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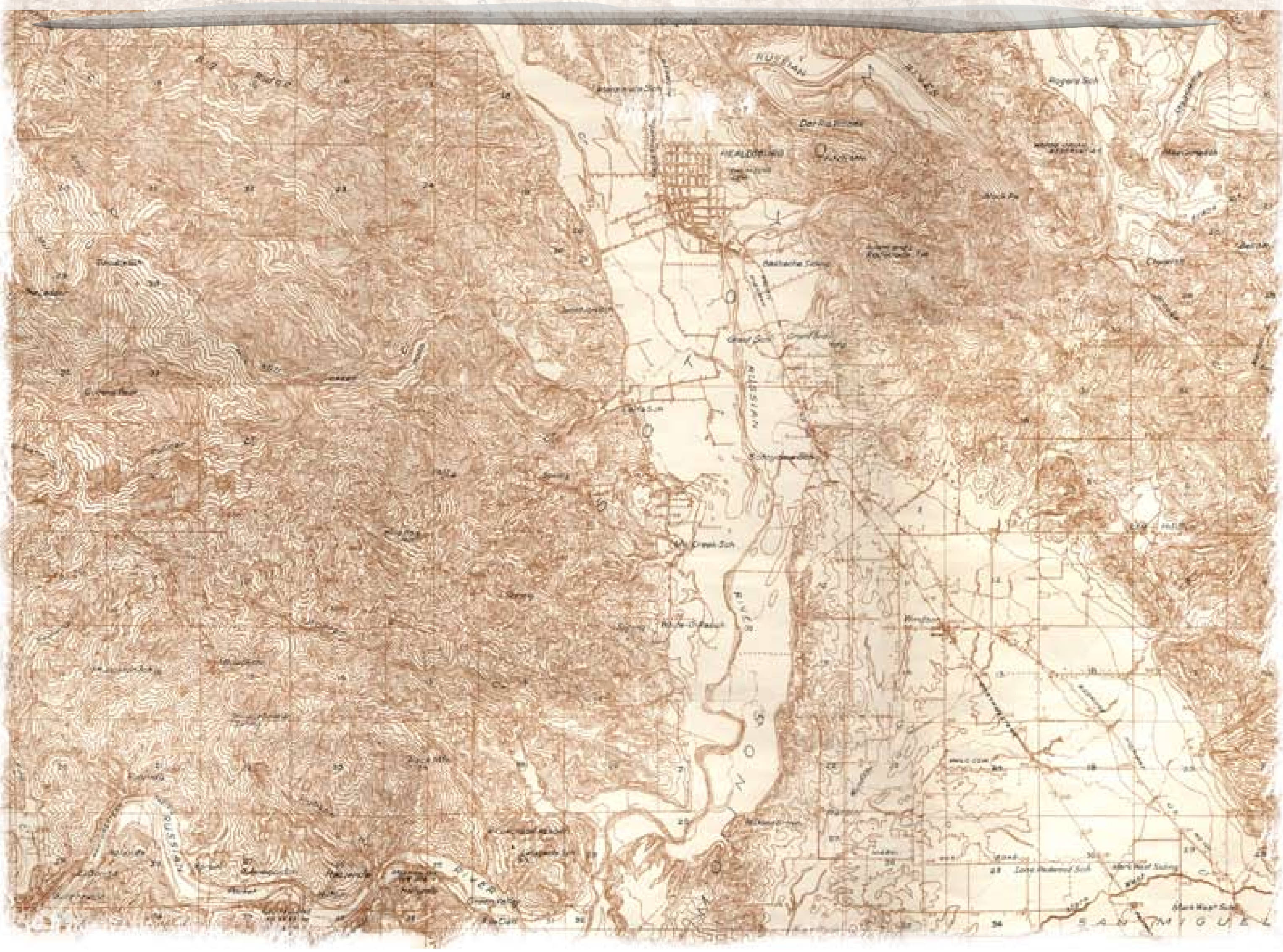

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Executive Summary

Throughout the world there is increasing public awareness of the importance of sustainable water management to meet both growing human demands and ecosystem needs. Predictions of increased climate variability and indicators of ecological and water quality deterioration have made water management a salient political issue, particularly in arid climate regions such as western North America and the Iberian Peninsula. In recent years, substantial effort has been focused on adopting sustainable water use practices and mitigating the impacts to natural rivers and streams resulting from human activities. Yet the restoration of natural biological communities has been more difficult than anticipated. Our inability to effectively restore and protect rivers and groundwater sources are in part due to the scale of environmental damage inflicted upon them, but also are a consequence of the legal and institutional frameworks under which water is managed. Assessments of the current state of the world's water resources suggest that conventional approaches to water management will be inadequate to sustainably balance human and ecosystem needs into the future. Furthermore, as nations around the world struggle with water management challenges, there has been little explicit attempt for one region to learn from the experience of another in approaching common problems.

The European Union's Water Framework Directive (WFD) defines a new strategy for meeting human water demands while protecting environmental functions and values and may be helpful in informing water management practices and policies in other regions of the world. In the report we explore how the management approach described under the WFD compares to the legal and institutional system of a California river basin, managed under distinctly different principles and objectives. Through a theoretical application of the WFD, we highlight the critical water management challenges of northern California's Russian River basin and use the Directive's approach to develop strategic recommendations for water management reform.

Europe's Water Framework Directive (WFD)

Adopted by the European Parliament and Council in 2000, the WFD represents a bold change in the way water is conceptualized and managed in Europe. Recognizing water as "a heritage which must be protected, defended, and treated as such," the WFD requires member states of the European Union (EU) to develop common institutional arrangements, monitoring methods and water quality objectives in order to substantially improve the ecological, chemical and quantitative status of rivers, lakes, groundwater and costal waters by specific deadlines. The heart of the WFD is a holistic water status assessment method, which defines "good" status by a combination of biological and physical elements characteristic of high-quality, local reference conditions. The WFD requires that all water bodies in the EU achieve good status by 2015. To meet this ambitious objective, the WFD establishes watershed-scale governance and environmental economics approaches to expand the capacity of agencies and communities to conduct integrated, long-term water-use planning. The interdisciplinary and holistic water management approach developed under the WFD has the potential to benefit not only biological systems, but also the economic performance and quality of life of human society by increasing water security, reducing pollution treatment costs and creating new employment opportunities in less environmentally damaging sectors.

The WFD's overall objective of improving water quality conditions is similar to the US Clean Water Act's call for fishable, swimmable waters across the nation. However, the WFD incorporates many innovative approaches to water management that are strikingly absent in the US. Most notable are basin-scale management units, a comprehensive science-based water status classification system, the integration of land-use and water-use planning, economic analyses of water uses, and an adaptive, iterative approach to evaluating and selecting appropriate management measures.

Russian River Basin Case Study

This report describes the analytical process by which water management measures would be developed and implemented under a theoretical application of the WFD to the Russian River Basin in northern California. The Russian River shares many elements characteristic of river basins throughout the state: multiple water uses, including drinking water, agricultural irrigation, hydropower, industry, fishing, recreation and endangered species protections; flow regulation from large dams and dispersed small-scale diversions; a controversial inter-basin water transfer; large agricultural water use relative to other consumptive uses; growing populations and increased pressures on the quality and quantity of water resources; and a complex administrative system responsible for managing water resources.

The report follows steps that would be taken under the proposed WFD implementation cycle for EU member states, beginning with the establishment of a competent administrative entity at the basin scale and identification of management units (water bodies) within the Russian River basin. An assessment of existing environmental conditions is then conducted, followed by an analysis of pressures and impacts within the basin. Next, an economic analysis of water uses is performed in order to determine if and to what extent, water pricing structures provide incentives for efficient water use. Finally, the findings of the environmental, pressures and impacts, and economic analysis are evaluated to develop recommended monitoring and management measures for the basin.

Findings and Recommendations

The application of the WFD approach confirms the designation of "impaired" under the Clean Water Act for water bodies in the Russian River basin. Despite substantial uncertainty due to data limitations, the environmental assessment and impacts analysis indicate that the current ecological and water quality conditions of nearly all of the identified water bodies in the basin would likely be at risk of failing to achieve "good status," based on WFD criteria. Hydromorphological impacts (including channel modifications and flow regime alterations) and water quality impacts (elevated sediment and nutrient loads) from diffuse pollution sources are the principal factors adversely affecting the condition of Russian River water bodies. Point source pollution and biological pressures (such as non-native species proliferation) are also responsible for placing several water bodies at risk of failing to reach the "good status" objective of the WFD.

Based on the findings of the Russian River basin characterization, environmental assessment and economic analysis, implementation of the Water Framework Directive would require fundamental change in current water management practices and policies. The analyses highlight three critical elements to be addressed as first steps towards achieving sustainable water management as part of WFD implementation. These are: (1) establishing administrative arrangements which could ensure coherent, integrated and participatory basin-scale water management, (2) creating a unified ecological classification system for all waters and (3) instituting an iterative decision-making process by which economic and environmental management measures could be developed and evaluated. Each of these steps is described in more detail below.

(1) Administrative and Legal Reform

The WFD would establish a central authority that has the power to oversee and coordinate all water-related activities in the river basin district. There is now no such authority in the Russian River basin and water management is currently carried out by broad range of agencies whose responsibilities are narrowly defined and often conflicting. The current water rights system and complex assortment of local, state and federal laws currently make it nearly impossible to develop and implement a comprehensive plan of measures necessary to effectively address water issues at river-basin scale. While it is difficult to envision the exact nature of river basin district authority in the Russian River basin, it is clear that a central agency or coalition would need to be identified and granted authority over water management and land use planning regulations. The resulting centralization of power would only be possible if all relevant water management agencies at local, state and federal level provided the enabling framework conditions to accommodate changes in jurisdictional and regulatory authority. Political safeguards in the form of elected representatives and public participatory requirements would be needed to ensure transparency and accountability of the centralized decision-making body. As has been demonstrated in Europe, the rearrangement of administrative authorities could be expected to be the most politically intensive aspect of WFD implementation.

(2) Consistent ecological monitoring and classification system

The environmental analysis reveals significant data gaps in both our understanding of the current ecological status of the basin and the main pressures and impacts causing ecological deterioration. Substantial ecological data are available for the Russian River basin, but they have not been integrated or collected in a manner to effectively inform management decisions at the river-basin scale. There is a critical lack of monitoring information with respect to groundwater pumping, surface water diversions and the effects of land use activities on water quality. This information is necessary to determine how water and land use activities may be affecting the ecological health of water bodies, to develop mitigation measures and realize alternative management strategies. To perform a coherent ecological assessment of Russian River water bodies at the level required by the WFD, an increased level of coordination between agencies is essential; both to broaden the scope of monitoring efforts and to develop a common basis to assess ecological conditions. A generalizable ecological classification system could be largely based on existing federal, state and regional classification systems, but would need to (1) be integrated into one unified system, (2) be comparable between different regions, (3) sufficiently reflect the unique susceptibilities of different biological parameters to different human pressures, and (4) reflect physical and ecological processes rather than only existing conditions.

(3) Economic and Environmental Evaluation of Management Measures

On-going monitoring efforts in the basin have shown that surface water conditions have fallen below healthy chemical and ecological standards throughout the Russian River Basin. A broad range of measures has been introduced to improve conditions, including habitat restoration, water conservation programs and recommendations for best management practices. However, there has been little effort directed towards monitoring and assessing the effectiveness of these measures or to developing novel strategies for achieving the environmental objectives. Most restoration measures so far have been focused on stabilizing and restoring the hydromorphology of relatively short river reaches, artificial fish stocking, and voluntary riparian and land management programs. The restoration of natural flow processes, floodplain connectivity, and implementation of water conservation measures targeted at non-domestic users at the river basin level have been absent.

In recognition of the revenue limitations for restoration and conservation, it is necessary to perform a critical evaluation of the cost effectiveness of on-going measures. It is vital to identify the measures that do not produce tangible benefits, in order to free limited resources for those that do. Therefore, a robust and environmentally meaningful economic assessment of water uses and the incentive function of water pricing is required. The economic analyses undertaken in this study, though limited by lack of data, reveal that many of the most environmentally damaging water uses are subsidized by the public at large and water prices provide little to no incentive to reduce the pressures. Economic and market based incentives (i.e., extraction charges or subsidies for water saving investments) are generally absent in the basin, yet could be a powerful tool to encourage the efficient use of water and support a more equitable distribution of environmental costs and benefits.

While adoption of the WFD represents a dramatic change for water management in the European Union, initial implementation reports indicate that EU member states have a long way to go to meet the WFD's ambitious standards. Setting a new trajectory for EU water management requires the mobilization of substantial resources to overcome political and administrative inertia. It is clear the WFD is not a "silver bullet" that provides simple solutions to challenging problems. However, as the Russian River case study illustrates, the WFD may provide a useful framework for building the capacity of communities to conduct long-term planning at the basin scale and manage water resources in a more deliberate and efficient manner. By redefining the role of agencies and the public to integrate segregated roles and functions into a participatory decision-making process, the WFD approach offers ways to improve water management practices in California and potentially elsewhere.

1.0 Introduction

Little known to most Americans, the European Union has recently embarked on an ambitious new system of water management affecting all member states. Adopted by the European Parliament and Council in 2000, the Water Framework Directive (WFD) (Scheuer 2005) emphasizes basin-scale, public participatory, and environmental economics approaches. It requires member states to make substantial progress towards improving the ecological, chemical and quantitative status of rivers, lakes, groundwater and costal waters by specific deadlines (Kaika 2003; Kallis and Butler 2001). For scholars of water resource management in the US, the WFD is of compelling interest and relevance because it brings innovative management approaches to EU nations with a level of economic development comparable to that of the US.

Since the Second World War, environmental river management in western Europe has evolved and expanded from an initial focus on water chemistry (and consequent construction of sewage treatment plants), to increased recognition of the importance of aquatic ecology (and consequent focus on limnology and the study of macrozoobenthos), to a current recognition of the role of geomorphology in supporting ecological functions. In the developed regions of the EU nearly all water bodies have been substantially modified by historical and current human activities. Water bodies in a semi-natural state exist only in the most remote areas, generally in small creeks of forested and mountainous regions.

A growing concern over the loss of biodiversity has recently lead to stronger environmental regulations in the EU to prevent further impacts to protected habitats and species, many of which are water dependent. For example, proposed new constructions of dams and diversions now undergo extensive public debate, many are altered to reduce environmental impacts and some are not approved. Increasing emphasis is placed on restoration of more natural river forms and processes and the demand for a better status of rivers has produced an intense dialogue between nature conservationists on the one hand and water managers and users on the other.

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The WFD attempts to unify the large diversity of water regulations in the European Union through a sequence of phases through 2027, with the goal of protecting and restoring the ecological condition of all water bodies, while sustaining multiple water uses for human benefit.

Not only is there little geographical integration of agency jurisdictions on the river-basin scale in the US, but there is also little interdisciplinary integration in the day-to-day management of water resources.

The WFD emerged out of this dialogue as a legal framework to establish a coherent and comprehensive decision-making process for managing water resources among all EU member states. The WFD attempts to unify the large diversity of water regulations in the European Union through a sequence of phases through 2027, with the goal of protecting and restoring the ecological condition of all water bodies, while sustaining multiple water uses for human benefit.

From a North American perspective, the WFD has a number of parallels to US legislation and practice, but with some distinctive aspects. One of the WFD's innovations is water management on a river-basin scale, intended to allow for improved integration of land use and water resource planning (Moss 2004). Basin-scale management was first proposed for the western US by John Wesley Powell during his tenure as Director of the US Geological Survey in the 1890s, but which was never implemented due to political opposition (Stegner 1992). With notable exceptions such as the Tennessee Valley Authority, basin-scale management agencies are either non-existent or have relatively little power (especially for river basins encompassing more than one state). Not only is there little geographical integration of agency jurisdictions at the river-basin scale in the US, but there is also little interdisciplinary integration in the day-to-day management of water resources. There are multiple agencies with overlapping (and often conflicting) mandates for various functions, such as providing water supply for domestic, industrial, and agricultural uses, issuing permits for surface water diversions and/or groundwater pumping, treating wastewater, monitoring surface water and groundwater quality, and protecting populations of aquatic and riparian organisms. In contrast, the WFD establishes river basin districts that have the authority to implement comprehensive river basin management plans designed to achieve environmental objectives.

The WFD's target for ecological health in rivers and other surface waters is similar to the US Clean Water Act's (CWA) call for fishable, swimmable waters across the nation. The CWA initially focused on chemical quality (dissolved oxygen, contaminants, etc.) and reduction of point-sources discharges. Congress directed funding to local and state agencies to construct wastewater treatment plants, resulting in overall improvements in water quality over the course of about a decade. However, despite these improvements, populations of native fish and other aquatic species continue to decline. In recent years, attention has been directed to the importance of river hydromorphology – the natural hydrologic and geomorphic processes that give rise to form, functions, and the ecological communities of rivers and streams. Incorporating these scientific advances in aquatic ecology, the WFD goes beyond existing US regulations by explicitly addressing the interacting roles of chemical and hydromorphological conditions to support the achievement of ecological objectives.

Mitigating the ecological impacts caused by hydromorphological alterations caused by land and water uses has proven more elusive than water quality improvements, in part because the impacts are associated with important economic services (e.g., levees for flood protection, dams for water storage and hydropower and diversions for agriculture irrigation). For this reason, another compelling aspect of the WFD is the requirement for economic analyses to determine the cost-effectiveness of water management measures (including water infrastructure development and maintenance) and the adequacy of water pricing structures to support environmental objectives. The WFD applies the principle of cost recovery, requiring that users of water make an adequate contribution to the costs (financial and environmental) of the water services from which they benefit (EEB and WWF 2006). Member states are now required to perform an economic analysis of their water uses to determine if and to what extent, water pricing recovers service costs and provides incentives for efficient water use. Furthermore, the WFD requires that the economic analyses and related decisions be transparent and involve the public. These and other approaches contrast with those of US water management, which, when viewed through the lens of the WFD, appears more splintered, and in many respects more rigid, than its European counterpart.

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1.1 Project Background

The Mediterranean climate prevailing in southern Europe (as well as coastal California, coastal Chile, southern South Africa, and southwestern Australia) exerts a pervasive influence on patterns of human settlement and resource use (Figure 1-1). Some of the characteristics of Mediterranean climate regions that pose challenges to land-use planning and design include summer drought, highly seasonal precipitation and river flow, high inter-annual variability in

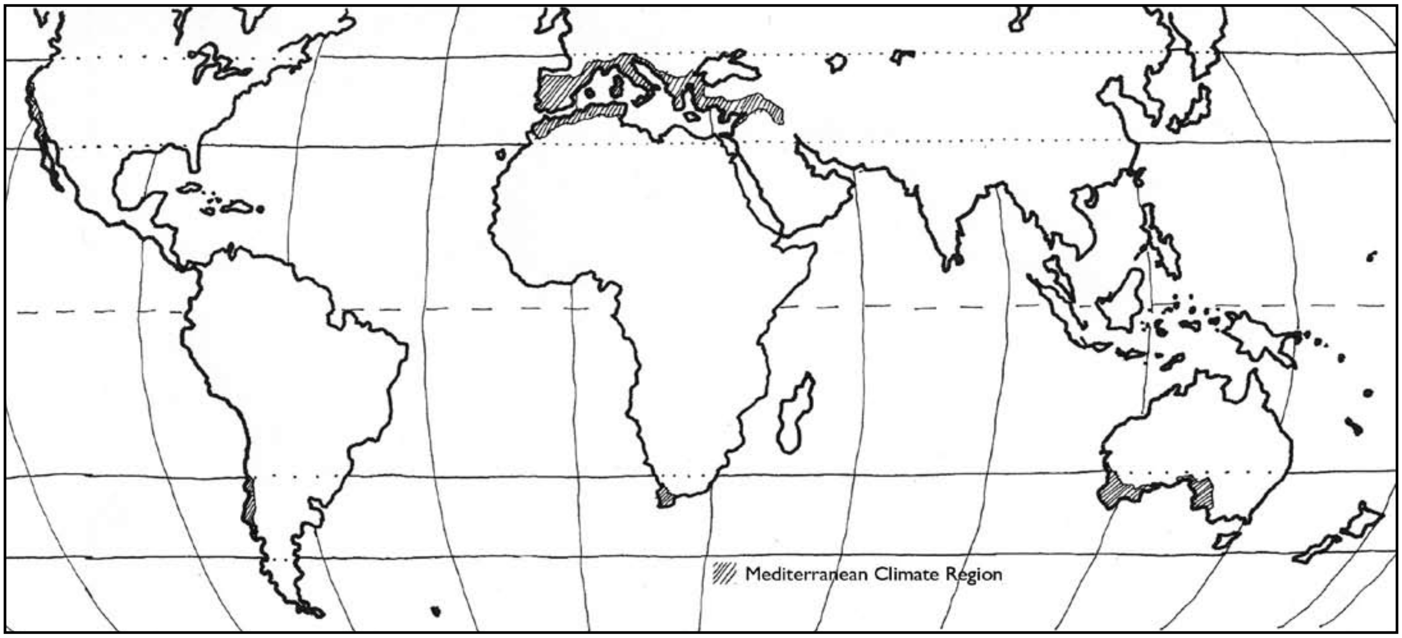

Figure 1-1. Mediterranean-climates of the world

precipitation, episodic floods and sediment transport, and the human response to this natural variability in constructing massive water supply and control infrastructure at a scale far exceeding that degree of control seen in more humid climates (Conacher and Sala 1998; Gasith and Resh 1999). As a result, the degree of hydrological alteration (and consequent ecological change) is typically much greater in Mediterranean-climate rivers than humid-climate systems (Batalla et al 2004; Kondolf and Batalla 2006).

Despite the strong parallels among Mediterranean-climate regions, and despite the transference of Iberian settlement patterns to Mediterranean-climate California by Spanish missionaries in the 18^{th}-19^{th} centuries, the similarities of the constraints and opportunities in water management have been little recognized in recent years. There has been little explicit attempt for one region to learn from the experience of another in approaching these common problems. In an attempt to develop potential collaborative and comparative studies, a new course entitled "Mediterranean-Climate Landscapes" was launched at UC Berkeley in 2005. The course involves comparative study of natural processes, planning, policy and legislation in California and other Mediterranean-climate regions, especially Portugal. Students conduct original research and/or develop plans or designs to enhance environmental and social conditions, undertaking research in California during the semester, and then abroad immediately following the end of term.

In spring 2007, the course focused on the European Water Framework Directive (WFD) and its implementation in Mediterranean countries. In addition to conducting independent research projects (available on line at http://landscape.ced.berkeley.edu/~kondolf/courses/LA229/229_Website.html), participants in the course worked together to investigate how the WFD approach compared to water management in a California river basin. We structured the analysis as a case study, based on the hypothetical premise that the Russian River was part of a European nation and thus subject to requirements of the WFD.

1.2 The Russian River Basin Case Study

The Russian River in northern California was selected because the basin presents many of the challenges that have been difficult to address under California's current water management system. These challenges include: multiple, competing water uses (such as drinking water, agricultural irrigation, hydropower, industry, fishing, recreation and endangered species protections); flow regulation from large dams and dispersed small-scale diversions; a controversial inter-basin water transfer; large agricultural water use relative to other consumptive uses; growing populations and increased pressures on the quality and quantity of water resources; and a complex and disjointed administrative system responsible for managing water resources.

In this study we drew upon available information to analyze the existing administrative, environmental, and economic setting of the Russian River basin and explored how water management practices and policies might differ under the WFD. We assessed how surface and groundwater bodies in the basin would rate in terms of their risk of not achieving ecological objectives as defined by the WFD. We then performed an economic assessment of water services in the basin to determine if current water pricing structures are consistent with cost recovery principles and promote water use efficiency. Finally, we identified critical issues in the basin that present the most significant obstacles to establishing a watershed management approach similar to the WFD that would allow for basin-scale planning, cost-effective decision making and environmentally sustainable water resource use.

Despite the strong parallels among Mediterranean-climate regions, there has been little explicit attempt for one region to learn from the experience of another in approaching these common problems.

2.0 What's in the Water Framework Directive?

2.1 Overview of Europe's Water Protection Policy

The WFD establishes a holistic environmental assessment method, by which water status is defined by its ecological, chemical, and in the case of groundwater, quantitative status (WFD 2000). The method defines a "good" status for surface waters when relevant biological parameters, including fish, macrophytes, benthic invertebrates and phytoplankton, deviate only "slightly" from the ones found or expected to occur under pristine, natural conditions and water quality (physico-chemical) standards are met (Figure 2-1). The greater the deviation of biological elements from reference conditions, the lower the classification status. Good status for groundwater is met when its chemical quality has no negative impact on drinking water supply; water extraction does not exceed the long-term natural groundwater recharge; and natural flow directions it does not negatively affect the status of surface waters and groundwater dependent terrestrial ecosystems. This good status should be achieved by 2015 in all waters, rivers, coastal water, lakes or groundwater, leaving no water unprotected, irrespective of its current or future anthropogenic use. As a minimum, all waters must be protected to avoid further deterioration from their current status when initially assessed.

But how can "good status" be defined for all water bodies across Europe? How can a river in Sweden, which is frozen half of the year, be compared with one in Portugal, which runs dry in summer? First, common "chemical quality standards" will be set for approximately 30 priority pollutants that apply to all Member States. (EC 2006). Second, the EU is conducting an "intercalibration" exercise, which aims to ensure that consistent and comparable ecological quality standards are set in all Member States (EC 2003a). The intercalibration process uses biological quality elements of physically undisturbed and unpolluted natural habitats in each country to define reference conditions by which similar water body types are assessed. Once the reference conditions are determined, biological quality elements may be defined to characterize the "good status" that member states must aim to achieve. In this way, natural variation in the ecological communities across the diverse biogeographic regions of the EU can be accounted for.

In comparison to previous water management in the EU member states, and most other countries in the world, water quality standards are based on setting acceptable levels of deterioration due to specific impact or pollution sources. In the US, for example, water quality standards and pollution limits are based on identified beneficial uses for a specified water body. The use, or purpose, of the water body determines its level of protection. Under such a system, two ecologically identical streams could have different protection standards if their identified beneficial uses are different. In contrast, under the WFD, good status is only achieved when the native ecological community is intact, regardless of identified uses or compliance with specific water quality standards. Furthermore, the WFD's so-called "one out, all out principle" requires that the overall classification status of a water body is set by the worst quality element present.

