Section 1 Introduction

1.1 Project Description

This report describes the development of a customized robust methodology for estimating environmental water demands under varying climatic/hydrologic and water management strategies. This methodology forms the foundation of an environmental water plan as a part of the Butte County Integrated Water Resources Program. The Program is intended to improve water management in the County and to maintain agricultural viability, meet urban and environmental needs, and ensure a future groundwater supply to overlying users, enhance the economy, and protect the citizens and natural resources of Butte County. Figure 1-1 shows the general location of Butte County in California.

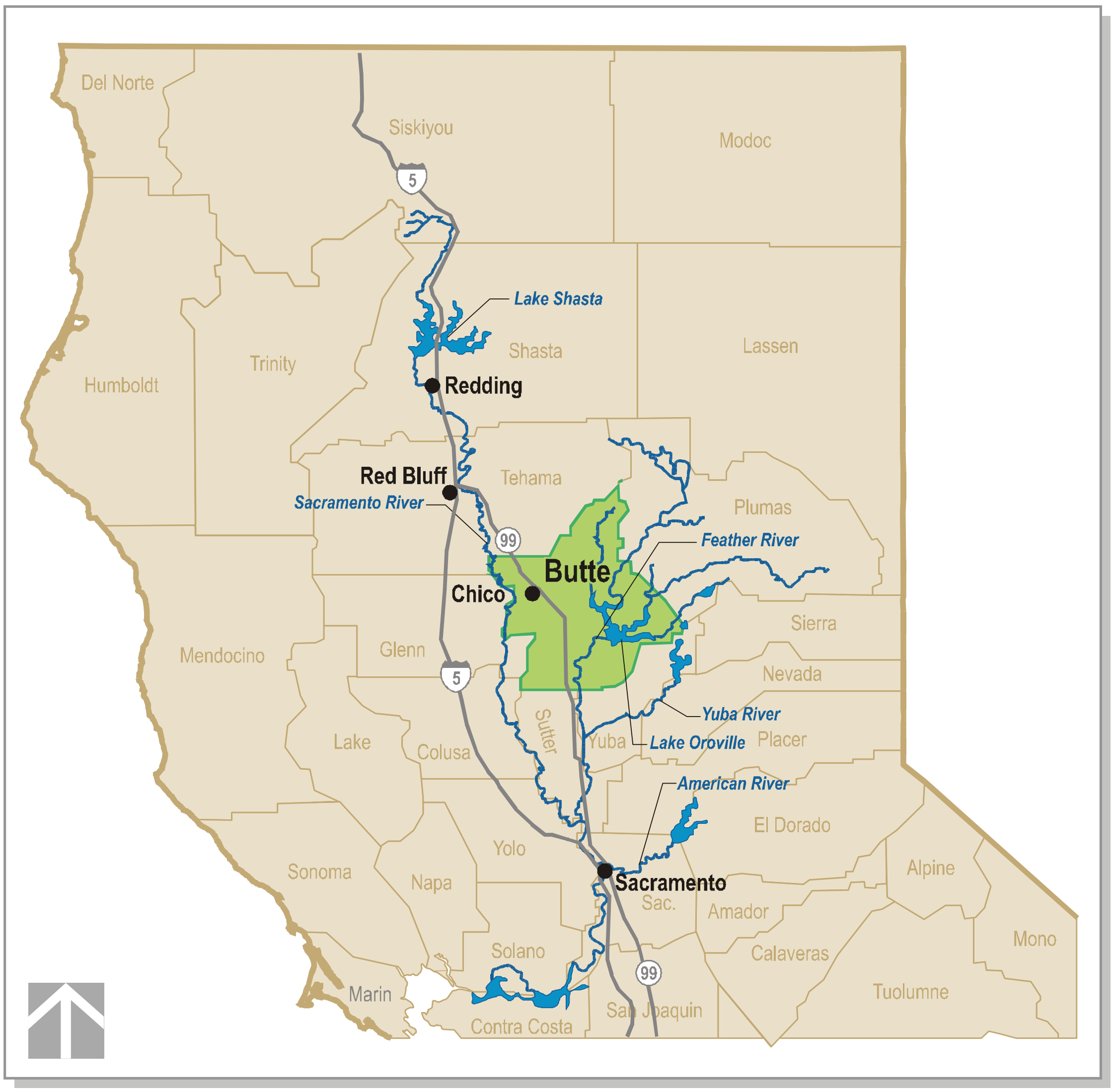


Figure 1-1
Butte County Vicinity Map

As part of the Integrated Water Resources Program, Butte County will develop:

- Basin Management Objectives
- Water Demand Forecasts
- An Environmental Monitoring Plan
- A Drought Preparedness Plan
- An AB 3030 Groundwater Management Plan
- An Integrated Watershed and Resource Conservation Plan
- An Updated Conservation Element of the County General Plan

Butte County seeks to develop these plan elements through an inclusive process that informs, educates, and involves local stakeholders.

