SWANSON HYDROLOGY + GEOMORPHOLOGY

draft final report

Upper Truckee River
Upper Reach Environmental Assessment

for the Bureau of Reclamation, Tahoe Resource Conservation District, and
Regional Water Quality Control Board - Lahontan Region

(cash match)

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I. Introduction and Problem Statement

The Tahoe Resource Conservation District (TRCD) and the U.S. Bureau of Reclamation (BR) are sponsoring this environmental assessment of the Upper Truckee River-Upper Reach to identify projects that reduce pollution discharged into Lake Tahoe and restore ecosystem function in the river and watershed. This effort is being completed in coordination with the programs of numerous agencies, other organizations and the public to implement environmental improvement projects in the Lake Tahoe Basin and to recover what has been lost to historic development and land use. This document provides the background for the development and assessment of environmental improvement alternatives, their costs benefits and impacts. Based upon the information provided herein and the agency and public planning processes, a set of recommended priority projects (priority list) will be produced for funding and implementation.

The Upper Truckee River (UTR) is the largest, longest water course, draining over 54 square miles in the Lake Tahoe Basin (Figure 1.1). The UTR originates in undeveloped wilderness, ten miles south of Lake Tahoe along the Sierra Nevada crest at Red Lake Peak (elevation 10,063 feet), then flows northward through a spectacular alpine terrain of lakes, meadows, forests and volcanic and granitic bluffs. It cascades down multiple waterfalls into the narrow, glacially-formed Christmas Valley and at that point enters the urban lands of Meyers and South Lake Tahoe. From South Upper Truckee Road crossing to Lake Tahoe, the UTR becomes more affected by roads, houses, bridges and other elements of urban landscape. The River flows over 15 miles through neighborhoods, old quarries, a golf course, an Airport and grazing lands before flowing away from its original delta lagoon system in the Barton Meadow. It then flows into a channelized section past the Tahoe Keys Project before discharging into Lake Tahoe.

The UTR has been identified as a major pollutant source of sediment and nutrients flowing into Lake Tahoe, owing largely to the large drainage area of urbanized land. Nutrients, including bioavailable nitrogen and phosphorous, have been identified as a major contributor to algae growth in Lake Tahoe, which has led to a significant decline in the clarity of the Lake since measurements began in the 1960s. Fine sediment contributes to lake clarity decline, as well as the degradation of aquatic habitat for fish and other wildlife in the UTR.

John C. Fremont was the first Anglo American to view Lake Tahoe (with the UTR in the foreground) from Red Lake Peak in February of 1844 (Figure 1.2). Although historical records do show that the native Washoe (Lindström, 2000) set fire to meadows to favor certain plants for food, baskets and medicine, major changes occurred to the UTR with the introduction of European-style land uses as early as the 1850s. An intensive period of change accompanied the development of the Upper Truckee River as the route to the Comstock Lode mining boom in Nevada of 1860-1890. With this boom, the UTR watershed became a major source of timber and grazing land, as timber harvest, road building and grazing in reclaimed marshes and throughout the watershed forever changed the landscape, wildlife and ecosystems in the region.

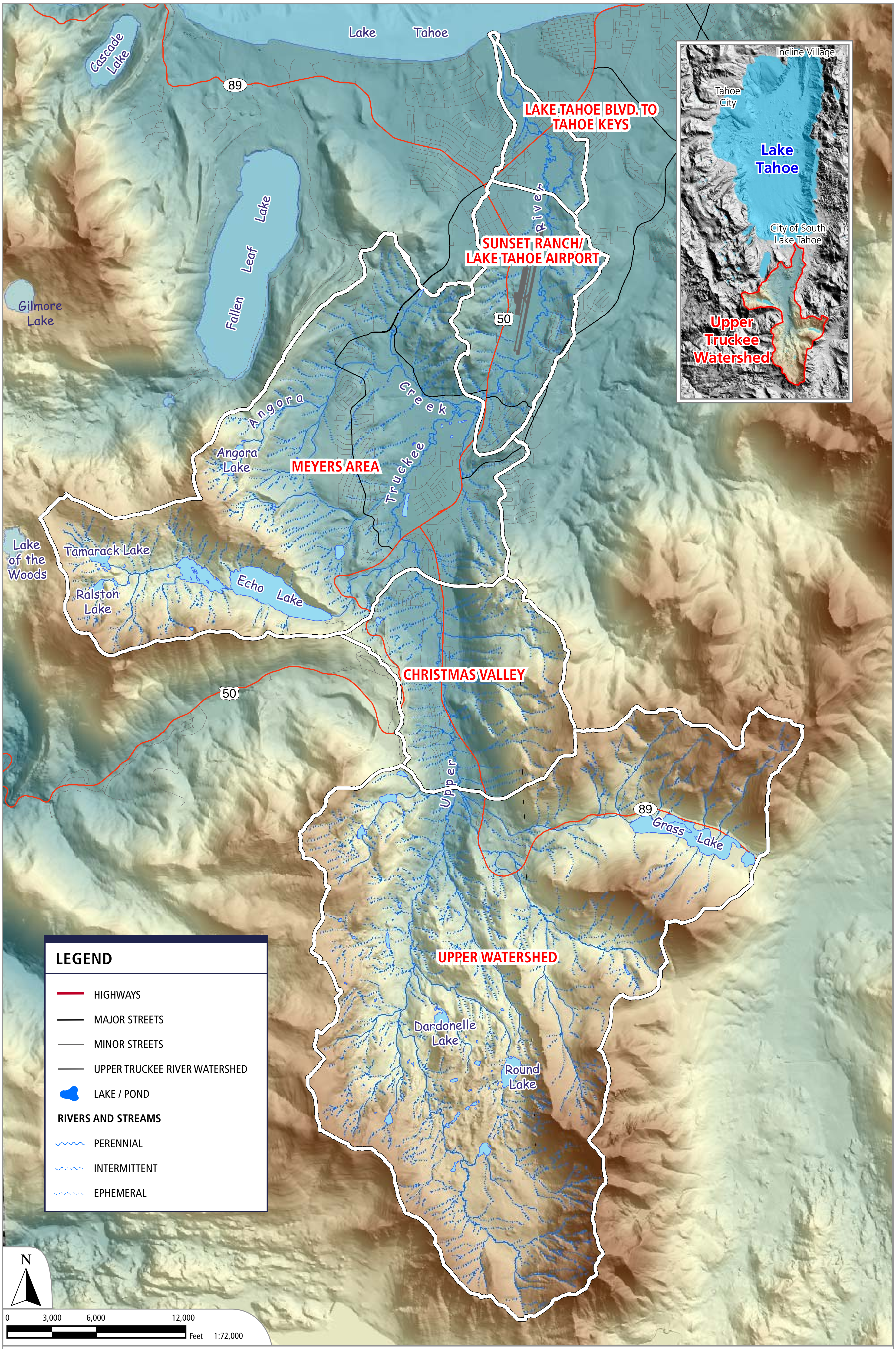

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FIGURE 1.1: Project Location Map.

FIGURE 1.2: Photo of the Upper Truckee River Watershed looking north from above Red Lake Peak.

After a period of relatively little development between 1900 and 1950, an expanding tourism economy began to take hold, including expanded year-round and summer vacation populations. After the winter Olympics of 1960 at Squaw Valley, winter tourism expanded greatly, and Lake Tahoe became a world renowned destination. The UTR was a major focus of this change, as much of the surrounding valley floor, floodplains and meadows were converted to accommodate an airport, golf courses, subdivisions and supporting infrastructure (e.g. bridges, sewer lines, roads). The rapid development of the Basin began to take a toll on the environmental quality of the Lake, and in recognizing the need for control, the bi-state Tahoe Regional Planning Agency (TRPA) was formed in 1968. Immediate measures were set in place to minimize the effects of development, beginning with the export of all wastewater out of the basin in 1974, part of which flows through a major export line along the UTR southward over Luther Pass (Highway 89).

The dramatic environmental changes that have occurred over the past 150 years resulted in obvious physical changes to the UTR and its watershed: channels were straightened, natural floodplains were filled for roads, bridges and buildings, marshes were converted to grazing meadows and golf courses, etc. In addition, and perhaps most importantly, there was an underlying change to the natural processes that had formed and sustained the natural ecosystem and held the geologic landscape in equilibrium and relative stability over thousands of years. A primary example was the upset of the delicate hydrologic and geomorphic balance of the UTR, a balance that dictates the dimensions and form of the stream channel and floodplain. This balance was substantially changed by channel straightening which in turn led to the incision or lowering of its streambed, the lowering of the groundwater table, drying of floodplain areas, conversion of riparian vegetation to less erosionally resistant species, and the narrowing of the riparian corridor. Natural geomorphic processes resulting from stream flow, erosion and sediment transport today favor an eroding channel with a far less valuable ecosystem function. It will be necessary to modify the way the river works, as well as its physical form, in order to regain the natural equilibrium and natural stability.

The focus and nature of this assessment is to examine the UTR for opportunities to restore its natural function while addressing the land use and economic factors surrounding land uses to assess how restoration can occur. The condition of the UTR, with regard to ecosystem function and stability, is presently well below its potential. This is the result of a lack of coordination between development of land use and environmental protection of the river corridor and its water quality. This assessment presents an opportunity to examine the overall condition and improve the relationship between the watershed and its land use to the benefit of both. Formulation of environmental restoration measures for the UTR requires that the underlying nature of geomorphic processes be understood and modified in order to obtain the most favorable self sustaining conditions. Although the effects of past land use change cannot be fully undone to “restore” the UTR to historical conditions, the best solutions lie in modifying the river to approach its natural function and allow for adjacent land uses to compatibly exist.

I.1 PROJECT GOALS AND RESEARCH OBJECTIVES

I.1.A Project Goals

Project goals as defined here are desired outcomes of plan implementation. They are the yardsticks by which the success of the proposed restoration action is measured for its benefits, costs and impacts.

The following goals were developed with the policies and activities of multiple agencies, as well as private landowners and other organizations, in mind (a more detailed discussion of each agency's role in the watershed follows). These were presented and approved at agency and public meetings in July and September of 2003.

- Restore ecosystem function to the UTR in terms of riparian vegetation, ecological processes and natural geomorphic processes that sustain channel morphology.
- Reduce erosion and sediment input to pre-disturbance levels to the extent possible.
- Manage for beaver activity in a manner that meets ecosystem and sediment reduction goals and addresses land use impacts.
- Offset pre-1850s impacts to the extent possible, given desires of landowners and agencies; provide a constructive basis for resolution of conflicts.

I.1.B Research Objectives

Research objectives are specific products of the work completed to prepare the assessment and watershed plan. For example, a GIS database of bank erosion along the river was developed to aid spatial examination of erosion problems and development of solutions. The following are the research objectives for this project:

- Develop geomorphic data to estimate pre-disturbance (pre-1850) conditions.
- Develop a sediment source database to determine areas in need of treatment (main channel, tributaries and roads).
- Complete an assessment of channel stability on UTR mainstem.
- Compile existing data and proposed ecosystem restoration and water quality improvement projects in the Upper Reach and assess priorities.
- Develop a master list of recommended projects that can be implemented to meet project goals.

I.1.C Agencies Programs and Policies

Many agencies are involved in a coordinated effort to restore the environmental quality of the UTR, including efforts to restore streams and wetlands and reduce pollutant discharge into Lake Tahoe. Some agencies regulate activities of public and private landowners (e.g. TRPA and Regional Water Quality Control Board (RWQCB-Lahontan)), some provide technical and grant funding assistance (Tahoe Resource Conservation District (TRCD), Natural Resources Conservation Service (NRCS)), while others oversee public land and manage according to their agencies' specific policies (e.g. California Tahoe Conservancy (CTC), U.S. Forest Service (USFS) Lake Tahoe Basin Management Unit (LTBMU) and California Department of Parks and Recreation (CDPR)).

The primary drive for many restoration projects in the UTR originates from the long range Environmental Improvement Program (EIP) that was prepared, and is being implemented, by TRPA and many partners. The EIP identifies the projects necessary to improve the environmental quality of Lake Tahoe to an acceptable and self-sustaining level by meeting specific environmental "thresholds." The EIP includes erosion control, drainage and ecosystem restoration projects that address specific problems in forests, wetlands, streams and watersheds. TRPA requires that each local agency (County, City, transportation agency) develop and implement construction plans to implement the EIP. In the UTR watershed, this includes Caltrans, El Dorado County, El Dorado County Department of Transportation, CDPR and the USFS. The EIPs listed for the UTR project area under this assessment are shown in Table 1.1.

The Lahontan Regional Water Quality Control Board regulates pollution discharge to protect beneficial uses of water in streams, waterways and lakes in the eastern Sierra Nevada region, including the Lake Tahoe Basin. Lahontan is active in funding and overseeing water quality improvement research and planning projects (including a portion of this plan), as well as regulating water quality protection for development and construction activities; this includes permitting for stream restoration projects.

The LTBMU has its own planning direction resulting from the adoption of the Sierra Nevada Forest Plan Amendment (SNFPA), which specifies the return of functional ecosystem processes to lands under their management and the inclusion of the TRPA thresholds into the Forest Plan. This includes specific goals for aquatic ecosystem management and restoration that are aimed at restoring the geomorphic processes essential for habitat development and sustenance. The LTBMU oversees and actively manages many parcels along the Upper Reach study area and in the Upper Watershed lands south of South Upper Truckee Road. Presently the LTBMU is preparing restoration plans for the Big Meadow Creek watershed which drains 4.0 square miles of the Upper Watershed.

The CTC acquires and manages lands for the purpose of conservation, water quality, recreation and wildlife ecosystem restoration. This work includes funding many erosion control and stream restoration projects in the Lake Tahoe Basin. CTC has participated in many projects in the UTR, including restoration of lower Angora Creek with CDPR.

Program	Project Name	Proj #	Start Date	Implement/ Construction	Lead Agency	Description	Total Cost
FISHERIES	BIG MEADOW CREEK - STREAM HABITAT RESTORATION	407		6/1/2009	CTC	PROJECT: Remove the cows from meadow area, reconstruct bridge in order to increase stabilization of banks (not in USFS plan), stabilize head cuts, fly in cobble (USFS,CTC). *This project will not effect the fisheries threshold rating, but it will improve fish habitat condition	$50,000.00
FISHERIES	ANGORA CREEK THROUGH MEADOW - STREAM HABITAT RESTORATION (COMPLETE)	437		6/1/2000	CTC	1.7 miles of channel naturalization and meadow enhancement on lower reach of Angora Creek (CTC, C-parks) (linked to SEZ 949,559).	$433,000.00
FISHERIES	GRASS LAKE CREEK IMPROVEMENTS - STREAM HABITAT RESTORATION	886		10/1/2010	CTC	PROJECT: Facilitate improvement of this resident fisheries stream from good to excellent by stabilizing banks, removing barriers to fish movement and facilitating the exchange of stream diversions with some other source.	$146,000.00
FISHERIES	HABITAT RESTORATION-UPPER TRUCKEE/UPPER SECTION	908		10/1/2011	CTC	PROJECT: In the upper reaches of the Upper Truckee and its tributaries the main habitat improvement need is bank stabilization. Along many of these reaches past grazing practices have caused bank erosion. Hikers on some reaches have current impacts. *With the completion of phases I, II, and III will improve 21.8mi of stream	$852,000.00
FISHERIES	HABITAT RESTORATION-UPPER TRUCKEE/MIDDLE PHASE II	909		10/1/2003	CTC	PROJECT: Middle section includes work along the stream where it parallels Tahoe Paradise Park (Lake Baron) and by the gravel pit. There are some barriers to migration along this section formed by dams, felled trees and beaver dams. Section = 5 miles. *With the completion of phases I, II, and III will improve 21.8 miles of stream	$3,150,000.00
FISHERIES	COOKHOUSE	10132	6/1/2001	6/1/2003	USFS	PROJECT: Construct stream channel, improve habitat, increase streambank stabilization.	$700,000.00
FISHERIES	COOKHOUSE MEADOW	10133	6/1/2001	6/1/2003	USFS	PROJECT: Restore eroding stream banks on Big Meadow Crk., through Cookhouse Meadow. Possibly reconstruct section of channel, install grade control structures or build floodplains within the current incised profile to reconnect the stream with the floodplain.	$160,000.00
SCENIC RESOURCES	MEYERS HWY 50 CENTER LANDSCAPED MEDIAN	140	6/1/2000	6/1/2001	CALTRANS	Install intermittent center landscaped median, curb & gutter planting bed, drainage, turn pockets and stacking spaces on US 50 between Apache/Santa Fe and SR 89. This is Phase I of Roadway Unit #36 improvement project.	$600,000.00
SOIL CONSERVATION/SEZ	RESTORE 40 ACRES OF SEZ - EL DORADO COUNTY	650	1/1/1999	6/24/2000	CTC	If found to be in need, restore 40 acres of SEZ on lands that have been acquired by the public in the subdivided, developed, and disturbed areas within the limits of El Dorado County	$4,850,000.00
SOIL CONSERVATION/SEZ	UPPER TRUCKEE/MEYERS BRIDGE BANK STABILIZATION	937	1/1/2000	6/23/2004	CTC	Stabilize 800 feet of eroding bank with riparian vegetation revetments, floodplain benches, and lateral channel shifts. Alternative approach would be to widen existing floodplain through excavation of terraces.	$4,000,000.00
SOIL CONSERVATION/SEZ	ANGORA CREEK STREAM RE-DIVERSION OFF SEWER LINE AL (COMPLETE)	949		6/22/2001	C-PARKS	Project would re-divert stream back to its original channel. Angora Creek currently runs directly over a sewer line for approx. 900 feet. Restore 2 acres of SEZ, 0.5 acres of meadow habitat improvement, and 0.1 acres of riparian and stream habitat improvements.	$690,000.00
SOIL CONSERVATION/SEZ	UPPER TRUCKEE RIVER BANK STABILIZATION-LAKE VALLEY	950	1/1/2000	6/23/2004	C-PARKS	Implement a range of stabilization treatments along eroding stream banks. Treatments would include riparian plantings, native materials revetment, riprap revetment and retaining walls less than 0.2 acres of SEZ preservation.	$3,000,000.00
SOIL CONSERVATION/SEZ	GEOMORPHIC ANALYSES/MONITORING OF UPPER TRUCKEE	951		6/21/2001	CSLT	Perform comprehensive analyses of fluvial processes to document trends in both treated and untreated areas. Studies will result in initial reports, followed by monitoring and annual updates.	$450,000.00
SOIL CONSERVATION/SEZ	ANGORA CK. SUBDIVISION SEZ RESTORATION	985	6/1/2002	6/22/2002	EL DORADO	Four acres of hydrology and floodplain restoration, and channel stabilization on Angora Creek between Lake Tahoe Blvd. and View Circle. CTC funding included under #650, Restore 40 Acres SEZ in El Dorado County.	$1,215,267.00
WATER QUALITY	MEYERS RESIDENTIAL	191		6/1/2010	EL DORADO	Erosion source controls and stormwater treatment faculties associated with the grantees roadways. Improvements will include revegetation. of disturbed soils; drainage stabilization (e.g. paved gutters, rock lined channels), infiltration and sedimentation facilities (e.g. veg. treatment ponds and various sediment traps), subdivision roads near Meyers School.	$5,900,000.00
WATER QUALITY	UPPER TRUCKEE FOCUSED WATERSHED GROUP	630	1/1/1996	1/1/1996	LWQCB	The Upper Truckee Focused Watershed Group coordinates agency activities occurring or planned in the watershed. A major objective is to complete a Watershed Plan with assistance from the US Army Corps of Engineers. Knowledge gained from this group will be applied to other watersheds in the future. Project costs at this time only include matching funds to the USCOE for preparation of the Project Study Plan (PSP). Other costs include indirect services from agency personnel who participate on the group.	$150,000.00
WATER QUALITY	ANGORA HIGHLANDS/BOULDER MT	705		6/1/2006	EL DORADO	CTC has identified conveyance and treatment needs within Angora Highlands and on Boulder Mt. Drive. Revegetation, curbs, gutters, storm drains, retaining walls and rock slope protection needed. Sediment basins may also be required. CTC references are Angora Highland and Boulder Mtn. ECP's	$2,107,229.00
WATER QUALITY	CHRISTMAS VALLEY	708		6/1/2004	EL DORADO	CTC has identified 3 CIP'S in this area which need re-vegetating: rock lined ditches, curbs, gut, retaining walls, and rock slope protection. Treatment facilities (sediment basins) also likely required.	$2,628,145.00
WATER QUALITY	SOUTH UPPER TRUCKEE & GRASS LAKE ROAD	709		6/1/2004	EL DORADO	Erosion source controls and stormwater treatment faculties associated with the grantees roadways. Improvements will include revegetation. of disturbed soils; drainage stabilization (e.g. paved gutters, rock lined channels), infiltration and sedimentation	$3,159,344.00
WATER QUALITY	SR 89 LUTHER PASS TO HWY 50 JUNCTION	1012	6/1/2004	6/1/2007	CALTRANS	The project involves slope stabilization, water collection, and treatment improvements along 8.56 miles of road from El Dorado mile post 0.00 to mile post 8.56.	$8,000,000.00
	PROGRAMS					SUBTOTAL	$42,240,985.00
WILDLIFE	REVIEW & REVISE WILDLIFE DISTURBANCE ZONES	341	9/1/2002	9/1/2004	TRPA	PROGRAM. Review the current special interest species disturbance, influence zone language, ecologically significant areas, and revise as appropriate (based upon watershed assessment) to update for 2007 wildlife thresholds and Regional Plan.	$200,000.00
WILDLIFE	REVISE REGULATIONS REGARDING SNAG & DOWN WOODY DEBRIS	342	5/1/2000	5/1/2000	TRPA	PROGRAM. Revise regulations regarding snag and down woody debris to accommodate wildlife needs.	$20,000.00
WILDLIFE	BEAVER MANAGEMENT PLAN	586	1/1/2005	11/1/2005	USFS	PROGRAM. In coordination with land managers, resource agencies and TRG develop and implement a beaver management plan.	$50,000.00
WILDLIFE	WILDLIFE SPECIAL INTEREST SPECIES MAP & DATABASE	592			USFS	PROGRAM. Annually update special interest species maps and database, create a "real-time" monitoring database through this process. (On going program, $20,000 per year).	$20,000.00
WILDLIFE	ASPEN COMMUNITY SPATIAL DISTRIBUTION AND CONDITION ASSESSMENT	10029	5/1/2002	5/1/2002	TRPA	Using GPS, delineate all aspen stands in the Basin and import information into a GIS. Assess the condition of all aspen stands with respect to age, dbh, vegetation composition, soils, canopy cover, encroachment from conifers, biological activity, impact from roads and trails, pathogen levels, hydraulic and soil characteristics. Assessment should provide a measurable index of stand health so that managers are able to monitor aspen stand conditions in the future and prioritize stands for enhancements.	$100,000.00
WILDLIFE	WETLAND HUMAN DISTURBANCE BMP	10045	10/1/2000	5/1/2002	USFS	Assess current human movement and use patterns at wetland communities. Use assessment to redesign human movement by incorporating improved vegetation buffers and cover, set backs, fencing, interpretive signing, and improve or provide viewing platforms designed as blinds. The objective of this project is to reduce impacts to marsh associated species from disturbing human activities.	$16,000.00
WILDLIFE	ASPEN COMMUNITY RESTORATION PROJECTS	10080	12/1/2002	5/1/2003	MULTIPLE	On a landscape scale, aspen communities provide for habitat diversity. This project is intended to build from the "Aspen community spatial distribution and condition assessment". Restoration projects will focus on those aspen stands that have been identified as in a deteriorating condition. Restoration project should attempt to re-invigorate declining aspen communities using a variety of techniques such as conifer removal, mild burning, group selection thinning, and mechanical pushing. The goal of this project is to re-establish vigorous and self-sustaining, unevenaged stands of aspen throughout the region. Note** This project needs to be refined in terms of location for treatment and thus will effect the cost associated with this project.	$250,000.00
WILDLIFE	RIPARIAN WILDLIFE ENHANCEMENT: PHASE II	10142		7/1/2002	CTC	Regional riparian wildlife enhancement program. The objectives of this program are to identify disturbed riparian habitats and implement restoration and enhancement projects at identified sites. Program includes acquisition of riparian lands. This program directly relates to EIP # 1003.	$1,867,000.00
WILDLIFE	RIPARIAN WILDLIFE ENHANCEMENTS: PHASE III	10143		7/1/2005	CTC	Regional riparian wildlife enhancement program. The objectives of this program are to identify disturbed riparian habitats and implement restoration and enhancement projects at identified sites. Program include acquisition of riparian lands. This program directly relates to EIP # 1003.	$1,866,000.00
Total Cost (All Projects)							$46,629,985.00

TABLE 1.1: List of projects and programs located in the Upper Truckee River Watershed proposed in the Environmental Improvement Program. Note: This may not be an exhaustive list of every EIP project within the Upper Truckee River Watershed.

The CDPR owns a significant portion of the UTR and surrounding lands within the Lake Tahoe Golf Course (LTGC) and Washoe Meadows State Park. CDPR has been actively researching and implementing enhancement projects on the UTR and Angora Creek, having restored 7,000 linear feet of the latter over the past six years. CDPR is presently overseeing the design of a stabilization project in the LTGC at the crossings at Holes 6 and 7.

II. Historical Changes

II.1 UPPER TRUCKEE RIVER WATERSHED DESCRIPTION

The Upper Truckee River flows from Red Lake Peak near Carson Pass to Lake Tahoe near the Tahoe Keys Marina, a distance of over 20 miles. The watershed can be segmented into five distinct areas as shown in Figure 1.1:

- Upper Watershed
- Christmas Valley
- Meyers Area
- Sunset Ranch/Lake Tahoe Airport
- Lake Tahoe Blvd. to Tahoe Keys

This assessment is focused on projects that can be carried out within the UTR corridor from Elks Club Highway 50 crossing to a point about 2,000 feet upstream of South Upper Truckee Road, encompassing the Meyers Area, Christmas Valley, and a portion of the Upper Watershed. But it also addresses the watershed conditions affecting environmental quality system-wide, and several watershed issues have emerged from this assessment that are pertinent to the entire UTR and are discussed where appropriate.

The UTR watershed is an elongated basin draining over 54 square miles. The Upper Watershed varies in elevation from over 10,000 feet along the Sierra Nevada crest down to 6,500 feet above MSL at South Upper Truckee Road. The river originates in the steep volcanic bluffs of the Upper Watershed surrounding Meiss Meadow near Carson Pass. It then flows northward through meadows, forests, lakes and barren rocky areas in a terrain highly modified by repeated glaciations. The headwaters area is a bowl-shaped cirque that once held glaciers that formed and disappeared over the past 1.8+ million years. Glacial erosion processes carved the Upper Watershed and left large areas of bedrock scraped clean of soil. Other areas have glacial deposits of till and boulder erratics. Over ten perennial lakes, formed primarily by glacial processes, are found within the Upper Watershed. The northern end of these glacial deposits rests upon a prominent 800-foot high glacial step over which the Upper Truckee River cascades down in multiple waterfalls of bedrock and large boulders to the head of Christmas Valley.

The Upper Watershed is entirely owned by the USFS and is managed by the LTBMU. Only one public road, Highway 89, is open for vehicular access and crosses over Luther Pass along Grass Lake and Grass Lake Creek on the southeastern side of the watershed. The remaining area has foot trails, equestrian access, and some designated mountain bike trails.

Christmas Valley is a classic U-shaped glacial valley created during the earliest and largest glaciation of over 1.8 million years ago. Since that time, glaciers have not advanced past the Upper Watershed, and the ancestral and present UTR have transported remobilized glacial sediments, carved floodplains and terraces, and interacted with higher and lower stands of Lake Tahoe. The valley floor in Christmas Valley is relatively flat and bounded by valley walls on the east and west that rise steeply over 1,000 feet. The area has a conifer forest cover with areas of meadows and aspen groves situated along the UTR tributary streams and springs. The Upper Truckee River flows within a geologically incised corridor, down the middle of the valley for six miles to the Meyers Highway 50 crossing. Deep, boulder lined reaches are separated by wider, alluvial floodplain areas of meadows and aspen groves. The valley floor has been developed since the 1960s with residential housing and summer cabins, most on city-sized lots criss-crossed by numerous all-season roads. Land ownership in Christmas Valley is a mix of private residential and ranch lands with State and LTBMU holdings interspersed.

The Meyers Reach is situated between the Meyers and Elks Club Highway 50 crossings. At Highway 50, the UTR changes abruptly from a confined, boulder-lined and geologically incised channel of Christmas Valley to a wider, alluvial river/floodplain corridor, free of boulders and bedrock, contained within the wider floor of Lake Valley. The UTR flows within a 100 to 200 foot wide, recently formed channel/floodplain system, bounded by low terraces of recently abandoned floodplain and high terraces of ancient ice age glacial outwash. The UTR flows through a narrow band of mixed conifer and riparian forest, past the reclaimed gravel pits of Lake Baron and through Washoe Meadows State Park before emerging into a reach bounded by a former large meadow that is now the Lake Tahoe Golf Course (LTGC).

Angora Creek enters the UTR at the lower downstream end of the golf course. Angora Creek drains a 5.9 square mile watershed that originates at Angora Lakes before flowing through residential neighborhoods, large meadows and the LTGC. 7,000 linear feet of the lower reaches of Angora Creek have been restored, including the last 600 feet flowing through the LTGC.

A second unnamed tributary (0.81 square miles) flows northward from Meyers into the UTR at Hole 10 of LTGC. This highly altered stream originates in the Tahoe Paradise Golf Course in Meyers before flowing northward across Highway 50, through a channelized ditch in the Tahoe Paradise residential area, then emerging onto the LTGC. The stream flows for 3,000 feet between fairways before flowing into the UTR near the clubhouse.

The UTR in the Meyers Reach predominately flows through State of California owned land; the exceptions are the land east of the river near Lake Baron and part of the land north of the river at the upstream end of the golf course.

The downstream boundary of the Meyers watershed area and the Upper Reach project area is the Elks Club Highway 50 crossing.

Below the project reach the UTR flows through Sunset Ranch, Lake Tahoe Airport and the channelized section near the Tahoe Keys. Much of the lower UTR flows though broad meadows surrounded by urbanized land. Nearly all of the lower reaches were channelized to accommodate grazing in the 1860s and for the construction of the Lake Tahoe Airport in the early 1960s. Environmental conditions in these areas are being addressed through the preparation of earlier plans (Middle Reach UTR – January 2003) and ongoing planning efforts (Lower West Side – Barton Meadow – CTC).

II.2 ORIGINAL CONDITIONS

Understanding the current environmental condition of the UTR requires a comparison with the best estimation of the original river form and process prior to introduction of European land use in the 1860s. The original pre-1860s condition resulted from geologic forces and recent climatic history, within which native vegetation and wildlife communities evolved and adapted to the environment of the late Holocene Epoch (past 10,000 years). This followed the end of the last glacial period of 26,000 to 18,000 years before the present. In order to recover ecosystem function, it is important to understand recent geologic history, the land use changes and their effect on ecosystems, in addition to the hydrologic and geomorphic processes that create and sustain the ecological habitat.

The geology of the UTR has been highly influenced by the large scale tectonic interaction of the Pacific and North American Plates and the evolution of the west coast of North America and San Andreas Fault system to the west. The oldest rocks in the watershed date back to the Mesozoic Era (over 150 million years ago) when the west coast of North America was expanding westward by accretion of continental crust that floated in on eastward moving plates. At this time, the west coast of California was a subduction zone, similar to the present west coast of South America where denser, eastward moving plates of oceanic crust plunged under the lighter and more buoyant continental crust. The ubiquitous outcroppings of granite visible in the Sierra Nevada today originated through the partial melting of the consumed oceanic crusts in the upper mantle. The melted constituents were lighter and more buoyant. The crust began a long cooling period that allowed for the formation of crystalline granitic rocks; these granitic rocks were later exposed by tectonic uplift and erosion to form today’s Sierra Nevada.

The present Sierra Nevada began uplifting 5.0 million years ago during the Pliocene Epoch, and since that time, the Sierra Nevada crest has risen over 5,000 feet in the UTR / Lake Tahoe area. As the Sierra Nevada uplifted, the land around Lake Tahoe stretched until three large blocks broke apart and formed, from west to east, the uplifted Sierra Nevada Crest, the down dropped Lake Tahoe graben and the uplifted Carson Range. Lake Tahoe was originally a northward sloping valley until volcanic flows and movement along faults formed the mountains along the north end of the Lake from Mount Rose to the Truckee River, which blocked drainage and created the Lake.

The UTR lies at the boundary of the Sierra Nevada and Basin and Range Provinces (Figure 2.1). The major faults that bound the three blocks originate in the UTR Upper Watershed and form the boundaries of Christmas Valley, before trending northward to Meyers where they split; the western fault continues north along the west shore of Lake Tahoe and the Sierra Nevada Front; the eastern fault bends eastward toward the Nevada side of Lake Tahoe and the Carson Range. These faults are still active and, in places, display ground breaks through sediments less than 10,000 years old.

The bedrock of the UTR watershed is predominately granitic; however there are significant outcroppings of highly erodible, tertiary-aged volcanic rocks that occur along the crest of the Upper Watershed. These were formed during the major volcanic eruptions of the Miocene period (5-24 million years ago) that covered the entire Sierra Nevada; subsequent erosion by glaciers and flowing water removed much of the original volcanic rock cover. A soils map is presented in Figure 2.2.

Geomorphology is concerned with recent and ongoing geologic processes of weathering, erosion and sediment transport and the development of landforms (e.g. hillslopes, valleys, streams, shorelines, etc.). The significant geomorphic events that formed the present UTR began over 2 million years ago when the first of four major glaciations occurred. Much of the evidence of the two earliest periods has been buried, re-worked or destroyed by the later two: the larger Tahoe period (60,000 to 90,000 years before present) and the later and smaller Tioga phase (18,000 to 26,000 years before present).

Birkeland (1963) identified limited exposures of the post-Plio-Pliestocene Hobart Till north of Lake Tahoe and in the Truckee River canyon below the Lake Tahoe outlet and postulated a pre-Wisconsian (pre-Tahoe) age well over 600,000 years before present. The second pre-Wisconsian was the “Donner Lake” glacial period 400,000 to 600,000 years ago, which at times blocked the Truckee River canyon north of Tahoe City with ice raising the level of Lake Tahoe by up to 600 feet above present levels (elevation 6800 feet above sea level). Periodic breaching of the ice dams caused large, catastrophic floods to spill down the Truckee River into the Truckee Meadows of present day Reno, carrying boulders as large as ten feet in diameter.

The later Wisconsian glaciations also raised Lake Tahoe to varying degrees. The earlier and larger Tahoe glacial period may have raised Lake Tahoe 90 feet above its present level; prominent shoreline terraces around the Lake indicate a constant level, 90 feet higher than present, but other shoreline terraces are found at 40 and 80 feet above present lake level.

Evidence for the Tahoe and Tioga period glaciers is well recorded on the south and west shore of Lake Tahoe (i.e. Fallen Leak Lake, Emerald Bay, Meeks Creek watershed), however the moraine deposits are not found north of the Upper Watershed of the UTR (i.e. the terminal moraines of recent times end at Cookhouse Meadow (elevation 7,000 feet)) and to the west. Terminal moraines from the Echo Lake area end just west of the Meyers Highway 50 crossing.

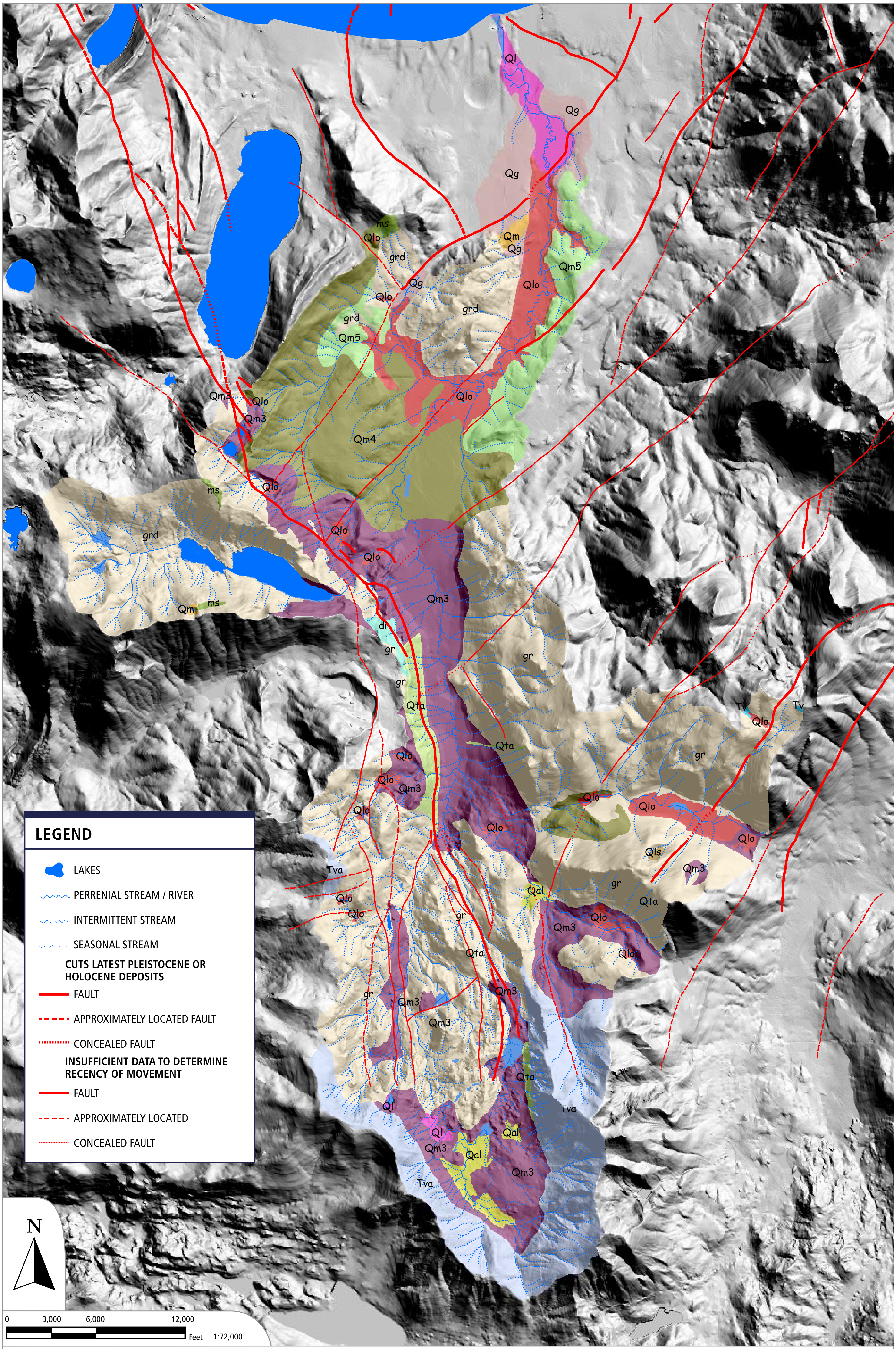

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FIGURE 2.1A: Upper Truckee River Geology Units Map. Refer to Figure 2.1B for for geologic units legend and desription. Faults source data: R.A. Schweickert, et.al. 1999.

Geologic Formations

Qal	Lake and Stream Sediments/ Deposits/ Alluvium
Qg	Glacial Outwash Deposits
Ql	Older Lakebed Deposits
Qlo	Older Lake Sediments
Qls	Rockslides
Qm	Glacial Deposits/ Moraines Undifferentiated
Qm3	Tioga Till Glacial Moraines
Qm4	Tahoe Till Glacial Moraines
Qm5	Pre-Tahoe Till
Qta	Talus
Tv	Undifferentiated Volcanic Rocks
Tva	Dominantly Andesite Breccias
di	Intrusive Rocks (diorite)
gr/grd	Granite Rocks
ms	Metasedimentary Rocks

Soil Types

Ca	Cagwin Series	C	The Cagwin series consists of gently rolling to very steep, somewhat excessively drained soils that are 20 to 40 inches deep over granitic material, or grus.
Co	Celio Series	D	The Celio series consists of poorly drained soils that are 40 to 60 inches deep over a very gravelly hardpan strongly cemented with silica.
Eb	Elmira Series	Variations in A & D	The Elmira series consists of nearly level to moderately steep, somewhat excessively drained soils that are underlain by sandy granitic alluvium or highly weathered till.
Ge	Gefo Series	A	The Gefo series consists of nearly level to moderately steep, somewhat excessively drained soils that are underlain by sandy granitic alluvium.
Ja	Jabu Series	Variations in B, C & D	The Jabu series consists of nearly level to moderately steep, well drained to moderately well drained soils that are about 40 inches deep over a dense fragipan.
Mk	Meeks Series	B	The Meeks series consists of level to very steep, somewhat excessively drained , stony soils that are 40 to 71 inches deep over a hardpan cemented with silica.
Mx	Mies Series	D	The Mies series consists of strongly sloping to steep, excessively drained soils that are 10 to 20 inches deep over hard andesitic rock.
Tc	Tallac Series	Variations in B & C	The Tallac series consists of gently sloping to steep, well drained and moderately well drained soils that are 40 to 70 inches deep over a weakly silica cemeted hardpan.
Tr	Toem Series	C	The Toem series consists of strongly sloping to very steep, excessively drained soils that are 8 to 20 inches deep over decomposed granitic material.
Wa	Waca Series	C	The Waca series consists of hilly to steep, well drained soils that are 20 to 40 inches deep over andesitic tuff.
Gr	Gravelly Alluvial Land	D	Gravelly Alluvial Land consists of small areas of recent gravelly alluvium adjacent to stream channels and in meadows.
Lo	Loamy Alluvial Land	D	Loamy Alluvial Land consists of small areas of recent alluvium adjacent to stream channels and in meadows.
Mh	Marsh	D	Marsh is in the Upper Truckee Marsh and in very poorly drained and in ponded meadows.
Px	Pits & Dumps	D	Pits and Dumps consists of sand and gravel pits, refuse dups, and rockl quarries.
Sm	Stony Colluvial Land	C	Stony colluvial land occurs in areas of colluvium from granitic, metamorphic, and volcanic rock and from highly fractured volcanic flow.
Fd	Fill Land	A	Fill land is sandy material dredged from the Upper Truckee Marsh to form a pad for urban development, mainly in the Upper Truckee Marsh area.
Rx	Rock Land	D	Rock land is in areas of granitic, metamorphic, and volcanic rocks.

Figure 2.1B: Legend describing geologic formations and soil types in the Upper Truckee River Watershed (Hydrologic soil group noted in blue).

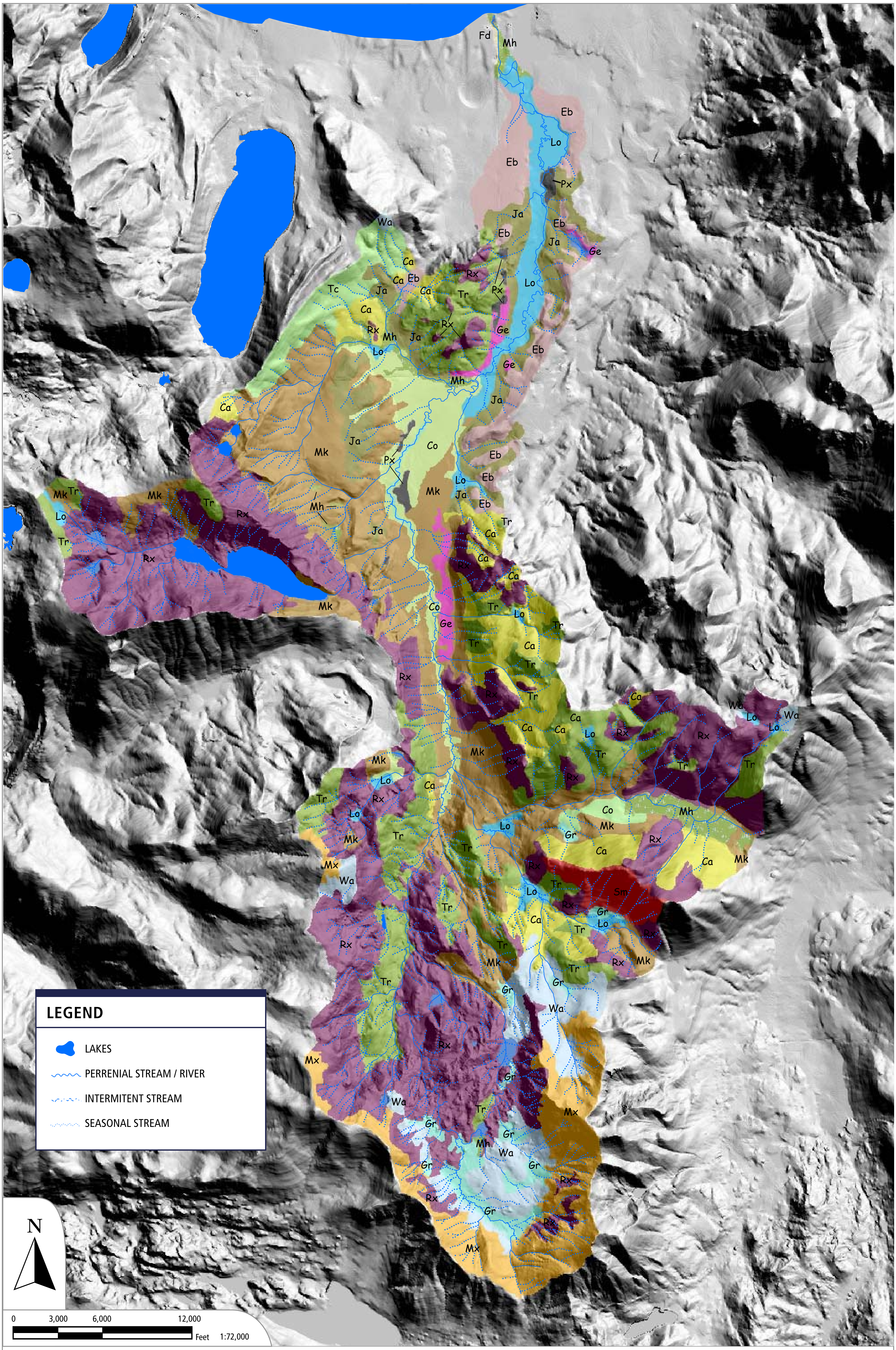

FIGURE 2.2: Upper Truckee River soils map. Refer to Figure 2B for legend and soil type descriptions.

The lack of glacial “till” deposits in Christmas Valley and downstream indicates that only the earliest glaciations could have carved Christmas Valley, Meyers and Lake Valley, and that the predominate geomorphic processes that formed the present landscape are related to active faulting, down-dropping valley floors, development of glacial outwash filled valleys and sub-aqueous glacial outwash deltas deposited below elevated stands of Lake Tahoe.

To understand the present UTR landscape and watershed, one has to imagine a dynamic sequence of rising and falling lake levels changing the base level for the UTR and the position of deltaic formation. Dramatic increases in sediment supply and stream flow during glacial periods were followed by drier interglacial periods, similar to present day conditions. Glacial outwash terraces, composed of large lag boulders, sand and gravel deposits, form the terraces along the floor of Christmas Valley and extending into Meyers; these outwash terraces merge into deltaic deposits in Meyers, which appear related to the 90 foot high Lake stand of the Tahoe glacial period. The boulders lining the bed of the UTR in many reaches of Christmas Valley may be the remnants of the early glaciations, and these end abruptly at the Meyers Highway 50 crossing. Older outwash deposits are found along the hills east of the Lake Tahoe Airport and west of the Lake Tahoe Golf Course.

Examination of aerial photographs and alluvial deposits along the UTR show evidence of the development of the modern, pre-disturbance UTR. Over the past 10,000 years, the UTR experienced a gradual drying, followed by a dry and warm period between 5,000 and 8,000 years before present. The present interglacial became slightly colder over the past 3,000 years and has remained fairly steady since. An investigation of pollen from Osgood Pond (Cushing, 1967), located just off Highway 50 near the Meyers Highway 50 crossing recorded this sequence of climatic change and vegetative response. In general, the pre-disturbance UTR was downcutting through the glacial outwash deposits, forming a meander belt and floodplain, riparian and wetland zone. There is evidence of past small lakes and ponds that have become meadows within the modern floodplain.

Figure 2.3 shows a geomorphic map of the UTR corridor and the delineation of glacial outwash terraces, deltaic deposits and the modern floodplain. The modern floodplain is the focus of attention with respect to estimating the pre-disturbance UTR ecosystem. It was formed in the present climate (past 10,000 years), as sediment supply and flow to the UTR from the watershed were greatly reduced. The UTR reworked and transported the materials in the outwash terraces and incised a narrow river corridor. There are places where erosion of the glacial outwash terraces continues and the UTR is slowly eroding through older outwash deposits but is geologically constrained.

II.2.A Geomorphic Variables Measuring Land Use Impacts

Examination of the physical form and processes of a river system falls within the study of fluvial geomorphology. To describe the original UTR system and the subsequent changes associated with land use effects, it is useful to define elements of river form.

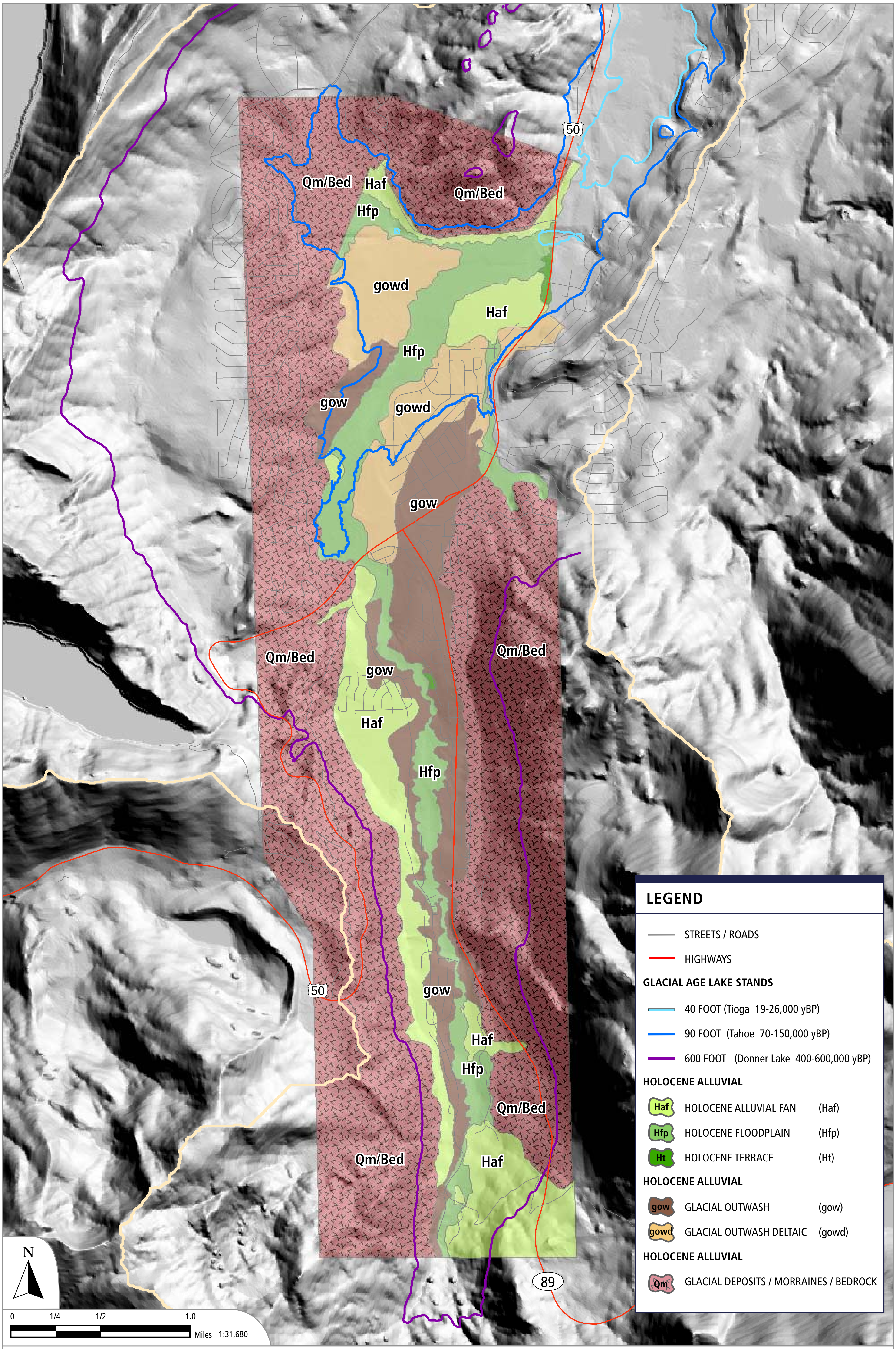

FIGURE 2.3: Land form map of glacial age and Holocene units along Upper Truckee River, Upper Reach Project as mapped by SH+G. Lake stands reference: Birkeland, 1964 and Birkland, 1968.

Channel morphology refers to the geometric characteristics of the channel and the pattern of the river as viewed from above. Channel geometry refers to the width and depth of the channel as viewed in cross section. It is important to distinguish the signature of different flow levels and flood events and the features and associated hydrologic events between the various stages of a stream channel: the low flow channel contains the smallest flow events that generally occur over 90% of the time; the bankfull channel occurs less than 10% of the time and is associated with channel forming process such as sediment deposition on new floodplain, point bar development and outer bank erosion in a meandering stream. On the UTR annual snowmelt runoff events have the most frequent impact on channel morphology. The flood channel occurs at a stage that often fills the largest channel and spills out onto the valley floor or terraces; terraces are old floodplain surfaces originally constructed by the river at the bankfull stage that are now elevated and abandoned by the bankfull flows (Figure 2.4). The morphology of these features can vary, especially when the stream in question is not fully "alluvial" and has geologic controls such as bedrock or older resistant materials along its boundaries that limit erosion.

Channel pattern refers to the shape of the river's path which generally falls into one of three categories: straight, meandering and braided. Generally, the pattern of interest is that of the bankfull channel, since it represents the present channel and floodplain forming processes. Most streams are meandering streams and sinuosity is the measure of curve of the river.

Finally, the channel longitudinal profile is of keen interest to tracking the impacts of historical land use effects. The longitudinal profile is a plot of the lowest points (i.e. thalweg or flow line) occurring along the path of the channel (Figure 2.5). The longitudinal profile exhibits the slope of the river and thus a measure of hydraulic energy grade of flows and erosive force.

The earliest aerial photograph available of the UTR is 1940 (Figure 2.6), which is 80 years following the introduction of intensive European land use during the Comstock Era. These photos show the river system already affected by grazing, reclamation, logging and roads and bridges. In order to estimate pre-1860 conditions, other indirect evidence must be used. Using a combination of aerial photographs and recent topographic data (1-foot contour LIDAR Map supplied by TRPA) an "original" channel pattern was developed (Figures 2.7A-D) along with the channel pattern shown in 1940 and 2003 aerials. The "original pattern" is that represented by drawing and connecting visible meander scars on Holocene floodplain areas, the 1940s from the 1940 aerial photographs, and 2003 from the LIDAR image and topographic map. The resultant channel pattern plot reveals an overall loss of pattern sinuosity of 20 percent in the Meyers Reach from 1.70 to 1.35; the loss in the Christmas Valley Reach is less, but measurable and significant in discrete reaches. A comparison of sinuosity of Reaches 1 – 4 in the original, 1940 and 2003 channels can be found in Table 2.1.

The loss of channel pattern sinuosity is related to the early European land use practices of land reclamation for grazing. Pattern sinuosity is a naturally developed characteristic of a stream, reflecting a balance of sediment supply, sediment sizes, flow and the natural tendency of a river

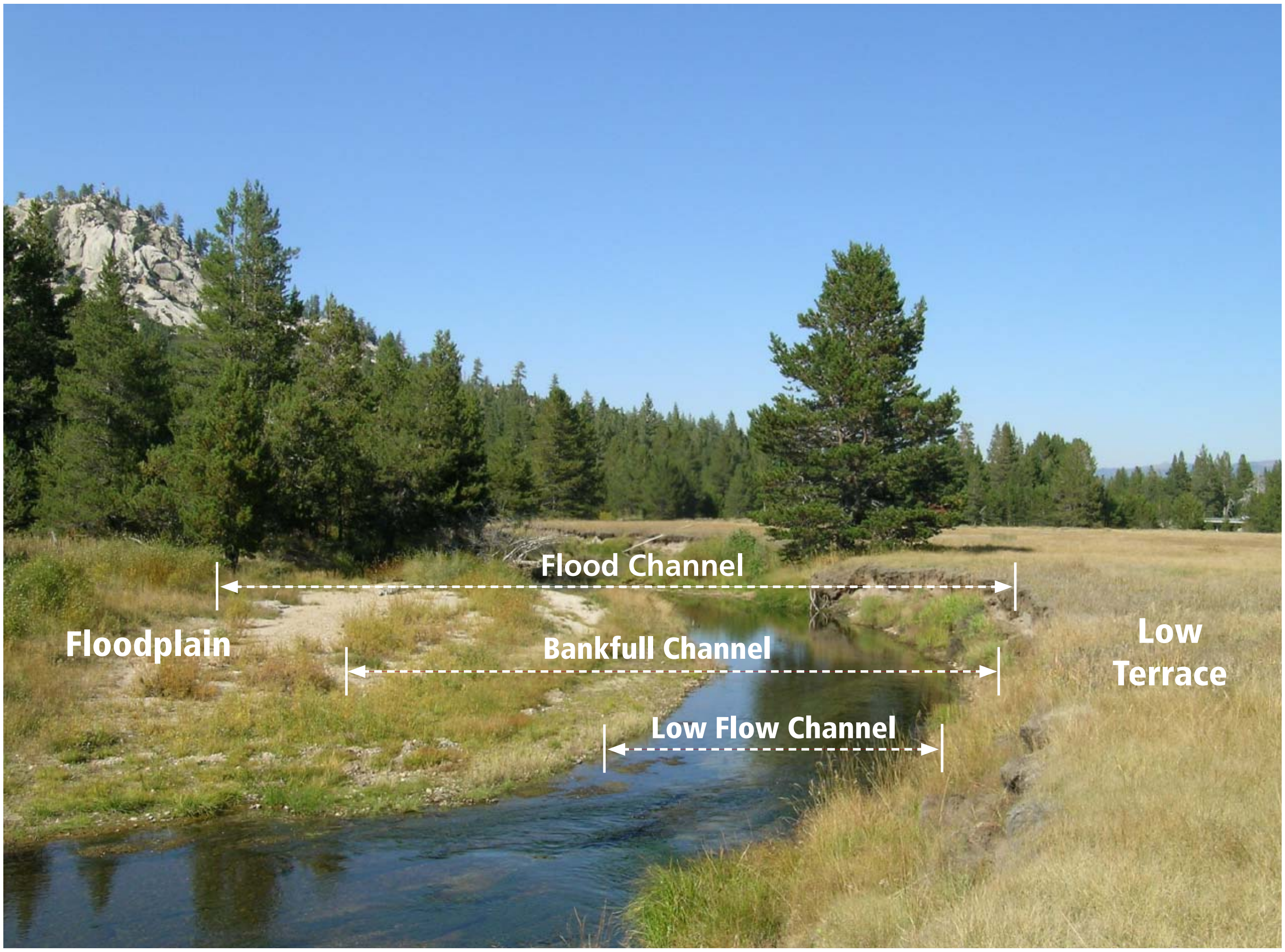

FIGURE 2.4: Photo of Upper Truckee River at SH+G river station 1800 indicating locations of flood channel, bankfull channel, low flow channel, floodplain and low terrace.

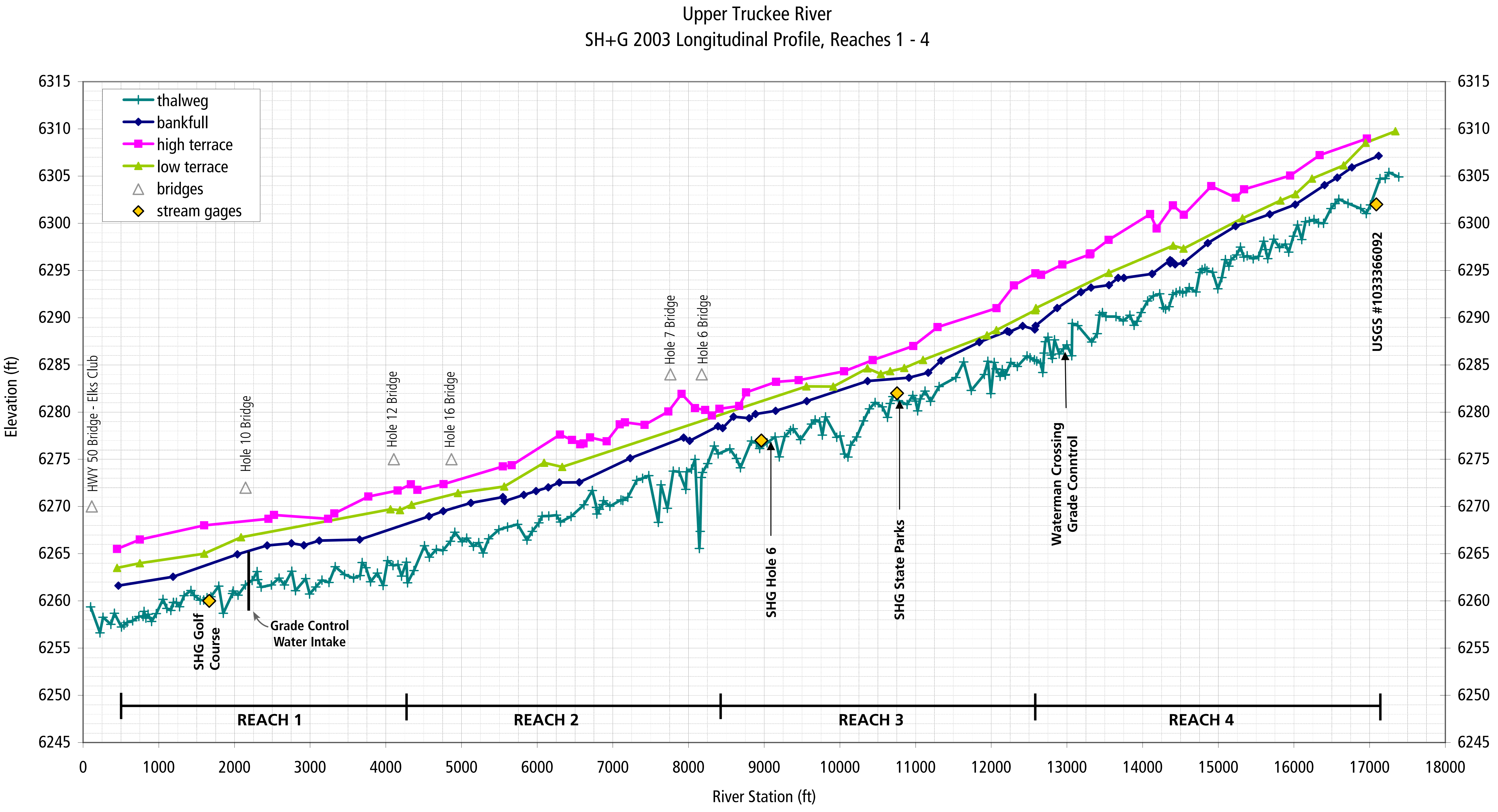

FIGURE 2.5: Longitudinal profile of Upper Truckee River from Elks Club Highway 50 crossing to Meyers Highway 50 crossing (Reaches 1-4). Bankfull, low terrace and high terrace features were also surveyed in the field.

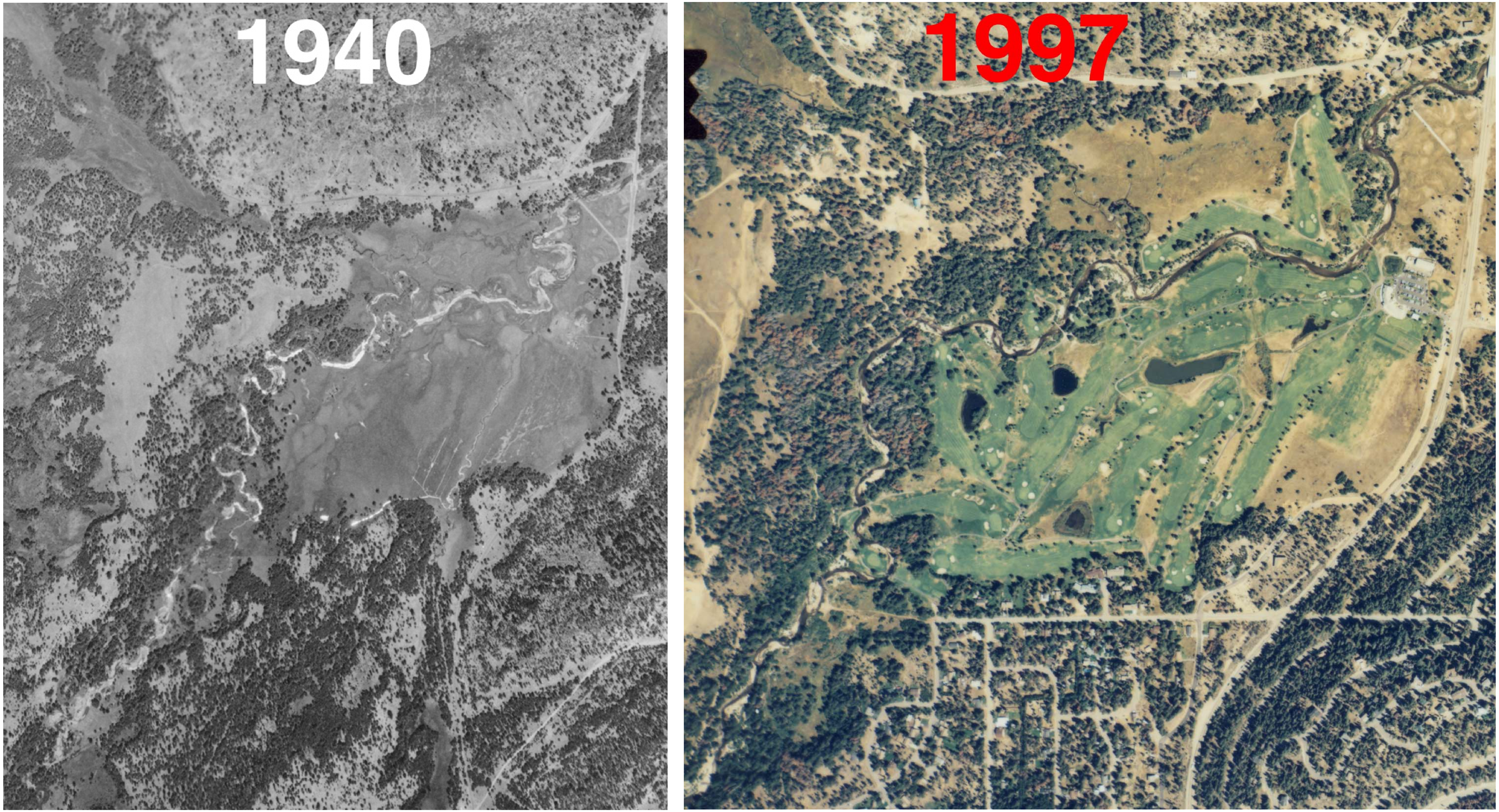

FIGURE 2.6: Aerial photographs of the Upper Truckee River from 1940 and 1997.

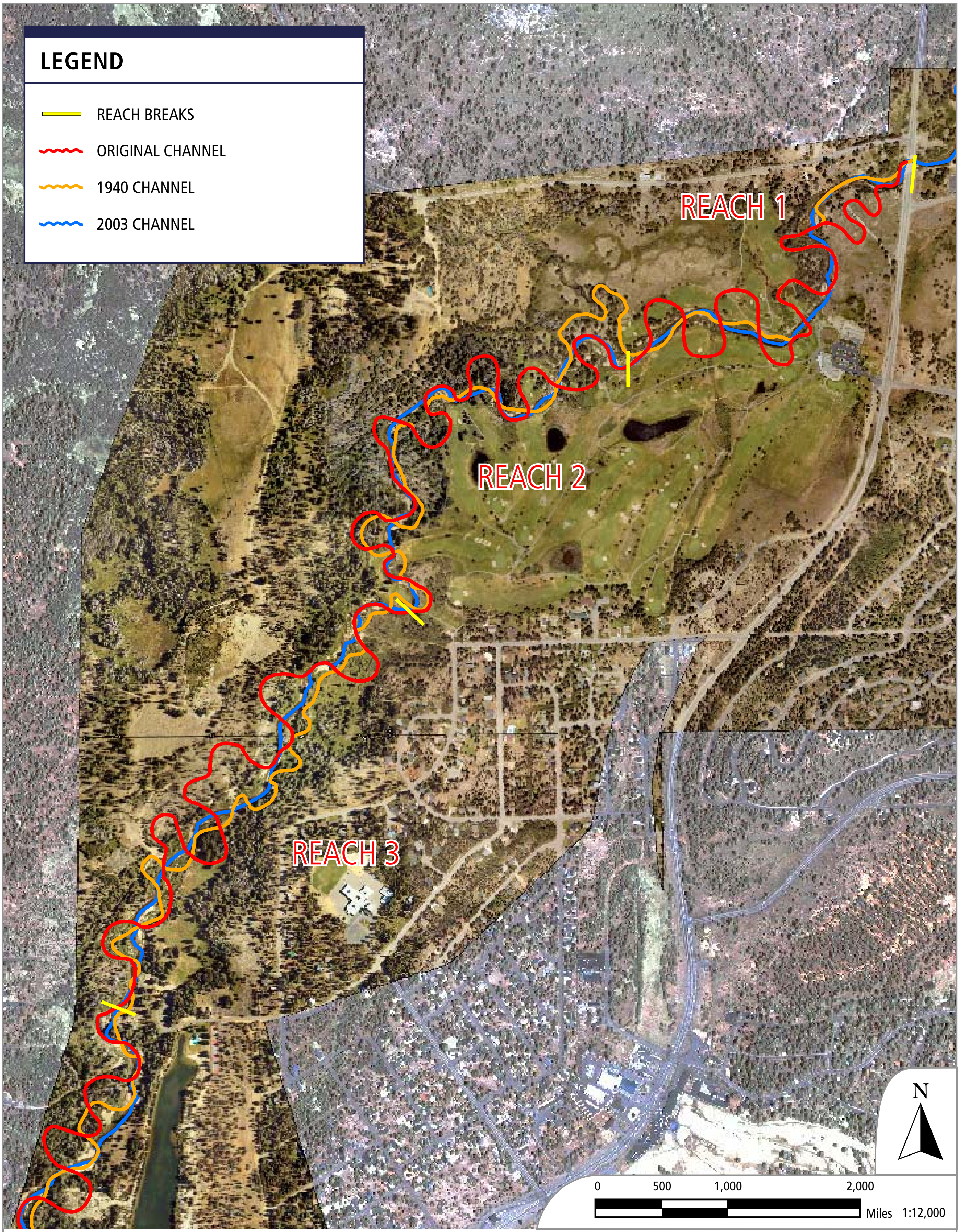

FIGURE 2.7A: Illustration of channel pattern for the original interpreted channel, 1940 channel, and present day channel (2003 channel) in Reaches 1-3.

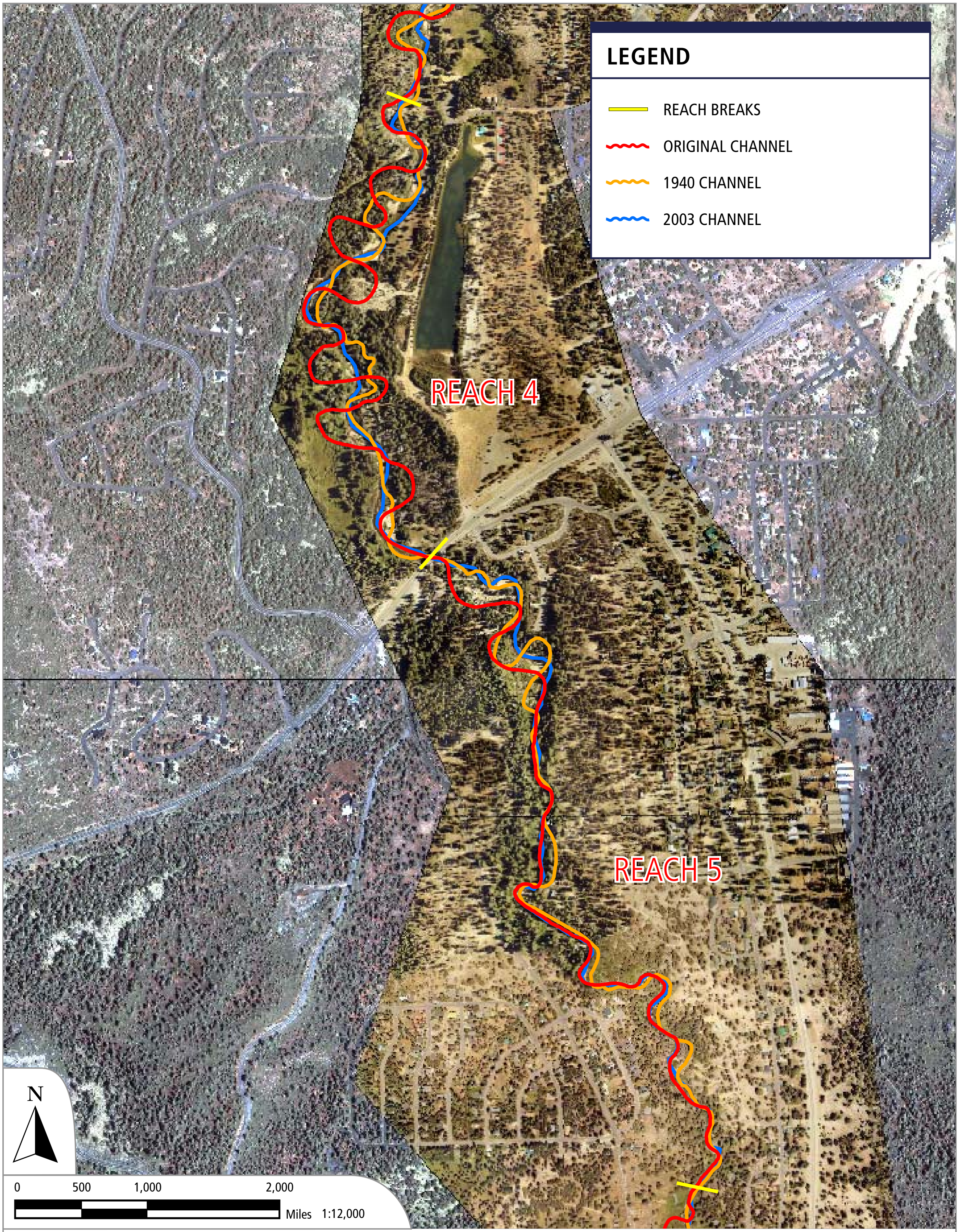

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FIGURE 2.7B: Illustration of channel pattern for the original interpreted channel, 1940 channel, and present day channel (2003 channel) in Reaches 4-5.

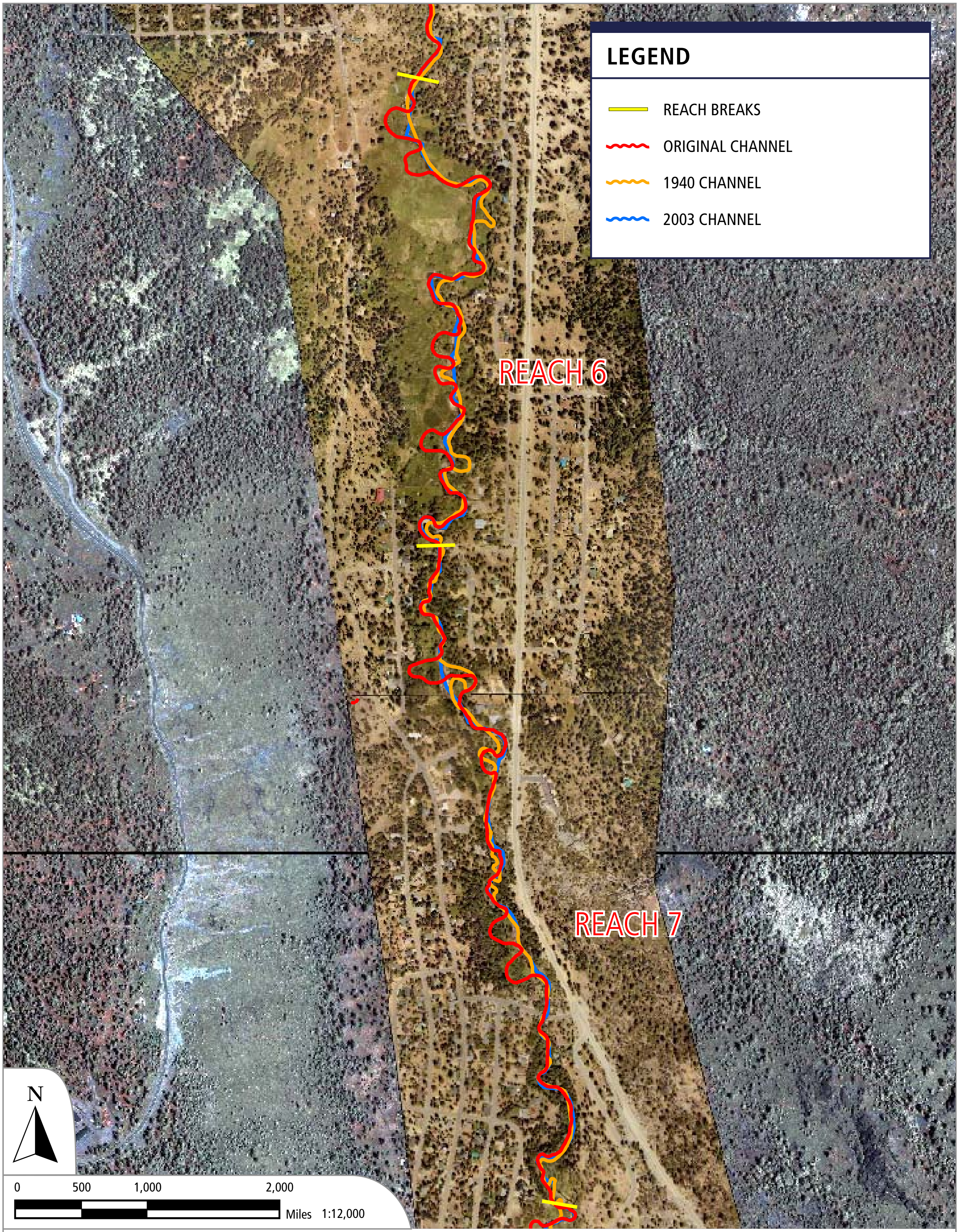

FIGURE 2.7C: Illustration of channel pattern for the original interpreted channel, 1940 channel, and present day channel (2003 channel) in Reaches 6-7.

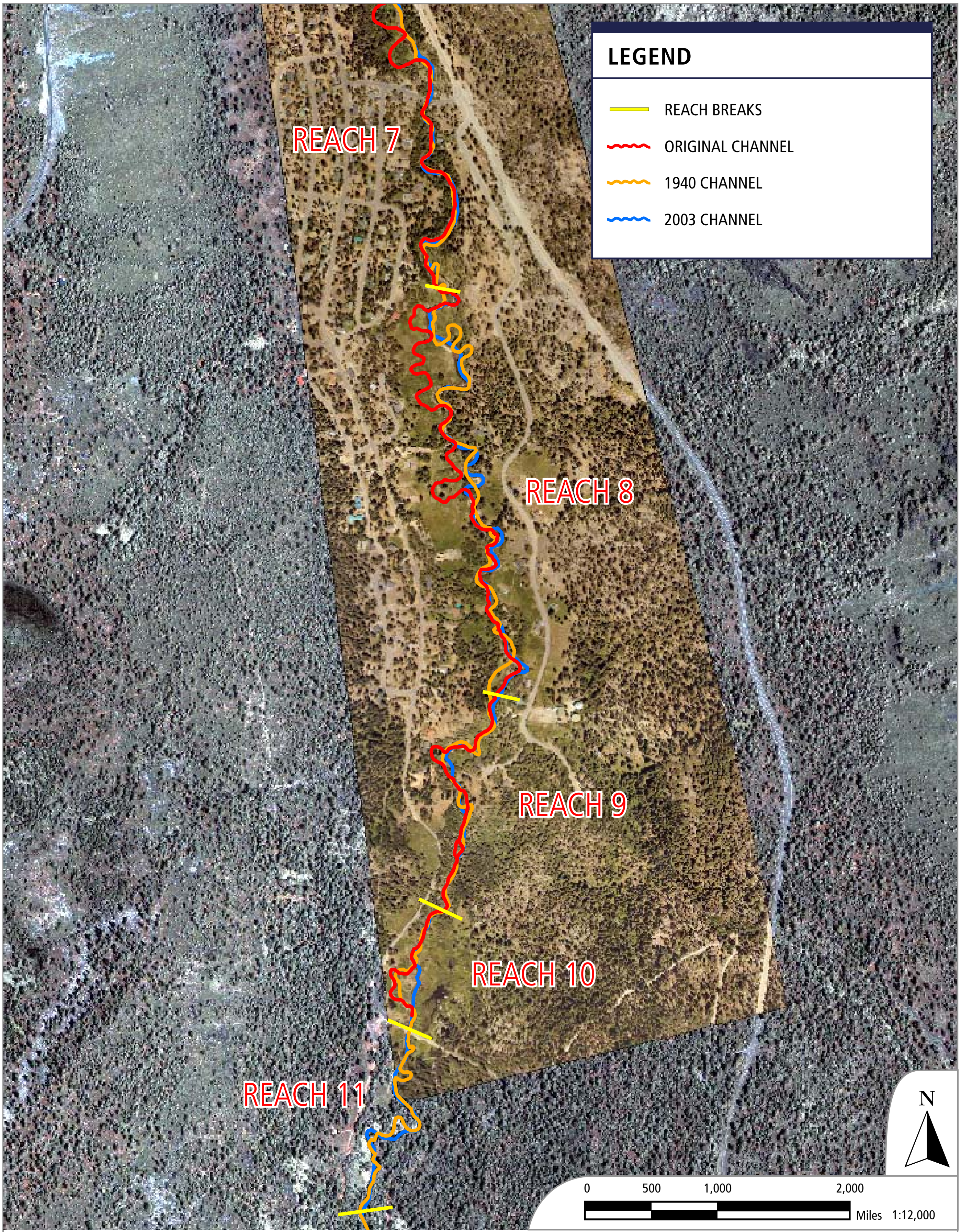

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FIGURE 2.7D: Illustration of channel pattern for the original interpreted channel, 1940 channel, and present day channel (2003 channel) in Reaches 7-11.

Sinuosity

Reach ID	Original Channel			1940 Channel			2002 Channel		
	Channel Length (ft)	Valley Length (ft)	Sinuosity	Channel Length (ft)	Valley Length (ft)	Sinuosity	Channel Length (ft)	Valley Length (ft)	Sinuosity
1	6721	2555	2.6	4603	2555	1.8	3650	2555	1.4
2	7229	2594	2.8	6597	2594	2.5	4383	2594	1.7
3	7239	3795	1.9	5329	3795	1.4	4425	3795	1.2
4	7432	3844	1.9	5202	3844	1.4	4745	3844	1.2
5	7442	5130	1.5	7941	5130	1.5	7245	5130	1.4
6	6845	3615	1.9	5449	3615	1.5	5362	3615	1.5
7	7557	5120	1.5	7016	5120	1.4	6162	5120	1.2
8	5443	3080	1.8	4843	3080	1.6	4922	3080	1.6
9	2279	1679	1.4	2315	1679	1.4	2148	1679	1.3
10	1345	938	1.4	1208	938	1.3	1096	938	1.2
11	1935	1427	1.4	2282	1427	1.6	1934	1427	1.4
Total	28621	12789	2.2	21730	12789	1.7	17202	12789	1.3

Meander Length

Reach ID	Original Channel		1940 Channel		2002 Channel	
	Average (ft)	Standard Dev.	Average (ft)	Standard Dev.	Average (ft)	Standard Dev.
1	423	161	433	72	341	N/A
2	423	97	366	145	361	92
3	563	90	289	81	383	81
4	577	74	276	105	509	233
5	397.5	98.5	385.1	85.5	353.1	66.6
6	249.3	70.5	187.0	51.5	320.9	125.9
7	270.1	76.2	142.0	51.3	358.6	120.4
8	197.6	32.8	190.2	43.7	204.2	36.3
9	262.4	n/a	209.9	70.1	265.7	9.3
10	203.4	37.1	111.5	n/a	124.6	17.0
11	246.0	n/a	115.6	52.0	177.1	n/a

Radius of Curvature

Reach ID	Original Channel		1940 Channel		2002 Channel	
	Average (ft)	Standard Dev.	Average (ft)	Standard Dev.	Average (ft)	Standard Dev.
1	122	68	165	48	113	9
2	109	39	107	43	108	40
3	137	26	82	42	163	56
4	134	29	73	34	172	91
5	99.1	23.9	103.8	39.8	103.6	19.7
6	63.6	23.5	41.5	15.2	100.5	51.6
7	68.3	27.6	35.6	28.1	114.0	30.4
8	48.2	11.4	46.6	20.3	56.2	16.5
9	111.5	32.5	68.6	43.2	99.6	30.0
10	64.8	8.7	36.9	12.8	42.4	12.6
11	121.4	9.3	28.5	10.1	86.1	54.5

TABLE 2.1: A comparison of planform characteristics for the original, 1940 and present (2002) Upper Truckee River channel. Channels shown on historical aerial photographs were analyzed in GIS to calculate measurements.

to transport sediment and flow in a manner that dissipates energy at an even rate. The interplay of pattern sinuosity, vegetation and small-scale erosion and sediment deposition patterns create hydraulic diversity in the channel, pools, riffles, undercut banks and well sorted coarse substrate – the medium for macroinvertebrates and salmonid spawning. Riffle elevations control surface water low flow elevations and the seasonal groundwater elevations in the surrounding floodplain areas. Groundwater elevation is a key physical factor for wetland and riparian vegetation growth on the adjacent floodplain areas.

