Class) in that the latter refers only to the dbh of "the stand's largest trees" (Northen 1991; 1992).

Upper Russian River Gravel Resource Management Plan Map Metadata Information Feb. 5, 1996

LEVEL I : BASIC IDENTIFICATION INFORMATION

1. Owner's Data File Name: **RRme9_xx.xxx**
2. Meta Data Entry Date: **February 5, 1996**
3. Data Set Identity (Name): **1992 Upper Russian River and Tributaries, Existing Riparian Vegetation, Landuse/Landcover.**
4. Data Set Name Abbreviation: **RRME9hab**
5. Data Set Location (geographic area description): **Russian River, York Creek, Feliz Creek, Dooley Creek, Morrison Creek, Ackerman Creek, Hensley Creek, Forsythe Creek, and Robinson Creek riparian zone, Mendocino County, California.**
6. Data Set Extent (Coordinates; USGS Quad #'s; Calwater ID #'s): **USGS 7.5 minute quads, no. 39123-C2 (Redwood Valley), 39123-C3 (Laughlin Range), 39123-B2 (Ukiah), 39123-A2 (Elledge Peak), 38123-H2 (Yorkville), and 38123-H1 (Hopland)**, **39123-A1 (Purdy's Garden).**
7. Data Set Keywords (descriptive of content): **Mendocino Water Agency/Philip Williams & Associates, Inc./Circuit Rider Productions, Inc., Upper Russian River Gravel Resource Enhance ment Plan, riparian zone, riparian corridor, land use, land cover, Russian River, 1992**
8. Data Set Description (description): **1992 land use/land cover polygons digitized from 1:6,000-scale aerial photo enlargements.**
9. Data Set Purpose: (description) **data layers will be used in riparian ecosystem management and planning analyses, impact assessment**
10. Data Set Source (organization) : **Mendocino County Water Agency (1989 aerial photos); WAC, Inc. (1992 aerial photos); American Digital Cartography, Inc. (digital base maps).**
11. Data Source Form (map; photos; ground; remote sensing, map type; other): **1:6,000-scale enlargements of 1992 aerial photos, printed on blueprint-quality paper ; digital maps based on USGS 1:100,000-scale DLGs; ground-truth of areas covered by riparian vegetation from 1992 ground surveys by Circuit Rider Production staff for area covered by the Russian River Resource Enhancement Plan, (Russian River mainstem from town of Calpella south to Hopland 101 Hwy. bridge).**
12. Representation Feature Type (point/line/polygon/raster/other): **polygon**
13. Data Set Resolution: **no GIS coverage made**
14. Minimum Mapping Unit (smallest resolvable object in acres, feet, lines/mm on film; pixel size):**0.5 acre**
16. Earliest Date for which Data are valid (DD/MON/YYYY): **May--, 1992**
17. Last Update: DD/MON/YYYY **20/Jan/1996**
18. Revision Cycle (every six months; annuals etc.): **uncertain**
19. Temporal Archive? (yes/no): **yes**
20. Data Set Size (in megabytes): **approx. 150 megabytes**
21. Related Data Sets for same Location (abbreviations): **Russian River Resource Enhancement Plan, ME90_hab, ME90_rip, ME90_loc, ME42_hab, ME42_loc.**
22. Data Set Quality and Limitations (comments): **Line work is complete and attribute information has been recorded; no GIS coverage made; ground truth has been obtained only for 1990 riparian vegetation polygons in the area described above. Although the aerial photos are not orthophotos, the terrain within the floodplain study area is relatively level and the the mapping results are considered acceptable for purposes of natural resources planning. Positional accuracy is limited by the 30 m Root Mean Square Error (RMSE) inherent in the 1:100,000-scale digital base map that was used for geo-referencing**.
23. Data Set Owner (organization): **Circuit Rider Productions, Inc., Philip Williams & Associates, Mendocino Water Agency**
24. Data Set Contact Person Name: **Karen Gaffney**
25. Position/ Title: **Environmental Projects Manager**

26. Address: **9619 Old Redwood Highway, Windsor, CA 95492**
27. Voice: **(707) 838-6641**
28. FAX: **(707) 838-4503**
29. E-mail: **CircuitRP@aol**
30. Data Distribution Limitations: **Call Circuit Rider Productions, Inc.**

