UPPER NORTH FORK FEATHER RIVER PROJECT

FERC NO. 2105

Attachment E2-A

Sediment Incipient Motion Analysis

Sediment Incipient Motion Analysis

Seneca Reach and Belden Reach of the Upper North Fork Feather River and the Lower Butt Creek Reach below Butt Valley Dam

Prepared for

Pacific Gas &Electric Company
Technical and Ecological Services
3400 Crow Canyon Road
San Ramon, CA 94583

Submitted By:

WRECO
1243 Alpine Road, Suite 108
Walnut Creek, California 94596

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EXECUTIVE SUMMARY

In the last couple of decades, Pacific Gas and Electric Company (PG&E) has sponsored a variety of studies to address the environmental issues on the North Fork Feather River (NFFR) related to the dams built on the NFFR for water-supply management and the generation of hydroelectric power. One of the key issues is the feasibility of increasing the release of coldwater from Lake Almanor and/or Butt Valley Reservoir that has been retained behind the dams. The increased release of colder water is essential to the fishery habitats downstream of the dams. Additionally, higher flow releases also are being studied for whitewater recreational use. These increased flow releases must be managed properly, so that higher flows will not disrupt the downstream sediment structure. Therefore, PG&E has authorized this incipient motion study of the Upper NFFR, which will provide important information for PG&E management to determine the optimal dam releases.

This study covers three separate river reaches along the Upper NFFR, the Seneca (NFFR) Reach, the Belden (NFFR) Reach and the Butt Reach (lower Butt Creek). PG&E supplied a total of 81 surveyed river cross-section (transect) data from the NFFR. The Seneca Reach of the NFFR is divided into seven sections, and extends from south of the Camp Almanor Gauging Station, downstream past the Seneca town-site and China Bar to just north of the Caribou Powerhouse. The Belden Reach of the NFFR is divided into five sections and extends from south of the Caribou Dam, downstream to the Belden town-site. The third river reach is the lower Butt Creek, a tributary to the NFFR, which is divided into two sections and extends two miles from the Butt Valley Dam into the NFFR just downstream of China Bar. The following table summarizes the number of transects analyzed and their characteristic river type.

Table E1 Summary of Transects in Three Studied Reaches

	Seneca Reach (7 Sections)	Belden Reach (5 Sections)	Butt Reach (2 Sections)	Total
Pocket Water (POW)	8	5	3	16
River Run (RUN)	11	9	3	23
Low Gradient Riffle (LGR)	4	5	2	11
River Pool (POOL)	16	7	5	28
Braided (**)	0	3(*)	0	3
Total Transects	39	29	13	81

* All three braided transects are located at the downstream end of Belden section 5

** Braided transects not analyzed for incipient motion conditions

The first step in the incipient motion analysis is the hydraulic analysis to establish the flow characteristics at each study location. PG&E conducted four test flow releases and measured the corresponding flow velocities, water surface elevations and slopes for each transect. The hydraulic flow characteristics, such as channel velocities and Manning's n values, were calibrated using these field data. Once the stage-flow values were developed, the mathematical relationship for each transect was extrapolated to determine a wider range of flows for use in the incipient motion analysis.

The incipient motion analysis determines the flow threshold of sediment motion, which is the minimum flow needed to mobilize a specific size of sediment. The predominant factors in the calculation of sediment incipient motion are: channel velocity, energy slope at the cross section, and characteristic roughness height of the bed. Movement of sediment (bed material) is defined by the dimensionless grain shear stress (τ^*). The τ^* value is the ratio of the grain shear stress (τ') to the critical shear stress (τ_c). When $\tau^* < 1$, there is insufficient shear stress to mobilize the bed material; when $\tau^* > 1$, particle mobilization occurs. The median (D_{50}) size of the bed material is typically used to evaluate incipient motion conditions because, in cobble and gravel bed streams, the full range of particle sizes in the bed are mobilized over a very narrow range of shear stresses. At discharges less than the critical discharge for the median size, the bed is essentially immobile. At higher discharges, virtually the entire bed material matrix is in motion.

Analysis of the variation in dimensionless grain shear stress (τ^*) with discharge at key locations provides a good representation of the dynamics of the study reach. Five gravel grain sizes, ranging from very fine to very coarse gravels, were included for incipient motion analysis. At each transect and a given sediment size, a shear stress and flow relationship was developed. The threshold flow at which the sediment incipient motion is expected for the given size is determined. Five threshold flows were used to construct the curve showing required minimum flow to mobilize the given sediment size. Each river section typically contained five to six riverine categories, varying from low gradient riffles to runs. No pools were included in the analysis. These threshold flows versus grain-size curves are then plotted together to determine an optimal range of discharges to mobilize various gravel sizes for each specific river section. The seven sections of the Seneca Reach, therefore, yielded seven "optimal discharge versus grain-size" relationships (**Exhibit 1**). From these seven relationships, a composite, best-fit relationship is then inferred to typify the entire Seneca Reach.

On the Seneca Reach, the seven dashed lines represent the trends for each specific river section. The solid, bold line falls within the upper and lower limits of these seven lines and represents the composite Seneca relationship. This line signifies the incipient motion boundary for which any grain-size versus discharge point above this boundary will not be in motion while any point below will be in motion. The five river section trends of the Belden Reach were similarly plotted in the Belden Reach (**Exhibit 2**) along with the composite Belden relationship. The two sections of the lower Butt Creek analysis yield much higher incipient motion thresholds due to its steeper grade and should be considered separately from the NFFR reaches (**Exhibit 3**).

The following Tables E2, E3 and E4 summarize the results of sediment incipient motion analysis for Seneca, Belden and Butt Reaches:

Table E2 Summary Results from Incipient Motion Analysis – Seneca Reach

Gravel Size	Threshold Flow (cfs)		
	Lower Threshold	Average Threshold	Upper Threshold
Very Fine Gravel (3 mm)	0.1	1	3
Fine Gravel (6 mm)	2	8	15
Median Gravel (12 mm)	25	55	100
Coarse Gravel (24 mm)	170	375	1,000
Very Coarse Gravel (48 mm)	950	2,600	5,200

Table E3 Summary Results from Incipient Motion Analysis – Belden Reach

Gravel Size	Threshold Flow (cfs)		
	Lower Threshold	Average Threshold	Upper Threshold
Very Fine Gravel (3 mm)	1	25	175
Fine Gravel (6 mm)	7	95	475
Median Gravel (12 mm)	45	330	1,260
Coarse Gravel (24 mm)	250	1,150	3,600
Very Coarse Gravel (48 mm)	1,400	4,000	11,000

Table E4 Summary Results from Incipient Motion Analysis – Butt Reach

Gravel Size	Threshold Flow (cfs)		
	Lower Threshold	Average Threshold	Upper Threshold
Very Fine Gravel (3 mm)	-	-	-
Fine Gravel (6 mm)	-	-	-
Median Gravel (12 mm)	0.01	0.02	0.1
Coarse Gravel (24 mm)	0.6	1	3
Very Coarse Gravel (48 mm)	50	70	70

Based on the composite curve for the Seneca Reach (Figure 15), the current instream flow release of 35 cfs at Canyon Dam will put sediments less than 10 mm (fine gravel) in motion. Based on the composite curve for the Belden Reach (Figure 16), the current instream flow release of 140 cfs at Belden Dam will put sediments less than 8 mm (fine gravel) in motion.

1. INTRODUCTION

In the last couple of decades, PG&E has sponsored a variety of studies to address the environmental issues on the North Fork Feather River (NFFR) related to the dams built on the NFFR for water-supply management and generation of hydroelectric power. One of the key issues is the feasibility of increasing the release of coldwater from Lake Almanor and/or Butt Valley Reservoir that has been retained behind the dams. The increased release of colder water is essential to the fishery habitats downstream of the dams. Additionally, higher flow releases also are being studied for whitewater recreational use. It is important that any increased flow releases be managed properly so that the higher flows will not disrupt the downstream sediment structure. Therefore, the Pacific Gas and Electric (PG&E) has authorized this incipient motion study of the Upper NFFR, which will provide important information for PG&E management to determine the optimal dam releases.

The main objective of this study is to estimate the sediment incipient motion in the Upper NFFR associated with different flow releases from Canyon Dam (Lake Almanor), Butt Valley Dam and Belden Dam. Surveyed river cross sections, measured flow characteristics and sediment samples were analyzed to evaluate the critical shear stress and corresponding threshold flow at which incipient motion of sediments will occur. The primary product resulting from this study is a table of threshold flows at which sediment motion is expected to commence in various reaches of the Upper NFFR. This information will assist in the optimization of flow releases from the dams for achieving a balance between desired resource conditions (e.g., stream temperature, fishery physical habitat and recreational needs) and sediment dynamics in the Upper NFFR. **Figure 1** shows the regional location of the studied areas.

2. PHYSICAL SETTING

The North Fork Feather River (NFFR) is a relatively steep gradient, canyon bound river that drains from the west slope of the Sierra Nevada Mountains. Channel form and sediment distribution within steep mountain channels are most influenced by infrequent hydrologic events. The transport of bed material is an episodic phenomenon requiring large magnitude flows to entrain the more coarse-grained sediments and finer sediments trapped in pools (Harvey, Mussetter and Wick, 1993).

This sediment incipient motion study covers three separate river reaches along the Upper NFFR, the Seneca (NFFR) Reach, the Belden (NFFR) Reach and the Butt Reach (lower Butt Creek). **Figure 2** shows the location of limits of the three studied reaches. PG&E supplied a total of 81 surveyed river cross-section (transect) data along the NFFR. These transects were selected for the PG&E study of the fishery habitats using the In-stream Flow Incremental Methodology (IFIM). The Seneca Reach of the NFFR is divided into seven sections, and extends from south of the Camp Almanor Gauging Station, downstream past the Seneca town-site and China Bar to just north of the Caribou Powerhouse. The Belden Reach of the NFFR is divided into five sections and extends from south of the Belden Dam, downstream to the Belden town-site. The third river reach, the lower Butt Creek (a tributary to the NFFR), is divided into two sections and extends two miles from the Butt Valley Dam into the NFFR just downstream of China Bar.

The characteristics of 81 cross sections can be grouped into different riverine categories, Pools, Low Gradient Riffles (LGR), Runs (Run) and Pocket Water (POW). The following definitions of the various habitats type are from the California Department of Fish and Game (Flosi, G. and F.L. Reynolds):

- Low Gradient Riffle – "LGR"
  Shallow reaches with swiftly flowing turbulent water with some partially exposed substrate; gradient < 4%, substrate is usually cobble dominated.

- Run – "RUN"
  Swiftly flowing reaches with little surface agitation and no major flow obstructions; often appears as flooded riffles; typical substrate consists of gravel, cobble, and boulders.

- Pocket Water – "POW"
  A section of swift flowing stream containing numerous boulders or other large obstructions which create eddies or scour holes (pockets) behind the obstructions.

- Pool – "STP"
  A series of pools separated by short riffles or cascades; generally found in high gradient, confined mountain streams dominated by boulder substrate.

Pictures 1 to 4 (see **Figure 3**) show representative cross sections for a pool, a low gradient riffle, a run and a pocket water. The detailed definitions and graphical exhibits of different habitats are shown in **Appendix A**.

3. FIELD DATA

To study the sediment incipient motion, it is necessary to fully understand the sediment and flow characteristics for the studied reaches. PG&E and their consultants performed field studies to survey river cross-sections, and to collect sediment as well as flow data. The data was used to evaluate the critical shear stress and corresponding threshold flow at which the incipient motion of sediments will occur.

Surveyed river cross sections (transects) were provided by PG&E from their IFIM studies on the defined reaches. The following table, **Table 1**, summarizes the number of transects analyzed and their characteristic river type.

Table 1 Summary of Transects in Three Studied Reaches

	Seneca Reach (7 Sections)	Belden Reach (5 Sections)	Butt Valley Reach (2 Sections)	Total
POW	8	5	3	16
RUN	11	9	3	23
LGR	4	5	2	11
POOL	16	7	5	28
Braided#	0	3*	0	3
Total	39	29	13	81

Braided transects not analyzed for incipient motion conditions

* All three braided transects are located at the downstream end of Belden section 5

All transects except those categorized as pools and braided channel reaches were analyzed for the incipient motion analysis. The number of transects studied is 50, out of the total 81 transects surveyed.

At each transect, velocities and water surface energy slopes were measured and analyzed for a range of stream flow conditions. PG&E conducted various flow releases from Canyon Dam, Butt Valley Dam and Belden Dam so that flow characteristics could be measured in the downstream reaches. The following table, **Table 2**, summarizes the approximate flow releases from three reservoirs:

Table 2 **Summary of Flow Releases for Field Study**

Flow Release No.	Flow from Canyon Dam (cfs)	Flow from Belden Dam (cfs)	Flow from Butt Valley Dam (cfs)
1	~ 700	~ 1,200	~10
2	~ 300	~ 750	
3	~ 100	~ 500	
4	~ 35	~ 215	

Sediment samples were collected from the surface of the streambed at three different locations, one below the Canyon Dam, one just upstream from the Seneca Bridge, and one above the Caribou Powerhouse. The three sediment samples were sent to a laboratory and analyzed for particle size gradation. **Figure 4** shows the locations where the sediment samples were taken. The following table, **Table 3**, summarizes the median grain size (d_{50}) for the 3 sediment samples. The sediment particle size gradation curves are shown in **Appendix B.**

Table 3 **Summary of Sediment Median Grain Size**

Sample No.	Sample Location	Median Grain Size (mm)	Classification
1	Below Canyon Dam	15	Median Gravel
2	Above Seneca Bridge	8	Fine Gravel
3	Above Caribou Powerhouse	11	Fine Gravel

There were additional sediment gradation data collected in a separate geomorphic study for PG&E (Entrix, 2002), which included pebble counts and bulk sediment samples (surface and subsurface) in Seneca and Belden reaches. Their sample median sizes, varying from 50 mm to 160 mm, were much coarse than the three above samples.

4. HYDRAULIC ANALYSIS

Before performing the incipient motion analysis, it is necessary to first complete the hydraulic analysis to establish the flow characteristics at each studied transect. PG&E provided four measured flow discharges and the corresponding water surface elevations at each transect for the purpose of calibrating the hydraulic models. River flow characteristics, such as channel velocities and Manning's n values, were calibrated using these, discharge versus measured water surface elevation, values.

The surveyed river transects provided a core around which to build the hydraulic models. The analysis was performed using the one-dimensional U.S. Army Corps of Engineers HEC-RAS computer program. Four sets of flow characteristics (except the Butt Reach, which only has 1 set of flow characteristics) were calculated for each transect based on the surveyed field hydraulic data. The main goal is to establish the velocity versus discharge relationship for each transect. Once the velocity versus discharge values are established, the mathematical relationship for each transect was extrapolated to determine a wider range of velocities for use in the incipient motion calculations. Hydraulic conditions within the study reach were evaluated for discharges ranging from 35 cfs to 10,000 cfs. Results were then used to establish hydraulic parameters and estimate incipient motion conditions for the range of discharges at specific transects within the reach.

Although the hydraulic analysis is based on a one-dimensional solution to a multi-dimensional hydraulic problem, the present assessment is adequate to provide a guideline and trend analysis for a sediment management plan. The present analysis clearly defines the variations in hydraulic energy that occur over a wide range of discharges at various transects.

5. INCIPIENT MOTION - THEORY

At low flows, movement of sediment only occurs for fine material. As shown in a typical movable bed physical model study, the flow may be laminar initially, which is an orderly flow that is constant with time. Typically, as flow volume and velocity increase, the turbulent threshold is reached and flow becomes less orderly, varying with time. At some point in the increase of flow volume and velocity, sediment begins to move. This initiation of movement is termed incipient motion. The start of sediment motion occurs sporadically. The particles more prone to move are the ones that have higher drag and less weight. Then as flow increases, the particles more resistant to movement begin to move (Shvidchenko, A.B., P. Gareth and T.B. Hoey, 2000).

Previous studies have indicated that the relative amounts of sand and gravel on the stream bottom affect the magnitude of the water flow that can move them. Sand sizes were all entrained over a narrow range of bed shear stress while entrainment of gravel sizes was still a function of grain size.

Given a flow, the incipient motion analysis determines the critical particle size (D_c); the riverbed grain size that is on the verge of motion for a specific transect under study. The critical particle size for the range of discharges modeled was estimated using the Shields (1936) relation:

$$\tau_c = \tau_{*c}(\gamma_s - \gamma)D \qquad (1)$$

where: τ_c is the critical shear stress,

τ_{*c} is the dimensionless critical shear stress,

γ_s is the unit weight of sediment (~165 lb/ft^3, γ_s is the unit weight of water (62.4 lb/ft^3), and

D is the particle size.

D_c is obtained by substituting the grain shear stress (τ') for τ_c, and D_c for D in Equation (1), and rearranging into the following form:

$$D_c = \frac{\tau'}{\tau_{*c}(\gamma_s - \gamma)} \qquad (2)$$

Reported values for τ_{*c} for the median particle size of the surface bed material range are from 0.03 (Meyer-Peter, Muller, 1948; Neill, 1968) to 0.06 (Shields, 1936).

Figure 5 is a graph of the data used by Shields to determine the Equation (1). The data delineating the curve were obtained by Shields and several other researchers from experiments in flumes with fully-developed turbulent flows and artificially flattened beds of non-cohesive sediments. In this graph, the quantity d_s is taken as the mean size of the sediment. The curve reaches a minimum of τ_{*c} (dimensionless critical shear stress) of 0.033 at R^*_c (critical boundary Reynolds number) near 10. For higher R^* the curve reaches the constant value of $\tau_{*c} = 0.06$.

Shields' results shown in Figure 5 have been widely accepted, although some researchers have reported somewhat different values for the parameters. A value of 0.047 is commonly used in engineering practice based on the Meyer-Peter, Muller bed-load transport equation (Meyer-Peter, Muller, 1948). More recent studies indicate that a value of 0.03 may be more reasonable for gravel and cobble bed streams (Parker et al., 1982; Andrews, 1983). Neill (1968) concluded that 0.03 maybe a good indicator of the incipient motion where the bed material is just at the verge of motion while 0.047 is indicative of a "low, but measurable transport rate." The value of 0.06 represents the condition when the bed is having a very active sediment transport.

For purposes of this analysis, incipient conditions were computed using τ_{*c} values of 0.03, 0.047, and 0.06 to address the range of conditions associated with uncertainty in selection of a single appropriate value. The bed shear stress due to grain resistance (τ') is a better descriptor of near-bed hydraulic energy in gravel-cobble bed streams than the more commonly used total shear stress because it eliminates the effects of flow resistance due to irregularities in the channel boundary, non-linearity of the channel, variations in channel width, and other factors that contribute to the total flow depth, but not the energy available to move individual particles on the channel bed (Einstein, 1950). The grain shear stress (τ') is computed from the following relation:

$$\tau' = \gamma Y' S \qquad (3)$$

where: Y' is the portion of the total hydraulic depth associated with grain resistance (Einstein, 1950) and S is the energy slope at the cross section. The value of Y' is computed by iteratively solving the semi-logarithmic velocity profile equation:

$$\frac{V}{V_*'} = 5.75 + 6.25\log\left(\frac{Y'}{K_s}\right) \tag{4}$$

where: V is the mean velocity at the cross section,
K_s is the characteristic roughness height of the bed, and
V_*' is the shear velocity due to grain resistance given by:

$$V_*' = \sqrt{gY'S} \tag{5}$$

The characteristic roughness height of the bed (K_s) was assumed to be 3.5 D_{84}, (Hey, 1979).

The dimensionless grain shear stress (τ^*), is the ratio of the grain shear stress (τ') to the critical shear stress (τ_c) or:

$$\tau'_* = \frac{\tau'}{\tau_c} = \frac{\gamma Y'S}{\tau_{*c}(\gamma_s - \gamma)D_{50}} \tag{6}$$

When $\tau^* < 1$, there is insufficient shear stress to mobilize the bed material; when $\tau^* > 1$, particle mobilization is indicated.

The median (D_{50}) size of the bed material was used to evaluate incipient motion conditions because, in cobble and gravel bed streams, the full range of particle sizes in the bed are mobilized over a very narrow range of shear stresses (Parker et al., 1982). At discharges less than the critical discharge for the median size, the bed is essentially immobile. At higher discharges, virtually the entire bed material matrix is in motion. Analysis of the variation in dimensionless grain shear stress (τ^*) with discharge at key locations provides a good picture of the dynamics of the study reach.

6. INCIPIENT MOTION - DATA ANALYSIS

For each transect in the study, discharge versus τ^* plots were generated for five median grain sizes: very fine, fine, medium, coarse and very coarse gravel; and for three values of dimensionless critical shear stress (τ_{*c}): 0.03, 0.047, and 0.06. The following table, Table 4, summarizes the diameters for various gravel sizes used for the present analysis.

Table 4 Typical Gravel Sizes

Class Name	Size Range (mm)	Size Used in Analysis (mm)
Very Coarse Gravel	64-32	48
Coarse Gravel	32-16	24
Medium Gravel	16-8	12
Fine Gravel	8-4	6
Very Fine Gravel	4-2	3

From these discharge versus τ^* plots, the corresponding points of intersection with the line $\tau^*=1$ are inferred to equal the discharge for that specific grain-size and location at which incipient motion will be initiated. For the purpose of this analysis, the $\tau_{\text{-}c}$ value of 0.047 is considered the ideal value, while the $\tau_{\text{-}c}$ values of 0.03 and 0.06 were analyzed as upper and lower boundaries to establish a range of incipient motion conditions.

The graphical results for the three typical transects within Upper NFFR Seneca Reach Section 7 (as shown in **Figure 3** pictures) are shown in **Figures 6 to 8**. Results are provided only for Transect 3 (LGR), Transect 4 (RUN), and Transect 5 (POW) because Transects 1 and 2 are pools. Incipient motion conditions were not analyzed for the pool transects in this study.

Figure 6 details dimensionless grain shear stress versus discharge for one specific grain size, medium gravel (12 mm), over the range of three dimensionless critical shear stresses: 0.03, 0.047, and 0.06. In the same figure, a dashed line (dimensionless grain shear stress = 1) is drawn to show the threshold value above which the medium gravel size (12 mm) would be mobilized. For instance, taking critical shear stress of 0.047 as the criterion, the interception point with the dashed line at flow of 22 cfs would mobilize the 12 mm gravel. The lower and upper boundaries of the incipient motion flow can be considered as 15 cfs (dimensionless critical shear stress = 0.03) and 30 cfs (dimensionless critical shear stress = 0.06). For the same gravel size, the sediment incipient motion characteristics for the other two transects are shown in **Figures 7 and 8**. Similar analyses were done for other gravel sizes.

Figure 9 consolidates the dimensionless grain shear stress versus discharge for one specific dimensionless critical shear stress, 0.047, over the range of median gravel grain sizes: very fine, fine, medium, coarse, very coarse. The graphs can provide information on whether each specific gravel size would move under certain flow conditions. **Figures 9 to 11** shows the results for the same Transects 3, 4 and 5 of Seneca Reach Section 7, respectively. Take **Figure 9** as an example, it will take 22, 50 and 200 cfs, respectively, to mobilize median gravel, coarse gravel and very coarse gravel in Transect 3 (LGR) of Seneca Reach 7. Similar information can be obtained from **Figures 10 and 11**.

From **Figures 9 to 11**, the interception points with the threshold dashed line for each sediment sizes are determined as the minimum flow requirement for sediment initiation. The sediment sizes and the required initiation flows were then used to construct the incipient motion relationship for the given transect as shown in **Figure 12**. Three dimensionless critical shears stresses of 0.03, 0.047 and 0.06 are included in the figure to provide the range of potential values for incipient motion. For each grain size diameter there are a range of discharges, which can mobilize the sediment. For example, the flows to mobilize median gravel (12 mm) are 22 cfs (average), 15 cfs (lower limit) and 30 cfs (upper limit), respectively. Or, for 30 cfs, it is possible to mobilize gravel between 12 mm (median gravel) and 24 mm (coarse gravel). **Figures 13 to 14** shows the results for Transects 4 and 5 (Seneca Reach Section 7).

The relationship of discharge versus grain-size incipient motion for each riverine category (runs, riffles, pocket waters, etc.) are then plotted together (**Figures 15 to 17**) to determine an optimal range of discharges, which would mobilize various gravel sizes for each specific river section. The seven sections of the Seneca Reach, for instance, yielded seven "optimal discharge versus grain-size" relationships. From these seven relationships, a composite, best-fit relationship is then inferred to typify the entire Seneca Reach. The incipient motion summary charts for Seneca, Belden, and Butt Creek reaches are shown in **Figures 15, 16 and 17**, respectively.

7. RESULTS AND DISCUSSIONS

On the Seneca Reach incipient motion summary chart (**Figure 15**), the seven dashed lines represent the trends for each specific river section in the Seneca Reach. The solid, bold line falls within the upper and lower limits of these seven lines and represents the composite Seneca relationship. This line signifies the overall incipient motion boundary, above which the given grain-size sediment will not be entrained, while below which will be in motion. The five river section trends of the Belden Reach were similarly plotted in the Belden Reach incipient motion summary chart (**Figure 16**) along with the composite Belden relationship. The two sections of the Butt Creek analysis yielded much higher incipient motion thresholds due to its steeper grade and should be considered separately from the NFFR reaches (**Figure 17**).

The following Tables 5 to 7 summarize the results of sediment incipient motion analysis for Seneca, Belden and Butt Reaches:

Table 5 Summary Results from Incipient Motion Analysis – Seneca Reach

Gravel Size	Threshold Flow (cfs)		
	Lower Threshold	Average Threshold	Upper Threshold
Very Fine Gravel (3 mm)	0.1	1	3
Fine Gravel (6 mm)	2	8	15
Median Gravel (12 mm)	25	55	100
Coarse Gravel (24 mm)	170	375	1,000
Very Coarse Gravel (48 mm)	950	2,600	5,200

Table 6 Summary Results from Incipient Motion Analysis – Belden Reach

Gravel Size	Threshold Flow (cfs)		
	Lower Threshold	Average Threshold	Upper Threshold
Very Fine Gravel (3 mm)	1	25	175
Fine Gravel (6 mm)	7	95	475
Median Gravel (12 mm)	45	330	1,260
Coarse Gravel (24 mm)	250	1,150	3,600
Very Coarse Gravel (48 mm)	1,400	4,000	11,000

Table 7 Summary Results from Incipient Motion Analysis – Butt Reach

Gravel Size	Threshold Flow (cfs)		
	Lower Threshold	Average Threshold	Upper Threshold
Very Fine Gravel (3 mm)	-	-	-
Fine Gravel (6 mm)	-	-	-
Median Gravel (12 mm)	0.01	0.02	0.1
Coarse Gravel (24 mm)	0.6	1	3
Very Coarse Gravel (48 mm)	50	70	70

Based on the composite curve for the Seneca Reach (Figure 15), the current instream flow release of 35 cfs at Canyon Dam will put sediments less than 10 mm (fine gravel) in motion and not median gravel or larger material. Based on the composite curve for the Belden Reach (Figure 16), the current instream flow release of 140 cfs at Belden Dam will put sediments less than 8 mm (fine gravel) in motion and not median gravel or larger material. From sediment gradation data collected by Entrix, sediments of less than 8 to 10 mm are generally less than 10% of the total fraction. This is in agreement with the results of this study.

It should be noted that this study is to provide a general guidance in optimizing a suitable regulated flow release to minimize sediment impact. The study does not address, nor is intended to, describe geomorphic process during high flows (in the range of thousands of cfs). This study does not address the sediment recruitment and/or sediment routing in the river system.

This study also only addresses an environment with uniform size sediment. Previous studies reveal that critical bed shear stress for incipient motion of uniform sediment depends not only on the grain size, but also on the bed slope. This is explained by the effect of relative roughness on overall flow resistance. It is also known that the value of critical dimensionless bed shear stress is not constant for rough turbulent flow, as is usually assumed, but gradually reduces for coarser gravel.

The incipient motion of individual size fractions within a mixture appears to be controlled by their relative size (d_{50} /d_{84}), median size (d_{50}), and sediment sorting. The experiments with graded sediment demonstrate that shear stress at incipient motion of median-sized particles (d_{50}) in mixtures with geometric standard deviation is the same as for uniform sediment of the same size. For mixtures with a wider grading, the critical shear stress of the d_{50} particles is higher compared to uniform sediment. This is explained by the silting effect reducing the overall mobility of the bed material.

8. REFERENCES

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9. ACKNOWLEDGEMENT

Dr. Scott Tu of PG&E Technical and Ecological Services provided basic data, background information and some of the concepts presented herein.

EXHIBITS

EXHIBIT 1

Gravel Grain-size Diameter versus Discharge

Incipient Motion Analysis

NFFR- Seneca Reach

$\tau^*_c = 0.047$

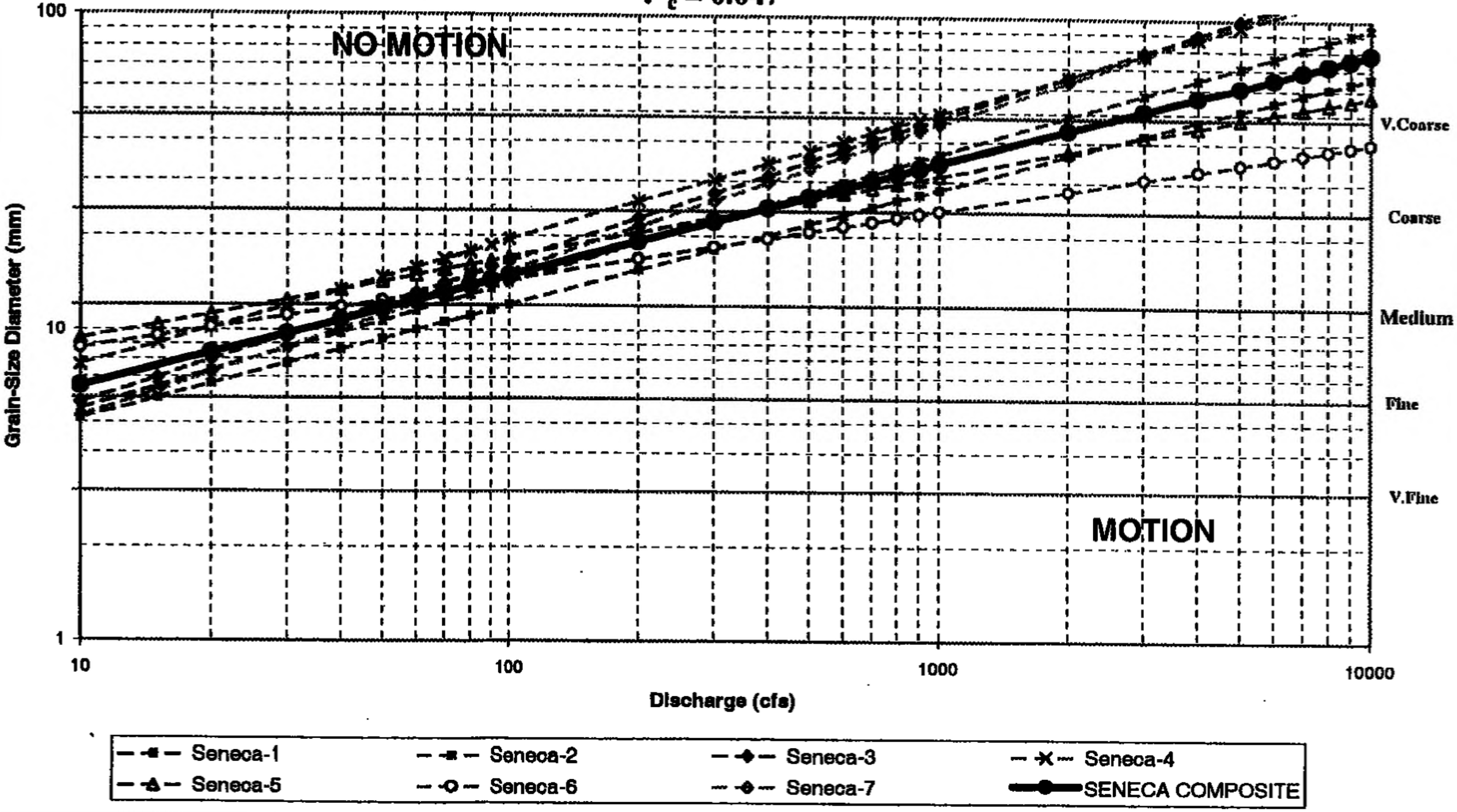

EXHIBIT 2

Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Belden Reach
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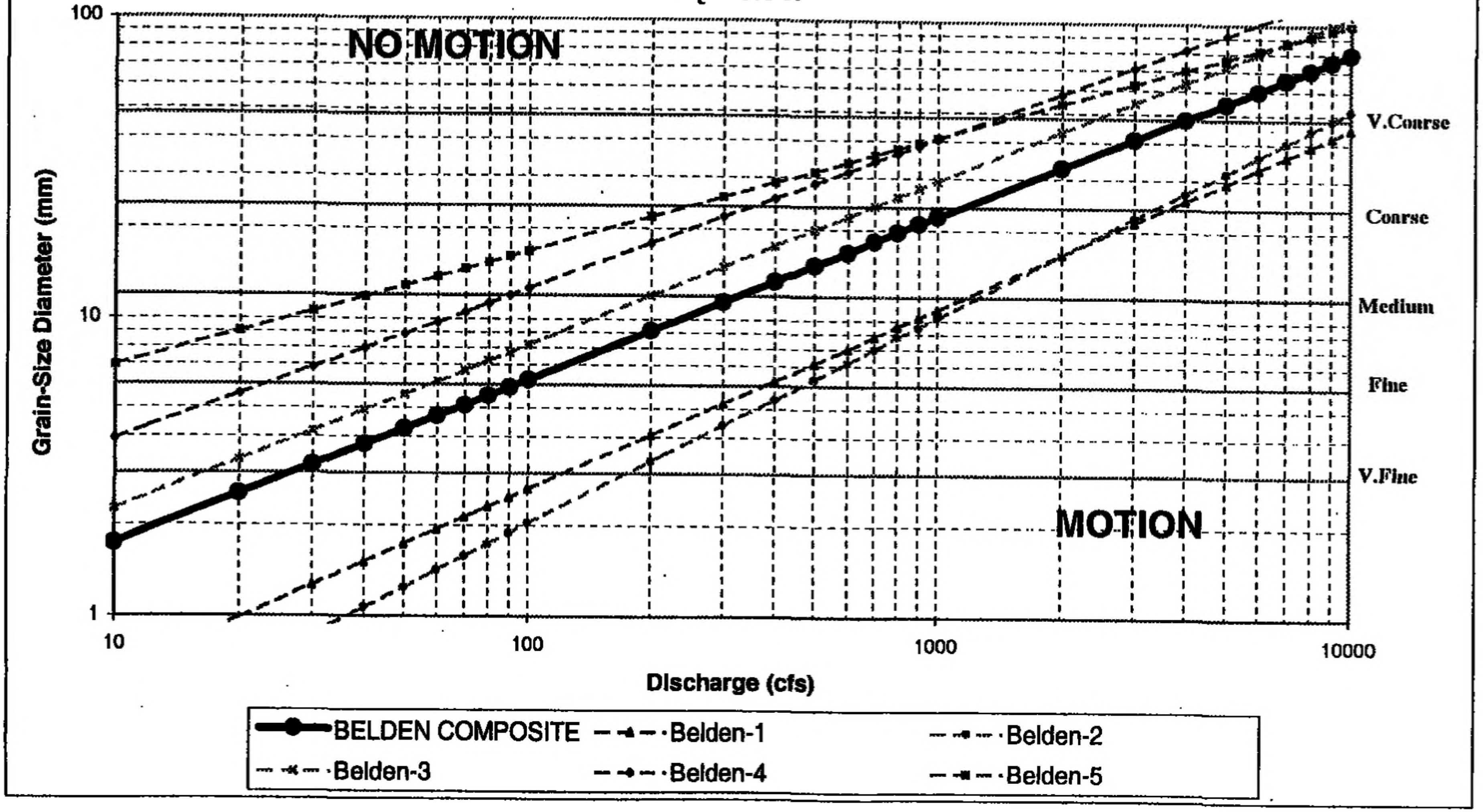
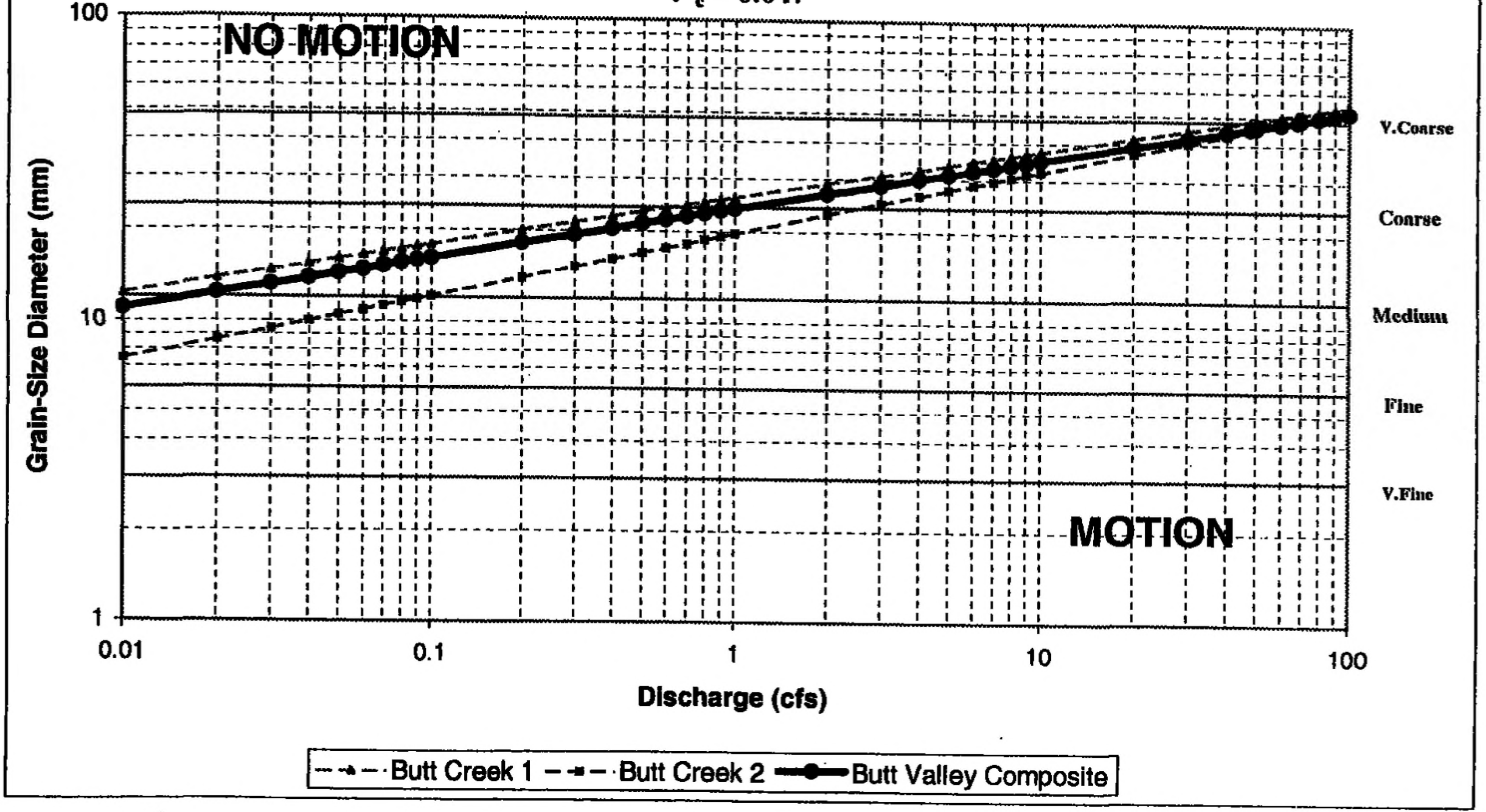
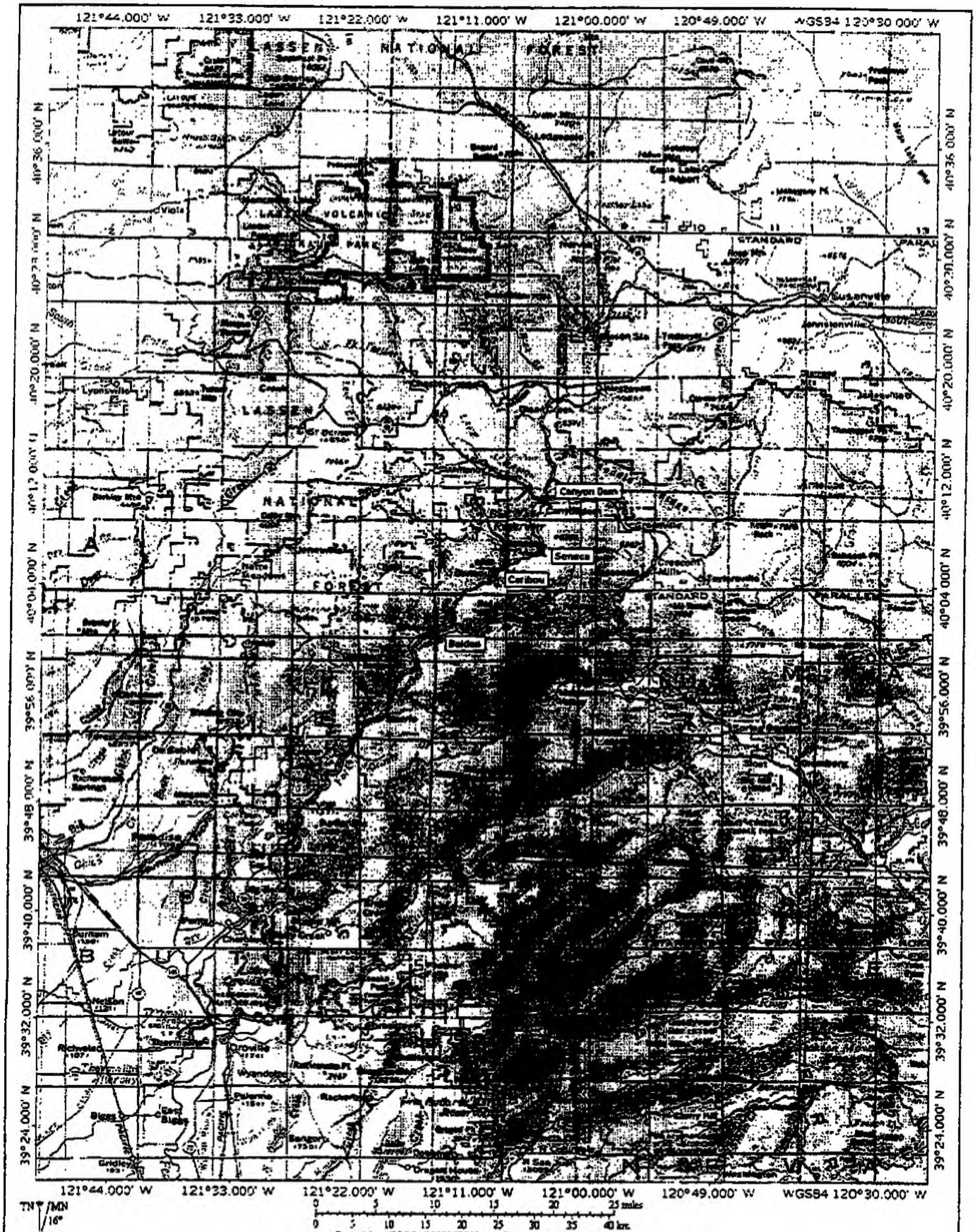


EXHIBIT 3
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
Butt Valley Creek Reach
$\tau^*_c = 0.047$



FIGURES



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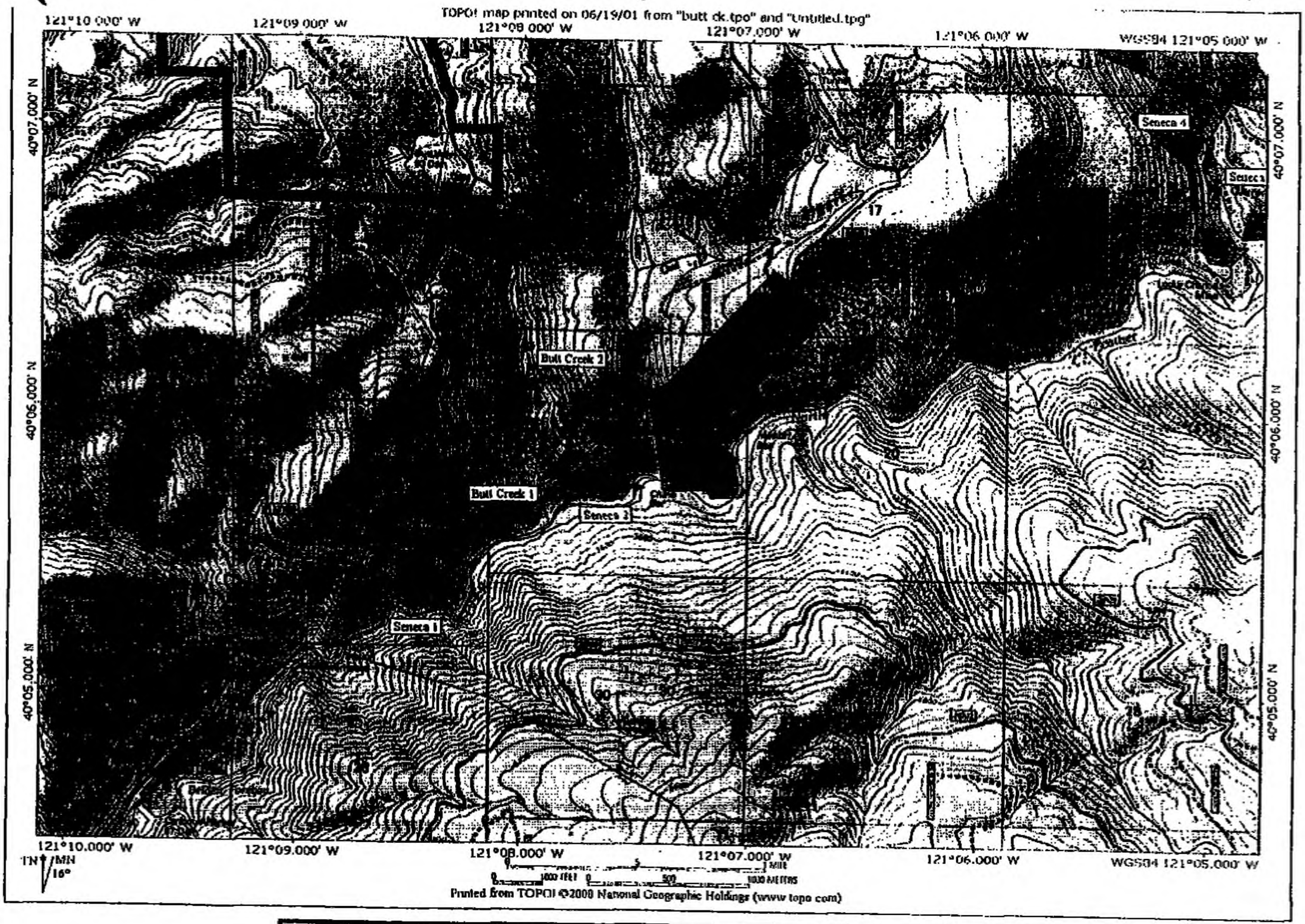
North Fork Feather River Regional Map
FIGURE 1

Upper NFFR Incipient Motion Study
December 2001

North Fork Feather River Regional Map **Seneca Reach Sections**	**FIGURE 2A**
Upper NFFR Incipient Motion Study	**December 2001**

TOPO! map printed on 06/19/01 from "butt ck.tpo" and "Untitled.tpg"



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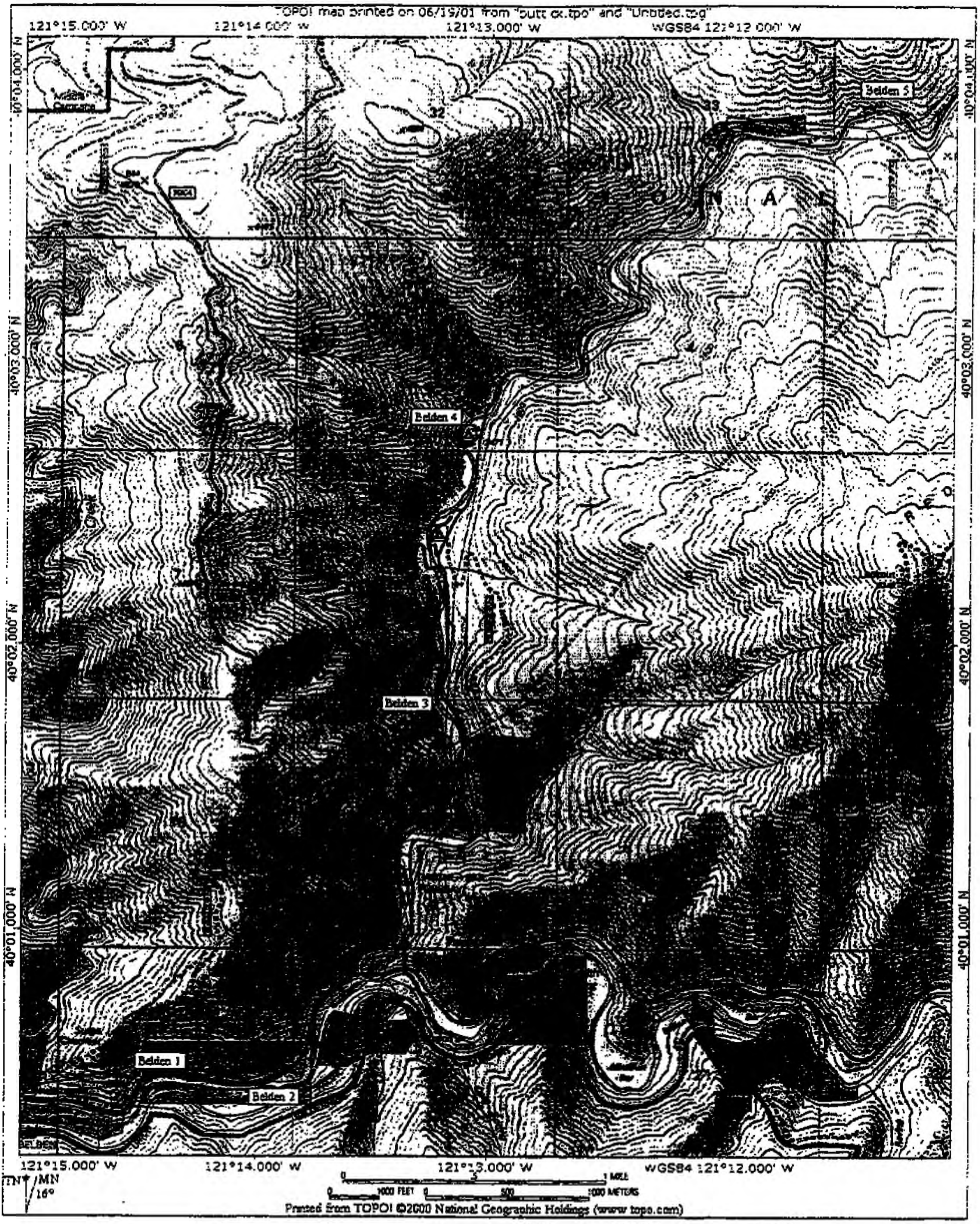
North Fork Feather River Regional Map
Seneca Reach and Butt Reach Sections

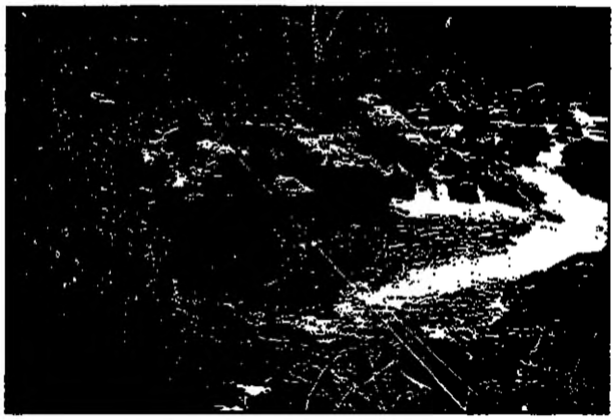
FIGURE 2B

Upper NFFR Incipient Motion Study

December 2001

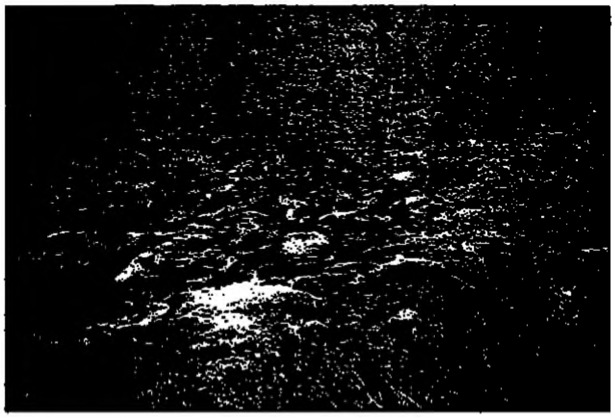


North Fork Feather River Regional Map Belden Reach Sections	**FIGURE 2C**
Upper NFFR Incipient Motion Study	**December 2001**



Picture 1

NFFR – Seneca Reach
Section 7, Transect 1
Habitat Type - **Pool**

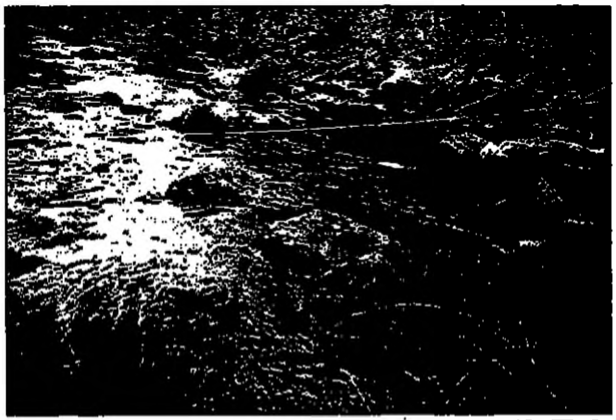


Picture 2

NFFR – Seneca Reach
Section 7, Transect 3
Habitat Type – **Low Gradient Riffle**

Picture 3

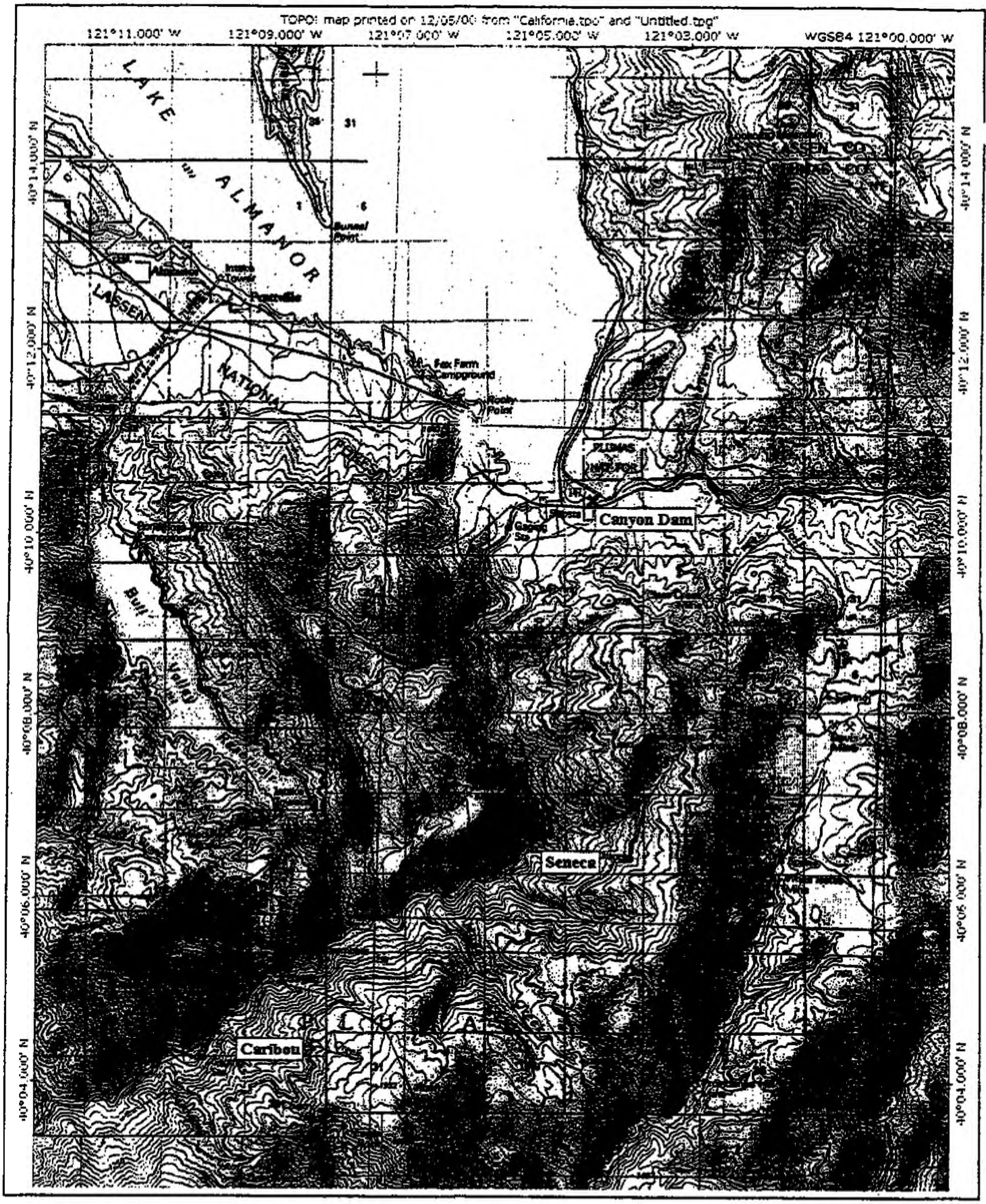
NFFR – Seneca Reach
Section 7, Transect 4
Habitat Type – **Run**



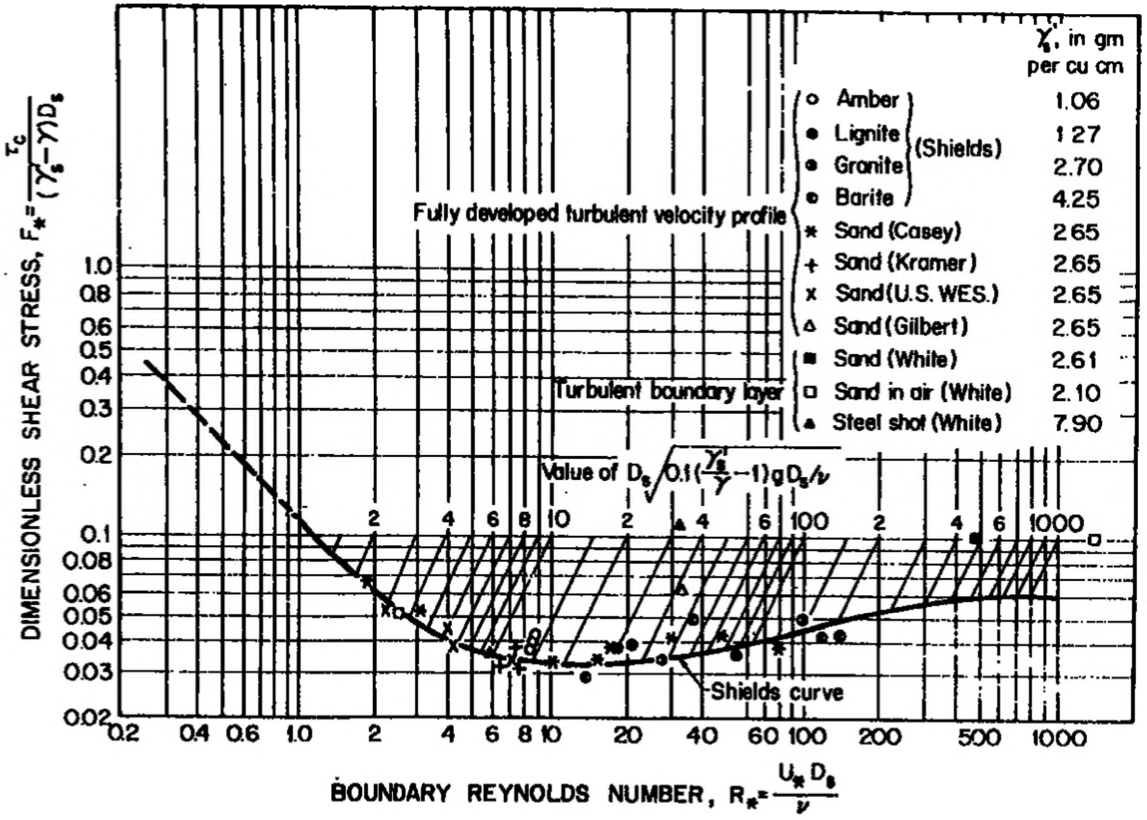
Picture 4

NFFR – Seneca Reach
Section 7, Transect 5
Habitat Type – **Pocket Water**

FIGURE 3 Photos for Four Habitat Types



Sediment Sampling Sites For Incipient Motion Analysis	**FIGURE 4**
Upper NFFR Incipient Motion Study	**December 2001**



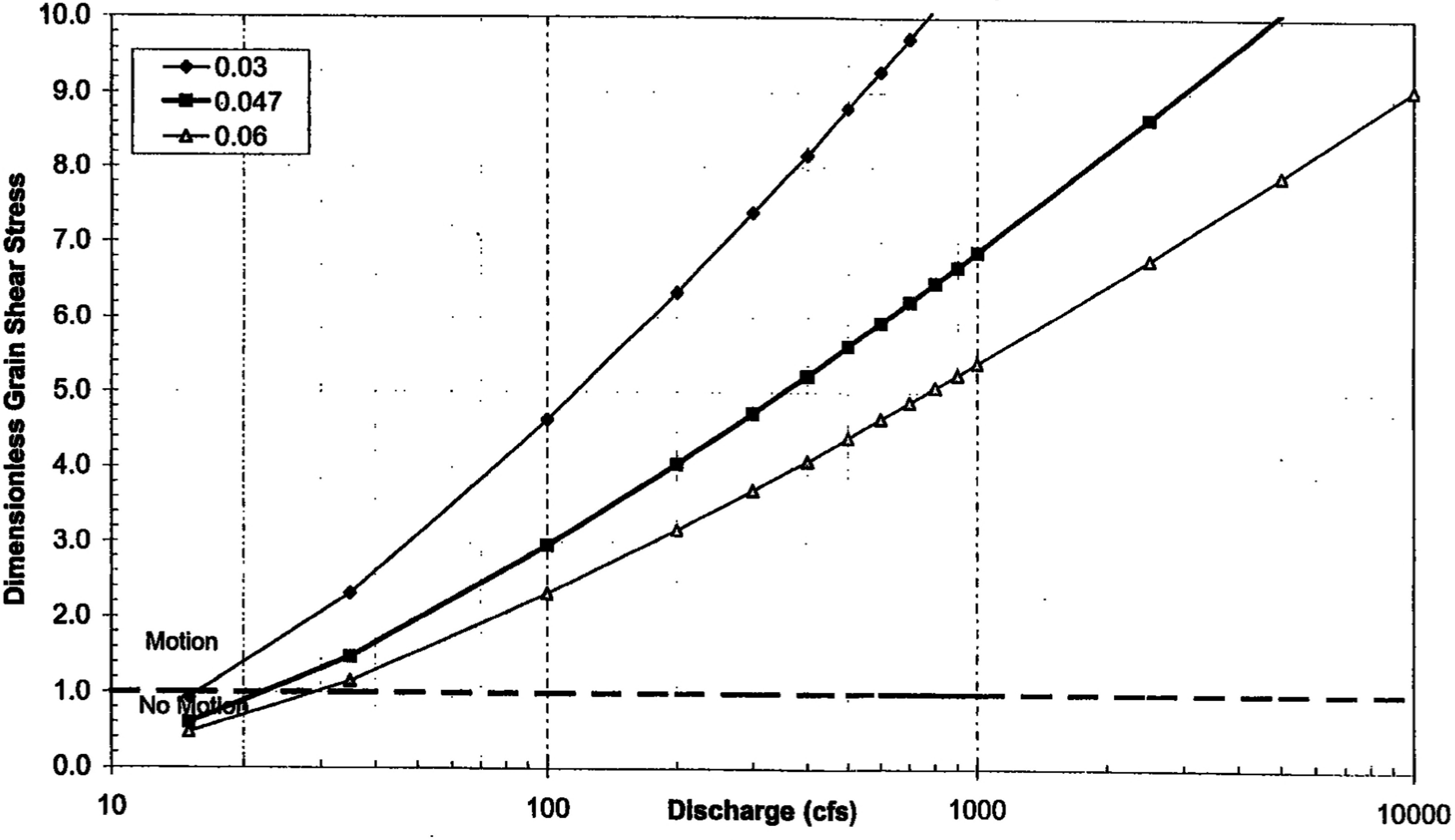
Shields Diagram: Dimensionless Critical Shear Stress

FIGURE **5**

Upper NFFR Incipient Motion Study

December 2001

FIGURE 6
Dimensionless Grain Shear Stress Versus Discharge
NFFR- Seneca Reach7 - Transect 3 LGR
Medium Gravel (12mm) Incipient Motion Analysis



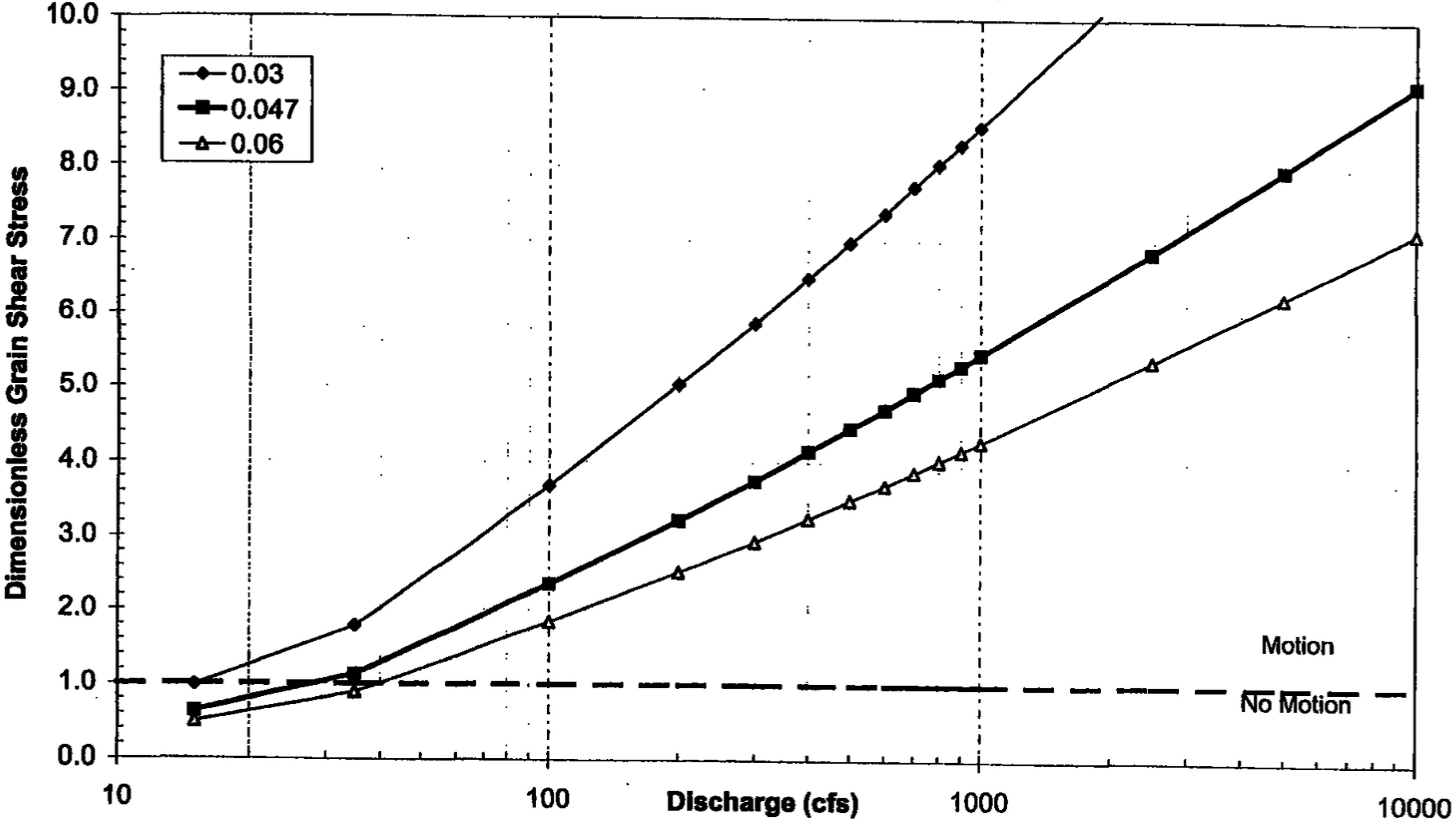
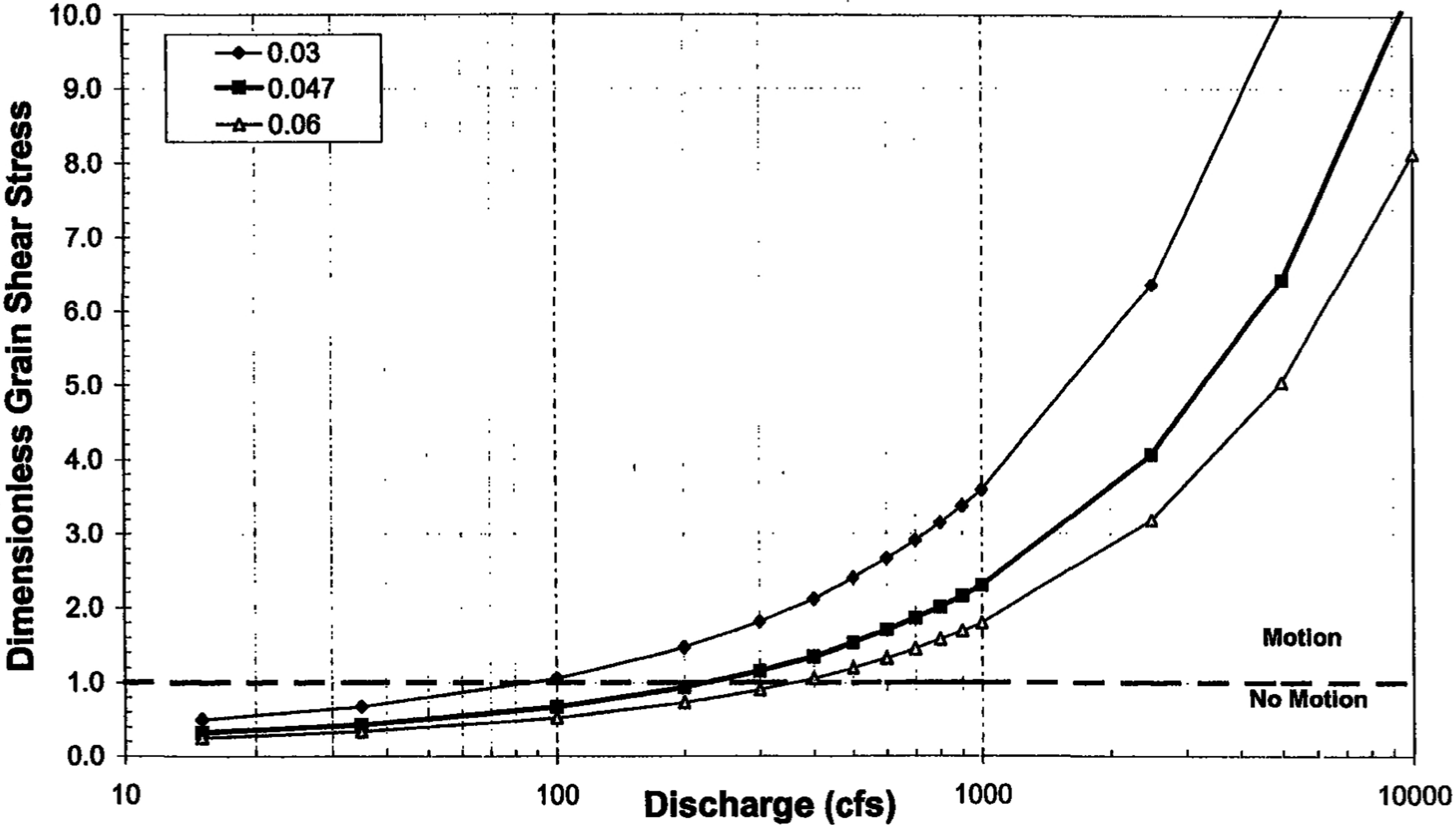


FIGURE 7
Dimensionless Grain Shear Stress Versus Discharge
NFFR- Seneca Reach7 - Transect 4 RUN
Medium Gravel (12mm) Incipient Motion Analysis

FIGURE 8

Dimensionless Grain Shear Stress Versus Discharge
NFFR- Seneca Reach7 - Transect 5 POW
Medium Gravel (12mm) Incipient Motion Analysis



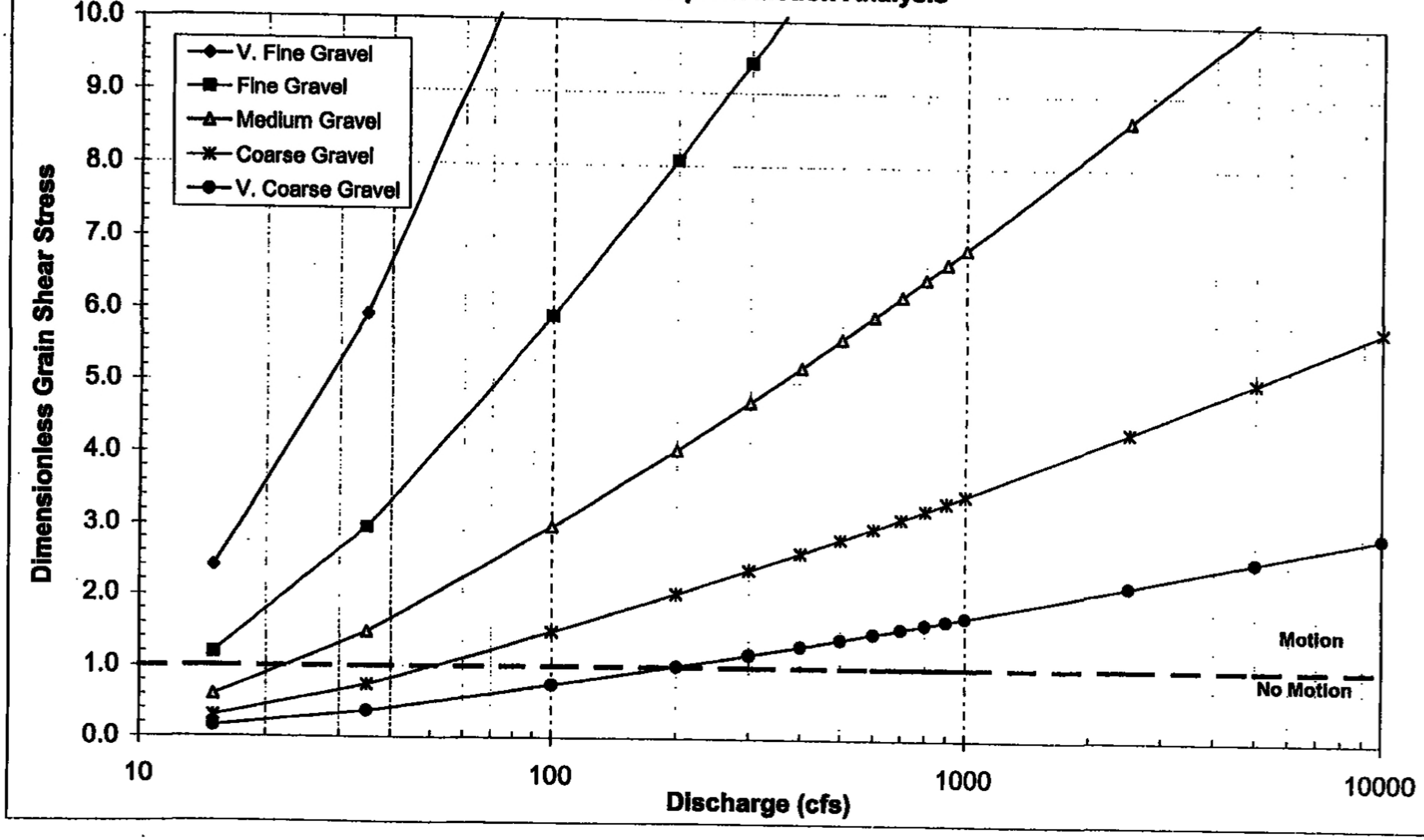


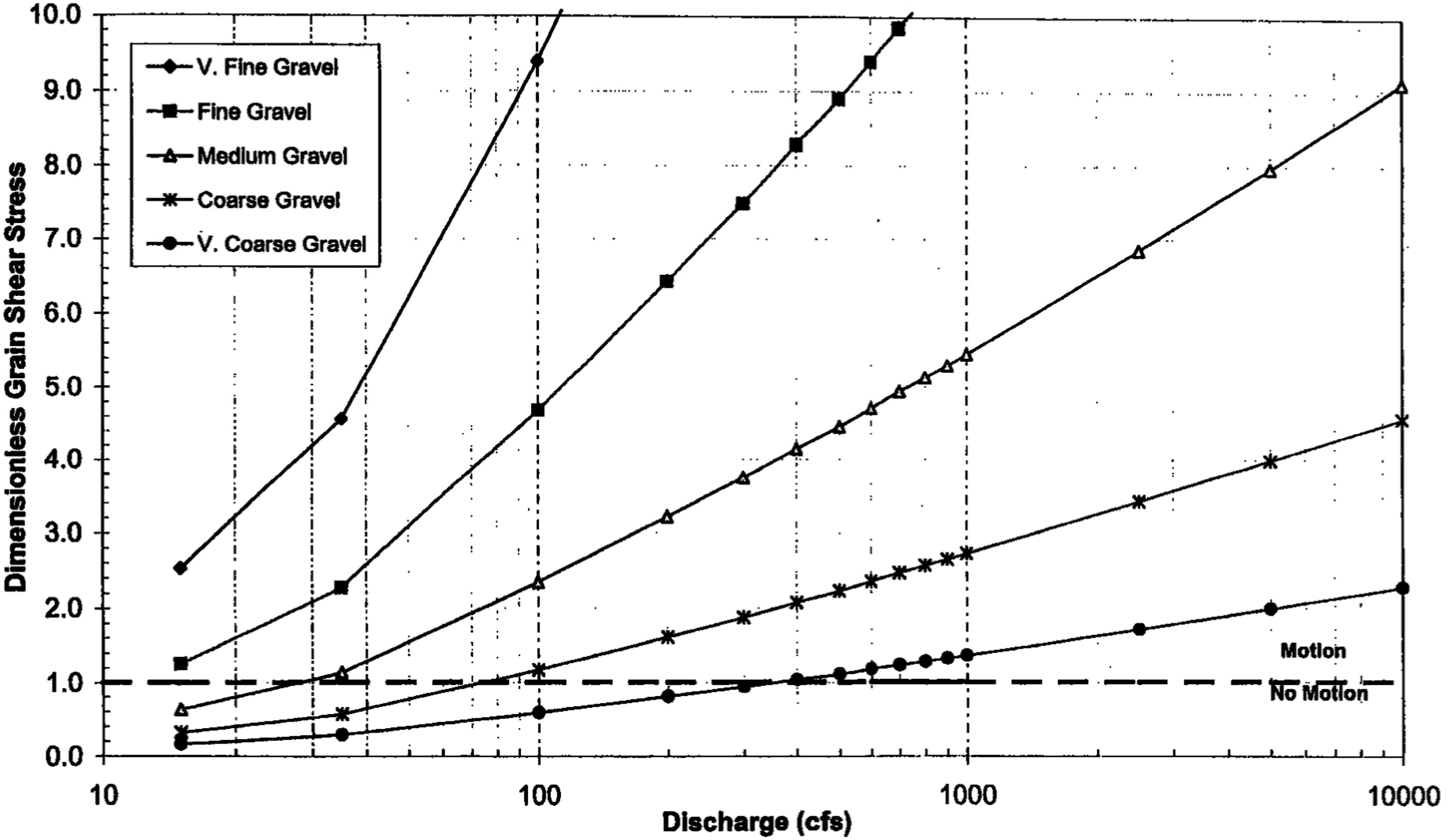
FIGURE 9
Dimensionless Grain Shear Stress Versus Discharge
NFFR- Seneca Reach7 - Transect 3 LGR
t*c = 0.047 Incipient Motion Analysis