The reduction of pattern sinuosity indicates a trend towards channel shortening, a steepening of channel slope and an increase in erosive force. Erosive force and the ability of the stream to move sediment is related to the product of flow depth and channel slope (i.e. mass of water times the energy slope). The overall effect is deepening or incision of the channel into the underlying substrate and a disruption of channel stability. Channel incision is self-feeding, in that channel deepening increases erosive force which in turn increases depth and so on. Deepening the channel also decreases bank stability by undercutting root strength of vegetation and increasing bank height. With channel deepening, there is a response towards forming a wider channel to reduce flow depth and erosive force; eventually the stream forms a new meander belt, lengthens and aggrades, if the independent variables of sediment supply and flow imposed by the watershed remain relatively constant.

Early historical land uses can account for the change in sinuosity between original and 1940. The onset of the Comstock Mining Boom to the east in Virginia City in 1860 led to the development of roads through the UTR watershed between Sacramento and San Francisco. This led to creation of toll houses along the way and the need for dairy and cattle products. The meadows along the UTR were ideal for grazing, and it is apparent that strategies of controlling snow melt runoff by increasing channel depth allowed for earlier seasonal grazing entry to meadows. Construction of diversion works enabled late season irrigation, extending the production of the meadows well into late summer. These practices are clearly visible on the 1940 and 1952 aerials in the lower project area at the present site of the Lake Tahoe Golf Course (Figures 2.6 & 2.8). The LTGC is the site of a former dairy (Lindström, 2003).

Other historic land use practices have contributed to channel straightening and incision. Bridge and road crossing construction often involves placing earthen fill along the approaching road, preventing flow from accessing the floodplain and creating a bottleneck. This change, although quite localized, can dramatically cause incision for considerable distances upstream and downstream of the crossing. Blocking the floodplain concentrates all of the hydraulic force through the bridge opening; in many cases, the channel is dredged within the local reach to maximize channel flood capacity and minimize flooding over the roadway. The presence of a bridge can create a deeper scour zone that may initiate a headcut that over time can migrate upstream. As described above, channel deepening increases hydraulic force for erosion and increases the ability of the flow to move more sediment (i.e. increased transport capacity) and larger sediment sizes (i.e. transport competence). Thus, channel deepening often increases the supply of sediment to downstream reaches and often in quantities and sizes that the normal

FIGURE 2.8: Aerial photograph taken in 1952 of Upper Truckee River upstream of the Elk's Club Highway 50 crossing (Reaches 1-3).

channel floodplain system cannot transport except in the highest flows. When excessive coarse sediment is deposited in a channel, the channel expands its width and depth by erosion into softer materials (i.e. in case of UTR, meadow alluvial sediments) to compensate for the loss of flow capacity due to the obstructing coarse sediment deposit. This process becomes self-reinforcing. As each reach adjusts by erosion it releases more coarse sediment downstream that overwhelms the next reach. This process appears to be the best explanation for the channel widening and downcutting along the Christmas Valley reach of the UTR observed by long time residents. The 1940 aerials (Figure 2.6) show four bridge crossings over the UTR in alluvial reaches and each of these has the same characteristics of fill in the floodplain and forcing all flow through a small bridge opening.

Besides grazing, logging in the UTR watershed was another important land use. Logging created roads and soil disturbance, which likely increased sediment supply to the river and to Lake Tahoe. Intensive logging was confined to the area surrounding the UTR corridor below the Meyers Highway 50 crossing; this included clear cutting and hauling. One method of log transport that may have had an impact on the UTR was the creation of "splash dams." Splash dams were temporary structures that impounded river flow and created a pond where logs could be floated. Once filled, the dam would be breached sending logs downstream to Lake Tahoe where they could be floated to the sawmill. Figure 2.9 shows such an operation near the Highway 50 Elks Club bridge, just downstream of the existing Lake Tahoe Golf Course (LTGC). Splash dams would have sent a large volume of flow instantly down the channel with logs bumping banks along the way. This method of transport would certainly have benefited from deepening and straightening the channel; old timber "bumpers" have been found in the UTR channel below the Highway 50 crossing in South Lake Tahoe.

Later land use activities, such as the channelization of the UTR near the Lake Tahoe Airport and construction of the LTGC, drove further channel incision in the 1960s. These events formed eroding headcuts which have migrated upstream. The 1940 aerials show two recently cut off meanders that appear to have been excavated by machinery such as bulldozers, which became more readily available in the 1940s (Figure 2.6). The second phase of channel straightening and deepening in the 1950s and 60s reinforced the earlier phases, and the results were similar: increased bank instability, chronic supply of sediment from bank erosion, a lowered water table and a decrease in wetland and riparian vegetation cover within the river corridor. The areas of significant channel de-stabilization and erosion led to the installation of rip rap revetments to protect bridges, sewer lines roads, structures and golf course facilities. The rip rap revetments were generally successful at reducing bank erosion locally, but they resulted in erosion at nearby locations, possess barren low value habitat and are an expensive long-term solution system wide.

In the early 1990s, several projects were attempted along the LTGC to stabilize banks through use of bioengineered structures, incorporating logs and root wads into more naturalistic cobble revetments. These were partially successful, but suffered from channel profile instability due to headcut migration and the lack of scour protection at the toe. Preventing scour would have

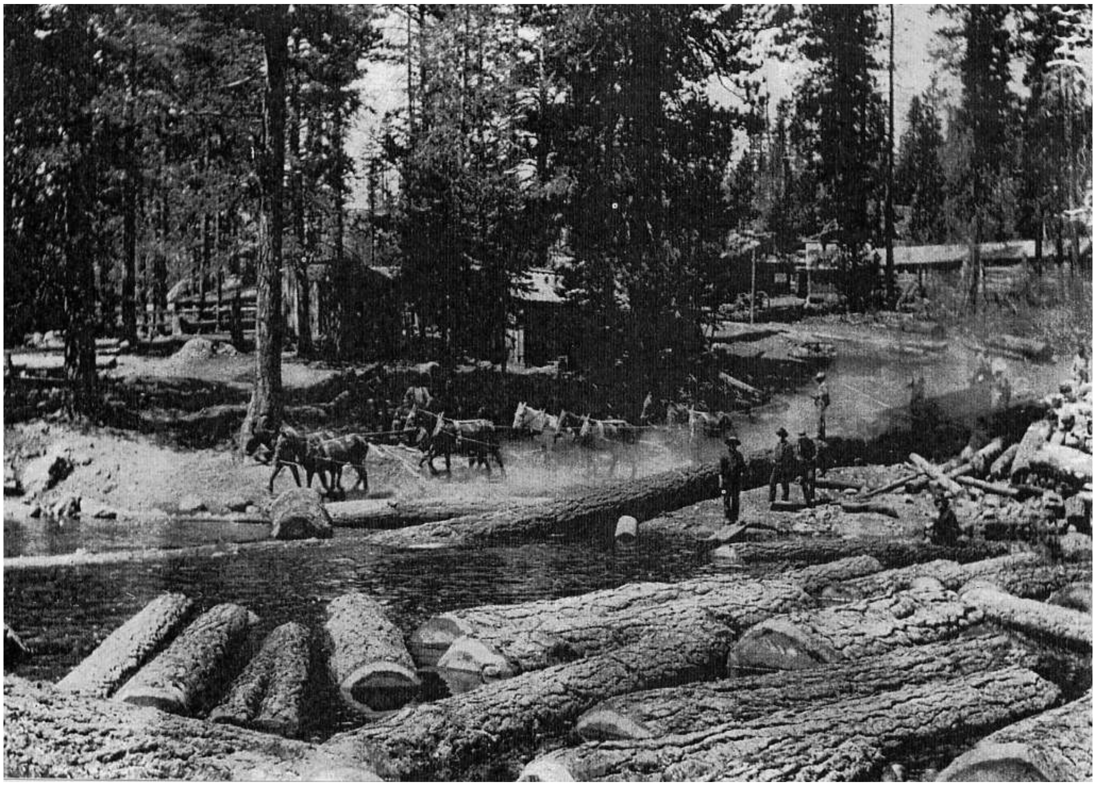


FIGURE 2.9: Photo of loggers using splash dam to transport logs. Saw logs were floated down the Upper Truckee River to Lake Tahoe. The site may be near the confluence of Angora Creek and the Upper Truckee River. (Photograph courtesy of Special Collections Department, University of Nevada, Reno.)

required excavation below the streambed, which was a construction method not in practice in the Lake Tahoe Basin at that time.

Between 1998 and 2002, two stream restoration projects were completed on Angora Creek yielding 7,000 linear feet of restored channel and floodplain. These projects involved reconstruction of the channel and/or re-occupation of old remnant channels, but the main objective was to overcome historic incision. The mouth of Angora Creek was relocated to near its original location.

II.3 IMPACTS TO ECOSYSTEM

The ecological effects of the UTR channel deepening over the last 140 years have been profound. While grazing, clearing land, controlling drainage, hunting and fishing directly impacted wildlife habitat and populations, the change in channel morphology negatively affected habitat-forming processes that sustained the original ecosystem. As described above, the original pre-1860s hydrologic conditions in the Holocene floodplain and riparian zone were controlled by groundwater levels that in turn were set by riffles in the low flow channel. With the channel incision, the groundwater table dropped, which eliminated wetland vegetation species in favor of drier upland species. Remnant channel oxbows show an abundance of wetter vegetation communities that have survived lowering the groundwater table by extending roots; the absence of saplings or young riparian plants and the invasion of species that favor drier conditions (lodgepole pine) indicate that the hydrologic conditions favoring their regeneration are gone. Many areas have converted from wet gaminoid meadows and obligate sedge wetland to dry meadow and lodgepole forest.

The native fisheries of Lahontan Cutthroat Trout and Mountain Whitefish have been largely extirpated from the UTR and the Lake Tahoe Basin, due to over-fishing and the introduction of competitive game fish, such as rainbow trout, brown trout, and brook trout. Lake trout and Kokannee have also been introduced into Lake Tahoe.

Aside from the direct effects of introduced species and over-fishing, the incision of the UTR has had several effects. First the straightening of the channel reduced channel length and available habitat between Meyers and Elk's Club by two miles. The incision of the channel bed introduced an increased supply of fine sediment, eroded from unstable banks into the low flow channel; this often reduces substrate quality affecting spawning habitat and macroinvertebrate production (i.e. fish food), however this has been partially offset by recruitment of gravel from bank erosion and complex deposition patterns in the low flow channel. Perhaps most importantly, straightening and incision has produced sections of channel that are homogenous in geometry and grain size without pool development, riparian cover, gravel substrate, or the hydraulic characteristics that favor foraging, refuge, spawning and rearing.

Terrestrial wildlife was also affected by historic changes in land use. The early reclamation of marsh areas for grazing reduced the available foraging areas for deer, bear and other mammals. Vegetation clearing and reduction in riparian plants has reduced songbird and other avian habitats; logging in the surrounding areas would has negatively impacted raptor and owl habitats as well.

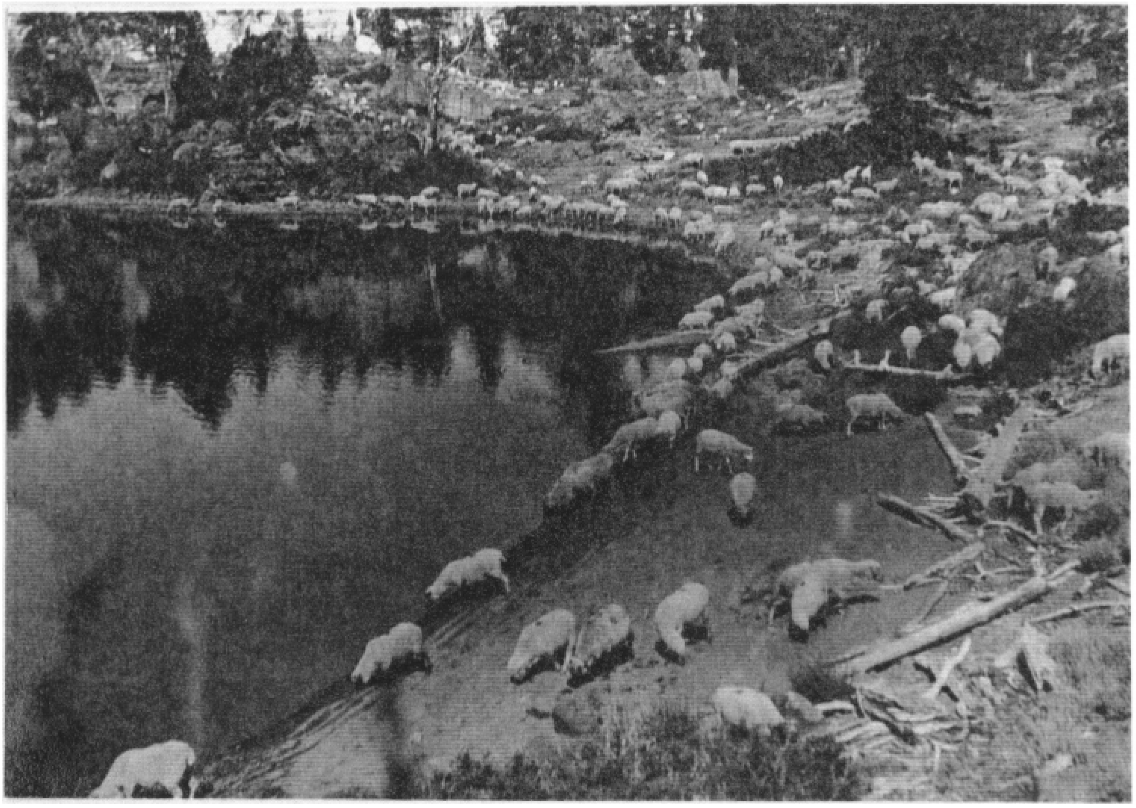
II.4 WATER QUALITY IMPACTS

The water quality of runoff from the UTR discharged into Lake Tahoe has degraded as a result of early land use changes. The introduction of grazing to the floodplain meadow areas and the watershed introduced pathogens, elevated nutrient levels and increased areas of soil disturbance and erosion. Grazing in the UTR project corridor occurred between the 1850s and the 1960s; in the Upper Watershed grazing could have started in the 1840s, and at some periods, included sheep grazing as well as cattle (Figures 2.10 & 2.11). Grazing along stream zones where the water course was the main supply of drinking water often resulted in "chiseled" banks with barren soils, a lack of vegetation cover and trampled substrate. The 1940s aerials indicate many barren streambanks, a wide channel with fresh bars of sediment and little indication of recent vegetation colonization. These features all suggest grazing impacts were significant in 1940.

Watershed conditions during the Comstock Era were also significantly affected by grazing and logging. As described above, sheep and cattle grazing were seasonal uses in the Upper Watershed area, particularly concentrated in meadows and lakes. Logging was intensive in the late 1800s and early 1900s in the lower project area surrounding the UTR below Meyers in what is now Washoe Meadows State Park. Historical accounts and the extensive stands of old growth Jeffrey Pine, red fir and white fir indicate that Christmas Valley and the Upper Watershed were not logged extensively. Shirley Taylor (2003) reports that her ancestors rejected a proposal to extend a rail line into the Christmas Valley for increased logging access.

The history of Lake Tahoe suggests that the clarity of the Lake was not seriously affected, or it recovered from Comstock Era logging and grazing. The period between the end of the Comstock boom and the 1950s was relatively quiet in the basin with the unique exception of the introduction of beaver into the watershed in the 1930s. Beavers are discussed in greater detail below. Although the landscape changed forever after the Comstock Era, it appears to have been fairly resilient to the effects of early land uses. That changed in the 1950s when the tourism economy began its mercurial rise.

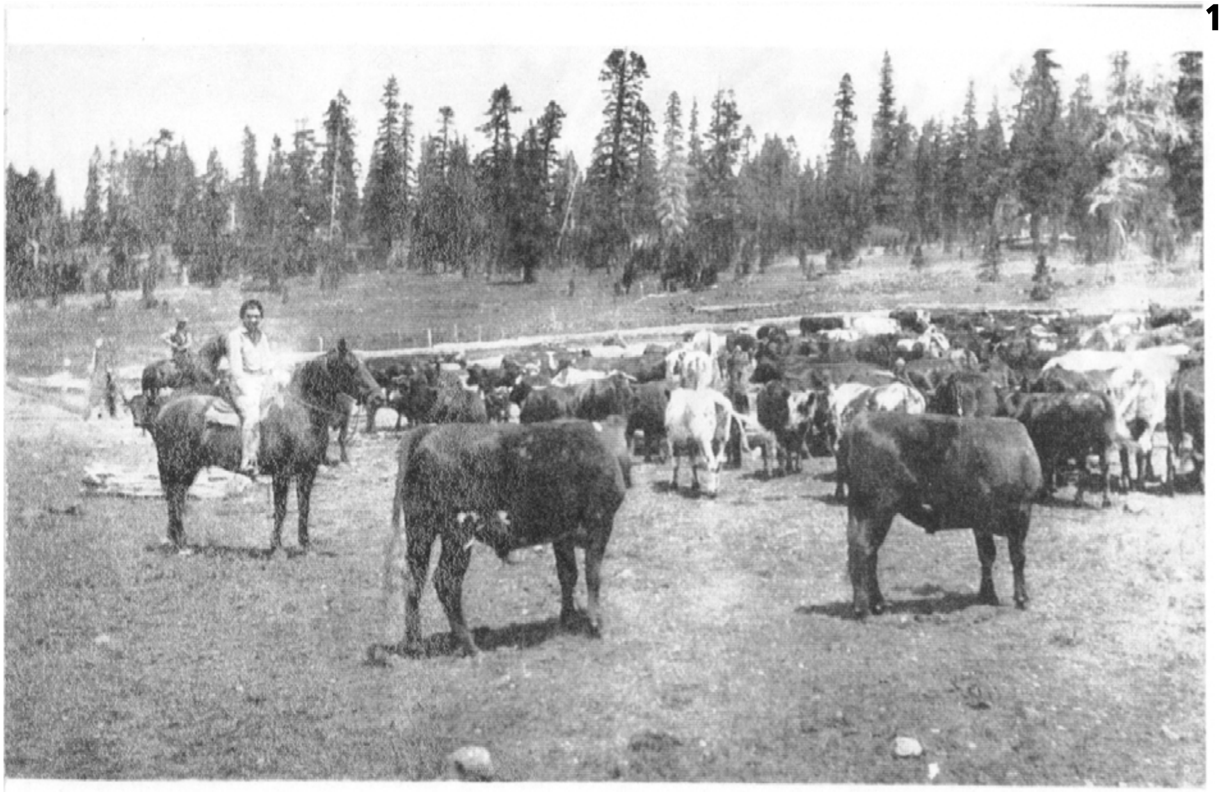
The expansion of tourism in the 1950s led to the development of summer homes and cabins in the South Shore and Meyers area surrounding the UTR. The Tahoe Paradise development included moderate density residential subdivisions, modeled after city suburban developments that had expanded in the post-war boom. This style of development resulted in many roads criss-crossing the landscape, including roads crossing steep terrain. Roads are the primary cause of watershed disturbance, since their construction involves soil disturbance and erosion. Modification of


1910


2003

FIGURE 2.10: Photos of Round Lake taken in 1910 and 2003. Notice the heavy sheep grazing in the 1910 photo.

1910



2003

FIGURE 2.11: Photos of Meiss Meadow taken in 1910 and 2003. Notice the heavy cattle grazing in the 1910 photo.

drainage patterns and localized hydraulic effects at road crossings that were often fill and culvert structures caused significant hydrologic and ecologic disruption. Road crossings often sever the continuity of streamflow and the riparian vegetation corridor and form barriers to the migration of aquatic wildlife. The roads are a component of urban hardscape that hydrologically generate more runoff than the natural landscape. Finally, roads provide access to undeveloped areas and lead to construction of more structures and greater hydrologic modification.

Urban development requires the expansion of infrastructure, such as highways, sewer and utility systems and dense commercial development. The Highway 50 corridor includes a commercial strip of gas stations, restaurants, stores and other businesses. The emphasis on recreational uses has led to construction of two golf courses, one in Meyers (i.e. Tahoe Paradise Golf Course) and the other located at the downstream end of the project area (i.e. LTGC). These uses have led to significant physical changes to the UTR and tributary streams, and perhaps more importantly, the introduction of new pollutant sources of sediment, nutrients and urban toxins, such as hydrocarbons and heavy metals.

The network of roads, commercial and residential development expanded quickly in the UTR Upper Reach project area between the late 1950s and early 1970s. Over 2,500 acres of the land within one mile of the UTR river corridor became developed urban land. Since the 1970s, the density has increased with infill developments in both commercial and residential areas.

It became apparent in the mid 1960s that the rapid urbanization led to a significant decline in the clarity of Lake Tahoe. The apparent resilience of the Lake to remain unaffected by land use impacts was lost, and with greater understanding of the rate of clarity loss and the projected limnological trends, the future of the Lake's legendary clarity was at risk. The loss of clarity has been attributed to an increase in algae growth induced by excessive nutrient and fine sediment delivery. Nutrient inputs from the surrounding urban land use stimulate algal growth in this naturally oligotrophic Lake. In the late 1960s, it was also apparent that treated and untreated wastewater effluent discharged to the Lake was a contributing factor. In response, all of the wastewater generated in the Tahoe Basin was exported, including construction of an export line along the UTR and over Luther Pass. Other measures taken include restrictions on development and development and implementation of Best Management Practices (BMPs) for water quality protection on all existing and proposed development. A list of BMPs can be found in Table 2.2.

In addition to implemented and planned BMPs for roads and structures within the UTR watershed (Figure 2.12A&B) and the greater Lake Tahoe Basin, the planning and implementation of stream restoration projects along the UTR began in 1993 with the Cove East Project sponsored by CTC. These projects are focused on water quality improvements, as well as ecosystem restoration.
The first phase of the Cove East or Lower West Side project was implemented in 2001 with the removal of 82,400 yards of fill and restoration of a portion of the marsh destroyed in the late 1950s by the Tahoe Keys development. The second phase is investigating the restoration of the lower three miles of the UTR, including what was once a deltaic/lagoon system near the mouth.

ID	Problem Description
1	Culvert FAP89-P002 is plugged from roadway sand. The water is forced through Culvert FAP89-C01. Neither culvert has treatment.
2	Sand accumulating on side of road. No current treatment for this area.
3	Culvert 2312-P001 has tendency to freeze in winter. Excess flow goes over roadway and onto parcel across the street (APN-036-554-11).
4	Water pools during storm events. Sand from culvert FAP89-P002 is deposited here. Excess back water from culvert 2312-P001 also pools here.
5	Roadside pull-out may be oversized for the amount of use occurring.
6	Roadside pull-out may be oversized for the amount of use occurring.
7	Runoff from HW 89 flows through this area and into culvert 2312-P002.
8	Culvert 2312-P002 experiences debris jams during storm events. Channel leading into 2312-P002 may be too small creating sheet flow across Grass Lake Road.
9	Evidence of eroding channel leading into natural rock lined channel. Also evidence of overflow during high events.
10	Water is flowing over the road and pooling at road side pull-out.
11	Road side pull-out that may be unnecessary.
12	Channel is eroding and may not be sized correctly.
13	Discharge from culvert 2312-P004 is directed at side of channel, causing erosion during high flow.
14	Outlet channel for culvert 2312-P004 requires treatment.
15	Potential livestock pollution form property (APN 036-502-01) upstream of culvert 2312-P005.
18	Culvert 2312-P006 backs up during high flow events. Culvert is also not located in a localized topographic low.
19	Roadside channel not sized correctly.
20	Grass Lake Creek may been diverted upstream creating excess flow for culvert 2312-P008. During high flow events water flows over sand bags placed just to the north of the inlet, down roadside ditch to culvert 2312-P007.
21	Roadway flooding from multiple sources: down Grass Lake Road, from roadside ditch on side of Grass Lake Road, overflowing roadside channel containing re-directed Grass Lake Creek flow.
22	Culvert 2313-P001 culvert may be undersized.
23	Culvert 2313-P002 is squashed with some flow occurring underneath the culvert. The culvert may also not be sized correctly.
24	Cut bank forming on side of Creek, which may infringe on Grass Lake Road.
25	Snowplow turn-around area creating shoulder erosion.
26	Two culverts in place where one may be more appropriate. During dry season water flows through culvert 2312-P010 and during storm events water also flows through culvert 2312-P009.
27	Sheet flow down road during high flow events.
28	Sheet flow from road flows through pullout and into river without treatment.
29	Denuded area
30	Three denuded areas on east side of Grass Lake Road. May be directly on top of export line.
31	Denuded area on west side of Grass Lake Road.
32	Denuded area in front to Forest Service Parcel (APN 036-48-102).
33	Cleared area on east side of Grass Lake Road across from southern boundary of APN 036-554-11.

TABLE 2.2: Identified road-related problems in El Dorado County. Taken from Christmas Valley Erosion Control Project Phase 1: Existing Conditions Report. February, 2003. Refer to Figure 2.12B.

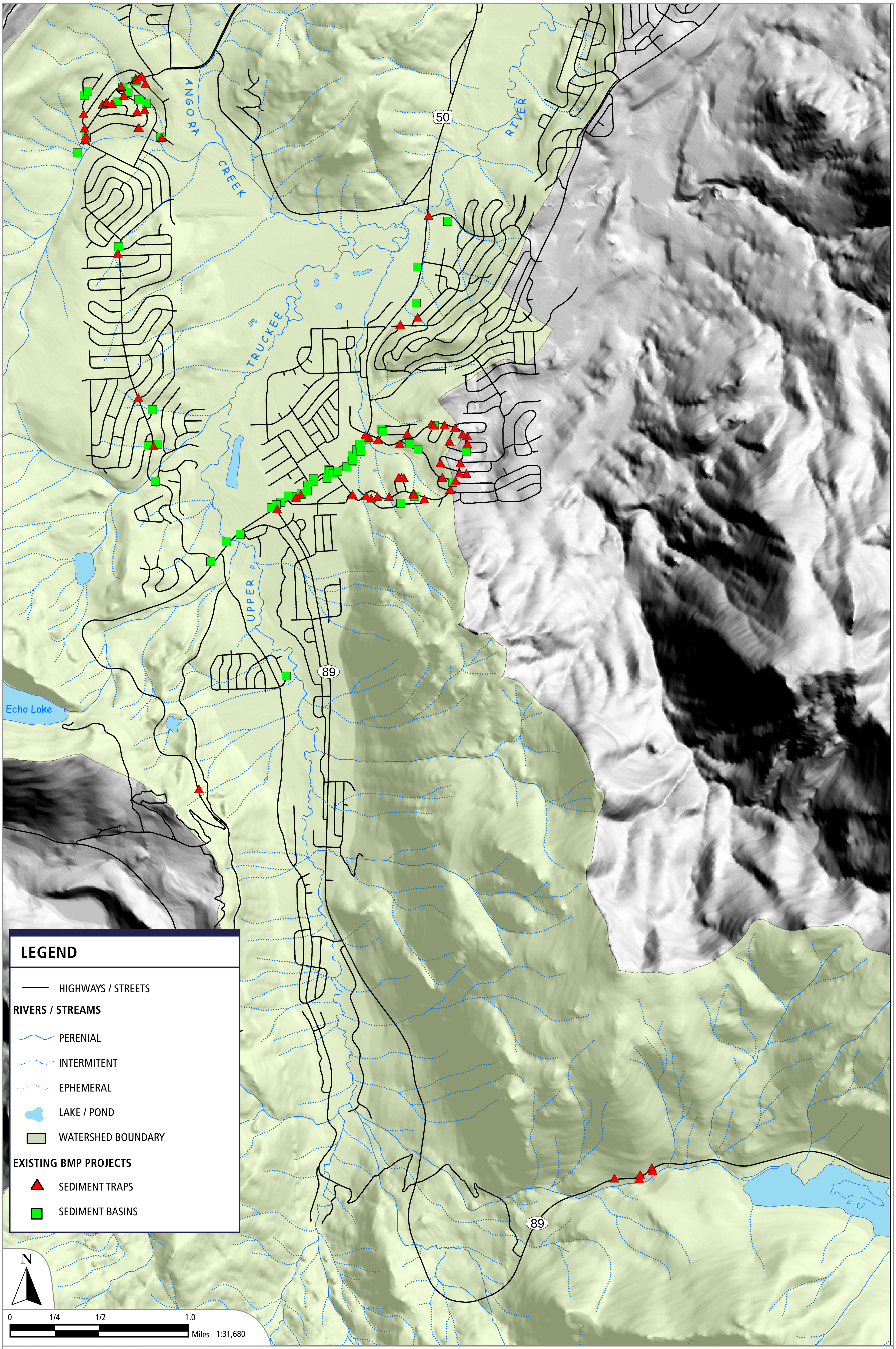


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FIGURE 2.12A: Map indicating existing BMP projects for the Upper Truckee River Watershed.
Data source: www.dot.ca.gov/dist3/projects/tahoe.

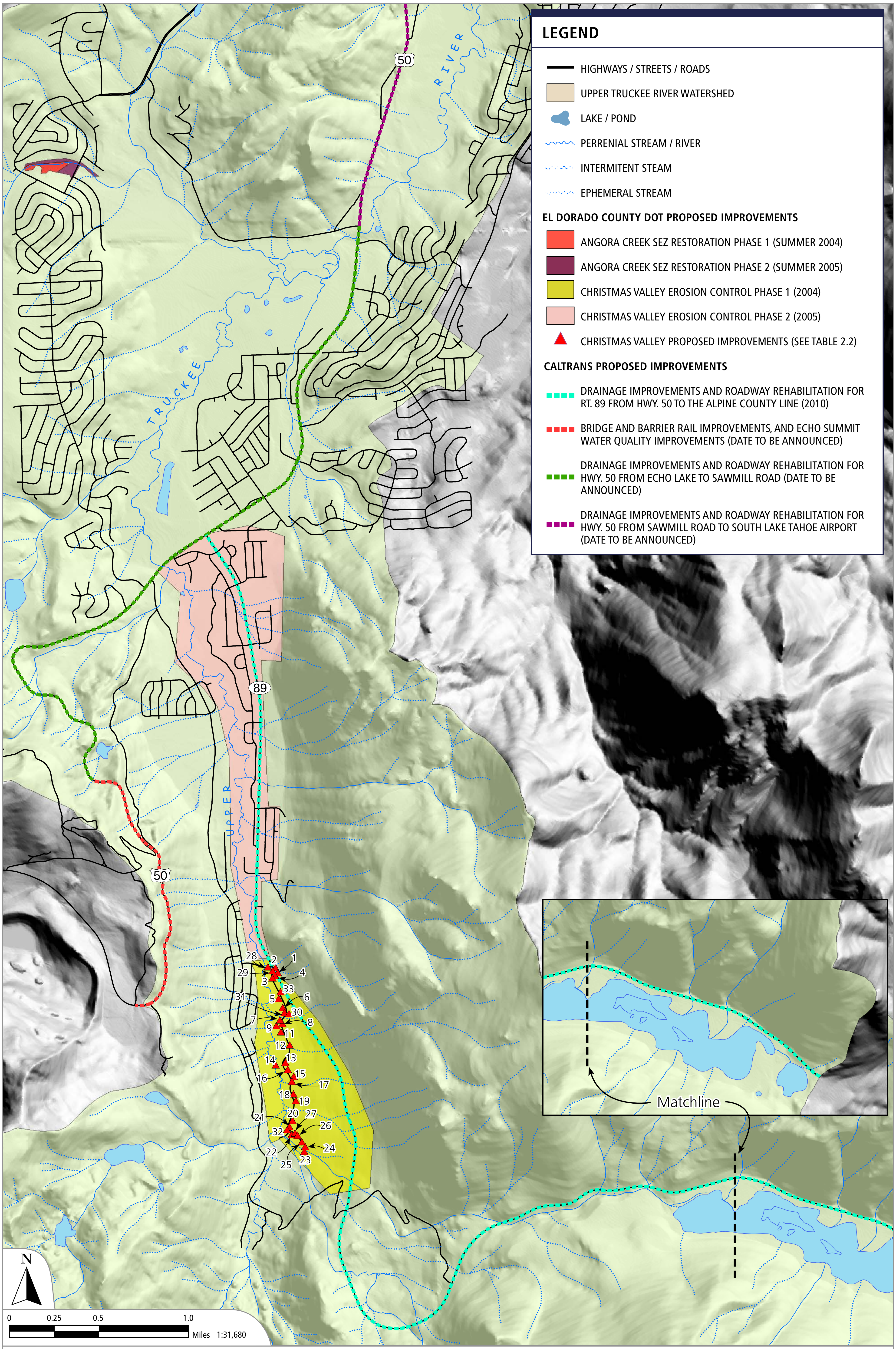

FIGURE 2.12B: Map indicating road-related drainage, erosion, and sediment control projects proposed by CalTrans and El Dorado County for the Upper Truckee River Watershed. Data source: www.dot.ca.gov/dist3/projects/tahoe and County of El Dorado Department of Transportation.

A plan for restoring or enhancing the Middle Reach of the UTR between the lower Highway 50 crossing and Sunset Ranch was completed in January of 2003 and is set to enter a design phase by January of 2004; project construction may begin as early as summer of 2005. The restoration or enhancement of the UTR Upper Reach is the focus of this report.

II.5 REFERENCES CITED

Birkeland, P.W. 1963. Pleistocene Glaciation of the Northern Sierra Nevada, North of Lake Tahoe, California. Jour. Geology, v. 72, p. 810 – 825.

Cushing, E.J. and Wright, H.E., Jr. Eds. 1967. Quaternary Paleoecology. New Haven. Yale University Press. p275 – 301.

Global Environmental. 1996. Upper Truckee River & Wetlands Restoration Project Lower West Side-Barton Meadow. July, 1996.

Lindström, Susan & Rucks, Penny. 2000. A contextual overview of human land use and environmental conditions. Lake Tahoe Watershed Assessment: Volume I. Prepared for USDA-Forest Service, Tahoe Regional Planning Agency, UC-Davis, University of Nevada-Reno, and Desert Research Institute.

-------2003. Upper Truckee River Reclamation Project. Upper Reach, Planning and Design Heritage Resource Study, Phase 1. October, 2003.

Swanson Hydrology + Geomorphology. Jan 2003. Final Report, Upper Truckee River Middle Reach Reclamation Project, Environmental Assessment, Feasibility Report and Conceptual Plans. Prepared for Tahoe Resource Conservation District. January, 2003.

Taylor, Shirley. 2003. Personal communication, 7-10/03 (great granddaughter of Amelia Celio who was the daughter of Carlo Guisseppi Celio, 530-577-0642). South Lake Tahoe.

III. Existing Conditions

The preceding discussion of historical changes to ecosystem function leads to the present conditions and the baseline conditions for any environmental restoration or enhancement projects. The following chapter presents existing conditions information and data for individual areas of concern to be used in the evaluation of the impacts and benefits of potential alternatives. Each section below provides a description of present conditions and the opportunities and constraints for development of restoration and enhancement options.

III.1 HYDROLOGY, WATER QUALITY AND GEOMORPHOLOGY

The UTR experiences cool dry summers and wet, cold winter seasons. The average precipitation for the UTR is around 32.8 inches, most of which occurs as snow between November and April. Table 3.1 shows the average monthly precipitation data for the station operated by NCDC near Tahoe City over the past 30 years. Although the bulk of precipitation occurs as snowfall, there are periods during El Nino years when large warm rainstorms occur in the middle of winter and melt the existing snowpack to create the highest peak streamflows of record. These events are referred to as 'Pineapple express' storms for the entrained subtropical jet stream that delivers warm moisture to the Lake Tahoe Basin following a winter snowfall. Outside of the main winter snow season, there are periods of rainfall during summer thunderstorms and the beginning and end of the winter season when the weather is warmer. Thunderstorms can be intense, as demonstrated by the storms of August 21, 2003, when nearly 1 inch of rain fell in South Lake Tahoe within a few hours.

Table 3.1: Mean monthly and annual weather data for the Lake Tahoe Basin area. Mean maximum and minimum temperature and mean precipitation provided by the NCDC Tahoe station near Tahoe City for 1971-2000 (www.wrcc.dri.edu)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Annual**
Mean Max. Temperature (F)	40.5	42.0	45.1	51.4	60.1	69.2	77.5	77.0	70.1	60.0	47.9	41.4	**56.9**
Mean Min. Temperature (F)	20.1	21.3	24.3	27.7	33.5	39.6	44.7	44.8	39.6	32.3	25.5	20.6	**31.2**
Mean Precipitation (in.)	6.01	5.71	4.57	1.82	1.21	0.77	0.33	0.46	0.90	1.95	4.25	4.68	**32.74**

III.1.A Hydrology

A USGS stream gage in the Study Area of the Upper Truckee River is located 1000 feet downstream of the Meyers Highway 50 crossing. USGS gage #10336600 operated from 1960-1986 above Echo Creek and the current stream gage, USGS gage #103366092 located below Echo Creek (see Figure 3.1 for locations), has been collecting data since 1991. Figure 3.2A shows the average annual and annual peak discharges measured at the two gages since 1960. The average annual discharge is 72 cfs over the 38 years of record. Figure 3.2B shows the average annual hydrograph as measured at the gages. Figure 3.3 is the monthly probability of exceedence for the Upper Truckee River at Meyers and shows the variance in monthly flow between wet and dry years.

Streamflow on the UTR is dominated by snowmelt runoff in the late spring-early summer months. The flow duration curves for spring (March through July) and winter (August through February) periods presented in Figure 3.4 show that the spring series has higher flows for the bulk of discharges (50 to 99.9% of time flow exceeded), but the winter series has higher peaks during the less frequent events (1 to 10% of time flow exceeded). The flood of record occurred on January 1, 1997 and resulted in a peak flow of 5,120 cfs at the Meyers USGS gage. This storm occurred after a series of snowstorms that left several feet of snowpack at lake level (6200 feet MSL). The storm of December 31, 1996 and January 1, 1997 was a classic “Pineapple express” storm with the resulting storm producing rainfall below elevation 8,000 feet. The rainfall rapidly melted the snow and essentially doubled runoff volumes. Flood damage and geomorphic change was unusually light in most reaches of the UTR, although in many areas significant bank erosion occurred, as well as channel incision and localized channel avulsions in Christmas Valley.

The annual and partial duration series peak flood frequency analyses for the Meyers gage is shown in Table 3.2. The partial duration analysis incorporates all flows exceeding 200 cfs for the period of record, in contrast to an annual series, which includes the single highest flow each year of record. When the rainfall events are separated from snowmelt significant differences are revealed between snowmelt and the rain on snow events, which produce the largest floods. For example, a 50-year discharge for the rain on snow events is 4160 cfs versus 1550 cfs for snowmelt (using the partial duration analysis). This difference is significant from a geomorphic perspective, as the landforms and geomorphic work produced by these two events are distinctly different; this is discussed in greater detail below; evidence shows that the channel forming processes are more related to annual snowmelt flow than large rain on snow events, which have occurred in 1997, 1986, 1974, 1964 and 1955.

III.1.B Water Quality

The main water quality concerns on the UTR are sediment, nutrients (nitrogen and phosphorous), iron, and to a lesser extent other urban runoff pollutants such as heavy metals, pesticides and hydrocarbons. The water quality data reviewed for this project was limited to fine sediment, nutrients, and iron data collected and provided by other sources.

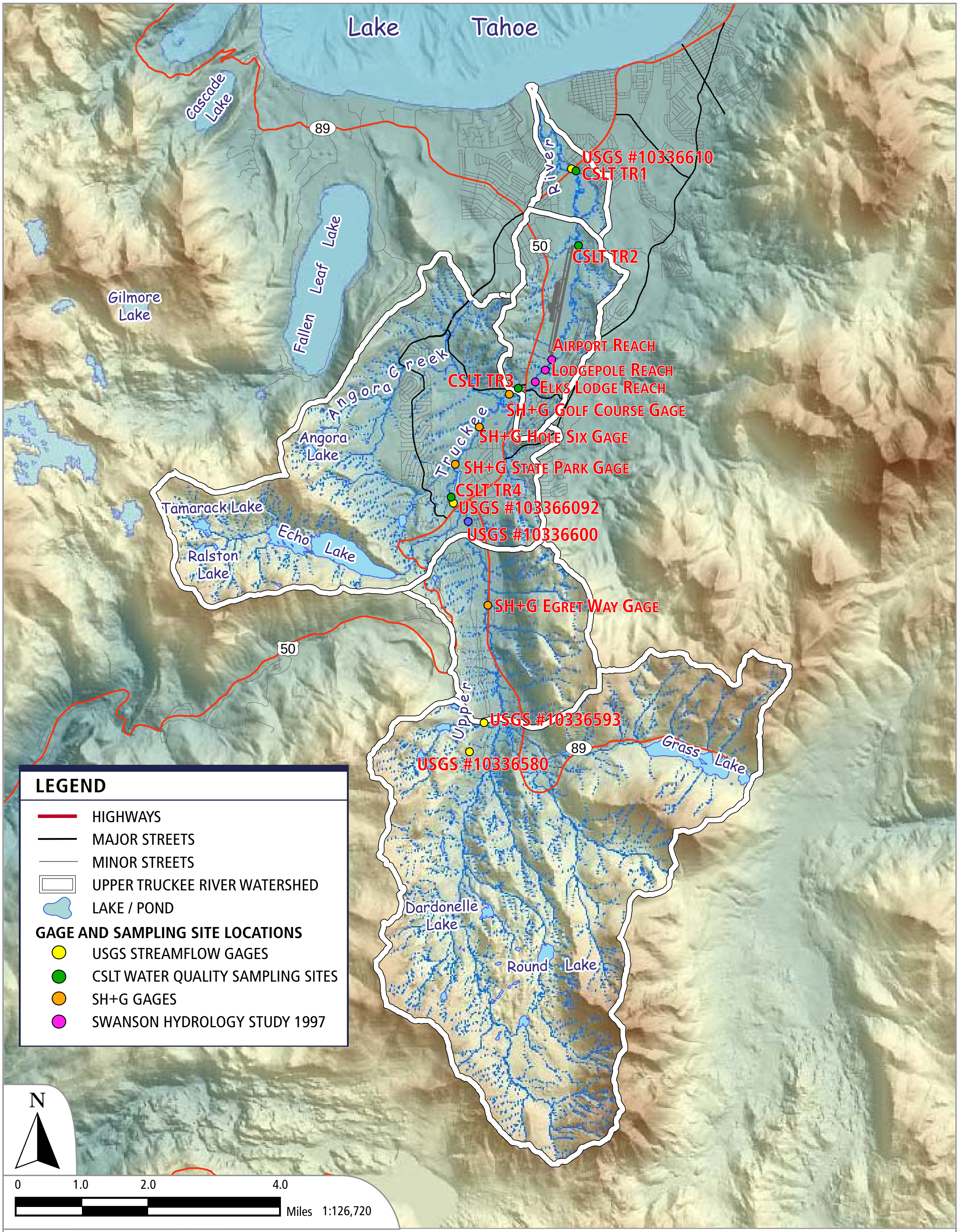

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FIGURE 3.1: Location of water quality and streamflow gages in the Upper Truckee River Watershed.

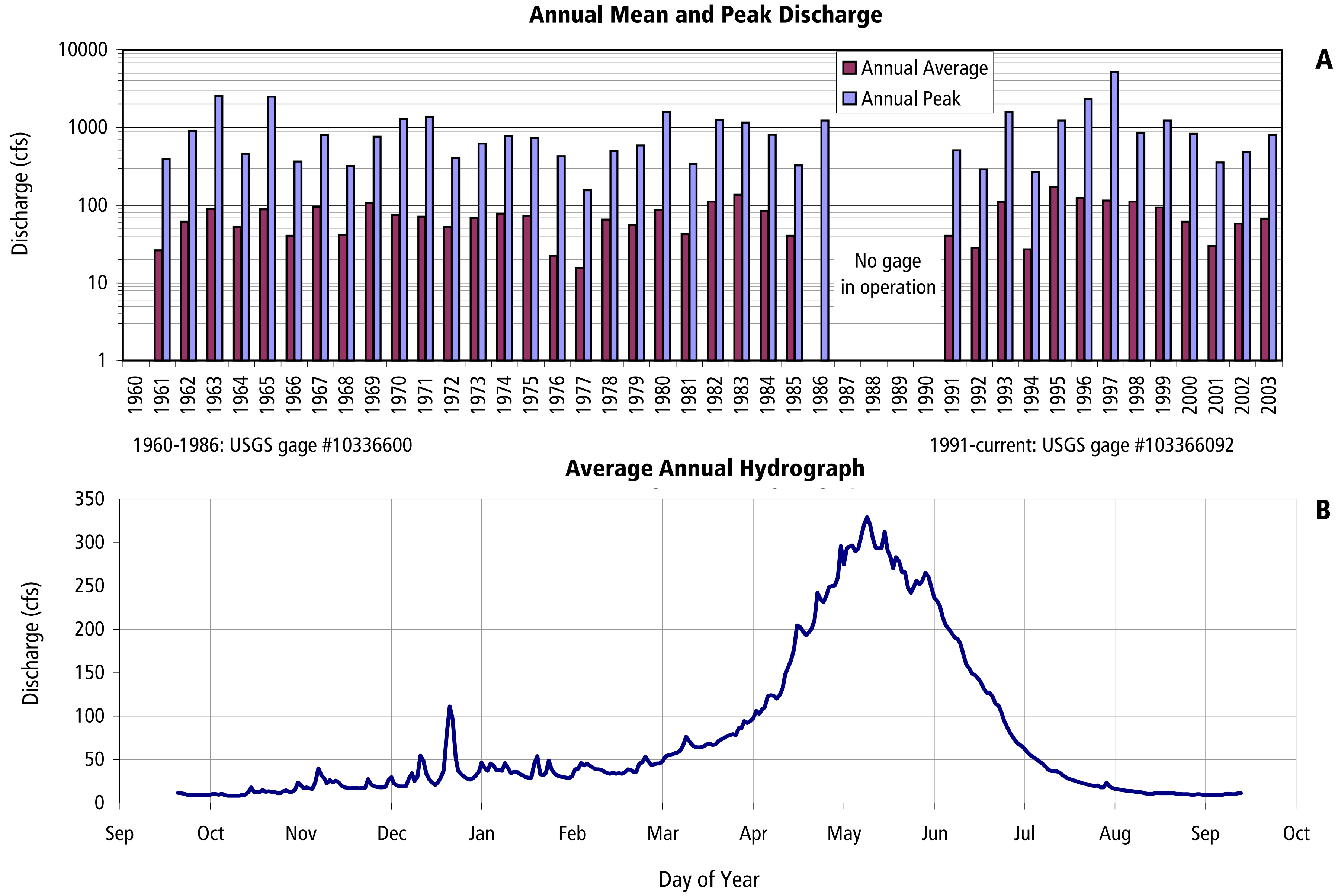


FIGURE 3.2: Hydrology summary for Upper Truckee River at Meyers using data from USGS gages #10336600 and #103366092. A: Annual mean discharge and annual peak discharge for years of record (1961-1986, 1991-2003). The average annual discharge was calculated to be 72 cfs. B: Average annual hydrograph based on 38 years of daily streamflow data.

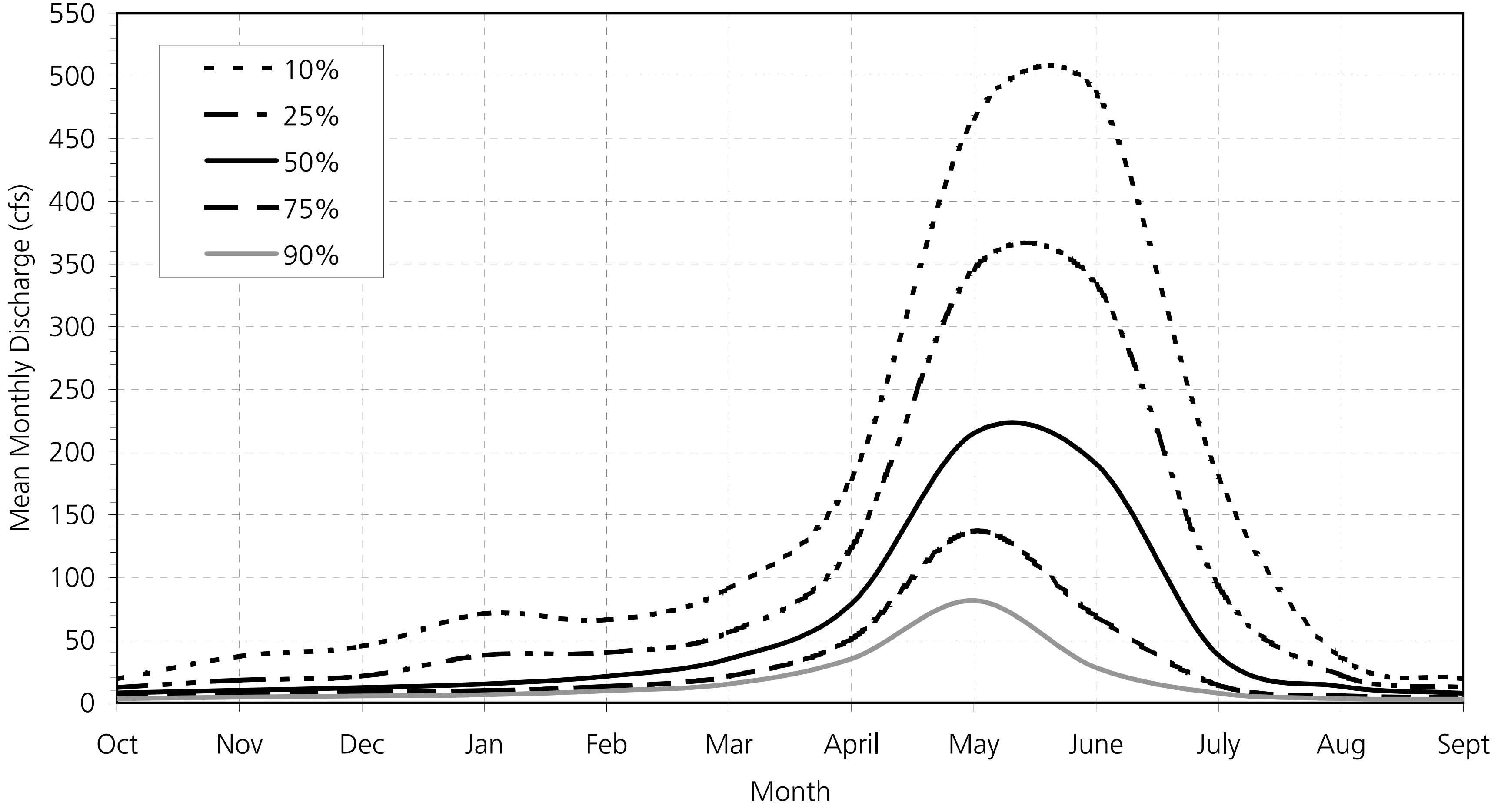


FIGURE 3.3: Percent exceedence of discharge per month for Upper Truckee River at Meyers. This is a cumulative distribution of flows by month, illustrating the magnitude of flows greater than 10, 25, 50, 75, and 90% of all the mean daily flows of record. Data from USGS #10336600 (1961-85) and #103366092 (1990-2001) are combined.

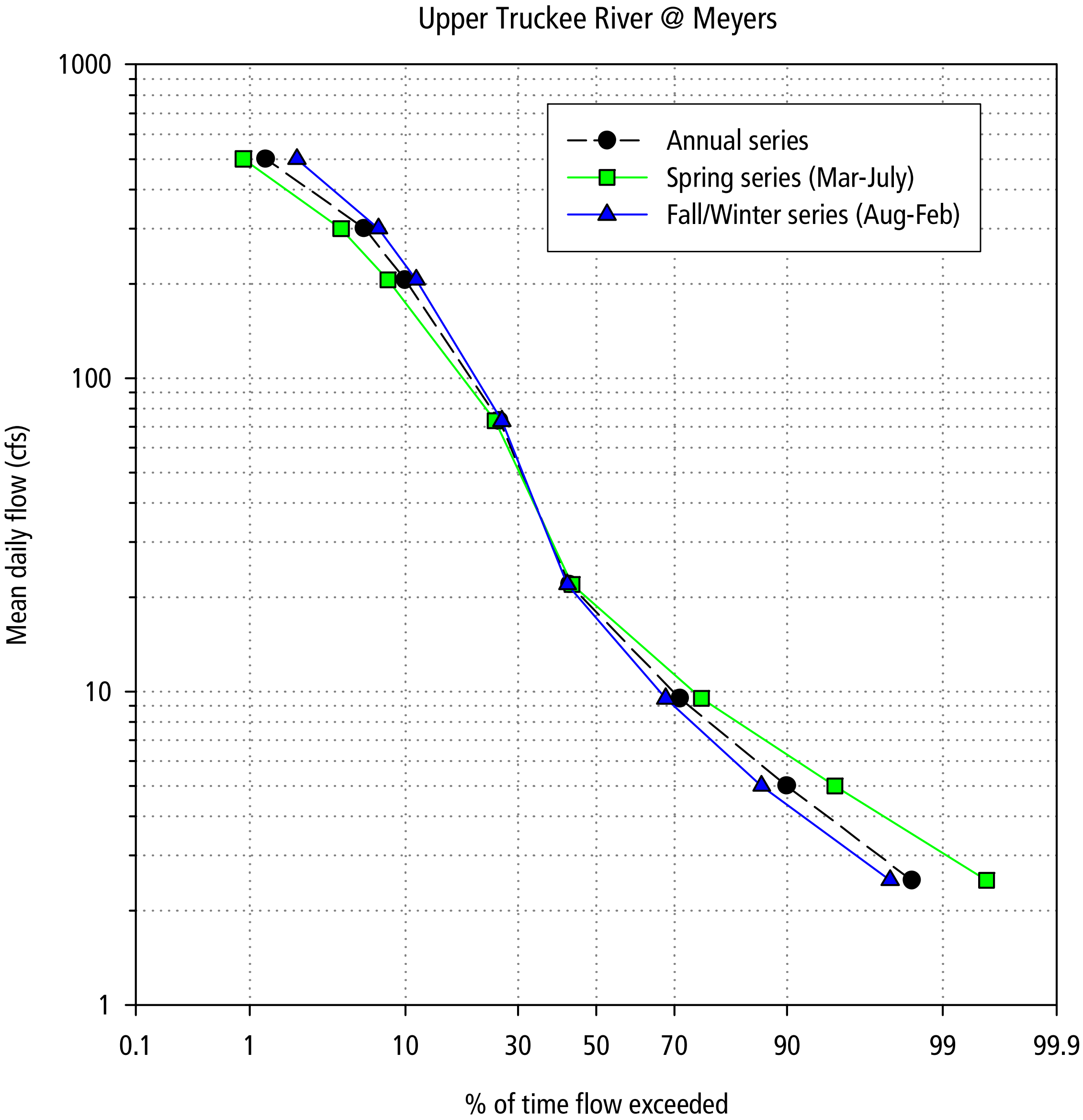


FIGURE 3.4: Flow duration curves for the annual, spring, and winter series for the USGS streamflow gages on Upper Truckee River at Meyers, #10336600 (1961-1986) and #103366092 (1990-2001). Data is compiled from mean daily discharges.

Analysis Type	All Data					Spring Series (Mar-Jun)					Fall/Winter Series (Aug-Feb)				
	n	Bankfull (1.5 return year) (cfs)	10-year (cfs)	50-year (cfs)	100-year (cfs)	n[□]	Bankfull (cfs)	10-year (cfs)	50-year (cfs)	100-year (cfs)	n[□]	Bankfull (cfs)	10-year (cfs)	50-year (cfs)	100-year (cfs)
Annual Peaks	39[♐]	502	1950	3780	4830	38	460	1310	2030	2380	38	146	1430	4520	6930
Partial Duration [♌]	129[♐]	336	1120	2250	2960	96	344	938	1550	1860	32	346	1720	4160	5830

[♌] A base discharge of 200 cfs was used for partial duration analysis.

[□] Peak winter and spring discharge for each year were either taken from the annual series or identified by peak mean daily flow and instantaneous peak discharge

[♐] Peak discharge data for Water Year 1961 did not include the date of the event. Consequently it was not used in the spring and winter series analysis.

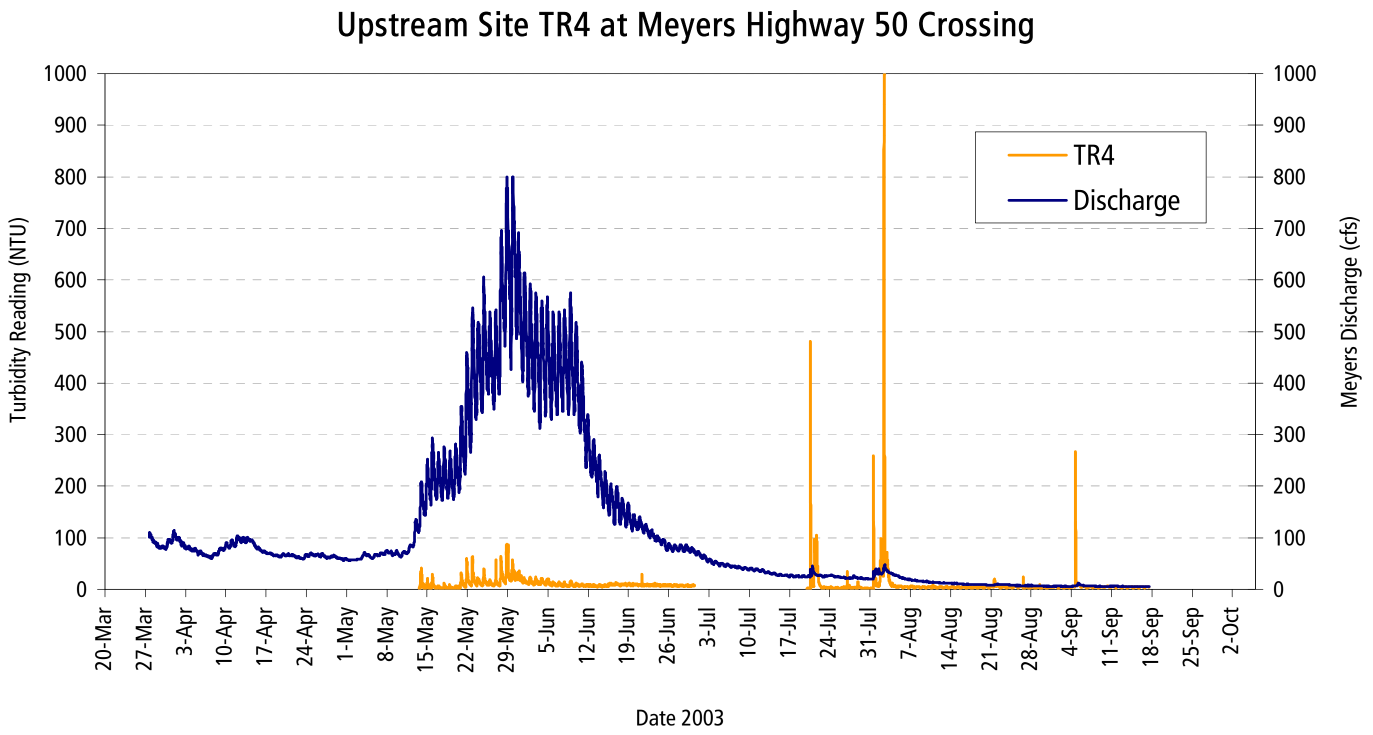
TABLE 3.2: Flood Frequency Analysis results for Upper Truckee River near Highway 50 in Meyers, CA. The data records for USGS gage #10336600 (1961 to 1986) and #103366092 (1991 to 2003) were combined for this analysis. Data provided by USGS website, Earthinfo USGS Peak Values software, and Kip Allander of the USGS. Analysis was performed using HEC-FFA.

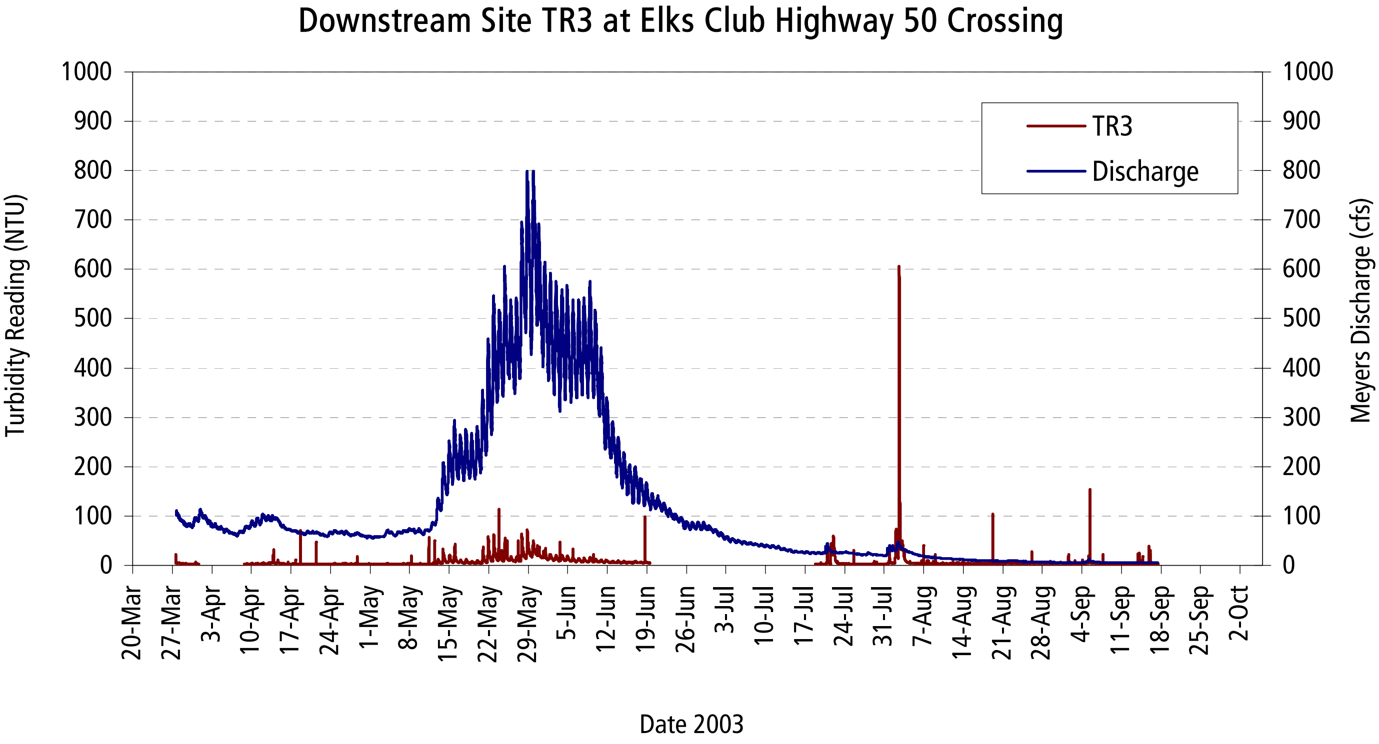
SEDIMENT

The UTR transports a wide range of sediment sizes from boulder to fine silts and clays and dissolved constituents (wash load). In general, the coarser sediments (cobble to gravel and sand sizes) can affect channel stability and substrate quality when released in excessive quantity; these effects are discussed further in the geomorphology and aquatic habitat sections. Fine sediment discharge (ranging from fine sand to clay sizes) has the greatest impact on the clarity of Lake Tahoe. Fine clay particles have a high affinity for adsorption by phosphorous and iron, thus transporting these nutrients to the Lake, where disassociation process can release these nutrients into solution at a later time. Also, fine sediments originating from volcanic rocks can become dispersive clays and remain in suspension in the water column for long periods of time. Excessive fine sediments also originate from soil disturbance areas along roads and developed areas (an assessment of erosion along roads in developed areas is presented in Section III.1.C).

A recent study by the USDA (Simon et al 2003) was conducted on the relative annual fine sediment sources to Lake Tahoe. The USDA Study found that the UTR is responsible for the highest annual sediment delivery to Lake Tahoe (2200 T/yr) followed by Blackwood (1930 T/yr) and Second Creek (1410 T/yr). These findings are not surprising given that the UTR has the largest drainage area of all Basin streams. The Upper Truckee River was also found to be the greatest contributor of fine sediment with an annual load of 1010 T/yr and the majority of the fine sediment sources in the UTR were found to originate within the channel due to increasing land use disturbances and channel instability (Simon et al 2003).

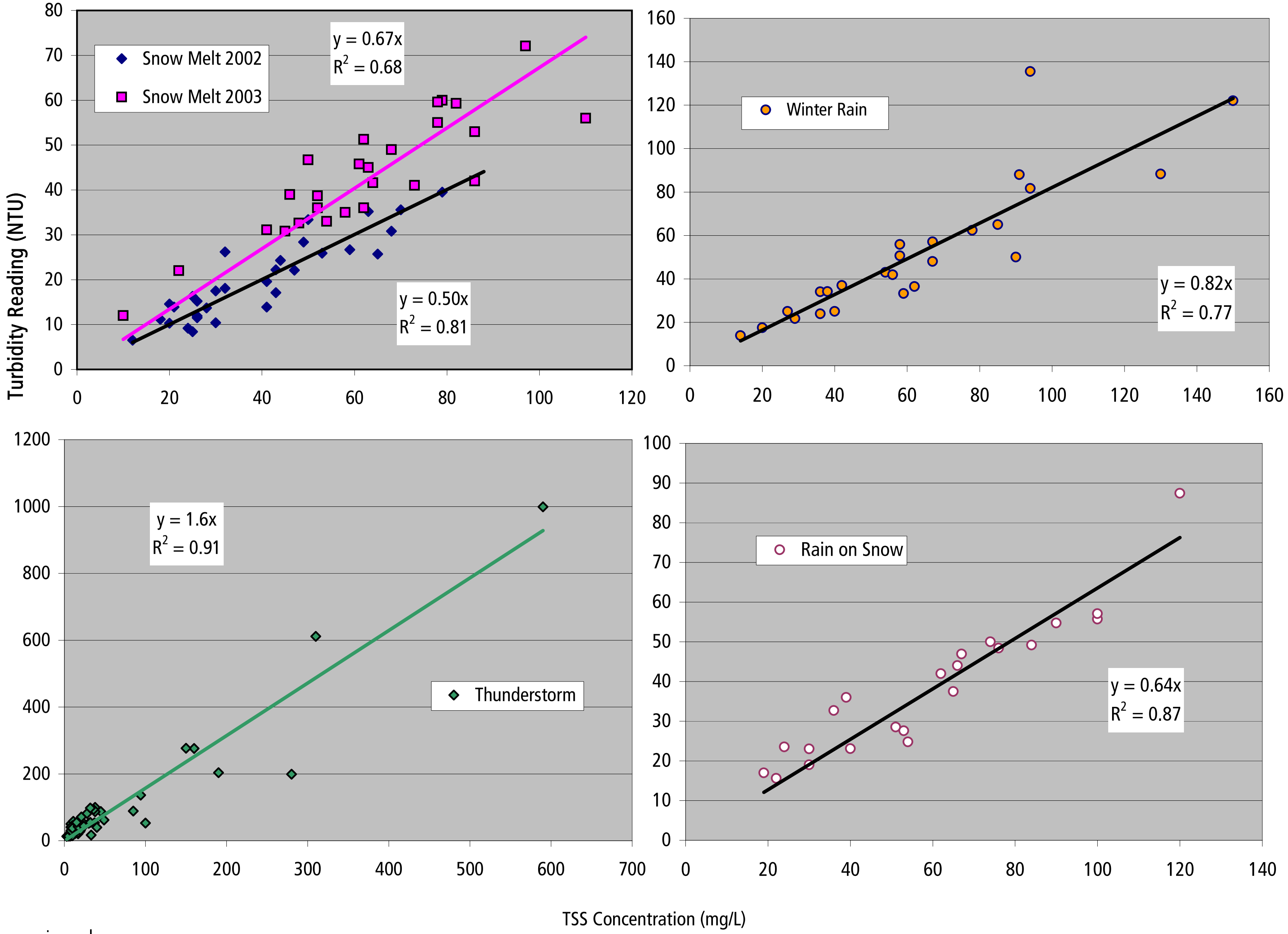
Continuous fine sediment measurements in the UTR have been collected at four locations in the UTR by R. Wigart of the City of South Lake Tahoe (CSLT) (see Figure 3.1 for CSLT TR monitoring locations). At each of these locations the CSLT has installed YSI data loggers complete with turbidity probes, capable of measuring stream turbidity on 15-minute intervals. The turbidity readings (NTU) can be calibrated to total suspended sediment (TSS) concentrations when instrument readings are correlated to grab sample TSS concentrations. The CSLT provided all of the available turbidity and grab TSS data to SH+G for interpretation. Only data from the monitoring stations TR4 and TR3 are discussed in this report, since these sites border the upstream and downstream ends of Reaches 1-4 (Elks Club Highway 50 crossing to Meyers Highway 50 crossing). Figure 3.5 presents the 2003 real-time turbidity data from TR4 (Meyers Highway 50 crossing) and TR3 (Elks Club Highway 50 crossing) along with 15-min streamflow data and illustrates that spring snowmelt delivers and carries a consistent fine sediment load, while flashy summer thunderstorms can mobilize high amounts of sediment in short periods of time. Based on TSS grab samples, a rating curve was created for each runoff event type and the real-time turbidity data can be converted to TSS loads (Figures 3.6 and 3.7A). Figure 3.7B presents the upstream and downstream instantaneous fine sediment loads measured during the 2003 snowmelt event. Figure 3.8 compares the total and daily peak snowmelt and thunderstorm fine sediment loads upstream and downstream of the Study Area. Two important findings are illustrated in this data: (1) The sustained elevated flows produced during spring snowmelt result in a total fine sediment load of over 900 tons over a 37-day period in 2003, an order of magnitude more sediment than that the summer thunderstorm series (69 days), and (2) Based on visual observations of the stream





Turbidity data provided by CSLT
Discharge data provided by USGS gage #103366092

FIGURE 3.5: Continuous real-time turbidity data collected by deployed YSI data loggers at sites TR3 and TR4 by City of South Lake Tahoe. Upper Truckee River at Meyers discharge recorded by USGS streamflow gages is also plotted. See Figure 3.1 for site locations.



*Note changes in scale

FIGURE 3.6: Correlation of CSLT turbidity readings to TSS sample concentrations over two years of data collection in Upper Truckee River at stations TR1, TR2, TR3 and TR4. See Figure 3.1 for station locations. The above relationships suggest that the type of storm event drives the fine sediment concentrations mobilized within the Upper Truckee River.

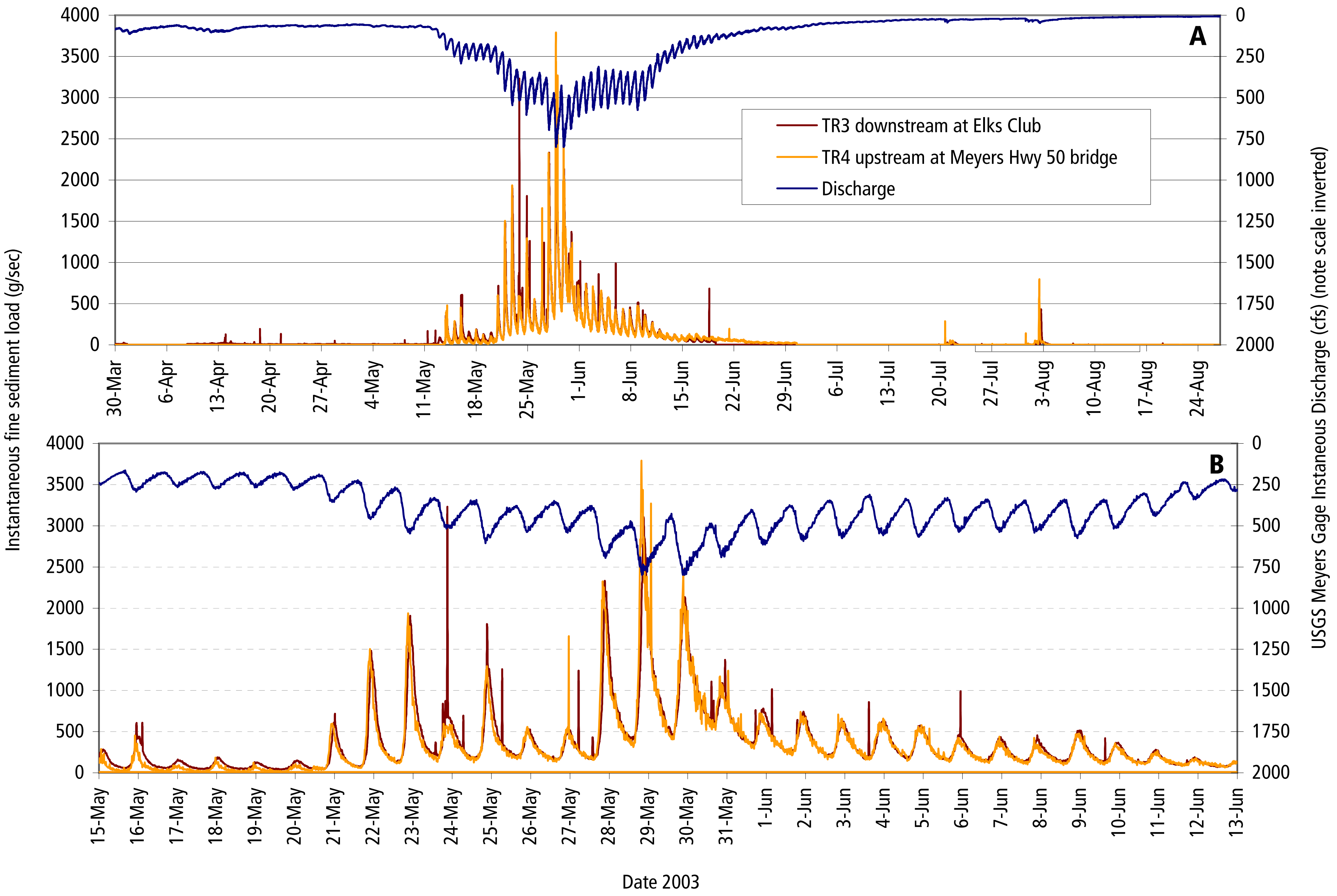
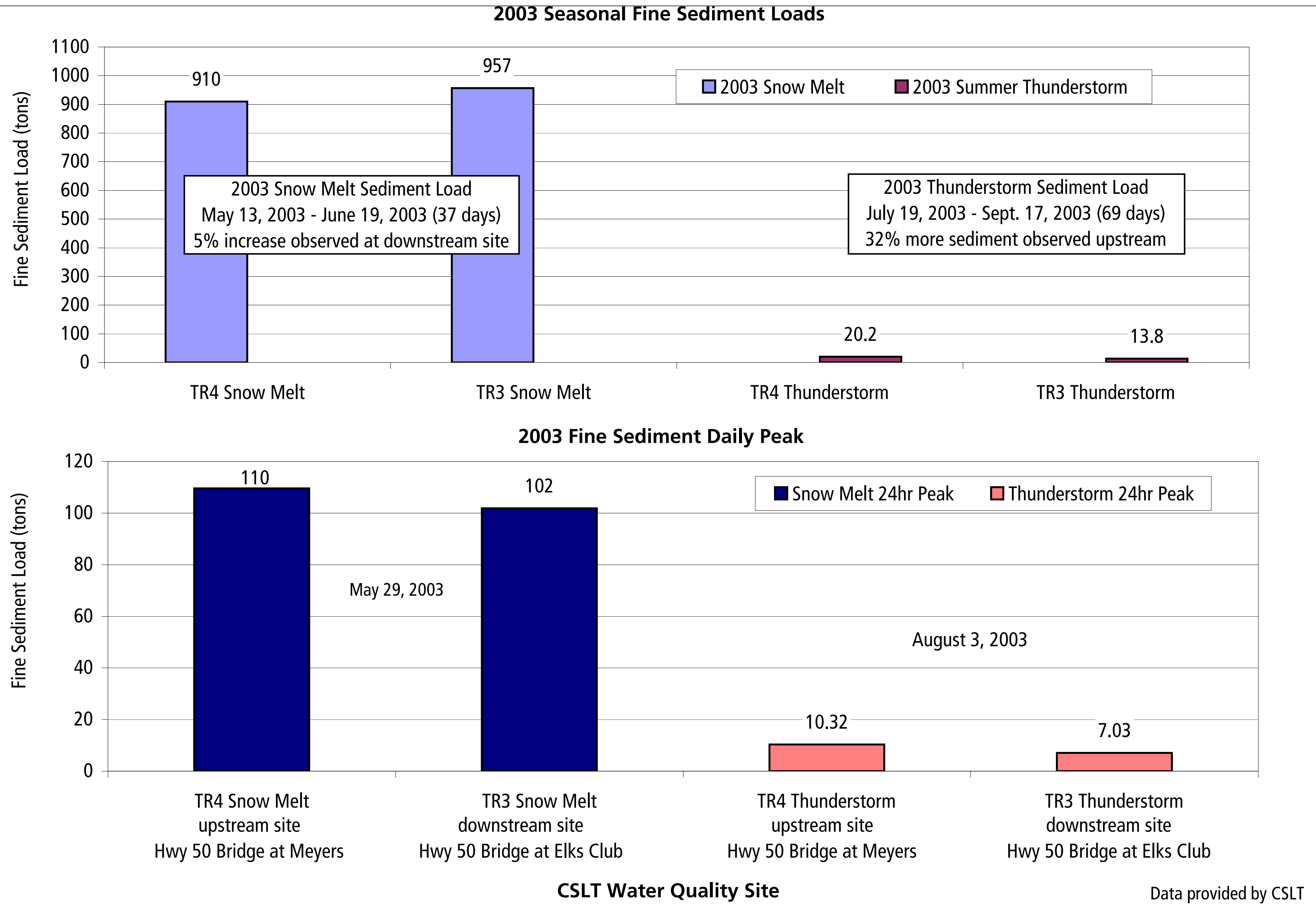


FIGURE 3.7A & B: A: Continuous turbidity data for sites TR3 and TR4 converted to instantaneous fine sediment loads for 2003 data collection period (March 30 - August 31). B: Sediment loads at each site are compared for the snowmelt season (May 15 - June 13). Sediment data provided by City of South Lake Tahoe. Stream discharge data provided by USGS.



Data provided by CSLT

FIGURE 3.8: Comparison of the upstream and downstream sediment loads observed in the Upper Truckee River during 2003 spring snow melt and 2003 summer thunderstorm season. Lower graph compares the upstream and downstream sediment loads during the 48-hour peak discharge for each type of event. See Figure 3.1 for station locations.

bank conditions and the data presented in Figure 3.8, the fine sediment loads may increase downstream through the project Reaches 1-4 as result of channel bank erosion, a finding similar to the results presented by Simon et al (2003) on the fine sediment source in the UTR.

NUTRIENT AND IRON DATA

Over the past 30 years, Lake Tahoe has shifted from a nitrogen-limited oligotrophic system to a phosphorous limited mesotrophic system (Goldman 1988). The clarity of Lake Tahoe has significantly been impacted by the delivery of phosphorous and potentially iron (Fe) (Chang et al 1992) from the surrounding land uses. The shift of the nutrient that limits primary productivity from N to P has profound implications on the future management of nutrient inputs to the Lake to reduce the annual rate of clarity decline of 1 foot per year, as estimated by researchers at Tahoe Research Group. The reduction of biologically and particulate P to the Lake will have the greatest immediate benefit on the metabolic rates of the phytoplankton in the Lake. Event based nutrient sampling conducted by SH+G in cooperation with the TRPA wetland efficiency study (SH+G 2003) found that ground surfaces subjected to the application of anthropogenic fertilizers can result in two orders of magnitude higher concentrations and runoff loads of biologically available P levels than runoff emanating from residential or industrial surfaces. The above SH+G findings lent to current efforts by TRPA to significantly reduce the concentration of P applied to manicured grass surfaces, thereby increasing the fertilizer management requirements of golf courses and recreational facilities. Based on the available surface water nutrient data available for the UTR (CSLT and the USGS), no definitive findings can be made to determine the water quality impact of the LTGC or other land use practices at this time. The data that is available is presented below.

In addition to turbidity measurements, the CSLT collects periodic water samples for nitrogen (N) and phosphorous (P) constituent analyses during elevated flows in the UTR. Figures 3.9 and 3.10 provide the N and P sample concentration data for samples collected and analyzed from TR3 and TR4 since May 2002. The relatively high analytical detection limits for the biologically available N and P species does not provide enough meaningful data. The TKN concentrations appear to be relatively consistent over the array of sampling but TP values were significantly elevated relative to other events during the summer thunderstorm sampling in August 2003 and may be the result of the high fine sediment loads observed during this flashy event.

The additional water quality data available for the UTR system is the periodic nutrient grab sampling done by the USGS at each of their three streamflow monitoring stations (Figure 3.1). Figures 3.11A-C present the daily loads from each of the three sites of the biologically available dissolved nutrient constituents (dissolved phosphorous (DP), dissolved nitrate (NO^{3-}) and biologically reactive iron) that would have the greatest immediate impact on the phytoplankton growth once delivered to Lake Tahoe. The instantaneous streamflow at the time of sample collection is presented in Figure 3.11D, to illustrate the strong correlation between daily loads and discharge, thus the bulk of nutrient loads are delivered to the Lake along with the greatest streamflow volumes.