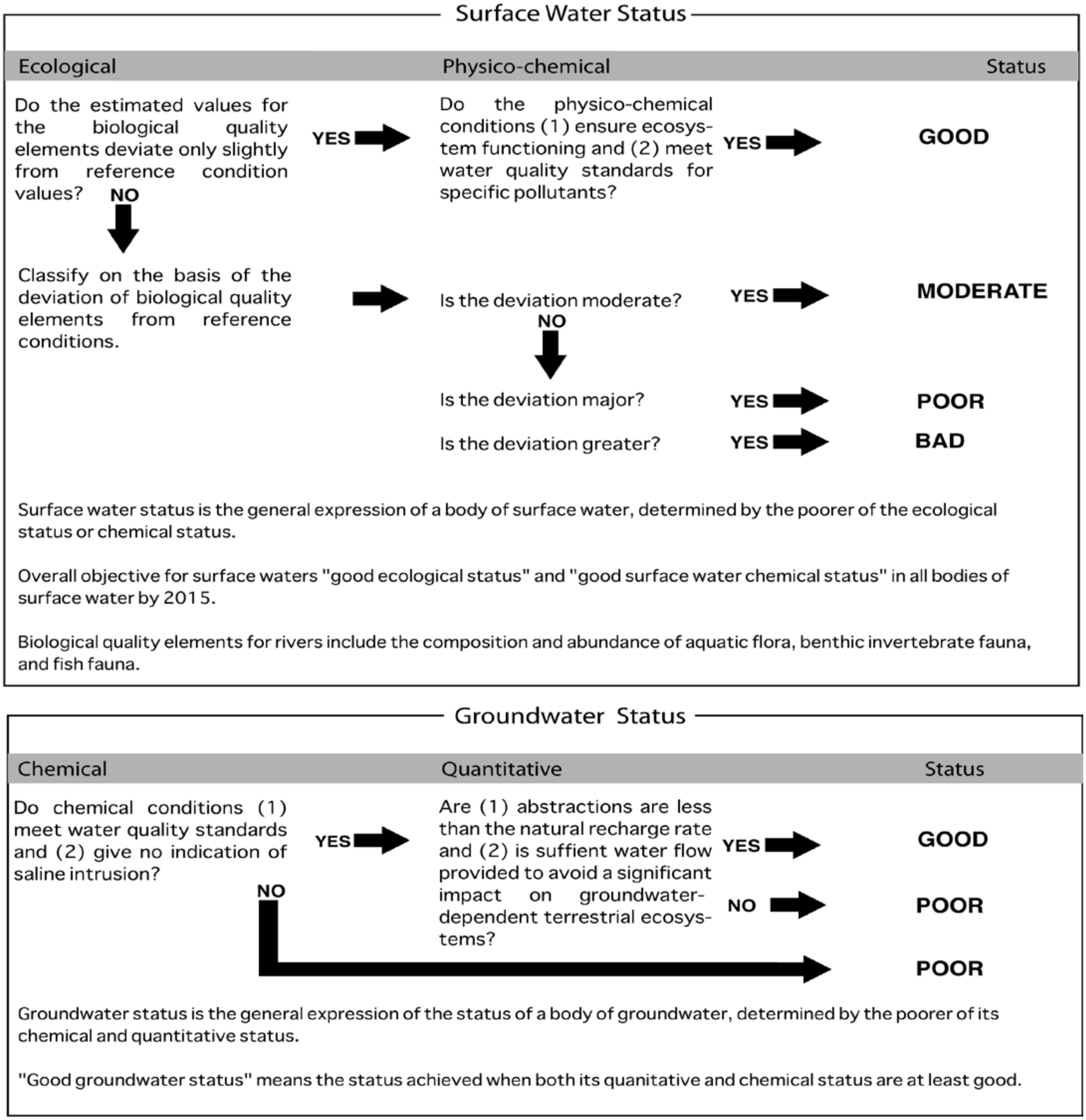

Figure 2-1. Classification system for surface and groundwater bodies under the WFD

The goal of this ecologically-based assessment method is the integration of a former piecemeal approach to water resources protection and land use management. Through a common management strategy addressing multiple water uses, functions and values important for the environment, economic sectors, health and human consumption and general public good, the outcome of the water status assessment will be comparable color coded maps for the whole of the European Union, which inform the decision-makers and the public about how far each river basin is away from good status and if water is being managed in an environmentally sustainable way. In order to achieve good status, the WFD proposes a wide range of regulatory measures, including emission and extraction controls, as well as financial instruments to encourage efficient water use (EC 2003b).

2.2 Administrative Arrangements: Spatial Integration and Cooperation

The natural scale for water management is the river basin (or watershed as it called in the US). Under the WFD, EU member states have defined over 100 river basin districts with varying sizes ranging from less than 1,000 square kilometers (400 square miles [mi^2]) in area to more than 50,000 square kilometers (20,000 mi^2). Forty-four international river basin districts cover more then 60% of Europe's territory, highlighting the importance of cooperation across national boundaries (CEC 2007 a). The WFD requires countries to establish a competent authority for each river basin district, which is responsible for implementing the water status classification process, setting of environmental objectives, coordinating management activities in the basin and executing regulatory action to achieve water quality objectives. Few agencies or public bodies currently have such authority and significant administrative reforms seem necessary. Indeed, while some countries have used the opportunity to engage in such reforms, the majority have avoided yet dealing with the difficult task of rearranging institutional jurisdictions and responsibilities (EEB and WWF 2006).

The WFD requires countries to establish a competent authority for each river basin district, which is responsible for implementing the water status classification process, setting of environmental ojectives, coordinating management activities in the basin and executing regulatory action to achieve water quality objectives.

2.3 The Management Process: Public Involvement and Transparent Decision Making

Implementation of the WFD follows a cyclical, stepwise management process that requires public involvement and transparency. Each implementation phase has to be publicly documented and main decisions taken with active public participation. All background documents, including monitoring data, must be made available on request. The management process began with an assessment of the environmental problems and economic analysis of water uses in 2004 and required that monitoring programs be put in place by 2006. By 2009, each river basin district must set objectives, and by 2015, a program of measures to achieve the objectives. The effectiveness of those steps are to be reviewed every six years until 2027 when the operational period of the WFD comes to an end (Figure 2-2).

2.4 Stocktaking of Environmental Conditions and Water Use Economics

As the first step in WFD implementation, established competent authorities analyze pressures and impacts on the status of waters and evaluate the risk of failing to achieve a good status by 2015. EU-wide, approximately 40% of surface waters are judged to be at risk of not achieving good status by 2015 if no action is taken to change current pressures and impacts (CEC 2007a). For approximately 30% of EU surface waters and 45% of ground water resources, data are insufficient to make a determination of their status. As a critical drinking water resource and main component of the natural water cycle, the lack of data on the status of groundwater is particularly alarming. The leading pressure responsible for placing so many surface waters at risk of not achieving a good ecological status is hydromorphological alteration – changes of the natural hydrology (water flow regime) and morphology (e.g., channel form, longitudinal and later connectivity) resulting from water diversions and extraction, as well as infrastructure such as dams, levees and artificial channels that provides services for flood defense, agriculture, navigation,

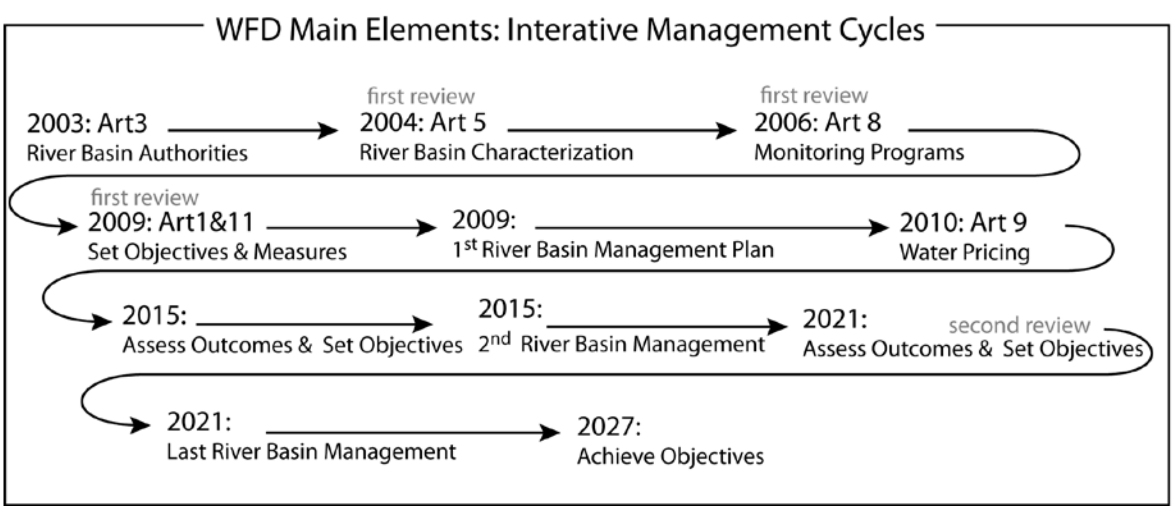

Figure 2-2. Iterative Management Cycle of the WFD.

hydropower and urban development (CEC 2007b). Compared to the focus on the chemical quality of water over the last 30 years, this presents a new environmental challenge that is closely linked to patterns of economic development.

In addition to the initial assessment of environmental conditions, the river basin authority must perform an economic analysis of water uses in the district in order to determine if current prices are recovering costs and providing an effective incentive to use water efficiently. A review of available assessment reports shows that, in general, EU member states have tried to conduct an honest and open assessment of the environmental problems caused by specific activities (EEB and WWF 2006). Yet in most cases they have failed to fully integrate those findings with an economic assessment of water uses and current water pricing policies. Considering the importance of economic instruments to influence behavior and raise financial resources to restore impaired ecosystems, this might represent a failure not only to obey to legal requirements of the WFD, but also a major obstacle in achieving environmental objectives.

The river basin authority must perform an economic analysis of water uses in the district in order to determine if current prices are recovering costs and providing an effective incentive to use water efficiently

2.5 Setting of Environmental Objectives

As explained above, the overall objective of the WFD is to achieve a good status by 2015 for all surface and ground water bodies. However, the competent authority may extend the compliance deadline up to 2027 if the rapid recovery of the ecosystem is not possible within the time limit (e.g., due to slow groundwater recharge rates). In other cases, the costs of restoration might be disproportional to the environmental benefits of a fully restored ecosystem. If the competent authority demonstrates this to the public, the WFD allows lower objectives to be set. Finally, there might be cases where new developments would lead to ecosystem deterioration but serve an overriding public interest. In those cases, the competent authority might set a lower water status objective, provided that no environmentally better alternative exists and all public participation requirements are fulfilled. For example, a new hydropower dam project should be approved only if the benefits of the project (e.g., cheap energy and employment) are shown to be greater than the costs associated with the environmental damage and could not be provided by less environmental damaging alternatives

The focus of the WFD is primarily on preventing further deterioration and avoiding repetition of past water management errors .

(e.g., energy-saving programs and new jobs in tourism).

Europe's waters have been subject to widespread physical alteration in the past 200 years. For many water bodies, it would be difficult and even impossible to restore them to their "natural" environmental conditions. For this reason, the WFD did foresee an extensive use of exemptions from the good status objective and introduced a specific category of waters, the heavily modified or artificial water body. For those waters, the biological parameters under natural and pristine conditions are no longer set as the benchmark. Instead, the ecological benchmark is set as the maximum ecological condition that could be achieved given the essential physical modifications, after all technically feasible mitigation measures are applied – the so-called "maximum ecological potential." The new objective for a given water body is then defined as a slight deviation from this potential – the "good ecological potential." The objective to prevent chemical pollution and achieve chemical water quality standards is not affected by this exemption.

The setting of environmental objectives is one of the most politically intensive aspects of implementing the WFD. Analysis of the preliminary designation of heavily modified water bodies in the EU has shown that in some countries the majority of waters might be considered to fall into this category (95% in the Netherlands) while in other it might be insignificant (less then 2% in Ireland) (CEC 2007b). In practice, exemptions for new developments that threaten water conditions from reaching good status are now highly restricted while exemptions for having to achieve good status due to existing infrastructure are relatively easy to obtain. Thus, the focus of the WFD is primarily on preventing further deterioration and avoiding repetition of past water management errors.

But what happens if environmental objectives are not achieved? The WFD is a binding European law, which means that EU Member States and their authorities can be challenged before court for failing to achieve its objectives. This can be done in national courts and at the European Court of Justice. The European Commission has the duty to ensure the enforcement of European law. Nevertheless upholding the law depends on access to accurate information on member states' compliance efforts and available EU-level enforcement mechanisms, both of which are limited and controversial. There are numerous reporting requirements set by the WFD, but they are often too vague to provide standing for formal legal action. It is also understandable that few countries would produce an official report stating that it failed to respect the law. The European Commission therefore relies strongly on information provided by alternative sources, such as citizen groups and non-governmental organizations. When a legal breach by a member state is suspected, the European Commission is authorized to launch an infringement procedure at the European Court of Justice and may request that the Court determine a daily fine for non-compliance. However, in practice most infringement procedures are settled before a court decision is reached. In addition to legal mechanisms, the European Commission has sought to improve environmental law compliance by publicly identifying the worst performing countries (CEC 2007a).

2.6 Regulatory Controls and Water Pricing

European environmental legislation generally follows the approach of setting common targets and allowing the Member States to determine how best to achieve them. The WFD represents a divergence from this approach in that it allows some degree of flexibility in setting the targets, while introducing a number of binding regulatory and administrative requirements. For example, public authorities now must keep updated records of all water abstractions above 10 cubic meters per day (2,500 gallons per day) or serving more then 50 people and are required to issue permits for activities that can impact water status. For many countries this has been a substantial change where for the first time existing water users, such as agricultural sectors pumping groundwater on private lands, are required to register their water use and comply with regulations to restrict extraction volumes. Further requirements, which have already been in place in most countries, include controls of point and diffuse source pollution and prohibition of direct discharge of pollutants into groundwater.

Water pricing takes a prominent place in the WFD. The Directive requires countries to ensure implementation of the principle of cost recovery and mandates that water users make an adequate contribution to the costs of water services to encourage efficiency and cooperation to achieve good water status. New water pricing policies

European environmental legislation generally follows the approach of setting common targets and allowing the Member States to determine how best to achieve them. The WFD represents a divergence from this approach in that it allows some degree of flexibility in setting the targets, while introducing a number of binding regulatory and administrative requirements.

do not have to recover all costs and can still include subsidies and take socio-economic considerations into account, but decisions on water pricing structures now must be made in a transparent way and, at a minimum, differentiate between the economic characteristics of households, agriculture and industry.

According the River Basin Characterization reports carried out in 2004, the water users with the most significant negative impact on the water status are agriculture, navigation, power generation and urban development (due to consumptive water use, waste water treatment and flood protection). The economic analyses, despite their deficiencies, shows that in general only urban dwellers pay most of the financial costs of their water supply and waste treatment. For other sectors, either no consistent data have been provided or case studies suggest that the charges for water use are far below financial costs of providing the water service, even before considering environmental and resource costs.

2.7 Current Outlook of WFD Implementation in Europe

The WFD is an ambitious legislation that takes a novel approach to managing water resources in all 27 Member States of the European Union. Water quality standards are based on a holistic assessment of ecological, chemical and quantitative status, which requires the integration of diverse environmental protection policies for improved water quality and quantity management for all waters, rivers, lakes, coastal waters and ground water resources. By requiring an economic appraisal of water uses, Member States must consider the impacts of human activities on the ecological status of water bodies and revaluate water pricing policies in terms of cost recovery.

The integrated water management approach has the potential to benefit not only environmental quality but also economic performance by increasing water security, reducing pollution treatment costs and creating new employment opportunities in less environmentally damaging sectors. Nevertheless, all of the countries in Europe have a long way to go to meet the high standards of water management required by the WFD. Initial findings indicate that the condition of aquatic ecosystems is worse off than expected. Nearly half of all EU waters are at risk of failing to achieve “good” status, based on their ecological, chemical and hydromorphological characteristics (CEC 2007a). Conventional water management practices in Europe have been characterized by negligence of environmental concerns. Setting a new trajectory for the EU water management will require mobilizing significant resources and overcoming substantial administrative inertia. Despite the challenges, the WFD presents a clear opportunity for water management reform in Europe.

3.0 Water Management in the Russian River Basin of California

As in Europe, California rivers have been extensively modified by human activities. Water infrastructure development in California has allowed for the transport of the water across broad geographic regions and has created a vast network of interdependent water users throughout the state. The large and intricate water distribution system is regulated by an equally complex institutional and legal framework. Numerous government agencies, at the local, state, and federal level, and interest groups from countless economic and political sectors play a role in managing the state's water resources.

The myriad dams, diversions, irrigation channels, storage and distribution facilities have played an important role in the state's economic development. Yet they have also resulted in the destruction of natural biological communities and the deterioration of water quality. Substantial effort has been invested in mitigating the impacts to natural rivers and streams associated with impoundments, diversions and other human activities. However, the restoration of natural biological communities and recovery of endangered freshwater species has proven difficult, in part due to California's complex legal and institutional water management framework. The current administrative system is ill-equipped to effectively balance human and ecosystem needs in a sustainable way.

Substantial effort has been invested in mitigating the impacts to natural rivers and streams...However, the restoration of natural biological communities and recovery of endangered freshwater species has proven difficult, in part due to California's complex legal and institutional water management framework. The current administrative system is ill-equipped to effectively balance human and ecosystem needs in a sustainable way.

The Russian River watershed in northern California provides an ideal case study to evaluate current water management challenges in California. The Russian River has many of the elements that are characteristic of river basins throughout the state: multiple water uses, including drinking water, agricultural irrigation, hydropower, industry, fishing, recreation and endangered species protections; flow regulation from large dams and dispersed small-scale diversions; a controversial inter-basin water transfer; large agricultural water use relative to other consumptive uses; growing populations and increased pressures on the quality and quantity of water resources.

As threatened fish populations decline and water quality conditions continue to deteriorate, there is an increasing public awareness of the importance of improving water management in the basin. Government

Government agencies, NGOs and stakeholder groups have begun gathering to discuss alternative strategies for obtaining water for human uses while protecting environmental functions and values. The opportunity is ripe to bring needed reform to an institutional and legal framework unable to address the causes of environmental deterioration, and to establish sustainable water management practices.

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The following section provides an introduction to the Russian River basin – its environmental characteristics, administrative setting, and current methods for classifying and monitoring water bodies. The purpose is to provide an overview of the existing water management framework based on California institutional arrangements and laws to allow for comparison with water management approaches promoted under the WFD.

3.1 Introduction to the Russian River Basin

3.1.1 Environmental Setting

The Russian River watershed drains Mendocino and Sonoma Counties in the Mediterranean-climate region of Northern California (Figure 3-1). It is roughly 160 kilometers (km; 100 mi) long, drains 3,900 kilometers (1,500 mi^2), and has an average annual discharge of 2 cubic kilometers (1.6 million acre-feet). From its headwaters, the Russian River flows southward for approximately 130 km (80 mi) through the cities of Ukiah, Hopland and Healdsburg to the northwest part of the Santa Rosa Valley. Along this reach, the river passes through several alluvial valleys separated by narrow bedrock reaches. In the Santa Rosa Valley, the river makes a sharp bend to flow westward for approximately 35 km (22 mi) through steep, forested mountains before entering the Pacific Ocean at Jenner. The Russian River is fed by tributaries from the Coast Range on the west side of the watershed and the Mayacama Mountains on the east side. Principal tributaries include the East Fork, Big Sulphur Creek, Dry Creek, Maacama Creek and Mark West Creek (RRIIS 2007).

The region is characterized by high seasonal variation in precipitation, with 65-80% or more of the annual rainfall generally occurring in winter, primarily in few large storm events. In addition, annual rainfall between years is highly variable and

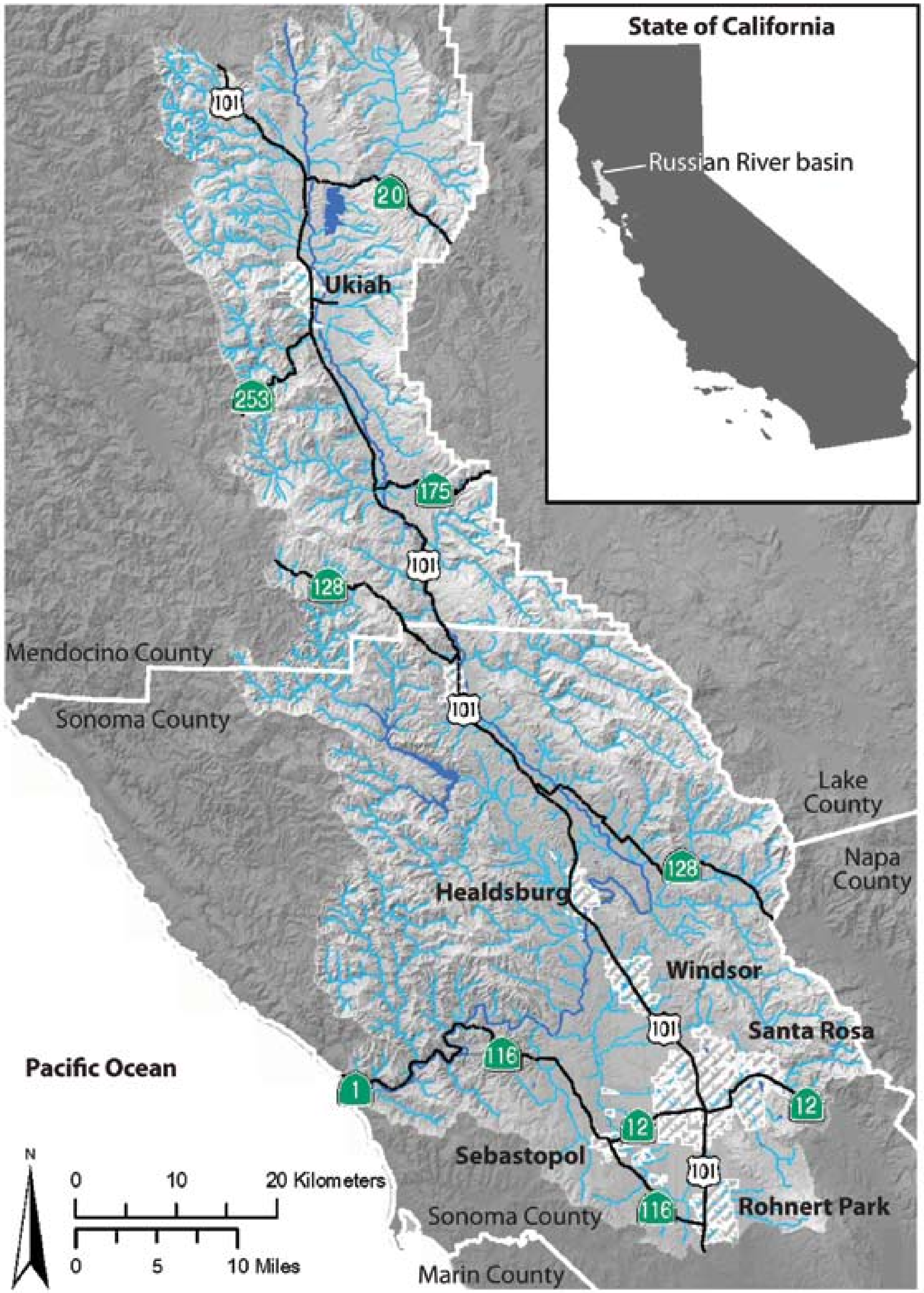

Figure 3-1. Russian River basin map

Efforts to increase agricultural productivity in the region resulted in significant modifications to the Russian River valley. Floodplain agriculture motivated filling wetlands and removing riparian vegetation removed. Segments of the river were also channelized, straightened and leveed.

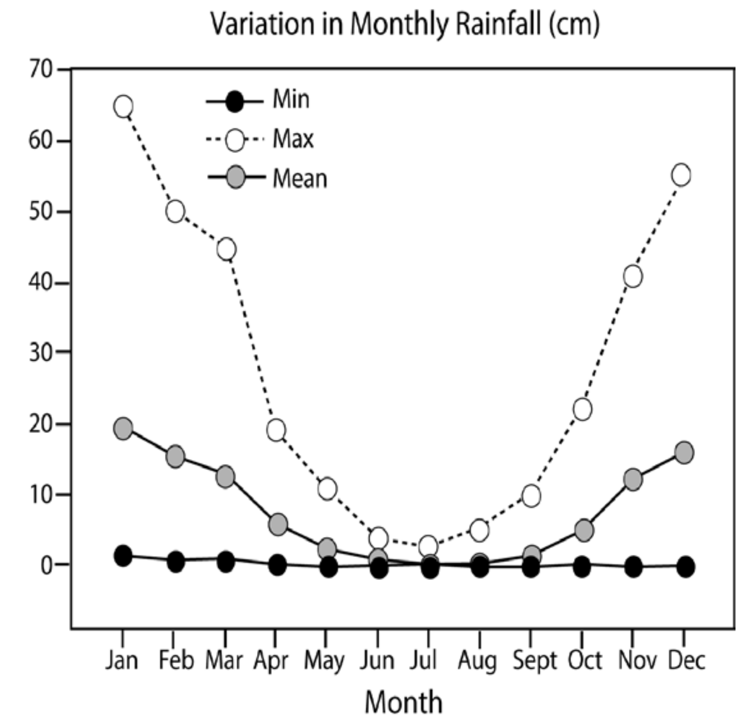

Figure 3-2. Seasonal rainfall patterns in the Russian River basin

periodic, multi-year droughts are common (Figure 3-2). Average annual precipitation in the Russian River basin is 104 centimeters (cm; 41 inches [in]), ranging from about 56 cm (22 in) over the southern portion of the region to over 200 cm (80 in) in the northern area. The quantity of annual rainfall increases with elevation, with the highest precipitation levels occurring over the basins upper ridges (Figure 3-3). Surface flows in the Russian River and its tributaries directly respond to precipitation patterns. Flows rise rapidly in the winter and may increase by several orders of magnitude during storms. Surface flows gradually recede over the spring and generally sustain low, base flow conditions throughout the dry summer season.

3.1.2 Land Use History & Water Infrastructure Development

Since the arrival of the European settlers in the early 19th century, economic development in the Russian River basin has been based on intensive natural resource use and included such activities ranching, fur trapping, logging and agriculture. Over time, efforts to increase agricultural productivity in the region resulted in significant modifications to the Russian River valley. Floodplain agriculture motivated filling wetlands and removing riparian

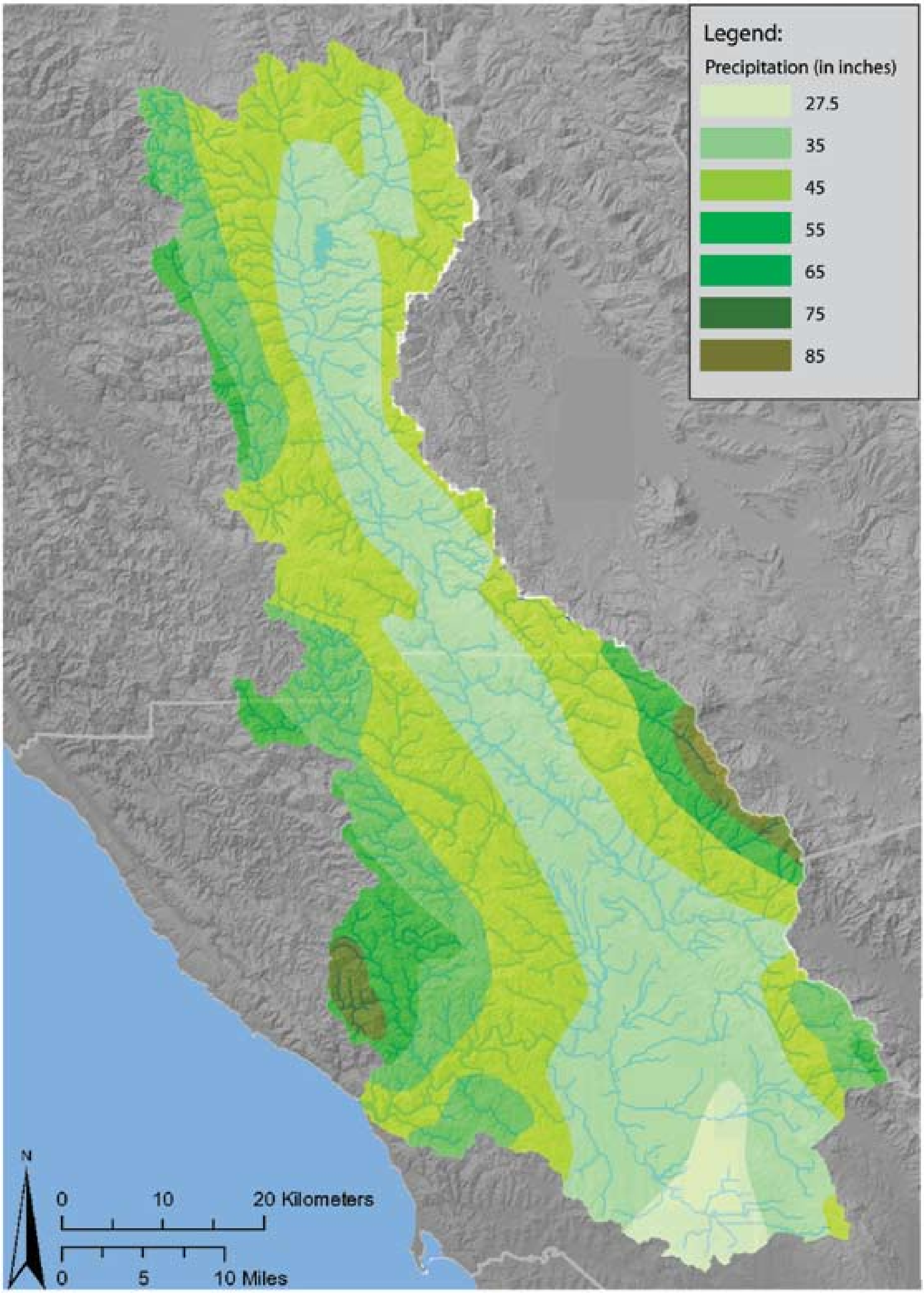

Figure 3-3. Spatial rainfall patterns in the Russian River basin
Source: Rainfall data are located on the Russian River Interactive Information System in the GIS database (RRIIS 2007).