FIGURE 10

Dimensionless Grain Shear Stress Versus Discharge

NFFR- Seneca Reach7 - Transect 4 RUN

t*c = 0.047 Incipient Motion Analysis



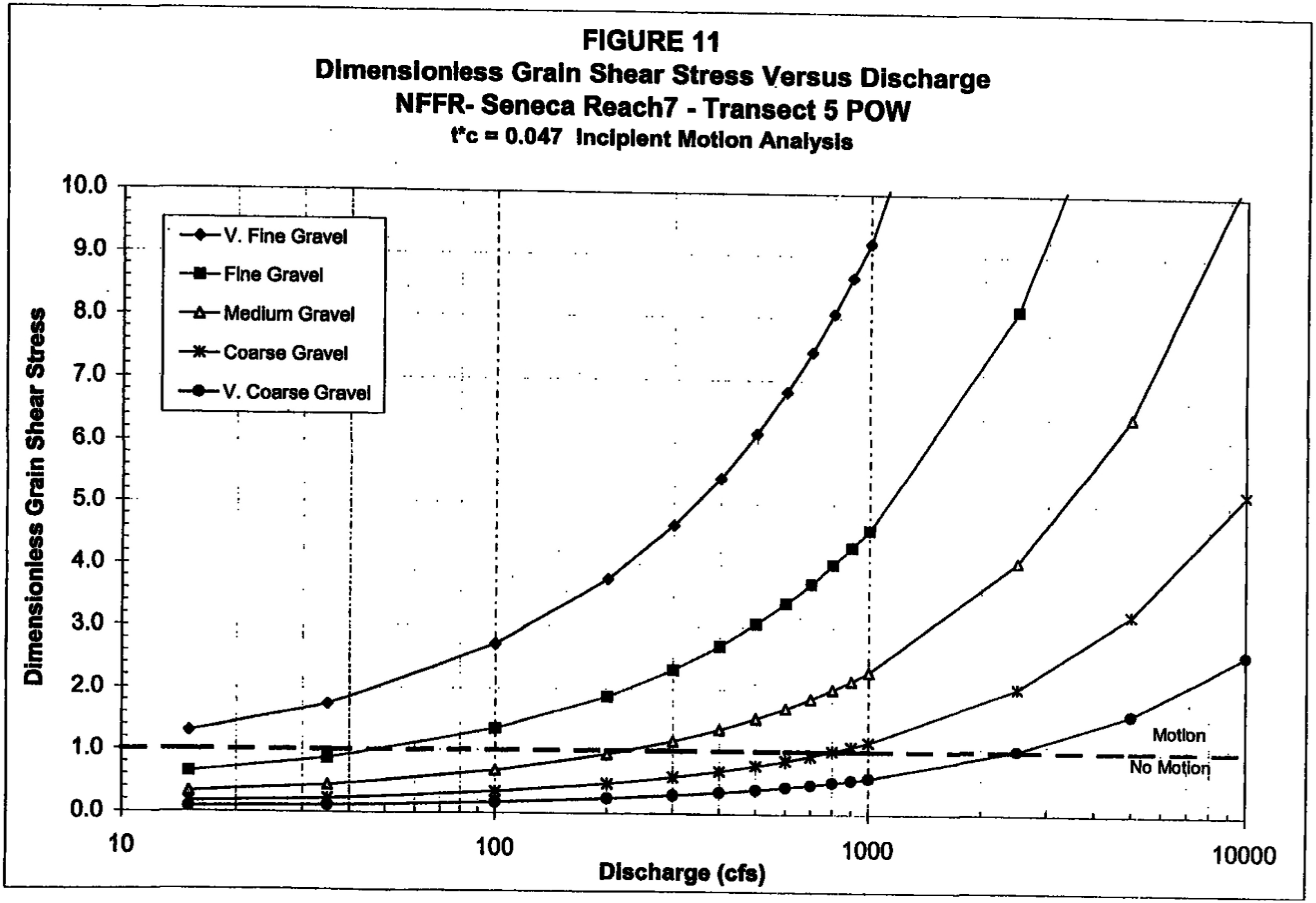


FIGURE 11
Dimensionless Grain Shear Stress Versus Discharge
NFFR- Seneca Reach7 - Transect 5 POW
t*c = 0.047 Incipient Motion Analysis
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Dimensionless Grain Shear Stress
10
100
1000
10000
Discharge (cfs)
V. Fine Gravel
Fine Gravel
Medium Gravel
Coarse Gravel
V. Coarse Gravel
Motion
No Motion

Figure 12
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 7 - Transect 3 LGR

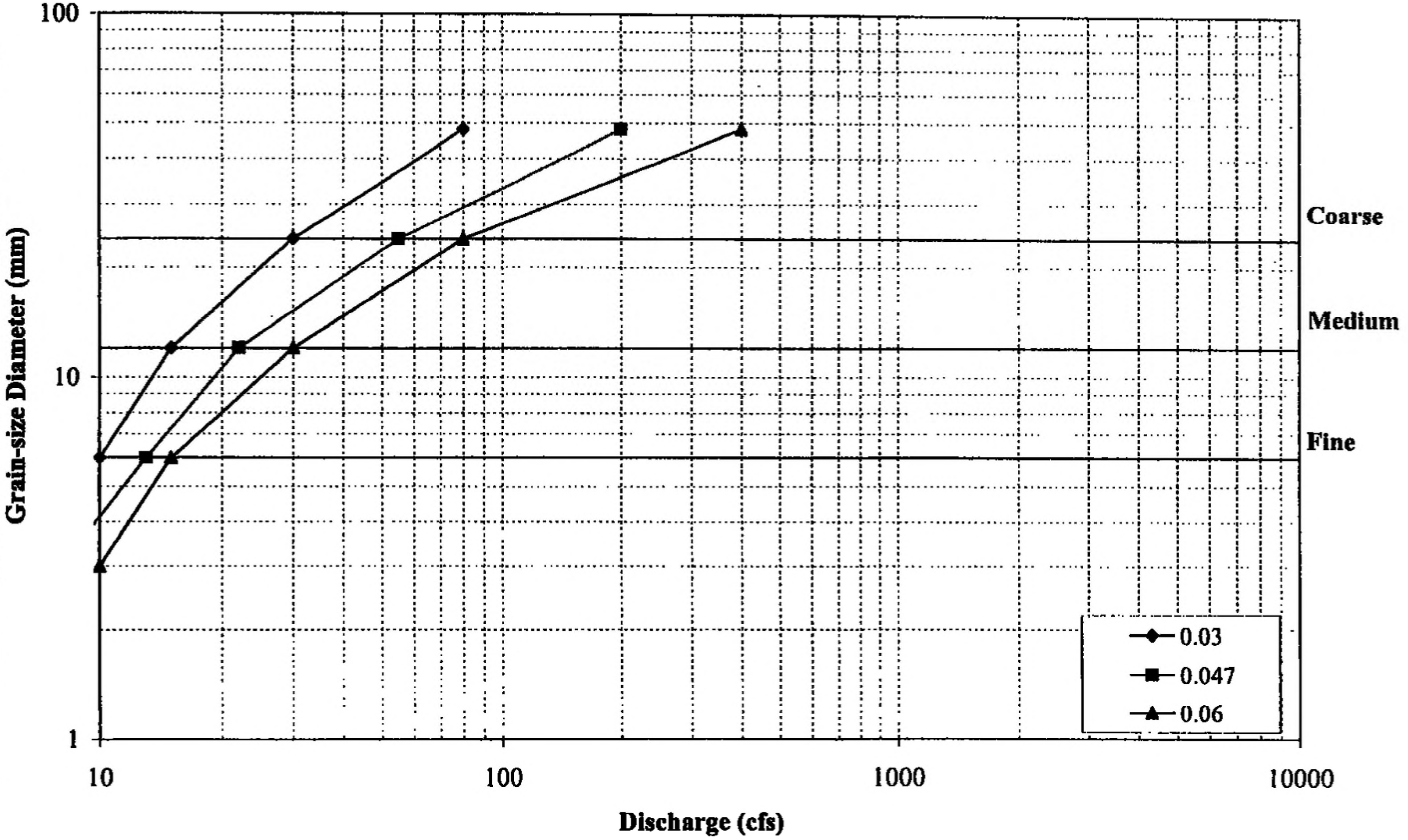


Figure 13
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 7 - Transect 4 RUN

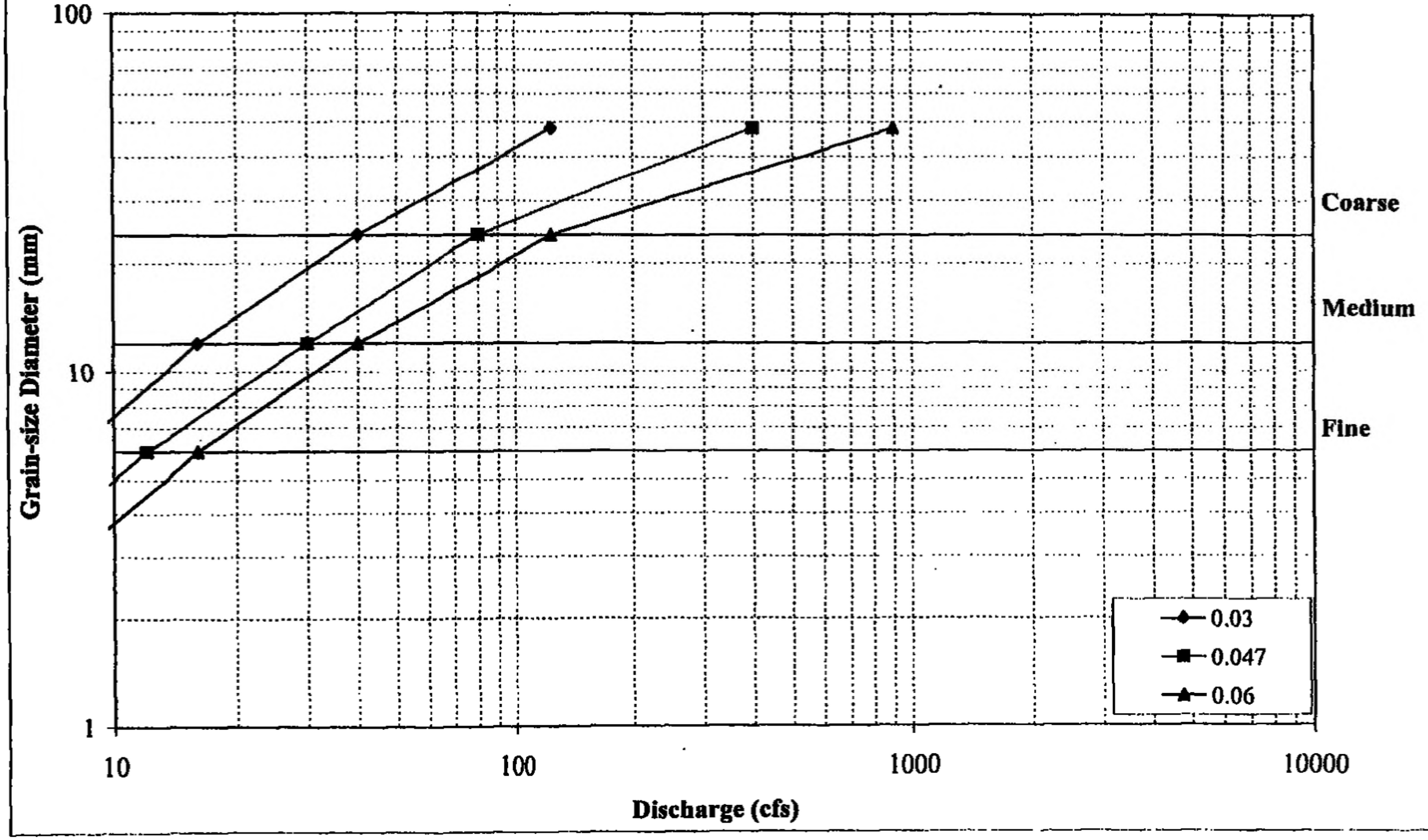


Figure 14
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 7 - Transect 5 POW

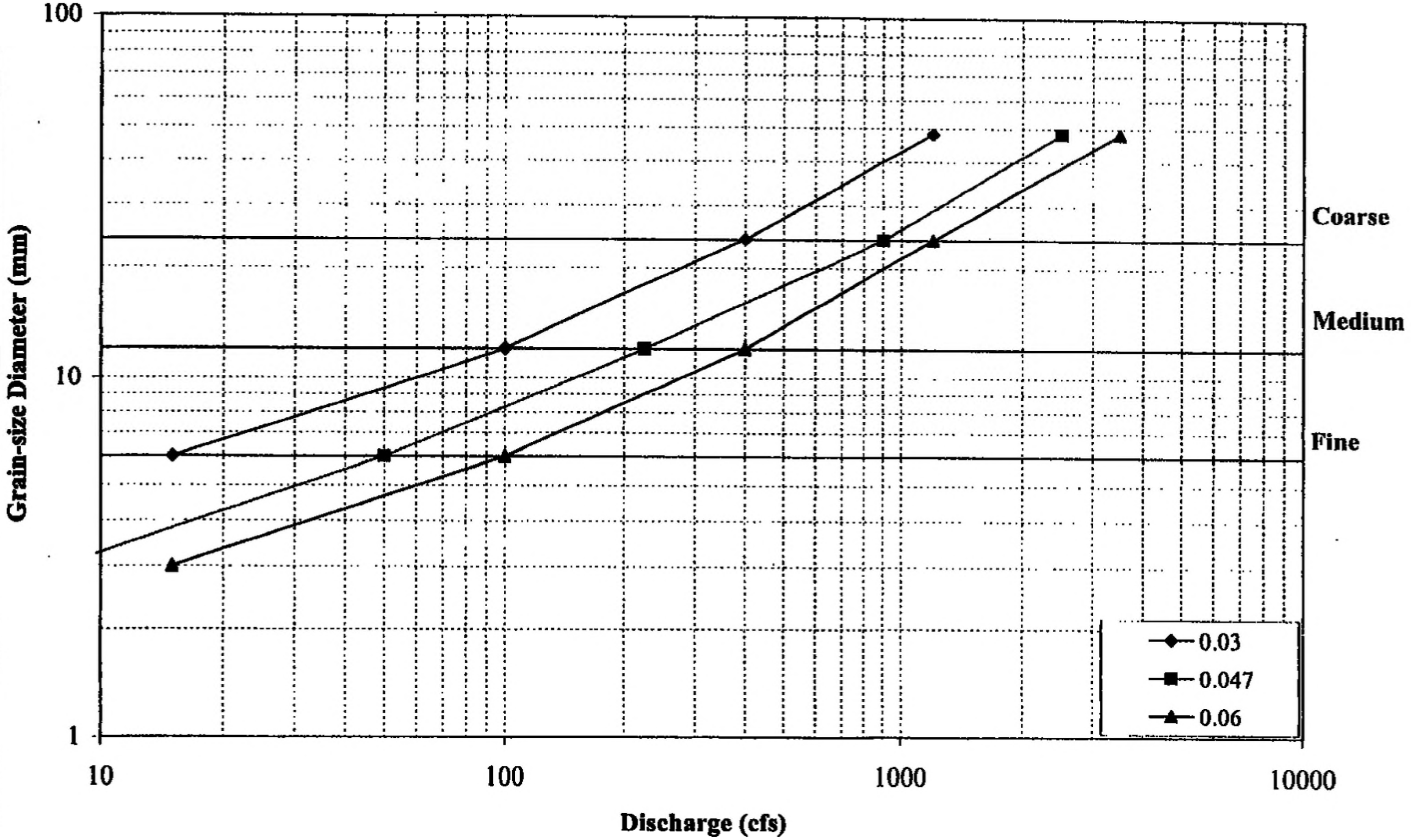


FIGURE 15
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach
$\tau^*_c = 0.047$

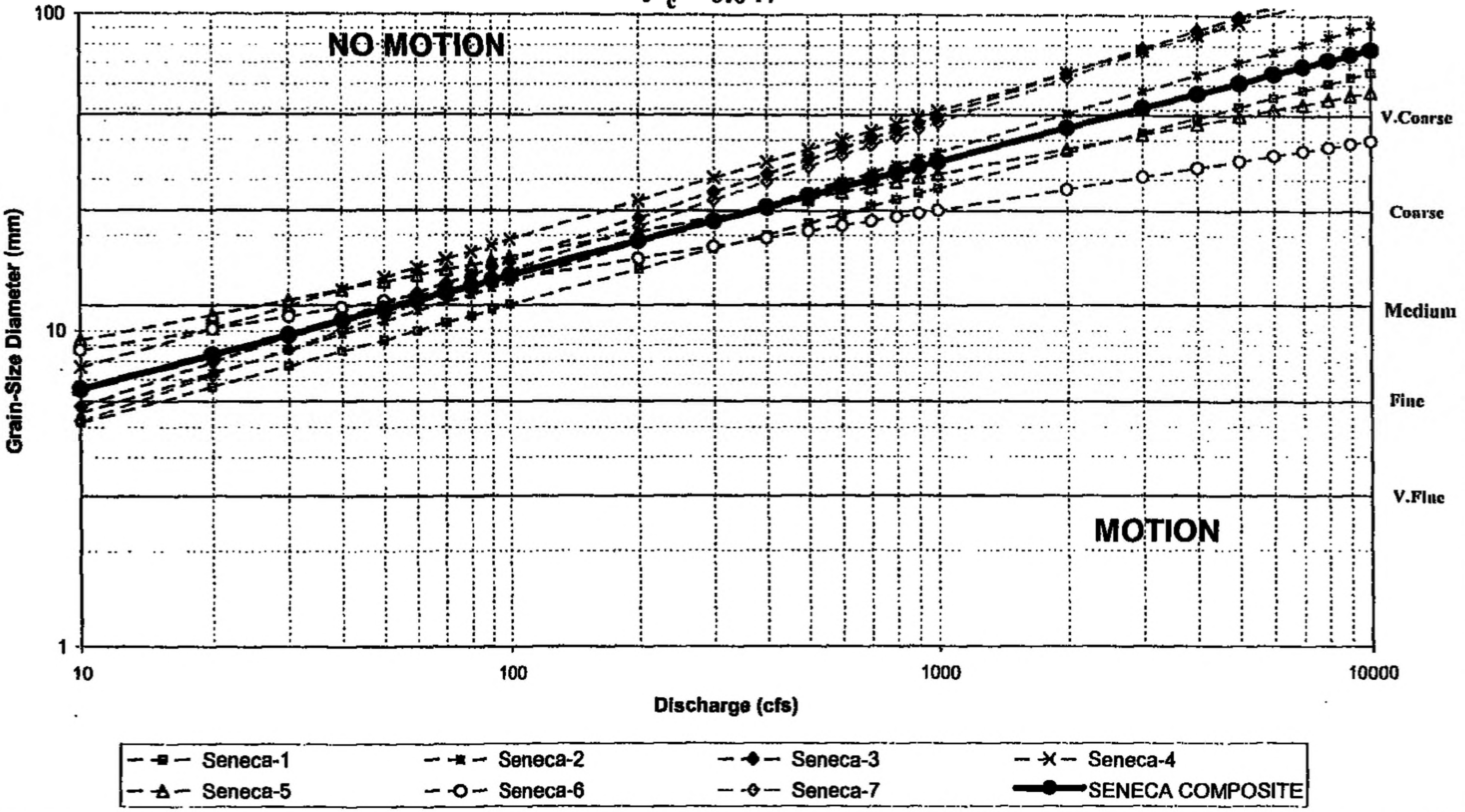


FIGURE 16

Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Belden Reach

$\tau^*_c = 0.047$

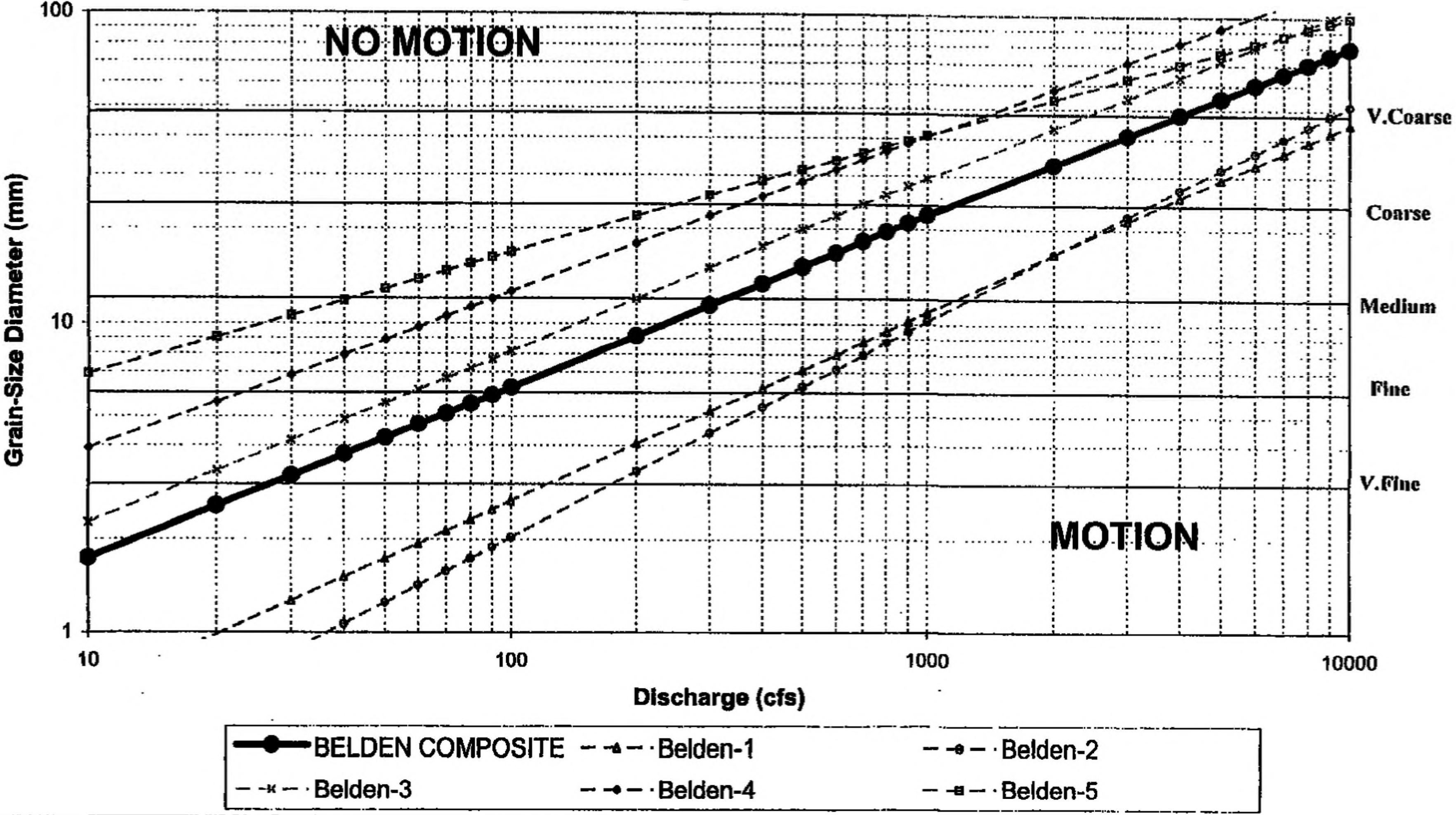
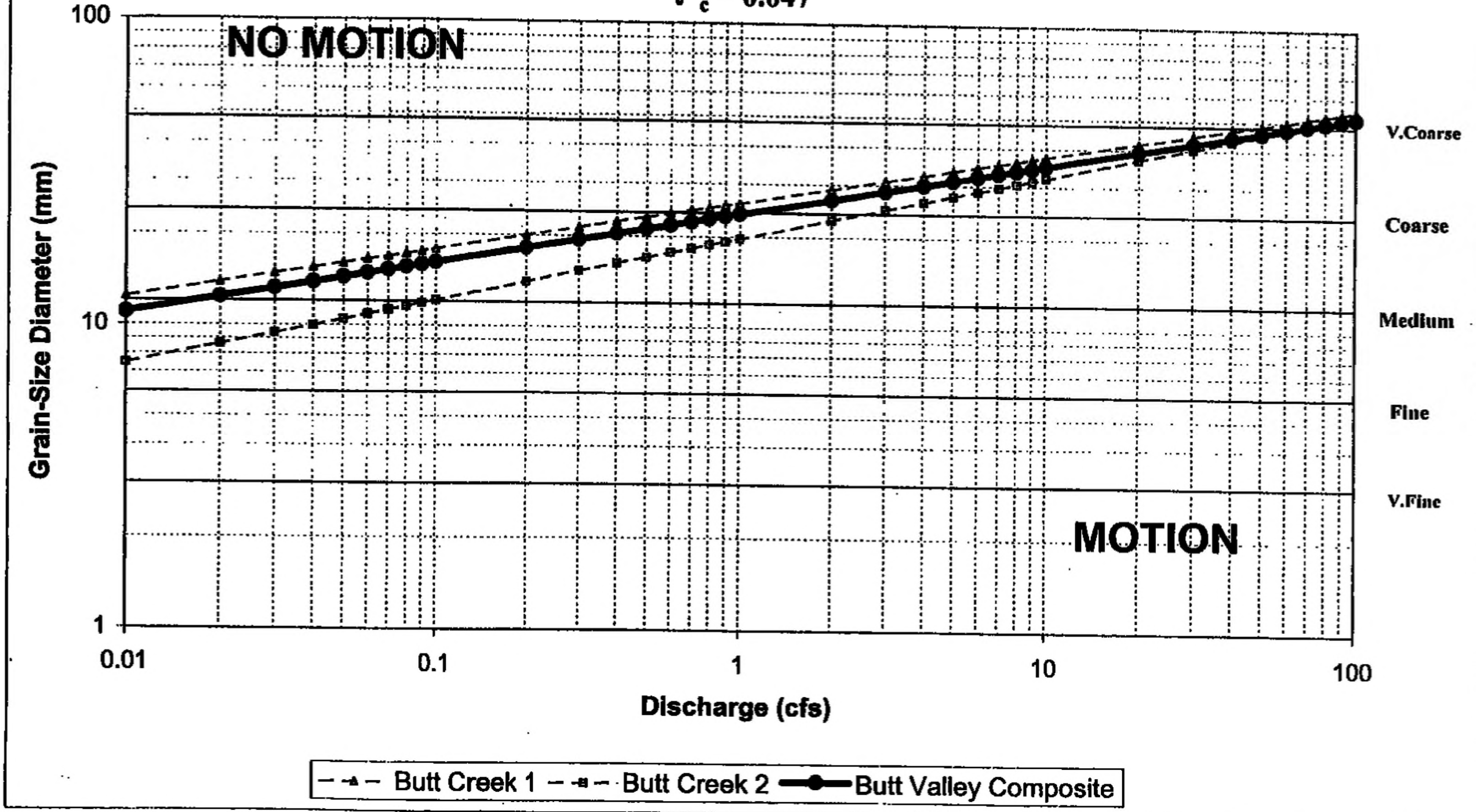


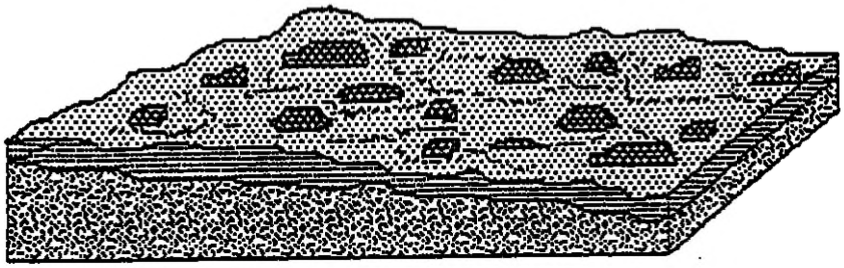
FIGURE 17
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
Butt Valley Creek Reach
$\tau^*_c = 0.047$



Appendix A.

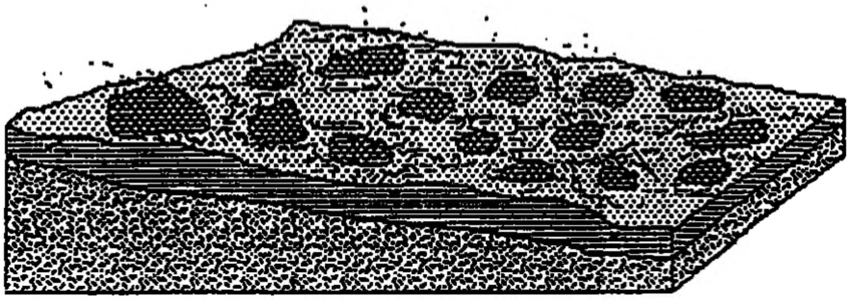
Habitat Types (US Department of Fish and Game)

Riffle



LOW GRADIENT RIFFLE - "LGR"

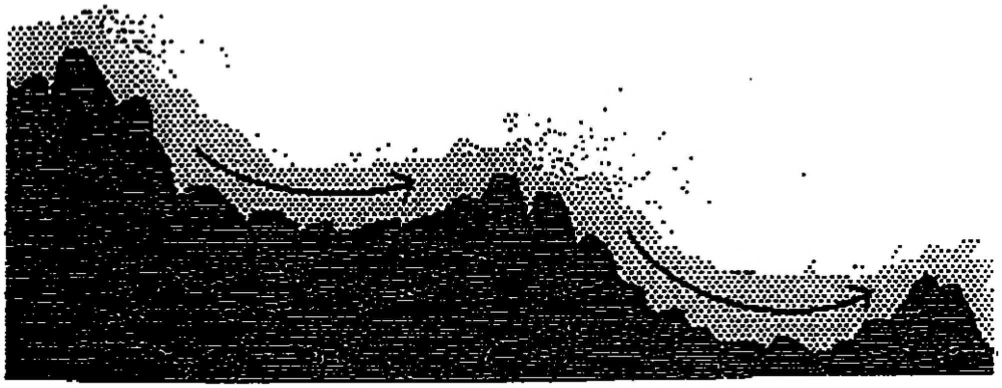
Shallow reaches with swiftly flowing turbulent water with some partially exposed substrate; gradient <4%, substrate is usually cobble dominated.



HIGH GRADIENT RIFFLES - "HGR"

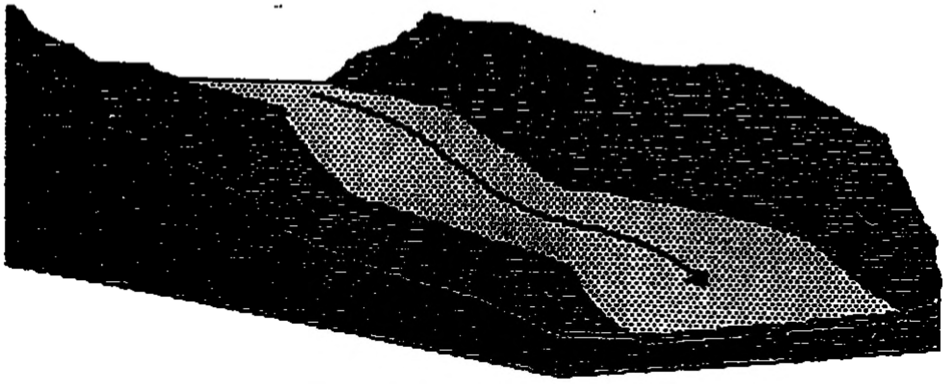
Steep reaches of moderately deep, swift, and very turbulent water, amount of exposed substrate is relatively high; gradient is >4%, and substrate is boulder dominated.

Cascade



CASCADE - "CAS"

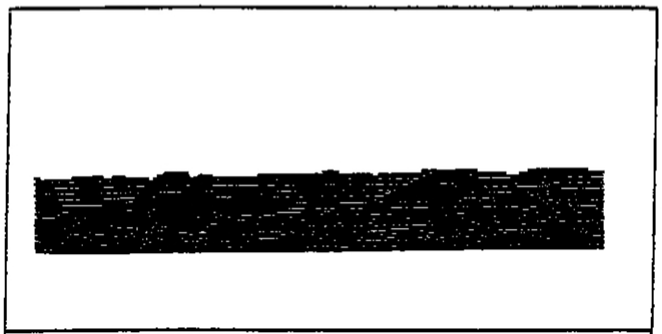
The steepest riffle habitat, consisting of alternating small waterfalls and shallow pools; substrate is usually bedrock and boulders.



BEDROCK SHEET - "BRS"

A thin sheet of water flowing over a smooth bedrock surface; gradients are usually variable.

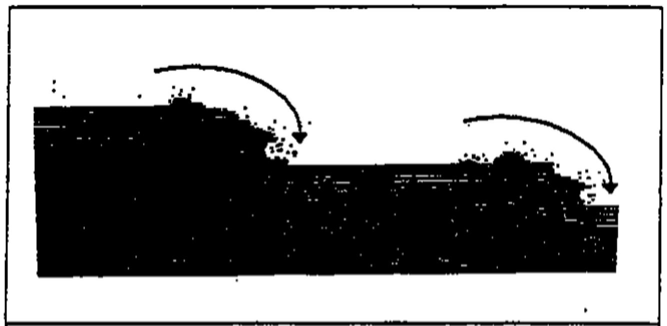
Flatwater



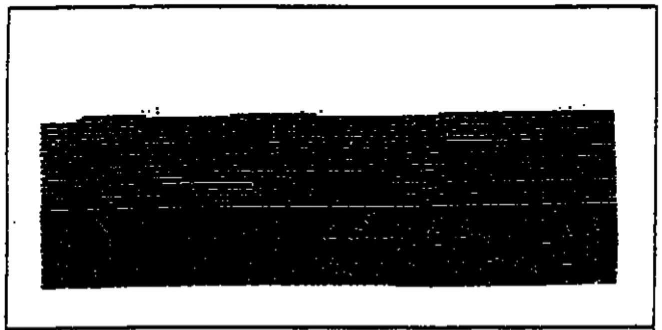
RUN - "RUN"

Swiftly flowing reaches with little surface agitation and no major flow obstructions; often appears as flooded riffles; typical substrate consists of gravel, cobble, and boulders.

A sequence of runs separated by short riffle steps; substrate is usually cobble and boulder dominated.



STEP RUN - "SRN"



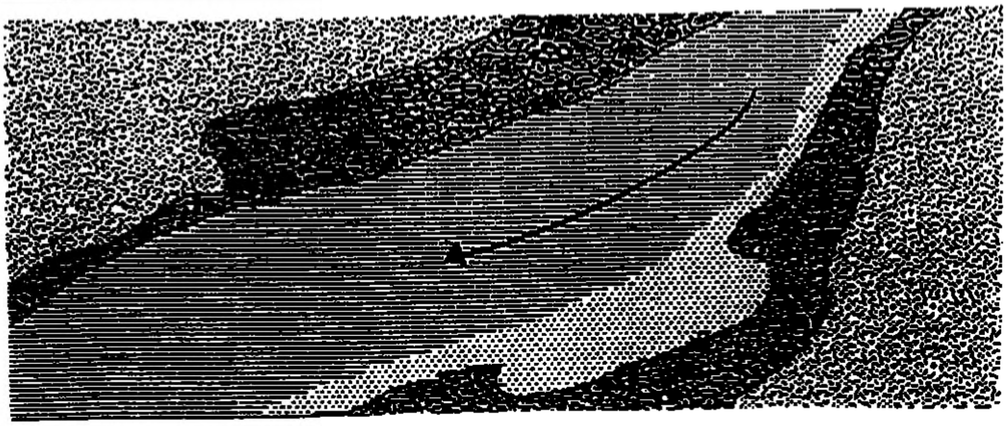
GLIDE - "GLD"

A wide uniform channel bottom; flow with low to moderate velocities; lacking pronounced turbulence; substrate usually consists of cobble, gravel, and sand.

Flatwater 2

POCKET WATER - "POW"

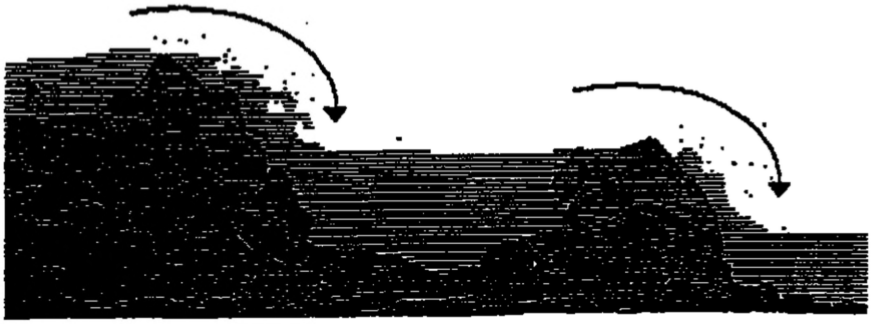
A section of swift flowing stream containing numerous boulders or other large obstructions which create eddies or scour holes (pockets) behind the obstructions.



EDGEWATER - "EDW"

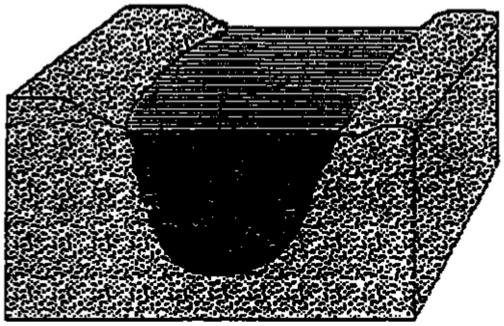
Quiet, shallow area found along the margins of the stream, typically associated with riffles; water velocity is low and sometimes lacking; substrate varies from cobbles to boulders.

Main Channel Pool



STEP POOL - "STP"

A series of pools separated by short riffles or cascades; generally found in high gradient, confined mountain streams dominated by boulder substrate.

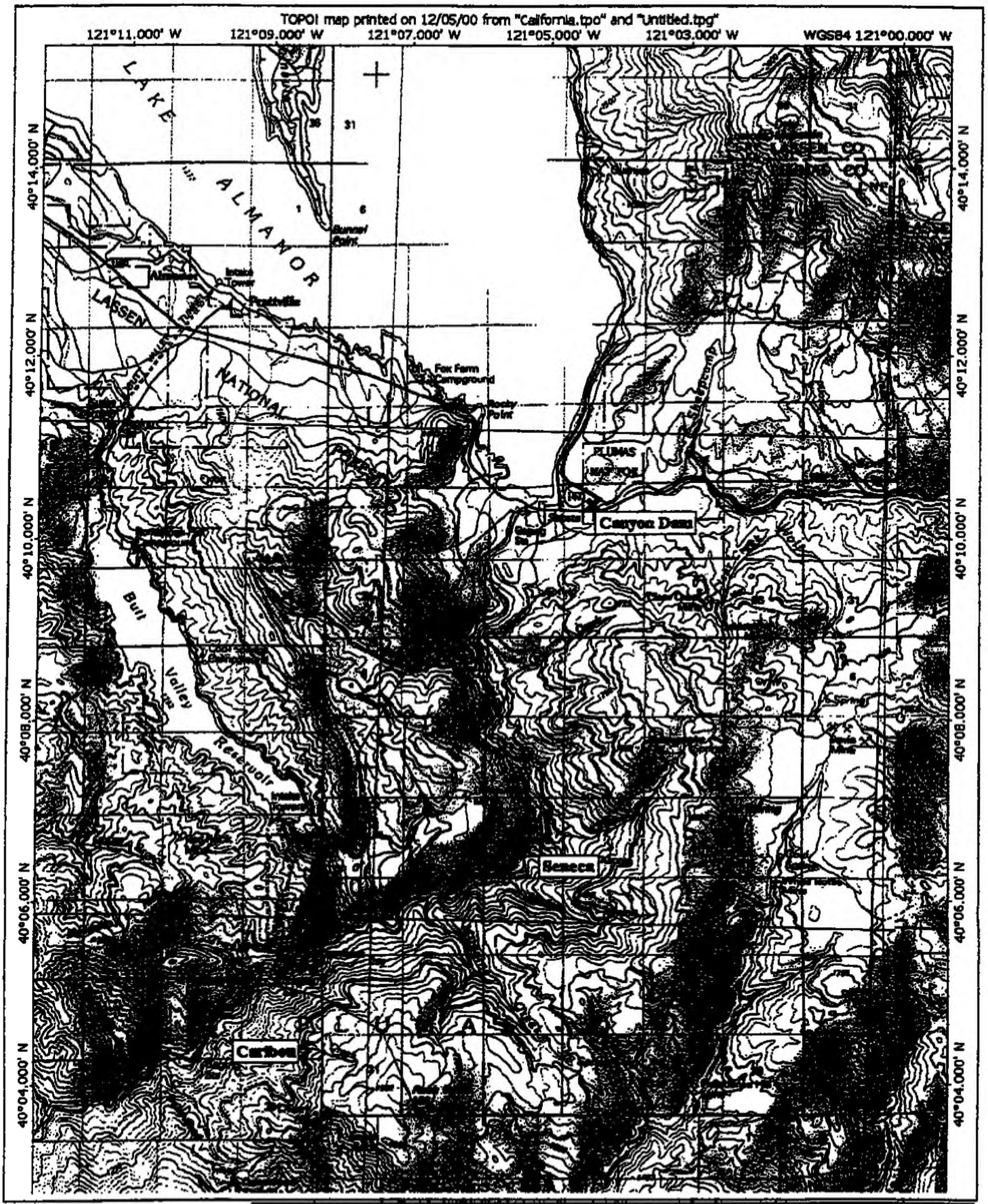


TRENCH/CHUTE - "TRP"

Channel cross-sections typically "U" shaped with bedrock or coarse grained bottom flanked by bedrock walls; current velocities are swift and the direction of flow is uniform.

Appendix B.

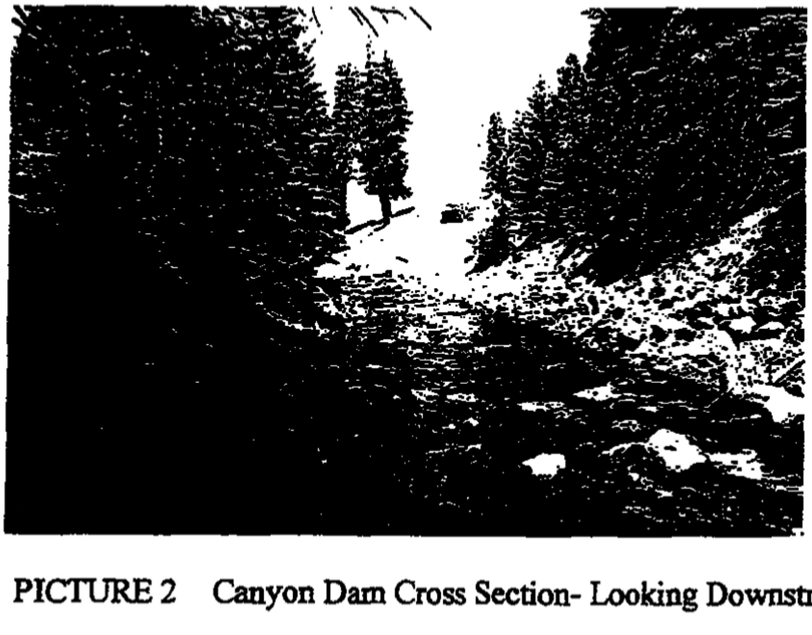
Sediment Samples Data



Sediment Sampling Sites For Incipient Motion Analysis

Upper NFFR Incipient Motion Study	**December 2001**

PICTURE 1 Canyon Dam Cross Section- Looking Upstream



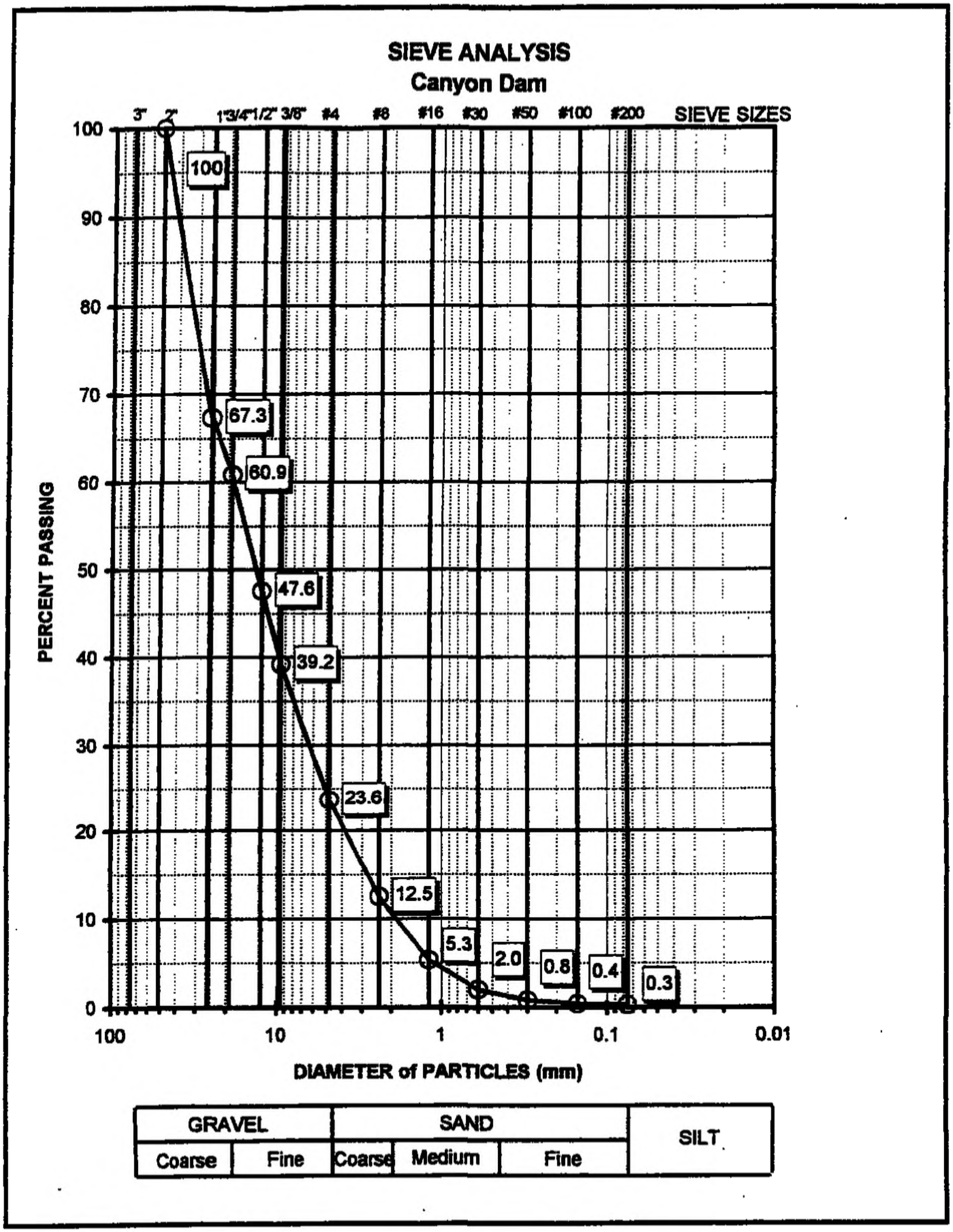
PICTURE 2 Canyon Dam Cross Section- Looking Downstream

PICTURE 3 Seneca Bridge Cross Section- Looking Upstream

PICTURE 4 Seneca Bridge Cross Section- Looking Downstream

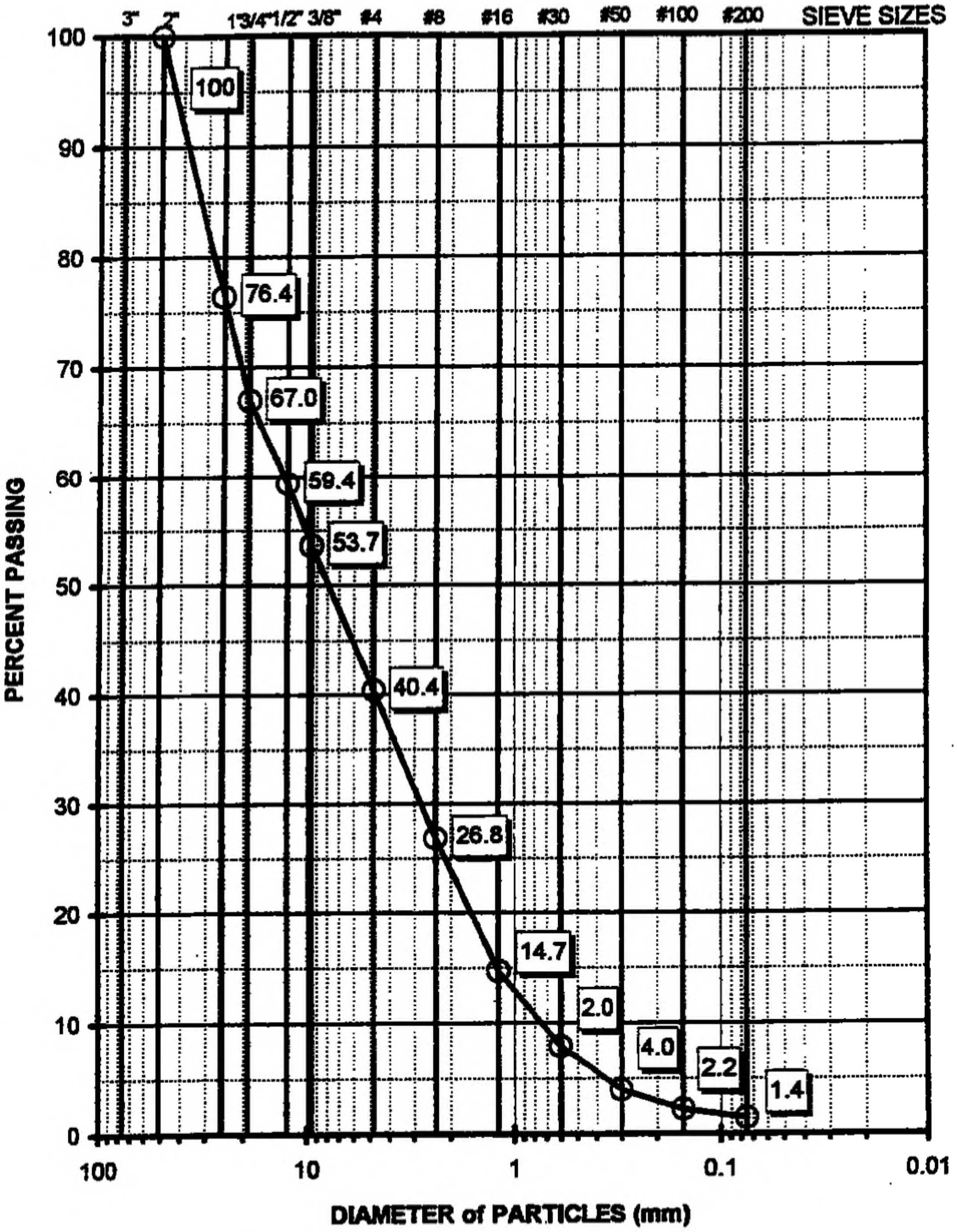
PICTURE 5 Caribou Cross Section- Looking Upstream

PICTURE 6 Caribou Cross Section- Looking Downstream


SIEVE ANALYSIS
Canyon Dam
3"
2"
1"
3/4"
1/2"
3/8"
#4
#8
#16
#30
#50
#100
#200
SIEVE SIZES
PERCENT PASSING
100
90
80
70
60
50
40
30
20
10
0
100
67.3
60.9
47.6
39.2
23.6
12.5
5.3
2.0
0.8
0.4
0.3
100
10
1
0.1
0.01
DIAMETER of PARTICLES (mm)
GRAVEL
SAND
SILT
Coarse
Fine
Coarse
Medium
Fine

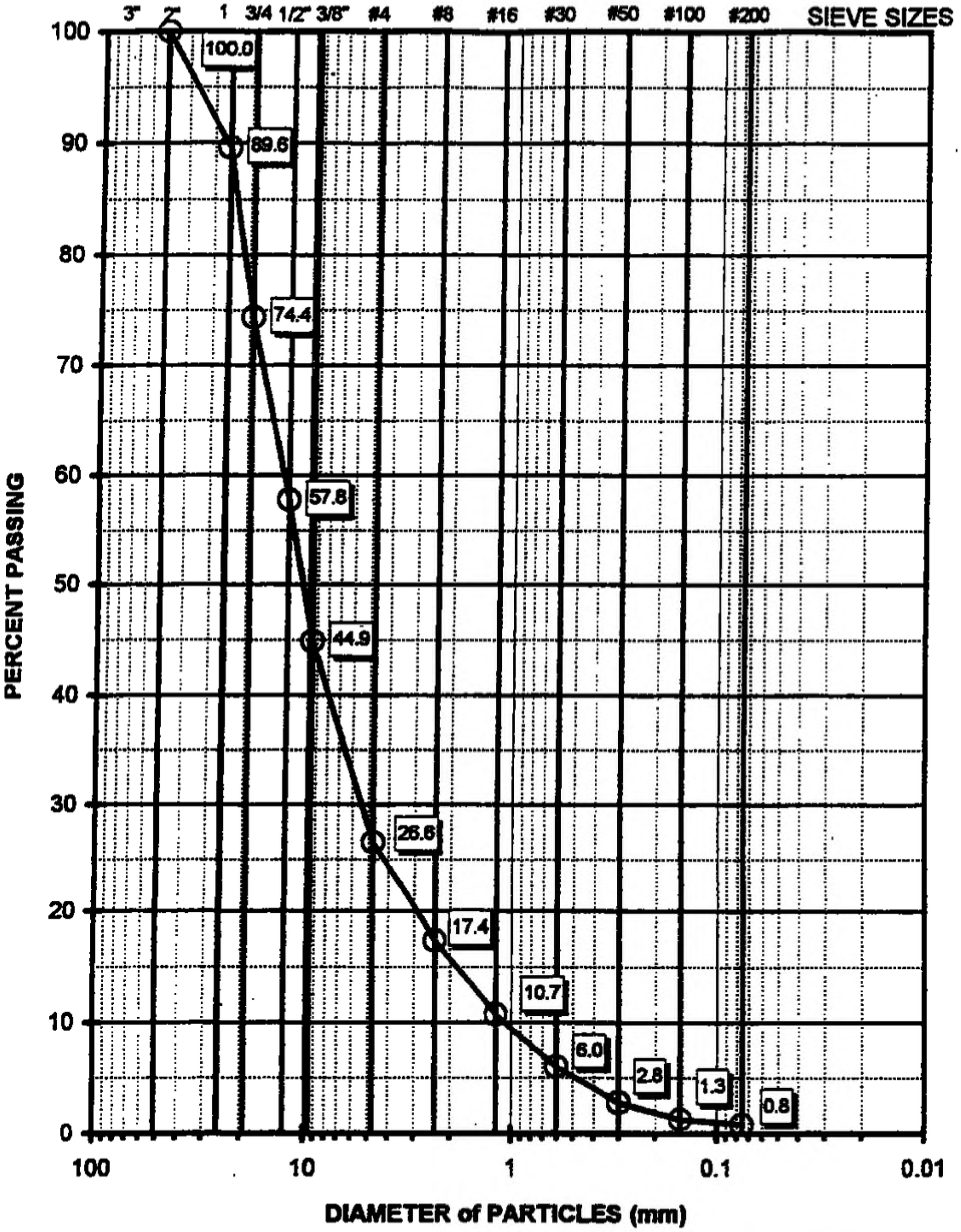
SIEVE ANALYSIS

Seneca Br.



GRAVEL		SAND			SILT
Coarse	Fine	Coarse	Medium	Fine	

SIEVE ANALYSIS
NFFR (CARIBOU)

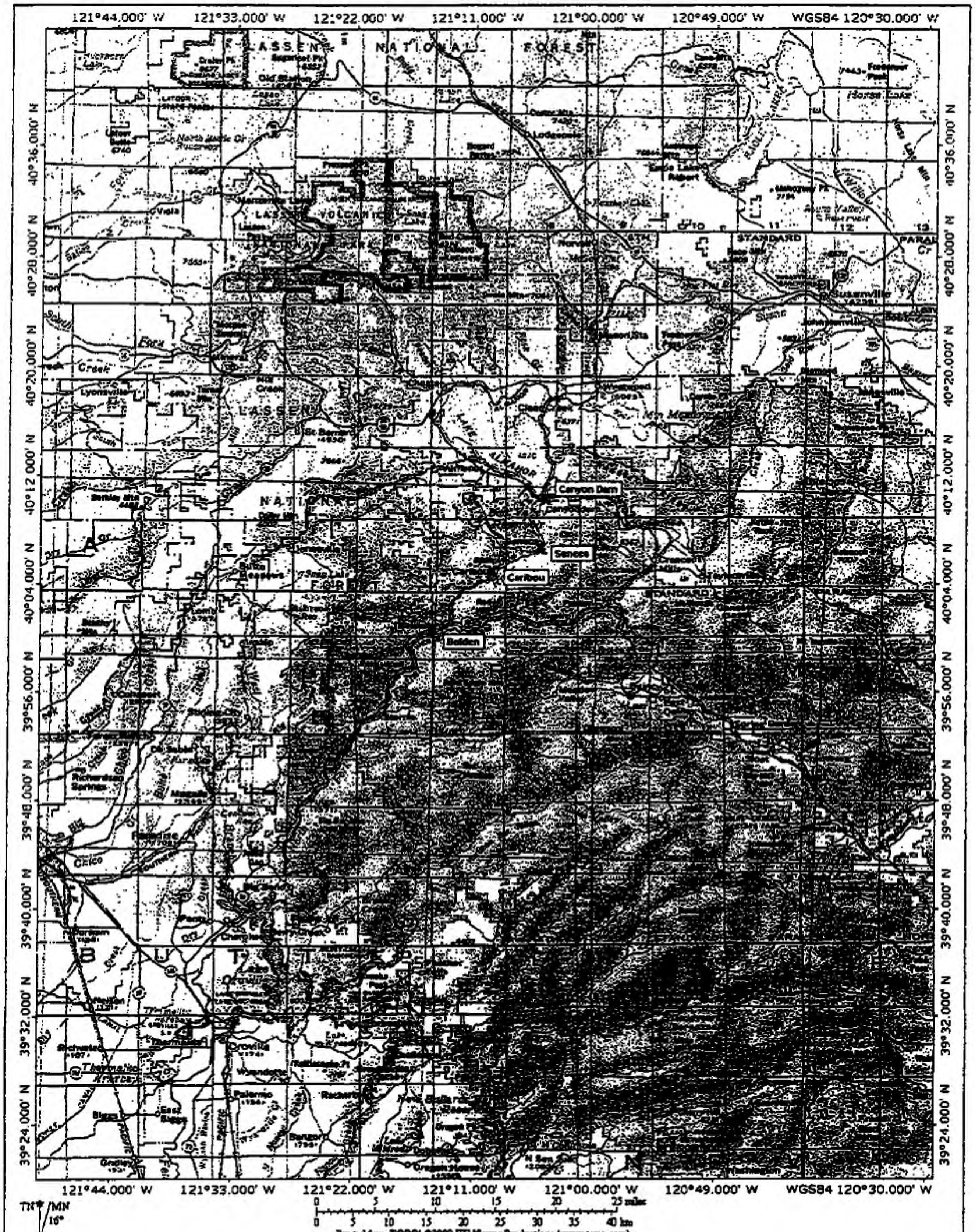


GRAVEL		SAND			SILT
Coarse	Fine	Coarse	Medium	Fine	

Appendix C.

Results of Incipient Motion Analysis for Each Transect

Seneca Reach Sections



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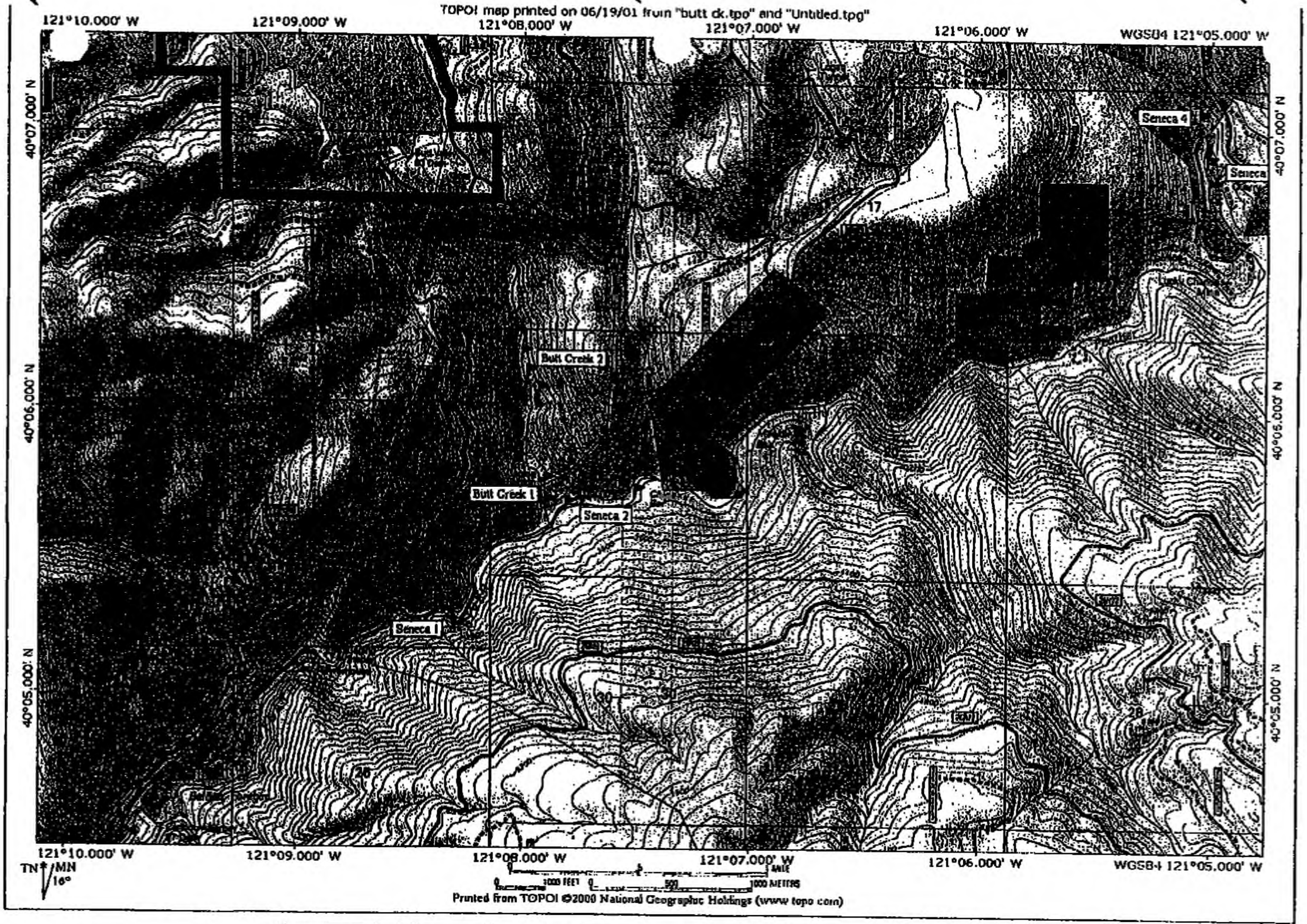
North Fork Feather River Regional Map	
Upper NFFR Incipient Motion Study	December 2001

North Fork Feather River Regional Map
Seneca Reach Sections

Upper NFFR Incipient Motion Study	**December 2001**

TOPO! map printed on 06/19/01 from "butt ck.tpo" and "Untitled.tpg"



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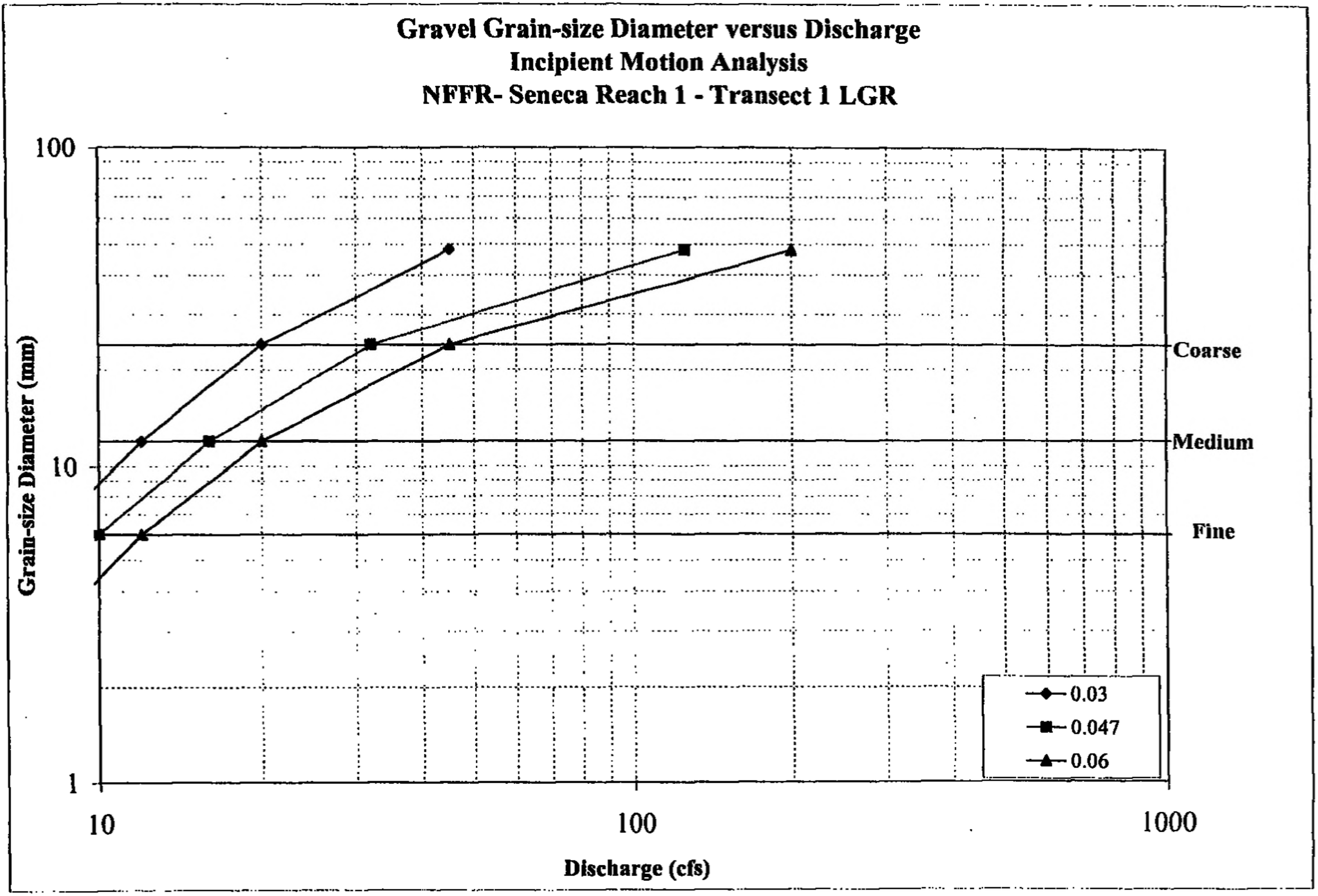
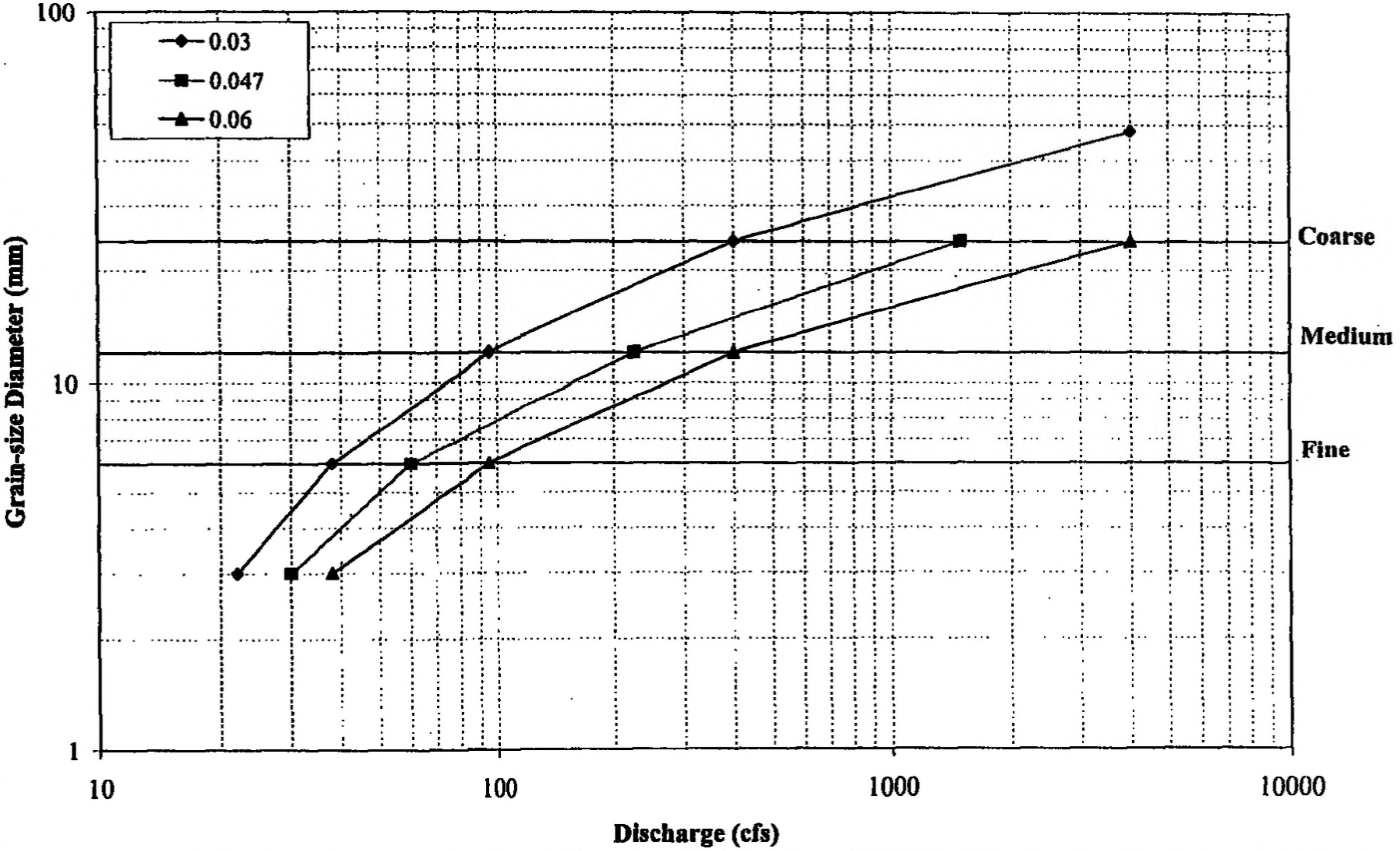
North Fork Feather River Regional Map
Seneca Reach and Butt Reach Sections

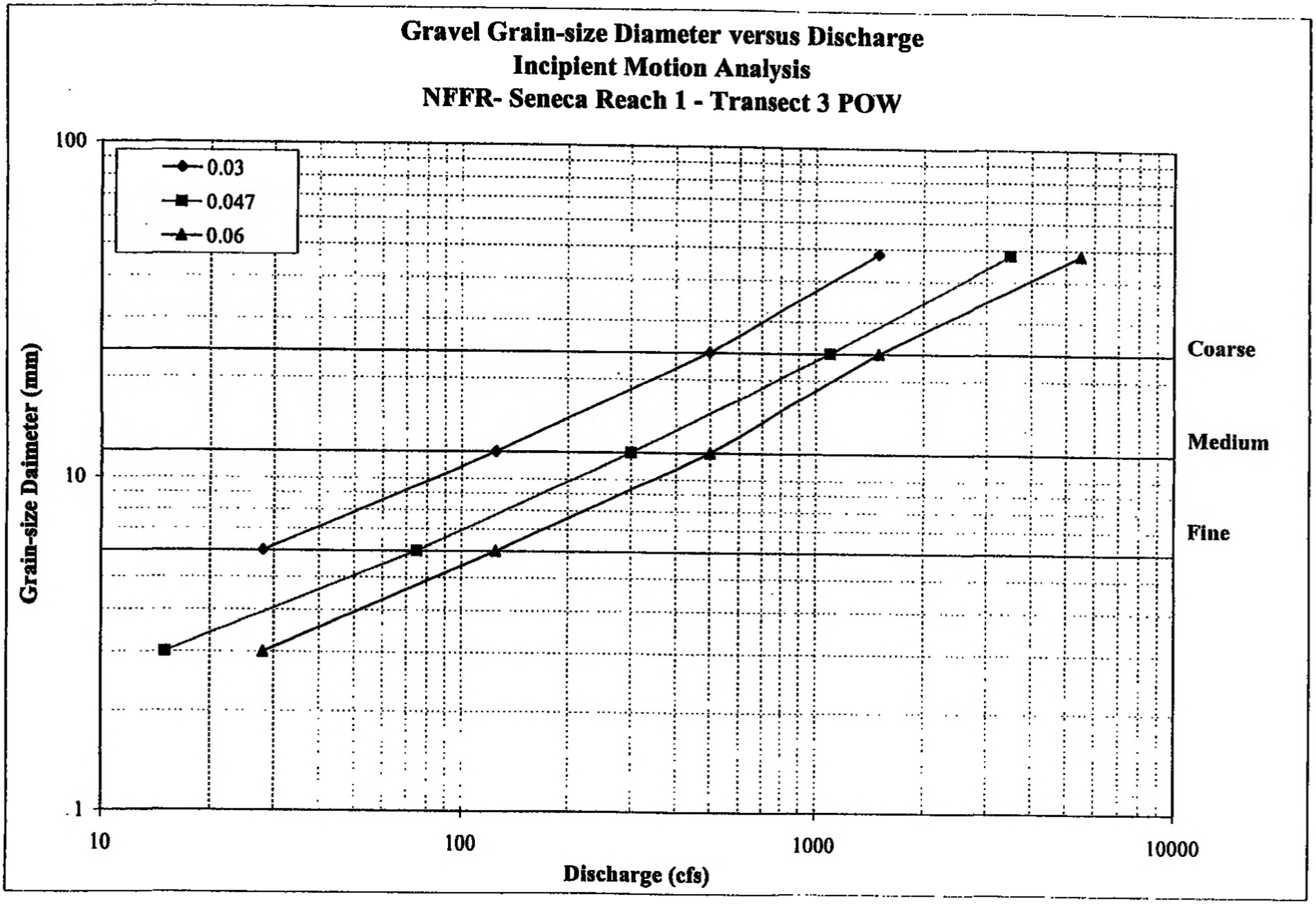
Upper NFFR Incipient Motion Study

December 2001

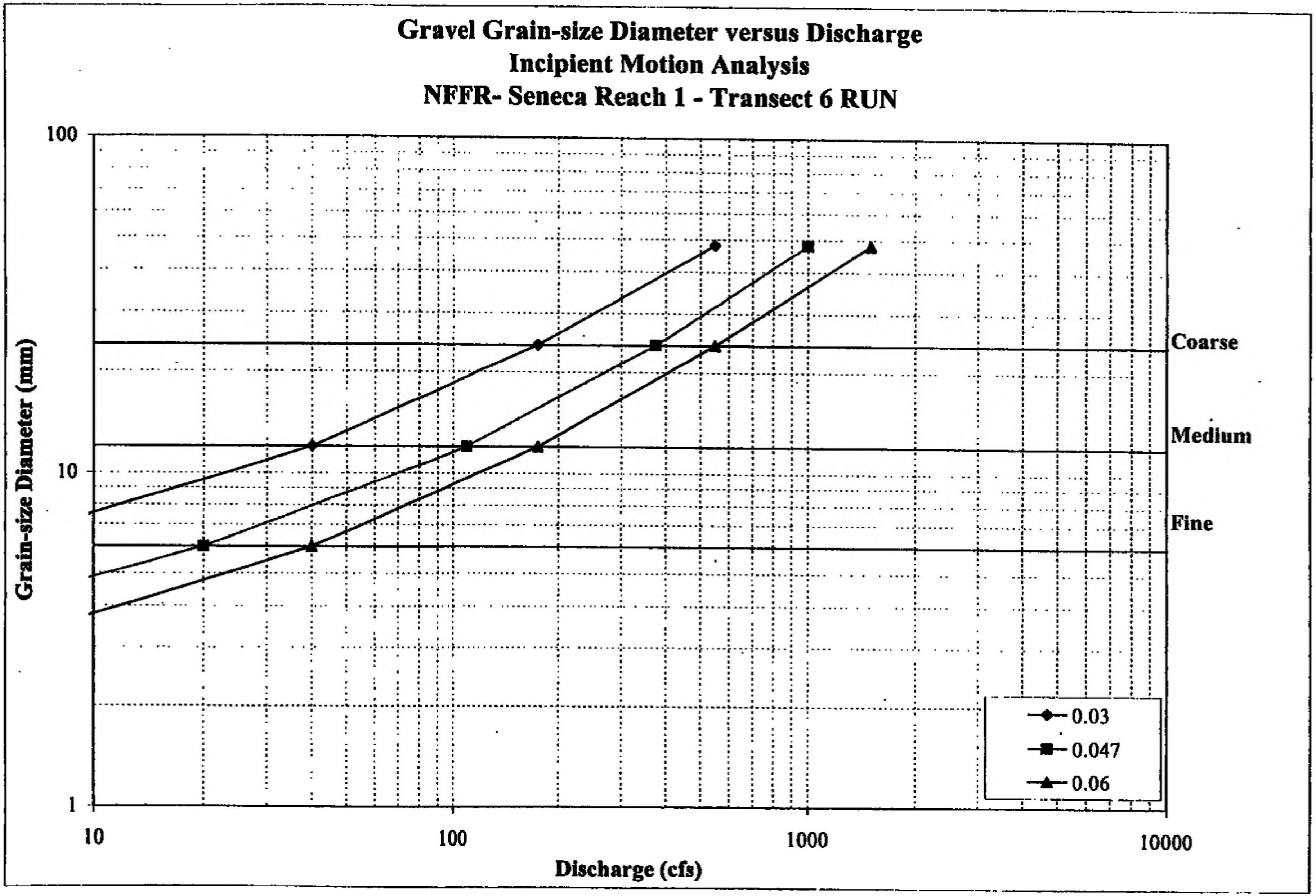

Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 1 - Transect 1 LGR
100
10
1
Grain-size Diameter (mm)
Coarse
Medium
Fine
10
100
1000
Discharge (cfs)
0.03
0.047
0.06



