Appendix C

M & M Consultants

Consultants Report

MAD RIVER: 1850-1925

THE EFFECTS OF FLOOD EVENTS

&

LAND USE ON SEDIMENT TRANSPORT PROCESSES

Presented to:

Humboldt County Department of Planning
3015 H Street
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Introduction

The transport and disposition of sediment in any given segment of river channel depends on many factors. Geology, climate, vegetation and land use activities being some of the more important variables. Each variable is not mutually exclusive, and each interacts with the others. A river channel responds to changes in these variables by adjusting its morphology through time. The most rapid adjustment periods often takes place during "channel forming" events. At any given location on a stream, conditions may favor the erosion of a bank at that point, and deposition of sediment at some location downstream.

Little is known about sediment transport processes of the pre- and early sediment period on Mad River. An understanding of the geomorphic agents controlling sediment transport processes in the river, and how historic land use activites have acted as geomorphic agents is relevant when making well-informed management decisions, and will be the focus of this report.

In terms of sediment transport processes, river morphology and riparian vegetation, Mad River in the 1850's was a very different river than it is today. Many of the features that regulated the disposition of sediment through the river, such as riparian vegetation, were removed, thereby producing more rapid transport of sediments through the project reaches.

The location, spatial distribution, and nature of river meanders and locations of flood-induced bank erosion and sediment deposition provide a marker for exploring the changes in river morphology since first settlement took place. A review of the more significant events during the first 75 years of settement will be presented as outlined below:

1). A description river morphology and vegetative conditions of the floodplains at a time shortly after the first settlers arrived in the early 1850's.

2). The geomorphic resoponse of the river to flood events, and the reconstruction of the geomorphic history of the river between 1861 and 1925.

From this, the following evaluations can be made:

1). The interaction between flood events and early land use activities as explained in newspaper accounts of the time.

2). The role of land use activities on river morphology and sediment transport mechanisms .

The following three periods will be discussed separately:

a). 1850 - 1889, *Early Settlement.*
b). 1890 - 1917, *Big Floods, Aggradation and the Railoads.*
c). 1917 - 1925, *Drought and the Onset of Bed Lowering*

The Study Site

The study site includes roughly the lower 25 miles of Mad River up to, but not including, its estuary. The study site will be broken into four distinct reaches based on general geomorphic features. Figure 1 shows the project reaches which are:

Reach 1: Sweazey Dam Site to Fish Hatchery
Reach 2: Blue Lake Valley- Fish Hatchery to Lindsay Creek
Reach 3: Lindsay Creek to North Bank Road Meander
Reach 4: North Bank Road Meander to Highway 101 Bridge

A few things to keep in mind

There are a few things the reader should keep in mind when reading this report:

1). Conditions in the upper catchment and surrounding hillslopes influence the delivery of sediment to the into the project reaches. Although not the main topic of this report, this should not be ignored when considering the origin of sediments.

2). Where the river can spread laterally across its floodplain, the amount and thickness of vegetation growing on the floodplain and terraces influences the rate of sediment transport and the sizes of sediment travelling through the reach. Hydraulic roughness is a term used to equate the degree to which physical features in a river bed and on the floodplain can slow water down as it flows.

3). River and floodplain management should take into consideration pre-existing conditions of a river when making decisions affecting the balance of sediments in the river.

4). A reasonable understanding of the role of geology and land use activities as geomorphic agents and as regulators of sediment transport processes will provide for better informed management decisions.

Abbreviations used:

SBF = Susie Baker Fountain papers, Humboldt State University
AU = Arcata Union, Arcata CA.
HT = Daily Humbodlt Times, Eureka, CA.
FE = Ferndale Enterprise, Ferndale, CA.
WCS = West Coast Signal, Eureka, CA.
HDS = Humboldt Daily Standard, Eureka, CA.