1.2 Project Context

The Department of Water and Resource Conservation is developing an Integrated Water Resources Plan (Plan) that will recommend actions for consideration by the Butte County Water Commission and Board of Supervisors. Development of the Plan focuses on policies that lead to a long-term sustainable supply of water to meet future needs for all sectors of water users. To facilitate water resource planning, it is necessary to understand the magnitude and location of environmental water needs in the county. Figure 1-2 is a hydrologic map of Butte County.

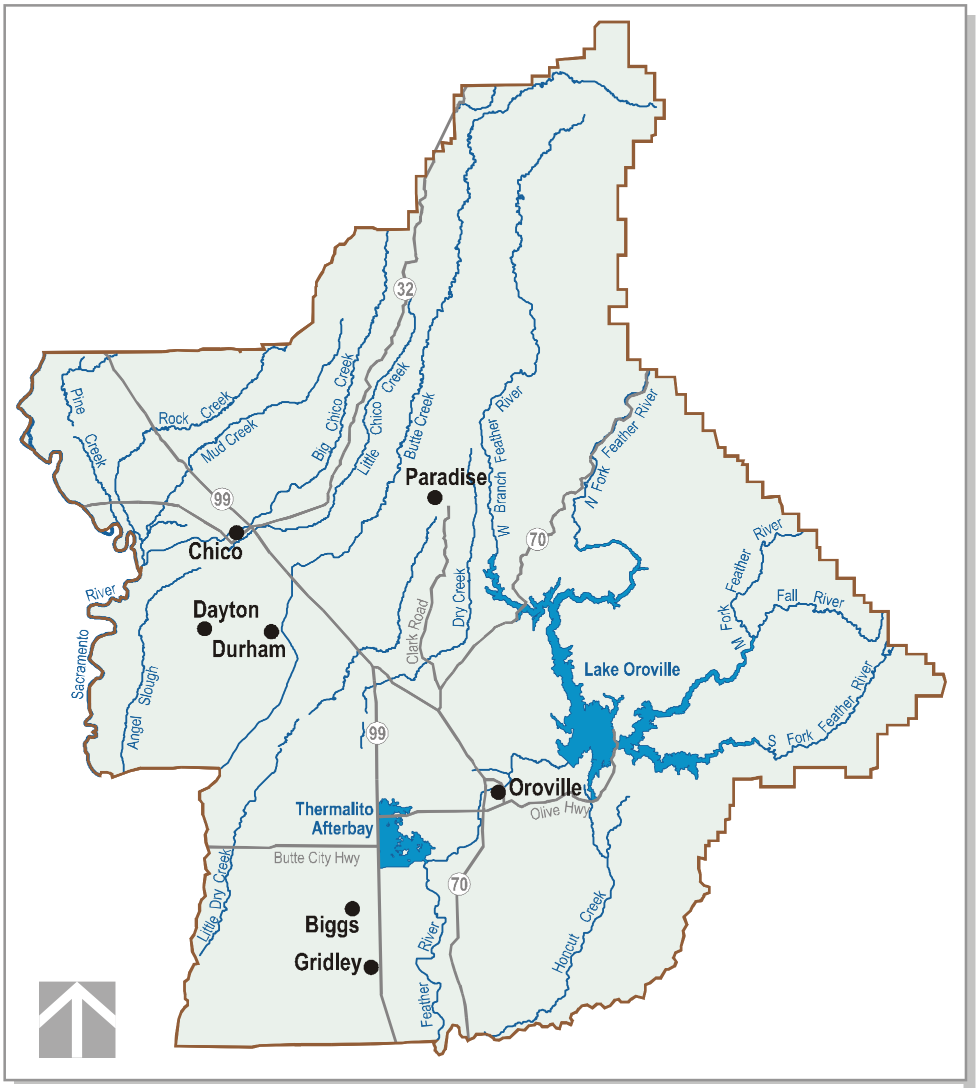


Figure 1-2
Butte County Hydrology Map

1.3 Purpose and Scope

The purpose of the project described in this report is to design a long-term monitoring program that can be used to 1) estimate the water demand of natural ecosystems in the County; and 2) monitor the health of terrestrial and aquatic habitats under changing water and land-use. Data obtained from the monitoring program will facilitate ecosystem management at the County-level through implementation of the Plan.