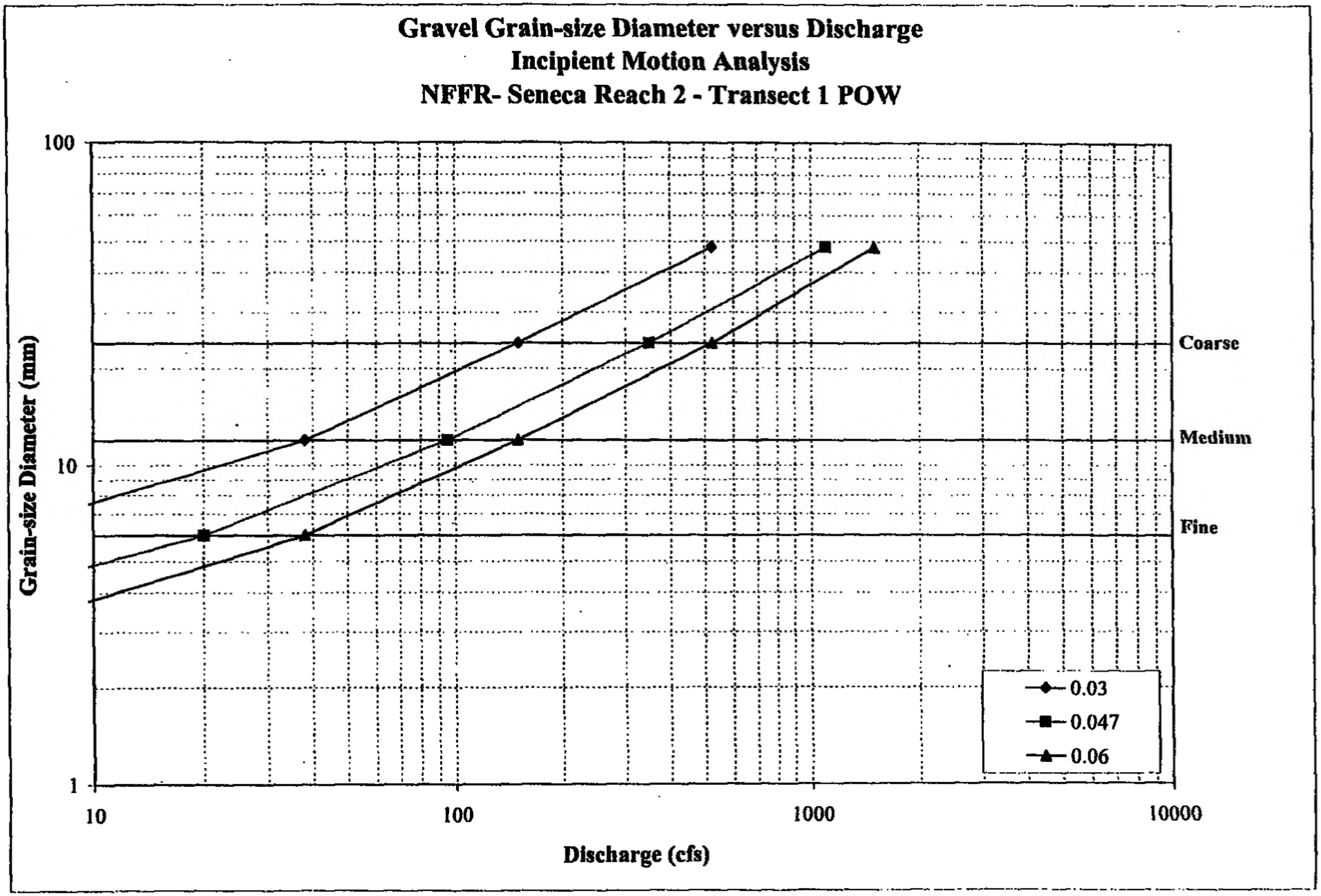
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 1 - Transect 2 RUN



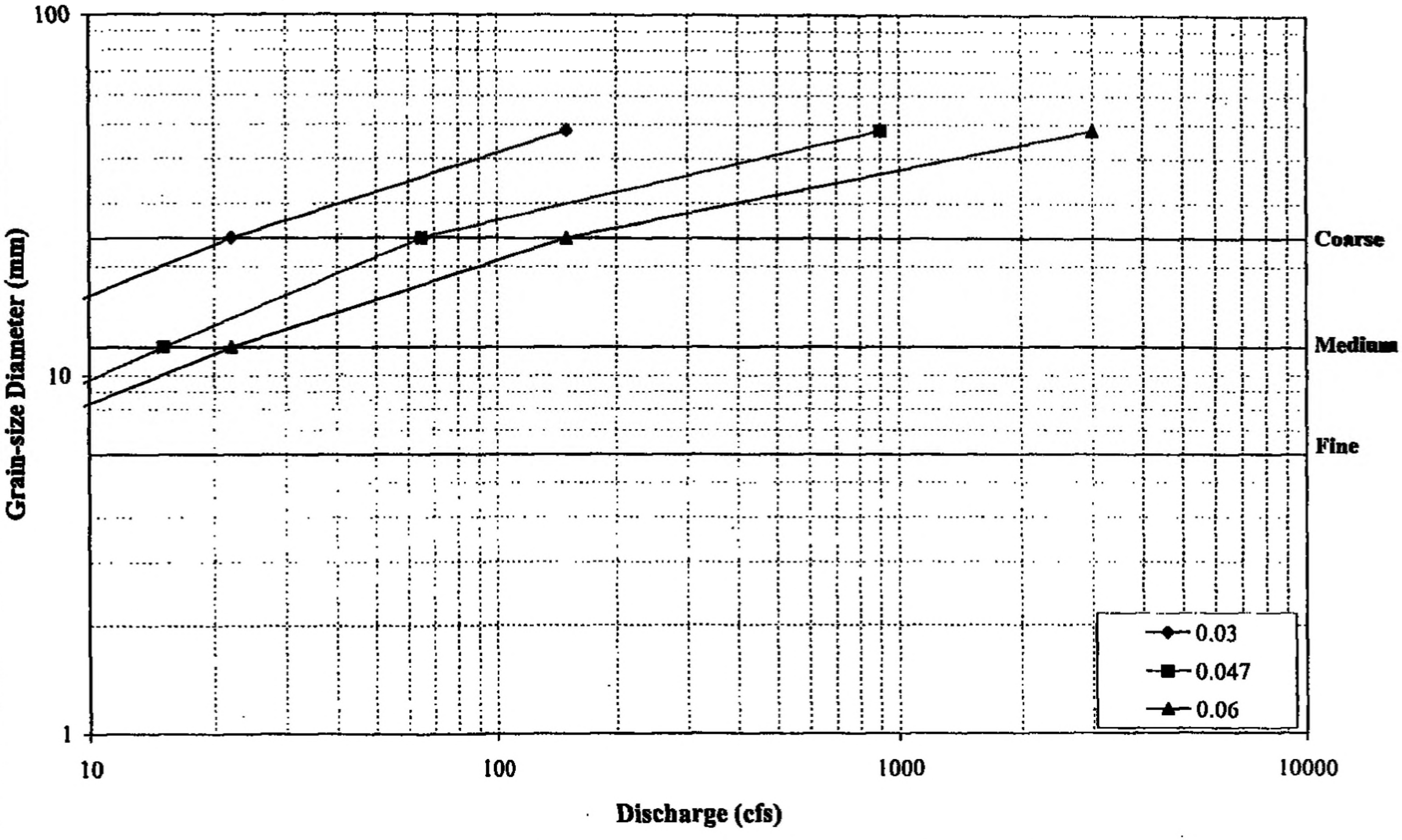
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 1 - Transect 3 POW

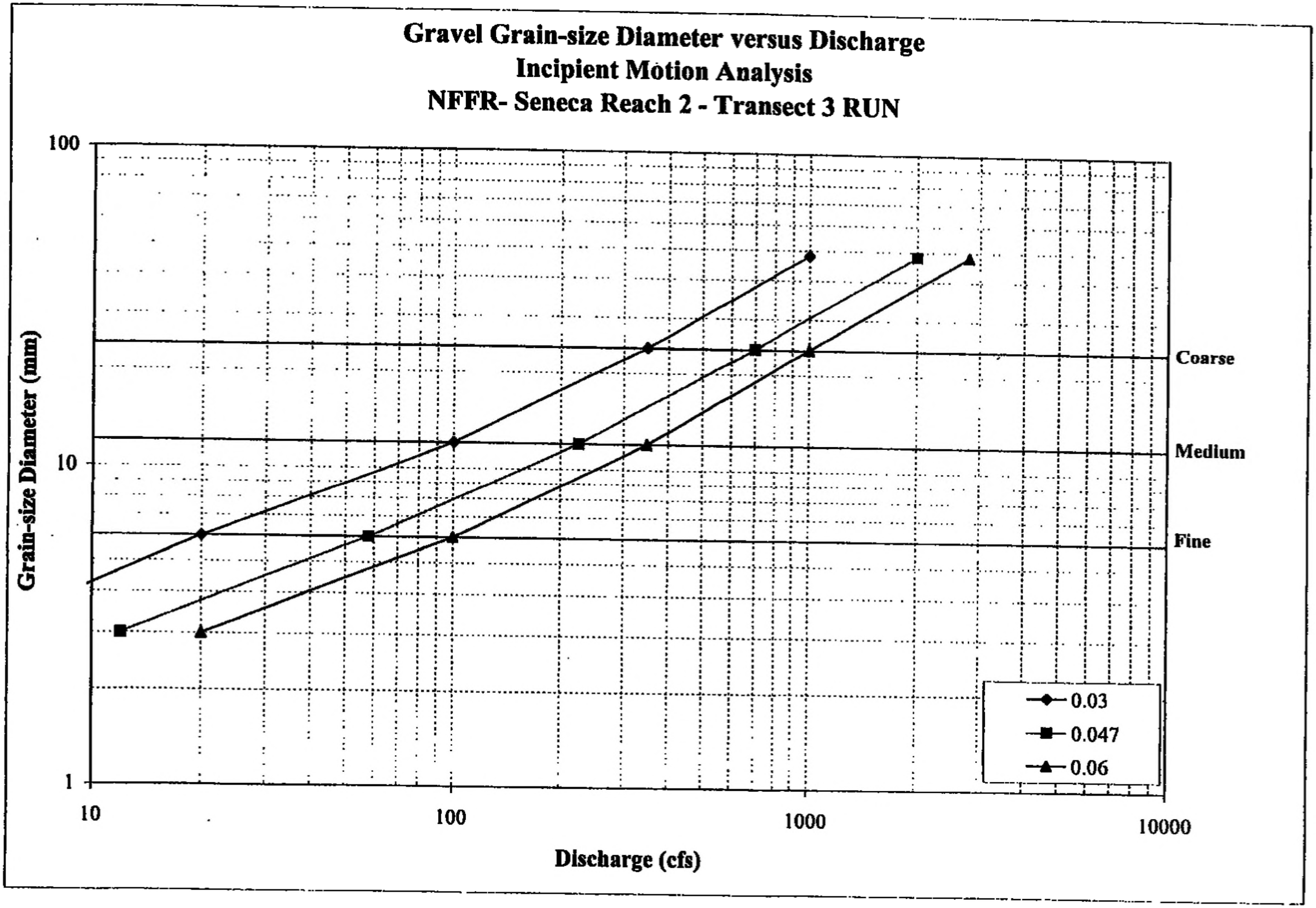


Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 1 - Transect 6 RUN

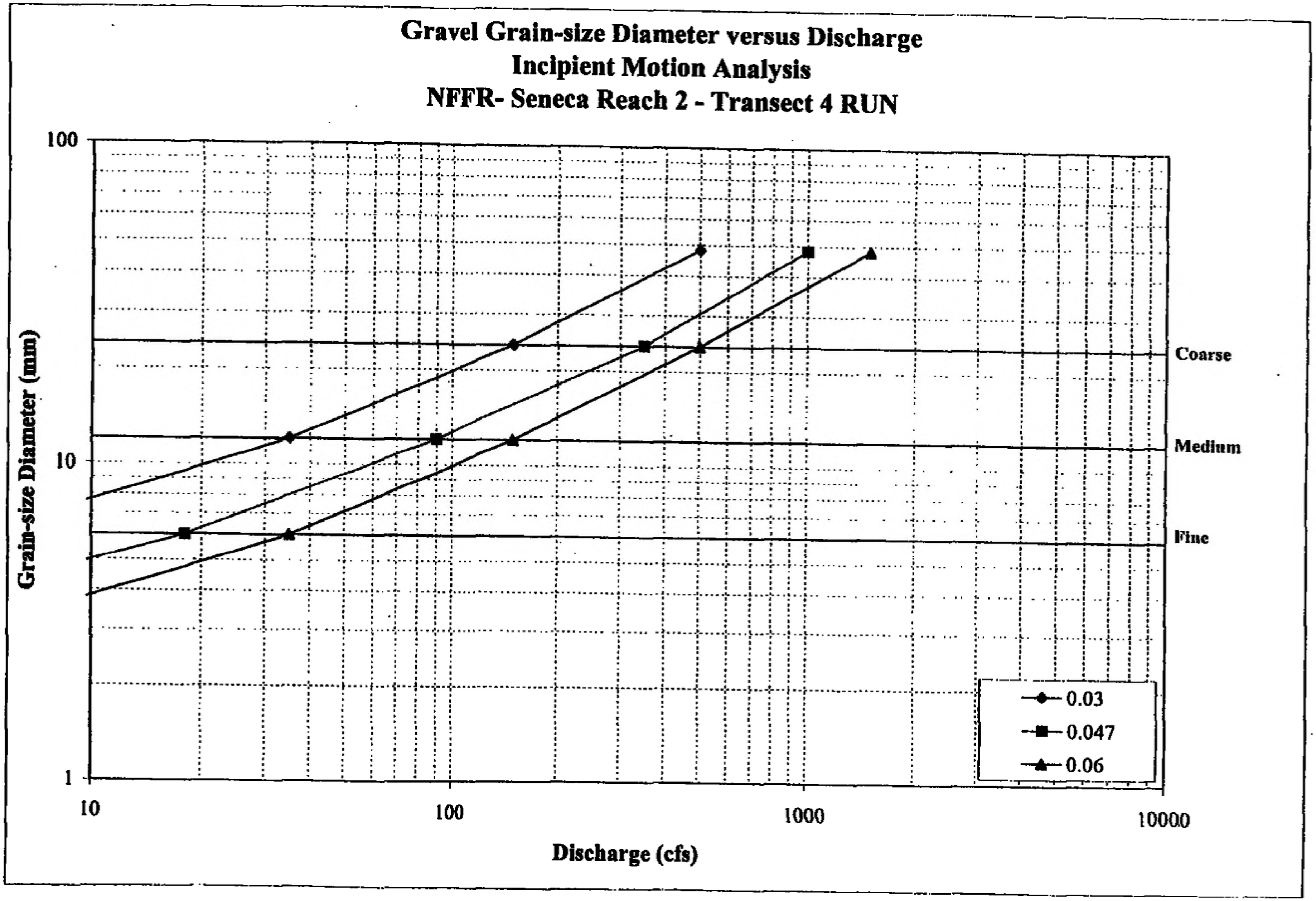

Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 2 - Transect 1 POW
Grain-size Diameter (mm)
100
10
1
Discharge (cfs)
10
100
1000
10000
Coarse
Medium
Fine
0.03
0.047
0.06

Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 2 - Transect 2 LGR

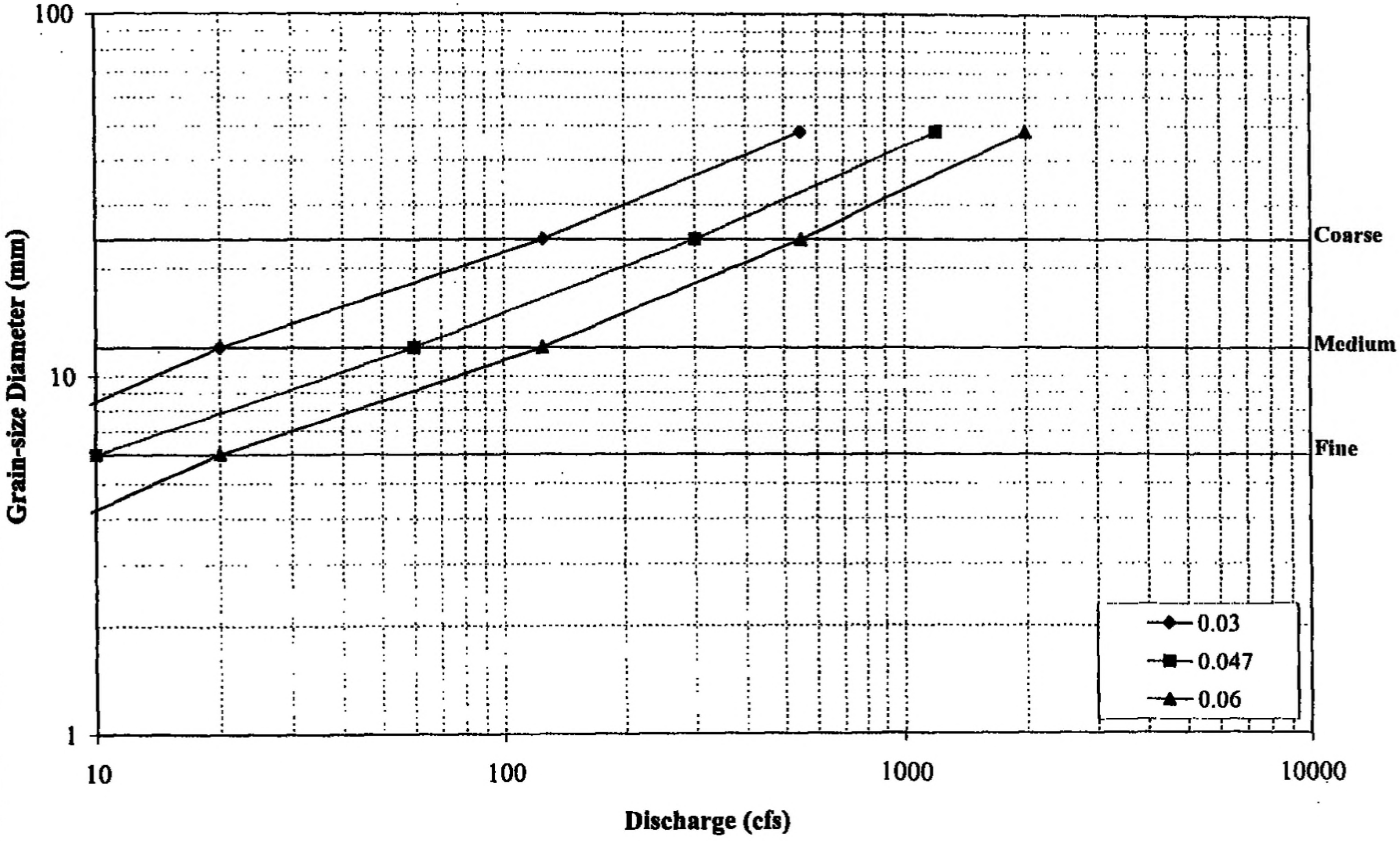


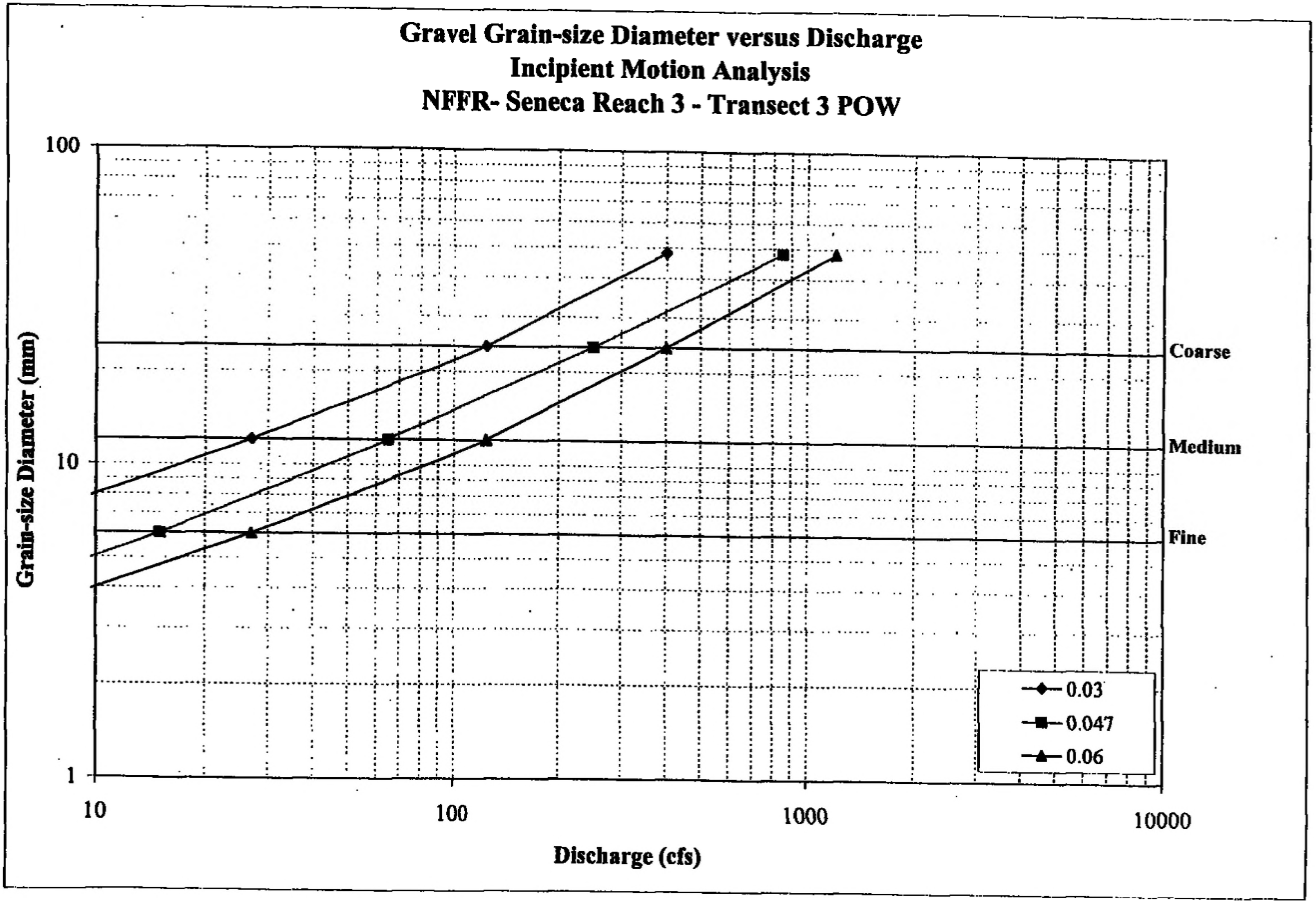


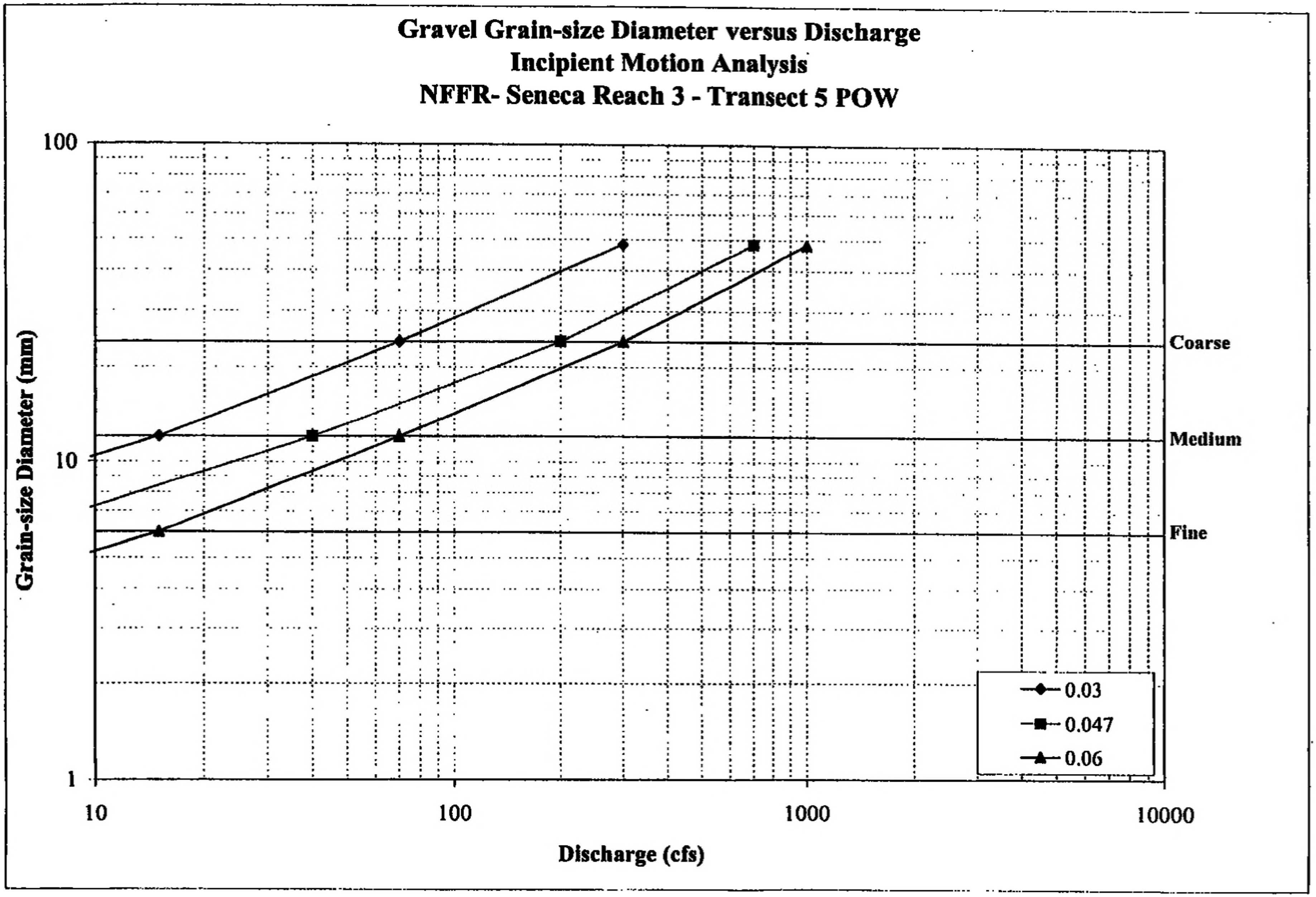
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 2 - Transect 3 RUN


Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 2 - Transect 4 RUN
Grain-size Diameter (mm)
100
10
1
Discharge (cfs)
10
100
1000
10000
Coarse
Medium
Fine
0.03
0.047
0.06

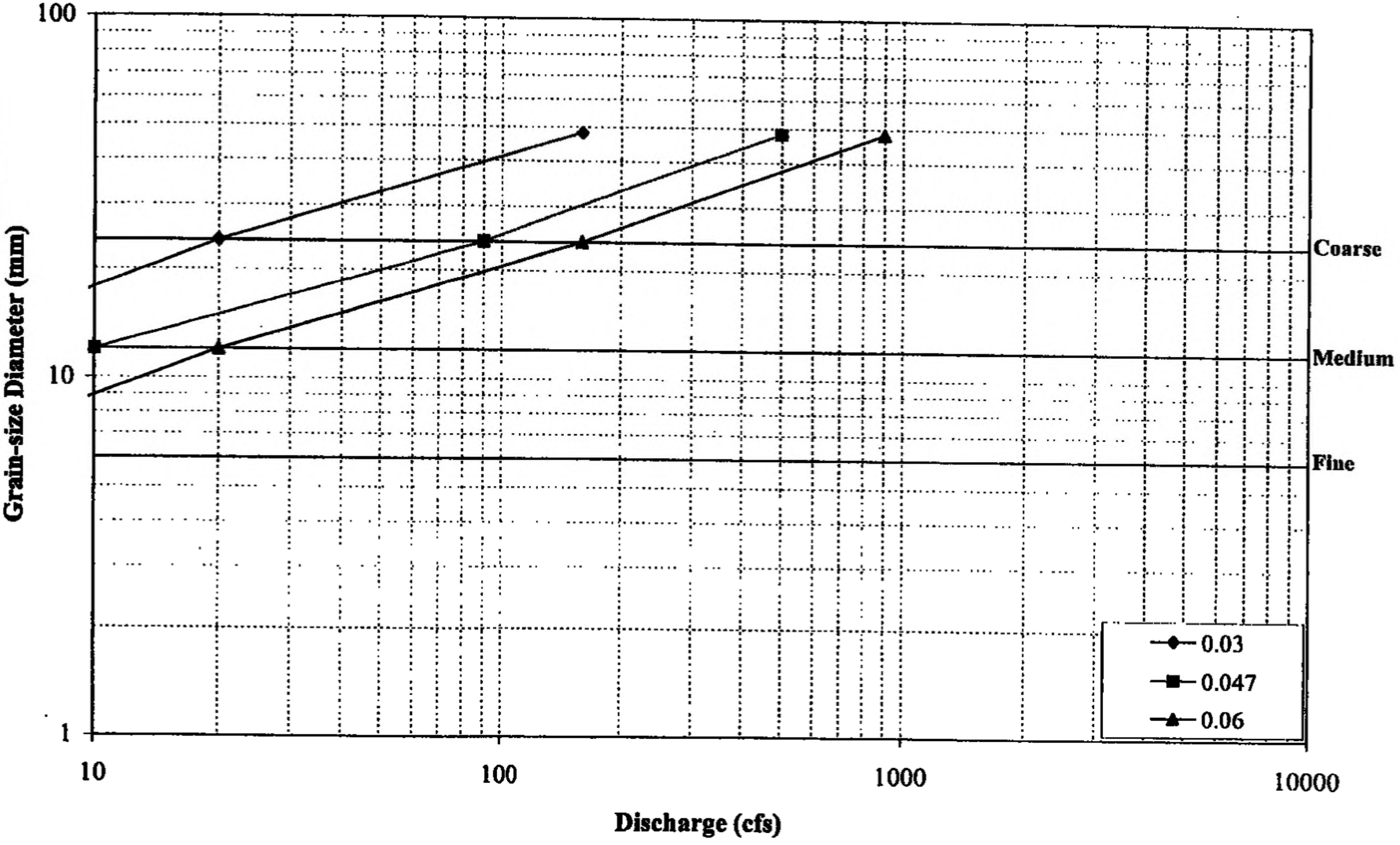
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 3 - Transect 1 RUN

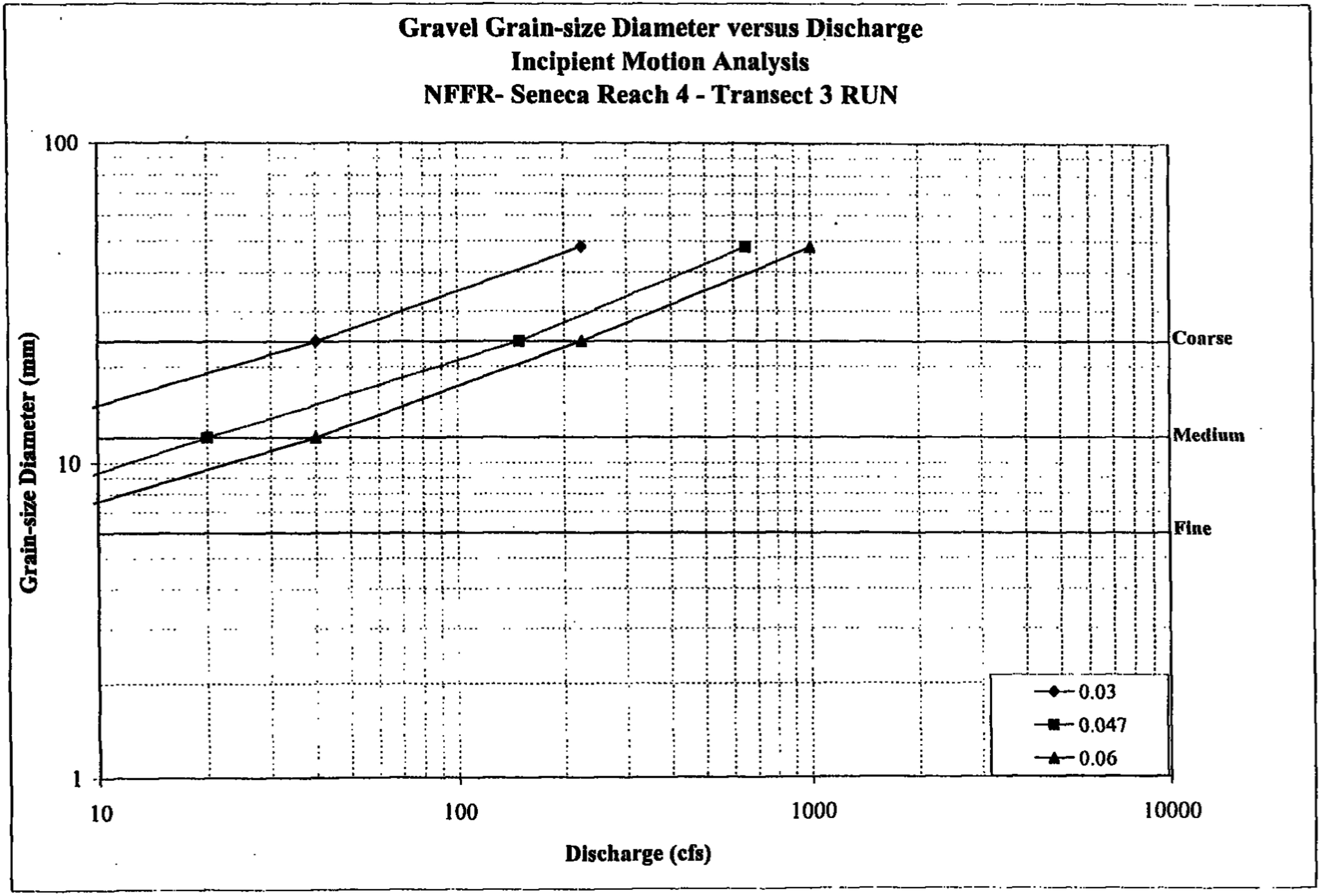


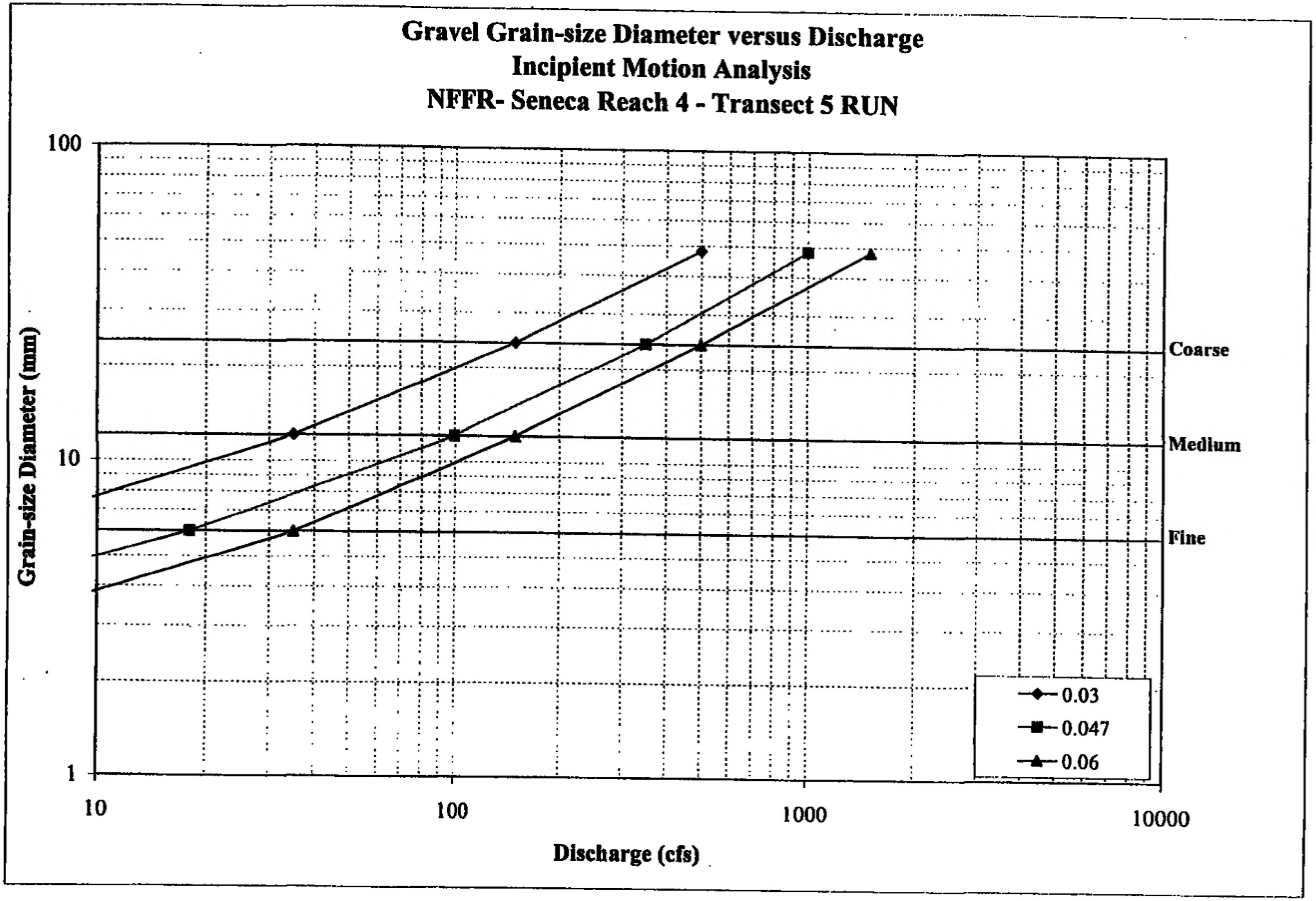

Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 3 - Transect 3 POW
100
10
1
Grain-size Diameter (mm)
10
100
1000
10000
Discharge (cfs)
Coarse
Medium
Fine
0.03
0.047
0.06


Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 3 - Transect 5 POW
Grain-size Diameter (mm)
100
10
1
10
100
1000
10000
Discharge (cfs)
Coarse
Medium
Fine
0.03
0.047
0.06

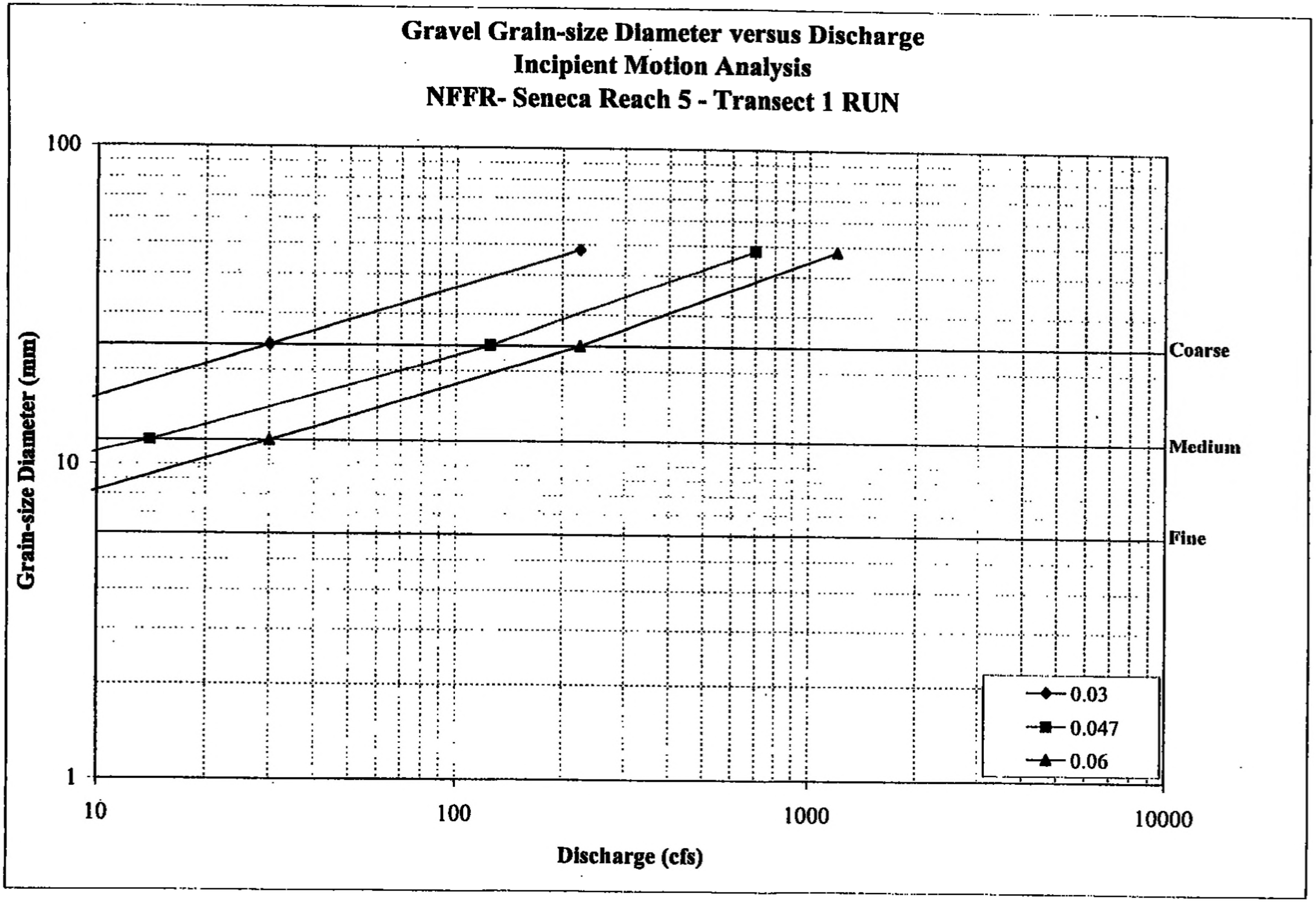
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 4 - Transect 1 POW



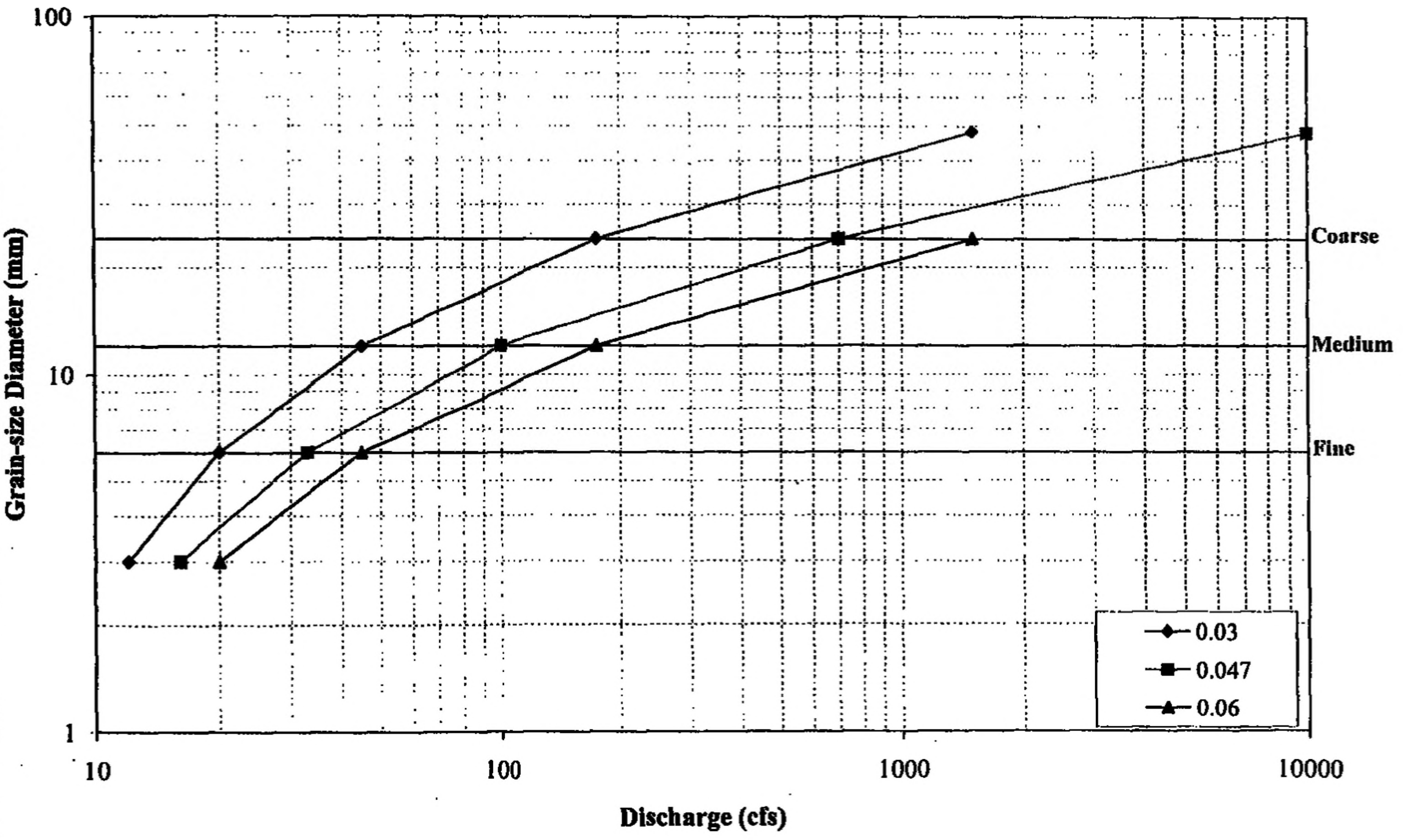

Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 4 - Transect 3 RUN
Grain-size Diameter (mm)
100
10
1
10
100
1000
10000
Discharge (cfs)
Coarse
Medium
Fine
0.03
0.047
0.06

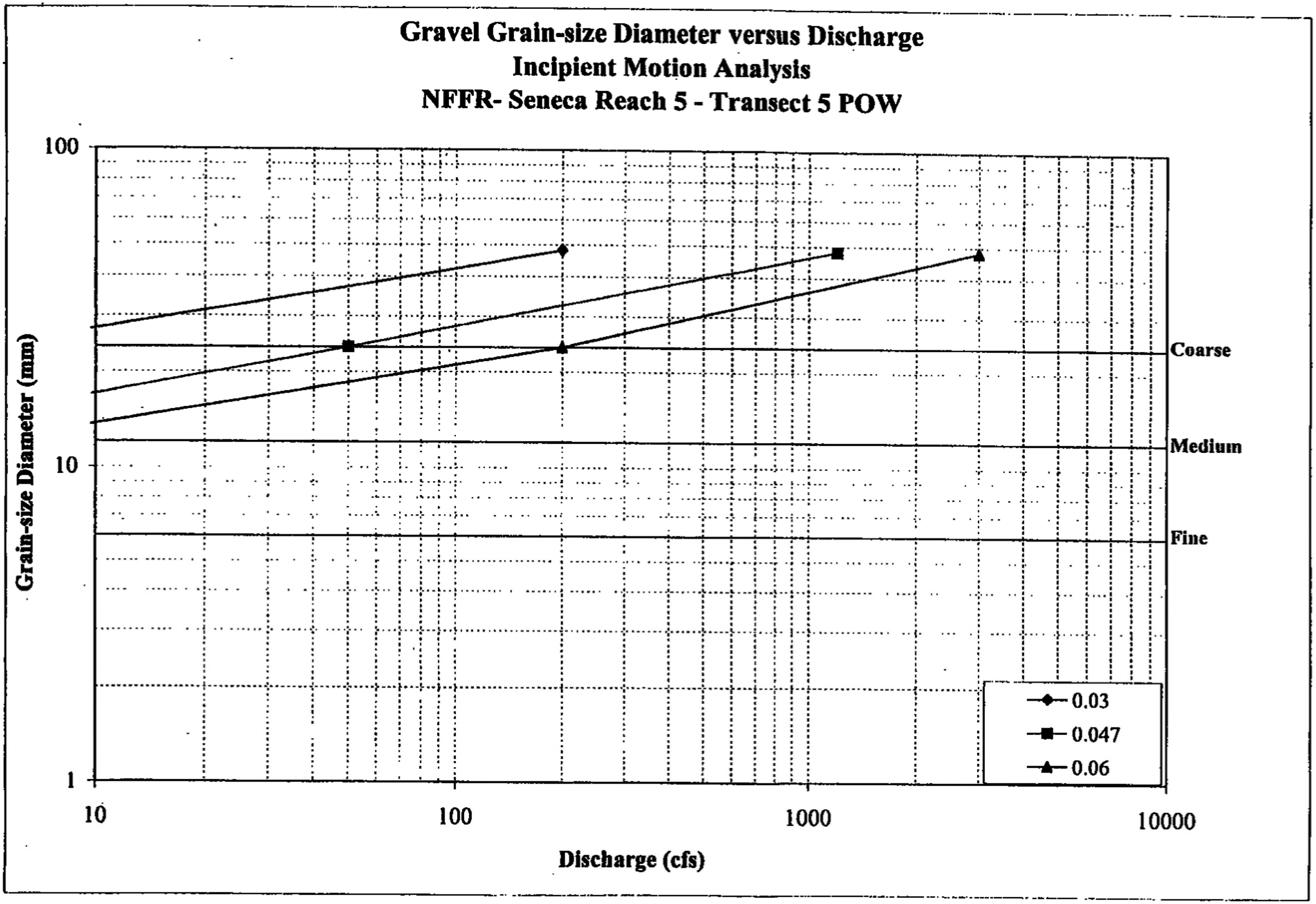


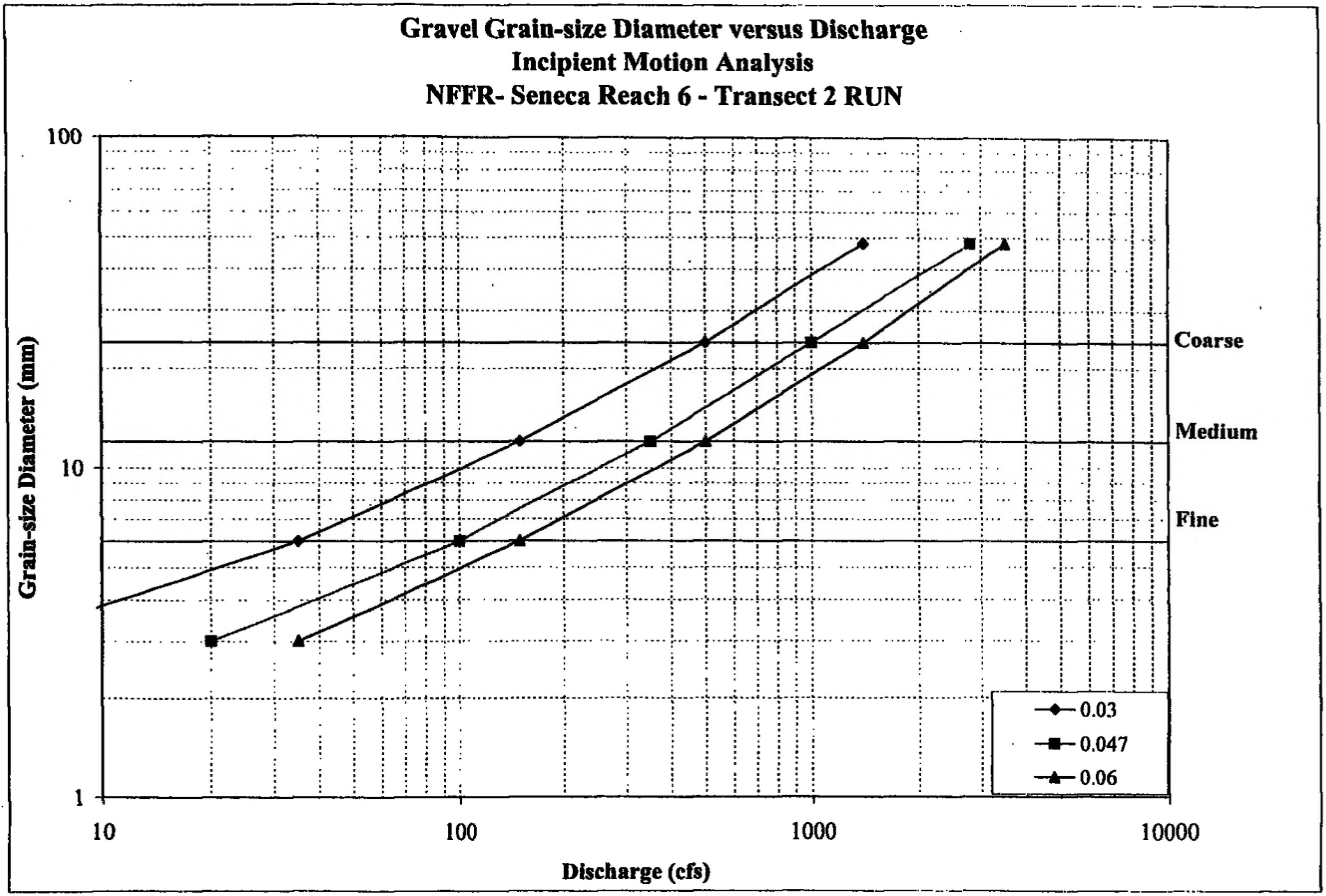
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 4 - Transect 5 RUN


Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 5 - Transect 1 RUN
100
10
1
Grain-size Diameter (mm)
10
100
1000
10000
Discharge (cfs)
Coarse
Medium
Fine
0.03
0.047
0.06

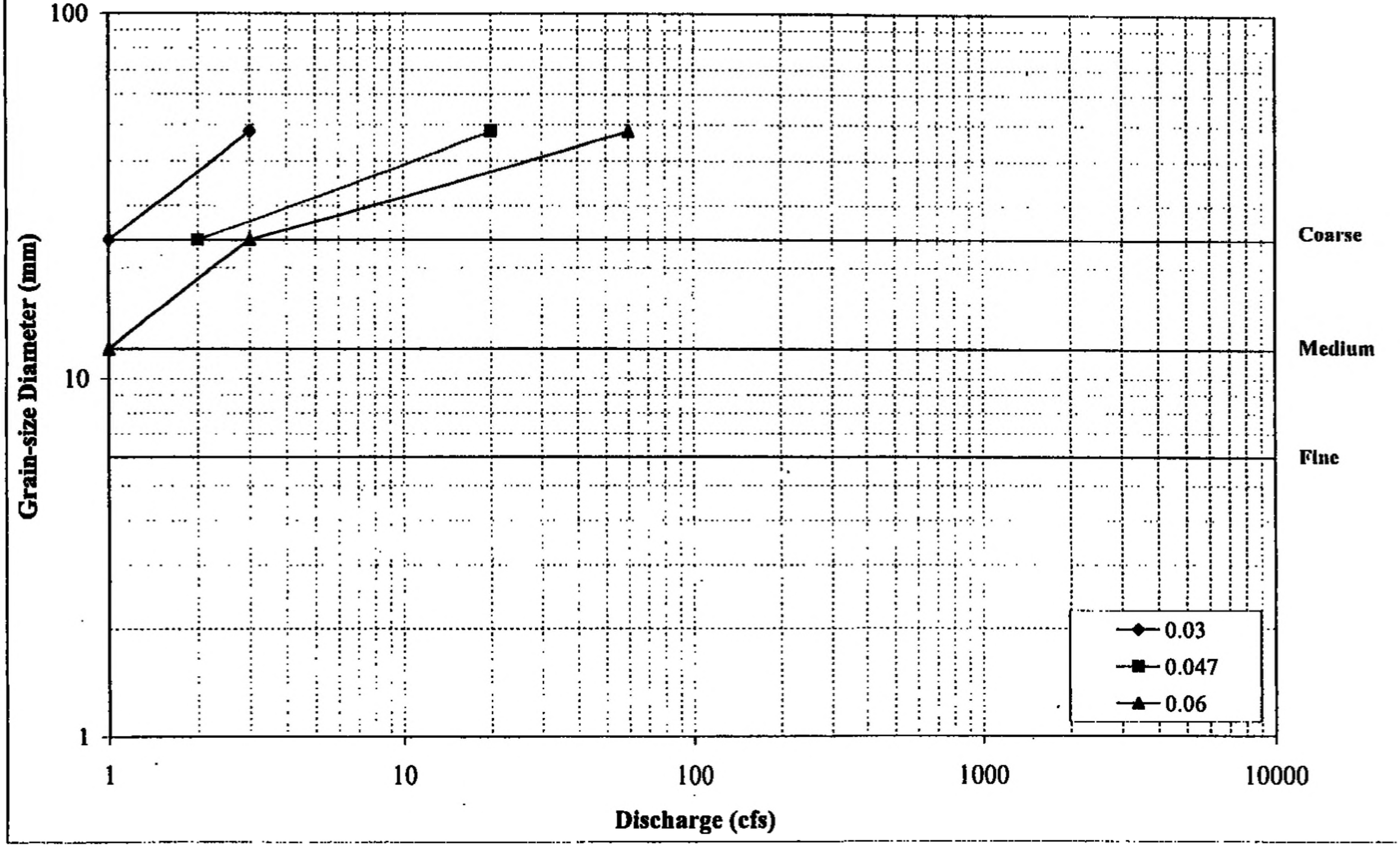
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 5 - Transect 4 POW

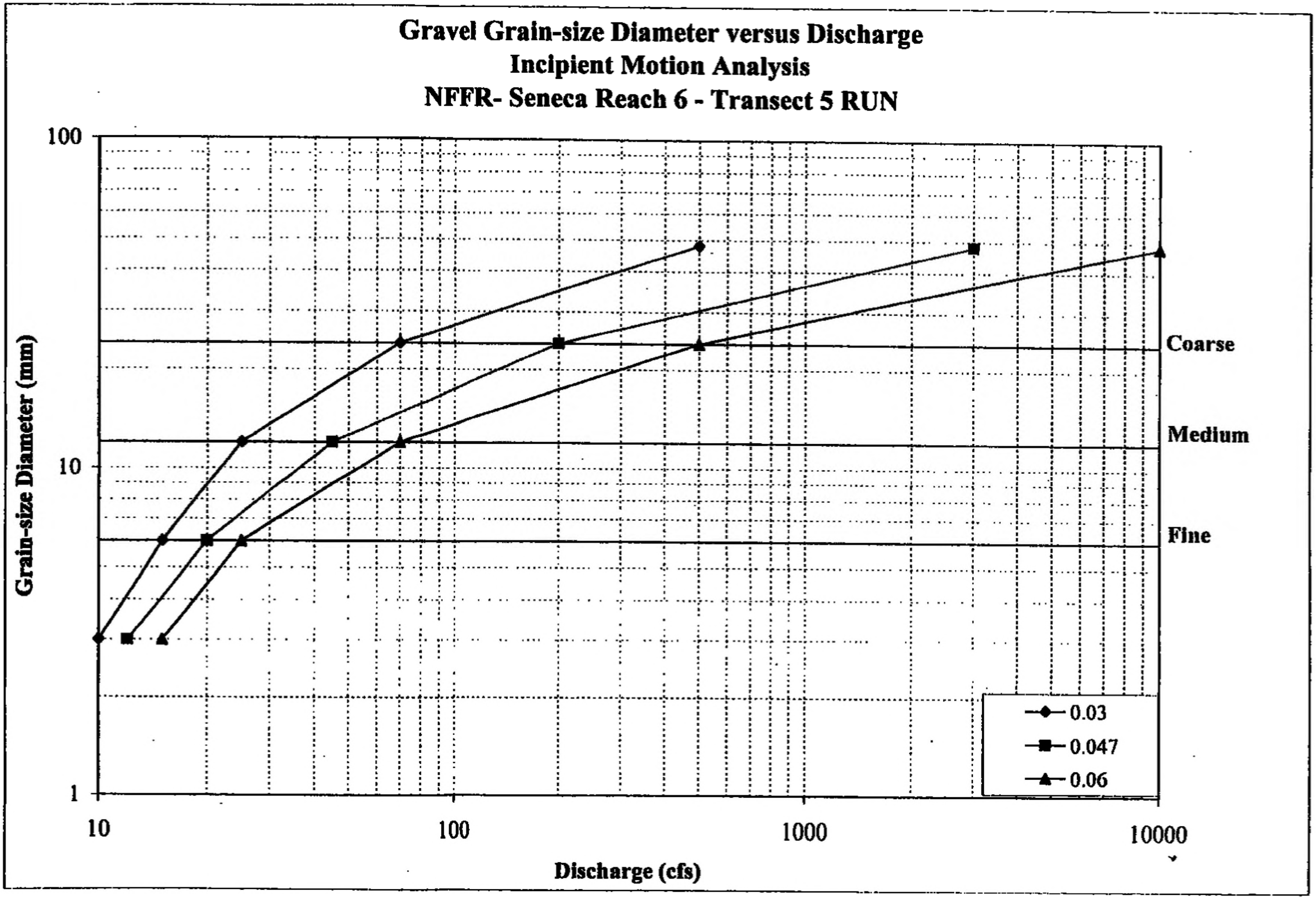


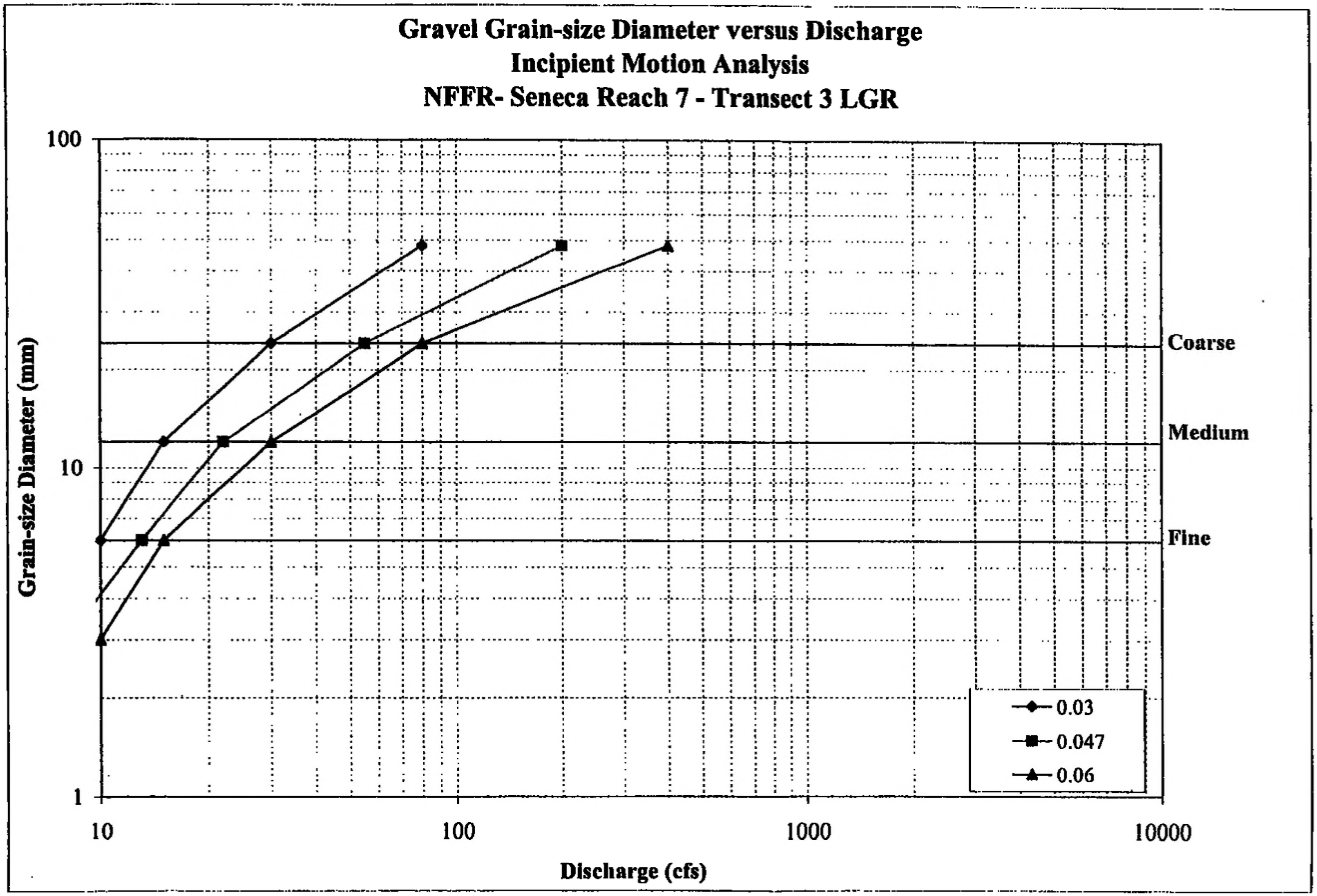

Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 5 - Transect 5 POW
Grain-size Diameter (mm)
100
10
1
10
100
1000
10000
Discharge (cfs)
Coarse
Medium
Fine
0.03
0.047
0.06


Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 6 - Transect 2 RUN
100
10
1
Grain-size Diameter (mm)
10
100
1000
10000
Discharge (cfs)
Coarse
Medium
Fine
0.03
0.047
0.06

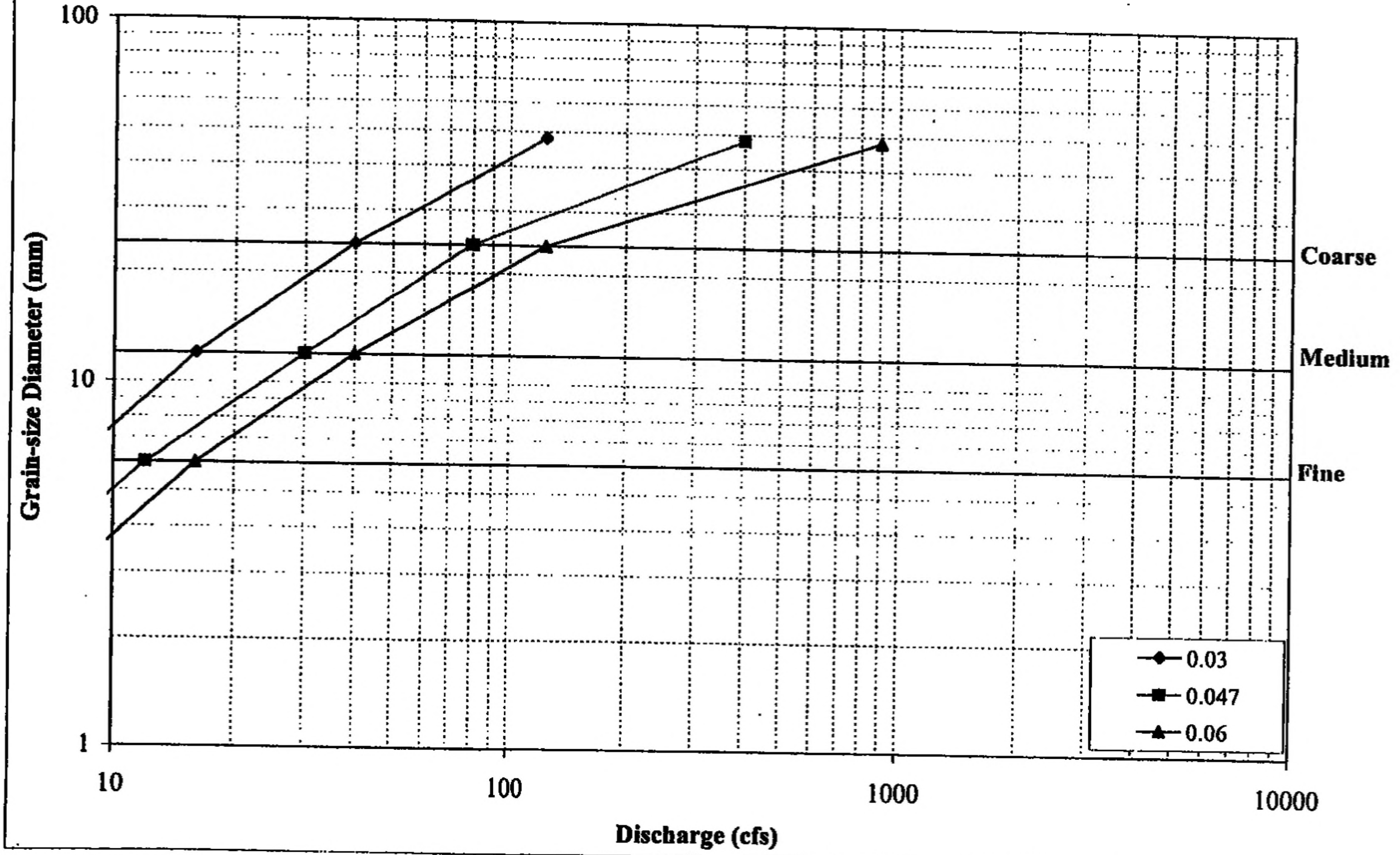
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 6 - Transect 4 LGR



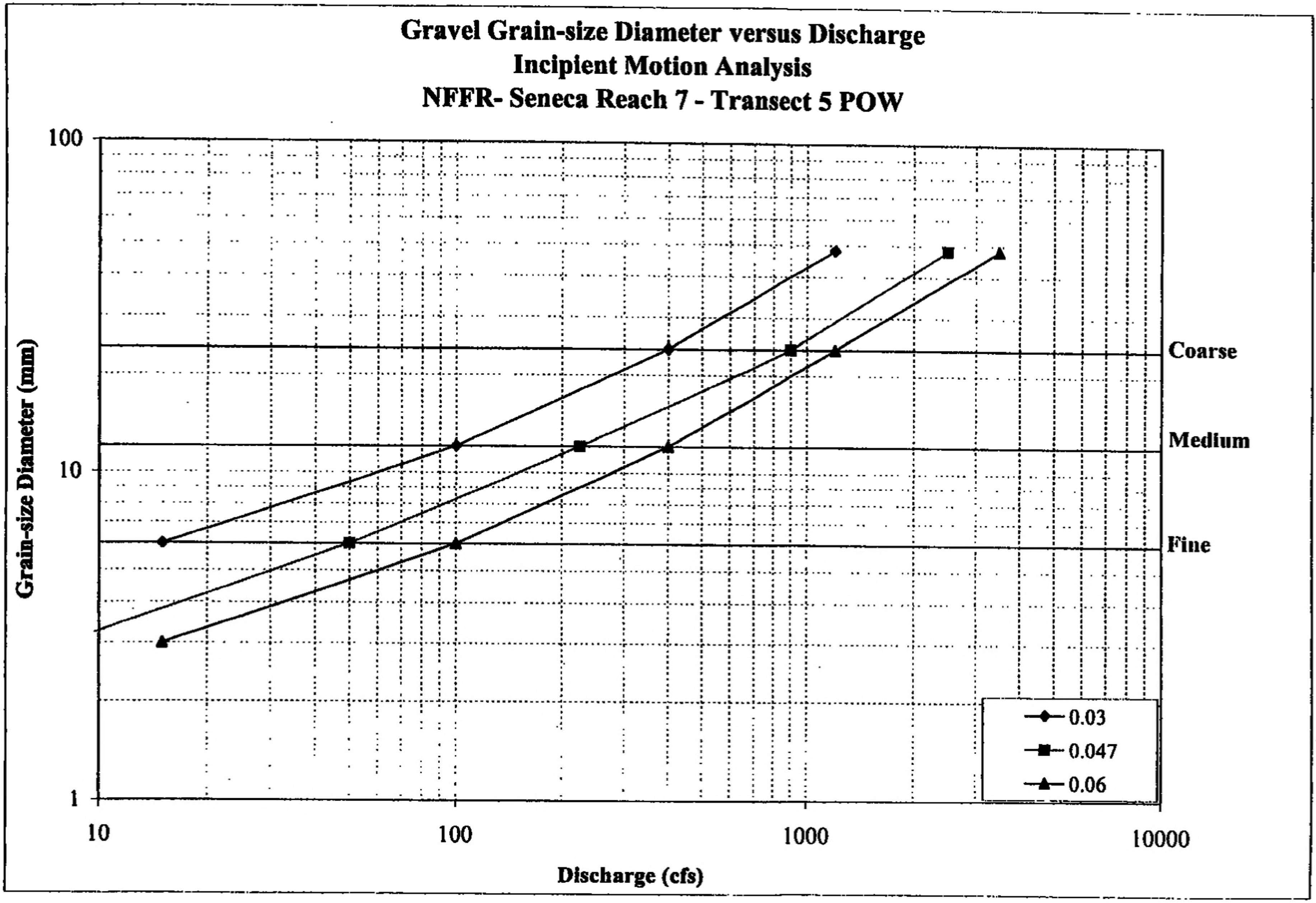

Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 6 - Transect 5 RUN
Grain-size Diameter (mm)
100
10
1
10
100
1000
10000
Discharge (cfs)
Coarse
Medium
Fine
0.03
0.047
0.06



Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 7 - Transect 3 LGR

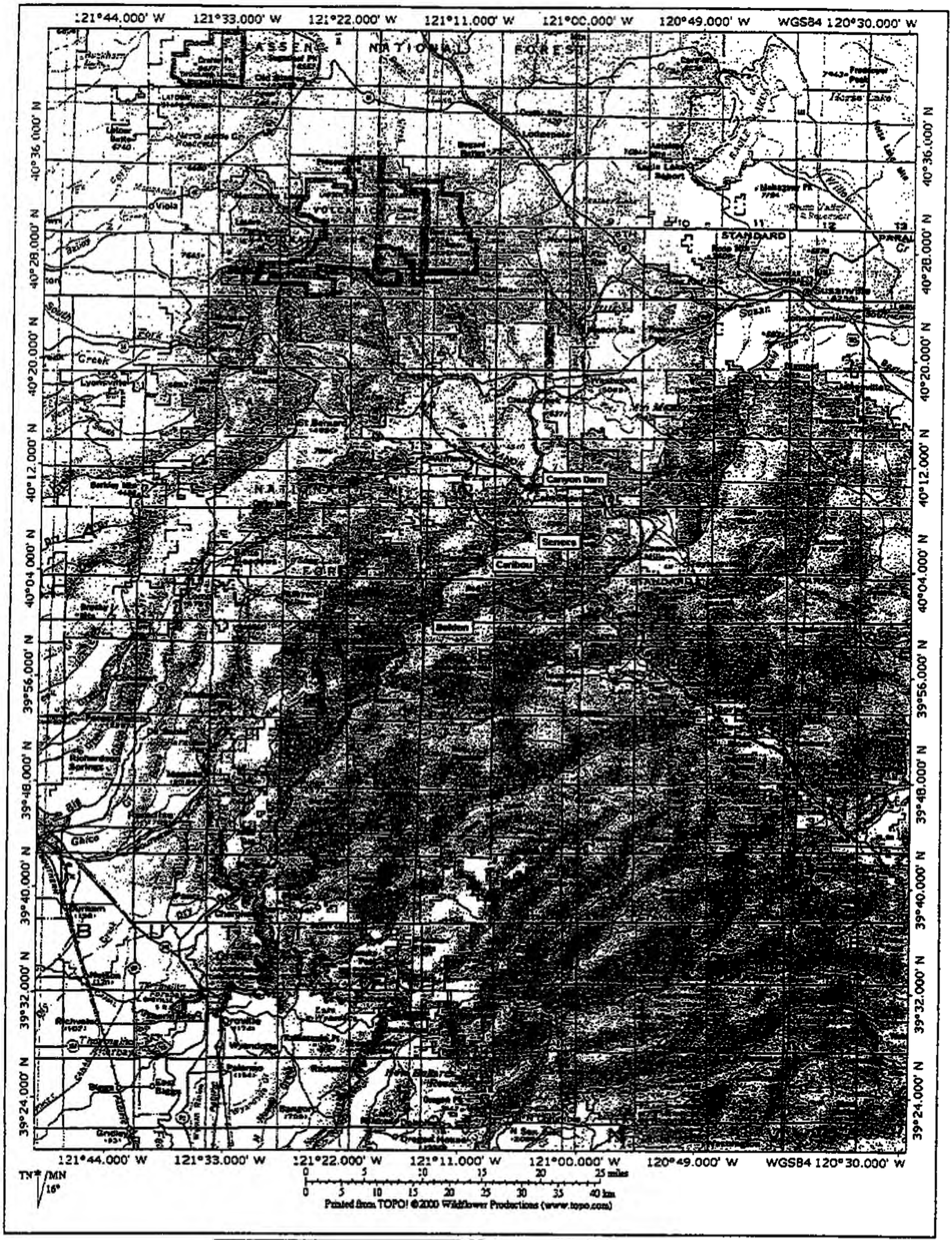


Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 7 - Transect 4 RUN



Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Seneca Reach 7 - Transect 5 POW

Belden Reach Sections



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North Fork Feather River Regional Map	
Upper NFFR Incipient Motion Study	December 2001