Figure 1. The project reaches. See figure 2

Methods

Mapping Early Settlement Features

The U.S.Coast and Geodetic Surveys of 1854 and 1874, and photographs of the time provide a glimpse of the landscape that existed when the area was first settled in the mid-1800's. To recreate the course of Mad River and the vegetation that existed prior to significant landscape modifications, the U.S. Coast and Geodetic Survey notes (Foreman, 1874) and plat maps were obtained. Pertinent spatial information, such as the location of the river course and slough channels, vegetation breaks and marker trees, was first traced from the map onto matte acetate. These features were then manually digitized using Intergraph software to develop computer-generated maps. Section corners and quarter sections were used as control points.

Flood Events, Land Use, and Geomorphic Changes of Mad River

The geomorphic changes associated with specific flood events and the people's responses to these events were reconstructed using original newspaper accounts contained on microfiche; the Susie Baker Fountain Papers, a collection of historic papers found in the Humboldt State Library; and Haynes (1986). Land ownership was obtained using the 1898 and 1921 Belcher's maps and descriptive information contained in newspaper articles. Site specific information mapped in the fashion explained above.

Summary

Large flood events combined with land use activities that precipitated bank migration dramatically altered the ways in which course sediments were delivered to and transported through the project reaches. Early land uses involved the clearing of vegetation on the floodplains and terraces along most of the project reach. The logging boom in the 1870's drove men and mills up the river and into Blue Lake valley where old-growth redwood and other timber on the valley terraces and lower hillslopes, were cut for lumber and homesteading. Early attempts to float the logs donwstream to the canal resulted in severe bank erosion (Haynes, 1986). During the flood events of 1878, '79, and 1880, moderate to severe erosion took place along much of the project reach. This dramatically increased the volume of sediment entering the project reaches that had been previously stored in raised fluvial terraces . The channel's responses were bank migration and bed aggradation. At the same time, efforts were being undertaken to stabilize the banks and prevent channel migration at certain locations. These sites, a few floods later, tended to be targets of erosion and would often fail.

The most catastrophic flood year was 1890 when one storm after another resulted in erosion in a number of places. A late February rain-on-snow event did severe damage in Blue Lake, West End, around Valley West, and near the old canal. It was this flood that placed the confluence of the North Fork with Mad River in a mid-valley position. The net effect has been an increase in gradient of the channel and a more rapid transport of sediment through the Blue Lake valley, a situation that has persisted ever since.

By the 1890's, technologic advances and a greater demand for the export of lumber, encouraged the expansion of logging and railroading further upstream and in the tributaries, and the expansion of the city of Blue Lake. During the 1902, '03, and '07 floods, more bank erosion and landslides occurred, resulting in damage to many structures, now built closer to the river. This resulted in pulses of sediment deposition into the river throughout the early 20th century.

After 1917, few devastating floods occurred. By the early 1920's, little of the sediment once stored in the Blue Lake valley terraces remained, although logging operations higher in the catchment probably still contributed large amounts of sediments as a result of bank erosion and slides. River bars along Arcata Bottom provided copious amounts of gravel for many local projects. By the late 1920's, signs that the river bed was starting to downcut became evident, a trend which has continued to the present. Removal of sediments from the project reaches, both by nature and by human extraction at rates that exceed the rate of recruitment into them, has resulted in a "net negative" balance of sediments and the bed lowering observed today.

Geologic and Geomorphic Setting

Figure 2 shows some general geologic and geomorphic features which affect the project reaches. The delivery of sediment into the project area and its subsequent transport through it are strongly influenced by thrust faulting in the vicinity and is described below. For a technical discussion of regional tectonics, see Clarke and Carver (1991) and references.