1.4 Previous Studies

There are very few studies that have attempted to estimate overall environmental water demand for terrestrial or aquatic ecosystems at the scale of Butte County. At most, individual components of terrestrial or aquatic systems have been addressed.

The environmental water demand of Chinese lakes was estimated by Jing-ling and Zhi-feng (2002). Incorporation of water consumption by terrestrial and wetland vegetation produced a water demand estimate that was approximately seven times greater than that of the lake itself. There is an extensive research base for evapotranspiration (ET) estimation and a growing number of studies concerned with estimation of instream (aquatic) flow demand. However, studies and models for integrated environmental water demand analysis have yet to be published in scientific or web-based literature. Thus, the methodology developed here appears to be a completely new contribution.

1.5 Document Overview

This report describes methods for delineating the habitat types in Butte County (Section 2); approaches for estimating the instream flow requirements of creeks (Section 3); and a methodology for estimating the current conditions of native terrestrial vegetation (Section 4). Concurrent environmental water planning efforts are described in Section 5. Proposed methods for estimating environmental water demands are presented in Section 6, and the proposed long-term monitoring program is presented in Section 7. The Project Report concludes with an implementation plan for the environmental monitoring program (Section 8).

Section 2
Assessment of Current Habitats in Butte County [Sub-task 1]

2.1 Classification Systems

A variety of protocols exist to categorize ecosystems function/condition as defined by community composition, ecosystem productivity and spatial extent. Classification systems developed by state agencies, The Nature Conservancy, U.S. Fish and Wildlife Service, and various academic sources were reviewed.

2.1.1 Natural Community/Ecological Site Classification

This approach was developed by The Nature Conservancy (TNC), NatureServe, and state natural heritage programs. Community classification groups species by plant community types (associations) co-occurring within landscapes with similar ecological processes, substrates, and/or environmental gradients. Natural communities constitute meso-scale classification units to be used for resource management and conservation planning. Classification units are defined by physiognomic and floristic characteristics and descriptions available nationally; state-level modifications.

2.1.2 GAP-derived Habitat (Gap Analysis Program)

"Gap Analysis" was developed for national use by the US Geological Survey Biological Resources Division. This GIS-based approach evaluates the management status of plant communities, vertebrate species and vertebrate species richness using GIS overlays of species distribution data and maps of existing biological reserves. The spatial detail of these overlays is relatively low (e.g., 1:100,000 map scale) making them more suited to larger regional planning. The GAP-analysis approach provides a broad overview of the distribution of species and their management status, and can be used to identify landscapes that contain large numbers of potentially unprotected vegetation types and vertebrate species. This facilitates more detailed analysis of management and conservation efforts to fill gaps in the reserve network.

2.1.3 Ecoregions

Developed by the U.S. Forest Service (Bailey, 1995), the ecoregion system is a hierarchical system of progressively smaller areas of increasingly uniform ecological potentials. Climatic factors of moisture and temperature are assumed to be the main abiotic factors controlling the distribution of ecosystems. Smaller subregions are defined by land form, relief, geology, and soils. The purpose for ecoregion planning is to implement ecosystem management with an understanding of inherent ecological patterns.

2.1.4 National Vegetation Classification

The overall objective of the National Vegetation Classification Standard (NVCS) is to support the use of a consistent national vegetation classification to produce uniform statistics in vegetation resources from vegetation cover data at the national level. Derived from TNC methods (see 2.1.1 above), the NVCS has been developed by the National Park Service and National Biological Survey. This system considers existing vegetation, combines physiognomic and floristic approaches to classification, and considers the role of environmental factors. The NVCS is currently being implemented through state natural heritage programs. Aquatic vegetation classification elements are still under development.

2.1.5 California State-specific Systems

Ecosystem classification efforts in California to date have implanted one of the approaches listed above, or employed combinations of these systems. Many of these projects have focused on state-level analysis for assessment of the status of biodiversity conditions. The availability and scale of geospatial data is another potential limitation.

2.1.5.1 California Wildlife Habitat Relationships

The California Wildlife Habitat Relationships (CWHR) System is functionally an information system for managing California's wildlife (Mayer and Laudenslayer, 1988). CWHR contains life history, management, and habitat relationships information on 675 species of amphibians, reptiles, birds, and mammals known to occur in the state. There are currently 59 wildlife habitats in the CWHR System, including habitats based on 27 trees, 12 shrubs, 6 herbaceous plants, 4 aquatic conditions, 8 agricultural settings, 1 developed habitat, and 1 non-vegetated condition.