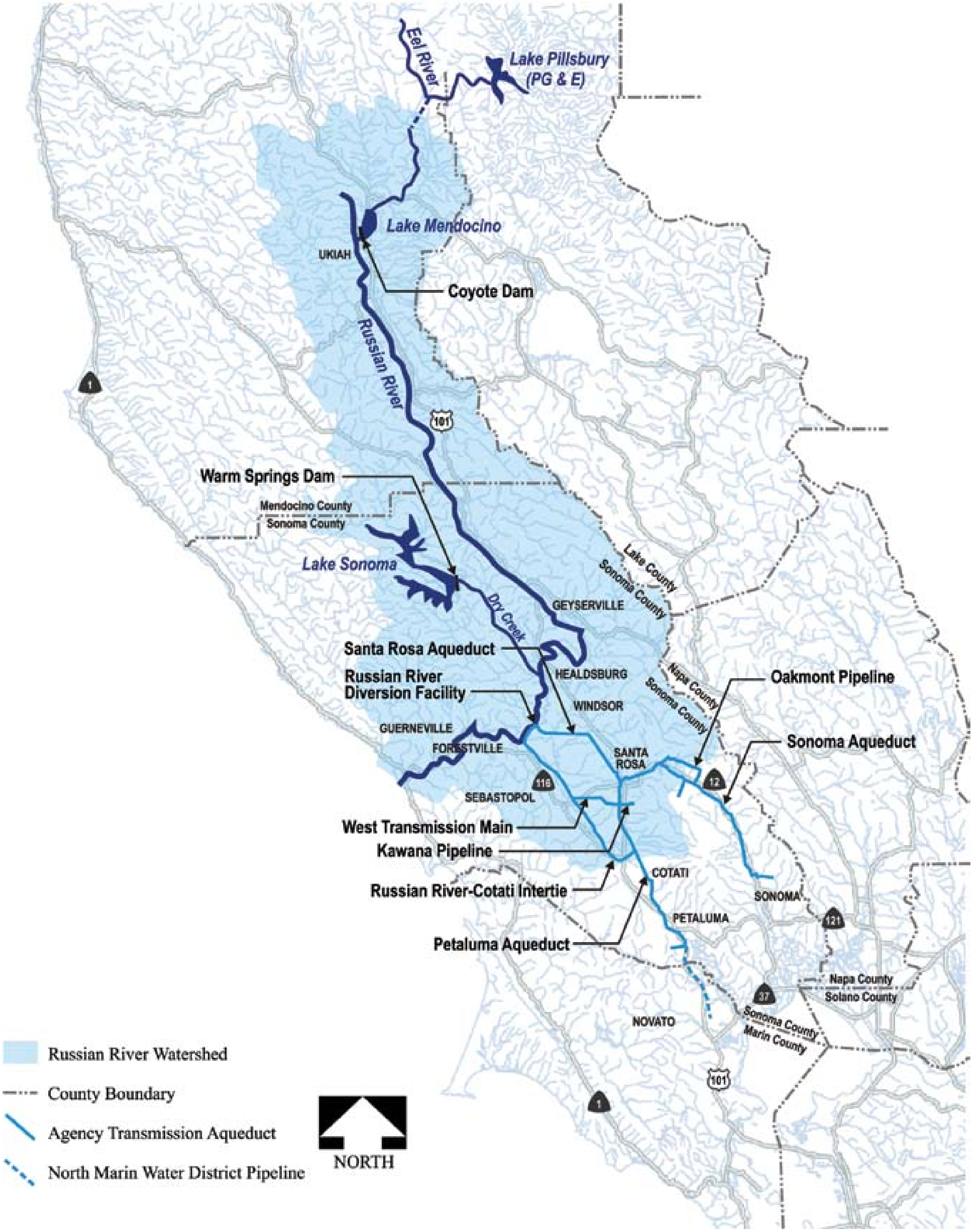

Figure 3-4. Russian River basin water infrastructure system
Source: Figure reproduced from Water Supply Workshop Staff Report (Sonoma County Water Agency 2004).

vegetation removed. Segments of the river were also channelized, straightened and leveed (Coey 2002).

Gravel and sand mining in the Russian River also began late 19th century. Excavated gravels from the river channel were used to make concrete for roads throughout the San Francisco Bay region (including in the construction of the Golden Gate Bridge). In the late 1950s, the Middle Reach of the Russian River, beginning just downstream of Healdsburg, was straightened and dredged, with some of the removed material sold as construction aggregate, and some (including non-commercial, finer-grained sediments) used to construct a levee along the dredged channel. Instream gravel mining continued in this reach through the 1980s, but at least for the last two decades the largest extractions have been from floodplain pits. Instream mining continues as "bar scalping" in the Alexander Valley and several tributaries, involving excavation from the tops of gravel bars in permitted volumes. A sequence of aerial photographs of the middle reach of the Russian River taken since 1942 illustrate the transformation of the environment from a meandering river course surrounded by a wide riparian corridor, to a narrow, channelized river path bounded by levees, floodplain agriculture and gravel excavation pits (Appendix A).

A major change in the natural flow regime of the Russian River occurred in 1908, when the hydropower financier W.W. Van Arsdale built a tunnel and diversion system across a natural mountain divide, bringing an average of 3.7 cubic meters per second (129 cubic feet per second) of water southward from the Eel River into the East Fork of the Russian River at Potter Valley (SCWA 2007) generating electricity by virtue of the elevation drop. The transfer of water from the Eel River created a new abundance of water for Russian River communities, particularly in the summer and early fall when much of the Russian River became dry (Langridge 2002). To provide water for urban growth in the southern part of the basin, the Sonoma County Water Agency was established in 1950 to partner with the Corps of Engineers in the construction of the Coyote Valley Dam, to impound runoff from the upper Russian River basin on the East Fork and capture Eel River diversion flows. While the storage reservoir is called Lake Mendocino Reservoir and is located in Mendocino County, Sonoma County has secured access to nearly 90 percent of the impounded water (Figure 3-4). Eel River diversion flows

Eel River diversion flows represent less than 10 percent of the Russian River annual discharge at Healdsburg, but can constitute more than half of base flows in the late summer and fall.

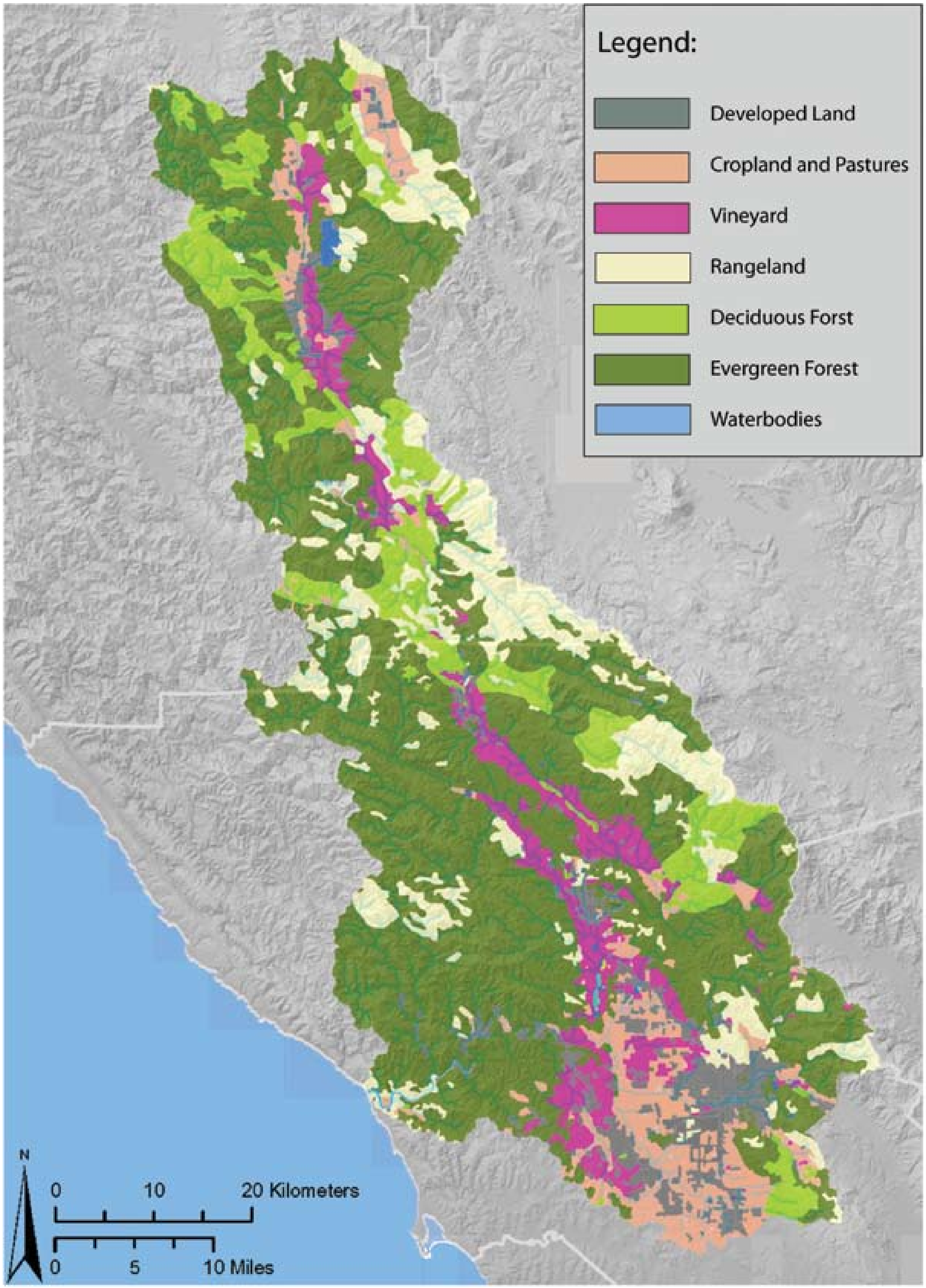

Figure 3-5. Russian River basin land use

Source: The land use and land cover data layer is located on the Russian River Interactive Information System GIS database (RRIIS 2007) and was originally developed by the US Geological Survey in 1990.

represent less than 10 percent of the Russian River annual discharge at Healdsburg, but can constitute more than half of base flows in the late summer and fall.

The other major water infrastructure element in the basin is Warm Springs Dam. Completed in 1983, Warm Springs Dam impounds runoff from the upper 337 square kilometers (130 mi^2) of the Dry Creek watershed to form Lake Sonoma Reservoir. The reservoir was constructed by the Army Corps of Engineers, in partnership with Sonoma County, for water storage-supply, flood protection and public recreation. Controlled releases from both Lake Mendocino and Lake Sonoma Reservoirs provide important sources of water for agricultural, municipal and industrial uses. In addition to meeting these water demands, the reservoirs store floodwaters to reduce flow peaks and are regulated to maintain minimum stream flows needed for fish habitat and recreation (SCWA 2007).

Urbanization in the river basin has expanded significantly in the past 20 years, particularly in the Santa Rosa valley. Urban growth has fueled ex-urban development, converting areas of natural vegetation and farmlands to residential land uses (Merenlender 2000). The Russian River currently serves as the primary water source for more than 500,000 people in Mendocino, Sonoma and Marin counties. Timber harvesting, cattle ranching and intensive agriculture (primarily vineyards and orchards) still dominate land uses (Figures 3-5). Tourism has become an important economic base in the Russian River basin, primarily through wine-related tourism and river-oriented recreation.

3.2 Administrative and Regulatory Setting of Russian River Water Management

3.2.1 California Water Law

The legal and institutional basis for control over water in California developed in response to its climate, diverse landscape and settlement politics. The west initially inherited a system of riparian rights from the more humid eastern part of the United States, which in turn had been derived from English Common Law. In the East, riparian rights linked water rights to land ownership and in-stream flows were shared among riparian owners. Under the riparian doctrine, owners of non-riparian lands have no right to access and use surface

Controlled releases from both Lake Mendocino and Lake Sonoma Reservoirs provide important sources of water for agricultural, municipal and industrial uses. In addition to meeting these water demands, the reservoirs store floodwaters to reduce flow peaks and are regulated to maintain minimum stream flows needed for fish habitat and recreation.

Miners not making "beneficial use" of their water were forced to surrender their claims to those who would. Limits were seldom placed on the maximum amount of water that a single appropriator could claim. Entire stream flows could be diverted from their channel, leaving dry streambeds and rivers with highly reduced flows.

waters and, when water flows are insufficient to meet all uses, deficiencies are borne as a common loss, with each user cutting back by the same proportion (Anderson 1977). The doctrine developed in England was well-suited to the eastern United States, where water supplies were generally abundant and predictable and irrigation typically not required for cultivation of land not contiguous to water courses. However, the riparian rights doctrine was less appropriate for governing the allocation and use water in the arid West, where water was scarce and often an object of competition. The dry physical climate conditions and rudimentary political authority existing at the time led early settlers in California to develop a new set of rules to guide water allocation decisions based on the doctrine of prior appropriation, applied throughout most of the Western US.

The doctrine of prior appropriation originates in Spanish Law and took shape in California during the Gold Rush in the mid-nineteenth century. Early mining activities in the state began along mountain streams, where runoff transported and separated gold from eroded rock and soil materials. Once mining claims were established on stream banks, later arrivals were forced to either transport water from streams and rivers to inland sites or shuttle dry gravels to the waterway. Mining operations increased in number and scale and by 1870, over 11,000 km (7,000 miles) of primary and secondary ditches had been constructed in the hills of California to divert water from natural streams to inland mines (Gillian and Brown 1997).

When water availability was limited, miners required a system to resolve disputes between competing claims. The doctrine of riparian rights was not well suited as a basis for water allocation principles because most mining occurred on federal or state lands, where traditional rules of property ownership (including riparian rights) did not apply. The miners adopted the 'first come, first serve' principle, which was already in wide use on the public domain, where rights were based on occupation rather than on ownership. Known as the doctrine of prior appropriation, miners with an older claim to water held a higher-ranking right than later appropriators. If claims to appropriate water exceeded availability during a period of water shortage, prior right holders would be first entitled to their permitted amount, potentially barring subsequent appropriators for withdrawing their full claim. Even if located upstream from a water user with "senior" rights, a subsequent "junior" appropriator was required to allow enough water pass to satisfy the downstream claim.

The prior appropriation system also required that water rights claims be actively used, or were otherwise forfeited (Olive 1981). Therefore, miners not making "beneficial use" of their water were forced to surrender their claims to those who would. Limits were seldom placed on the maximum amount of water that a single appropriator could claim. Entire stream flows could be diverted from their channel, leaving dry streambeds and rivers with highly reduced flows.

By the late 19th century, settlers in the valleys had begun developing extensive irrigation systems for farming. Settlers occupying non-riparian lands obtained water through the appropriative rights system, while established landowners adjacent to rivers and streams claimed water by riparian right. As settlement continued, disputes between competing claims escalated and anti-riparian organizations were formed to lobby against the riparian doctrine. Rather than recognize one of the doctrines as paramount, courts sought to accommodate both doctrines within the scope of California water rights law (Commission 1978).

Economic growth in California in the early 20th century brought about a transformation in water demand and use with the creation of irrigation districts, construction of hydroelectric plants, and development of large municipal water supply projects. Water disputes became more complex and contentious, as individuals, water districts, public utilities, and private companies vied to secure water rights for their particular purposes. In order to ensure the efficient use of water in the context of competing uses and limited availability, California voters approved an amendment (Article X) to the State Constitution in 1928 to limit all water rights (both riparian and appropriative) to "reasonable and beneficial uses" in accordance with the public interest.

Riparian rights continue to be recognized in the State, but are curtailed from their original scope under English common law. The prior appropriation doctrine is the dominant system guiding water allocation decisions in California today. These basic features of the doctrine continue to be the basis of California water rights law:

> (1) the right to use water is obtained by taking the water and putting it to beneficial use; (2) the right is limited to the amount of water that is beneficially used; (3) first in time is first in right; and (4) the water must be used or the right is lost (Gillian and Brown 1997).

Overall, California water law under the prior appropriations doctrine has encouraged the development and use of its water resources for off-stream, consumptive uses. The law provided incentives for appropriators to physically control and apply as much water as quickly they could, facilitating the construction of dams and storage facilities to support municipal growth and large-scale irrigation throughout much of California. The "take" of water exercised through the development of dams and diversions resulted in substantial alterations to the flow regime and morphology of natural river channels. Vast quantities of water were removed from natural water courses as individual appropriators sought to secure as much water as possible. Appropriations frequently exceeded the physical amount of water flowing down a river, limiting the potential for instream uses or other future consumptive beneficial uses to be realized.

Table 3.1 Government Agencies and Water Management Responsibilities in the Russian River Basin

	Local/Regional						State				Federal				
Responsibility:	City Councils	Mendocino & Sonoma Co. Planning Comm.	Sonoma Co. Water Agency	Mendocino Co. Water Agency	Potter Valley Irrigation District	Other Water Districts	Dept. of Fish & Game	Regional Water Quality Control Board	State Water Board	Dept. of Water Res.	US Army Corps of Engineers	EPA	National Marine Fisheries Service	USGS	Federal Energy Regulatory Comm.
Water Storage/ Distribution Ops.			X	X	X	X				X					
Interbasin Water Transfer Ops.			X		X										
Surface Water Diversion Permitting							X		X	X					
Groundwater Diversion Regulation															
Flood Control			X	X	X	X					X				
Stormwater Management	X														
Hydropower Generation			X		X										X
Wastewater Treatment	X		X		X	X		X							
Surface/ Groundwater Monitoring			X	X						X		X		X	
Water Quality Regulation								X		X	X	X			
Ecological Monitoring			X				X						X		
Landuse Planning	X	X													
Fisheries Mgmnt.							X					X	X		
Recreation & Public Access	X	X	X	X	X	X									

The theme of "reasonable and beneficial use" established by the Article X amendment of the California Constitution continues to guide water use decisions today. In theory, the provision provides the flexibility to modify permitted water allocations in response to the changing notion of what is reasonable or beneficial with respect to the public interest (Commission 1978). Recently, the concept of beneficial-use has been broadened to include recreational use, fish and wildlife protection, and enhancement and aesthetic enjoyment. While these factors are now given consideration when permitting new appropriations, the enforcement of beneficial-use requirements to regulate or restrict existing water appropriations has been limited up to this point in California (Gillian and Brown 1997).

Recently, the concept of beneficial-use has been broadened to include recreational use, fish and wildlife protection, and enhancement and aesthetic enjoyment. While these factors are now given consideration when permitting new appropriations, the enforcement of beneficial-use requirements to regulate or restrict existing water appropriations has been limited up to this point in California.

3.2.2 Government Agencies & Key Regulations

Today, water resources in the Russian River are managed by a broad array of agencies and organizations at the federal, state and regional/local levels. These institutions form a network of overlapping roles and jurisdictions that, together, fulfill essential water management responsibilities in the basin, including water storage and distribution, flood control, water quality and natural resource protection, regulation of water diversions and discharges, monitoring and ecological restoration. Some of the key agencies in the basin and their water management roles are summarized in Table 3-1.

The majority of the listed water management functions are performed at the County level. For example, the Sonoma County Water Agency (SCWA) holds primary authority for domestic water supply delivery to cities in the southern portion of the county, including Santa Rosa, Petaluma, Sonoma and Rohnert Park. In addition to water supply services, the SCWA supervises flow releases from Warm Springs Dam at Lake Sonoma, maintains flood control infrastructure, manages public recreation areas, and provides sanitation services to five county sanitation districts. In Mendocino County, the principal water management functions and services (including water supply, wastewater treatment, water storage management, and flood protection) are performed or authorized by the Mendocino County Water Agency (MCWA). Both the SCWA and MCWA are Special Districts governed by their respective County Boards of Supervisors (Beach 1996). Officers of the two agencies are appointed by members of the Board, who themselves are elected by County voters.

Water appropriators have frequently reported water use exceeding their actual needs in order to protect their right from potential forfeiture under the "use it or lose it" provision of the prior appropriation doctrine. The unknown amount of water actually used by right-holders makes it difficult for the State Water Board to assess the cumulative effects of diversions within a stream system and determine how new appropriations might affect existing water rights or beneficial instream uses such as wildlife protection and commercial fisheries.

While County water agencies appear to have broad control over water management in the basin, decision-making authority is in fact shared with other local, state and federal agencies. The relationships of the various governmental agencies are generally hierarchical, with increasing regulatory power extending from the local to the state and federal levels. The federal Clean Water Act (CWA) and federal Endangered Species Act (ESA) are two of the most important federal laws that represent "top-down" regulatory mechanisms to control local water management policies and practices. The CWA is aimed at protecting water resource values that provide beneficial uses to the public while the purpose of the ESA is to protect, and facilitate the recovery of, native species in danger of extinction. Both laws outline procedures for setting the minimum water quality standards and protection measures required to support designated beneficial uses and populations of imperiled species.

The CWA requires that states designate uses for surface waters and adopt water quality standards consistent with those uses (US EPA 2007). Beneficial uses are identified by taking into consideration all of the existing uses and values of the water body, including public water supply, protection of fish, shellfish, and wildlife, recreational, agricultural, industrial, and navigation activities. In designating uses for a water body, the state examines the suitability of that water body for specific uses based on the physical, chemical, and biological characteristics. The geographical setting, scenic qualities, and economic potential are also considered.

In the Russian River basin, the North Coast Regional Water Quality Board (Water Quality Board) is the lead agency responsible for protecting the quality of surface waters under the CWA. When a water body fails to meet the minimum water quality standards for its designated use, it is listed as "impaired" and the state must implement remediation measures to restore water quality conditions. The Water Quality Board is currently initiating a process in the Russian River basin to control both point and diffuse source pollution by setting total maximum daily load (TMDL) limits for a wide range of pollutants including chemicals, biological pathogens (e.g., fecal coliform) and fine sediment (e.g., from land use conversion). A TMDL provides a quantitative assessment of specific water quality parameters, an analysis of contributing sources, quantitative pollution reduction targets needed to attain water quality standards, pollution allocations for each contributing source and, more recently, an implementation plan that may include “best management practices” for contributing sources. In California, the development of TMDL standards is relatively recent trend in water quality protection that began in the mid-1980s. The actual effectiveness of the approach to improving other water quality problems has yet to be determined in California basins where TMDL standards have recently been established.

Whereas the regional Water Quality Boards have primary responsibility for protecting water quality, the California State Water Resources Control Board (State Water Board) is responsible for regulating the quantity of the state’s surface waters. Through the water rights process, the State Water Board administers permits and licenses for surface water diversions and maintains records of appropriations and statewide water use. The primary functions of the State Water Board are to facilitate water resources development in an orderly manner, prevent the unreasonable use and waste of water resources, and manage water resources in the public interest, including protections of environmental values (State Water Resources Control Board 2006).

Effective management of state water resources is greatly hindered by the incomplete record of appropriators. While all appropriative rights have been quantified and recorded since 1914, riparian users and pre-1914 appropriations are not required to file a record of appropriation with the State Water Board. A related recordation problem is the prevalence of appropriative claims for excessive amounts of water beyond the reasonable quantity required for the stated beneficial use. Water appropriators have frequently reported water use exceeding their actual needs in order to protect their right from potential forfeiture under the “use it or lose it” provision of the prior appropriation doctrine (Gillian and Brown 1997). The unknown amount of water actually used by right-holders makes it difficult for the State Water Board to assess the cumulative effects of diversions within a stream system and determine how new appropriations might affect existing water rights or beneficial instream uses such as wildlife protection and commercial fisheries (Deitch 2006).

Groundwater abstractions are not regulated in the state of California and there are generally no legal requirements for reporting diversion rates and quantities.

> **At the local scale, little legal authority has been granted to watershed groups. However, they have used collective action and citizen science to act as whistle-blowers on local issues such as unpermitted water uses and inappropriate agricultural management practices.**

The responsibility for protecting the quality and quantity of groundwater resources is shared by the State Department of Water Resources (DWR) and the Department of Health Services (DHS). The delineation and monitoring of groundwater basins is performed by DWR, although the spatial extent of wells and monitoring frequency are limited. The DHS works with local water agencies to assess the threat of contamination to groundwater used as a drinking water source. Groundwater extraction is not regulated in the state of California and there are generally no legal requirements for reporting diversion rates and quantities. In Sonoma County, permits must now be obtained for proposed groundwater wells. However, the permits do not restrict the quantity of water to be abstracted nor are they conditioned on the long-term capacity of the underlying aquifer to supply groundwater (Sonoma Country 2006b).

As damage to river ecosystems has become more apparent, and environmental legislation and case law have created new agency responsibilities, there has been increasing social pressure to protect the habitat of endangered species and other public trust values. Three salmonid species in the Russian River basin are listed under the federal ESA as threatened or endangered: steelhead trout, Chinook and Coho salmon. These species are also protected under the California ESA and other state regulations (e.g., Fish and Game Code). The federal National Marine Fisheries Service (NMFS) and state Department of Fish and Game (DFG) are the principal agencies responsible for implementing measures to protect and restore salmonid populations. However, all of the agencies involved in water management in the basin are required to comply with the state and federal environmental protection laws.

3.2.3 Advisory Organizations & Public Participation

Government agencies involved in various aspects of water management are generally required to hold public meetings and, in the case of changing or promulgating new regulations, solicit and respond to public comment. Non-governmental organizations (NGOs) and agency-supported public advisory groups play an important role in Russian River basin water management, by establishing environmental monitoring programs, forming local watershed stewardship groups and providing a forum for collective political and legal action to influence agency decisions. Public participation occurs at several scales, involving different interests and possessing varying levels of authority. There are almost a dozen watershed groups in the Russian River basin that are dedicated to preserving and restoring local streams. There are also two groups, the Russian River Watershed Council and the Russian River Watershed Association, that are concerned with activities throughout the basin.

At the local scale, little legal authority has been granted to watershed groups. However, they have used collective action and citizen science to act as whistle-blowers on local issues such as unpermitted water uses and inappropriate agricultural management practices. In addition, they have mounted powerful defenses against proposed actions like "water bagging" (collecting water from northern California and transporting it in large plastic bags via sea to southern California) (San Francisco Chronicle 2004) and land use conversions (particularly from forest/woodland to vineyard) (Friends of the Gualala River 2007).

The two basin-scale watershed councils have divergent histories, representing different political entities and interests. The Russian River Watershed Council was established in 1998 by the Army Corps of Engineers as part of the mitigation program for the two dams that they helped build in the basin (Coyote Dam and Warm Springs Dam). The Council provides a forum for dialogue among stakeholders, who are separated into three caucuses – economic, environmental and public. Representatives of agencies are invited to participate but serve as non-voting members of the council. Over time, the Council has defined its role as one of coordination and planning, as evidenced by its three major products: a Plan of Action for the watershed, a Watershed Management Plan Scope of Work, and the GIS-based Russian River Interactive Information System (Russian River Watershed Council 2007). The work of the Council depends, in large part, on the continued financial support of the Army Corps of Engineers and it possesses no regulatory or permitting authority of its own.

The second basin-wide watershed council, the Russian River Watershed Association, was established in 2003 by the Sonoma County Water Agency as an association of eleven cities, counties and special districts in the southern portion of the Russian River basin. Similar to the Council, the Association's mission is works to

Despite the water supply security represented by the basin's two water storage reservoirs, the threat of water shortage remains a central issue in the basin. Increasing demand for water coupled with highly variable precipitation rates places intense pressure on water agencies to effectively manage water to satisfy the multiple beneficial uses in the basin.

> The overlapping water management jurisdictions, in combination with narrowly defined regulatory roles, produces an institutional arrangement that, as a whole, is unable to prioritize and effectively carry out actions at the basin scale. The consequence is that management actions in the basin tend to be highly reactive and focused on specific segments of the basin, where water issues are most politicized.

promote cooperation and implementation of projects that protect watershed resources, restore fisheries and improve water quality. However, in marked contrast to the Council, the Association aims to achieve membership that includes all local government agencies in the watershed, rather than directly represent the various, diverse stakeholders in the basin. The Association has been involved in developing the North Coast Integrated Regional Watershed Management Plan (funded by California State Proposition 50), a program intended to "integrate projects and management plans of water-related public agencies; to foster coordination, collaboration and communication among those organizations and to improve regional competitiveness for state and federal grant funding" (Northcoast IRWMP website 2007). Though the Association lacks formal regulatory authority, it does have the political power to affect water distribution and supply issues at the city scale, among its member cities and their public works authorities.