Reach Description

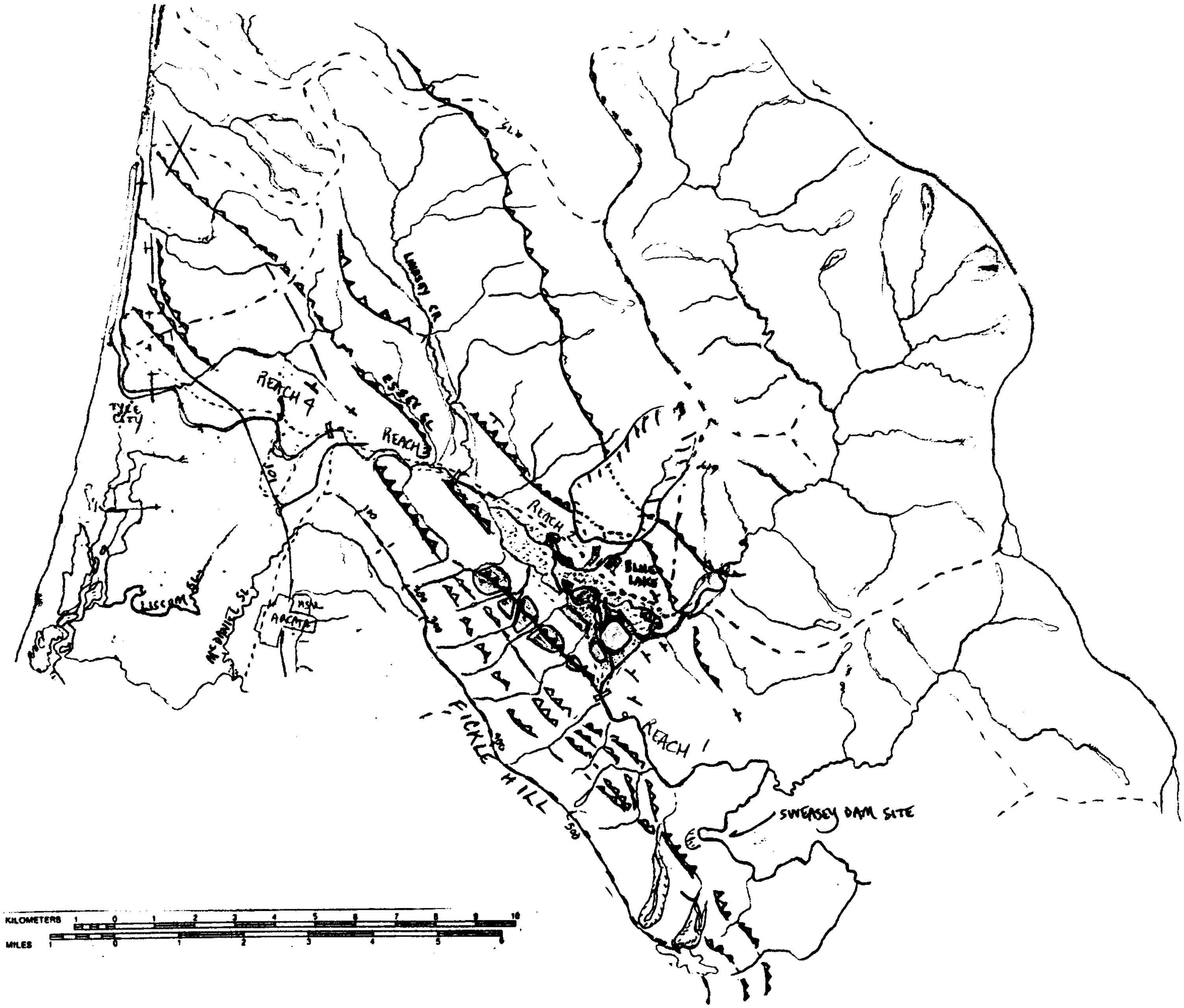
Reach 1: Sweazey Dam Site to Fish Hatchery

Reach 1 is a narrow canyon about 9 km long with a sinuosity of 1.6. The first 1.9 km is follows a northeast-trending ridge until it reaches the Canyon Creek meander. This meander is about 600 meters long by 400 meters wide and possesses at least 3 terraces. The river then flows west about 2.7 km contacting the Mad River fault zone where it deflects north-northwest. The river then parallels this fault boundary for the lowermost 3 km of this reach. From here, it empties out to the broad unconfined Reach 2, known as the Blue Lake valley.