2.1.5.2 California Vegetation Classification and Mapping Program

The primary purpose of the California Natural Diversity Database classification was developed to assist in the location and determinations of significance and rarity of various vegetation types. As was noted earlier, this classification system is limited to vegetation, and thus doesn't provide a broader basis for ecosystem monitoring.

2.1.5.3 California Gap Analysis Project

The California Gap Analysis Project (CA-GAP) was conducted during the 1990s as a joint effort of the U.S. Fish and Wildlife Service and researchers at the University of California, Santa Barbara. The objectives of the project were to 1) develop new geographic information system (GIS) databases of land-cover, wildlife habitats, predicted distributions of native wildlife species, and land stewardship and management; 2) identify land-cover types and wildlife species that are inadequately represented in existing biodiversity management areas (i.e., the "gaps"); and 3) make all CA-GAP information available to users to encourage and facilitate its use so that resource managers may be more effective stewards of California's biological heritage (UCSB, 2002).

2.1.5.4 Sacramento River Conservation Area (SB 1086)

Limited in geographic scope, the Sacramento River Conservation Area was formed with passage of SB 1086 in 1986. The SB 1086 process originally focused on developing land and resource management plans for the Sacramento River and it tributaries. Through that planning process, a number of riparian habitat types (willow scrub, mixed riparian forest, etc.) were identified. These are generally confined to the riparian zone and floodplain of the Sacramento River.

2.1.6 Candidate Protocol

The classification systems described above were reviewed for their applicability to Butte County habitat conditions. One of the major limitations of the established classification systems is the large regional and hierarchical scales of their implementation to date. Successful classification depends heavily on local field data, and these data are generally incomplete. Thus, the non-local (federal and TNC) approaches are not feasible for implementation in Butte County at the present time. The classification systems developed in California appear to be the most practical for immediate application. Of these systems, the proposed candidate classification system is the California Wildlife Habitat Relationships (CWHR) System protocol developed by the California State Department of Fish and Game and implemented by the Department of Forestry and Fire Protection. This selection was made after review of the local implementation and consultation with local ecologists and wildlife biologists. Of particular importance was CWHR's inclusion of agricultural and general urban conditions to support analysis of mixed developed-natural ecosystems.

It should be noted that the existing vegetation classification for Butte County is almost entirely based on remote sensing and air photo interpretation. Current maps show many errors due to inadequate ground-truthing (field verification). We have reviewed existing sources of remotely sensed data, including NASA and SPOT imagery. We have initially selected 30-m resolution Thematic Mapper (TM) images for ecosystem monitoring and estimation of environmental water demand. The 30-m spatial scale was selected based on our ability to utilize it in distinguish between differing land-cover types with the added advantage of averaging small spatial scale anomalies into more homogenous landscape views. Additionally, these TM 30-m images will provide the most cost effective analysis on county scale assessments. In the long-term, based on quantitative ground-truthed data and modeling effort, it may become necessary to obtain data at finer scales of spatial and temporal resolution to achieve the desired resource and conservation management strategies.

2.2 Habitat Categories

For the purposes of this project the following broad habitat categories were identified:

1. Instream aquatic habitat in rivers, creeks, and sloughs

2. Riparian zones along rivers, creeks, and sloughs

3. Managed wetlands
4. Upland wetlands including vernal pools and springs
5. Upland terrestrial vegetation
6. Lake and reservoir aquatic habitat
7. Lacustrine (lake shore environment) habitat

The spatial extent of specific lacustrine habitat is unknown based on existing vegetation mapping for Butte County. Lacustrine habitat is likely to be somewhat limited given the relatively small amount of land surface covered by lakes. Also, many of the lakes that occur locally are artificial, such as Lake Oroville. Reservoir operation causes dynamically changing water levels that will affect the duration of lake influences on terrestrial vegetation. Also, steep slopes adjoining gradients may limit the extent of lake influences on lacustrine soil water and groundwater conditions in the near-shore area. Field surveys are needed to verify existing lacustrine habitat and its spatial extent in Butte County.