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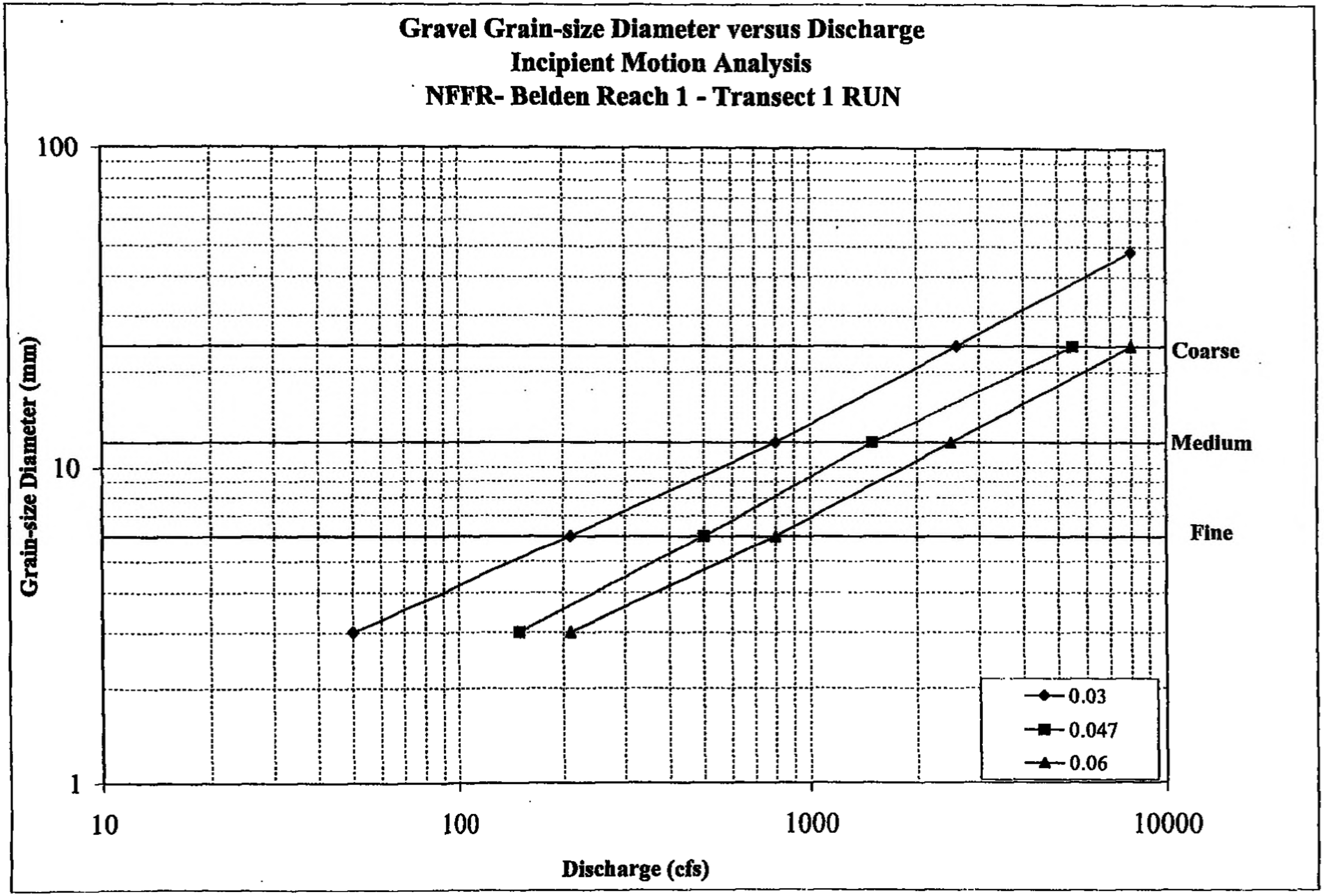
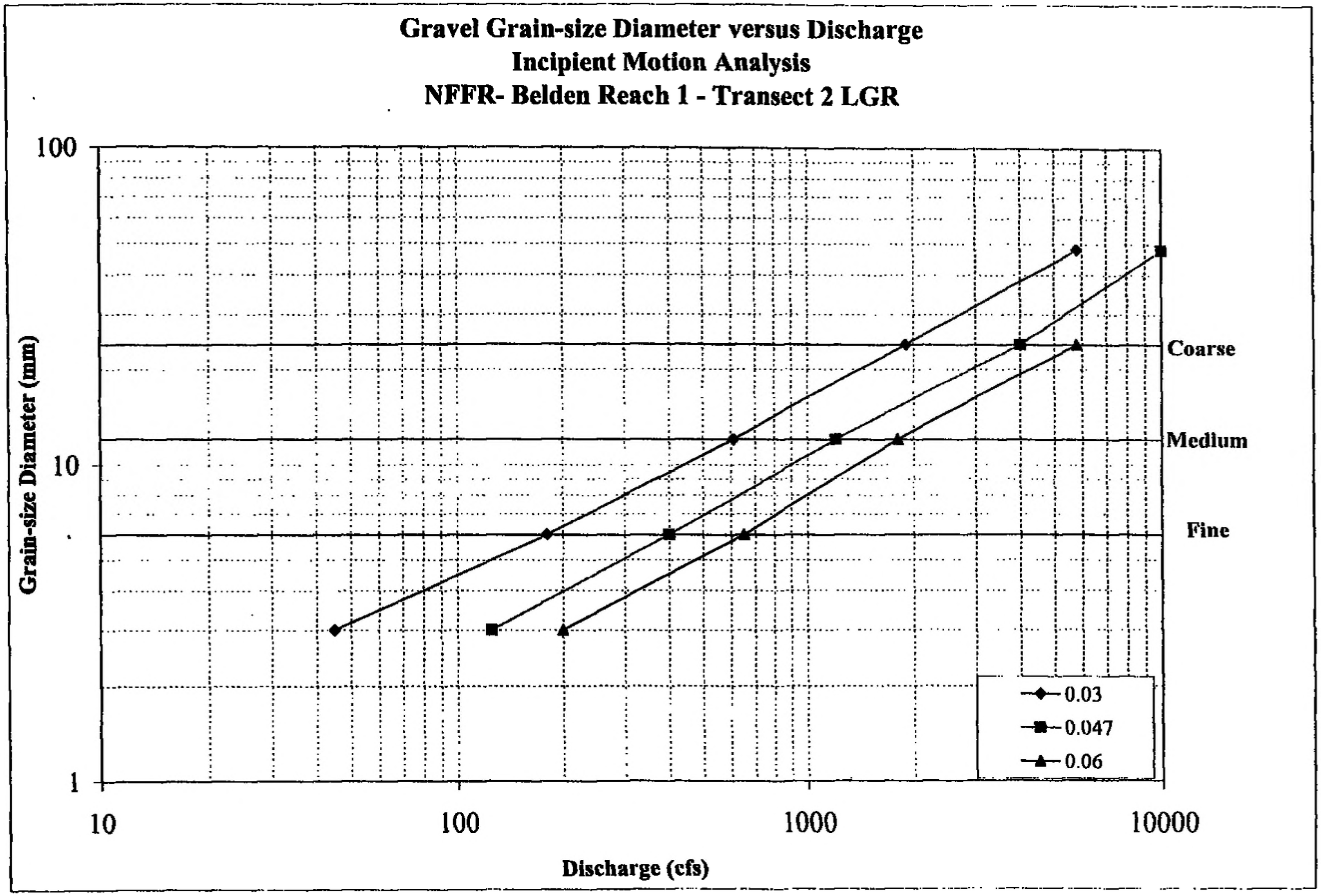
North Fork Feather River Regional Map
Belden Reach Sections

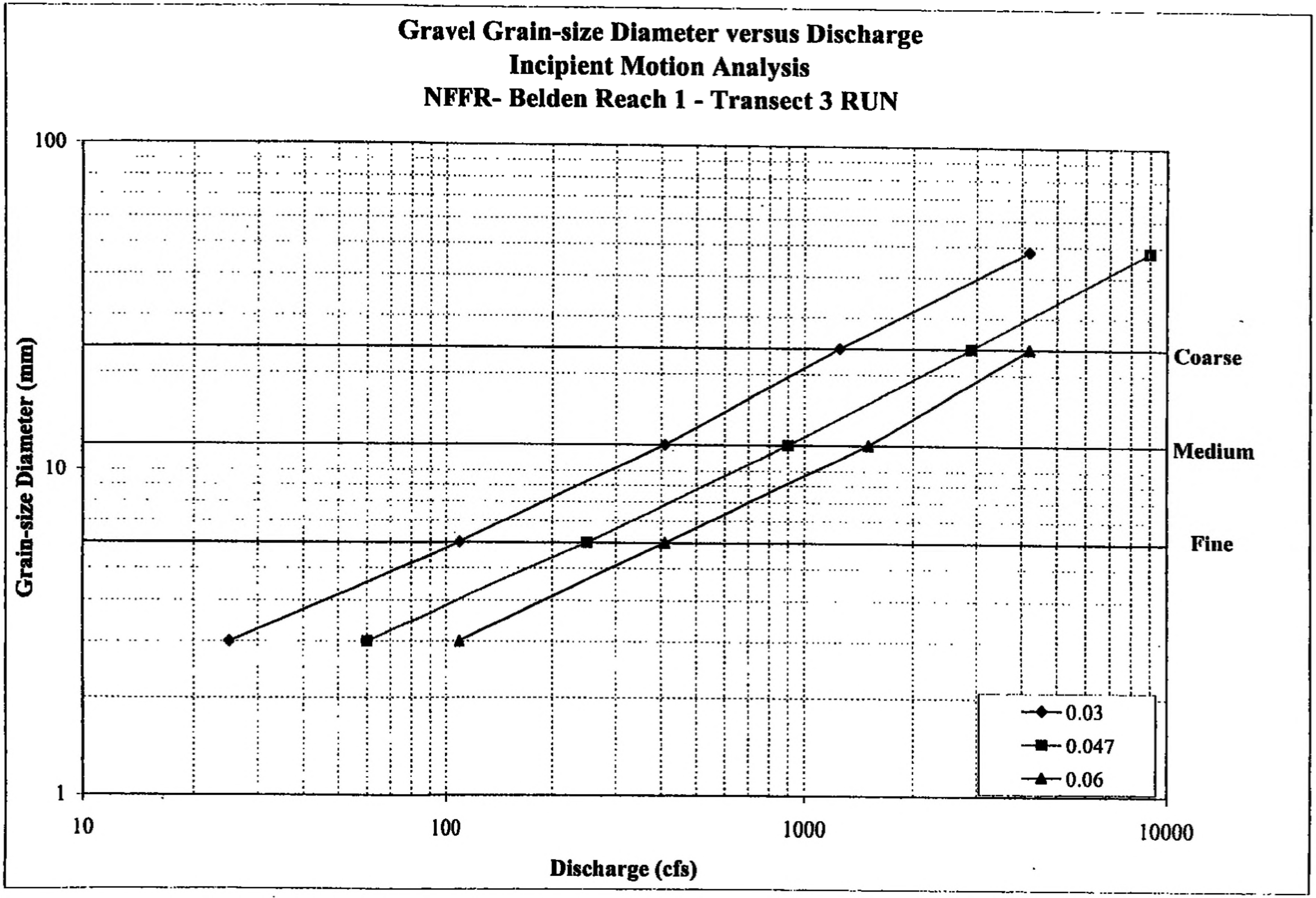
Upper NFFR Incipient Motion Study

December 2001

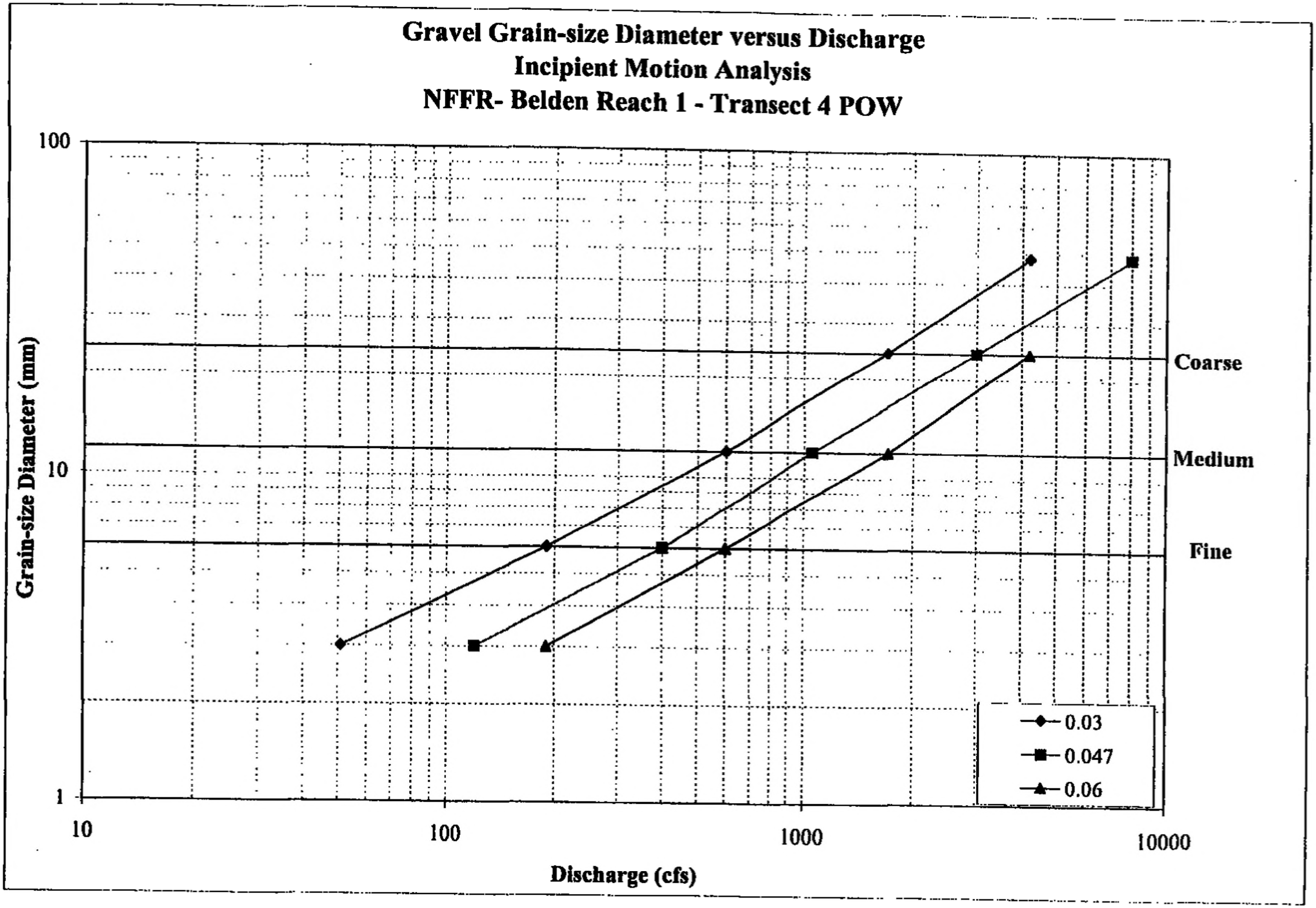


Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Belden Reach 1 - Transect 1 RUN


Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Belden Reach 1 - Transect 2 LGR
Grain-size Diameter (mm)
100
10
1
10
100
1000
10000
Discharge (cfs)
Coarse
Medium
Fine
0.03
0.047
0.06

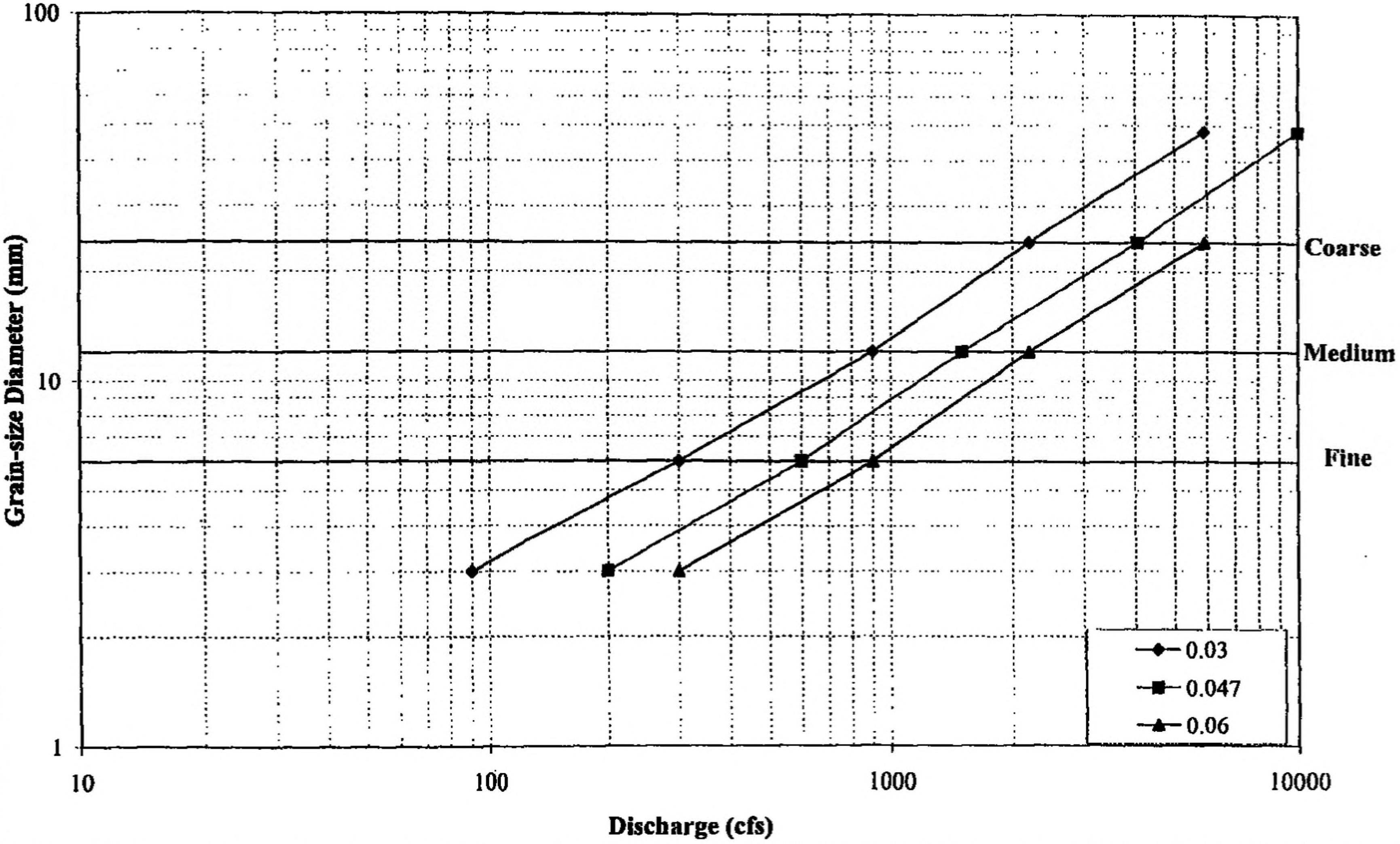


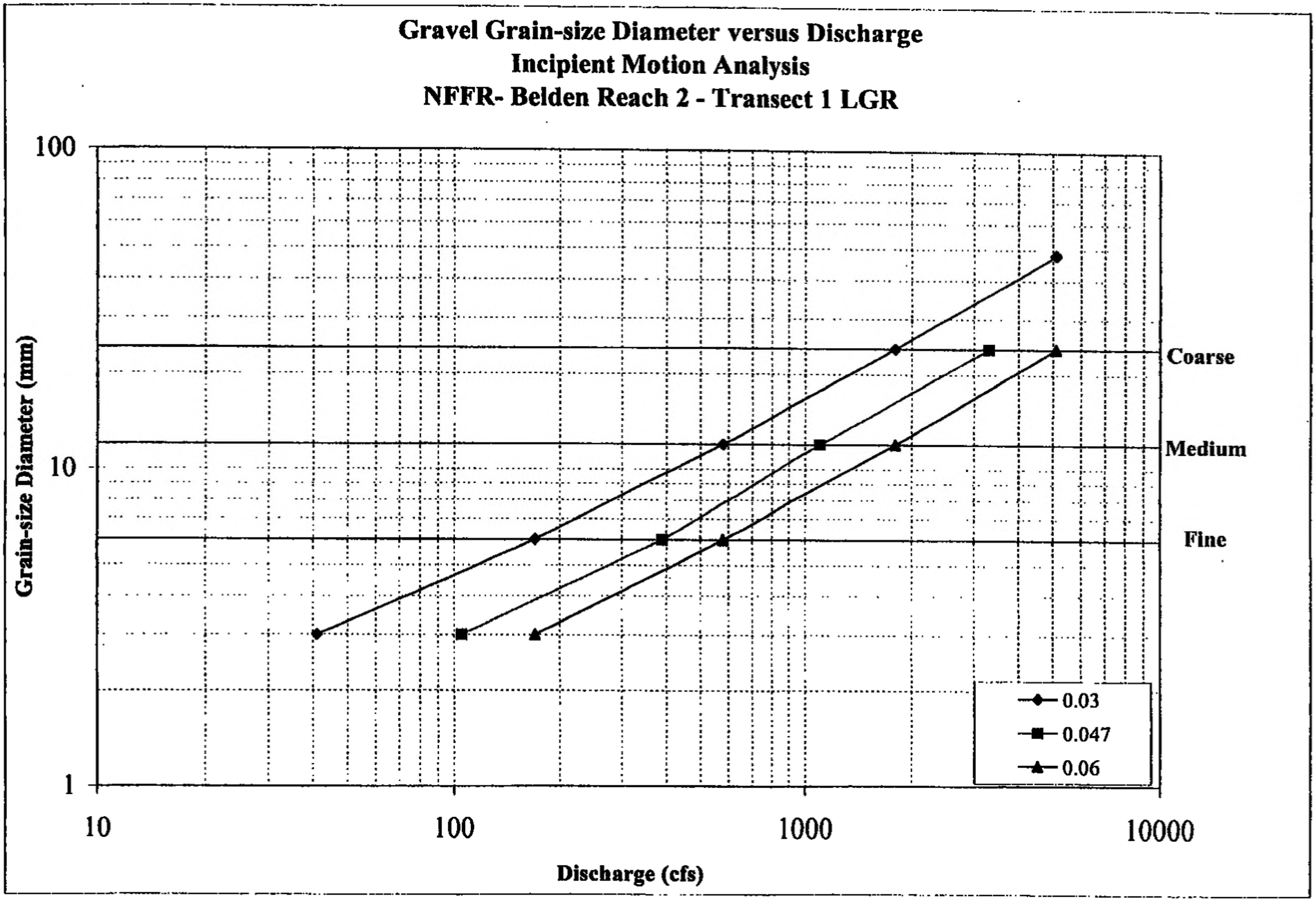
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Belden Reach 1 - Transect 3 RUN



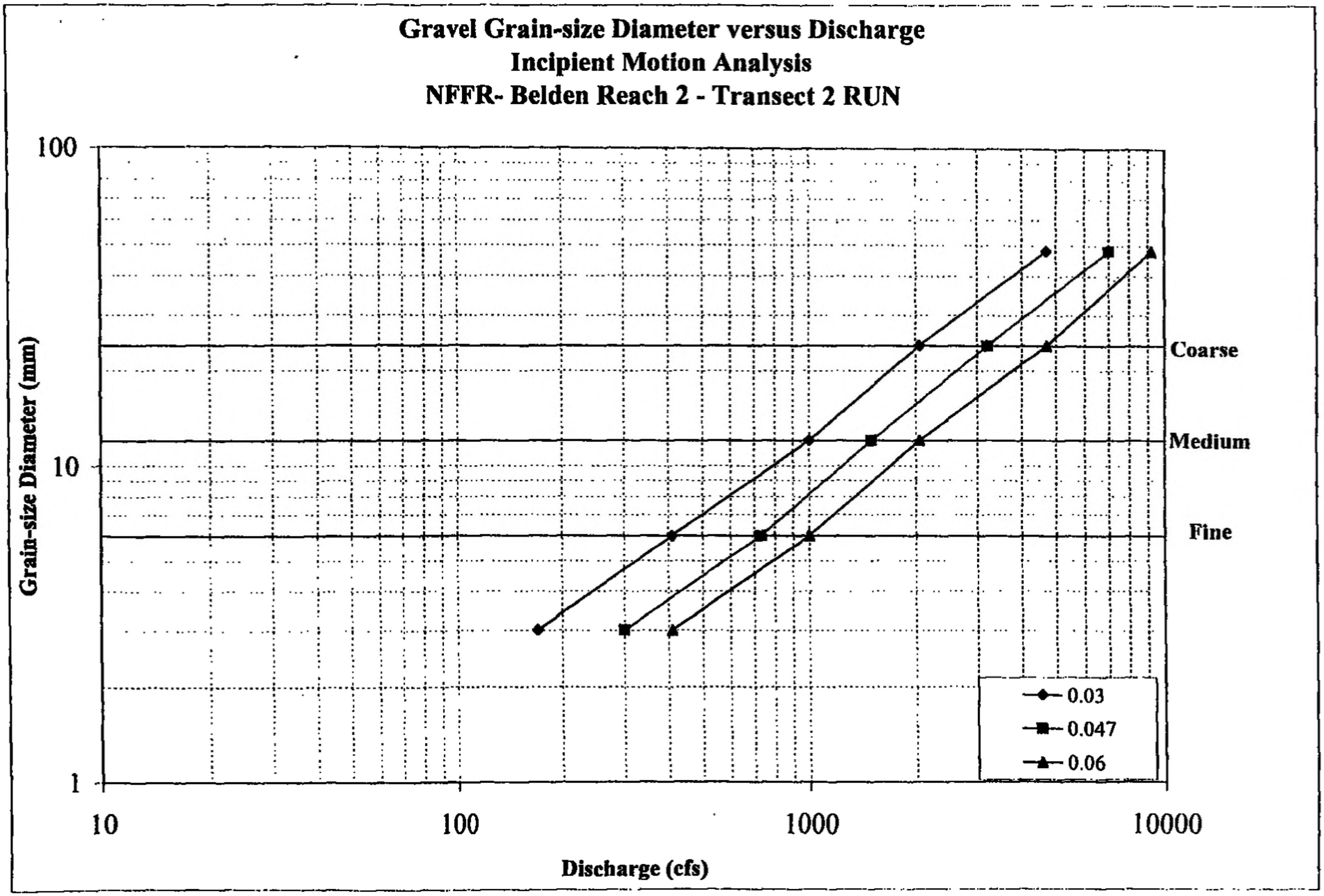
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Belden Reach 1 - Transect 4 POW

Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Belden Reach 1 - Transect 6 POW



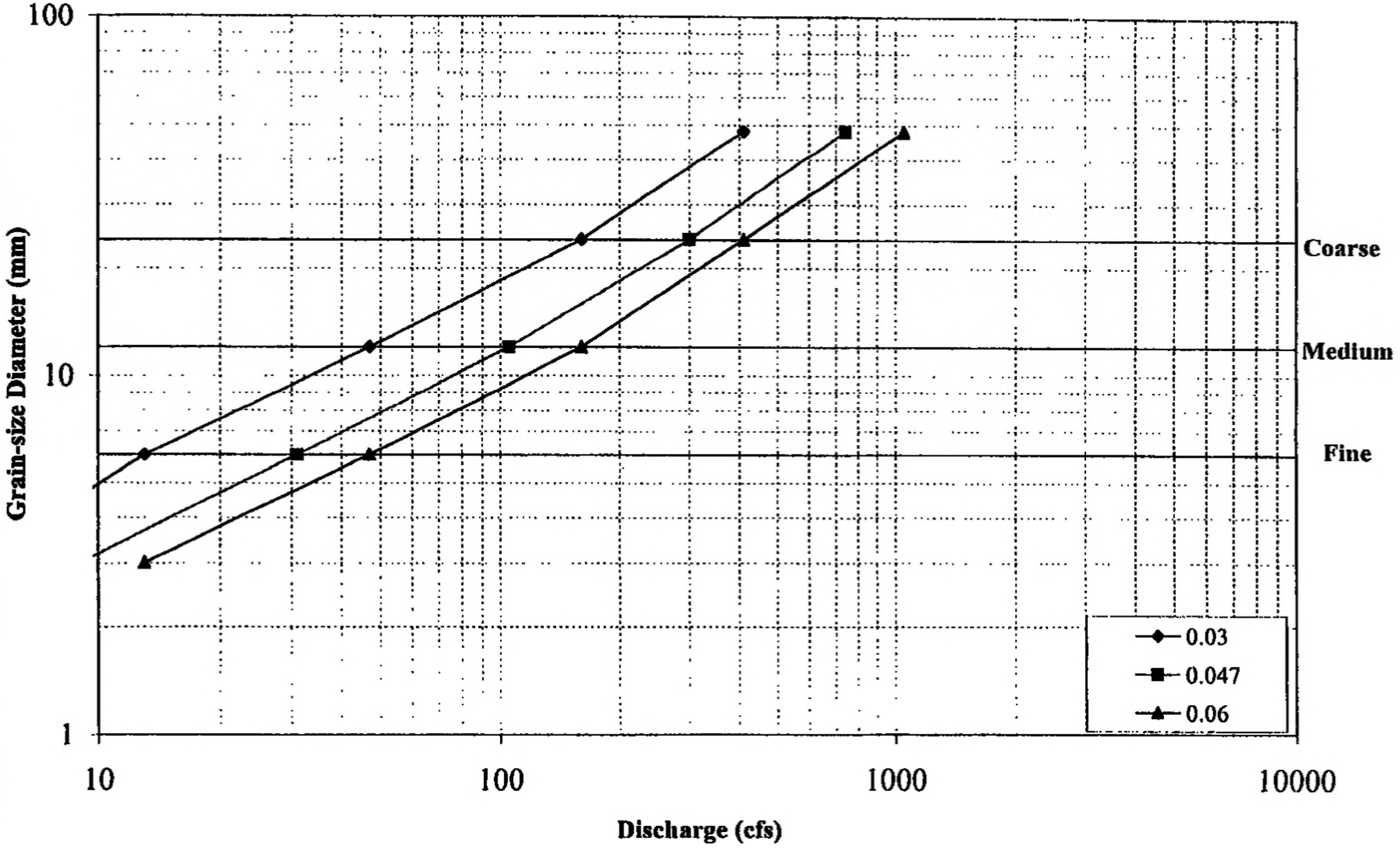


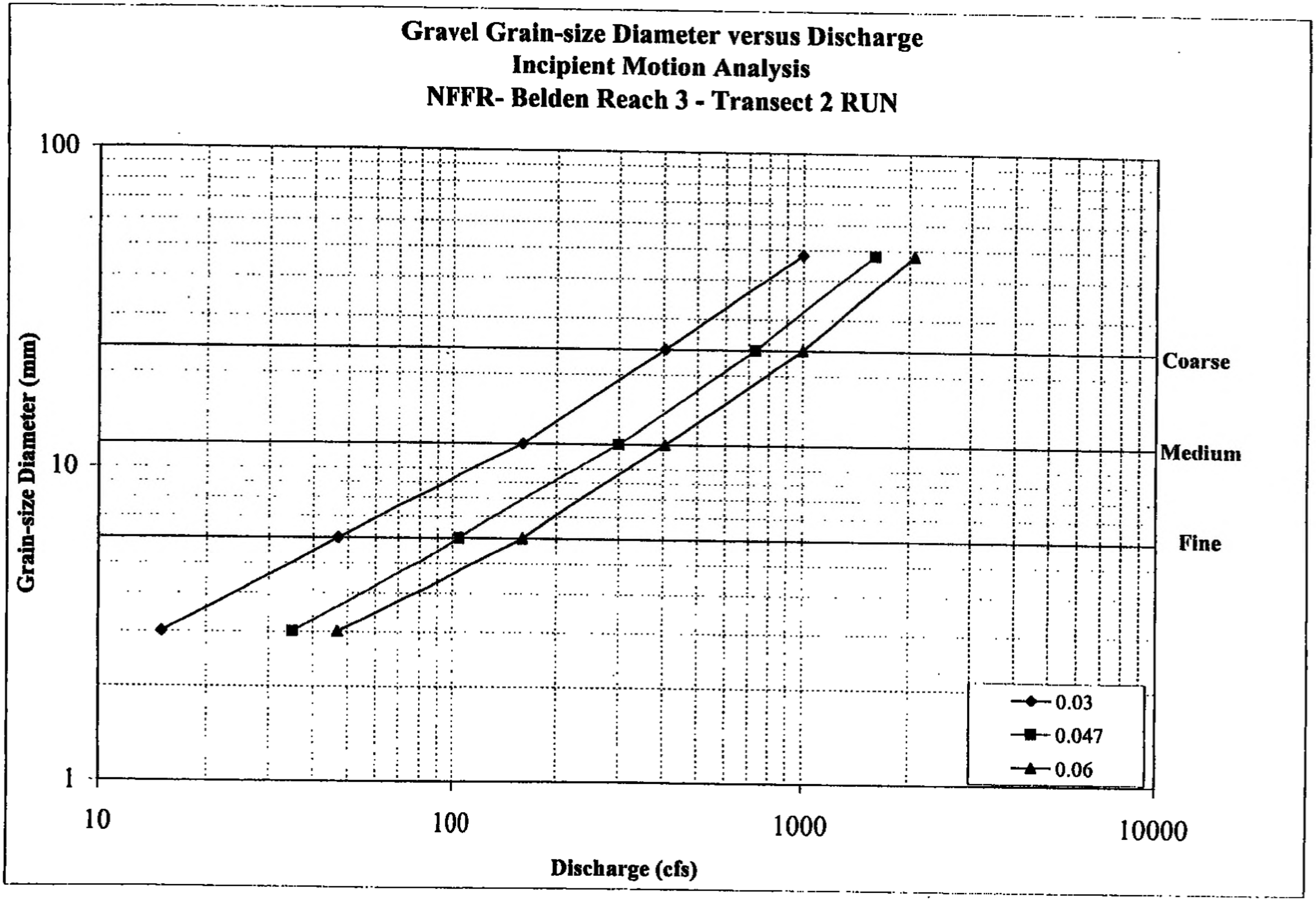
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Belden Reach 2 - Transect 1 LGR



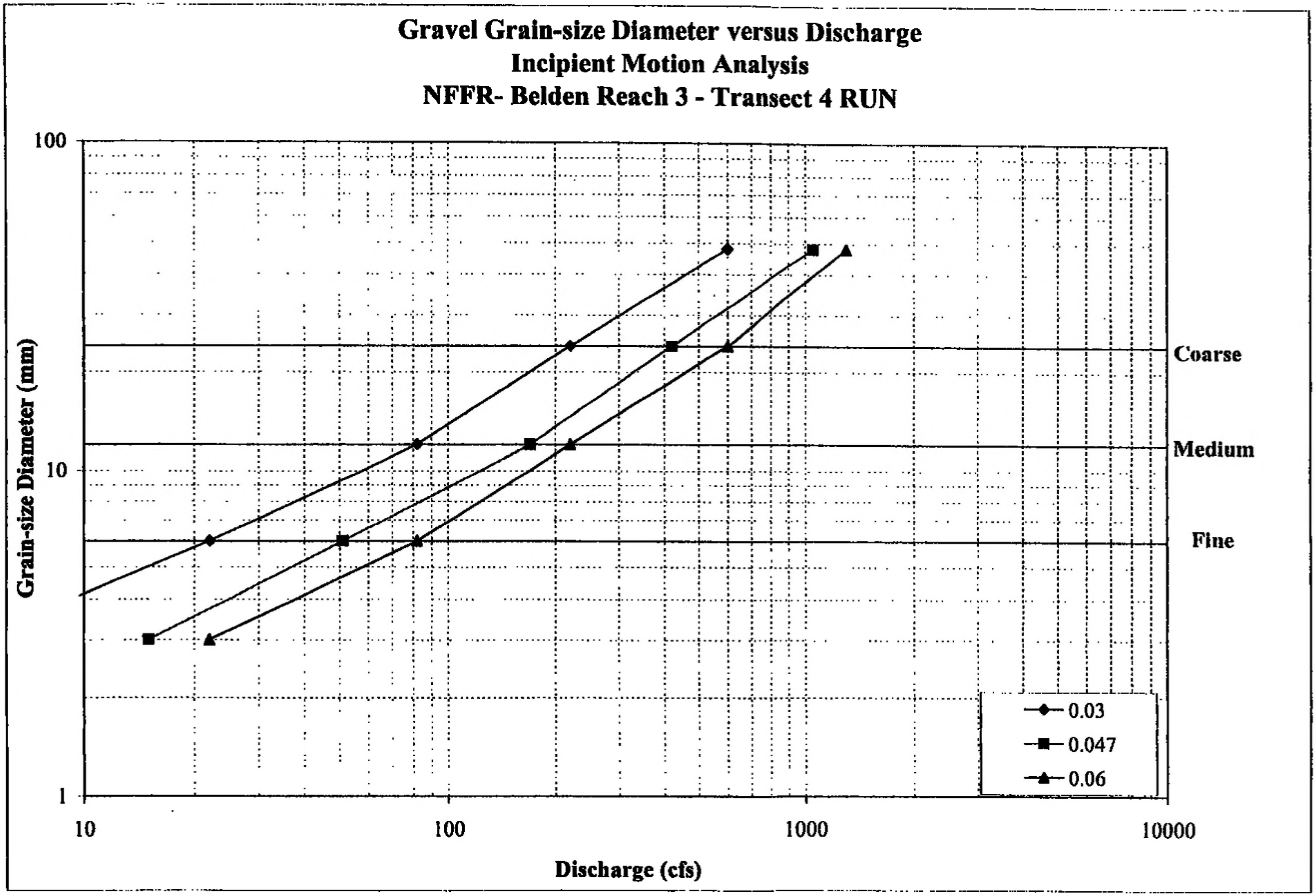
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Belden Reach 2 - Transect 2 RUN

Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Belden Reach 3 - Transect 1 LGR



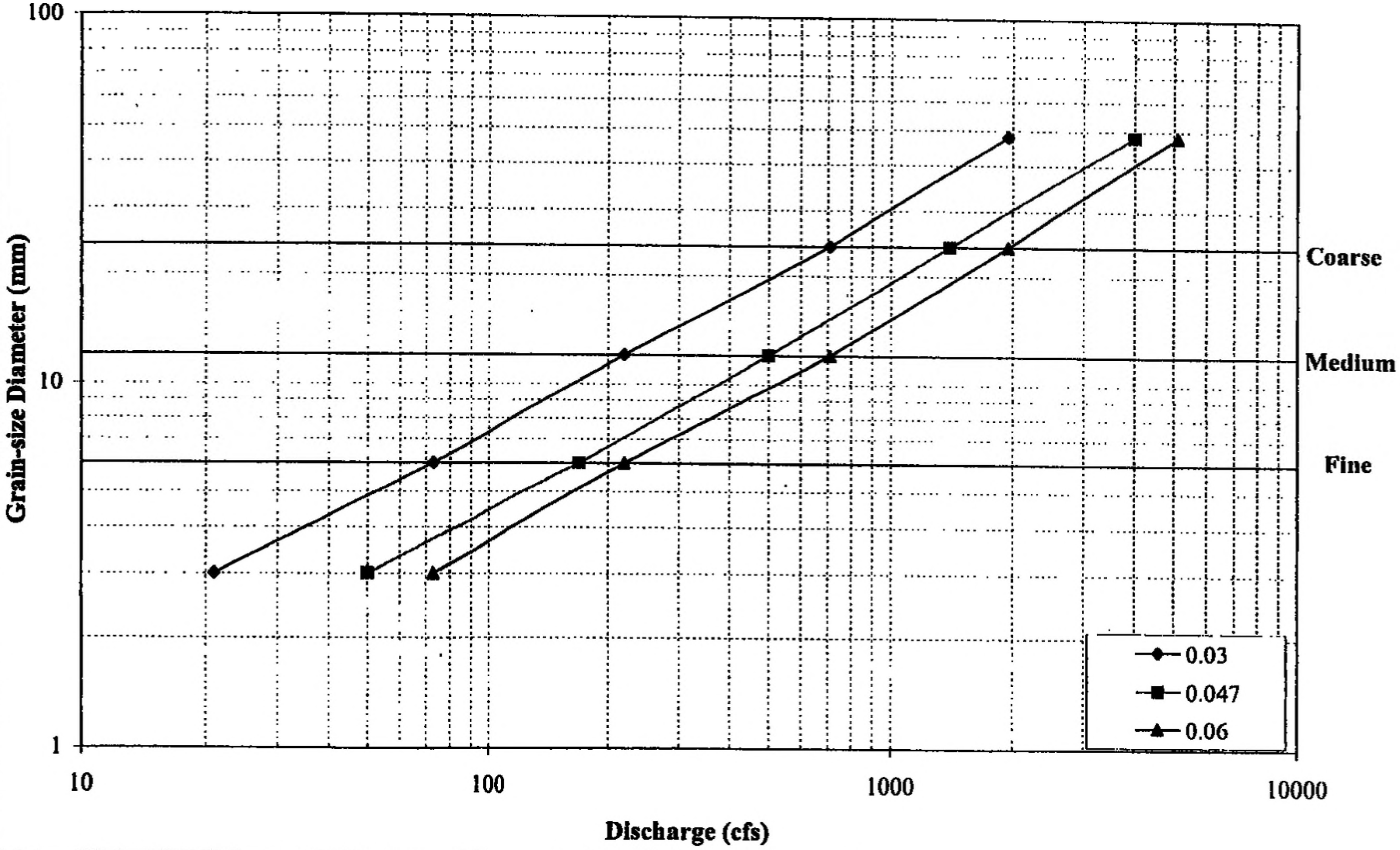


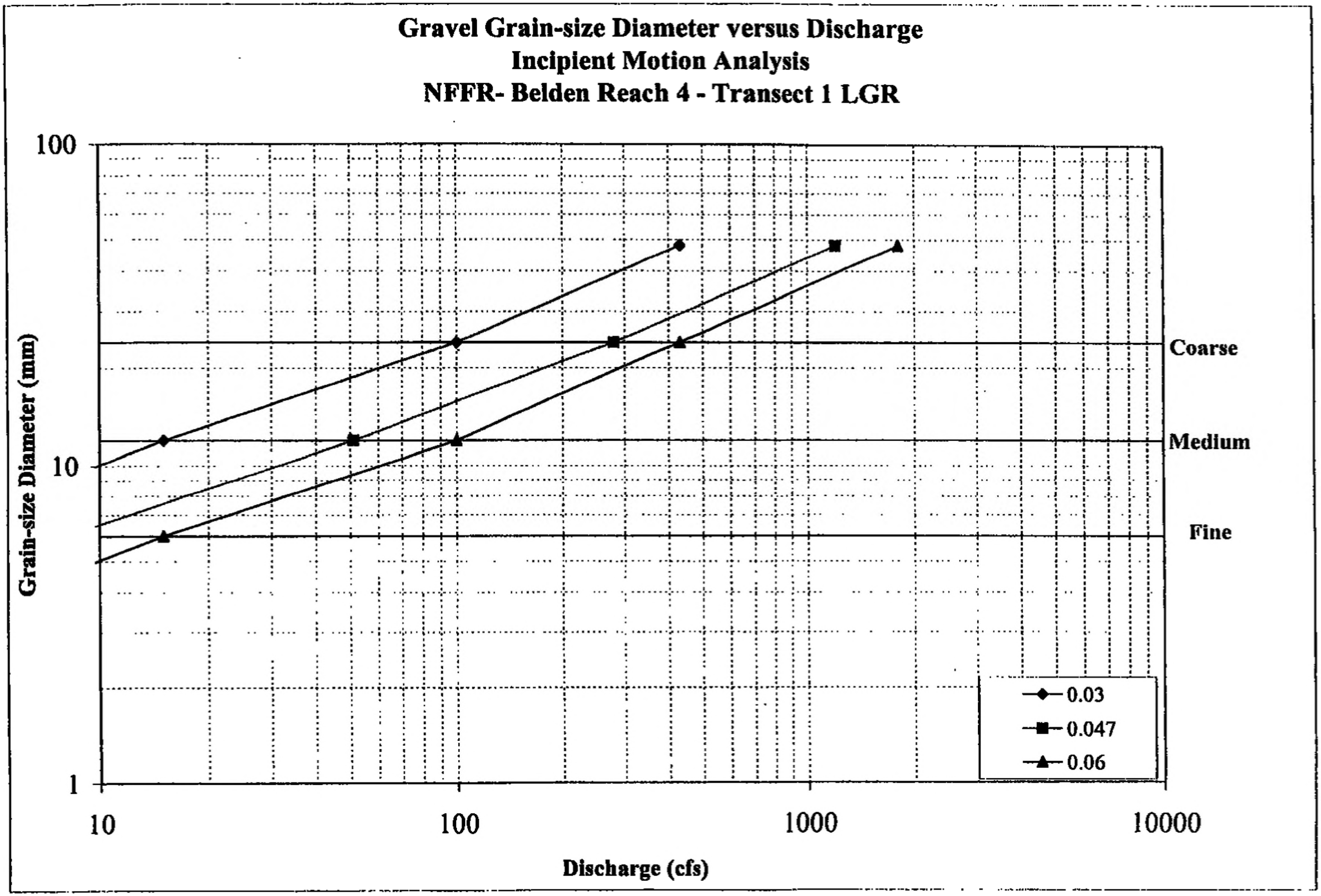
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Belden Reach 3 - Transect 2 RUN

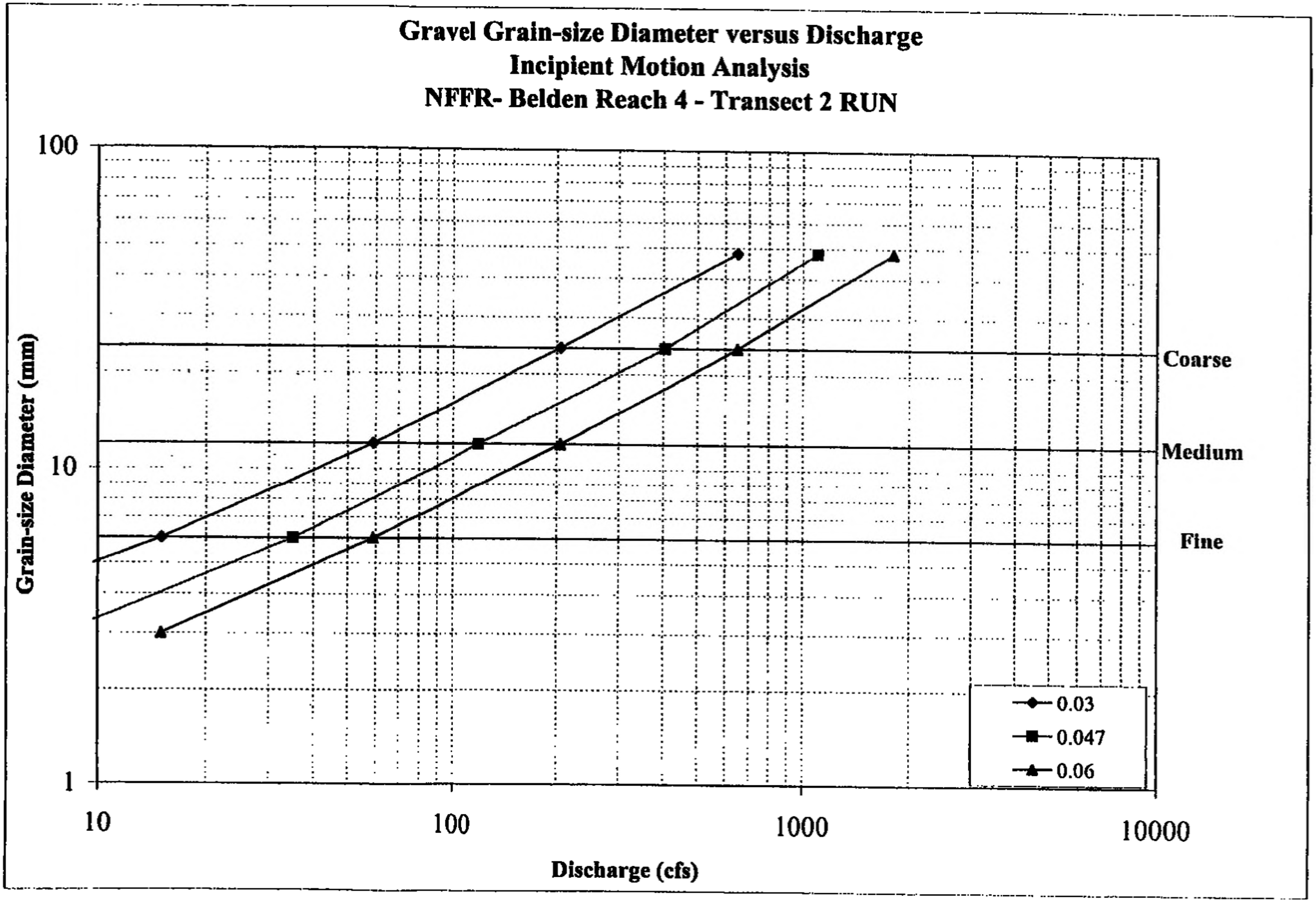


Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Belden Reach 3 - Transect 4 RUN

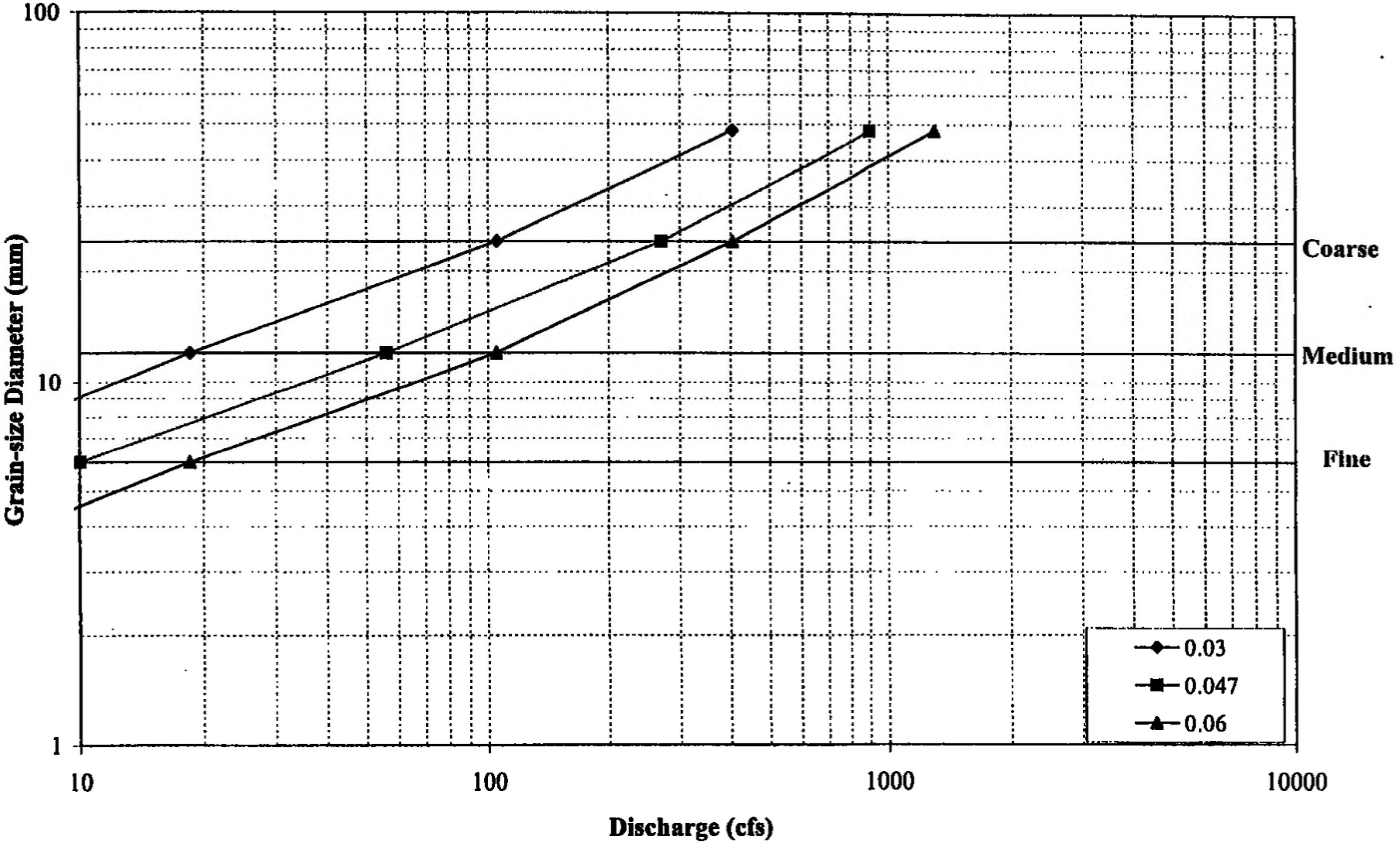
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Belden Reach 3 - Transect 5 POW

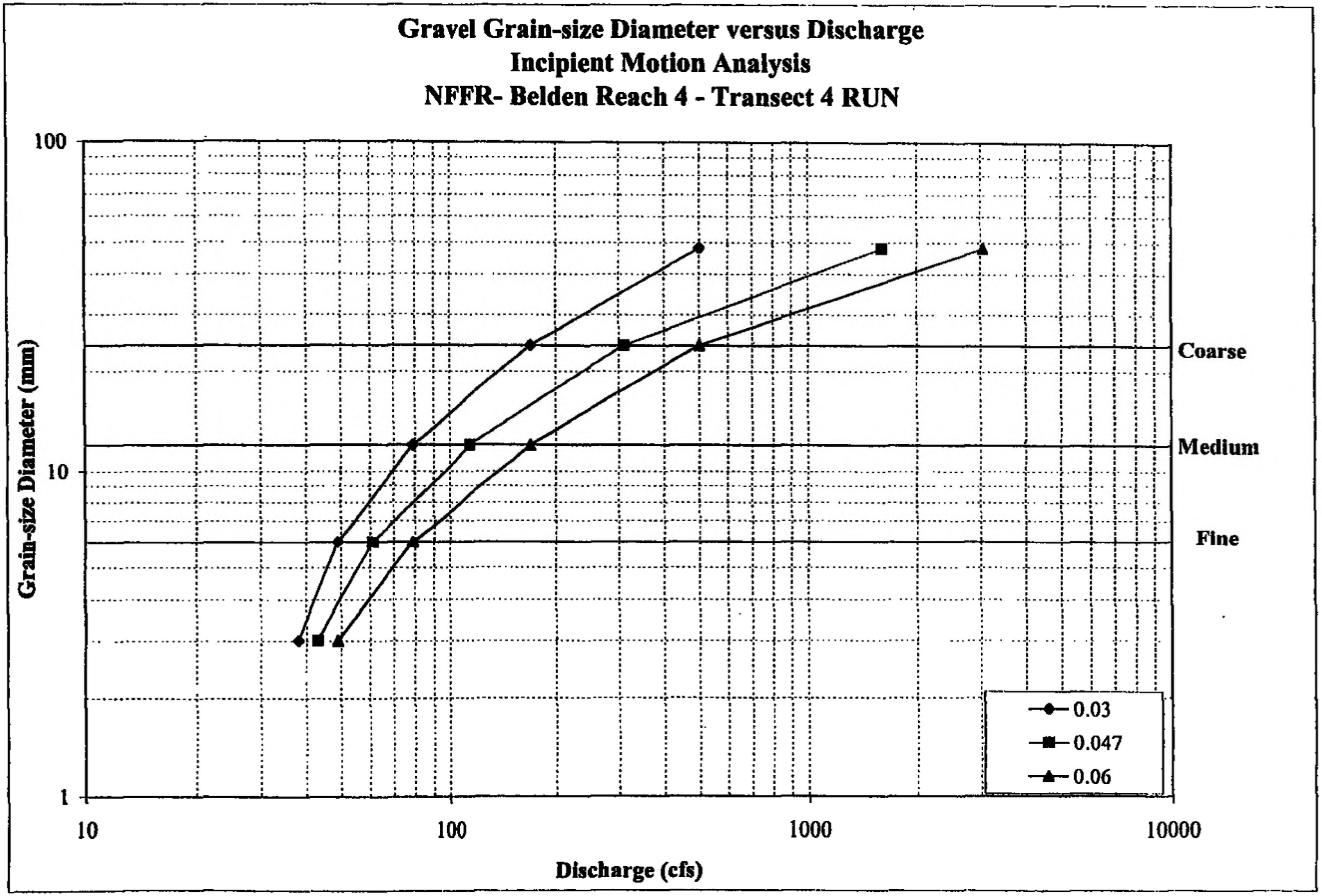



Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Belden Reach 4 - Transect 1 LGR
Grain-size Diameter (mm)
100
10
1
10
100
1000
10000
Discharge (cfs)
Coarse
Medium
Fine
◆ 0.03
■ 0.047
▲ 0.06

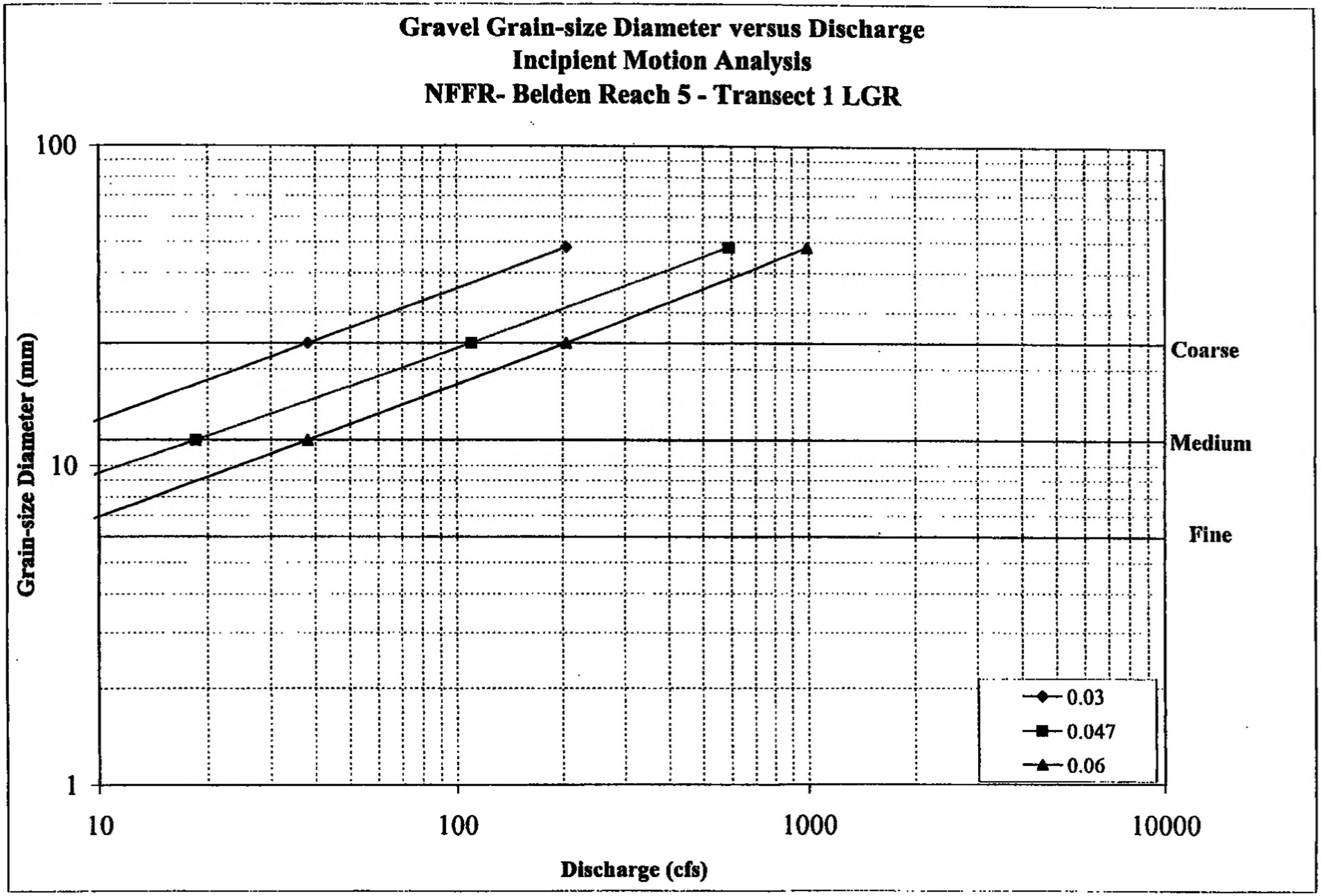

Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Belden Reach 4 - Transect 2 RUN
100
10
1
Grain-size Diameter (mm)
10
100
1000
10000
Discharge (cfs)
Coarse
Medium
Fine
0.03
0.047
0.06

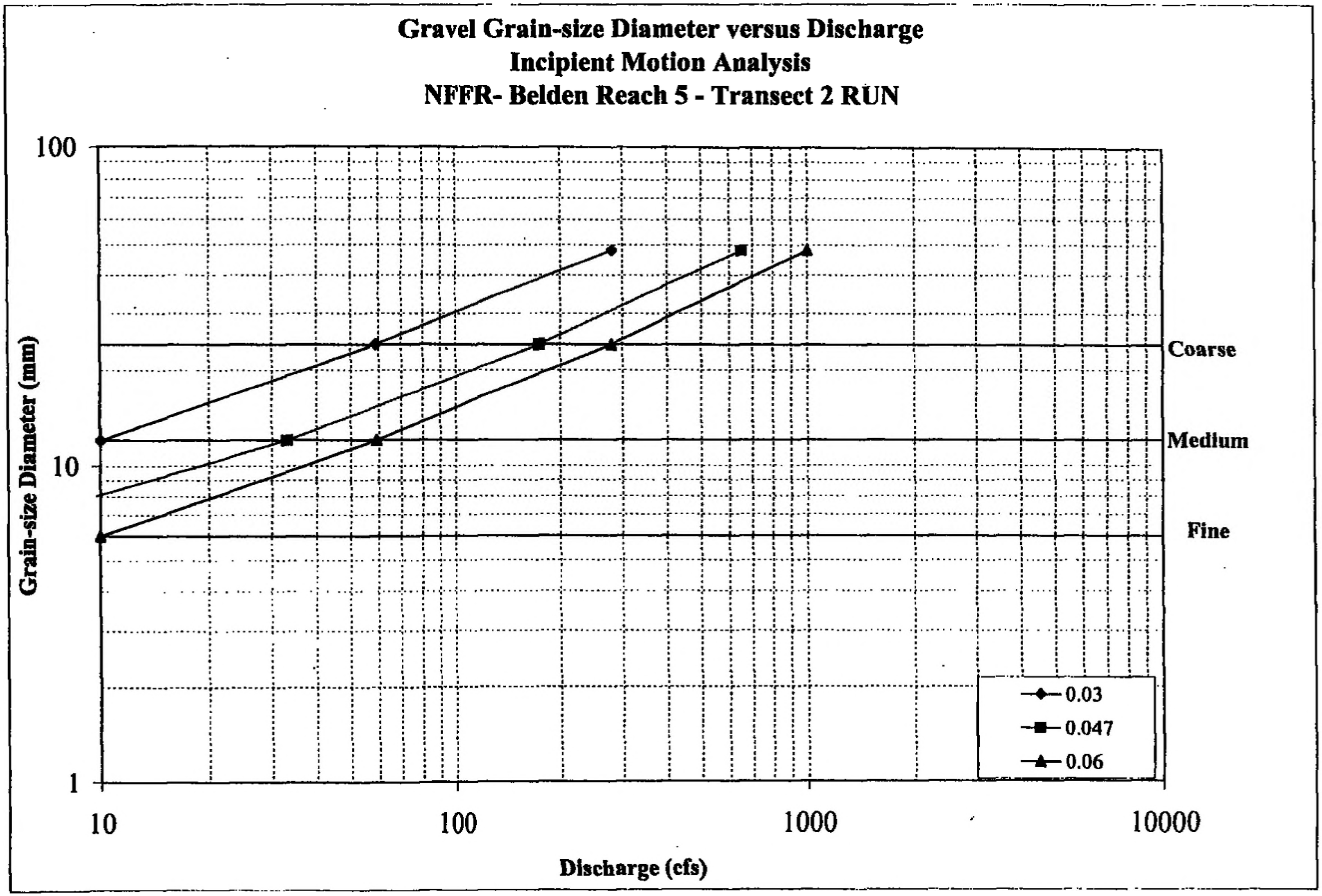
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Belden Reach 4 - Transect 3 POW

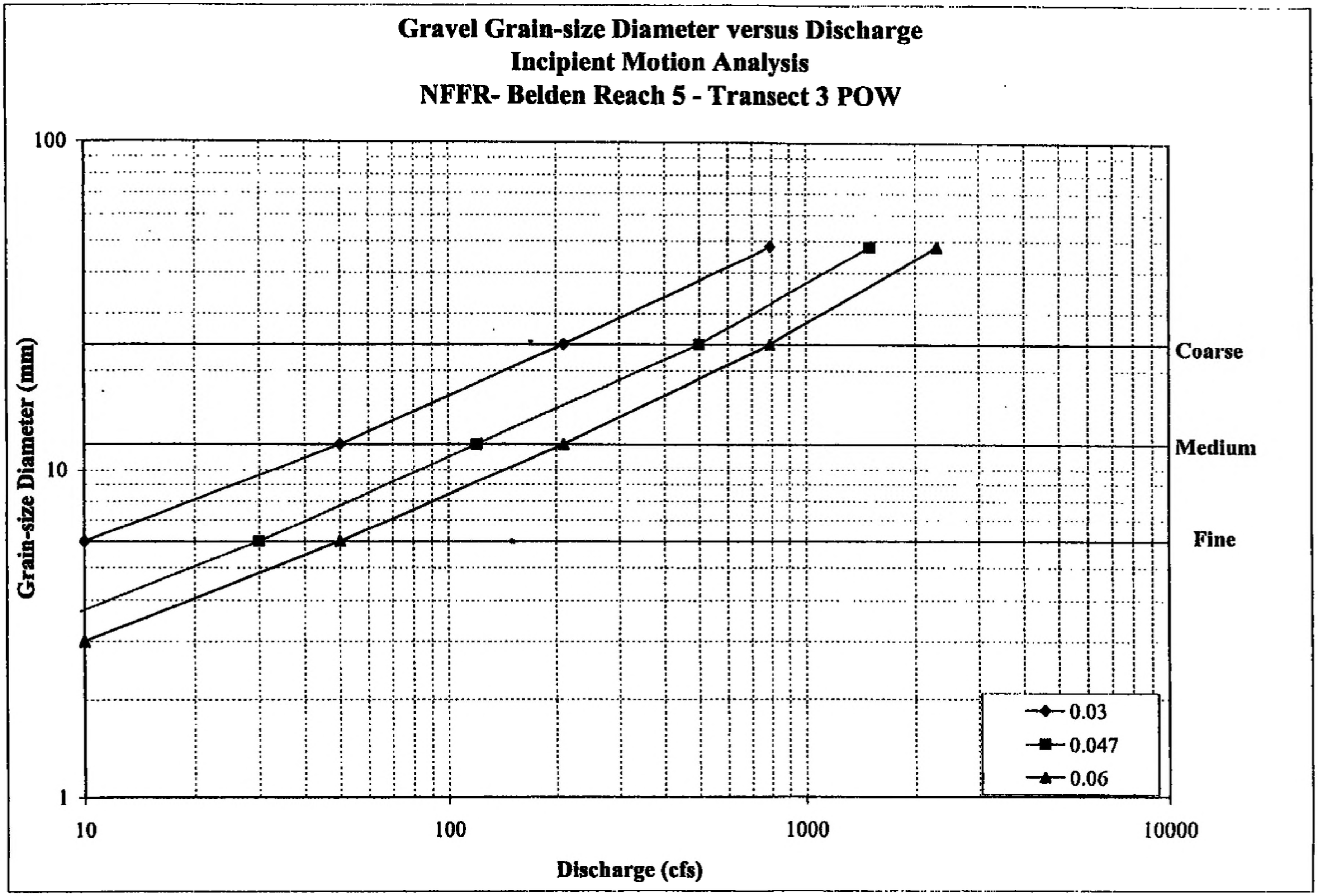




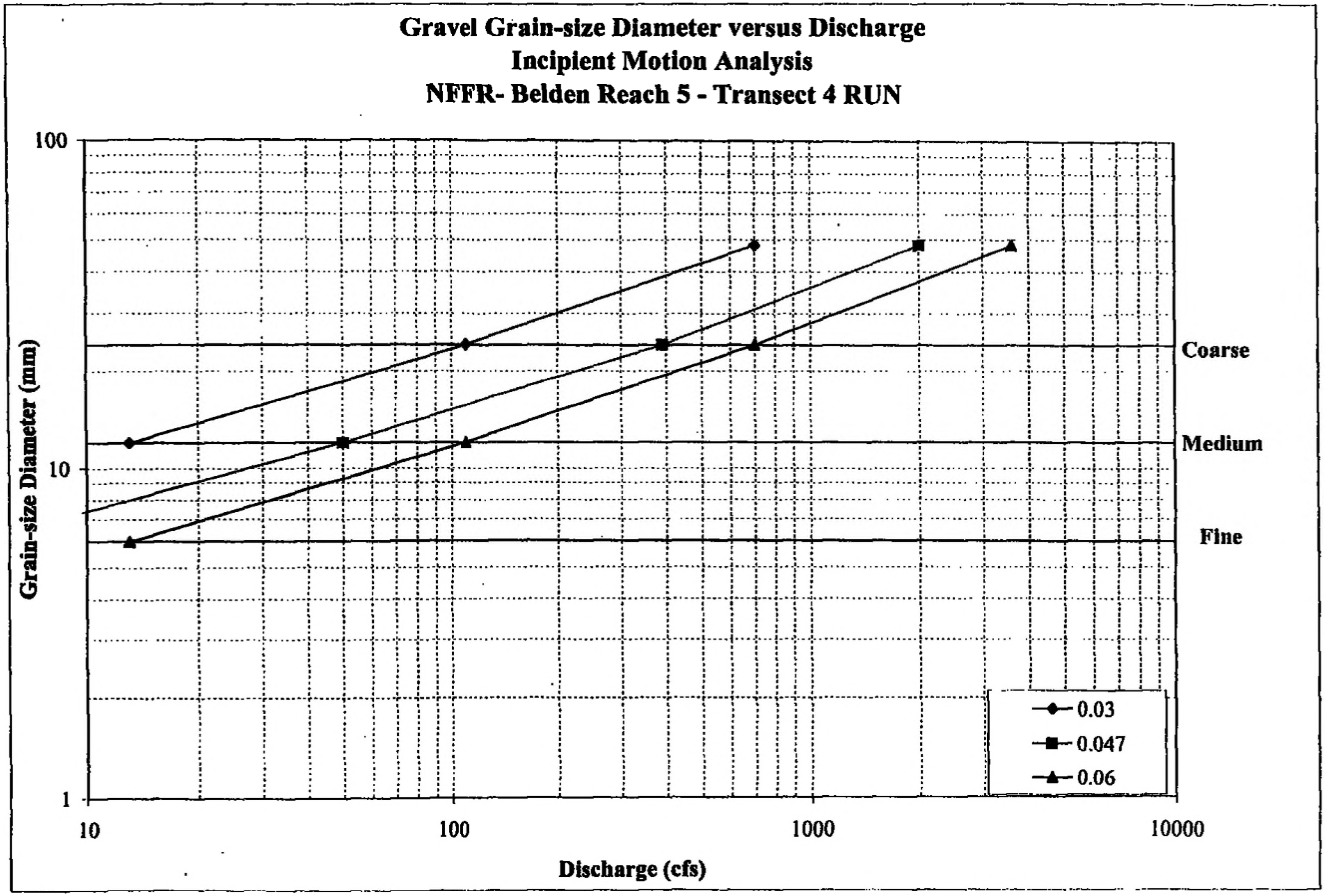
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Belden Reach 4 - Transect 4 RUN


Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Belden Reach 5 - Transect 1 LGR
Grain-size Diameter (mm)
100
10
1
Discharge (cfs)
10
100
1000
10000
Coarse
Medium
Fine
0.03
0.047
0.06


Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Belden Reach 5 - Transect 2 RUN
100
10
1
Grain-size Diameter (mm)
10
100
1000
10000
Discharge (cfs)
Coarse
Medium
Fine
0.03
0.047
0.06

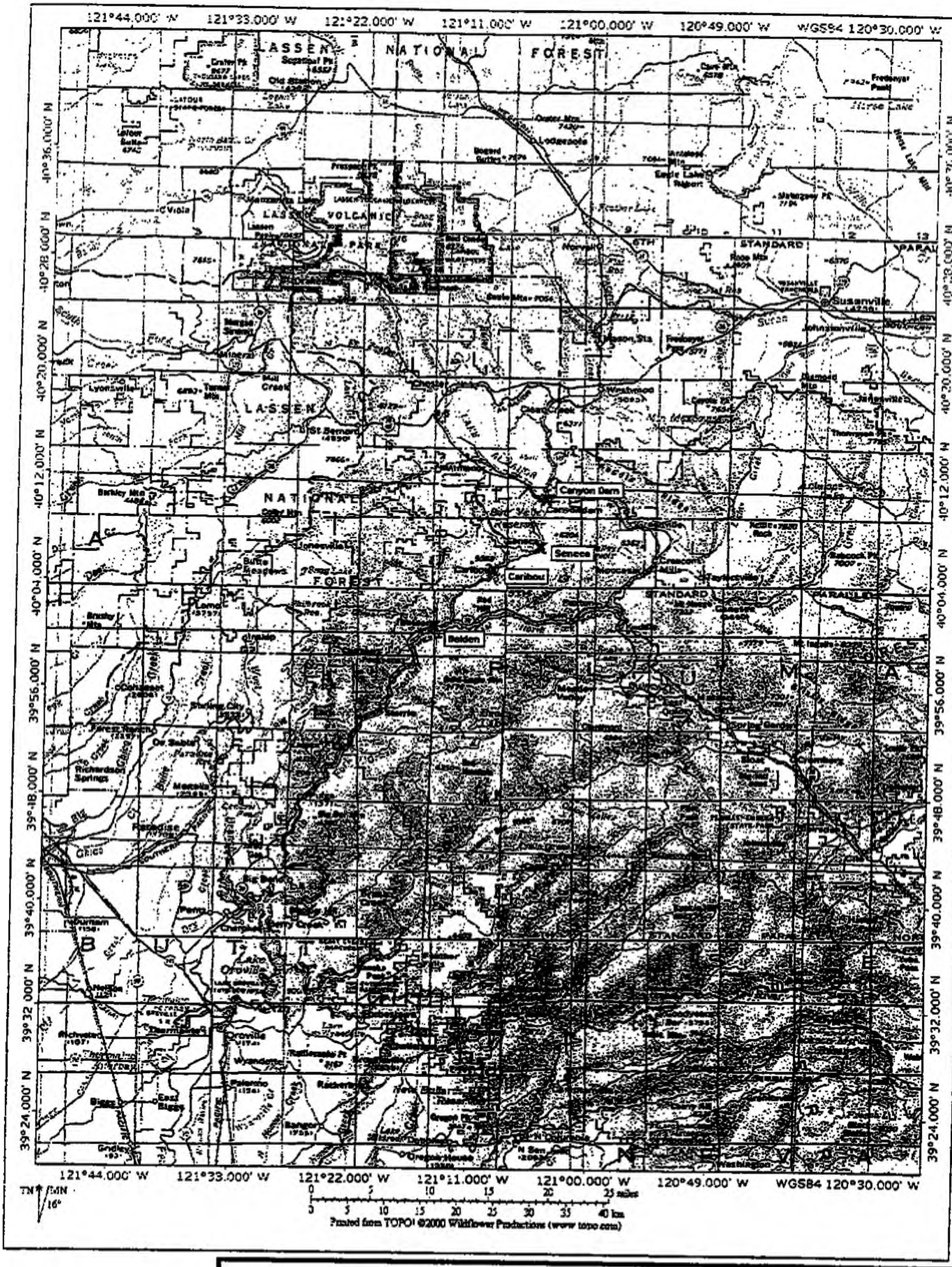


Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Belden Reach 5 - Transect 3 POW



Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
NFFR- Belden Reach 5 - Transect 4 RUN

Butt Reach Sections



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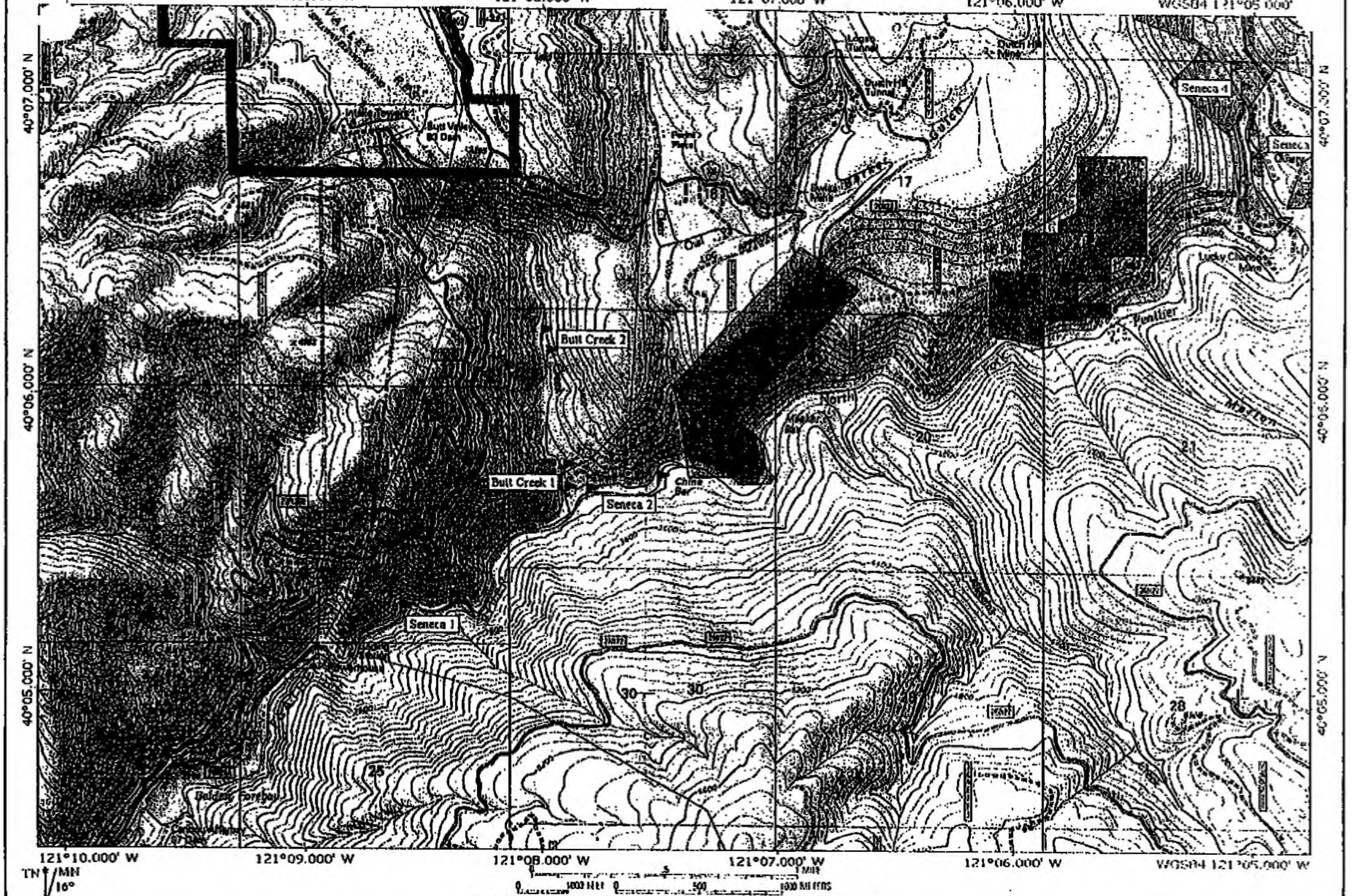
North Fork Feather River Regional Map	
Upper NFFR Incipient Motion Study	December 2001



TOPO! map printed on 06/19/01 from "butt ck tpo" and "Untitled.tpg"