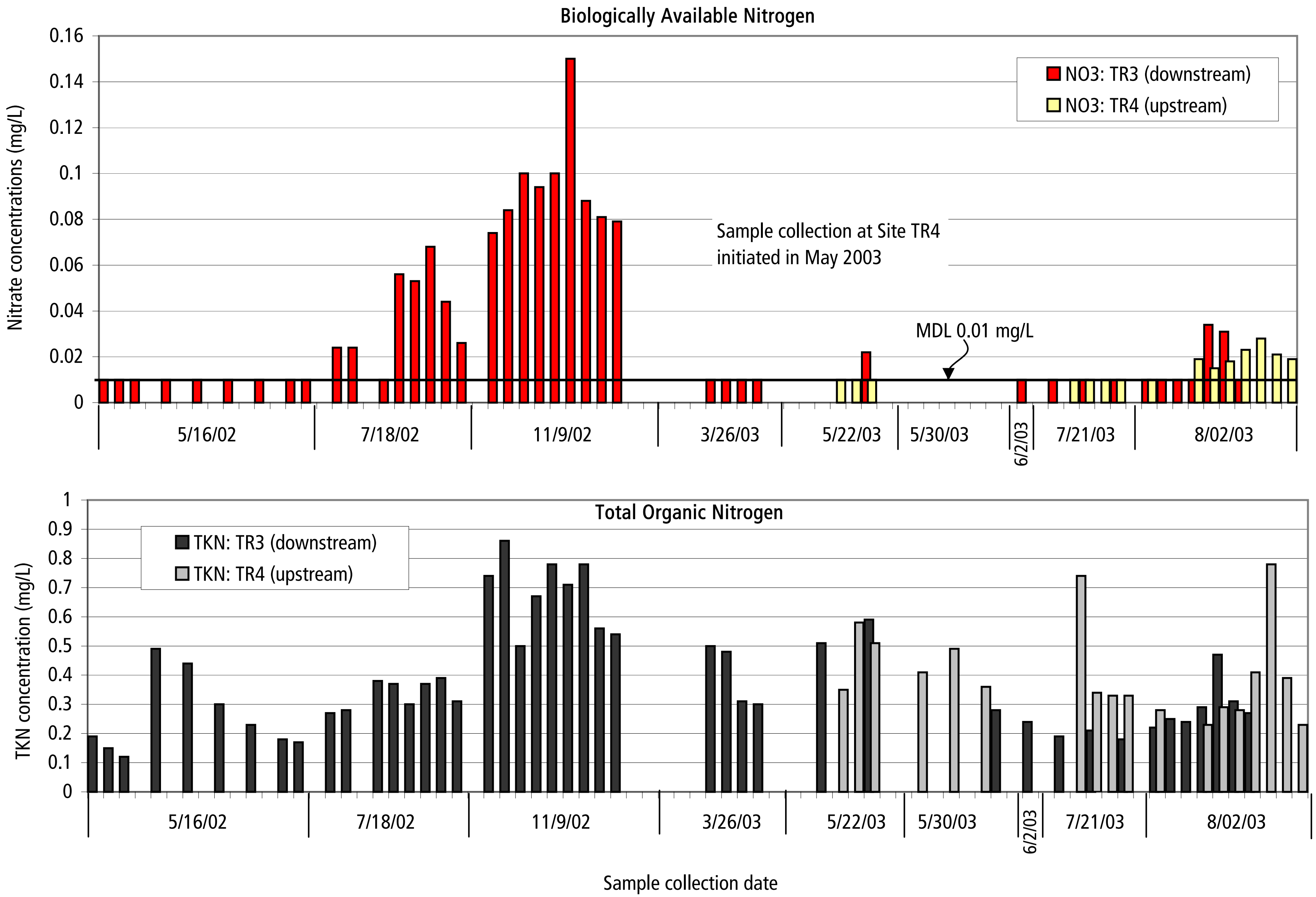
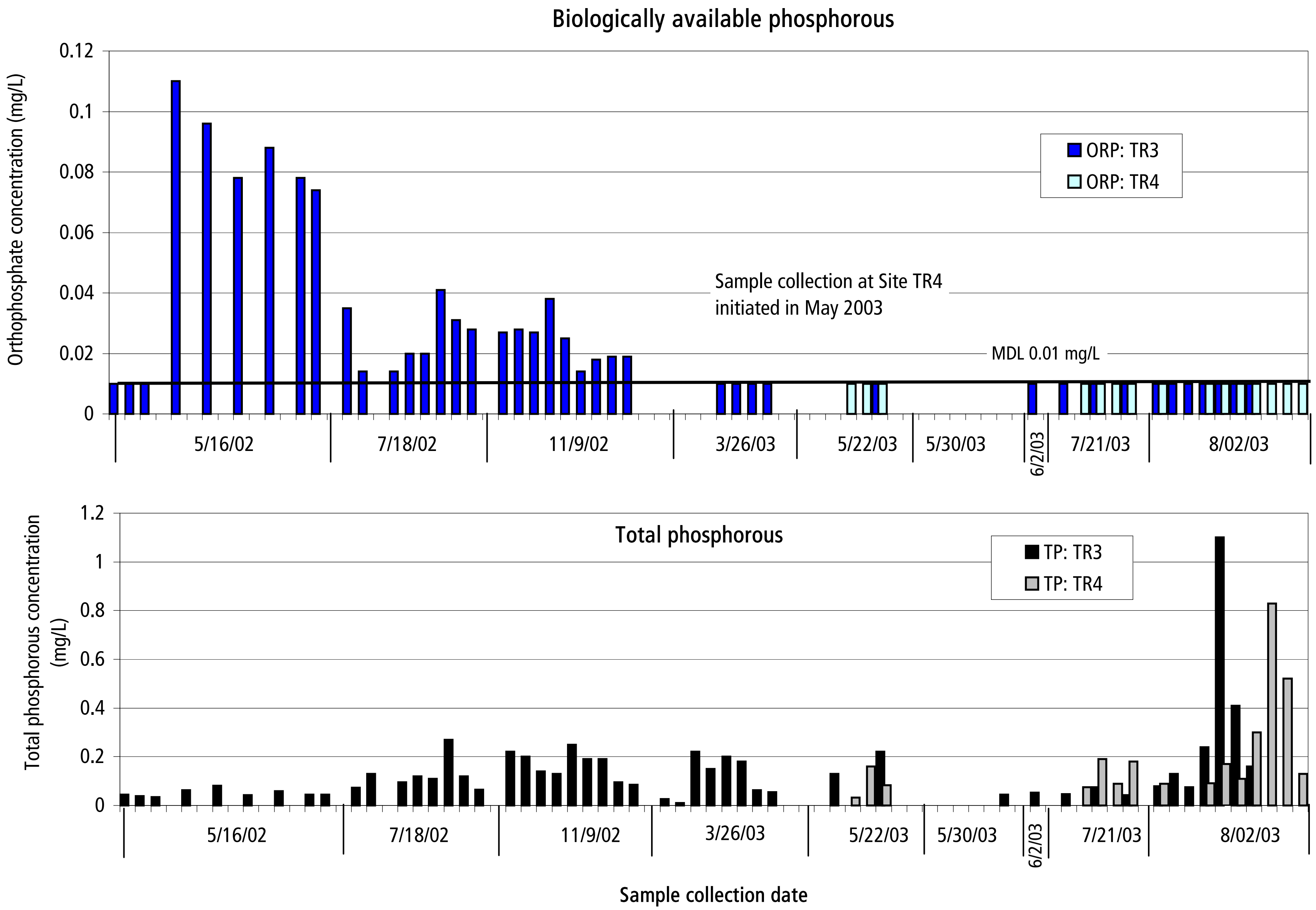


FIGURE 3.9: Concentration data for Nitrate and TKN samples collected at stations TR3 and TR4 during the 2002 and 2003 collection periods. See Figure 3.1 for sample locations.



Biologically available phosphorous

Total phosphorous

FIGURE 3.10: Concentration data for orthophosphate and total phosphorous samples collected at stations TR3 and TR4 during the 2002 and 2003 collection periods. See Figure 3.1 for sample locations.

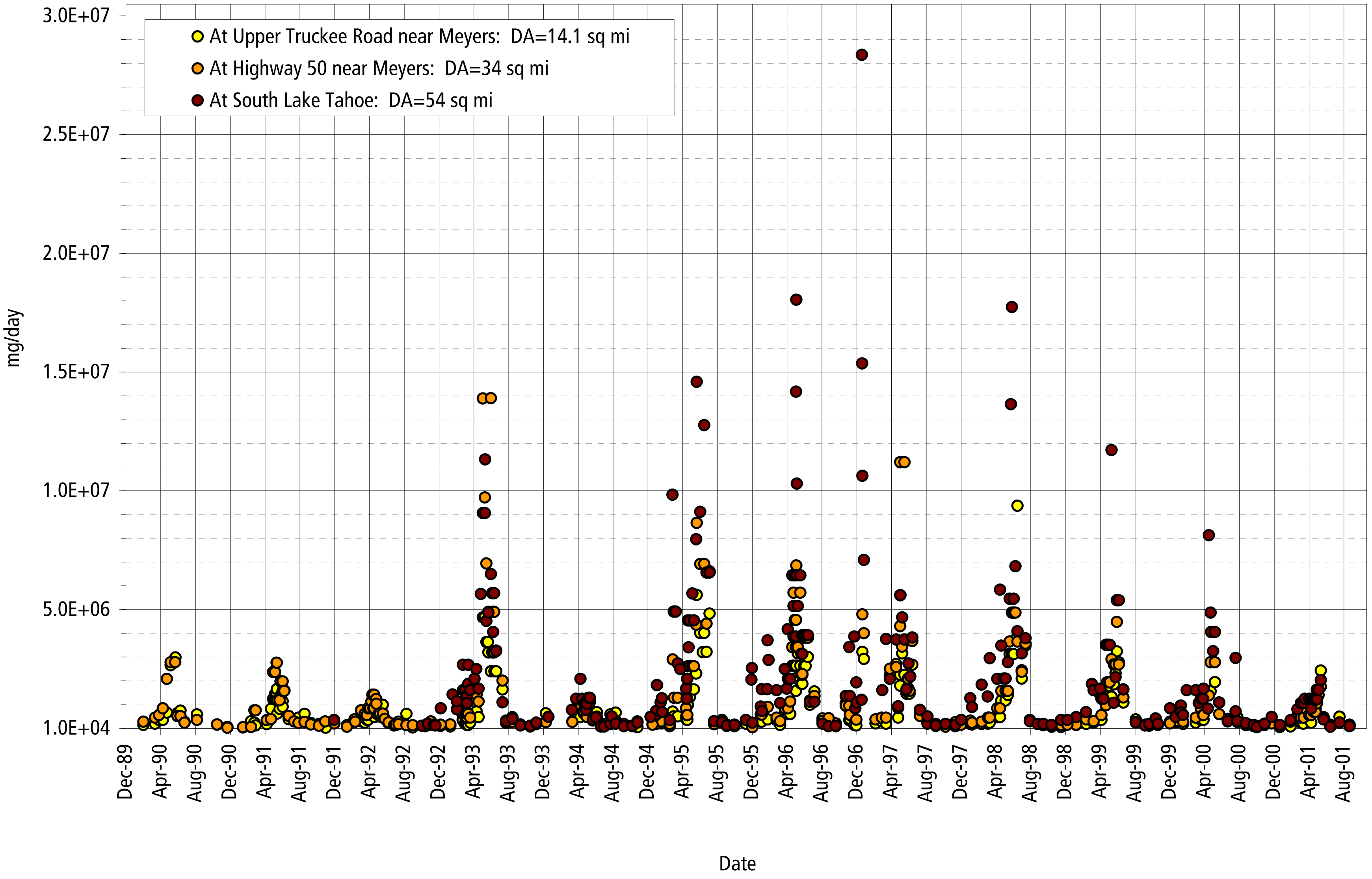


FIGURE 3.11A: Daily dissolved phosphorous loads as measured at the three USGS streamflow monitoring stations.

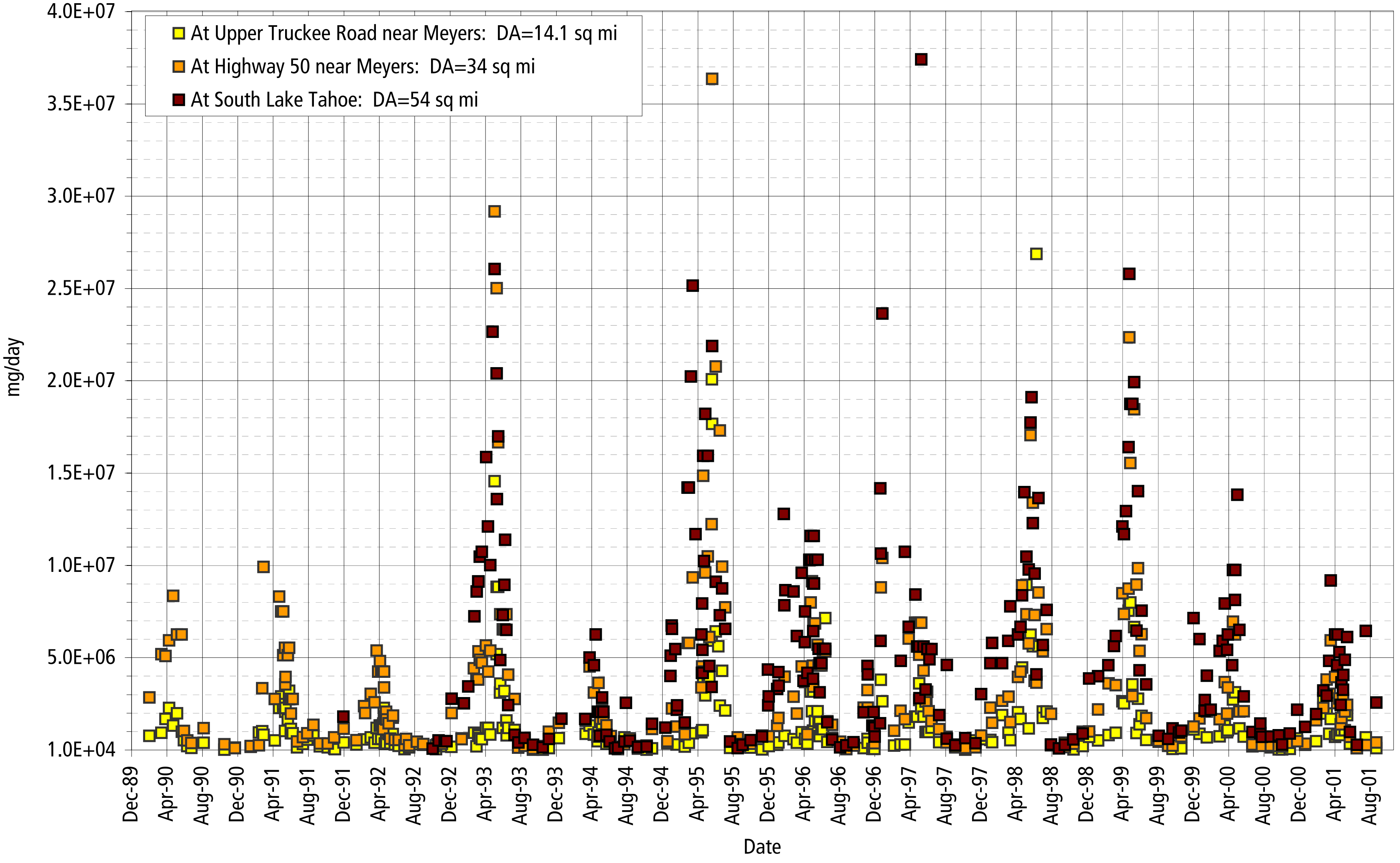


FIGURE 3.11B: Daily dissolved nitrate loads as measured at the three USGS streamflow monitoring stations.

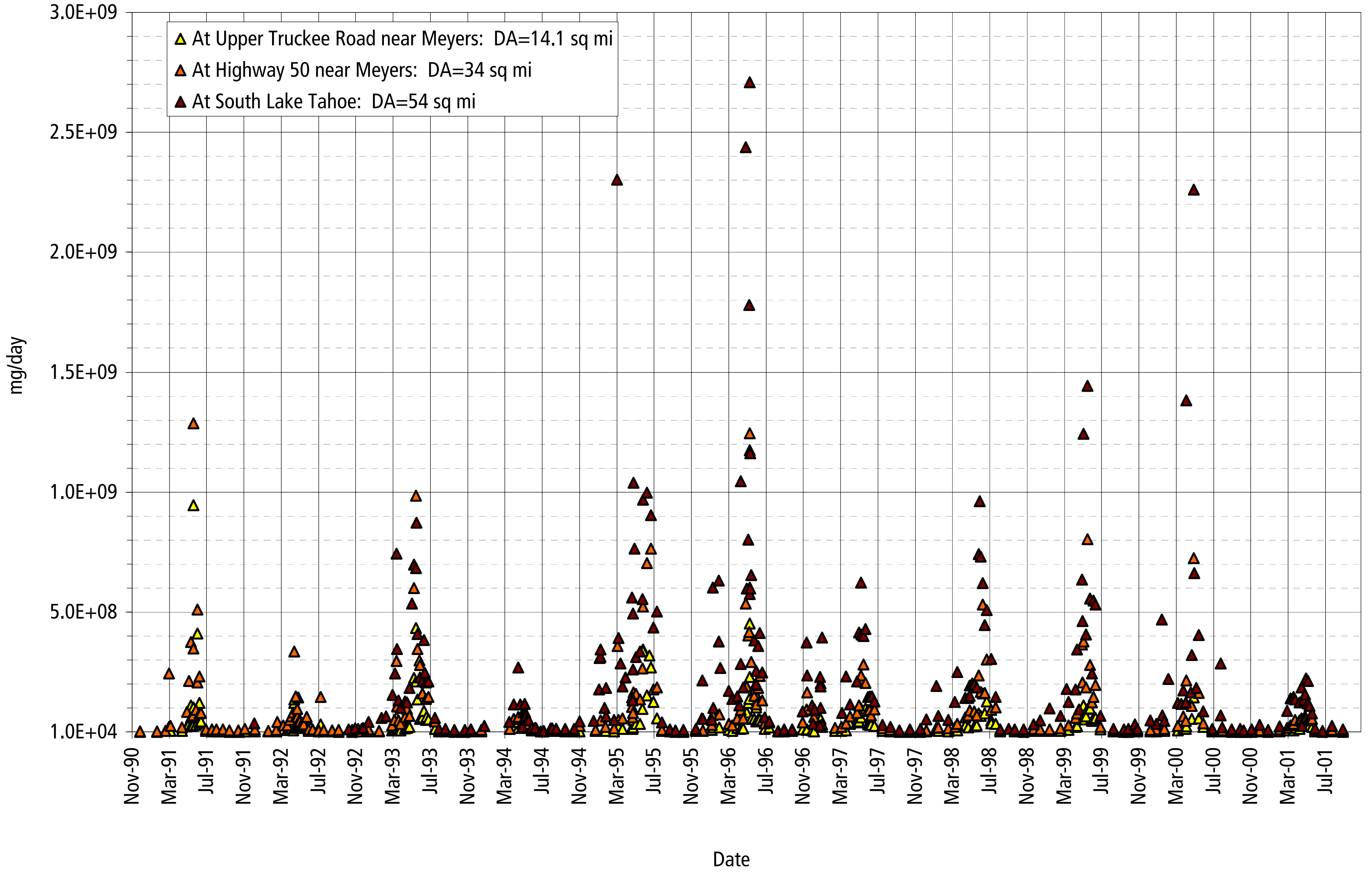


FIGURE 3.11C: Daily biologically reactive iron loads as measured at the three USGS streamflow monitoring stations.

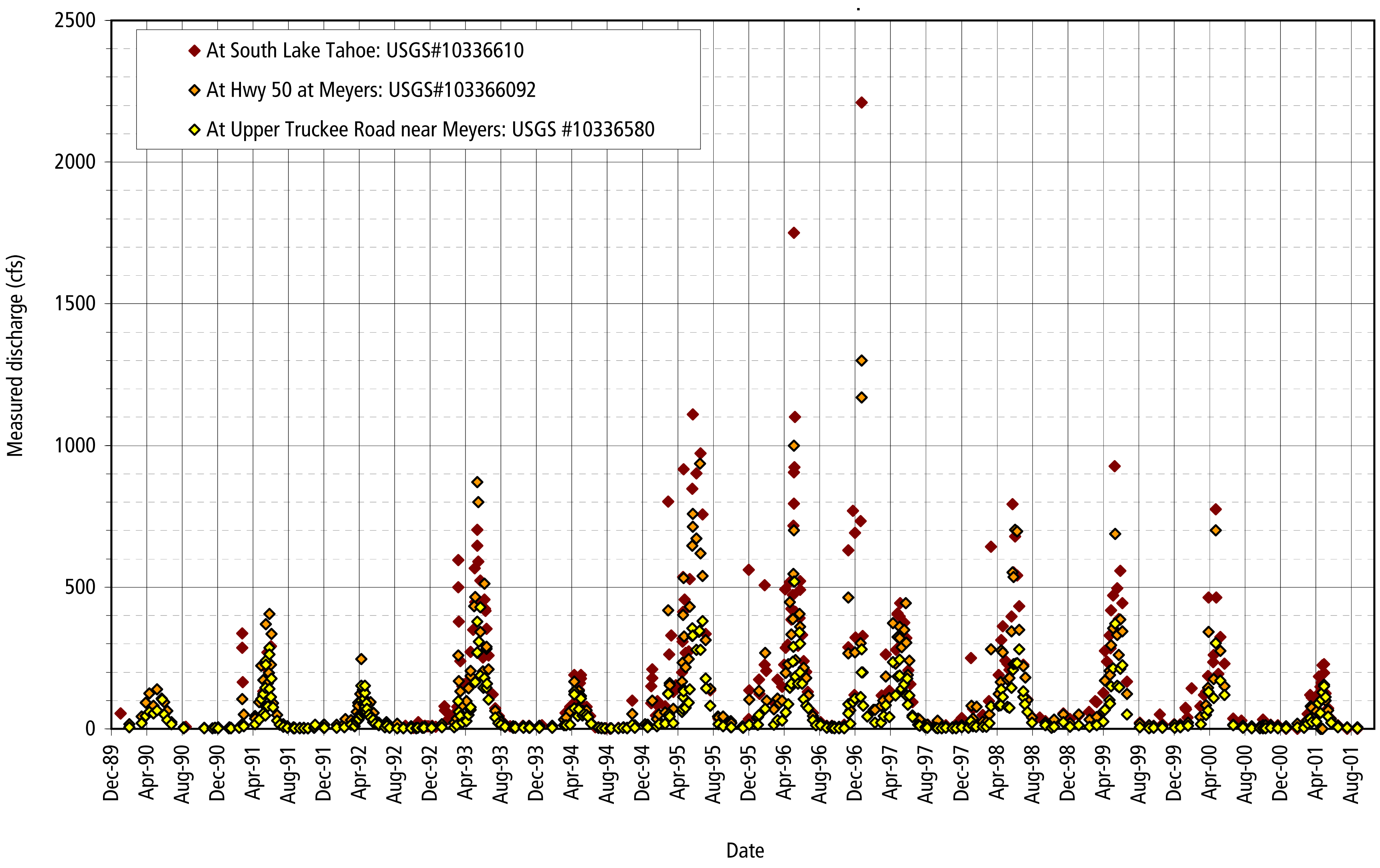


FIGURE 3.11D: Instantaneous streamflow as measured at the three USGS streamflow monitoring stations. Samples were taken at the same time as the constituents shown in Figures 3.11 A-C.

In 2002, the USGS released a report comparing the streamflow and water quality data for selected watersheds throughout Lake Tahoe Basin (Rowe et. al. 2002). The UTR had the largest median monthly loads for six of the seven constituents analyzed (nitrite, ammonia, total nitrogen, total phosphorus, biologically reactive iron, and suspended sediment). However, it must be noted that the UTR was also one of the largest watersheds studied and had the highest annual runoff. The report found the following trends in seasonal and monthly loading in the UTR: the highest median seasonal loads occurred in the spring during snowmelt, the lowest median seasonal loads were in the summer months, the largest median monthly loads occurred in May, and the lowest median monthly loads occurred in August, September, or October, depending on the constituent.

III.1.C Geomorphology

The geomorphology of the UTR reflects the physical processes underlying ecosystem processes. Watersheds produce water, sediment and organic materials, all of which interact with biological processes to form aquatic habitat and riparian and wetland vegetation communities that in turn form wildlife habitats.

The geomorphic assessment for the UTR Upper Reach Study Area has been divided into three segments: the stability and geomorphic processes of the main UTR channel, the relative sediment production from urbanized subwatersheds in the Meyers Area and Christmas Valley, and the general geomorphic conditions in the Upper Watershed.

MAIN UTR CHANNEL MORPHOLOGY

The morphology of the UTR was analyzed using current and past aerial photographs, topographic maps, specific surveys of channel forming features, hydrologic monitoring of the stream, and the relation between geomorphic surfaces and flow. Based upon the results of these analyses, eleven distinctive reaches were identified along the project reach (Figures 3.12 and 3.13A-E).

Longitudinal Profile

A longitudinal profile was field surveyed in May 2003 between Elks Club Highway 50 crossing and Meyers Highway 50 crossing (Figure 2.5), which repeated and expanded profile surveys completed by CDPR in 1993, 1994 and 2002 to reveal recent changes, especially from the record January 1997 rain on snow event. The long profile of Christmas Valley reach from Meyers Highway 50 crossing to the South Upper Truckee Road crossing was created using the 2003 LIDAR topographic survey, which offers less detail (Figure 3.14), but still shows key details.

The 2003 longitudinal profile for the Elks Club Highway 50 crossing to Meyers Highway 50 crossing reach reveals several key features (Figure 2.5), including a flattened area in the lowermost reach, where meander cutoffs and channel deepening have been pronounced, followed by gradually steeper sections upstream. Two prominent grade control structures are found at station 2100 and 13000; the 2003 profile also reveals several significant active headcuts or knickpoints in

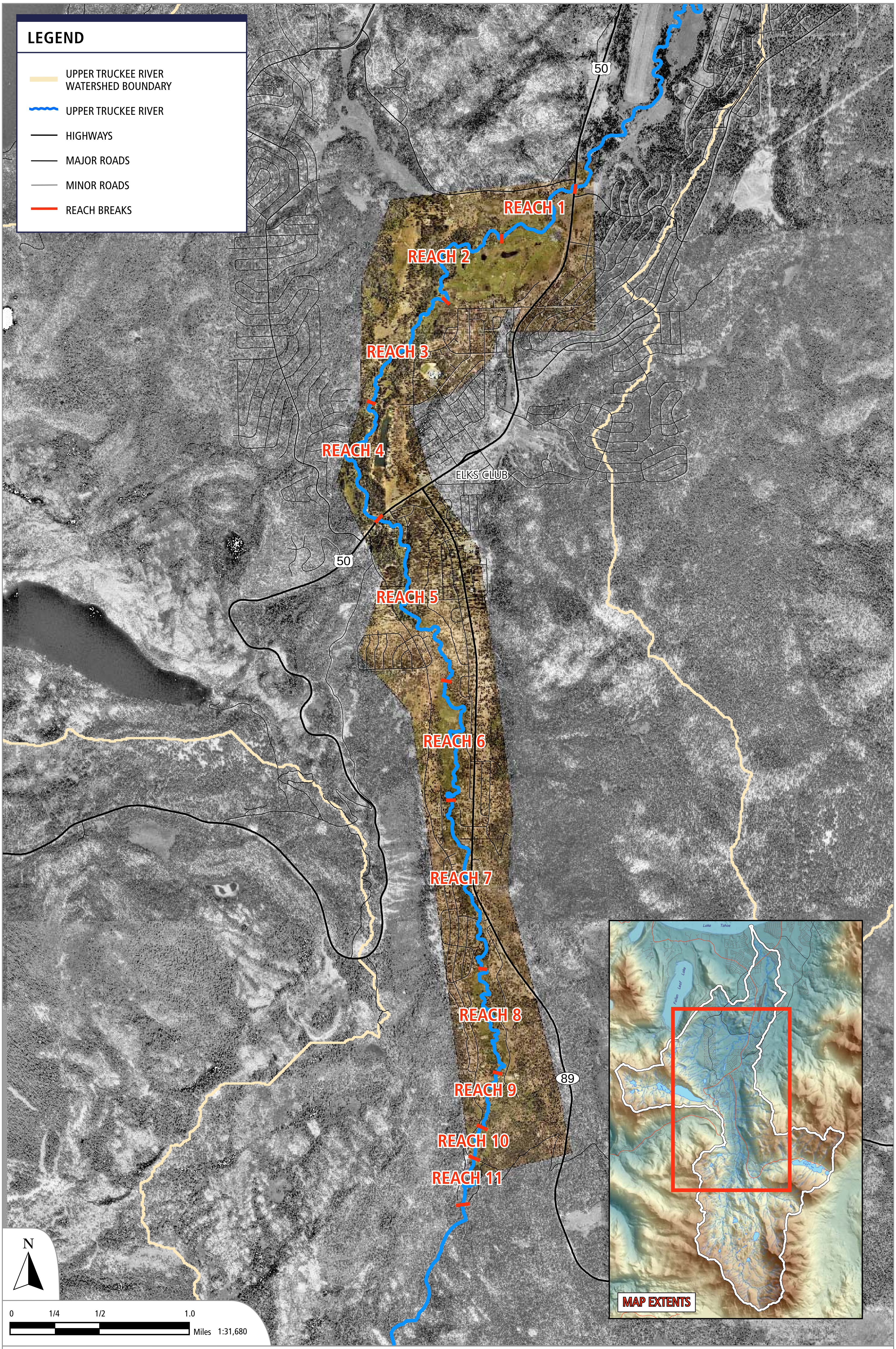


FIGURE 3.12: Reach break designations for the Upper Truckee River Upper Reach Study Area. Reaches were identified based upon analysis of aerial photographs, topographic maps, surveys of channel forming features, hydrologic monitoring of the stream and relationships between geomorphic surfaces and flow.
Data sources: USGS DOQQ, 1998. Lidar survey, 2003.

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FIGURE 3.13A: Map indicating the location of underground utilities relative to the Upper Truckee River (Reaches 1-3).

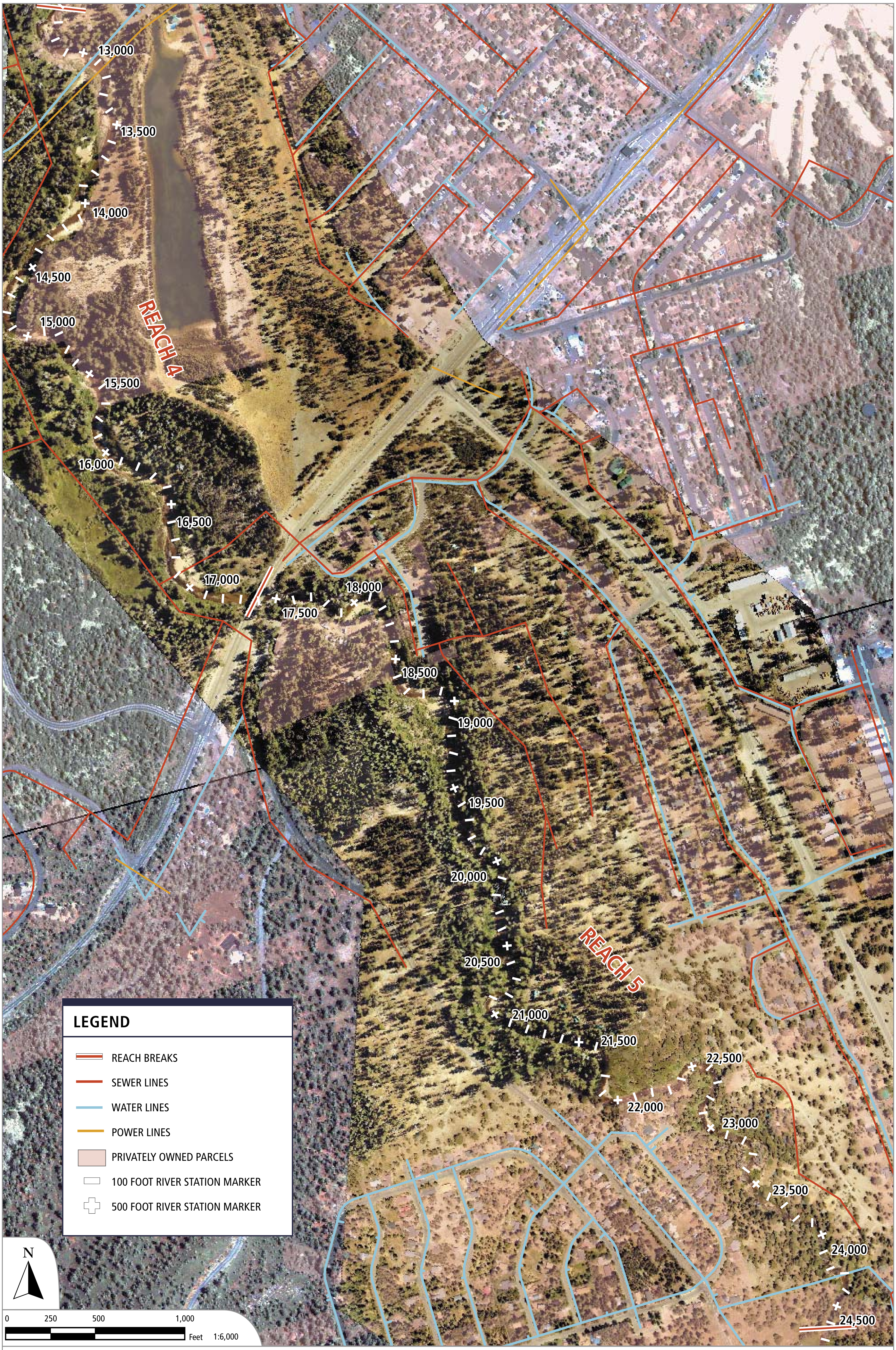


FIGURE 3.13B: Map indicating location of sewer and water lines relative to the Upper Truckee River (Reaches 4-5).

FIGURE 3.13C: Map indicating location of sewer and water lines relative to the Upper Truckee River (Reach 6).

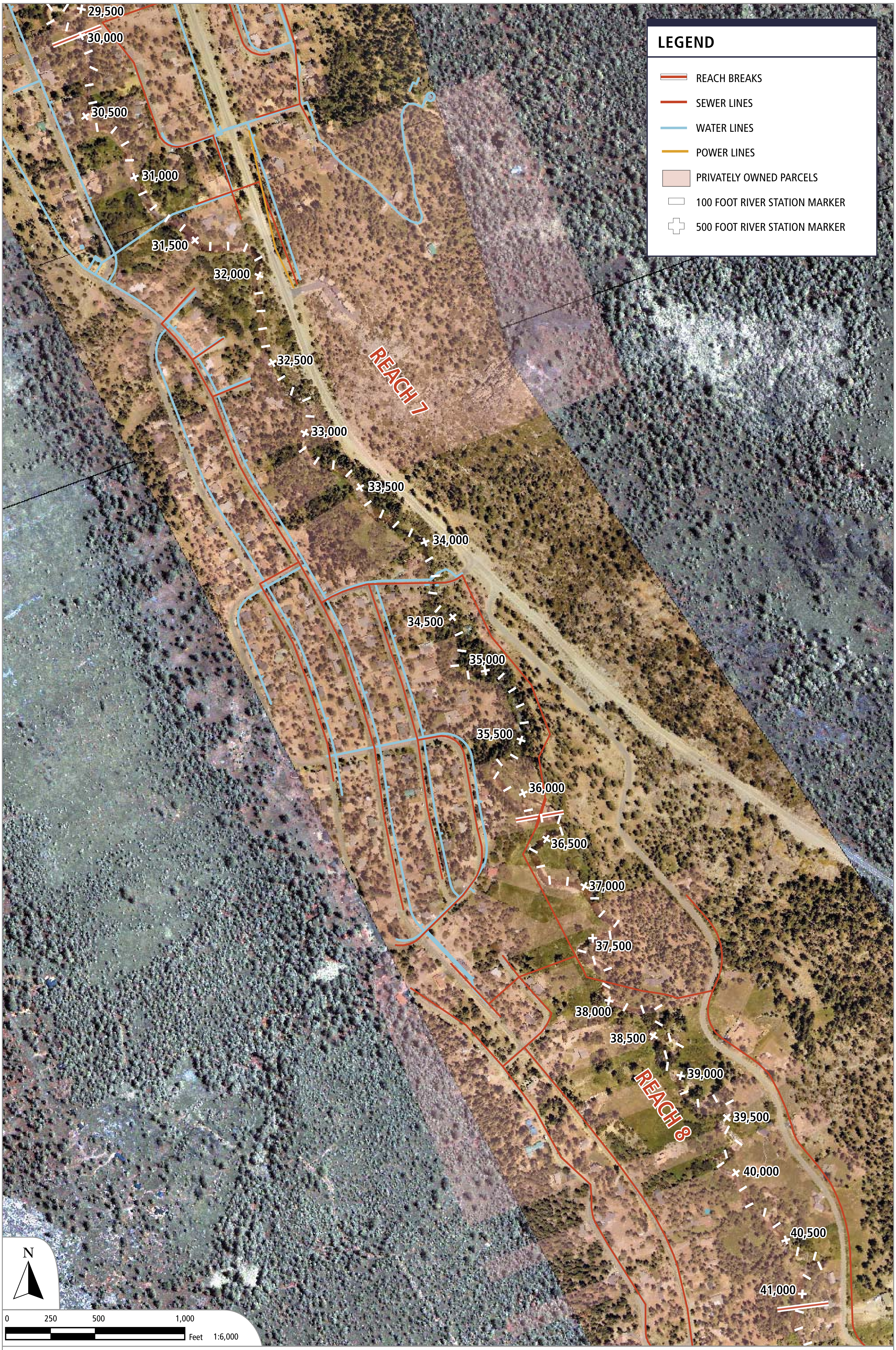


FIGURE 3.13D: Map indicating location of sewer and water lines relative to the Upper Truckee River (Reaches 7-8).

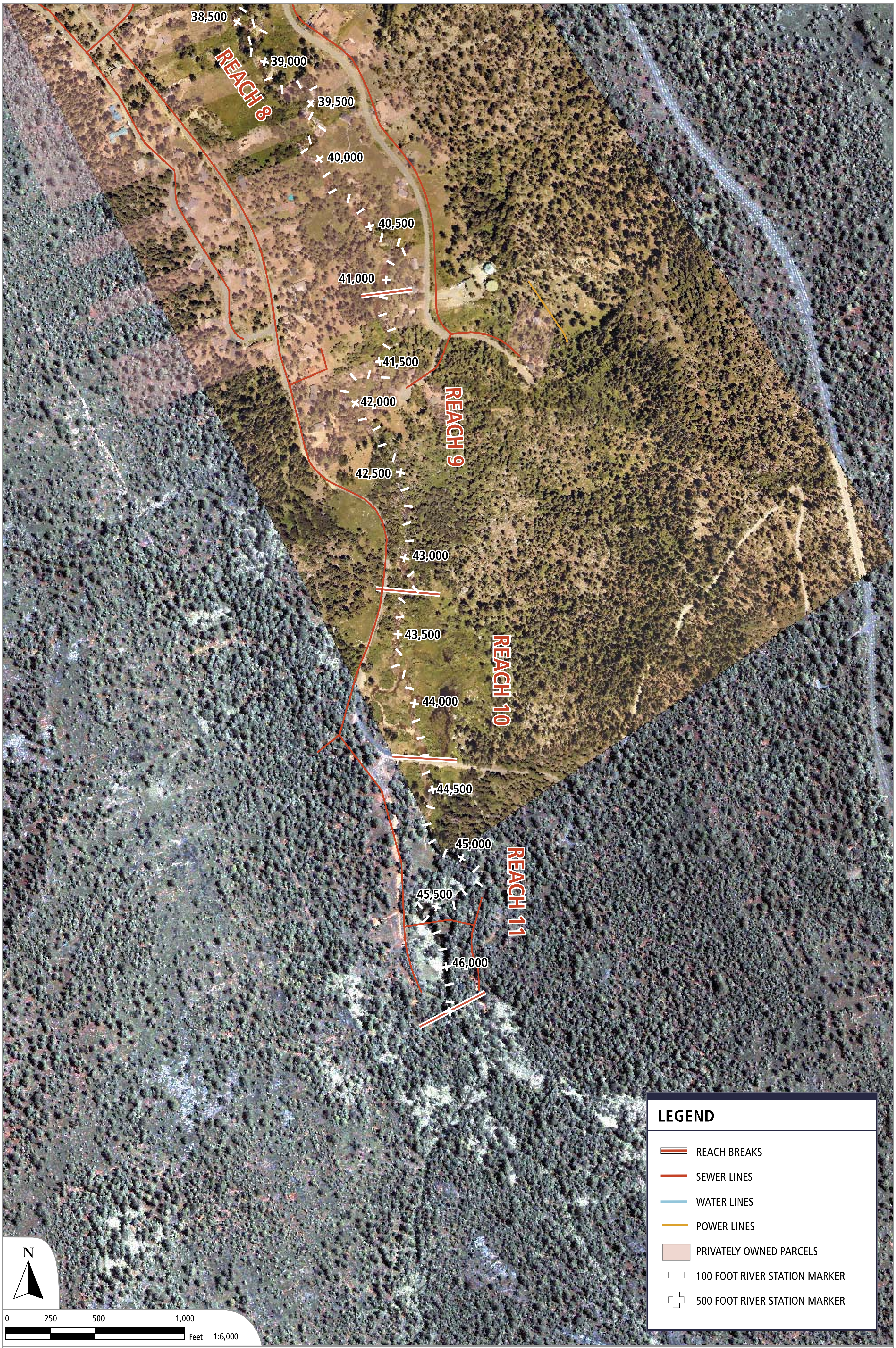


FIGURE 3.13E: Map indicating location of sewer and water lines relative to the Upper Truckee River (Reaches 9-11).

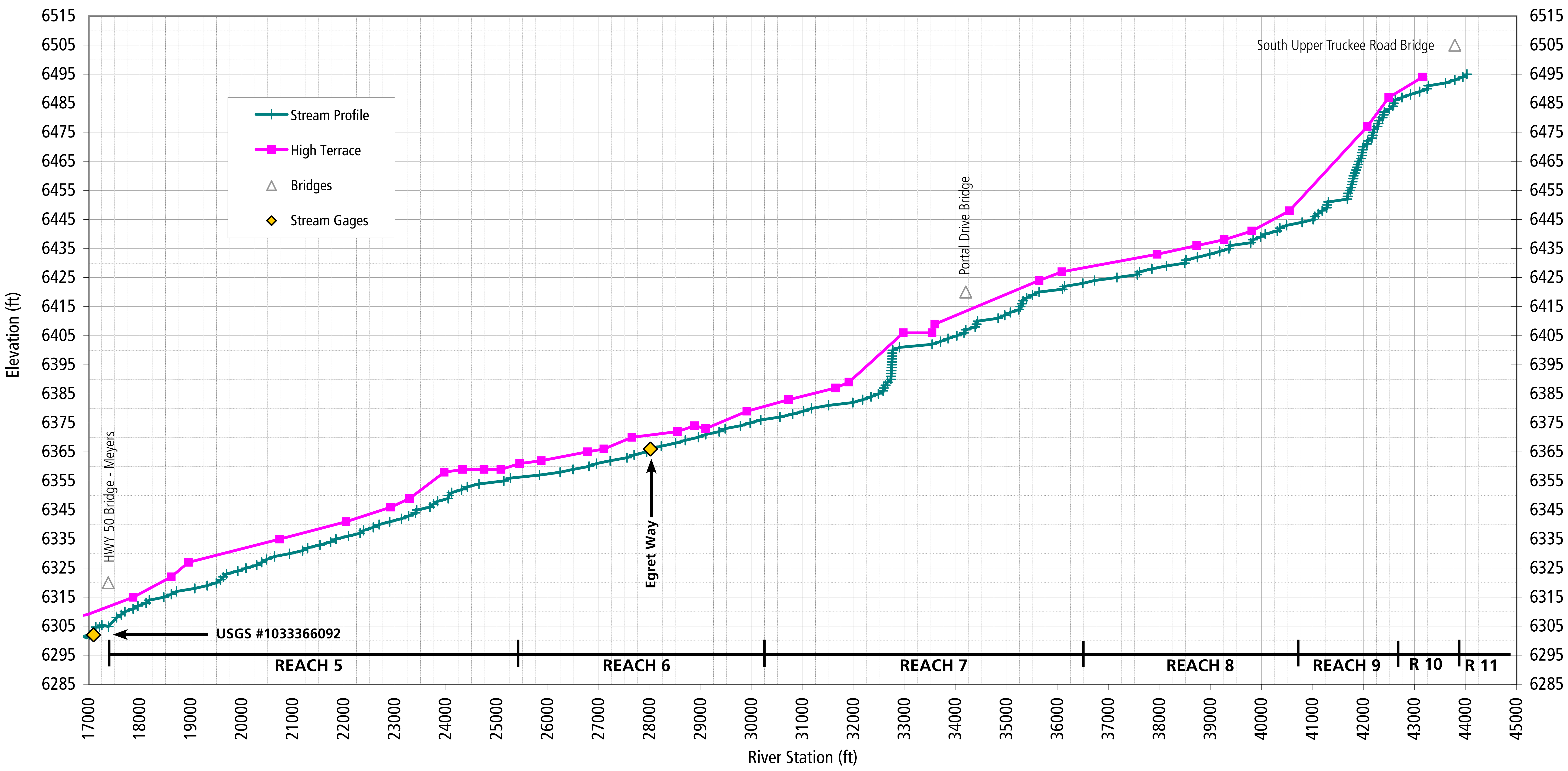


FIGURE 3.14: Longitudinal profile of Upper Truckee River from Meyers Highway 50 crossing to the South Upper Truckee Road Bridge (Reaches 5-11). Profile and high terrace elevations were created using the 2003 LIDAR survey.

the profile. The Christmas Valley profile reveals several significant steep bedrock or boulder control reaches separated by several reaches of flatter meadow sections.

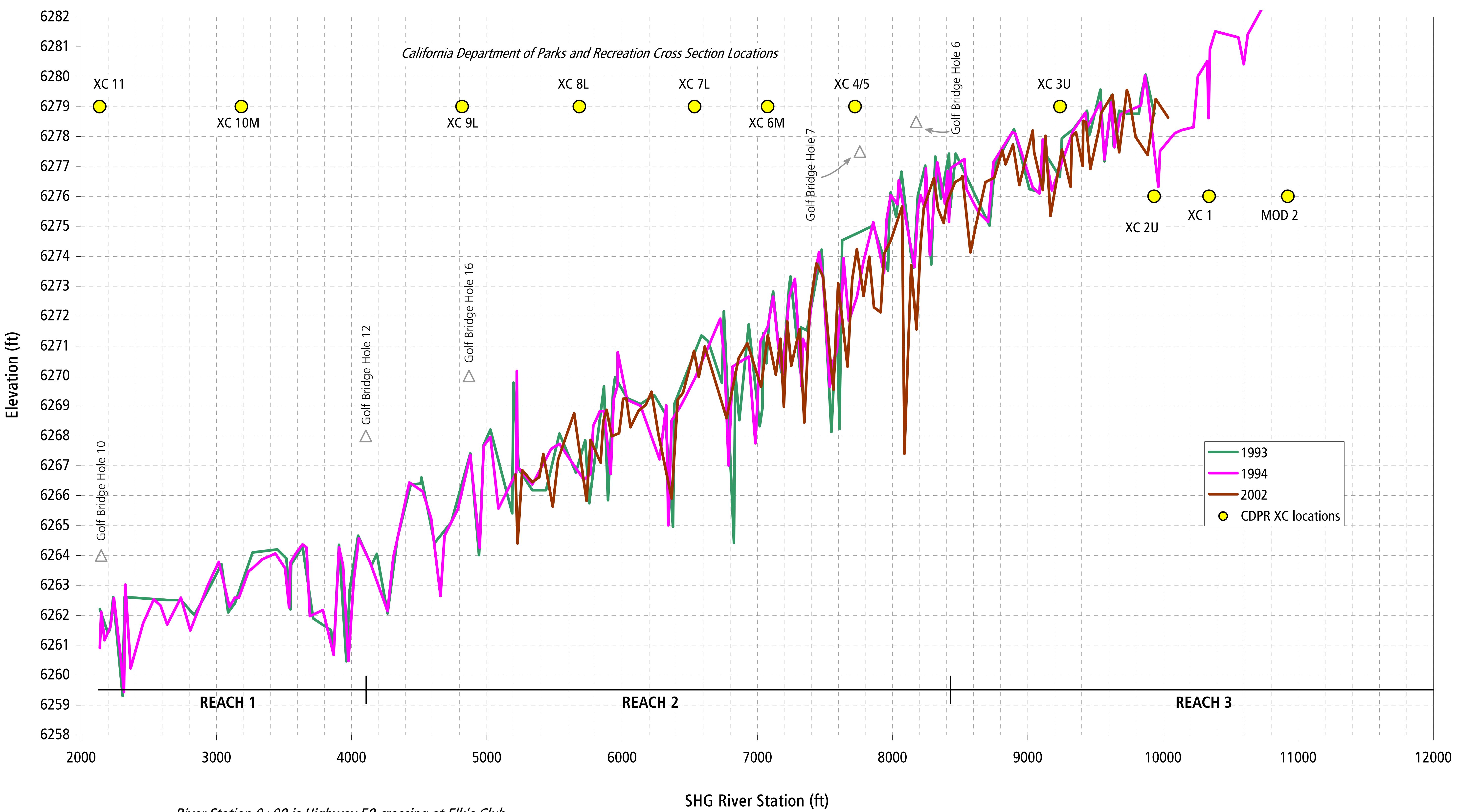
Sequential long profile plots provided by the CDPR (ongoing from 1992) show profile instability in the movement of headcuts along with areas of pool development (Figure 3.15).

Channel Geometry

Channel hydraulic geometry relationships for the UTR were developed for multiple locations. Channel geometry was measured at repeated cross sections set up by CDPR, in addition to several other locations established by SH+G. Three stage recorders were installed in Reaches 1 through 4 and one in Christmas Valley from March through July 2003 to record the stage and water surface elevations of various flows occurring during the 2003 snowmelt (Figure 3.1). The instrument installed in Christmas Valley failed and no useful data was obtained from that station. Stage measurements at each cross section were correlated with the continuous flow measurements taken at the USGS stream gage Upper Truckee River near Meyers (#106633092). Rating curves were created to relate water surface elevation to streamflow. Based on cross-sectional area measurements, channel geometry and water surface elevation for key discharge values for channel forming features (bankfull stage, terrace elevations) were calculated for each of the three gage locations. Additionally, during the longitudinal profile survey, measurements of channel forming features were taken, including the elevation of bankfull indicators and terraces. The results of this monitoring are shown in Figures 3.16A-C through 3.18A-C.

As the cross-sections illustrate, the clearest bankfull indicators of recent geomorphic floodplain formation occur in the narrow zone of the incised channel between 350 and 400 cfs. This bankfull flow agrees with the partial duration flood frequency analysis of 1.5-year flow at the USGS gage in Meyers (Table 3.2), as well as with past measurements and estimates of bankfull flow in the UTR (Table 3.3), which also correspond to the 1.5-year peak flow for snowmelt events (Swanson, 2003; Hanes and Swanson 1997; 1995). Based upon the spring 2003 stage measurements and channel geometry, the estimated channel flood capacity at these three sites is on the order of 600 to 800 cfs.

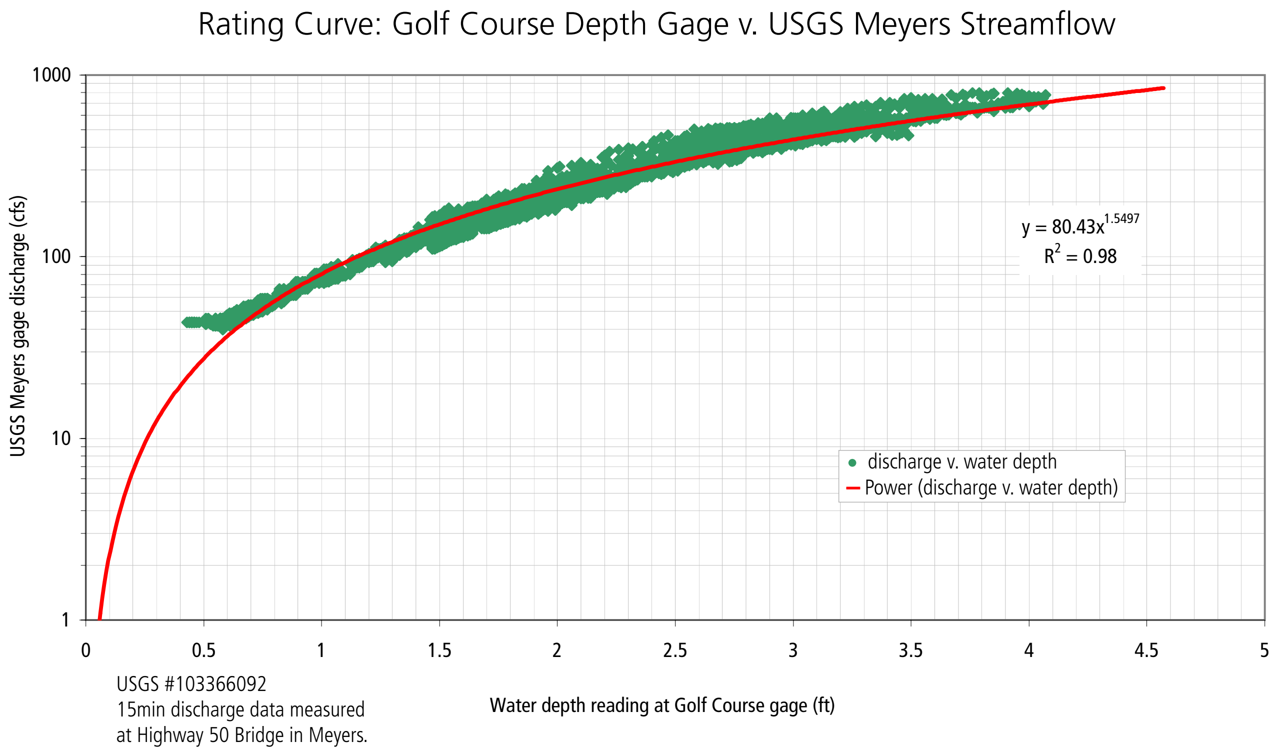
Sequential cross sections (ongoing since 1992) plotted by the CDFG show significant bank erosion and incision in recent years (Appendix A). Some of this change was likely due to the record 1997 flood, however there are changes that do signify ongoing instability in cross section and planform, suggesting continuing adjustment to channelization (Figure 3.19). This must be carefully considered in designing any restoration plan.



River Station 0+00 is Highway 50 crossing at Elk's Club

FIGURE 3.15: Comparison of longitudinal profile of Upper Truckee River in Reaches 1-3 as surveyed by the California Department of Parks and Recreation in 1993, 1994 and 2002. Note the movement of the active headcuts through the profile. See Appendix A for site locations.

SH+G GOLF COURSE GAGE



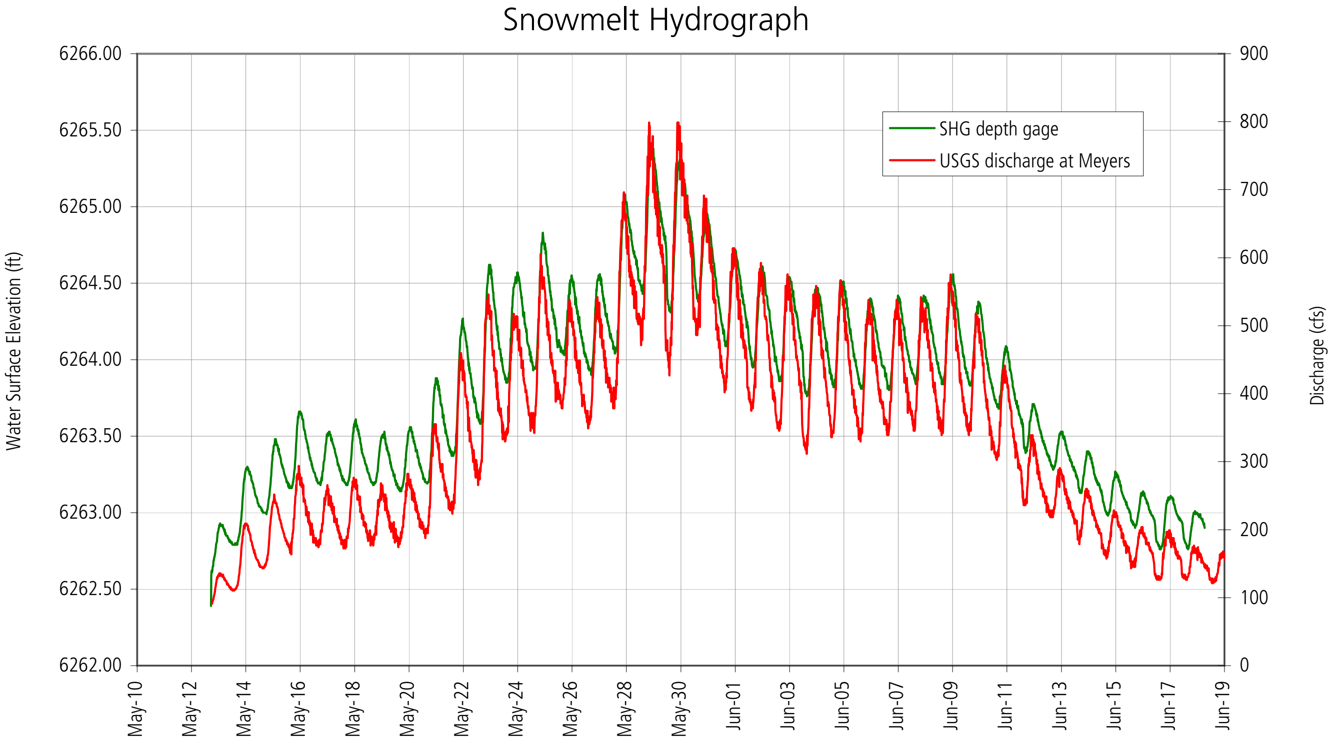
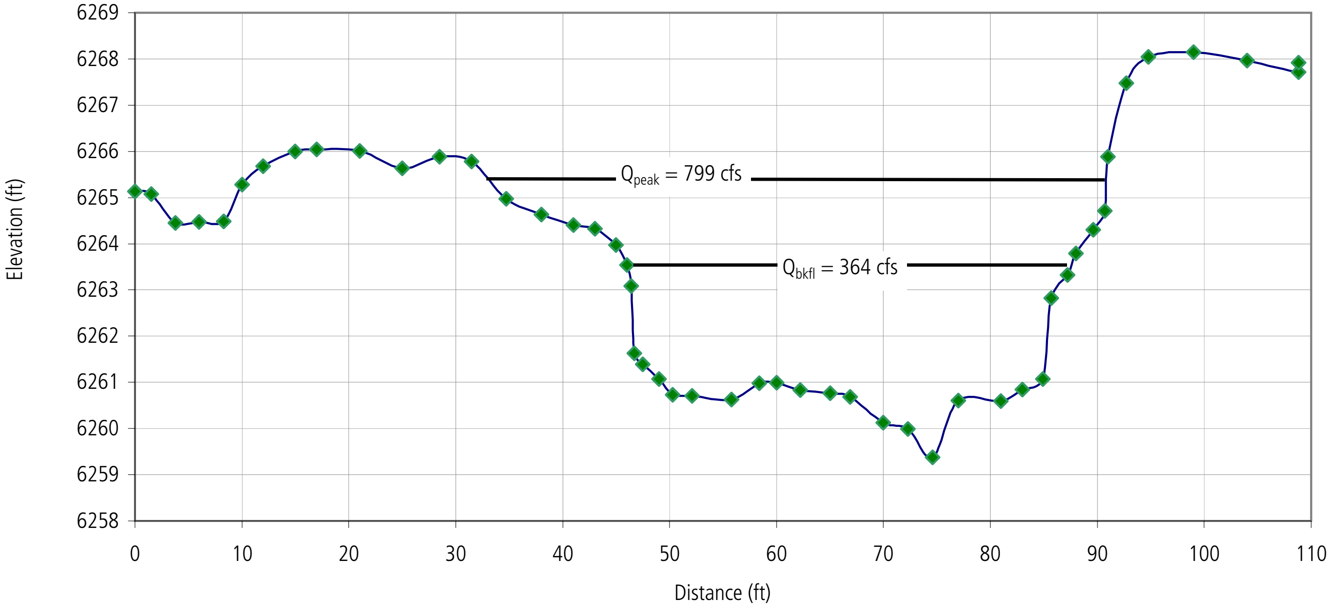


FIGURE 3.16A: WY 2003 snowmelt data for the Upper Truckee River at the SH+G Golf Course gage (see Figure 3.1 for gage locations). Upper graph presents simultaneous readings at USGS #103366092 and SH+G Golf Course depth gage. The bottom graph is the snowmelt hydrograph recorded by the SH+G Golf Course gage and USGS gage.

SH+G GOLF COURSE GAGE

Channel Cross-section at Gage and Key Channel Features



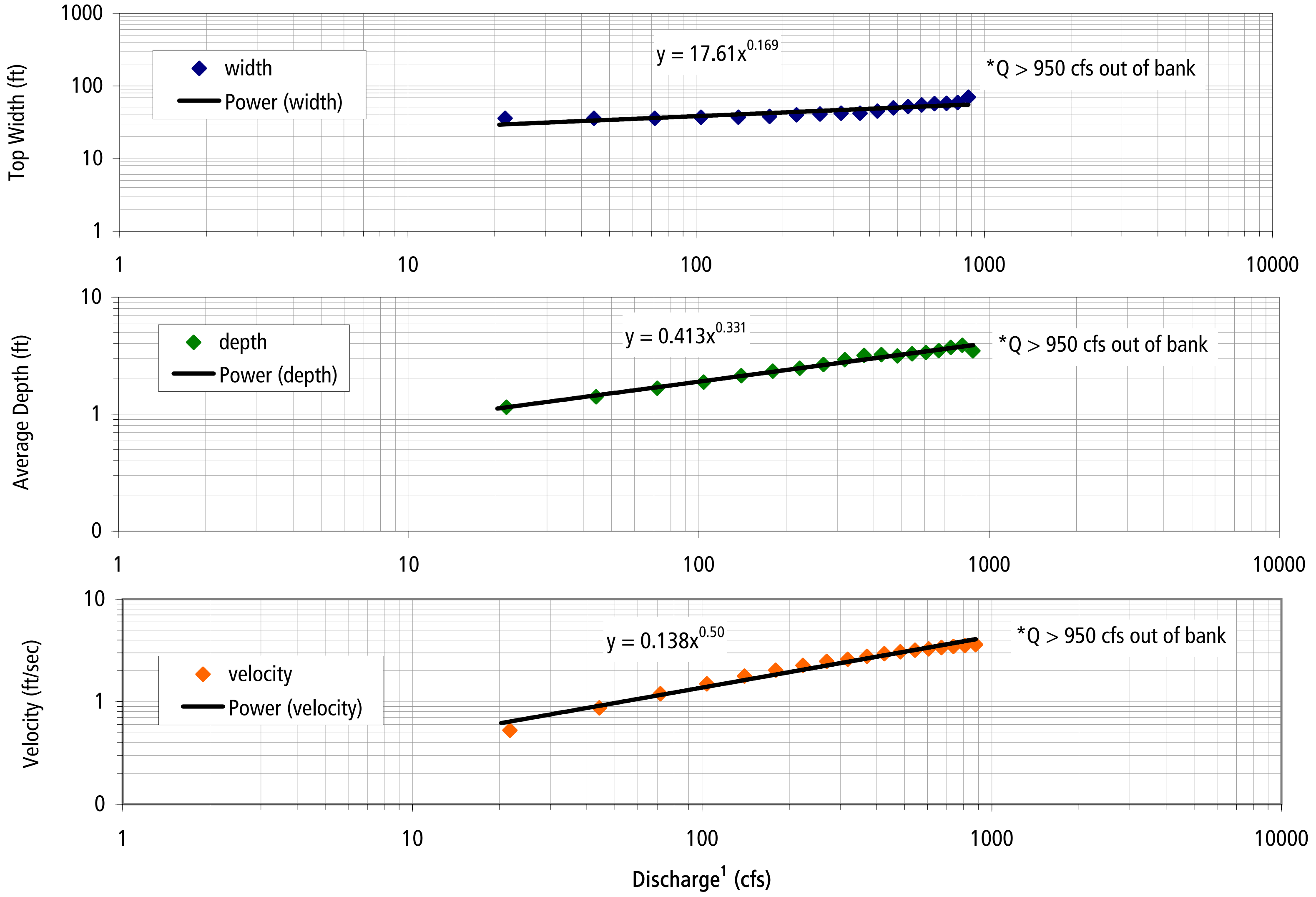
Q_{peak}: 2003 SHG depth gage peak on 5/29/03

Q_{bkfl} : based on channel features

Photo of Channel at Gage Looking Downstream

FIGURE 3.16B: Channel cross-section surveyed at location of SH+G Golf Course gage by California State Parks in September, 2003. Key channel features were identified in the field and associated discharge was calculated using depth gage data.

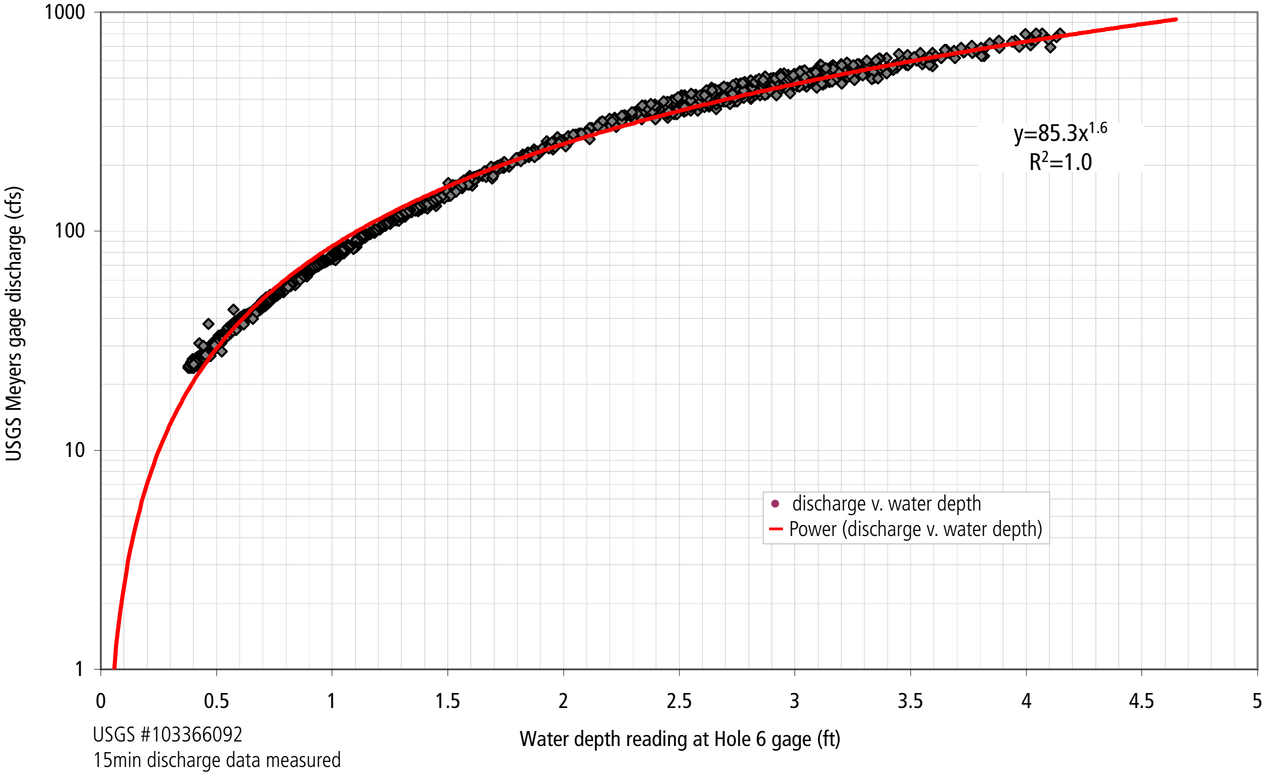
SH+G GOLF COURSE GAGE



[1] discharge measured at USGS Gage #103366092 in Meyers

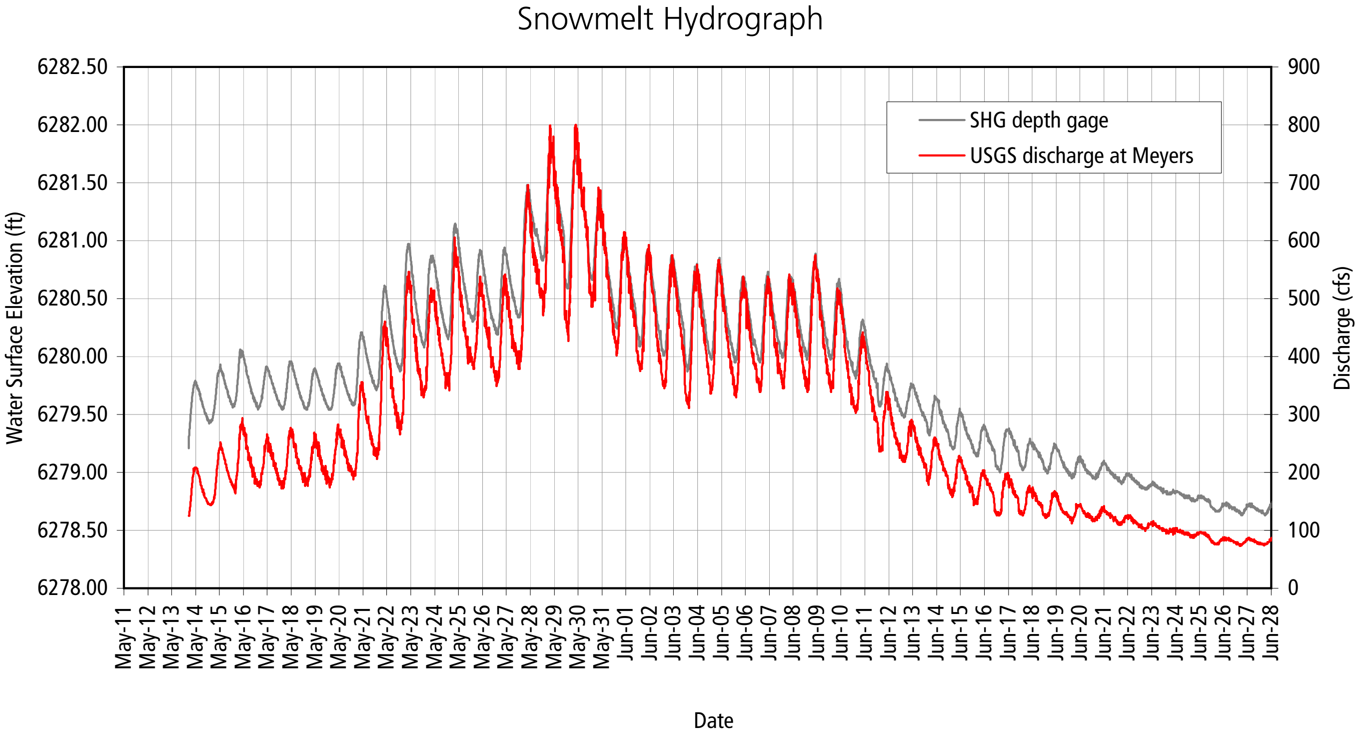
FIGURE 3.16C: Channel geometry calculated for Upper Truckee River at SH+G Golf Course Gage.

SH+G HOLE 6 GAGE



Rating Curve: Hole Six Depth Gage v. USGS Meyers Streamflow

USGS #103366092
15min discharge data measured
at Highway 50 Bridge in Meyers.



Snowmelt Hydrograph

FIGURE 3.17A: WY 2003 snowmelt data for the Upper Truckee River at the SH+G Hole 6 gage (see Figure 3.1 for gage locations). Upper graph presents simultaneous readings at USGS gage #103366092 and the SH+G Hole 6 depth gage. The bottom graph is the snowmelt hydrograph recorded by the SH+G Hole 6 gage and the USGS gage.

SH+G HOLE 6 GAGE

Channel Cross-section at Gage and Key Channel Features

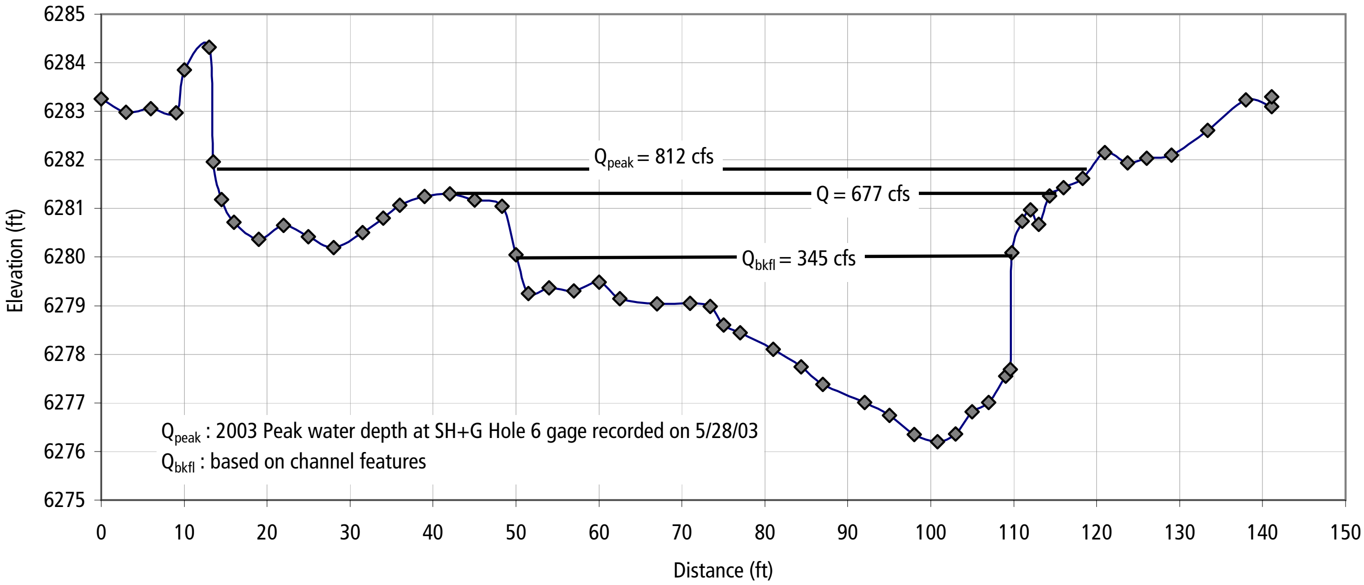


Photo of Channel at Gage

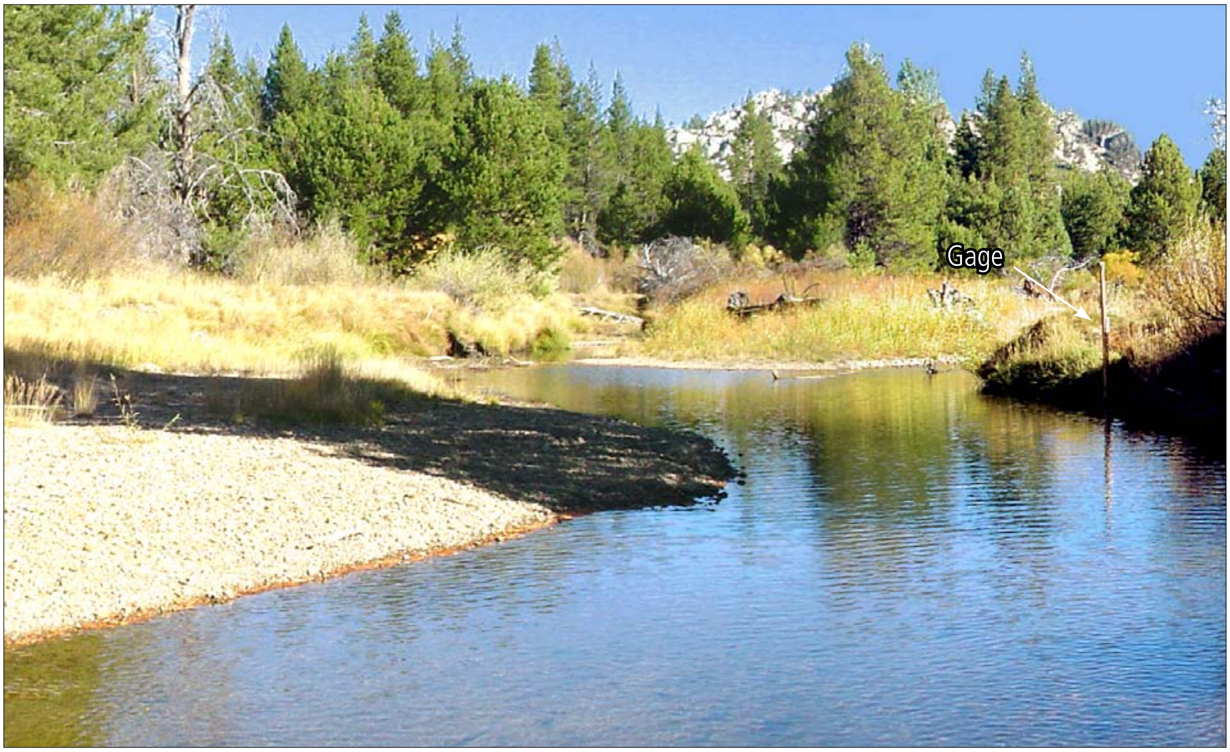
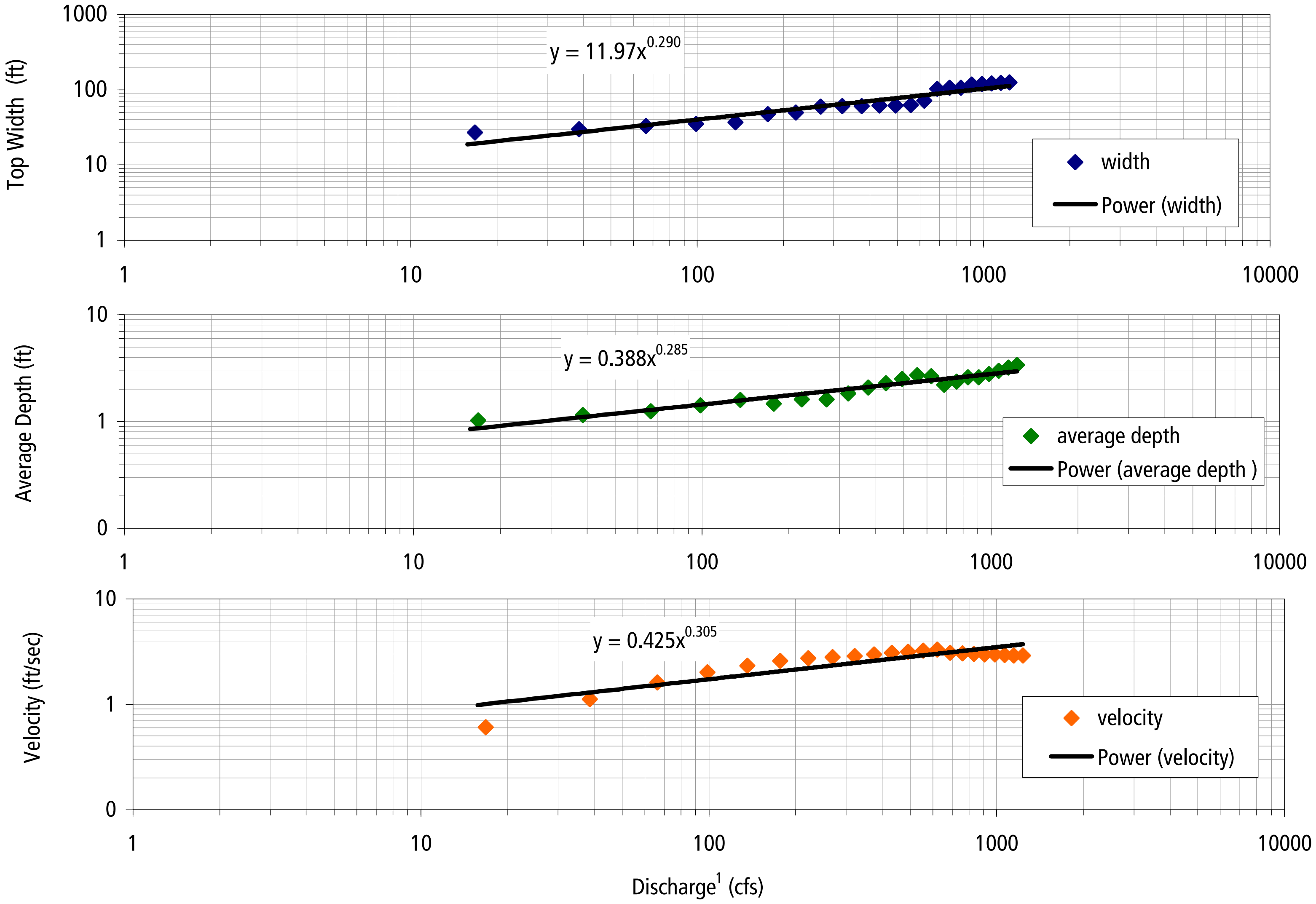


FIGURE 3.17B: Channel cross-section surveyed at location of SH+G Hole 6 gage by California State Parks in September, 2003. Key channel features were identified in the field and associated discharge was calculated using depth gage data.

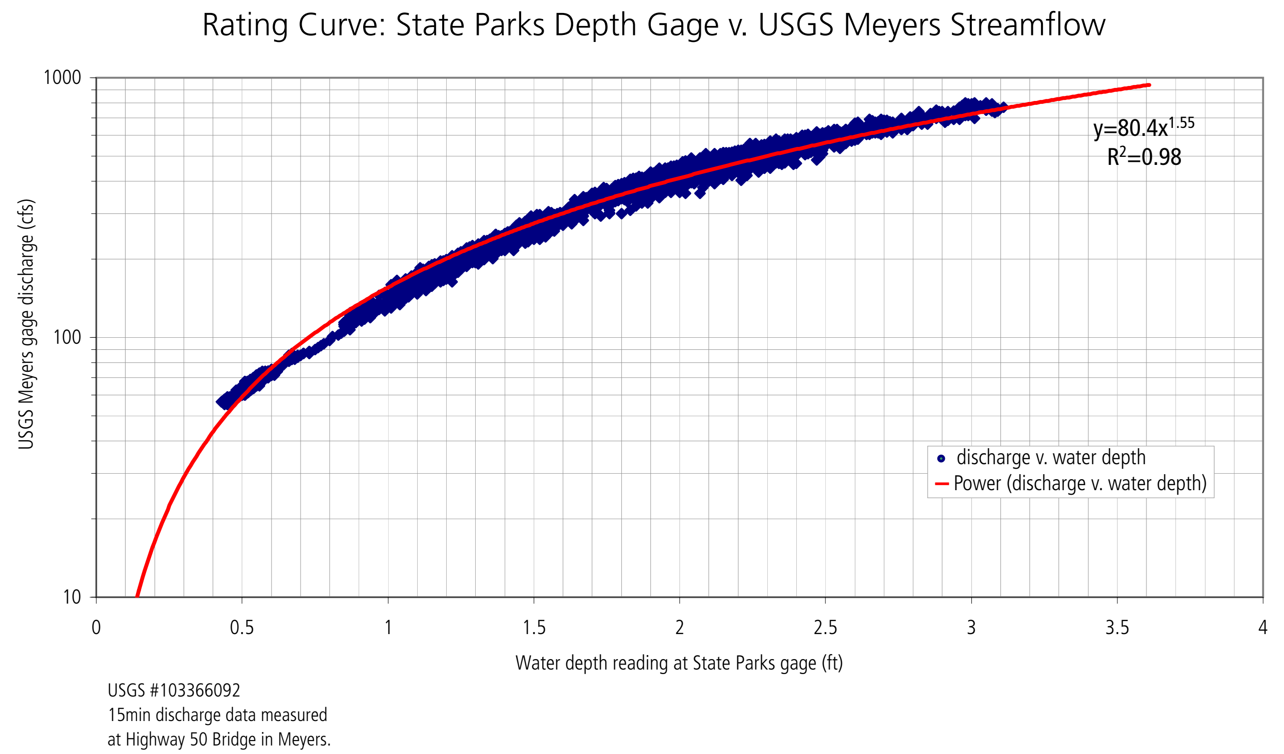
SH+G HOLE 6 GAGE



[1] discharge measured at USGS Gage #103366092 in Meyers

FIGURE 3.17C: Channel geometry calculated for Upper Truckee River at SH+G Hole 6 Gage.

SH+G STATE PARKS GAGE



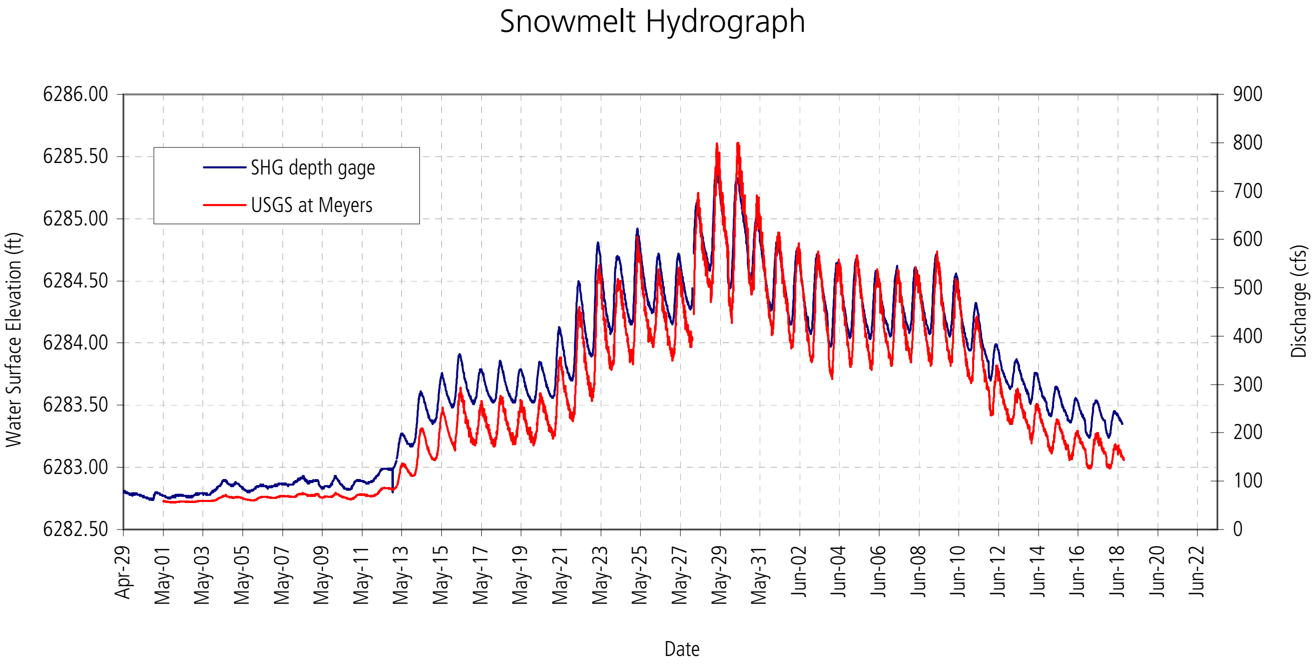


FIGURE 3.18A: WY 2003 snowmelt data for the Upper Truckee River at the SH+G State Parks gage (see Figure 3.1 for gage locations). Upper graph presents simultaneous readings at USGS #103366092 and SH+G State Parks depth gage. The bottom graph is the snowmelt hydrograph recorded by SH+G State Parks gage and USGS gage.