3.3 Russian River Water Management Challenges

3.3.1 Water Supply Constraints and Competing Water Uses

The augmentation of summer baseflow in the Russian River by diversion of Eel River water had created a more stable flow, which has encouraged municipal development and spurred the growth of agriculture and tourism (Langridge 2002). In particular, the southern part of the basin has experienced a recent boom in suburban and urban development around the city of Santa Rosa. Despite the water supply security represented by the basin's two water storage reservoirs, the threat of water shortage remains a central issue in the basin. Increasing demand for water coupled with highly variable precipitation rates places intense pressure on water agencies to effectively manage water to satisfy the multiple beneficial uses in the basin. Furthermore, the listing of several Russian River salmonid species to the Endangered Species Act, undocumented surface diversions and unregulated groundwater withdrawls present an increasing challenge for agencies responsible for the allocation of limited water resources among competing water uses.

The regulation of flow releases from the two dams is the primary method of managing water supply in the basin. Decisions on the timing and volume of flow releases during periods of shortage are politically controversial due to competing water needs. For example, in the spring of 2007, the Sonoma County Water Agency introduced a plan to reduce summer flow releases in order to ensure that there would be a sufficient water supply late in the dry season when water availability is critical for salmon populations. The plan was supported by the environmental community and vineyard operators (who also need water late in the season). However, the proposed flow release schedule was strongly opposed by members of the community involved in the river tourism industry that depend on higher summer flows for boating and other river recreation activities (The Press Democrat 2007). Water supply remains a central challenge to water management in the basin and is the focus of ongoing debate among domestic water users, environmentalists, agricultural and industrial users and river-tourism advocates.

3.3.2 Lack of Agency Coordination and Conflicting Management Goals

As discussed in Section 3.2, water management in the Russian River basin is performed by multiple agencies operating at various jurisdictional scales. Many interrelated water management activities, such as water supply delivery, water rights administration and environmental monitoring are performed by distinct entities that operate under different regulations and legal agendas. The overlapping water management jurisdictions, in combination with narrowly defined regulatory roles, produces an institutional arrangement that, as a whole, is unable to prioritize and effectively carry out actions at the basin scale. The consequence is that management actions in the basin tend to be highly reactive and focused on specific segments of the basin, where water issues are most politicized. There is no single authorized entity capable of coordinating the multiple agencies operating in the Russian River basin. While the Russian River Watershed Council and Russian River Watershed Association are improving coordination of management measures in the basin, they lack the legal authority to enforce decisions. Therefore, proactive, basin-scale management planning is nearly impossible.

Another related consequence of the current institutional arrangement is the lack of coordinated monitoring and restoration efforts in the basin. Substantial resources are allocated to environmental monitoring

While much is known about the water quality condition and ecological state of the Russian River and its tributaries, there is currently no systematic process of identifying and implementing restoration priorities at the basin scale.

and habitat restoration in the Russian River basin. However, the type and location of such efforts are not coordinated in a way to provide a comprehensive assessment of the condition of the basin's water bodies or to ultimately achieve restoration goals. While much is known about the water quality condition and ecological state of the Russian River and its tributaries, there is currently no systematic process of identifying and implementing restoration priorities at the basin scale.

4.0 WFD Approach to Water Management in the Russian River Basin

In the context of the Russian River basin, an approach to water management based on the Water Framework Directive would require a major shift in administrative arrangements, environmental assessment principles and management objectives. Here, we describe how the WFD might be implemented in the Russian River, consider potential implications of such an approach in addressing critical water management issues and discuss obstacles to be overcome before a WFD-based water management system could be established.

In brief, following the establishment of a River Basin District authority (WFD Article 3), distinct surface and groundwater bodies within the basin are designated and characterized (WFD Article 5, Annex II 1.1, 1.2, 1.3 and 2.1, Article 6). Pressures and impacts to identified water bodies are then assessed at the basin scale to identify areas at risk of failing to meet WFD targets (WFD Article 5, Annex II 1.3 -5 and 2.3-5). Next, an economic analysis of the water uses in the basin is performed to assess if existing pricing mechanisms are adequate to create an incentive structure for water users consistent with WFD objectives (WFD Article 5, Annex III). Finally, key elements of a Russian River Basin District Management Plan (WFD Article 13) are proposed to support reaching the ultimate water quality and ecological objectives for the basin's water bodies.

4.1 River Basin District Administrative Arrangements

4.1.1 Russian River Basin District

The first step of WFD implementation is to establish administrative arrangements that "ensure that the requirements of the Directive for the achievement of the environmental objectives…are coordinated for the whole of the river basin district." (WFD 2000 [Article 3, paragraph 4]) The primary administrative unit for management water-related activities under the WFD is the River Basin District (RBD). River Basin Districts typically encompass several individual river basins and their associated surface waters, coastal waters and groundwaters. In the Russian River context, a hypothetical RBD for the region might include the Russian River basin and the small, neighboring coastal watersheds to the west.

4.1.2 Russian River Basin District Authority

The Russian River Basin District would comprise portions of both Sonoma and Mendocino Counties and many municipalities. For this reason, substantial rearrangement of existing administrative boundaries would be required to effectively coordinate water management activities in the RBD. The new RBD Authority would either replace, or have superior authority over, other management agencies in the RBD. The rearrangement of institutional roles and jurisdictional boundaries in the Russian River basin would be a significant challenge under the current regulatory framework. However, the WFD would provide a significant political and legal driver for such a change.

The rearrangement of institutional roles and jurisdictional boundaries in the Russian River basin would be a significant challenge under the current regulatory framework. However, the WFD would provide a significant political and legal driver for such a change.

Water management activities in the basin are currently conducted by a wide variety of agencies, with different authorities at the federal, state, and local level (Table 3-1). There have been efforts to coordinate basin-scale water management and develop a long-term basin plan for water management in the Russian River. However, these basin-planning efforts have not involved all jurisdictional agencies working in the basin and have been unable to produce binding measures of action.

It is difficult to predict how a central competent authority would be established for the Russian River basin given the administrative and legal complexity of the current water management system. However, it is clear that the WFD should result in a consolidation of regulatory powers to establish an integrated framework to address critical water management issues in the basin. Such a change would also require improved integration of federal and state funding mechanism, that currently support distinct water management programs and functions at the local level. Such an administrative rearrangement would present a considerable challenge due to existing legal mandates of the various agencies and political nature of water management. Nevertheless, the establishment of a central authority would be a fundamental first step to implementing the WFD and setting a new course for water management in the Russian River Basin.

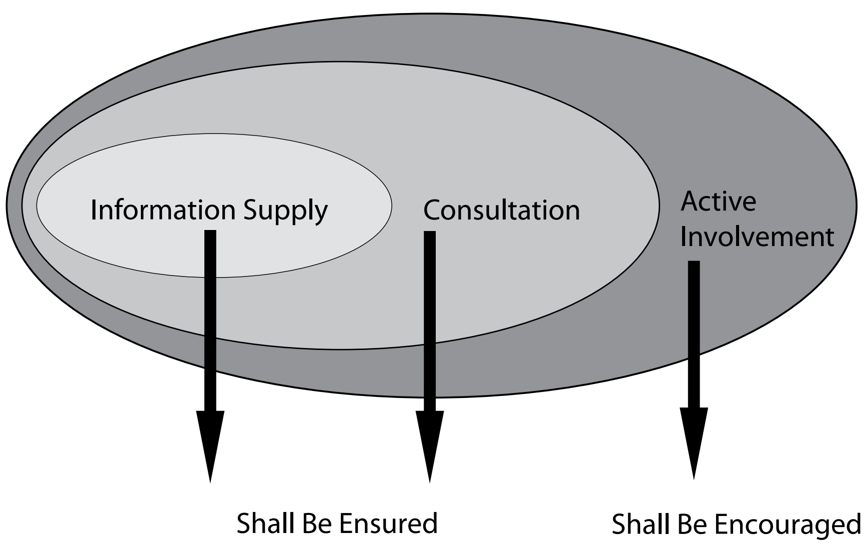

Figure 4-1. Minimum public participation requirements under the WFD

4.1.3 Public Participation

Article 14 of the WFD specifies that Member States shall encourage the active participation of all interested parties in the implementation of the Directive and development of river basin management plans. Three forms of public participation with an increasing level of involvement are recognized: information supply, consultation and active involvement. According to the WFD, the first two are "to be ensured" and the latter should "be encouraged" (Figure 4-1) (EC 2003c). The WFD allows flexibility for public participation processes to be adapted to national, regional and local circumstances and does not set specific guidelines as to how public participation should be integrated with WFD implementation.

As discussed in Section 3.2.3, public participation forums are well established in the Russian River and the public's involvement in water management issues is increasing. While efforts to organize and disseminate existing information on watershed management issues have been initiated, overall access to environmental and economic data is insufficient with respect to public information requirements of the WFD. Participation of NGOs and advisory groups in water management is generally restricted to consultation. There are a few examples of active involvement of the public in influencing agency decisions and it appears that many water management decisions are currently not subject to strong participatory requirements. It is possible that the WFD would help to incorporate existing public participation arrangements into more formal processes of information supply, consultation and active discussion and decision-making.

There are a few examples of active involvement of the public in influencing agency decisions and it appears that many water management decisions are currently not subject to strong participatory requirements. It is possible that the WFD would help to incorporate existing public participation arrangements into more formal processes of information supply, consultation and active discussion and decision-making.

4.2 River Basin Characterization

After the identification of River Basin District boundaries, creation of the competent authority and formal establishment of public participation processes, the next step in WFD implementation is an analysis of baseline environmental conditions in the RBD. The environmental analysis is based on the identification and characterization of water bodies, which are the fundamental management and reporting units of the Directive. The purpose of characterization process is to provide the basis to develop monitoring programs and determine the status of water bodies (WFD 2000

The biological community (including fish, macroinvertebrate, phytoplankton and macrophyte species) expected to occur in each water body type in undisturbed conditions would be determined in order to provide the reference conditions for a ecological status classification scheme.

(WFD 2000 [Article 5]).

Under Annex II of the WFD, water bodies would be grouped into different types according to their physical and chemical characteristics. The biological community (including fish, macroinvertebrate, phytoplankton and macrophyte species) expected to occur in each water body type in undisturbed conditions would be determined in order to provide the reference conditions for a ecological status classification scheme. Based on the WFD assessment framework, the higher the degree of similarity (of biological and chemical indicators) that exists between a water body and its reference conditions, the higher the ecological status the water body would be given.

In this analysis, River Basin characterization is limited to the identification of distinct surface and groundwater bodies in the basin. Descriptions of water body conditions are provided where environmental data are available. However, identifying water body typologies and reference conditions, as required for the assessment of water body status, is beyond the scope of this study.

4.2.1 Bodies of Surface Water

The designation of surface water bodies is an iterative process based on ecologic and hydrogeographic features as well as known pressures and water quality differences. Water bodies serve as management units for developing operational and investigative monitoring, setting environmental objectives and putting in place measures for their achievement. They should be small enough to address localized environmental problems yet large enough to suit practical administrative purposes.

An existing watershed classification system (CalWater 2.2) used by several agencies responsible for managing water resources could be used as a basis to partition the Russian River basin into distinct surface water bodies (California Interagency Watershed Mapping Committee 2007). However, the CalWater system delineates hydrologic basins and the resulting maps emphasize basins and subbasins, rather than the “water bodies” (rivers, streams, and lakes) themselves. Based on the CalWater system, the Russian River basin is identified as a Hydrologic Unit, comprised of eleven Hydrologic Subareas. Under the WFD classification system, the stream network

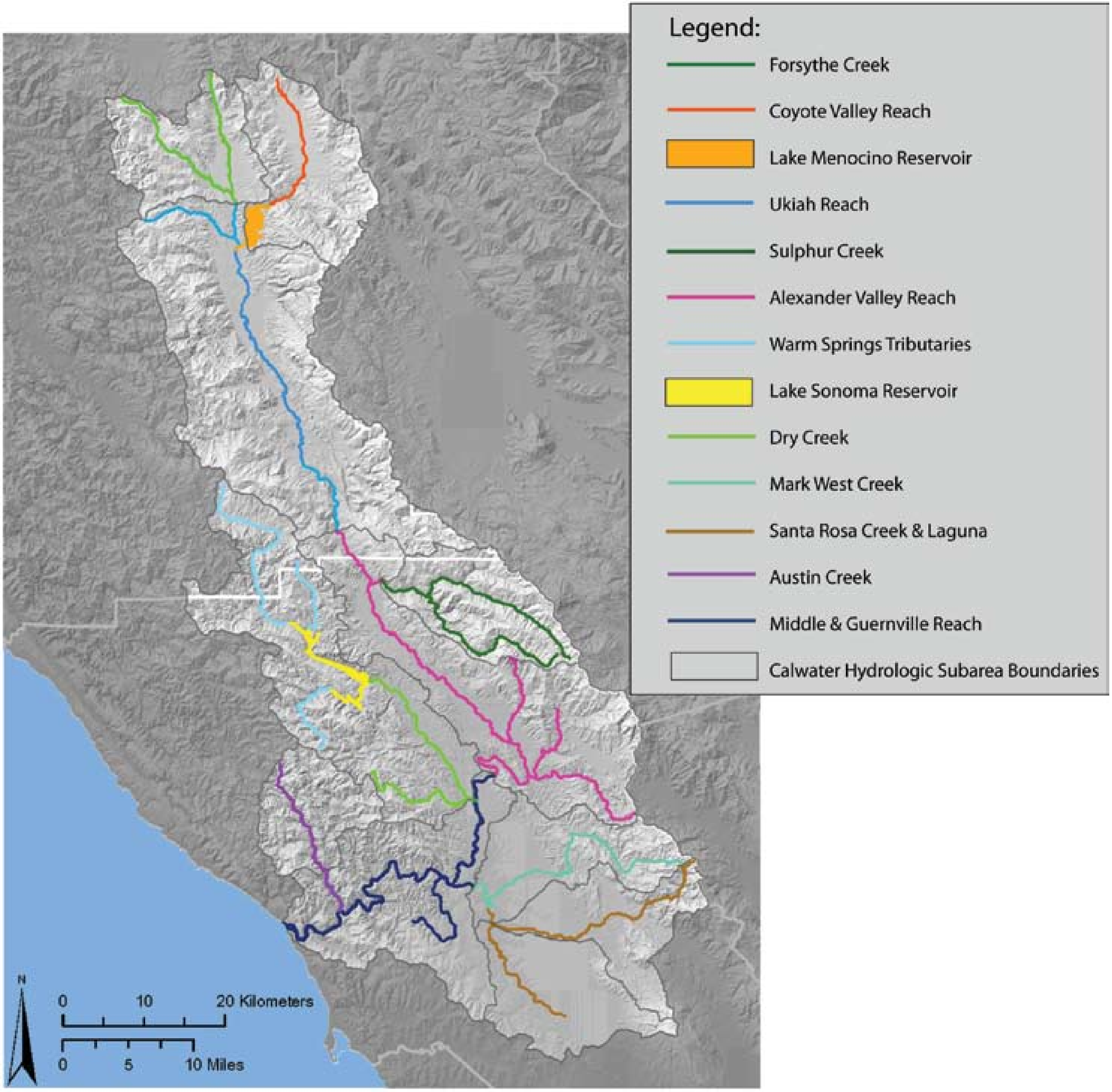

Figure 4-2. Russian River basin surface water bodies

Surface water bodies in the Russian River Basin significantly altered by urbanization and flood control infrastructure might be designated as HMWBs. Less stringent objectives for these water bodies to achieve a "good ecological potential" would be defined on a case-specific basis as part of the designation process (Appendix B).

contained within each Hydrologic Subarea would be classified as a surface water body. In some cases, the Hydrologic Subarea stream network would be further subdivided into smaller water bodies, while in other cases they might be aggregated. Recall that for administrative purposes, the Russian River would be combined with other watersheds (presumably the coastal drainages to the west) into the Russian River Basin District, but for the purposes of this report, we focus only on thirteen water bodies delineated in the Russian River basin (Figure 4-2).

4.2.2 Heavily Modified and Artificial Water Bodies

Because the WFD makes an exception to the goal of achieving "good status" for heavily modified water bodies (HMWB) and artificial water bodies (AWB), we identified water bodies that were substantially changed from natural conditions or created by human activity (WFD 2000 [Article 4.3]). The HMWB designation is primarily intended for water bodies affected by major infrastructure projects that support activities such as navigation, water storage and supply, flood protection and power generation, allowing for the continuation of these specified uses which provide valuable social and economic benefits but at the same time allow mitigation measures to improve water quality (EC 2003d).

In the Russian River Basin, the two major impoundments (Lakes Sonoma and Mendocino Reservoirs) would be designated as AWBs, because the restoration of these water bodies to their natural state as unimpeded rivers would preclude their use as important water storage facilities. Other surface water bodies in the Russian River Basin significantly altered by urbanization and flood control infrastructure might also be designated as HMWBs. Less stringent objectives for these water bodies to achieve a "good ecological potential" would be defined on a case-specific basis as part of the designation process (Appendix B).

4.2.3 Groundwaters

The WFD requires that all groundwater bodies be characterized in order to asses their uses and risk of failing to meet the objectives of the WFD, which is the achievement of good quantitative and chemical status. Specifically, the WFD requires that groundwater extraction be less than the natural recharge rates and not have a

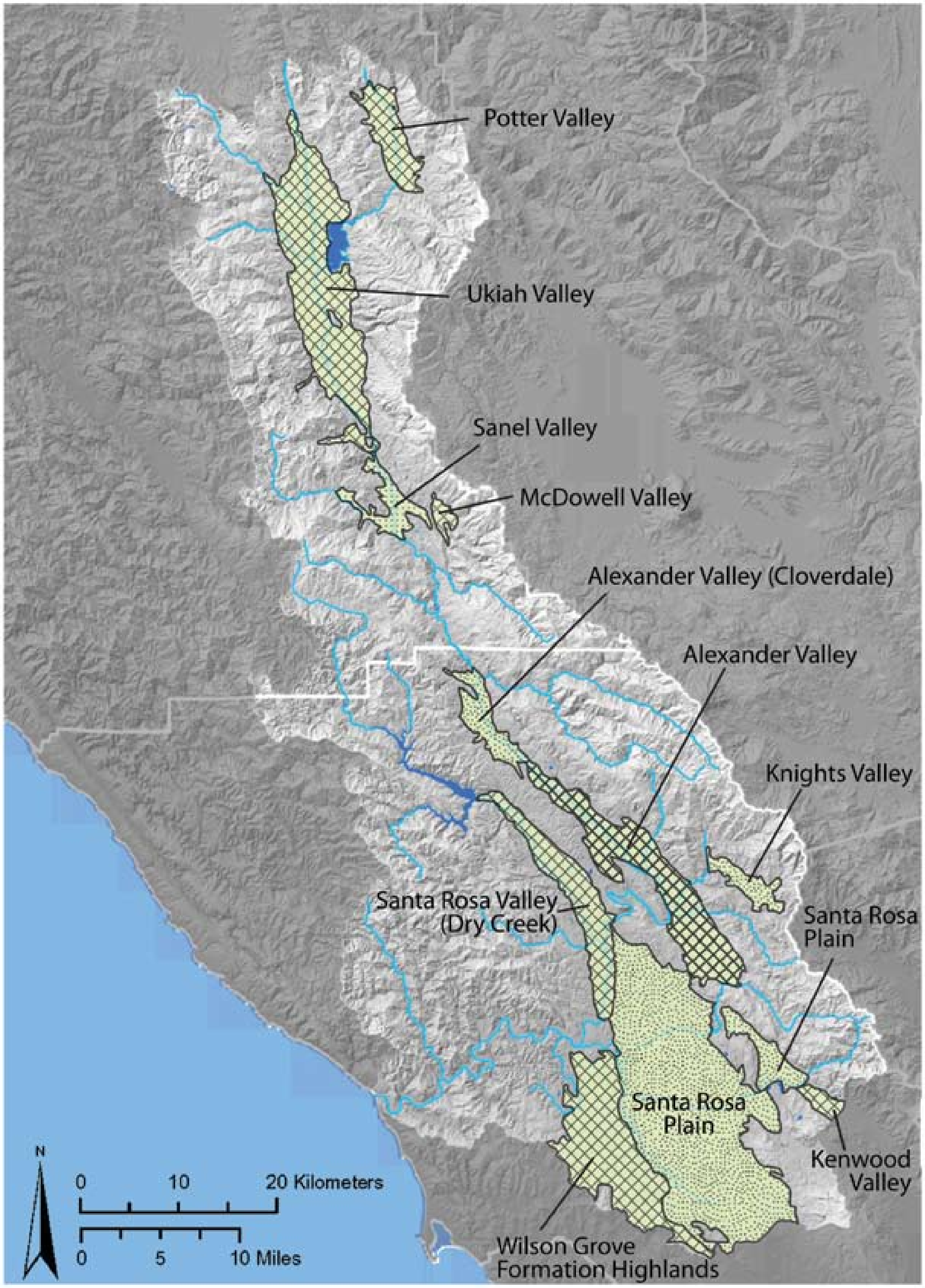

Figure 4-3. Russian River basin groundwater bodies
Source: Groundwater bodies in the Russian River basin are derived from Groundwater Basin Maps procedued by the California Department of WAter Resources (DWR 2007).

significant negative effect on groundwater dependent ecosystems. In addition, saltwater intrusion or other chemical contamination must be prevented (Scheuer 2005). The California Department of Water Resources (DWR) operates a system of groundwater monitoring wells sparsely distributed throughout the state, and delineates and classifies groundwater bodies. In the Russian River basin, DWR identified eight groundwater bodies based on geologic contacts and hydrogeologic divides on 1:250,000 scale geologic maps (Figure 4-3) (DWR 2003). Their mapped extent was then refined using available local geologic and hydrologic reports, observation well data and court-adjudicated boundaries (DWR 2007).

4.2.4 Protected Areas

Under Article 6 and Annex IV of the WFD, the river basin management plan must make a registry of all areas within the basin requiring special protection under existing legislation, which includes areas designated for drinking water, fishing or bathing or habitat/nature conservation. The WFD states that the river basin management plans are to include maps of the protected lands as well as a description of the community, national, or local legislation under which they have been designated (Annex IV.2). For the Russian River Basin, approximately 300 square kilometers (114 mi^2) of the 3,900 square kilometer (1,500 mi^2) basin (or 8 percent) are government-owned protected areas. The remainder of basin is under private ownership (Figure 4-4).

4.2.5 Monitoring and Existing Environmental Conditions

The environmental conditions of the Russian River watershed have been assessed in a wide variety of ways by several different entities, including agencies, municipalities, environmental organizations and watershed groups. In general, assessments have focused on a single environmental parameter and were conducted within a limited portion of the watershed. While there hasn't been a general, unified effort to classify the ecological status of water bodies in the basin, there is a substantial repository of environmental data available, covering a large extent of the watershed. A catalog of environmental data available for the Russian River watershed has been compiled on the KRIS Information System (KRIS 2007) and Russian River Interactive Information System (RRIIS 2007) . The types of available data relevant to determining the ecological status of a water body are described below. Available data on the spatial distribution of monitoring activities are depicted in Figure 4-5.

Macroinvertebrate Bioassessments

The California Department of Fish and Game collected benthic invertebrates at multiple stream sites in the lower Russian River basin. Sampling was limited to 21 tributary streams and one reach on the mainstem Russian River, conducted over three seasons between 1995 and 1997. Sampled streams were selected based on their importance as salmonid habitat and represented the highest quality habitat in the drainage. The environmental conditions at each site were determined using several biological metrics based on the abundance and composition of collected macroinvertebrate species. Of the sites sampled, one reach on the mainstem (within the Dry Creek Reach) and two lower reaches of tributary streams (in the Mark West Creek and Middle and Guernville Reaches) had biological metric values indicative of

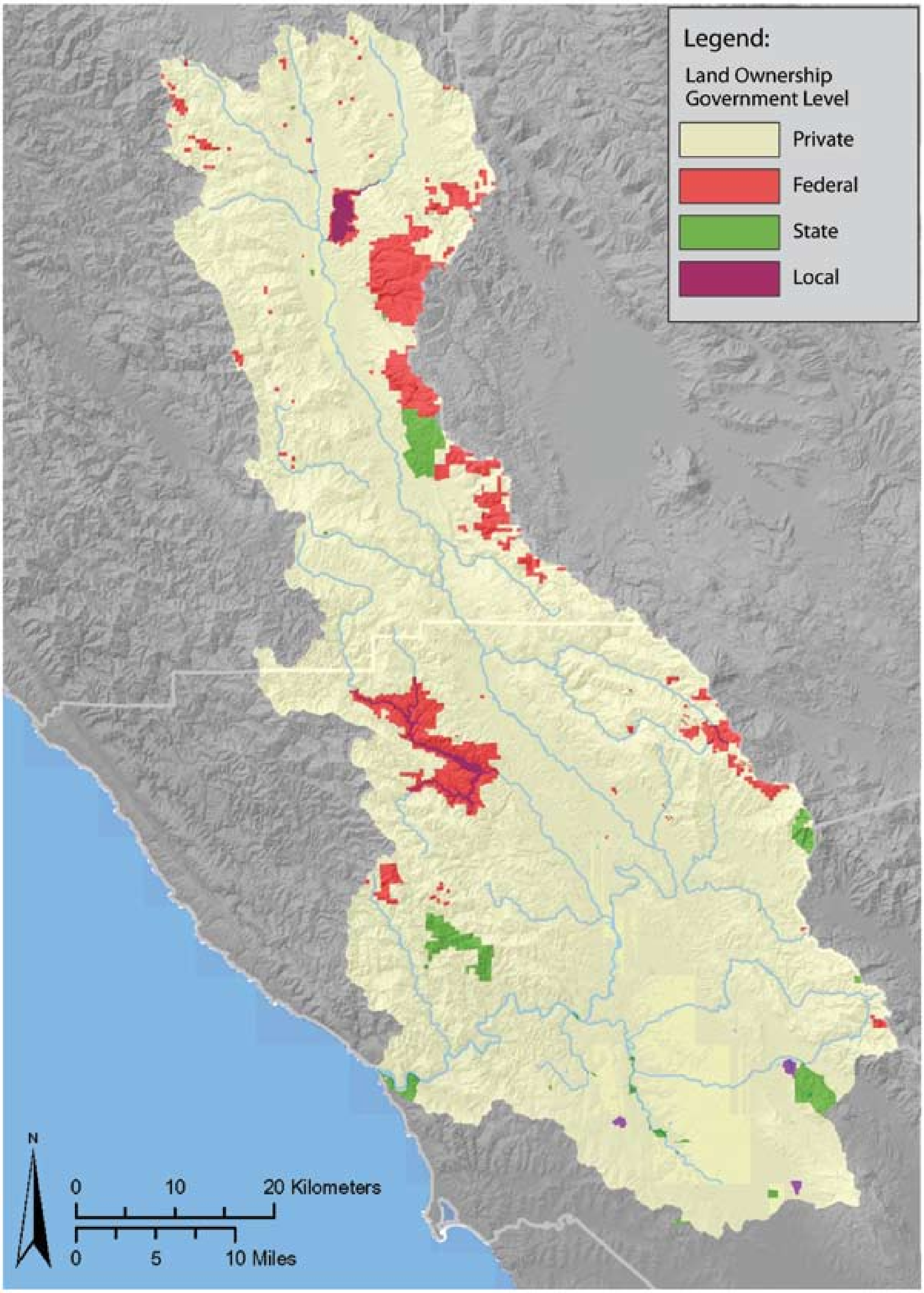

Figure 4-4. Russian River basin protected areas

Source: The land ownership layer was obtained from the Russian River Interactive Information System GIS database (RRIIS 2007) and last updated in 1999 based on 1:100,000 scale Bureau of Land Management Surface Management.