Reach 2: Blue Lake Valley

Blue Lake valley is an elongated, triangular basin that has inflows; one at its southern end and one on its eastern end. The apex of the triangle is the outlet flowing northwestward. It is about 2 km wide along its southern base, narrowing to less than 1 km wide at its apex near Glendale. The delivery of sediments into the valley comes from several sources. The most relevant input of course sediments (gravels and cobbles) into the valley comes from the main stem Mad River. Its drainage area (da) is about 780 km^2 and flows into the valley from the south. The North Fork Mad River has a drainage area about 7.5 times smaller (da =105 km^2) and entered from the east. Relative to the main Mad River, the North Fork probably contributes an additional 10-15% the amount of sediment to reach 2.

The valley is sandwiched between thrust faults of the McKinleyville and Mad River fault zones. This faulting increases the quantity of sediments entering the valley. Three steep, fault-bound gulches (Quarry, Palmer and Kelly Creeks) descend from Fickle Hill contributing sediments along the western margins of the valley. Episodes of earthquake-induced slumps, earthflows, and debris torrents have occurred down these gulches that have incised uplifted fluvial terraces at their bases. Descending down the southwestern flank of Liscom Hill some time in the recent geologic past was a large earthflow (figure 2) that probably dumped a wide mix of sediments across the northern margin of Blue Lake valley.



Earthflow

Thrust fault

Uplifted fluvial terrace

Strike and dip of bedding

Figure 2. Some general geologic and geomorphic features affecting sediment delivery into the project reaches.

On the periphery of the valley are uplifted fluvial terraces. Trenches across the McKinleyville fault near the town of Blue Lake showed late Pleistocene and Holocene river terraces that are offset due to thrust faulting (Carver, et al., 1991). Thrusted overbank floodplain sediments and scarp-derived colluvium were found representing 4 distinct events, occurring at roughly 3,000-5,000 year intervals, with the last one occurring more than 660 years ago (Carver, et al., 1991). Each event had 3 to 3.5 meters of slip on a northeast-dipping fault (Carver, et al., 1991).