SH+G STATE PARKS GAGE

Channel Cross-section at Gage and Key Channel Features

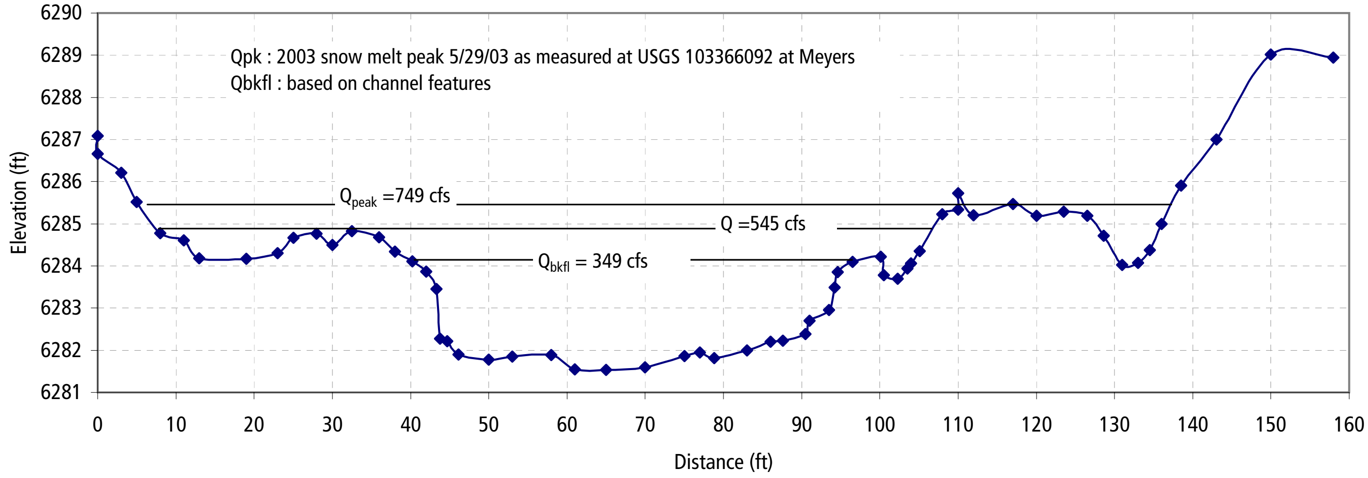
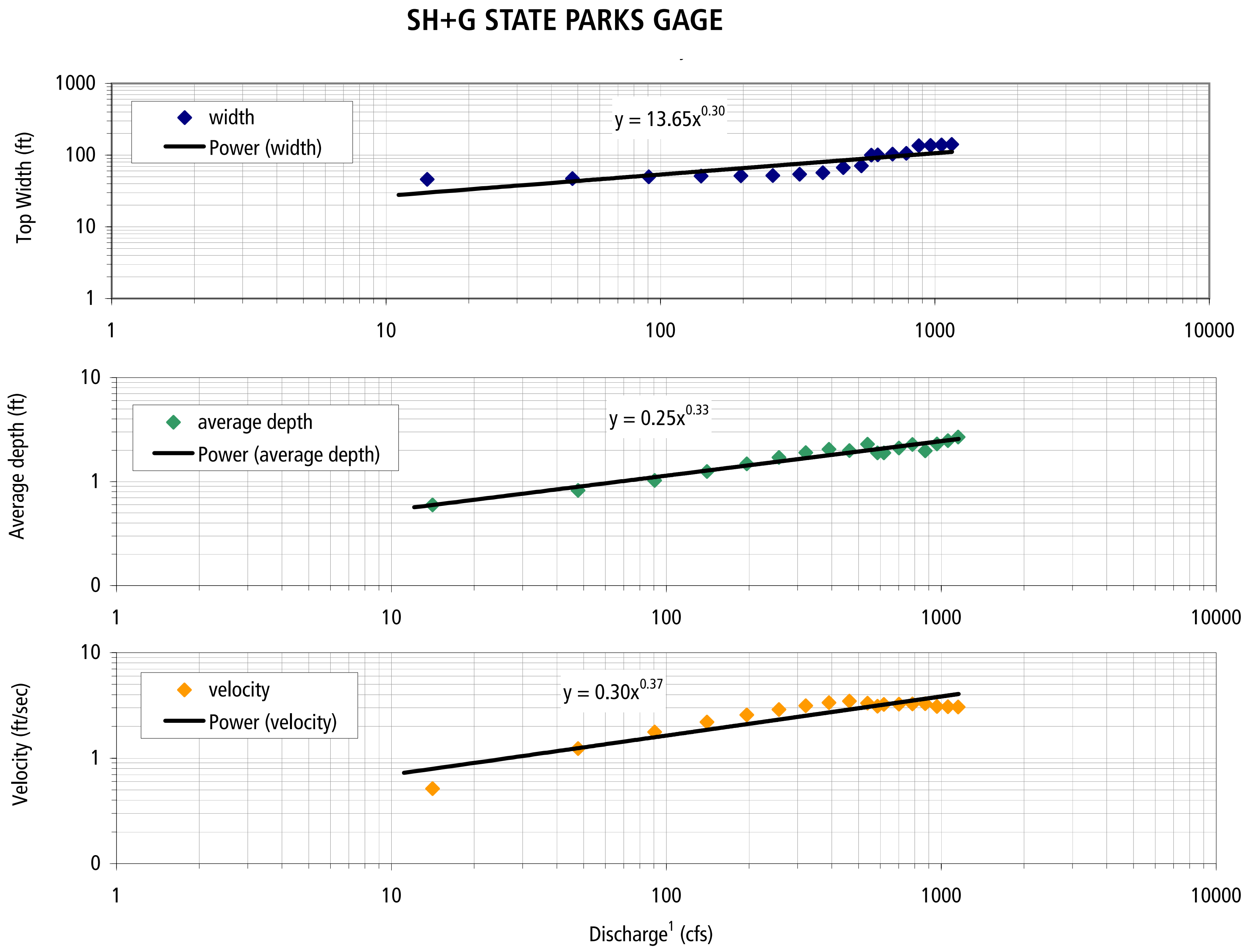


Photo of Channel at Gage Looking Upstream

FIGURE 3.18B: Channel cross-section surveyed at location of SH+G State Parks gage by California State Parks in September, 2003. Key channel features were identified in the field and associated discharge was calculated using depth gage data.



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[1] discharge measured at USGS Gage #103366092 in Meyers

FIGURE 3.18C: Channel geometry calculated for Upper Truckee River at SH+G State Parks Gage.

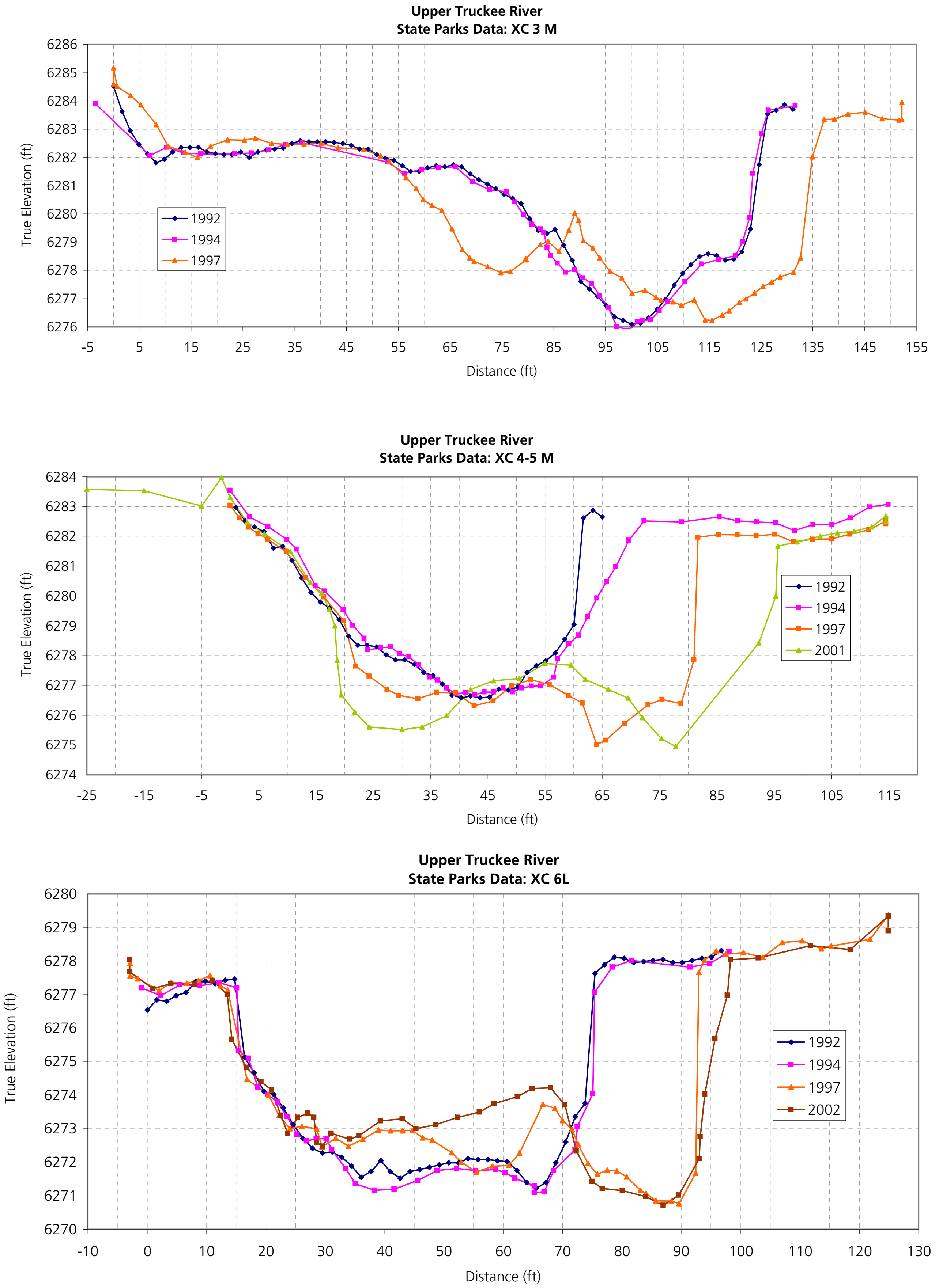

FIGURE 3.19: Comparison of cross-section surveys of the Upper Truckee River by California Department of Parks and Recreation from 1992-2002. See Appendix A for locations of cross sections.

Upper Truckee River
Bankfull Channel Charactertistics

						Channel Geometry at Bankfull Flow		
	Station Location[1]	Station Operator	Station ID	Date of Measurements[2]	Q_{bkfl}	mean depth (ft)	top width (ft)	mean velocity (ft/s)
upstream	SHG River Station 17000 DA= 34.3 mi^2	USGS	#103366092	2003	336	1.8	62	3.2
	SHG River Station 10800	SHG	State Parks	2003	364	2.9	56	2.6
↓	SHG River Station 8900	SHG	Hole 6	2003	346	2.1	65	2.5
	SHG River Station 1600	SHG	Golf Course	2003	349	1.7	79	2.6
	Downstream of Elks Club (Station -1750)	SHG	Elks Lodge Reach Ave	1997	370	2.4	68	2.4
	Downstream of Elks Club (station -3600)	SHG	Lodgepole Reach Ave	1997	370	2.7	63	2.3
downstream	Downstream of Elks Club (station -6000)	SHG	Airport Reach Ave	1997	370	2.3	51	3.2
				Recent	**Ave**	**2.3**	**63**	**2.7**

1995 channel comparison

pre-1997 storm	Downstream of Elks Club (Station -1750)	SHG	Elks Lodge Reach Ave	1995	370	2.3	58	2.8
	Downstream of Elks Club (station -3600)	SHG	Lodgepole Reach Ave	1995	370	1.6	41	5.7
	Downstream of Elks Club (station -6000)	SHG	Airport Reach Ave	1995	370	2.2	47	3.7
					1995 Ave	**2.0**	**49**	**4.1**

TABLE 3.3: Summary of bankfull flow and channel geometry measurements taken on the Upper Truckee River from 1995 to 2003. [1]SHG 2003 Upper Truckee River at Elks Club Hwy 50 crossing 0+00; Approximate distance (ft) upstream (+) or downstream (-) of Elks Club provided. [2]SHG 2003 data from this study; USGS 2003 data from USGS 9-207 forms; SHG1995 & 1997 from Upper Truckee River prepared for The California Tahoe Conservancy, by Swanson Hydrology & Geomorphology and Hydroscience. October 27, 1997.

Planform Sinuosity

Changes in planform sinuosity were assessed using aerial photographs, the longitudinal profile survey, and field evidence of past channel and floodplain formation. Some planform characteristics were presented in Chapter II and plotted in Figure 2.7. The historic loss of planform was greater in Reaches 1 – 4 and less pronounced in Reaches 5-11. The present values are shown in Table 2.1 and range between 1.2 and 1.7.

The historic assessment found evidence in planform sinuosity reduction and consequent channel incision. There has been between one and eight feet of channel bed incision historically in the project reach. This corresponds to the difference between terrace elevations and bankfull presented in Figures 2.5 and 3.14.

CHANNEL BANK EROSION SURVEY

A database of erosion hazard potential for the banks of the UTR was completed in the spring and summer of 2003. SH+G used a methodology modified after Rosgen (1996) that measures key geomorphic and vegetative variables associated with bank stability. These were mapped for each uniform segment of bank along the mainstem UTR from the Elks Club Highway 50 crossing to the USFS Bridge Tract Summer Homes over seven miles upstream. In addition, several of the main alluvial tributaries to the mainstem UTR were surveyed and measured, including Big Meadow Creek in Cookhouse Meadow and select reaches of Grass Lake Creek and are discussed below.

The results of the mainstem UTR bank erosion survey are presented in Figures 3.20A-F and 3.21 and summarized in Table 3.4 (the complete database is presented in Appendix B). The data reflect the recent history of channel incision, with many reaches of unstable banks undercutting bank vegetation, especially in Reaches 1-4. High erosion hazards are also found in the alluvial reaches of Christmas Valley, especially the meadow areas of Reaches 5, 7, 10 and 11. The erosion hazard rating also reflects the fact that many of the banks rating high erosion potential or above are chronic sources of fine sediments. Areas exhibiting low or moderate erosion hazards occur in reaches lined in boulders or bedrock. An interesting exception occurs in the lower end of Reach 3, where it appears that the stream bed is being held nearly at grade with adjacent valley flat similar to the relief that would have been expected prior to disturbance; this appears to be the result of an erosionally resistant layer of older glacial outwash cobble and small boulder underlying the stream bed.

Beyond the bank erosion survey, it is worth noting the effects of the beaver on the UTR, apparent since their introduction in the 1920s and 1930s. Beavers have a profound effect on channel morphology, erosion, and the hydrology of wetlands on the valley floor, and there are many active colonies in the study area and on other streams in the Tahoe Basin. Interviews conducted with Washoe Elders for this study did not reveal any recollection of beavers in the original landscape (see Section III.5); given the attention paid to the riparian landscapes by Washoe Tribe in their plant gathering and hunting activities, this seems to be reliable information. In other cases, there

Reach 1 Statistics

Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach	Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach
Right Bank	Very Low	476	12.7%	Left Bank	Very Low	95	2.5%
	Low	377	10.0%		Low	0	0.0%
	Moderate	997	26.6%		Moderate	1364	35.8%
	High	1191	31.7%		High	2352	61.7%
	Very High	305	8.1%		Very High	0	0.0%
	Extreme	410	10.9%		Extreme	0	0.0%
	Total	3756	100.0%		Total	3811	100.0%

Reach 2 Statistics

Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach	Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach
Right Bank	Very Low	640	12.0%	Left Bank	Very Low	397	8.5%
	Low	636	11.9%		Low	397	8.5%
	Moderate	1932	36.1%		Moderate	1916	41.0%
	High	308	5.8%		High	213	4.6%
	Very High	1391	26.0%		Very High	663	14.2%
	Extreme	440	8.2%		Extreme	1082	23.2%
	Total	5346	100.0%		Total	4667	100.0%

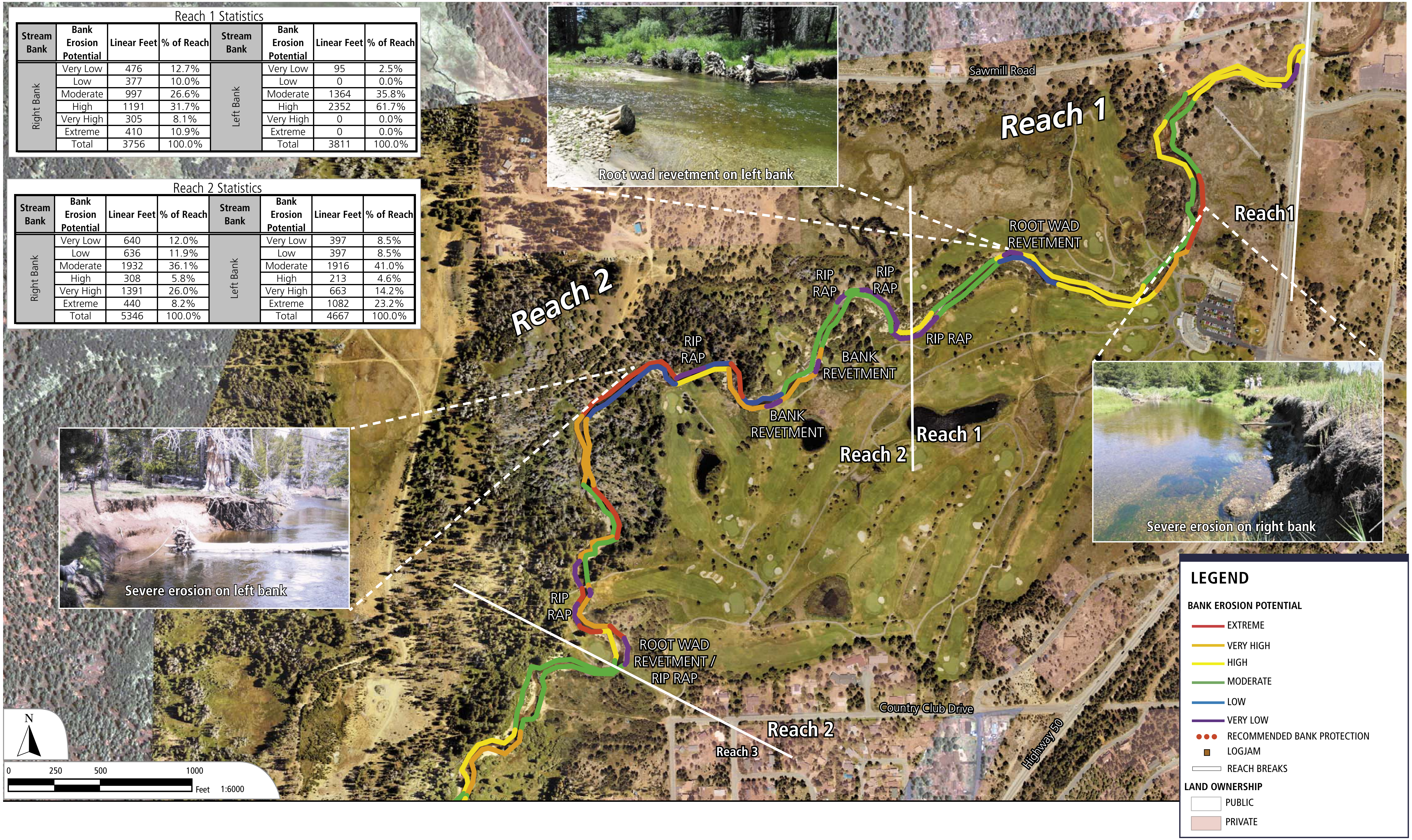

FIGURE 3.20A: Results of channel bank erosion survey for Reaches 1-2. Statistics by reach are summarized and photos provide visual reference for bank erosion potentials. Locations of bank erosion stabilization efforts are noted.

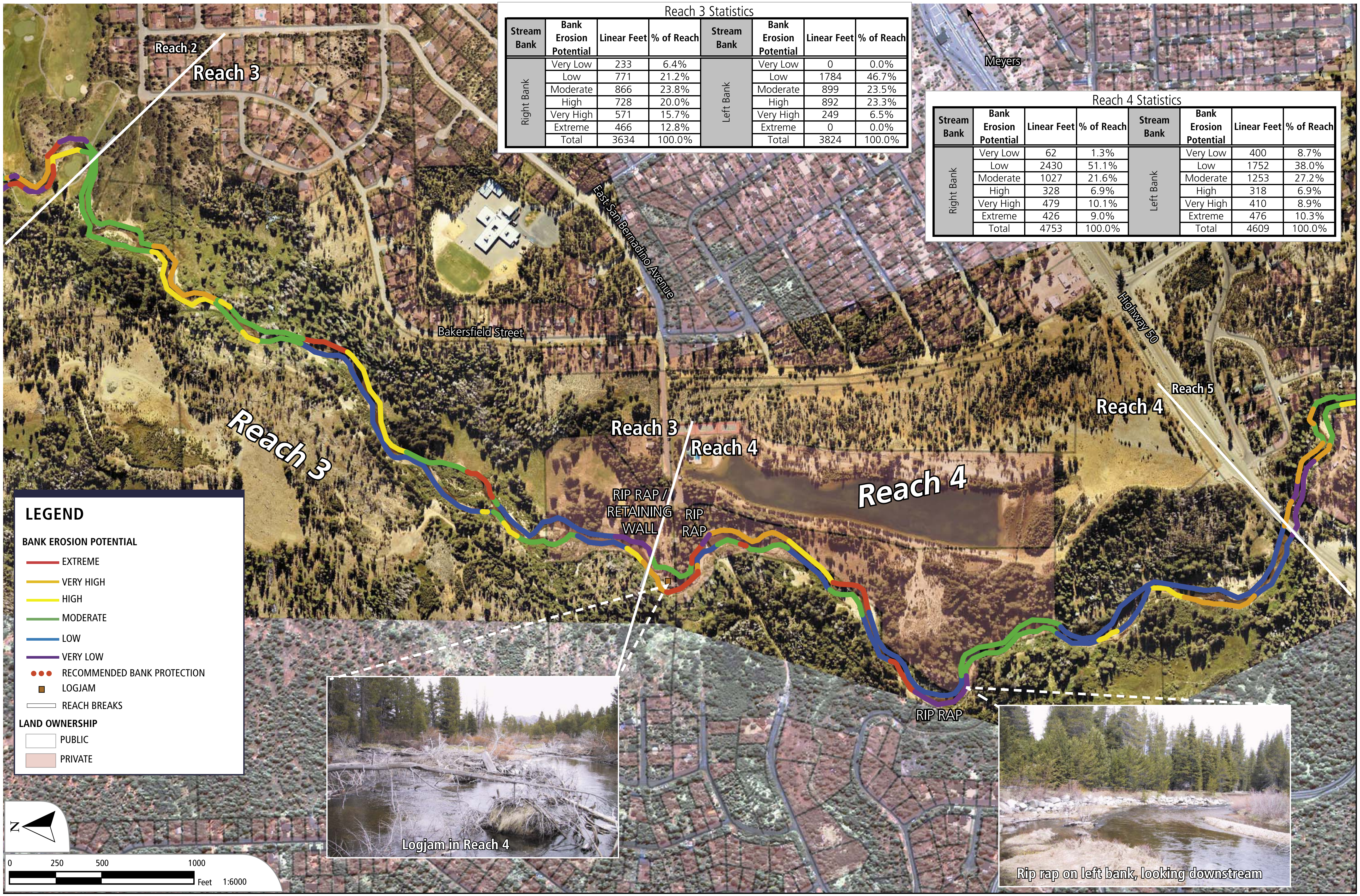

FIGURE 3.20B: Bank erosion potential ratings for Reaches 3 and 4.

Reach 3 Statistics

Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach	Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach
Right Bank	Very Low	233	6.4%	Left Bank	Very Low	0	0.0%
	Low	771	21.2%		Low	1784	46.7%
	Moderate	866	23.8%		Moderate	899	23.5%
	High	728	20.0%		High	892	23.3%
	Very High	571	15.7%		Very High	249	6.5%
	Extreme	466	12.8%		Extreme	0	0.0%
	Total	3634	100.0%		Total	3824	100.0%

Reach 4 Statistics

Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach	Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach
Right Bank	Very Low	62	1.3%	Left Bank	Very Low	400	8.7%
	Low	2430	51.1%		Low	1752	38.0%
	Moderate	1027	21.6%		Moderate	1253	27.2%
	High	328	6.9%		High	318	6.9%
	Very High	479	10.1%		Very High	410	8.9%
	Extreme	426	9.0%		Extreme	476	10.3%
	Total	4753	100.0%		Total	4609	100.0%

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Reach 5 Statistics

Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach	Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach
Right Bank	Very Low	118	1.5%	Left Bank	Very Low	440	5.8%
	Low	220	2.9%		Low	236	3.1%
	Moderate	1338	17.5%		Moderate	1050	13.9%
	High	600	7.8%		High	656	8.7%
	Very High	5380	70.3%		Very High	5002	66.4%
	Extreme	0	0.0%		Extreme	148	2.0%
	Total	7656	100.0%		Total	7531	100.0%

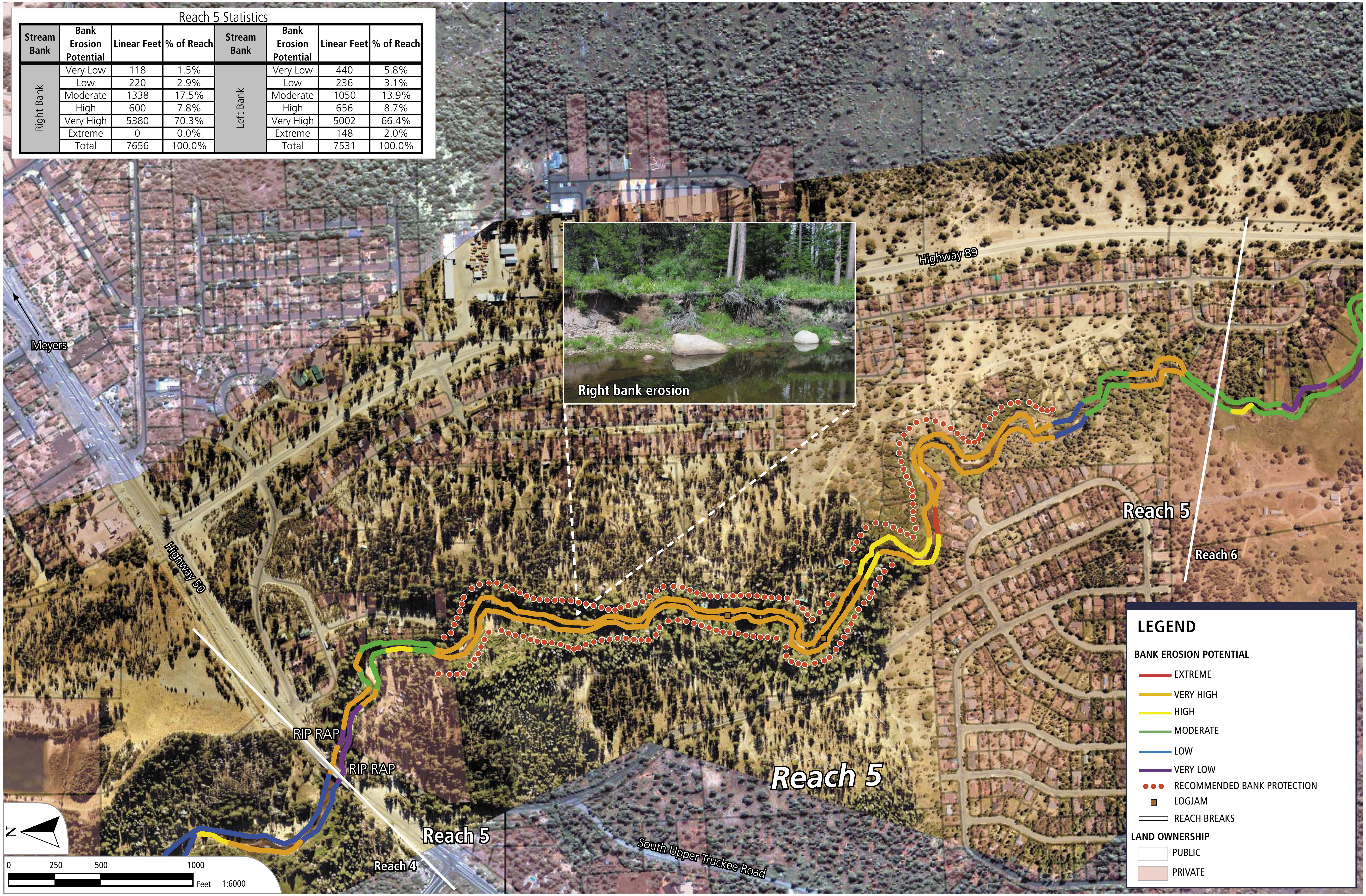

FIGURE 3.20C: Bank erosion potential ratings for Reach 5.

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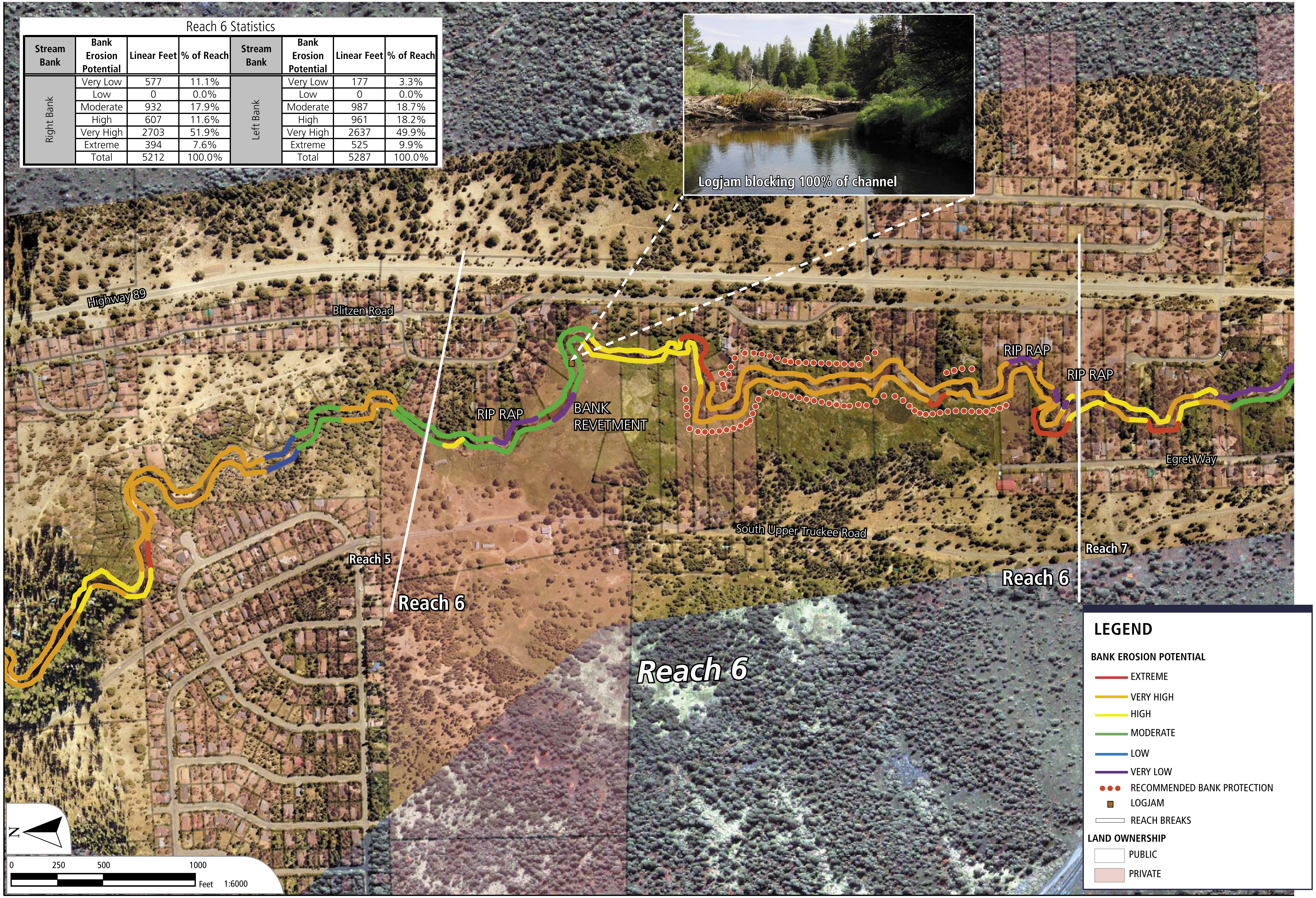
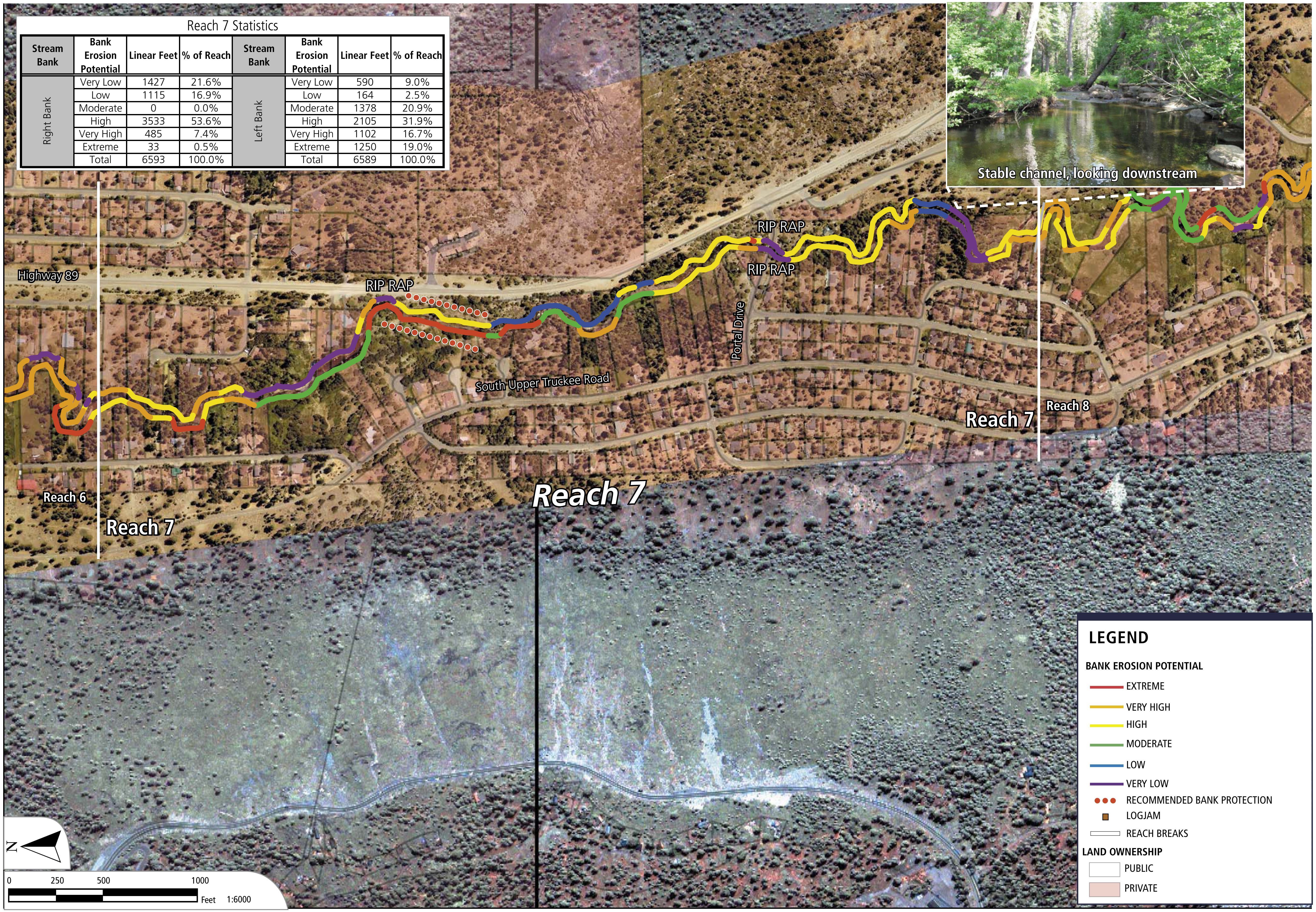


Reach 6 Statistics

Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach	Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach
Right Bank	Very Low	577	11.1%	Left Bank	Very Low	177	3.3%
	Low	0	0.0%		Low	0	0.0%
	Moderate	932	17.9%		Moderate	987	18.7%
	High	607	11.6%		High	961	18.2%
	Very High	2703	51.9%		Very High	2637	49.9%
	Extreme	394	7.6%		Extreme	525	9.9%
	Total	5212	100.0%		Total	5287	100.0%

FIGURE 3.20D: Bank erosion potential ratings for Reach 6.



Reach 7 Statistics

Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach	Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach
Right Bank	Very Low	1427	21.6%	Left Bank	Very Low	590	9.0%
	Low	1115	16.9%		Low	164	2.5%
	Moderate	0	0.0%		Moderate	1378	20.9%
	High	3533	53.6%		High	2105	31.9%
	Very High	485	7.4%		Very High	1102	16.7%
	Extreme	33	0.5%		Extreme	1250	19.0%
	Total	6593	100.0%		Total	6589	100.0%

FIGURE 3.20E: Bank erosion potential ratings for Reach 7.

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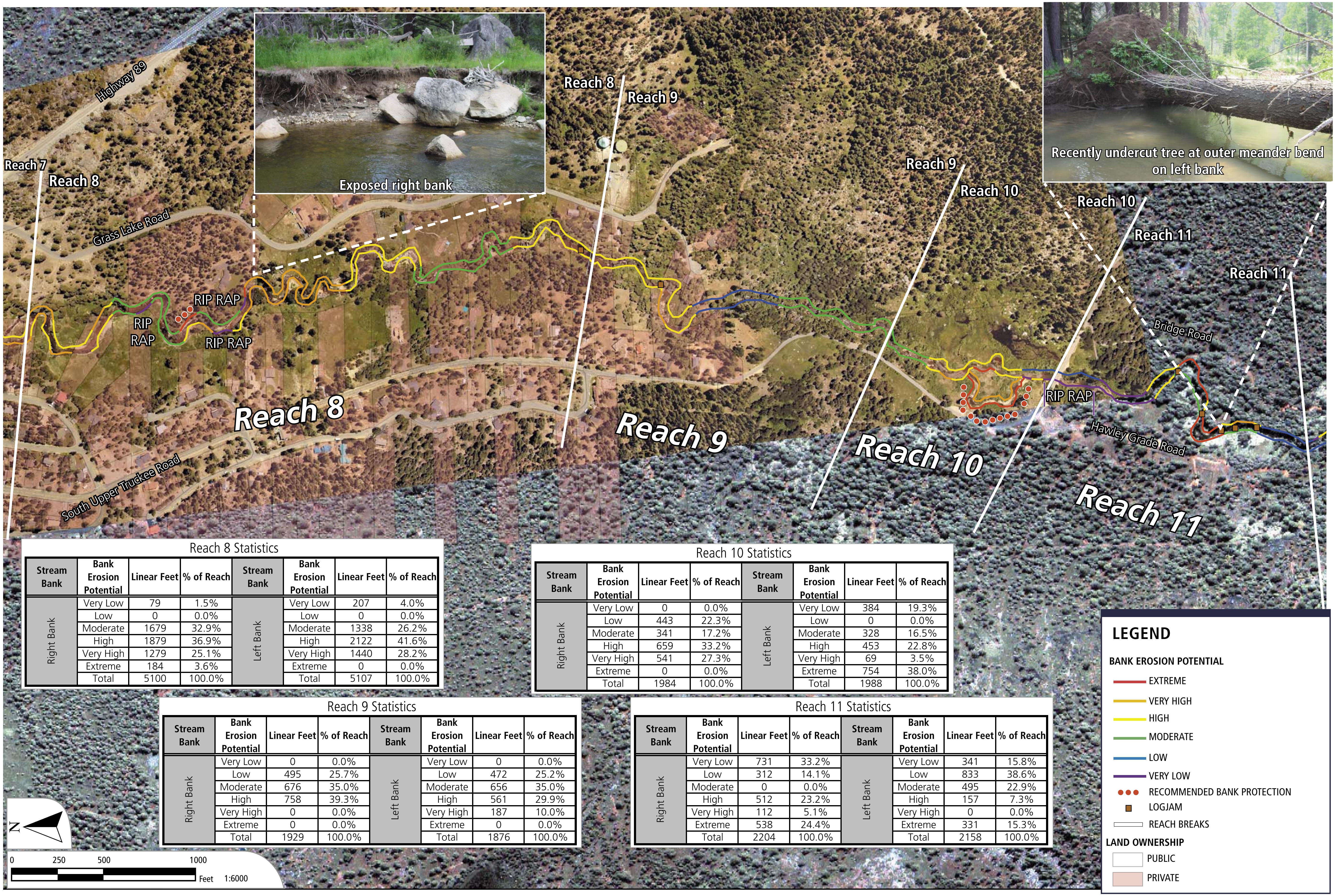

Reach 8 Statistics

Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach	Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach
Right Bank	Very Low	79	1.5%	Left Bank	Very Low	207	4.0%
	Low	0	0.0%		Low	0	0.0%
	Moderate	1679	32.9%		Moderate	1338	26.2%
	High	1879	36.9%		High	2122	41.6%
	Very High	1279	25.1%		Very High	1440	28.2%
	Extreme	184	3.6%		Extreme	0	0.0%
	Total	5100	100.0%		Total	5107	100.0%

Reach 9 Statistics

Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach	Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach
Right Bank	Very Low	0	0.0%	Left Bank	Very Low	0	0.0%
	Low	495	25.7%		Low	472	25.2%
	Moderate	676	35.0%		Moderate	656	35.0%
	High	758	39.3%		High	561	29.9%
	Very High	0	0.0%		Very High	187	10.0%
	Extreme	0	0.0%		Extreme	0	0.0%
	Total	1929	100.0%		Total	1876	100.0%

Reach 10 Statistics

Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach	Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach
Right Bank	Very Low	0	0.0%	Left Bank	Very Low	384	19.3%
	Low	443	22.3%		Low	0	0.0%
	Moderate	341	17.2%		Moderate	328	16.5%
	High	659	33.2%		High	453	22.8%
	Very High	541	27.3%		Very High	69	3.5%
	Extreme	0	0.0%		Extreme	754	38.0%
	Total	1984	100.0%		Total	1988	100.0%

Reach 11 Statistics

Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach	Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach
Right Bank	Very Low	731	33.2%	Left Bank	Very Low	341	15.8%
	Low	312	14.1%		Low	833	38.6%
	Moderate	0	0.0%		Moderate	495	22.9%
	High	512	23.2%		High	157	7.3%
	Very High	112	5.1%		Very High	0	0.0%
	Extreme	538	24.4%		Extreme	331	15.3%
	Total	2204	100.0%		Total	2158	100.0%

LEGEND

BANK EROSION POTENTIAL

🟥	EXTREME
🟧	VERY HIGH
🟨	HIGH
🟩	MODERATE
🟦	LOW
🟪	VERY LOW
●●●	RECOMMENDED BANK PROTECTION
■	LOGJAM
▭	REACH BREAKS

LAND OWNERSHIP

☐	PUBLIC
▨	PRIVATE

FIGURE 3.20F: Bank erosion potential ratings for Reaches 8, 9, 10, and 11.

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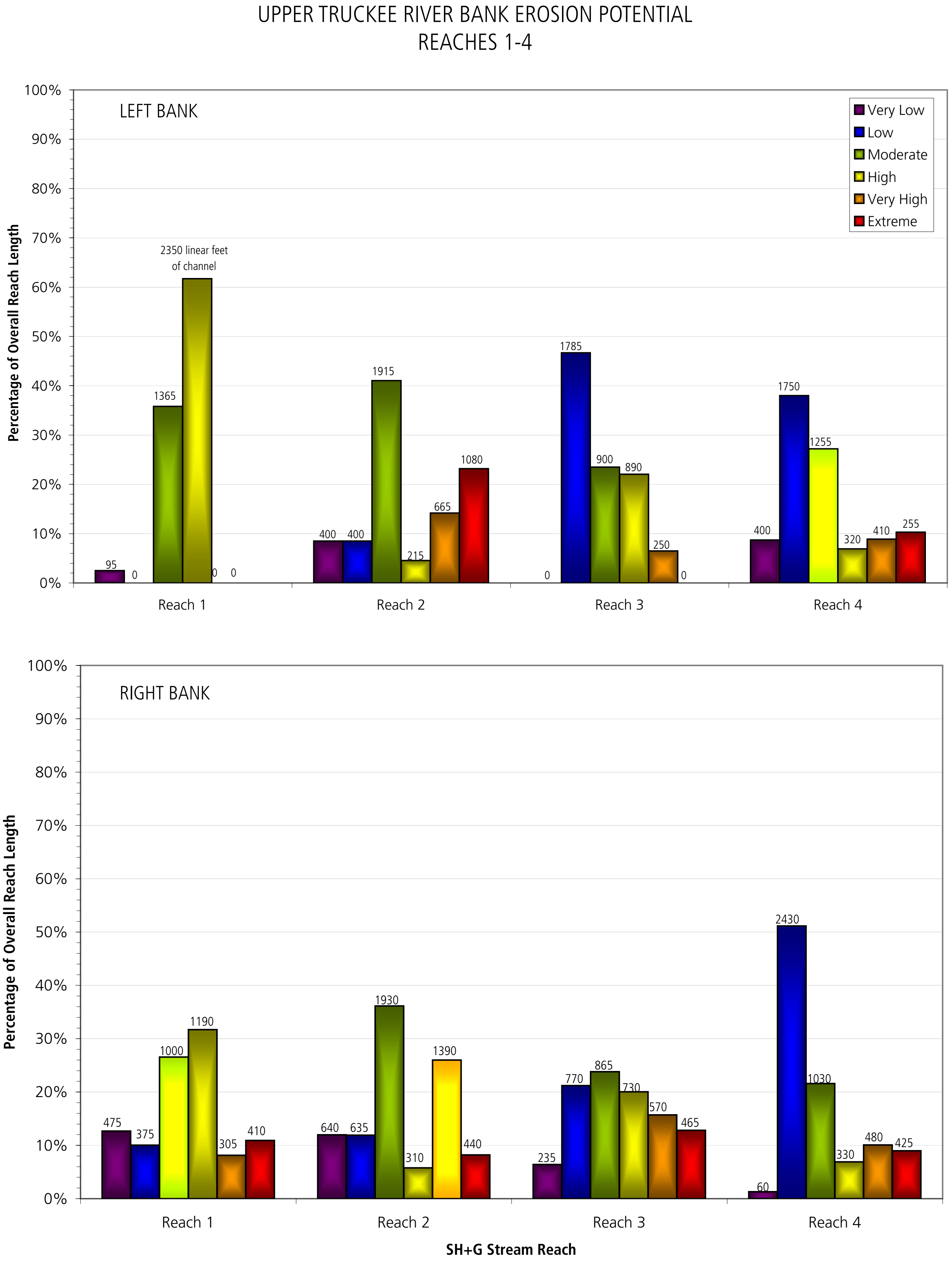

FIGURE 3.21A: Histograms illustrating the bank erosion potential for the left and right banks of Reaches 1-4 by percentage of overall reach length. See Figures 3.20A and B for locations.

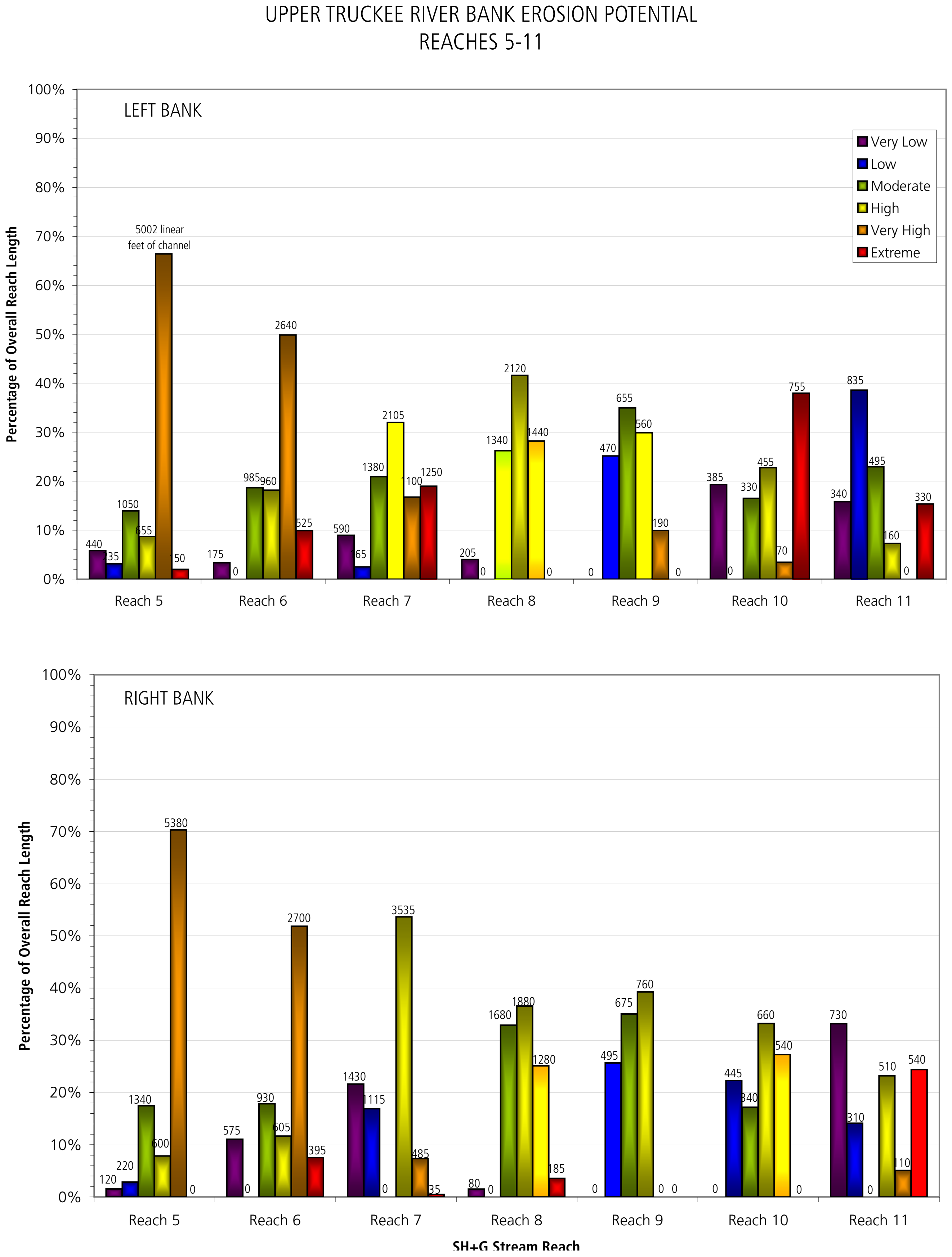

FIGURE 3.21B: Histograms illustrating the bank erosion potential for the left and right banks of Reaches 5-11 by percentage of overall reach length. See Figures 3.20C-E for locations.

Reach	Left Bank												Right Bank											
	Very Low		Low		Moderate		High		Very High		Extreme		Very Low		Low		Moderate		High		Very High		Extreme	
	ft	%	ft	%	ft	%	ft	%	ft	%	ft	%	ft	%	ft	%	ft	%	ft	%	ft	%	ft	%
Reach 1	95	2.5	0	0.0	1364	35.8	2351	61.7	0	0.0	0	0.0	476	12.7	377	10.0	997	26.6	1190	31.7	305	8.1	410	10.9
Reach 2	397	8.5	397	8.5	1915	41.0	213	4.6	663	14.2	1082	23.2	640	12.0	636	11.9	1931	36.1	308	5.8	1390	26.0	439	8.2
Reach 3	0	0.0	1784	44.1	898	22.2	892	22.1	249	6.2	220	5.4	233	6.4	770	21.2	865	23.8	728	20.0	570	15.7	466	12.8
Reach 4	400	9.1	1751	39.9	1252	28.6	318	7.2	410	9.3	255	5.8	6232	1.3	2430	51.1	1026	21.6	328	6.9	479	10.1	426	9.0
Reach 5	440	5.8	236	3.1	1050	13.9	656	8.7	5002	66.4	148	2.0	118	1.5	220	2.9	1338	17.5	600	7.8	5380	70.3	0	0.0
Reach 6	177	3.3	0	0.0	987	18.7	961	18.2	2637	49.9	525	9.9	577	11.1	0	0.0	932	17.9	607	11.6	2703	51.9	394	7.6
Reach 7	590	9.0	164	2.5	1378	20.9	2105	31.9	1102	16.7	1250	19.0	1427	21.6	1115	16.9	0	0.0	3533	53.6	485	7.4	33	0.5
Reach 8	207	4.0	0	0.0	1338	26.2	2122	41.6	1440	28.2	0	0.0	79	1.5	0	0.0	1679	32.9	1879	36.9	1279	25.1	184	3.6
Reach 9	0	0.0	472	25.2	656	35.0	561	29.9	187	10.0	0	0.0	0	0.0	495	25.7	676	35.0	758	39.3	0	0.0	0	0.0
Reach 10	384	19.3	0	0.0	328	16.5	453	22.8	69	3.5	754	38.0	0	0.0	443	22.3	341	17.2	659	33.2	541	27.3	0	0.0
Reach 11	341	15.8	833	38.6	495	22.9	157	7.3	0	0.0	331	15.3	731	33.2	312	14.1	0	0.0	512	23.2	112	5.1	538	24.4

% = percent of reach classified by specified rating

TABLE 3.4: Summary of channel bank erosion survey in the Upper Reach Study Area for the left and right banks. Ratings range from very low bank instability to extreme bank instability. See Figures 3.20A-F for maps showing exact location of instabilities.

have been accounts of beaver signs in the late 1800s in the adjacent Carson River basin to the south (Tappe, 1942). Beavers reportedly were introduced as a commercial venture and for habitat enhancement by CDFG (Tappe 1942). The effects on stream channel behavior and morphology were profound, since beaver dams on some streams are able to withstand snowmelt runoff events and thus impound flow and sediment. When the impoundment has filled with sediment, the dams are often abandoned and subsequent flows breach the dam. This leaves an area of marsh with a knickpoint in the stream profile that de-stabilizes the local reach. Subsequent erosion outflanks the dam and avulses the channel. Beaver dams appear to be far less effective on the UTR, as the hydraulic force of snowmelt flows is sufficient to breach and remove the dams each year. Beavers re-build dams beginning in late summer and into the fall. It is possible that some marsh surfaces in the historic floodplain were formed by beaver activity rather than geomorphic processes, as occurs in areas of their natural habitat. The role of beavers is discussed further in the wildlife section below (Section III.3).

ROADS AND SUBWATERSHED EROSION SURVEY

The level of disturbance of the urbanized watersheds adjacent to the main UTR corridor was evaluated through a detailed assessment of soil disturbance and erosion along roads (road cuts, shoulders and drainage ditches) and in tributary stream channels. The roads database was developed using a modified method developed by NRCS (2000), as well as reconnaissance of connecting tributary streams. The assessment attempts to prioritize subwatersheds for erosion and drainage control treatment based upon a combination of the degree of soil disturbance, the slope of the subwatershed, the effects of any installed erosion control and sediment retention facilities, and the connectivity of the tributary to the main stem UTR. The methodology is summarized in flow chart shown in Figure 3.22 and the full methodology is described in Appendix C. The results of the road and subwatershed survey are shown in Figure 3.23 and Table 3.5. The full roads database is presented in Appendix D.

The assessment found that the erosion along Highway 89 (Luther Pass Road) is unusually high. There has been little BMP retrofit (scheduled by Caltrans for 2007/2008) on steep roadcuts of unconsolidated glacial deposits and the sediment discharges directly into Grass Lake and Big Meadow Creeks, which flow along the road corridor. The other high priority watersheds are situated in Meyers and lower Christmas Valley, where steep areas covered in subdivision roads are untreated.

A preliminary, reconnaissance-level survey of channel conditions on tributaries to the Upper Truckee River was conducted in the spring of 2003 to assess potential cumulative land use impacts and determine the need for more site-specific surveys. During the reconnaissance-level surveys, tributaries within urbanizing or road influenced areas were assessed at road crossing or other public right-of-way locations. General notes on incision, bank erosion, access to floodplain, channelization, straightening, sedimentation, and overall health of the channel were noted. This information was integrated with an assessment of the level of connectivity between road

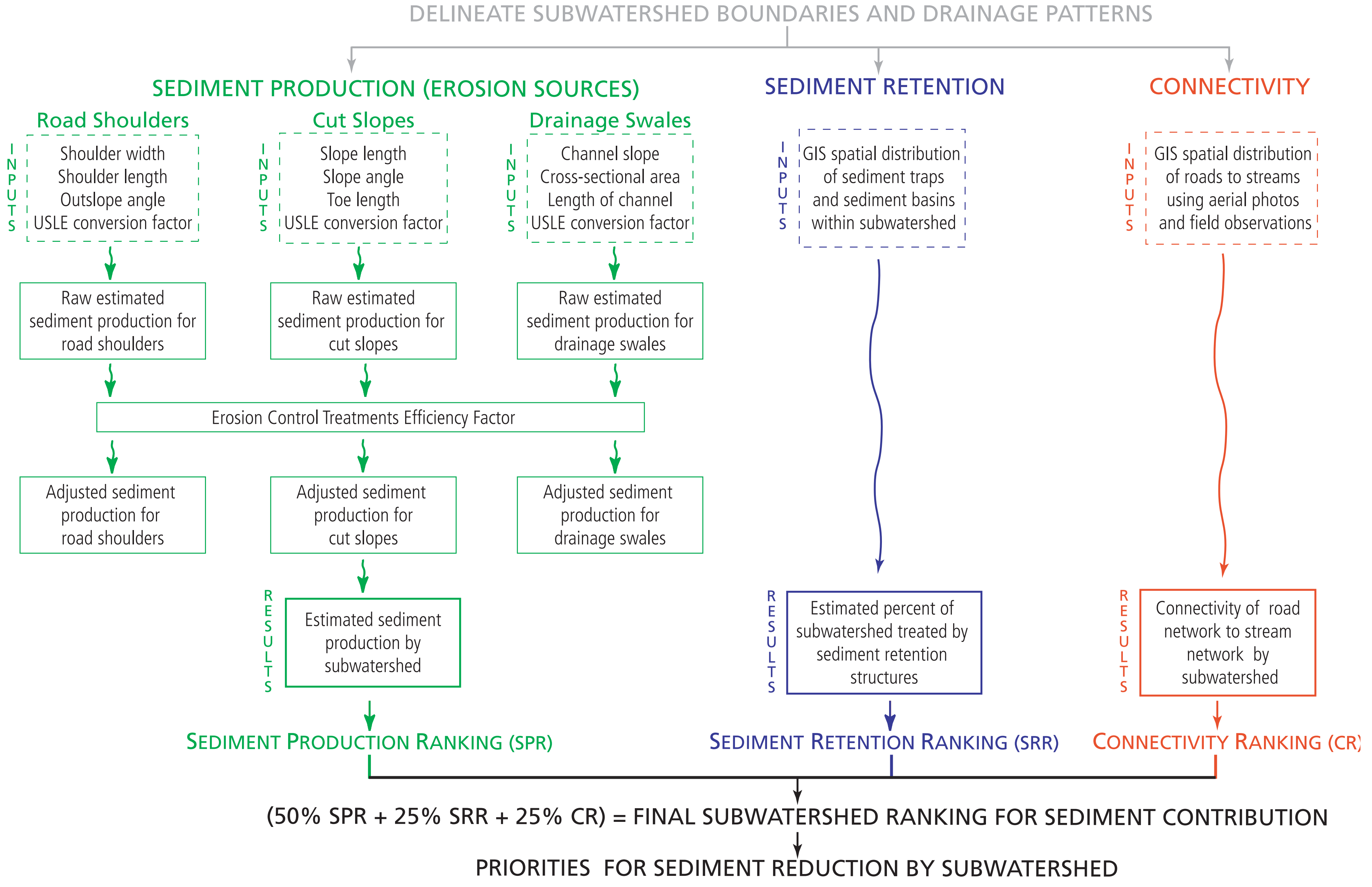

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FIGURE 3.22: Flow chart illustrating the process by which priorities for sediment reduction by subwatershed were determined. All rankings were scaled from 1 to 5 (1 = low priority). Rankings for sediment production (1 = low production), sediment retention (1 = high retention), and connectivity (1 = little connectivity) determined the final subwatershed ranking for sediment contribution.

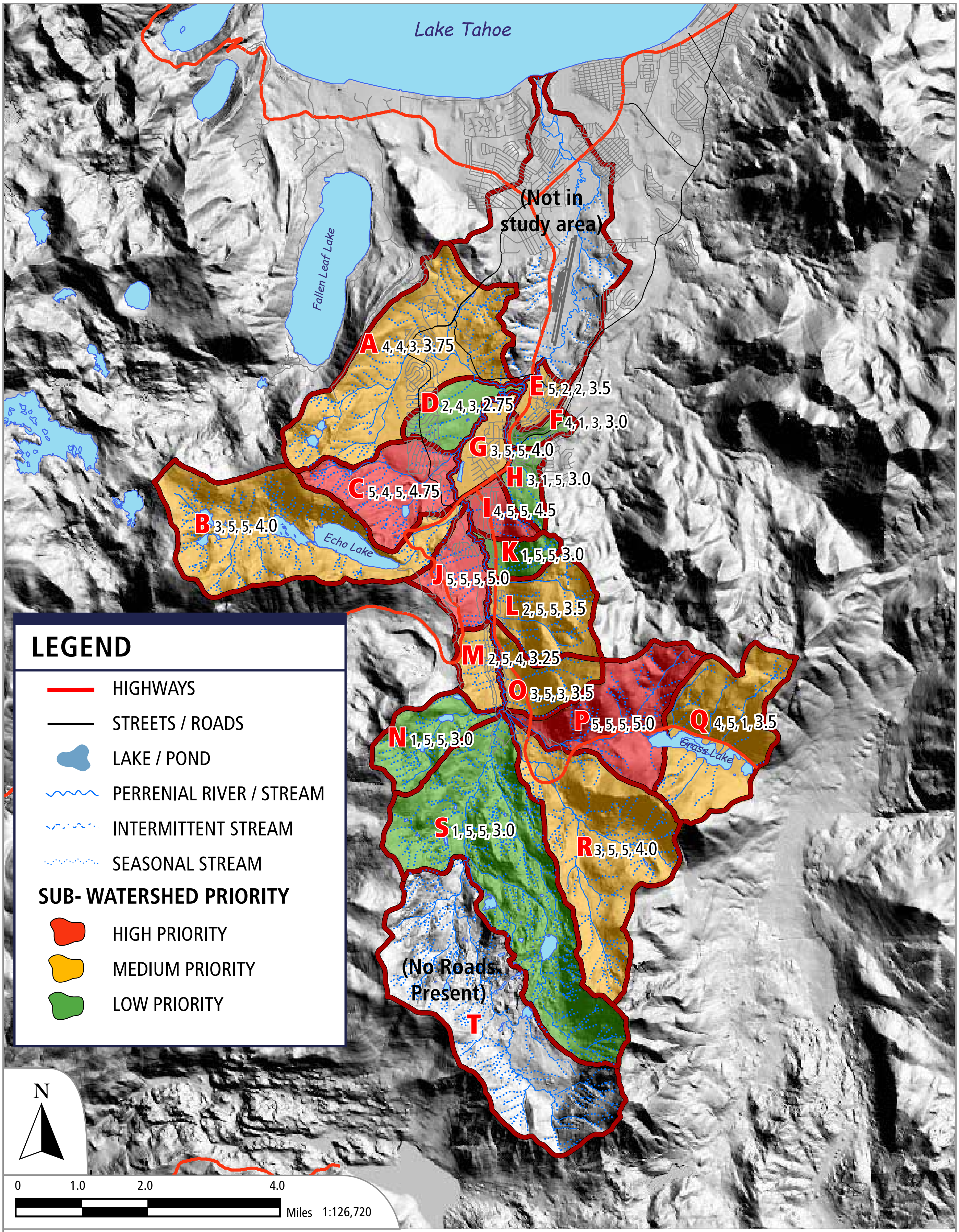

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FIGURE 3.23: Map indicating subwatershed priority based on cumulative ranking from the road and subwatershed survey. Numerical rankings are ordered as follows: Erosion Control Rank, Sediment Retention Rank, Connectivity Rank, Final Rank.

Sub-watershed ID	Erosion Control Rank - Primary Treatment (50% of Ranking)	Sediment Retention Rank - Secondary (25% of Ranking)	Connectivity Rank (25% of Ranking)	Final Ranking in Order of Treatment Priority	Priority	Recommended Treatments	Treatment Discussion
P	5	5	5	**5**	HIGH	Cut slope treatments, drainage swale improvements, sediment traps at cross culverts, upgrade Forest Service access road	This subwatershed primarily consists of road runoff from Hwy 89. Recommended treatments include rock lining of bare drainage swales and sediment vaults at cross culverts. The campground access road through the Forest Service campground should also be upgraded to reduce erosion from poor drainage conditions.
J	5	5	5	**5**		Cut slope treatments, sediment traps at cross culverts from Hwy 50, sediment basins at base of Hwy 50 slope, curb and gutter and drainage swale improvements in neighborhood off of S. Upper Truckee Road	Though this neighborhood is fairly flat and primarily consists of road shoulders with a few cut slopes, it was ranked as a high priority due to the fact that it is well connected and has several tributary channels that have been modified and straightened into drainage swales. Many of these channels originate from Hwy 50 which is untreated and well connected to the Upper Truckee River.
C	5	4	5	**4.75**		Curb and gutter, drainage swale improvements, cut slope treatments, sediment basins	Fairly steep subwatershed with little to no treatment of runoff. One sediment basin occurs on the upstream end of N. Upper Truckee Road and one drainage swale is lined. Otherwise, road runoff is discharged directly to well-connected channels. Recommend curb and gutter, improvements to drainage system, and installation of sediment basins.
I	4	5	5	**4.5**		Cut slope treatments, drainage swale improvements, sediment traps, sediment basins	This neighborhood is a mix of commercial, industrial, and residential land uses. There is evidence of high sediment production in several untreated drainage swales that occur through this neighborhood. Road cuts on the east side and large road shoulders used by heavy equipment likely contributes a significant amount of sediment directly to the Upper Truckee River.
B	3	5	5	**4**	MODERATE	Curb and gutter, drainage swale improvements, cut slope treatments, sediment basins	This neighborhood is closely connected to the neighborhood in subwatershed C. Similar road and drainage improvements within this subwatershed could be implemented in conjunction with the improvements in subwatershed C.
G	3	5	5	**4**		Curb and gutter, drainage swale improvements, restoration of historic wet meadow	Much of this neighborhood is flat with exposed road shoulders and an efficient, untreated drainage system that eventually flows through the golf course and into the Upper Truckee River. On the east side of this subwatershed, just downstream of Hwy 50 on a tributary to the Upper Truckee, there is an opportunity to restore a degraded wet meadow area that is currently under public ownership. This project could be used to treat some of the runoff in this neighborhood and runoff from subwatersheds #18 and #20.
R	3	5	5	**4**		Cut slope treatments, drainage swale improvements, sediment traps at cross culverts	This subwatershed primarily consist of road runoff from Hwy 89. Recommended treatments include rock lining of bare drainage swales and sediment vaults at cross culverts.
A	4	4	3	**3.75**		Curb and gutter, cut slope treatments	Much of watershed has secondary treatments. Erosion control is recommended within neighborhoods off of N. Upper Truckee Road including curb and gutter and treatment of road cuts. This subwatershed is also treated by restoration projects recently developed on Angora Creek.
E	5	2	2	**3.5**		Drainage swale improvements, cut slope treatments, sediment traps.	Some treatments exist within this watershed including vegetated drainage swales and cut slopes and secondary treatment through sediment basins. Much of the subwatershed is steep and additional primary treatment elements could be implemented.
Q	4	5	1	**3.5**		Cut slope treatment, drainage swale inprovements, sediment traps at cross culverts	Runoff from Hwy 89 discharges directly into Grass Lake Creek which acts as a treatment area prior to discharging into Grass Lake Creek and on to the Upper Truckee River.
O	3	5	3	**3.5**		Cut slope treatments, drainage swale improvements, sediment traps at cross culverts	This subwatershed primarily consist of road runoff from Hwy 89. Recommended treatments include rock lining of bare drainage swales and sediment vaults at cross culverts.
L	2	5	5	**3.5**		Curb and gutter, sediment traps, sediment basins	This neighborhood is fairly flat and consist primarily of untreated road shoulders. Drainage is well connected with the Upper Truckee River and tributary channels have been modified and straightened to act as drainage swales for roads.
M	2	5	4	**3.25**		Curb and gutter, sediment traps, sediment basins	This neighborhood is fairly flat and consist primarily of untreated road shoulders. Drainage is well connected with the Upper Truckee River and tributary channels have been modified and straightened to act as drainage swales for roads.
F	4	1	3	**3**	LOW	Upgrades to existing erosion control treatment, sediment traps, sediment basins	Many of the erosion control treatments in this neghborhood are older and require some upgrades (treatment of cut slopes consist of shockcrete walls that are failing in some areas). Secondary treatments are absent and could be added, inlcuding diversion of much of the runoff through a proposed wetland enhancement in subwatershed #17.
H	3	1	5	**3**		BMP's on golf course	Implement BMP's on Golf Course. Neighborhood within subwatershed is well treated.
K	1	5	5	**3**		Curb and gutter, sediment traps, sediment basins	This neighborhood is fairly flat and consist primarily of untreated road shoulders. Drainage is well connected with the Upper Truckee River and tributary channels have been modified and straightened to act as drainage swales for roads.
S	1	5	5	**3**		Curb and gutter, drainage swale improvements	The only road through this subwatershed is a portion of S. Upper Truckee. Some gullies have formed as road drainage is discharged into the Upper Truckee River.
N	1	5	5	**3**		Curb and gutter, drainage swale improvements	The only road through this subwatershed is a portion of S. Upper Truckee. Some gullies have formed as road drainage is discharged into the Upper Truckee River.
D	2	4	3	**2.75**		curb and gutter, sediment traps	Much of the drainage within theis neighborhood is distributed, rather than concentrated. N. Upper Truckee Road has been treated.

TABLE 3.5: Priority Ranking Matrix. Treatment rankings from Levels 1 (Erosion Control Treatment) through 3 (Connectivity) are combined to produce a final treatment priority ranking in order of importance. Subwatersheds with higher erosion estimates are given a higher priority ranking when ties occur. Erosion control elements include BMP's that treat the erosion source such as rock slope protection, retaining walls, curb and gutter, and rock lining of drainage swales. Subwatersheds with higher erosion source rankings have higher sediment production from erosion source features. Sediment retention elements filter or retain sediment delivered from an erosion source before it reaches a drainage feature that provides direct connectivity to the stream network. Sediment retention includes sediment traps, sediment basins, or distributed flow paths. Subwatersheds that lack sediment retention elements were assigned a value of 5. Connectivity is a ranking of the efficiency of the drainage system to deliver sediment to the stream network. Highly connected subwatersheds receive a value of 5.

runoff and stream channels, as discussed in Appendix D. Table 3.6 summarizes the results of the preliminary survey for the channels that are experiencing a degree of cumulative impacts.

Table 3.6: Preliminary survey results for tributary channel conditions within Upper Truckee River Study Area.

Tributary	Survey Segment	Level of Impact	Discussion
Grass Lake Creek	Grass Lake to 1st Hwy 89 crossing	High	Channel and floodplain constricted and straightened along Hwy 89 right-of-way. Channel subsequently incised with lack of complexity.
	First Hwy 89 to 2nd Hwy 89 crossing	Moderate	High gradient channel crosses a Forest Service recreation road in several places. Road is poorly maintained resulting in delivery of sediment and bank erosion in more alluvial reaches.
Grass Lake Creek tributaries	Hwy 89 crossings between 1st crossing and Grass Lake	Moderate	Road runoff and roadside drainage swales empty directly into these tributaries. Ditch relief culverts interact directly with natural drainage system.
Big Meadow Creek	Cookhouse Meadow	High / Moderate	Historic downcutting has resulted in an incised channel with no floodplain access.
Unnamed tributary near Meyers	Through Paradise Golf Course	High	Stream channels denuded of vegetation. Likely to have significant water quality impacts.
Unnamed tributary near Meyers	Highway 50 / Santa Fe Road to San Diego Road	High	Realigned and channelized away from historic wet meadow adjacent to Hwy 89.
Unnamed tributary near Meyers	San Diego Road to Country Club Drive	Moderate	Historic downcutting and evidence of recent bank sloughing. Very little riparian vegetation. May experience some flooding due to urban runoff volumes.
Unnamed tributary near Meyers	Through Lake Tahoe Golf Course	Moderate	Channelization has occurred in most areas though riparian vegetation is present. Impacted areas occur as channel crosses fairways or is culverted.

Channels determined to have a significant level of impact with potential for future restoration were surveyed in more detail. Impacted alluvial channel reaches on Grass Lake and Big Meadow Creeks were assessed using a bank erosion potential method developed by Rosgen (1996). This method is discussed in more detail in the section of this report describing the Channel Bank

Erosion Survey for the mainstem of the Upper Truckee River. Survey results for the Big Meadow and Grass Lake Creek drainages are presented in Figure 3.24. The Unnamed Tributary was assessed via a detailed walk-through of the channel to identify impacts and potential restoration opportunities.

The Unnamed Creek near Meyers flows northward from the Lake Tahoe Paradise Golf Course, across Highway 50, through the East San Bernardino residential neighborhood, and into the Lake Tahoe Golf Course where it meets the mainstem UTR (see Figure 5.1). Much of its runoff originates from the commercial and residential areas located between the Paradise Golf Course and the East San Bernardino neighborhood. The headwaters in the Paradise Golf Course have been extensively modified, including channelization and removal of riparian vegetation. In many cases, turf grass abuts the channel banks, resulting in the potential for direct discharge of fertilizers and other inorganic compounds, creating water quality concerns. Highway 50 road runoff is also discharged directly into the channel as it intersects roadside ditches before crossing Highway 50 at the Santa Fe Road intersection.

Downstream of the Santa Fe Road crossing, the tributary has been channelized away from a historic wet meadow between Arrowhead Drive and Highway 50. This channelization likely occurred to make room for development of a commercial area along Highway 50. A recent attempt has been made to divert flow out of the channelized section of creek and back into the meadow. To do this a berm was placed across the channel. Subsequent storm flows have overtopped the berm, resulting in a large scour hole downstream that may have initiated or exacerbated downcutting and channel widening within that reach (Figure 3.25). Given the absence of development on the historic wet meadow, there may be an opportunity to restore this feature, providing flow attenuation for downstream residents and water quality treatment for the Paradise Golf Course and adjacent neighborhoods. This and other restoration opportunities are discussed in great detail in Chapter 5.

Morphologically, channels and banks within the Grass Lake and Big Meadow Creek drainages consist of resistant material derived from lateral moraine deposits that have been reworked by periodic channel migrations. Abundant large woody material, natural stable boulder weirs, and access to secondary or floodplain channels during high flow events provide relative stability and a capacity to store and attenuate transport of fine sediment that is delivered to the channel from disturbances within the watershed. Several “alluvial” reaches do occur within these drainages, namely Cookhouse Meadow on Big Meadow Creek and the lower gradient reach of Grass Lake Creek just downstream of Grass Lake.

Cookhouse Meadow is thought to have historically been a wet meadow. Currently, the meadow is deeply incised into the meadow, the causes of which are being assessed as part of a watershed analysis and meadow restoration plan being funded by the USFS. The lower gradient reach of Grass Lake Creek has been directly impacted by development of Highway 89. It is likely that Grass Lake Creek was moved to the edge of the valley to accommodate Highway 89, resulting in the loss

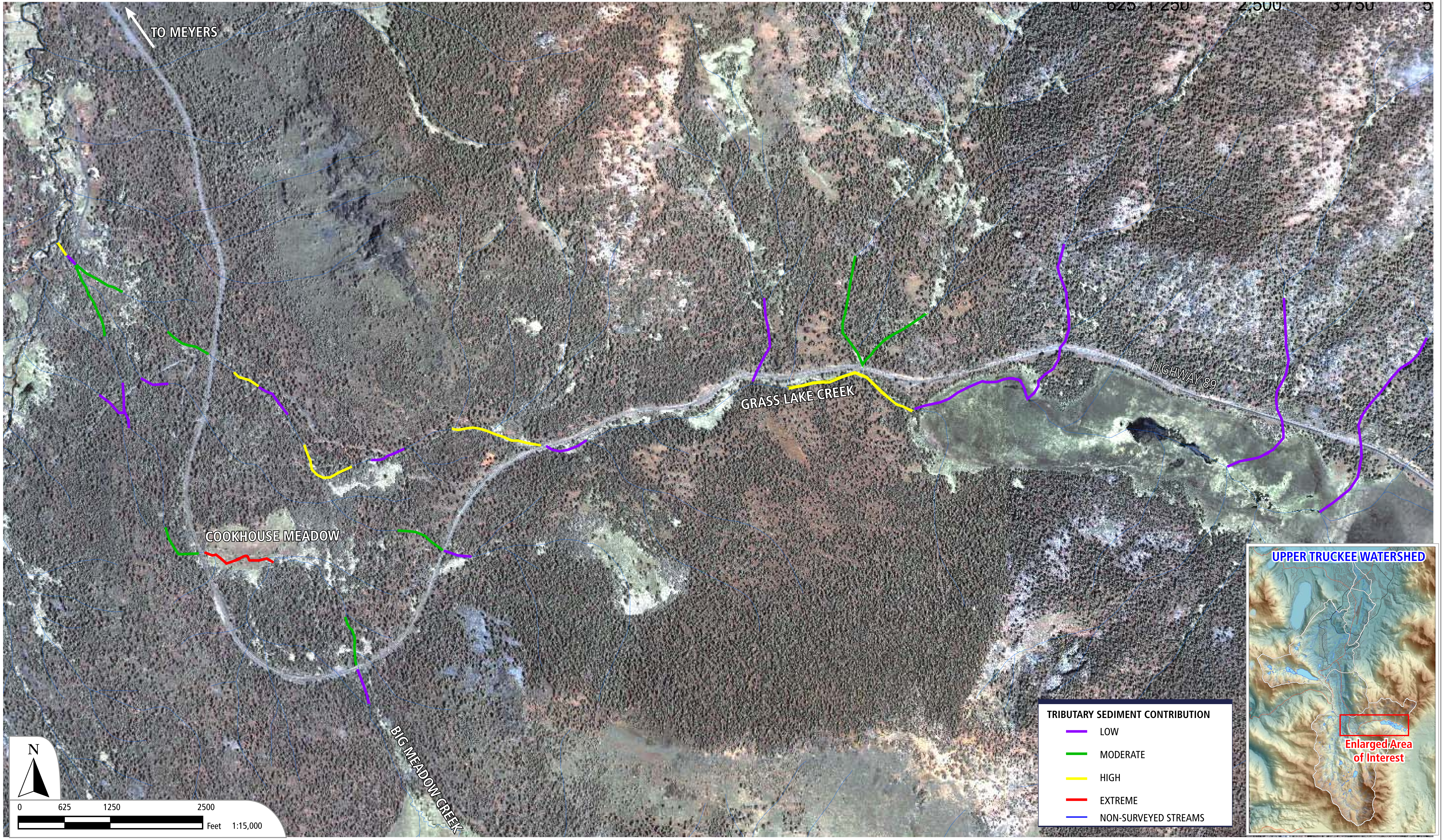


FIGURE 3.24: Map indicating the relative contribution of sediment of tributaries to the Grass Lake and Big Meadow Creek reaches of the Upper Truckee Watershed observed during June 25-26, 2003 site visit.

FIGURE 3.25: Photo of the unnamed tributary near Meyers downstream of the Santa Fe Road crossing. A berm was placed across the channel to divert flow from the channelized creek back to the adjacent floodplain. Subsequent flows have overtopped the berm, creating the large scour hole shown in the photo above.

of channel complexity, efficient movement of delivered sediment, and an increase in bank erosion as the channel attempts to rebuild lost floodplain.

UPPER WATERSHED SURVEYS

The Upper Watershed was surveyed on a reconnaissance basis in order to assess the condition of tributary streams and drainages that flow into the mainstem UTR. The LTBMU is preparing a watershed assessment of Big Meadow Creek Drainage, which includes treatment of a large gully in Cookhouse Meadow, and it is assumed that detailed plans will be addressed under that plan.

Grass Lake Creek has been highly impacted by the construction of Highway 89, which filled the creek and floodplain along much of its length from Grass Lake to the Highway 89 crossing near the Big Meadow Trailhead. Several stream reaches and tributaries were surveyed during the road erosion survey. Grass Lake Creek is also affected by fill and crossings on South Upper Truckee Road; these areas are noted on the roads survey.

Besides the roads affecting Grass Lake and lower Big Meadow Creeks, there are no road networks in the Upper Watershed. In general, the Upper Watershed streams flow through bedrock, alluvial fans and fills, meadows, glacial deposits, or boulder/bedrock reaches. All of the meadows have been historically grazed (Figures 2.10 and 2.11) and beavers have been influential factors in stream and marsh vegetation development and forest mortality (Figure 3.26).

The limited survey indicates that the UTR appears to be in reasonably good condition, although the aftereffects of grazing are visible. Meiss Meadow was heavily grazed by sheep and cattle between the 1860s and the 1970s. It is likely that the meadows and lakes were areas of intensive grazing, while the steep alluvial slopes and conifer forests offered little forage. The sage/aspen communities support some grasses on alluvial slopes. Historical photos provide an indication of the historic density of herds (Figures 2.10 and 2.11). Reoccupation of photographed sites shows some recovery. However, other areas exhibit remnant soil pedestals and exposed regolith and subsoil (Figure 3.27).

One striking feature of the Upper Watershed is the observed erosion and sediment production rates of the Tertiary volcanic rocks (Tv) that form the rim of the Upper Watershed. These are predominately volcaniclastic rocks (breccias) that form cliff faces (Figure 3.28), but are readily weathered and eroded. The erosion rates of the volcanic bluffs were demonstrated by the immense volume of post-glacial alluvial fans formed below the bluffs and the recent evidence of debris-flow landslides that occurred with the severe thunderstorm event of August 21, 2003 (Figure 3.29). Beyond the shear volume and erodibility of the Tertiary volcanics, the erosion and weathering products include fine sediments and clays that may be dispersive in nature and an important factor for Lake Tahoe clarity. It is doubtful that the areas underlain by Tertiary volcanics, or the alluvial deposits derived from them, were ever impacted heavily by historic grazing, given the fact that little forage occurs under the predominately old growth Jeffrey pine and red fir

FIGURE 3.26: Photo showing stand of dead lodgepoles in former beaver dam impoundment. USFS biologist Mollie Hurd (Personal Communication, 2003) indicates that these dead stands are important bird habitat.

FIGURE 3.27: Photo showing regolith exposed below soil pedestals in area affected by historic grazing. This area was apparently a trail access to Elbert Lake. (July, 2003)

FIGURE 3.28: View of Upper Truckee River, upper southwest watershed divide showing Tertiary Volcanic (Tv) rocks overlying granitic rocks.