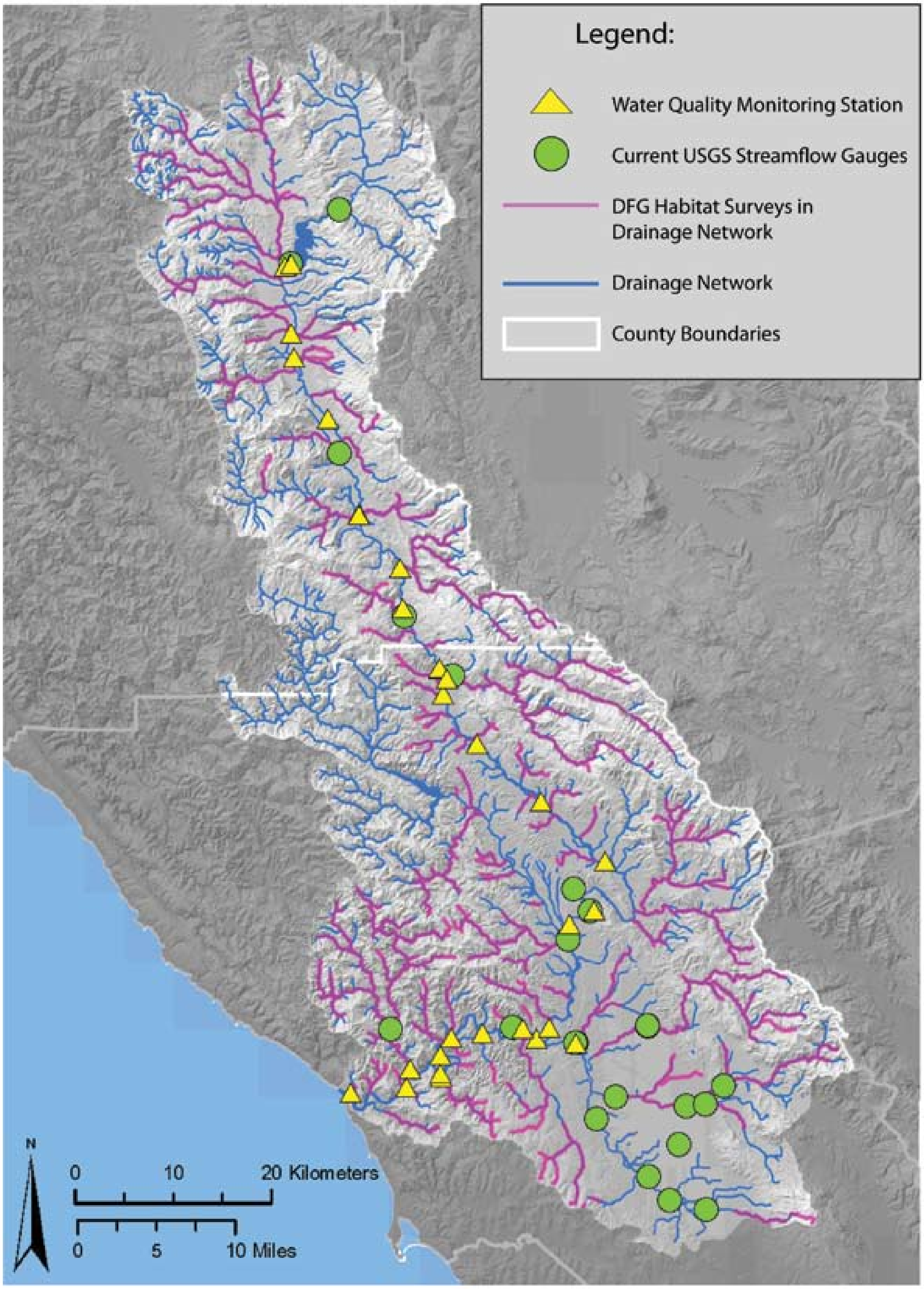

Figure 4-5. Streamflow, Water Quality and Biological Monitoring in the Russian River Basin

Source: Water quality monitoring data was obtained from the Russian River Interactive Information System GIS database (RRIIS 2007). The California Department of Fish and Game provided the biological survey data and locations of current streamflow gauges operated in the Russian River basin are provided on the US Geological Surey Naitonal Water Information System website (USGS 2007).

impaired water quality (Harrington 1999) .

Fish Population Monitoring

Several agencies have funded past and current monitoring programs to evaluate the status of fish populations in the Russian River and its tributaries. Fish surveys are currently conducted by the Sonoma County Water Agency, DFG and NOAA fisheries on various streams throughout the basin. Due to the limited scope of this report, we did not conduct an analysis of fish community biotic indicators based on the reported distribution and abundance of species. However, such an analysis would be conducted as part of the WFD basin characterization process, in which reference conditions and an ecological classification system for the basin would be developed.

Habitat Monitoring

The Department of Fish and Game has conducted stream habitat surveys on Russian River tributaries since the mid-1990s. The stream survey method is intended to characterize the suitability of stream habitats for salmon and is primarily used to identify potential threats to salmon populations, set management objectives, and determine what restoration measures may be appropriate (Flosi et al. 1998). By 2001, approximately 60 percent of tributary streams within the basin had been surveyed and superficially characterized as to channel morphology, substrate, riparian vegetation cover and instream shelter for salmonids (Figure 4-5). The surveys represent the highest resolution data on stream conditions available in the basin. However, the monitoring methods do not include metrics for overall ecological status of the surveyed streams and thus are not easily interpreted when assessing environmental conditions across the basin in a WFD context.

Water Quality Monitoring

The North Coast Regional Water Quality Control Board has been monitoring water quality on the Russian River and some of its tributaries since the 1970s. Between 1980 and 1996, water quality monitoring was conducted at 30 sites along the Russian River (Figure 4-5). Most of the water quality monitoring is focused on examining the effects of wastewater discharge (KRIS 2007). The primary driver behind monitoring efforts is to determine if important

The surveys represent the highest resolution data on stream conditions available in the basin. However, the monitoring methods do not include metrics for overall ecological status of the surveyed streams and thus are not easily interpreted when assessing environmental conditions across the basin.

Table 4.1 Russian River basin water bodies with water quality impairments			
	Type of Impairment		
Surface Water Body	Temperature	DO	Sediment
Forsythe Creek	X		X
Coyote Valley Reach			
Lake Mendocino Reservoir			
Ukiah Reach	X	X	X
Sulphur Creek			X
Alexander Valley Reach	X	X	X
Warm Springs Tributaries	X		X
Lake Sonoma Reservoir			
Dry Creek			
Mark West Creek	X		X
Santa Rosa Creek & Laguna	X	X	X
Austin Creek	X		
Middle & Guernville Reach	X	X	X
Temperature threshold based on reported ecological thresholds for native salmon species (KRIS 2007). DO threshold based on minimum levels stated in the Water Quality Control Plan for the North Coast (2006). Streams reported to have high sediment loads (North Coast Regional Water Quality Control Board 2006).			

water quality parameters (e.g., temperature, pH, dissolved oxygen, sediment, nitrates, etc.) are within a range suitable for drinking water or to support healthy fish populations.

Several locations in the Russian River basin stream network had water quality conditions that were not suitable for native fish species (due to high temperatures, streambed sedimentation or low dissolved oxygen) or did not meet objectives set forth by the North Coast Regional Water Quality Control Board for the Russian River (Table 4-1) (2006).

Stream Flow Monitoring

The USGS has operated many flow gauge stations on the Russian River and a few of its major tributaries (Figure 4-5). Approximately 21 gauges are currently in operation, most of which are located on the Russian River and in the southern portion of the basin, near the city of Santa Rosa. Current and historical stream flow conditions of most tributary and low-order streams in the basin are generally unknown.

Groundwater Monitoring

DWR maintains groundwater-monitoring wells throughout the state and has recently completed an inventory of California's groundwater bodies. Of the groundwater basin delineated in the Russian River watershed, basic information on storage capacity, groundwater level trends and water budgets is limited. While efforts to improve the monitoring and management of groundwater are increasing, there is effectively no regulation of groundwater withdrawals in the Russian River basin. On a statewide basis, groundwater is estimated to provide about 30 percent of California's water supply in an average year, but actual amounts of groundwater extracted and effects of extraction water tables is generally not known (DWR 2003).

4.3 Pressures and Impacts Analysis

To design monitoring programs and establish management objectives for River Basin District, it is first necessary to assess the impact of human activities on the condition of water bodies identified in the characterization phase. The goal of the analysis is to identify water bodies that are potentially at risk of failing to achieve good status classification by specific deadlines. The results of the impact assessment then inform the economic analysis (Section 4.4), which provides the basis for assessing the cost-effectiveness of water use practices, setting environmental objectives and developing water pricing policies. In practice, the initial risk assessment would be followed by a more detailed evaluation of specific pressures and impacts and additional data collection in order to characterize the status of all water bodies in the basin in comparison to quantified reference conditions (Figure 4-6). These monitoring and assessment programs would provide a starting point for developing the program of measures for water management and restoration in the basin.

The pressures and impacts analysis for surface water bodies entails the identification of human activities that exert pressures on water bodies to produce a detectable environmental impact. For example, surface runoff containing high concentrations of fertilizers might be recognized as a pressure associated with agricultural practices. In this case, the environmental impact would be elevated nutrient loads and low dissolved oxygen content in the water body. Types of pressures considered for surface water bodies include point source pollution, diffuse source pollution, hydromorphological alterations and biological pressures. For groundwater, the impacts analysis focuses on diffuse and point pollution sources, abstraction and artificial recharge activities.

This assessment attempts to identify the relationship between activities, pressures, sensitivities of the receiving water bodies and their consequent impacts. To the extent possible, monitoring data on existing environmental conditions (Section 4.2.5) have been used to inform the pressure and impacts analysis. However, there are significant gaps in available environmental data due the narrow scope and restricted spatial extent of past monitoring programs. In many cases, the ecological impact of identified pressures has not been monitored or is not well understood. For

Of the groundwater basin delineated in the Russian River watershed, basic information on storage capacity, groundwater level trends and water budgets is limited. While efforts to improve the monitoring and management of groundwater are increasing, there is effectively no regulation of groundwater withdrawals in the Russian River basin.

The initial risk assessment would be followed by a more detailed evaluation of specific pressures and impacts and additional data collection in order to characterize the status of all water bodies in the basin in comparison to quantified reference conditions. These monitoring and assessment programs would provide a starting point for developing the program of measures for water management and restoration in the basin.

example, there is no available information on impact of existing hydromorphological alterations on the ecology of water bodies in the river basin. Therefore, in many cases, pressures are used as a surrogate for impacts in the analyses of this report. In other cases, impact information is available, such as water quality data and macroinvertebrate community indices.

4.3.1 Surface Waters

Point Source Pollution

Point source pollution is defined as the discharge of pollutants from a distinct, source location. Potential pollution point sources in the Russian River include sewage treatment plants, industrial areas and identified hazardous waste sites (Table 4-2). Pollutants from point sources known to disrupt ecological processes include toxic chemicals, heavy metals, and biological toxins, in addition to elevated temperature and sediment inputs. The location of some of the point pollution sources have been mapped in the Russian River basin (Figure 4-7), and include abandoned hazardous waste sites and EPA-regulated facilities that handle hazardous waste (e.g., manufacturing and industrial facilities, power, chemical and wastewater treatment plants, gas stations, dry cleaners, livestock ranches, etc.).

Diffuse Source Pollution

Diffuse source (non-point) pollution is defined as pollution runoff coming from a variety of sources dispersed across a basin. Individual sources may have a minor effect on the environment, but cumulatively may significantly impact water quality and associated beneficial uses. Diffuse source pollution is generally delivered by rainfall runoff and therefore tends to occur in discrete pulses to the aquatic environment. The first rain event of the season can result in a particularly high ecological impact when several months of accumulated chemicals and sediment are flushed into streams and rivers.

Diffuse pollutant sources in the Russian River include agricultural runoff containing pesticides and nitrates and increased sediment delivery due to forestry, land use conversion/development, and dirt roads. Urban development and paved roadways are also important

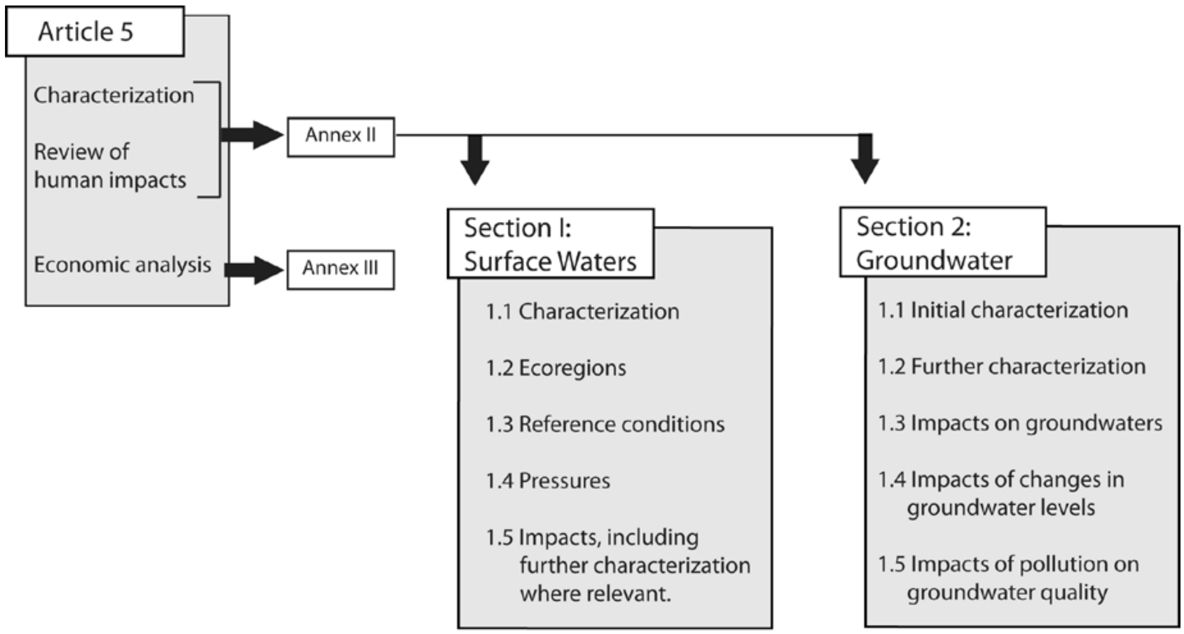

Figure 4-6. Schematic of WFD Article 5 analysis
Source: European Communities (2003 e)

Table 4.2 Point source pollution pressures in surface water bodies

Point Pollution Sources	Pressure	Potential Ecological Effects
Outfalls for industrial and commercial waste and sewage treatment plants; Urban stormwater systems	Increased toxins	Causes physiological damage to aquatic species
Outfalls from sewage treatment plants and rural wastewater systems	Increased nutrients	Results in eutrophication and reduced dissolved oxygen levels

Table 4.3 Diffuse source pollution pressures in surface water bodies

Diffuse Pollution Sources	Pressure	Potential Ecological Effects
Agricultural landscape disturbance; forestry practices; landuse conversion; rural development	Increased sediment	Degrades fish spawning habitat and fills streambed habitat. Turbidity reduced visibility and disrupts feed behavior of aquatic species.
Agricultural operations and rural wastewater	Increased toxins (pesticides and other toxic chemicals)	Causes physiological damage to aquatic species
Runoff of nitrates from agricultural operations; rural wastewater disposal	Increased nutrients	Results in eutrophication and reduced dissolved oxygen levels

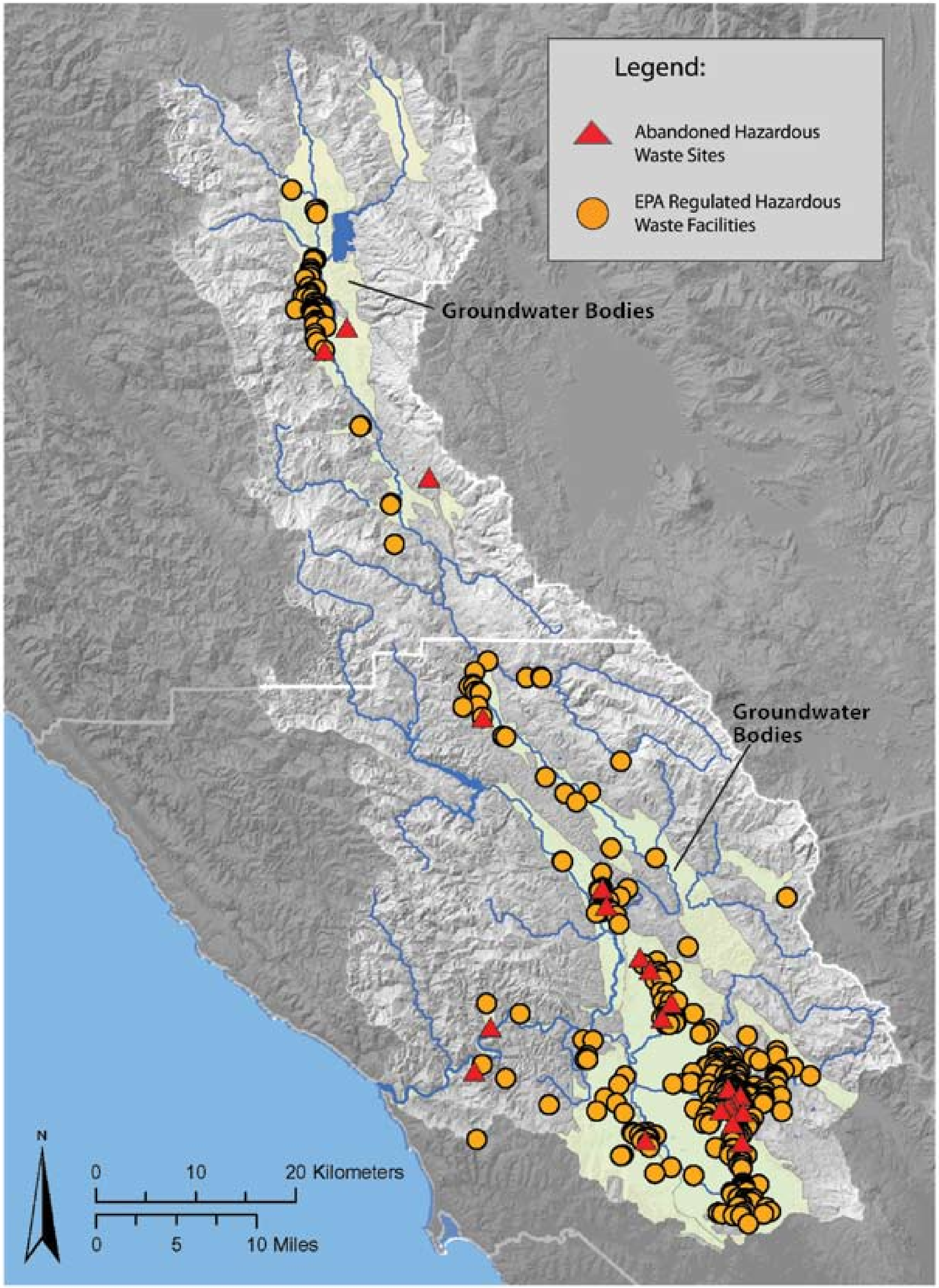

Figure 4-7. Point pollution pressures in the Russian River basin
Source: Point source hazardous waste information obtained from the Russian River Interactive Informaiton System GIS database (RRIIS 2007).

diffuse pollution sources of sediment and toxins (heavy metals and petroleum chemicals). Finally, wastewater from rural development across the basin contributes to elevated nutrient and toxin loads in Russian River Basin water bodies. Specific diffuse pollution sources, their pressures and environmental impacts are summarized in Table 4-3.

A spatial analysis of diffuse source pollution pressures in the Russian River Basin has not been conducted, however it is possible to infer from land use classifications where diffuse pressures may be concentrated (Figure 3-5). The region around Santa Rosa, Healdsburg, Ukiah and other population centers are likely to be associated with diffuse pollution associated with urban runoff, while areas along the Russian River dominated by agricultural and rural development may be subject to elevated nutrient, pesticide and sediment discharges from the landscape.

Hydromorphological Alterations

Hydromorphology encompasses dynamic hydrological processes and physical characteristics affecting sediment transport and river channel form. There are no established standards for evaluating river hydromorphology in California, but we can identify several pressures in the Russian River Basin with clear potential to have ecologically significant hydromorphological impacts on surface waters. These include flow regulation, abstractions and diversions, water infrastructure (e.g., dams, levees, bridges), and direct channel modifications from gravel mining, dredging, and channelization.

The most notable basin-scale hydromorphological alteration on the Russian River is the change in flow regime due to regulation by the basin's two major reservoirs. Since the inter-basin transfer of water from the Eel River began, summer flows in the mainstem Russian River are no longer low to intermittent. The two reservoirs have significantly reduced winter peak flows compared to historical conditions (Coey 2002). Warm Springs Dam has significantly reduced winter peak flows and increased summer base flows on Dry Creek. On some tributary streams, baseflows are reduced by withdrawals for agricultural irrigation and domestic uses (Deitch 2006).

The construction of levees along the river for flood protection and floodplain agricultural is another significant hydromorphological

The most notable basin-scale hydromorphological alteration on the Russian River is the change in flow regime due to regulation by the basin's two major reservoirs. On some tributary streams, baseflows are reduced by withdrawals for agricultural irrigation and domestic uses.

Table 4.4 Hydromorphological pressures and impacts in surface water bodies		
Source of Impact	**Pressure**	**Potential Ecological Effects**
Interbasin water transfer	Disruption of natural flow and sediment-transport dynamics	Degradation of habitat conditions for aquatic species
Flow regulation from dams	Disruption of natural flow and sediment-transport dynamics	Degradation of habitat conditions for aquatic species
Physical barriers (e.g., dams and weirs)	Alteration of flow characteristics (e.g., volume, velocity and depth) upstream and downstream of barrier	Loss and degradation of habitat for aquatic species
Flood control structures (e.g., levees)	Loss of floodplain connectivity	Loss and degradation of habitat for aquatic species
Channel maintenance (e.g., dredging)	Modification of streambed substrate and natural debris deposition processes	Degradation of habitat conditions for aquatic species
Channel modification (e.g., straightening and channelization) for flood control	Alteration of flow characteristics (e.g., volume, velocity and depth)	Loss and degradation of habitat for aquatic species
Surface water abstractions and diversions for agricultural and residential use	Reduction in surface flows and water level	Loss and degradation of habitat for aquatic species; reduction in downstream energy transport and nutrient cycling (drift)
Agricultural landuse	Loss of riparian vegetation (and associated increase in stream temperatures)	Degradation and loss of wildlife habitat and increase of stream temperatures above physiological thresholds of cold-water species
Gravel mining	Removal of substrate; channel incision and associated change in water table and habitat conditions (e.g., riparian vegetation)	Degradation of habitat conditions (e.g., spawning areas) and impacts to wildlife dependent on riparian vegetation

alteration in the basin. The construction of levees results in the loss of floodplain connectivity and can have significant adverse effects on river flow dynamics and habitat conditions (Anderson et al. 1996). Although the current extent of levees and channelization within the Russian River basin has not been mapped, flood protection infrastructure has been constructed primarily along the mainstem Russian River valleys and along Dry Creek, below Warm Springs Dam.

Dredging and instream gravel mining have also resulted in significant hydromorphological alterations in the Russian River basin, directly affecting the sediment budget of the river, and typically inducing incision of the channel upstream and downstream of the mining site itself (Kondolf 1994). The incision can lead to undermining of infrastructure, concentration of scouring flows in-channel, bank undercutting and coarsening of the river bed, and lowered water tables.

Gravel mining from floodplain pits has fewer direct hydromorphological impacts if floodplain pits remain isolated from the river channel. However, by creating large areas of exposed water connected to the alluvial aquifer, concerns have been raised over potential contamination of water supplies and increased evapotransirative losses. Moreover, floodplain pits are a lentic aquatic environments, (unnatural along most Mediterranean-climate rivers), which support principally exotic warm-water fish species, such as large-mouth bass, voracious predators of juvenile salmon.

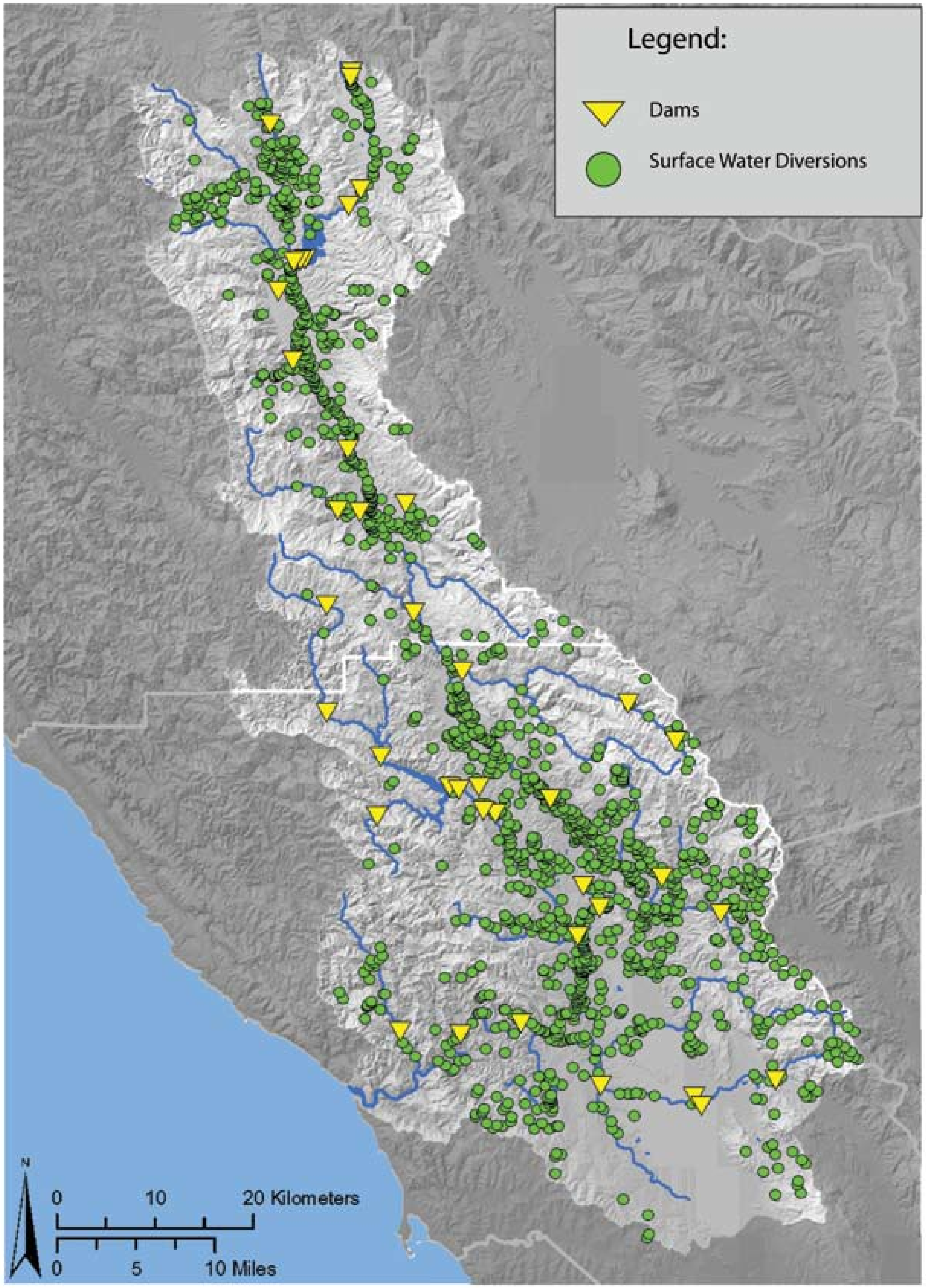

Figure 4-8. Dams and small surface water diversions
Source: Dam location layer obtained from the Russian River Interactive Information System GIS database (RRIIS 2007).
Matt Deitch (2006) generated the surface water diversions GIS layer.

Specific types of hydromorphological alterations in the Russian River basin and their associated pressures and environmental impacts are summarized in Table 4-4 and depicted in Figure 4-8.

Biological Pressures

Biological pressures are those that can have a direct impact on living resources, either quantitatively or qualitatively. Critical biological pressures in the Russian River Basin include the stocking of the Russian River with hatchery-raised fish and introductions of non-native plant and animal species (Table 4-5). The fish hatchery at Warm Springs Dam releases approximately 300,000 juvenile steelhead trout into the Russian River basin at Dry Creek every year. Although the effects of hatchery-raised fish on native aquatic species have not been studied in the Russian River, there is increasing awareness of the potentially negative impacts of hatcheries on wild, native fish populations, including the loss of genetic diversity, interference with spawning behavior, spread of disease or parasites, and predation or competition with juvenile fish (Moyle 2002).

Non-native species can have a significant effect on populations of native species by competing directly for food and habitat or by modifying habitat conditions so that are no longer suitable for natives. There was no data available to represent the current spatial distribution of exotic fish and other non-native aquatic species in the basin. However, biological surveys indicate that introduced fish species have become established in the mainstem Russian River and the lower reaches of tributary streams (Coey 2002). A highly invasive non-native plant species, *Arundo donax*, has spread to several water bodies and riparian areas throughout the basin (Figure 4-9). Arrundo propagates rapidly on stream and river banks, reducing recruitment of native riparian species and eliminating habitat for native wildlife, and is considered a significant threat to native stream ecosystems (Circuit Riders Productions, Inc. 2007).