Section 3
Evaluation of In-stream Flow Requirement Estimation Approaches [Sub-task 2]

3.1 Streamflow Monitoring Within Butte County

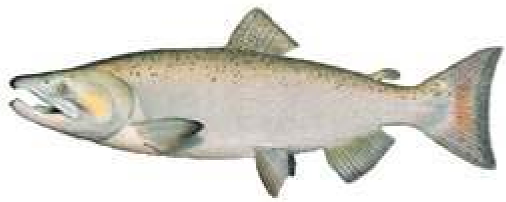
Surface flow monitoring is maintained primarily by the California Department of Water Resources (DWR). There is currently only one active U.S. Geological Survey (USGS) gaging station in Butte County on Butte Creek near Chico (Station number 11390000). Of the data collected, stage and volumetric flow data are useful for monitoring and modeling water availability for environmental demands. Twelve real-time gaging stations are currently accessible through the California Data Exchange Center (CDEC) via the world-wide web (http://cdec.water.ca.gov). The Northern District Office of DWR also maintains 38 stream gages that supply daily stage and flow data throughout the County. However, data from these gages are collected monthly and only available through individual data requests. A listing of all reported USGS and DWR gages is presented in Appendix A. Additional information about selected Butte County gaging locations can be found at the Dreamflows website (http://www.dreamflows.com). Butte County stations listed at Dreamflows include: Butte Creek, the North Fork Feather River, Middle Fork Feather River, East Branch of the North Fork Feather River, and the Sacramento River.

In general, gaging data is unevenly distributed within Butte County. The most extensive gaging network occurs along Butte Creek due to extensive efforts to restore and manage spring run Chinook salmon *(Oncorhynchus tshawytscha)*, a federally listed endangered species. Several gages are clustered in the vicinity of Chico, both upstream and downstream of the urban area. Butte Creek has two major tributaries: Little Chico Creek and the Cherokee Canal. Both of these channels have a single DWR gage on the valley floor. Smaller tributaries in the northern part of the County such as Pine Creek and Rock Creek lack gages entirely. In general, all of the smaller creeks on the valley floor creeks are intermittently dry over significant reaches and flow only during the winter months. Seepage from irrigated agricultural area contributes to limited summer flows in the lowermost reaches of these smaller creeks, including Little Chico Creek, Cherokee Canal, and Pine Creek. Within Butte County, the only three perennial channels that flow year-round over their entire course are Big Chico Creek, Butte Creek, and the Feather River.

3.2 Biological Background

3.2.1 Aquatic Resources of Butte County

Butte County should be considered ecologically wealthy in terms of its aquatic resources, as there is an abundance of naturally diverse aquatic capital within the county. The streams and rivers of this region are home to a large number of aquatic organisms that are found in very few other places around the state. We have two federally listed endangered species, spring run Chinook salmon *(Oncorhynchus* *tshawytscha)* and Central Valley ESU steelhead (Oncorhynchus mykiss). In addition we have at least five aquatic species that are listed as California Species of Special Concern (river lamprey *Lampetra ayersi*, green sturgeon *Acipenser medirostris*, hardhead *Mylopharodon conocephalus*, foothill yellow-legged frogs *Rana boyleii*, and western pond turtle *Clemmys marmorata*). As such, any future water development plans need to begin within this sensitive ecological context.



(a)

(b)

Figure 3-1.
(a) Chinook salmon *(Oncorhynchus tshawytscha)*; (b) western pond turtle *Clemmys marmorata*)

An additional aspect of the natural aquatic capital in the county is the wide diversity of stream habitats including temporary or seasonal tributaries. Recent work has suggested the importance of connectivity between temporary and more permanent stream habitat for aquatic organisms (Fausch et al. 2002). The importance of across-landscape connectivity also suggests the need to manage and plan future water development at scales larger than that of single streams.

3.2.2 Stream Health

Biodiversity is being rapidly lost from aquatic environments around the world, more so than in terrestrial systems (Moyle et al. 1998). Many streams in the western U.S. have been substantially altered due to dams, diversions and development. The importance of quantity, quality and timing of instream flows has been long recognized (Moyle et al. 1998), but solid measures of integrated fisheries-level stream health have not been fully developed. Yet, in a landmark 1996 legal case in Yolo County CA regarding water rights and stream health the following three-level framework for healthy fish communities within streams was successfully defended in court (Moyle et al. 1998).

A stream considered healthy and in good condition must meet all the criteria at each of the three levels.

Individual level: Fish in a healthy stream should have a robust body conformation, should be relatively free of diseases/parasites/lesions, should have reasonable growth rates for the region and should respond appropriately to stimuli.

Population level: Each fish species present should have multiple age classes (evidence of reproduction), extensive habitat should be available for all age classes and life history stages, and there should be a broad enough distribution of all age classes and life history stages to sustain the species in the creek indefinitely.

Community level: The fish community is dominated by co-evolved species (not exotic species), has predictable structure as indicated by limited niche overlap among species, is resilient in recovery from extreme events (droughts etc.), is persistent in species membership through time and the community is replicated geographically.

Planning for future water development must allow fish taxa (and other aquatic organisms) to meet or exceed these criteria for healthy streams throughout the entire County. In addition, all future water planning should attempt to meet these criteria over both short (1-10 year) and long (10-100 year) time scales in order to fully protect the native aquatic organisms.