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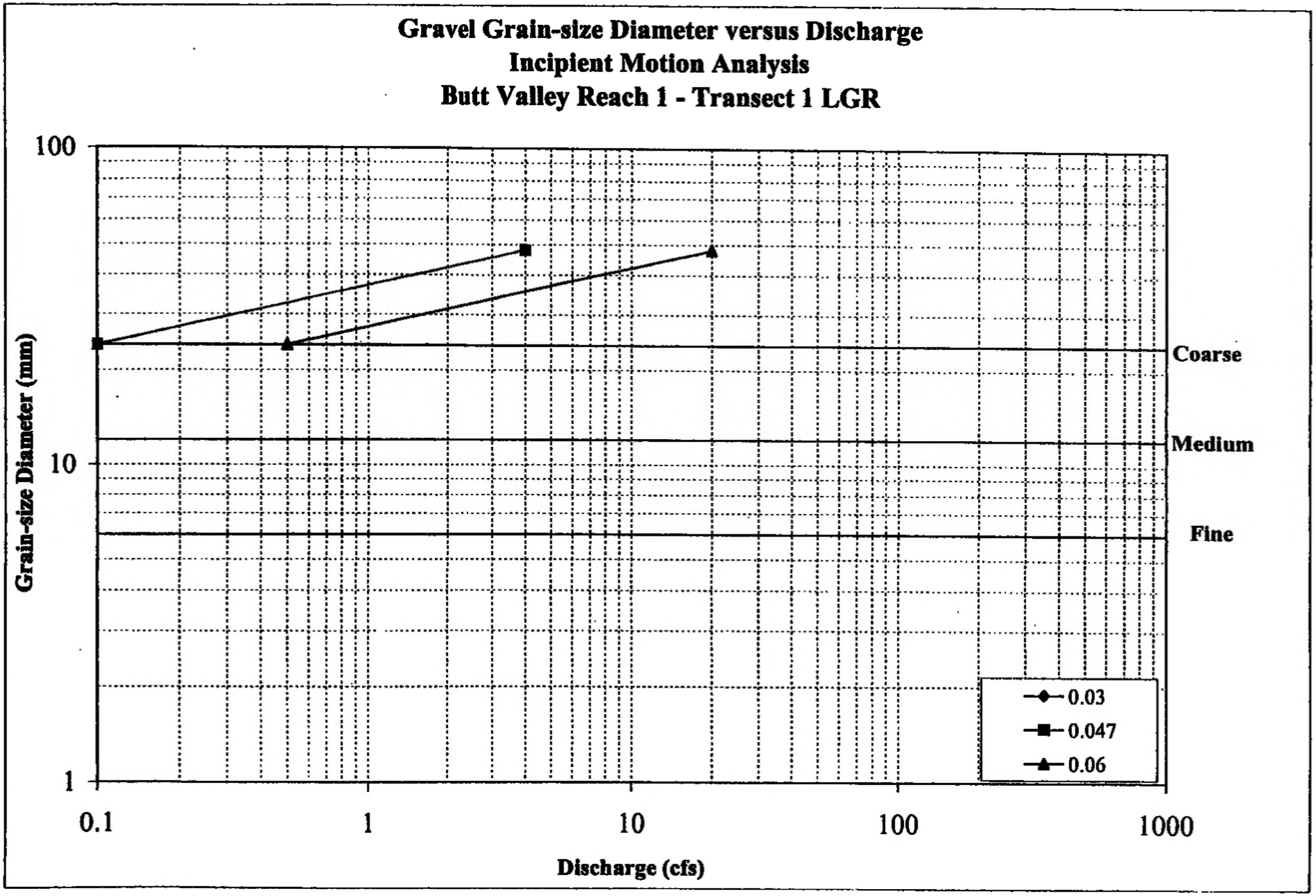
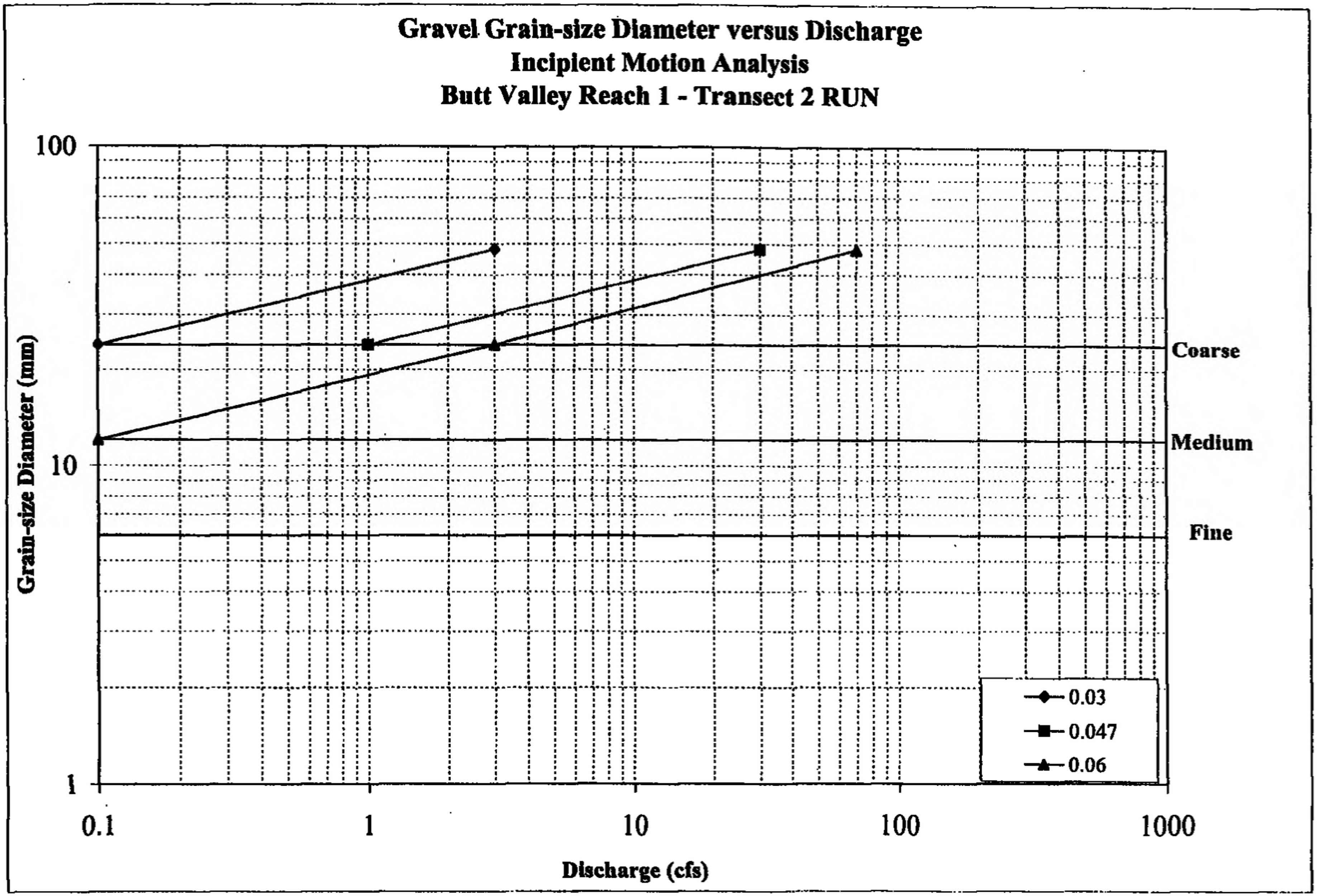
North Fork Feather River Regional Map
Seneca Reach and Butt Reach Sections

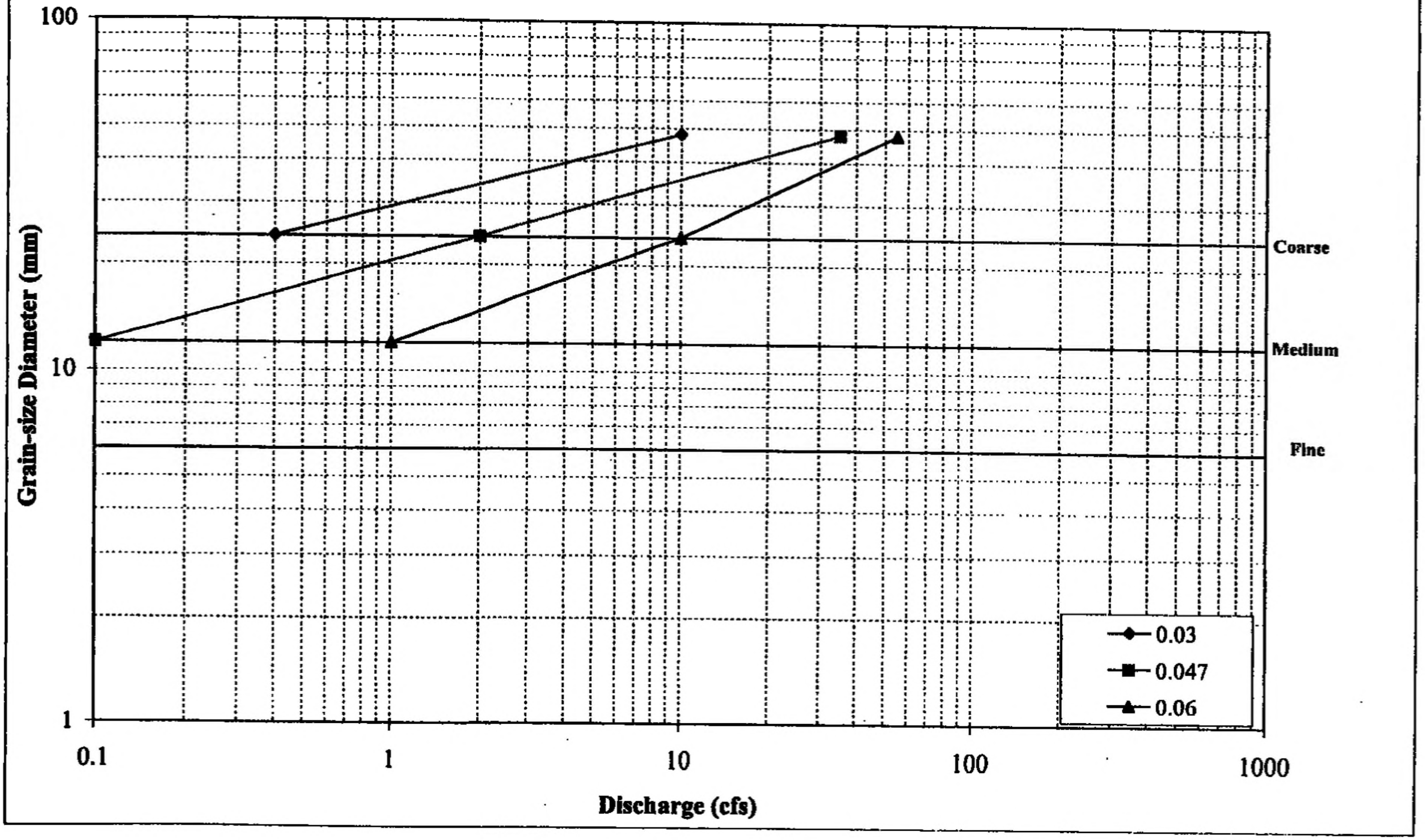
Upper NFFR Incipient Motion Study

December 2001

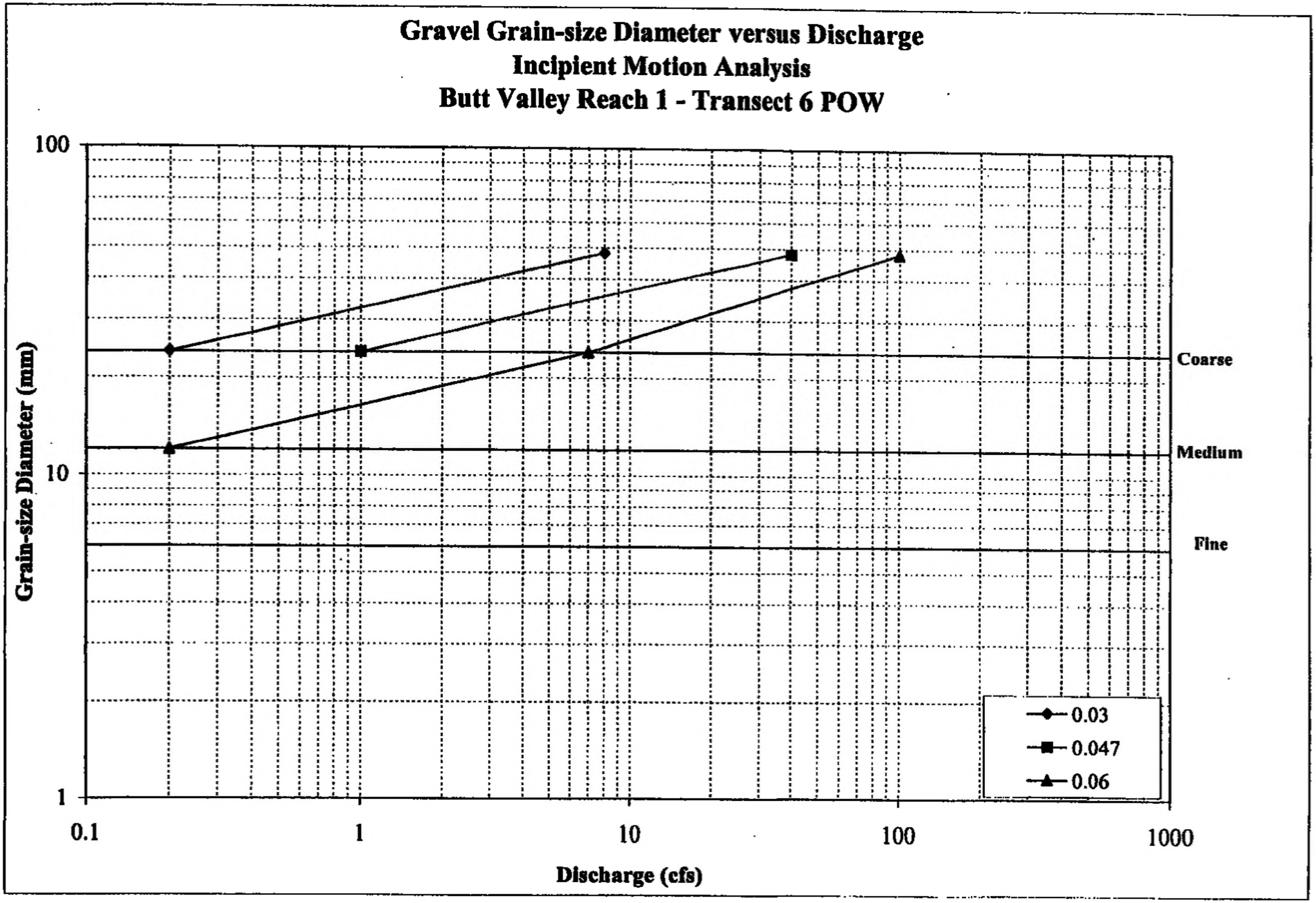


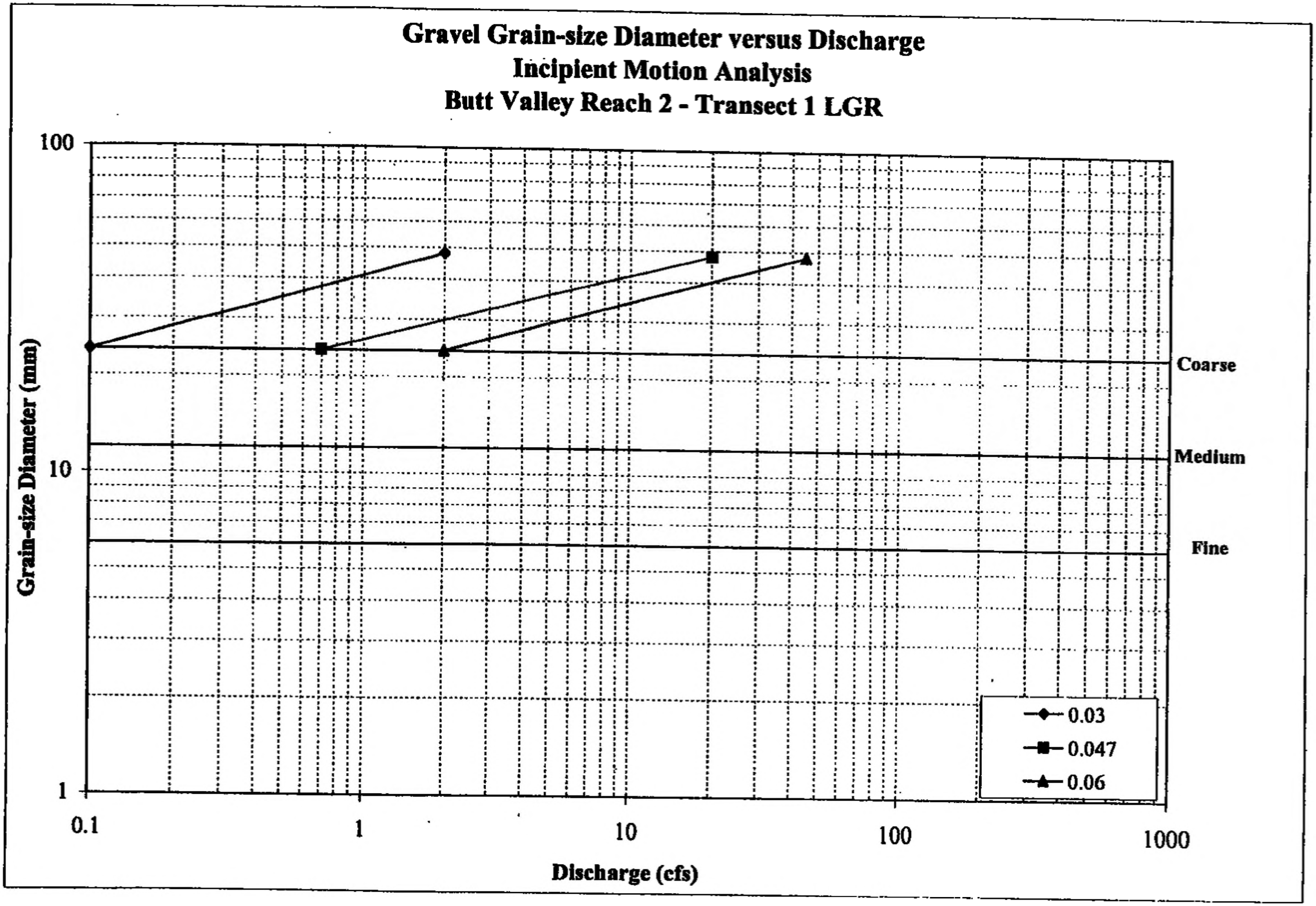
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
Butt Valley Reach 1 - Transect 1 LGR


Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
Butt Valley Reach 1 - Transect 2 RUN
Grain-size Diameter (mm)
100
10
1
Discharge (cfs)
0.1
1
10
100
1000
Coarse
Medium
Fine
◆ 0.03
■ 0.047
▲ 0.06



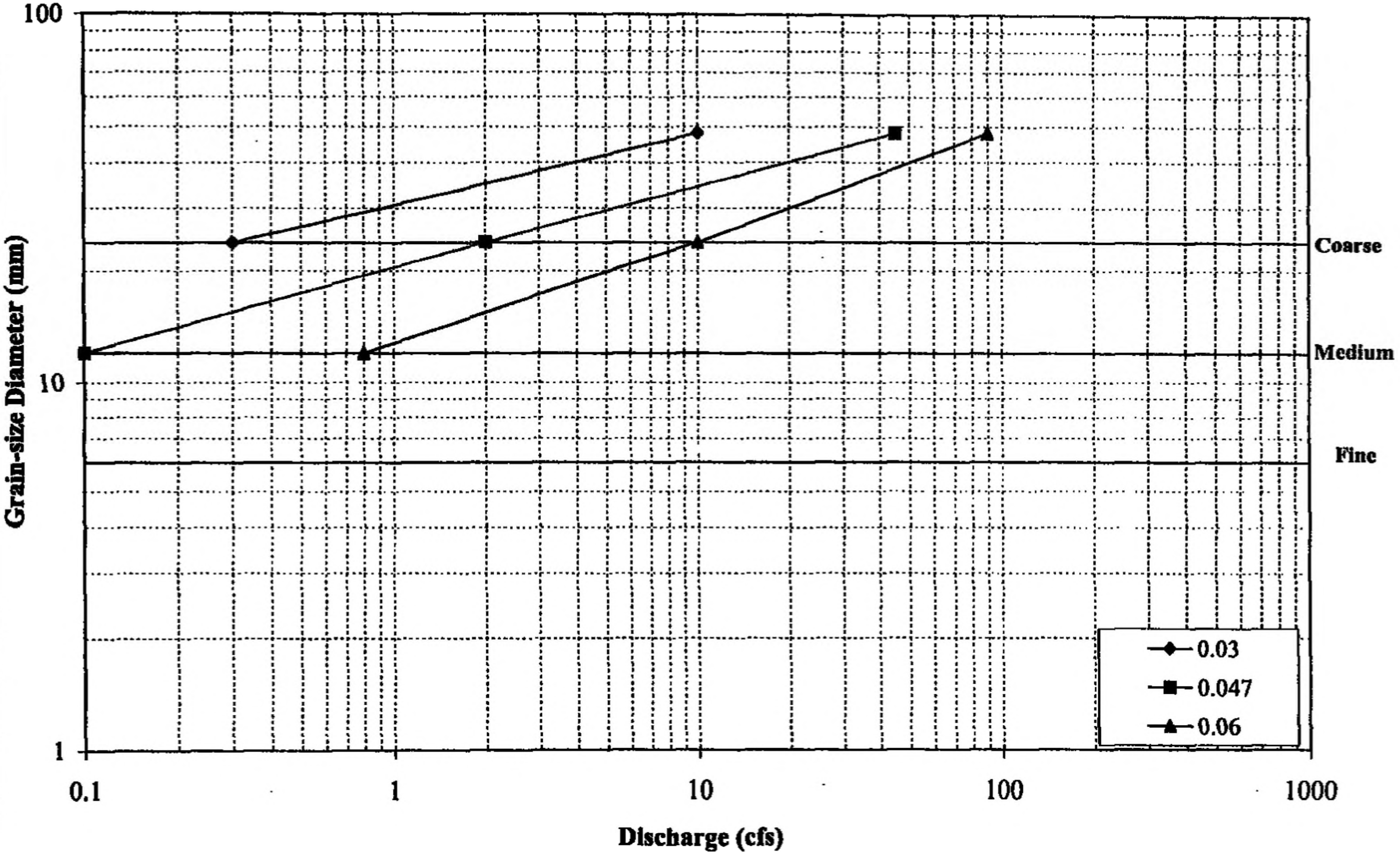
Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
Butt Valley Reach 1 - Transect 4 RUN

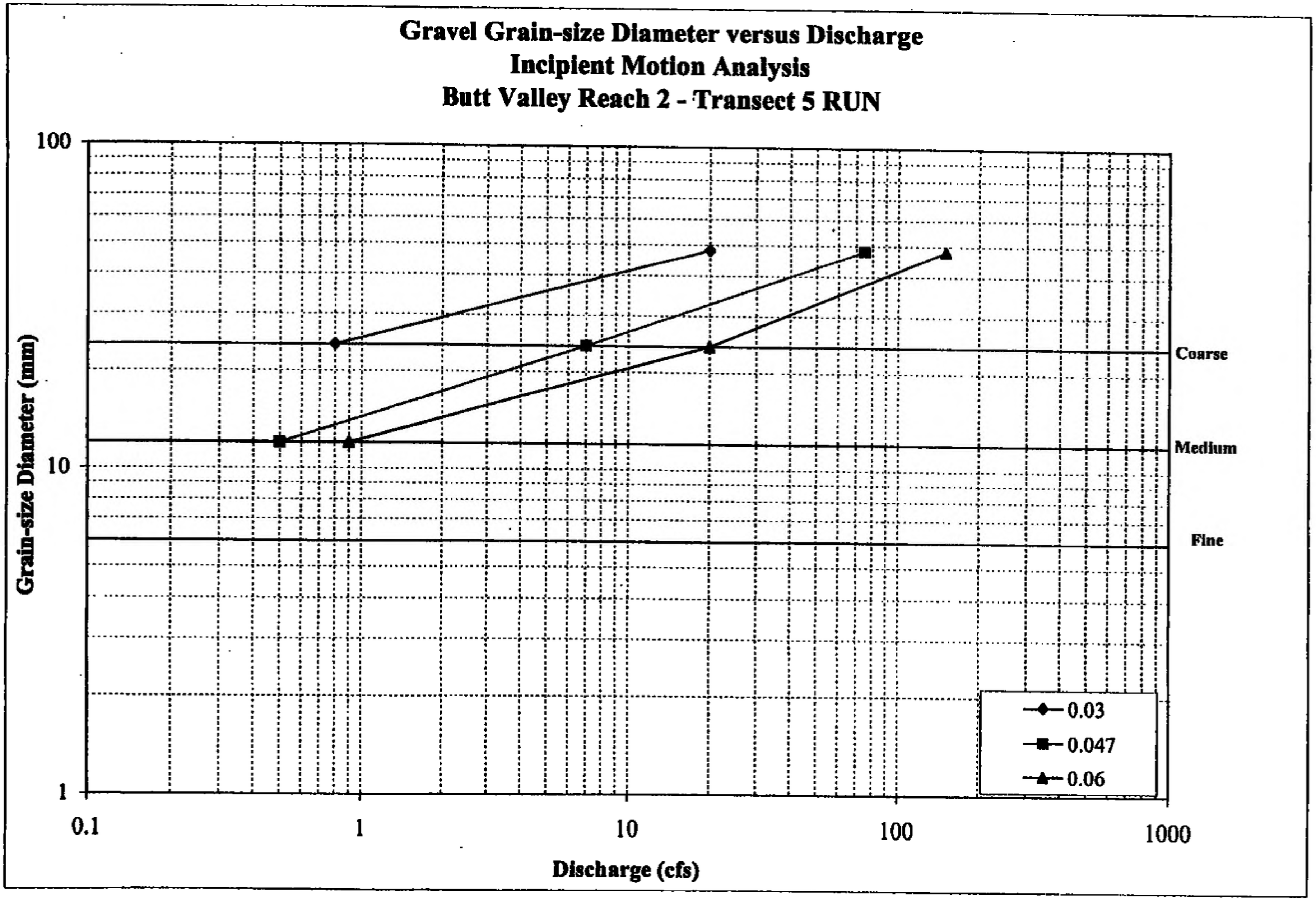

Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
Butt Valley Reach 1 - Transect 6 POW
100
10
1
Grain-size Diameter (mm)
0.1
1
10
100
1000
Discharge (cfs)
Coarse
Medium
Fine
0.03
0.047
0.06

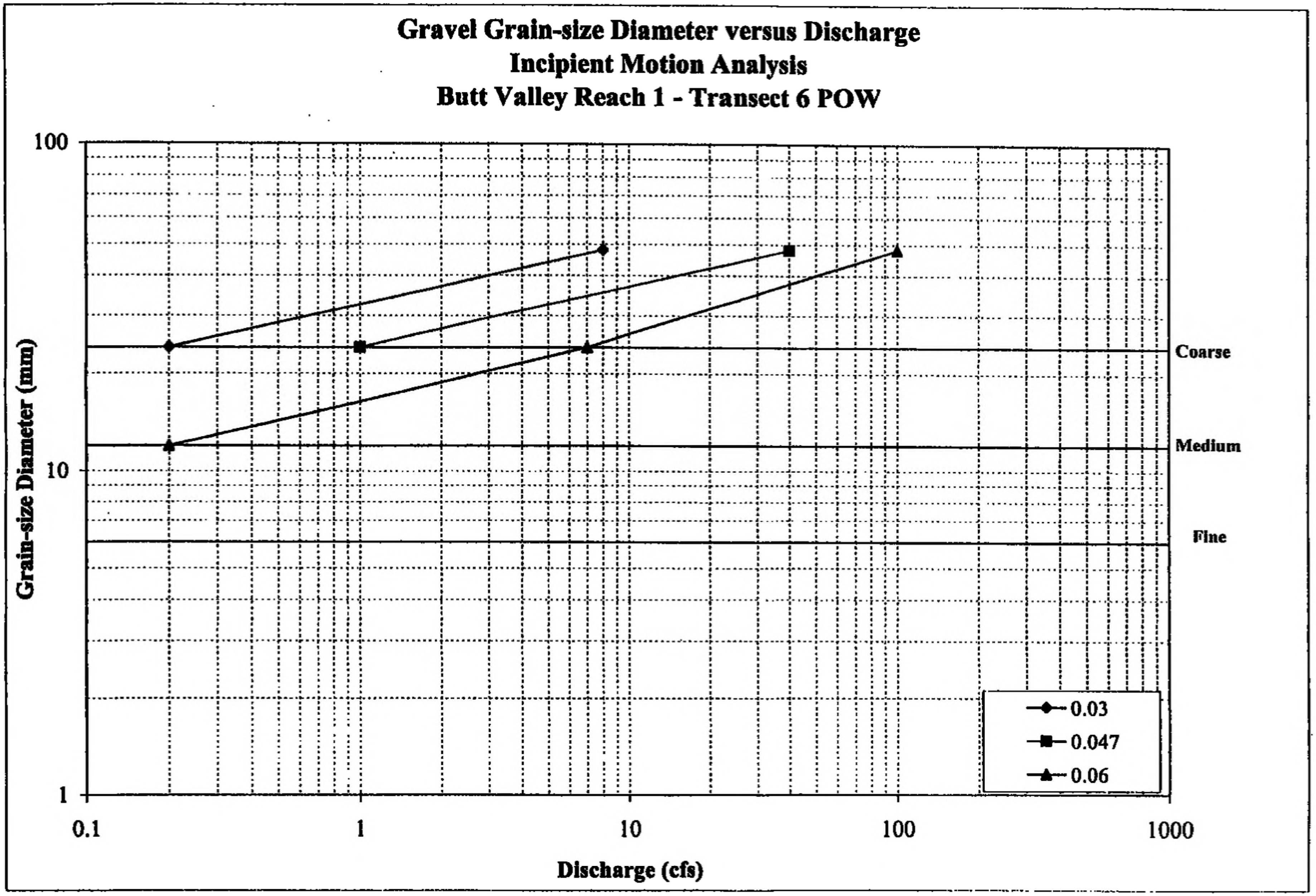


Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
Butt Valley Reach 2 - Transect 1 LGR

Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
Butt Valley Reach 2 - Transect 4 POW



Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
Butt Valley Reach 2 - Transect 5 RUN
Grain-size Diameter (mm)
100
10
1
0.1
1
10
100
1000
Discharge (cfs)
Coarse
Medium
Fine
0.03
0.047
0.06


Gravel Grain-size Diameter versus Discharge
Incipient Motion Analysis
Butt Valley Reach 1 - Transect 6 POW
Grain-size Diameter (mm)
100
10
1
0.1
1
10
100
1000
Discharge (cfs)
Coarse
Medium
Fine
0.03
0.047
0.06

UPPER NORTH FORK FEATHER RIVER PROJECT

FERC NO. 2105

Attachment E2-B

Lake Almanor Shoreline Erosion Study

Lake Almanor Shoreline Erosion Study

Prepared for

Pacific Gas &Electric Company
Technical and Ecological Services
3400 Crow Canyon Road
San Ramon, CA 94583

Submitted By:

WRECO
1243 Alpine Road, Suite 108
Walnut Creek, California 94596

March 2002

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A. Shoreline Erosion Analysis Summary

EXECUTIVE SUMMARY

Lake Almanor is a reservoir in Plumas County, California, operated by Pacific Gas and Electric Company (PG&E) for the purpose of hydroelectric power generation. Over the past decades, shoreline erosion has occurred along a portion of shoreline at Lake Almanor. As part of the PG&E Upper North Fork Feather River re-licensing study, PG&E assessed the shoreline erosion areas in 2000 and measured the turbidity plumes that were resulted from shoreline erosion. The issue of turbidity plumes was raised as a water quality concern by several homeowners in the Lake Almanor community. PG&E retained WRECO to review the plume turbidity data and analyze wind/wave climates for the area and the probability of occurrence for high winds and high water levels. WRECO also compared PG&E's 2000 shoreline erosion assessment data with the data from a 1974 shoreline erosion assessment study by Dames & Moore (D&M). Following is the summary of WRECO's findings.

The results from the 2000 PG&E turbidity plume field study along the eastern shoreline of the Almanor Peninsula indicated that turbidity levels as high as 10 NTU were measured near the shoreline, but not at the shoreline area with active shoreline erosion (see **Exhibit 1**). This result revealed that the turbidity plume was not initiated from the eroded shoreline area; therefore, the water quality impact from shoreline erosion may not be as significant as local residents thought.

Turbidity plumes typically occur in small pockets at different shoreline areas, and are associated with moderate to large waves. These waves cause re-suspension of fine slits locally deposited in the shoreline. It is expected that under high wind conditions, a high turbidity plume will further confine the plume close to the shoreline with minimal water quality impact. After winds subside, the suspended sediments are expected to settle back in the lake. The amount of turbidity in the lake caused by bank erosion is probably decreasing as the banks stabilize at 4,490 feet (PG&E datum) and as flushing action continues to remove some of the silt and clay particles.

WRECO analyzed five years of wind record data from Chester Airport, and performed a wind-wave hindcast to determine the probability of severe storm wave conditions in Lake Almanor. The northwest and southeast orientations represent the dominant wind directions, accounting for 38% and 16% of the total wind measurements, respectively. The stronger winds (average hourly wind speeds higher than 10 miles per hour (mph)) seem to be coming from the south through west. The maximum hourly average wind speeds range from 16 to 22 mph; the significant average hourly wind speed ranges from 6 to 10.5 mph.

A wind-wave hindcast determines the largest probable wave heights for each region based on the longest fetch length approach to each specific shore region and the corresponding wind velocities. From the wave hindcast analysis using the maximum hourly wind record, the maximum wave heights range from 1.3 to 2 feet with maximum wave periods of 2.6 to 3.2 seconds. During winter storms, bigger waves can be generated.

Wave run-up was calculated from shore slope, wave height, and wave period. Wind-induced wave run-ups are higher in the eastern lobe of the lake (range from 1.9 to 3.6 feet) than those in the western lobe (range from 0.3 to 1.4 feet) mainly due to the much steeper beach slopes present. The maximum impact zone from wave run-up occurs with the combination of the highest wind and the maximum operating water level of 4,494 feet.

From historic daily average lake water surface elevation data for the period of 1974 to 2000, only 930 days of the past 26 years equaled or exceeded 4490 feet, which corresponds to a 9.8 percent probability of occurrence within Lake Almanor. Those 930 days occurred in 10 of the 26 years. The lake reached 4494 feet only once in the 26 years of water surface elevation record, the equivalent of a 0.01% probability.

By reviewing the results of wind and wave data analysis for each shoreline region, it appears that the active erosion shoreline areas typically match those areas with high winds, large waves, and high run-ups. The waves will continue to approach those shoreline areas, regardless of erosion prevention measures. In general, high water levels occur about 10% of the time; high winds also occur less than 10% of the time. The probability of high wind and high water level happening at the same time will be even lower.

In 1974, PG&E applied for permanent certification from the Division of Dams of the California Department of Water Resources (DDCDWR) to increase the reservoir's maximum operational water surface elevation from 4490 feet to an elevation of 4494 feet to increase power generation needs for the downstream power plants. PG&E received the permit in 1976. At that time, D&M surveyed the entire shoreline of Lake Almanor in October 1974 for soil type, bank slope, damage potential, and degree of erosion. D&M's estimate of the extent of shoreline erosion are considered conservative by today's standard, since PG&E and many private homeowners riprapped many shoreline areas after D&M conducted its field investigations.

The 2000 PG&E shoreline assessment survey was conducted in the format similar to the D&M 1974 survey. PG&E's survey focused only on the eastern lobe of Lake Almanor because of its steeper bank slopes and greater degree of erosion. PG&E adopted the same "degree of erosion condition' – Class A for significant, Class B for slight, and Class C for none. Lake Almanor's shoreline was also delineated into regions A through L as per Figure 14 of the 1974 D&M report to identify variations in degree of erosion around the reservoir (see **Exhibit 2**).

In order to compare the 1974 and 2000 data, GIS maps with data from both surveys were examined. From these maps, a Shoreline Erosion Index was developed for each region. This index used the surveyed erosion data, weighted by its degree of erosion condition, to estimate each region's effective erosive shoreline length. Class A degree of erosion counts for 100 percent, class B counts for 30 percent, and class C is zero. Because the region lengths from the 1974 and 2000 surveys are nearly identical, the shoreline erosion index allows for a direct comparison to determine any increase or reduction in actively eroding shoreline length. Due to natural shoreline slope stabilization and the addition of riprap in various shoreline properties over the 26-year period between surveys, the Shoreline Erosion Index decreased by 24% from 1974 to 2000 in the eastern lobe of Lake Almanor. The summary of WRECO's shoreline erosion analysis is shown in **Exhibit 3**.

The most effective form of bank stabilization on Lake Almanor is the placement of riprap. The greatest reduction in Shoreline Erosion Index from 1974 to 2000 occurred in the regions with the greatest increase in riprapped shoreline length. With the exception of a few shoreline segments, PG&E has the right (Clifford Deed Provisions) to erode on parcels above 4,500 feet (PG&E datum). PG&E owns most of the land in fee simple absolute below that elevation and can erode as it needs to without any easement. The few exceptional shoreline segments not covered by Clifford Deed Provisions have been provided riprap for protection. Of the 58 miles of shoreline surrounding Lake Almanor, approximately 4 miles were classified as significantly eroding (Class A) in 2000. Ninety percent of this significantly eroding shoreline was unprotected. In the future, these unprotected areas with high erosion potential in Lake Almanor's eastern lobe are expected to continue to exhibit active erosion activities, until the slopes become stable by the natural armoring process.

1. INTRODUCTION

This report presents the results of an analysis of shoreline erosion in Lake Almanor. The objective of this study is to evaluate the effects of erosion along the shoreline of Lake Almanor with respect to water quality during the summer season, and to determine the effect of wind and wave action on shoreline erosion. Lake Almanor is a reservoir in Plumas County, California, operated by Pacific Gas and Electric Company (PG&E) for the purpose of hydroelectric power generation. **Figure 1** shows the regional location of the lake.

This study is part of PG&E's effort for the re-licensing of the Upper North Fork Feather River Project. One of the key environmental issues is the impact to water quality from shoreline erosion. This issue was raised by some local residents living in the Lake Almanor shorefront community. To address this issue, PG&E collected water quality samples in areas of visually identifiable shoreline erosion during the summer months of 2000. Water samples and in-situ data were collected from accessible locations at each site from shore or boat. Water quality parameters tested for each sample included turbidity, temperature, pH, dissolved oxygen, and electrical conductivity. Data were mapped to depict the size and extent of the turbidity plumes. PG&E also conducted a shoreline assessment of Lake Almanor in 2000 to evaluate the current state of the shoreline erosion, similar to the assessment performed by Dames & Moore (D&M) for PG&E in 1974.

PG&E retained WRECO to review the plume turbidity data and shoreline erosion assessment data. There are three major tasks performed by WRECO for this study: 1) evaluation of the plume turbidity data; 2) comparison of the 1974 and 2000 shoreline erosion assessment data; and 3) an analysis of wind and wave climate of the lake to determine probability of their occurrence. All elevations in this report are in PG&E datum unless otherwise specified. To convert from PG&E datum to U.S. Geological Survey datum, add 10.2 feet to the PG&E elevation value.

2. BACKGROUND INFORMATION

2.1 Historic Background

In 1914, Lake Almanor was created by the construction of a hydraulic fill dam, which flooded the former Big Meadows with waters from the Upper North Fork Feather River Watershed. Between 1963 and 1974, PG&E operated the lake with a normal maximum elevation of 4490 feet. In 1974, PG&E applied for a permit to increase the reservoir's maximum operational water surface elevation from 4490 feet to an elevation of 4494 feet. The permit was granted in 1976. During the permit application process, PG&E retained Dames and Moore (D&M) in 1974 to conduct an environmental impact analysis to determine the effects of increased water surface elevation on shoreline erosion within Lake Almanor (D&M, 1974). The D&M study concluded that the increase in maximum operational water surface would not have significant environmental impacts.

2.2 Geographic Setting

Lake Almanor is located in Plumas County in northeast California. It is about 260 miles northeast of San Francisco and about 160 miles northeast of Sacramento (**Figure 1**). The lake is one of the larger man-made lakes in California and the largest in Plumas County. It is in the headwaters region of the North Fork and the Hamilton Branch of the Feather River, upstream of the Feather River Canyon.

Figure 2 illustrates the immediate region around Lake Almanor. Lake Almanor is partially separated into two lobes by Almanor Peninsula. The western lobe is characterized by relatively shallow water with slight bank slopes, while the eastern lobe has deeper water and steeper bank slopes. The lake is encircled primarily by mountainous forestlands, with Lassen National Forest to the north and Plumas National Forest to the south and east. The communities of Chester, Almanor, Prattville, and Canyon Dam are located near the shoreline.

2.3 General Hydrology

The lake is about 13 miles long and 6 miles wide. It has a surface area of 27,000 acres and a storage volume of 1,142,000 acre-feet. It is the uppermost reservoir of PG&E's Upper North Fork Feather River Project. The Upper North Fork Feather River Project consists of three dams and reservoirs and five powerhouses with associated water conveyance systems.

Each of the two lobes of the lake contains one of the major tributaries to the lake. The western lobe receives the flow of the North Fork Feather River, which amounts to about half of the annual flow. The eastern lobe of the lake receives the flow of the Hamilton Branch of the North Fork Feather River, which normally provides 20 to 25 percent of the inflow. Other smaller drainages, subsurface runoff and underwater springs contribute the rest of the inflow. Based on drainage records, Lake Almanor controls about 25 percent of the watershed of the North Fork Feather River (D&M, 1974).

Lake Almanor reservoir was formed by an earth-filled dam 135 feet high and 1,400 feet wide at the base. This dam is referred to as both Lake Almanor Dam and Canyon Dam. The dam has a simple overflow spillway with no gates at elevation 4,500 ft. The maximum authorized operational (storage) water elevation for the reservoir is 4,494 ft, and the reservoir has never exceeded this level. The dam has an outlet tower and tunnel capable of releasing up to 2,200 cfs, through the Butt Valley Powerhouse, to the NFFR when the reservoir is at elevation 4,494 feet. Minimum instream releases are currently 35 cfs. Major seismic dam repairs were completed in 1998.

3. PHYSICAL ENVIRONMENT

In the following sections, only those environmental factors linked to shoreline erosion will be discussed.

3.1 Topography

Elevations around the immediate perimeter of the lake range from 4,500 to 5,100 feet, and rise to 7,000 to 8,000 feet on the surrounding mountain peaks. Lassen Volcanic National Park is about 10 miles to the north, where Lassen Peak attains an elevation of 10,457 feet.

Based on rough visual estimates by D&M, the slope on the immediate shoreline at Lake Almanor is as follows:

Slope	Percentage of Shoreline
0-9 %	29
10-19 %	41
20-29 %	19
30-49 %	2
50-80 %	9

Figure 3 shows soils and approximate shoreline slope at Lake Almanor, prepared by D&M.

3.2 Soils

The predominant soils in the Lake Almanor region are in the Cohasset Association and cover gently sloping to steeply sloping areas that have formed in weathered volcanic rocks (see **Figure 3** for soil information). These soils are porous and quite permeable. Other soil types in the Lake Almanor area include the Greenhorn-Massack Association, which overlies the floodplain and lakebed deposits on the northwest rim of the lake. These soils have similar characteristics to the Cohasset, although they occur on more gentle slopes, usually less than five percent. In a small area at the south end of the lake, Plumas-Forgay Association soils have developed on older metamorphic rocks. They are somewhat less permeable than other soils on the lake's shore and slightly more resistant to wave erosion.

3.3 Climate

The Lake Almanor area is within the Mediterranean Climate Zone, which consists of cold, wet winters and warm, dry summers. The crest of the Sierra Nevada acts as a barrier to the moisture laden air coming from the Pacific Ocean, and the cold dry air masses from the central United States in the winter. During the summer, the crest also acts as a barrier to the hot, dry air masses that develop over the central United States. This situation thus creates a high precipitation, cool summer, and mild winter climate on the western slope of the Sierra.

The dominating factor controlling the climate of the Lake Almanor watershed is the semi-permanent high-pressure system (Pacific High) of the north Pacific Ocean, which is responsible for the pronounced wet and dry seasons of California. During the summer, the Pacific High moves northward, tending to prevent storms from moving eastward across the state. During the winter, the Pacific High migrates southward, permitting storm centers to move in (D&M, 1974).

The climate of Lake Almanor is typical of mountain valleys in northern California at similar elevations. The annual mean temperature at Canyon Dam is 47°F. The mean maximum temperature of 86°F occurs in July, and the mean minimum temperature of 20°F occurs in January.

Precipitation at Lake Almanor may occur in every month of the year. However, 96 percent of the annual average of about 40 inches occurs during October-May. The wettest month is January and the driest is July. For the region, the average frost-free period is 119 days. As one progresses up the slope, precipitations increase 2-4 inches for each 300-foot rise in elevation, reach a maximum at elevations of 5,000-6,000 feet, and then decrease with a further increase in elevation. There appears to be a 15-year periodicity of wet-dry cycles based on a plot of the 10-year moving averages for precipitation.

Wind speeds at Lake Almanor are typically less than 10 miles per hour, except during stormy conditions. The prevailing wind directions are controlled by local topography and are from the northwest or southeast.

3.4 Vegetation

Vegetation changes depend on elevation and precipitation. For the region, the majority of the area is covered by mixed conifer timber. The most common conifers are Jeffery and Ponderosa pine. Other conifers include incense cedar, white fir, red fir, Douglas fir, and sugar pine. Ceanothus and manzanita are common brush species associated with the mixed conifer forest. Riparian vegetation includes dogwood, grasses, sedges, willows, rushes, alders, cottonwoods, rose, ferns, and Ceanothus. Willows are the most common component.

Most of the slopes surrounding the lake are forest-covered. The forested areas around the lake consist either of lodgepole pine or mixed conifers. The trees experienced selective cutting in the 1950's and 60's. Some trees and vegetation along the shoreline have also died as a result of flooding during previous increases in the maximum water level of the lake and during previous normal operation of the lake. PG&E maintenance crews selectively removed dead trees.

3.5 Land Use

The economy in the lake Almanor area is oriented toward timber and recreation and the economy on the lake shoreline is oriented practically exclusively toward recreation. Land use at the Lake Almanor shoreline is virtually all recreational above 4,500 feet. Below 4,500 feet, the lake is used for both recreation and hydroelectric water storage. **Figure 4** shows the land use at the lake. The data in the figure was prepared in 1974, but the land use has not changed significantly since that time. The recreational facilities on the shoreline include resorts, campgrounds, picnic areas, boat launching areas, marinas, and private residences, most of which are summer homes.

4. EROSION MECHANISM

Erosion is defined as the process through which soil particles are dislodged and transported to other locations by the actions of water and/or wind. Water erosion increases with the length and steepness of shoreline slope. A general rule is that if the length of slope is doubled, soil loss from erosion will increase by a factor of 1.5. The relationship between the gradient (degree of slope) and erosion potential can be specified in general terms as follows:

10 percent >= highly erodible
10 percent = moderately erodible
2 percent <= slightly erodible

4.1 Influencing factors

Shoreline erosion problems exist in both ocean and lake systems. Beaches on coast and lake respond in similar fashion to storms and water level changes, and the fundamental principles of surf zone littoral transport apply to both cases. Average wave energy, which is proportional to wave height, is generally higher on open ocean shorelines, but storm waves can attain impressive energy levels on lake shorelines, especially on reaches with significant fetch. When severe winds and high waves are superimposed on a high water level, significant damage to property could result.

Erosion of lake shoreline is a complex process that, although accelerated by high water, results from many factors, including loss of vegetation, occurrence of naturally erodible earth materials, starvation of littoral drift, and inadequate shore protection. Factors affecting the modification of shorelines include:

- The proximity of a shoreline to sediment-laden rivers,
- The degree of tectonic activity,
- The topography and composition of the land,
- The configuration of the shoreline and near-shore areas,
- The prevailing wind and weather patterns, and
- The water level variations.

Any loss of vegetation along the shoreline causes only temporary changes in vegetation patterns, and after trees along the edge of the shoreline are lost, other nearby trees can adapt to their new shoreline position.

Erosion of the shoreline occurs at all lake levels. It is a continuous process that is accelerated significantly during high levels. Low water levels expose wider beaches providing a means to dissipate wave energy. High water levels bring this energy into direct contact with the toe of bluffs and produce accelerated rates of erosion.

4.2 Winds and Waves

Winds blowing over open water transfer energy to the water surface. The two controlling factors in local wind circulation are land-lake temperature differences and terrain variation. Lake temperatures are relatively consistent, with little changes from summer to winter. Land temperatures vary greatly and tend to be very warm in summer and very cold in winter. This seasonal temperature gradient establishes a strong breeze from lake to land in summer and a moderate land breeze from land to lake in winter. Diurnal wind patterns also occur due to the same general concept with morning land-breezes and afternoon lake breezes often occurring along a shoreline. Topographic relief affects where these breezes can flow, either blocking winds approaching from certain directions, impeding and reflecting airflow, or funneling winds through lower relief valleys and swales.

The height, length, and period of a wave depend on:

- The wind speed,
- The length of time the wind has blown, and
- The fetch, the distance the wind has traveled across open water.

The magnitude of the wind waves is proportional to the wind speed and the length of time the wind has blown. In addition to wind speed and duration, the direction from which winds come is crucial in wave generation. Fetch is the open water distance over which winds blow in the same direction consistently for some duration of time. In general, wave energy increases with increasing fetch. Depending on the geographic location of a site, winds of long fetch have the potential to deliver the greatest erosive energy to the shorelines. Winds are not capable of delivering energy only when they have negligible fetch lengths, are blocked by local topography relief, or blow away from the shoreline.

4.3 Wave Forces

In geologic terms, lakes are short-lived features. As soon as a lake basin forms, internal and external forces begin a process of change that leads to its eventual extinction. Wave action is one obvious force. Waves wear away exposed points and transport beach materials to form bars cutting off bays. Newly formed lakes are usually irregular in shape; older lakes approach an oval. Natural lakes have been worked on so long that the process is less obvious than the results: smooth outlines and flowing sand spits.

As time went on, wave action smoothed the lake's outline. Violent geologic processes then re-roughened portions of it, but the relentless waves keep working. The processes of wave erosion and sediment transport eventually build stable, equilibrium beaches. Wave actions sometimes can carry beach sands and pebbles from one end of a lake to the other.

Wave refraction is the bending of waves as they move into shallow water. Waves seldom approach the shoreline from the open water straight on. Bending occurs because the part of the wave nearest the shore feels the bottom and slows down first. The net result is that the wave may approach nearly parallel to the shore regardless of the original direction of the wave. Due to wave refraction, wave energy is concentrated on headlands and diminished in bays. Although waves are refracted, most still reach the shoreline at some angle. The upwash is thus oblique while the backwash is largely in the direction of the slope of the beach. The result is the transport of sand particles in a zigzag path parallel to the beach, a process termed longshore drift. Sand can be moved many kilometers along the beach each year. In this way, beaches can be extensively modified in relatively short periods of time.

As the quantity of energy transmitted from the wind to the water increases, the height and steepness of the waves increase as well. When the waves get too high or too steep, they break. Breaking waves may hurl a large quantity of water against the shore. The tremendous forces can move sediment and cause erosion. Abrasion occurs in the surf zone by the back and forth motion of the waves armed with suspended coarse sediments.

Wave run-up represents the additional rise in water level produced from a wind wave striking a sloped beach, and is a function of bank slope, wave height, and wave period. Wave run-ups could extend the impact zone of onshore waves.

4.4 Natural Shoreline Erosion Processes

Beaches

Small pocket beaches are common on the shoreline of Lake Almanor and most of them are backed by cliffs and protected by rock headlands flanking either end. The dark gray-black sand, eroded from the shale cliffs backing the beach, is often covered with flat pebbles, another result of shale cliff erosion. The beach erosion depends primarily on the onshore wave energy.

The size and shape of beach sediments are determined primarily by local wave and current conditions and the composition of the rock from which the sand originated. Beach sediments are also determined by beach slope and profile geometry. The fine sands are found on beaches with flat slope and less energy. The close relationship between the grain size of sediment on a beach and the wave energy introduces the phenomenon of sediment sorting by waves. Generally, beaches exposed to the full impact of waves have coarse sand grains, while those that are more protected have finer sands. Because sands are naturally sorted, based upon their ability to remain suspended in the water, high-energy waves deposit only the heavier, coarser sands on shore. When wave energy is more moderate, finer-grained sands are deposited.

When the contours of a beach are changed by the addition of man-made structures, the natural equilibrium is affected. The affected area will, however, eventually attain a new equilibrium profile as a result of the changes in the refraction, diffraction and reflection of waves.

Cliffs and Bluffs

The erosion at shorelines with cliffs and bluffs is a much slower process in time scale (geologic time frame) than the beach or marsh shorelines. The degree to which shoreline cliffs and bluffs are affected by wave erosion depends primarily on their physical composition. Softer materials are slowly washed away while harder rock promontories persist in spite of heavy wave action. Besides waves, other factors instrumental in causing the collapse of a cliff or bluff include overland runoff, groundwater seepage, wind, rain, and ground freezing.

Cliff or bluff erosion is predominantly episodic in that certain conditions of high water level and wave intensity must be met before erosion is effected. It is not until removal has reached a critical stage that the cave collapses and the face subsides. This is likely to occur during a storm when shaking of the whole soil structure takes place due to massive wave forces.

5. SHORELINE ASSESSMENT

The environmental impacts of shoreline erosion, and their extent, can be both subtle and obvious. The process of shoreline erosion occurs constantly and goes unnoticed in many places, while producing dramatic results in many others. The intensity of impacts within a lake system varies greatly with season and location. Many factors, including shore physiography, lake bathymetry, and the intensity of human development, influence the nature and extent of these effects. The eastern lobe of Lake Almanor, for example, is more prone to erosion due to its deeper water and steeper bank slopes. The western lobe of Lake Almanor, however, which has shallower water and gentle bank slopes, is less prone to erosion.

In general, the impacts of shoreline erosion upon a lake system are extremely difficult to quantify because of the large scale of the lake environment and the complexity of interactions which factor into the health of the system. In this study, two shoreline erosion assessments were compared and analyzed, one by D&M in 1974, and one by PG&E in 2000. It must be noted that two different parties performed the two assessments at different times, utilizing different field technicians to perform the shoreline erosion assessment. These circumstances create variability in assessment results due to the highly subjective nature of quantifying the magnitude and significance of erosion.

5.1 Existing Shoreline Protections

Hard stabilization is generally the most widely used approach for shoreline stabilization in all of Lake Almanor. Hard stabilization refers to the emplacement of "permanent" structures designed to halt shoreline retreat. Structures built parallel to the shoreline include revetments (rock riprap), and bulkheads. These structures are designed to halt shoreline erosion by providing a fixed line of defense against which storm waves will occasionally impact. A secondary role of many of these structures is to "shore up" and hold back beach erosion bluffs.

Advantages of a hard stabilization:

- Protect property by reducing erosion.
- Increases stability of landward slope.

Disadvantages of a hard stabilization:

- Increases rate of erosion in front of the structure.
- Increase rate of erosion of adjacent, unprotected shorelines.
- Limits access to the shoreline.
- Reduces the aesthetic value of the shoreline.
- Is costly and requires periodic maintenance.

5.2 1974 Shoreline Erosion Assessment

D&M surveyed the entire shoreline of Lake Almanor by boat in October 1974 for soil type, bank slope, damage potential, and degree of erosion. In their study, they separated the shoreline into 14 segments, as shown in **Figure 5**. Damage potential was classified by the perceived threat to structures or roads. Degree of erosion was sorted into three groups:

Class A	Indicates significant erosion and was defined by D&M as, "Noticeable slope scars on the shoreline and the sloughing of material into the water, which will increase turbidity."
Class B	Signifies slight erosion and was defined as, "Slight slope scars resulting from small wave cutting action, with limited water turbidity."
Class C	Denotes no detectable erosion.

D&M determined the Lake Almanor shoreline to be composed of 23% class A, 55% class B, and 22% class C degree of erosion. These estimates are considered conservative since PG&E, along with some private property owners, constructed riprap protection along many shoreline areas after D&M conducted its field investigations. PG&E has found the use of riprap to be an effective method to prevent shoreline erosion. The D&M classification for areas already rip-rapped was Class B or C, with no or slight erosion.

D&M found no shoreline slope instability problem when the lake water level is up to 4490 feet. The potential for erosion below elevation 4490 feet is minimal due to the natural flattening of the shoreline slopes by erosion, which probably ranged from significant to slight, in the past years. D&M concluded that significant erosion potential is expected during storm wave conditions for silty shoreline slopes approximately steeper than 20 to 25 percent, which denotes roughly 30% of the shoreline.

According to D&M, the potential for erosion below elevation 4490 feet is minimal due to the natural flattening of the shoreline slopes by erosion, which probably ranged from significant to slight, in past years. D&M estimated that at and slightly above 4490 feet there is virtually no erosion at shoreline areas designated as having no erosion potential, i.e. 22 percent of the shoreline. Such areas include areas with slight slope and areas rip-rapped. D&M stated that there might be slight erosion at and slightly above 4490 feet until bank stabilization occurs, and during storm wave conditions at shoreline areas designated to have significant or slight erosion potential, i.e. 78 percent of the shoreline. PG&E concluded, after D&M's 1974 study, that the most effective form of bank stabilization on Lake Almanor is the placement of riprap.

Due to the long period of time between shoreline assessments, D&M's original report is no longer available. The information cited from the 1974 assessment was provided by PG&E as excerpts from within their January 1975 Environmental Data Report.

5.3 2000 Shoreline Erosion Assessment

In 2000, PG&E did a shoreline assessment boat survey similar to the D&M 1974 survey. PG&E staff classified bank slope, degree of erosion, and damage potential for various shoreline reaches. PG&E's survey focused only on the eastern lobe of Lake Almanor because of its steeper bank slopes and greater erosion potential. Like the D&M approach, the degree of erosion was again classified as:

Class A: Significant Erosion; Class B: Slight Erosion; Class C: None

Signs of a serious problem for a shoreline to be defined as Class A (significant erosion) include:

- A large area of bare soil on a steep, high shoreline bank.
- A measureable change of the shoreline over a period of time.
- Leaning or downed trees with exposed roots on the shoreline.

- Large patches of muddy water near a lake shore during periods of high water or following a rainstorm.

The shoreline was also delineated into regions A through L as per Figure 14 of the 1974 D&M report to identify variations in degree of erosion around the reservoir between the two shoreline assessments. **Figure 5** illustrates the shoreline delineations. **Figure 6** shows examples from 2000 of the three 'degree of erosion' classes. The three pictures in the figure represent the Classes A, B and C, respectively. Most of the areas experiencing significant erosion are those with steep beach slopes or bluffs and cliffs.

Figure 7 shows the summary of both 1974 and 2000 shoreline erosion assessment data. Figure 7 is the key map with the master legend. It is followed by a series of GIS maps showing the summary of shoreline erosion assessment for each region. The darkened lot areas adjacent to the lake represent that those lots have riprap protection along the shoreline. From the 2000 survey results, WRECO determined Lake Almanor's eastern lobe is composed of 22% Class A, 26% Class B, and 52% Class C. Comparing to the 1974 data of 23% Class A, 55% Class B and 22% Class C, the 2000 data shows a significant increase in the no erosion (Class C) category.

5.4 Shoreline Erosion Index

In order to compare the 1974 D&M erosion assessment with PG&E's 2000 survey data, PG&E generated graphical-information-system (GIS) maps with the data from each survey superimposed (Figure 7). From these maps, a Shoreline Erosion Index was developed for each region to define the percentage of shoreline length actively eroding. This index uses the defined degree of erosion from each survey as a multiplier to adjust each region's shoreline length into effective erosive length, which is then divided by the total region length. A Shoreline Erosion Index (SEI) value was assigned to every beach segment.

- Class A degree of erosion counts for 100 percent
- Class B counts for 30 percent
- Class C has a value of zero.

The equation for calculating the SEI for an entire region is:

$$\overline{SEI} = \frac{\sum_{i=1}^{N} (SEI_i * L_i)}{\sum_{i=1}^{N} L_i}$$

Where: $\overline{SEI}$: shoreline erosion index for specific region.
SEI_i : shoreline erosion index for each beach segment within region.
L_i : length of each beach segment.
N : number of beach segments in the region.

Higher SEI values represent that the shorelines have active erosion; while lower SEI values represent stable shorelines with little or no shoreline erosion concern. If a region of shoreline has a SEI value of 100, it indicates the whole region has significant erosion problems. Alternatively, a SEI value of 0 means there is no shoreline erosion for the whole region. It should be noted that the assignment of SEI values was meant to provide a subjective reference index to represent the overall significance of the shoreline erosion in a region. The numbers do not actually represent the rate of shoreline retreat in the region. Instead, the values can provide a good indication of the state of the shoreline erosion, and a basis for comparison with erosion at other times.

The Shoreline Erosion Index results are summarized in **Table 1.** Because the region lengths from the 1974 and 2000 surveys are nearly identical, the shoreline erosion index allows for a direct comparison to determine any increase or reduction in actively eroding shoreline length. Shoreline Region E, in the southeast corner of Lake Almanor, had the highest Erosion Index in 1974 and 2000 due to its unprotected shoreline, high bank slopes, and long fetch length oriented with the dominant northwest wind direction. Due to natural shoreline slope stabilization and the addition of riprap in various shoreline properties over the twenty-six year period between surveys, the Shoreline Erosion Index decreased by twenty-four percent from 1974 to 2000 in the eastern lobe of Lake Almanor.

6. DATA ANALYSIS

6.1 Turbidity Plume

Turbidity is an expression of the optical property of water that scatters light. The scattering increases with suspended particulate matter, which may be organic or inorganic. The presence of fine materials of colloidal, clay, or even silt size gives water a cloudy or opaque appearance. Turbidity increases with, but not as fast as, suspended-load concentration. Turbidity reduces the depth to which sunlight penetrates and thus alters the rate of photosynthesis. Water turbidity partly determines the amount of light, which is transmitted below the water's surface. Turbidity may, therefore, affect algal growth, which is dependent on light, and the visual acuity of aquatic animals.

According to D&M, short-term turbidity presently occurs at the lake from muddy waters flowing into the lake during heavy runoff periods; from discharge into the lake as, for example, from the Chester Sanitary District; and also in shallow water near shoreline areas which have experienced or do experience erosion, and in other areas of the lake depending on water circulation patterns, during and for sometime after storm wave conditions and as boats pass. The larger silt-sized particles settle to the bottom more readily than the smaller clay-sized particles, which remain in suspension longer. According to the Lake Almanor Limnologic Investigation, the lake is of moderate to high water clarity, with an increase in clarity from spring to summer and a decrease in clarity from summer to fall.

PG&E, in addition to the shoreline survey, conducted a turbidity plume measurement during July 2000 to determine the magnitude and extent of these plumes within Lake Almanor. The survey focused on the northwest corner of Lake Almanor's eastern lobe, which encompasses active erosive shoreline Regions A and B. Water temperature, flow velocity and turbidity were recorded for analysis. Turbidity data were surveyed during 3 to 6 pm on July 7, 2000. Winds were mild, changing from 1 mile per hour (mph) in the morning to about 4 mph in the afternoon. Wave heights ranged from 1.5 to 2.5 feet with a wave period of 4 to 5 seconds. Water surface was at 4490 feet (PG&E datum). A noticeable turbidity plume, about 200 feet by 600 feet in size, was observed on the eastern shore of the Almanor Peninsula in Region A, as shown in **Figure 8.** Turbidity levels as high as 10 NTU were measured near the shoreline, but not at the area with active shoreline erosion. The turbidity plume was mapped up to the ambient level of 1 NTU (**Figure 8**). The area with high turbidity is located near the shore to the south of the shoreline with active erosion.

This mapping result revealed that the turbidity plume was not initiated from the eroded shoreline area; therefore, the water quality impact is not necessarily related to the shoreline erosion process. On another occasion, a turbidity plume of similar size was noticed on the eastern shoreline area. In both instances, turbidity plumes were associated with moderate waves, which caused the re-suspension of fine slits locally deposited in the shoreline. The attempt to map the turbidity plumes at a combined event of high water levels, high winds and high waves was unsuccessful. It was partly due to the scarcity of combined events in 2000 and partly due to a very low lake level in 2000. It is expected that a high-density turbidity plume under high wind conditions will be further confined close to the shoreline with minimal water quality impact. After winds subside, the suspended sediments are expected to settle back in the lake. The amount of turbidity in the lake caused by bank erosion is probably decreasing as the banks stabilize at 4490 feet and as flushing action removes some of the silt and clay particles.

Many investigations were conducted to determine how much of the nutrient and sediment loading to Lake Tahoe is caused by various sources, including shoreline erosion. In the "Lake Tahoe Watershed Assessment," Reuter and Miller list five sources of pollution to the lake: (1) direct wet and dry atmospheric deposition, (2) stream discharge, (3) overland runoff directly to the lake, (4) groundwater and (5) shoreline erosion." By compiling data from various research studies, they concluded the contribution of nitrogen and phosphorus loading from the five sources:

Source	Nitrogen	Phosphorus
Direct wet and dry atmospheric deposition	56%	27%
Stream discharge	20%	29%
Overland runoff directly to the lake	10%	34%
Groundwater	14%	9%
Shoreline erosion	< 1%	~ 1%

It is evident that direct runoff from urban areas supplies the most phosphorus to the lake – and phosphorus is the most important nutrient for stimulating algal growth. Atmospheric deposition contributes most of the nitrogen. According to the assessment, shoreline erosion is a hard-to-measure source. For purposes of compiling a nutrient budget for the watershed assessment, it was estimated that shoreline erosion was not important (Poppoff, 2001). Shoreline erosion does contribute to nutrient loading to lakes and has its share of impact upon lake water quality. However, this impact is relatively small compared to the other main sources.

6.2 Wind Data Analysis

PG&E obtained five years of wind record data (1995, '96, '97, '98, 2000) collected from Chester Airport, located on the northwest shore of Lake Almanor. The wind record data, presented in average hourly wind speeds, was separated into eight representative directions (N, NE, E, SE, S, SW, W, NW) each encompassing 45 degrees, as defined in **Table 2**. The wind orientation is recorded in the direction it is coming from, not the direction it is heading. The wind with a direction North (N) means it is blowing from north to south. As shown in **Table 2**, the northwest and southeast orientations represent the dominant wind directions, accounting for 38% and 16% of the total wind measurements, respectively. The stronger winds, for those average hourly wind speeds higher than 10 miles per hour (mph), seem to be coming from the south to west. **Figure 9** shows graphically the Lake Almanor wind distribution. The maximum and significant wind speeds for each direction were determined for use in the wind wave hindcast. Significant wind speed represents the average of the fastest one-third wind measurements. The maximum hourly average wind speeds range from 16 to 22 mph; and the significant average hourly wind speed ranges from 6 to 10.5 mph.

The cumulative distribution function was used to calculate the probability of exceedence for the maximum-recorded wind speed for each direction (see **Figure 10**). From the figure, winds from south, northeast and east have the higher probability of stronger winds occurring. On the other hand, winds from south and southwest have the lowest probability of weaker winds occurring. A cumulative distribution function curve was calculated for winds from all directions, as shown as the solid line in **Figure 10**. For example, the average hourly wind speed with 10% probability of exceedence is about 8 mph, and the average hourly wind speed with 1% probability of exceedence is about 13.5 mph. These estimates of probability should be considered conservative since the one-hour average wind record data was used to calculate probability of exceedence, compared with minimum wind durations necessary to generate maximum wave conditions on the order of two hours.

6.3 Wind Wave Hindcast Analysis

The direction from which winds come from is crucial in order to examine wave generation. The wind directions that are of concern with regards to shoreline erosion in Lake Almanor are those from the northwest and southeast. Such winds have the potential to blow over long fetches and deliver onshore energy to the shorelines. Fetch is the open water distance over which winds blow in the same direction consistently for some duration of time. Winds blowing from other compass directions are not capable of delivering significant energy to the shorelines because they have negligible fetch lengths, are blocked by local topographic relief, or blow away from the shoreline.

WRECO performed a wind-wave hindcast to determine the probability of severe storm wave conditions in Lake Almanor. A wind-wave hindcast determines the largest probable wave heights for each region based on the longest fetch length approach to each specific shore region and the corresponding wind velocities. A wind wave hindcast can only be applied when long-term records of climate are available. Established empirical methods are commonly applied to hindcast waves generated by winds over water. The formulae in those methods can give very approximate estimates of wave height and period for waves that would be generated given a particular wind speed, fetch distance, and water depth. The deep-water wind wave hindcasting model, described in the U.S. Army Corps of Engineers (ACOE) Shore Protection Manual (CERC, 1984), was used. **Figure 11** summarizes the equations of the ACOE deepwater wave hindcasting model.

For each region, radial lines were drawn from the shore till they intersected the opposite shore. The longest radial line and its corresponding fetch angle from north (zero degrees) determine the maximum fetch length and the dominant wind direction. Significant and maximum wave height is then calculated using the ACOE Nomograms of deepwater wave prediction curves as functions of wind speed, fetch length, and wind duration (**Figure 12** of this report and Figure 3-23 within the Shore Protection Manual).

The wind-wave hindcast analysis results are summarized in **Table 3**. The maximum wave heights range from 1.3 to 2 feet. Results from the analysis indicated that prevailing winds generate waves with maximum wave periods of 2.6 to 3.2 seconds. During winter storms, bigger waves can be generated. Shoreline Region B, in the northwest corner of Lake Almanor's eastern lobe, had the greatest calculated maximum wave height due to its relatively long fetch and southerly dominant wind direction which had a high maximum recorded wind velocity.

The effect of single-storm generated waves on a shoreline can often greatly exceed the average seasonal variation. Although strong winds can occur any time in the year, mostly in the spring and early summer, the highest wind speeds accompany major storm events occurring in the winter months. The winter months are defined as the period from November to February.

6.4 Wave Run-up Analysis

Wave run-up represents the additional rise in water level produced from a wind wave striking a sloped beach, and is a function of bank slope, wave height, and wave period. **Figure 13** shows the definition sketch of wave run-up. The height or elevation to which a wave runs up the shore is of considerable interest to engineers, because it affects the upper limits of wave-lain deposition and the design and construction of shore protection measures. Run-up height is dependent on a range of factors, including wave height, wave period, waveform, angle of wave approach, beach slope, beach roughness, water depth at the beach toe and inshore wave interference. The maximum and significant wave run-up for each region was calculated as per the nomograph of Figure 7-20 in the Shore Protection Manual (see **Figure 14**). The analysis was done for both the smooth slope and rubble mound (permeable) slope.

Table 4 summarizes the results of wave run-up analysis. Generally, wind-induced wave run-ups are higher in the eastern lobe of the lake (range from 1.9 to 3.6 feet) than those in the western lobe (range from 0.3 to 1.4 feet), mainly due to the overall steeper slope. The highest wave run-up occurs in Region E. Shoreline Region E has the greatest calculated maximum wave run-up, even though its maximum wave height was slightly less than that for Region B, due to the extremely steep bank slopes of Region E. In Region E, the maximum impact zone from wave run-up, when the highest wind occurs in combination with the maximum operation water level of 4,494 feet, will be up to the elevation of 4,497.6 feet (4,494 plus 3.6). The probability of this water level occurring corresponds to the probability of exceedence of the maximum wind speed at the longest fetch angle for each region.

6.5 Water Level Analysis

The water level of Lake Almanor is constantly changing. There are four main categories of fluctuations: (1) short-period fluctuations caused by meteorological events that can last from a few hours to several days (e.g.. storms); (2) seasonal fluctuation that reflect the annual hydrologic cycle; (3) long-term fluctuations spanning several years, decades, or centuries that result from long-term precipitation trends or geologic events; and (4) fluctuations that result from generation needs as regulated by PG&E. With the exception of a few shoreline segments, PG&E has the right (Clifford Deed Provisions) to erode on parcels above 4,500 feet (PG&E datum). PG&E owns most of the land in fee simple absolute below that elevation and can erode as it needs to without any easement. The few exceptional shoreline segments not covered by Clifford Deed Provisions have been provided riprap for protection.

Effects to shore property resulting from lake level fluctuations are those associated with (1) inundation from direct overland flooding, or wind-generated waves, or a combination of these, and (2) erosion. Inundation and erosion are more significant during high water events. Damage to shore property occurs during inundation or from wave impact, and is confined to low-lying areas and the lower reaches of tributary streams that are affected by backwater from high lake levels. Inundation occurs when static lake levels exceed the elevation of low-lying areas and may also occur, or be aggravated by, storm surge and wave run-up.

Figure 15 illustrates the historical water surface elevation analysis. From historic daily average lake water level elevation data for the period of 1974 to 2000, only 930 days of the past 26 years equaled or exceeded 4490 feet. This corresponds to a 9.8 percent probability of occurrence within Lake Almanor. Those 930 days occurred in 1982 to 84, 1986, 1993, 1995 to 96, and 1998 to 2000. The daily lake level reached 4494 feet only once in the 26 years of water surface elevation record, the equivalent of a 0.01% probability. In general, high water level occurs in about 10% of the time; high winds also occur in about less than 10% of the time.

6.6 Sediment Incipient Motion Analysis

The potential for sediment entrainment in the littoral zone is directly related to the magnitude of shear stress applied to the shoreline. A good indicator of bed shear stress intensity is the representative wave's orbital velocity (U_m), which is a function of the wave height (H), wavelength (L), and water depth (d). For shallow water conditions ($d < L/20$), the value of U_m is given by the equation:

$$U_m = H/2 * (g/d)^{1/2}$$

As waves move into progressively shallower water, the wave height increases due to shoaling, which, in addition to the decrease in depth, causes a marked increase in the maximum orbital velocity. Therefore, as waves shoal, the bed shear stress increases until the critical threshold velocity (U_t) is exceeded, at which point sediment movement begins and particles from the lakebed will be re-suspended. **Figure 16** shows the relationship between near-bed maximum orbital velocity and sediment movement under waves of different periods, as well as the distribution of critical grain sizes for six representative shorelines of Lake Almanor. The critical grain sizes marked on **Figure 16** for Regions A, B, C, D, E, and F all fell between the range of coarse sand and fine gravel (2 to 5 mm). To protect the lakebed from erosion, sediment with grain-sizes greater than fine gravels are desired.

Beach profile is another factor in sediment erosion potential because the shoreline slope affects the energy dissipation of a breaking wave. Small beach slopes enable greater wave surge up the beach allowing for greater energy dissipation. Steeper slopes prevent this surge, reflecting more of the wave's energy and increasing the potential for offshore sediment transport. Wave steepness (H/L) also influences the distribution of energy dissipation upon the beach. The energy of steep waves is dissipated over a narrow area, so less energy is lost through the pushing of sediment up the beach and through percolation of water into the face. Therefore, the backwash of steep waves is stronger, creating greater potential for erosion. Less steep waves dissipate more energy as sediment is transported up the beach slope, and tend to build up beaches. The potential for sediment erosion increases as beach slope and wave steepness both increase. **Figure 17** displays the relationship between beach slope, wave steepness, and average grain size, as well as the distribution of critical grain sizes for six representative shorelines of Lake Almanor. The critical grain sizes marked on **Figure 17** for Regions A, B, C, D, E, and F also correspond the range of coarse sand to fine gravel.

6.7 Shoreline Morphodynamics

The response of a shoreline to local environmental conditions, such as near shore wave climate, is exemplified by the relationship between shoreline profile variability and applied wave energy. Shorelines can be classified into three representative morphodynamic types based on this relationship: reflective, intermediate, and dissipative. A reflective beach state is associated with low steepness waves steadily acting on coarse-grained beach sediments, and exhibits consistently steep beach profiles. Dissipative beach states result from a high-energy wave climate continuously interacting with fine-grained, or well-supplied beaches and are characterized by persistently low-angle beach profiles. Intermediate beach states exhibit the greatest degree of profile variability and are associated with highly inconsistent wave conditions, medium grained sediment and a limited sediment supply. (Wright and Short, 1984)

Shoaling waves increase in height as they approach the shore, shifting kinetic energy to potential energy. Komar and Gaughan (1972) determined, through experimental results, an empirical relationship between the breaking wave height and the deepwater wave height, given by:

$$H_b = 0.563 * H_o / (H_o / L_o)^{0.2}$$

Where H_o is the deepwater wave height, and
L_o is the deepwater wavelength

The relationship between breaking wave height, deepwater wavelength, and beach slope is indicative of a shoreline's response to wave energy. Iribarren and Nogales (1949) developed the surf similarity parameter, which incorporates these three factors, and is representative of morphodynamic beach type. The surf similarity parameter is estimated using the Iribarren relationship:

$$\Sigma_b = \tan\beta / (H_b / L_o)^{0.5}$$

where β is the shoreline slope.

The surf similarity parameter delineates the morphodynamic nature of shorelines into three domains. An Iribarren Number between 0.1 and 2.5 signifies a reflective beach regime. A Σ_b value between 2.5 and 20 falls within the intermediate morphodynamic domain. An Iribarren Number greater than 20 indicates a dissipative beach regime (Carter, 1988).

A similar morphodynamic parameter was developed by Guza and Inman (1975) for classifying shoreline type, known as the surf-scaling parameter. The surf-scaling parameter can be directly related to the Iribarren Number through the equation:

$$\xi = \pi * \Sigma_b^{-2}$$

The surf-scaling parameter also differentiates between the three common morphodynamic domains. A surf-scaling parameter value greater than 1.0 indicates a reflective beach regime. A ξ value between 1.0 and 0.23 falls within the intermediate morphodynamic domain. A dissipative beach regime is indicated when ξ is less than 0.23 (Carter, 1988).

The surf similarity and surf scaling parameters were calculated for each shoreline region of Lake Almanor and are summarized in **Tables 5 and 6**. **Table 5** represents the extreme condition, utilizing each region's maximum shore slope and wave height values. **Table 6** represents the typical conditions, utilizing average bank slope and significant wave height values. In general, the western lobe of Lake Almanor is characterized by the dissipative morphodynamic regime due to its minimal bank slopes and smaller significant wave heights, which also accounts for the negligible amount of shoreline erosion observed in this region. The eastern lobe of Lake Almanor, characterized by a high degree of shoreline erosion, is dominated by the reflective morphodynamic regime because of the region's steeper bank slopes and greater significant wave heights.

7. CONCLUSIONS

Water Quality Concern

Erosion along the Lake Almanor shore has always been a major concern to the Lake Almanor local community. Local residents raised concerns on impacts to water quality from shoreline erosion. The results from the 2000 PG&E turbidity plume field study indicated that turbidity levels as high as 10 NTU were measured near the shoreline, but not at the shoreline area with active shoreline erosion. The result revealed that the turbidity plume was not initiated from the eroded shoreline area; therefore, the water quality impact from shoreline erosion may not be as significant as local residents thought.

Turbidity plumes typically occur in small pockets at different shoreline areas and are associated with moderate to large waves, which can causes re-suspension of fine slits locally deposited in the shoreline. It is expected that a high turbidity plume under high wind conditions will further confine the plume close to the shoreline with minimal water quality impact. After winds subside, the suspended sediments are expected to settle back in the lake. The amount of turbidity in the lake caused by bank erosion will probably decrease as the banks stabilize at 4,490 feet and as flushing action removes some of the silt and clay particles.

Wind and Wave Climate

The northwest and southeast orientations represent the dominant wind directions, accounting for 38% and 16% of the total wind measurements, respectively. The stronger winds, for those average hourly wind speed higher than 10 miles per hour (mph), seem to be coming from the south to west. The maximum hourly average wind speeds range from 16 to 22 mph; and the significant average hourly wind speed ranges from 6 to 10.5 mph. These estimates of probability should be considered conservative since the one-hour average wind record data was used to calculate probability of exceedence, when the minimum wind durations necessary to generate maximum wave conditions are on the order of two hours.

From the wave hindcast analysis using the maximum hourly wind record, the maximum wave heights range from 1.3 to 2 feet with maximum wave periods of 2.6 to 3.2 seconds. During winter storms, bigger waves can be generated. Maximum wave height occurs due to the relatively long fetch and strong winds from dominant wind direction.