Surface Water Bodies Risk of Failure

Based on the distribution of known pressures and impacts and available environmental data, it is possible to perform a preliminary assessment of water body conditions and their risk of failing to achieve WFD objectives. However, it is important to note that these initial determinations findings are largely based on limited data with substantial uncertainty. Ideally, the risk assessment would inform managers of priority research and monitoring needs in order to conduct a more comprehensive and informative assessment of environmental conditions within the basin. Based on the reported environmental conditions and the

Table 4.5 Biological pressures in surface water bodies

Impact Sources	Pressure	Potential Ecological Effects
Introduced fish and invertebrate species	Establishment and spreading of introduced species distribution	Substitution of populations, degradation of habitats and food competition
Introduced plant species	Establishment and spreading of introduced species distribution	Substitution of native vegetation communities and degradation of habitats
Fish hatchery	Stocking water bodies with hatchery-raised fish to water bodies	Genetic contamination of wild populations, spread of disease, and predation/ competition with native species

Table 4.6 Russian River basin surface water body risk status and significant pressures				
Surface Water Body	**Overall Risk Status**	**Key Pressures & Severity (1 = low to 5 = high)**	**Source of Pressures**	**Ecological Indicators**
Forsythe Creek	Probably at risk	Potential alteration of natural flow regime (4); elevated sediment (3); invasive riparian vegetation (1)	Abstractions for residential and agricultural water use on mainstem and tributaries; ag and residential development	Moderate embeddedness values; presence of Arundo donax
Coyote Valley	Probably at risk	Alteration of natural flow regime (5); potential for elevated sediment and nutrient levels (2)	Water transfer and flow regulation from Van Arsdale dam; agricultural land use	
Lake Mendocino Reservoir	Probably at risk*	Alteration of natural flow regime (5)	Coyote Dam	
Ukiah Reach	Probably at risk	Alteration of natural flow regime (4); high levels of toxins (4); invasive riparian vegetation (2)	Abstractions for agricultural water use; industrial and urban pollution inputs around City of Ukiah	Moderate embeddedness values; presence of Arundo donax
Sulphur Creek	Probably not at risk	Aleration of natural flow regime (1)	Abstractions for agricultural and residential water use	Low embeddedness values
Alexander Valley Reach	Probably at risk	Alteration of natural flow regime (5); potential for elevated sediment (4) and nutrient levels (3); high levels of toxins (4); loss of floodplain connectivity (4); invasive riparian vegetation (3)	Abstractions for agricultural water use on mainstem and tributaries; agricultural land use; urban wastewater and stormwater inputs	Moderate embeddedness values; presence of Arundo donax
Warm Springs Tributaries	Probably not at risk	No pressures identified		
Lake Sonoma Reservoir	Probably at risk*	Alteration of natural flow regime (5)	Warm Springs Dam	
Dry Creek	Probably at risk	Alteration of natural flow regime (5) and channel incision below dam (4); invasive riparian vegetation (2)	Flow regulation from dam & abstractions for agricultural water use; reduced sediment load from dam and downcutting from gravel mining	Low to moderate embeddedness values; presence of Arundo donax
Mark West Creek	Probably at risk	Alteration of natural flow regime (3); elevated sediment levels (4); Invasive riaprian vegetation (1)	Abstractions for agricultural and rural residential water use; agricultural landuse and residential development	High embeddedness values; presence of Arundo donax
Santa Rosa Creek & Laguna	Probably at risk	Increased toxin and nutrient levels (5); loss of floodplain connectivity (4); Invasive riaprian vegetation (1)	Wastewater and urban stormwater inputs; channelization of urban streams	Low embeddedness values; presence of Arundo donax
Austin Creek	Probably not at risk	Invasive riaprian vegetation (1)	Agricultural landuse and residential development activites along stream channels	Low to moderate embeddedness values; presence of Arundo donax
Middle & Guernville Reaches	Probably at risk	High levels of toxins and nutrients (4); Invasive riaprian vegetation (4)	Urban and rural residential landuse and associated wastewater inputs and development activites along stream channels	Moderate to high embeddedness values; presence of Arundo donax

* These water bodies would likely be desinated as Heavily Modified Water Bodies and would have a lower environmental objective than "good status". Thus, the risk of failing to achieve a lower environmental status would be lower.

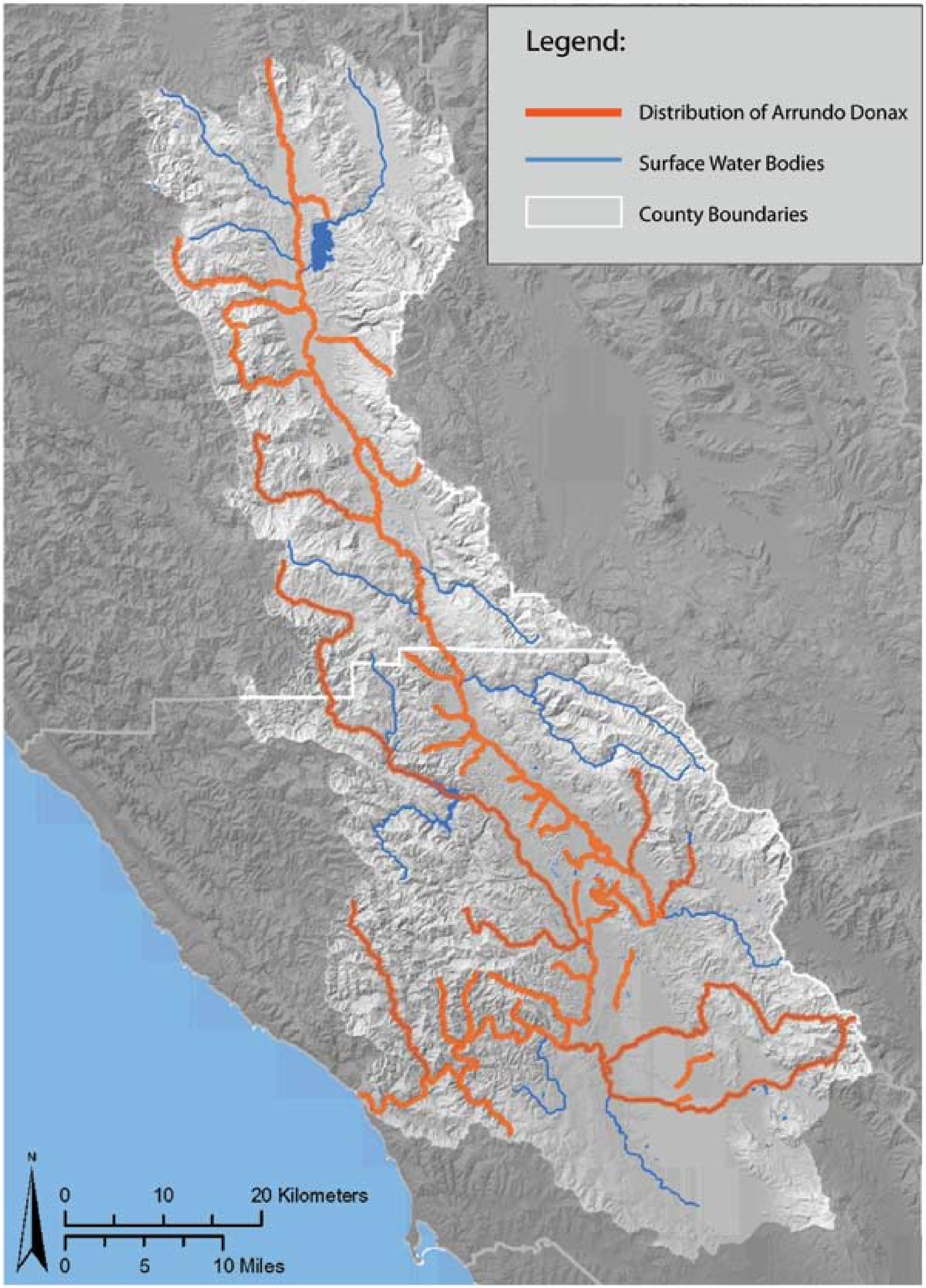

Figure 4-9. Distribution of invasive Arrundo Donax
Source: Arundo donax distribution data was generated by Circuit Riders Productions, Inc. and obtained from the Russian River Interactive Information System GIS database (RRIIS 2007).

distribution of known pressures and impacts, it is likely that eleven of the thirteen surface water bodies in the basin would be at risk of failing to achieve WFD objectives (Table 4-6).

4.3.2 Groundwaters

Assessing the impacts on a groundwater body requires quantitative and qualitative information to determine the state of the water body and the identification of the pressures acting upon it. The limited data available on groundwater resource in the Russian Basin makes it difficult to determine the extent at which mapped groundwater bodies are at risk of failing to achieve good chemical and quantitative status, as required by the WFD. Where information was not available, we inferred pressures on groundwater bodies from known landuse patterns in the basin and used as a basis for identifying water bodies potentially at risk. Potential pressures on groundwater bodies include withdrawls (for agricultural and rural residential water use), chemical pollution (associated with industrial, agricultural, or urban sources) and groundwater recharge activities (Table 4-7). Based on the distribution of known pressures and the uncertainty of groundwater body conditions, there is the potential that all of the groundwater bodies would be at risk of failing to achieve WFD objectives (Table 4-8). The assessment highlights the need for expanded groundwater monitoring in order to determine their status, identify significant pressures and develop a cost-effective program of measures to protect the condition of groundwater bodies in the basin.

The assessment highlights the need for expanded groundwater monitoring in order to determine their status, identify significant pressures and develop a cost-effective program of measures to protect the condition of groundwater bodies in the basin.

4.3.3 Findings of Pressures and Impacts Analysis

Most surface water bodies in the Russian River Basin would be potentially at risk of failing WFD good ecological status due a wide range of human pressures. Only a few upper tributaries are likely to be in good or high ecological status, which could provide suitable ecological reference conditions to evaluate other deteriorated headwaters. For the main reaches of the Russian River it is unlikely that high status conditions can be found, and historical or modeled conditions would likely be needed to establish reference conditions. The status of groundwater in the basin is largely unknown.

The main pressures identified are point and non-point source pollution from land use activities, which have removed riparian vegetation, increased bank and hillslope erosion, and increased levels

Table 4.7 Potential pressures on groundwater bodies		
Impact Sources	**Pressure**	**Potential Impacts**
Abstractions for agricultural and rural residential drinking and irrigation water use	Reduction in recharge or aquifer storage	Reduced storage; reduced dilution of chemical fluxes; modified flow and ecological regimes
Chemical pollution from industrial, agricultural, and urban sources	Change in composition and concentrations of groundwater chemistry	Contamination of drinking water sources
Groundwater recharge	Increased flow and aquifer storage	Increased outflow; contamination of drinking water

4.8 Russian River basin groundwater body risk status and significant pressures			
Groundwater Body	**Overall Risk Status**	**Key Pressures**	**Source of Pressures**
Ukiah Valley	Probably at risk	Potential for reduction in aquifer storage; potential chemical pollution	Withdrawls for agricultural and rural residential use; chemical pollution from industrial, ag and urban sources
Santa Rosa Plain	Probably at risk	Potential for reduction in aquifer storage; potential chemical pollution	Withdrawls for agricultural and rural residential use; chemical pollution from industrial, ag and urban sources
Potter Valley	Probably at risk	Potential chemical pollution	Chemical pollution from ag sources
Sanel Valley	Probably at risk	Potential chemical pollution	Chemical pollution from ag sources
Alexander Valley (Cloverdale)	Probably at risk	Potential for reduction in aquifer storage; potential chemical pollution	Withdrawls for agricultural and rural residential use; chemical pollution from industrial, ag and urban sources
Alexander Valley	Probably at risk	Potential for reduction in aquifer storage; potential chemical pollution	Withdrawls for agricultural and rural residential use; chemical pollution from ag sources
Knights Valley	Probably at risk	Potential for reduction in aquifer storage; potential chemical pollution	Withdrawls for agricultural and rural residential use; chemical pollution from ag sources
Santa Rosa Valley (Dry Creek)	Probably at risk	Potential for reduction in aquifer storage; potential chemical pollution	Withdrawls for agricultural and rural residential use; chemical pollution from industrial, ag and urban sources
Wilson Grove Formation Highlands	No data available	Potential for reduction in aquifer storage; potential chemical pollution	Withdrawls for agricultural and rural residential use; chemical pollution from industrial, ag and urban sources
Kenwood Valley	No data available	Potential for reduction in aquifer storage; potential chemical pollution	Withdrawls for agricultural and rural residential use; chemical pollution from ag sources
McDowell Valley	No data available	Potential for reduction in aquifer storage; potential chemical pollution	Withdrawls for agricultural and rural residential use; chemical pollution from ag sources

of fine sediment, pesticides, fertilizers and other toxins. Substantial hydromorphological alterations due to dam construction, abstractions, channel dredging, gravel mining, and flood control management have also placed water bodies at risk.

The significant water management issues associated with environmental impacts, which were already widely known in the river basin, are confirmed by the pressures and impacts analysis: hydromorphological impacts due flow regulation for water supply, flood and gravel mining; diffuse pollution from agricultural, urban and industrial areas; and impacts to native aquatic communities due to the introduction of exotic species.

The risk assessment highlights significant data gaps in basic chemical, physical and ecological indicators on the basin scale. In particular, more information is needed on the spatial distribution of hydromorphological pressures and on the state of ecological communities, including macroinvertebrates, fish, macrophytes and phytoplankton. The lack of information relating to pressures on groundwater bodies is striking. The DWR assessment of state groundwaters (DWR 2003) reports that there is insufficient data to determine groundwater budgets for all groundwater bodies in the Russian River basin. However, based on landuse patterns and known water demands by residential agricultural water users, decreases of groundwater table levels are considered likely.

It is important to note that the identification of pressures does not indicate that they necessarily are *causing* significant ecological impacts. In most cases, current monitoring programs are not designed in coordinated in such a way to conclusively link potential pressures to ecological indicators. There is limited data available to determine exactly how specific activities result in impacts to the system. Focused investigations on the effects of landuse practices (including agricultural, urban and rural landuse types) on ecological conditions must be conducted in order to design management plans for improving the ecological status of water bodies in the basin. These investigations should be coordinated with ongoing environmental monitoring efforts so that the effectiveness of management measures can be evaluated.

The risk assessment is not conclusive, but as a first step, identifies significant methodological and monitoring gaps that must be addressed in order to perform a coherent assessment of water body status and provide the basis to develop effective measures to achieve a lasting recovery of the aquatic ecosystem. Table 4-9 summarizes the priority monitoring needs in the Russian River basin based on this assessment.

4.4 Economic Analysis of Water Uses

The economic analysis of water uses for each River Basin District is intended to produce the information necessary to implement water-pricing policies that provide an incentive for efficient water use and

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Table 4.9 Priority environmental monitoring needs in the Russian River basin		
Parameter	**Indicators**	**Pressures**
Ecological	macroinvertebrate, fish, phytoplankton and macrophyte/riparian community metrics	physio-chemical and hydromorphological modifications, invasive species
Physio-chemical	temperature, sediment load, DO, pH, toxins	riparian vegetation removal, diffuse pollution sources from land use activities (ag operations, wastewater disposal, urban stormwater, rural development)
Hydromorphological	flow regime, channel morphology and floodplain connectivity	channelization, levees, diversions dredging
Groundwater condition	water level reduction, chemical pollutants	abstractions, chemical contamination from agricultural, industrial and urban sources

contribute to the achievement of environmental objectives. The WFD requires the implementation of policies that ensure that water users contribute adequately to the costs of water services (cost-recovery principle) and that the costs of environmental damage be paid for by the party responsible (polluter pays principle) (WFD 2000 [Article 9]). The economic analysis also plays an important role in developing a cost-effective combination of measures to achieve environmental objectives and in determining whether there are over-riding socio-economic reasons to apply exemptions to the general environmental objectives (EC 2003b).

The analysis should address water supply and demand issues, current water prices and costs for water services and be informed by the findings of the pressures and impacts assessment. As shown by data collection efforts of EU Member States, economic data are collected for different purposes and by different departments or ministries than those responsible for water management. As a result, the WFD-required economic analyses in most river basins have been relatively poor, and focused mainly on drinking water supply, where data are more readily available (CEC 2007).

Similar obstacles to performing an economic analysis are present in the Russian River Basin. The ability to perform a full economic analysis of water use in the basin is limited by several significant factors. First, water use and economic data are only available at the county or municipality and not at the river basin level. Because the Russian River basin spans two counties (Mendocino and Sonoma) with substantial parts of both counties occurring outside of the basin, the available data does not correspond with the area of analysis.

Second, county-level economic data are available only for compensation, wages and employment by economic sector, but not for gross county product. The latter would be the more appropriate economic dimension to assess the water-use practices associated with various economic activities and their relative contributions to the counties' economic performance. The only economic productivity data available for both counties were in the manufacturing sector. Data on service, tourist and retail sectors were available only for Sonoma County.

Finally, estimates of water use are available only for the general categories of domestic, industrial and agricultural use. Monitoring data are available only for public water supply for domestic, industrial/commercial and agricultural uses, but not for "self-supplies," (i.e., individual wells or surface diversions) which in the Russian River basin represent a larger proportion of water use than public supply.

For these reasons, a complete and robust economic assessment of water uses in the Russian River Basin is currently not feasible. In particular, it is impossible to quantify the current level of cost recovery for water services and the incentive role of current water pricing policies. Nonetheless, the analysis draws attention to general patterns and trends in economic and water use activity, highlights important data gaps, and qualitatively indicates the effectiveness of current water pricing for recovering costs and promoting efficient use.

4.4.1 Population and Economic Characteristics

The two counties that encompass the Russian River basin have distinct economic and demographic profiles. In 2000, Mendocino County's population of 86,700 was dwarfed by the Sonoma County population of 461,600. A recent study by the California Department of Finance, projected an annual growth rate of just over 1 percent for both counties through 2050. Under this growth scenario, the Mendocino populations would grow by 55 percent to reach 134,400 by 2050, while Sonoma would experience a 65 percent increase in population with 761,200 residents (California Department of Finance [Cal] 2007). However, these growth forecasts are considered highly uncertain and the actual growth rate in Sonoma County from 2000 to 2005 was only 0.3 percent perannum (Sonoma 2006). At a 0.3 percent growth rate perannum, a population increase of 16 percent would be expected by 2050.

Between 2000 and 2005, the annual gross regional product for Sonoma County was approximately $17 billion (Sonoma 2006). Comparable data were unavailable for Mendocino County. Of the identified economic sectors, the largest contributors to Sonoma County's gross regional product and employment were services, retail trade followed by high-tech manufacturing, financial activities and agricultural food processing (Figure 4-10). Grape-production/winemaking is identified as a key industry in the regional economy, directly supporting the retail trade and service sectors (e.g. wine-related tourism).

Value added from manufacturing and agricultural products in

As shown by data collection efforts of EU Member States, economic data are collected for different purposes and by different departments or ministries than those responsible for water management. Similar obstacles to performing an economic analysis are present in the Russian River Basin.

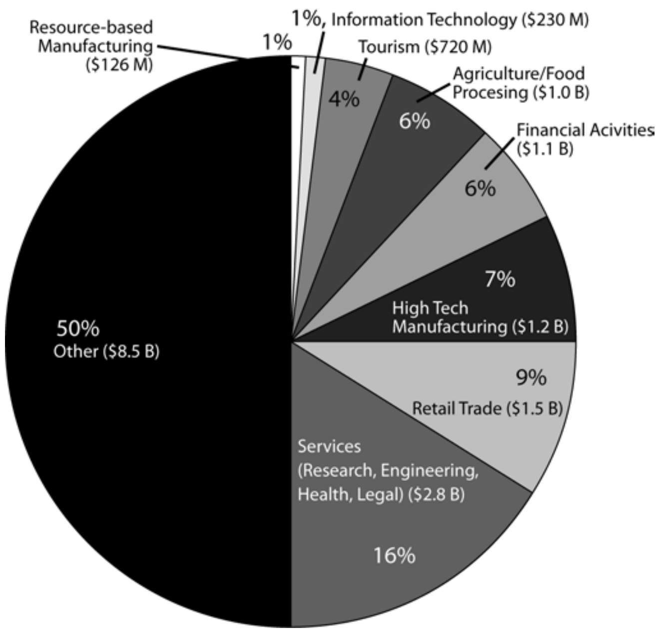

Figure 4-10.
Sonoma County gross product for select economic sectors
Source: Sonoma County (2006 a)

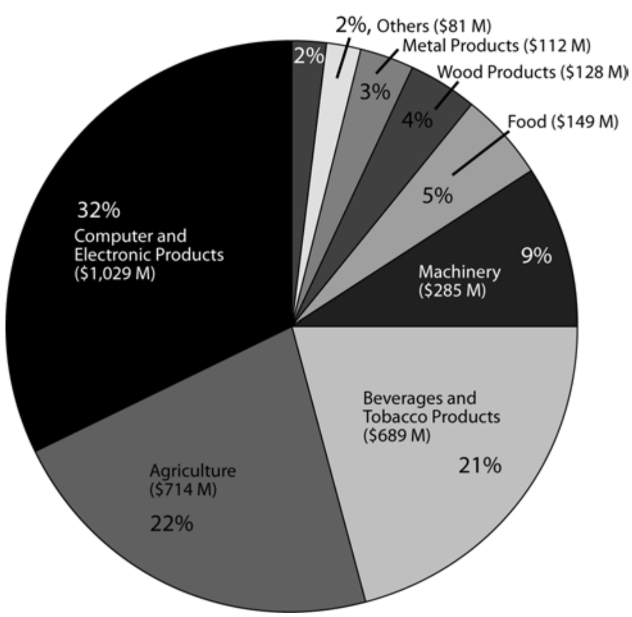

Figure 4-11.
Value added in manufacturing in Sonoma and Mendocino Counties, 1997
Source: California Department of Finance (2002)

both Sonoma and Mendocino Counties is approximately $3.4 billion per year (Figure 4-11) (Cal 2002). In both Counties combined, high-tech manufacturing is the largest contributing sector (approximately $1 billion) to total product value, followed by agriculture ($0.7 billion of which $0.5 billion grapes) and beverages and tobacco ($0.7 billion). These figures do not include illegal marijuana production, which may be significant especially in Mendocino County.

Employment in both counties totaled approximately 230,000 (Figure 4-12) with two thirds occurring in services, government and trade sectors (Cal 2002). Agriculture employed fewer than 10,000 people (about 4%) but this statistic probably does not account for temporary and seasonal workers.

In Sonoma County, economic forecasts through 2011 predict a 2% increase in employment, with a slight shift in employment from high-tech manufacturing and agriculture to information technology and service sectors (Sonoma 2006a). Still, high-tech manufacturing is expected to have the largest growth rate in terms of gross regional product, followed by financial activities, retail trade and tourism. Agriculture and food processing and resource-based manufacturing are predicted to have the weakest economic growth among the main economic clusters analyzed.

4.4.2 Water Supply for Main Sectors

The total water use in Sonoma and Mendocino County is estimated at 300x10^6 cubic meters (m^3; 242,000 acre feet [AF]) per year (USGS 2000). Agriculture (irrigation, livestock, and aquaculture) is responsible for approximately 65% of water usage in the region. Domestic water use accounts for 27% of total water use and industry/commerce the remaining 8% (Figure 4-13). Approximately one third of all water use is supplied via public services and two thirds via self-services. Public services include utilities operated by municipalities or public agencies, for which in general economic data are reported. Self-services include all private operators, such agricultural and residential water users, who obtain their water by diverting from a river or stream or by abstracting groundwater from a private well. For such self-services, economic and environmental data are not readily available.

Agriculture

Agriculture is the largest water user in Sonoma and Mendocino Counties and is estimated to be 194×10^6 cubic meters (m^3; 157,000 AF) per year (USGS 2000 and Santa Rosa 2006). Irrigation represents most of this use 173×10^6 m^3 (140,000 AF), in addition to livestock 10×10^6 m^3 (8,000 AF) and aquaculture 11×10^6 m^3 (9,000 AF). Nearly all of the water used for irrigation 162×10^6 m^3 (131,000 AF) comes from self-supplies, while the remaining 11×10^6 m^3 (9,000 AF) is delivered by public supply services. Of the self-supplied irrigation water, approximately 118×10^6 m^3 (96,000 AF) are appropriated from surface water and 42×10^6 m^3 (34,000 AF) from groundwater (Figure 4-14).

Domestic

Sonoma and Mendocino County water utilities deliver 91×10^6 m^3 (74,000 AF) per year water to approximately 403,000 people for domestic, industrial/commercial and irrigation uses. It is estimated that 142,000 people in the two Counties meet their domestic water needs via self-supply, withdrawing about 14×10^6 m^3 (11,000 AF) per year primarily from groundwater sources, but also from surface flows (USGS 2000). According to the available statistics from Santa Rosa, the largest city in the region with a population of over 150,000, 71% of its water supply goes to domestic uses, 17% to industrial/commercial use and 12% to irrigation uses (Santa Rosa 2006). Assuming similar allocation patterns for public supply throughout the Russian River basin, a rough estimate of total domestic water use is 78×10^6 m^3 (63,500 AF) per year, or 0.39 m^3 per day (104 gallons per day [gpd]) per capita. Domestic water users with public supply

Agriculture (irrigation, livestock, and aquaculture) is responsible for approximately 65% of water usage in the region. Domestic water use accounts for 27% of total water use and industry/commerce the remaining 8%.

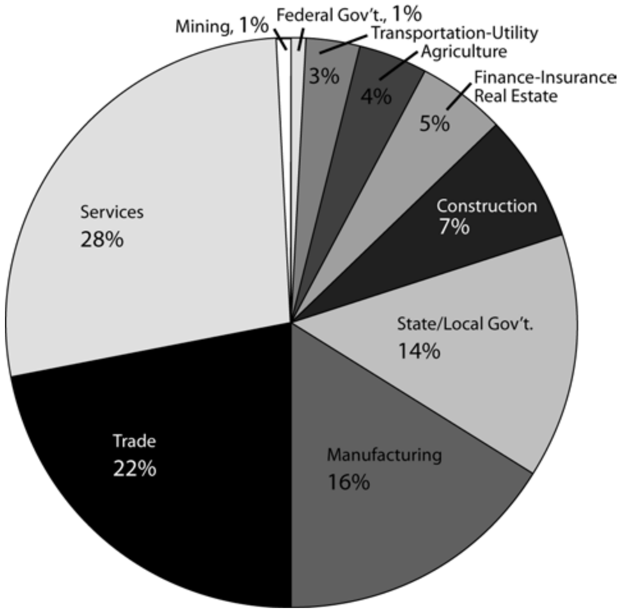

Figure 4-12.
Sonoma and Mendocino County employment, 2000
Source: California Department of Finance (2002)

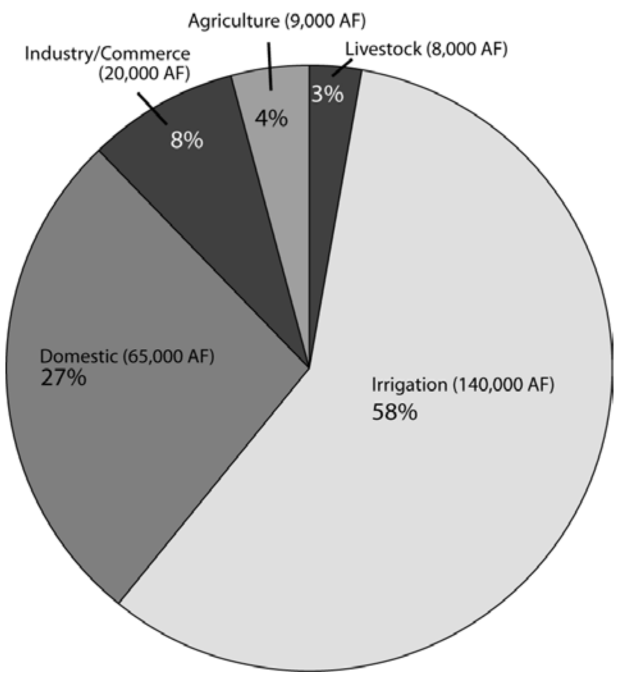

Figure 4-13.
Water use by sector in Sonoma and Mendocino Counties
Source: US Geological Survey (2000)

use approximately 0.44 m^3 per day (116 gpd), while self-service users average 0.26 m^3 per day (69 gpd) (Calculations based on USGS 2000). By contrast, per capita domestic water use in Spain, which has a climate comparable to California, is around 0.21 m^3 per day (55 gpd) (EEA 2003). Per capita domestic water use in southern California is approximately 0.36 m^3 per day (94 gpd) (DWR 2005).