3.3 Water Management and Planning

There are two major approaches in planning for instream flow recommendations. The first is an intensive field and computer based simulation of stream flow models called the Instream Flow Incremental Methodology (IFIM). This method calculates potential aquatic habitat based on physical transects in the stream and relates this information to fish requirements. Typically this method has two parts, a Physical Habitat Simulation component (PHABSIM) and a species specific Habitat Suitability Index (HSI) component.

PHABSIM uses hydrologic and geomorphological transect and survey data for targeted stream reaches to forecast the amount of physical habitat available (termed wetted usable area or WUA) at various stream discharge levels. The WUA is then weighted by Habitat Suitability Indices (HSI) or suitability curves representing the physical habitat needs of a particular target species. The WUA is calculated at various discharges to show the incremental change in habitat with changes in discharge.

The IFIM methodology has some major drawbacks and has increasingly come under fire from aquatic ecologists and fisheries biologists (Mathur et al. 1985, Williams 1996, Castleberry et al. 1996). Its primary problems are the following:

1. It is labor intensive, time consuming and very expensive.

2. The outcome of IFIM (WUA at varying discharge levels) depends greatly on the particular choice of stream reach surveyed (Williams 1996).

3. IFIM is targeted for individual game species management (generally bass and trout) and ignores native non-game species (i.e. hardhead or lampreys), non-fish species (yellow-legged frogs and western pond turtles) and all community-level ecological interactions (Castleberry et al. 1996).

4. The method implicitly suggests that fish population numbers respond only to substrate type and discharge, which is categorically untrue, as fish respond to a suite of both biological (food and predator abundance) and abiotic factors (Castleberry et al. 1996).

5. The method has been shown not to work very well, as there is very little evidence for a positive relationship between WUA and increased fish biomass (Mathur et al 1985).

6. The entire IFIM process is site specific and depends on selecting 'representative stream sections' across heterogeneous landscapes. The selection process is therefore fraught with potential bias (Williams 1996).

7. As a result of #6 above, in order to generate accurate predictions the entire IFIM process has to be repeated for each stream under scrutiny (Williams 1996).

8. IFIM does not lend itself to seasonal and temporary streams systems nor does it account for the inherent connectivity and importance of seasonal habitat to overall stream health.

A second method for instream flow planning involves employing the principles of adaptive management. Adaptive management originated from the field of ecological management and inherently recognizes that temporal and spatial scales are important and that ecosystems are dynamic and changing. Adaptive management tries to recognize that our current knowledge of ecological systems is incomplete and therefore provisional. Under this scheme, management goals are seen as hypotheses to be tested and refined, rather than proscriptive and inflexible. The three general ideas behind an adaptive management strategy are:

1. Develop a long term planning strategy (10-50 years) rather than a specific short-term plan.

2. Explicitly recognize the inherent fluctuating nature of ecological systems and build uncertainty into the overall management framework.

3. Use knowledge from early stages in the management process to refine targets and management goals at later stages in the management process.

Adaptive management as applied to water resource planning can be accomplished in a number of general formats. A team of professionals and experts (plant ecologists, ichthyologists, hydrologists, geographers etc.) can join together, examine the current resources and make flexible, long-term planning recommendations based on current available data and best professional opinion. A more flexible management approach has been used successfully in adaptive management proposals for Northern Spotted Owls *(Strix occidentalis)*, where the adopted recovery and management plans are adaptive in nature rather than proscriptive.

A second approach using an adaptive management framework for water planning would be to hire one or two permanent 'stream keepers' for the region under scrutiny. In Butte County there are annual, seasonal and daily variations in the biological conditions of aquatic resources. The stream-keeper job would be to do real-time monitoring of the aquatic resources across the county. This would potentially include salmon spawning and redd counts, salmon out-migration surveys, native non-game fish spawning and population surveys, sensitive amphibian population surveys as well as monitoring of stream discharge and infiltration rates. The stream-keepers would then make real-time stream flow recommendations based on accurate knowledge of the stream conditions in the particular streams of interest. This model allows more ecologically and environmentally based management and planning decisions. This adaptive management strategy has been applied successfully in water planning situations in Putah Creek (Yolo Co.CA) and as well as in multiple regions in Europe.