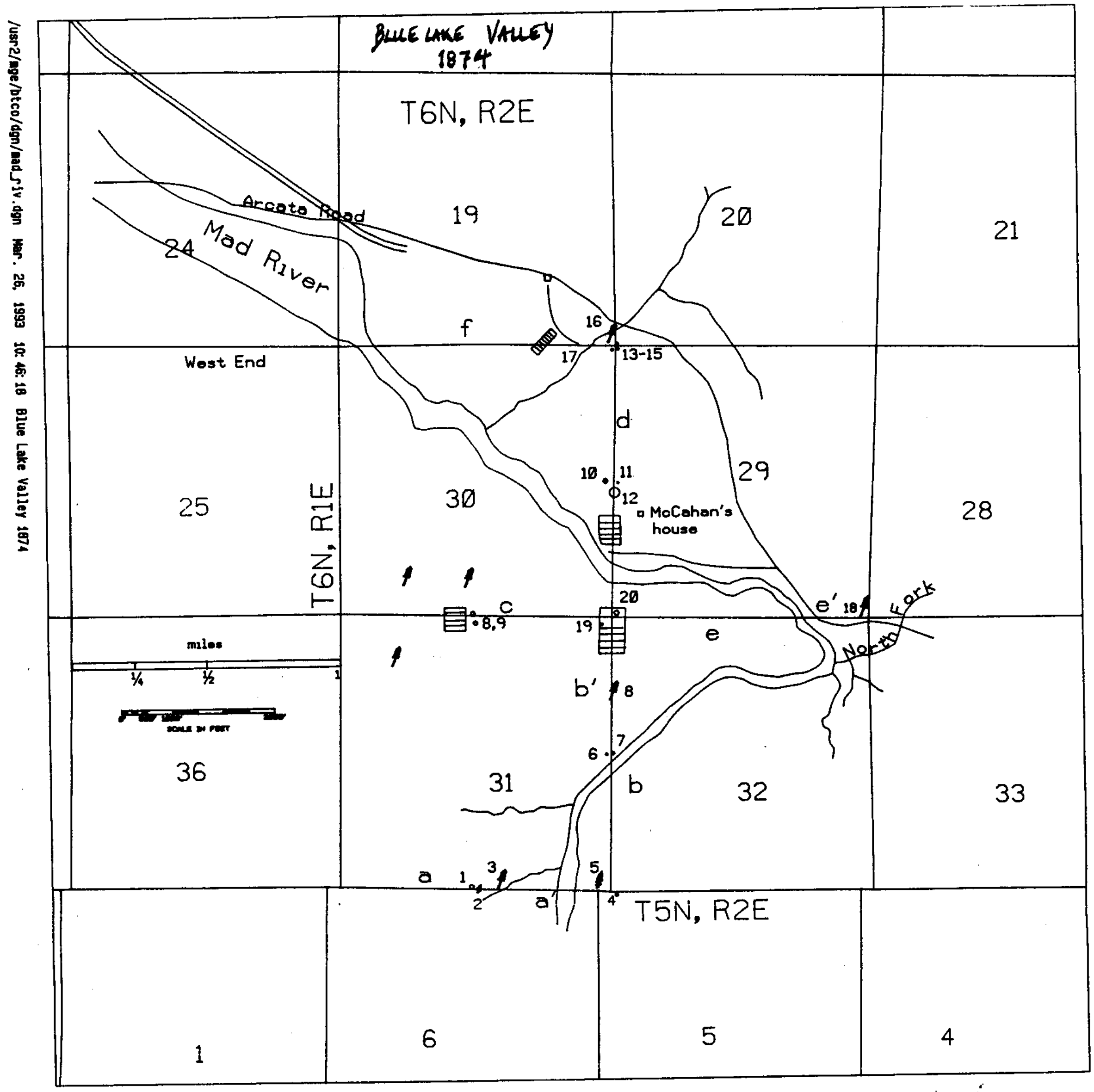
Geomorphology & Vegetation of Reach 2, 1870's

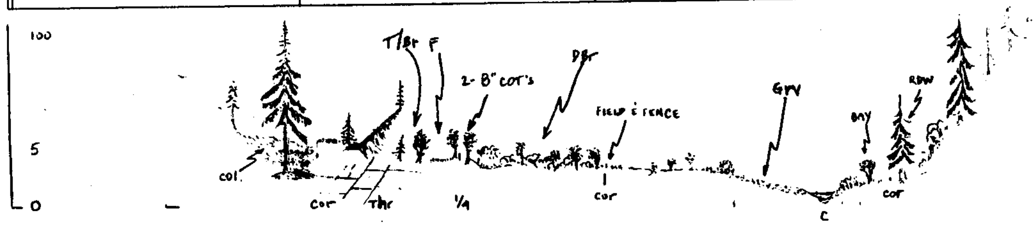
Figure 3 is reproduction of the U.S.Coast and Geodetic Survey map of Blue Lake valley, surveyed by S.W. Foreman in 1874. It shows the approximate location of the river course and the vegetation that existed at the time. Total length of the river between the east-west line between section 31, T6N-R2E and section 6 in T5N-R2E to the river's crossing of the north-south line of sections 19 and 24 was about 4 miles (6.4 km). The linear distance between these two points is 2.38 miles (3.84 km), giving a sinuousity of 1.67.* The following is the description of the valley given by Foreman in 1874:

> "Along the East boundary and in sections 29 and 34, there are small prairies good for grazing. Timber is of excellent quality being mostly redwood, pine, and oak. The latter will afford a great quantity of tanbark. Mad River runs diagonally through the township from southeast to northwest. It is a rapid stream, well adapted to floating timber to the sea."