Most public water supply in Mendocino and Sonoma Counties is reported to come from groundwater sources (approximately $85x10^6$ m^3 (69,000 AF) of $91x10^6$ m^3 (74,0000 AF) total annual supply; Figure 4-15). This figure is misleading however, as the main water supply is appropriated through an infiltration system, which diverts water from the mainstem Russian River to off-channel groundwater infiltration basins. The ponded water percolates into the soil and is pumped from the groundwater to treatment stations (SCWA 2007). The supply system relies on water level regulations in the Russian River, which are raised during summer base flows via an inflatable dam on site that diverts river water into the infiltration ponds.

Industrial and commercial water use

Industrial and commercial water use in Sonoma and Mendocino Counties totals $25x10^6$ m^3 (20,000 AF) per year, with $15x10^6$ m^3 (12,000 AF) from public supplies and $10x10^6$ m^3 (8,000 AF) from self-supplies (USGS 2000 and Santa Rosa 2006). Most of the water used for industrial/commercial use is derived from groundwater sources. No information about sector specific water use is readily available.

4.4.3 Economic Analysis of Water Uses and Their Environmental Pressures

The WFD defines water uses as all activities that could have a significant impact on the water status.

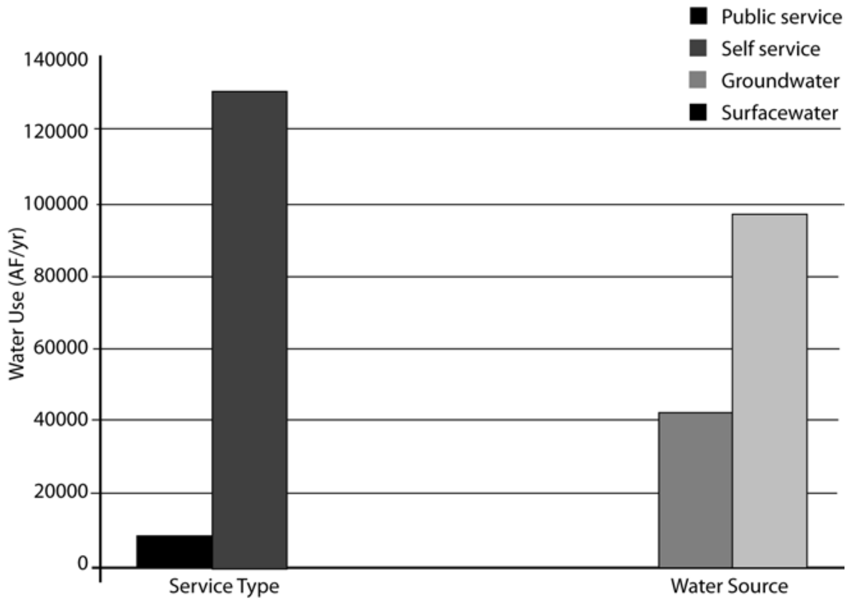

Figure 4-14. Agricultural water use in Sonoma and Mendocino Counties
Source: US Geological Survey (2000)

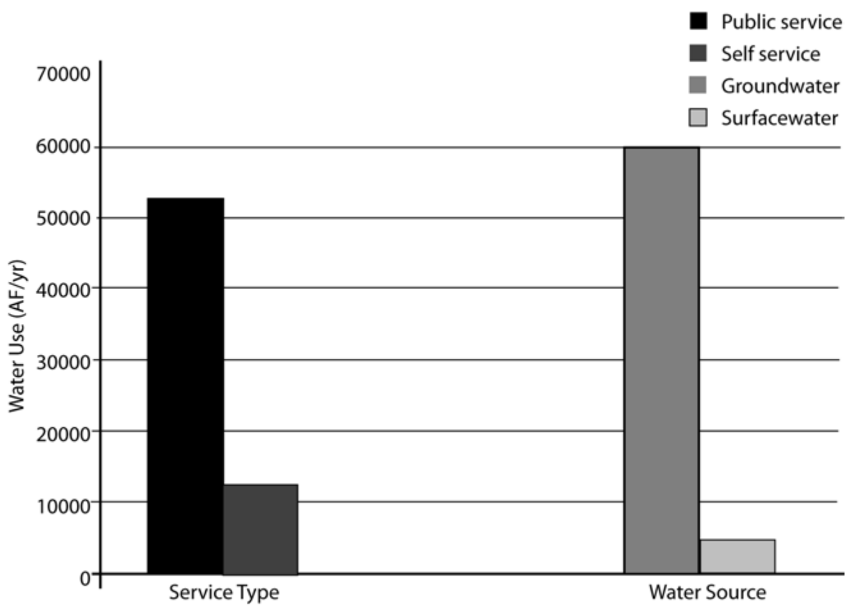

Figure 4-15. Domestic water use in Sonoma and Mendocino Counties
Source: US Geological Survey (2000)

Based on the results of the pressures and impacts assessment, the principal activities that are placing Russian River Basin surface water bodies at risk of failing to achieve good status are flow regulation in the Russian River, water withdrawl for residential and agricultural water use, floodplain agriculture and development, gravel mining, wastewater and urban stormwater pollution, invasive species, and

Domestic water users with public supply use approximately 0.44 m^3 per day (116 gpd), while self-service users average 0.26 m^3 per day (69 gpd). By contrast, per capita domestic water use in Spain, which has a climate comparable to California, is around 0.21 m^3 per day (55 gpd) .

In terms of total annual water use, vineyards use slightly more water per acre than other agricultural crops. However, the per acre production value for vineyards is more than 10 times greater than other crops (Table 4-10).

a variety of land use activities that result in increased sediment and nutrient transport to water ways. A comprehensive analysis of each of these pressures was not possible due to data limitations. A brief assessment of water uses by sector has been restricted to agriculture, City of Santa Rosa water use, flood management and gravel mining.

Agriculture

Agriculture is the main water user in the Russian River Basin and places a number of pressures on the aquatic environment. Most directly, water used for irrigation is directly abstracted from streams and groundwater wells, which can lead reductions in flows, decreased water levels, and higher water temperatures, all of which have important consequences for aquatic habitat quality. The different agricultural water uses in Sonoma County have different characteristics in terms of water needs, timing, and economics. In terms of annual water use, vineyards use slightly more water per acre than other agricultural crops. However, the per acre production value for vineyards is more than 10 times greater than other crops (Table 4-10). The proportion of livestock grazing land in Sonoma County that is irrigated was not reported, so the water use value for this agricultural sector can not be determined.

Other impacts associated with agricultural activities include the removal/alteration of riparian habitat, increased sediment and nutrient runoff, and construction of levees, which disconnect floodplain habitat from the river channel. Unfortunately, there are no quantitative data readily available relating specific agricultural types and practices to these impacts.

Predictions on the future growth of the agricultural sector in the Russian River Basin are highly uncertain, but available short-term predictions for Sonoma County do not suggest significant increases in agricultural land area (Sonoma 2006a). It is possible that new technologies and practices could to lead to a reduction of water use for irrigation by applying more efficient irrigation devices and using re-cycled water from urban waste water treatment (The City of Santa Rosa sends $25x10^6$ m^3 (20,000 AF) of treated waste water northward through a pipeline to the Geysers, where it is injected to generate geothermal power with another $6x10^6$ m^3 (5,000 AF) from the pipeline used for irrigation en route (Santa Rosa 2006).

Public water supply of Santa Rosa

The City of Santa Rosa has the largest water demand of any city in the Russian River Basin, requiring $30x10^6$ m^3 (24,000 AF) per year for commercial, industrial and domestic water use in a service area that supports approximately 153,800 people. The City relies exclusively on water delivered by the Sonoma County Water Agency, which obtains most of its water from the Russian River via delivery from storage reservoirs and diversion into a groundwater infiltration system. The impacts of the water supply system on the aquatic environment are likely to be significant as they involve dams and reservoirs and alterations to the natural flow regime (affecting water levels, flow velocity, turbidity, temperature, etc.)

Growth forecasts for the City predict that the population will reach 206,000 by 2030. Under this scenario, water demand is expected to increase to $42x10^6$ m^3 (34,000 AF) per year (Santa Rosa 2006b). Those forecasts are based on a 1% annual population growth projection and constant water use of 0.38 cubic meter per day (102 gpd) for domestic use, 4.9 cubic meters per day (1,295 gpd) for commercial and 5.7 cubic meters per day (1,508 gpd) for irrigation (Figure 4-16). As noted above, actual growth rates for 2000-2005 have been lower than 1%. Nonetheless, even slower growth rates will increase water demand, aggravating the environmental problems described above, especially as recent population growth in the region has been in the form of urban sprawl, with potentially significant impacts to the aquatic environment due to impervious surface and poor water quality (Appendix C).

Flood management

Flood control infrastructure protects a multitude of human activities in floodplains, including residential settlement, transport, agriculture and industry. Some of these types of floodplain activities derive a direct benefit from their proximity to the river and would thus be considered important water uses, as defined by the WFD, but other activities could be sited on uplands equally well. In both Mendocino and Sonoma Counties, large segments of the Russian River have been modified by channelization and levees to protect human activities on the floodplain. In addition, Warm Springs Dam was built in part to provide flood protection for development on the lower

The increase in water demand can be expected to aggravate the environmental problems associated with the water supply system.

Many areas that were historically flooded and are now protected by levees may not be included in the FEMA flood risk zone. Land use behind those levees are likely to be dominated by residential, industrial and agricultural activities, which given the risk of levee failure and flooding, should be classified as users of flood protection services.

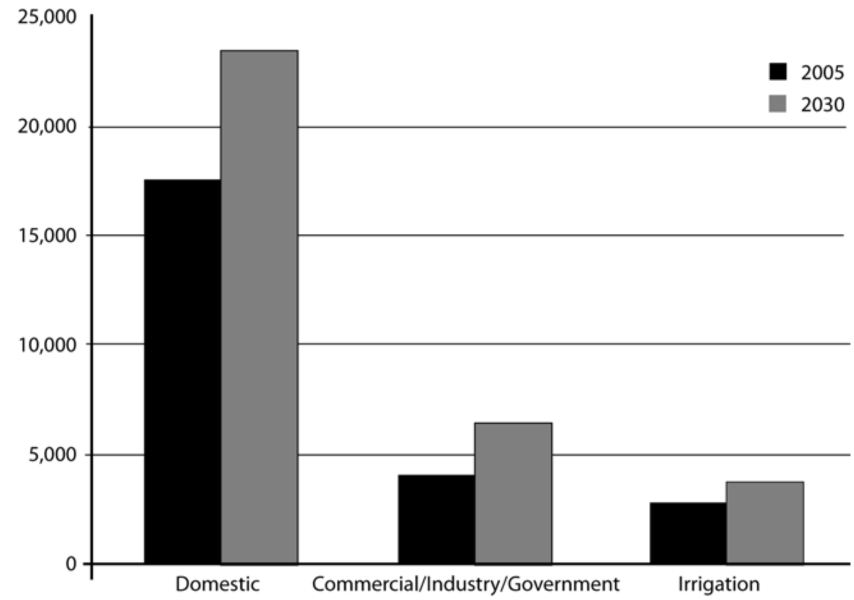

Figure 4-16. Current and projected Santa Rosa water demand by sector, 2005 – 2030
Source: Santa Rosa (2006)

Russian River. To a lesser extent, Coyote Dam and five smaller water retention reservoirs in the Central Sonoma Watershed Project are operated to control floods (SCWA 2007a). The SCWA also actively maintains the flood capacity of about 130 kilometers (80 mi) of river by removing and cutting back vegetation in the channel and banks (SCWA 2007b). All of these activities have resulted in substantial alterations to the natural hydromorphology of the river and are known to have a significant negative impact on salmonids and other aquatic species (Coey 2002).

The distribution of land use types in the flood risk zones identified by the Federal Emergency Management Agency (FEMA) indicates that the dominant floodplain land use is agriculture, although residential and commercial development also significant (Table 4-11). It is also important to note that many areas that were historically flooded and are now protected by levees may not be included in the FEMA flood risk zone. Land use behind those levees are likely to be dominated by residential, industrial and agricultural activities, which given the risk of levee failure and flooding, should be classified as users of flood protection services.

Table 4-10. Agricultural water use and production values in Sonoma County						
Agricultural Use	**Area (km2)[1]**	**Annual Water Use (10^6 m^3/year)[2]**	**Water Use per Area (10^6 m^3/yr/km^2)**	**Annual Production Value (dollars/yr)**	**Annual Production Value per Area (dollars/yr/km^2)**	**Water Use Value per Area (dollars/10^6 m^3/km^2)**
Vineyards	237	48	0.20	$389,853,900	$8,042,231	$33,970.58
Non-grape crops	421	65	0.15	$50,609,400	$783,010	$1,860.44
Livestock Grazing Land[3]	1,704	9	NA	NA	NA	NA

[1]Source: Sonoma County General Plan 2020 Draft EIR
[2]Source: U.S. Geological Survey Estimated Use of Water in the United States County-Level Data for 2000, based on assumption that all microirrigation was used for vineyard production.
[3]Water use values for grazing lands could not be determine because the proportion of the total area subject to irrigation is unknown.

Table 4-11. Land use coverage in flood risk zones in the Russian River Basin.			
	Area (km^2)	**Area (mi^2)**	**Percent of Total Floodplain**
DEVELOPED LAND			
Residential	143.3	55.3	14%
Commercial and Services	124.0	47.9	12%
Industrial	0.2	0.1	0%
Other urban or built-up land	10.0	3.9	1%
Total	277.4	107.1	27%
AGRICULTURAL LAND USES			
Cropland and pasture	125.3	48.4	12%
Orchards, groves, vineyards, nurseries	152.4	58.8	15%
Herbaceous rangeland	81.1	31.3	8%
Mixed rangeland	57.0	22.0	6%
Total	415.8	160.6	40%
NATURAL VEGETATION			
Deciduous forest land	6.3	2.4	1%
Evergreen forest land	161.1	62.2	16%
Mixed forest land	168.6	65.1	16%
Streams and canals	3.2	1.2	0%
Total	339.3	131.0	33%
Grand Total	**1032.6**	**398.7**	

The gravel miner has no economic incentive to switch from cheap and easily-exploited in-channel deposits, as the considerable environmental impacts of this mining are externalized, and not reflected in the costs paid by consumers of the gravel or concrete.

Gravel mining

The gravel mining industry employs several hundred people in Sonoma County, with total reported earnings of about $22 million (U.S. Department of Commerce 2005). However, this number may underestimate the overall mining contribution to the economy because it only recorded the earnings of gravel mining operations with offices in the county. Several gravel mining companies operate in the Russian River basin but are headquartered elsewhere, such as Syar Industries of Napa.

Gravel is essentially free to extract from the river channel or recent channel deposits in the floodplain because the river has sorted similarly-sized gravels together so that little processing is required. All that is needed is the heavy equipment to excavate and sort the materials by size. The gravel is then washed to remove fine sediments and the product is ready for market. Transport costs are frequently the greatest cost component, both because the costs of trucking are high and because other costs (extraction, processing) are typically so low. Unfortunately, no data were readily available on water usage from the gravel mining industry, but principal uses would include washing fines from gravel and spraying to control dust.

There are alternative sources of gravel available, such a reservoir delta deposits, older terraces, quarried rock, but they typically involve more processing and often greater transport distances. Thus, the gravel miner has no economic incentive to switch from cheap and easily-exploited in-channel deposits, as the considerable environmental impacts of this mining are externalized, and not reflected in the costs paid by consumers of the gravel or concrete. The costs of mining-related damage, such as failed bridges, lost salmon habitat, lost aquifer storage, and possible degradation of water quality from the extent of exposed surface water in abandoned gravel floodplain gravel pits (Kondolf 1998), has not been calculated, however it is clear that they have been external to the economic decisions made by gravel miners about where to mine and how.

4.4.4 Cost Recovery and Price Incentives

This section assesses the degree to which water service costs are covered by uses and if water pricing structures provide incentives for efficient water use. Overall data are insufficient or not easily accessible to perform a robust assessment of water use economics in the Russian River basin. Therefore, only general conclusions can be drawn about whether users pay the full costs for water services and whether the pricing structure provides incentives to reduce the use.

Water services are defined as all services (including self-services) which provide for households, public institution or any economic activity and include diversions, impoundment, waste water disposal and treatment. Water uses means all water services and other activities which have a significant impact on the ecological or chemical status of a water body.

Costs to be considered in the economic analysis include all financial expenditures, as well as environmental and resource costs (Appendix D). Financial costs include all direct costs, such as administrative, capital and operation costs, as well as internalized costs for such items as permitting fees, environmental review and public participation. Environmental costs are the non-internalized costs of the damage caused by water uses to the aquatic environment. Resource costs are the value lost when certain uses are excluded due to limited water availability. Resource costs often arise in situations dealing with historical water rights, where one user has the right to use the water for an activity providing a lower benefit then a potential alternative user.

The environment has use (e.g., drinking water, fisheries) and non-use values (e.g., protection for future generations, spiritual and existence values). Some indicative figures can be produced to estimate environmental values for the Russian River Basin, based on the costs of current mitigation and restoration projects invested to improve environmental conditions. Between 1981 and 2003, a total of $47 million (approximately $2 million per year) was spent on river restoration projects primarily financed through the Californian Department of Fish & Game (Salmonid Restoration Fund, $43 million from 1981-2003), the US Department of Agriculture (Environmental Quality Incentive Program, $2 million from 1981-2003, 50% of which was contributed by private landowners) and the Sonoma County Water Agency (Fisheries Enhancement Program, $1 million from 1981-2003) (Table 4-12) (Christian-Smith and Merenlender *In Press)*. Because these programs were primarily targeted at salmonid population recovery, the costs represent a combination of use and non-use values and account for only a small fraction of the full environment costs associated with water services in the Russian River Basin.

Agriculture Irrigation

The vast majority of irrigation water comes from self-services, including surface water diversions and groundwater withdrawls, for which no detailed data on the quantities and costs are available. Nevertheless, one can assume that self-services are close to full financial cost-recovery as the private landowner is responsible for all investment, operation and maintenance costs for abstracting, transporting and storing the irrigation water. However, diversions of irrigation water from the Russian River during the dry periods depend on flow regulation upstream from Lake Sonoma and Mendocino Reservoirs. Those dams and reservoirs are financed, maintained and operated by Federal and County agencies, which recover their costs from general tax revenues. Therefore, a part of the financial costs of supplying

Table 4.12 Restoration and mitigation costs in the Russian River basin, 1981-2003	
Contributor	**Restoration Cost (million dollars)**
U.S. Department of Agriculture	2
Department of Fish and Game	43
Sonoma County Water Agency	1
Other	1
TOTAL	47

Source: Christian-Smith and Merenlender (In Press)

irrigation water is not recovered directly from the irrigation users but is paid for by taxpayers. Whether this subsidy is significant could not be determined from annual budget data provided by the respective agencies.

The environmental costs of irrigation water use are unknown. Based on the conservative assumption of environmental costs being equal to restoration costs (approximately $2 million per year) and irrigation representing 58% of all water use, agricultural water users would have to contribute $1.2 million annually to offset environmental costs. Currently, it appears that agriculture only provides approximately $0.05 million per year as co-funding to the US Department of Agriculture's Environmental Quality Incentive Program. Therefore, these findings suggest that agriculture does not cover occurred environmental costs associated with irrigation water uses.

It is difficult to determine whether water pricing for irrigation water use in agriculture provides an incentive to use water more efficiently. There is currently no effective regulatory mechanism to limit groundwater extraction and enforcement penalties for unauthorized surface water diversions are rare. Therefore, financial costs are the primary mechanism by which use is regulated. Volume dependent costs are likely to be small and strongly linked to energy costs. Therefore, the cost of water per unit volume has a regressive pricing structure, indicating that the current system provides little to no incentive for water conservation in the agricultural sector.

Domestic water use

The total domestic water use for both counties is estimated at 79×10^6 m^3 (64,000 AF) per year, of which 65×10^6 m^3 (52,500 AF) are supplied via public services and 14×10^6 m^3 (11,000 AF) via self services. As in the case of irrigation water uses, one can assume partial financial cost recovery for self-services. Furthermore, since 90% of domestic self supplies come from groundwater sources, water users are not directly dependent on regulated surface flows in the river (USGS 2000). The level of financial cost recovery for domestic self supplies is thus likely to be higher than for agriculture irrigation uses that depend on surface waters.

The 2004-05 annual budgets for the City of Santa Rosa urban water management plan indicate that water pricing is based on full financial recovery policy (City of Santa Rosa 2006). The City's water supply expenses amount to $23.6 million compared to $26.7 mill revenues from fees and charges. In contrast, financial cost recovery is not achieved for wastewater collection and treatment services, whose expenses amounted to $54.9 million compared to $49.2 million in revenues from wastewater fees and charges. Furthermore, the City has outstanding debts of $226.5 million in wastewater improvement bonds and $140.2 million in wastewater state loans.

To assess water-supply economics of the City of Santa Rosa, it is necessary to consider the budget of their principal supplier, the Sonoma County Water Agency. The agency's financial statements are difficult to assess. Some budget reports indicated full recovery of financial costs for supplying water from its costumers (SCWA 2003), while the 2005-06 budget, for example, indicates net costs of $17.7 million. Additionally, as discussed above, the costs of flow regulations in the Russian River from Warm Springs and Coyote dams are covered by general property and income taxes. The maintenance of adequate flow conditions in the summer is critical to the agency's water supply system, which diverts water from the mainstem.

Based on the assessment of Santa Rosa and SCWA financial records, full financial cost recovery cannot be assumed for domestic water supply in the City of Santa Rosa.

The environmental costs of domestic water use in the Russian River Basin are unknown. Based on the assumption of environmental costs being equal at least to restoration costs ($2 million per year) and the share of domestic water (27%) of all water uses in the basin, domestic water user would have to contribute $0.55 million annually to offset environmental costs. There are no data readily available to determine the contribution of domestic water users to environmental costs such as habitat restoration.

Water pricing for domestic water uses in the City of Santa Rosa is composed of 15% fixed costs and 85% volume dependent costs, with an increasing block price tariff structure (Appendix E). Water pricing for commercial and irrigation uses are identical. A fixed price of $3.43 per 4 m^3 (1,000 gallons) for up to 340 m^3 (90,000 gallons) can be obtained for the biggest meter size, which would easily serve the domestic needs of 25 people. For the next 114 m^3 (30,000 gallons), costs increase to $4.04 per 4 m^3 (1,000 gallons), and in the last tier to $6.03 per 4 m^3 (1,000 gallons).

There is currently no effective regulatory mechanism to limit groundwater extraction and enforcement penalties for unauthorized surface water diversions are rare.

Based on the assessment of Santa Rosa and SCWA financial records, full financial cost recovery cannot be assumed for domestic water supply in the City of Santa Rosa.

Although dependent on meter size, the incentive function of water prices to reduce consumption appears limited. Furthermore, since meters are generally only provided for single structures, there is likely less incentive to reduce consumption in multi-family housing units. With respect to domestic self supplies, service costs can be assumed to be fixed with regressive costs per increasing volumes. Therefore, there is a negative incentive to reduce water use. Despite this fact, it is interesting to note that per capita consumption for domestic self supply is significantly lower than that for public services (Figure 4-15).

Overall, water prices for publicly served domestic water uses provide a limited incentive to conserve water. Indeed, per capita consumption in Sonoma County has only slightly decreased over the last 15 years and has remained high above levels in other comparable regions in the world (Appendix F).

Flood management

Flood management is primarily carried out by Mendocino and the Sonoma County Water Agencies and the Army Corps of Engineers, both of which recover their respective costs from general taxes on income or property. One could argue that property tax reflects costs to users of the flood service as it is established at county level. However, the majority of taxes are raised from properties not within flood risk zones or behind levees. Thus no financial cost recovery can be assumed from the specific users of flood risk zones, including households, businesses and agriculture, the latter being the dominant user.

The environmental and resource costs of flood management are significant as explained above, but no quantitative assessment is possible due to lack of information. And as there is no cost recovery from the users of the flood management services there is no financial incentive to reduce and remove human activities from floodplains.

Gravel mining

The true costs of gravel mining are poorly documented. While miners directly use little water, instream mining produces significant environmental impacts at substantial costs that are born by other parties, including the state. Thus, we conclude that cost recovery is not achieved. Furthermore, gravel mining stands out as an activity that makes a relatively small direct financial contribution to the local economy, while causing significant environmental damages, and whose costs are largely externalized.

4.4.5 Findings of Economic Analysis

A robust economic analysis of water uses has not been possible given the absence of information organized at the level of the Russian River Basin and lack of environmental and economic data integration due to the disparate agencies responsible for environmental, water resources, and economic management and reporting. Nevertheless, based on available water use estimates, financial and budget statements of water service providers and general assumptions, conclusions can be drawn with respect to the economic importance of water uses, the level of cost recovery for water services in the main water use sectors and the incentive role of water pricing in the Russian River Basin.

The economies in Sonoma and Mendocino are dominated by the service sector and retail trade, which depend strongly on agriculture as well as high-tech production. Agriculture is by far the largest water user and imposes significant pressure on the aquatic environment, not only from irrigation water consumption but also flood defense infrastructure. Domestic water use per capita is stable at high levels, with further increases expected under population growth scenarios. Urban sprawl will have further negative consequences for the aquatic environment, in particular where housing developments occur in floodplains. Industrial water abstractions are much smaller but might still have a considerable impact on water quality. In particular, gravel mining has a significant negative impact on the river ecosystem while the sector plays only a minor role in the river basin's economy. Water supply is predominantly provided via self-services with only a significant role of public services in the domestic sector.

Only a small fraction of the total costs for water services is recovered from agricultural, domestic and industrial water users. All public water supplies in the Russian River Basin rely directly or indirectly on two large reservoirs which are financed, operated and maintained via general county, state and federal taxes. Furthermore, only a small fraction of the current costs of programs to restore rivers, which itself represents only a fraction of the overall environmental damage costs,

Overall, water prices for publicly served domestic water uses provide a limited incentive to conserve water. Indeed, per capita consumption in Sonoma County has only slightly decreased over the last 15 years and has remained high above levels in other comparable regions in the world.

Gravel mining stands out as an activity that makes a relatively small contribution to the local economy, while causing significant environmental damages, whose costs are largely externalized.

is covered by the respective water users while the bigger share is covered by federal and state programs. Resource costs (i.e., the cost of foregone opportunities due to inefficient water resource allocation) are likely to be high although no data are available for that determination. In a qualitative cost recovery ranking, flood management services and gravel mining appear to have the lowest levels of cost recovery, while domestic and agricultural water users who rely on self supplies appear to be closer to full financial cost recovery for their water use.

Current water pricing structures are marked by weak or absent incentives to conserve water or reduce environmental harmful activities. Given that the per capita domestic consumption is significantly higher than in other comparable regions in the world, there is a potential to further increase water use efficiency. Based on forecasts of population growth in the basin, shrewd water pricing may be essential for not only drinking water supply security but also to limit further environmental degradation.

When comparing the findings and conclusions of this analysis with EU member states, there are many similarities. In particular, there appears to be a ubiquitous problem with the lack of integration of economic and environmental considerations at government level and a general inadequacy of pricing mechanisms to provide environmental incentives. A comprehensive economic analysis of water use would also include an assessment of the cost-effectiveness of environmental restoration and protection measures. This task was beyond the scope of this study. However, considering the substantial amount of money currently being invested in river and watershed restoration projects, it seems worthwhile to perform such an assessment at the basin scale to help inform and prioritize future efforts. In both the EU and California, resource costs are high and large amounts of money are being mobilized for restoration projects that often are implemented without basin-wide coordination, leading an ineffective combination of measures to achieve environmental objectives at the river basin level.

4.5 Key Elements of an Russian River Basin Management Plan

The environmental and economic analysis of the Russian River

Basin undertaken in Section 4.4 represents the first phase of WFD implementation. In practice, the analysis would highlight information gaps and be used to develop monitoring programs and preliminary recommendations for changes in policy and management practices. As monitoring programs are established and more information obtained, a formal program of measures would be then developed and integrated as a comprehensive River Basin Plan.