LEVEL II: DISTRIBUTION INFORMATION

31. Distribution Contact Name and Address: **See 24 to 28 above**
32. Distribution Policy: **Call Circuit Rider Productions, Inc.**
33. Copyright Status: **as above**
34. Custodial Liability: **as above**
35. Transfer Options: **as above**
36. Transfer Format (MOSS exhcange, IGDS, DIME): **AutoCAD dwg or dxf formats, Excel xls format.**
37. Transfer Mode/ Media (modem, network, tape, disk): **diskette**
38. Turnaround Time (time to receipt of order): **?**
39. Transfer Size Information (megabytes): **2.5 megabytes**
40. File Compression Techniques (software and version): **Stacker**
41. Dialup Instructions: **no**

INFORMATION ABOUT THE DATA BASE

42. System and Software (model #'s and versions): **Database created on 486 PC running MSDOS v.6.0, 16 MEG RAM and 240 MEG hard drive; spatial data files in AutoCad format; attribute data files in Excel format.**
43. Projection (Universal Tranverse Mercator; Polyconic etc.): **UTM, Zone 10**
44. Horizontal Datum (NAS, NAX, WGA, WGE, other): **NAD27**
45. Ellipsoid: **?**
46. Data Extent: (exact coordinates): **474306.4m E, 4302594.0m N; 496130.6m E, 4302594.0m N; 474306.4m E, 4355095.4m N; 496130.6m E, 4355095.4m N.**
47. Data Capture and Transfer Method/s (digital download; digitizing from photos; scanning; GPS): **Digitizing from aerial photos**

PROCESSING INFORMATION

48. Post Capture Processing? (Yes or No): **Yes**
49: Describe Post Capture Processing (what was done to the data after it was transferred from the source): **Feature boundaries were interpreted from aerial photos and were registered to a digital map based on USGS 1:1000,000-scale DLGs using the projective transformation routine in AutoCAD Release 12.0. Manual digitizing was done on a 24" x 36" CalComp Drawing Board II digitizing tablet. AutoCAD commands were used to determine polygon areas and to label polygons. Attribute data in Excel format linked to drawing polygons by Acad_text labels.**

DATA DICTIONARY (list of items in attribute tables)

50. Table Name: **MeRR9hab.exl**
Item list: **Acad_Text\USGS_Quad\Aerial_#\Reach\Poly\Bank\Area_meter\Area_Ac\LandUse\LandCover\WHR\CNDDB\LandForm\Canopy_Closure\Ground_Coverage\Crown_Sz\Av_DBH**
Description: **Location information, landuse/landcover information and riparian vegetation habitat typefor each 1992 polygon in study area.**

QUALITY

51. Positional Accuracy (absolute and relative accuracy of data set in percent): **Overall accuracy has not been determined; see no. 52.**
52. Positional Accuracy Explanation (definition of measure used and description of how estimate was derived): **Positional accuracy was determined by reference to a digital 7.5-minute quad map based on a 1:100,000 USGS DLG having an inherent RSME of 30 m or less. Aerial photo copies were registered to the reference map with the projective transformation routine in AutoCAD Release 12.0 using a minimum of five control points, each of which was common to both the map and the overlay.**

The accuracy of registration between aerial photo copies and the base map was measured by the RMSE calculated in map units (meters). Since the <u>output</u> maps for the project were to be plotted at a scale of 1:24,000, the tolerance value specified by the National Map Accuracy Standards for maps of this scale was used as a guide during the registration operation. The appropriate RMSE value when registering the overlays to the digital base maps was 7.31520 m (or 0.010 inch in digitizer units). 82.35% of the overlays for the 1992 drawings were able to meet this standard, and 17.65% had RMSE values of between 7.31520 m and 9.0 m.

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Northen, Philip. 1991. Classification Scheme for Landforms, Land Uses, and Vegetation Types in the Planning Area for Sonoma County Aggregate Resources, July 1991.

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APPENDIX D

Memoranda: Potential Withholding of Federal Funds/Aggregate Mining in Rivers

Letter from FHWA to Caltrans
Letter from Caltrans to Mendocino County
Letter from County Public Works to Mendocino County Board of Supervisors

APPENDIX E

Draft Instream Monitoring Guidelines Prepared by the Resources Agency (1996)

APPENDICES

FIGURES

TABLES