FIGURE 3.29: The upper photo shows recent sediment generated on hillslopes of tertiary volcaniclastic (Tv) rocks. Photo taken south of Round Lake in Upper UTR watershed (10/03). The lower photo shows debris flow chute emanating from Tv terrace near Round Lake in the Upper Watershed.

forest vegetation cover. However, the incorporation of fine sediments derived from Tv into runoff and into the UTR is readily apparent. While the rate of volcanic sediments generated appears to be close to natural background rates (given a lack of disturbance), once entrained in the streamflow there is little chance of settlement or deposition until flow overtops banks in the large meadows downstream, in the study area and below. Given the fact that all of the meadows have been disrupted and now have deeply incised channels that rarely flow overbank (through Christmas Valley, the LTGC, Sunset Ranch and Lake Tahoe Airport, Mosher Meadow and Barton Meadow), the natural mechanism for removing fine sediments has been removed. This function was especially important at the mouth of the UTR in the Barton Meadow, where the UTR was channelized away from its historic path during the Comstock Era and thus away from its historic delta. The historic delta would have allowed the UTR to discharge directly into the lagoon formed behind the barrier beach and would have been the best opportunity to deposit fine sediments over the full range of discharges before flowing into Lake Tahoe. The historic trend of channel incision is thus a double negative: it increased channel instability and chronic fine sediment sources from eroding banks, and it significantly reduced the overbank flow onto meadows where hydraulic residence times are the longest (especially in the Barton Meadow delta).

Another factor presented by Tertiary volcanics is the natural presence of phosphorous. Although a specific chemical analysis of eroded sediments and clays was not conducted, indirect evidence suggests that the Tv do produce abundant phosphorous. Observation of Round Lake, both in 2003 and earlier in the 1970s by hydrologist Toby Hanes (personal communication 2003), found decreased water clarity compared to other lakes in the Upper Watershed. The difference appears to be watershed sources of sediment and phosphorous, as Round Lake has a contributing watershed of Tv versus others that are predominately granitic and without significant phosphorous. The greenish tint of Round Lake observed in 2003 was evidently far more intense (described as "pea green") in the 1970s when observed by Toby Hanes. The best explanation is that there was still extensive cattle grazing of the Upper Watershed in the 1970s, which would have introduced greater nitrogen levels (likely the limiting factor for algae production in Round Lake).

An analysis of the mapped geologic units and the drainage network of the Upper Watershed reveals 4.72 square miles of Tv. Of this 2.92 square miles (62%) flow into one of the ten lakes in the Upper Watershed, leaving 1.8 square miles (38%) contributing directly to the UTR and available for discharge downstream.

III.1.D Opportunities and Constraints

The following opportunities and constraints were identified for geomorphology, hydrology and water quality.

OPPORTUNITIES

- There are opportunities to stabilize and restore geomorphic functions to the UTR mainstem through channel reconstruction and/or bioengineered stabilization projects. These must be carefully designed in order to gain hydraulic and sediment transport continuity. There must be consideration of the acceptable risks involved in attempting to "stabilize" the unstable reaches.
- Projects that restore channel function would also benefit native riparian vegetation communities and wildlife habitat. Restoration of groundwater conditions and riparian plant communities along channel banks would help increase channel stability and reduce sediment supply.
- There is a significant opportunity to implement channel reconstruction and/or stabilization projects in Reaches 1 through 4, where nearly all of the land is under public ownership.
- A significant improvement in the environmental quality of the UTR could be attained in Christmas Valley, Reaches 5 through 11, by implementing low-tech bioengineering and revegetation projects.

CONSTRAINTS

- Any effort to restore the UTR requires land already in use. Different objectives by private landowners could be a constraint to restoration activities. However, cooperative projects and incentives could be developed by public agencies and private sources. Public land is subject to policies of a number of agencies and is focused on developing the best possible use of the land given the many constraints involved. Current public land use can be changed, but not without the proper processes.
- Any effort to restore and/or stabilize the UTR will involve construction activities in the SEZ, which could lead to short term water quality and wildlife impacts. The projects will have to be carefully designed and implemented to avoid significant impacts and to gain regulatory permits and requirements.
- Infrastructure may require modification to allow for restoration of UTR.
- Construction access to most of the UTR in Christmas Valley is difficult.

III.1.E References Cited

Chang, C.Y.Y., J.S. Kuwabara and S.P. Pasilis. 1992. Phosphate and iron limitation of phytoplankton biomass in Lake Tahoe. *Can. J. Fish. Aquat. Sci.* 49:1206-1215.

Goldman, C.R. 1988. Primary productivity, nutrients, and transparency during the early onset of eutrophication in ultra-oligotrophic Lake Tahoe, California-Nevada. *Limnology Oceanography*. 33(6, part 1): 1321-1333.

Hanes, T. 2003. Personal communication. Registered Professional Hydrologist, HydroScience, Vacaville, CA.

Hanes, T. and M.S. Swanson. 1997. Upper Truckee River Bankfull Discharge Monitoring Survey. Prepared for The California Tahoe Conservancy. October 27, 1997.

Hurd, M. 2003. Personal communication. USFS biologist. Fall 2003.

Natural Resource Conservation Service. 2000. NRCS Field Office Technical Guide. Prepared by the South Lake Tahoe Branch Office of the NRCS.

Reuter, J.E. and W.W. Miller. 2000. Aquatic resources, water quality and limnology of Lake Tahoe and its upland watershed. The Lake Tahoe Watershed Assessment: Volume I. Prepared for USDA-Forest Service, Tahoe Regional Planning Agency, UC-Davis, University of Nevada-Reno, and Desert Research Institute.

Rosgen, D.L. 1996. Applied River Morphology. Wildland Hydrology.

Rowe, T.G., D.K. Saleh, S.A. Watkins, and C.R. Kratzer. 2002. Streamflow and water quality data for selected watersheds in the Lake Tahoe Basin, California and Nevada, through September 1998. U.S. Geological Survey Water-Resources Investigations Report 02-4030.

Simon, A., W. Dickerson, and A. Heins. 2003. Suspended-sediment transport rates at the 1.5-year recurrence interval for ecoregions of the United States: Transport conditions at the bankfull and effective discharges? Geomorphology. In press.

Swanson Hydrology and Geomorphology. 2003. Assessment of seasonal pollutant loading and removal efficiency of detention basins. Prepared for Tahoe Regional Planning Agency and United States Environmental Protection Agency. February, 2003.

Swanson Hydrology and Geomorphology. 2003. UTR – Middle Reach

Tappe, D.T. 1942. The status of beavers in California. State of California, Department of Natural Resources, Division of Fish and Game. Game Bulletin No. 3.

III.2 VEGETATION AND WETLANDS

III.2.A Purpose

The study of vegetation carried out for this project had the following partially overlapping objectives:

- To provide a map of existing vegetation communities and a description of the ecological conditions of those communities, against which the predicted consequences of different restoration options could be compared, and which can be used as a baseline map for monitoring of restoration effects;
- To help elucidate the ecological processes that maintain, enhance, or are altering the existing communities under the present hydrologic regime;
- To propose and explain reasonable hypotheses about the pre-settlement vegetation and ecological processes, which is the only available reference basis for the restoration objectives of some of the community types; and
- To identify feasible and appropriate restoration actions that can be applied to the various communities.

III.2.B Methods

Existing vegetation of the Upper Reach Study Area was examined on foot throughout most of the Study Area, with the exception of small areas where private ownership closely adjoins the river. Field work was carried out by Adrian Juncosa and Julie Etra between July and September, 2003. Observed plant communities were noted on prints of the Ikonos data set, to the extent feasible from the highly pixellated image. The mapped vegetation boundaries were based primarily upon the field observations and, to a lesser extent, on the color signatures of known community types. The nature of the Ikonos imagery limits the accuracy of the vegetation mapping that was produced. The NAPP aerial photograph and 2003 aerial photographs for the Study Area were not available for the purposes of the vegetation study and draft mapping, therefore the accuracy of discrimination, especially between some vegetation types, was limited.

A series of historic aerial photographs (1940 through 1997) were examined to discern vegetation conditions over time. Although it is generally not possible to assign areas precisely to the various community types described here, we could usually discriminate among coniferous forest, deciduous riparian forest, woody riparian scrub, and herbaceous communities. The timeline for recolonization of disturbed areas is also easily determined. However, aerial photographs crucially fail to reveal pre-settlement (pre-1860) ecological conditions. Thus, despite the value of historic aerial photographs, much of our understanding of ecological changes and trends comes from knowledge of the ecology of dominant species and from clues derived from field work, rather than from aerial photograph comparisons.

III.2.C Areas and Features Not Mapped

Some polygons within the Study Area were areas which have been substantially developed or modified from native vegetation. These areas are designated Developed (see below) and include the Lake Tahoe Golf Course and small patches of native vegetation within it, playing fields and parking areas in the park in Reaches 3 and 4, and lawns or other heavily modified portions of residential lots in reaches upstream of Highway 50.

Old channels that were once either the main Upper Truckee River channel or subsidiary channels were found in many places throughout the Study Area, but were concentrated in certain reaches. These features were noted on field maps, but not transferred to the vegetation maps because they are linear features rather than polygons.

Finally, one of the most interesting areas in the study region lies a short distance outside the limits of the Study Area and is therefore not mapped. This feature is a spring that has developed within approximately the last 10 years and now supports a sizable and rich wetland community. It is of importance because it exemplifies the potentially dynamic nature of groundwater removed from the existing channel.

III.2.D Vegetation Classification for the Study Area

No single available reference accommodates the observed community types accurately and comprehensively. Sawyer and Keeler-Wolf (1995), which is often preferred for vegetation mapping in California project sites, does not provide sufficient discrimination among the types of vegetation that are found within the Study Area to be used for the present project. To the extent feasible (only a few communities), the community types described are drawn from the two most applicable references (Manning and Padgett, 1995; CDFG, 2002). However, both of these references subdivide some vegetation complexes too finely for practical application to the present project site. For example, CDFG (2002) recognizes separate willow scrub communities for the various willow species (Lemmon's Willow Scrub; Geyer's Willow Scrub). It was our observation that most of the willow communities in the Upper Reach Study Area were not monospecific, but instead were mixtures of two or three species. Similarly, large areas of meadow habitat that were ecologically cohesive (that is, for the purposes of the present project, they constituted one continuous community type) included numerous small patches that would conform to one or another graminoid-dominated community type described by the sources cited above.

Commonly, shrub-dominated and herbaceous communities occurred in mosaics that appeared to be either dynamic or comprised of sufficiently small patches that it was neither practical nor useful to map the constituent communities separately. For example, Willow Scrub often occurred mixed with mesic or wet meadow types, and the mixed nature of these communities has ecological values that are not reflected in either one or the other. Such areas were mapped as, for example, Willow/Wet Meadow.

III.2.E Floristics and Nomenclature

A list of the plant species that were observed in the Study Area is included as Appendix E. The vast majority of species were identified on the basis of sight identification, but fragments were obtained from some, especially graminoids, for microscopic examination. Taxonomy and nomenclature follows the Jepson Manual (Hickman, 1993). Plants that form the majority of the structure of a given community are referred to mostly by common names; others are usually referred to by scientific binomials to avoid confusion that results from multiple or unfamiliar common names.

III.2.F Plant Species Ecology

Statements regarding dominance and occurrence are based on subjective observation; no quantitative vegetation sampling was carried out for the present phase of study. Terms such as abundant, common, rare, and so on are used according to common usage. For example, a ubiquitous or common species would be within sight from nearly any point within a particular map unit; occasional or scarce plants would not be. Rare or scarce species might not be encountered at all during a casual reconnaissance of a community. Locally common species are abundant only within specialized microsites.

Ecological status of plant species is sometimes discussed in terms of the U. S. Fish and Wildlife Service wetland indicator statuses (USFWS, 1996). Despite imperfections, this system and the statuses of many common riparian plant species are widely known (if not universally agreed to be accurate), thus it is an extremely useful communications tool. The status definitions are as follows, with comments on the soil moisture regime that is often found along with plants in each category:

- **OBL** Species found in wetlands >99 percent of the time; occurrence of vegetation dominated by plants in this category is usually strongly correlated with soils subject to annual prolonged near-surface saturation.
- **FACW** Species found in wetlands 67 to 99 percent of the time; usually correlated with moderately prolonged near-surface saturation in nearly all years.
- **FAC** Species found in wetlands 34 to 66 percent of the time; species in this category are frequently found in a wide range of soil moisture conditions, from short-duration saturation during most years to almost never saturated during the growing season.
- **FACU** Species found in wetlands 1 to 33 percent of the time; correlates with soil that is almost never saturated, or is only saturated very briefly during the early part of the growing season.
- **Upl** Species found in wetlands <1 percent of the time (also notated NI or "--" in the USFWS lists); correlates with soils that are never subject to prolonged saturation during the growing season.

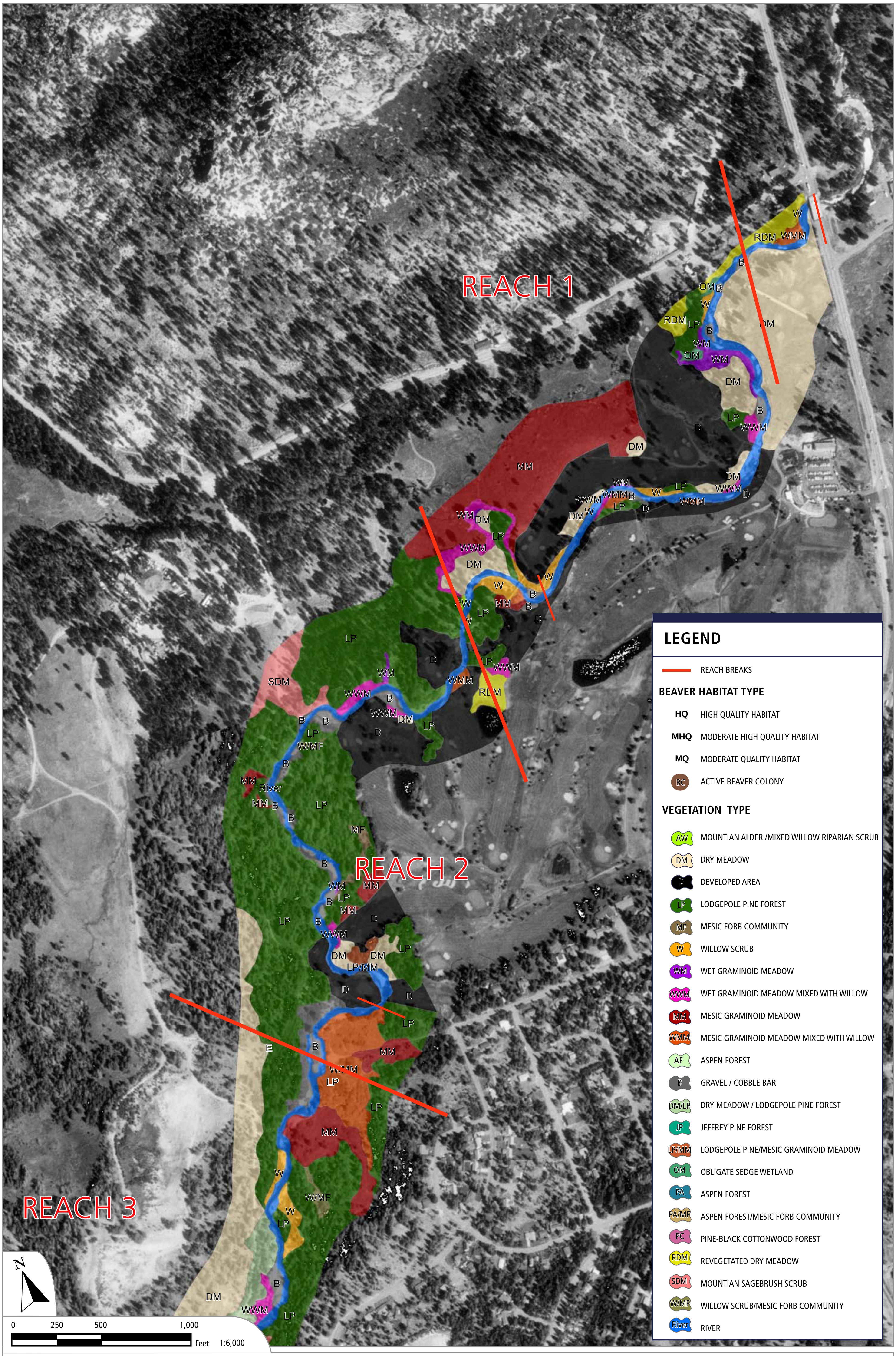
The indicator statuses are defined for particular geographic regions; they are not necessarily the same for the California and Intermountain Regions (including Nevada). The project site lies almost exactly on the boundary between these two regions. Also, it is not known to what degree these experts tried to consider the range-wide ecology of particular species (that is, whether a species with a wide altitudinal range might be more or less closely associated with wetlands in the mountains versus the foothills).

To the best of our knowledge, the assignment of species to indicator status categories was not based upon any quantitative sampling, but upon the subjective impressions of contributing experts. It is our observation that, for some or many species, the indicator status that would be assigned based upon quantitative sampling would be different than that provided by the USFWS list. Also, many common wetland-associated species (FACW or OBL) become established only under a wetland hydrologic regime, but are able to persist for long periods of time even if the soil moisture regime becomes much drier. This can be misleading in making wetland determinations, but is extremely useful to an experienced field botanist in interpreting ecological history and trend. Finally, some species that are closely associated with wetland soil saturation regimes may nevertheless require more dissolved oxygen than other wetland species and are consequently tend to be found in wet areas where the water is flowing rather than stagnant.

Notwithstanding all of these considerations, the familiar USFWS wetland indicator status list does provide a useful relative categorization of the soil moisture regime with which the listed species are associated. Also, most areas that are dominated by species that are regarded as hydrophytic by the federal wetland identification manual (FAC, FACW, and/or OBL species) are likely to delineate as wetlands, so the community mapping provides a useful initial guide to permitting requirements. However, some areas that are defined as Stream Environment Zones (SEZs) by the Tahoe Regional Planning Agency lie outside the federal wetland definition.

III.2.G Community Types

The following community types occur within the Study Area, roughly arranged from upland forests to perennial wetlands, and are shown in Figures 3.30A-E. Some vegetation types occurred characteristically (not merely occasionally) as mosaics with one another. The poor resolution of the Ikonos imagery made it impossible to circumscribe the separate types of vegetation in these areas; such detailed mapping would be of questionable ecological and planning value anyway. Accordingly, some areas appear on the map as mixed communities, for example, Willow mixed with Wet Meadow (WWM). On the other hand, where scattered elements of one community (e.g., individual lodgepole pines) occurred within another community type (e.g., Dry Meadow), the entire area was mapped according to the predominant ecological character for wildlife habitat and planning purposes. Only where the mixture of community elements was more even was a mixed community mapped.



SWANSON HYDROLOGY + GEOMORPHOLOGY
115 Limekiln Street Santa Cruz, CA 95060
PH 831.427.0288 FX 831.427.0472

FIGURE 3.30A: Map describing beaver habitats and vegetation communities within the project area (Reaches 1-3).

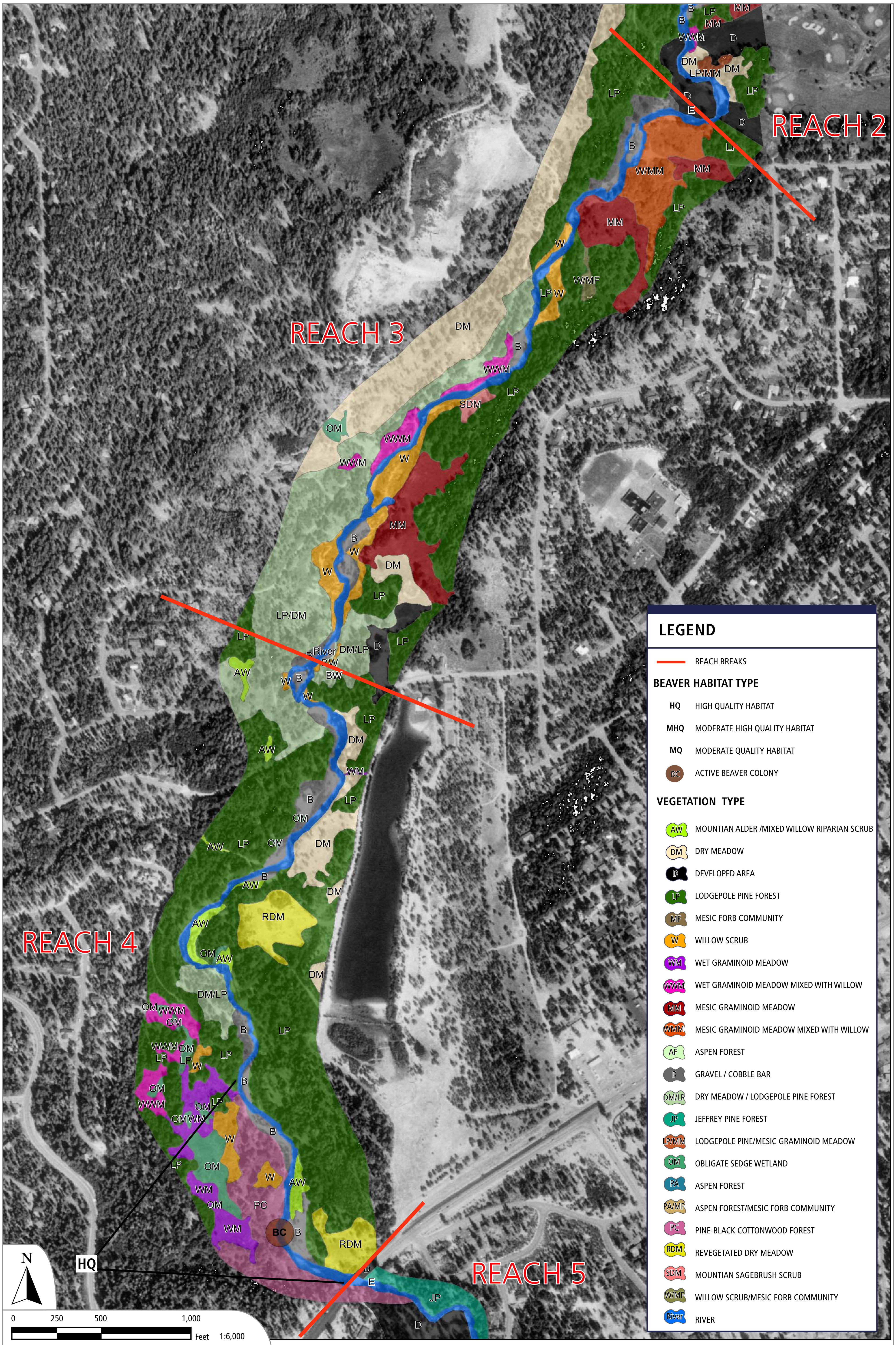
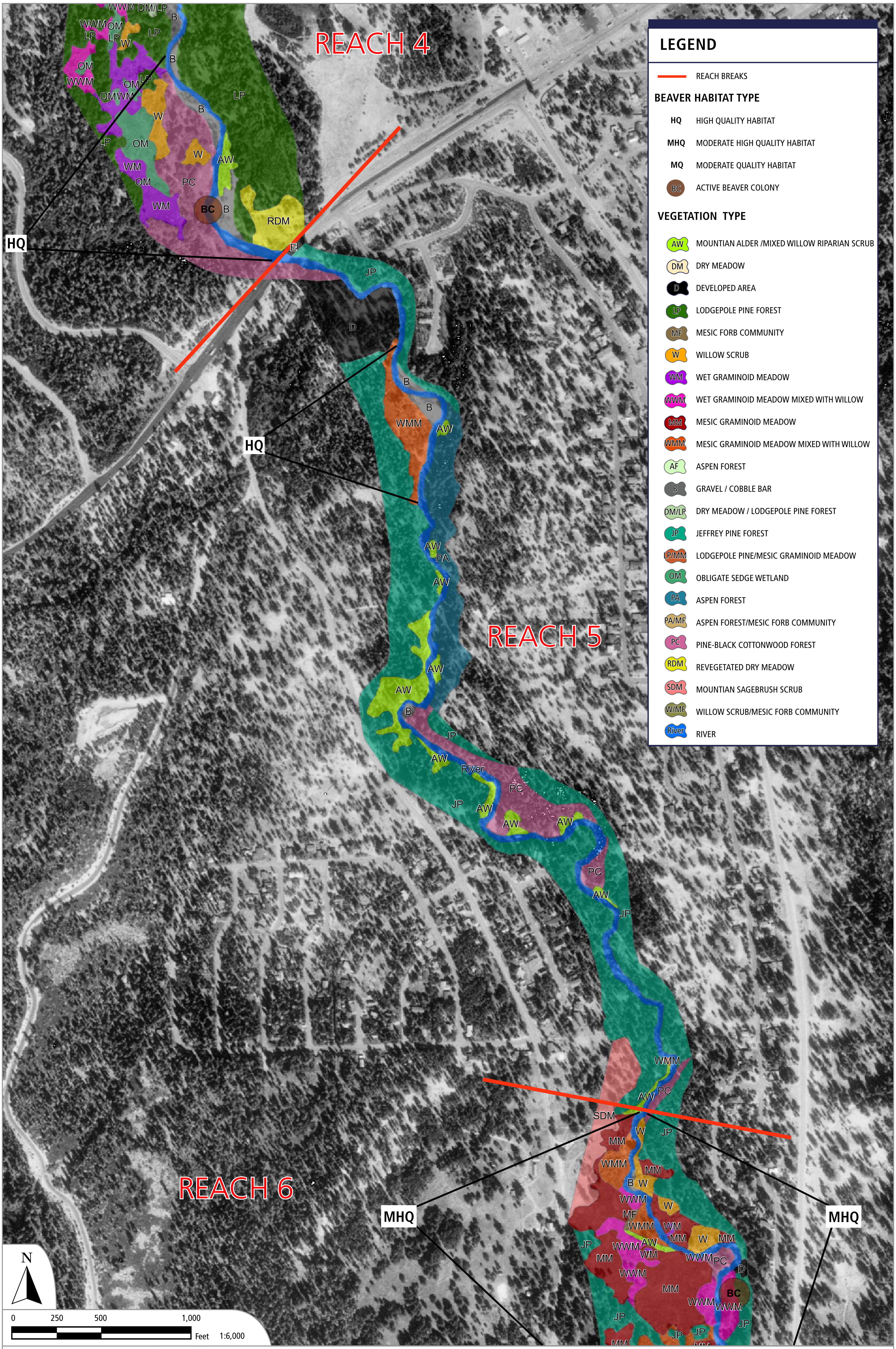


FIGURE 3.30B: Map describing beaver habitats and vegetation communities within the project area (Reaches 2-5).



SWANSON HYDROLOGY + GEOMORPHOLOGY
115 Limekiln Street Santa Cruz, CA 95060
PH 831.427.0288 FX 831.427.0472

FIGURE 3.30C: Map describing beaver habitats and vegetation communities within the project area (Reeches 4-6).

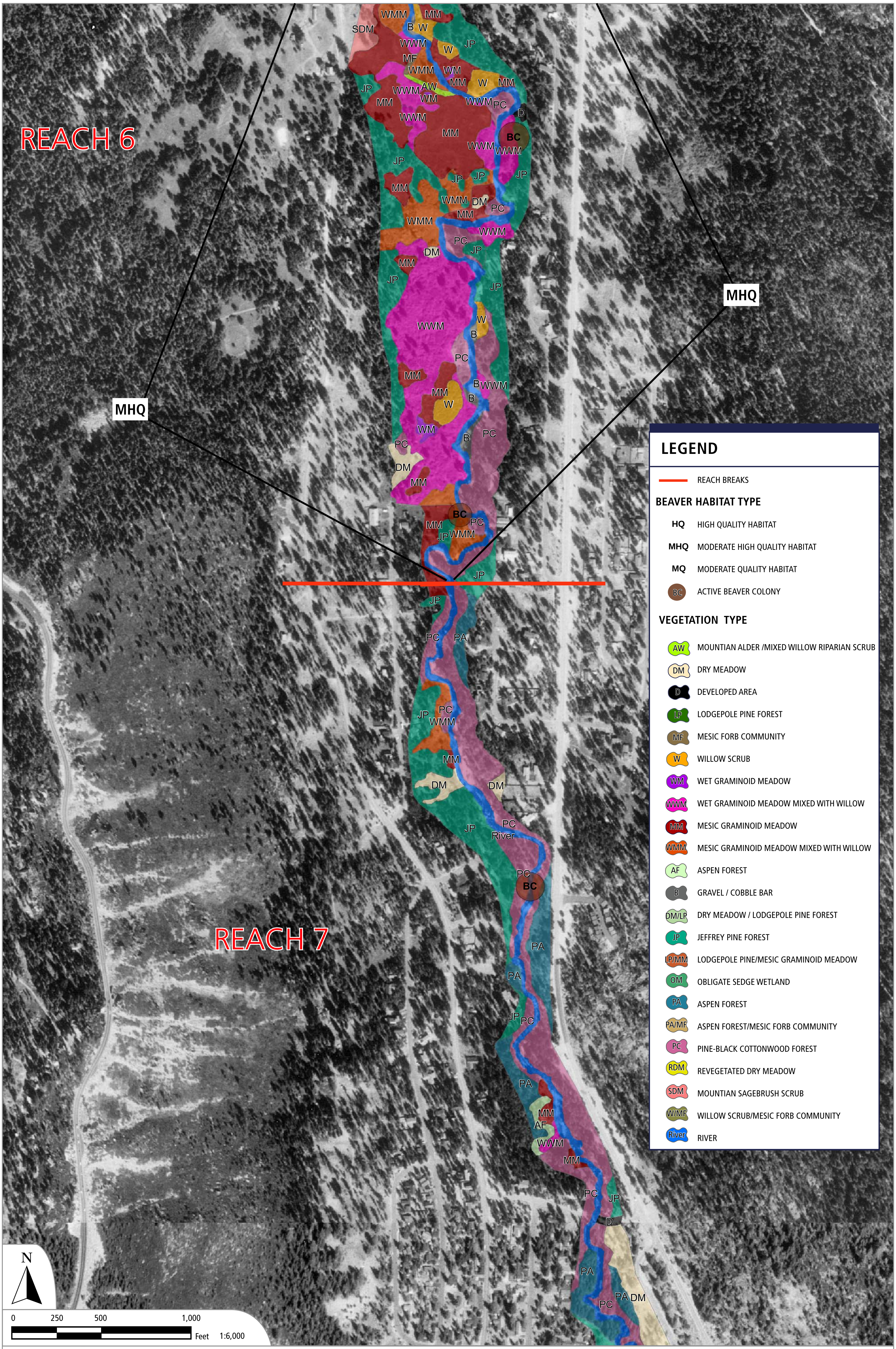


FIGURE 3.30D: Map describing beaver habitats and vegetation communities within the project area (Reaches 6-7).

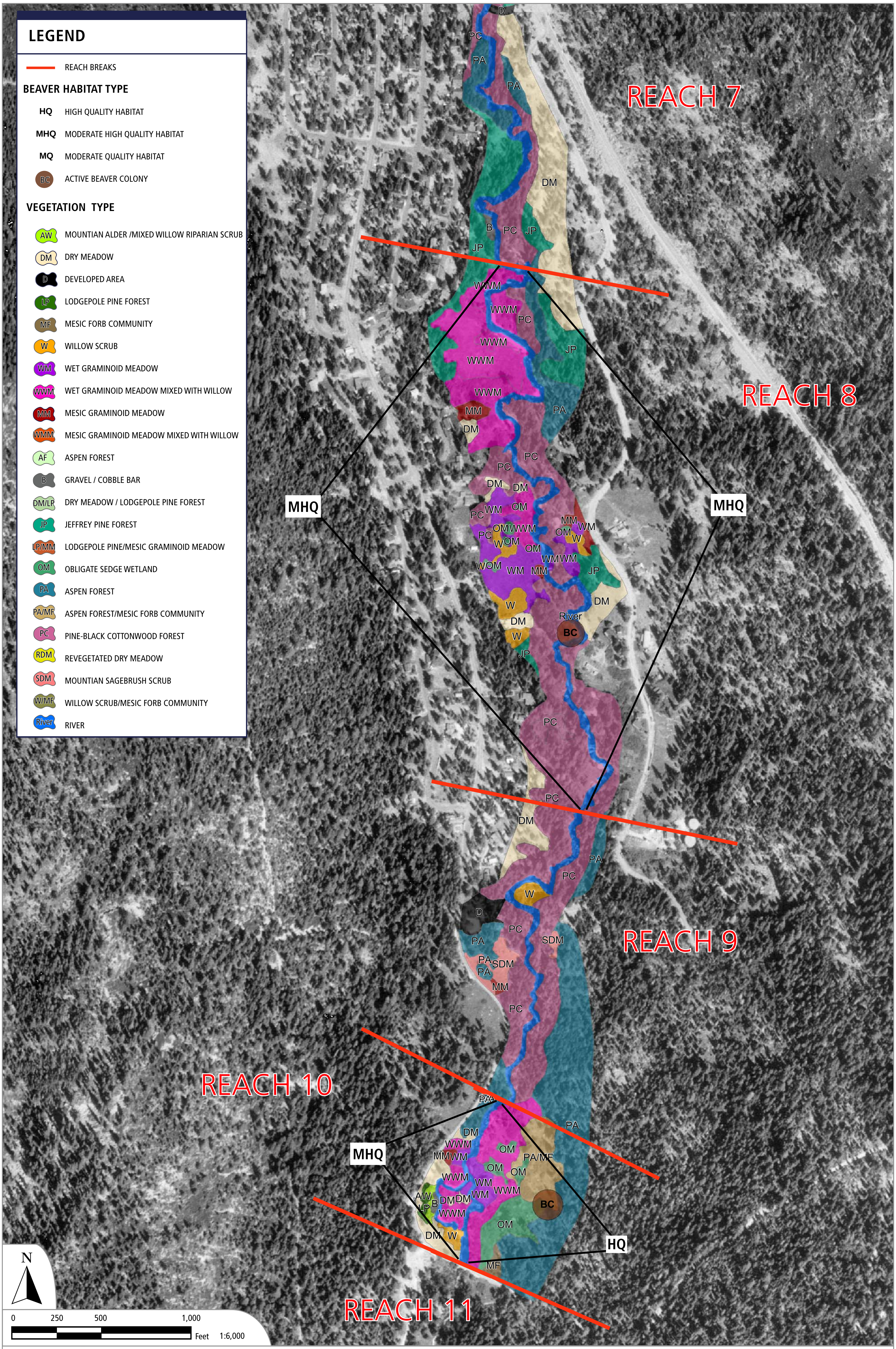


FIGURE 3.30E: Map describing beaver habitats and vegetation communities within the project area (Reaches 7-11).

Lodgepole Pine Forest (LP)
Jeffrey Pine Forest (JP)
Jeffrey Pine - Aspen Forest (JPA)
Pine-Black Cottonwood Forest (PC)
Black Cottonwood Forest (CF)
Quaking Aspen Forest (A)
Mountain Alder-Mixed Willow Riparian Scrub (AW)
Willow Scrub (W)
Dry Meadow (DM)
Revegetation Dry Meadow (RDM)
Mountain Sagebrush Scrub (SDM)
Mesic Graminoid Meadow (MM)
Mesic Forb Community (MF)
Wet Graminoid Meadow (WM)
Obligate Sedge Wetland (OM)
Gravel/Cobble Bar (B)
Developed Areas (D)
Historic Channels (not a map polygon)

III.2.H Community Type Descriptions

LODGEPOLE PINE FOREST (LP)

Occurrence and Structure

This community type includes extensive areas of forest with variable canopy structure, ranging from open woodland with canopy closure of 30 percent or less, to densely forested areas with 100 percent canopy cover. It occurs primarily in Reaches 1-4, and along portions of upstream reaches, on the left bank. Where the canopy is more open, scattered shrubs are present, but do not form a nearly continuous shrubby understory. A herbaceous stratum is present only where canopy cover is low; generally, this stratum resembles Dry Meadow, described below.

Trees larger than 24 inches diameter at breast height (dbh) are very scarce in this community type. Over very large areas where the pre-existing forest community was disturbed by logging and/or mass grading, the forest is composed of an extremely high density (individuals per unit area) of small trees (almost all less than 12 inches dbh).

Species Composition
The woody canopy is comprised almost entirely of lodgepole pine (*Pinus contorta* ssp. *murrayana*). In some areas, occasional trees of white fir (*Abies concolor*) and/or Jeffrey pine (*Pinus jeffreyi*) are present, but almost never form an ecologically significant portion of the canopy.

The shrub stratum, where it exists at all, varies from remnants or stringers of riparian (FACW or OBL) species that persist along abandoned small channels to strictly upland species such as wax currant (*Ribes cereum*) or *Ceanothus cordulatus*.

The herbaceous stratum similarly varies from mesic species typical of the meadow communities (for example, *Elymus glaucus* and *Poa pratensis*) to dry site species such as *Elymus elymoides*, *Gayophytum sp.*, or *Achnatherum lettermanii*.

Ecological History and Trend
Based upon examination of the historic aerial photographs and considering the small diameter of the overwhelming majority of the lodgepole pines in the Study Area, it is clear that most of the area mapped as Lodgepole Pine Forest constitutes an early-seral-stage (early successional), colonizing forest. In 1940, a large proportion of what is now mapped as Lodgepole Pine Forest appears to have been a very open pine savannah, probably maintained in that condition by livestock grazing. Under pre-settlement conditions, it is unlikely that Lodgepole Pine Forest was an ecologically stable community as it presently occurs in the project region. The present extremely densely stocked conifer stands in this community would, if ignited by lightning or humans, burn at a very high temperature, and the entire stand and canopy would most likely be consumed; that is, a stand-replacing fire would occur. Due to its thin bark, lodgepole pine is relatively sensitive even to low-intensity fires, such as the ground fires that burn through and maintain meadow communities at higher elevations. Also, lodgepole pine is a relatively short-lived conifer among the species that occur on the project site. Thus, in the absence of fire for an extremely long period of time (much longer than the known natural fire return interval for the Lake Tahoe region), lodgepole pines would very gradually be replaced as the dominant canopy component by other species, such as white fir and Jeffrey pine.

In sites where lodgepole pines colonize exposed soil very densely, such as much of the mapped Lodgepole Pine Forest, it is likely that the natural pre-settlement community was either dry to mesic meadow that was maintained in meadow condition by frequent low-intensity fires, or a community that functioned somewhat like a chaparral community: dense shrubby (pine) vegetation would establish itself directly after the fire, only to be consumed in a subsequent fire a few decades later.

Thus, Lodgepole Pine Forest that is mapped in the Study Area should be regarded as a transitional community, not a "climax" community type whose character can be maintained while enhancing habitat values incrementally. From an overall habitat value standpoint, the short life span of lodgepole pine itself indirectly provides some habitat value by virtue of the occurrence of standing dead trees and snags, which are essential to many insectivorous birds and to cavity nesters. However, such resources are not absent from other coniferous forest types, where occasional to many trees are killed by bark beetles.

With few exceptions (some notable ones occur in close proximity to the river), the lodgepole pines in the Study Area are of relatively small stature and are therefore of less value in contributing large woody debris to the channel/floodplain system than other species and communities. Drastic thinning of the Lodgepole Pine Forest would result in growth rate release of the remaining trees, and therefore would improve the production of large woody debris by the community. Data derived from another site within the Lake Tahoe Basin showed that the maximum growth rate of any native tree, slightly over 1 inch in diameter in a single year, was achieved by open-grown lodgepole pine, exceeding the fastest rate observed in black cottonwood by some 10-20 percent (Swanson, 2002).

Restoration Notes

From the perspectives of erosion control, wildlife and plant diversity habitat values, and community stability, the most desirable restoration actions for Lodgepole Pine Forest would include a drastic reduction in the amount of standing live and dead fuel by removal of nearly all of the smaller trees (at a minimum, all lodgepole pine and white fir trees less than 12 inches dbh). Ideally, the drier portions of the community would be converted to eastside pine - sagebrush/bitterbrush habitat, and the more mesic portions would be converted to meadow and maintained in that condition by low-intensity natural and/or prescribed fire. However, many of the desired restoration actions are the same and, in any case, require removal of large amounts of small caliber (<12 inch) trees and fuel prior to any other action.

An important riparian restoration objective that is highlighted by the behavior of the recent human-caused fire near Heavenly Ski Area, but rarely considered in large-scale riparian restoration, is fire protection. Where high fuel loads occur in close proximity to woody riparian communities, major damage to these communities and consequent water quality impacts, often occur when the inevitable high intensity wildland fires occur. Accordingly, it is preferable to reduce the load of small sized woody fuel (trees less than 12 inches, slash, and small-caliber ground fuels) throughout all coniferous forest communities that adjoin riparian habitat.

JEFFREY PINE FOREST (JP)

Occurrence and Structure

This community type presently occurs along Reaches 5-11, especially on the eastern (right bank) side of the valley, where the landforms slope relatively steeply upward from the river corridor. The forest canopy is composed primarily of very variable aged pine trees, some of them emergent individuals of extremely large size for the Lake Tahoe region (exceeding 72 inches dbh). The subcanopy and understory are patchy but generally sparse, without any areas of the typically solid shrub layer that is seen in many mixed coniferous forest communities in the Basin. Herbaceous vegetation is also very sparse. Recruitment of new pines is ongoing at a relatively slow rate, compared with the Lodgepole Pine Forest, where many hundreds of small sized trees are present per acre.

Species Composition

The majority of the canopy, and all of the largest trees, are Jeffrey pines; a small portion of the canopy is lodgepole pine and white fir. In some areas in Reaches 5 through 10, a much more substantial lodgepole component is present, but the larger trees are almost all Jeffrey pines, showing that this is the real community type and that the lodgepole pines represent a flush of new establishment during the recent decades of more vigorous fire suppression. Species composition of the shrubby and herbaceous understory strata is similar to that of the Lodgepole Pine Forest and Dry Meadow communities (typical shrubs include *Ribes cereum* and *Ceanothus cordulatus*; herbs include *Monardella odoratissima, Aster sp., Eriogonum nudum, Elymus elymoides, Achnatherum lettermanii, Bromus carinatus,* and *Wyethia mollis*).

Ecological History and Trends

Based upon stand data from approximately 100 years ago for pre-logging conifer forests in various parts of the Sierra Nevada, the present vegetation conditions in the Jeffrey Pine Forest within the Upper Reach Study Area conform more closely to the conditions believed to have occurred in pre-settlement conifer forests than any other stand of upland forest we have observed directly in the region. The largest trees are at least several feet in diameter and occur at spacings of only a few emergent trees per acre, a variety of age classes are represented, and the trees in the youngest cohorts (less than 50 years old) do not occur at excessively high densities. Although no increment coring was carried out for the present project, information from an 84-inch Jeffrey pine tree in Truckee indicated an age in the range of approximately 450 years. That tree is growing in a much drier setting, a Jeffrey pine - bitterbrush community, and therefore could be older than an equivalent sized tree in the Upper Reach Study Area. However, it is safe to conclude that the many trees in the 72-inch size class within the Study Area are at least 300 years old. Since these trees are in superb condition, with perfectly straight and unflawed boles, it is certain that the area was not logged during the Comstock era. This makes it the probably the most easily accessible old growth Jeffrey pine forest community in the Basin and provides a perfect model for restoration of upland coniferous forest in the immediate vicinity of the riparian zone.

Restoration Notes

As noted above, this community provides a good ideal for restoration of upland forests at the lower elevations within the Lake Tahoe Basin. Although additional thinning of smaller diameter trees may still be beneficial, the only useful restoration action would be the application of prescribed fire, which, however, is unadvisable in any site with in-filled residential development. Absent low-intensity fire, we advise that residents be permitted, even encouraged, to remove the majority of the existing small-diameter trees (especially white fir) from their property. Felled trees and other ground fuel should be removed from the site entirely, or can be chipped and spread thinly as an aid to erosion control. These actions are both ecologically beneficial and increase the defensibility of the houses from wildfire.

JEFFREY PINE - QUAKING ASPEN FOREST (JPA)

The Jeffrey Pine - Quaking Aspen Forest community type is almost identical to the preceding one, except that aspens are present either in moderately dense stands or as isolated stems scattered throughout the understory and subcanopy. This community occurs primarily on the lower slope above the right (east) bank of the river in Reaches 5-11, and in small patches in the floodplain on the west side. Despite the usual (not universal) association of aspen with moist sites, within the Upper Reach Study Area, Jeffrey Pine - Quaking Aspen Forest is neither a wetland nor even a riparian plant community.

Structure

Canopy and subcanopy structure are similar to Jeffrey Pine Forest: scattered very large trees, proportional representation of most age classes of trees, and moderate density of trees that are less than 50 years old. Quaking aspen (*Populus tremuloides*) occurs as occasional to common stems, almost never as clumps or groves. Some of the aspen trees are fairly large for the species (exceeding 12 inches dbh), which likely places them in the 60 to 80 year old age range. (Quaking aspen trees in our region rarely survive past 100-120 years old.)

Species Composition

Species composition of this community is essentially identical to that of Jeffrey Pine Forest except for the addition of quaking aspen. The lower fringe of the community (upper non-wetland riparian zone) also supports abundant plants of *Lonicera conjugialis*, which is uncommon anywhere else within the Study Area, and other mesic riparian species. This fringe definitely constitutes a riparian Jeffrey pine community subtype that is not recognized in the literature. However, the occurrence of this vegetation type was narrow and discontinuous, and it was therefore not mapped as a separate community.

Ecological History and Trends

Quaking aspen does not naturally reproduce by seed under the climatic conditions that presently prevail in the West, but instead regenerates solely by sprouting from roots. Thus, all occurrences of quaking aspen in our region are believed to have been present, in those locations, since the post-glacial period 10,000 years ago. A few occurrences may represent whole plant communities that moved downslope in massive landslides, but this is an extreme exception. Although most aspen groves on slopes occur as stringers along spring-supported, steep-gradient creeks with long-seasonal or perennial flow, the Jeffrey Pine - Quaking Aspen community is one recognized by the CDFG vegetation classification system, so it is not at all unique to the present study site.

As a consequence of its regeneration exclusively from root sprouting, aspen occurrences are clonal, typically with all of the stems of a particular occurrence either physically connected via the roots or genetically nearly identical. Stems sprout densely when a tree dies or is badly damaged, or when low-intensity fire creates high light levels and hormonal release of the root-sprouting behavior.

In light of our knowledge of the ecological history of aspen in the arid West, it seems certain that the Jeffrey Pine – Quaking Aspen community described and mapped here occurred, with its present structure and composition, prior to 1860. Although regeneration in the Upper Truckee River occurrence of this community is relatively sparse, the aspen does not yet appear to be in danger of becoming completely extinguished by competition with the coniferous component of the forest.

Restoration Notes
As for Jeffrey Pine Forest, some thinning of the smaller diameter conifers in this community would be beneficial. If this were focused in the immediate vicinity of existing aspens, regeneration of the aspen clone would be expected to be more robust, with benefits to wildlife habitat values.

PINE-BLACK COTTONWOOD FOREST (PC)

Occurrence and Structure
This community is present extensively at the outer fringe of the floodplain, and even on the lower portions of the valley slopes, in Reaches 5 through 11. It corresponds to Jeffrey Pine - Black Cottonwood as recognized in the CDFG vegetation classification system (2002), except that lodgepole pine is present as well as Jeffrey pine. Within the Upper Reach Study Area, Pine - Black Cottonwood is present only in patches of limited lateral extent. The community is composed of a tree canopy of variable density. Generally, there is relatively little regeneration of the canopy species underneath, but an understory of willow and/or alder may be present in portions of Pine - Black Cottonwood forest close to the channel.

Species Composition
This community is characterized by the dominance of large black cottonwood (*Populus trichocarpa*) trees, mixed with Jeffrey pine and/or lodgepole pine. Few other species are present within the mapped patches of Pine - Black Cottonwood Forest, although divergent upland and wetland species are present in the adjacent communities.

Ecological History and Trends
This community is one that results from establishment of cottonwood trees at the edge of the floodplain during major flood events. Once established, the deeply rooted cottonwoods continue to grow vigorously on the basis of groundwater that is present through the years within the subsoil of the floodplain. As best as can be determined from the 1940 and 1952 aerial photographs, and

from the sizes of the trees observed in the field, the Pine - Black Cottonwood Forest occurrences in the Upper Reach Study Area were present at least 60 years ago, and most likely occurred in the same or analogous locations under pre-settlement conditions. However, it is possible that watershed alterations during the late 19th century resulted in high sediment loads and consequent major deviations of the course of the channel during high flow events. Such planform deviations and large-scale sediment deposition are known to be associated with the establishment of mixed cottonwood - coniferous forest communities in other sites in the Lake Tahoe Basin, both under pre-1860 and more recent (human-altered) conditions.

Within the Upper Reach Study Area, not all size (age) classes of cottonwood trees are well represented, although there are some individuals present of every size from <5-year old saplings to trees larger than two feet in diameter. The very large (>4 foot dbh) individuals that are present in some other Lake Tahoe Basin watersheds are essentially absent from the present Study Area, and relatively few individuals in the 6-12 inch size class are present. Recruitment of new saplings is more limited than in some other watersheds. Thus, although the existing trees nearly all appear to be in very robust condition and the community does not appear to be in danger of declining, it is appropriate to note that the younger size classes are less well represented than would generally be expected in a plant community that is perpetuating itself by establishment of new individuals of all of its major structural components.

Clues to the pattern of establishment are found in the historical aerial photographs and in a small tributary in Reach 4, where several cottonwood trees have become established, apparently within the last five to ten years. We conclude that this community results from establishment of cottonwoods within riparian conifer vegetation (see below), rather than from simultaneous establishment of both components of the canopy or from invasion of cottonwood groves by conifers. (The latter would be highly unlikely because lodgepole and Jeffrey pines generally establish poorly or not at all under a pre-existing dense canopy.)

In the context of this community description, it is appropriate to include an ecological note regarding Jeffrey pine. The typical and widely familiar ecological role of this tree is as the sole or a codominant canopy tree in very dry eastside Sierra Nevada habitats. In settings that are not adjoined by pinyon-juniper woodland, Jeffrey pine is often the last remaining tree species present when Sierran coniferous vegetation gives way to sagebrush-bitterbrush scrub vegetation. However, another setting where Jeffrey pine paradoxically is very successful is as a large tree on riparian floodplains; hence the recognition of a Jeffrey pine - Black Cottonwood community by CDFG (2002). We have observed sizeable (>12 inch dbh) trees growing vigorously in a wetland setting with shallow, slowly flowing surface water surrounding the trunk, and it is often the largest (albeit not most numerous) tree present in white fir - lodgepole pine - Jeffrey pine floodplain forest. The relative sizes of trees in these sites indicates that the Jeffrey pines persist from a time when the floodplain was the wettest, followed in establishment by the lodgepole pine and white fir that now comprise the majority of the canopy.

In summary, it is useful to recognize that one of the diverse ecological roles of the Jeffrey pine is as a large floodplain tree, not merely as a dry-site dominant.

Restoration Notes
From a restoration planning standpoint, any riparian communities including black cottonwood are regarded as desirable, both from a wildlife habitat standpoint and as a source of large woody debris in the system. However, since the community becomes established only under occasional very high flow events, the only restoration actions that enhance the likelihood of establishment of Pine - Black Cottonwood Forest are the maintenance of sufficiently open conditions in the understory of the floodplain/terrace coniferous forest (e.g., by thinning of the subcanopy as recommended above). The high light levels that prevail are favorable for the establishment of cottonwood under 10-20 year flood events.

BLACK COTTONWOOD FOREST (CF)

Occurrence, Structure and Species Composition
This community occurs in narrow patches immediately adjacent to the present or a past channel in Reaches 5 through 7. Although occasional individuals of cottonwood are present downstream of the Meyers Highway 50 crossing, for reasons which we do not fully understand, no cottonwood groves are present. In its mature form, Black Cottonwood Forest is a dense monospecific stand (essentially 100 percent canopy closure) of black cottonwood. Other broad-leaved riparian species such as mountain alder and willows may adjoin it closely, but are not present as a significant understory under the dense canopy. In very early successional stages, the community may be a mixture of all three components, but the shrubby species are outcompeted and ultimately disappear as the cottonwoods overtop them.

Ecological History and Trends
As for Pine - Black Cottonwood, the Black Cottonwood Forest community becomes established in the mixed and coarse sediments that are deposited thickly under high flow events. Observations of other cottonwood species in the Platte River (USFWS 1981) show that establishment of new seedlings does not occur on sites that remain inundated for a prolonged period of time after seed dispersal, although seedlings that do attain a sufficient size are then able to survive the extended inundation that occurs subsequently. Also, the seedlings only survive if the groundwater level drops moderately slowly (less than an inch per day, but may vary depending upon the texture of the soil). Even when such events occur at a time that does not coincide with the dispersal of cottonwood seeds (as was the case in the January 1997 event), the soil moisture regime in freshly deposited bars during the dispersal period may be conducive to cottonwood establishment.

Species of the genus *Populus*, with the notable exception of *P. tremuloides* (quaking aspen), characteristically have a phreatophytic root system, which extends deeply into the soil profile and accesses groundwater far from the surface. Once established and grown to reach the canopy, that is, no longer subject to suppression by competition for light, cottonwood trees typically survive to their maximum life span (100-150 years) regardless of changes in soil and hydrology.

To the extent we can see in the 1940 and 1952 aerial photographs, the present patches of Black Cottonwood Forest became established during the mid-20th century. It is reasonable to expect that cottonwood groves established themselves in the adjoining or analogous locations under pre-settlement conditions as well.

Restoration Notes
Optionally, cottonwoods can be planted in areas where suitable sediments were deposited by the 1997 event, such as gravel bars in Reaches 3 and 4. Obviously, such revegetation would be undesirable within play areas of the golf course. Natural fluvial geomorphic processes can reasonably be expected to ensure the periodic establishment of new cottonwood groves throughout any portion of the system where the floodplain is not constrained by adjacent slopes or filled areas.

QUAKING ASPEN FOREST (A)

Occurrence and Structure
Quaking Aspen Forest typically occurs as a nearly pure stand only on floodplains or low terraces, specifically in Reach 7. Generally, in the Study Area, aspen occurs only as scattered individuals and groups of stems within Jeffrey Pine-Aspen forest. However, the one major aspen grove in Reach 7 was so notable that it merited separate recognition. Structure of this community is essentially identical to that of Black Cottonwood Forest (dense canopy, little understory), although the stature of the trees is somewhat smaller.

Species Composition
The community is dominated by quaking aspen, but with minimal occurrence of black cottonwood, one or another willow species, and/or mountain alder.

Ecological History and Trends
Discussion of the ecology of quaking aspen is provided above under Jeffrey Pine - Quaking Aspen Forest. As for that community type, Quaking Aspen Forest must have occurred in essentially its present location and character since the immediate post-glacial period.

Restoration Notes
No restoration actions are needed or appropriate within this community type, unless encroaching vegetation of other types (e.g., pines) begin to create sufficient competition for (primarily) light. Under normal conditions, vigorously growing aspen tree shoots will synthesize hormones to inhibit the initiation of new shoots. When the aspen is cut, or as it gets very old, not as much of

the suppression hormone is produced and recruitment of new root sprouts begins. If these new sprouts are competing for light with other vegetation (pines) their health and survival will be in jeopardy and in this instance, the competing vegetation should be cleared.

MOUNTAIN ALDER-MIXED WILLOW RIPARIAN SCRUB (AW)

Occurrence and Structure

Alder and willow scrub occurs throughout the Study Area, but riparian thickets that include mountain alder as a codominant species are much more common upstream of Meyers Highway 50 crossing (that is, in Reaches 5 through 11) than they are in Reaches 1 through 4. This community is a shrub-dominated community approximately 10-15(-20) feet tall, generally with 100 percent canopy cover. Where the canopy is closed, there is usually no actual understory. However, the fringe of the community and, at rare times, the interior when the canopy is partially open, is vegetated by FACW and OBL species of forbs (broad-leaved herbaceous plants, as distinguished from graminoid, or grasslike, species).

Species Composition

This community is characterized by having a canopy that is rarely purely comprised of, but always codominated by, mountain alder (*Alnus incana* ssp*. tenuifolia*). Usually, all three willow species that we found within the Study Area are present in significant numbers: Lemmon's willow (*Salix lemmonii*), Geyer's willow (*S. geyeriana*), and Pacific willow (*S. lucida var. lasiandra*). In some sites, other riparian shrubs, such as *Cornus sericea* and *Sorbus sp*., are also present but almost never codominant.

The understory may include a diverse assemblage of FACW and sometimes OBL forbs, such as *Heracleum lanatum*, *Thalictrum fendleri*, *Lupinus polyphyllus*, *Epilobium angustifolium*, and *Veratrum californicum*, and less commonly also FACW graminoids. Where the canopy is thin or absent, the alder-willow community intergrades with Mesic Forb Community Type, thus, mapping of a mosaic of these two types is often appropriate.

Ecological History and Trends

Examination of the historic aerial photographs suggests that riparian shrub and herbaceous communities (specifically ones dominated by hydrophytic species and lacking any coniferous component) were much more extensive prior to the last few decades. The area of riparian wetlands, both shrubby and herbaceous dominated types, has been substantially reduced by both direct fills in portions of the lower reaches (1-4) and by what seems to be invasion of wetland communities by lodgepole pine and mesic/dry meadow vegetation. Areas that appear to be mixed Mountain Alder - Willow Scrub and Mesic Forb communities, occurring on cut-off meanders in the 1940 and 1952 photographs, are presently much narrower due to encroachment of lodgepole pine. Only the center of the old channel remains dominated by the original FACW and OBL species. These observations clearly indicate a drying trend in most portions of the floodplains in Reaches 1-4. They also emphasize the closer association between alder and flowing water (channel banks) than is the case for our willow species. Within the Upper Reach Study Area, the latter occur extensively throughout wet meadow sites, far from the channel banks.

The history of one patch of alder-willow habitat in particular is revealing. This thicket occurs on a very large gravel/cobble bar in Reach 5, possibly the result of more than one event. Regardless of its fluvial history, in 1940, the riparian scrub community occurred as scattered solid patches with significant expanses of substrate that were either unvegetated or thinly vegetated. This indicates that the community did not arise from one establishment event, as we normally implement in riparian revegetation, but instead was colonized by scattered patches of shrubs first, followed by gradual in-fill by others. A plausible hypothesis to account for this pattern is that whole shrubs with their root systems were dislodged from riverbank sites upstream and deposited along with the bar materials during the flood event. This demonstrates, on the basis of natural process alone, the utility of using salvaged willow and alder clumps for stabilization and large-scale revegetation of areas of newly established low floodplain. Mountain alder, in particular, seems not to colonize coarse substrates especially vigorously; close examination of bars that were deposited in 1997 shows that the vast majority of riparian shrub seedlings are willows.

Restoration Notes

In order to become established and persist, Mountain Alder - Mixed Willow Scrub habitat is closely dependent on precise hydrologic conditions, with a long period of near-surface saturation, normally in a setting where the water is flowing at or nearby the community edge. Accordingly, maintenance of existing alder-willow habitat and establishment of new areas is primarily a matter of channel-floodplain connectivity and deposition of appropriately sized sediment (finer than those that seem to be most conducive to the establishment of cottonwoods, for example).

WILLOW SCRUB (W)

Occurrence and Structure

Willow Scrub community types occur throughout the Study Area, generally in combination with mesic and wet meadow vegetation, but also on depositional bars. The structure of this community is essentially identical to that of Mountain Alder - Mixed Willow Riparian Scrub.

Species Composition

There appear to be two intergrading, but still slightly ecologically divergent, types of willow communities within the Study Area. Time and analytical constraints posed by the reliance on Ikonos prints limited our ability to discriminate between these in the maps. Consequently, they are mapped as one vegetation type for the present baseline purposes.

One of the communities, which seemed to be more common in newly colonized settings (1997 bars) and in meadow settings that are more remote from the channel (thus, in slightly drier settings), was comprised of Lemmon's and Geyer's willows and usually, but not always, dominated by Lemmon's willow. In the Upper Reach Study Area, it is ecologically misleading and impractical to discriminate between community types dominated by these respective species, as is done by both Manning and Padgett (1995) and CDFG (2002). Coyote or sandbar willow (*S. exigua*) occurs very uncommonly and only on recently deposited bars.

The other willow scrub community is characterized by codominance of Lemmon's, Geyer's, and Pacific willow. It was our impression that this mixed willow community was more closely associated with sites having a longer period of saturated soil, but groundwater monitoring would be required to confirm this hypothesis.

Ecological History and Trends

Mixed willow scrub habitat areas appear to have occurred generally in their present locations from pre-settlement times through the period for which we have aerial photographs. It is likely that willow/meadow mosaics were the existing condition even before livestock grazing was introduced. Fires, which we know were commonly set by native Americans, would tend to maintain a patchy scrub/meadow landscape very similar to that which we have today. Based upon the series of aerial photographs and on comparison with many other study sites, it appears that the occurrences of these community types in the Upper Reach Study Area have benefited from relatively enlightened grazing management throughout the recent decades.

From 1940 to the present day, some areas of willow scrub have shrunk in area, others have been lost to erosion, and still others (specifically in Reaches 3 and 4) have evidently become slightly drier than they were previously. Evidence for drier conditions include a gradual and slight change in the composition of the meadow vegetation with which the willow scrub are associated and the invasion of some willow/meadow mosaic areas by lodgepole pines over the last few decades.

Restoration Notes

In most portions of the Study Area, the present willow scrub communities exhibit relatively vigorous conditions, with few moribund plants and abundant colonization of new substrate. The most appropriate restoration actions pertain to maintenance of sufficiently wet conditions in the floodplains. As is discussed more fully elsewhere in this report, willows are the most suitable woody plants for bank stabilization and can be used to rapidly revegetate large expanses of newly disturbed soil within the reach of seasonal inundation or near-surface saturation.

DRY MEADOW (DM)

Structure

Dry Meadow is a herbaceous plant community dominated by upland (including FACU and some FAC) plant species. Scattered trees, primarily lodgepole pine, are present in most areas mapped as Dry Meadow, however, for the purposes of understanding of habitat values and planning restoration efforts, the character of these areas is primarily meadow rather than woodland.

Dry Meadow habitat is structurally very different from other meadow types discussed below, as they have much lower aerial and basal vegetative cover. Consequently, this community type is highly susceptible to erosion, both the small-scale surface erosion resulting from intense precipitation and the large-scale erosion that results when channels become reoriented through previously unflooded areas.

Species Composition

The species composition of this community is somewhat variable depending upon its ecological history. Typical dominant species include *Bromus carinatus, Carex filifolia, Carex subfusca, Lupinus lepidus, Gayophytum sp.,* and *Achnatherum lettermanii*.

Ecological History and Trends

In pre-settlement times, much of the area now mapped as Dry Meadow probably supported Mountain Sagebrush Scrub, or scrub mixed with meadow (as described below). However, it is equally possible that these areas were maintained in a purely herbaceous condition by frequent fire. It is not possible to discriminate between meadow and sagebrush scrub/meadow in the 1940 and 1952 aerial photographs, and is even somewhat speculative in any others as well.

Restoration Notes

This community is not important from a restoration planning standpoint, except to avoid creating concentrated flow patterns that impinge directly on dry meadow sites by anticipating flow regimes and patterns.

REVEGETATION DRY MEADOW (RDM)

Occurrence and Structure

This community is ecologically similar to native Dry Meadow, but occurs in areas of surface disturbance that were revegetated using species not native to the area. Primary areas where it occurs are along the east side of Reaches 3 and 4, in the large-scale surface disturbance associated with the construction of Highway 50, and in various locations in Reaches 1 and 2. The structure of this community is similar to that of Dry Meadow.

Species Composition

Due to the long time period that has elapsed since these areas were revegetated, they have been colonized by many of the native Dry Meadow species. However, Revegetation Dry Meadow is characterized by the frequent to dominant presence of soil stabilization species such as *Dactylis glomerata, Bromus inermis, Festuca trachyphylla,* and *Elytrigia intermedia* (‘Luna’).

Ecological History and Trends
This community has existed in the Study Area only in recent decades, and in the absence of new surface disturbance, would be expected to persist long term because of their tendency to reseed in place. They generally seem not to spread to other habitats, however.

MOUNTAIN SAGEBRUSH SCRUB (SDM)

Occurrence and Structure
This community is a mixed scrub and meadow vegetation type, with somewhat lower shrub cover than is usually the case for Mountain Sagebrush Scrub. As for Dry Meadow, some scattered trees are present, but the predominant characteristics and habitat values of the community type are of scrub and meadow rather than woodland.

Species Composition
The dominant species composition of Mountain Sagebrush Scrub is essentially the same as that of Dry Meadow, described above, except for the addition of mountain sagebrush (*Artemisia tridentata ssp. vaseyana*). Also, FACU species such as *Poa pratensis* and *Elymus glaucus* are rare to absent in Mountain Sagebrush Scrub.

Ecological History and Trends
Prior to 1860, this community type probably prevailed, or occurred as a Jeffrey/lodgepole pine savannah, over most of the drier upland portions of the Study Area. Through that time, this condition may have been maintained, entirely or in part, by frequent low-intensity natural or human-caused fires and more recently by livestock grazing.

Restoration Notes
No special considerations of this community need to be made when planning restoration projects in the Upper Reach Study Area.

MESIC FORB COMMUNITY (MF)

Structure
Mesic Forb Community is a dense herbaceous wetland community, typically with 90 to 100 percent canopy cover. Due to the different subterranean growth forms of forbs and graminoids (the latter having much more rhizome and root biomass at and near the soil surface), Mesic Forb community type is much more susceptible to erosion than are graminoid-dominated meadows.

Species Composition
Typical examples of Mesic Forb Community type include a relatively diverse assemblage of plants that are codominant or at least common in one or another microsite within the habitat patch.

These species include *Veratrum californicum, Lupinus polyphyllus, Thalictrum fendleri, Heracleum lanatum, Polemonium occidentale,* and *Senecio triangularis*. Numerous other species are common in one or another example of this community, such as *Dodecatheon jeffreyi, Geum macrophyllum, Smilacina stellata,* and *Platanthera leucostachys*. Graminoids may also be present, usually as a small component of the vegetative cover. Depending upon the soil moisture regime, the associated graminoids may vary from dry-site species such as Poa pratensis to OBL species such as Carex and Juncus species.

Ecological History and Trends

Mesic Forb Community occurs where there is long seasonal surface flow supported by channel flow or on hillside sites kept saturated by water originating from a spring. (Spring-supported sites with flat topography typically support graminoid wetlands; see below.) Mesic Forb sites typically have perennial or nearly perennial near-surface saturation. One notable example of the community occurs where a spring has recently begun to flow in the middle of an area previously dominated by dense Lodgepole Pine Forest with a dry to mesic meadow understory. The new spring flow has drowned the pines and given rise to a wetland community within the last 10-20 years.

As discussed earlier under Mountain Alder - Mixed Willow Scrub, Mesic Forb assemblages are frequently a good marker for abandoned meanders. Thus, as the sinuosity of the channel has decreased over time and the soil moisture regime in the floodplain in Reaches 1-4 has become drier, the extent of Mesic Forb vegetation has decreased substantially. Although the color signature of this community is not easily distinguished from Mesic and Wet Meadow types, some of the even dark green that characterizes all of them in the photographs from 1971 and more recently has been replaced by other vegetation types, primarily Lodgepole Pine Forest.

Restoration Notes

Due to the high plant species diversity of Mesic Forb communities, they can reasonably be presumed to contribute importantly to the base of a food chain and provide for a greater diversity of insect and vertebrate life than is the case for ecologically similar graminoid communities. Thus, to the extent that restoration opportunities and feasible actions permit the establishment of conditions favorable to patches of Mesic Forb habitat, this would be desirable from an overall habitat perspective.

MESIC GRAMINOID MEADOW (MM)

Occurrence and Structure

Mesic and Wet Graminoid Meadow communities are only slightly different, but are distinguished in this report and map in order to provide some indication of subtle differences and trends in soil moisture regime over wide areas of superficially similar vegetation. Ecologically, these meadow types have very similar topographic, edaphic, and hydrologic requirements to Willow Scrub; consequently the meadow and wetland scrub communities generally occur as mixed mosaics, as shown by the vegetation base map (Figures 3.30A-E). Mesic Graminoid Meadow usually has moderately high basal and aerial vegetative cover, typically in the range of 70-80 percent. Due to the rhizomatous and fibrous-rooted nature of the dominant graminoid vegetation, areas of Mesic Graminoid Meadow with higher cover have relatively high resistance to erosion and also tend to exclude colonization by other species except lodgepole pine.

Species Composition

Species composition includes plants with a range of wetland indicator statuses. Dominants usually include both FACU species such as *Poa pratensis* and *Achillea millefolium*, FACW plants such as *Potentilla gracilis, Sidalcea oregana, Penstemon rydbergii var. oreocharis,* and *Juncus balticus* (this last usually not as a codominant), and species with upland affinities such as *Elymus trachycaulus* and *Lupinus lepidus*. Depending on hydrology, areas of Mesic Graminoid Meadow might delineate either as upland or as jurisdictional wetland.

Ecological History and Trends

It is not possible to confidently discriminate between Mesic and Wet Meadow habitat in the historical aerial photographs, therefore trends of change between them are not known with certainty. However, it seems likely that much of the Mesic Meadow actually represents former Wet Meadow (as indicated by the presence of Juncus balticus and other FACW species), which has become markedly drier due to lowering of the floodplain water table and was consequently invaded by species with Dry Meadow affinities.

As for all meadow types in the project region, it is also likely that their treeless condition was maintained at least in part by frequent low-intensity fires, both lightning-strike and human-caused.

Restoration Notes

Rewatering of Mesic Graminoid Meadow areas is desirable to maintain or enhance their value both for wildlife and for sediment/nutrient removal. However, these meadows are more susceptible to erosion than are Wet Graminoid Meadows and Willow Scrub. Therefore, care must be taken to ensure either that the likelihood of channel evulsions through Mesic Meadow is minimized and/or that sufficient floodplain flow obstacles, such as large woody debris or pre-established willow clump barriers, are installed to keep the flow velocities low.

In areas disturbed for restoration-related construction, Mesic Graminoid Meadow can be quickly and effectively re-established from seed and salvaged topsoil.

WET GRAMINOID MEADOW (WM)

Structure

Wet Graminoid Meadow is structurally distinguished from Mesic Graminoid Meadow by its higher basal and aerial cover, commonly 95-100 percent. Consequently, this community has the highest erosion resistance of any herbaceous dominated vegetation type within the Study Area.

Species Composition

Species composition of Wet Graminoid Meadow is dominated by FACW and OBL plants such as *Carex nebrascensis, Juncus balticus, Sidalcea oregana, Potentilla gracilis,* and *Penstemon rydbergii var. oreocharis*. Wet Graminoid Meadow sites near the river channel are also (or alternatively) dominated by a slightly different suite of FACW species such as *Poa trivialis* and *Juncus nevadensis*. Most Wet Graminoid Meadows also include some proportion of one or more FACU species such as P*hleum pratense, Poa pratensis, Achillea millefolium, Taraxacum officinale,* or *Perideridia lemmonii*.

Ecological History and Trends

Wet Graminoid Meadow probably represents the typical wetland meadow community type that has existed extensively throughout the floodplains of the Study Area since pre-settlement times. It is maintained by seasonal near-surface saturation in flat topography. Fire probably played an important role in maintaining the extent of wet meadow originally, followed by livestock grazing since 1860. Hypothetically, it seems ecologically likely that, absent these influences, Willow Scrub would gradually replace wet meadow, however, the historic aerial photographs do not provide unequivocal evidence that this is the case. In any case, interpretation of such a trend is confounded by the concurrent incision of the channel and resulting change in groundwater levels.

Restoration Notes

As noted above, Wet Graminoid Meadow constitutes the most erosion resistant herbaceous community in the Study Area. Strips of Wet Graminoid Meadow turf can be excavated from ‘safe’ areas (i.e. the middle of a meadow, far from a high energy channel) to provide superlative material for biotechnical erosion control, as discussed elsewhere in this report. The excavated areas can be easily backfilled, seeded and mulched and new meadow will quickly regenerate in its place.

OBLIGATE SEDGE WETLAND (OM)

Occurrence and Structure

Obligate Sedge Wetland occurs primarily in floodplain areas where springs supply perennial surface saturation. Specifically, major areas of this community type are found at the upstream extremity of the Study Area (Reach 11) and in a very large obligate/wet meadow complex west of the river in Reach 4. Small patches of Obligate Sedge Meadow also occur near the river. OM is structurally almost identical to Wet Graminoid Meadow, forming a sufficiently dense rhizome and root turf, as illustrated by the floating bog in Reach 4.

Species Composition

Floristically, Obligate Sedge Meadow is markedly distinct from Wet Graminoid Meadow, as it has much lower diversity (typically only two or three species are present), dominated or composed entirely of OBL sedges: *Carex utriculata, Carex nebrascensis, Carex aquatilis,* and *Scirpus microcarpus*.

Ecological History and Trends

This community has almost certainly existed in its present occurrences and conditions since the post-glacial era. Since the larger area occurrences are spring-supported, they are extremely robust to climatic changes and alteration attempts by humans (such as draining a site to favor other vegetation). The dam-building activity of beavers may expand or alter the configuration of Obligate Sedge Wetland occurrences, but probably does not create them where they were not already supported by springs.

Restoration Notes

The two main occurrences of this community are the two sites that are most conducive to the persistence of beaver. Thus, absent complete extirpation of this species from the region, restoration planning should incorporate the expectation that dam-building will be a continual feature of the landscape in these portions of the Study Area.

In other respects, Obligate Sedge Wetland can be expected to arise wherever restoration-related hydrologic changes result in prolonging the season of surface saturation beyond that tolerated by FACW and drier-affinity plants. However, it would not be a preferred restoration target from the perspective of ecosystem-wide habitat values, erosion control (Wet Graminoid Meadow is at least as erosion resistant), or nutrient scavenging.

GRAVEL/COBBLE BAR (B)

Occurrence and Structure

This community type occurs on recently deposited sediment bars, the surface of which is usually covered mostly by cobble-sized particles, with sand to gravel size material in the interior. The community has a highly variable structure, in keeping with its extremely patchy species composition. Typically there are patches of 100 percent shrub cover, patchy forb vegetation, and areas of low to 100 percent graminoid cover.

Species Composition

Species composition includes a very wide variety of plant species groups: Lemmon's and Geyer's willows, OBL sedges (see Obligate Sedge Wetland), Wet Graminoid Meadow species (*Poa trivialis* and *Juncus nevadensis* are particularly common), FAC herbs such as *Solidago canadensis*, and fully upland, colonist species such as *Lupinus lepidus* and *Lepidium densiflorum*.

Ecological History and Trends

It seems unlikely that the soil moisture regime within a particular Gravel Bar map unit varies as much as does the species composition of the vegetation. Notably, the FACW and OBL species tend to occur as relatively dense vegetation, whereas the FAC and upland species occur as scattered, clearly distinct individuals. This suggests a reasonable hypothesis that the willow and OBL/FACW sedge component of Gravel Bar vegetation might represent pre-existing wetland vegetation that was buried by the sediment deposition, then grew through the material to form the present above-ground wetland vegetation. The upland and FAC species clearly appear to have colonized the Gravel Bar communities since the material was deposited.

These patterns would certainly have occurred since prehistoric times, and, we believe, can be discerned on the historic aerial photographs as well.

Restoration Notes

A desirable and very cost-effective element of any restoration planning for the Upper Reach Study Area would be to enhance the revegetation of Gravel Bar sites by planting appropriate species, such as alder and willow species, in the more thinly vegetated areas.

DEVELOPED AREAS (D)

This map unit was used for areas within the Study Area that are highly modified by development. In Reaches 1 and 2, the Lake Tahoe Golf Course is a Developed Area, in Reaches 3 and 4 (east bank), recreational fields and parking areas within the park, in Reach 5 (west bank), the campground, and in Reaches 6-11, residences and associated landscaped yards.

HISTORIC CHANNELS

In many places in the Study Area, especially in Reaches 3 and 4, but also in Reach 2 and in the large meadow systems in Reaches 6 and 8, historic channels were discernible within communities that are now (variably) either upland forest (usually Lodgepole pine) or more mesic communities. Most of these channels appear to be too small to represent old oxbows of the main channel. These features are not large enough to be mapped as polygons, but are revealing of past fluvial history (most likely, the influence of beaver dams) and are ecologically significant because they support Alder-Willow and Mesic Forb vegetation within a dense forest context. They are therefore indicative of sufficient near-surface soil moisture for deciduous riparian communities or mesic/wet meadows to be supported with only moderate changes in channel grade and modification of the encroaching weedy lodgepole pine forest.

III.2.I Opportunities and Constraints

OPPORTUNITIES

- Encourage property owners to remove small diameter trees (lodgepole pine, white fir, Jeffrey pine) from their property. The practice would be ecologically beneficial, as well as increase defensibility from wildfire. Thinned trees near existing quaking aspens allow for more robust regeneration of species and improved wildlife habitat. Thinning the subcanopy will also encourage the open conditions necessary for the recruitment of black cottonwood, a desirable species for wildlife habitat as well as a source of woody debris.
- Use the small trees to aid in erosion control by chipping and spreading thinly on property.
- Plant cottonwoods in suitable sediment depositional areas, such as the gravel bars in Reaches 3 and 4.
- Encourage the natural fluvial geomorphic process (that is, floodplain connectivity and deposition of appropriately sized sediment) and ensure cottonwood, mountain alder, mesic forb community, and mixed willow scrub habitat establishment.
- Revegetate areas disturbed by restoration-related construction with the quickly and effectively re-established Mesic Graminoid Meadow community.
- Use Wet Graminoid Meadow as a source for biotechnical erosion control, due to its high resistance to erosion.

CONSTRAINTS

- Infill residential development constrains the application of prescribed fire as a means of thinning trees.
- The play areas of the LTGC constrain the locations available for revegetation of cottonwoods, like the gravel bars in Reaches 3 and 4.
- The high erosional susceptibility of the Mesic Graminoid Meadow means that sufficient care must be taken to avoid channel avulsions through this habitat. Recommended steps to be taken include large woody debris or pre-established willow clump barriers.
- Beavers and their dam construction constrain the restoration efforts of the obligate sedge wetland communities in the Study Area. Any restoration planning will have to include for the persistence of flooding due to beaver activity.
- Obligate sedge wetland is not a preferred restoration target for habitat values, erosion control, or nutrient scavenging reasons. However, the community is expected to arise wherever restoration prolongs the surface saturation season beyond what is tolerated by FACW and drier-affinity plants.

III.2.J References Cited

California Department of Fish and Game (CDFG). 2002. List of California Terrestrial Natural Communities Recognized by the California Natural Diversity Data Base, May 2002 edition. California Department of Fish and Game, Wildlife and Habitat Data Analysis Branch, Sacramento, California.

Franklin, J. F., and J. A. Fites-Kaufman. 1996. Assessment of late-successional forests of the Sierra Nevada. Pp. 627-661 in Status of the Sierra Nevada, Volume II: Assessments and Scientific Basis for Management Options. Sierra Nevada Ecosystem Project Final Report to Congress. Wildland Resources Center Report No. 37, Centers for Water and Wildland Resources, University of California, Davis.

Franklin, J. F., and Skinner, C. N., and Chi-Ru Chang. 1996. Fire regimes, past and present. Pp. 1041-1069 in Status of the Sierra Nevada, Volume II: Assessments and Scientific Basis for Management Options. Sierra Nevada Ecosystem Project Final Report to Congress. Wildland Resources Center Report No. 37, Centers for Water and Wildland Resources, University of California, Davis.

Hickman, J. C. 1993. The Jepson Manual: Higher Plants of California. University of California Press, Berkeley, California.

Manley, P. N., J. A. Fites-Kaufman, M. G. Barbour, M. D. Schlesinger, and D. M. Rizzo. 2000. Biological integrity. Pp. 403-598 in D. D. Murphy and C. M. Knopp (eds.), Lake Tahoe Watershed Assessment: Volume 1. General Technical Report PSW-GTR-175. USDA Forest Service, Pacific Southwest Research Station, Albany, California.

Manning, M. E., and W. G. Padgett. 1995. Riparian Community Type Classification for Humboldt and Toiyabe National Forests, Nevada and Eastern California. USDA Forest Service, Intermountain Region. Technical report R4-Ecol-95-01.

McKelvey, K. S., and J. D. Johnston. 1992. Historical perspectives on forests of the Sierra Nevada and the Transverse Ranges of Southern California: Forest conditions at the turn of the century. Pp. 225-246 in The California Spotted Owl: A Technical Assessment of its Current Status. General Technical Report PSW-GTR-133. USDA Forest Service, Pacific Southwest Research Station, Albany, California.

Sawyer, J.O. and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society. Sacramento, California.

Swanson Hydrology and Geomorphology. 2003. Blackwood Creek stream restoration project – final design report. Prepared for USFS Lake Tahoe Basin Management Unit. April 29, 2003.

United States Fish and Wildlife Service. 1981. Platte River Ecology Study. Special Research Report.

United States Fish and Wildlife Service. 1996. National list of vascular plant species that occur in wetlands: 1996 National Summary.

III.3 TERRESTRIAL WILDLIFE

III.3.A Introduction

This report provides an evaluation of wildlife conditions in the Upper Reach Study Area. The report specifically addresses the following six issues:

- Identify the wildlife management policies of local resource agencies.
- Identify known or potential threatened and endangered wildlife species, as well as sensitive habitat sites within and near the Study Area.
- Develop a list of wildlife species with known and potential occurrences in the Study Area.
- Investigate the occurrence and behavior of beaver within the Study Area. Provide an initial approximation of population dynamics and trends. Discuss the conflicts and/or benefits to ecosystem function and land use.
- Assess opportunities and constraints for wildlife ecosystem restoration.
- Provide priorities for wildlife habitat restoration and management.

BEAVERS

In particular, this report focuses on the beavers (*Castor canadensis*) in the Study Area. Beavers are of interest because they can alter both landscape form and function, and this ability brings them into conflict with people. The effects of beavers are often described as either beneficial or detrimental. Beaver-altered environments are generally acknowledged to increase habitat suitability for waterfowl, furbearers, amphibians, upland game, and deer (Reed 1980; Muller-Schwarze and Sun 2003), but can affect fish in both beneficial and detrimental ways. Detrimental effects due to beavers include property damage from flooding, softening of road banks due to flooding, tree loss, and a potential increase in mosquitoes due to the availability of dammed water (Muller-Schwarze and Sun 2003). (It should be noted that mosquitoes can become less numerous in beaver ponds because mosquito species adapted to temporary-pool environments are unlikely to be able to develop in the permanent standing water impounded behind beaver dams (Butts 1992; Butts 2001)).

Beavers have been intentionally introduced into some areas for the purpose of restoring degraded watersheds. Dams constructed by beavers alter watersheds by trapping sediment, storing water, modifying flow regimes, expanding the extent and dynamic of riparian zones, and providing exposed sediment for willow establishment (Naiman et al. 1988). In some areas, cyclic beaver habitat occupancy and abandonment results in wetter environments with substantially more riparian habitat, even in areas located away from beaver ponds (Muller-Schwarze and Sun 2003).

Native to Tahoe?

The available evidence suggests that beavers did not occur in the Lake Tahoe Basin until some time in the early 1900s when they were formally and informally introduced. The beaver is absent from traditional Washoe Indian heritage, as reported by the living elders who recollect memories of beavers only from the 1930s-1950s (Susan Lindström, project archeologist, September 17 and 23, 2003, personal communication).

Tappe (1942) provides the first documentation on the introduction of two pairs of beavers to Meiss Meadow by the California Department of Fish and Game (CDFG) in 1938. Federal agencies introduced beavers to uninhabited locations because of their value as a fur resource and as an aid in water conservation and control of soil erosion (Tappe 1942). Besides the introduction documented in Tappe's report, a long-time resident of the Basin cites an additional release of beavers into Lily Lake in the early 1940s by the USFS (Craven, personal communication). According to Craven, some earlier introductions might also have been attempted but were unsuccessful due to winter weather. These introductions were to establish a fur trade during the depression years (Craven, personal communication).

Informal introductions prior to agency introductions probably occurred by individuals who wanted to establish an additional income source from trapping (Peralt, retired California Department of Fish and Game warden, September 11, 2003, personal communication). Project archeologist Susan Lindström (email communication) notes beaver conflicts with irrigation systems for cattle grazing were a problem in the 1920s in North Canyon Creek (Spooner Summit Area).

Beavers were not included in Orr's (1949) book titled Mammals of Lake Tahoe, which included mammals currently occurring in the Basin or those recorded in the past. He might have been unaware of the introductions (perhaps due to poor research or scarcity of the population in areas he surveyed), or he chose to include only native species.

Reconstructing a timeline of when and where beavers colonized the Upper Truckee River would be useful to understanding some of their effects on the watershed. However, little information on this subject is available. A long-time resident of the Upper Truckee River Watershed stated that her family did not observe beavers in the Upper Truckee River, specifically Reach 6, until the early 1960s (Shirley Taylor, personal communication). Consultation with El Dorado County officials reveals that one colony site on the river has been active for at least seventeen years. A review of California Department of Fish and Game (CDFG) could provide more comprehensive information.

Study Area Beaver Habitat Suitability

A goal of this assessment is to develop an initial ranking of beaver habitat suitability within the Study Area. Because of the effects beavers produce through feeding and dam-building activities, ranking habitat suitability can assist in assessing beavers' potential effects on the river and restoration projects and can help to focus management activities related to nuisance beavers.