Generally, wind-induced wave run-ups, are higher in the eastern lobe of the lake (range from 1.9 to 3.6 feet) than those in the western lobe (range from 0.3 to 1.4 feet), mainly due to the overall steeper bank slope. The maximum impact zone from wave run-up will occur when the highest wind occurs in combination with the maximum operation water level of 4,494 feet. The probability of this water level occurring corresponds to the probability of exceedence of the maximum wind speed at the longest fetch angle for each region.

From historic daily average lake water level elevation data for the period of 1974 to 2000, only 930 days of the past 26 years equaled or exceeded 4490 feet, which corresponds to a 9.8 percent probability of occurrence within Lake Almanor. Those 930 days occurred in 1982 to 84, 1986, 1993, 1995 to 96, and 1998 to 2000. The lake reached 4494 feet only once in the 26 years of water surface elevation record, the equivalent of a 0.01% probability. In general, high water level occurs in about 10% of the time; high winds also occur in about less than 10% of the time.

By reviewing the results of wind and wave data analysis for each shoreline region, it is obvious that the active erosion shoreline areas typically match those areas with high winds, large waves, and high wave run-up. The waves will continue to approach those shoreline areas, regardless of erosion protection measures.

Shoreline Characteristics

In general, the western lobe of Lake Almanor is characterized by the dissipative morphodynamic regime due to its minimal bank slopes and smaller significant wave heights. This accounts for the negligible amount of shoreline erosion observed in this region. The eastern lobe of Lake Almanor, characterized by a high degree of shoreline erosion, is dominated by the reflective morphodynamic regime because of the region's steeper bank slopes and greater significant wave heights.

Most of the shoreline areas with significant erosion are those with bluffs and cliffs at the shorefront. Future developments shall be permitted if design and setback are adequate to assure stability and structural integrity for the expected economic lifespan of the development and if the development will neither create nor contribute significantly to erosion problems or geologic instability of the site or surrounding area.

PG&E concluded, after D&M's 1974 study, that the most effective form of bank stabilization on Lake Almanor is the placement of riprap. This supposition is evidenced by the greatest reduction in Shoreline Erosion Index between 1974 and 2000 in the regions with the greatest increase in rip-rapped shoreline length. Of the 58 miles of shoreline surrounding Lake Almanor, approximately 4 miles were classified in 2000 as class A-significantly eroding, with ninety percent of this significantly eroding shoreline unprotected, as summarized **Table 7**.

With the exception of a few shoreline segments, PG&E has the right (Clifford Deed Provisions) to erode on parcels above 4,500 feet (PG&E datum). PG&E owns most of the land in fee simple absolute below that elevation and can erode as it needs to without any easement. The few exceptional shoreline segments not covered by Clifford Deed Provisions have been provided riprap for protection. In the future, the unprotected areas with high erosion potential in Lake Almanor's eastern lobe are expected to continue to be subjected to active erosion, until its slope becomes stable by the natural armoring process.

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9. ACKNOWLEDGEMENT

Dr. Scott Tu of PG&E Technical and Ecological Services provided basic data, background information and some of the concepts presented herein.

EXHIBITS

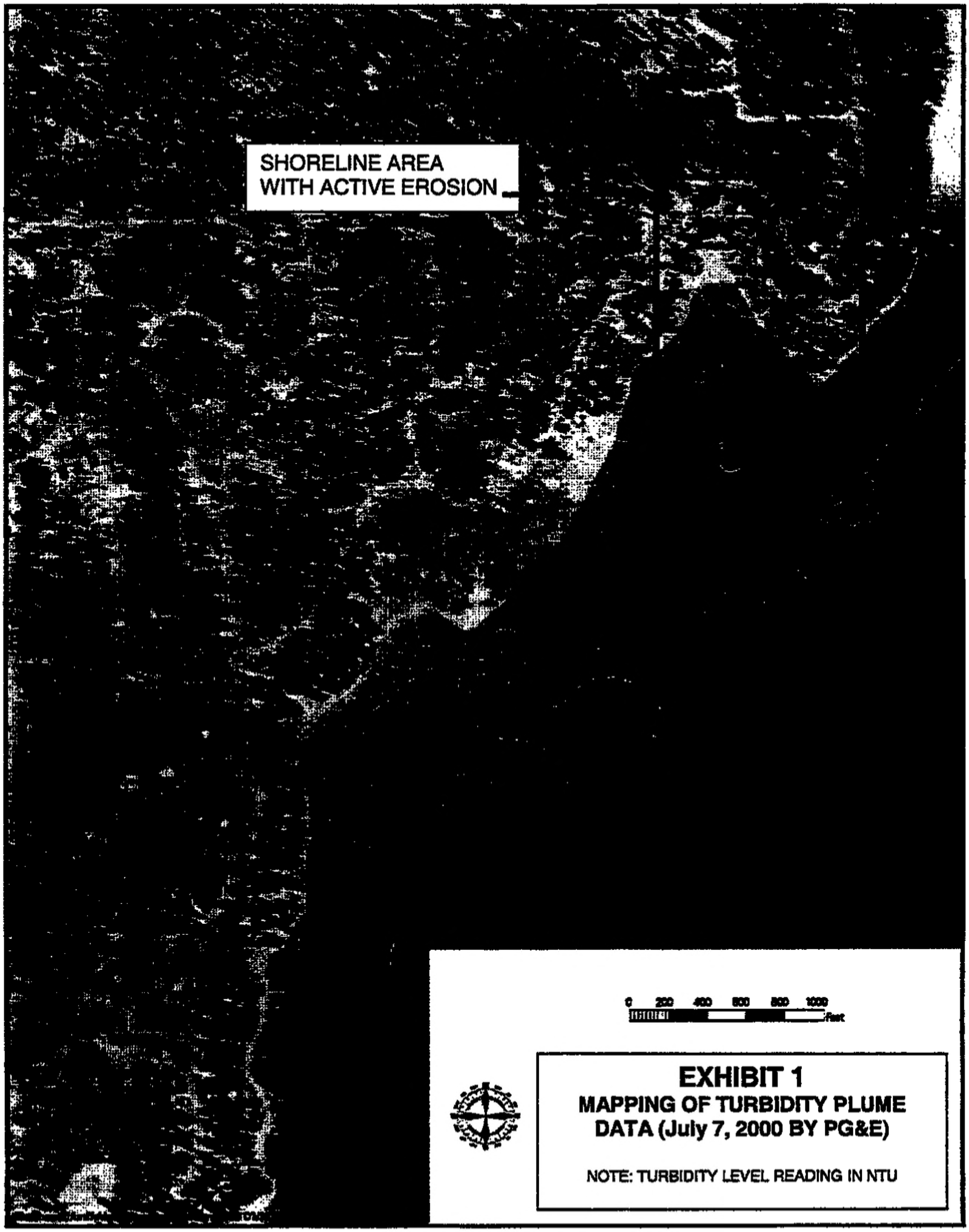
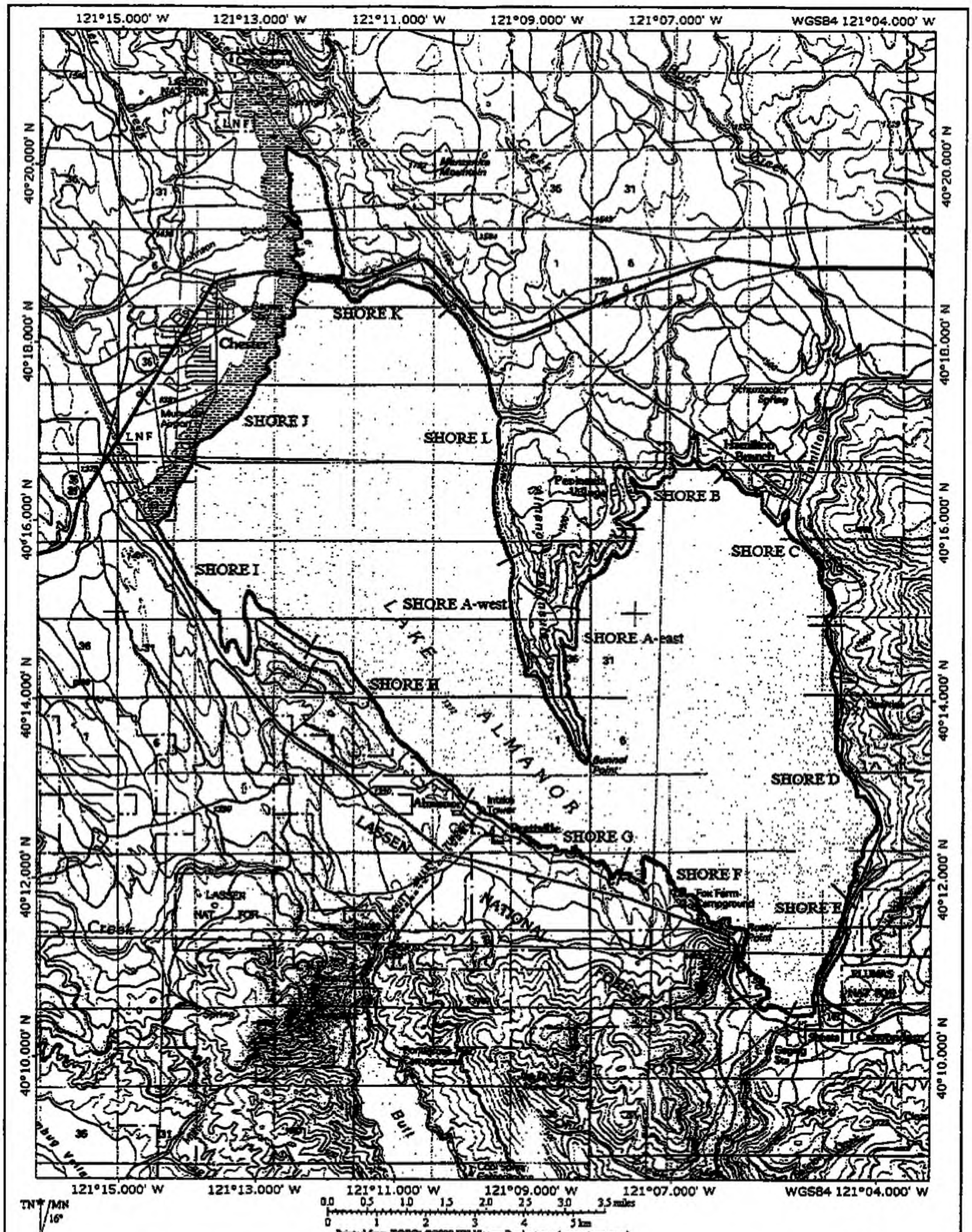


EXHIBIT 1

MAPPING OF TURBIDITY PLUME DATA (July 7, 2000 BY PG&E)

NOTE: TURBIDITY LEVEL READING IN NTU



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Shoreline Segment Delineation
as per Dames and Moore Report of 1974

EXHIBIT 2

Lake Almanor Shoreline Erosion Study

January 2002

Shore•	Total Region Length (mi)	Shoreline Erosion Index 1975 ϕ	Shoreline Erosion Index 2000 ϕ	Longest Fetch Angle (°)	F Fetch Length (Miles)	Wind Direction	S_{max} Maximum Bank Slope (%)	$U_{10\ max}$ Maximum Wind Velocity at 10m (mph)	$U_{10\ max}$ Probability of Exceedence$ (%)	H_{max} Wave Height (ft)	T_{max} Wave Period (sec)	R Maximum Run-Up# (ft)
A West	2.3	35	36	290	5.0	W	50	18.0	0.15	1.39	2.62	2.64
A East	4.2	43	31	148	5.8	SE	35	16.0	0.02	1.29	2.62	2.19
B	3.1	43	24	163	7.0	S	40	21.0	0.05	1.98	3.12	3.47
C	3.8	55	6	178	6.2	S	28	21.0	0.05	1.87	3.00	2.62
D	4.0	58	32	266	5.1	W	56	18.0	0.15	1.39	2.63	2.64
E	1.7	89	82	300	10.0	NW	56	17.0	0.01	1.83	3.23	3.57
F	5.5	17	-	355	6.0	N	25	17.0	0.06	1.42	4.73	1.85
G	2.7	15	-	337	8.5	NW	25	15.0	0.01	1.69	5.61	2.28
H	3.7	13	-	102	6.2	E	25	17.0	0.05	1.87	4.40	2.34
I	5.4	0	-	36	4.9	NE	5	22.0	0.15	1.75	3.82	0.32
J	8.1	0	-	139	8.9	SE	5	16.0	0.02	1.60	5.90	0.32
K	9.7	19	-	157	7.8	SE	5	17.0	0.02	1.50	5.49	0.30
L	3.6	24	-	251	4.6	W	20	17.0	0.15	1.33	4.04	1.40
	57.6											

Change in Shoreline Erosion Index: **24.0** (%) reduction (Regions A through E)

Notes:

- • as per 'figure 14' - PG&E Records, Correspondence,Documents - Dames and Moore Report of 12/12/74; Shore regions A-West and A-East are separated by Bunnel Point at the tip of Almanor Peninsula.
- ♦ Shoreline Erosion Index calculated using Index values: A=100, B=30, C=0.
- # Run-up values calculated using R/H coefficients from Figure 7-20 in the Shore Protection Manual.
- $ Probability of exceedence calculated from 5 year wind record at Chester.

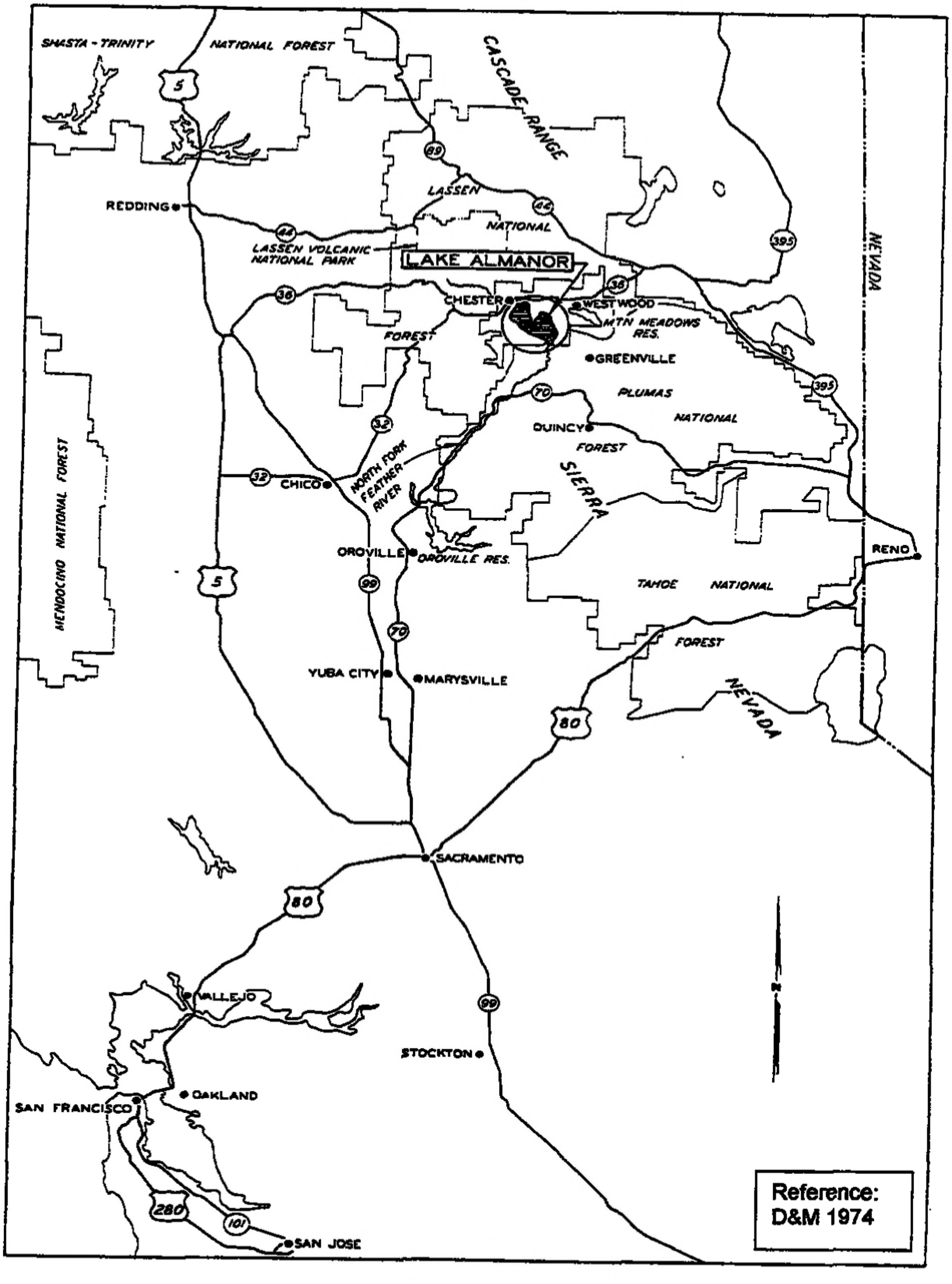
Shoreline Erosion Analysis Summary

Lake Almanor Shoreline Erosion Study

EXHIBIT 3

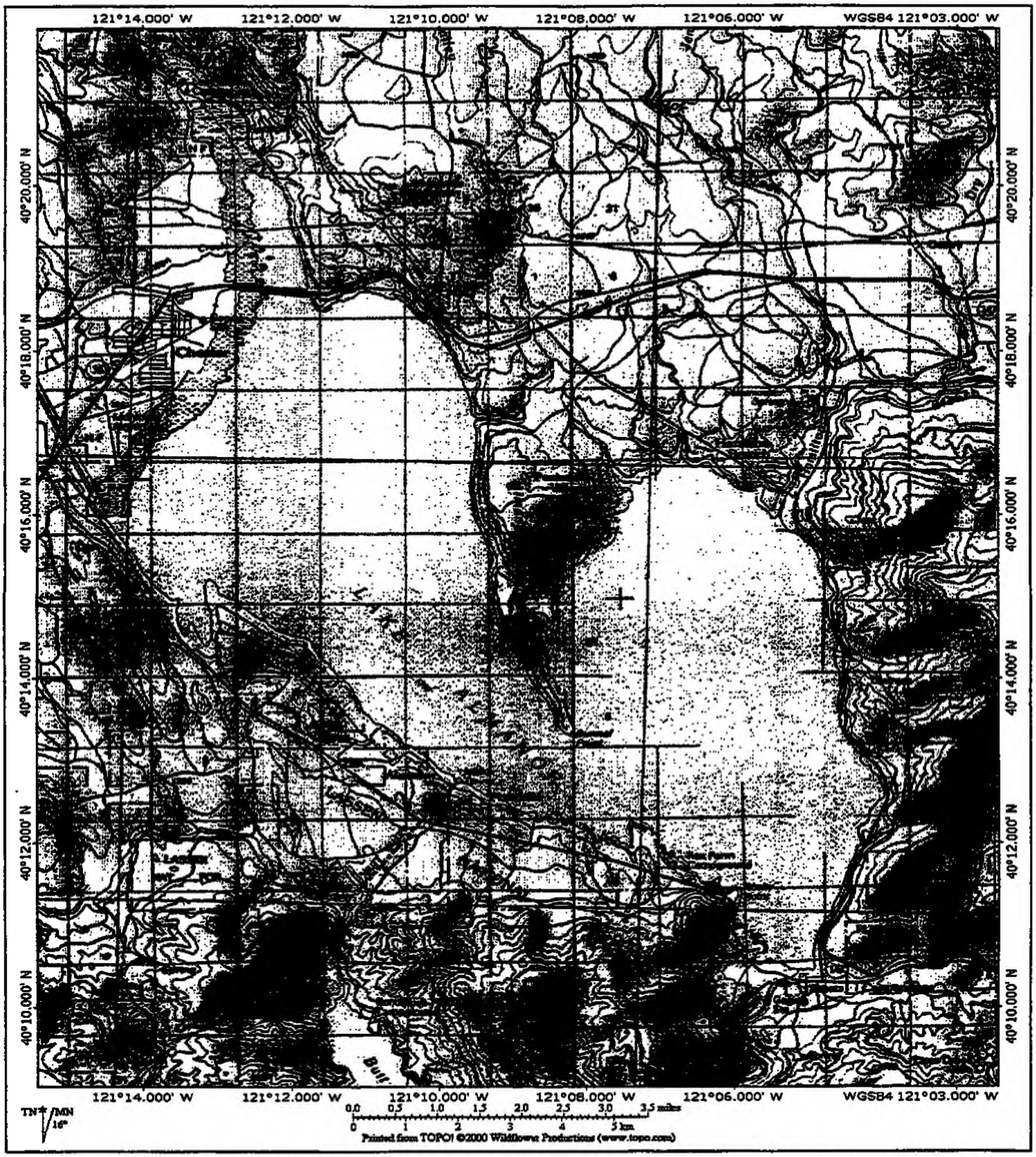
January 2002

FIGURES



Reference:
D&M 1974

Regional Location of Lake Almanor	FIGURE 1
Lake Almanor Shoreline Erosion Study	January 2002



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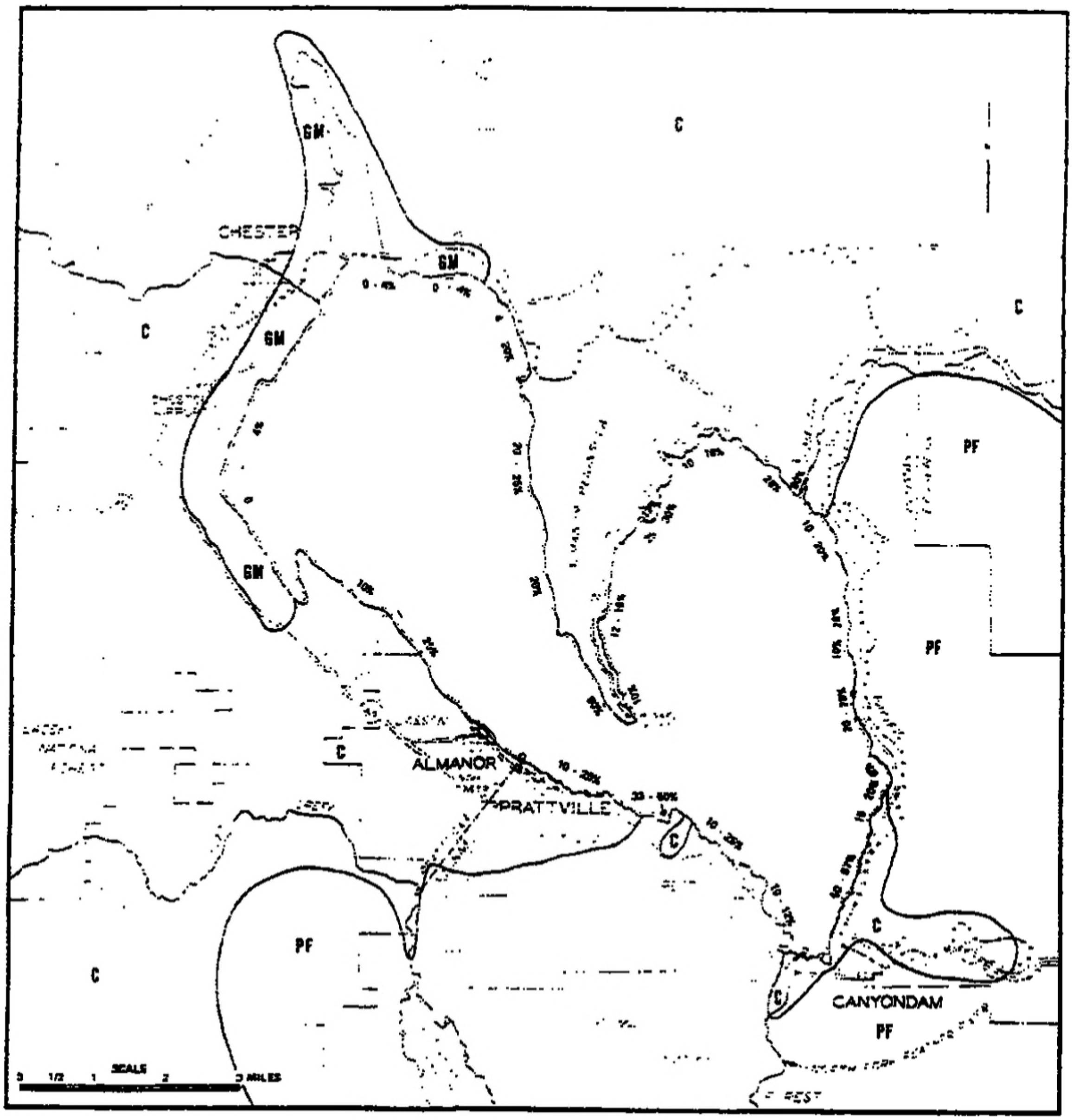
Vicinity Map of Lake Almanor

FIGURE 2

Lake Almanor Shoreline Erosion Study

January 2002



SOILS*

BOUNDARY ————————
Cohasset Association (C)
Greenhorn – Massack Association (GM)
Plumas – Forgay Association (PF)

APPROXIMATE SLOPE OF IMMEDIATE SHORELINE**

SLOPE	% OF SHORELINE
0 - 9%	29
10 - 19%	41
20 - 29%	19
30 - 49%	2
50 - 80%	9

*Source:
U.S. Department of Agriculture,
Soils Conservation Service

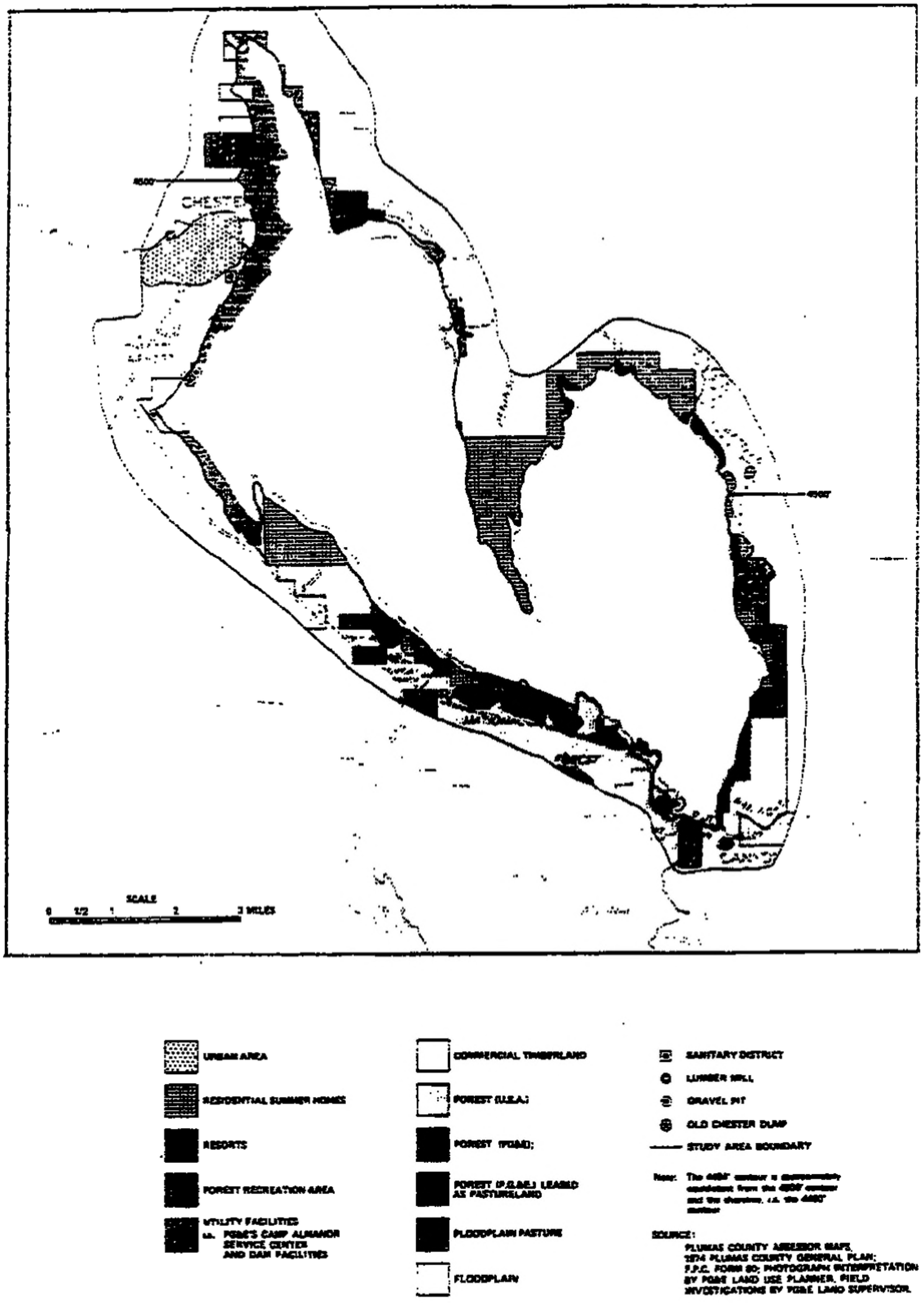
**Source:
Rough Visual Estimates
By Dames & Moore, October 21, 1974

Soils and Approximate Shoreline Slope at Lake Almanor

FIGURE 3

Lake Almanor Shoreline Erosion Study

January 2002



General Land Use Surrounding Lake Almanor	FIGURE 4
Lake Almanor Shoreline Erosion Study	January 2002

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Shoreline Segment Delineation as per Dames and Moore Report of 1974	**FIGURE 5**
Lake Almanor Shoreline Erosion Study	January 2002

CLASS A:
SIGNIFICANT EROSION

PHOTOGRAPH: by Scott Tu (PG&E)

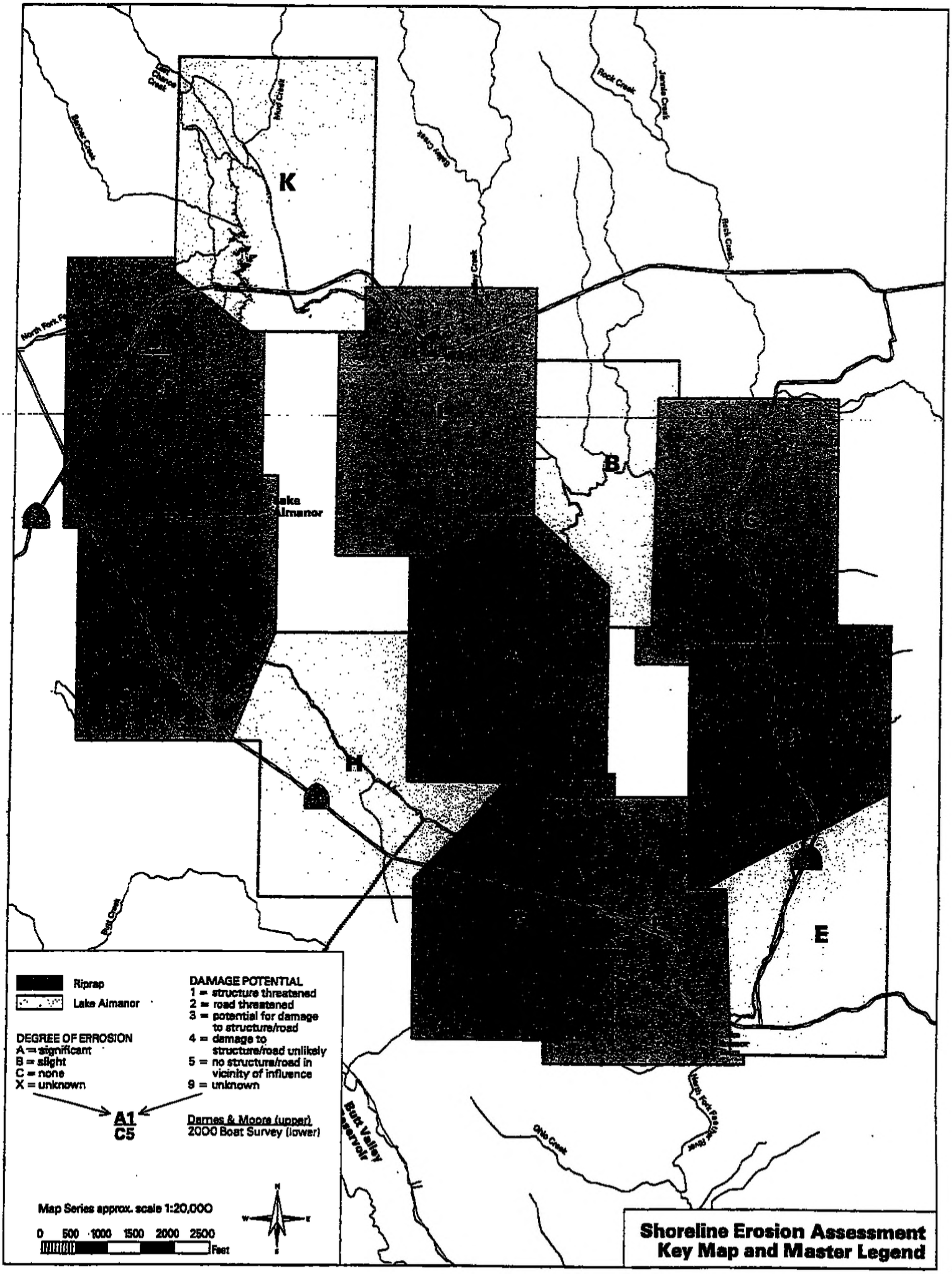
CLASS B:
SLIGHT EROSION

PHOTOGRAPH: by Scott Tu (PG&E)

CLASS C:
NO EROSION

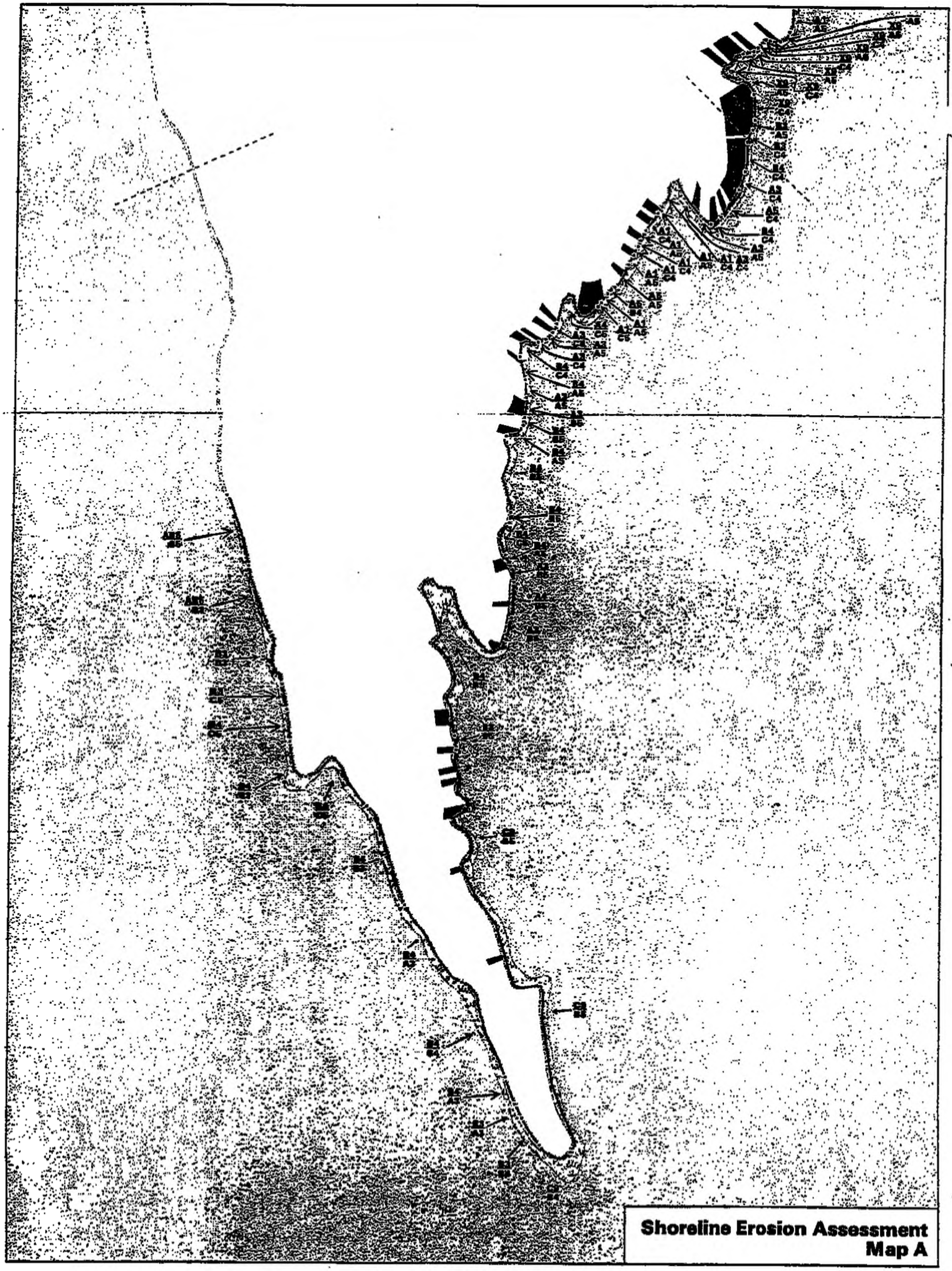
PHOTOGRAPH: by Scott Tu (PG&E)

EROSION CONDITIONS DURING 2000 AT LAKE ALMANOR	**FIGURE 6**
Lake Almanor Shoreline Erosion Study	January 2002



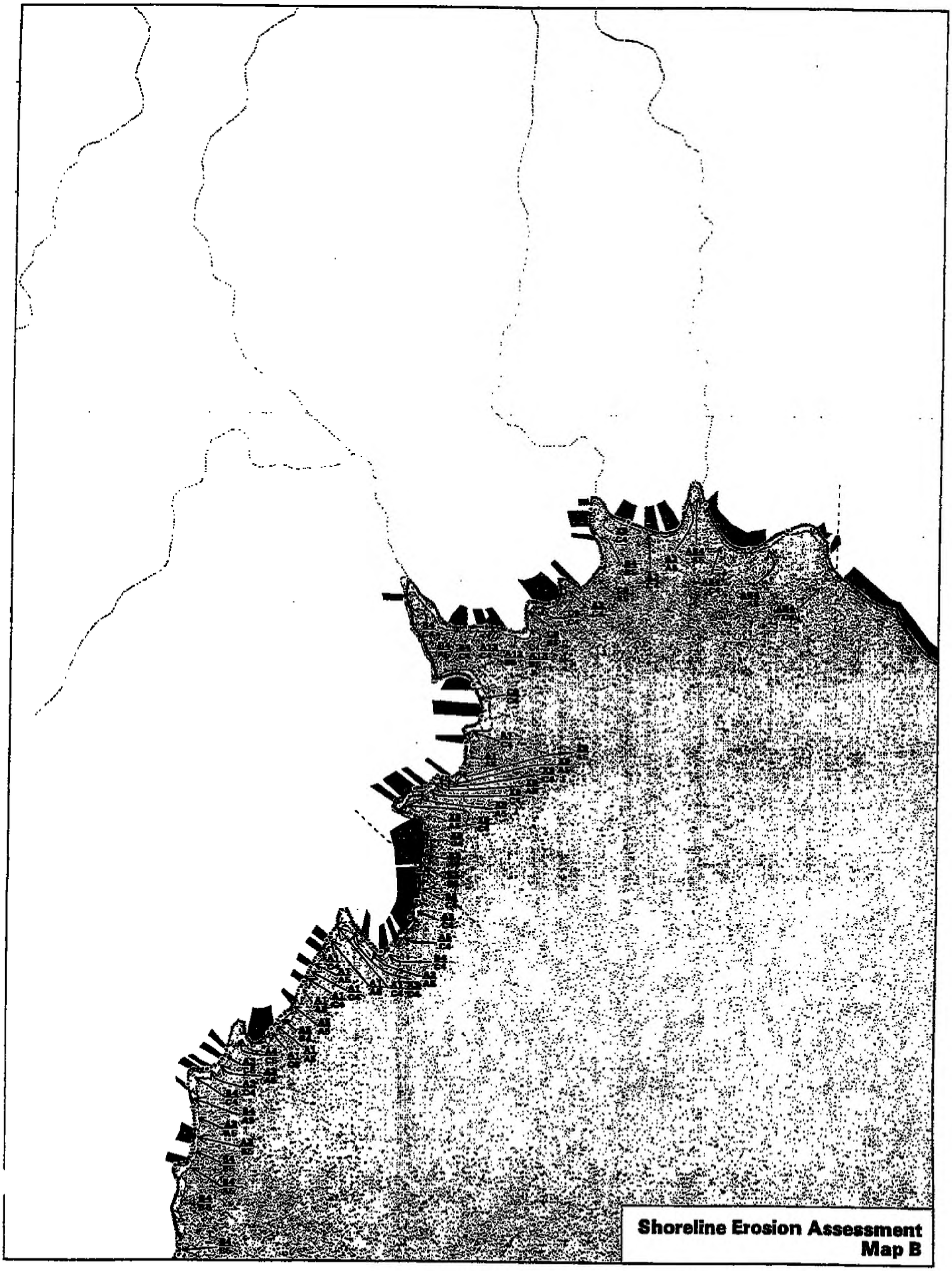
Shoreline Erosion Assessment Key Map and Master Legend

FIGURE 7



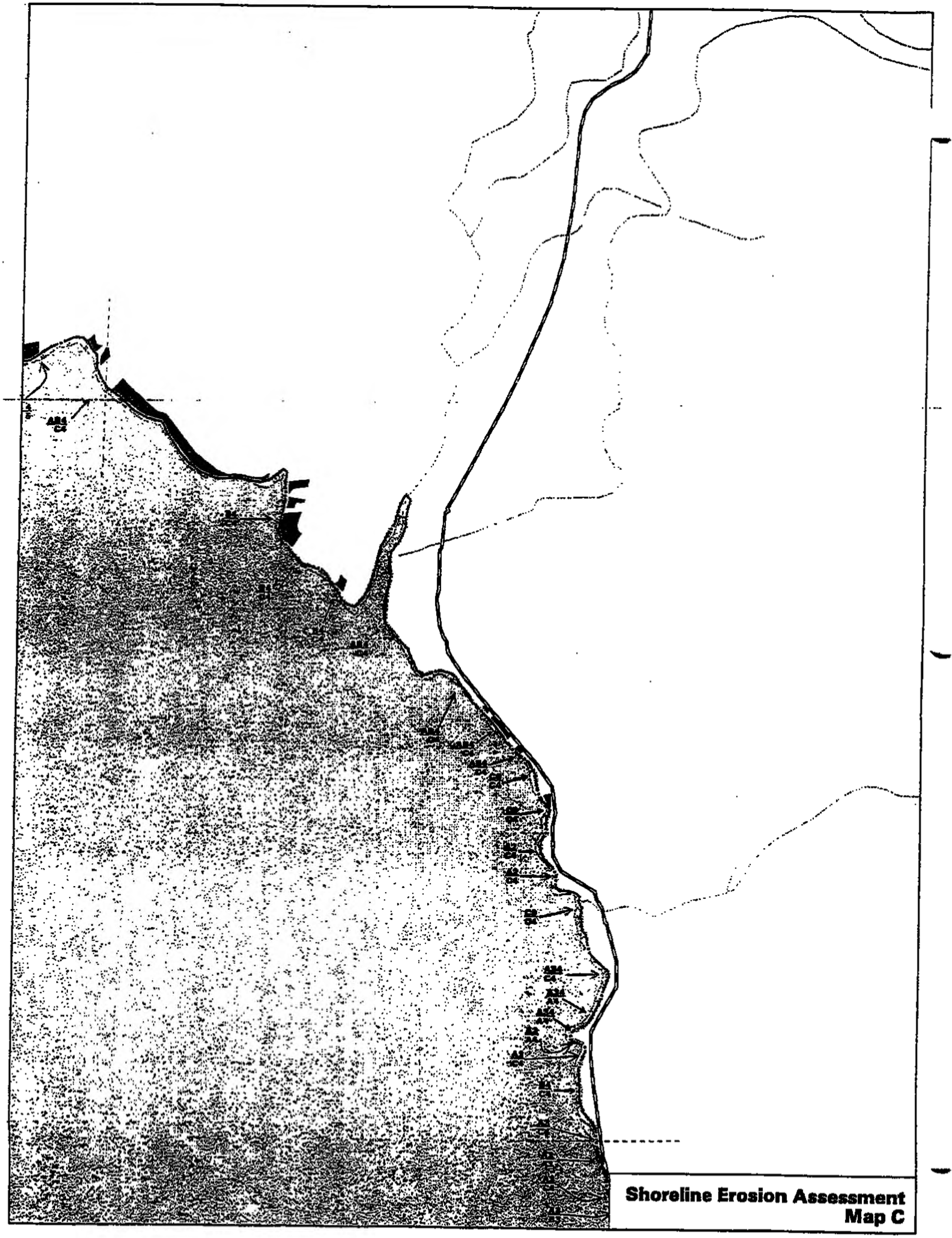
Shoreline Erosion Assessment
Map A

FIGURE 7A



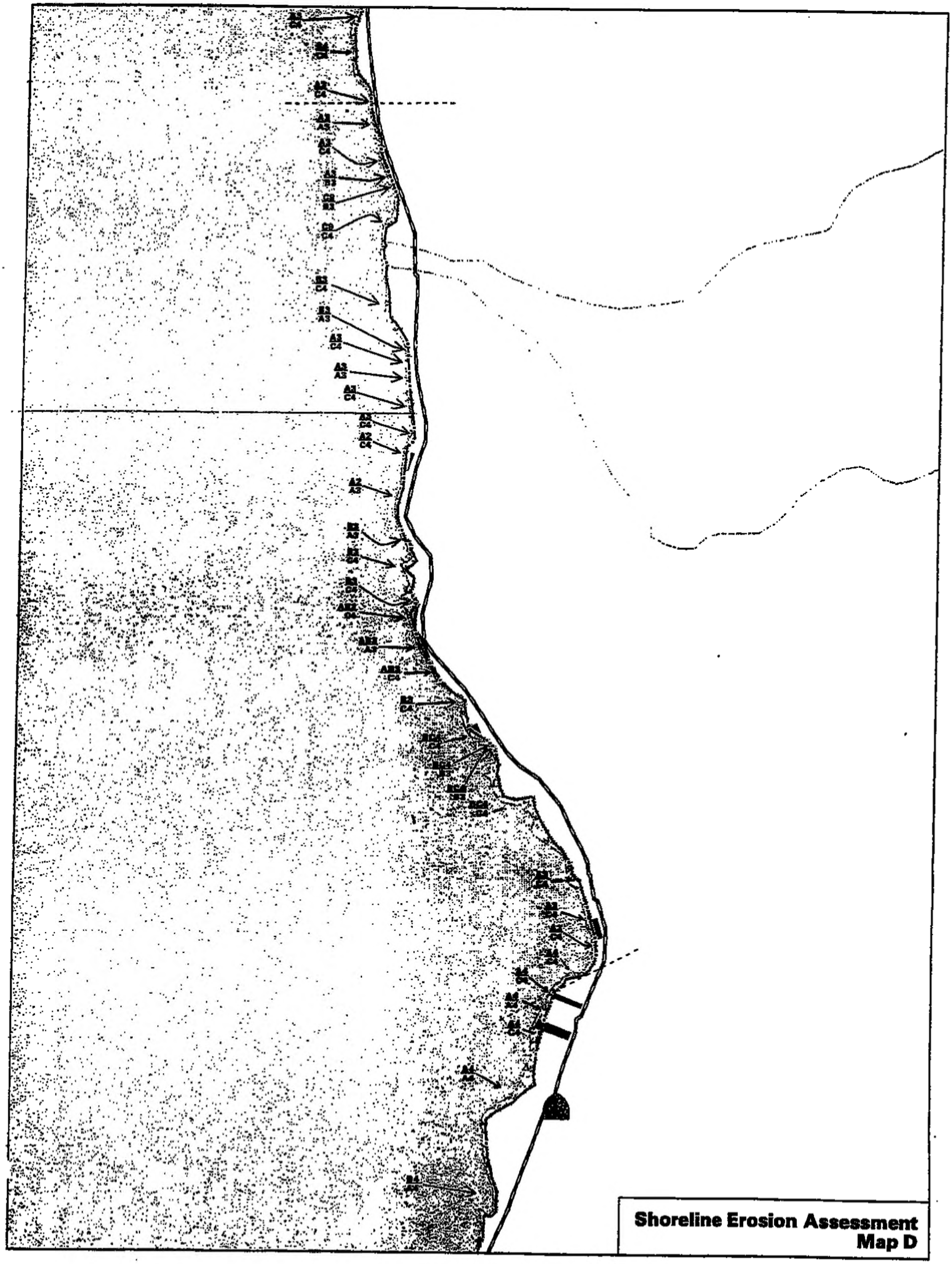
Shoreline Erosion Assessment Map B

FIGURE 7B



Shoreline Erosion Assessment
Map C

FIGURE 7C

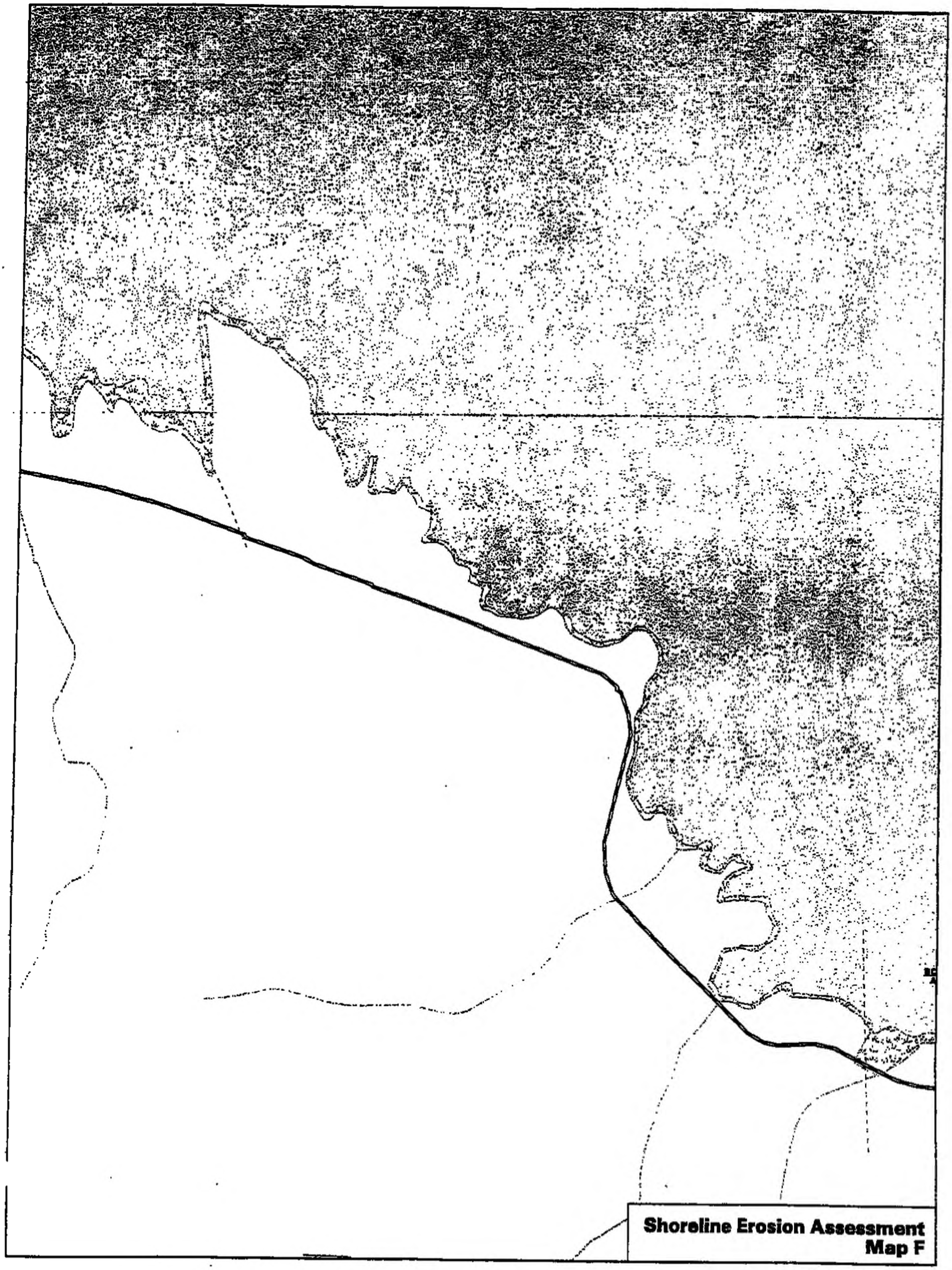


Shoreline Erosion Assessment
Map D

FIGURE 7D

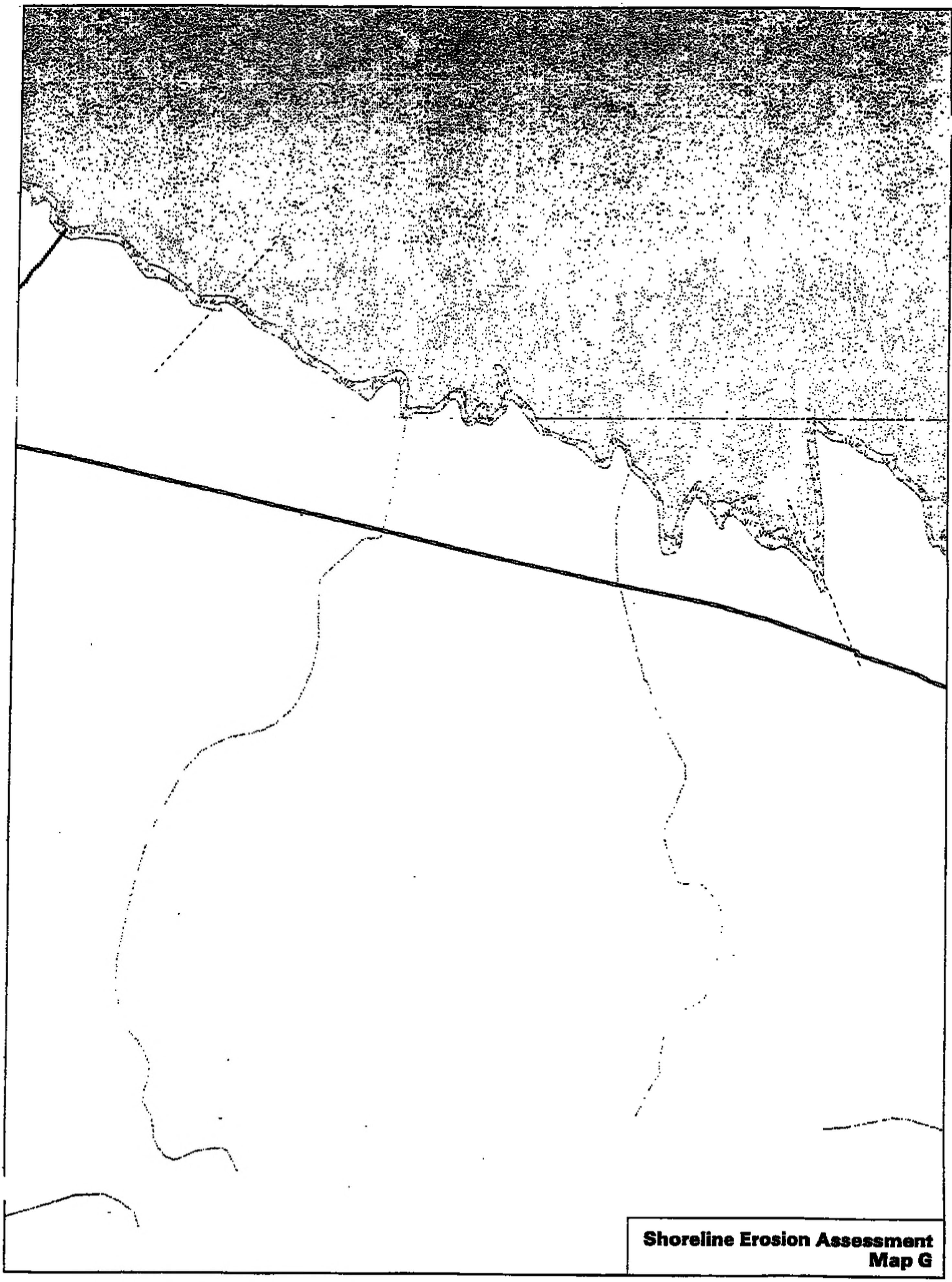

A4
C4
A4
A4
A4
C4
A4
A4
B4
A4
A7
A4
A5
A4
A4
A4
A5
A4
A5
B4
A6
A5
BC5
A5
Shoreline Erosion Assessment
Map E

FIGURE 7E



Shoreline Erosion Assessment
Map F

FIGURE 7F



Shoreline Erosion Assessment
Map G

FIGURE 76

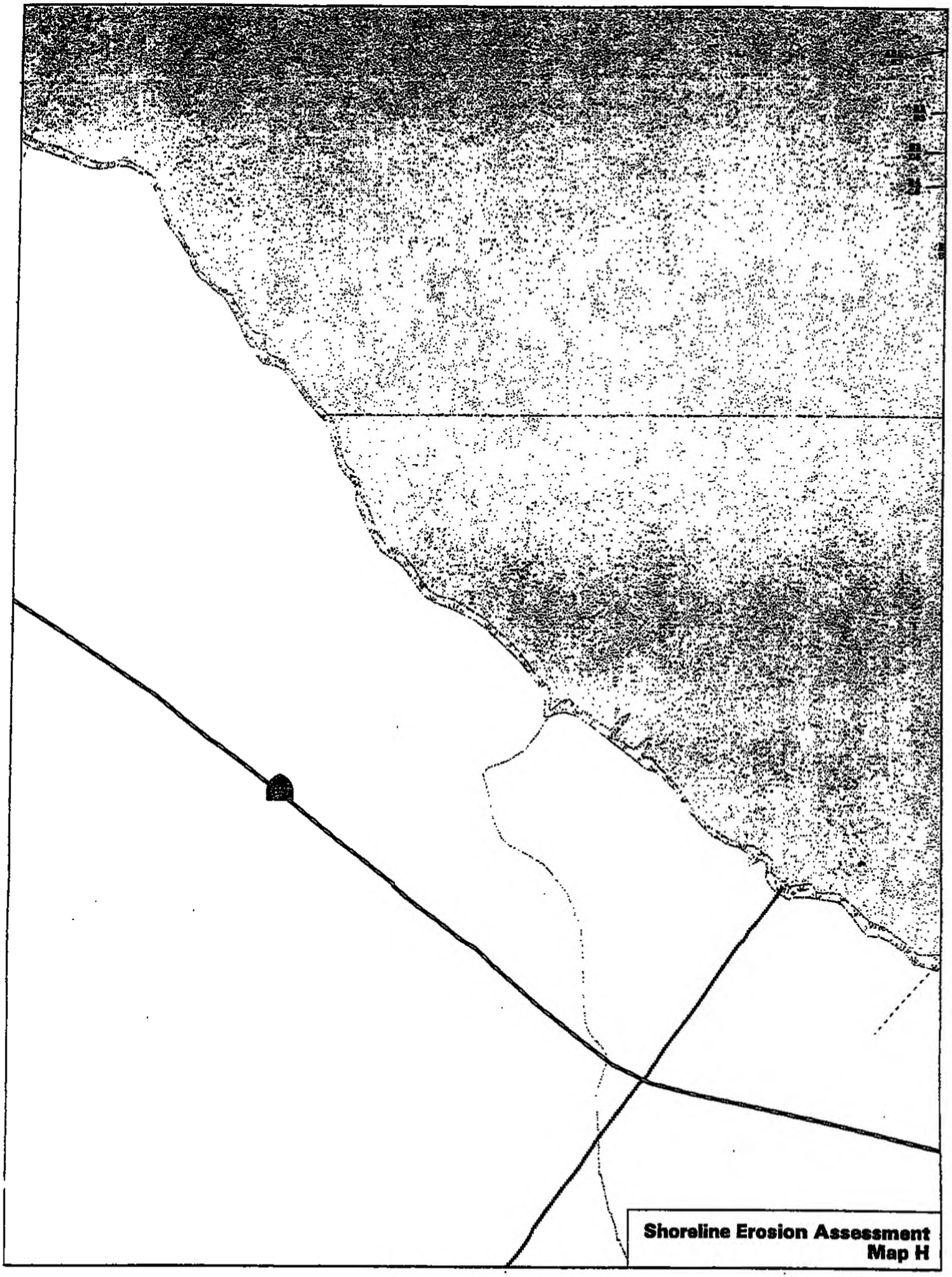
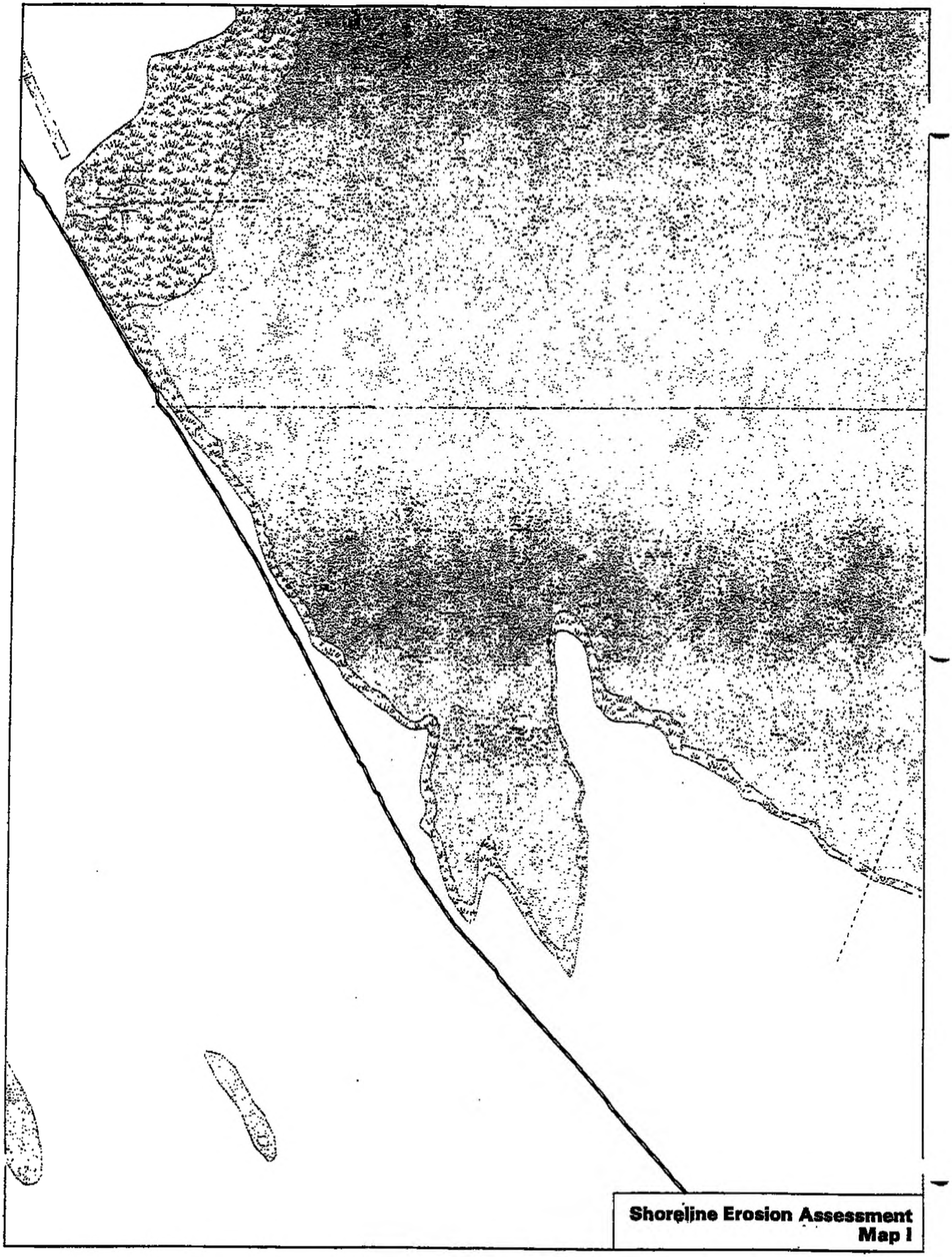


FIGURE 7H



Shoreline Erosion Assessment Map I

FIGURE 7I

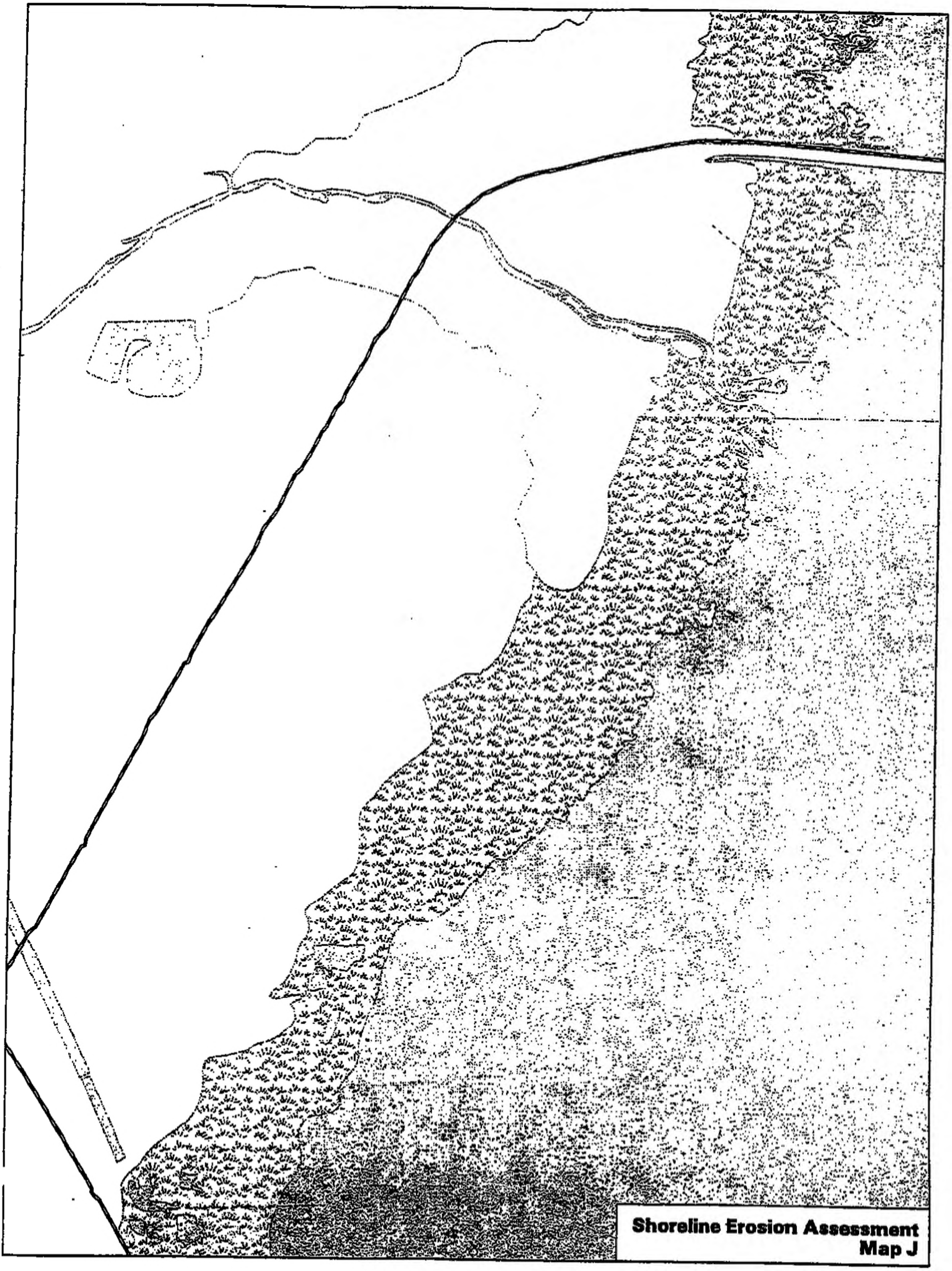


FIGURE 7J

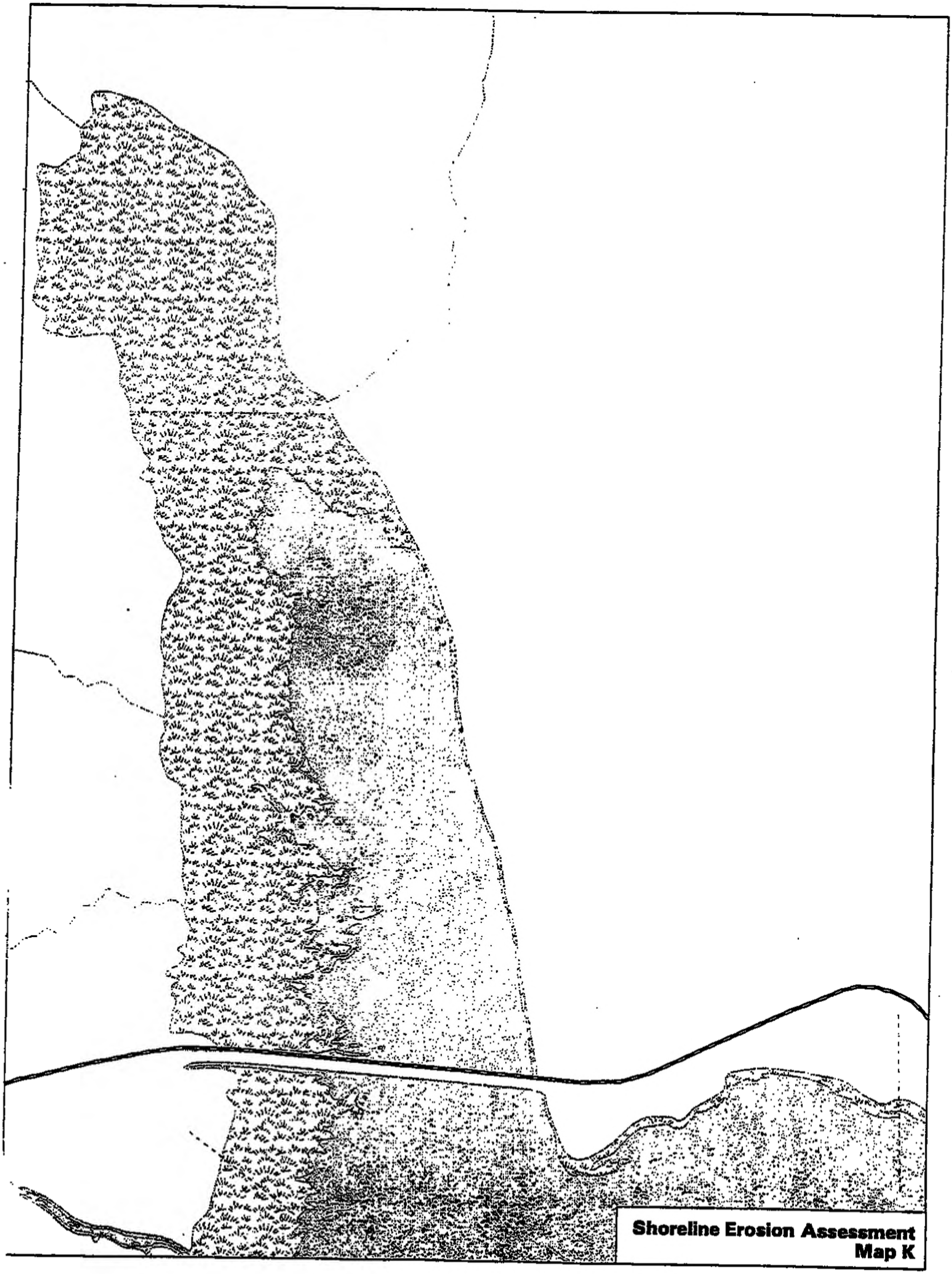
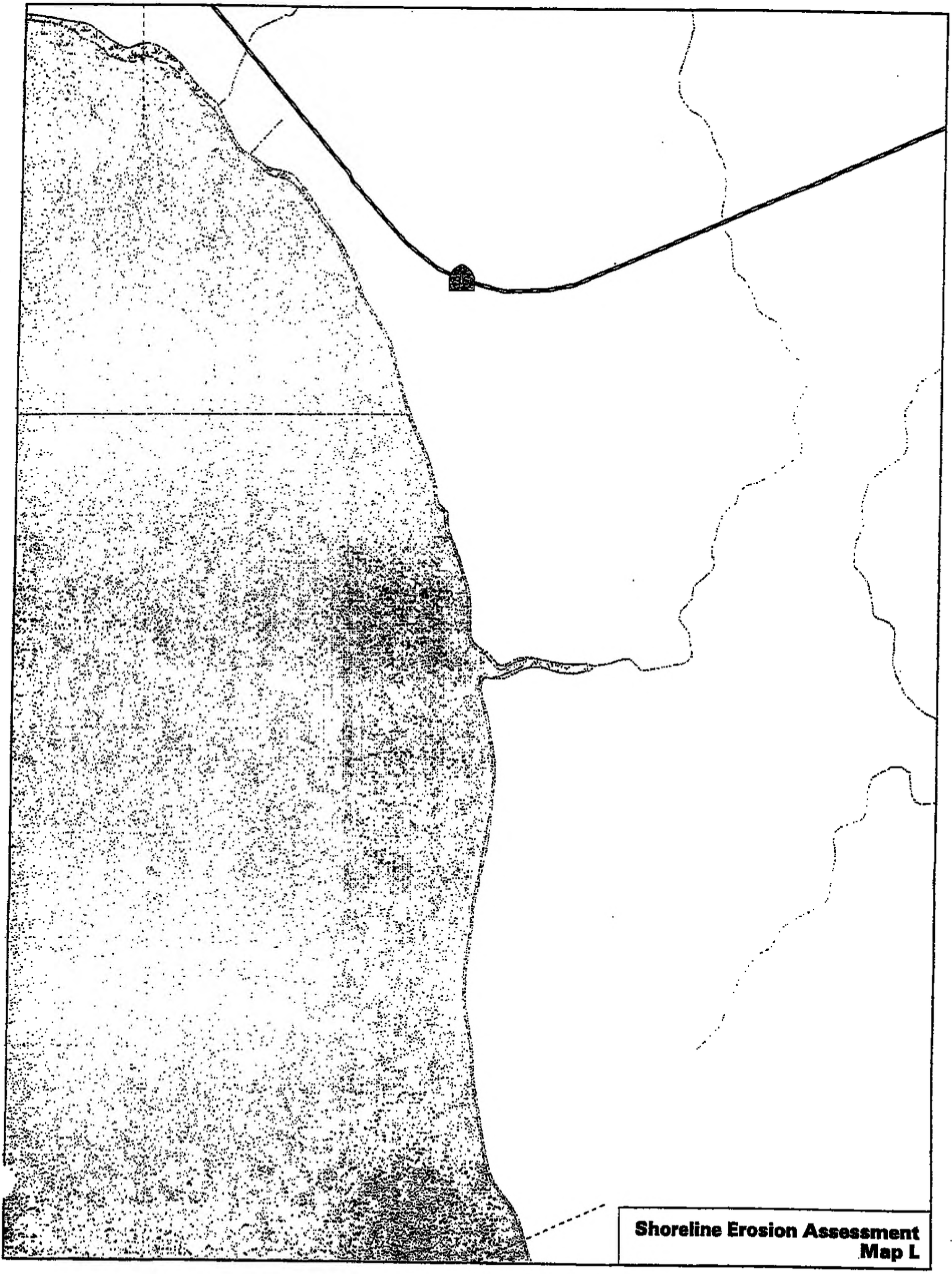