Only the section boundaries (1 mile intervals) were surveyed and the descriptions given below will be referenced to these boundaries. In figure 3, note the course of the river as it entered the valley. The lower 1,680 feet (510 meters) flowed directly north much as it does today. Following the dip of the bedding, the river deflected northeastward toward its confluence with the North Fork around an uplifted terrace. An area of "brush and timber" grew on this uplifted terrace, which forced the river in this direction. Prior to being wiped out by flood events of the late 1800's, this terrace probably received much of the finer sediments coming down from Mad River basin. The vegetation here consisted of "redwood, cottonwood, pepperwood (bay laurel), hazel, and salmon brush". This thickly-vegetated terrace slowed the velocity of overbank flows and received deposits of fine sediments coming down from the upper parts of the basin. The soil on the line between sections 30 and 31 was considered "first rate" and the land was "generally level".

*NOTE: Sinuousity is the ratio of a length of river from one point to another to the linear distance between those two points. As will be seen later, the length of river between these two points today is about 2.46 miles (4 km) giving a sinuosity is now nearly 1.0. This is important when considering the transport of sediments through the valley.





Diagrammatic cross sectional view, west to east along the southern border of sections 25, 30, 29 and 28.

T/Br = timber & brush	Grv = gravel
Thr = Thrust fault	Rdw = redwood
D.Br = dense brush	Col = colluvium

Transect descriptions, Foreman, 1874.

a. Land steep, hill broken by tributaries of Mad River. Pine, cedar, bay, oak, fir.
a'. On river bottom. Undergrowth dense oak brush.
b. Timber redwood, cottonwood, pepperwood, pine, hazel & salmon brush.
b'. Brush and timber
c. Land level, soil 1st rate. Redwood, cottonwood, pepperwood, hazel, salmon brush.
d. Land level, soil 1st rate. Redwood, maple, pine.
e. Waste land of river bed. No timber.
e'. Timber- redwood, pepperwood.
f. Timber & brush (T/Br).

Marker trees

1	10 in. bay	10	3 in. maple
2	3 ft. pine	11	6 in. maple
3	12 ft. redwood	12	24 in. maple
4	30 in. oak	13	4 in. fir
5	36 in. cedar	14	4 in. fir
6	10 in. cottonwood	15	6 in. fir
7	10 in. cottonwood	16	16 ft. redwood
8	10 ft. redwood	17	3 ft. fir
9	2- 8 in. cottonwoods	18	8 ft. redwood

Figure 3. Blue Lake Valley, 1870's. From Foreman, 1874. The letters represent general vegetation descriptions along each surveyed transect and the numbers represent trees that the survey used as markers.

The river flowed northwestward for about 5,900 feet (1,800 m) and was joined by the North Fork at the eastern corner of the valley. On the east end of the line between sections 29 & 32, (transect *e'*) timber consisted of old-growth redwood and bay laurel. With the additional water and sediment contributed by the North Fork, the river was then deflected westward across the southern boundary of section 29. The land was "level", soil "first rate except on water land in bed of (Mad) river." (transect *e*). This area was described as "waste land of the river bed" and "contained no timber." This was apparently a site where course sediments such as gravels, would deposit and spread laterally in the valley. A road traversed the valley on the north side of the river, probably an historic Indian trail that was used by the miners accessing their claims in the Trinity mines.

The river then flowed northwestward paralleling the Mad River fault zone. Where it crossed the line between sections 29 adn 30, its active channel was 100 feet (30 meters) wide. About 650 feet (200 meters) south of the river (at the corner of sections 29, 30, 31, and 32), a 4 foot diameter bay laurel and a 30 inch diameter cottonwood stood as marker trees (veg.#'s 19 $ 20) with "no other tree in marking distance." North of the river along this line, they crossed a field and McCahan's place. Two small maples (veg.#'s 10 & 12) were the 1/4 section marker trees that grew 1,530 feet (465 m) north of the river, probably well away from . Another 420 feet (128 m) north, the survey entered brush and timber consisting of "redwood cottonwood, pepperwood, pine, and hazel and salmon brush." (transect *d*) The soil along this line was considered "first rate."