Delineation of habitat quality can help to differentiate where beaver colonies are likely to persist from locations where they are likely to be transitory. The assumption is that unmanaged beavers will always occupy high quality habitat. Any vacant high-quality habitat will be re-occupied as soon as possible, and the emigrants would not need to construct a lodge or den, merely repair what is existing. Locating high quality habitat has management implications because these sites are least likely to be naturally vacated by beavers, and they serve as sources of young dispersing beavers. These sites are also least likely to experience potential adverse effects such as a decline in vegetation diversity and structure.

Numerous models to assess habitat suitability and quality for beavers and a site's associated carrying capacity have been developed (Slough and Sadler 1977; Willis 1978; Allen 1983; Howard and Larsen 1985; Beier and Barrett 1987; Robel et al 1993). These models typically incorporate quantitative measurements of key abiotic and biotic habitat variables that are thought to affect beaver populations.

Most models show that the most important factors related to beaver habitat use are physical factors, such as stream gradient (low), stream depth (deeper), and stream width (wider). Variables related to vegetation add little to the understanding of beaver occupancy (Beier and Barrett 1987). Reasons cited for the lack of a relationship include the opportunistic nature of food selection and that the observed plant species may have little relationship to the plant species that were present when the colony was established. The models have varying rates of effectiveness in predicting habitat quality/suitability in different habitat types and regions of the country, and some researchers suggest modification of models based on local conditions (Robel et al 1993).

While collecting data to implement a model is beyond the scope of this assessment, a method was developed to provide an initial ranking of habitat suitability.

III.3.B Methods

AGENCY CONSULTATION

Biologists at the United States Forest Service (USFS) Lake Tahoe Basin Management Unit (LTBMU), the Tahoe Regional Planning Agency and the California State Park system were consulted to determine which federal, state, or regional special status wildlife species could potentially occur within the Study Area. No protocol surveys for special status wildlife species were conducted.

FIELD SURVEYS

Field surveys were conducted on foot in Reaches 3 through 11 between August 6 and October 29, 2003. The surveys consisted of walking meandering paths along each side of the river. A list of wildlife species directly observed or detected based on their sign (e.g., scat, tracks) was compiled. Each species' association with Study Area plant communities was recorded.

All beaver dens, lodges, and dams were mapped. Because colonies can construct several dens, more than one den in an estimated 50-foot radius was considered part of the same system and recorded as one den. Active colony sites were distinguished from inactive sites by the presence of freshly cut vegetation, recent maintenance of dams, muddy canals, scent mounds, scat, tracks, and trails that showed recent use (e.g., trampled herbaceous growth).

BEAVER HABITAT RANKING

For this ranking, beaver habitat is defined as locations where colonies could be established and three criteria were used to develop three classes of beaver habitat in the Study Area (see Table 3.7): presence of riparian habitat, presence of additional water sources, and presence of beaver signs. Factors affecting colony site longevity were chosen as the criteria to rank Study Area habitat because long-term occupancy of an area is highly related to habitat suitability (Muller-Schwarze and Sun 2003). The Study Area habitat was ranked based on the assumption that areas with high quantities of these parameters provide more suitable habitat than areas with low amounts. The extent of riparian vegetation was measured using a dot grid over aerial photographs (1:300 and 1: 400 scale) and reviewing the project's plant community maps (Figures 2.30A-E). Both sides of the river were ranked independently of each other.

Table 3.7: Criteria used to define the three classes of beaver habitat on the Upper Truckee River.

High quality	Moderate quality	Poor-quality
At least 50 feet of riparian habitat is present with a variable moist, herbaceous understory.	Less than 50 feet of riparian habitat is present with a mostly dry herbaceous understory.	Less than 50 feet of riparian habitat is present with little or no herbaceous understory.
Presence of an additional stable water source, such as a spring, seep, or tributary, and abandoned river channels that could flow with water during spring run-off.	No additional water sources are present; any abandoned river channels are unlikely to fill with water during spring run-off.	No additional water sources or abandoned channels are present
Beaver sign* indicates long-term occupancy with little or no indication of a decline in beaver habitat quality (e.g., hedging of shrubs).	Beaver sign* indicates intermittent occupancy with scattered signs of a decline in beaver habitat quality (e.g., hedging of shrubs).	Scant to no beaver feeding sign is present, indicating rare to no use of the site.

* Beaver sign includes dens, lodges, and cuts on woody vegetation

BEAVER POPULATION ESTIMATE

Adult beavers are colonial, non-migratory, and occupy an established territory and home range. While beaver populations are difficult to census accurately, counting the number of active beaver colonies and multiplying this figure by the average number of beavers per colony is a common procedure to estimate density (Busher and Jenkins 1983).

An estimated number of active beaver colonies in the Study Area from Reaches 3 through 11 was developed based on: (1) the linear extent of beaver signs along the river indicating current use (e.g., cuttings in water at den sites, actively maintained dams, trampled trails, lodges with cuttings, etc.), (2) the home range sizes of beaver families in Sagehen Creek, California of 656 to 2,625 feet (Busher 1975), (3) the average nearest neighbor distance between colonies at Sagehen Creek of 3,937 feet (Busher and Jenkins 1983), and (4) the number and location of scent mounds.

Data on Study Area beavers are compared with data on beavers from Sagehen Creek (located approximately 60 miles northwest of the Study Area), because they are the closest population of well-studied beavers. Data is available on a beaver population in Little Valley, Nevada, which is located approximately twenty miles northeast of the Study Area. However, because less data is available from this population (two versus more than thirty years for beavers at Sagehen Creek) and the population exhibited unusual colony composition (Busher and Jenkins 1983), it was not used for comparison.

Because each colony constructs only one winter food cache, a survey was conducted October 29 in Reaches 8 through 11 for winter food caches as an indicator of active colony sites.

Two colony types were recorded: established family colonies and colonizing colonies. The former were distinguished from colonizing colonies based on a subjective interpretation of the extent of sign indicating long-term occupancy and on consultation with local residents and El Dorado County officials regarding colony site longevity.

The distinction is important because beaver colonies consist of variable numbers of animals. Most family groups consist of the parents, young of the year, and yearlings. Two-year olds may or may not be present. Colonies can also consist of temporarily single adults and pairs without kits. According to Dr. Peter Busher (Boston University, November 5, 2003, personal communication), an average colony is composed of five to six beavers. This average holds across the beavers' distribution throughout the United States. Therefore, within the Study Area, six animals were assumed to occupy each established family colony. Young, colonizing beavers have small litters compared to established family colonies (Muller-Schwarze and Sun 2003). Therefore, within the Study Area, four animals were assumed to occupy each colonizing colony.

Where beaver sign (e.g., fresh cut branches) was detected at a distance greater than 2,625 feet from an active colony (the maximum home range of beavers in Sagehen Creek), or the sign was isolated from all other signs of current beaver activity (i.e., outside the estimated home range of the closest colony), it was assumed to represent a single animal.

VEGETATION

At varying intervals, the following information was recorded for plants cut by beavers: species, height at which the vegetation was cut, and the diameter of the cut stem or trunk. Where aspens had been cut, the presence of juvenile-form and/or adult-form trees was recorded along with the height of the new growth. Recently cut woody vegetation was distinguished from older cuts by the color and condition of the wood. Searches were conducted to locate stumps and beaver cut logs that were obscured by an overstory of shrubs and/or herbaceous vegetation. The base of fallen trees in log jams across the river was examined to determine whether beavers were responsible.

III.3.C Agency Wildlife Management

The following section describes the agencies that administer the federal, state, and local environmental laws and policies that apply to special status wildlife species in the Study Area. Special status species are native species that are accorded special legal or management protection because of concern for their continued existence. There are several different categories of protection at both federal, state, and local levels, depending on the magnitude of threat to continued existence and existing knowledge of population levels. Special status species are defined as follows:

- Wildlife species listed or proposed for listing or candidates for listing under federal or state Endangered Species Acts;
- Wildlife species considered Species of Special Concern by the United States Fish and Wildlife Service (USFWS);
- Wildlife species considered sensitive by other federal agencies, such as the United States Forest Service (USFS);
- California Department of Fish and Game (CDFG) threatened, endangered, and Species of Special Concern; and
- Tahoe Regional Planning Agency Species of Special Interest.

FEDERAL ENDANGERED SPECIES ACT

In 1973, the United States Congress enacted the Federal Endangered Species Act (ESA) to protect those species that are endangered or threatened with extinction. The United States Fish and Wildlife Service (USFWS) is responsible for implementation of the ESA. The USFWS identifies specific species of wildlife as threatened, endangered, or sensitive.

Section 7 of the ESA directs federal departments and agencies to ensure that actions authorized, funded, or carried out by them are not likely to jeopardize the continued existence of any threatened or endangered species or result in the destruction or adverse modification of their critical habitat.

The USFS is required to manage National Forest lands so that all existing native and desired nonnative wildlife, fish, and plants can maintain at least viable populations. Forest activities are to be conducted so as to avoid actions that may cause a species to become threatened or endangered (FSM 2670.12). Current management direction is to manage National Forest system habitats and activities for threatened and endangered species to achieve recovery objectives so that special protection measures provided under the ESA are no longer necessary (FSM 2670.21).

CALIFORNIA ENDANGERED SPECIES ACT

In 1984, the State of California passed the California Endangered Species Act. The CDFG exercises authority to implement and enforce statutes that affect wildlife, particularly those that involve sensitive species. Through a cooperative agreement with the USFWS, the CDFG is responsible for sensitive species identified by the federal ESA.

TAHOE REGIONAL PLANNING AGENCY

Within the Lake Tahoe Basin, the Tahoe Regional Planning Agency (TRPA) has developed goals, policies, thresholds and ordinances pertaining to wildlife. TRPA has established Environmental Thresholds for wildlife that address special interest species, habitats of special significance, stream habitats, and instream flows. These Environmental Thresholds are used to establish the significance of an environmental effect to wildlife resources in the Lake Tahoe Basin.

The Thresholds establish a non-degradation management standard for significant wildlife habitat consisting of deciduous trees, wetlands, and meadows, while providing for opportunities to increase the acreage of such riparian associations.

The TRPA has designated six species and one category of species as species of special interest because of rarity or other public interest. The Thresholds provide a minimum number of population sites and designate disturbance zones for the species identified in Table 3.8.

Table 3.8: TRPA Environmental Thresholds for Special Interest Species.

Species of Interest	Population Sites	Disturbance Zone	Influence Zone
Goshawk	12	0.50	3.50
Osprey	4	0.25	0.60
Bald Eagle (Winter)	2	Mapped Areas	Mapped Areas
Bald Eagle (Nesting)	1	0.50	Variable
Golden eagle	4	0.25	9.0
Waterfowl	18	Mapped Areas	Mapped Areas
Deer	0	Meadows	Mapped Areas
Peregrine Falcon	2	0.25	7.6

The TRPA Goals and Policies provide for maintenance of suitable wildlife habitats for all game and non-game indigenous species by maintaining and increasing habitat diversity. Habitats essential for threatened, endangered, or sensitive (TES) wildlife species must be preserved and enhanced. The Goals and Policies also reinforce the provisions of state and federal protection for TES wildlife species. The TRPA Code of Ordinances establishes standards for wildlife resources. They require identification of potential impacts, such as habitat alteration, establish protection mechanisms, and require mitigation measures when necessary.

The TRPA Goals and Policies and Code of Ordinances provide that stream environment zones adjoining creeks and major drainages that link islands of habitat shall be managed, in part, for use by wildlife as movement corridors. Structures proposed within these movement corridors shall be designed so they do not impede the movement of wildlife. Riparian vegetation shall be protected and managed for wildlife.

UNITED STATES FOREST SERVICE

Beaver Management Plan

The USFS Lake Tahoe Basin Management Unit (LTBMU) produced a beaver management plan in 1980 (Reed 1980). The report recommended dividing the Lake Tahoe Basin into beaver management zones. The physical boundaries, the carrying capacities, and the management priorities for each major area were to be determined through interdisciplinary consultation. The plan called for annual or biannual surveys to determine population parameters and distribution within each management zone. Removal of beaver was to be conducted when populations exceeded desired levels, the effects on the watershed and its vegetation were unacceptable, new areas were colonized where beavers were undesirable, beavers were damaging property and/or improvements, or any water supply occupied by beaver was determined to be infected with Giardia spp. or other diseases transmissible from beavers to humans. According to Kathy Campion, LTBMU wildlife biologist (August 13, 2003, personal communication) the beaver management plan was never implemented.

1988 Land Resource Management Plan

The LTBMU Land and Resource Management Plan (LRMP) (USDA1988) was developed to direct management of USFS lands in the Lake Tahoe Basin. For wildlife, the LRMP selected the following ten management indicator species (MIS) to monitor the effects of management practices on native and desired nonnative vertebrate species within the planning area: bald eagle, peregrine falcon, goshawk, spotted owl, mule deer, pileated woodpecker, mallard, black bear, blue grouse, and willow flycatcher. These MIS represent groups of species with similar habitat requirements. Management of these species to maintain viable population levels should also provide for viable populations of the remaining species in the group they represent.

For forest planning purposes, the LTBMU is divided into twenty-one management areas (MA). These MAs represent sections of land that have similar character and/or use, and MA-specific management direction is provided.

The Upper Reach Study Area is in the Tahoe Valley Management Area South Half. The resource emphasis in this area is to meet the recreation, scenic and special uses demands of the large visiting and urban population in the area. The desired future condition for this MA is to have healthy and diverse forest conditions that can support the variety and intensity of recreation and other activities demanded by the large nearby local and visiting population. No MA prescriptions are given for the section of the Tahoe Valley Management Area South Half where the Upper Truckee River is located.

Beaver management is not noted in the 1988 LRMP.

Sierra Nevada Framework

The Sierra Nevada Forest Plan Amendment (SNFPA) (USDA 2000) and Record of Decision (ROD) (USDA 2001) amend management direction in national forest land management plans, including the LTBMU Land and Resource Management Plan (USDA 1988). The SNFPA and ROD will guide activity-level decision making in the LTBMU until they are replaced through subsequent amendment or revision. Where there is overlap between the 1988 LTBMU Land and Resource Management Plan and the SNFPA and ROD, the latter two supplant the LRMP.

As required by the SNFPA and ROD, the LTBMU delineated land allocations for special status wildlife species. These delineations are based on records of occurrences and on areas with potentially suitable habitat characteristics. Each land allocation has a set of standards and guidelines that determine management. Management for lands allocated as protected activity centers (PACs) for the northern goshawk, California spotted owl, great gray owl, and den sites for fisher and marten are as follows:

- California spotted owl nest and roost sites: 300 acres of the best available habitat surrounding each owl activity center detected since 1986, arranged in as compact a unit as possible. Activity centers are based on documented nest sites, most recently known roost sites, or a central point based on repeated daytime detections.
- Northern goshawk breeding sites: 200 acres of the best available forested habitat surrounding nest sites (or, if the nest cannot be located, the location of territorial adults or recently fledged juveniles during the fledgling dependency period) in the largest contiguous blocks possible.
- Great gray owl nest sites: 50 acres of the best available forested habitat plus adjacent meadow habitat surrounding nest sites.
- Fisher den sites: 700 acres of the highest quality habitat in a compact arrangement surrounding den sites in the largest, most contiguous blocks available.
- Marten den sites: 100 acres of the highest quality habitat surrounding den sites, arranged in as compact a unit as possible.
- Willow flycatcher habitat. The standards and guidelines for willow flycatcher habitat include assessing impacts of livestock grazing and conducting surveys for willow flycatchers.
- California Spotted Owl Home Range Core Areas. California spotted owl home range core areas surround and include the 300-acre PAC. Home range core area sizes vary by national forest; for the Tahoe National Forest, it is 1,000 acres. Management objectives for California spotted owl home range core areas are identical to those for old forest emphasis areas. This direction applies to California spotted owl home range core areas, except where home range core areas overlap with urban wildland intermix zone.

Limited operating periods (LOPs) are applied to PACs and den sites during nesting and denning seasons to protect breeding adults and their offspring as follows:

- California spotted owl: within ¼ mile of nest site March 1 through August 31, unless surveys confirm that California spotted owls are not nesting.
- Northern goshawk: within ¼ mile of nest site February 15 through September 15, unless surveys confirm that northern goshawks are not nesting.
- Great gray owl nest sites: within ¼ mile of active great gray owl nest stands March 1 through August 15.
- Fisher den sites: March 1 through June 30.
- Marten den sites: May 1 through July 31.

Although the Framework (USDA 2001) does not include LOPs or buffer zones for willow flycatchers, the California Department of Fish and Game (CDFG) has implemented no-disturbance buffer zones of several hundred feet for any activities that could potentially impact nesting willow flycatchers. The TRPA does not currently have limited operating periods or buffer zones for willow flycatchers, but defers to existing management schemes.

SENSITIVE HABITAT SITES WITHIN THE STUDY AREA

Sensitive habitats within the Study Area are sites that could affect project activities through imposition of agency restrictions on timing of activities and alteration of vegetation.

Sensitive habitats within the Study Area include those identified by the USFS as occupied, emphasis, and suitable willow flycatcher habitat and the habitat delineated as a spotted owl protected activity center.

All riparian habitat consisting of willows and alders provide suitable habitat for willow flycatchers. Any activities in these locations would require annual pre-project surveys. If willow flycatchers are found, a variable LOP would be developed in consultation with agency biologists. Activities that caused the loss or temporary alteration of willows at documented willow flycatcher nesting sites would probably not be allowed.

The aspen and cottonwood forests in the Study Area are considered sensitive wildlife habitat. Aspen stands are designated an Ecologically Significant Area (ESA) in the Lake Tahoe Basin because they are uncommon and because they have an exceptionally diverse array of associated species. Manning and Schlesinger (2001) suggest that aspen and cottonwood in the Basin may function as keystone species because they rated relatively high in biological diversity despite occurring infrequently on their sample reaches. Project activities that occur in aspen or cottonwood forests would probably be subject to restrictions on loss or alteration of habitat.

III.3.D Results and Discussion

SPECIAL STATUS SPECIES

The following three special status species and category of special status species occur in the Study Area: willow flycatcher, spotted owl, mule deer, and waterfowl.

Willow flycatcher

Willow flycatchers are summer resident breeders in the Sierra Nevada. Suitable breeding habitat for willow flycatchers includes large, open stands of willows in wet meadows. The presence of water during the breeding season is an important habitat component. The minimum size meadow is assumed to be 0.62 acres (Fowler et al. 1991). While wet meadows are the most common habitat used for breeding, willow flycatchers have been found breeding in riparian habitats of various types and sizes, including grasslands, boggy areas, riparian deciduous shrubs along streams, and small lakes and ponds surrounded by willows with a border of meadow or grassland.

Breeding populations of willow flycatchers in the Sierra Nevada can occur in isolated mountain meadows up to 8,000 feet in elevation (Harris et al. 1988).

Willow flycatchers arrive at their breeding territories in early May and nesting begins between late May and late July. The cup-shaped nests are usually between 3.7 to 8.3 feet above the ground and are found most often near the edge of clumps of deciduous riparian shrubs (Sanders and Flett 1989; Harris 1991). Eggs are incubated about twelve days and chicks fledge after 12-15 days. The adults and fledglings generally remain in the breeding area through August. Willow flycatchers forage by either aerially gleaning or hawking insects.

Alteration and loss of riparian habitats are believed to be the main causes for declining breeding populations of willow flycatchers (Sanders and Flett 1989). Other factors that might have contributed to its decline include nest parasitism by brown-headed cowbirds (*Molothrus ater*), disturbance and habitat degradation from grazing, and events occurring on wintering grounds (Serena 1982; Harris et al. 1988).

Occupied habitat is meadow or riparian sites with documented willow flycatcher occupancy. Emphasis habitat is defined as meadows larger than 15 acres that have standing water on June 1 and a deciduous shrub component. Suitable (potential) habitat includes (1) occupied willow flycatcher habitat; (2) known willow flycatcher sites; (3) emphasis habitat; and (4) small, wet woody meadows (meadows less than 15 acres that have standing water on June 1 and a deciduous shrub component).

The LTBMU has mapped three types of willow flycatcher habitat within the Study Area. Approximately 20,610 feet are delineated occupied habitat in Reaches 5 through 11 and approximately 3,960 feet in Reach 3, approximately 2,640 feet are delineated emphasis habitat (Reach 4), and approximately 9,240 feet are mapped as suitable habitat (portions of Reaches 1 through 4).

The USFS implements a limited operating period from June 1 to August 31 due to willow flycatcher breeding. These dates may be modified when multi-year monitoring data support different dates for a particular breeding location.

California spotted owl

According to the California Spotted Owl Sierran Province Interim Guidelines Environmental Assessment (CASPO Report) (USDA 1993), nesting and roosting habitat typically includes a forest stand with greater than 70% canopy cover. Optimum habitat consists of dense, mature trees with multiple canopies and abundant snags and down woody material. Nesting habitat is characterized by dense canopy closure (>70%) with medium to large trees and usually at least two canopy layers present. In addition, nest stands usually have some large snags and an accumulation of logs and limbs on the ground (USDA 1993). Foraging habitat can include all medium to large tree stands with 50% or greater canopy closure.

The CASPO Report (USDA 1993) provides management guidelines for forests in the Sierran Province that support populations of the California spotted owl. The report specifies that a Protected Activity Center (PAC) be established around all known owl sites (including pair, resident single, and single bird locations) detected between 1987 and 1992. According to the technical team recommendations from a June 1994 meeting, if owls are detected on the LTBMU, then their habitat will be managed in accordance with the Modified Cumulative Effects Analysis (CEA) Process.

A spotted owl PAC is mapped in the vicinity of Reaches 10 and 11. A 1,000-acre home range core area is also designated around the PAC and encompasses the best available spotted owl habitat in closest proximity to the PAC.

A quarter-mile limited operating period prohibits activities within approximately ¼ mile of the nest during the breeding season from March 1 through August 31, unless surveys confirm that California spotted owls are not nesting. The LOP may be waived for individual projects or activities of limited scope and duration or when the biological evaluation documents that such projects are unlikely to result in breeding disturbance considering their intensity, duration, timing, and specific location. Where a biological evaluation determines that a nest site will be shielded from planned activities by topographic features that minimize disturbance, the LOP buffer may be reduced.

Mule deer

The Study Area contains summer range for the Carson deer herd. Deer habitat in the LTBMU consists of summer range only, mostly in the form of meadows and early to mid-successional vegetation stages with brush that can be used for forage and cover (USDA 1988). Preferred habitat requirements for fawning include undisturbed meadow and riparian areas that provide hiding cover and succulent forage. Mule deer preferentially browse on shrubs rather than graze on forbs and grasses. Preferred shrubs are mostly in the rose family and include bitterbrush, cliff-rose, and rose. Willows and many other riparian species are also favored. To avoid heavy snows and reduced forage, mule deer migrate primarily altitudinally. The regional migrations of the Carson deer herd entail movements from summer range into lower elevation winter range, located outside the Tahoe Basin, east of the Study Area.

The Study Area is located in summer habitat for the Carson Deer Herd. No mapped migration routes or critical winter, fawning, or summer range habitat for the Carson Deer Herd occurs in or near the Study Area. Mule deer beds, scats, and tracks were observed in the upper Study Area. Signs of browsing by deer on dogwood were conspicuous, but were not obvious on either willow or alder. The historic conditions described in this assessment's vegetation report (Section III.2) suggest that plant communities used by deer for foraging (e.g., mountain sagebrush scrub, Jeffrey/lodgepole pine savannah) were once more extensive. The invasion of meadows by conifers has reduced the extent of edge habitat preferred by deer. No restrictions, such as LOPs, are applied to the presence of mule deer.

Waterfowl

Preferred habitat for waterfowl includes marshes, wet meadows, creek drainages, and along the shallow shorelines of lakes. A total of 18 sites within the Lake Tahoe Basin are designated as mapped waterfowl habitat by TRPA. Mapped waterfowl habitat is present five miles north of the Study Area in the Upper Truckee River Marsh. This site is the primary nesting area used by waterfowl in the LTBMU (USDA 1988). More than half of the marsh has been replaced by urban development (USDA 1988). No mapped waterfowl habitat is delineated in the Study Area.

The waterfowl detected in the Study Area were common species such as Canada geese, mallards, and mergansers. Spotted sandpipers and killdeer were observed along the sandy, open shores of the river. Both are ground nesting species that nest in the Study Area. Snipes were observed in marshy areas in the vicinity of beaver dams that were constructed on side channels and springs. No restrictions, such as LOPs, are applied to the presence of waterfowl.

Field Survey

A list of wildlife species observed during the field surveys was compiled. A total of 41 bird species, 14 mammals, one reptile, and one amphibian species were detected either by direct observation or by sign, such as scat, tracks, burrows, and/or carcass. These species and their associated habitat types are shown in Tables 3.9 and 3.10. The habitat types are composed of one or more of the community types discussed in the vegetation report (Section III.2).

Table 3.9: Bird species observed in the Upper Reach Study Area, August 6 to October 29, 2003.

COMMON NAME	SCIENTIFIC NAME	SIGN*	PREFERRED HABITAT **
American robin	*Turdus migratorius*	O, V	ALL TYPES
Mallard	*Anas platyrhyncos*	O, V	WM, RI
Common merganser	*Mergus merganser*	O, S	RI
Common snipe	*Gallinago sericea*	O, S	WM, RI
Killdeer	*Charadrius vociferus*	O	WM, RI
Spotted sandpiper	*Actitis macularia*	O, V	RI
Canada goose	*Branta canadensis*	S	WM, DM, M
Belted kingfisher	*Ceryle alcyon*	O, V	RI
Cooper's hawk*	*Accipiter cooperi*	F	CF, MF, DF
American dipper	*Cinculus mexicanus*	O, V	RI
Red-tailed hawk	*Buteo jamaicensis*	O	CF, MF, DF, R, M, WM
Cassin's finch	*Carpodacus cassinii*	O	CF, MF, DF
Hermit thrush	*Cathartes aura*	O	CF, MF, DF
Northern flicker	*Colaptes auratus*	O, V	CF, MF, DF
Band-tailed pigeon	*Columba fasciata*	O	CF, MF, DF
Western wood-peewee	*Contopus sordidulus*	O, V	CF, MF, DF, R, EDGES
Common raven	*Corvus corax*	O	ALL TYPES
Stellar's jay	*Cyanocitta stelleri*	O, V	CF, MF, DF
Yellow-rumped warbler	*Dendroica coronata*	O, V	CF, MF, DF
Brewer's blackbird	*Euphagus cyanocephalus*	O, V	R, M, WM
Red-winged blackbird	*Agelaius phoeniceus*	O, V	R, M, WM
Tree swallow	*Tachycineta bicolor*	O	R, M, WM, RI

COMMON NAME	SCIENTIFIC NAME	SIGN*	PREFERRED HABITAT **
Black phoebe	*Sayornis nigricans*	O	R, M, WM, RI
Barn swallow	*Hirundo rustica*	O	R, M, WM, RI
Dark-eyed junco	*Junco hyemalis*	O, V	CF, MF, DF, WM, EDGE
Song sparrow	*Melospiza melodia*	O, V	R, WM, FOREST EDGE
Clark's nutcracker	*Nucifraga Columbiana*	O	CF, MF, DF
Fox sparrow	*Passerella iliaca*	O, V	CF, MF, DF, R, MS
Cliff swallow	*Petrochelidon pyrrhonota*	O	R, M, WM, RI
Black-headed grosbeak	*Pheucticus melanocephalus*	O	R, M, WM
Downy woodpecker	*Picoides pubescens*	O	CF, MF, DF
Mountain chickadee	*Poecile gambeli*	O, V	CF, MF, DF
Mountain bluebird	*Sialia currocoides*	O	M, WM. MS
Red-breasted nuthatch	*Sitta canadensis*	O	CF, MF, DF
White-breasted nuthatch	*Sitta carolinensis*	O, V	CF, MF, DF
Western meadowlark	*Sturnella neglecta*	O	M, WM
House wren	*Troglodytes aedon*	O	CF, MF, DF
Warbling vireo	*Vireo gilvus*	O, V	MF, DF, R
Wilson's warbler	*Wilsonia pusilla*	O	R, M, WM
Mourning dove	*Zenaida macroura*	O, V, C	CF, MF, DF, R, M, WM
White-crowned sparrow	*Zonotrichia leucophrys*	O, V	R, WM

* O–Observed, V-Vocalization, B-Burrow, T-tracks, S-scat, F-foraging sign, C-carcass

** Coniferous forest (CF) (Lodgepole pine forest Jeffrey pine forest)

Mixed forest (MF) (Jeffrey pine-aspen forest, Pine-black cottonwood forest)

Deciduous forest (DF) (Black cottonwood forest, Quaking aspen forest)

Riparian (R) (Mountain alder-mixed willow riparian scrub, willow scrub)

Meadow (M) (Dry meadow, Revegetation dry meadow, Mesic graminoid meadow, Mesic forb community)

Wet Meadow (WM) (Wet graminoid meadow, Obligate sedge wetland)

Mountain sagebrush (MS)

River (RI)

Table 3.10: Mammal, reptile, and amphibian species detected in the Study Area, August 6 to October 29, 2003.

COMMON NAME	SCIENTIFIC NAME	SIGN*	PREFERRED HABITAT **
Coyote	*Canis latrans*	O, T, S	ALL TYPES
Porcupine	*Erithrozon dorsatum*	S, F	CF, MF, DF
Vole	*Microtus spp.*	O, S, B	M, WM
Mule deer	*Odocoileus hemionus*	T, S, F	ALL TYPES, EDGES
Raccoon	*Procyon lotor*	T	R
Shrew	*Sorex spp.*	C	M, WM
Golden-mantled ground squirrel	*Spermophilus lateralis*	O, B	M, MS
Douglas squirrel	*Tamiasciurus douglasii*	O, V	CF, MF, DF
Mountain pocket gopher	*Thomomys monticola*	B	CF, M, MS
Broad-footed mole	*Scapanus latimanus*	B	CF, M, MS
Black bear	*Ursus americanus*	S, T	CF, MF, DF, WM, M, R
Western gray squirrel	*Sciurus griseus*	O	CF, MF, DF
Beaver	*Castor canadensis*	O, S, F, T	R, RI
Muskrat	*Ondatra zibethicus*	S, T	R, RI
Garter snake	*Thamnophis spp*	O	R, WM
Pacific tree frog	*Hyla regilla*	O	R, WM

BEAVERS

Habitat Ranking

Using the criteria in Table 3.7, the approximate number of linear feet in each category for each reach is presented in Table 3.11. The high quality habitat is depicted on Figures 3.30A-E. The plant communities associated with the three classes of beaver habitat are presented in Table 3.12.

Table 3.11: Approximate linear extent (feet) of the three categories of beaver habitat quality n Reaches 3 through 11. The linear length is for both sides of the river.

Reach Number	High quality	Moderate quality	Poor quality
1	NS	NS	NS
2	NS	NS	NS
3	0	5,250	0
4	1,800	2,000	1,150
5	0	8,800	0
6	0	7,150	0
7	0	4,100	0
8	1,050	5,550	0
9	0	2,400	0
10	1,200	300	0
11	0	2,750	0
Total	4,050	38,250	1,150

NS=Not surveyed for beavers

Table 3.12: Study Area plant communities associated with the three classifications of beaver habitat.

Preferred Habitat	Moderate quality	Poor-quality
Cottonwood forest Aspen forest Pine-cottonwood forest Alder-willow thicket Willow thicket Mesic forb Wet meadow Obligate marsh	Pine-cottonwood forest Jeffrey pine aspen forest Dry meadow Alder-willow thicket Willow thicket Mesic forb	Lodgepole pine forest Jeffrey pine forest Sagebrush-dry meadow

The number of dens and lodges per project reach are summarized in Table 3.13 and depicted on Figures 3.30A-E. The number of signs indicating beaver colony presence (i.e., dens and lodges) does not correlate with habitat quality. The number of dens and lodges shows locations that beavers have established colonies. Fewer dens and lodges are constructed in high quality habitat with long-term occupants, thus these features do not increase in number. Dispersing beavers that must occupy less suitable habitat will use existing lodges and dens but might also need to construct new lodges or dens.

Table 3.13: Number of beaver bank den sites and lodges on the Upper Truckee River detected during surveys conducted between August 6 and October 29, 2003.

Reach Number	Dens	Lodges
1	NS	NS
2	NS	NS
3	10	0
4	15	0
5	12	0
6	8	1
7	4	0
8	16	2
9	4	0
10	0	1
11	8	0

NS=Not surveyed for beavers

Beavers do not appear to have established colonies in sections of the river that are narrow and confined. Signs of foraging were also scarcer in these areas. For example, no dens or lodges were found in the confined, upstream portion of Reach 9. Such sections might be more appropriately ranked as poor quality beaver habitat. A model that included physical factors such as floodplain width and water depth would further refine the ranking of beaver habitat in the Study Area.

Beavers maintain an underwater entrance to their lodge or bank den for security and safety from land predators. Usually dams are necessary to provide sufficient water depth for this purpose. The inactive dens and lodges provide indirect information regarding the river's likely location when these features were constructed. They also indicate the general locations beavers constructed dams.

The location of high quality habitat is dynamic and can change unfavorably for beavers if the additional source of flowing water is compromised. For example, at one time, approximately 750 feet of the west side of the river in Reach 5 provided high quality habitat. A pond depicted on the 1992 USGS Echo Lake quadrangle appears to be due to a beaver dam on a side channel of the river. Observations of beaver herbivory in the vicinity suggest this was a long-term colony site. However, once the flow of water into this site was altered, perhaps during the 1997 rain on snow event, the beavers probably abandoned the area.

Another example of the beavers' response to change in the flow regime of the additional water source is from the colony in Reach 10. The large beaver pond in this reach began to decline in depth in late August, 2003. By the end of October, the water level was several feet lower than in August and no longer surrounded the lodge. The site's function was compromised and the beavers began to build dams in the main channel of the river. The cause of the declining water is not known, but it did not appear to be due to a breach in their dam. This site has previously provided suitable winter habitat, as evidenced by the lodge and the presence of old winter food caches.

In high quality habitat, much damming activity occurs on side channels, springs, and seeps, although dams are also constructed on the main river channel. An additional water source is essential to the development of long-term colonies in the Study Area. Beaver colonization in high quality habitat typically produces many of the benefits associated with beavers, such as improved wildlife habitat complexity and diversity. These positive effects occur because dams constructed in locations other than the river's main channel are relatively stable.

In habitat ranked as moderate quality, less water is available to dam in areas away from the main river channel, and therefore colonies must construct dams in the main river channel. These main channel dams are less stable and more likely to blow out during high runoff years. Predicting where beavers will establish colonies is difficult. However, there are sites within the moderate quality habitat where old remnant channels or ephemeral drainages are present. These sites lack enough water for the beavers to establish functional dams. Restoration projects that cause these sites to fill with water would increase their suitability for beavers. Beaver colonization of these locations could subsequently produce more complex habitats.

Population Estimate

Surveys for winter food caches are reliable indicators of active beaver colonies. However, the October 29 survey for winter food caches in Reaches 8 through 11 was not effective in locating food caches at all active colony sites. Because of the poor results, this method was not used to confirm the presence of active colonies in other reaches.

The estimated number of all colony types in the Study Area from Reaches 3 through 11 is six (Table 3.14). Assuming six beavers per established family colony and four beavers per colonizing colony, the six colonies consist of 28 beavers. Including the three single beavers, the total number of beavers in the surveyed portion of the Study Area is 31. Using a distance of 4.3 miles between Reaches 3 and 11, the number of beavers per mile is 7.2.

This number is greater than the highest number of beavers per mile reported by Busher (1987) for beavers at Sagehen Creek. Busher summarized the 34-year demographic history of this non-trapped, marked, beaver population. He identified two demographic phases in which the beaver population was high. For both periods, the number of beavers was 6.4 individuals per mile. Busher used habitable length of stream when calculating Sagehen Creek's population density. When correcting for uninhabitable length of stream in the Study Area (1,150 poor quality habitat in Reach 4), the number of beavers per mile is 7.6.

Busher et al (1983) reported a mean number of beavers per colony of 4.8 for colonies in Sagehen Creek. When using 4.8 to compute the number of beavers in the Study Area's established family colonies, the number of beavers per mile is 6.7 (for a population of 29). The indirect data collected to determine beaver numbers in this study could overestimate the number of beavers by including the category individual beavers. Even when that number is excluded, the number of beavers per mile is 6.5.

An assessment was made that the beaver activity in Reach 11 is from the same colony of animals occupying Reach 10. If this assumption is incorrect, then the number of colonies within the Study Area would be increased by one colonizing colony, with a concomitant increase in population size.

The total colony density in Reaches 3 through 11 is 1.39 colonies per mile. Suitable habitats can accommodate 1.8 colonies per mile (Muller-Schwarze and Sun 2003). Busher (1987) found a family colony density of 1.12 per mile at Sagehen Creek. Beaver colony densities in other regions range from 0.64 per mile in Alaska to 1.76 per mile in Brunswick, New Jersey (Muller-Schwarze and Sun 2003).

Table 3.14: Estimated number of active beaver colonies and number of single beavers per reach determined from surveys conducted between August 6 and October 29, 2003.

Reach Number	Established Family Colony	Colonizing Colony	Single Beavers
1	NS	NS	NS
2	NS	NS	NS
3	0	1	0
4	1	0	0
5	0	0	1
6	0	0	1
7	0	2	0
8	0	1	1
9	0	0	0
10	1	0	0
11	*	0	0
TOTAL	2	4	3

* The home range of the established family colony in Reach 10 encompasses Reach 11
NS= Not surveyed for beaver

Including both active and inactive sites, beavers have colonized the entire Study Area, however the river is not currently saturated with beavers. This is most likely due to ongoing nuisance beaver removal. Whether the Study Area's population is expanding, stable, or declining can be determined only from long-term studies, although a review of CDFG records could contribute to a better understanding. The comparison of the population estimate derived from the field survey with the data reported from Sagehen Creek suggests that the population is approaching carrying capacity, although long stretches of the river are currently unoccupied by colonies (e.g., Reach 5).

Effects on Study Area Vegetation

The entire Study Area provides potential foraging habitat for beavers. Signs of foraging by beavers were continuously present along most portions of the surveyed reaches. The distance from the river at which signs of foraging were found was variable. In one location (Reach 5), beavers foraged up to 120 feet from the river, in other locations with less suitable habitat, only riparian shrubs immediately adjacent to the river were cut.

RIPARIAN VEGETATION

Willows exhibited good vigor and a wide variety of age classes and sizes, despite heavy use in some reaches. Excessive foraging on individual plants can cause a hedged architecture. Hedged plants have more basal branches and are shorter than willows farther away from the river. Hedging of willows and alders growing along the river's edge was noted primarily in Reaches 3 and 4.

No preference by beaver for one species of willow over another was detected. However, willows growing in tree form were used more often in winter (based on cut height) than those in shrub form. The secondary stems growing from the primary trunk of tree-form willows were preferred by beavers rather than the large primary trunks. Each cut stem subsequently produced tertiary stems that beavers harvested in following seasons.

Willow cutting by beavers promotes suckering and rapid growth (Kindschy 1989). It does not typically result in loss of the willow plants. However, in one location in Reach 6, several very old willow plants that had been cut by beavers were observed. These plants never regenerated and thus died. Browsing by beaver, in conjunction with other herbivores such as cattle and elk was found to cause the loss of young shoots and saplings (Zeigenfuss et al. 2002; Muller-Schwarze and Sun 2003). While deer browsing on dogwood was apparent, no other herbivore browsing was observed that could account for the death of the willows. Other conditions, such as water stress due to altered hydrology, could have made the plants more vulnerable to herbivory and reduced their ability to compensate for the lost stems and foliage.

Compared to willows and alder, dogwood was the least preferred food plant. Dogwood is present in discrete patches along the river corridor, but is the most abundant shrub in Reach 11. This species was cut less often than alder or willows, except in Reach 11. Beavers at all sites cut dogwood but they mainly used it for construction of dams and food caches. The leaves and bark were often not stripped from dogwood branches prior to use in dams. The leaves of alder branches were typically stripped but the bark was often left intact. Willow branches were always stripped of leaves and were usually stripped of their bark.

Aspen

Aspen reproduces asexually by root sprouts that occur in two morphologies: adult-form sprouts have small leaves and heavy lateral branching, and juvenile-form sprouts have large leaves and an absence of lateral branching. In areas newly occupied by beaver, adult-form sprouts predominate, whereas an abundance of juvenile-form sprouts is associated with prolonged beaver activity (Basey et al. 1988). Due to altered chemistry, juvenile-form sprouts are avoided by beavers when adult-form sprouts are available (Basey et al. 1990). Based on tree height and stem diameter, the age of the juvenile-growth form aspens in the Study Area ranged from less than one year to ten years of age.

In some areas, beavers can cause local extinction of aspens (Beier and Barrett 1987). Local extinction of aspen due to beavers (both browsing and flooding) was found outside of the Study Area, approximately 0.6 miles south and upstream of Reach 11. However, no locations were found within the Study Area where aspen was used to the point of extinction, or where most stems have died

Longer occupancy by beavers at a site is reflected by greater use of aspen (Basey et al 1990). The beaver colony in Reach 10 has been active for at least 17 years, although beaver occupancy might have been interrupted during some years due to unconfirmed nuisance beaver removal. Even so, a large stand of vigorous aspen of mixed ages is present east of the colony site. Historic use of this stand is evident by cut stumps, but large stands of mature aspen remain, as well as extensive stands of adult-form saplings. It is likely that potential loss of aspen stands due to beaver foraging is moderated by nuisance beaver removal.

Two sites were identified in the Study Area where beavers affected the presence of aspens. In Reach 9, a mature aspen grove was cut by beavers and replaced by tree-like alders that measure between five and eight inches in diameter (at one foot high) and are approximately 20 feet high. Both mature and sapling-sized aspens still grow on the periphery of this site. Beavers caused the loss of the mature aspen, but additional conditions are likely responsible for the lack of root suckering at this site (Dr. Adrian Juncosa, project botanist, November 4, 2003, personal communication).

An extensive area of declining aspen numbers was noted for approximately 1,200 feet on the west side of Reach 5. Beavers have cut the aspens in this area, which grow in a relatively narrow swath. Root suckering has occurred in places and juvenile-form aspens are also present. The beaver cutting, in conjunction with conifer invasion (e.g., lodgepole, white fir), has contributed to a decline in stand vigor as more dead than live stems were present.

One decadent stand of aspen was noted in the southernmost portion of Reach 6 on the river's west bank. Several standing dead aspens were observed, but the mortality was not due to cutting by beaver. Beaver cut mature aspen in this area and are currently cutting smaller aspen. Based on the spongy, wormy quality of the wood present in cut stumps, the mature trees were probably cut at least twenty years ago (Dr. Adrian Juncosa, project botanist, November 25, 2003, personal communication). No suckering on the large cut stumps was present. Both adult-form and juvenile-form aspens are present west of this old cutting area. Based on the fifteen-foot height of the adult-form saplings and stems measuring one to three inches diameter at breast height (dbh), these trees are between ten and twenty years old (Gese and Shadle 1943; Stegeman 1954).

Cottonwood

Cottonwood trees are discontinuously distributed from Reaches 4 through 11. The trees typically occur as single plants with multiple trunks or as small stands of several trees. In general, the trees appear similar in age with a trunk diameter at 20 inches height (the approximate height at which beavers cut cottonwood trees) of three to four feet, although a few smaller individuals were noted.

Historic and current beaver foraging activities appear to have minimal effects on survival of mature cottonwood trees in the Study Area. In a 1,800-foot section (900 feet up and 900 feet back) encompassing parts of Reach 6 and 7 (from UTM 0758802/4301197 to 0758859/4302242), the location of all cottonwood trees was recorded, along with whether the trees were cut by beavers or not.

A total of 28 sites with cottonwood trees were documented along both sides of the river (approximately 1,800 feet in length). At three sites, some cottonwood trees were protected with wire. Of the 28 sites, beaver cutting was found on six sites (21%). On some tree trunks, adventitious buds and branches developed below the cuts, which beavers subsequently cut at various intervals. Except for two sites, the beaver cuts did not result in the trees falling or in tree mortality. In the two cases of felled trees, the felled trees were much smaller than the mature specimens noted throughout the majority of the Study Area (16 inches at cut height of approximately 19 inches). The felled cottonwoods were located beneath alder thickets that measured approximately 15 to 20 feet in height, which suggests the trees were felled more than ten years ago. No cuts were noted on the alder.

To varying extents, similar trends in cuts on mature cottonwood trees were noted in the other reaches. Beavers do not appear to preferentially forage on mature cottonwood trees. Compared to younger specimens, the thick platey bark of mature cottonwood trees might render them less palatable to beavers (Dr. Peter Busher, Boston University, November 5, 2003, personal communication). Sufficient sources of other food plants, including aspen, willows, and herbaceous vegetation, might also reduce the need for beavers to cut mature cottonwoods.

Trees larger than approximately 20’ dbh in log jams across the Upper Truckee River were examined for signs that beavers had felled them. Cottonwood trees were distinguished from other tree species on the basis of morphology, such as branch characteristics and the presence of bark. Trees in seventeen log jams were examined. Only one contained a cottonwood tree felled by beavers.

Five sites were noted in the 1,800-foot section where cottonwood regeneration was occurring. Multiple sprouted cottonwoods and/or saplings were present at these sites. At three sites, the trees measured between three and four feet in height, while trees at the other sites were approximately 15 feet in height. Cottonwood regeneration was noted in a few other reaches, but not to the same extent as that found in the 1,800-foot surveyed section. The current regeneration throughout the Study Area might not be sufficient to replace the existing cottonwood stands as they become decadent.

Signs of beavers browsing on cottonwood saplings were not found. However, if beavers prefer smaller cottonwoods, cottonwood recruitment could be suppressed as beavers selectively forage on these trees in the future.

Beavers can cause local extinction of cottonwood trees and this effect was documented in the Truckee River Basin, California (Beier and Barrett 1987). The potential effects of beaver foraging on smaller cottonwood trees could be moderated by the presence of other food species, such as aspen and willows, which are abundant in this area. In addition, beaver numbers in this area are likely to remain low due to nuisance beaver removal.

III.3.F Beaver Mediated Effects in the Study Area

Beaver dams constructed on the main river channel often do not last following spring runoff and must be constructed again in the summer and fall. Dam failure could lead to erosion of banks and loss of bank vegetation, including trees. There might be areas where the likelihood of failure for main channel dams is minimized and where the effects of dam failure could also be reduced. Identification of these locations could assist in river restoration. In areas where dam wash-outs could cause bank failure, beavers could be controlled in the fall, prior to dam construction. Following any beaver removal, dams should also be removed.

It should be assumed that beavers will dam any side channels with flowing water, especially when the channels occur in conjunction with suitable habitat, such as herbaceous and woody vegetation. The beaver dams raise the water table level, which support further growth of these plant communities. The networks of dams placed in side channels do not appear to fail during spring runoff as they were still readily detectable in numerous places without active colonies. Beaver dam activity in side channels increases the complexity and diversity of the system.

Greater numbers and diversity of wildlife were observed in dammed side channels compared to these pools of water created when beavers dammed the main river channel. Dammed pools on the river did not develop the complex plant communities associated with the side channels, probably because the dams frequently blow out.

The vegetation report prepared for this assessment concluded that riparian shrub and herbaceous communities, specifically ones dominated by hydrophytic species and lacking any coniferous component, were much more extensive prior to the last few decades. These types of communities provide preferred habitat conditions for several special status species, including the willow flycatcher and mountain yellow legged frog. Beavers can help to create these community types through the sequence of events that transpire following construction of their dams at stable sites.

The greater extent of historic riparian vegetation predicted by the assessment's vegetation report would have provided suitable willow flycatcher habitat. Beaver colonies help create suitable breeding habitat for willow flycatchers. Specifically in Reach 10, the extensive network of dams in the wet meadow, in addition to the large dam on the beavers' main pond, creates a wetter environment than what would be present without the beavers. Many of the willow flycatcher's insect prey species have aquatic life stages. The presence of abundant water in a variety of forms, still water with a silt bottom in addition to running water in the Upper Truckee River, probably increases habitat suitability for this species. In addition, by cutting willows and building dams, the beavers have created an environment where a variety of willow seral stages are present.

Stable, inactive beaver dams were observed to accumulate sediment and silt. This led to changes in plant succession as riparian shrubs and wetland plants invaded the former ponds. An interesting example of this phenomenon is located in Reach 6, in the vicinity of a westward flowing tributary to the Upper Truckee River. Multiple dams are present with no evidence of failure. Deposition of sediment and silt behind the dams created flat areas with lush herbaceous vegetation. Snipe, bear, and muskrat were detected at this location, and a single beaver appears to be re-colonizing this site adjacent to the river. Opportunities for succession are limited to stable dams constructed outside the river's main channel.

Although beavers will cut all sizes of preferred species such as aspen, they do prefer smaller aspens (2-4" dbh) when available (Basey et al 1990). Based on the record of beaver herbivory provided by cut stumps, it appears that mainly mature aspen were cut when beavers first entered an area. This might be because only mature trees were available. Assuming the same rate of decomposition for stumps of variable sizes, the lack of sapling-sized cut stumps in these areas supports this assumption. Beaver cutting of mature aspen stands has resulted in a shift toward younger age classes for most aspen stands in the Study Area. In some locations, juvenile-form aspen predominate, but in other areas a mix of both adult- and juvenile-forms are present, along with mature individuals.

Aspen regenerate in response to disturbance such as fire. Fire suppression in the Basin could have resulted in mostly mature aspen stands with less diverse age classes. Aspen cutting by beaver in some locations might contribute to the renewal of aspen stands. Changes in stand composition due to foraging by beavers affects tree height and canopy cover. Canopy cover is lower in mature aspen stands (25 to 60%) than in young and intermediate aged stands ((60-100%) (Verner 1988). Wildlife species associated with mature stands (e.g., northern goshawk) might be expected to decline while wildlife species associated with young stands (e.g., mule deer) might be expected to increase as a result of this shift.

III.3.F Opportunities and Constraints

OPPORTUNITIES

- A beaver management plan should be developed for the Study Area. Managing beaver populations is necessary; unmanaged beaver populations will grow to capacity and saturate their habitat (Muller-Schwarze and Sun 2003). Beaver populations change slowly and do not experience the cyclical population patterns that characterize other rodent species. Beaver populations do experience some self-regulation. For example, sparse populations produce more offspring than saturated populations. However, before self-regulation is likely to occur, beavers will be in conflict with people and other resources.

  Coyotes (*Canis latrans*) are a major predator of beavers (Jenkins and Busher 1979) and they, along with black bears (*Ursus americansus)*, are one of the few potential predators of beavers present in the Study Area. Because there are few predators that could prey on Study Area beavers, nuisance removal is an important component that will prevent beavers from exceeding the Study Area's carrying capacity.

  Management of beaver colonies requires providing sites for dispersing beavers to colonize. Beavers leave their home colony at about two years old. Young beavers may emigrate considerable distances over both land and water. Distances traveled average about 4.8-9.6 stream miles. In one study of yearling movements (Muller-Schwarze and Sun 2003), 70% moved at least one mile, one individual moved six miles, and another individual moved ten miles. Thus, beavers dispersing from Study Area colonies could remain within the Study Area, move farther up or downstream, or move out of the watershed. Likewise, beavers dispersing from colonies outside the Study Area (i.e., Upper Watershed of Upper Truckee River, Elbert Lake, etc.) could emigrate into the Study Area.

  Ideally, population density should be low enough so that young beavers leaving their parental colony can find places to settle without becoming nuisance beavers in conflict with people's land use. On a landscape level, this means management activities should be designed to provide suitable immigration sites by keeping enough stream sections and other wetlands free of beavers.

  Determining a suitable number of colonies within the Study Area and vicinity is necessary. North American wildlife managers aim for 10-30% occupancy of potential beaver sites (Muller-Schwarze and Sun 2003). Based on 30% occupancy of the Study Area, two colonies are appropriate for Reaches 3 through 11.

  Currently, beaver management in the Study Area and vicinity consists of responding to residents' complaints, which results in the elimination of the nuisance animals. Nuisance beavers have also been removed by California State Park officials from Lake Valley State

Recreation Area and Washoe Meadows State Park (Reaches 1 and 2) (California State Parks Document, 1989).

A better approach would be proactive management to reduce conflict between beavers, people, and other resources (e.g., other wildlife, erosion). The best places for beavers to settle are defined as sites where they cause the least amount of damage and the most benefits. Beavers could be allowed to colonize such locations. Management actions could be directed away from these colonies and instead could focus on colonies that produce neutral or undesirable results. As habitat conditions change over time, the location of beaver management sites would change.

Colonies that produce neutral or positive effects can still be in conflict with people (e.g., Reaches 8 and 10, due to residents and county roads, respectively). In such cases, measures to minimize the concurrent negative effects could be implemented (e.g., dam leveler pipe systems, coating specimen trees with sand and paint to deter cutting).

- Project actions that contribute to water flowing into old channels would improve habitat conditions for a variety of wildlife, such as waterfowl, muskrats, beavers, and neotropical birds, including willow flycatchers. Some side channels only have water during spring runoff. Beaver dams constructed at these sites fail to retain sufficient water and beavers move into the main river channel after water levels drop. Actions that restore historic overbank flow regimes could contribute to increased riparian and wetland communities in these channels. This would improve the likelihood of standing water being present on June 1, which would improve habitat suitability for willow flycatchers. Restoration projects that help retain water longer in these side channels could also reduce the need for beavers to dam the main channel.
- Reaches 1 through 3 are the best areas to improve wildlife habitat. These areas show less diversity and complexity than that found in the other project reaches. Restoration of areas with native vegetation in Reaches 1 and 2 would improve habitat quality for wildlife. In addition, restoration activities that improve the quality of the wetland areas associated with the river would also improve wildlife habitat.
- Hand thinning invading conifers could contribute to the long-term viability and renewal of declining aspen in Reach 5 and other locations.
- Allowing beaver colonies to remain established on some side channels could result in improved habitat for willow flycatchers (i.e., to the extent possible, minimize nuisance beaver removal in these locations).
- Although widely distributed from Reaches 4 through 11, the majority of cottonwood trees in the Study Area appear to be even aged. Events that contribute to cottonwood recruitment do not appear to have been replicated in succeeding years. The saplings and recently sprouted cottonwood trees noted in the Study Area are not sufficient for stand replacement. Cottonwood trees provide valuable wildlife habitat. Restoration of processes

that result in additional recruitment of cottonwood saplings would improve future habitat conditions for wildlife in the Study Area. To the extent that proposed restoration projects improve recruitment and retention of cottonwood trees, wildlife habitat would be improved.

- The restoration actions suggested in the vegetation report (Section III.2) will contribute to improved habitat for wildlife.

CONSTRAINTS

- The Limited Operating Periods for special status wildlife species provide potential time constraints on proposed environmental improvement projects in the watershed. The LOPs would be implemented if any of the special status wildlife species are determined to be nesting or denning within the vicinity of the restoration project area.
- Willow flycatchers are known to nest in portions of the Study Area. A LOP between June 1 to August 31 is applied to a variable radius around known nest sites. In addition, some of the USFS SNFPA Standard & Guideline's for willow flycatchers could affect implementation of restoration projects (see FEIS Volume 4, Appendix D1-12-D13, Preferred Alternative Standards and Guidelines). Surveys for willow flycatchers will need to be performed prior to any project activities.
- California spotted owls are known to nest in the southernmost portion of the Study Area. A LOP within ¼ mile of active nest sites is applied between March 1 through August 31 unless surveys confirm that California spotted owls are not nesting. At this time, PACs and LOPs applicable to other special status species are not expected to affect implementation of potential restoration projects. If any projects are scheduled within the vicinity of the spotted owl PAC, the USFS unit wildlife biologist should be consulted to determine whether a survey for nesting owls is necessary.
- Damming and foraging activities of beavers could affect restoration projects. Delineating areas where beavers will be actively managed from those where no or minimal management will occur can assist in mitigating any impacts from dam construction. Using a mix of shrub species during revegetation, including alder and dogwood in addition to willow, would minimize any adverse effects from beaver foraging.

III.3.G References

Allen, A.W. 1983. Habitat suitability index models: beaver. USFWS. FWS/OBS-82/10.30. 20pp.

Basey, J.M., S.H. Jenkins, and P.E. Busher. 1988. Optimal central-place foraging by beavers: tree size selection in relation to defensive chemicals of quaking aspen. Oecologia. 76:278-282.

Basey, J.M. S.H. Jenkins, and G.C. Miller. 1990. Food selection by beavers in relation to inducible defenses of Populus tremuloides. Oikos. 59:57-62.

Beier, P. and R.H. Barrett. 1987. Beaver habitat use and impact in Truckee River Basin, California. J. Wildl. Manage. 51(4):794-799.

Busher, P. 1975. Movements and activities of beavers, *Castor canadensis*, on Sagehen Creek, California (M.A. Thesis). San Francisco: San Francisco State University.

Busher, P. 1987. Population parameters and family composition of beaver in California. J. Mamm. 68(4):860-864.

Busher, Peter. Personal communication. November 5, 2003. Professor, Department of Biology. Boston University, Boston, Massachusetts.

Busher, P. and S.H. Jenkins. 1983. Population density, colony composition, and local movements in two Sierra Nevada beaver populations. J. Mamm. 64:314-318.

Butts, W.L. 1992. Changes in local mosquito fauna following beaver (*Castor canadensis)* activity- an update. Journal of American Mosquito Control Association 8:331-332.

Butts, W.L. 2001. Beaver ponds in upstate New York as a source of anthropophilic mosquitoes. Journal of American Mosquito Control Association 17(1): 85-86.

California State Parks Document. 1989. Beaver control at Lake Valley SRA and Washoe Meadows State Park. Prepared January 1989 by Gary Walter, Associate State Park Resource Ecologist.

Campion, Kathy. Personal communication. August 13, 2003. LTBMU wildlife biologist.

Craven, Bill. Personal communication. October 2, 2003. Resident, Fallen Leaf Lake, CA.

Fowler, C.B., B. Valentine, S. Sanders, and M. Stafford. 1991. Suitability Index Model: Willow Flycatcher (*Empidonax traillii*). Unpublished document. USDS Forest Service, Tahoe National Forest. 15 pp.

Gese, C.G. and A.R. Shadle. 1943. Restoration of aspen after complete cutting by beavers. J. Wildl. Manage. 7(2):223-228.

Harris, J. 1991. Effects of brood parasitism by brown-headed cowbirds on will flycatcher nesting success along the Kern River, California. Western Birds 22:13-26.

Harris, J.H., S.D. Saunders, and M.A. Flett. 1988. Willow flycatcher surveys in the Sierra Nevada. Western Birds 18:27-36.

Howard, R.J. and J.S. Larson. 1985. A stream habitat classification system for beaver. J. Wildl. Manage. 49(1):19-25.

Jenkins, S.H. 1979. Seasonal and year-to-year differences in food selection by beavers. Oecologia. 44:112-116.

Jenkins, S.H. and P.E. Buscher. 1979. *Castor canadensis*. Mamm. Species, 120:1-8.

Juncosa, Adrian. Personal communication. November 4, 2003. Project botanist.

Juncosa, Adrian. Personal communication. November 25, 2003. Project botanist.

Kindschy, R.R. 1985. Willow response to beaver use. J. Wildl. Manage. 49(1):26-28.

Kindschy, R.R. 1989. Regrowth of willow following simulated beaver cutting. Wildl. Soc. Bull. 17: 290-294.

Lindström, Susan. Personal communication. September 17, 2003. Project archeologist.

Lindström, Susan. Personal communication. September 23, 2003. Project archeologist.

Lindström, Susan. E-mail communication. Fall, 2003. Project archeologist.

Manning, P. and M.D. Schlesinger. 2001. Riparian biological diversity in the Lake Tahoe Basin. April 2001. A final report to the California Tahoe Conservancy.

Maslich, W.J., J.D. Brotherson, and R.G. Cates. 1988. Relationships of aspen (*Populus tremuloides*) to foraging patterns of beaver (*Castor canadensis*) in the Strawberry Valley of central Utah. Great Basin Naturalist. 48(2):250-262.

Muller-Schwarze, D. and L. Sun. 2003. The beaver Natural History of a Wetlands Engineer. Comstack Publishing Associates, division Cornell University Press. Ithaca, NY.

Naiman, R.J., C.A. Johnston, and J.C. Kelly. 1988. Alteration of North American streams by beaver. Bioscience 38(11):753-762.

Orr, R.T. 1949. Mammals of Lake Tahoe. California Academy of Sciences. San Francisco, CA.

Peralt. Personal communication. September 11, 2003. Retired CDFG warden.

Reed, S.B. 1980. Beaver management plan. U.S. Forest Service Lake Tahoe Basin Management Unit. Report on file USFS-LTBMU. South Lake Tahoe, CA.

Robel, J.R., L.B. Fox, and K.E. Kemp. 1993. Relationship between habitat suitability index values and ground counts of beaver colonies in Kansas. Wildl. Soc. Bull. 21:415-421.

Sanders, S.D. and M.A. Flett. 1989. Ecology of a Sierra Nevada population of willow flycatchers (*Empidonax traillii*), 1986-1987. California Department of Fish and Game, Wildl. Manage. Div. Admin. Rep. 88-3.

Sererna, M. 1982. The status and distribution of the willow flycatcher in the Sierra Nevada. California Department of Fish and Game Wildlife Mgmt. Branch Admin. Rep 87-2.

Simonsen. T.A. 1973. Feeding ecology of the beaver (*Castor fiber L.*). Medd. Statens. Viltunders. 2: 20-61.

Slough, B.G. and R.M.F.S. Sadleir. 1977. A land capability classification system for beaver (*Castor canadensis Kuhl*). Can. J. Zool. 55:1324-1335.

Stegeman, L.C. 1954. The production of aspen and its utilization by beaver on the Huntington forest. J. Wildl. Manage. 18(3):348-358.

Svendsen, G.E. 1980. Seasonal change in feeding patterns of beavers in southeastern Ohio. J. Wildl. Manage. 44(1) 285-290.

Tappe, D.T. 1942. The status of beavers in California. State of California, Department of Natural Resources, Division of Fish and Game. Game Bulletin No. 3.

Taylor, Shirley. Personal communication. September 26, 2003. Resident, South Lake Tahoe, CA.

United States Department of Agriculture. 1988. Land and resources management plan. Forest Service, Region Five, Tahoe National Forest, Lake Tahoe Basin Management Unit. South Lake Tahoe, CA.

United States Department of Agriculture. 1993. California Spotted Owl Sierran Province Interim Guideline Environmental Assessment. Forest Service, Pacific Southwest Region. San Francisco, CA January.

United States Department of Agriculture. 2000. Sierra Nevada Forest Plan Amendment Final Environmental Impact Statement. Forest Service, Pacific Southwest Region, December 2000.

United States Department of Agriculture. 2001. Sierra Nevada Forest Plan Amendment Final Environmental Impact Statement, Record of Decision. Forest Service, Pacific Southwest Region, January 2001.

Verner,J. 1988. Aspen. Pages 66-67 in Mayer,K.E. and W.F. Laudenslayer, Jr., eds. A guide to wildlife habitats of California. California Department of Fish and Game, Sacramento, CA.

Willis, R.M. 1978. A beaver habitat classification system for the Truckee River. M.S. Thesis, Univ. Nevada, Reno. 69 pp.

Zeigenfuss, L.C., F.J, Singer, S.A. Williams, and T.L. Johnson. 2002. Influences of herbivory and water on willow in elk winter range. J. Wildl. Manage. 66(3):788-795.

III.4. AQUATIC ECOSYSTEM

This section contains a review of fisheries resources within the Upper Reach Study Area, both current and historical. The regulatory background with respect to fish and aquatic resources is reviewed, and potential effects of the project on these resources are described.

III.4.A. Regulatory Background

TRPA GOALS AND POLICIES

The Tahoe Regional Planning Agency (TRPA) is responsible for regulating local development to ensure preservation of fish resources. The following discussion of the regulatory background was excerpted from various TRPA documents.

The TRPA must attain and maintain fishery thresholds and other adopted standards. Fishery thresholds consider the importance of all existing fish species and their contribution to the ecological balance of the total fishery resource. The TRPA fishery thresholds, along with other agency's standards, are summarized in Table 3.15.

The maintenance of essential habitat serves as the fisheries management emphasis. For streams, thresholds call for the maintenance of 75 miles of excellent stream habitat, 105 miles of good habitat, and 38 miles of marginal habitat. Habitat is rated by a technical committee at regular intervals, based on professional judgment regarding substrate quality, bank stability, and other habitat features. Also, stream habitat is classified as resident or migratory, based on suitability for spawning by lake resident fish. The Upper Truckee within the Study Area is classified as migratory habitat and was rated as marginal at the last threshold update, though it has the potential for excellent. Fish thresholds are currently being updated by TRPA.

OTHER AGENCIES

The mission statement of the California Department of Fish and Game (CDFG) is to manage California's diverse fish, wildlife, and plant resources and the habitats upon which they depend. These resources are to be managed for their ecological values and for their use and enjoyment by the public. The CDFG is the lead agency in California for safeguarding and regulating the uses of fish and wildlife.

The United States Fish and Wildlife Service (USFWS) is charged with the responsibility to protect, preserve and, if possible, enhance the nation's fish, wildlife, and related ecological resources for the benefit and utilization of the people of the United States. In fulfilling this responsibility, one of the USFWS functions is to review proposals for the erection of structures in navigable waters of the United States to insure that: 1) fish and wildlife resources and their habitats receive due consideration in the decision-making process, and 2) the public's interest in fish and wildlife resources, and in the uses of these resources, are protected. Authority for the USFWS review of such proposals originates from the Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.). The USFWS is also responsible for the status of wild populations of flora and fauna and for the identification of those that are in danger of extinction, pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. 1533). Permits from, or consultation with, the USFWS is required for most actions that may affect listed threatened or endangered species.

Table 3.15: Fishery ordinances, policies and regulations

Plan/Policy	Standard/Criteria
TRPA Thresholds	Lahontan Cutthroat Trout: It shall be the policy of the TRPA Governing Board to support, in response to justifiable evidence, state and federal efforts to reintroduce Lahontan cutthroat trout.
	Stream Habitat: Maintain 75 miles of excellent, 105 miles of good, and 38 miles of marginal stream habitat.
	Instream Flows: a non-degradation standard shall apply.
TRPA Goals and Policies Fishery Policies	Goal #1, Policy 1: Development proposals affecting streams, lakes, and adjacent lands shall evaluate impacts to the fishery.
	Policy #2: Unnatural blockages and other impediments to fish movement will be prohibited and removed wherever appropriate.
TRPA Code of Ordinances	Chapter 79 Fish Resources: Ensures the protection of fish habitat and provides for the enhancement of degraded habitat.
California Department of Fish and Game	Manages California's fishery resources and habitat on which they depend. These are to be managed for their ecological values and for their use and enjoyment by the public. Fish and Game issues streambed alteration agreements for construction, modification or reconstruction of shorezone structures. They are currently reviewing their standards and policies for the issuance of these agreements.
California Water Quality Control Board	Various policies and regulations for providing water quality sufficient to support cold-water fish and other aquatic organisms.

III.4.B Existing Conditions

AQUATIC COMMUNITIES

Fish found in the Upper Truckee River, and their distribution, are shown in Table 3.16 (Snider et al 1987). Much of the current fish assemblage consists of non-native fish, either introduced by governmental agencies, generally to provide sportfishing, or by the public, either to provide fishing opportunities or inadvertently through the use of live bait.

Table 3.16: Fish in the Upper Truckee River

Common Name	Scientific Name	Native?	Distribution
Lahontan Redside	*Richardsonius egregius*	native	Resident: downstream from Echo Creek Migratory: downstream from Angora Creek
Tui Chub	*Siphateles bicolor*	native	Primarily near mouth
Speckled Dace	*Rhinichthys osculus*	native	Near mouth
Tahoe Sucker	*Catostomus tahoensis*	native	Resident: downstream from Echo Creek Migratory: downstream from Angora Creek
Mountain Whitefish	*Prosopium williamsoni*	native	Rare in river
Piute Sculpin	*Cottus beldingi*	native	Throughout
Lahontan Cutthroat	*Oncorhynchus clarki henshawi*	native	Stocked in headwaters
Brown Bullhead	*Ameirus nebulosus*	introduced	Downstream from Echo Creek
Kokanee Salmon	*Oncorynchus nerka*	introduced	Rare in river
Brook Trout	*Salvelinus fontinalis*	introduced	Echo Creek upstream to 1 mile south of S. Upper Truckee Road
Brown Trout	*Salmon trutta*	introduced	Resident and migratory: 1 mile south of S. Upper Truckee Road
Rainbow Trout	*Oncorynchus mykiss*	introduced	Resident: throughout Migratory: mouth to 1 mile south of S. Upper Truckee Road

Fish migrating from Lake Tahoe, particularly rainbow and brown trout, use the Upper Truckee for spawning from the mouth upstream to the cascades about one mile south of the South Upper Truckee Road crossing. Migratory rainbow trout spawning appears to be concentrated from Echo Creek upstream to the cascades above South Upper Truckee Road, while the majority of migratory brown trout appear to spawn from Angora Creek upstream to Benwood Creek (Snider et al 1987). Because of its size and flow volume, the Upper Truckee is one of the most important producers of fish in the Lake Tahoe Basin (TRPA threshold updates).

Fall population estimates of trout abundance were conducted throughout the Upper Truckee River in the fall of 1985 (Table 3.17) in conjunction with a study on instream flow requirements (Snider et al 1987). Although no estimates of statistical variance were presented, population density was substantially lower in the two segments furthest downstream, below Echo Creek. Population density was lowest in the segment from Angora Creek to Echo Creek, encompassing the lower part of the Study Area (Reaches 1 through 4). Trout density in this reach was around ten times lower than in the two segments upstream (Reaches 5-10). The magnitude of the difference in population estimates between the Angora to Echo Creek segment and upstream segments suggests substantial impairment of aquatic habitat in the Angora to Echo segment, or Reaches 1 to 4 in the Study Area.

Table 3.17: Results of Fall 1985 electrofishing surveys.

Segment Species	Number per Mile (by age)					
	Young of year	1	2	3	4	total
Mouth to Angora Creek						
rainbow trout	267	17	0	0	9	293
brown trout	1385	6	12	6	15	1424
Angora Creek to Echo Creek						
rainbow trout	594	0	0	0	0	594
brown trout	594	40	26	0	0	660
Echo Creek to Benwood Creek						
rainbow trout	5924	173	31	0	0	6128
brown trout	2860	487	0	0	31	3378
Benwood Creek to Upstream End of Christmas Valley						
rainbow trout	7550	1126	123	18	0	8817
brown trout	0	180	0	0	0	180
brook trout	1109	528	18	0	0	1665

Macroinvertebrate studies also suggest that biotic integrity within the lower reaches of the Upper Truckee River has been impaired. Herbst (2001) found that several measures of biotic integrity declined substantially in study sites downstream of the Study Area boundary (downstream of the Elks Club Highway 50 crossing). However, this study detected little or no impairment of macroinvertebrate populations in study sites located within the State Park Recreation Area, within the segment with low trout density in the 1987 study. Additional macroinvertebrate sampling conducted for this project detected few differences between biotic integrity in samples taken upstream of the State Park and within the State Park.

Available data on trout populations thus appear to suggest that impairment has occurred in Reaches 1 through 4, but biotic impairment cannot be detected in populations of macroinvertebrates sampled from selected riffles. There may be two reasons for this. First, macroinvertebrates were sampled from selected riffles, which was likely the best habitat available within the reach. Although this was relatively high quality habitat based on indices of biological integrity, its distribution throughout Reaches 1 through 4 was not measured and is likely low, based on field reconnaissance. Put another way, the high-quality riffle habitat in which macroinvertebrates were sampled was scarcer in Reaches 1 through 4 than in upstream reaches, possibly due to infiltration of finer sediment from bank erosion or other sources.

It is also possible that trout populations show impairment in response to habitat impacts that do not substantially impair macroinvertebrate community indices. For example, the abundance of pools and available cover can significantly influence fish populations. These habitat variables would be less likely to influence community composition of macroinvertebrate samples collected in high-quality riffles.

AQUATIC HABITAT

In the most recent TRPA threshold update (TRPA 2001), the 21 miles of resident and migratory habitat in the Upper Truckee was classified as marginal habitat, the lowest designation. Habitat deficiencies, based on qualitative judgments of fishery managers and experts, included a lack of pools, poor spawning substrate, low canopy cover, low streambank and channel stability, water diversion, and barriers to fish migration. With the improvement of some or all of these factors, habitat has the potential to improve to good or excellent. The TRPA threshold updates do not provide adequate detail to address variability in habitat within the river system.

Downstream of the Meyers Highway 50 crossing, the river is relatively unconfined and has a low gradient. Riffles are generally composed of gravel, and pools tend to be found on outside bends, resulting from lateral scour. Extensive side channel systems are found throughout this portion of the river, though most are not active today. These channels may provide ephemeral aquatic habitat today, though this habitat may have been more extensive historically.

From the Meyers Highway 50 crossing upstream to the cascades about one mile upstream of the South Upper Truckee Road crossing, the channel is steeper and substantially more confined by valley walls. Some relatively unconfined meadows are found interspersed through these reaches, with pool-riffle type habitat similar to lower reaches, but these tend to be relatively small. Intervening reaches tend to have step-pool rather than pool-riffle habitat. Large boulders are numerous and important as instream cover and for pool development.

The cascades that begin upstream of the South Upper Truckee Road continue for several thousand feet. The channel is extremely steep, and several waterfalls are present. Habitat primarily consists of step-pools formed by large boulders. These cascades are not passable to fish migrating upstream from Lake Tahoe.

Above the cascades, stream habitat is highly variable. Much of the channel is relatively low gradient with pool-riffle habitat, as in unconfined meadows like Meiss. Other portions are relatively confined and forested, with a combination of pool-riffle and step-pool habitat types. There are also several lakes in the Upper Watershed, many of which have been stocked with trout.

Some are too small or shallow to support fish, but many still do (Showers Lake, for example, contains brook trout).

Tributaries to the Upper Truckee likewise exhibit alternating unconfined and confined reaches, a legacy of glaciation. The lower portions of both Big Meadow and Grass Lake Creeks, for example, are steep, step-pool type channels with extensive boulder substrate. Both also have extensive meadow systems (Cookhouse and Big Meadow on Big Meadow Creek, and Grass Lake on Grass Lake Creek) that are relatively unconfined, with lower gradients, pool-riffle habitat, and gravel substrate.

LAHONTAN CUTTHROAT TROUT RECOVERY EFFORTS

The combination of habitat loss, changes in water quality conditions, and introduction of non-native salmonids and warm water predatory fish has resulted in extirpation or significant reduction in the native fish species found in the Upper Truckee River. The focus of recovery efforts in the Upper Truckee River Watershed has been on reintroduction of Lahontan cutthroat trout (LCT) and removal of non-native fish from treated reaches.

The Lahontan cutthroat trout was listed as an endangered species in 1970 under the Federal Endangered Species Act. To facilitate restoration and allow limited catch and release angling, the LCT was reclassified as threatened in 1975. Since then, several efforts have been launched to plan for and implement projects to return LCT to its native range. Those efforts involving the Upper Truckee River Watershed include:

- U.S. Forest Service reintroduction of LCT in Meiss Meadows,
- U.S. Forest Service reintroduction of LCT in Showers Lake,
- U.S. Fish and Wildlife Service LCT Recovery Plan,
- Multi-agency Truckee River Basin Recovery Implementation Team, and
- Short-term Action Plan for LCT in the Truckee River Basin.

Due to the presence of non-native salmonids throughout the Upper Truckee River Watershed, LCT recovery planning has focused on isolated reaches of the mainstem within the headwaters or smaller lakes that have high quality habitat and could be intensively managed. Locations targeted for reintroduction of LCT populations have been classified to be managed solely as an LCT fishery, where non-native species are actively eliminated from the management area, or as a reintroduction area, where it is hoped that successive plantings results in development of self-sustaining populations.

The most significant long-term reintroduction program in the Upper Truckee River Watershed began in 1989 and is being directed by the U.S. Forest Service in the Meiss Meadows area. In 1989 and 1990 rotenone was applied to approximately four to six miles of the Upper Truckee River to remove brook trout prior to reintroduction of LCT. In 1990, following the rotenone treatment, LCT were introduced. Despite the rotenone application, brook trout were still present in an area adjacent to a well-used trail crossing, resulting in suspicions of reintroduction from anglers rather than a lack of success from the rotenone applications. In an effort to completely remove the remaining brook trout populations and understand population dynamics within the reintroduced LCT populations, the Meiss Meadows area has been electrofished annually since 1990. The electrofishing takes place for three separate weeks between September 10 and October 15. In the most recent electrofishing treatment, conducted in the fall of 2003, no brook trout were captured, raising hope that the remaining brook trout populations have been completely removed.

Beginning in 2000, the U.S. Forest Service has also begun introducing LCT into Showers Lake, despite the presence of brook trout. Showers Lake is a popular destination along the Pacific Crest Trail and is northwest of the Meiss Meadows LCT reintroduction area. Showers Lake is thought to be the source of brook trout reintroduced to the Upper Truckee River following the rotenone application in 1989 and 1990. The success of LCT introduction into Showers Lake will be closely monitored to determine whether LCT can coexist with brook trout and other non-native salmonids in a lake environment.

To determine the future success of the current and future reintroduction and recovery programs, like the one being implemented by the USFS in Meiss Meadows, the Truckee River Basin Recovery Implementation Team developed a set of success criteria that include the following (TRBRIT, 2003):

- A self-sustaining, networked LCT population is established, composed of wild, indigenous strains, in streams, lakes, mainstem and tributaries of the Truckee River Basin.
- Physical connectivity exists between spawning and rearing habitats in lakes, mainstem and tributaries of the Upper Truckee River basin to support natural LCT reproduction and recruitment and restore self-sustaining lacustrine LCT in the Truckee River Basin.
- A self-sustaining lacustrine population shall be considered to be naturally reproducing with a stable age-class structure consisting of at least four year classes and a stable or increasing population size with documented reproduction and recruitment. These conditions must be demonstrated to have been met for a minimum period of 20 years.
- Water is obtained through water right purchases or other means to protect and secure a stable Pyramid Lake ecosystem and meet life history and habitat requirements of LCT.
- A flow regime for the Truckee River is implemented which facilitates LCT migration, life history and habitat requirements.
- A commitment is secured to develop and maintain opportunities for fish passage within the Basin in a manner that facilitates migration and reproductive behavior of LCT.
- Threats to LCT and its habitat have been reduced or modified to a point where they no longer represent a threat of extinction or irreversible population decline.

The USFS, USFWS, CDFG, and other government agencies and non-profits will continue to implement recovery projects based on the direction of the TRBRIT planning document and the USFWS LCT Recovery Plan until these criteria are met.

HISTORIC CHANGES IN AQUATIC ECOSYSTEMS

Prior to the arrival of white man, Lahontan cutthroat trout and mountain whitefish were the only salmonids in the Upper Truckee River and were the top predators in the aquatic community. Both fish spent most of their adult lives in the Lake and migrated into the river to spawn. Juveniles likely spent a few months to a couple of years in the river before migrating back to the Lake. Cutthroat may have had resident life-history patterns as well.

Both fish were very important parts of the native Washoe culture (Lindström and Rucks, 2003). Several Washoe fishing camps were located on the Upper Truckee River, probably targeting both cutthroat and Tahoe suckers. The best fishing sites were apparently just downstream of the cascades south of South Upper Truckee Road, which were historically a barrier to additional upstream migration. Trout Creek, a tributary to the Upper Truckee River downsteam of the Study Area, was known for having large runs of whitefish. The importance of these fish in Washoe culture suggests that historic spawning runs were quite large.

An extensive fishery developed around Lahontan cutthroat after white settlement of Lake Tahoe, both in the Lake and on spawning runs in the streams. Evidence from this fishery also suggests that spawning runs were large and composed of large individual fish, often 20-30 pounds (Scott 1957). Along with introduction of exotic salmonids, overfishing led to the extirpation of Lahontan cutthroat from the Upper Truckee Watershed by the 1930s. Mountain whitefish are now rare throughout the watershed.

Most of the changes in the original fish assemblage have occurred in the salmonids due to their importance as sport fish. All of the native minnows still occur in the watershed, as well as the Piute sculpin, though some of their ranges may be more restricted, either due to habitat changes or competition with introduced fish.

There is some evidence that substantial changes in fish habitat have occurred in the Study Area. George Snooks, a Washoe familiar with the historic fishery and fish habitat, sketched a map in 1937 showing the location of spawn beds (Lindström and Rucks, 2003). Several good spawning beds are shown on the map in Reaches 1 though 4. Although migratory brown trout use this area for spawning today, rainbow trout (whose spawning behavior and habitat preference is most like that of Lahontan cutthroat) mostly spawn upstream of these reaches today. This suggests that spawning habitat in Reaches 1 through 4, which consists of gravel riffles, may be less extensive in these areas than historically.

Several potential impacts to aquatic ecosystems have occurred since white settlement of the area. Timbering was extensive, and logs were transported in the river (Lindström and Rucks, 2003), likely resulting in fairly extensive habitat disturbance. Grazing was also common throughout meadows historically. For example, dairy farms operated in the meadows around the Angora Creek confluence for several decades, starting as early as the 1860s. Grazing also occurred extensively in meadows throughout the upper portion of the watershed, such as Meiss Meadow. Overgrazing may have had impacts on streambank stability and riparian vegetation.

Stream channels and adjacent riparian habitat were also directly altered in many situations. Analysis of historic maps suggests that the lower portion of Big Meadow Creek was moved several thousand feet sometime before 1940. Substantial constrictions of the channel occur at both the Elks Club Highway 50 crossing at the lower end of the Study Area and on South Upper Truckee Road; both of which likely affected the channel and habitat both upstream and downstream.

Confined and unconfined channels, however, were probably much different in their response to human disturbance. The confined channel types, which predominantly occur upstream of Meyers, were less likely to show negative effects from human disturbance because of the stability conferred by larger substrate. The unconfined channels, found predominantly in Reaches 1 through 4, were more likely to be significantly impacted by land use practices, and were less likely to recover, due to smaller substrate and less erosional resistance.

In many of the meadows throughout the Study Area, there is evidence that the stream has incised relative to the floodplain, a common response to land use impacts. The evidence of incision includes dry side channels, reduction in extent of riparian vegetation, and channel straightening. This has occurred not only in meadows in Reaches 1 through 4, but also in smaller meadows higher up in the watershed, such as Cookhouse Meadow on Big Meadow Creek.

The distribution of trout in the Upper Truckee River suggests that habitat impacts in meadows are still affecting biologic integrity. Habitat degradation includes bank instability, lack of riparian and instream cover, reduction in instream habitat complexity, and reduction in the occurrence and length of high-quality riffles.

EFFECTS OF WATERSHED RESTORATION

Based on this discussion, several potential effects to aquatic habitat should be considered during watershed restoration planning.

- The greatest impacts to aquatic habitat have occurred in the Reaches 1 through 4, and in other low-gradient, unconfined meadows throughout the watershed, and the greatest aquatic habitat benefits will accrue from restoration projects in these areas.
- Rip-rap stabilization of streambanks may increase the amount of cover available for fish and may increase the frequency and depth of pools. However, rip-rap is not likely to

increase riparian vegetation density and overhanging cover (unless designed with a strong bioengineering component). Also, without addressing changes in channel planform and geometry resulting from incision, rip-rap will not restore historic in-channel habitat, including pool-riffle ratios and quality and complex side-channel habitat.

- Stream restoration alternatives in Reaches 1 through 4 that restore historic channel fluvial geomorphology (including relationship between the channel and floodplain) are likely to provide the greatest aquatic habitat benefits.
- Reduction of fine sediment entering the river from anthropomorphic sources (roads, cutslopes, eroding streambanks, etc.) may provide benefits to the aquatic ecosystem, especially in Reaches 1 through 4 or other low-gradient areas. However, macroinvertebrate analysis suggests that improvements would likely primarily accrue to reaches downstream of the Study Area.

III.4.C Opportunities and Constraints

The following opportunities and constraints have been identified with respect to fisheries and aquatic habitat.

OPPORTUNITIES

- Several miles of TRPA stream habitat ratings could be upgraded from marginal to good or excellent through bank stabilization, substrate improvements, or other restoration measures.
- Utilization of Reaches 1 though 4 by migrant spawning fish could substantially increase with substrate improvements.
- Restoration of smaller meadows higher up in the watershed, above fish migration barriers, may provide opportunities for introduction of Lahontan cutthroat trout.

CONSTRAINTS

- Any construction must be accomplished to minimize potential impacts to fisheries and aquatic resources. Construction may not be allowed when spawning fish are in the river.
- Restoration projects must be designed to protect water quality, both during and following construction.

III.4.D References

Herbst, D. B. 2001. Biomonitoring on the Upper Truckee River using aquatic macroinvertebrates: watershed restoration baseline data for 1998-2000. Report prepared for the Lahontan Regional Water Quality Control Board, South Lake Tahoe, CA.

Lindström, S, and P. R. Rucks. 2003. Upper Truckee River Reclamation Project Upper Reach, Planning and Design, Heritage Resource Study, Phase 1. Report prepared for Swanson Hydrology, Santa Cruz, CA.