FIGURE 7K



Shoreline Erosion Assessment
Map L

FIGURE 7L

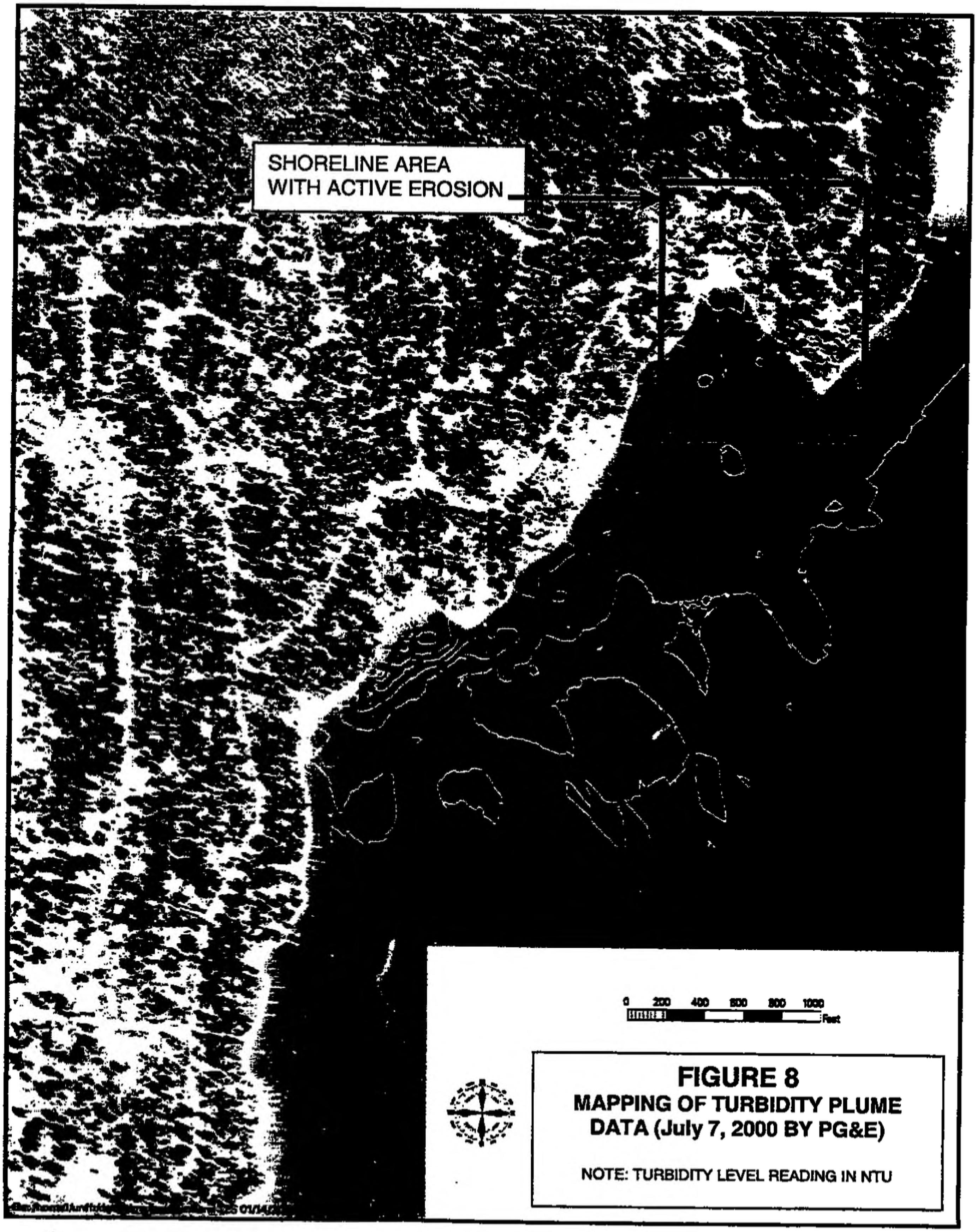
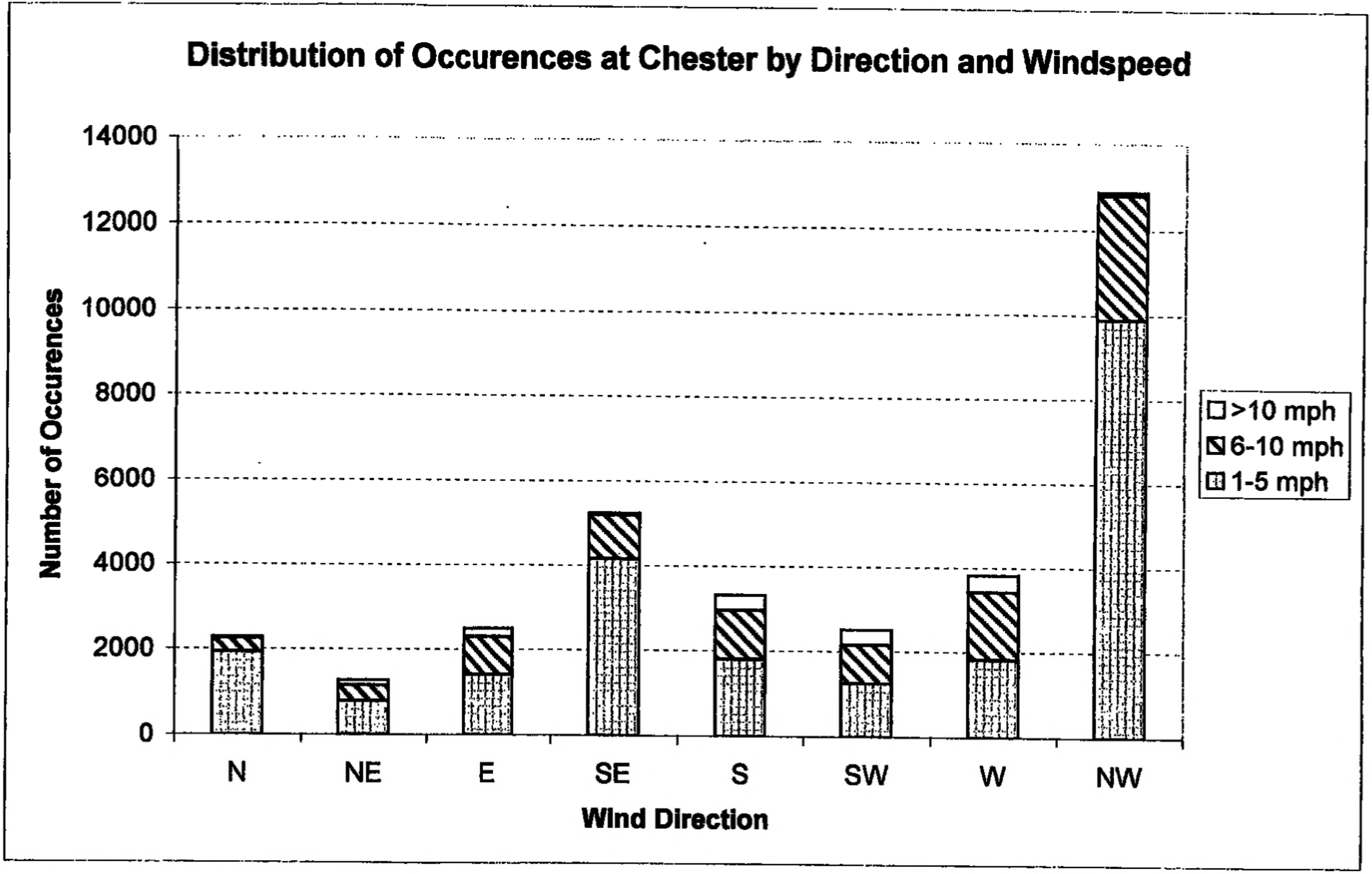
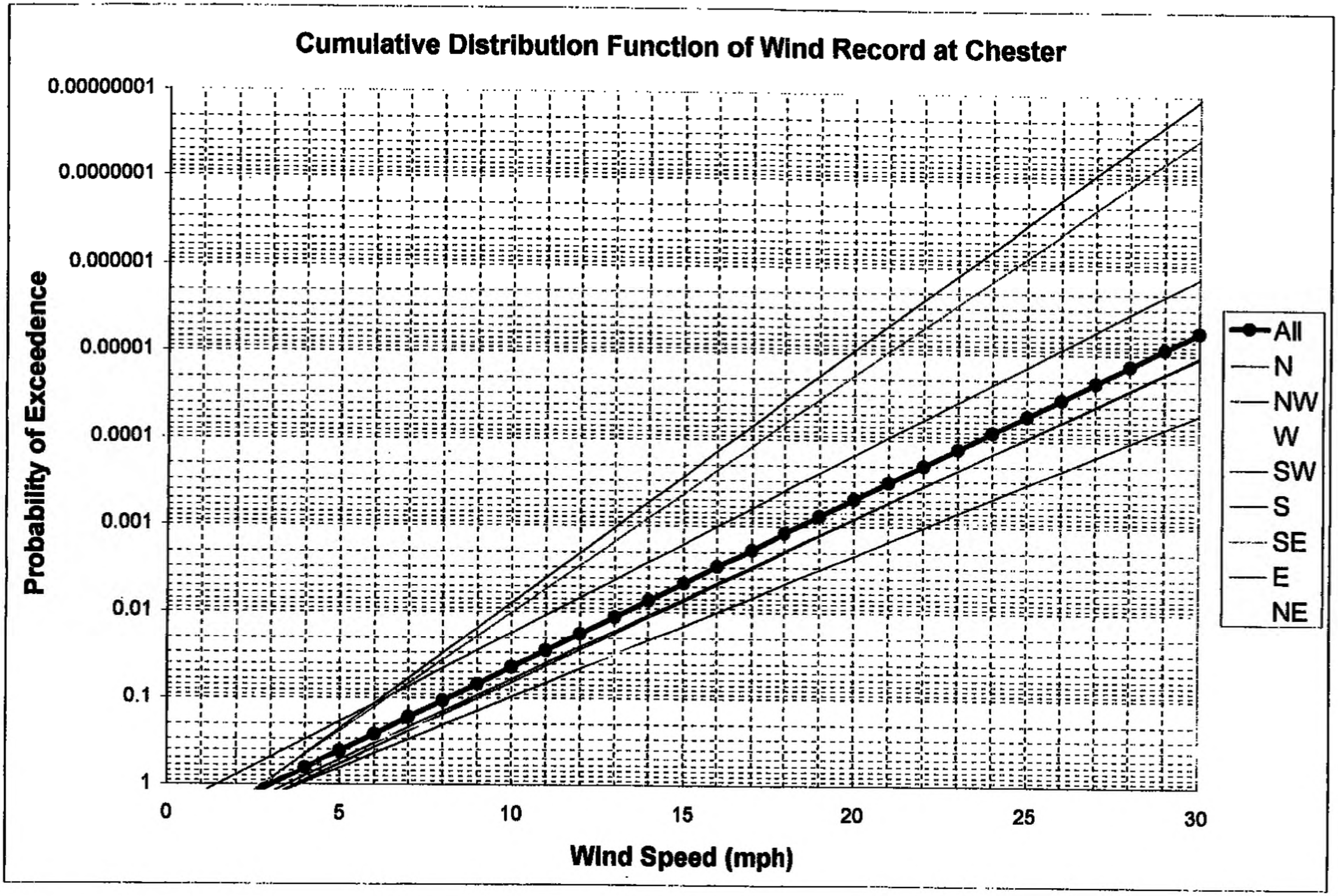


FIGURE 8
MAPPING OF TURBIDITY PLUME DATA (July 7, 2000 BY PG&E)

NOTE: TURBIDITY LEVEL READING IN NTU



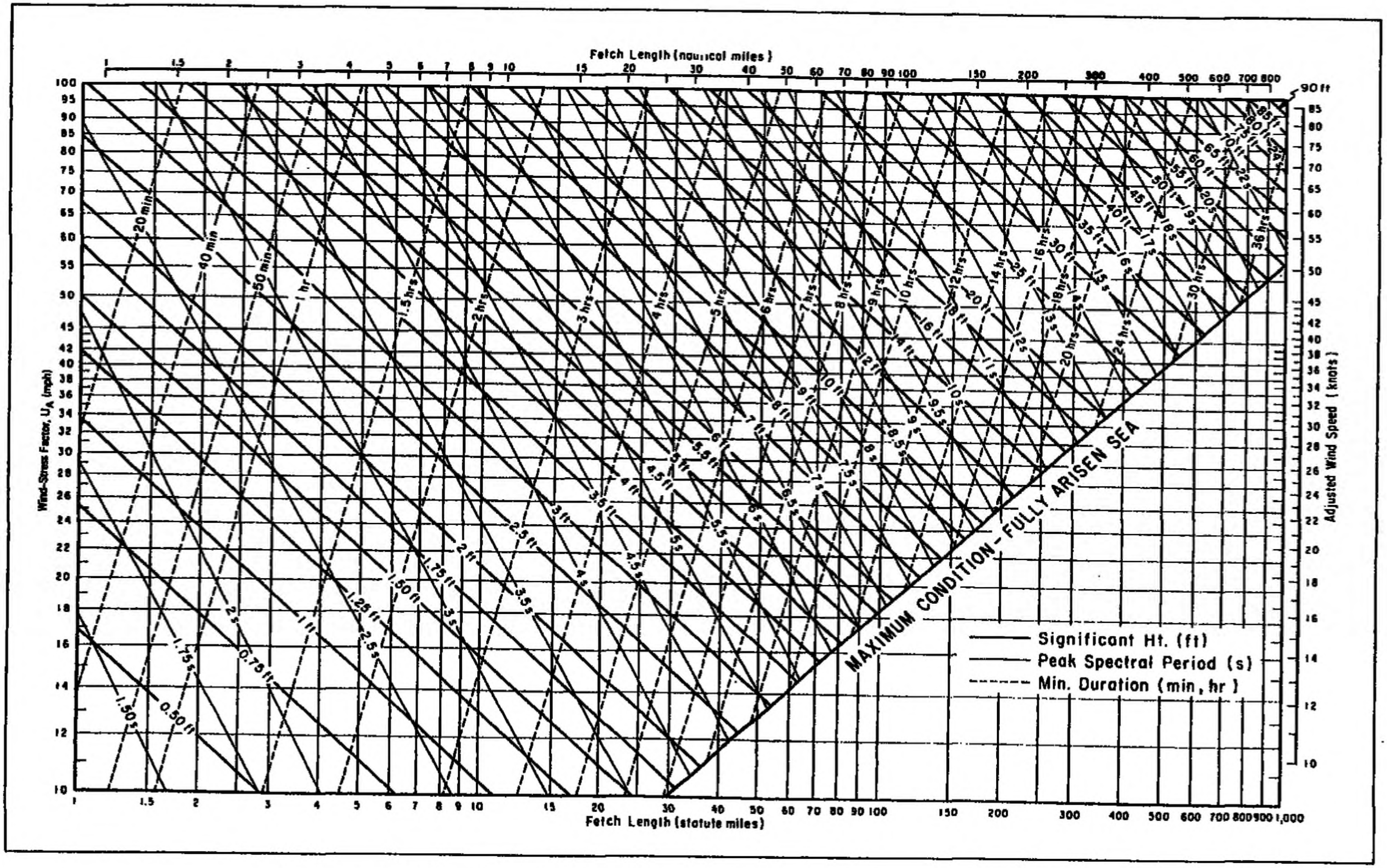
Lake Almanor Wind Distribution	**FIGURE 9**
Lake Almanor Shoreline Erosion Study	January 2002



Wind Record Probability of Exceedence	**FIGURE 10**
Lake Almanor Shoreline Erosion Study	January 2002

	English Units	
H(ft), T(s), U_A(ft/s), F(ft), t(s)	H(ft), T(s), U_A(mi/hr), F(mi), t(hr)	H(ft), T(s), U_A (kn), F(nmi), t(hr)
FETCH LIMITED (F, U)		
$H_{m_o} = 2.82\text{x}10^{-4}\ U_A F^{1/2}$ (3-33c)	$H_{m_o} = 3.01\text{x}10^{-2}\ U_A F^{1/2}$ (3-33d)	$H_{m_o} = 3.714\text{x}10^{-2}\ U_A F^{1/2}$ (3-33e)
$T_m = 2.825\text{x}10^{-2}\left(U_A F\right)^{1/3}$ (3-34c)	$T_m = 5.59\text{x}10^{-1}\left(U_A F\right)^{1/3}$ (3-34d)	$T_m = 6.14\text{x}10^{-1}\left(U_A F\right)^{1/3}$ (3-34e)
$t = 2.16\text{x}10^{1}\left(\frac{F^2}{U_A}\right)^{1/3}$ (3-35c)	$t = 1.603\left(\frac{F^2}{U_A}\right)^{1/3}$ (3-35d)	$t = 1.680\left(\frac{F^2}{U_A}\right)^{1/3}$ (3-35e)
FULLY DEVELOPED		
$H_{m_o} = 7.553\text{x}10^{-3}\ U_A^2$ (3-36c)	$H_{m_o} = 1.625\text{x}10^{-2}\ U_A^2$ (3-36d)	$H_{m_o} = 2.154\text{x}10^{-2}\ U_A^2$ (3-36e)
$T_m = 2.53\text{x}10^{-1}\ U_A$ (3-37c)	$T_m = 3.706\text{x}10^{-1}\ U_A$ (3-37d)	$T_m = 4.244\text{x}10^{-1}\ U_A$ (3-37e)
$t = 2.220\text{x}10^{3}\ U_A$ (3-38c)	$t = 9.045\text{x}10^{-1}\ U_A$ (3-38d)	$t = 1.04\ U_A$ (3-38c)
NOTATIONS $g = 32.2$ ft/s^2	$g = 32.2$ ft/s^2 1 mile = 5280 ft miles per hour = 1.467 ft/s 1 hour = 3600 s	$g = 32.2$ ft/s^2 1 nautical mile = 6080 ft 1 knot = 1.689 ft/s 1 hour = 3600 s

Deepwater Wave Forecasting Equations	**FIGURE 11**
Lake Almanor Shoreline Erosion Study	January 2002

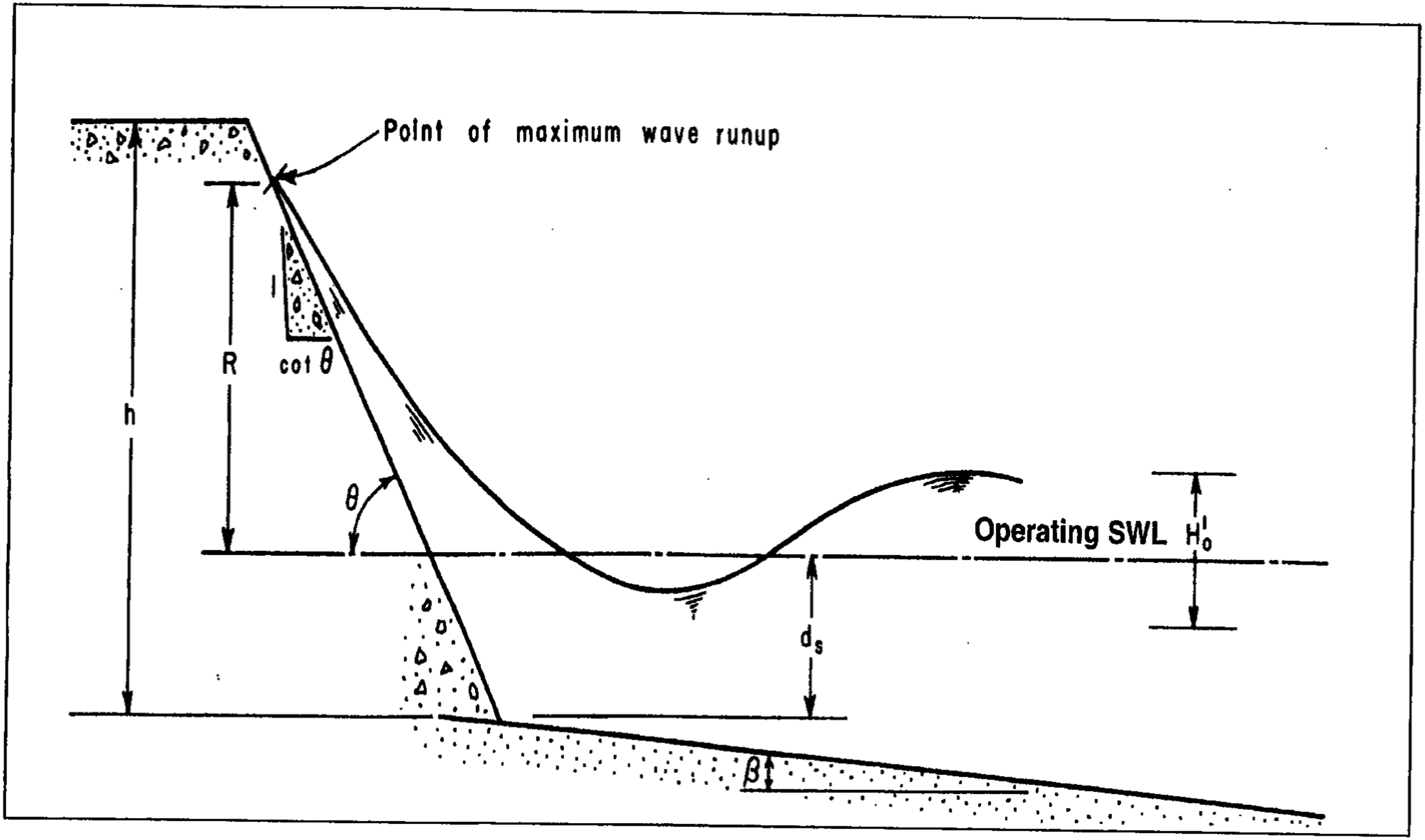


Nomograms of deepwater significant wave prediction curves as functions of windspeed, fetch length, and wind duration.

FIGURE 12

Lake Almanor Shoreline Erosion Study

January 2002

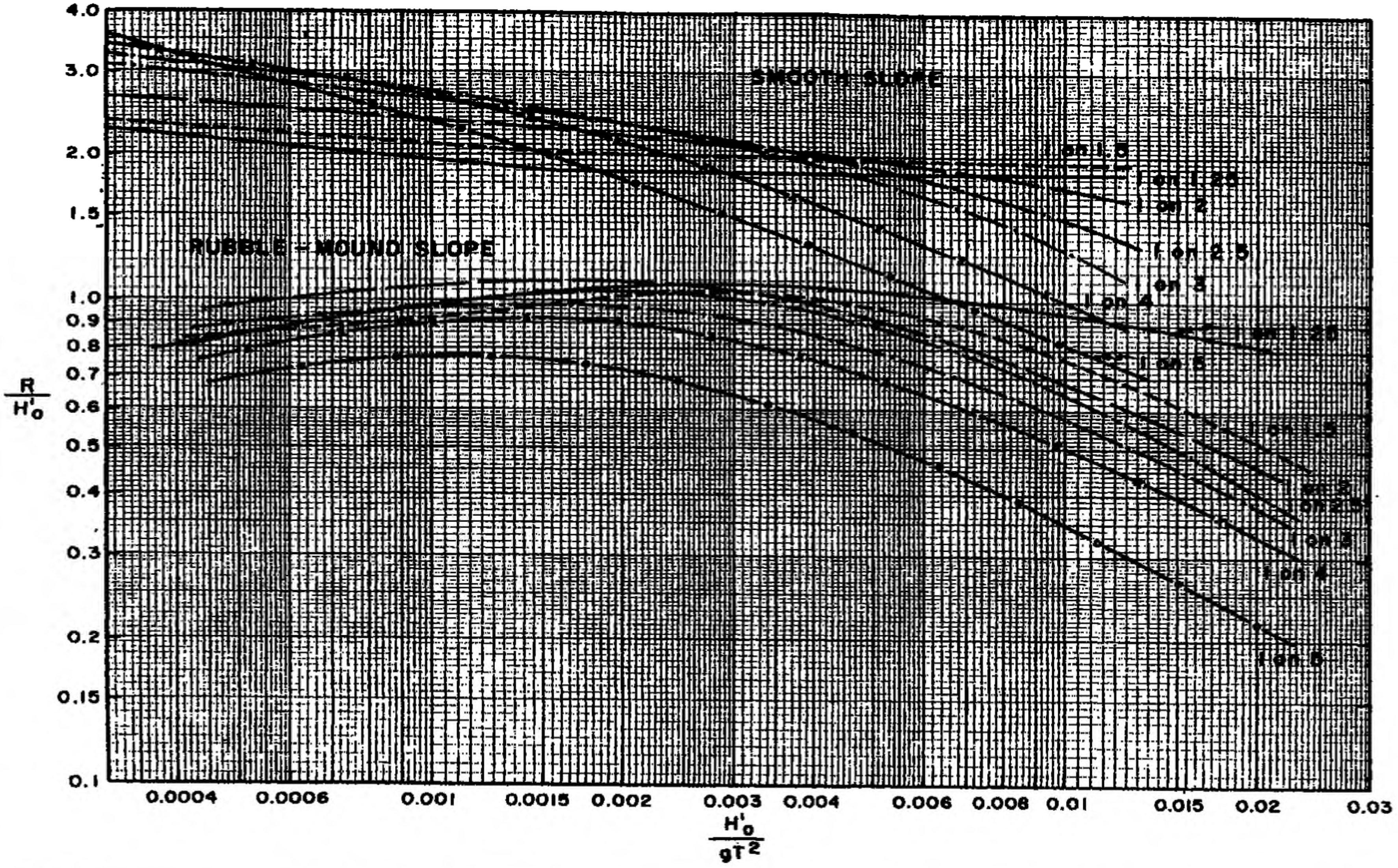


Definition Sketch: wave runup and overtopping

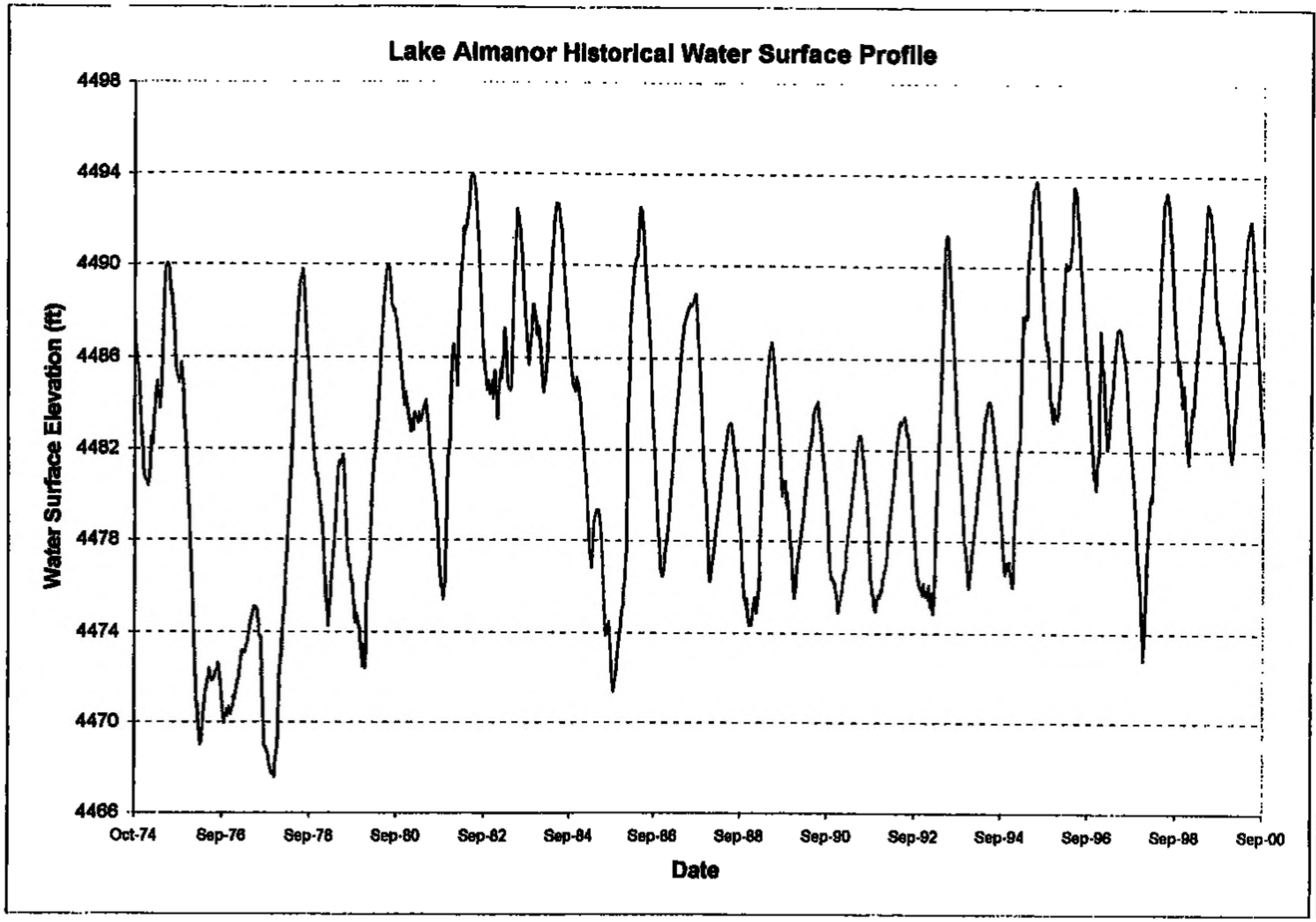
FIGURE 13

Lake Almanor Shoreline Erosion Study

January 2002



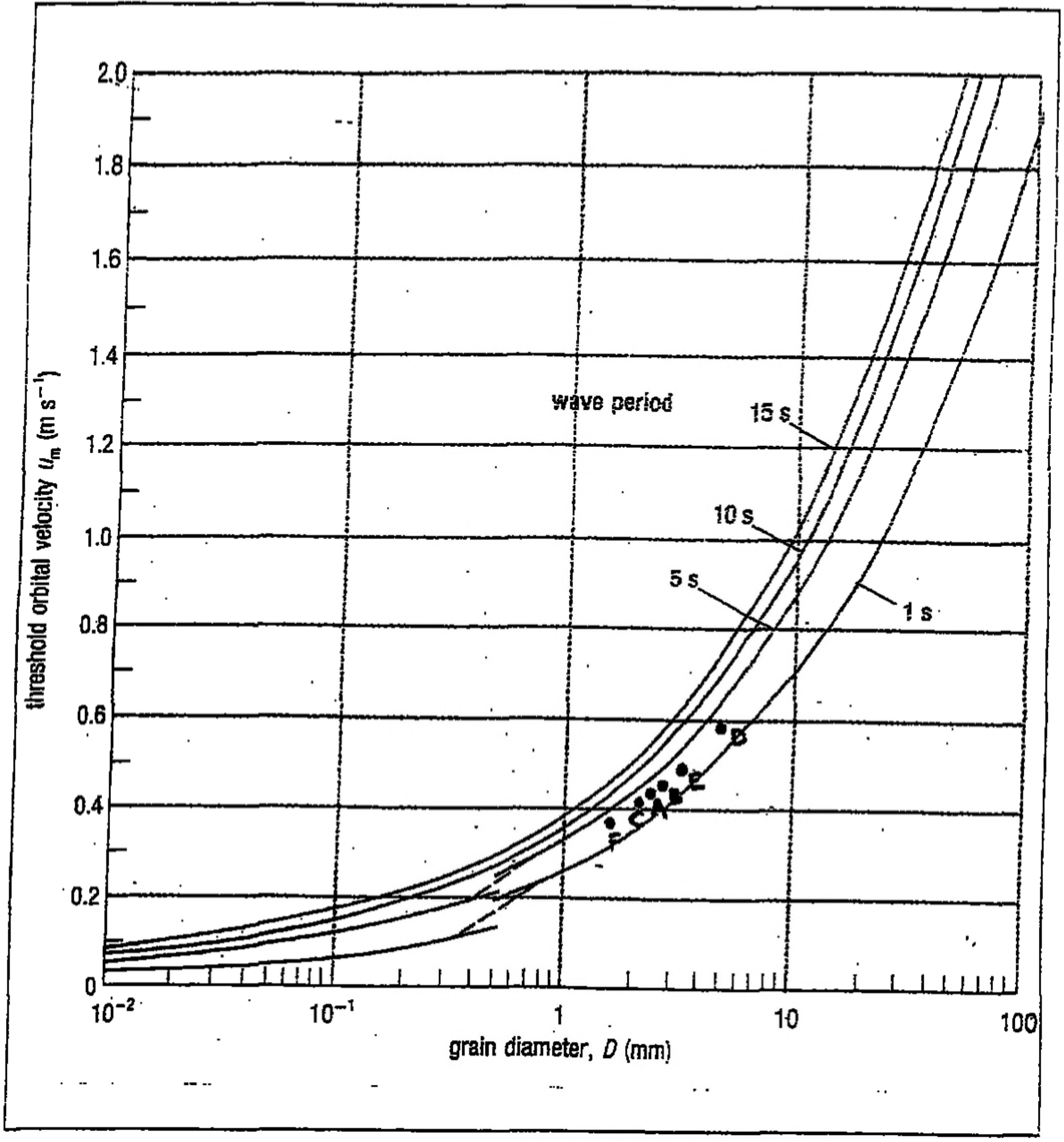
Nomograms for comparison of wave runup on smooth slopes with runup on permeable slopes.	FIGURE 14
Lake Almanor Shoreline Erosion Study	January 2002



# of Readings	Water Year	Yearly Avg. (ft)	# of days water level equal to or above 4490'
365	1975	4485.0	2
366	*1976*	4474.6	0
365	1977	4472.3	0
365	1978	4478.5	0
365	1979	4478.9	0
366	*1980*	4481.7	0
365	1981	4482.8	0
365	1982	4487.2	151
365	1983	4486.8	68
366	*1984*	4488.4	103
365	1985	4479.6	0
365	1986	4482.9	83
365	1987	4483.1	0
366	*1988*	4480.8	0
365	1989	4479.9	0
365	1990	4480.2	0
365	1991	4478.5	0
366	*1992*	4479.3	0
365	1993	4481.3	41
365	1994	4480.5	0
365	1995	4485.1	112
366	*1996*	4487.8	120
365	1997	4484.2	0
365	1998	4483.5	93
365	1999	4487.0	82
366	*2000*	4486.6	75
9497	26	4482.2	930
		Probability (%)	**9.8**

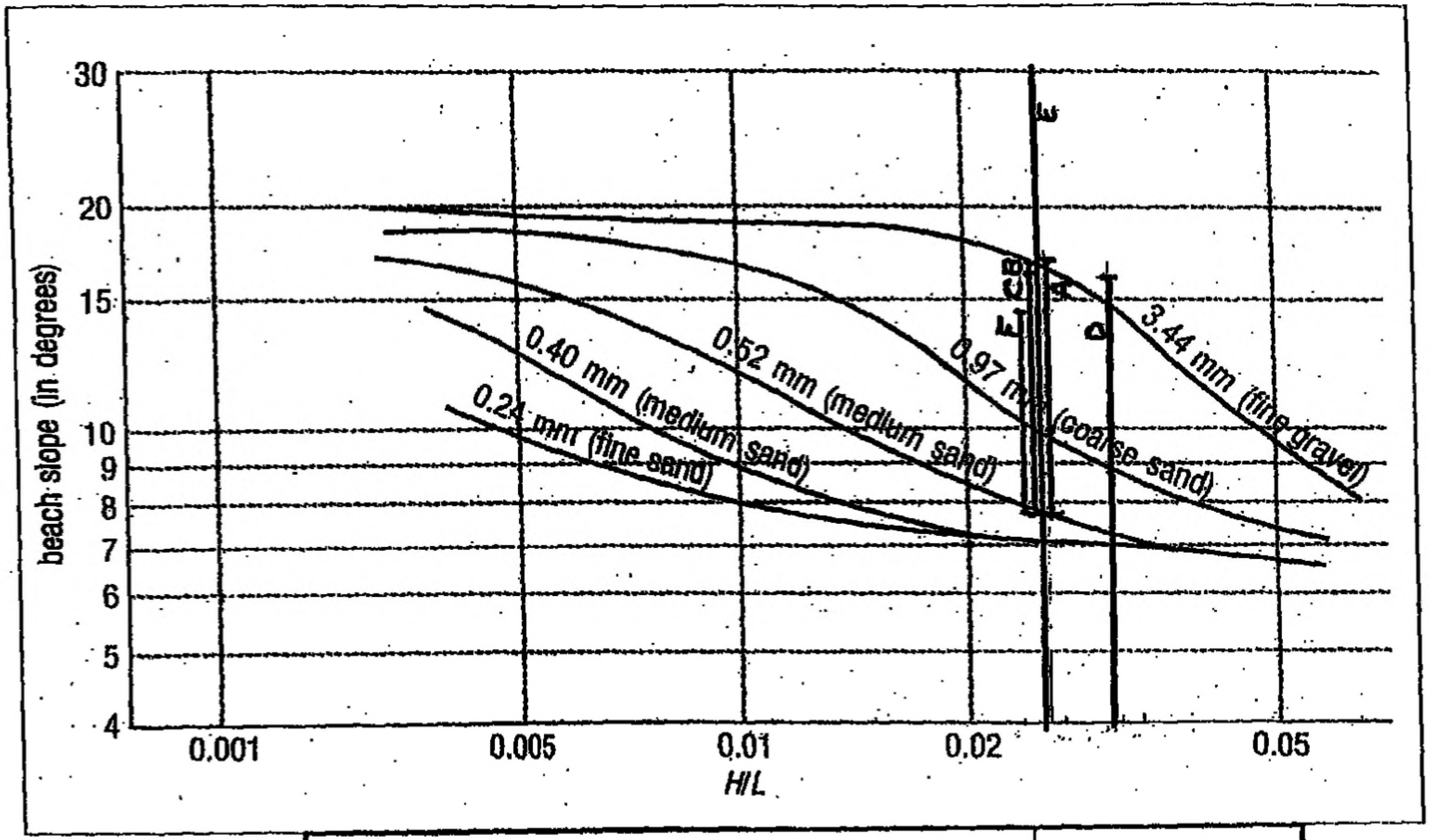
Historical Water Surface Elevation Analysis	**FIGURE 15**
Lake Almanor Shoreline Erosion Study	January 2002

Distribution for Lake Almanor: shores A,B,C,D,E, and F are shown.



The Relationship between near-bed maximum orbital velocity and sediment movement under waves of different periods.	FIGURE 16
Lake Almanor Shoreline Erosion Study	January 2002

Distribution for Lake Almanor: shores A,B,C,D,E



The Relationship between beach slope, wave steepness, and average grain size.

Lake Almanor Shoreline Erosion Study

FIGURE 17

January 2002

TABLES

Table 1 Summary of 1974 and 2000 Shoreline Erosion Index

Shore*	Total Region Length (mi)	Shoreline Erosion Index 1974 ϕ	Shoreline Erosion Index 2000 ϕ
A West	2.3	35	36
A East	4.2	43	31
B	3.1	43	24
C	3.8	55	6
D	4.0	58	32
E	1.7	89	82
F	5.5	17	-
G	2.7	15	-
H	3.7	13	-
I	5.4	0	-
J	8.1	0	-
K	9.7	19	-
L	3.6	24	-
	57.6		

Change in Shoreline Erosion Index: **24.0** (%) reduction (Regions A through E)

Notes:

* as per 'Figure 14' - PG&E Records, Correspondence,Documents - Dames and Moore Report of 12/12/74; Shore regions A-West and A-East are separated by Bunnel Point at the tip of Almanor Peninsula.

ϕ Shoreline Erosion Index calculated using Index values: A=100, B=30, C=0.

Distribution of hourly wind occurences at Chester

***(zero and null intensities removed)**

	Total	Direction							
		N	NE	E	SE	S	SW	W	NW
Angle =	360°	338°-22°	23°-67°	68°-112°	113°-157°	158°-202°	203°-247°	248°-292°	293°-337°
# occurences =	33869	2380	1279	2477	5238	3311	2497	3821	12866
Percentage =	100%	7.0%	3.8%	7.3%	15.5%	9.8%	7.4%	11.3%	38.0%
Velocity =	0.1-5	1921	790	1411	4146	1794	1249	1823	9886
Velocity =	6-10	312	357	868	1044	1150	897	1590	2910
Velocity =	11-20	34	129	197	48	366	349	408	70
Velocity =	21-30	0	2	1	0	1	2	0	0
Velocity =	>30	*113*#	*1*#	0	0	0	0	0	0
U_{10} max (mph) =	-	17	22	21	16	21	22	18	17
U_{10} sig (mph) =	-	6.0	9.6	9.1	6.4	9.8	10.5	10.0	6.1

 # : Anomalous intensities not factored into significant U_{10} calculations

Lake Almanor Wind Distribution	**Table 2**
Lake Almanor Shoreline Erosion Study	January 2002

Table 3 Summary of Wind Wave Hindcast

Shore*	Total Change in Erosion Index Length per Region (ft)	Percent Change Per Region	Longest Fetch Angle (°)	F Fetch Length (Miles)	Wind Direction	$S_{average}$ Bank Slope (%)	$U_{10\ max}$ Maximum Wind Velocity at 10m (mph)	$U_{10\ max}$ Probability of Exceedence$ (%)	H_{max} Wave Height (ft)
A West	0	0.0	290	5.0	W	35	18.0	0.15	1.39
A East	0	0.0	148	5.8	SE	10	16.0	0.02	1.29
B	0	0.0	163	7.0	S	15	21.0	0.05	1.98
C	0	0.0	178	6.2	S	20	21.0	0.05	1.87
D	0	0.0	266	5.1	W	30	18.0	0.15	1.39
E	0	0.0	300	10.0	NW	50	17.0	0.01	1.83
F			355	6.0	N	25	17.0	0.06	1.42
G			337	8.5	NW	25	15.0	0.01	1.69
H			102	6.2	E	25	17.0	0.05	1.87
I			36	4.9	NE	5	22.0	0.15	1.75
J			139	8.9	SE	5	16.0	0.02	1.60
K			157	7.8	SE	5	17.0	0.02	1.50
L			251	4.6	W	20	17.0	0.15	1.33

Notes:

* as per 'figure 14' - PG&E Records, Correspondence, Documents - Dames and Moore Report of 12/12/74; Shore regions A-West and A-East are separated by Bunnel Point at the tip of Almanor Peninsula.

$ Probability of exceedence calculated from 5 year wind record at Chester.

Table 4 Summary of Wave Run-up Analysis

Shore*	S_{max} Maximum Bank Slope (%)	$S_{average}$ Bank Slope (%)	H_{max} Wave Height (ft)	R Maximum Smooth Slope Run-Up# (ft)	R Maximum Rubble Slope Run-Up# (ft)
A West	50	35	1.39	2.64	1.20
A East	35	10	1.29	2.19	0.95
B	40	15	1.98	3.47	1.62
C	28	20	1.87	2.62	1.23
D	56	30	1.39	2.64	1.20
E	56	50	1.83	3.57	1.65
F	25	25	1.42	1.85	0.91
G	25	25	1.69	2.28	1.45
H	25	25	1.87	2.34	1.16
I	5	5	1.75	0.32	0.18
J	5	5	1.60	0.32	0.16
K	5	5	1.50	0.30	0.15
L	20	20	1.33	1.40	0.82

Notes:

* as per 'Figure 14' - PG&E Records, Correspondence,Documents - Dames and Moore Report of 12/12/74; Shore regions A-West and A-East are separated by Bunnel Point at the tip of Almanor Peninsula.

Run-up values calculated using R/H coefficients from Figure 7-20 in the Shore Protection Manual.

Shore*	Bank Slope$_{max}$ (%)	tan β	H_{max} (ft)	T (sec)	L_o (ft)	H_o/L_o	H_b (ft)	Surf Similarity Parameter Σ_b	Surf Similarity Domain[1]	Surf Scaling Parameter ζ	Surf Scaling Domain[2]
A-west	50	0.5	1.39	2.62	35.20	0.039	1.49	2.43	reflective	0.53	reflective
A-east	35	0.35	1.29	2.62	35.20	0.037	1.41	1.75	reflective	1.02	reflective
B	40	0.4	1.98	3.12	49.91	0.040	2.13	1.94	reflective	0.84	reflective
C	28	0.28	1.87	3.00	46.15	0.041	2.00	1.35	reflective	1.73	reflective
D	56	0.56	1.39	2.63	35.47	0.039	1.50	2.73	reflective	0.42	reflective
E	56	0.56	1.83	3.23	53.49	0.034	2.02	2.88	reflective	0.38	reflective
F	25	0.25	1.42	2.73	38.21	0.037	1.54	1.24	reflective	2.03	reflective
G	40	0.4	1.69	3.06	48.01	0.035	1.86	2.03	reflective	0.76	reflective
H	25	0.25	1.87	3.00	46.15	0.041	2.00	1.20	reflective	2.18	reflective
I	5	0.05	1.75	2.82	40.78	0.043	1.85	0.23	intermediate	56.97	dissipative
J	5	0.05	1.6	3.03	47.07	0.034	1.77	0.26	intermediate	47.27	dissipative
K	5	0.05	1.5	2.89	42.82	0.035	1.65	0.25	intermediate	48.42	dissipative
L	25	0.25	1.33	2.55	33.34	0.040	1.43	1.21	reflective	2.15	reflective

1 - Surf Similarity Domain: Reflective = $\Sigma_b > 1.0$, Intermediate = 1.0 - 0.23, Dissipative = $\Sigma_b < 0.23$

2 - Surf Scaling Domain: Reflective = 0.1 - 2.5, Intermediate = 2.5 - 20, Dissipative = 20 - 200

*as per 'figure 14' - PG&E Records,'Correspondence,Documents - Dames and Moore Report of 12/12/74, Shore regions A-west and A-east are separated by Bunnel Point at the tip of Almanor Penninsula.

MORPHODYNAMIC ANALYSIS	Table 5
Lake Almanor Shoreline Erosion Study	January 2002

Shore*	Bank Slope$_{avg}$ (%)	tan β	H_{sig} (ft)	T (sec)	L_o (ft)	H_o/L_o	H_b (ft)	Surf Similarity Parameter Σ_b	Surf Similarity Domain^1	Surf Scaling Parameter ζ	Surf Scaling Domain^2
A-west	34	0.34	0.67	2.06	21.76	0.031	0.76	1.82	reflective	0.94	reflective
A-east	7	0.07	0.42	1.80	16.61	0.025	0.49	0.41	intermediate	19.03	intermediate
B	11	0.11	0.77	2.28	26.65	0.029	0.88	0.61	intermediate	8.57	intermediate
C	17	0.17	0.73	2.20	24.82	0.029	0.83	0.93	intermediate	3.64	intermediate
D	27	0.27	0.68	2.07	21.97	0.031	0.77	1.44	reflective	1.50	reflective
E	48	0.48	0.52	2.12	23.04	0.023	0.62	2.91	reflective	0.37	reflective
F	17	0.17	0.39	1.78	16.25	0.024	0.46	1.01	reflective	3.10	intermediate
G	17	0.17	0.48	2.01	20.72	0.023	0.57	1.02	reflective	3.01	intermediate
H	17	0.17	0.67	2.13	23.26	0.029	0.77	0.94	intermediate	3.58	intermediate
I	2	0.02	0.63	2.01	20.72	0.030	0.71	0.11	dissipative	270.28	dissipative
J	2	0.02	0.52	2.08	22.18	0.023	0.62	0.12	dissipative	219.46	dissipative
K	2	0.02	0.48	1.99	20.30	0.024	0.57	0.12	dissipative	220.95	dissipative
L	15	0.15	0.65	2.01	20.72	0.031	0.73	0.80	intermediate	4.93	intermediate

1 - Surf Similarity Domain: Reflective = $\Sigma_b > 1.0$, Intermediate = 1.0 - 0.23, Dissipative = $\Sigma_b < 0.23$

2 - Surf Scaling Domain: Reflective = 0.1 - 2.5, Intermediate = 2.5 - 20, Dissipative = 20 - 200

*as per 'figure 14' - PG&E Records, Correspondence,Documents - Dames and Moore Report of 12/12/74, Shore regions A-west and A-east are separated by Bunnel Point at the tip of Almanor Penninsula.

MORPHODYNAMIC ANALYSIS	**Table 6**
Lake Almanor Shoreline Erosion Study	January 2002

Shore*	Total Region Length (mi)	Actively Eroding Shoreline[ϕ] (mi)	Unprotected Actively Eroding Shoreline (mi)	Percent of Actively Eroding Shoreline Length Unprotected (%)
A West	2.3	0.39	0.39	100
A East	4.2	0.46	0.33	72
B	3.1	0.62	0.41	66
C	3.8	0.21	0.21	100
D	4.0	1.23	1.15	93
E	1.7	1.33	1.33	100
	19.0	4.24	3.82	90

Notes:

* as per 'figure 14' - PG&E Records, Correspondence,Documents - Dames and Moore Report of 12/12/74; Shore regions A-west and A-East are separated by Bunnel Point at the tip of Almanor Penninsula.

ϕ Actively Eroding Shoreline as classified Index 'A' in 2000 boat survey.

Summary of Significantly Eroding Unprotected Shoreline	**Table 7**
Lake Almanor Shoreline Erosion Study	January 2002

APPENDIX A

SHORELINE EROSION ANALYSIS SUMMARY

Shoreline Region A-West

Shoreline Length (meters)	Shoreline Length (feet)	Degree of Erosion 1974	Damage Potential 1974	Degree of Erosion 2000	Damage Potential 2000	slope1 2000 (%)	slope2 2000 (degrees)	Erosion Multiplier 1974	Effective Erosion Length 1974 (ft)	Erosion Multiplier 2000	Effective Erosion Length 2000 (ft)	Change in Effective Erosion Length
343.78	1127.95	ab	5	B	5	50	45	0.65	733.2	0.3	338.4	394.8
316.25	1037.63	ab	5	B	3	45	41	0.65	674.5	0.3	311.3	363.2
257.49	844.83	b	3	B	3	45	41	0.3	253.4	0.3	253.4	0.0
115.66	379.48	b	3	C	5	50	45	0.3	113.8	0	0.0	113.8
145.76	478.25	b	4	C	5	50	45	0.3	143.5	0	0.0	143.5
194.80	639.14	b	4	B	3	15	14	0.3	191.7	0.3	191.7	0.0
427.40	1402.29	b	4	C	5	25	23	0.3	420.7	0	0.0	420.7
482.05	1581.61	b	4	B	3	45	41	0.3	474.5	0.3	474.5	0.0
438.38	1438.34	b	4	A	3	30	27	0.3	431.5	1	1438.3	-1006.8
475.06	1558.69	b	4	B	4	25	23	0.3	467.6	0.3	467.6	0.0
127.28	417.61	b	4	A	3	40	36	0.3	125.3	1	417.6	-292.3
68.33	224.20	b	3	A	3	40	36	0.3	67.3	1	224.2	-156.9
139.96	459.20	b	3	B	4	10	9	0.3	137.8	0.3	137.8	0.0
172.84	567.10	c	9	B	4	10	9	0	0.0	0.3	170.1	-170.1
Σ = 3705	12156								4234.7		4425.0	-190.3

Total Lengths		1974	2000	(mi)
a	A	0	2080	0.39
ab	AB	2166	0	0.00
b	B	9424	7816	1.48
bc	BC	0	0	0.00
c	C	567	2260	0.43
		12156	12156	2.30

Shoreline Erosion Analysis Summary	FIGURE A-1
Lake Almanor Shoreline Erosion Study	January 2002

Shoreline Region A-East

Shoreline Length (meters)	Shoreline Length (feet)	Degree of Erosion 1974	Damage Potential 1974	Degree of Erosion 2000	Damage Potential 2000	slope1 2000 (%)	slope2 2000 (degrees)	Erosion Multiplier 1974	Effective Erosion Length 1974 (ft)	Erosion Multiplier 2000	Effective Erosion Length 2000 (ft)	Change in Effective Erosion Length
2109.40	6920.94	c	9	B	5	5	5	0	0.0	0.3	2076.3	-2076.3
64.92	213.00	b	3	B	5	5	5	0.3	63.9	0.3	63.9	0.0
1360.30	4463.15	b	4	B	5	5	5	0.3	1338.9	0.3	1338.9	0.0
103.29	338.90	a	3	B	5	5	5	1	338.9	0.3	101.7	237.2
158.74	520.81	a	4	B	5	5	5	1	520.8	0.3	156.2	364.6
77.83	255.35	a	3	B	5	5	5	1	255.4	0.3	76.6	178.7
58.64	192.41	b	4	A	5	10	9	0.3	57.7	1.0	192.4	-134.7
163.98	538.01	b	4	C	5	3	3	0.3	161.4	0.0	0.0	161.4
46.59	152.87	b	4	B	5	5	5	0.3	45.9	0.3	45.9	0.0
362.35	1188.88	b	4	B	5	5	5	0.3	356.7	0.3	356.7	0.0
101.24	332.16	b	4	A	5	5	5	0.3	99.6	1.0	332.2	-232.5
90.48	296.87	a	3	B	5	5	5	1	296.9	0.3	89.1	207.8
34.66	113.74	b	4	B	5	5	5	0.3	34.1	0.3	34.1	0.0
76.75	251.80	a	3	A	5	5	5	1	251.8	1.0	251.8	0.0
105.00	344.49	b	4	A	5	5	5	0.3	103.3	1.0	344.5	-241.1
141.59	464.57	b	4	C	4	5	5	0.3	139.4	0.0	0.0	139.4
37.39	122.68	a	3	C	4	5	5	1	122.7	0.0	0.0	122.7
44.63	146.42	a	3	A	5	5	5	1	146.4	1.0	146.4	0.0
43.39	142.37	a	3	C	5	5	5	1	142.4	0.0	0.0	142.4
356.71	1170.38	a	4	C	5	5	5	1	1170.4	0.0	0.0	1170.4
23.12	75.85	a	1	C	5	5	5	1	75.9	0.0	0.0	75.9
47.97	157.38	a	1	A	5	5	5	1	157.4	1.0	157.4	0.0
43.73	143.47	a	5	B	4	5	5	1	143.5	0.3	43.0	100.4
119.71	392.77	a	5	A	5	30	27	1	392.8	1.0	392.8	0.0
45.95	150.76	a	1	A	5	30	27	1	150.8	1.0	150.8	0.0
44.03	144.45	a	1	C	4	30	27	1	144.4	0.0	0.0	144.4
29.80	97.78	a	1	C	4	30	27	1	97.8	0.0	0.0	97.8
49.23	161.53	a	1	A	5	30	27	1	161.5	1.0	161.5	0.0
92.07	302.08	a	1	C	4	25	23	1	302.1	0.0	0.0	302.1
35.33	115.93	a	1	A	5	35	32	1	115.9	1.0	115.9	0.0
125.24	410.91	a	1	C	4	10	9	1	410.9	0.0	0.0	410.9
212.07	695.82	a	3	C	4	10	9	1	695.8	0.0	0.0	695.8
61.05	200.31	a	3	A	5	8	7	1	200.3	1.0	200.3	0.0
58.26	191.15	b	4	C	4	6	5	0.3	57.3	0.0	0.0	57.3
146.58	480.94	a	5	C	4	6	5	1	480.9	0.0	0.0	480.9
84.36	276.77	a	3	C	4	6	5	1	276.8	0.0	0.0	276.8
Σ = 6756	22168								9510.7		6828.4	2682.3

Total Lengths		D&M	2000	(mi)
a	A	7052	2446	0.46
ab	AB	0	0	0.00
b	B	8194	14608	2.77
bc	BC	0	0	0.00
c	C	6921	5114	0.97
		22168	22168	4.20

Shoreline Erosion Analysis Summary	**FIGURE A-2**
Lake Almanor Shoreline Erosion Study	January 2002

Shoreline Region B

Shoreline Length (meters)	Shoreline Length (feet)	Degree of Erosion 1974	Damage Potential 1974	Degree of Erosion 2000	Damage Potential 2000	slope1 2000 (%)	slope2 2000 (degrees)	Erosion Multiplier 1974	Effective Erosion Length 1974 (ft)	Erosion Multiplier 2000	Effective Erosion Length 2000 (ft)	Change in Effective Erosion Length
129.91	426.24	b	4	C	4	6	5	0.3	127.9	0	0.0	127.9
59.67	195.78	b	3	C	4	6	5	0.3	58.7	0	0.0	58.7
43.25	141.89	b	3	A	5	20	18	0.3	42.6	1	141.9	-99.3
111.71	366.51	x	9	C	4	25	23	unknown	unknown	0	0.0	unknown
97.76	320.77	x	9	A	5	40	36	unknown	unknown	1	320.8	unknown
223.66	733.84	x	9	C	4	25	23	unknown	unknown	0	0.0	unknown
49.96	163.92	x	9	A	5	15	14	unknown	unknown	1	163.9	unknown
27.55	90.39	x	9	C	4	5	5	unknown	unknown	0	0.0	unknown
29.75	97.60	x	9	A	5	5	5	unknown	unknown	1	97.6	unknown
39.18	128.54	x	9	C	4	5	5	unknown	unknown	0	0.0	unknown
46.28	151.85	x	9	A	5	5	5	unknown	unknown	1	151.9	unknown
62.60	205.39	x	9	A	5	10	9	unknown	unknown	1	205.4	unknown
119.70	392.74	a	1	A	5	10	9	1	392.7	1	392.7	0.0
169.02	554.55	a	1	C	4	5	5	1	554.6	0	0.0	554.6
147.41	483.64	c	9	C	4	5	5	0	0.0	0	0.0	0.0
977.45	3207.01	b	4	C	4	5	5	0.3	962.1	0	0.0	962.1
90.24	296.08	b	4	A	5	45	41	0.3	88.8	1	296.1	-207.3
76.42	250.73	b	4	C	4	40	36	0.3	75.2	0	0.0	75.2
109.21	358.33	a	13	C	4	40	36	1	358.3	0	0.0	358.3
63.82	209.40	a	13	B	5	3	3	1	209.4	0.3	62.8	146.6
63.93	209.76	a	13	B	5	3	3	1	209.8	0.3	62.9	146.8
79.04	259.35	c	9	B	5	3	3	0	0.0	0.3	77.8	-77.8
117.47	385.43	c	9	C	4	3	3	0	0.0	0	0.0	0.0
251.48	825.12	a	3	C	4	3	3	1	825.1	0	0.0	825.1
134.94	442.75	c	9	B	5	5	5	0	0.0	0.3	132.8	-132.8
260.78	855.63	b	4	B	5	5	5	0.3	256.7	0.3	256.7	0.0
260.79	855.64	x	9	C	4	1	1	unknown	unknown	0	0.0	unknown
339.72	1114.62	a	3	C	4	1	1	1	1114.6	0	0.0	1114.6
119.52	392.15	a	3	A	5	20	18	1	392.2	1	392.2	0.0
130.39	427.82	ab	4	A	5	20	18	0.65	278.1	1	427.8	-149.7
305.35	1001.84	ab	4	C	4	20	18	0.65	651.2	0	0.0	651.2
204.33	670.40	ab	4	A	5	20	18	0.65	435.8	1	670.4	-234.6
Σ = 4942	16216								7033.7		3853.7	4119.6

Total Lengths		D&M	2000	(mi)
a	A	4057	3261	0.62
ab	AB	2100	0	0.00
b	B	5373	1977	0.37
bc	BC	0	0	0.00
c	C	1571	10978	2.08
x	x	3114	0	0.00
		16216	16216	3.07

Shoreline Erosion Analysis Summary	FIGURE A-3
Lake Almanor Shoreline Erosion Study	January 2002

Shoreline Region C

Shoreline Length (meters)	Shoreline Length (feet)	Degree of Erosion 1974	Damage Potential 1974	Degree of Erosion 2000	Damage Potential 2000	slope1 2000 (%)	slope2 2000 (degrees)	Erosion Multiplier 1974	Effective Erosion Length 1974 (ft)	Erosion Multiplier 2000	Effective Erosion Length 2000 (ft)	Change in Effective Erosion Length
1497.66	4913.83	ab	4	C	4	17	15	0.65	3194.0	0	0.0	3194.0
263.16	863.41	b	4	C	4	17	15	0.3	259.0	0	0.0	259.0
201.48	661.06	b	4	C	4	11	10	0.3	198.3	0	0.0	198.3
664.36	2179.75	b	4	C	4	17	15	0.3	653.9	0	0.0	653.9
302.60	992.82	ab	4	C	4	17	15	0.65	645.3	0	0.0	645.3
1171.59	3844.00	ab	4	C	4	17	15	0.65	2498.6	0	0.0	2498.6
233.15	764.97	ab	4	C	4	17	15	0.65	497.2	0	0.0	497.2
71.87	235.81	ab	4	C	4	11	10	0.65	153.3	0	0.0	153.3
181.54	595.63	c	9	C	4	11	10	0	0.0	0	0.0	0.0
203.18	666.64	c	9	C	4	28	25	0	0.0	0	0.0	0.0
206.66	678.06	a	2	C	4	28	25	1	678.1	0	0.0	678.1
42.60	139.76	a	2	C	4	11	10	1	139.8	0	0.0	139.8
403.46	1323.76	c	9	C	4	11	10	0	0.0	0	0.0	0.0
254.28	834.29	a	34	C	4	11	10	1	834.3	0	0.0	834.3
193.45	634.71	a	34	A	4	17	15	1	634.7	1	634.7	0.0
52.68	172.83	a	34	A	4	17	15	1	172.8	1	172.8	0.0
91.93	301.62	a	3	A	4	17	15	1	301.6	1	301.6	0.0
79.10	259.52	a	3	C	4	17	15	1	259.5	0	0.0	259.5
Σ = 6115	20063								11120.5		1109.2	10011.3

Total Lengths		D&M	2000	(mi)
a	A	3021	1109	0.21
ab	AB	10751	0	0.00
b	B	3704	0	0.00
bc	BC	0	0	0.00
c	C	2586	18953	3.59
		20063	20063	3.80

Shoreline Erosion Analysis Summary	FIGURE A-4
Lake Almanor Shoreline Erosion Study	January 2002

Shoreline Region D

Shoreline Length (meters)	Shoreline Length (feet)	Degree of Erosion 1974	Damage Potential 1974	Degree of Erosion 2000	Damage Potential 2000	slope1 2000 (%)	slope2 2000 (degrees)	Erosion Multiplier 1974	Effective Erosion Length 1974 (ft)	Erosion Multiplier 2000	Effective Erosion Length 2000 (ft)	Change in Effective Erosion Length
349.09	1145.37	b	4	C	4	17	15	0.3	343.6	0	0.0	343.6
29.27	96.04	a	3	C	4	17	15	1	96.0	0	0.0	96.0
201.82	662.16	a	3	A	3	17	15	1	662.2	1	662.2	0.0
107.56	352.90	a	3	C	4	11	10	1	352.9	0	0.0	352.9
42.98	141.01	a	3	B	3	17	15	1	141.0	0.3	42.3	98.7
52.26	171.47	c	9	B	3	17	15	0	0.0	0.3	51.4	-51.4
345.38	1133.18	c	9	C	4	11	10	0	0.0	0	0.0	0.0
393.62	1291.48	b	3	C	4	11	10	0.3	387.4	0	0.0	387.4
51.56	169.17	b	3	A	3	56	50	0.3	50.8	1	169.2	-118.4
79.81	261.86	a	3	C	4	56	50	1	261.9	0	0.0	261.9
57.76	189.50	a	3	A	3	44	40	1	189.5	1	189.5	0.0
190.59	625.32	a	3	C	4	11	10	1	625.3	0	0.0	625.3
67.12	220.23	a	3	C	4	44	40	1	220.2	0	0.0	220.2
173.47	569.15	a	2	C	4	44	40	1	569.2	0	0.0	569.2
243.69	799.54	a	2	A	3	44	40	1	799.5	1	799.5	0.0
78.70	258.21	b	3	A	3	44	40	0.3	77.5	1	258.2	-180.7
277.18	909.42	b	3	C	4	11	10	0.3	272.8	0	0.0	272.8
39.65	130.09	b	3	C	4	56	50	0.3	39.0	0	0.0	39.0
150.06	492.34	ab	3	C	4	56	50	0.65	320.0	0	0.0	320.0
147.60	484.27	ab	3	A	3	56	50	0.65	314.8	1	484.3	-169.5
91.73	300.98	ab	3	C	4	17	15	0.65	195.6	0	0.0	195.6
261.92	859.37	b	3	C	4	17	15	0.3	257.8	0	0.0	257.8
39.91	130.95	bc	4	B	3	33	30	0.15	19.6	0.3	39.3	-19.6
110.26	361.77	bc	4	C	4	17	15	0.15	54.3	0	0.0	54.3
24.05	78.90	bc	4	B	3	33	30	0.15	11.8	0.3	23.7	-11.8
705.56	2314.93	bc	4	C	4	11	10	0.15	347.2	0	0.0	347.2
222.75	730.84	a	3	C	4	11	10	1	730.8	0	0.0	730.8
143.58	471.08	a	3	C	4	33	30	1	471.1	0	0.0	471.1
74.75	245.25	a	3	C	4	11	10	1	245.2	0	0.0	245.2
252.58	828.71	a	4	C	4	11	10	1	828.7	0	0.0	828.7
63.23	207.47	a	4	C	4	11	10	1	207.5	0	0.0	207.5
84.97	278.79	a	4	A	4	28	25	1	278.8	1	278.8	0.0
155.66	510.72	a	4	C	4	39	35	1	510.7	0	0.0	510.7
513.67	1685.37	a	4	A	4	50	45	1	1685.4	1	1685.4	0.0
596.30	1956.44	b	4	A	4	50	45	0.3	586.9	1	1956.4	-1369.5
Σ = 6420	21064								12155.2		6640.1	5515.1

Total Lengths		D&M	2000	(mi)
a	A	8876	6483	1.23
ab	AB	1278	0	0.00
b	B	6720	522	0.10
bc	BC	2887	0	0.00
c	C	1305	14059	2.66
		21064	21064	3.99

Shoreline Erosion Analysis Summary	**FIGURE A-5**
Lake Almanor Shoreline Erosion Study	January 2002

Shoreline Region E

	Shoreline Length (meters)	Shoreline Length (feet)	Degree of Erosion 1974	Damage Potential 1974	Degree of Erosion 2000	Damage Potential 2000	slope1 2000 (%)	slope2 2000 (degrees)	Erosion Multiplier 1974	Effective Erosion Length 1974 (ft)	Erosion Multiplier 2000	Effective Erosion Length 2000 (ft)	Change in Effective Erosion Length
	593.33	1946.73	a	2	A	4	50	45	1	1946.7	1	1946.7	0.0
	168.29	552.15	a	4	A	4	50	45	1	552.2	1	552.2	0.0
	169.43	555.89	a	3	A	4	50	45	1	555.9	1	555.9	0.0
	268.81	881.95	a	4	A	4	50	45	1	882.0	1	882.0	0.0
	81.98	268.98	a	4	C	5	50	45	1	269.0	0	0.0	269.0
	257.17	843.77	a	4	C	4	28	25	1	843.8	0	0.0	843.8
	506.99	1663.45	a	4	A	4	50	45	1	1663.4	1	1663.4	0.0
	33.57	110.14	a	5	A	4	50	45	1	110.1	1	110.1	0.0
	198.01	649.68	a	5	B	4	44	40	1	649.7	0.3	194.9	454.8
	72.28	237.15	a	5	A	5	56	50	1	237.1	1	237.1	0.0
	335.36	1100.32	bc	5	A	5	56	50	0.15	165.0	1	1100.3	-935.3
Σ =	2685	8810								7874.9		7242.7	632.3

Total Lengths		D&M	2000	(mi)
a	A	7710	7048	1.33
ab	AB	0	0	0.00
b	B	0	650	0.12
bc	BC	1100	0	0.00
c	C	0	1113	0.21
		8810	8810	1.67

Shoreline Erosion Analysis Summary	**FIGURE A-6**
Lake Almanor Shoreline Erosion Study	January 2002

UPPER NORTH FORK FEATHER RIVER PROJECT

FERC NO. 2105

Attachment E2-C

North Fork Feather River and Butt Creek Stream Network Temperature Models

NORTH FORK FEATHER RIVER and BUTT CREEK STREAM NETWORK TEMPERATURE MODELS

UPPER NORTH FORK FEATHER RIVER HYDROELECTRIC PROJECT

FERC PROJECT NO. 2105

Prepared for:

Pacific Gas & Electric Company
Technical and Ecological Services
3400 Crow Canyon Road
San Ramon, CA 94583

Prepared by:

Thomas R. Payne & Associates
P.O. Box 4678
890 L Street
Arcata, California 95521
(707) 822-8478

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NORTH FORK FEATHER RIVER and BUTT CREEK STREAM NETWORK TEMPERATURE MODELS
UPPER NORTH FORK FEATHER RIVER HYDROELECTRIC PROJECT
FERC PROJECT NO. 2105

EXECUTIVE SUMMARY

As part of relicensing the Upper North Fork Feather River Hydroelectric Project, FERC No. 2105, a stream temperature study was developed on two reaches of the upper North Fork of the Feather River (NFFR) and its tributary, Butt Creek, between Canyon Dam (Lake Almanor) and Belden Powerhouse using the computer model SNTEMP (Stream Network Temperature Model). For one of the two NFFR reaches, a temperature model previously developed by Woodward-Clyde Consultants (1986) (WCC) was updated and utilized in this study. The calibration and validation of the three reach models was based upon two years of hydrological and meteorological data (2000 & 2001). In the analysis, calibration of each temperature modeled reach utilizing one year of data was followed by validation testing of the calibrated model with the other year's data.

SNTEMP can be used to predict stream temperatures along a section of stream under variable conditions of flow, weather, channel configuration, and alternative structural flow release scenarios. This report documents the model construction from data collection, through development and calibration, to model validation. As a next step, this model as calibrated, is usable and appropriate as a tool in the evaluation of alternative project management scenarios for enhancement of fish populations.

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Introduction

The Upper North Fork Feather River (UNFFR) Hydroelectric Project (Federal Energy Regulatory Commission Project No. 2105) is located in Plumas County within the Plumas National Forest between Lake Almanor and the small town of Belden. The UNFFR Project is a vital part of Pacific Gas and Electric Company's North Fork Feather River hydropower system, where water released from storage, mainly from Lake Almanor, produces electricity through a series of nine powerhouses before reaching Lake Oroville (Figure 1). The current FERC license expires on October 31, 2004, and part of the relicensing effort requires that Pacific Gas and Electric Company perform a temperature analysis of the effect of the project operation on the aquatic resources of the UNFFR.

This study was performed on the UNFFR Project to assist with evaluation of potential alternatives in operations and flow releases in the by-passed stream reach. The process-oriented temperature model SNTEMP (Theurer et al., 1984) was used to predict water temperatures in this reach under various simulated flow regimes. Measurements of stream temperature, flow, geometry, and localized meteorology were utilized in the construction and calibration of the temperature model. This model has the benefit of being peer-reviewed, published, and widely applied. SNTEMP incorporates (1) a complete solar model that includes both topographic and riparian vegetation shade; (2) a meteorological correction model to account for the change in air temperature, relative humidity, and atmospheric pressure as a function of elevation; (3) a complete set of heat flux components to account for all significant heat sources; (4) a heat transport model to determine longitudinal water temperature changes; (5) regression models to smooth or complete data gaps by known water temperature data sets; (6) a flow mixing model at tributary junctions; and (7) calibration equations to help eliminate bias and reduce errors at calibration nodes (Theurer et al, 1984).

Following calibration and validation of these three stream reaches, the SNTEMP models, in conjunction with the reservoir models, which were developed for Lake Almanor and Butt Valley Reservoir (Bechtel 2002), provided a series of linkable tools to study temperature effects in UNFFR for various gaming scenarios. The gaming scenarios included a variety of flow management and structural intake modifications under a range of hydrological and meteorological conditions (PG&E, Draft Application for New License (DAL], 2002).

Upper North Fork Feather River Project

The UNFFR Project is composed of several reservoirs and powerhouse facilities that have been constructed and placed in operation throughout the last century. The system is operated in concert to maximize power generation from water stored in Lake Almanor (Figure 1). The normal maximum generation capacity for the entire project is

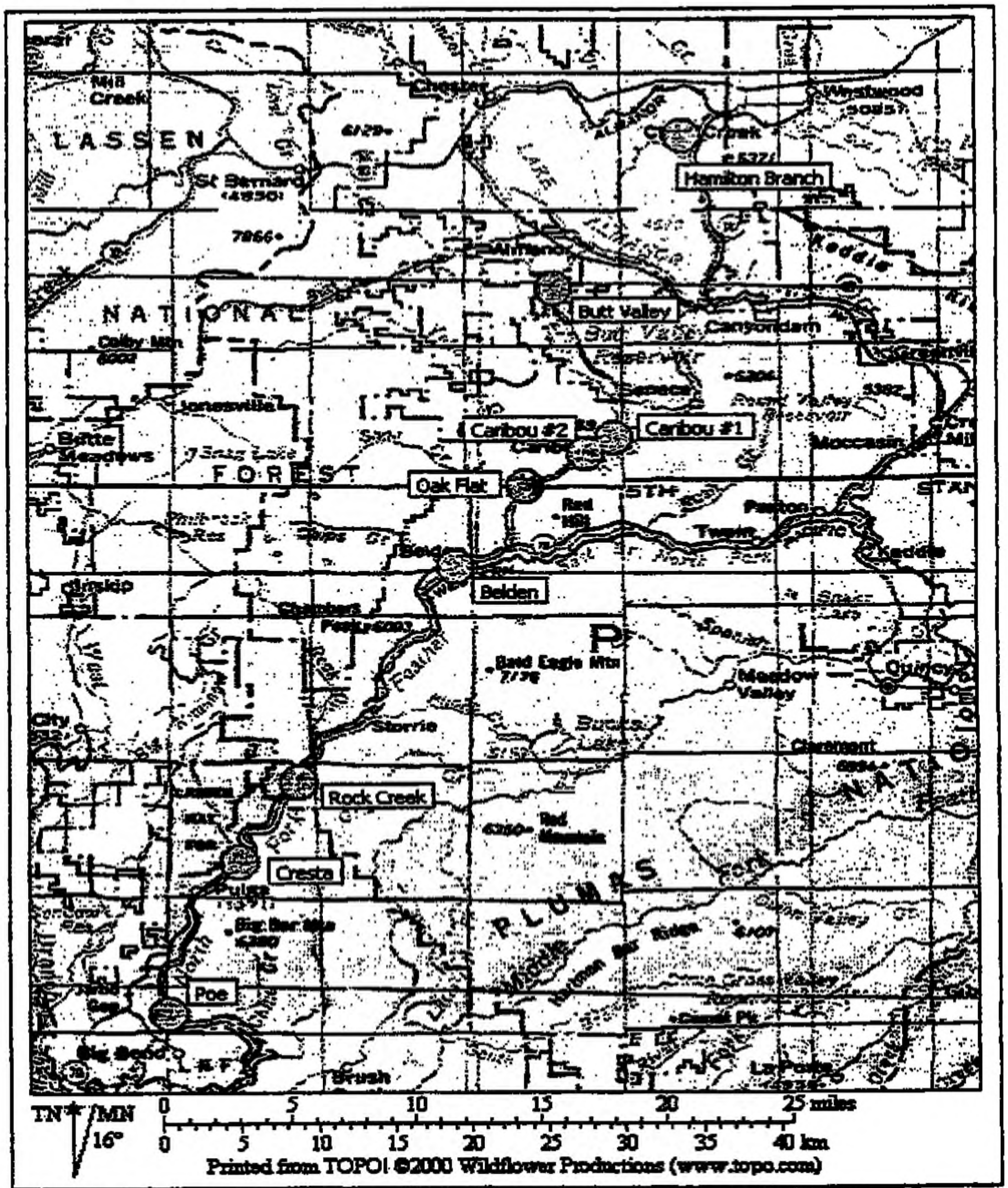

Figure 1. Pacific Gas and Electric Company's powerhouses on the North Fork Feather River system.

362.3 Megawatts (MW). Lake Almanor, originally formed by a dam completed in 1914 (and subsequently replaced in 1927 by Canyon Dam), is the main water storage facility for the UNFFR Project. Lake Almanor has a usable storage capacity of 1.13 million acre-feet (AF).

Water stored by the project flows from Lake Almanor via a tunnel and penstock (maximum capacity of 2,118 cubic feet per second [cfs]) to Butt Valley Powerhouse (41 megawatt [MW] capacity; completed in 1958) and into Butt Valley Reservoir, constructed on Butt Creek, a tributary of the UNFFR. From Butt Valley Reservoir (49,900 AF storage capacity) water is conveyed via tunnels and penstocks to the

Caribou 1 (75 MW; completed 1921) or Caribou 2 (120 MW; completed 1958) powerhouses, which have a combined flow capacity of 2,578 cfs. Water from the Caribou powerhouses is returned to the UNFFR at the Belden Forebay (2,400 AF storage capacity) at Oak Flat.

From the Belden Forebay, water flow up to 2,410 cfs is diverted through tunnels, siphons, and penstocks to the Belden Powerhouse (125 MW; completed 1969) where it is discharged into Rock Creek Reservoir (FERC Project No. 1962). Minimum flow releases to the UNFFR out of the Belden Forebay pass through the Oak Flat Powerhouse, a small energy recovery facility (1.3 MW; completed 1985).

The existing license specifies a minimum flow of 35 cfs released at all times into the UNFFR through Canyon Dam from Lake Almanor. Flow releases from Belden Forebay through Oak Flat powerhouse and into the UNFFR are specified to be 140 cfs from the last Saturday in April through Labor Day and 60 cfs for the remainder of the year. No flow releases are required from Butt Valley Dam into lower Butt Creek, although there is a small amount of leakage directly below the dam (about 0.1 to 2.0 cfs depending on the time of year). Another 12 to 14 cfs flows into Butt Creek from springs located between 0.2 to 0.4 miles below Butt Valley Dam.

The primary use of water within the UNFFR Project area is power generation. In addition, however, water releases serve to support recreation and fish and wildlife habitat. Flow from the UNFFR also serves municipal, industrial, and agricultural uses in the Sierra Nevada foothills and the Sacramento Valley (Aspen Environmental Group 2000).

Study Area and Reach Designation

The study area covered by the SNTEMP analysis is the section of the UNFFR between Canyon Dam and Belden Powerhouse, and includes the 2.0-mile long portion of lower Butt Creek below Butt Valley Dam (Figure 2). In relation to the multiple storage and generating facilities, the project area was divided into three discreet reaches:

Seneca Reach – The first study segment extends from Canyon Dam to just above the Caribou Powerhouse tailrace at the head of Belden Forebay. This 10.9 mile long segment of the UNFFR is referred to as the Seneca Reach because of the historic settlement town of the same name located in the approximate middle of the reach. Stream gradient varies between relatively low gradient to areas of moderately high gradient, with an average of 2.5% for the reach. Sources of tributary accretion flow within the Seneca Reach include Ohio, Salmon, Pliocene, Davis, Muggins, Clear, and Butt creeks. Butt Creek is the only significant contributor of tributary inflow in the summer and fall seasons into the Seneca Reach.

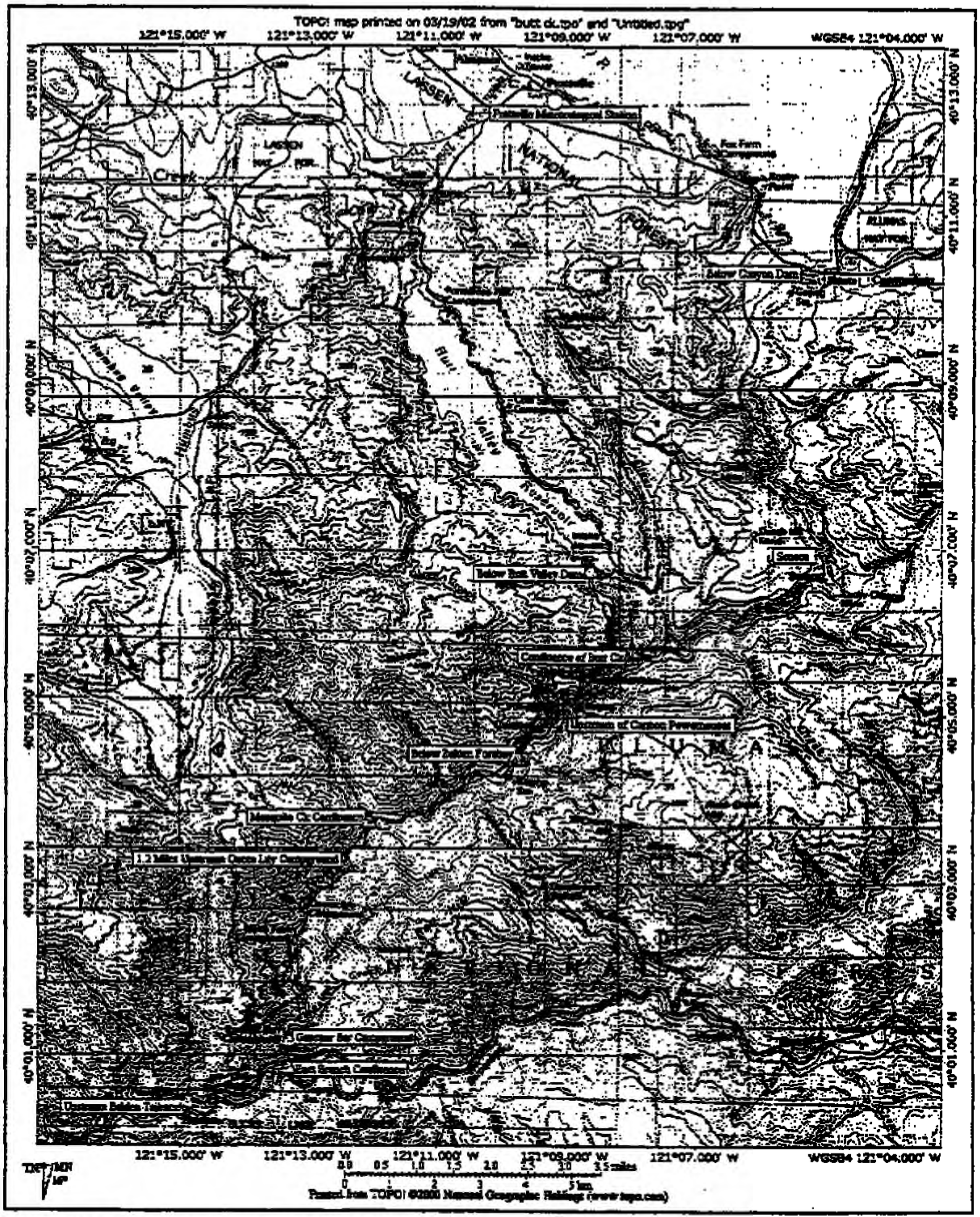

Figure 2. Locations in 2000 and 2001 of temperature sensors and meteorological station for the Upper North Fork Feather River Hydroelectric Project, FERC No. 2105, SNTEMP temperature model.

Butt Creek Reach – The Butt Creek Reach includes the two miles of lower Butt Creek from Butt Valley Dam downstream to the UNFFR confluence, which is located about 1.3 miles upstream of the Belden Forebay. This study reach has a much higher average stream gradient of 8.3%. Other than the springs located between 0.2 to 0.4 miles downstream of the Butt Valley Dam, there is no significant tributary (point source) accretion within this reach.