Based on the findings of the Russian River basin characterization, environmental assessment and economic analysis, implementation of the Water Framework Directive in the basin would require fundamental change in current water management practices and policies. The analyses highlight three critical elements to be addressed as first steps towards achieving sustainable water management as envisioned by the WFD. These are: (1) an administrative arrangement which can ensure coherent, integrated and participatory basin-scale water management, (2) comparable ecological classification for all waters irrespective their actual use and (3) the evaluation and iterative development of economic and environmental management measures.

4.5.1 Administrative Arrangement for River Basin Management

The WFD recognizes that basin-scale management requires the establishment of a central authority that has the power to oversee and coordinate all water-related activities in the river basin district. A river basin district authority should have the capacity to effectively regulate diverse water and landuse activities that potentially affect the status of water bodies. There is now no such authority in the Russian River Basin. As described in previous sections, water management is currently carried out by broad range of agencies whose responsibilities are often competing. The water rights system and complex assortment of local, state and federal laws currently make it nearly impossible to develop and implement comprehensive combination of measures necessary to effectively address water issues at river-basin scale.

The analysis of Russian River Basin administrative arrangements indicates that a fundamental restructuring of powers would be necessary. While it is difficult to envision the exact nature of river basin district authority in the Russian River basin, it is clear that

Current water pricing structures are marked by weak or absent incentives to conserve water or reduce environmental harmful activities. Given that the per capita domestic consumption is significantly higher than in other comparable regions in the world, there is a potential to further increase water use efficiency. Based on forecasts of population growth in the basin, shrewd water pricing may be essential for not only drinking water supply security but also to limit further environmental degradation.

Explicit requirements for public participation would also be necessary in order to make water management decision making more transparent and increase the public's role in implementation of measures. In particular, the coherent presentation of environmental and economic data and restoration/protection goals would empower citizens and their organization to contribute effectively to the management decisions and the success of their outcomes.

a central agency or joint powers authority would need to be identified and granted superior authority over water management and land use planning regulation. Such an arrangement would effectively lead to the centralization of power, which would only be possible if all relevant water management agencies at local, state and federal level provided the enabling framework conditions to accommodate changes in jurisdictional and regulatory authority.

The centralization of powers at the river basin scale would also require the establishment of safeguards to ensure transparency and accountability in decision making. First, members of the decision-making authority should be elected by the public. Currently many County-level positions in water-related agencies are appointed and therefore are not held directly accountable to the public for their decisions. Explicit requirements for public participation would also be necessary in order to make water management decision making more transparent and increase the public's role in implementation of measures. In particular, the coherent presentation of environmental and economic data and restoration/protection goals would empower citizens and their organization to contribute more effectively to management decisions and the success of their outcomes.

4.5.2 Comprehensive Ecological Assessment and Monitoring Methodology

The WFD pressures and impacts analysis reveals significant data gaps in both our understanding of the current ecological status of the basin and the main pressures and impacts causing ecological deterioration. In order to perform a coherent ecological assessment of Russian River water bodies, an increased level of coordination between agencies is essential; both to broaden the scope of monitoring efforts and to develop a common basis to assess ecological conditions. A generalizable ecological classification system keyed to conditions in the Russian River basin could be a key element in avoiding "paralysis by analysis." Such a system could largely be based on existing federal, state and regional classification systems, but would need to ensure (1) integration into one system, (2) comparability between different regions, (3) sufficiently reflect the different susceptibility of different biological parameters to different human pressures, and

(4) reflect physical and ecological processes rather than only existing conditions.

Current monitoring efforts and restoration projects are too narrowly focused on salmon habitat requirements and generally do not consider the other biological community elements that are important ecological indicators. In addition, there is no system is in place to classify the ecological status of water bodies based on reference conditions, as proposed by the WFD. This is an essential element to ensure that the classification allows for a comparison of different regions and ecosystems.

Finally, there is a critical lack of monitoring information with respect to groundwater pumping, surface water diversions and the effects of landuse activities on water quality, for both chemical and biological parameters. This information is necessary in order to determine how water and land use activities may be affecting the ecological health of water bodies and to develop mitigation measures and realize alternative management strategies.

4.5.3 Evaluation and Iterative Development of Cost-effective Management Measures

On-going monitoring efforts in the basin have shown that surface water conditions have fallen below healthy ecological standards throughout the Russian River Basin. Falling salmon populations and declines in water quality and quantity have inspired action in the basin to reverse the trends. A broad range of measures has been introduced to improve conditions, including habitat restoration, water conservation programs and recommendations for best management practices. However, there has been little effort directed towards monitoring and assessing the effectiveness of these measures or to developing novel strategies for achieving the environmental objectives. Most measures so far have been focused on stabilizing and restoring the hydromorphology of relatively short river reaches, artificial fish stocking, and voluntary riparian and land management systems. Restoration of natural flow processes and water conservation measures targeted at the river basin level have been absent.

In recognition of the revenue limitations for restoration and conservation measures, it is necessary to perform a critical evaluation of the cost effectiveness of on-going measures. It is vital to identify

An ecological classification system could largely be based on existing federal, state and regional classification systems, but would need to ensure (1) integration into one system, (2) comparability between different regions and (3) sufficiently reflect the different susceptibility of different biological parameters to different human pressures.

In recognition of the revenue limitations for restoration and conservation measures, it is necessary to perform a critical evaluation of the cost effectiveness of on-going measures. It is vital to identify the measures do not produce tangible benefits, in order to free limited resources for those that do.

the measures that do not produce tangible benefits, to free limited resources for those that do. Therefore, a robust and environmental meaningful economic assessment of water uses and the incentive function of water prices is required. The limited economic analysis undertaken in this study reveals that most environmental harmful water uses are subsidized by the public at large and water prices have no or little incentive to reduce the pressures.

Consequently, it is important for an effective and successful Russian River Basin Management Plan to collect data on the economics of water uses and services in the basin as well as their environmental and resource costs. This would greatly help to set environmental objectives and design a program of measures that are more effective in terms of costs and environmental benefits. Economic and market based incentives are generally absent in the basin, yet could be a powerful tool to encourage the efficient use of water and ensure an equitable distribution of environmental costs and benefits.

The Water Framework Directive now being implemented in Europe has a number of features relevant to water managers in the United States. For the state of California, long at the forefront in addressing environmental concerns such as air pollution and controlling greenhouse gas emissions, there is growing interest in creating a statewide watershed program. Many facets of the proposed statewide program mirror aspects of the WFD, most notably the central tenet of managing water resources based on natural boundaries rather than jurisdictional ones. As the statewide watershed program gains traction because of constraints on diversions to protect endangered species and because of greater water scarcity due to climate change, policy makers could take many lessons from both the successes and challenges of the implementation of the WFD in Europe.

The analyses presented highlight three critical elements to be addressed in the Russian River as first steps towards achieving sustainable water management that would be part of the WFD implementation process. These are: (1) establishing administrative arrangements which could ensure coherent, integrated and participatory basin-scale water management, (2) creating a unified ecological classification system for all waters and (3) instituting an iterative decision-making process by which economic and environmental management measures could be developed and evaluated.

5.0 Conclusions

The current institutional framework of water management in California contributes to a highly fragmented, piece-meal approach to water management. Jurisdictional precincts do not coincide with relevant geographic boundaries and agency mandates are narrowly defined and often conflicting. The WFD model proposes a highly integrated governance system to manage water resources at the basin scale and directly addresses the need to coordinate various water and land management activities in order to achieve environmental objectives.

The Endangered Species Act has been an important catalyst in the US for increasing water allocations for species preservation and curtailing environmentally-damaging land and water use practices. However, the focus on the ESA on the life cycle and habitat requirements of single species has lead to highly uneven protections of US waters as well as narrowly-defined objectives for restoring environmental conditions. In contrast, the WFD approaches aquatic environment with a larger, more systemic perspective that considers multiple biological community elements and applies to all waters, regardless of condition or beneficial use. Whether the WFD approach will achieve environmental objectives in Europe remains to be seen. But it provides an instructive contrast to the ESA-driven approach common in the US.

The attempt at full-cost recovery for water services under the WFD is probably its most controversial and potentially revolutionary concept of the legislation. Not only must economic analyses be performed in evaluating proposed projects and measures, the WFD also requires that all existing water services be evaluated in terms of their financial and environmental costs and degree to which those costs are recovered. This scope of analysis required, coupled with obligations for transparency in decision-making, goes far beyond what is currently required in the US for assessing environmental and economic impacts associated with water management practices. The WFD goes even further in requiring that the cost-effectiveness of proposed conservation and restoration measures also be evaluated. Given the limited financial resources available for environmental restoration, measuring the benefits and costs of various measures should be a necessary action, yet is often absent in the US.

It is clear the WFD is not a "silver bullet" that provides simple solutions to challenging problems. However, as the Russian River case study illustrates, the WFD can provide a useful framework for building the capacity of communities to conduct long-term planning at the basin scale and manage water resources in a more deliberate and efficient manner. By redefining the role of agencies and the public to integrate segregated roles and functions into a participatory decision-making process, the WFD approach suggests ways to improve water management practices in other countries of the world. In California, the opportunity is ripe to bring needed reform to an institutional and legal framework unable to address the causes of environmental deterioration and balance the needs of diverse, and often competing, water uses. The process of water management reform will doubtless be a challenging and politically intensive process, yet the successes and difficulties in implementing Europe's Water Framework Directive could provide valuable lessons for bringing about such change.

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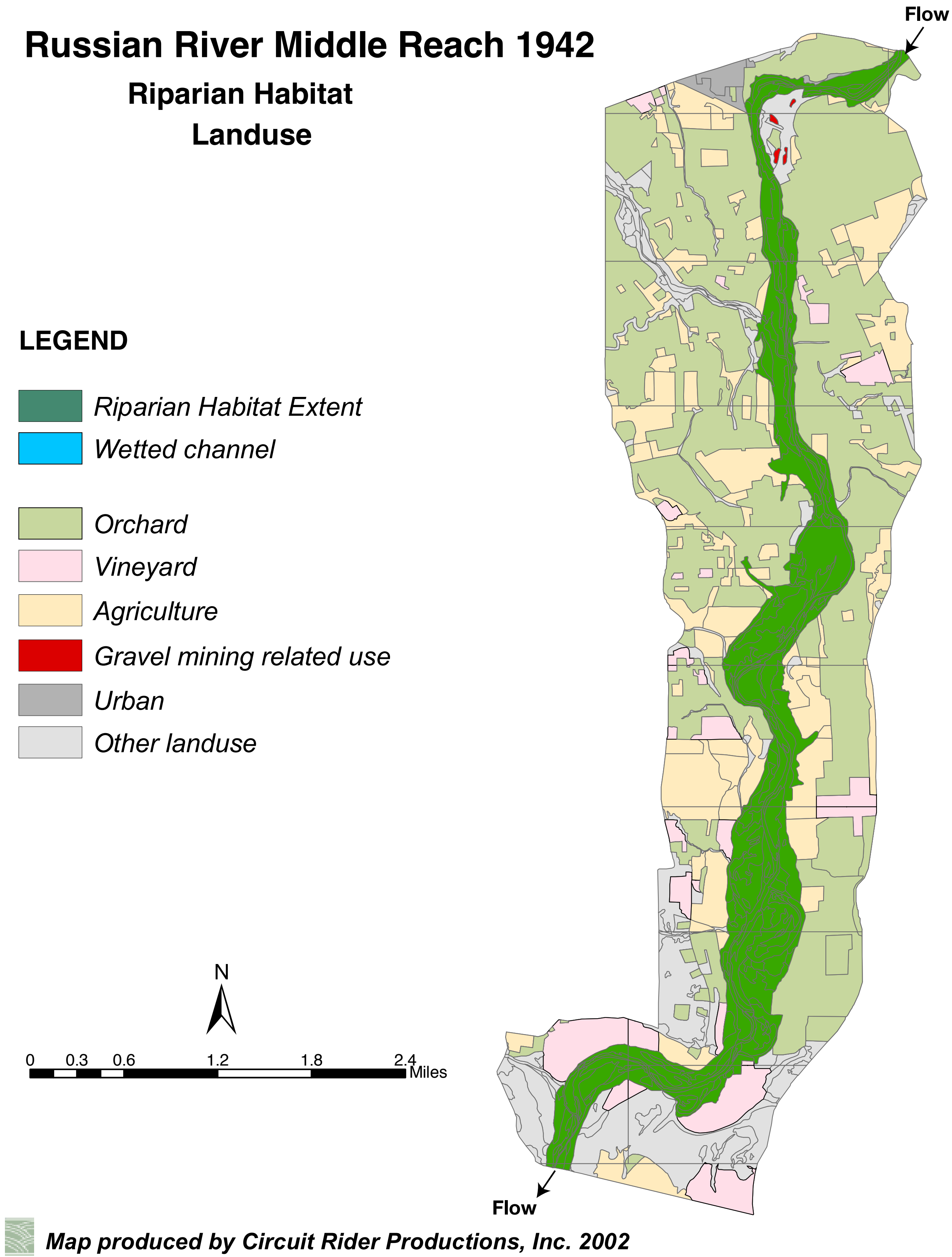
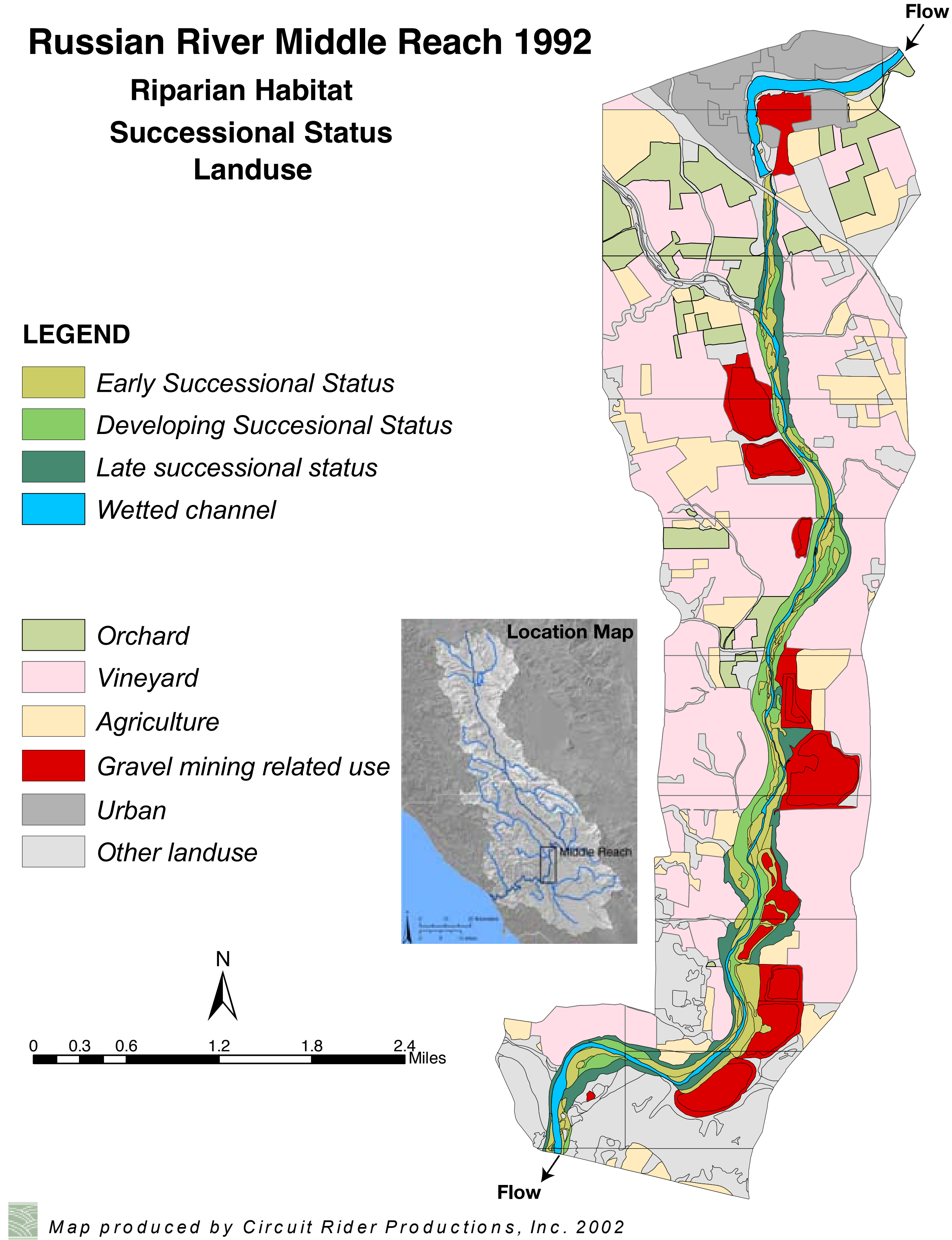
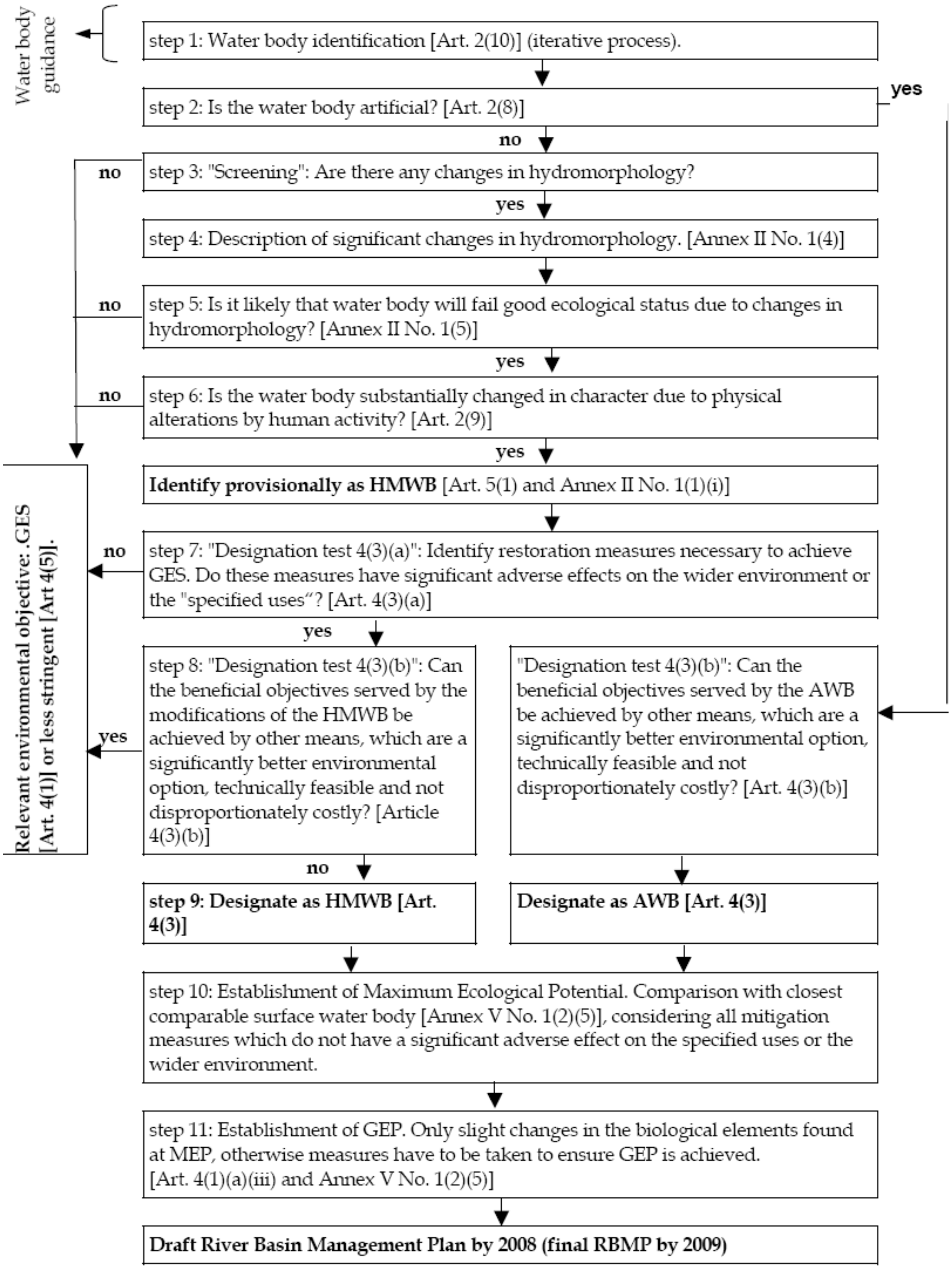
Appendix A


Russian River Middle Reach 1942
Riparian Habitat
Landuse
LEGEND
Riparian Habitat Extent
Wetted channel
Orchard
Vineyard
Agriculture
Gravel mining related use
Urban
Other landuse
N
0
0.3
0.6
1.2
1.8
2.4
Miles
Flow
Flow
Map produced by Circuit Rider Productions, Inc. 2002

Appendix A (continued)



Appendix B —
Heavily Modified Water Body Designation Process



Appendix C — Development of Housing in the City of Santa Rosa

City of Santa Rosa Total Housing Units

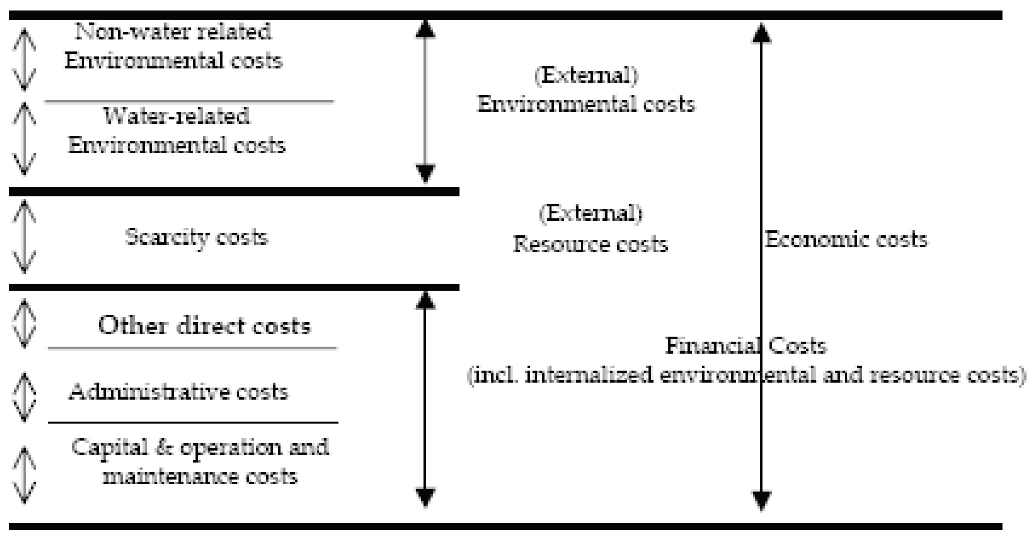
Year	Single-family units	Multiple-family units	Mobile Homes	Total housing units	Annual percent change
1990	31,753	13,458	2,500	47,711	n/a
1991	32,324	13,733	2,500	48,557	1.8%
1992	33,124	14,180	2,500	49,804	2.6%
1993	33,807	14,534	2,504	50,845	2.1%
1994	34,261	14,550	2,536	51,347	1.0%
1995	34,917	14,640	2,536	52,093	1.5%
1996	35,597	14,757	2,544	52,898	1.5%
1997	36,172	14,841	2,545	53,558	1.2%
1998	37,692	15,619	2,546	55,857	4.3%
1999	38,479	15,631	2,621	56,731	1.6%
2000	39,775	15,134	2,669	57,578	1.5%
2001	40,382	15,242	2,673	58,297	1.2%
2002	41,236	15,482	2,680	59,398	1.9%
2003	42,052	15,824	2,682	60,558	2.0%
2004	42,417	16,028	2,685	61,130	0.9%
2005	42,790	16,102	2,694	61,586	0.7%

Source: California Department of Finance, Demographic Research Unit

Source: Sonoma County 2006, Economic and Demographic Profile, Presented by Sonoma County Economic Development Board in partnership with the Sonoma County Workforce Investment Board

Appendix D — Different Types of Costs of Water Services

Box 1 – What are the different types of costs mentioned in the Directive?



Source: Rogers *et al.* (1997)

Source: Common Implementation Strategy for the Water Framework Directive (2000/60/EC); WFD CIS Guidance Document No. 1: Economics and the Environment – The Implementation Challenge of the Water Framework Directive; European Commission 2003

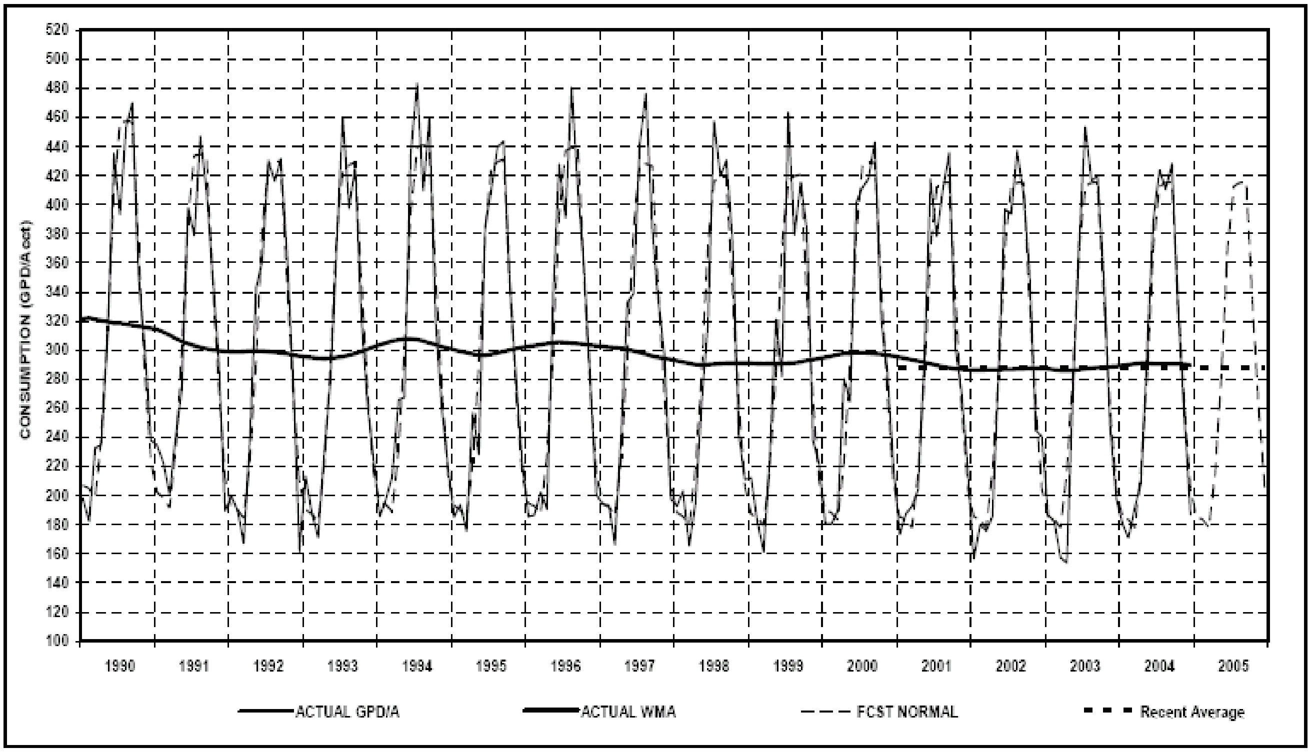
Appendix E — Public Water Prices in the City of Santa Rosa

Monthly Fixed Charge		
Meter Size	**Water**	**Wastewater**
5/8"	$6.03	$13.97
1"	$10.97	$31.11
1.5"	$20.98	$66.39
2"	$35.26	$115.66
3"	$82.46	$256.60
4"	$140.28	$453.85
6"	$307.10	$1,017.50
Quantity Charge Per Thousand Gallons	$3.43	$8.56

Tier Allocation	**Use Charge ($ Per Thousand Gallons)**
Tier 1 Your “cap plus up to 8,000 gallons	$3.22
Tier 2 All water use above Tier 1, up to 30,000 above the cap	$4.02
Tier 3 All water use above tiers 1 and 2	$6.03

Source: City of Santa Rosa Residential and Water and Wastewater Rates (2007).

Appendix F —
Water Supply for Single family Residents in the City of Santa Rosa



Source: City of Santa Rosa, 2005 Urban Water Management Plan, May 30, 2006