Scott, E. B. 1957. The saga of Lake Tahoe. Sierra-Tahoe Publishing Co., Antioch, CA. 519 p.

Snider, W. M., J. L. Kershner and G. E. Smith. 1987. Instream flow requirements of selected salmonid resources, Lake Tahoe Basin, California and Nevada. California Department of Fish and Game Stream Evaluation Report No. 87-1. The Resources Agency, Sacramento, CA.

Tahoe River Basin Regional Implementation Team. 2003. Short-term action plan for Lahontan Cutthroat Trout (*Oncorhynchus clarki henshawi*) in the Truckee River Basin. Prepared for USFWS, Reno, Nevada. August 2003.

TRPA. 2001. Threshold evaluation-draft. Zephyr Cove, Nevada.

------ 2002. 2001 Threshold evaluation report – July 2002. Zephyr Cove, Nevada.

III.5 CULTURAL RESOURCES

III.5.A Methods

Heritage work for the Upper Reach Study Area was accomplished in two phases aimed at assessing project opportunities and constraints that will influence the selection of a preferred project alternative. Initial Phase IA research was conducted to gather the necessary background data in order to assist project planners. Upon completion of background research, a Phase IB field archaeological reconnaissance was performed to identify existing heritage resources within the Study Area.

PHASE IA: PREFIELD RESEARCH

Baseline information on the prehistoric/Native American and historic/Euroamerican land use were analyzed in order to better identify the location, nature and intensity of environmental/cultural changes occurring within the Study Area, with a focus on past environmental conditions and prehistoric and historic alterations of the UTR channel and its surrounding floodplain.

Heritage research entailed a literature search of prehistoric and historic themes for the Study Area. This included a review of prior archaeological research and of pertinent published and unpublished sources in order to identify any properties listed on national registers, state registers and other listings, including the files of the State Historic Preservation Office. A cursory historic chain of title search was conducted of El Dorado County deeds, pre-emptions and homesteads (J. Starns, personal communication). Richard Solbrig, General Manager of the South Tahoe Public Utilities District (STPUD), was called to clarify details of recent historic development of the Study Area, such as the establishment of subdivisions, formation of assessment districts and installation of sewer and water lines and other accompanying infrastructure. John Stanowski, Maintenance Manager of the Lake Tahoe Golf Course, provided helpful field orientation and offered information on the history of the course. Descendents of pioneer families in Lake Valley, along with other individuals knowledgeable in local history, were contacted and focused oral history interviews were conducted as appropriate (Lindström and Rucks 2003 for interview notes).

Lindström et al (2000) provide the most recent summary of Washoe Indian history, fishing, and land use at Lake Tahoe, drawn from the core Washoe ethnographic literature (e.g., Barrett 1916; Lowie 1939; d'Azevedo 1986; Downs, 1966; Nevers 1976). Most pertinent to the Study Area and aboriginal fishing are Freed (1966); Lindström's research (1992; 1996); and the unpublished field notes Edward Siskin (90-03). These were summarized and incorporated in Lindström and Rucks (2002). There is continuing value in Washoe traditional knowledge for reconstructing environmental history, and there is much to document about the post-contact period through individual family histories (Lindström and Rucks 2003).

PHASE IB: FIELD ARCHAEOLOGICAL RECONNAISSANCE

Prefield research provided the rationale with which to develop a strategy for the on-the-ground archaeological field reconnaissance. Lindström and two assisting archaeologists (Lizzie Bennett and Charles Blanchard) walked 480 acres of Study Area (Figure 3.31), employing a pedestrian surface survey that was structured by a mixed archaeological reconnaissance strategy. Potential impact areas within the 1000-foot (305-meter) corridor within the UTR floodplain were targeted for field examination by systematically walking parallel transects. Transect intervals and distances were established by pacing. Cardinal directions were maintained by compass readings.

An attempt was made to employ a surface-intensive coverage type by walking parallel transects at no greater than 15-meter (50-foot) intervals. Such coverage was accomplished in areas along the riverbank, on drier grassy meadows, on terraces above the river, and within gently sloping forested uplands above the wetlands. However, due to extensive riparian thickets, standing water, and canals and ponds excavated by beaver, systematic transects over considerable portions of the Study Area were impossible to maintain and coverage was broadened to surface-30 (100-foot) coverage type, employing transect intervals between 15 and 30 meters. In this case, vegetation and/or water precluded any ground surface visibility and areas within this 30-meter span were left unexamined. These areas of more cursory coverage entail wet grassy meadows and riparian thickets adjacent to the river. Ground surface visibility within the Study Area is variable. Overall, the ground surface is obscured by meadow grass, pine duff and riparian vegetation. Some of the area was inaccessible due to standing/flowing water and impenetrable vegetation.

During this “sweep” survey, all heritage resources were briefly described and plotted on project maps (1”=200’ and 1”=400’ scales). Field recording of the heritage finds is deferred until Phase II work, at which time heritage resources will be recorded in accordance with the guidelines outlined in the "California Archaeological Inventory Handbook for Completing an Archaeological Site Record".

PREVIOUS ARCHAEOLOGICAL INVESTIGATIONS AND KNOWN HERITAGE RESOURCES

Portions of the Study Area have been subject to an archaeological survey and several heritage resources studies have been done within or immediately adjacent to the project, including CDPR, USFS, Caltrans, MACTEC, and Lindström in the Meyers Area, Hintz, Kraushaar, and Dexter in Christmas Valley, and Marvin and Holson in the Upper Watershed (see Lindström and Rucks 2003 for detailed descriptions of findings). See Figures 3.32A&B for extent of area previously surveyed.

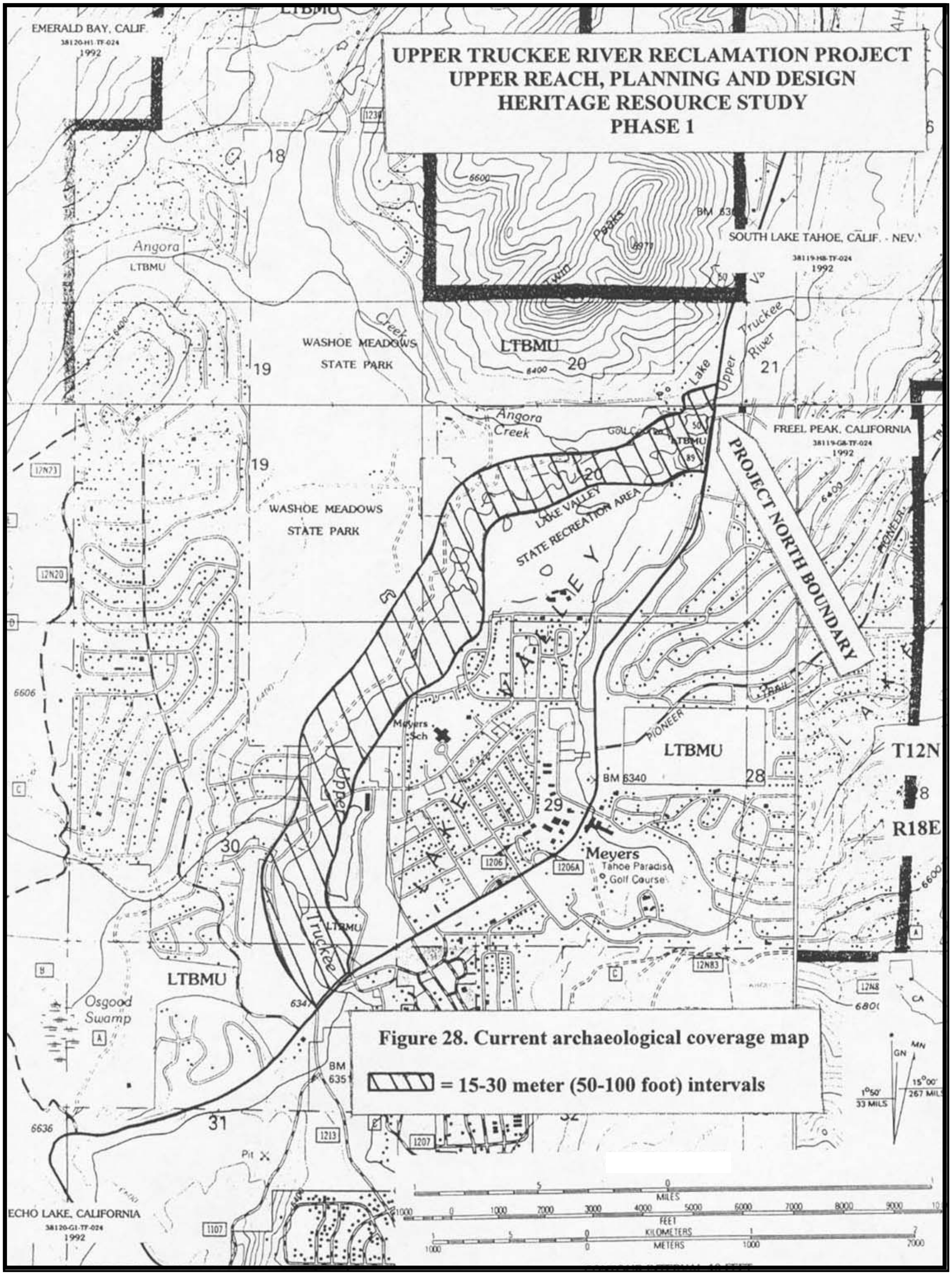


FIGURE 3.31: Map displaying extent of Upper Reach Study Area surveyed in Phase 1B of the field archaeological reconnaissance by S. Lindström, Fall 2003.

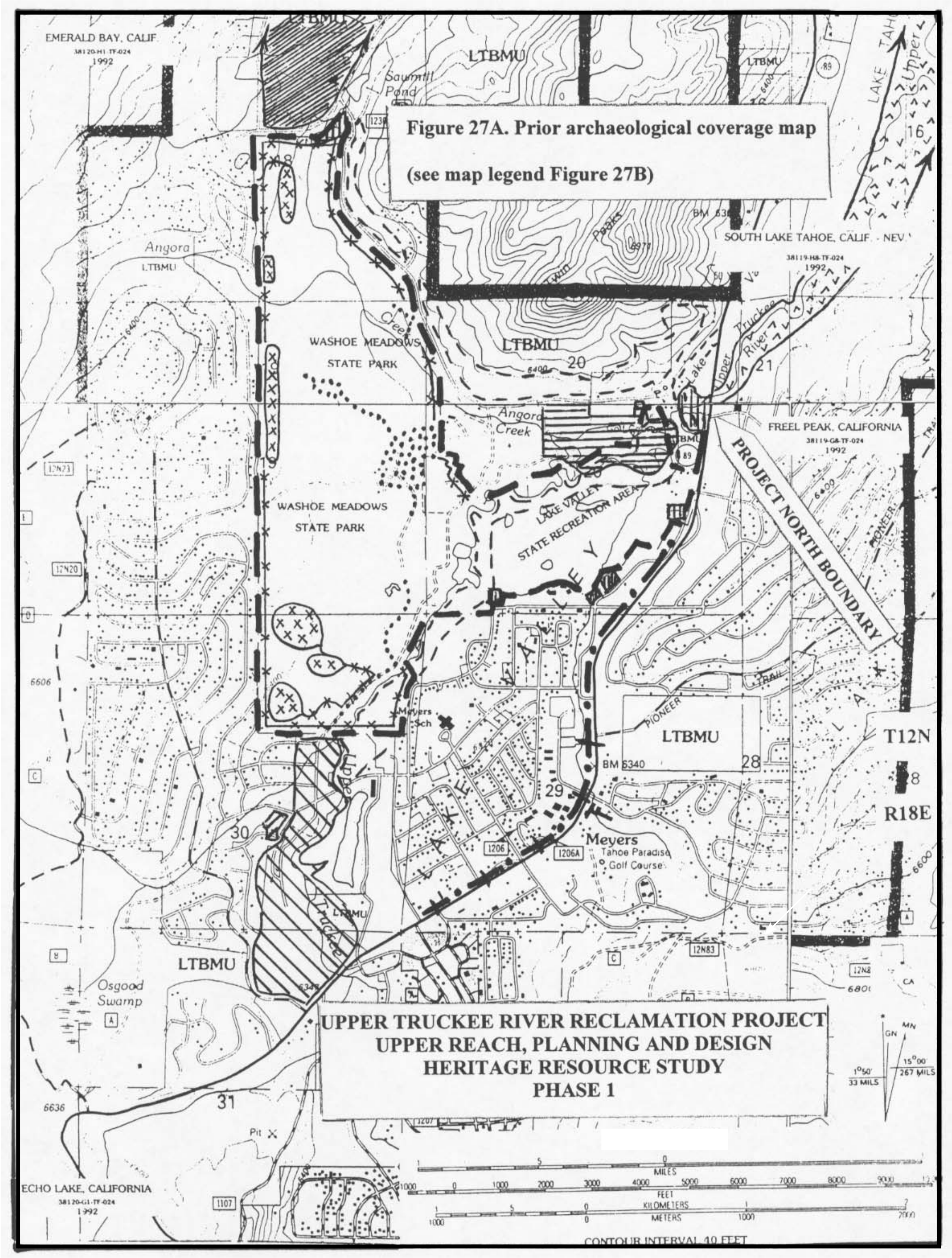


FIGURE 3.32A: Map displaying the location and extent of previously surveyed archaeological studies in the Upper Reach Study Area.

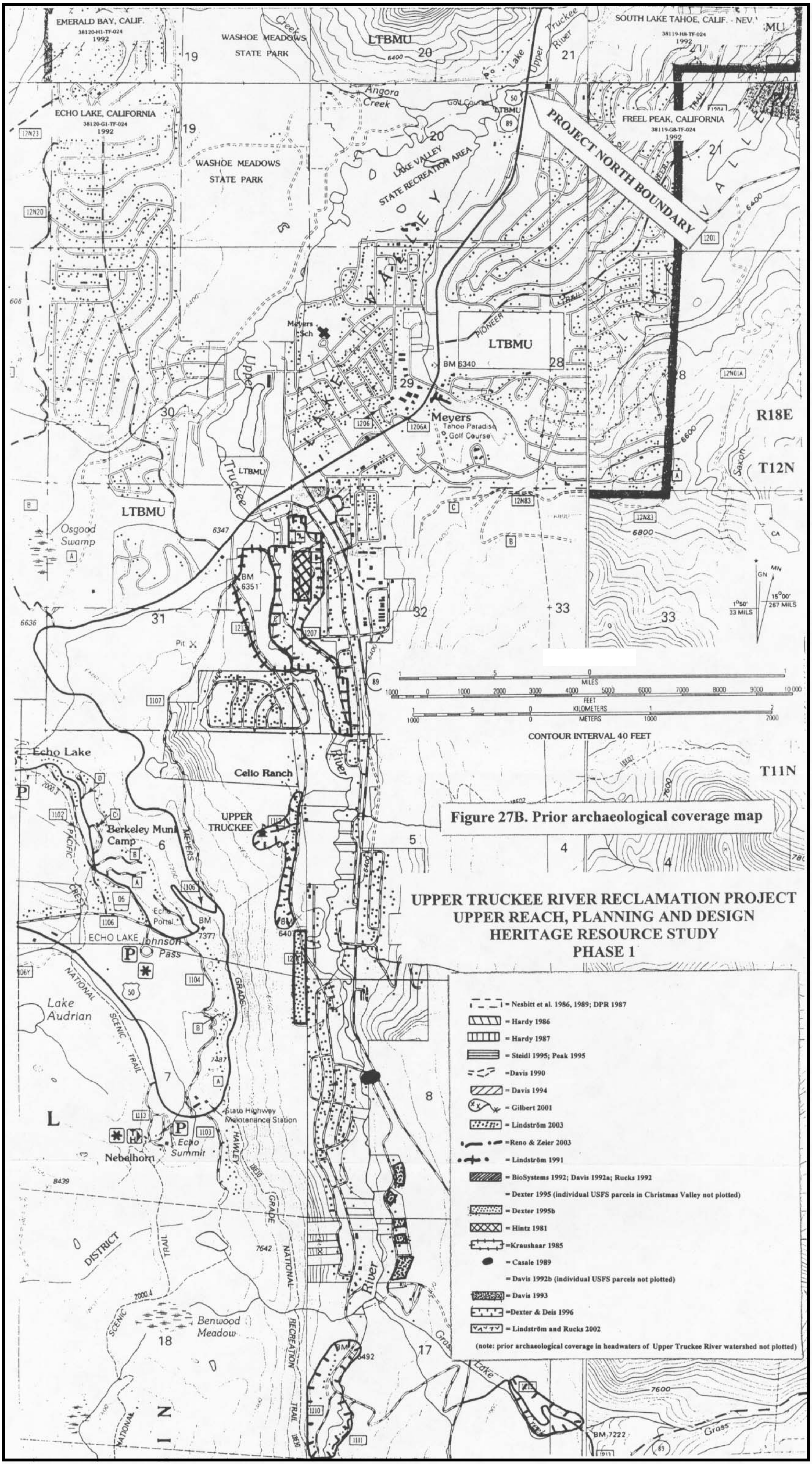


FIGURE 3.32B: Map displaying the location and extent of previously surveyed archaeological studies in the Upper Reach Study Area.

III.5.B Summary of Heritage Resources Survey Result

Heritage resources noted during this study are described below and summarized on Table 3.18. Note that these resources have not yet been formally recorded as part of Phase I research. This task should be accomplished as part of Phase II work prior to any project ground disturbance activities and preferably at the earliest stage of project planning. The project sponsor may have additional responsibilities under the following circumstances:

- if the project changes in ways that could impact heritage properties;
- if heritage properties are discovered during the implementation of this project or if a known heritage property will be impacted in an unanticipated manner;
- if a property that was to be avoided has been inadvertently or otherwise impacted;
- if any condition of the project, such as a delay in implementation or implementation in phases over time, may justify reconsideration of the current significance status of heritage properties within the project's area of potential effect.

Table 3.18: Summary of heritage resources recorded within project corridor: Elks Club Highway 50 crossing to Meyers Highway 50 crossing.

Resource #	Description
Native American Sites and Isolates:	
UTR-1	water worn obsidian chunk in exposed stream channel
UTR-2	lithic scatter (1 gneiss biface; flakes: 4 gneiss, 1 basalt)
UTR-3	obsidian flake (mixed into a pile of asphalt at log landing near Amacher Quarry)
UTR-4	lithic scatter (1 basalt biface; 40 flakes, 14 basalt, 21 obsidian, 4 gneiss, 1 igimbrite)
UTR-5	lithic scatter (1 chert uniface/scraper; 36 flakes: 17 obsidian, 16 basalt, 3 gneiss)
UTR-6	1 red chert flake in dirt road
05-19-613	4 bedrock milling features, two hand stones, midden, lithic scatter
Euroamerican Sites, Linear Features and Isolates :	
UTR-7	olive glass fragment (pre 1917)
UTR-8	2 multi-serve cans (early sanitary, 1898-pre-1930s)
UTR-9	"Pearl Oil" can (lead solder with "D" ring handle)
UTR-10	dirt road trace (pre 1940?)
UTR-11	dirt road trace (pre 1940?)
UTR-12	dirt road trace (pre 1940?)
UTR-13	dirt road trace (pre 1940?)
UTR-14	Hwy 50/89 abandoned "dog-leg" segment
UTR-15	Harms Bros. Quarry/Asphalt Plant (pre 1952); now Lake Baron
CA-Eld-556/H	Locus A: irrigation ditch (pre 1940)
CA-Eld-556/H	Locus B: recent CDFG concrete fish ladder; historic railroad grade

NATIVE AMERICAN SITES AND ISOLATES

UTR-1 Obsidian Chunk. A water worn obsidian chunk is exposed in the UTR stream channel. Its cultural associations and provenience are unknown.

UTR-2 Lithic Scatter. A sparse lithic scatter consists of one gneiss biface and one basalt and four gneiss waste flakes. The site covers an area about 10 meters diameter above the west side of the river and down slope of the termination of Shawnee Street.

UTR-3 Obsidian Flake. An isolated obsidian flake occurs in a pile of asphalt on top of a log landing near the Amacher Quarry.

UTR-4 Lithic Scatter. A widely-broadcast but sparse lithic scatter occurs on a bench above the east bank of the Upper Truckee River and along Bakersfield Street. The site is about 45 meters diameter. One basalt biface and 40 waste flakes were observed (14 basalt, 21 obsidian, four gneiss, and one igimbrite). A quartz crystal fragment is of questionable cultural origins. The site is highly disturbed and flakes tend to cluster along the edge of the road.

UTR-5 Lithic Scatter. Another widely-broadcast but sparse lithic scatter occurs on a bench above the east bank of the Upper Truckee River and along Bakersfield Street, north of UTR-4. It is about 30 meters in diameter. One chert uniface (scraper?) and 36 waste flakes (17 obsidian, 16 basalt and 3 gneiss) were observed.

UTR-6 Chert Flake. One isolated red chert flake occurs in a dirt road that accesses the “back” side of Amacher Ranch.

FS-05-19-613 Camp. A prehistoric camp consists of four bedrock milling features, two hand stones, extensive midden, and lithic scatter. The site is located on a bench above the west bank of the Upper Truckee River and along a tributary stream waterfall. The site was previously recorded by the USFS.

EUROAMERICAN SITES AND ISOLATES

UTR 7 Glass Fragment. An isolated olive glass fragment neck finish (pre 1917) is located along the east side of a dirt road that traverses the west bank of the Upper Truckee River.

UTR-8 Two Cans. Two multi-serve cans (early sanitary ca. 1898-pre 1930s) occur as isolates on a forested bench above the east bank of the Upper Truckee River.

UTR-9 Can. A “Pearl Oil” can (refined white kerosene) with lead solder and “D” ring handle occurs as an isolate along the west bank of the Upper Truckee River near the southern boundary of the Amacher Ranch.

UTR 10-13. West Bank Road System. Four faint traces of a possible contiguous road occur along the west bank of the Upper Truckee River. Its existence is problematic, however, it is persistent and very overgrown. No road appears in this location on historic maps that date from 1895 or aerials that date from 1940. It is not until the 1969 photo-revised 1955 USGS quadrangle and the 1971 aerial photograph that the present system of roads appears. However, Cass Amacher has claimed (personal communication 9/20/03): "there has always been a road up the west side of the Upper Truckee River."

UTR 14 Highway 50 Bridge. Remains include an abandoned dirt and asphalt grade and the dismantled and partly washed-out foundations of a highway bridge and rip-rap over the Upper Truckee River. The 1945 highway plans depict the bridge as about 20 feet wide and about 120 feet long. The feature has been formally recorded by Reno and Zeier (2003:16). The road segments and bridge were abandoned ca. 1946-1948 when Highway 50/89 was straightened through Lake Valley. The dogleg may have initially been selected to avoid crossing the wetland traversed by the modern route on a raised causeway. The historic road segment between Sawmill Road and the Upper Truckee River has been obliterated recently and converted to landscaping (Yant, personal communication 2003).

UTR 15 Harms Bros. Quarry/Lake Baron. Lake Baron is formed from a quarry pit and adjoining asphalt plant operated by the Harms Bros. of Sacramento ca. 1952. An asphalt plant was located on the west side and southern third of quarry area. This area is presently razed and mostly devoid of vegetation. Huge granite blasted boulders are stockpiled at various locales within the quarry and down slope towards the river.

The lake was created ca. 1969. Natural springs feed the lake on south end and lake levels are maintained by draining surplus water into the Upper Truckee River or pumping water out of the river during low periods. Obscured at the lower end of the boulder scatter is a discarded concrete, wire and rebar "animal form" (characteristics of an alligator) with cylindrical legs for mounting (perhaps at an old miniature golf course?).

CA-Eld-556-H-Locus A, This long ditch is dug deeply into the ground and extends from the Upper Truckee River, due north of Lake Tahoe Paradise Park and contours imperceptibly down slope on the east side of the river and along the base of the slope break. It is lost in a subdivision in residential landscaping near the corner of San Diego and Bakersfield streets. The ditch is up to four meters wide and 1.5 meters deep. Trees embedded in the berm are mostly lodgepole pine of considerable size. A head gate, constructed near the mouth of the ditch by CDFG, suggests its modern reuse. This irrigation feature may have been reused by the CDFG to divert water in order to avoid erosion of fish spawning beds along the river during flood periods. Attached to the head gates at the river intake point is a brass padlock used to secure the diversion gate with letter embossing "C.F.& G. 95." A large pipe extends outward and downstream from the gates for diversion of water from the gates. A wide platform (10 feet wide by 17 feet long) and secured by four massive split cedar beams and cross planking with wire nails, spans the ditch down slope from the head gate and is believed by DPR personnel (Evans et al. 1987) to be a bridge.

The ditch clearly appears on a 1940s aerial photograph, with a termination point into a series of lateral irrigation ditches that drain into meadowlands within the current LTGC. The ditch was used in the 1920s-1940s to irrigate the pasture surrounding the Lawrence/Scott Dairy and later Broder Dairy (Davis, personal communication with Vera Broder Silberstein 1992).

CA-Eld-556-H-Locus B. The USFS (Davis 1990) recorded a winged concrete weir (42 feet long and five feet high) with narrow spillway and fish ladder along the west bank of the river and across from the ditch and head gate (Locus A). It is surmised that Locus A and Locus B were at one time contiguous. The Locus B weir is no longer in the river channel, but is partly buried in flood deposits at some distance from water. In addition, Davis recorded an earthen mound, located 30 meters (100 feet) downstream from the weir, thought to be part of a railroad grade that allegedly crossed the river in this locale. A standard (?) gauge logging railroad crossed the river at this point and then continued northward along the dirt road following the west bank and through WMSP (Davis, personal communication with Vera Silberstein, 1992). No further evidence of the railroad could be found on the ground or in archival records or on maps during this study.

PROBLEMATIC HERITAGE RESOURCES NOTED NOT FORMALLY RECORDED

Certain heritage resources were detected on historic maps or reported in oral history interviews but there is no archaeological evidence remaining on the ground. These resources are were not formally recorded, but deserve mention here, including submerged stumps, historic cut stumps, fence lines, irrigation ditches, Tahoe Telegraph Line, logging railroad, flotsam, golf course refuse, stream measure gaging facilities, modern ford and check dam, modern dumps, and Ethel's Pie Shop. For a complete discussion of these resources, see Lindström and Rucks 2003.

RESOURCE SIGNIFICANCE

Decisions regarding the management of heritage resources depend upon a determination of their significance based on established criteria for significance, historic context and resource integrity. If project impacts are likely to occur, the significance of the resource must be determined. Significance is commonly based upon the four criteria of eligibility for inclusion in the National Register of Historic Places (NRHP 36 CFR 60.4). Another federal program that acknowledges significance is the National Historic Landmark Program. The California Environmental Quality Act (CEQA Section 15064.5) has established significance criteria that are modeled after National Register guidelines. California also has a State Register, State Historic Landmark Program and Point of Historic Interest Program that recognize buildings, sites, and objects of local or statewide importance. In the Lake Tahoe Basin, the importance of a cultural resource is also assessed according to Subsection 29.5 of the TRPA Code.

Important considerations in federal, state and regional significance criteria focus upon a heritage property's association with important (a) historical associations, (b) personalities, (c) technological and artistic characteristics, and (d) research potential (a heritage property must have the potential to contribute important information towards scholarly research to then be conveyed to the general public). These significance criteria provide legal and professional guidelines and have been summarized in Lindström and Rucks (2002).

In addition to meeting at least one of the criteria of significance listed above, a property must have integrity of location, design, setting, materials, workmanship, feeling, and/or association (relative to other heritage resources similar in kind). To possess integrity a resource must retain sufficient physical character so that it conveys an association with prehistoric or historic patterns, persons, designs, or technologies.

Prior to determining the significance of a heritage resource, it must be formally recorded (typically on State of California archaeological site record forms). This task is out of the current project scope and is reserved for Phase II research. Based upon results of the DPR surveys, Nesbitt (1986) concluded that all Native American sites recorded within WMSP and LVSRA are significant. Euroamerican sites had compromised integrity and were determined non-significant.

HERITAGE RESOURCE SENSITIVITY

Native American Theme

Based upon results of the DPR survey of WMSP/LVSRA, Nesbitt et al. (1966) concluded that Native American archaeological sites tend to occur on glacial moraines and relatively high ground above the Angora Creek/Upper Truckee River floodplain. This trend is confirmed by results of this assessment. However, it is important to add that, while habitation and camp locales may have been situated above the floodplain, task sites for fishing, plant gathering, etc., typically occur along the river channel throughout the watershed, as well as in adjoining meadowlands within the floodplain. Given the extreme amount of disturbance along the river channel and adjoining floodplain, it is likely that an unknown number of Native American sites have been obliterated or obscured by historic and modern development, e.g., a 150-acre golf course development, channel modifications for irrigation, etc., as well as the natural processes of bank erosion and flood deposition by the Upper Truckee River. Given the fact that the Native American record extends back about 9000 years, it is possible that sites and isolated features and artifacts could be deeply buried beneath UTR flood deposits (providing they survived episodes of erosion).

Apart from archaeological issues, the Study Area assumes cultural significance to modern Washoe people. The Washoe Tribe has developed a comprehensive land-use plan (Washoe Tribal Council 1994) that includes goals of reestablishing a presence within the Lake Tahoe Basin, revitalizing Washoe heritage and cultural knowledge, protecting traditional properties within the cultural landscape, and harvesting and caring for traditional plant resources (Rucks 1996:3). Although no "Traditional Cultural Properties" were identified as part of this study (a resource designation that might certainly constrain future project activities), the Study Area holds great interest to the Washoe and the tribe should be consulted as stakeholders throughout the future decision-making process. As part of an on-going process of reinforcement and discovery that encourages recall and experimentation, Washoe traditionalists should be consulted regarding culturally important plants and traditional use areas. Project revegetation efforts might incorporate native plants of importance to Washoe plant specialists, for example, certain species of desirable basket willow.

Transportation, Communication and Community Development Theme
Historic maps, along with a few archaeological traces on the ground, indicate that several roads and bridge crossings traversed the Study Area. Yet, relative to the downstream reach of the UTR, fords and bridge abutments are rare; they are either non-existent or have been removed. This is in contrast to the Airport Reach where several fords and dams remain in place. Official historic maps indicate that only two roads crossed the river in the reach between Elks Club Highway 50 crossing and Meyers Highway 50 crossing. Schematic maps show at least one "Big Dam", a possible logging railroad and maybe three roads through the area. The present network of dirt roads does not appear on maps or aerial photographs until the 1960s. Some of these roads follow sewer lines, which were installed in this part of Lake Valley during the late 1950s and 1960s. Untold numbers of historic sites have been lost to modern development in the Study Area, with the construction of subdivisions and accompanying infrastructure, channel straightening ca. 1955-1959 to accommodate a 150-acre golf course, and excavation and filling of a seven-acre Amacher quarry and the larger Harms Bros. pit and asphalt plant.

Grazing Theme
Euroamerican sites occur throughout the Study Area. Unlike Native Americans, Euroamericans may not have necessarily favored upland locales to inhabit. In fact, all but one site (the Forni Cabin) recorded by DPR within WMSP/SVSRA (Nesbitt et al. 1986, 1989) occur on lower ground within the Angora Creek and UTR floodplain. Remaining historic water management features are also likely to be located near the river. The presence of grazing related sites are more likely to occur along the river reach between Angora Creek and Christmas Valley and at the head of the watershed at Meiss Meadows. Stretches with steeper gradients would be of lower archaeological sensitivity. Relative to downstream reaches, the Study Area exhibits fewer irrigation features. This may be due to the greater wetness of the Study Area (springs and tributary streams), whereby at least some ditches were used for draining rather than irrigating. Either way, the hydrology of the Study Area has been altered by grazing activities, the most dramatic changes involving the 1926-1940 diversion of Angora Creek into the Upper Truckee River west of their point of conversion.

The Study Area seems to have been more intensively grazed by dairy and beef cattle than sheep, although sheep are documented in the Upper Watershed at Round Lake.

As a related issue, the successful survival of beaver in the Lake Tahoe Basin (*Castor spp*.), not to be confused with the native Mt. Beaver (*Aplodontia rufa*), and their prolific numbers in certain areas have led to a series of problems initially recognized by ranching and related environmental interests. They claimed that beavers altered the hydrology of streams and adjoining wetlands in a negative way. Throughout this course of events, the question remains whether or not beaver (*Castor spp*.) was ever a native of the Lake Tahoe Basin. The lack of historic fur trade in the Lake

Tahoe Basin/Upper Truckee Watershed, the absence of beaver in Washoe tradition, subsistence and technology, and the unanimous opinion by descendents of pioneer families in Lake Valley tentatively suggest that beavers (*Castor spp.*) were not native to this area. However, it is possible that beaver may have gone without mention in Washoe and Euroamerican literature because they occurred in such low numbers.

Logging Theme

Archival research and historic stump fields bear witness to a patchwork of successive and sometimes overlapping logging episodes within the Study Area. First was the CTLFC/EWLC (ca. 1885 to late 1890s), who acquired lands outright or obtained leases to timber and water rights from other landowners; second was C.G. Celio and Sons (ca. 1927-1942), who subsequently acquired land containing virgin stands and also acquired lands previously logged by CTLFC/EWLC, reentering stands to harvest trees that were too young at the time CTLFC initially harvested. Lastly PLC (ca. 1942-1952) cut remaining timber left over from the initial two efforts.

Oddly, this fairly intensive history of logging within the Study Area is not well represented in the archaeological record. With the exception of the Celio sawmills and surrounding site complex, no archaeological sites associated with the logging theme (camps, flumes, chutes, haul roads, skid trails, etc.), were encountered during the field survey or records search of the river corridor or upper watershed. Reports of a logging railroad through the Study Area remain unconfirmed. Camp quarters, usually found in association with logging landscapes, may have been confined to the mill sites and/or boarding facilities offered at nearby Meyers Station. It is possible that future survey of the uplands surrounding the river will disclose more archaeological sites.

Environmental disturbances associated with logging and river driving involve alteration of forest structure and composition, eroding logging roads as conduits of sediment into drainages, soil compaction in near logging camps and staging areas, and fire frequency, as historically fire has been a companion to logging and its associated debris.

Fisheries

Dams, diversions, over-fishing, logging, pollution, and competition from non-native species have caused the decline of Tahoe's fisheries and the extinction of the native Lahontan cutthroat trout. At one time, the Study Area of the Upper Truckee River was considered to be an exceptional fishery containing excellent spawning. In terms of numbers of people supported, the UTR may have been the single richest fishery and premier destination for the Washoe at Lake Tahoe. A map of the Upper Truckee fishery, sketched by Washoe George Snooks in 1937, designates at least seven stretches of "good spawning beds" and fish trap locales within the river reach between the Elks Club Highway 50 crossing and the Meyers Highway crossing. Other aquatic resources of interest noted by the Washoe include "oysters" (fresh water mollusks).

In the last few decades, the California Department of Fish and Game has attempted to enhance damaged spawning gravels along the river. A partly buried fish ladder (trap) was observed at a point on the river near the southern boundary of WMSP. Here, floodwaters were diverted into a historic diversion ditch in order to protect downstream spawning gravels from washing away. Further attempts to restore the Upper Truckee River fishery by mechanically reestablishing and maintaining spawning gravels should consider the impacts of beaver activity on fisheries.

III.5.C Opportunities and Constraints

OPPORTUNITIES

- Project revegetation efforts might incorporate native plants of importance to Washoe plant specialists, including, certain species of desirable basket willow.

CONSTRAINTS

- All heritage resources should be formally recorded prior to any project ground disturbances. Additional issues may arise if: (a) if the project changes in ways that could impact heritage properties, (b) if heritage properties are discovered during the implementation of this project or if a known heritage property will be impacted in an unanticipated manner, (c) if a property that was to be avoided has been inadvertently or otherwise impacted, and/or (d) if any condition of the project, such as a delay in implementation or implementation in phases over time, may justify reconsideration of the current significance status of heritage properties within the project's area of potential effect.
- If project impacts are likely to occur, the significance of the resource must be determined. Decisions regarding the management of heritage resources depend upon a determination of their significance based on established criteria for significance, historic context and resource integrity.

III.5.D References Cited

Amacher, Cass, Jr. 2003. Personal communication. July 26, 2003. Son of Cass and Virginia Amacher. South Lake Tahoe.

Barrett, S. 1916. The Washoe Indians. Bulletin of the Public Museum of the City of Milwaukee Vol.2 NO.1:1-52.

Davis, Herschel D. 1990. Cultural reconnaissance Report for Re-Location of CA-Eld-24 and CA-Eld-25 (CRR #05-19-244). Report on file USFS-LTBMU, South Lake Tahoe.

Davis, Herschel D. 1992a. A Bibliographic Survey of the History of the Celio Sawmill Site. Report prepared for and on file with USFS-LTBMU. South Lake Tahoe.

Davis, Herschel D. 1992b. Cultural Reconnaissance Report for Ground Truthing and Correlation of Freed, d'Azevedo and Heizer Site Numbers and Names for Tahoe Basin Management Unit (CRR 05-19-296, 296A, 296B). Report on file USFS-LTBMU. South Lake Tahoe.

Davis, Herschel D. 1993. Grass lake Road Hazardous Tree Removal (CRR-05-19-310C). Report on file USFS-LTBMU. South Lake Tahoe.

Davis, Herschel D. 1994. Hersch's Projects: Cherry's Orchard (CRR-05-19-310D). Report prepared for and on file with USFS-LTBMU. South Lake Tahoe.

d'Azevedo, W. 1956. Washoe Place Names. Unpublished manuscript in possession of author. Reno, Nevada.

------1984. The Washoe. Unpublished manuscript in possession of author.

------1986. The Washoe. In The Great Basin, edited by Warren L. d'Azevedo, pp.466-499. Handbook of North American Indians, vol.11, William G. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

------97-04 & 99-14. Washoe Indian Research Papers of Warren L. d'Azevedo. Special Collections Department University Library. University of Nevada-Reno.

Dexter, Sean. 1995a. Urban Lots Management Project (USFS TB-95-4). Report on file USFS-LTBMU. South Lake Tahoe.

------1995b. Urban Fringe Management Project (USFS TB-95-6B). Report on file USFS-LTBMU. South Lake Tahoe.

Dexter, Sean and Richard Deis. 1996. Cultural Resource Survey of the Proposed Developed Sites Pest Management Project (CRR-05-19-335). Report on file USFS-LTBMU. South Lake Tahoe.

Downs, J. 1966. The Two Worlds of the Washoe: an Indian Tribe of California and Nevada. Holt Rinehart and Winston, Inc. Fort Worth.

Freed, S. 1966. Washoe Habitation Sites in the Lake Tahoe Area. In Notes on Western Nevada Archaeology and Ethnography. University of California Archaeological Survey Reports 66(3):73-84. Berkeley.

Gilbert, Shannon. Washoe Meadows Fence Repair. DPR Historic Facility and Archaeological site Project Evaluation. Report on file DPR. Tahoma.

Hardy, Kathy. Upper Truckee Erosion Control Project (ARR 05-19-151). Report on file USFS-LTBMU. South Lake Tahoe.

Lake Country Estates Land Exchange (ARR 05-19-162). Report on file USFS-LTBMU. South Lake Tahoe.

Hintz, Tom. 1981. Rainbow Summer Home Tract Salvage Sale (ARR-05-19-94). Report on file USFS-LTBMU. South Lake Tahoe.

Kraushaar, Richard. 1985. Hardway Sale (ARR-05-19-137). Report on file USFS-LTBMU. South Lake Tahoe.

Lindström, Susan. 1991. A Cultural Resources Evaluation of the Meyers Bike Trail, South Lake Tahoe. Prepared for the El Dorado County Department of Transportation. Report on file NCIC-CSUS. Sacramento.

------1992. Great Basin Fisherfolk: Optimal Diet Breadth Modeling the Truckee River Aboriginal Subsistence Fishery. Unpublished PhD dissertation, Department of Anthropology, University of California, Davis.

------1994. Heritage Resource Inventory South Tahoe Public Utilities District A-Line Export Pipeline Relocation Project: 6.5-Mile Pipeline in South Lake Tahoe. Report on file NCIC-CSUS. Sacramento.

------1996. Great Basin Fisherfolk. In Prehistoric Hunter-Gatherer Fishing Strategies, edited by M. Plew. Boise State University Press.

------1997. Heritage Resource Inventory of the Upper Truckee River Restoration Project. Report on file NCIC-CSUS. Sacramento.

------2003. Washoe Meadows Road and Trail Rehabilitation. DPR Historic Facility and Archaeological site Project Evaluation. Report on file DPR. Tahoma.

Lindström, Susan and Jeffrey Hall. 1998. Archaeological Survey and Site Recording for the Pioneer Timber Sale with a Contextual History of the Lake Valley Railroad (HRR-TB-9-5). Report prepared by Garcia and Associations, San Anselmo. Report on file USFS-LTBMU. South Lake Tahoe.

Lindström, Susan and Laura Leach-Palm. 2002. Archaeological survey of 2489 Acres in Lake Tahoe Nevada State Park, Nevada: Volume 1 Report. Prepared for Nevada Department of Conservation and Natural Resources, Nevada-Tahoe resource Team. Carson City.

Lindström, Susan and Penny Rucks. 2002. Upper Truckee River Reclamation Project: Heritage Resource Study Phase 1A, 837 Acres, South Lake Tahoe. Report prepared for Tahoe Resource conservation District. Report on file USFS-LTBMU. South Lake Tahoe.

------2003. Upper Truckee River Reclamation Project Upper Reach Planning and Design Heritage Resource Study Phase I. Prepared for Swanson Hydrology + Geomorphology. October 2003.

Lindström, Susan, Penny Rucks and Peter Wigand. 2000. A Contextual Overview of Human Land Use and Environmental Conditions. In Lake Tahoe Watershed Assessment: Volume 1. Dennis D. Murphy and Christopher M. Knopp (eds.). USDA Forest Service General Technical Report PSW-GTR-174. May 2000. pp. 23-130.

Lindström, Susan and Sharon Waechter. 1995. North Shore Ecosystems Project Heritage Resources Inventory – Nevada Area. Report on file USFS-LTBMU. South Lake Tahoe.

Lowie, R. 1939. Ethnographic Notes on the Washoe. University of California Publications in American Archaeology and Ethnology. Vol.5 No.7.

------1963. Text No. 27 from the Weasel Myth as told by Bill Cornbread in Washoe Texts. Anthropological Linguistics Vol 5 No 7.

Marvin, Judith and John Holson. 1992. Recordation and Eligibility Assessment for the Meiss Meadow Historic Cabin and Barn Complex. Prepared by BioSystems Analysis, Tiburon. Report on file USFS-LTBMU. South Lake Tahoe.

Nevers, J. 1976. Wa She Shu. Inter-tribal Council of Nevada.

Reno, Ronald and Charles Zeier. 2003. Cultural Resources Inventory Report: Sawmill Bicycle Path Corridor, Meyers. Prepared for El Dorado County Department of Transportation by MACTEC Engineering and Consulting, Carson City. Report on file NCIC-CSUS. Sacramento.

Rucks, Merideth (Penny). 1987. The Historic Archaeology of Italian Swiss Settlement in Sierra Valley: A Preliminary Study. Report on file USFS-LTBMU. South Lake Tahoe.

------1993. Evaluation of Significance, Celio Saw Mill (FS-05-19-390). Report prepared for and on file with USFS-LTBMU. South Lake Tahoe.

------1996. Ethnographic Report for North Shore Ecosystems Heritage Resource Report (HRR 05-19-297). Report on file USFS-LTBMU. South Lake Tahoe.

------2001. Ethnographic Element: Chapter 6. In Summer in the Sierras: 6000 Years of Occupation in Bagley Valley. Report prepared for the Carson Field Office of the U.S. D. A. Forest Service, Carson City, Nevada by Summit Envirosolutions, Carson City, Nevada..

Solbrig, Richard. 2003. Personal communication, 9/19/03 (General Manager, STPUD, 530-544-6474). South Lake Tahoe.

Stanowski, John. 2003. Personal communication, 8/25/03 and 9/20/03 (Maintenance Manager, Lake Tahoe Golf course, 530-577-0788. South Lake Tahoe.

Starns, Jean. 2003. Personal communication, 9/2003 (Historian, El Dorado County, 530-333-1070). Georgetown.

Yant, Tom. 2003. Personal communication, 8/28/03 (owns property on Sawmill Road that contains the abandoned dog-leg of Highway 50/89 and is adjacent to CA-Eld-24). Meyers.

III.6 LAND USE, INFRASTRUCTURE AND REGULATORY COMPLIANCE

This section addresses the infrastructure, land use, and regulatory issues related to implementation of UTR restoration projects and potential impact concerns.

III.6.A Infrastructure

BURIED UTILITIES

Figures 3.13A-E show the locations of underground utilities in relation to the Upper Reach Study Area. The river corridor has several types of buried sewer, water and power utility lines.

Most of the trunk lines for STPUD sewer pipelines that service Meyers, Tahoe Paradise and Christmas Valley are located within the UTR river corridor. These are northward flowing gravity lines that are connected to a lift station located on Beecher Avenue, downstream of the South Lake Tahoe Airport. In Reaches 1 through 4 a trunk line parallels the river to the west and north. In most other locations the sewer lines are near streets, however there are several crossings where the line is under the river.

STPUD also has export lines buried under the Highway 50 and 89 corridors. These lines come close to the UTR in several spots.

Figures 3.13A-E also show the location of underground water and power lines.

ROADS

Caltrans maintains Highway 50 and Highway 89, the main thoroughfares in the Study Area. El Dorado County Department of Transportation maintains all paved roads in the subdivisions in Tahoe Paradise development and in Christmas Valley. The LTBMU maintains roads accessing summer cabin tracts in Meyers and Christmas Valley (most of these are unpaved) and the southern end of South Upper Truckee Road between the Highway 89 crossing and the Big Meadow Trailhead. The CDPR maintains roads within the LTGC and Washoe Meadows State Park. All of these agencies are participating in projects to implement retrofit erosion control BMPs. Figure s 2.12A&B show the BMP retrofit projects underway in the Study Area.

III.6B Land Use

LAND OWNERSHIP

The Upper Reach Study Area has a mix of land ownerships, including private, state, and federal. Figure 3.33 shows these various ownerships and local roads. Reaches 1 through 3 are primarily state ownership, whereas ownership along Reaches 6 through 10 is very fragmented with federal and private land alternating along the river corridor.

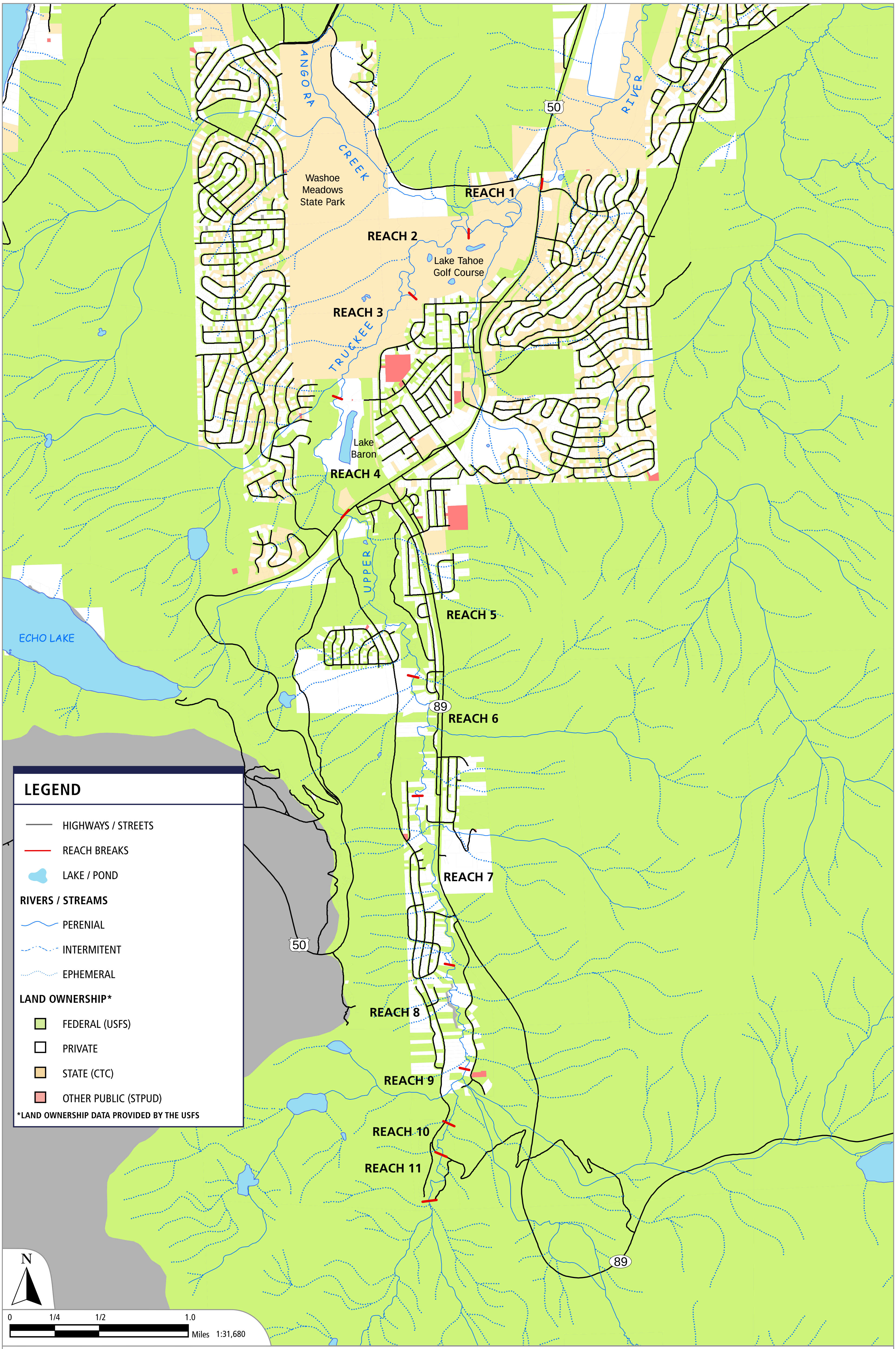


FIGURE 3.33: Map indicating existing land ownership and roads in the Upper Truckee River Watershed.

RECREATION

There are several major recreation areas within the Study Area (Figure 3.33).

CDPR, under contract with US Golf, operates the LTGC, which occupies approximately 125 acres in the lower Study Area. The LTGC offers 18 holes (some which cross over the UTR) and is operated between May and October. During the winter months there have been snowmobile and cross-country skiing concessions on the golf course, but not every year.

CDPR also operates and maintains the Washoe Meadows State Park as a natural preserve. This area encompasses 620 acres and includes much of the river corridor between LTGC and the Meyers Highway 50 crossing. The natural preserve designation limits recreation use to hiking, and local residents often bring their dogs for walks in this area.

Lake Baron and Tahoe Paradise Park are privately owned but open to the public. Facilities offer boating and fishing on Lake Baron, as well as picnic and soccer fields and tennis courts along the east side of the river and tennis courts.

There are numerous informal hiking trails along the banks of the UTR between the upstream end of the LTGC and the Meyers Highway 50 crossing. These are lightly used in the summer months, mostly by local residents in the surrounding subdivisions. Some trails are used for fishing access.

Upstream of Meyers Highway 50 crossing, trails along the banks of the UTR are discontinuous, owing to the fragmented land ownership. Nonetheless, there are long segments of hiking trails immediately along the banks of the river. One private campground is located on the west bank of the river immediately upstream of the Meyers Highway 50 crossing.

The Upper Watershed has a defined trail network for hiking, mountain biking and horse back riding. These are maintained by the LTBMU.

III.6.C Regulatory Compliance

The Lahontan Regional Water Quality Control Board (RWQCB), Tahoe Regional Planning Agency (TRPA), US Army Corps of Engineers, El Dorado County, and California Department of Fish and Game (CDFG), all have permitting authority in the Upper Reach Study Area. Most stream enhancement and restoration projects involve activities within the areas of interest of these authorities, including work in streambed, damming or diversion of streamflow, and work within sensitive habitat areas. Each project requires a lead agency to conduct environmental review, disclosing all of the potential impacts of a project and the measures taken to avoid or reduce impact significance. In the Tahoe Basin, there are local processes that usually involve a Technical Advisory Committee to review plans at several steps leading up to a project, so that designs can reflect the measures deemed necessary to manage impacts.

This project has involved most of the regulatory agencies mentioned above in developing the plan and priority project list. Nearly all of these agencies have programs to enhance and restore the resources that they are also authorized to protect through permitting authority, so there is a high level of cooperation. In addition, projects such as Trout Creek Restoration Project involved construction activities of a similar nature as considered in alternatives herein, and thus there is a good knowledge base of how to manage impacts.

III.6.D Opportunities and Constraints

OPPORTUNITIES

- Most of the Study Area in Reaches 1, 2, 3, 4, 10 and 11 is in public ownership, allowing for ease of access for restoration projects.

CONSTRAINTS

- Some public utility lines are in close proximity of the river corridor, and, in some cases, even cross the UTR river channel. These will require careful consideration and perhaps additional project costs to manage potential impacts.
- Land ownership in Study Area Reaches 5, 6, 7, 8 and 9 is a mix of public and private, making coordinated access for restoration activities difficult.
- The LTGC and WMSP are popular recreation sites. Any extensive restoration projects affecting these sites will have to consider the effects on public recreation.

IV. Alternatives Analysis and Environmental Assessment

The forgoing assessment of historical change and current conditions on the UTR found that present conditions are far below the potential environmental quality. The key problem for any proposed restoration project will be to overcome the effects of channel incision and restore channel stability.

The UTR is presently in a state of responding to past land use through erosion of its channel banks to gain a wider meander belt and higher planform sinuosity. There are sections of the UTR in Reaches 3 and 4 where the bank erosion has restored what appears to be a quasi-stable width of 200 to 250 feet +/- (Figure 4.1) and some bank stability. There are also locations with vertical instability and active headcuts, as discussed in Section III.1.C and shown in Figure 3.15. It is probable that the UTR would continue to expand and erode until the stable width and/or planform is achieved. It is likely that such quasi-stability would reduce sediment input and enhance shoreline habitat. However, the condition achieved would likely occur with the existing incised channel longitudinal profile and the resultant groundwater table would remain well below pre-disturbance elevations, retaining the drying trend in terrace riparian and wetland areas.

The process of developing a "preferred plan" requires analysis of a range of alternatives from no action to restoring the original river to the extent feasible, given land ownership and land use. The alternatives must be evaluated for feasibility, cost, the resultant benefits, environmental impacts, constructability, socio-economic effects and the likelihood of receiving approval from regulatory agencies. The effort to prepare this assessment has involved presentations and consultations with a Technical Advisory Committee (TAC) and the public. This section of the report presents a range of feasible alternatives and an analysis of the costs, benefits and impacts of each. The project reach within the river corridor has been divided into 11 distinct reaches and the alternatives and alternatives analysis has been developed so that each reach can be addressed individually. The alternatives chapter is followed by a chapter of general recommendations designed to move the project forward towards design and implementation.

IV.1 DESCRIPTION OF ALTERNATIVES BY REACH

Five alternatives were identified to present a range of environmental restoration and enhancement options for the mainstem UTR from Elks Club Highway 50 crossing to the upstream end of the USFS Bridge Tract Summer Homes.

1- No Action

No Action Alternative 1 takes existing conditions and projects them into the future, as if no projects will be implemented. This mostly extends existing geomorphic processes of the UTR into the future. This alternative was applied to all reaches for analysis.

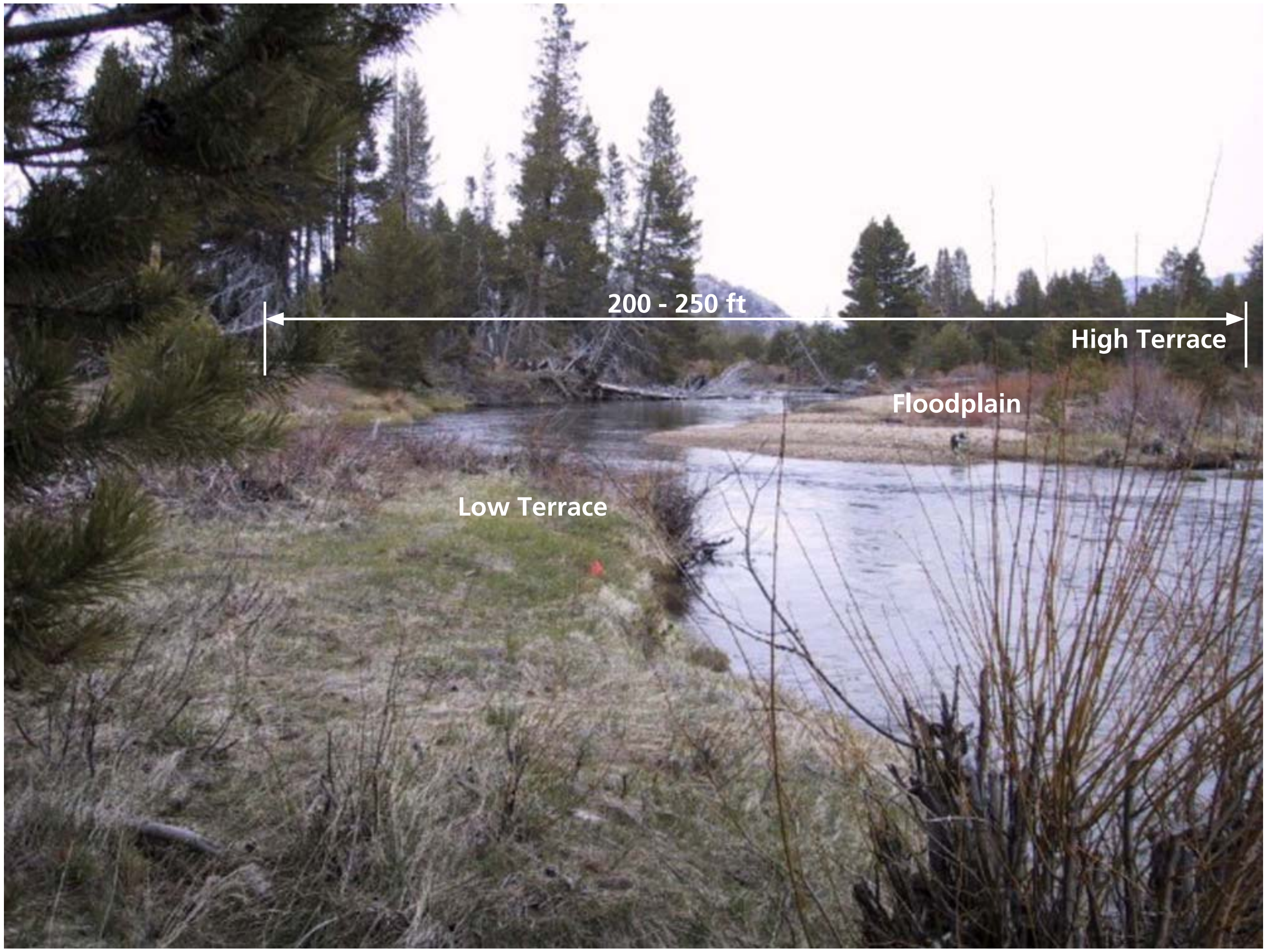


FIGURE 4.1: Photo depicting portion of Upper Truckee River in Reach 3 with wide, quasi-stable channel geometry.

2- Stabilization

Alternative 2 involves a systematic installation of bank protection revetment (rip rap) and grade controls (boulder weirs), incorporating bioengineering with native riparian vegetation to the extent possible. Alternative 2 would use the existing stream channel longitudinal profile and planform. Figures 4.2A-B show typical drawings of the proposed treatments. The areas receiving bank treatment and grade control were selected to achieve system-wide stability and to minimize the risks of outflanking erosion, avulsion or other damage.

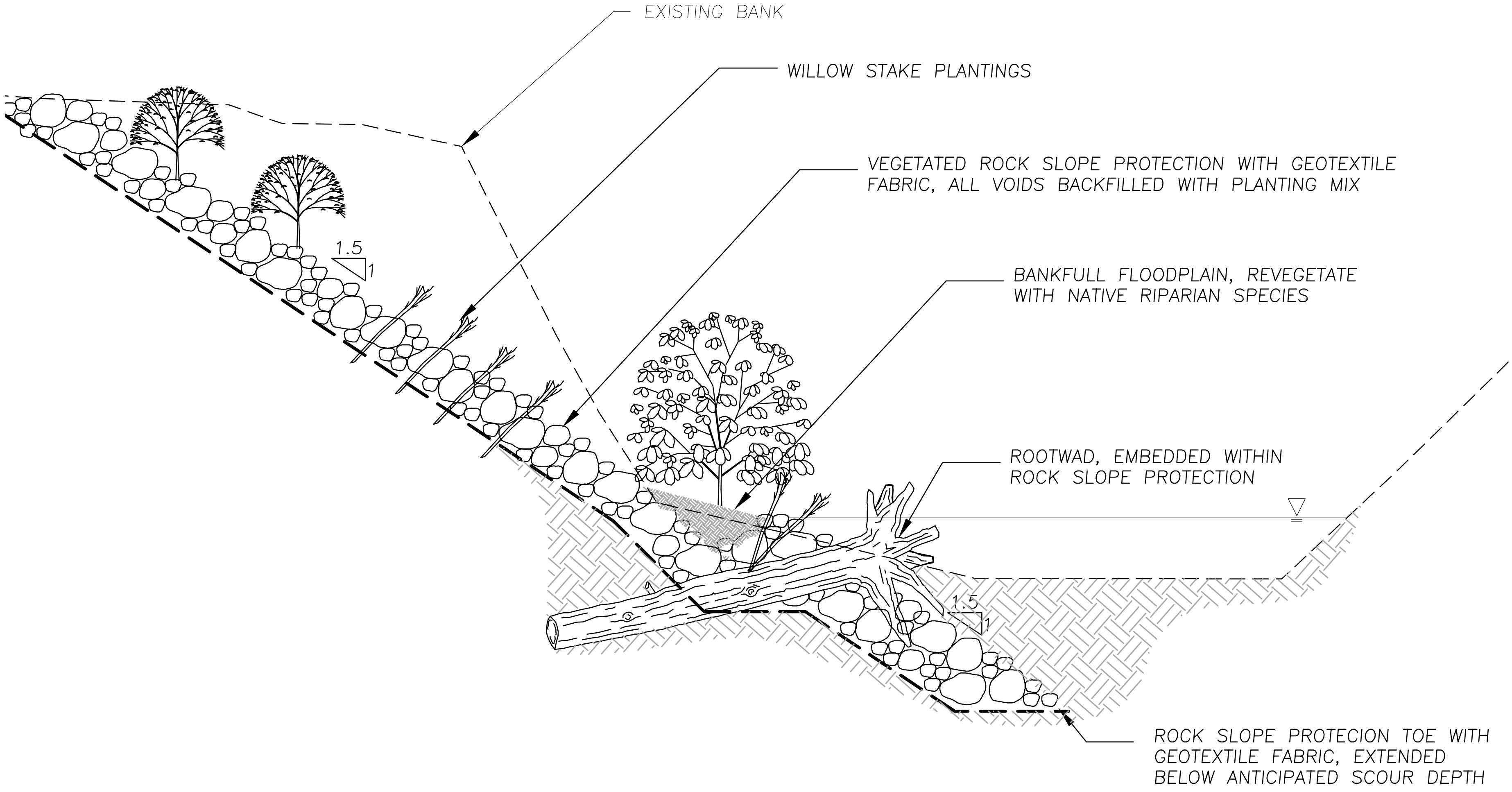
The project would be constructed using heavy equipment (excavators, dump trucks, loaders), which would be brought in through temporary access roads. Several routes on public land are available to gain access to the UTR in Reaches 1 through 4. Access to Reaches 5 through 9 is problematic due to limited physical access and a need for easements and permission across numerous private lands. Alternative 2 would involve an excavation and off-haul of approximately 52,000 yd^3 of alluvial soils and the placement of 157,000 tons of rock slope protection and 11 grade control structures.

3- Floodplain Excavation

Alternative 3 would accelerate the present geomorphic trends toward widening by excavating the banks adjacent to the existing channel down to the elevation of the modern geomorphic floodplain formation (4 feet below terrace on average). Alternative 3 would create a 200-foot wide floodplain and utilize the existing profile and planform. The excavation would occur in two phases: the first would involve the excavation of an area behind the existing banks followed by one or two growing seasons of revegetation, and the second phase would excavate the banks to connect the Phase 1 floodplain to the existing channel.

The project would be constructed using heavy equipment (excavators, dump trucks, loaders), which would be brought in through temporary access roads. Several routes on public land are available to gain access to the UTR in Reaches 1 through 4. Access to Reaches 5 through 9 is problematic due to limited physical access and a need for easements and permission across numerous private lands. Alternative 3 would involve an excavation and off-haul of approximately 350,000 yd^3 of alluvial soils in Reaches 1, 2, 3, and 4.

The need for grade control structures will be specifically determined in more detailed design studies, should this alternative move forward. For the purpose of cost estimation, these structures were assumed to be present in Reaches 1, 2, 3 and 4. In general, extensive grade control structures for Alternative 3 are problematic since the risk of erosion outflanking the structures is quite high, unless they are extended into the terraces. This design would be prohibitively expensive as well as risky, given that the channel is subject to lateral migration.



ROCK SLOPE PROTECTION

N.T.S.

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FIGURE 4.2A: Typical drawing showing vegetated rip rap cross section for proposed Alternative 2.

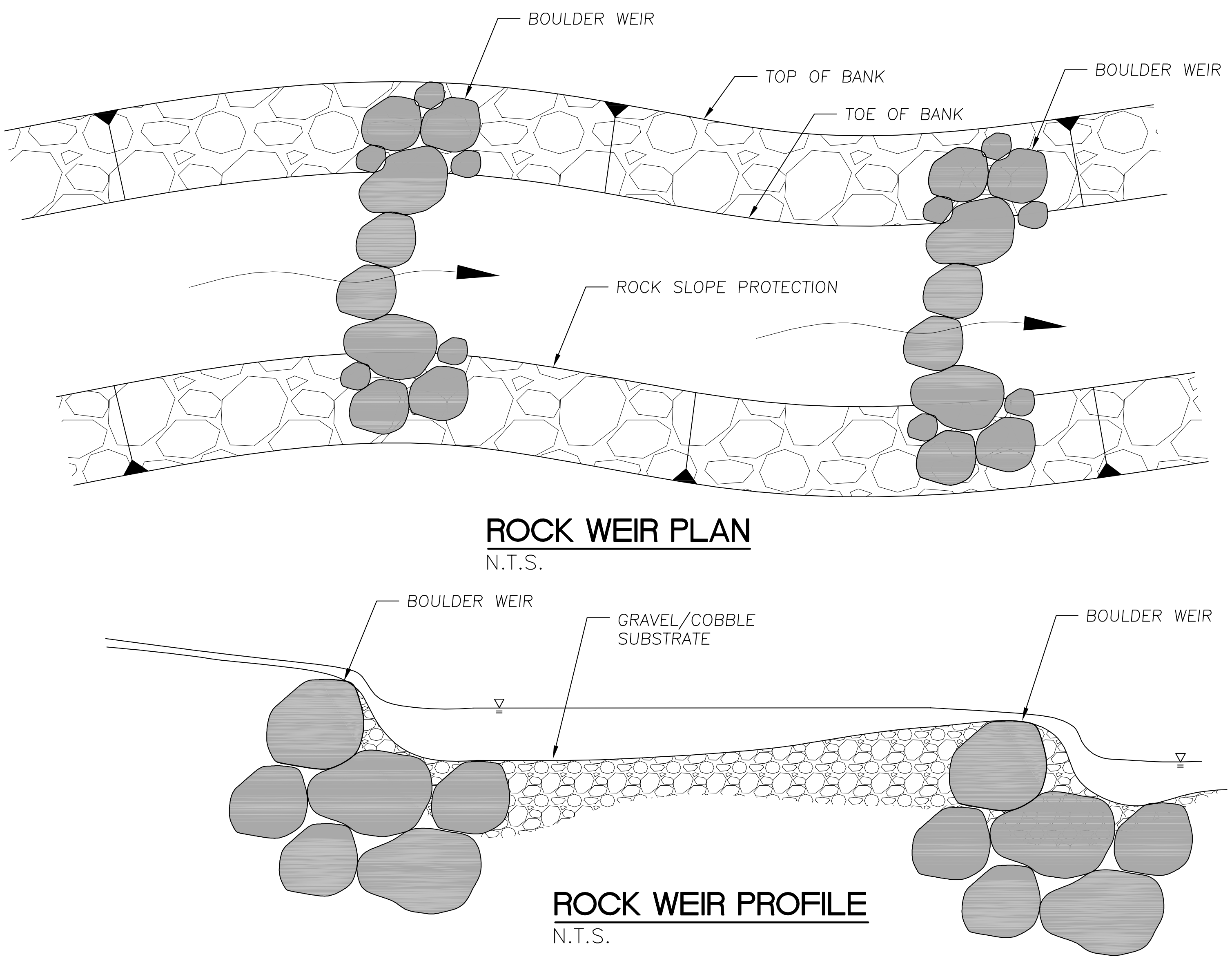

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FIGURE 4.2B: Typical drawing showing rock weir plan and profile for proposed Alternative 2.

4- Restore Original Channel Morphology and Profile

This alternative would reconstruct the original channel and restore the pre-disturbance conditions to the extent possible. Alternative 4 would restore the original profile grade and planform. The new channel would be constructed in segments around the existing channel and revegetated in a first phase of construction. This would be followed in Phase 2 with connecting and watering the new channel, filling the old channel and revegetating exposed areas (similar to the Trout Creek Restoration Project).

The project would be constructed using heavy equipment (excavators, dump trucks, loaders), which would be brought in through temporary access roads. Several routes on public land are available to gain access to the UTR in Reaches 1 through 4. Access to Reaches 5 through 9 is problematic due to limited physical access and a need for easements and permission across numerous private lands. Alternative 4 would involve an excavation of approximately 206,000 yd^3 of alluvial soils and a replacement of approximately 161,000 yd^3 into filling the existing channel. Total off-haul of alluvial soil is approximately 45,000 yd^3.

The concepts of Alternatives 1, 2, 3, and 4 are presented in Figure 4.3

5- Selective Bioengineering and Revegetation

Alternative 5 would involve installation of revegetation and bioengineered bank protection at selective sites with the primary aim to revegetated barren banks and expand the native riparian vegetation corridor. The projects would be low tech and many could be carried out by handcrews using minimal heavy equipment. The projects could also be implemented over short reaches as the alternative does not aim for system-wide stabilization. The types of treatments would be developed on a site-specific basis but could involve one or more of seven bioengineered treatments as presented in Figures 4.4 through 4.8.

IV.2 ALTERNATIVE ANALYSIS

IV.2.A Initial Feasibility Assessment

A first order assessment of alternatives was conducted on a reach-by-reach basis in order to determine preliminary feasibility, costs, impacts and benefits. As a result of this initial appraisal, the following conclusions were drawn.

Reaches 1, 2, 3, and 4 are primarily within public ownership and share similar characteristics as relatively open alluvial stream systems. Historical analysis has revealed that Reaches 1 through 4 share similar channel morphology and loss of planform sinuosity. Given these unified geomorphic characteristics, the majority of publicly owned land, and readily available access, Reaches 1 through 4 lend themselves to system-wide stabilization projects, such as Alternatives 2, 3 and 4.

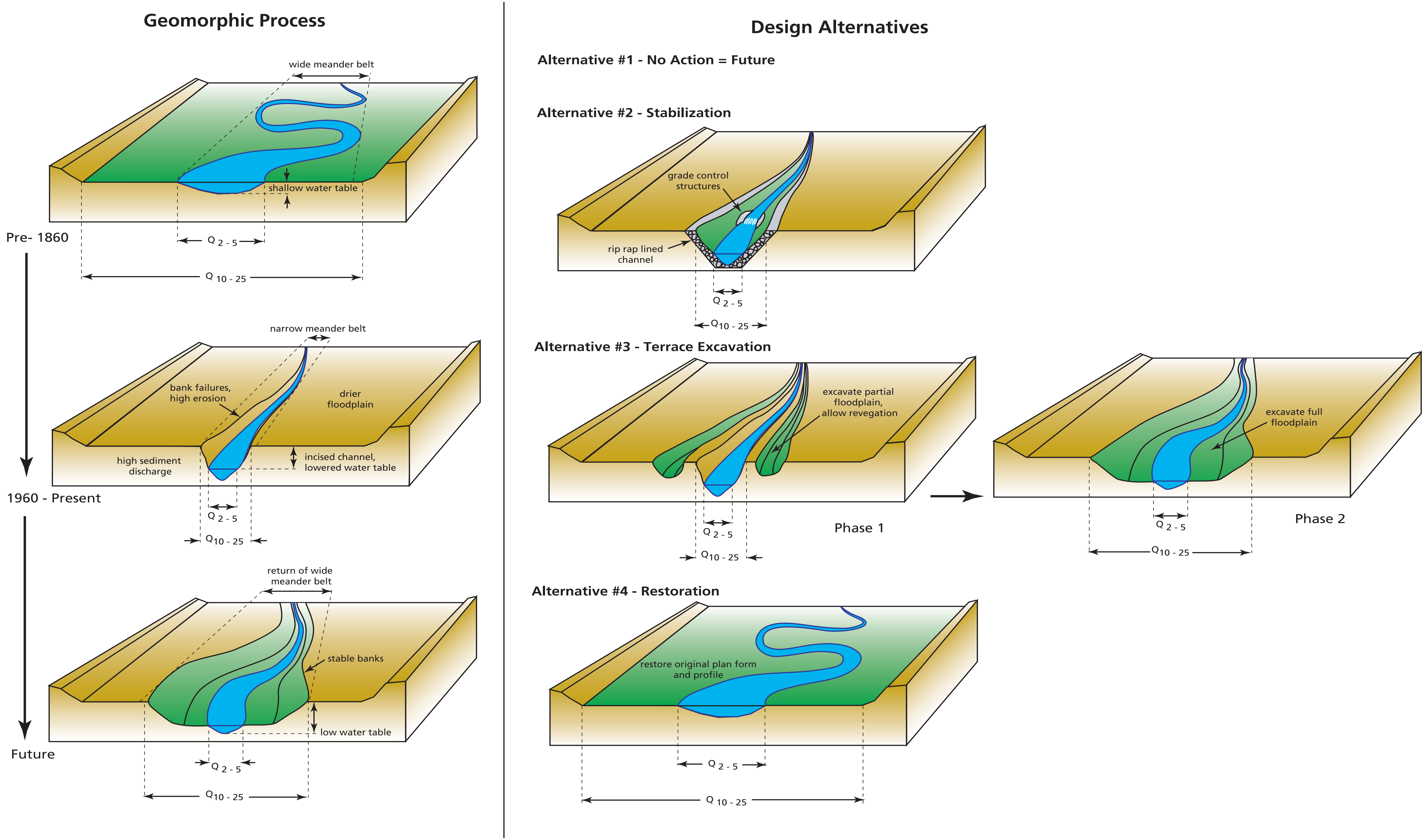

FIGURE 4.3: Conceptual diagrams showing the geomorphic process of the Upper Truckee River over time and proposed Alternatives 1, 2, 3, and 4 for Reaches 1 - 4.

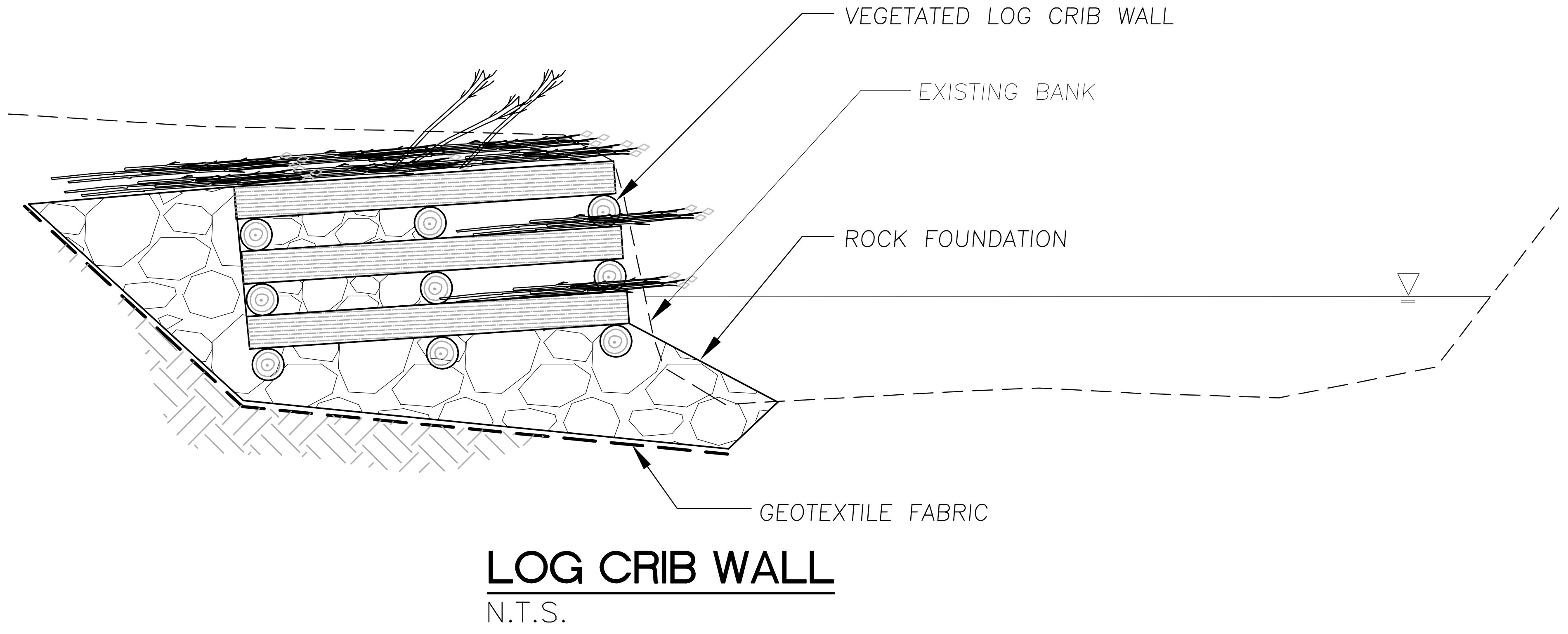

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FIGURE 4.4: Typical drawing showing log crib wall as bioengineered treatment for bank stabilization.

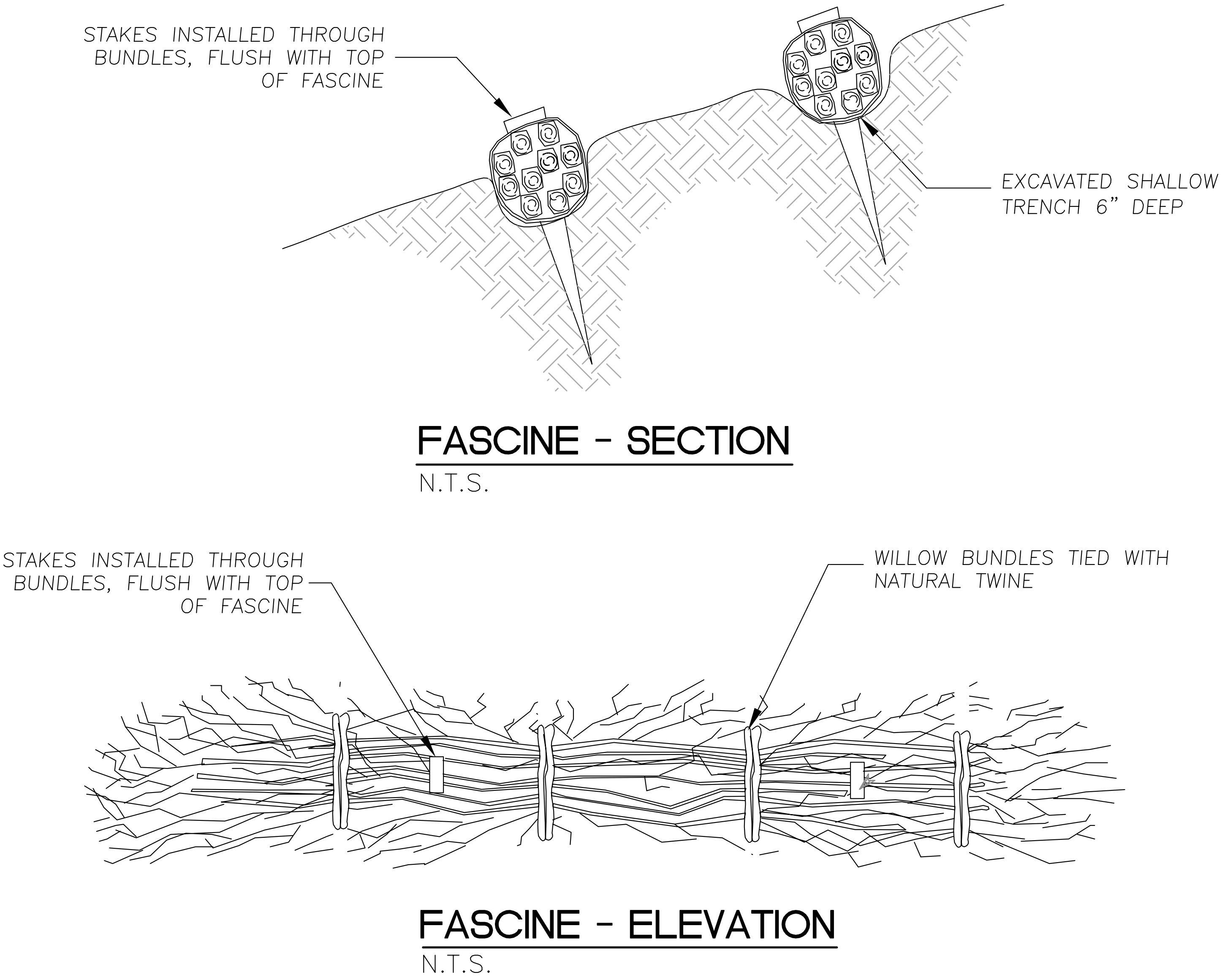

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FIGURE 4.5: Typical drawing showing fascine as bioengineered treatment for bank stabilization.

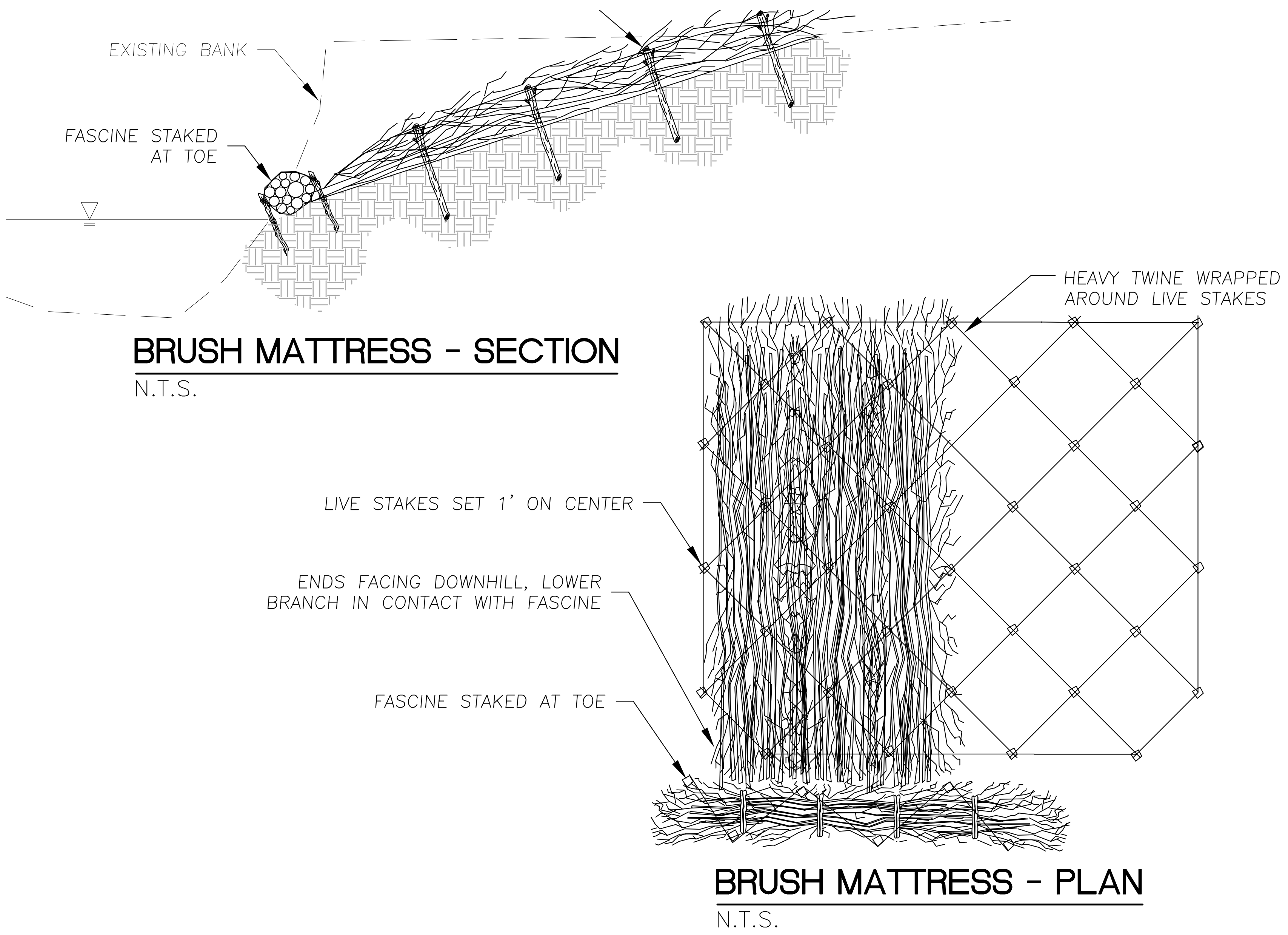

FIGURE 4.6: Typical drawing showing brush mattress as bioengineered treatment for bank stabilization.