3.4 Recommended Approach

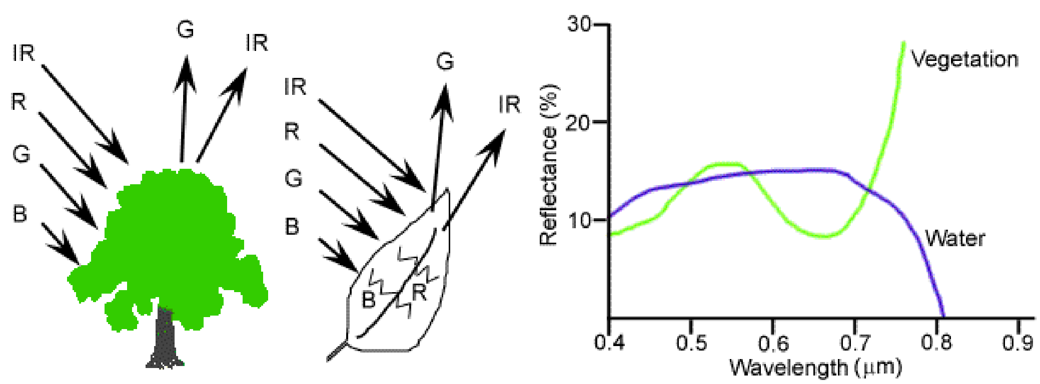
In order to maintain the county's aquatic biodiversity and allow its fish assemblages to thrive at all three levels of stream health (individual, population and community) in perpetuity, planning for future water development must begin now. We would strongly recommend embracing an adaptive management approach as a general management strategy for a number of reasons. Annual rainfall in our California Mediterranean climate is defined by its variability rather than its constancy, meaning that water availability and stream discharge (flow) are inherently fluctuating through time. The distribution and abundance of aquatic organisms in Butte County is likely to change through time with increasing development and urbanization as well as between years with annual changes in surface flow. Finally, Butte County sits in a climatically diverse position, straddling both the Central Valley and the Sierran foothills; an area which is likely to be altered in future global climate changes scenarios.

Future water development planning must take these sources of uncertainty and variability into account, and the best way to accomplish this is by building uncertainty and hypothesis testing into the planning process from the beginning. If the county does not adopt an adaptive management approach at this time, it is likely that water development plans originating now will become obsolete before implementation and may actually endanger the health and welfare of the abundant aquatic resources in the county.

Section 4
Development of a Methodology for Establishing Baseline Conditions [Sub-task 3]

4.1 Native Vegetation

Remote Sensing of vegetation is dependent on the interaction of the plant with incoming solar radiation (light). For any surface that light strikes there are three (3) forms of interaction that can take place when light strikes, or is incident (I) upon the surface: (1)Absorption (A) radiation is absorbed into the target; (2)Transmission (T): radiation passes through a target; (3)Reflection (R): radiation "bounces" off the target and is redirected away from the surface. The proportions of each interaction will depend on the wavelength of the light and the material and condition of the feature. Plants can be distinguished from other terrestrial surfaces by their specific absorption and reflections patterns. Specifically, plants absorb red and blue wavelengths of light and reflect green and infrared wavelengths. This absorption characteristic is dependent upon the physiological status of the plant and may be considered a measure of greenness. Other land based surface exhibit different light absorption and reflectance patterns and can therefore be distinguished from vegetative landcover. To detect the health of plants remote sensors employ ratios of the absorbed and reflected light, these ratio are referred to as vegetative indices (VI's).



The most commonly employed remotely sensed indicator of vegetative status is the normalized vegetative difference index (NDVI). NDVI has been demonstrated to be highly correlated with chlorophyll content of vegetation and the amount of absorbed photosynthetically active radiation by plant canopies. As such NDVI can be used as an input parameter in hydrological models indicative of amount of energy being absorbed by the vegetation, of which a fraction will drive plant canopy transpiration. NDVI is calculated by the following normalized ratio:

$$NDVI = \frac{(IR - R)}{(IR + R)}$$

In this equation IR (near infrared light) represents the reflectance of incoming solar radiation in the range of 0.76 -0.90 µm and R (red light) is the light between 0.63and 0.69 µm in wavelength. This ratio represents the fractional difference due to the absorption of red light by chlorophyll from the total of infrared and red light being reflected from the surface of vegetative structures. NDVI can be used directly or converted into leaf area index (LAI) and inputted to the hydrological model as an indicator of canopy evaporation and transpirational surfaces in the computation of

4.2 Aquatic Macroinvertebrate Reference Conditions in Butte County

Aquatic macroinvertebrate organisms (insects and other taxa) have become an increasingly common element of water quality and aquatic ecosystem monitoring. Collectively, these protocols form the basis for bioassessment. The California Department of Fish and Game (DFG) collects benthic samples and analyzes aquatic macroinvertebrate distribution and abundance for numerous environmental monitoring programs. One current DFG project is the development of a reference collection of aquatic macroinvertebrates from the Sierran foothills, including Butte County. From their database, a listing of bioassessment sampling locations is presented on Table 4.1.