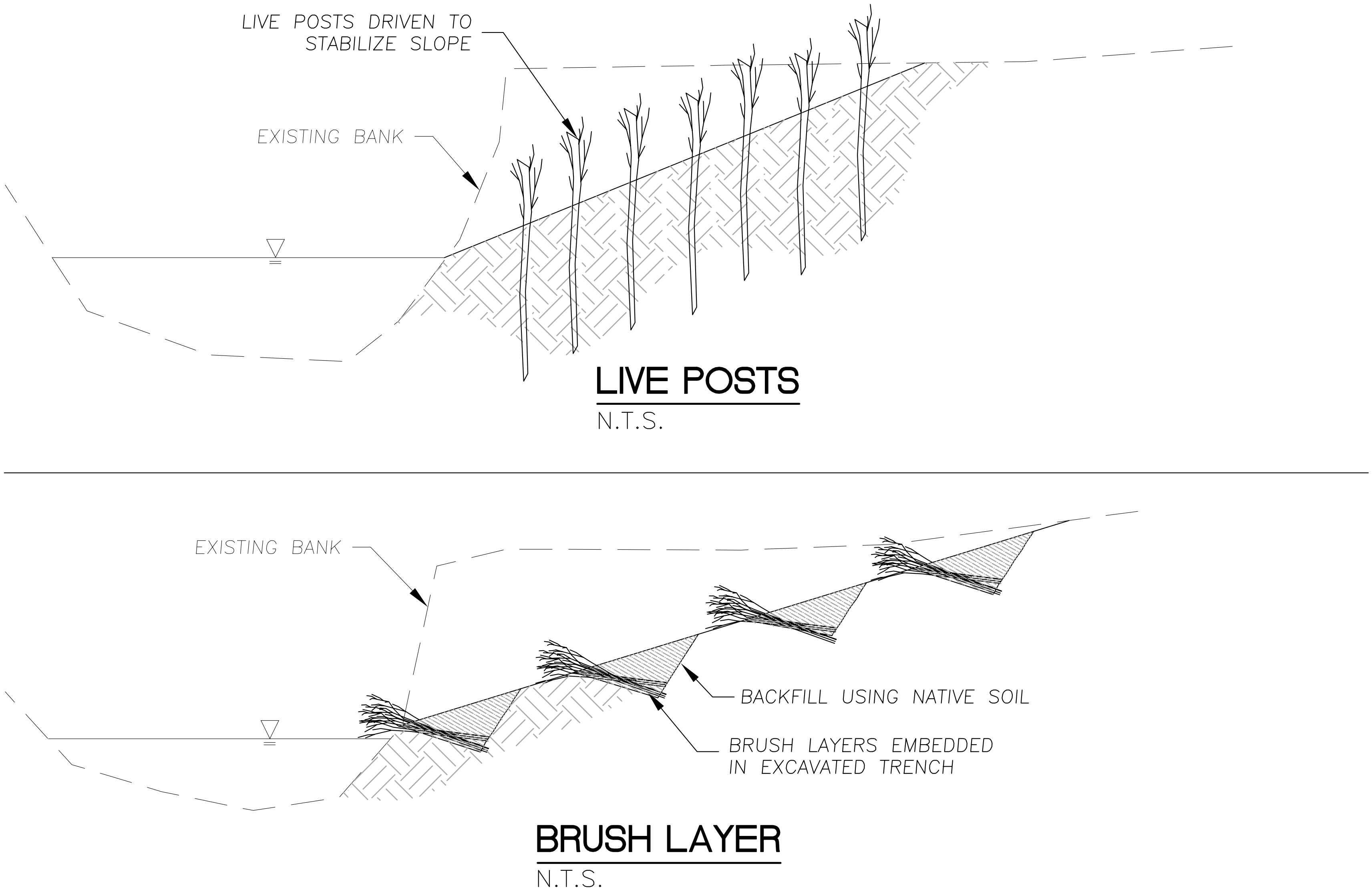

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FIGURE 4.7: Typical drawing showing live posts and brush layering as bioengineered treatment for bank stabilization.

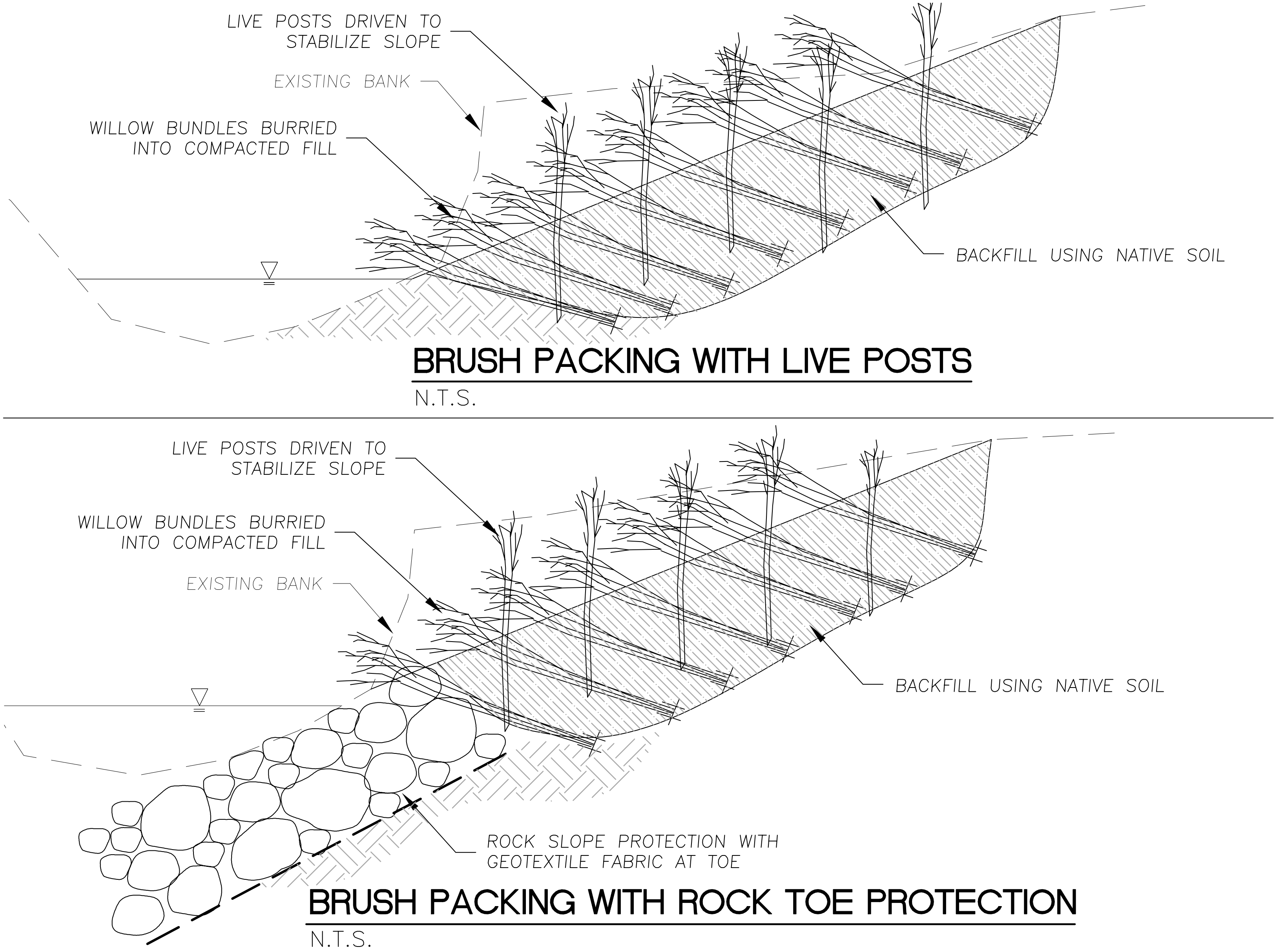

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FIGURE 4.8: Typical drawing showing brush packing with and without rock slope protection at the toe as bioengineered treatment for bank stabilization.

Mixing different alternatives in each reach must be approached with caution, since system-wide stability requires hydraulic and longitudinal profile continuity.

In contrast, Reaches 5 through 9 have multiple land ownerships, difficult access and short reaches of highly degraded stream. Reaches 10 and 11 are in public ownership (USFS LTBMU), but are too small of areas for major reconstruction efforts to have any substantial benefits. In the case of the Reach 11 Bridge Tract, large scale projects that restore original function would greatly increase flooding in areas where cabins are now sited. Thus, Reaches 5 through 11 are not well suited for system-wide major construction alternatives, but rather a site-by-site bank stabilization and revegetation approach more in line with Alternative 5. The need for landowner cooperation also makes small-scale projects appealing since cooperation of all is not necessary to implement projects. For these reasons, Alternatives 2, 3 and 4 were not evaluated further for Reaches 5 through 11, rather a programmatic approach of implementing bioengineered erosion control and revegetation projects appears far more feasible and appropriate. The program would include an intensive design and public involvement process on individual and groups of properties; the details of the recommended program are found in Chapter V.

The No Action Alternative can be applied to all 11 reaches of the Study Area and is compared to the other alternatives below. The analysis presented below is strictly focused on conditions in the UTR river corridor, however recommendations are presented for the Upper Watershed in Chapter V.

IV.2.B Cost Estimates

Estimated project costs for Alternatives 2, 3, 4 and 5 were developed for Reaches 1 through 4. A summary of the results is presented in Table 4.1; a full detailed preliminary engineering cost estimate for Alternatives 2, 3, and 4 is presented in Tables 4.2-4.4

Table 4.1: Summary of cost per reach for Alternatives 2, 3, and 4.

	Alternative 2	Alternative 3	Alternative 4
Reach 1	$3,410,016	$2,268,658	$4,396,722
Reach 2	$6,717,008	$3,484,210	$4,080,116
Reach 3	$5,532,520	$2,275,578	$5,066,964
Reach 4	$5,159,495	$5,427,742	$5,187,890
Total	$22,900,943	$14,801,807	$18,731,692

In order to develop an implementation cost for each of the 11 reaches, a melded average per linear foot cost was developed for seven potential stabilization/revegetation treatments and applied to all of the banks rated with a high, very high, and extreme erosion hazard. This resultant cost estimate per reach is presented in Table 4.5.

Table 4.2: Cost of Proposed Alternative 2 by Reach

REACH	ACTION	QUANTITY	UNITS	UNIT COST	ITEM TOTALS
REACH 1	CLEARING AND GRUBBING	2	ACRE	$9,500	$15,790
	TREE REMOVAL	16	EA	$500	$8,000
	SITE PROTECTION FENCING	3620	LF	$4	$14,480
	NATIVE CUT	8492	CY	$18	$152,847
	NATIVE FILL	0	CY	$18	$0
	OFFHAUL OF SOIL	8492	CY	$6	$50,949
	IMPORT OF SOIL	0	CY	$6	$0
	ROCK SLOPE PROTECTION	25474	TONS	$85	$2,165,290
	ROOT WAD STRUCTURES	72	EA	$800	$57,920
	TEMPORARY ACCESS, WATERING, DUST CONTROL	1685	LF	$40	$67,400
	DRAINAGE IMPROVEMENTS	3620	LF	$4	$14,480
	CONSTRUCTION STAKING	3620	LF	$8	$28,960
	UTILITY RELOCATION	1	LS	$0	$0
	REVEGETATION	1	LS	$56,400	$56,400
	EROSION CONTROL	2	ACRE	$12,000	$24,000
	GRADE CONTROL STRUCTURE	2	EA	$60,000	$120,000
	TEMPORARY FLOW DIVERSION	3620	LF	$175	$633,500
			SUBTOTAL		**$3,410,016**
REACH 2	CLEARING AND GRUBBING	3	ACRE	$9,500	$29,573
	TREE REMOVAL	55	EA	$500	$27,500
	SITE PROTECTION FENCING	6780	LF	$4	$27,120
	NATIVE CUT	16368	CY	$18	$294,615
	NATIVE FILL	0	CY	$18	$0
	OFFHAUL OF SOIL	16368	CY	$6	$98,205
	IMPORT OF SOIL	0	CY	$6	$0
	ROCK SLOPE PROTECTION	49103	TONS	$85	$4,173,755
	ROOT WAD STRUCTURES	136	EA	$800	$108,480
	TEMPORARY ACCESS, WATERING, DUST CONTROL	3300	LF	$40	$132,000
	DRAINAGE IMPROVEMENTS	6780	LF	$4	$27,120
	CONSTRUCTION STAKING	6780	LF	$8	$54,240
	UTILITY RELOCATION	1	LS	$0	$0
	REVEGETATION	1	LS	$101,900	$101,900
	EROSION CONTROL	3	ACRE	$12,000	$36,000
	GRADE CONTROL STRUCTURE	7	EA	$60,000	$420,000
	TEMPORARY FLOW DIVERSION	6780	LF	$175	$1,186,500
			SUBTOTAL		**$6,717,008**
REACH 3	CLEARING AND GRUBBING	3	ACRE	$9,500	$27,043
	TREE REMOVAL	36	EA	$500	$18,000
	SITE PROTECTION FENCING	6200	LF	$4	$24,800
	NATIVE CUT	14121	CY	$18	$254,169
	NATIVE FILL	0	CY	$18	$0
	OFFHAUL OF SOIL	14121	CY	$6	$84,723
	IMPORT OF SOIL	0	CY	$6	$0
	ROCK SLOPE PROTECTION	42361	TONS	$85	$3,600,685
	ROOT WAD STRUCTURES	124	EA	$800	$99,200
	TEMPORARY ACCESS, WATERING, DUST CONTROL	1640	LF	$40	$65,600
	DRAINAGE IMPROVEMENTS	6200	LF	$4	$24,800
	CONSTRUCTION STAKING	6200	LF	$8	$49,600
	UTILITY RELOCATION/PROTECTION	1	LS	$10,000	$10,000
	REVEGETATION	1	LS	$92,900	$92,900
	EROSION CONTROL	3	ACRE	$12,000	$36,000
	GRADE CONTROL STRUCTURE	1	EA	$60,000	$60,000
	TEMPORARY FLOW DIVERSION	6200	LF	$175	$1,085,000
			SUBTOTAL		**$5,532,520**
REACH 4	CLEARING AND GRUBBING	3	ACRE	$9,500	$23,946
	TREE REMOVAL	50	EA	$500	$25,000
	SITE PROTECTION FENCING	5490	LF	$4	$21,960
	NATIVE CUT	13254	CY	$18	$238,563
	NATIVE FILL	0	CY	$18	$0
	OFFHAUL OF SOIL	13254	CY	$6	$79,521
	IMPORT OF SOIL	0	CY	$6	$0
	ROCK SLOPE PROTECTION	39761	TONS	$85	$3,379,685
	ROOT WAD STRUCTURES	110	EA	$800	$87,840
	TEMPORARY ACCESS, WATERING, DUST CONTROL	1950	LF	$40	$78,000
	DRAINAGE IMPROVEMENTS	5490	LF	$4	$21,960
	CONSTRUCTION STAKING	5490	LF	$8	$43,920
	UTILITY RELOCATION/PROTECTION	1	LS	$20,000	$20,000
	REVEGETATION	1	LS	$82,350	$82,350
	EROSION CONTROL	3	ACRE	$12,000	$36,000
	GRADE CONTROL STRUCTURE	1	EA	$60,000	$60,000
	TEMPORARY FLOW DIVERSION	5490	LF	$175	$960,750
			SUBTOTAL		**$5,159,495**
			TOTAL		**$20,819,039**
			CONTINGENCIES		**$2,081,904**
			GRAND TOTAL		**$22,900,943**

Table 4.2: Detailed cost estimate of Alternative 2 for Reaches 1 - 4.

Table 4.3: Cost of Proposed Alternative 3 by Reach

REACH	ACTION	QUANTITY	UNITS	UNIT COST	ITEM TOTALS
REACH 1	CLEARING AND GRUBBING	9	ACRE	$7,000	$64,400
	SITE PROTECTION FENCING	3600	LF	$4	$14,400
	DEMOLITION	1	LS	$55,500	$55,500
	NATIVE CUT	42231	CY	$12	$506,772
	NATIVE FILL	0	CY	$18	$0
	OFFHAUL OF SOIL	42231	CY	$6	$253,386
	IMPORT OF SOIL	0	CY	$6	$0
	TEMPORARY ACCESS, WATERING, DUST CONTROL	270	LF	$40	$10,800
	DRAINAGE IMPROVEMENTS	3600	LF	$4	$14,400
	CONSTRUCTION STAKING	3600	LF	$10	$36,000
	UTILITY RELOCATION	1	LS	$250,000	$250,000
	REVEGETATION	9	ACRE	$52,000	$468,000
	EROSION CONTROL	9	ACRE	$7,000	$63,000
	TEMPORARY FLOW DIVERSION	1	LS	$50,000	$50,000
	PHASE 1 FLUSHING / IRRIGATION	1	LS	$50,000	$50,000
	WOODY DEBRIS STRUCTURES	3600	LF	$120	$432,000
			SUBTOTAL		**$2,268,658**
REACH 2	CLEARING AND GRUBBING	17	ACRE	$9,500	$160,550
	SITE PROTECTION FENCING	4186	LF	$4	$16,744
	DEMOLITION	1	LS	$111,250	$111,250
	NATIVE CUT	82319	CY	$12	$987,828
	NATIVE FILL	0	CY	$18	$0
	OFFHAUL OF SOIL	82319	CY	$6	$493,914
	IMPORT OF SOIL	0	CY	$6	$0
	TEMPORARY ACCESS, WATERING, DUST CONTROL	1000	LF	$40	$40,000
	DRAINAGE IMPROVEMENTS	4186	LF	$4	$16,744
	CONSTRUCTION STAKING	4186	LF	$10	$41,860
	UTILITY RELOCATION	1	LS	$10,000	$10,000
	REVEGETATION	17	ACRE	$52,000	$884,000
	EROSION CONTROL	17	ACRE	$7,000	$119,000
	TEMPORARY FLOW DIVERSION	1	LS	$50,000	$50,000
	PHASE 1 FLUSHING / IRRIGATION	1	LS	$50,000	$50,000
	WOODY DEBRIS STRUCTURES	4186	LF	$120	$502,320
			SUBTOTAL		**$3,484,210**
REACH 3	CLEARING AND GRUBBING	9	ACRE	$9,500	$81,510
	SITE PROTECTION FENCING	4278	LF	$4	$17,112
	DEMOLITION	0	LS	$20,000	$0
	NATIVE CUT	49178	CY	$12	$590,136
	NATIVE FILL	0	CY	$18	$0
	OFFHAUL OF SOIL	49178	CY	$6	$295,068
	IMPORT OF SOIL	0	CY	$6	$0
	TEMPORARY ACCESS, WATERING, DUST CONTROL	1750	LF	$40	$70,000
	DRAINAGE IMPROVEMENTS	4278	LF	$4	$17,112
	CONSTRUCTION STAKING	4278	LF	$10	$42,780
	UTILITY RELOCATION / PROTECTION	1	LS	$17,500	$17,500
	REVEGETATION	9	ACRE	$52,000	$468,000
	EROSION CONTROL	9	ACRE	$7,000	$63,000
	TEMPORARY FLOW DIVERSION	1	LS	$50,000	$50,000
	PHASE 1 FLUSHING / IRRIGATION	1	LS	$50,000	$50,000
	WOODY DEBRIS STRUCTURES	4278	LF	$120	$513,360
			SUBTOTAL		**$2,275,578**
REACH 4	CLEARING AND GRUBBING	21	ACRE	$9,500	$199,500
	SITE PROTECTION FENCING	4620	LF	$4	$18,480
	DEMOLITION	0	LS	$20,000	$0
	NATIVE CUT	175649	CY	$12	$2,107,788
	NATIVE FILL	0	CY	$18	$0
	OFFHAUL OF SOIL	175649	CY	$6	$1,053,894
	IMPORT OF SOIL	0	CY	$6	$0
	TEMPORARY ACCESS, WATERING, DUST CONTROL	1000	LF	$40	$40,000
	DRAINAGE IMPROVEMENTS	4620	LF	$4	$18,480
	CONSTRUCTION STAKING	4620	LF	$10	$46,200
	UTILITY RELOCATION / PROTECTION	1	LS	$50,000	$50,000
	REVEGETATION	21	ACRE	$52,000	$1,092,000
	EROSION CONTROL	21	ACRE	$7,000	$147,000
	TEMPORARY FLOW DIVERSION	1	LS	$50,000	$50,000
	PHASE 1 FLUSHING / IRRIGATION	1	LS	$50,000	$50,000
	WOODY DEBRIS STRUCTURES	4620	LF	$120	$554,400
			SUBTOTAL		**$5,427,742**

TOTAL	**$13,456,188**
CONTINGENCIES	**$1,345,619**
GRAND TOTAL	**$14,801,807**

Table 4.3: Detailed cost estimate of Alternative 3 for Reaches 1 - 4. Note: Estimates do not include costs associated with land use alterations.

Table 4.4: Cost of Proposed Alternative 4 by Reach

REACH	ACTION	QUANTITY	UNITS	UNIT COST	ITEM TOTALS
REACH 1	CLEARING AND GRUBBING	22	ACRE	$7,000	$154,000
	SITE PROTECTION FENCING	6800	LF	$4	$27,200
	DEMOLITION	1	LS	$100,000	$100,000
	NATIVE CUT	46212	CY	$18	$831,816
	NATIVE FILL	41581	CY	$20	$831,620
	OFFHAUL OF SOIL	4631	CY	$6	$27,786
	IMPORT OF SOIL	0	CY	$6	$0
	TEMPORARY ACCESS, WATERING, DUST CONTROL	7200	LF	$40	$288,000
	DRAINAGE IMPROVEMENTS	6800	LF	$4	$27,200
	CONSTRUCTION STAKING	6800	LF	$12	$81,600
	UTILITY RELOCATION / PROTECTION	1	LS	$235,000	$235,000
	REVEGETATION	25	ACRE	$13,000	$325,000
	EROSION CONTROL	25	ACRE	$7,000	$175,000
	TEMPORARY FLOW DIVERSION	1	LS	$180,000	$180,000
	IMPORTED RIFFLE SUBSTRATE	15450	CY	$50	$772,500
	WOODY DEBRIS STRUCTURES	1	LS	$136,000	$136,000
	BANK AND FLOODPLAIN ARMORING	6800	LF	$30	$204,000
			SUBTOTAL		**$4,396,722**
REACH 2	CLEARING AND GRUBBING	19	ACRE	$9,500	$180,500
	SITE PROTECTION FENCING	7175	LF	$4	$28,700
	DEMOLITION	1	LS	$130,000	$130,000
	NATIVE CUT	45913	CY	$18	$826,434
	NATIVE FILL	29041	CY	$20	$580,820
	OFFHAUL OF SOIL	16872	CY	$6	$101,232
	IMPORT OF SOIL	0	CY	$20	$0
	TEMPORARY ACCESS, WATERING, DUST CONTROL	8372	LF	$40	$334,880
	DRAINAGE IMPROVEMENTS	7175	LF	$4	$28,700
	CONSTRUCTION STAKING	7175	LF	$12	$86,100
	UTILITY RELOCATION	1	LS	$0	$0
	REVEGETATION	20	ACRE	$13,000	$260,000
	EROSION CONTROL	20	ACRE	$7,000	$140,000
	TEMPORARY FLOW DIVERSION	1	LS	$209,000	$209,000
	IMPORTED RIFFLE SUBSTRATE	16300	CY	$50	$815,000
	WOODY DEBRIS STRUCTURES	1	LS	$143,500	$143,500
	BANK AND FLOODPLAIN ARMORING	7175	LF	$30	$215,250
			SUBTOTAL		**$4,080,116**
REACH 3	CLEARING AND GRUBBING	28	ACRE	$9,500	$266,000
	SITE PROTECTION FENCING	7210	LF	$4	$28,840
	DEMOLITION	1	LS	$20,000	$20,000
	NATIVE CUT	41941	CY	$18	$754,938
	NATIVE FILL	50682	CY	$20	$1,013,640
	OFFHAUL OF SOIL	0	CY	$6	$0
	IMPORT OF SOIL	8741	CY	$6	$52,446
	TEMPORARY ACCESS, WATERING, DUST CONTROL	8556	LF	$40	$342,240
	DRAINAGE IMPROVEMENTS	7210	LF	$4	$28,840
	CONSTRUCTION STAKING	7210	LF	$12	$86,520
	UTILITY RELOCATION/PROTECTION	1	LS	$460,000	$460,000
	REVEGETATION	31	ACRE	$13,000	$403,000
	EROSION CONTROL	31	ACRE	$7,000	$217,000
	TEMPORARY FLOW DIVERSION	1	LS	$214,000	$214,000
	IMPORTED RIFFLE SUBSTRATE	16380	CY	$50	$819,000
	WOODY DEBRIS STRUCTURES	1	LS	$144,200	$144,200
	BANK AND FLOODPLAIN ARMORING	7210	LF	$30	$216,300
			SUBTOTAL		**$5,066,964**
REACH 4	CLEARING AND GRUBBING	24	ACRE	$9,500	$228,000
	SITE PROTECTION FENCING	7435	LF	$4	$29,740
	DEMOLITION	1	LS	$20,000	$20,000
	NATIVE CUT	71670	CY	$18	$1,290,060
	NATIVE FILL	39729	CY	$20	$794,580
	OFFHAUL OF SOIL	23200	CY	$6	$139,200
	IMPORT OF SOIL	0	CY	$6	$0
	TEMPORARY ACCESS, WATERING, DUST CONTROL	9240	LF	$40	$369,600
	DRAINAGE IMPROVEMENTS	7435	LF	$4	$29,740
	CONSTRUCTION STAKING	7435	LF	$12	$89,220
	UTILITY RELOCATION/PROTECTION	1	LS	$210,000	$210,000
	REVEGETATION	27	ACRE	$13,000	$351,000
	EROSION CONTROL	27	ACRE	$7,000	$189,000
	TEMPORARY FLOW DIVERSION	1	LS	$231,000	$231,000
	IMPORTED RIFFLE SUBSTRATE	16900	CY	$50	$845,000
	WOODY DEBRIS STRUCTURES	1	LS	$148,700	$148,700
	BANK AND FLOODPLAIN ARMORING	7435	LF	$30	$223,050
			SUBTOTAL		**$5,187,890**
			TOTAL		**$18,731,692**

Table 4.4: Detailed cost estimate of Alternative 4 for Reaches 1 - 4. Note: Estimates do not include costs associated with land use alterations.

Table 4.5: Summary of costs per reach for Alternative 5.

	Ownership	Total Length of Bank Protection (ft)	Avg. Cost per linear foot	Total Cost
Reach 5	Mixed	11786	$220	$2,592,920
Reach 6	Mixed	7827	$220	$1,721,940
Reach 7	Mixed	8508	$220	$1,871,760
Reach 8	Mixed	6904	$220	$1,518,880
Reach 9	Mixed	1506	$220	$331,320
Reach 10	USFS	2476	$220	$544,720
Reach 11	USFS	1650	$220	$363,000
			Combined Total	**$8,944,540**

IV.2.C Alternatives Assessment Reaches 1 through 4

Alternatives 1 through 5 were assessed for Reaches 1 through 4 by discipline area (geomorphology, water quality, hydrology, construction impacts, vegetation and wetlands, terrestrial wildlife, aquatic wildlife and habitat, cultural resources, and infrastructure, land use and regulatory compliance). Table 4.6 is a matrix of the effects of each alternative by discipline areas.

Figures 4.9 through 4.13 present conceptual plans for Alternatives 2, 3, and 4 overlain onto a current aerial photograph for Reaches 1 through 4, respectively. These figures show the proposed areas of rip rap and bank protection placement for Alternative 2, the area of floodplain excavation for Alternative 3, and the original channel planform, which is the assumed reconstructed channel for Alternative 4. The estimated areas for Alternative 5 projects are drawn from site specific, linear foot bank stability ratings presented in Section III.1.C.

Table 4.6: Matrix of effects of alternatives on various resource disciplines.

Discipline	Alternative					
	No Action	2	3	4	5 (Reaches 1-4)	5 (Reaches 5-11)
Geomorphology	-	+	++	++	+	++
Water Quality	-	+	++	++	+	++
Hydrology	0	0	+	++	0	0
Vegetation and Wetlands	-	+	++	++	0	+
Terrestrial Wildlife	-	-	++	++	-	+
Aquatic Wildlife and Habitat	0	+	++	++	0	+
Cultural Resources	0	0	0	0	0	0
Infrastructure	0	++	-	--	0	0
Land Use	0	0	--	--	0	0
Ease of Regulatory Compliance	N/a	--	--	--	-	-
Short-term Construction Impacts	N/a	--	--	--	0	-

++ : very significant improvement	- : degradation
+ : significant improvement	-- : significant degradation
0 : neutral	

Alternative #1 - No Action

Alternative #2- Provide Rip Rap Protection along banks and Grade Control in channel.

= proposed Rip Rap

= proposed Grade Control

Alternative #3- Excavate incised banks to create Floodplain Terraces.

= proposed Floodplain Terraces

Alternative #4- Restore channel to its original planform and profile. Fill existing channel.

= proposed Channel Alignment

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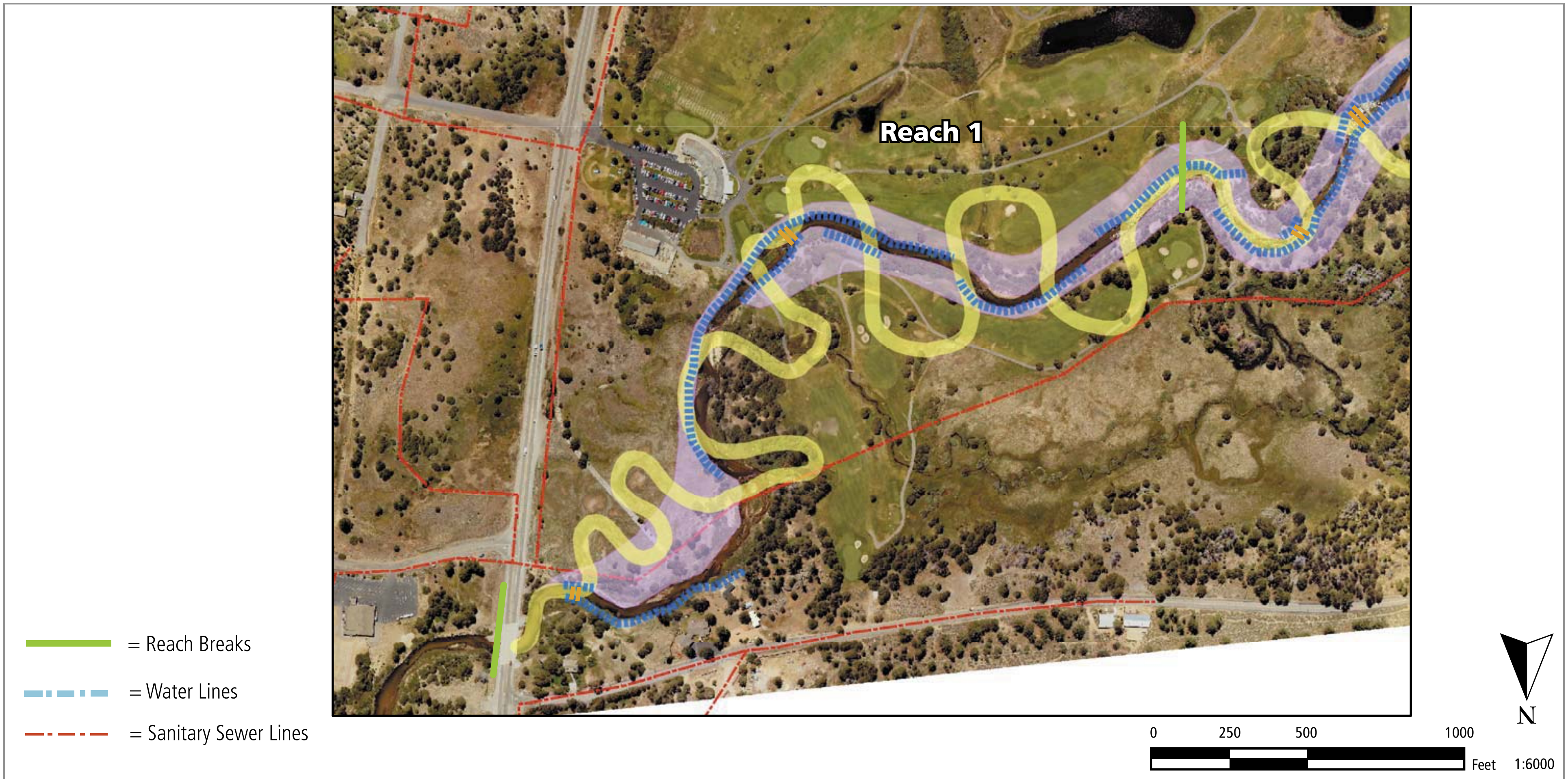
FIGURE 4.9: Design alternatives for Reaches 1- 4.



Alternative #1 - No Action

Alternative #2- Provide Rip Rap Protection along banks and Grade Control in channel.

= proposed Rip Rap

= proposed Grade Control

Alternative #3- Excavate incised banks to create Floodplain Terraces.

= proposed Floodplain Terraces

Alternative #4- Restore channel to its original planform and profile. Fill existing channel.

= proposed Channel Alignment

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FIGURE 4.10: Design alternatives for Reach 1.

Alternative #1 - No Action

Alternative #2- Provide Rip Rap Protection along banks and Grade Control in channel.

= proposed Rip Rap

= proposed Grade Control

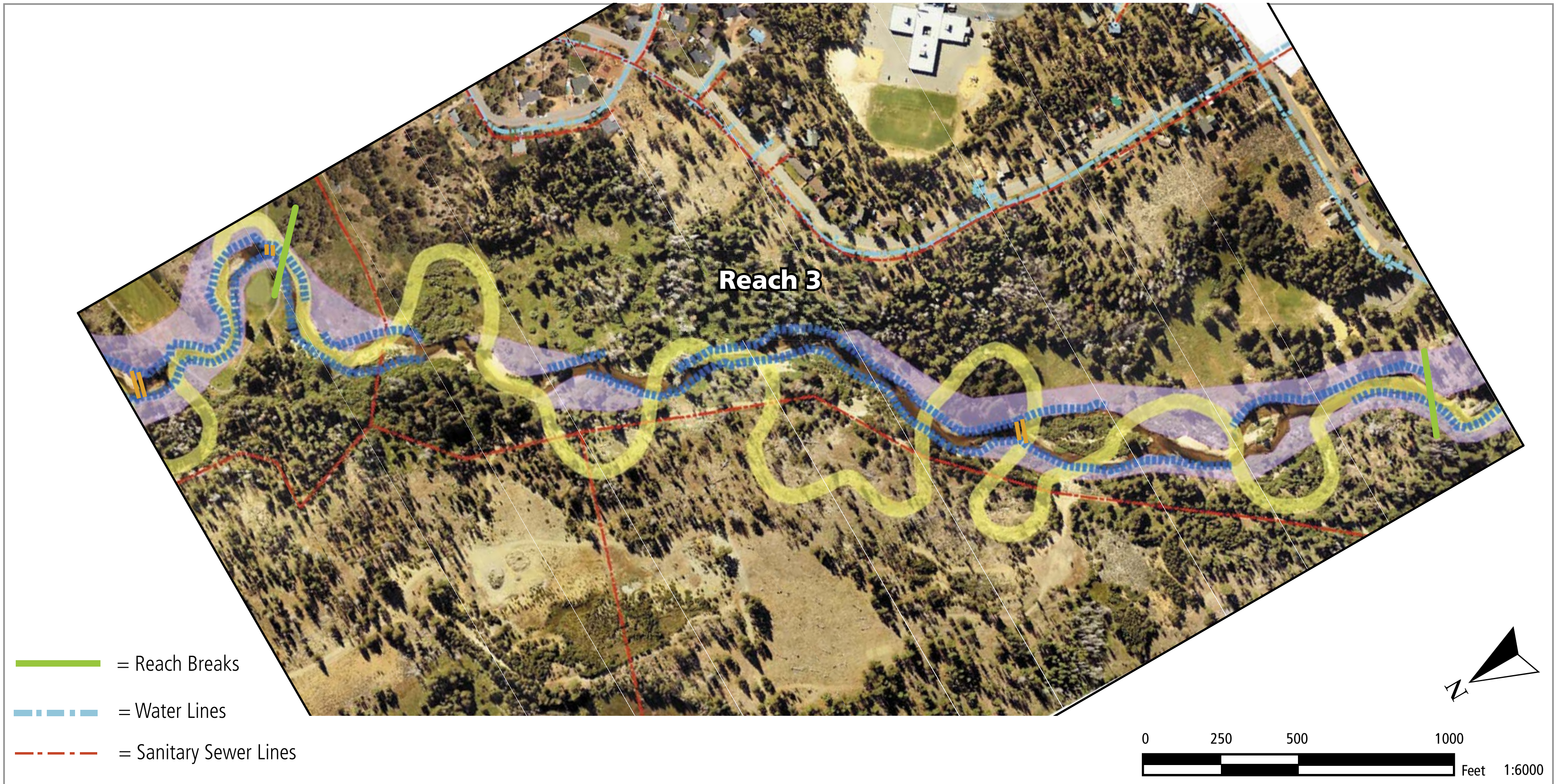
Alternative #3- Excavate incised banks to create Floodplain Terraces.

= proposed Floodplain Terraces

Alternative #4- Restore channel to its original planform and profile. Fill existing channel.

= proposed Channel Alignment

FIGURE 4.11: Design alternatives for Reach 2.



Alternative #1 - No Action

Alternative #2- Provide Rip Rap Protection along banks and Grade Control in channel.

▮▮▮ = proposed Rip Rap

// = proposed Grade Control

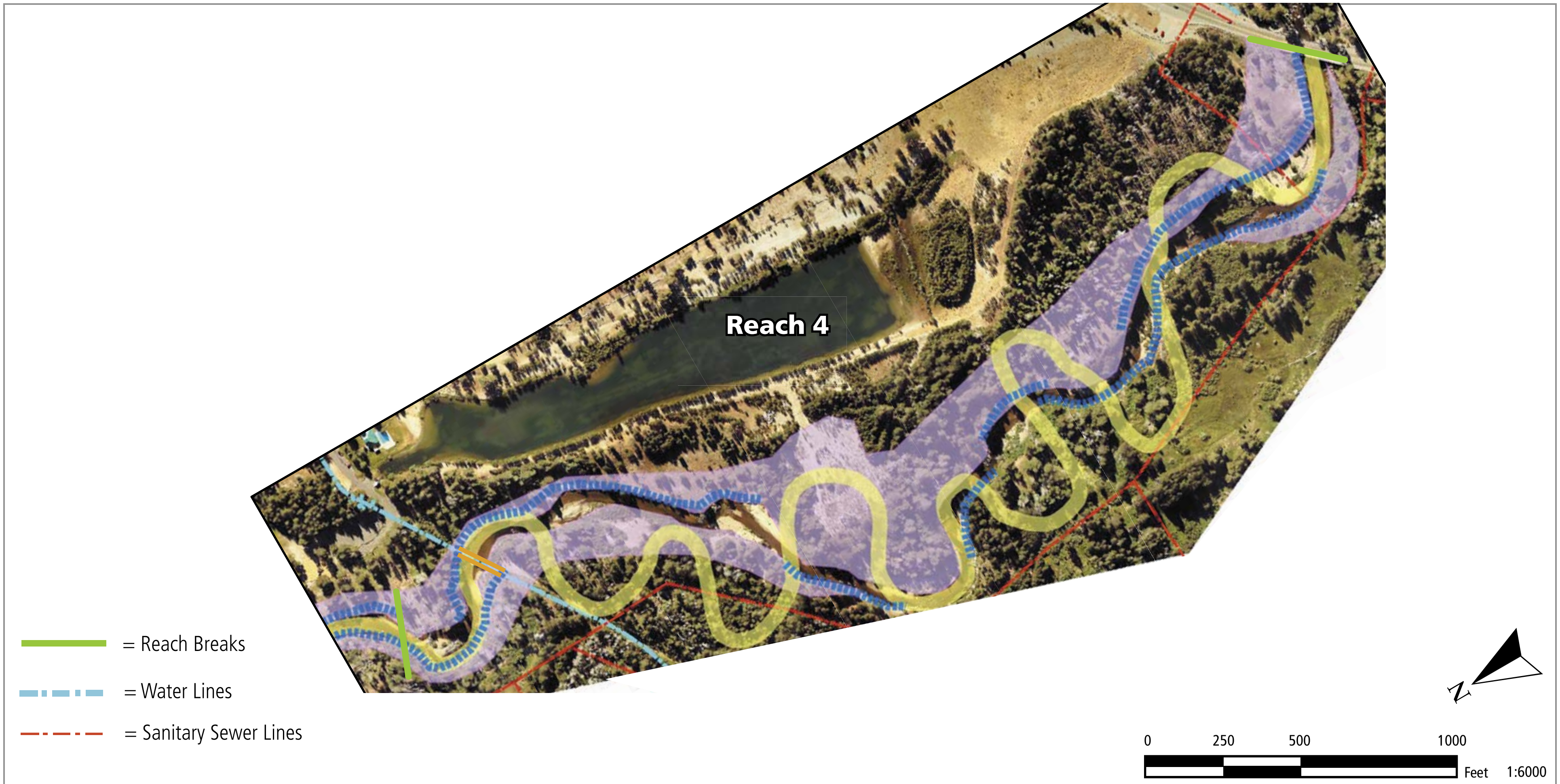
Alternative #3- Excavate incised banks to create Floodplain Terraces.

⬬ = proposed Floodplain Terraces

Alternative #4- Restore channel to its original planform and profile. Fill existing channel.

∿ = proposed Channel Alignment

FIGURE 4.12: Design alternatives for Reach 3.



Alternative #1 - No Action

Alternative #2- Provide Rip Rap Protection along banks and Grade Control in channel.

= proposed Rip Rap

= proposed Grade Control

Alternative #3- Excavate incised banks to create Floodplain Terraces.

= proposed Floodplain Terraces

Alternative #4- Restore channel to its original planform and profile. Fill existing channel.

= proposed Channel Alignment

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FIGURE 4.13: Design alternatives for Reach 4.

ALTERNATIVE 1 – NO ACTION

Geomorphology, Water Quality and Hydrology

The present degraded channel would remain unstable and a chronic source of fine sediment. There would be continued widening of the river corridor until a stable section is achieved; this appears most problematic in Reaches 1, 2, 3 and 4, since the actively moving headcuts continue to incise the longitudinal profile. In Reaches 5 through 11 the presence of bedrock and boulder control appears to arrest any further downcutting in most reaches. Using the present erosion hazard ratings as a guide, it is possible that up to 350,000 cubic yards (525,000 tons) of sediment (equivalent to the amount being excavated under Alternative 3) will be released from the Reaches 1 through 4 over the next several decades if the channel is allowed to adjust to a new equilibrium width on its own. The volume eroded from streambanks in Reaches 5 through 11 would be less as most of the deepening and widening has already occurred, however in all cases fine sediment production would be greater than background pre-disturbed conditions for decades to come. Channel instability would continue until a stable width and profile is achieved, a period of at least several decades at minimum.

The present water quality conditions would continue into the future with excessive chronic fine sediment supplied from unstable banks and the continued discharge of untreated to partially treated urban runoff from residential roads, commercial areas and golf courses. The lack of overbank flooding in the UTR will allow all entrained sediments, nutrients and other pollutant constituents to flow into the UTR and directly into Lake Tahoe.

With respect to hydrology, the No Action plan will retain the existing degraded conditions in all reaches indefinitely into the future. The shallow groundwater table surrounding the river will be well below it historic level, at least 3-4 feet through the Study Area. This will limit the recovery of native vegetation, wetlands and associated wildlife habitats to the channel. As mentioned above, overbank flow out of the channel will continue to be infrequent since channel flood capacity is so high.

The No Action Alternative would avoid short-term construction impacts that could affect water quality, increase noise, traffic and reduce air quality. With other alternatives, these could be significant impacts during multiple-year construction scenarios associated with each.

Vegetation and Wetlands

Under No Action plan, native vegetation in the riparian zone will continue to reflect a drying trend favoring facultative and upland species over wetlands and obligate species. This trend will re-enforce existing conditions by reducing plant diversity and ecosystem function as vegetation is generally less dependent upon riverine hydrology and fluvial processes. Invasion of dense lodge pole forests into former floodplain and wetland areas, now on terraces, will continue and perhaps replace existing decadent willow and cottonwood stands. Important exceptions to this outcome will be the areas of tributary spring flow in Reaches 3, 4 and 10, for example, where independent sources of surface flow and shallow groundwater occur. These independent hydrologic sources could be enhanced though isolated and specific activity of beavers, such as that occurring on the east bank of the UTR in Reach 10.

There will be an expansion of riparian vegetation as the UTR erodes to a wider channel and meander belt. There are areas in Reach 3 where an overall stable width has been achieved and there has been a development of new riparian and wetland vegetation. However, many of the channel banks and terrace areas will remain too dry to support riparian species for decades to come.

Forest conditions would remain favoring dense, young stands of lodgepole pine and white fir in densities far greater than the original forest structure. Historically logged areas around Meyers and in WMSP will be subject to destruction by catastrophic fire, which also threatens many properties and structures.

Terrestrial Wildlife

Terrestrial wildlife conditions would remain unchanged, with the exception of a continuing drying of terrace surfaces and invasion of upland species. This will influence habitat for several key species. The loss of willow scrub habitat due to drying on terraces will reduce the extent of willow flycatcher habitat in the river corridor; this will be partially offset by generation of new willow scrub in some locations where the UTR channel will widen in the future and create new floodplain, although the suitability will be less until the new plants mature. The conditions surrounding beavers would remain unchanged. Encroaching land use will continue to impact potential riparian areas, especially in the LTGC.

Overall, the condition of wildlife habitat would remain far below its potential diversity and abundance. Riparian areas are unusually rich wildlife habitat areas, especially when geomorphic processes are functional and creating erosion and sediment deposition disturbances. The present incised channel confines these processes to the narrow area of the channel, which is often less than 100 feet in width; in the pre-disturbed condition the entire meander belt, up to 1,000 feet or more wide, was subject to erosion and deposition, beneficial disturbance processes.

One potential benefit of the No Action plan is that wildlife habitat will not be disturbed by construction activities. Although, future bank erosion may necessitate bank repairs to stabilize sewer lines or facilities associated with the LTGCand thus affect wildlife habitat.

Aquatic Wildlife and Habitat

Under the No Action plan, the conditions supporting aquatic habitat would remain unchanged. This means that fine sediment will still affect substrate quality for macroinvertebrate production and spawning success. CDFG would continue its program of fisheries management.

The condition of the UTR would continue to be far below its potential due to a lack of optimum channel morphology: the straight channel planform creates a flat streambed profile, instead of the more valuable pool and riffle morphology. The lack of riparian vegetation along the bank edges reduces cover and the formation of rooted undercut banks; that may be partially offset by enhanced logjam formation as undercut trees fall into the low flow channel.

Cultural Resources

Cultural resources will not be affected by the No Action plan since no projects are proposed.

Infrastructure, Land Use and Regulatory Compliance

The No-Action plan would not affect present land use, infrastructure nor require regulatory permits.

ALTERNATIVE 2: STABILIZATION IN REACHES 1 THROUGH 4.

Geomorphology, Water Quality and Hydrology

Channel stabilization would reduce channel erosion and arrest headcut migration. This would improve channel stability and reduce fine sediment supply from the channel. Conversely, reduction of erosion could reduce coarse gravel supply to the channel, which is important for substrate.

Although the project aims to provide stability, there is a measure of risk and uncertainty under future conditions because this alternative simply fixes the position of the channel that has an unstable geometry and planform. There are several examples of failed rip rap structures in teh UTR channel, which have exacerbated bank instability at those locations. Proper design and placement will be essential and the main test for stability will be during a large rain on snow flood event, which occur roughly once every 10 years on average. The initial design identified selected treatment sites based upon present erosional processes; there may be some need to re-enter to maintain existing structures, extend some structures and/or install new structures. As a result, there would be a need to sustain funding for post-project maintenance and monitoring.

Water quality would be improved to the extent that erosion and fine sediment supply is reduced. Otherwise, discharges from existing land uses in the historic floodplain would continue as no new buffer areas or land use conversions would occur.

The hydrology of the UTR would remain unaffected under Alternative 2, because the stream profile would remain unchanged.

Vegetation and Wetlands

Riparian vegetation along the channel banks would expand somewhat under Alternative 2 since it is proposes to use bioengineered designs. However, there would be vegetation removal in order to provide construction access the proposed sites. In most cases, it appears that most of the removal would involve taking lodgepole pine along the immediate upper bank area; removing these from the riparian corridor is deemed beneficial due to their dense stands and low habitat value. The removed logs could be incorporated in the bioengineered bank structures to provide aquatic cover and shoreline diversity.

In some cases, high quality riparian vegetation would be removed to allow space for the bank structure. There would be an offset gained by allowing riparian planting in the structures to the greatest extent possible; this would primarily include the multiple willow species available locally. Some of the willow and alder removed for construction could be salvaged and incorporated in new structures and/or new plantings in the floodplain and providing little habitat value.

Alternative 2 would not create conditions for natural plant colonization and would arrest the present trend of channel widening and floodplain formation, thereby reducing the formation of new stands of riparian and wetlands plants.

The need to re-enter the project sites and to repair, extend or construct new structures could lead to more impacts to vegetation beyond the initial construction.

Terrestrial Wildlife

Terrestrial wildlife habitat would be affected by the construction activities during the initial period and during any maintenance repair, extension or new installations afterward. This would include wildlife disturbance from noise, excavation and removal of vegetation to allow for construction. There are measures that could be implemented to avoid wildlife impacts such as LOPs to avoid breeding periods and identification and exclusion of sensitive habitat areas from access or construction. The degree of vegetation replacement in the bioengineered structures in the riparian zone should be sufficient to offset short-term losses of construction.

Alternative 2 essentially confines geomorphic processes important for riparian habitat generation to the limited space within the channel and will not change hydrologic conditions in the river corridor or on the terraces. Therefore, the terrace areas of former floodplain and riparian zones will continue to dry and become more upland in composition and wildlife habitat will continue to shift from riparian to upland in the terrace areas with riparian zones confined to the river channel.

Aquatic Wildlife and Habitat

Aquatic habitat and wildlife would benefit from the reduction of fine sediment supply which impacts coarse substrate for macro invertebrate production, viability for successful spawning, and fills pools.

The bioengineered bank protection structures would include features beneficial to shoreline habitat for fish, including irregular shoreline, boulders, logs and root wads for cover and hydraulic roughness to scour pools, and opportunities to convert barren banks to vegetated shorelines. These changes would improve fisheries habitat over present conditions.

Alternative 2 would reduce the recruitment of logs from eroding banks and thus reduce habitat complexity and cover. This could be partially offset by incorporating logs into the bioengineered bank protection structures.

Alternative 2 would also reduce the level of geomorphic disturbance in the channel, resulting in more stable but uniform conditions. Some of the channel instability such as headcuts and areas of abrupt geomorphic change can actually create some good fish habitat (pools, bars, side channels etc.). These processes would be reduced.

Cultural Resources

Impacts to cultural resources should be very limited under Alternative 2. Most of the sensitive sites are located at the fringes of the floodplain near the upland boundary; it does not appear, based upon the surveys conducted in Reaches 1 through 4, that any sites exist near the river channel, in historic terraces or other areas that were riparian or wetland areas under pre-disturbance conditions. These sites could be avoided during construction by properly locating construction access away from these areas.

Infrastructure, Land Use and Regulatory Compliance

Alternative 2 would benefit infrastructure by providing added erosion control protection to sewer and other utility lines. The LTGC would receive erosion control protection within the existing river boundaries, thereby not affecting the present golf course operation or layout.

The Alternative 2 project would require permits from RWQCB, TRPA, US Army Corps of Engineers, El Dorado County and California Department of Fish and Game. The project would have to overcome several unprecedented challenges in order to obtain permits. It would be the largest rip rap revetment project to be undertaken in the Lake Tahoe Basin. It would require excavation below the streambed in order to construct grade control weirs and to extend rip rap slope revetment to a suitable depth below scour; this will require partial damming and/or diversion of surface flow during construction. In addition, stabilization runs counter to the policies of several agencies in the Lake Tahoe Basin to restore natural geomorphic and ecosystem function.

ALTERNATIVE 3: FLOODPLAIN EXCAVATION

Geomorphology, Water Quality and Hydrology

Alternative 3 would significantly improve channel stability through a reduction of hydraulic force associated with a wider cross section and an increase of deeply rooted riparian vegetation in banks. The width of excavation would approximate what appears to be a stable width, based upon observation of some areas in Reach 3. These areas were naturally formed through erosional processes over a decades time scale, and it is assumed that it would require decades into the future for the UTR in Reaches 1, 2, 3, and 4 to reach the same quasi-stable configuration.
An estimated 350,000 cubic yards or 525,000 tons of alluvial soils would be removed by implementing Alternative 3, which corresponds to what might be expected to be eventually eroded and discharged to downstream reaches and Lake Tahoe.

Alternative 3 would be implemented in two phases of grading and revegetation: the first would allow for the substantial area of new floodplain away from the channel to become stabilized through revegetation. The second phase involves excavating soil from the remaining bank and installing temporary erosion control. This approach is designed to minimize risk of soil loss in the early stabilization period.

The project could address bank instability, however it would be excavated to use the existing stream bed profile and adopt the existing planform. This leaves a residual risk of instability in profile due to head cuts and in cross section due to impingement of terraces. It is not feasible to use grade control for Alternative 3 since the lower floodplain surface would allow for outflanking of the structure. To reduce outflanking, grade control would have to be tied into the terraces and be over 200 feet wide. For cost estimation purposes we assumed these structures would be constructed in Reaches 1, 2, 3 and 4. Erosion and channel stability should be closely monitored after the project and provisions for possible repair and remediation should be planned.

The change in hydraulics associated with Alternative 3 could reduce the bedload transport capacity and create new areas of bedload deposition. This could create discontinuities in bedload transport and create areas could that might become unstable and initiate channel widening. Reach 4 exhibits evidence of being in a zone of net bedload deposition; the effect of Alternative 3 would likely move this zone upstream closer to the Meyers Highway 50 crossing, which should not have a significant impact because the area is confined by high terraces.

Water quality would be improved under Alternative 3 by reducing the supply of fine sediments from eroding banks and by increasing floodplain area from 24 acres of existing channel to over 80 acres subject to overbank flow. This combination would significantly reduce fine sediment supply (up to 350,000 cubic yards) and increase deposition of fine sediments in the new floodplain area for flows higher than 350 cfs (the design bankfull channel capacity before overbank flow would occur). This should improve water quality within Reaches 1 though 4 and downstream.

Alternative 3 would also set back the land uses from the river corridor allowing for a buffer to reduce direct urban runoff and pollutant discharge. This effect would be most profound along the LTGC where the setback would allow for runoff to flow through riparian vegetation buffers. This would be a significant improvement.

The hydrology of the UTR would only be affected during periods of overbank flow (flows greater than 350 cfs). Enhanced overbank flow would increase flood storage, increase percolation of surface water into shallow groundwater, and attenuate floods downstream. Alternative 3 would create over 200 acre-feet of new flood storage between 350 cfs and about a 10-year flood. This would significantly improve hydrologic function but only partially restore historic floodplain storage and function.

Vegetation and Wetlands

Alternative 3 would create significant benefits for riparian vegetation and wetlands by expanding the area with a shallow groundwater table in the created floodplains and by restoring overbank flow and associated geomorphic function, including fine mineral sediment deposition that drives native riparian plant colonization. The project would create 56 acres of new floodplain that will support native riparian and a range of wetland habitats. It is anticipated that natural geomorphic processes and restored hydrologic conditions will create a self-sustaining riparian corridor.

Alternative 3 would require removal of existing vegetation in the terrace areas in order to excavate the project floodplains. This area includes decadent stands of willow scrub and dry meadow grasses. The project would provide for salvaging willow and alder clumps by moving them into restored floodplain areas. The meadow grasses could be enhanced to wet meadow sod by irrigation in the year or two prior to construction. This could provide a ready source of sod for Phase 2 construction when the banks near the edge of the channel would be excavated. The dominant dense stands of lodgepole pine would be removed and the logs used as floodplain roughness features or as streambank enhancements for fisheries habitat. It is assumed that removal of the dense stands of lodgepole and replacement with riparian species would be a significant benefit.

The project will remove significant stands of riparian vegetation and replace them with new riparian wetland plantings and salvaged plantings; considerable amounts of decadent lodgepole pines will also be removed. This will result in a short-term loss of native vegetation until the plantings become established. It is believed that the short-term impacts are acceptable given the long-term gains in benefits for vegetation in the natural riparian corridor.

Terrestrial Wildlife

Alternative 3 will have significant short-term impacts to wildlife associated with construction (noise), vegetation removal and habitat disruption. The greatest potential impact would be to willow flycatcher habitat where large decadent willow scrub stands would be removed or relocated from the terraces. This could be offset by limiting operation periods for construction, avoiding known nesting stands, and replacing drier terraces with functional floodplain areas capable of naturally generating new willow scrub stands.

Once the construction and initial vegetation stabilization period has passed, the potential benefits of Alternative 3 for wildlife are significant. The project will greatly diversify the riparian plant communities and restore significant, naturally functional wetland areas adjacent to the river. This would expand habitat for many species that utilize riparian and wetland areas during their life cycle. Restoration of riparian corridor would greatly increase primary productivity and foraging for higher mammals and for avian wildlife.

Aquatic Wildlife and Habitat
Aquatic wildlife and habitat would benefit from Alternative 3 through increased shoreline riparian vegetation and development of densely rooted undercut banks for cover. The increase is shoreline riparian vegetation will also increase insect drop for food production for fish. A reduction in eroding banks should reduce localized fine sediment supply affecting substrate quality.

Construction of Alternative 3 could result in significant short-term impacts to aquatic habitat and fisheries. The project will remove some bank-side vegetation, which might provide habitat, and would not be replaced until new riparian plantings matured. This could be offset by installing boulders, root wads and logs to provide shoreline habitat until riparian plantings mature.

Cultural Resources
Cultural resources should not be affected by implementation of Alternative 3 since excavation would occur away from the terrace/upland fringe where most significant sites in the area are typically found. Care must be taken to avoid sites along construction access roads and along the outer edges of the terrace excavation areas. A preconstruction survey should be conducted prior to final design to avoid significant sites.

Infrastructure, Land Use and Regulatory Compliance
Alternative 3 could have significant impacts to infrastructure, land use, traffic and noise. The proposed floodplain excavation area comes close to sewer line locations, which might require armoring to protect from lateral erosion or to maintain suitable cover. In some cases, line relocation or siphoning may be required. The precise parameters and mitigation measures would have to be developed in consultation with STPUD.

The proposed excavation corridor includes areas within the LTGC. The proposed project could affect several holes that would have to be reconfigured. Although there appears to be opportunities to do so, neither specific plans nor associated costs have been developed and any effort to do so would have to be considered in consultation with CDPR and the contractor lessee.

The project proposes restoration on some private lands near Lake Baron along the east bank of the river in Reach 4. Landowner permission would have to be acquired.

The Alternative 3 project would require permits from RWQCB, TRPA, US Army Corps of Engineers, El Dorado County and California Department of Fish and Game. The project would have to overcome several unprecedented challenges in order to obtain permits: first the method and design, although based upon observed natural stream behavior, is untried on the scale proposed for UTR and this may present some reluctance on part of agencies. Water quality protection during construction would be a significant challenge since the acreage of soil disturbance along the river corridor would be significant.

ALTERNATIVE 4 RESTORE ORIGINAL PROFILE AND PLANFORM

Geomorphology, Water Quality and Hydrology

Alternative 4 would restore the pre-disturbance channel morphology in planform, geometry and profile grade. The proposed channel alignment was derived from an analysis of historical aerial photographs and topographic maps. The intent of the design is to restore the natural form of geomorphic processes upon which the original UTR ecosystem existed. This infers a high degree of natural stability in channel bed and banks. The reconstructed channel would eliminate existing headcuts. Alternative 4 would minimize stability risk factors associated with the existing planform and profile since it would minimize concentration of erosional force and create significant backwater and overbank flooding areas. The restoration of the original channel morphology means that the channel form most appropriate for the balance of flow and sediment generated by the watershed will be in place. Since the channel forming flows are associated with snowmelt flows generated high above the area of urban development, it is doubtful that channel forming flows have been affected from pre-Comstock era.

Restoring natural geometry and planform will drive the natural processes of meandering, point bar formation and floodplain terrace destruction. Restoration of these processes will greatly benefit wildlife, aquatic habitat, and creation and sustenance of native riparian vegetation and wetlands. This would essentially restore the original natural ecosystem of the UTR in Reaches 1, 2, 3 and 4.

Water quality would greatly benefit due to the reduction of fine sediment supply from unstable, chronically eroding banks and replacement with deeply rooted riparian plants. The project would remove pollutant sources near the channel and provide a large buffer from urban runoff. The restoration of the original profile to a point that has overbank flow above 350 cfs will allow for the natural filtering of flow and deposition of fine sediments. Increases in riparian vegetation will enhance nutrient uptake in overbank flow areas.

The hydrology of UTR in Reaches 1 through 4 will be greatly enhanced under Alternative 4. The restored profile will allow for more overbank flow and percolation into shallow groundwater, this may increase base flows within the Study Area and downstream of the project site in the late summer and early fall months thereby enhancing aquatic habitat. The streambed would be a least three feet higher than existing bed. This will allow for shallower groundwater storage and availability for gaining surface flow in late summer and fall months.

Short-term construction impacts would include soil disturbance away from the river in the riparian zone associated with excavating new channel segments in Phase 1. These segments would be irrigated to allow for vegetation establishment prior to Phase 2 when the segments would be linked and flow moved from the original channel into the restored channel. These methods and activities have been tested successfully on the smaller scale Trout Creek Restoration Project and are deemed appropriate for UTR in Reaches 1, 2, 3 and 4.

Vegetation and Wetlands

Native riparian and wetland plant communities would be greatly enhanced with Alternative 4. The project would create 267 acres of restored floodplain suitable for wetlands and native riparian vegetation communities. By virtue of increased overbank flow and shallower groundwater, native riparian plants will colonize and be sustained naturally. Shoreline areas will be enhanced to support native riparian plants, increasing channel stability and enhancing aquatic habitat. Implementing Alternative 4 would reverse the drying trend presently occurring in terrace areas and would expand, widen and diversify the riparian and wetland habitat.

Short-term construction impacts could occur with Alternative 4. In contrast to Alternative 3, most, if not all, of the existing decadent willows on terraces could be avoided and preserved. Some may occur in or near the proposed channel alignment; these could be avoided through alignment modifications or willow plants could be salvaged and re-planted. A significant reduction in lodgepole pine forests within the river corridor would occur with the project; some stands would be removed and some would suffer mortality due to an increase in the water table. This is deemed to be a benefit for vegetation and wildlife as the replacement stands will be more diverse riparian communities.

Terrestrial Wildlife

Terrestrial wildlife habitat would greatly benefit from implementation of Alternative 4. This would result from the diversification and expansion of native riparian and wetland plant communities. Increasing wetlands will enable primary productivity to increase benefiting higher mammals and avian species. The restored wetland and riparian areas will replace drying terrace plant communities that are less diverse and less productive.

As mentioned above, it is possible to retain much if not all of the existing decadent willow scrub stands for willow fly catcher habitat on the terrace areas. These stands can be avoided or salvaged and moved. The restored channel should present many opportunities for natural regeneration of willow stands. Removal of dense lodgepole pine stands is deemed to be a benefit to wildlife habitat, as it will be replaced with diverse riparian and wetland habitats.

Short-term impacts associated with construction disturbance are expected to be offset by LOPs and by avoiding sensitive areas. It is generally believed that the long-term benefits outweigh short-term impacts of construction.

Aquatic Wildlife and Habitat

Aquatic habitat should benefit from implementation of Alternative 4 as a more natural pool-riffle meandering planform morphology will diversify habitat. Establishment of deeply rooted riparian plants on shoreline and banks will allow for diversification of aquatic habitat and creation of deeply rooted undercut banks. Natural geomorphic processes of meandering and pointbar formation will create and sustain high quality riparian shoreline and aquatic habitat.

Short-term impacts associated with Alternative 4 construction are expected to be offset through salvage operations and relocation techniques that were successful on Trout Creek Restoration Project.

Cultural Resources

No impacts to cultural resources are anticipated with the project. Sensitive areas near the floodplain fringe / upland boundary can be avoided. Based upon surveys and research conducted for this study, it is not anticipated that any cultural resource sites will be encountered in the historic floodplain areas.

Infrastructure, Land Use and Regulatory Compliance

Alternative 4 would significantly impact infrastructure, most notably the sanitary sewer line west of the river. In places, sewer lines would need to be armored or relocated in order to accommodate channel construction. A specific plan would be developed during the design phase.

Another significant impact of Alternative 4 will be to the LTGC. The proposed reconstructed channel alignment is within areas now in the golf course; this and the increase flooding associated with restoring the profile could affect up to 10 holes. No specific plans or costs have been developed for golf course reconstruction. CDPR would have to address land designations and accomplish internal environmental review in order to address this issue.

Construction of Alternative 4 would include significant grading and channel relocation on a large scale. This would present challenges to water quality protection, aquatic habitat and wildlife protection, noise and air quality. It is anticipated that 44,000 cubic yards of excess fill would be generated and this would have to be hauled offsite, thus traffic impacts may be significant although less so than Alternative 3.

ALTERNATIVE 5 SELECTIVE BIOENGINEERING AND REVEGETATION

Geomorphology, Water Quality and Hydrology

Alternative 5 involves installation of low tech bioengineered revegetation projects on stream banks at selected sites. It is anticipated that most of the projects could be installed by handcrews without the need for significant heavy equipment use.

The proposed treatments would be placed on existing eroding banks in reaches with significant profile instability. This means that the installed structures will be subject to instability, erosion and destruction. Although the intent is to not invest as much as other alternatives that are designed to stabilize channel profile and planform, there could be a diminished return due to the high risk of destruction and short time of proper function. The risks to Alternative 5 structures on Reaches 1, 2, 3 and 4 are higher than 5 though 11, due to profile instability. Reaches 5-11 have short alluvial reaches separated by boulder and/or bedrock control reaches. It also appears that the historical incision has reached a limit since no active headcuts were observed. In addition, Reaches 5 through 11 exhibit far greater riparian plant regeneration after the 1997 flood than Reaches 1 through 4; this appears to be the result of having achieved a stable width and suitable new floodplain surfaces.

Notwithstanding the risks, implementing Alternative 5 in Reaches 1 through 4 should generate some measurable benefits albeit potentially short-lived. Much will depend upon the unpredictable flood seasons subsequent to the installation and the rate of plant establishment. Unfortunately, the sites in need of stabilization do not appear well suited for riparian revegetation due to excessively coarse substrate and/or banks elevation high above shallow groundwater in the growing season.

Water quality benefits would be significant if areas could be successfully revegetated. However, as mentioned above substrate, channel grade and groundwater do not appear as favorable. It is possible to incorporate irrigation into the projects, but this would require significant maintenance and would not result in a self-sustaining project. Given the risks to the revegetation sites without modification to channel morphology and soil/groundwater conditions, there does not appear to be grounds for claiming significant water quality benefits.

Since the projects are designed to be installed with handcrews and limited, if any, heavy equipment, no significant construction impacts are foreseen.

Alternative 5 would not change nor benefit or impact hydrologic conditions.

Vegetation and Wetlands

The benefits to vegetation will depend upon the success of the installed plantings. Unfortunately, the soil and groundwater conditions in Reaches 1 through 4 are not suitable for successful revegetation. Many of the banks are vertical, eroding, and do not have a stable platform for planting. In other areas, recently deposited substrate is too coarse to retain adequate soil moisture through the growing season; the coarse substrate may also indicate excessive scour, which would also be a limiting factor for successful revegetation. Given the risks of the revegetation projects to stream banks, significant benefits can not be claimed in Reaches 1, 2, 3,and 4.

It is feasible to revegetate areas away from the main river channel, such as converting dense lodgepole forest to more Jeffrey pine and, in some places in upper Reach 4, black cottonwood and alder. These projects do not address the quality of riparian habitat in and near the existing channel.

Terrestrial Wildlife

There is little effect in terms of benefits and impacts to terrestrial wildlife with implementation of Alternative 5 in Reaches 1 through 4. For the most part, the present trends under the no action plan would occur with gradual degradation into the future, resulting from the fact that Alternative 5 would not affect the underlying hydrology of geomorphic processes.

Aquatic Wildlife and Habitat

The effects of Alternative 5 on aquatic wildlife and habitat are insignificant in terms of benefits and impacts. Given the risks to plantings and the probable lack of success, little benefit can be ascribed. Limiting construction activities to handcrews will minimize potential disturbance to wildlife.

Cultural Resources

There are no significant effects to cultural resources resulting from implementation of Alternative 5 in Reaches 1 through 4.

Infrastructure, Land Use and Regulatory Compliance

Implementation of Alternative 5 will not result in any significant impact to land use, infrastructure. Regulatory permitting will be challenged by the risks and potential short-term life of the projects. The project will not generate self-sustaining revegetation projects.

ALTERNATIVE ANALYSIS REACHES 5-11

As discussed above, Reaches 5-11 (Christmas Valley) occur within multiple land ownerships in a terrain of difficult construction access and it appears that channel profile instability has run its course. Since bank erosion is the primary problem to be addressed, the alternatives addressing large-scale instability (i.e. Alternatives 2, 3 and 4) were eliminated from detailed consideration. Only Alternative 5 bioengineered revegetation was assessed in detail.

Alternative 5 was developed assuming that six types of treatment would be applied to streambanks that received high, very high and extreme erosion hazard ratings as a result of the surveys conducted for this study. The proposed treatments and costs are showing Figures 4.4 through 4.8 and Table 4.5. It is assumed that most of the projects can be installed by handcrews and that only limited, if any, heavy equipment is needed. It is also assumed that specific plans would be generated by a Cooperative Authority (CA), an organization that would conduct public outreach, oversee the design, installation, monitoring and maintenance of projects and coordinate with permitting agencies and public ownership agencies.

Geomorphology, Water Quality and Hydrology

Installation of bioengineered revegetation projects will significantly improve stream bank stability over about seven miles of stream banks in Christmas Valley. The projects would utilize native species of willow, alder, sedge and other species that provide habitat and deep roots in bank soils. The loss of root strength and vegetation cover is a primary reason for eroding banks. When installed and established, the erosion ratings of the treated banks would be reduced from high, very high, or extreme erosion hazard to low or moderate.

Water quality should improve significantly with the bioengineered projects in place. All of the eroding banks contribute to the sediment load of the UTR and discharge into Lake Tahoe and potentially degrade the aquatic habitats. The project will result in treatment of over 7 miles of stream bank, nearly 1/3rd of the total stream bank length of the UTR (about 24.5 miles).

The project will not change hydrologic conditions in surface water or groundwater in the UTR.

The impacts of construction should be limited as most, if not all, of the installations would be accomplished by use of handcrews. The projects will not involve significant earthmoving at the project sites or for access roads.

Vegetation and Wetlands

The project would significantly increase native riparian and wetland vegetation cover along the UTR in Christmas Valley. It would increase the diversity of riparian plant species present and would replace bare eroding banks with dense vegetation cover. This will benefit bank stability, water quality, and wildlife habitats. The project would help offset historic losses of riparian and wetland habitats related to urbanization and channel incision.

Terrestrial Wildlife

Terrestrial wildlife would greatly benefit from the project with an expansion of native riparian vegetation and the diversification of shoreline and riparian corridor structure. Since most of the projects involve use of willows for bank stabilization, the habitat for willow flycatcher could increase significantly. Also, the projects could convert areas of urban land encroachment with native riparian vegetation and thus create potential wildlife habitat.

There should not be any significant impacts resulting from construction of the projects, since little, if any, existing habitat would be disturbed. In addition, the projects would be carried out by handcrews, thereby avoiding impacts associated with noise and disturbance by heavy equipment.

Aquatic Wildlife and Habitat

Aquatic wildlife and habitat would benefit significantly from the proposed project, as nearly all involves revegetation of shorelines that are presently degraded and barren of vegetation. The projects will increase shoreline cover and diversity and structural complexity. An increase in rooted banks will allow for development of undercut banks along the shoreline in alluvial reaches.

No significant construction impacts are anticipated since installation would be carried out by handcrews and will not involve heavy equipment or any flow diversion or dewatering operations.

Cultural Resources

Cultural resources should not be significantly affected since the proposed projects do not involve earth grading or any work with heavy equipment.

Infrastructure, Land Use and Regulatory Compliance

The proposed projects will not affect infrastructure since no earth grading, drilling or other activities that could affect utilities, roads or bridges is anticipated.

The projects will not affect land use. All projects on private lands would necessitate an agreement for access to install and maintain the projects and thus the cooperation and permission of the landowners.

The projects will require permits for TRPA, Lahontan, US Army Corps of Engineers and CDFG. The nature of the projects being revegetation by handcrews lends itself to development of a programmatic permit allowing for a one-time permitting process to the proposed Cooperative Authority.

V. Recommended List of Priority Projects

V.1 UTR RIVER CORRIDOR

The preceding analysis and discussion of alternatives reveals significant potential impacts to land uses associated with the projects that might have the greatest ecosystem and environmental benefits for the Upper Truckee River Upper Reach. For the Christmas Valley areas (Reaches 5 through 11), the mixed private public ownerships, potential flood impacts and difficult physical access outweighed the potential benefits of implementing large scale restoration projects. However, since it appears that historic incision has stabilized, small scale low tech streambank and floodplain revegetation projects are suitable.

In Reaches 1 through 4, the systematic geomorphic instability induced by historic channelization continues and these reaches do not lend themselves to piecemeal restoration or stabilization projects – the connection of each reach to the next is important in order to minimize project risks. However, implementing the most environmentally beneficial alternatives (Alternatives 3 and 4) requires conversion of land presently in golf course use to floodplain. New aqency and public consultations and decisions by the various agencies involved are needed to move any proposal forward. Moreover, funding sources will have to be identified. All of these issues and planning activities are beyond the scope and time allotted for the present study.

Notwithstanding the inability to provide firm project recommendations for Reaches 1 through 4, there are some projects that can be recommended and move forward while a new interagency planning process addresses the key land use conversion and funding issues.

V.2 PRIORITY PROJECT LIST

1. Develop a recommended project for Reaches 1 through 4 given the analysis presented in Chapter 4.

2. Implement the recommended bioengineered revegetation projects in Christmas Valley (Reaches 5-11) by: 1) establishing a project funding account to implement projects, 2) establishing a cooperative project authority (CA) entity within the TRCD to develop cooperative agreements with landowners to gain access and implement revegetation projects on private lands, and 3) organizing and implementing the construction of projects and post-project monitoring and maintenance. The CA would coordinate with the USFS LTBMU in order to extend projects in and across USFS ownerships and link project reaches. The CA would have the lead role planning projects and developing site-specific designs using the bank erosion ratings contained within as an initial guide. The CA would acquire permitting for the projects, which ideally would be issued on a programmatic basis to cover activities related to installing and maintaining the projects.

3. The El Dorado Department and Transportation and California Department of Transportation should utilize the subwatershed erosion assessment completed for this study as a guideline for planning future BMP retrofit projects on State Highways and County Roads. The BMP projects should coordinate with the TRCD in order to integrate tributary enhancement projects with road BMPs wherever possible; this will allow for sharing of permitting and allow for coordination of designs above and below road crossings.

4. The waterway and drainage system for the unnamed tributary in the northeastern Study Area in Meyers should be the focus of rehabilitation and restoration. There are four individual projects identified along this creek that could be accomplished by one or more agencies (see Figure 5.1 and Table 5.1).

Table 5.1: Restoration projects identified for the unnamed tributary in Meyers.

Project Reach	Land Owner	Recommended Projects	Estimated Cost
Reach 1: Lake Tahoe Paradise GC / Shopping Center to Highway 50	Private (GC and Lira's shopping center) and Caltrans (along Highway 50)	Reconfigure drainage entering the inlet basin behind 18th green into a constructed buffered water way and wetland; repair riser to outlet culvert and erosion around edge.	$200,000
Reach 2: Highway 50 ditches	Caltrans	Convert road ditches to curb and gutter in order to separate road runoff from streamflow; install separate WQ treatment system	$150,000
Reach 3: Highway 50/ Santa Fe Road to San Diego Street	CTC;USFS-LTBMU; Caltrans (Hwy 50 easement)	Restore creek to meadow from ditch; construct treatment wetland at mouth of Highway 50 culvert.	$300,000
Reach 4: San Diego Street to Country Club Drive	Numerous Private Parcels with some CTC and LTBMU	Stabilize profile and streambanks through site-specific projects; TRCD could lead a Cooperative Authority to implement	$500,000
Reach 5: Country Club Drive to confluence with UTR in LTGC	CDPR	Restore natural morphology and floodplain; setback fairway turf grass and revegetated	$250,000

V.3 RECOMMENDED BEAVER MANAGEMENT PLAN

The TRCD should lead an effort to coordinate the management of beaver populations in the UTR Upper Reach Project Corridor. The present program involves some individual private landowners acquiring permits from CDFG to remove and destroy beavers on their land. The USFS does not actively remove beaver. CDPR recently had a policy to remove and destroy beaver from LTGC

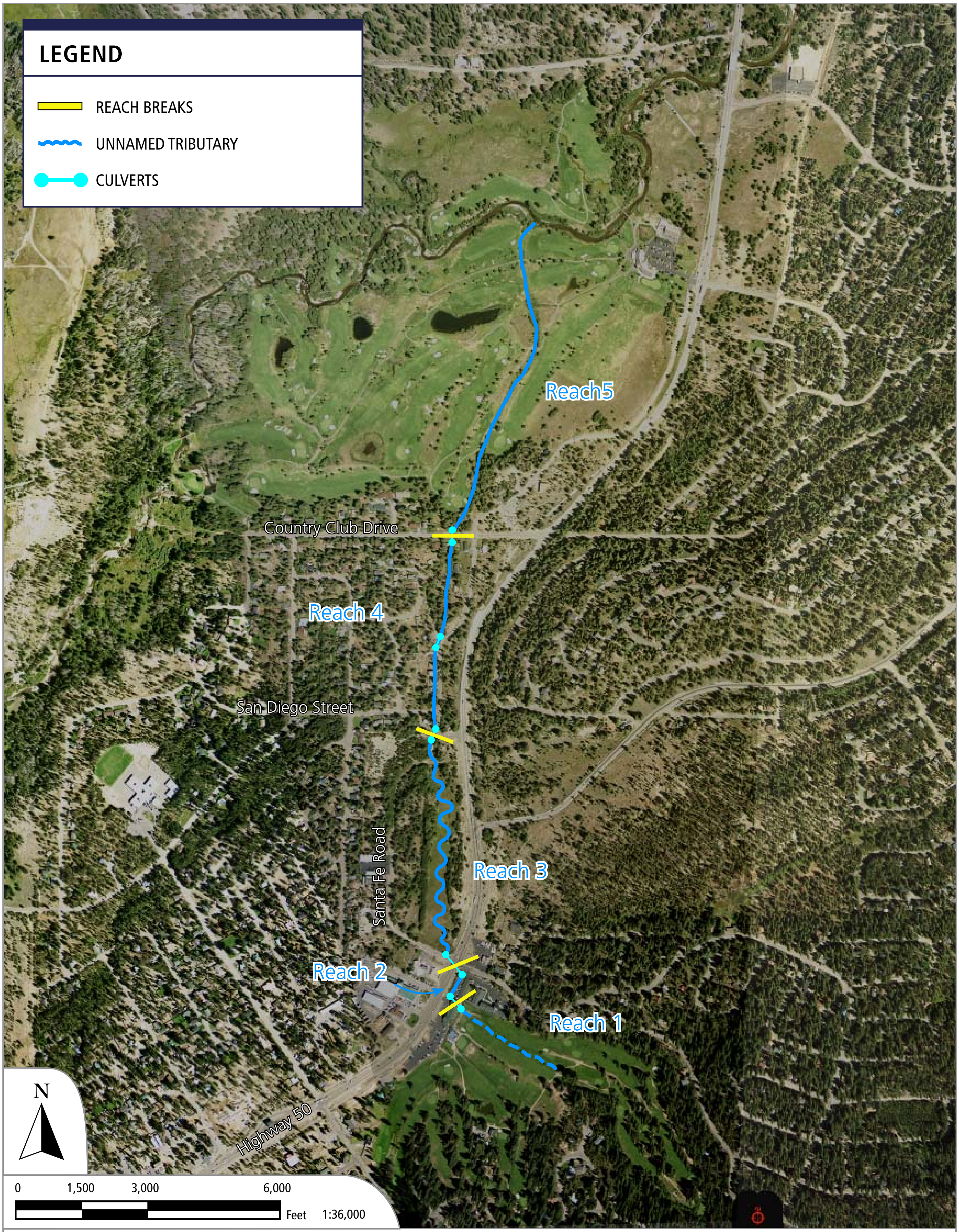

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FIGURE 5.1: Reachbreak designations for the unnamed tributary in Meyers. Scale is approximate.

and WMSP reach (Reaches 1 through 4), however it appears that that policy has lapsed with subsequent personnel changes.

The TRCD has taken initiative to help residents protect trees and to investigate use of drainage devices to control flooding of beaver dam impoundments. TRCD helped USFS Bridge Tract residents protect aspen trees by applying wire or a sand/glue paste to the tree trunks.

The conclusion of this report is that beaver can have beneficial effects on wetlands and in development of habitat for certain key species, such as willow fly catcher, however the range where beaver can exist is limited when private landownership is in conflict. Although the beaver activity appears to be stable or declining in some areas of the river, the lack of natural predators in the urban setting of the UTR Upper Reach retains the possibility of future change. In the future, the revegetation projects recommended herein may require protection to prevent destruction from beaver prior to establishment.

The TRCD should continue its role as a liaison between landowners and agencies in monitoring and managing beaver activity. The TRCD should participate in development of a Lake Tahoe beaver management plan (as identified in the TRPA EIP projects).

V.4 RECOMMENDED ACTIONS IN THE UPPER WATERSHED

The Upper Watershed forests on the UTR exhibit characteristics of past fire suppression efforts as dense stands of white fir and lodgepole have invaded stands of old growth Jeffrey pine and red fir. The dense young stands would have normally burned due to periodic fires that have been suppressed over the past 80+ years. The problem of dense stands is more severe in areas adjacent to the UTR in WMSP where historic clear cut logging occurred. The presence of dense understory can lead to excessively hot fires which can kill both young and old growth trees. This was demonstrated in the 2002 Showers fire in the Upper Watershed. In many cases old growth trees survived the burning of understory stands of white firs, while in other cases stands of old growth were killed near dense white fir stands and where fire intensity was high.

It appears that many of the forest stands would benefit from selective mechanical removal of dense understory conifer stands. These operations would leave large old growth trees, but clear dense conifer stands in favor of more diverse understory shrubs. These projects would benefit plant diversity and wildlife habitat and would help preserve old growth trees.

List of Reviewers, Draft Report - Upper Truckee River Upper Reach Environmental Assessment, December 15, 2003.

Reviewer	Agency
Cyndi Walck	California Department of Parks and Recreation
Jerry Dion	Tahoe Regional Planning Agency
Brian Wilkinson	California Tahoe Conservancy
Myrnie Mayville	Bureau of Reclamation
Jim Howard	United States Forest Service
Jane Schmidt	Natural Resources Conservation Service
Chuck Taylor	Natural Resources Conservation Service
Mary Fiore-Wagner	State Regional Water Quality Control Board – Lahontan Region
Jim Hoggatt	South Tahoe Public Utility District
Tim Oliver	Tahoe Resource Conservation District
Kim Melody	Tahoe Resource Conservation District