Table 4-1
Aquatic Macroinvertebrate Sampling Locations

Sample Event	Waterbody Name	Location	Date
N/A	Butte Creek	Above Centerville	9/25/2001
N/A	Butte Creek	At Powelton	9/13/2001
N/A	Butte Creek	Above Parrott-Phelan Dam	9/26/2001
N/A	Butte Creek	Bellow Bridge	9/22/1995
N/A	Butte Creek	Below Centerville	10/2/2001
N/A	Butte Creek	Below Gorrill Dam	10/4/2001
N/A	Butte Creek	Near Chico	9/21/2001
N/A	Butte Creek	Near Durham	10/2/2001
N/A	Feather River	At Oroville	9/7/2000
N/A	Little Chico Creek	At Magalia	9/13/2001
N/A	Little Butte Creek	Below Honey Run	9/13/2001
N/A	Little Butte Creek	Near mouth	9/14/2001
N/A	Feather River Middle Fork	Near Merrimac	8/9/2000
N/A	Feather River North Fork	At Pulga	8/11/2000
N/A	Feather River South Fork	Above Ponderosa	9/7/2000
2001	Little Dry Creek	~2mi S Paradise	9/7/2001
2002	Live Oak Slough	~0.2 miles North of Meteer Rd.	9/3/2002
2002	Sacramento River	~2mi N Sidds Landing	5/14/2002
2002	Concow Creek	At Jordan Hill Rd.	11/6/2002
2002	Feather River	At Archer Ave.	10/4/2002
2002	Feather River	Upstream from Afterbay Outlet.	10/16/2002
2002	Fall River	Upstream from Feather Falls.	10/17/2002
2002	Feather River	Above Honcut Creek	10/1/2002
2002	Feather River	At Oroville.	10/1/2002
2002	Feather River	At Shanghai Bend Falls.	10/3/2002
2002	Feather River	Downstream from project boundary	10/3/2002
2002	Feather River	Downstream from SCOR Outlet.	10/16/2002
2002	Feather River	Downstream from hatchery.	9/16/2002
2002	Feather River	Downstream from HWY 162.	9/17/2002
2002	Feather River Middle Fork	Near Merrimac.	10/2/2002
2002	Feather River	Near Fish Barrier Dam	11/7/2002
2002	Feather River North Fork	Downstream from the POE pump-house	9/19/2002
2002	Feather River	Near Mile Long Pond.	9/19/2002
2002	Feather River	At Robinson Riffle.	9/18/2002
2002	Feather River South Fork	Above Ponderosa reservor.	10/1/2002
2002	Feather River South Fork	Inundation zone	10/1/2002
2002	Feather River	Upstream from hatchery.	9/16/2002
2002	Glen Creek	Upstream from Glen PD.	10/2/2002
2002	Mile Long Pond	West of Oak Grove	11/7/2002
2002	Sucker Run Creek	near Forbestown	10/1/2002
2002	Feather River West Branch	Upstream from lake Oroville	10/1/2002
October 1993	Philbrook Creek	Jones Resort	10/19/1993

Table 4-1 (Continued)
Aquatic Macroinvertebrate Sampling Locations

Sample Event	Waterbody Name	Location	Date
June 1994	Philbrook Creek	Upstream of discharge	6/4/1994
June 1994	Philbrook Creek	Discharge channel	6/4/1994
June 1994	Philbrook Creek	Downstream of discharge	6/4/1994
Fall 2000	Big Chico Creek	Upper Bidwell Park	10/26/2000
Fall 1997	Big Chico Creek	Forest Ranch	10/8/1997
2002	Big Chico Creek	Hwy 32	10/9/2002
Fall 1997	Butte Creek	Cherry Hill Campground	10/6/1997
Fall 2000	Big Chico Creek	Rose Avenue Bridge	10/24/2000
Fall 1997	Butte Creek	Doe Mill Road	10/6/1997
Fall 2000	Butte Creek	Honey Run Bridge	10/26/2000
Fall 2000	Butte Creek	Rich Bar Road	11/3/2000
2002	Dry Creek	at Dry Creek Road.	10/10/2002
2002	Galen Creek	at Galen Ridge Road.	10/10/2002
2002	Little Chico Creek	at Schott Road.	10/9/2002
2002	Martin Creek	at Galen Ridge Road.	10/10/2002
Fall 2000	Sacramento River	Hamilton	9/26/2000