Belden Reach – The third study segment is the 8.8 mile long segment of the UNFFR between the Belden Forebay Dam and the Belden Powerhouse (Figure 1). This portion of the project study area has an average stream gradient of 1.3%. Mosquito Creek and the East Branch of the North Fork Feather River are sources of significant tributary accretion flow within the Belden Reach, with the East Branch contributing substantially more than Mosquito Creek.

SNTEMP Model Data Acquisition

Topographic and Vegetative Shade

Site-specific measurements of topographic shade angle and vegetative shade angle were taken from the middle of the stream, together with wetted stream width, distance from stream edge to shade producing vegetation, crown width and quantity, and vegetative shade quality using a foot candle meter. These values (Table 1) were used to construct the shade file module used within SNTEMP.

Meteorology

Hourly air temperature, relative humidity, wind speed and solar radiation values were primarily obtained from the meteorological station located near Canyon Dam at Prattville. With solar radiation, the calculated mean daily values were divided by known clear sky potential values. These were transformed into normalized, decimal values for use in the model. All meteorological data were reduced to mean daily value for input to SNTEMP.

Data were missing for the Prattville meteorological station between July 17 and September 5, 2000, and were replaced using data for the same period from the California Data Exchange Center operated by the Department of Water Resources in Chester. Correlations of overlapping data for the two stations indicated a reasonable basis for the replacement. Figures 3 and 4 illustrate the meteorological data used in the SNTEMP model for 2000 and 2001.

Stream Geometry

Stream elevations and distances are fundamental stream geometry measurements required in SNTEMP. Elevation and distance values for the three modeled reaches were derived using the TOPO! mapping program (National Geographic Holdings, 2000).

Water Temperature and Hydrology

Development of an accurate temperature model for streams such as Butt Creek and the Feather River involves acquiring as much real, measured data as might be available for calibration. Hogan et al. (1973) found that analysis of data for a period of two years leads to the same general distribution of equilibrium temperatures as does a ten year period. Pacific Gas and Electric Company personnel placed Vemco, Scientific, and Datapod temperature and flow loggers at key locations throughout the study reaches in 2000 and 2001 (Figure 2). Each temperature logger was checked for accuracy through a range of temperatures prior to installation. The sampling interval for the various temperature and stage recorders was set to one-hour or less. Loggers were in place collecting data from mid to late May through early to late October each year. The flow data together with the temperature data were provided by Pacific Gas and Electric Company and served as the basis for the hydrology input data file within the SNTEMP model. Data for each study reach are presented within their respective sections.

Seneca Reach

Stream temperature data was obtained in the UNFFR for the summer and fall of 2000 and 2001 at three locations: below Canyon Dam, near the town of Seneca, and upstream of the Caribou Powerhouse (Figures 5 and 6). Butt Creek (tributary to the UNFFR in the lower portion of the Seneca Reach) temperatures were also measured and are included in these graphs. Hydrology data for the two years was collected below Canyon Dam, at the Seneca Bridge, in Butt Creek, and just upstream of the Caribou Powerhouse (Figures 7 and 8). The flow spike evident in early October of 2000 coincides with recreational rafting study flow releases.

Site-specific measurements of topographic shade angle and vegetative shade angle were taken throughout the Seneca Reach at 22 locations from the middle of the stream, together with wetted stream width, distance from stream edge to shade producing vegetation, crown width and quantity, and vegetative shade quality using a foot candle meter. Average input values for the model were calculated for each reach segment azimuth and entered into the SNTEMP shade component file (Table 1). Photographic records were also taken at each measurement point.

Butt Creek Reach

Stream temperature recorders were placed in 2000 and 2001 at the first significant source of flowing water in Butt Creek (approximately 1000 feet below Butt Valley Dam), and just upstream of the confluence with the UNFFR (Figure 9). A pressure transducer for recording water surface elevations was also installed in Butt Creek near the mouth and discharges computed for the two years (Figure 10). In addition, five stream flow measurements were made from the confluence upstream to Butt Valley Dam to determine longitudinal stream flow levels and identify sources of accretion. No apparent tributary inflow was present, but near the upper portion of the study reach significant spring inflow was documented. The flow measurements by distance above the mouth were as follows:

Kilometers above mouth	(River Miles)	Flow in cfs	Flow in cfs
0.02	(0.01)	13.85	0.39
1.07	(0.66)	11.31	0.32
1.91	(1.19)	11.49	0.32
2.67	(1.66)	10.42	0.30
3.06	(1.90)	0.66	0.02
3.30 Butt Valley Dam	(2.05)		

Topographic and vegetative shade measurements and stream widths were collected approximately every 500 feet in Butt Creek, for a total of 20 locations. Average input values were calculated and entered into the SNTEMP shade component file (Table 2). Photographs documenting riparian shade at each location were also taken.

Belden Reach

Stream temperature recorders were placed in the UNFFR below Belden Forebay, 1.2 miles upstream of the Queen Lily Campground, at Gansner Bar Campground, and upstream of the Belden Powerhouse, and in Mosquito Creek and the East Branch of the North Fork Feather River. The mean daily stream temperatures in 2000 and 2001 for these locations appear in Figures 11 and 12, respectively.

Within the Belden study reach, stream flows were monitored by permanent established gages, except on Mosquito Creek. In 2000 and 2001, several measurements of flow were made on Mosquito Creek for later correlation with a nearby gaged watershed (Yellow Creek) for mean daily flow determination. Figures 13 and 14 illustrate the 2000 and 2001 mean daily flow data for the three Belden Reach locations.

An SNTEMP temperature model developed by Woodward-Clyde Consultants (1986) in the Belden Reach was updated and utilized as the framework for the current study of this reach. Shade data were taken from the existing model and no additional topographic or vegetative shade measurements were collected (Table 3).

Calibration and Analysis

Calibration of the temperature model is the process by which certain parameters are adjusted to allow the model to more accurately simulate observed water temperatures. Adjustments are often needed to correct for differences in physical conditions between the water surface where temperature change occurs and the sites of data collection. For instance, the Prattville station air temperature logger is located near Canyon Dam, but on the shore of Lake Almanor. The modeled study reaches are located in a more confined river canyon and although in relatively close proximity to Prattville, they can be exposed to slightly different wind, relative humidity, or other weather variables. Any differences in conditions could affect the ability of the model to reproduce the observed water temperatures and would warrant calibration adjustments. These calibrations should be within reasonable limits, as defined in the documentation for the models (Bartholow 1989).

The input data to these parameters are modified globally (the entire input data set of the specified parameter) by the application of a constant and coefficient modifier to each daily input value. The global calibration factors were used in the computer program to modify the meteorological parameters according to the general form of:

$$Y = a_0+a_1y$$

where:

Y is the modified meteorological parameter
y is the original input meteorological parameter
a_0 is the calibration constant factor
a_1 is the calibration coefficient factor

Seneca Reach Calibration and Validation

The Seneca Reach temperature model was calibrated using five months of daily data (May 18 - October 15, 2000). Through a series of iterations and testing of different combinations of constants and coefficients for the model variables, only global calibration of air temperature (constant 0.00, coefficient 0.92) proved necessary to achieve satisfactory calibration statistics. The practical effect of this adjustment is to reduce all mean daily air temperatures by 8%. Goodness-of-fit criteria for a "good' calibration are as follows (Bartholow 1989):

1 - Simultaneously maximizing the R^2 value while minimizing the mean error to near zero.
2 - No more than 10% of the simulated temperatures are greater than 1°C from measured temperatures.
3 - No single simulated temperature is greater than 1.5°C from measured temperatures.
4 - The mean of the absolute values of the observed minus the predicted is less than 0.5°C.
5 - There is no trend in spatial, temporal, or "temperature" error.

Figure 15 illustrates the match between observed and simulated water temperatures at Seneca and above the Caribou Powerhouse, with the following calibration statistics for the 2000 results:

Stream Reach Node	Correlation Coefficient (R^2)	Mean Error (°C)	Probable Error (+/-°C)	Maximum Error (°C)	Bias (+/-°C)	Errors > 1.0
At Seneca	0.9412	-0.08	0.22	-1.00	0.02	1
Upstream of Caribou	0.9485	-0.03	0.27	1.36	0.02	4

Validation of the model was accomplished by applying the same constants and coefficients to the second year of data (2001) and running the model as a test of the calibration. Comparable goodness-of-fit validation statistics are an indication of satisfactory temperature model calibration. Simulated temperatures (Figure 16) and the following validation statistics were achieved (with no modifications) at the same nodes for 2001:

Stream Reach Node	Correlation Coefficient (R^2)	Mean Error (°C)	Probable Error (+/-°C)	Maximum Error (°C)	Bias (+/-°C)	Errors > 1.0
At Seneca	0.9614	-0.25	0.20	-1.12	0.02	1
Upstream of Caribou	0.9635	0.04	0.20	-1.08	0.02	1

In addition to the seasonal modeling, random individual days from each month for June through September in the two years were modeled with frequent output nodes to generate a stream temperature longitudinal profile (Figures 17 and 18). These figures illustrate the general downstream increase in temperature, with the shading influence of the canyon near Salmon Creek Falls and the cooling created by Butt Creek inflow. The September 7 date modeled in 2001 was cool, resulting in downstream cooling of water released from Lake Almanor.

Butt Creek Reach Calibration and Validation

In constructing the Butt Reach hydrology data file for the SNTEMP model, gaged flow data near the mouth had to be reconciled with the flow measurements made within the reach by fixing the major spring point source inflows and matching total reach accretion. Beginning at 3.3 river kilometers (km) from the mouth, dam leakage was set at a constant 0.1 cfs to start the reach. At 3.0 km, a "P" node (point source) represented the first significant spring (2.0 cfs), along with the measured temperatures (ranging from 10.3 to 10.8°C), which were also used for the dam leakage. At 2.7 km (upstream of the mouth), a second P node was established as the location of the second significant spring, using the balance of the water measured at the confluence, with the exception of 3.0 cfs which was treated as continuous accretion. Missing temperature data at the upper thermograph site between July 13 – August 8, 2001 was filled with a constant 10.67°C.

It proved necessary to adjust the water temperature of both the second P spring node and the accretion flow to correct a systematic error found during calibration. Generally, most groundwater within a geographic area has similar and relatively constant temperature, which was assumed to be the case in Butt Creek. The groundwater temperature measured just below the dam was initially used for the downstream unmeasured springs (second P node) and accretion. Simulation, however, revealed a systematic error of prediction that held true for both years of data, over-predicting early in the season and under-predicting later (Figure 19). The nearly constant input temperature of 10+°C was adjusted by a constant increase of 0.014°C per day, starting at 9.50°C on June 1 to 11.25°C on September 30. The adjustment erased the systematic error (Figure 19) and ended up in a pattern nearly identical to that of water released from Lake Almanor at Canyon Dam (Figure 5). Most likely, water entering Butt Creek downstream from the first spring is a mixture of fairly rapid leakage from Butt Valley Reservoir (that does not have residence time long enough in the ground to acquire the local groundwater temperature) together with some ground water and could be confirmed with additional data. Measured temperatures at the first spring were not adjusted, but used in the model as measured.

The Butt Creek Reach temperature model was calibrated using five months of daily data (May 18 - October 15, 2000). Through a series of iterations and testing of different combinations of constants and coefficients for the model variables, only global calibration of air temperature (constant 2.00, coefficient 0.85) proved necessary to achieve satisfactory calibration statistics. This calibration reduced all input air temperatures by 85% and then added 2°C to each result. Simulated temperatures (Figure 20) and the following goodness-of-fit statistics resulted from the final calibration:

Stream Reach Node	Correlation Coefficient (R^2)	Mean Error (°C)	Probable Error (+/-°C)	Maximum Error (°C)	Bias (+/-°C)	Errors > 1.0
Butt Creek at Mouth	0.9295	-0.05	0.12	-0.50	0.01	0

Using 2001 data as a validation test, the same calibration was applied. Simulated temperatures were similar to observed temperatures (Figure 21) and had the following validation statistics:

Stream Reach Node	Correlation Coefficient (R^2)	Mean Error (^{0}C)	Probable Error (+/-^{0}C)	Maximum Error (^{0}C)	Bias (+/-^{0}C)	Errors > 1.0
Butt Creek at Mouth	0.9431	0.02	0.11	0.47	0.01	0

In addition to the seasonal modeling, random individual days from each month for June through September in the two years were modeled with frequent output nodes to generate a stream temperature longitudinal profile for Butt Creek (Figures 22 and 23). These figures illustrate a general downstream increase in temperature, with rapid warming of the very low flow below the Dam, the cooling effect of the springs, and slight warming thereafter. Water temperatures remain quite cool at all times in Butt Creek.

Belden Reach Calibration and Validation

The previously constructed SNTEMP model (Woodward-Clyde Consultants 1986) for Belden Reach was updated and utilized as the framework for the current study, but was modified slightly to account for a different source of meteorological data. The 1986 model used data from a temporary meteorological station, which had been established downriver at Rock Creek Diversion Dam, a distance of approximately 6 miles from the center of the reach. This meteorological station was no longer in service during the 2000-2001 study period. As noted above, data from the Prattville Meteorological Station was used for calibration and validation of the current model.

Missing temperature data for Mosquito Creek between July 19-September 22 and October 5-15, 2000 was synthesized by subtracting 1.4°C from recorded temperatures at nearby Yellow Creek. Yellow Creek data was available for July 19-August 23, then lost due to wildfire, so a fixed value of 11.55°C was used for August 24-September 22, and another fixed value of 10.85°C for October 5-15. The flow from Mosquito Creek is insignificant compared to the UNFFR during this time, so the data synthesis was considered a reasonable approach.

The temperature data for the probe located at Gansner Bar Campground was also missing between June 1-9, 2000. This gap was filled using the temperatures recorded at the site upstream of the Queen Lily Campground, plus 0.25°C, the average differential of the majority of the remaining data.

The Belden Reach SNTEMP model was calibrated using the 2000 data set. Through a series of iterations, different combinations of constants and coefficients in the meteorological parameters resulted in an acceptable calibration. Maximum and minimum shade values from the WCC (1986) model were generally increased by 10% down to the Gansner Campground and decreased 10% downstream from there, based on model performance and site specific recollections. Global adjustment of air temperature with a constant factor of 0.00 and a calibration coefficient factor of 0.865 made for the best match of the predicted with the observed data (Figure 24).

Stream Reach Node	Correlation Coefficient (R^2)	Mean Error (°C)	Probable Error (+/-°C)	Maximum Error (°C)	Bias (+/-°C)	Errors > 1.0
Above Queen Lily	0.9962	0.14	0.10	0.56	0.01	0
Gansner Bar Campground	0.9883	0.09	0.18	0.93	0.02	0
Upstream Belden PH	0.9973	0.00	0.11	0.56	0.01	0

The validation of the model was accomplished by applying these same calibration factors to the 2001 data and comparing predictions to observations (Figure 25). The following statistics are measures of the model's performance at the validation nodes:

Stream Reach Node	Correlation Coefficient (R^2)	Mean Error (°C)	Probable Error (+/-°C)	Maximum Error (°C)	Bias (+/-°C)	Errors > 1.0
Above Queen Lily	0.9934	0.02	0.14	-0.69	0.01	0
Gansner Bar Campground	0.9853	0.03	0.23	-1.06	0.02	1
Upstream Belden PH	0.9918	-0.01	0.19	-0.89	0.02	0

Random individual days from each month for June through September in the two years were modeled using frequent output nodes to generate stream temperature longitudinal profiles for the Belden Reach (Figures 26 and 27). These figures illustrate a general lack of much warming or cooling within the reach, down until the East Branch of the North Fork Feather enters and creates substantial warming.

Gaming Simulations

The calibrated and validated SNTEMP model for the three reaches are believed to be sufficiently accurate for gaming the temperature effect of alternative flow releases.

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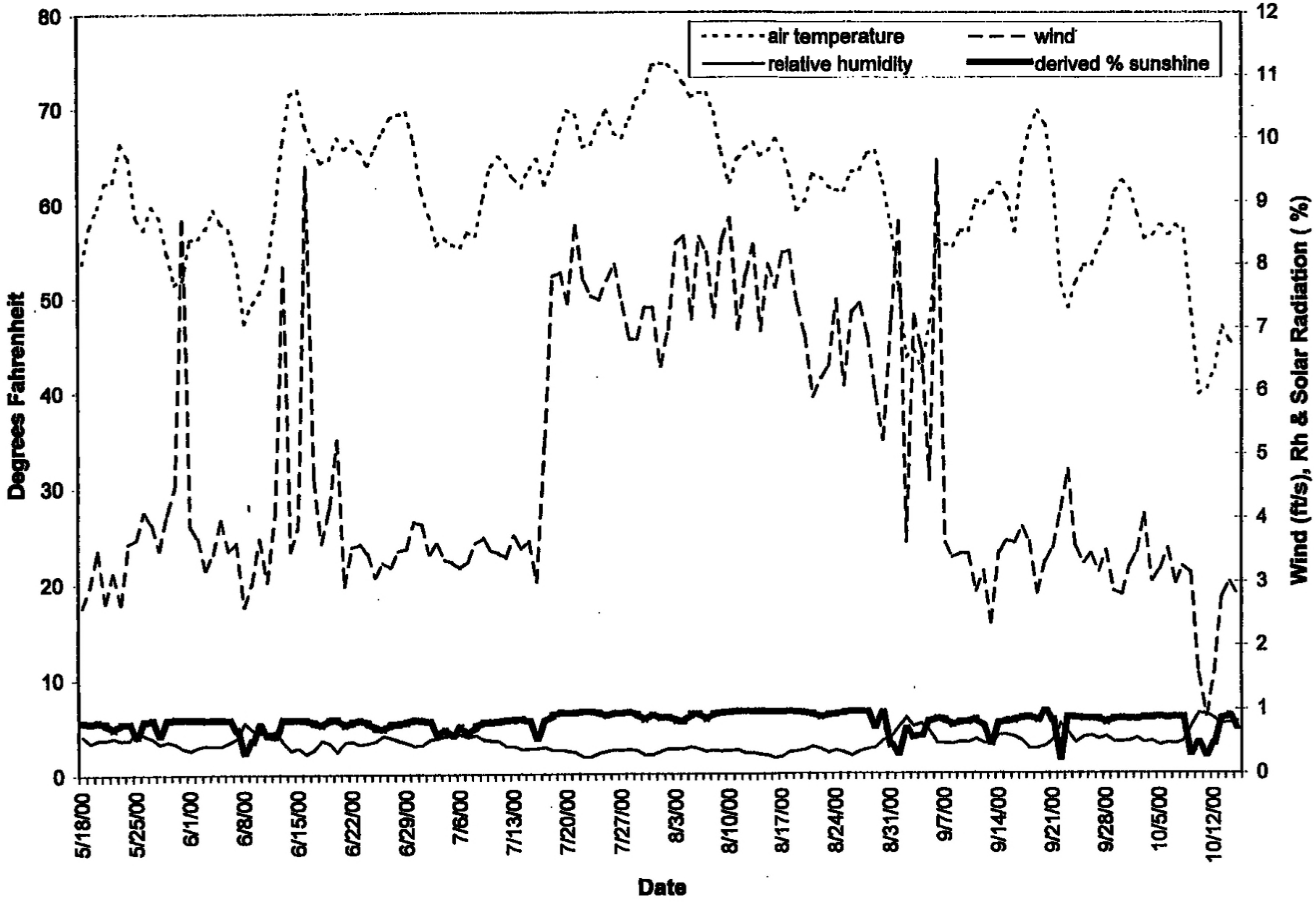


Figure 3. Year 2000 climatological data for Prattville, CA used in PG and E's Upper North Fork Feather River Hydroelectric Project Temperature Model.

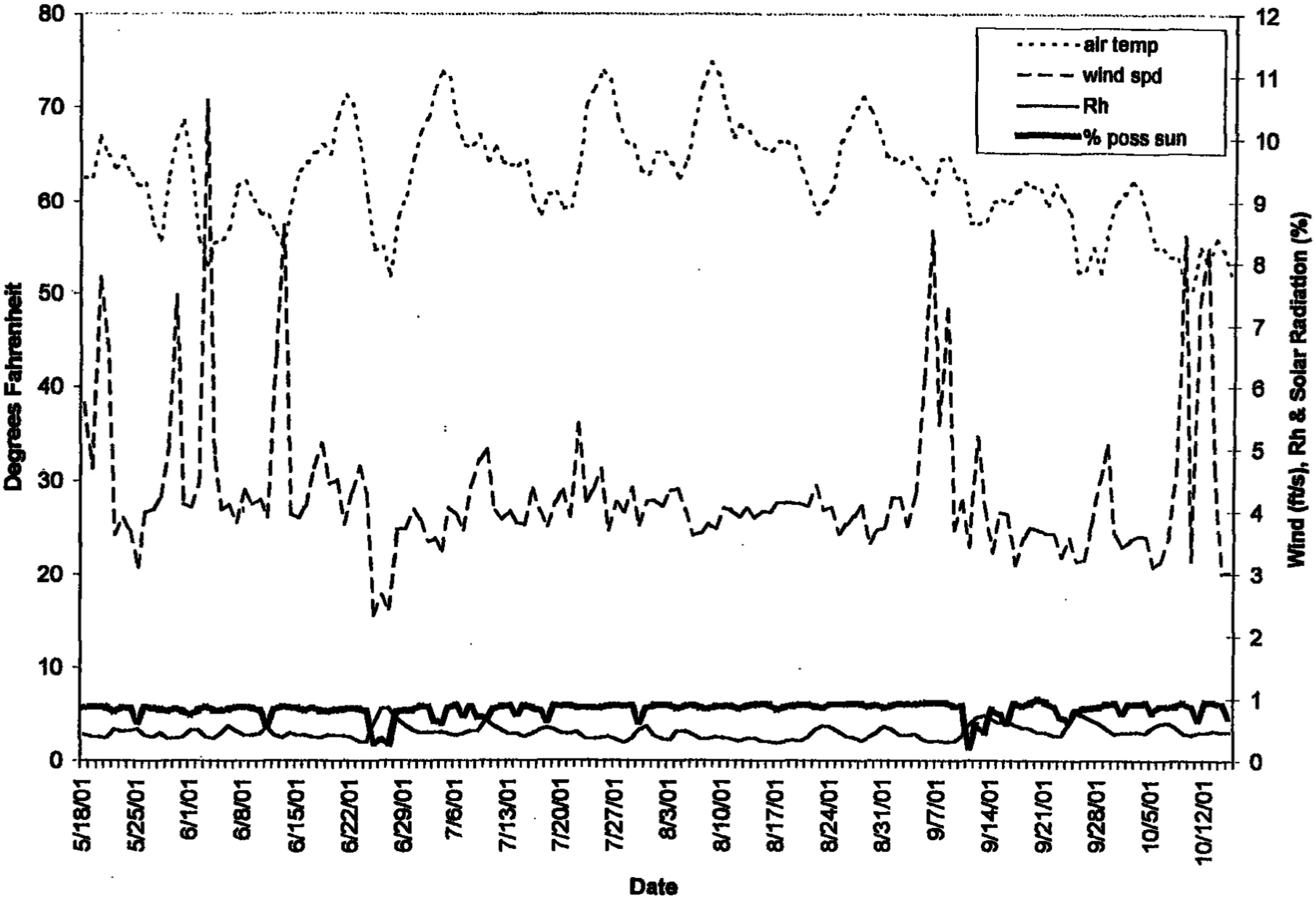


Figure 4. Year 2001 climatological data for Prattville, CA used in PG and E's Upper North Fork Feather River Hydroelectric Project Temperature Model.

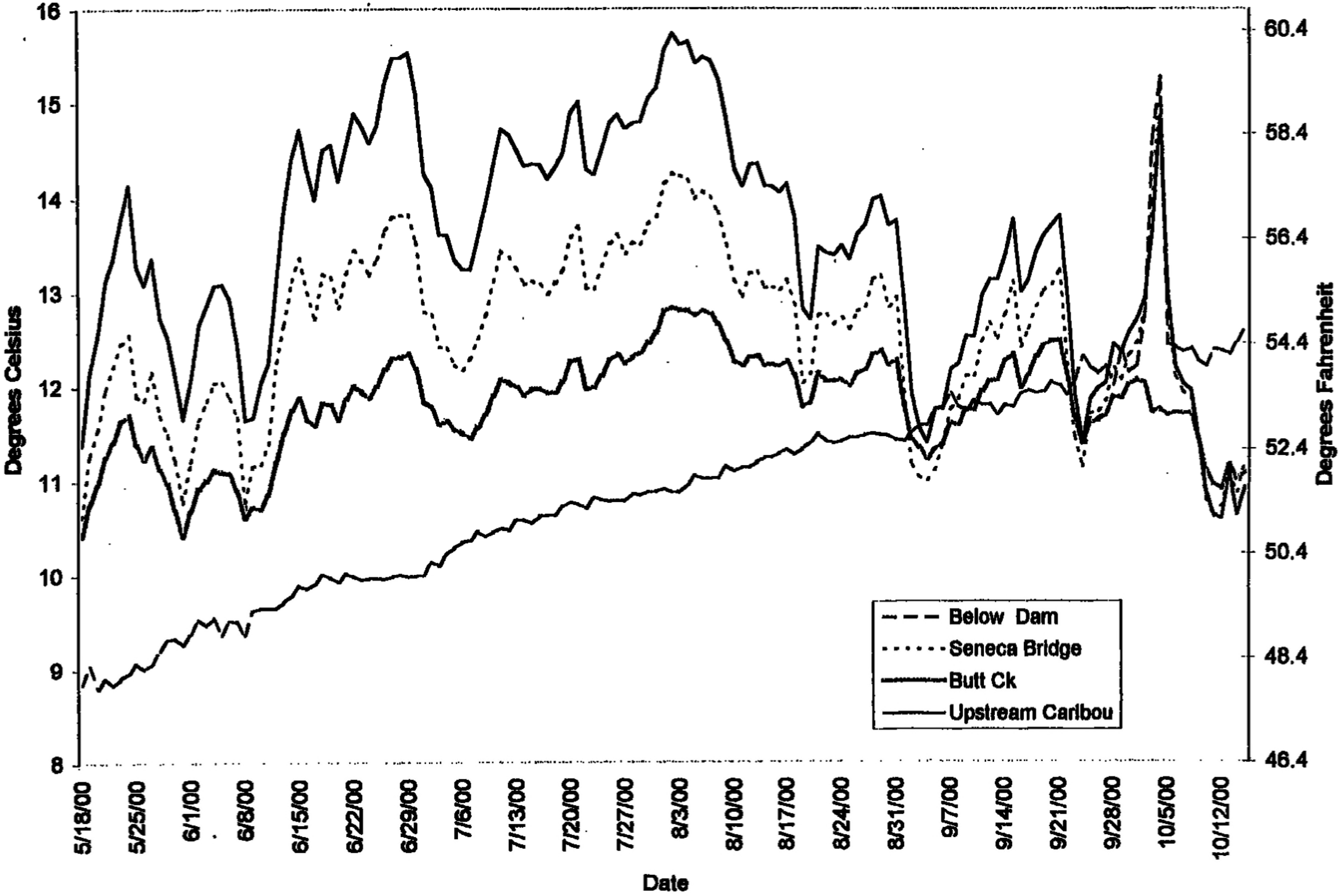
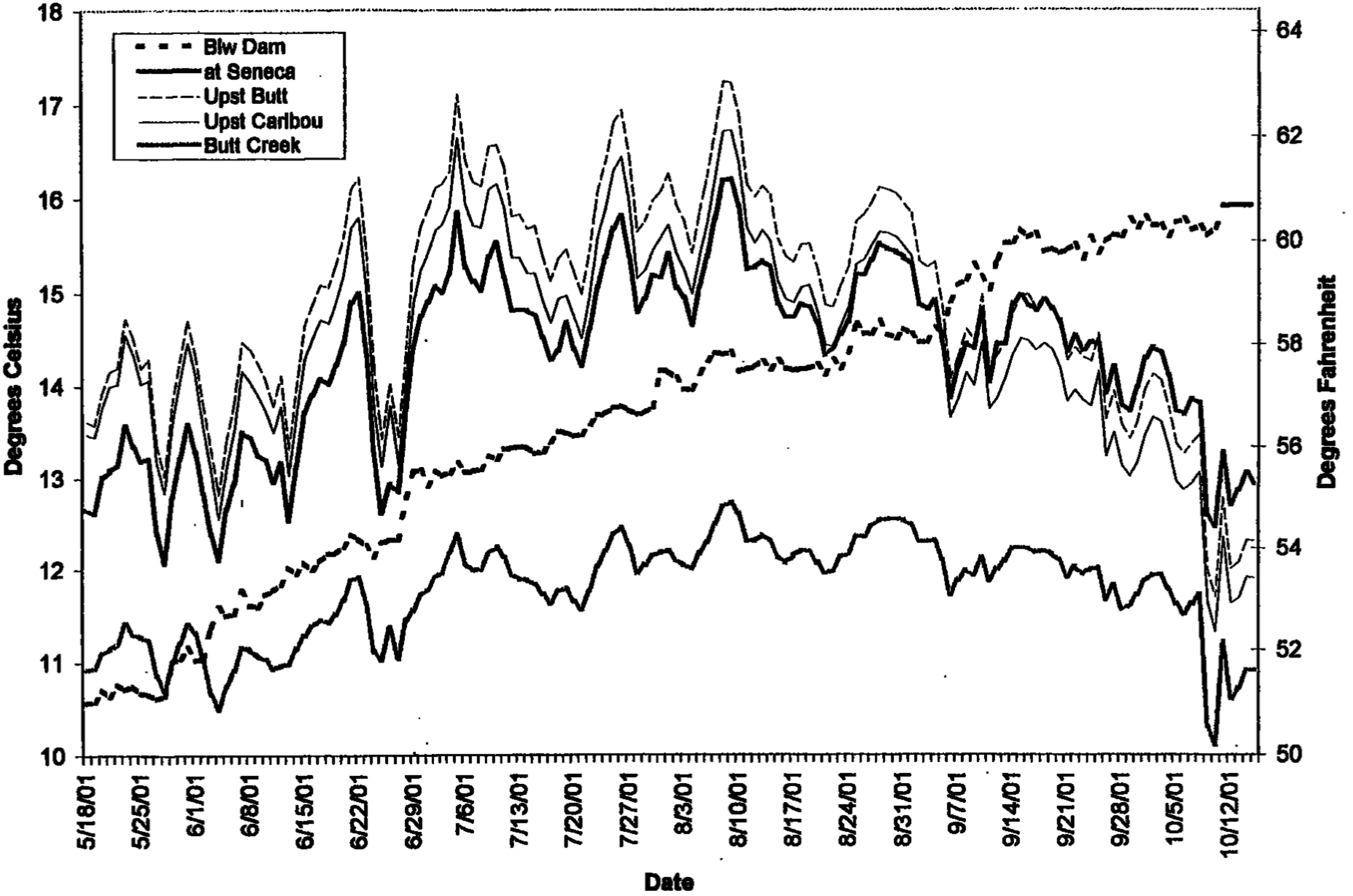


Figure 5. Year 2000 observed mean daily stream temperatures used in the Seneca Reach temperature model for PG and E's Upper North Fork Feather River Hydroelectric Project.



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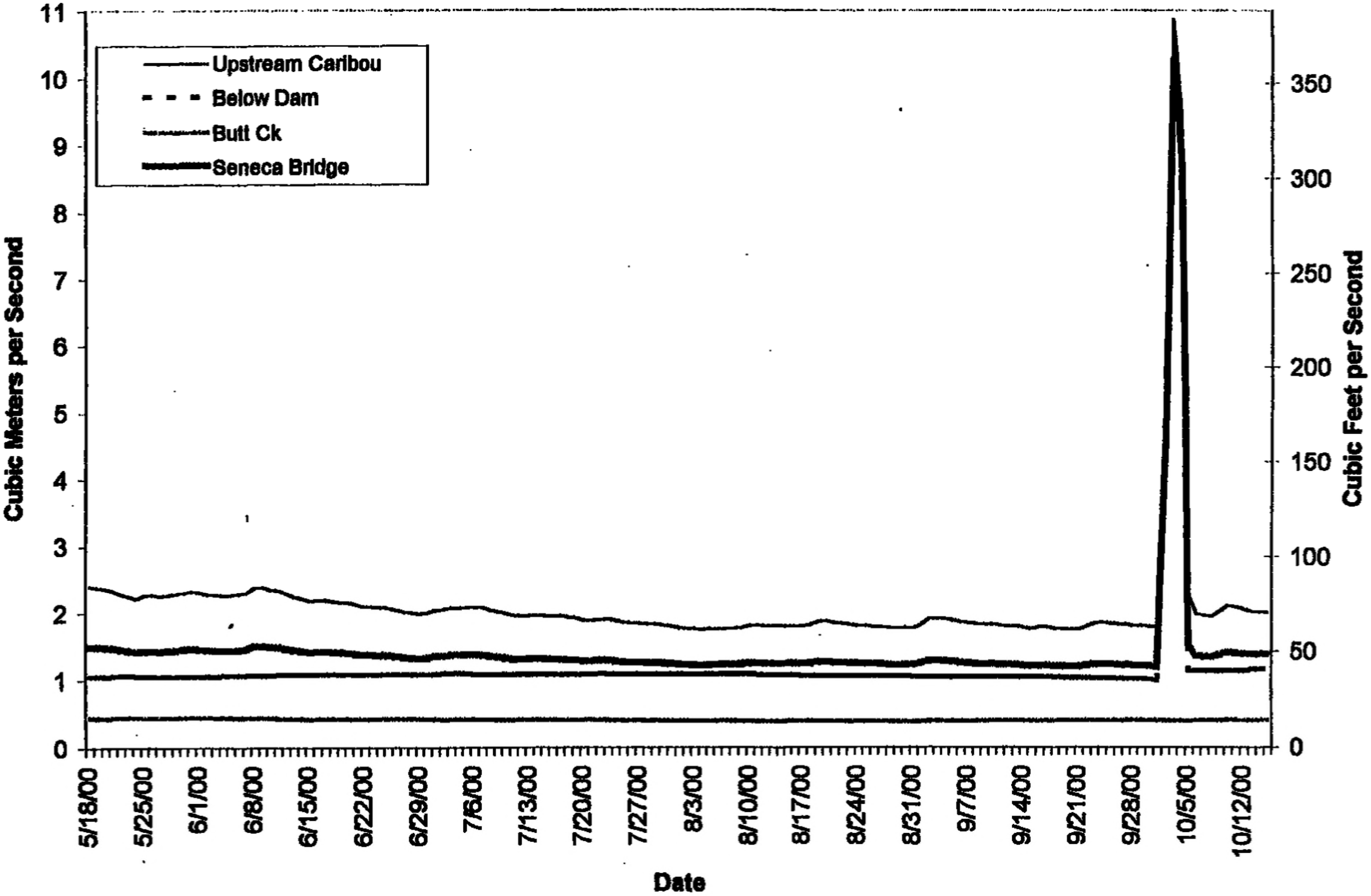

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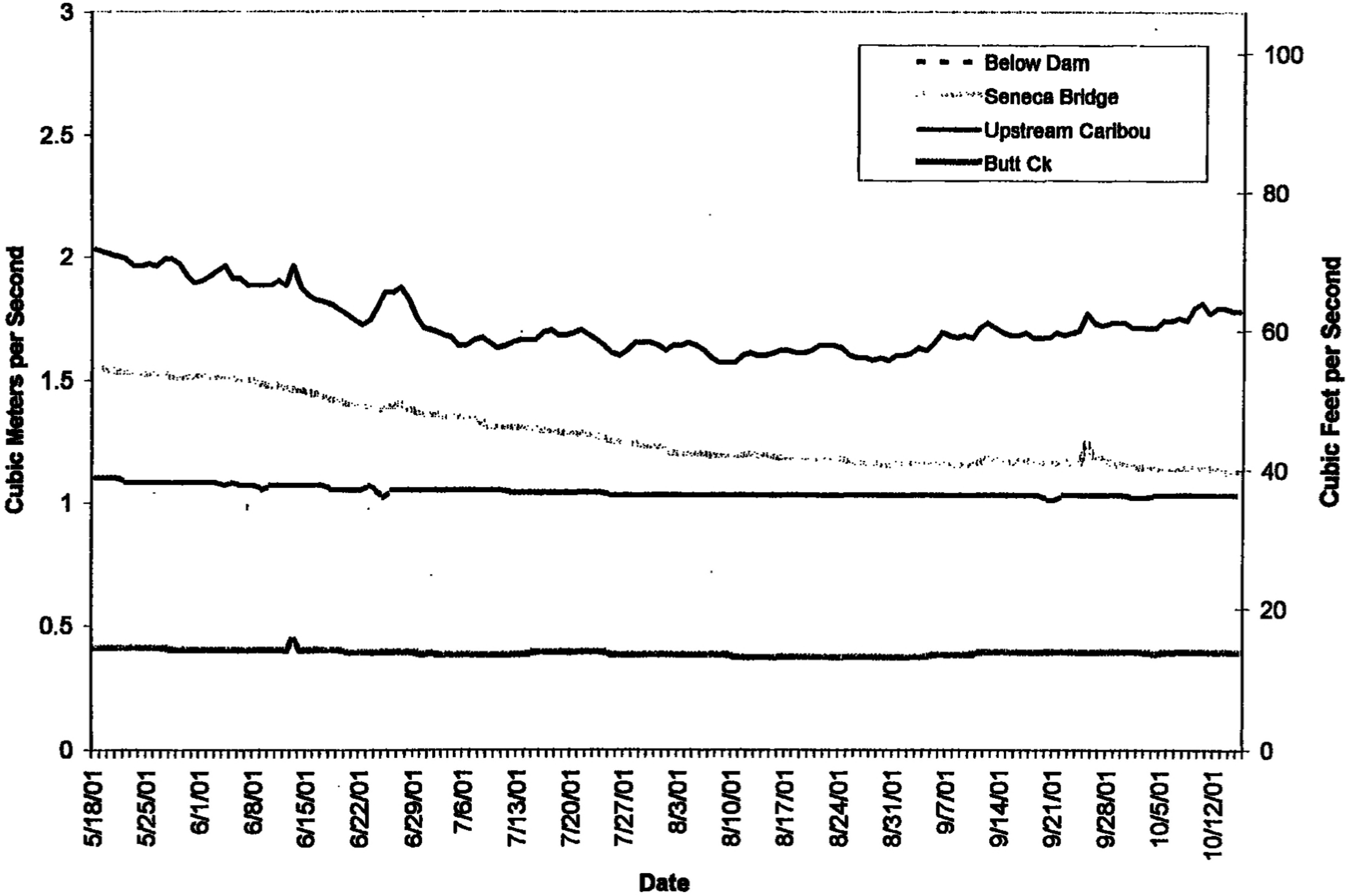
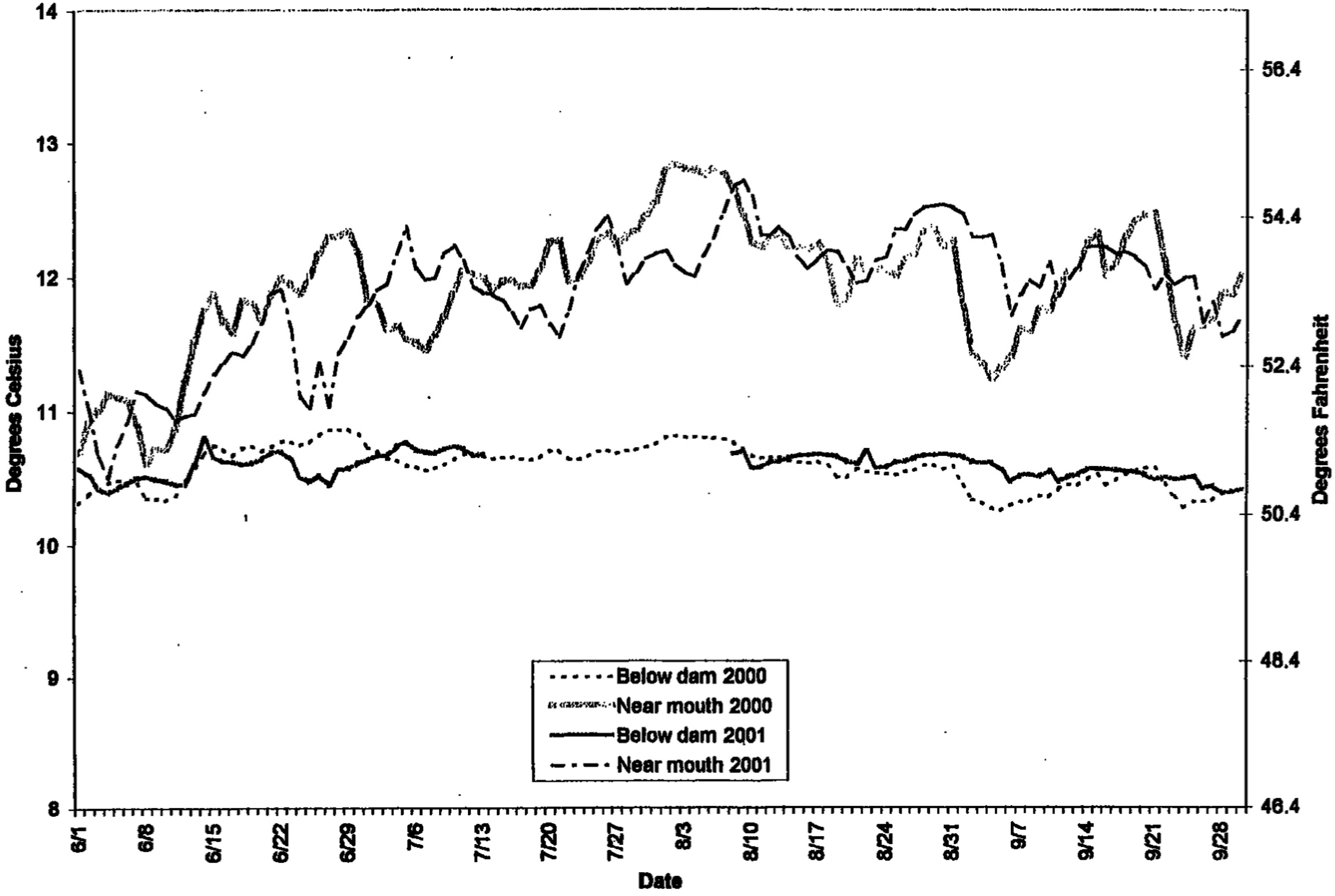


Figure 8. Year 2001 observed mean daily stream flows used in the Seneca Reach temperature model for PG and E's Upper North Fork Feather River Hydroelectric Project.



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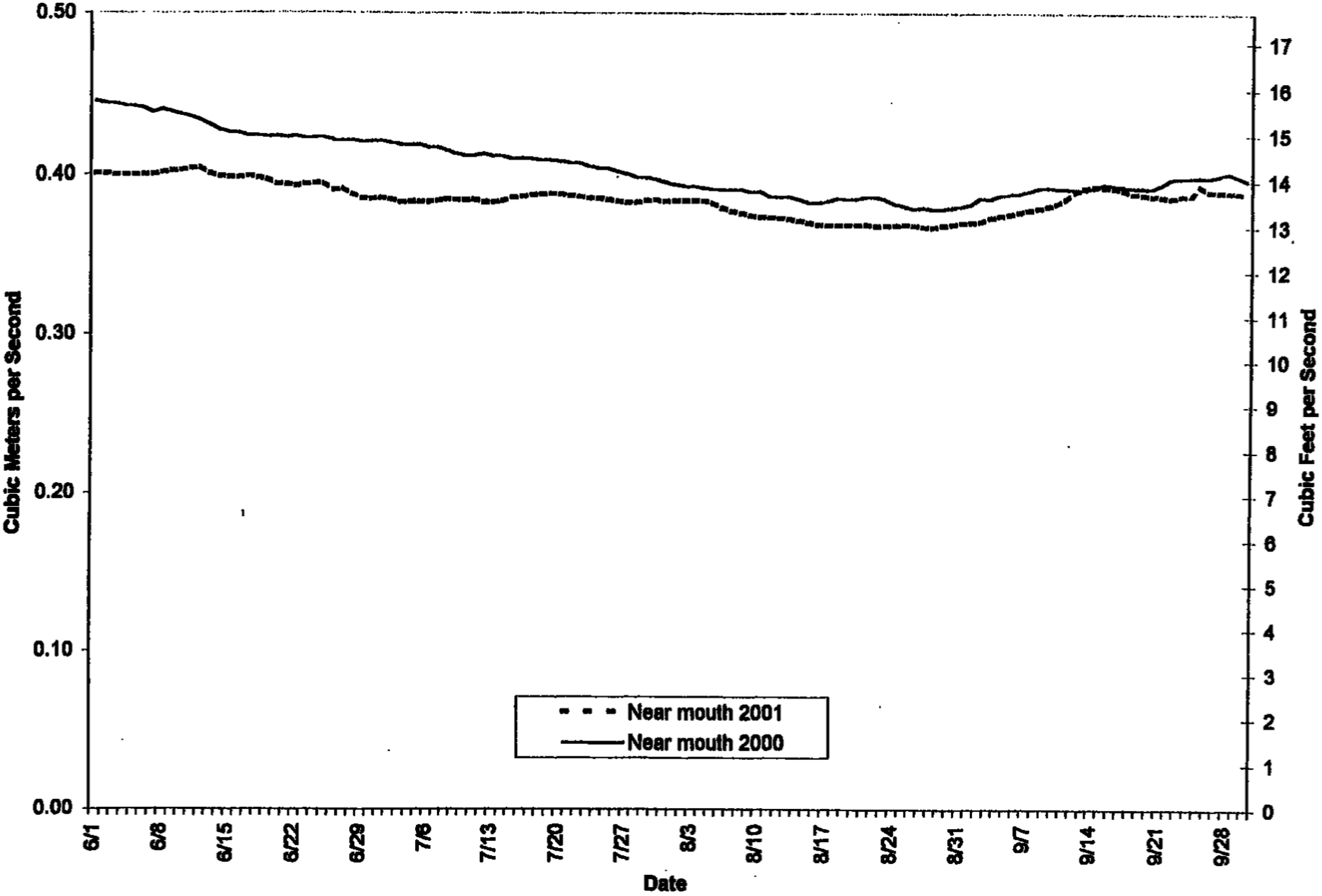

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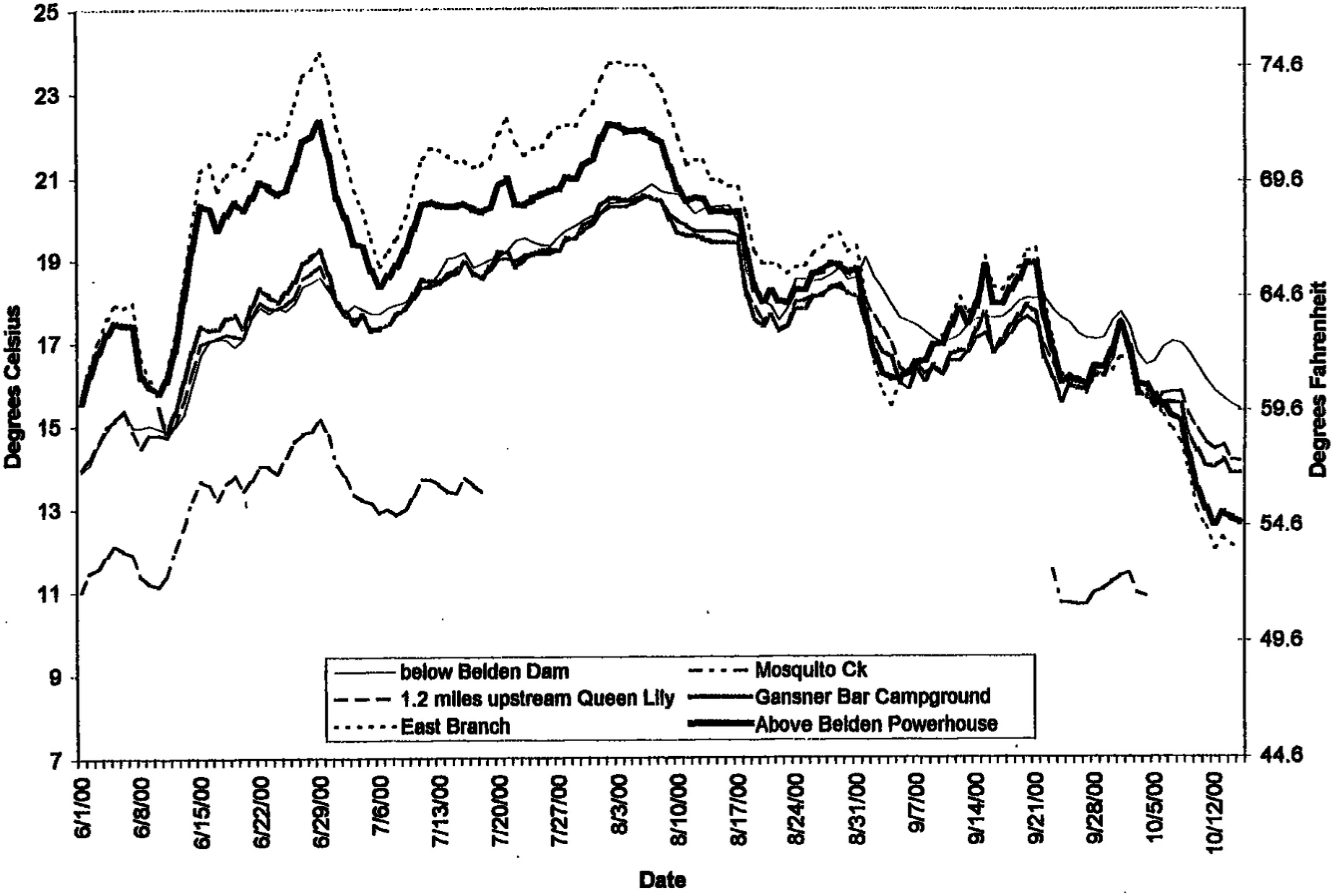

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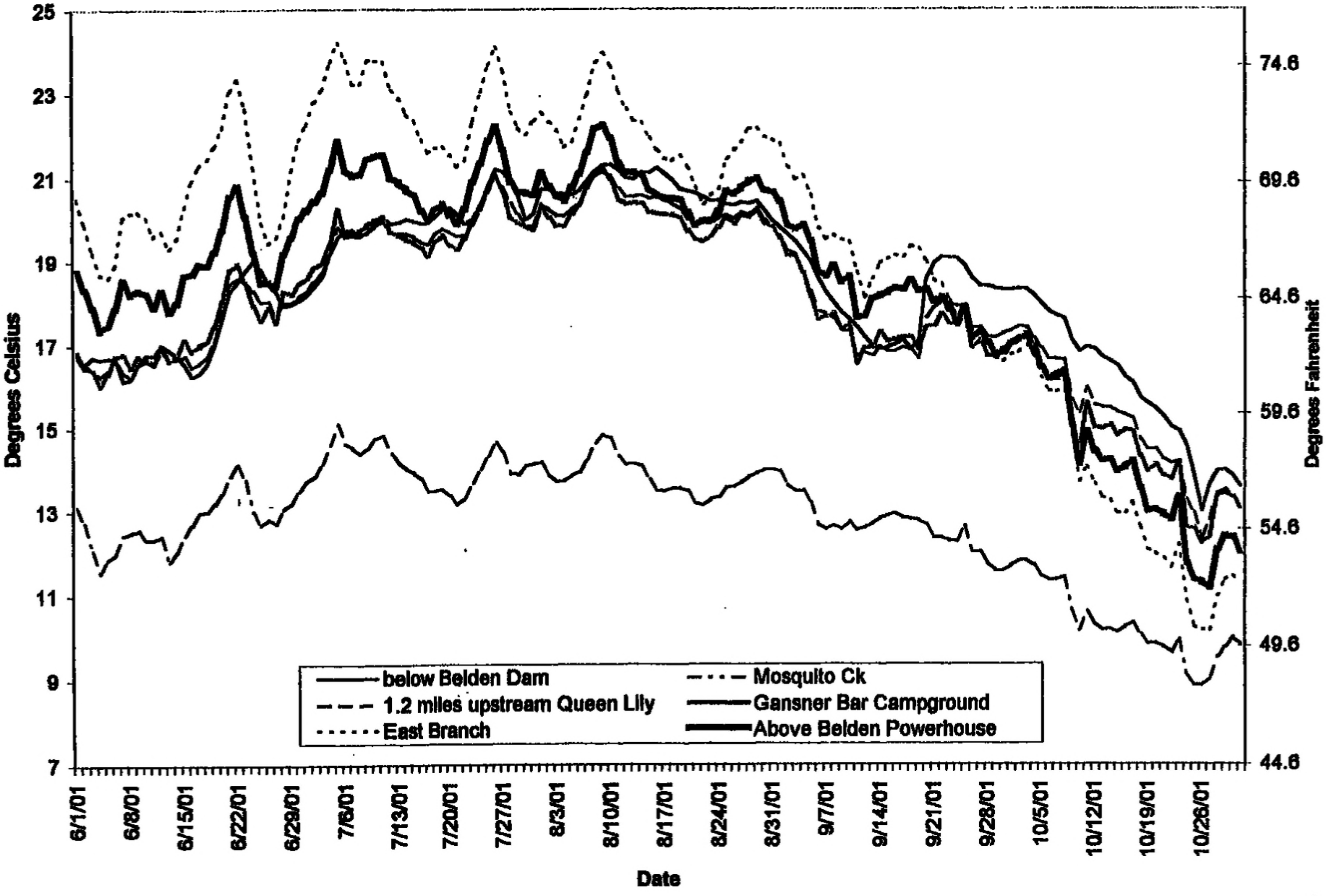

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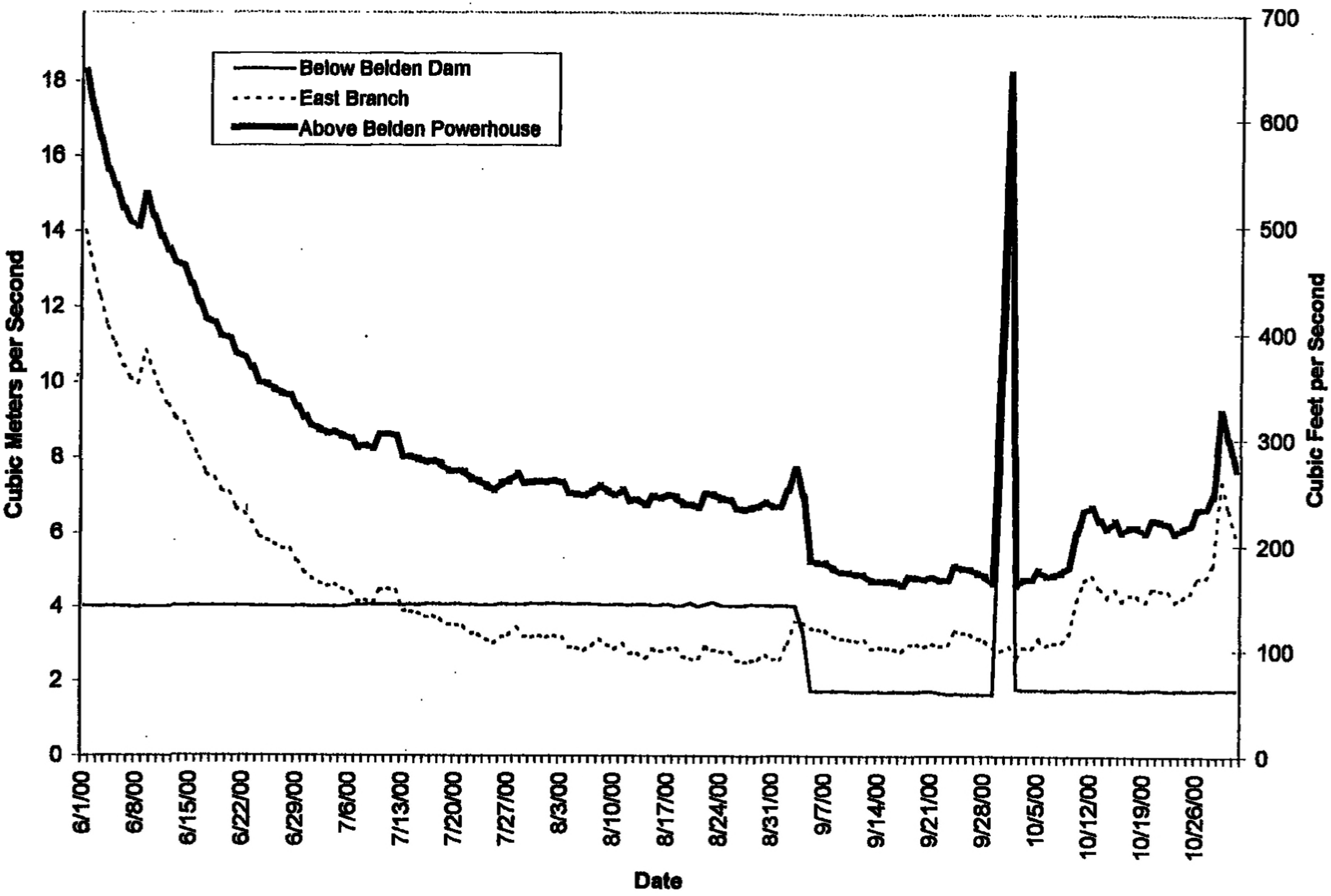

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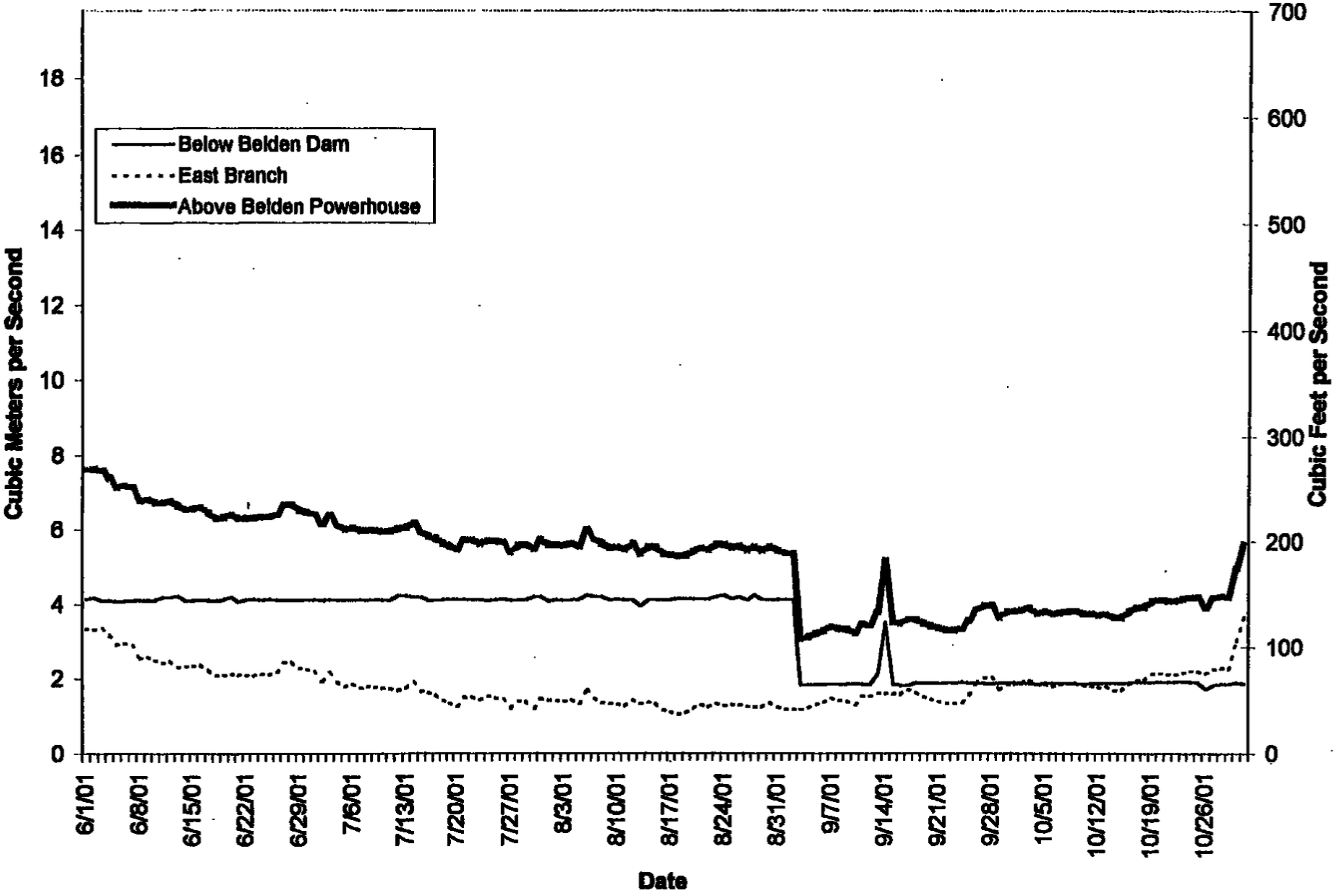

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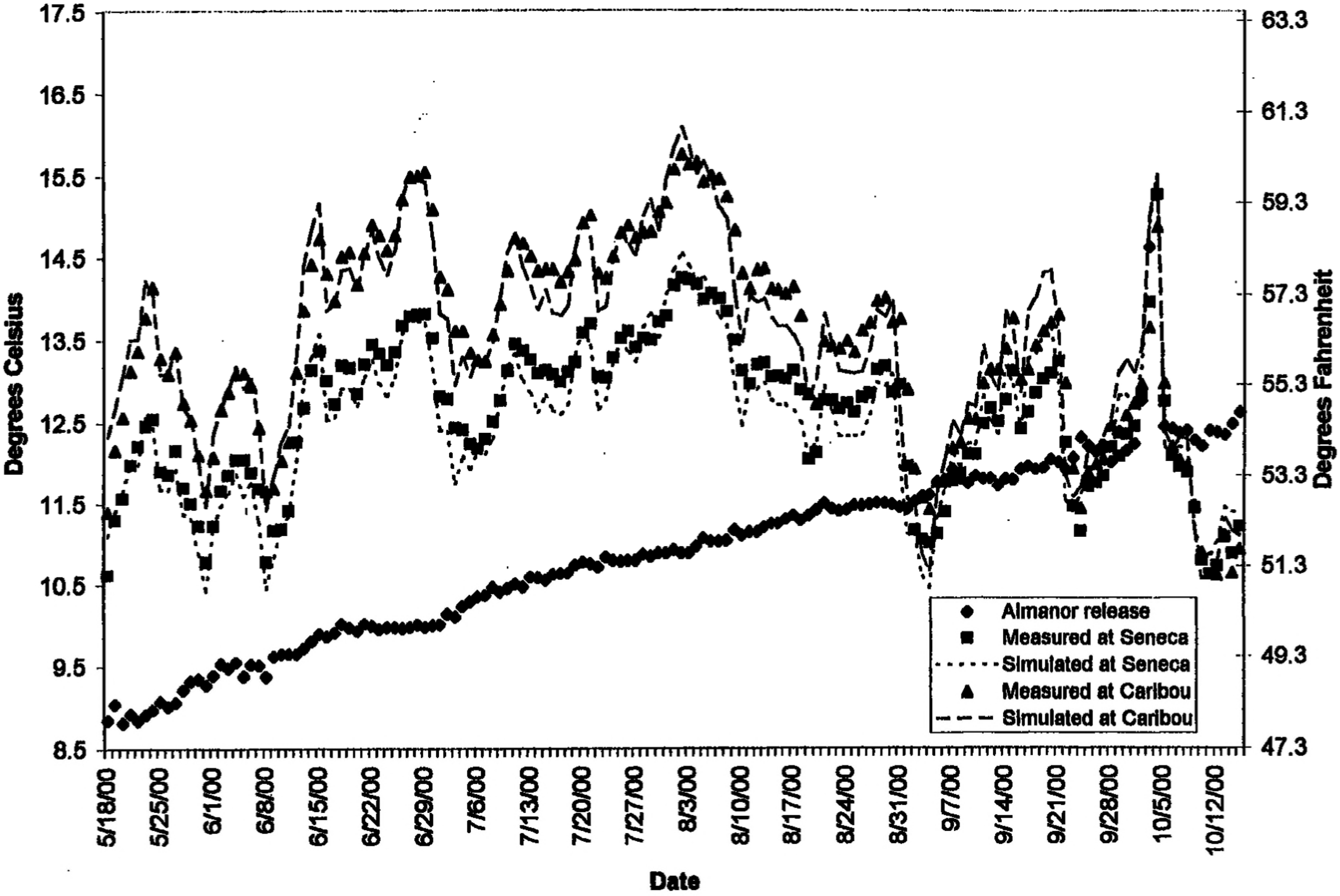

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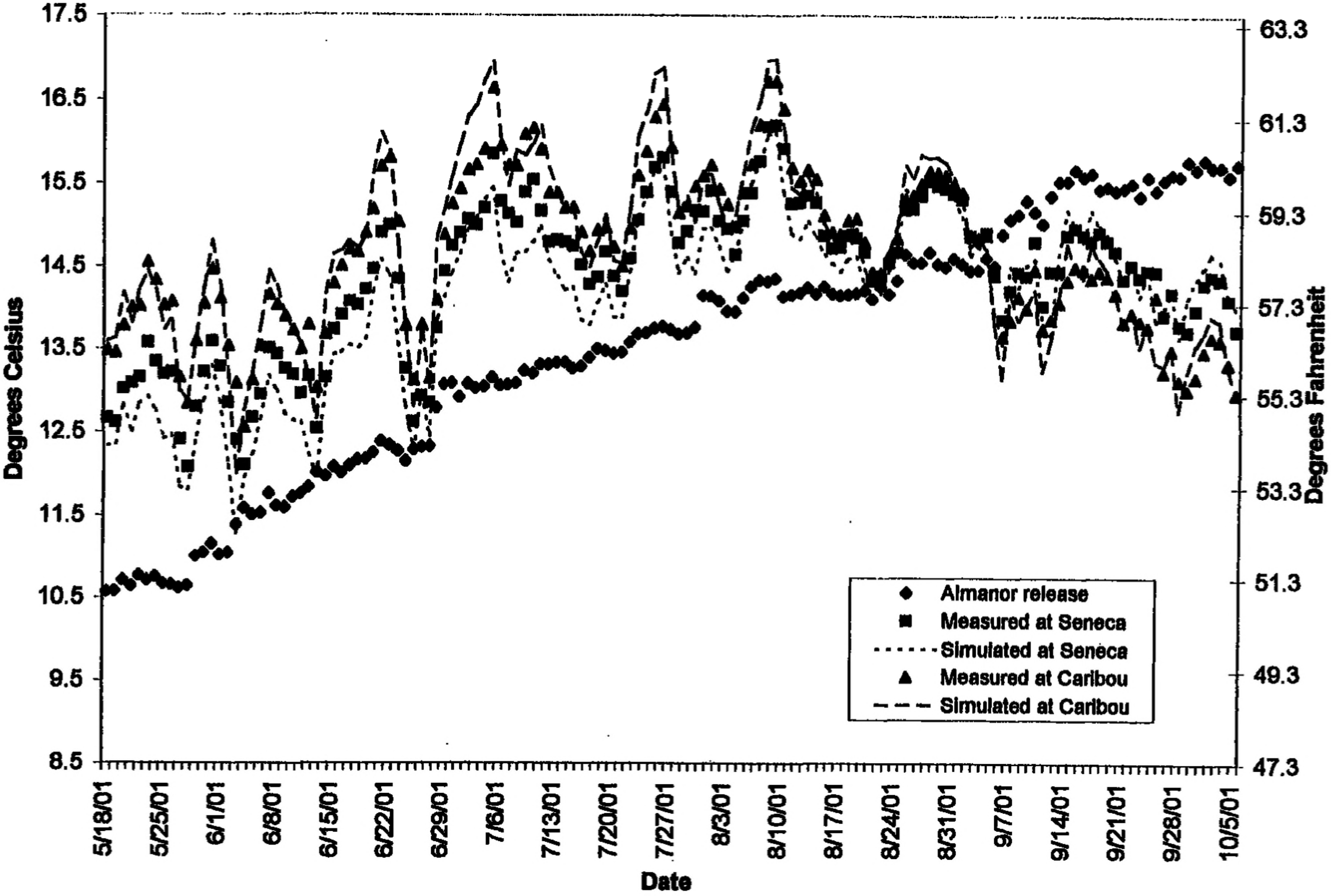

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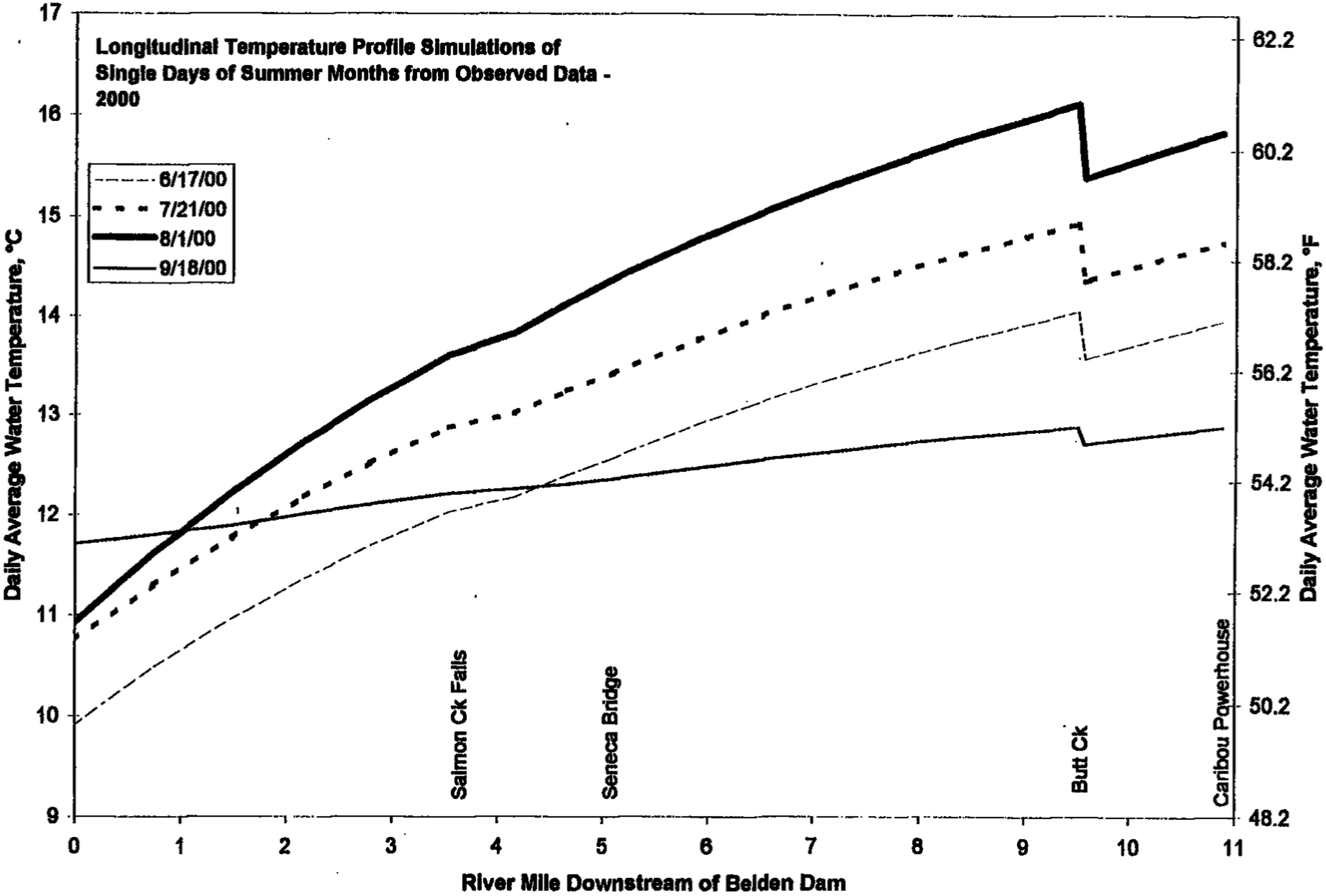

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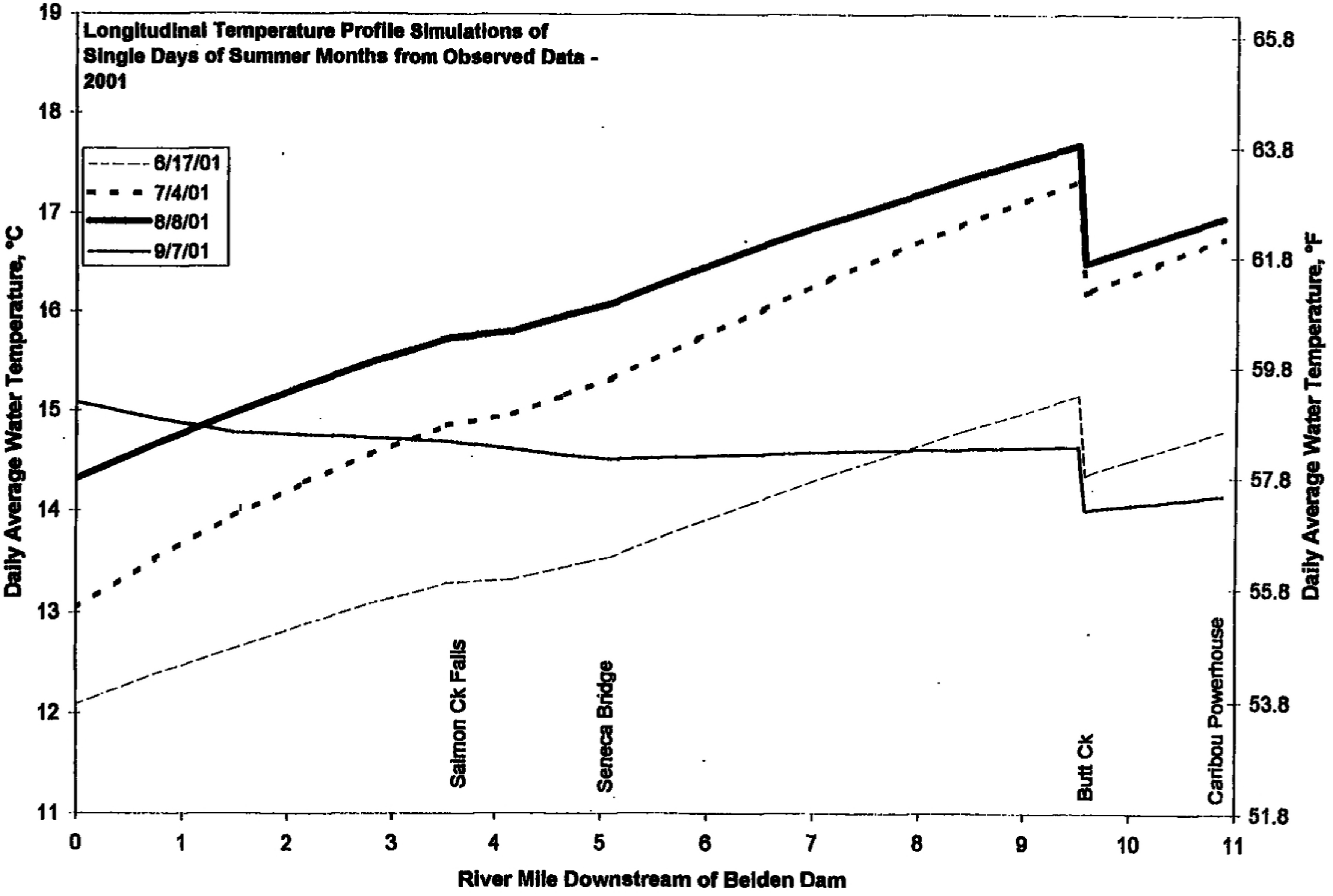

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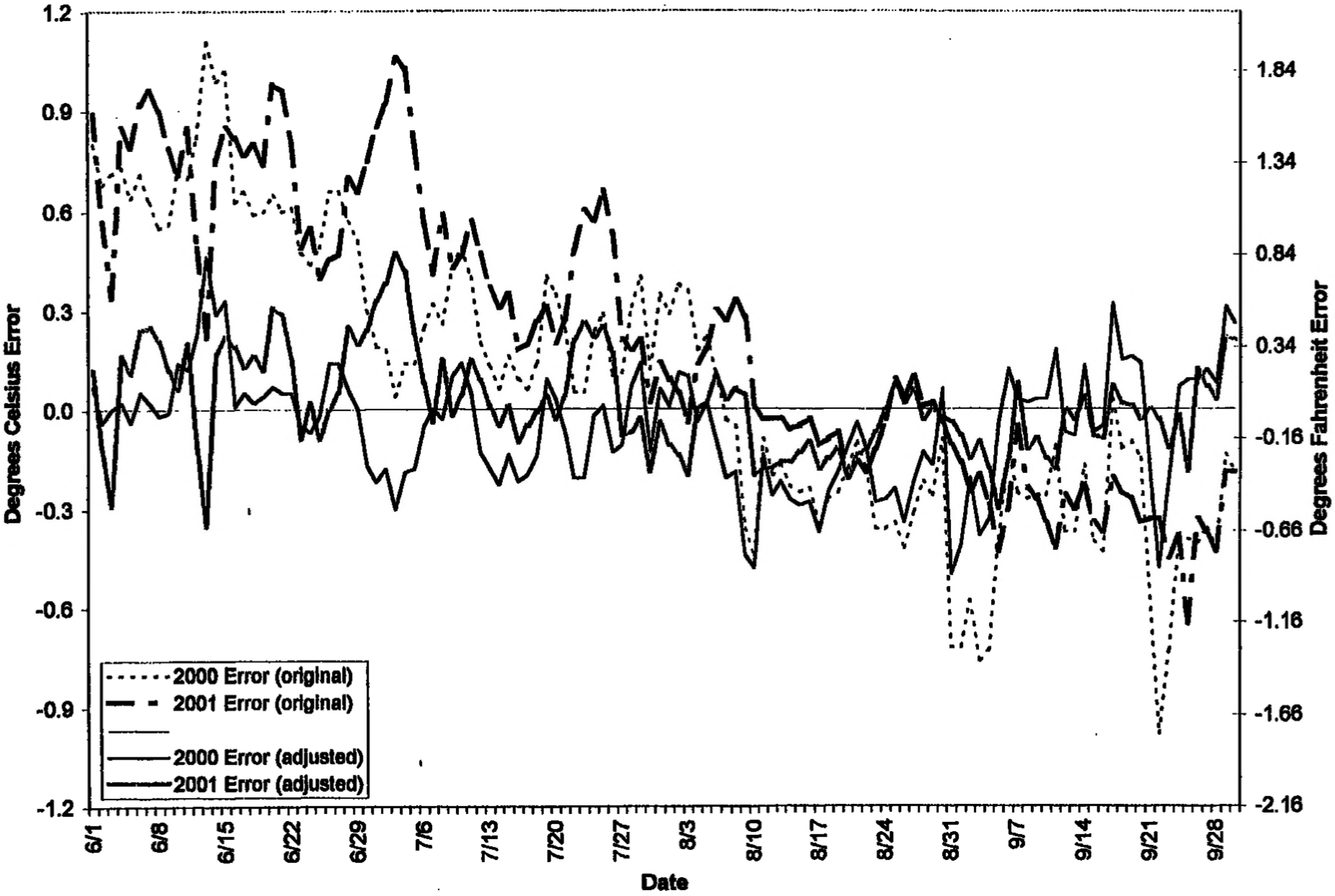

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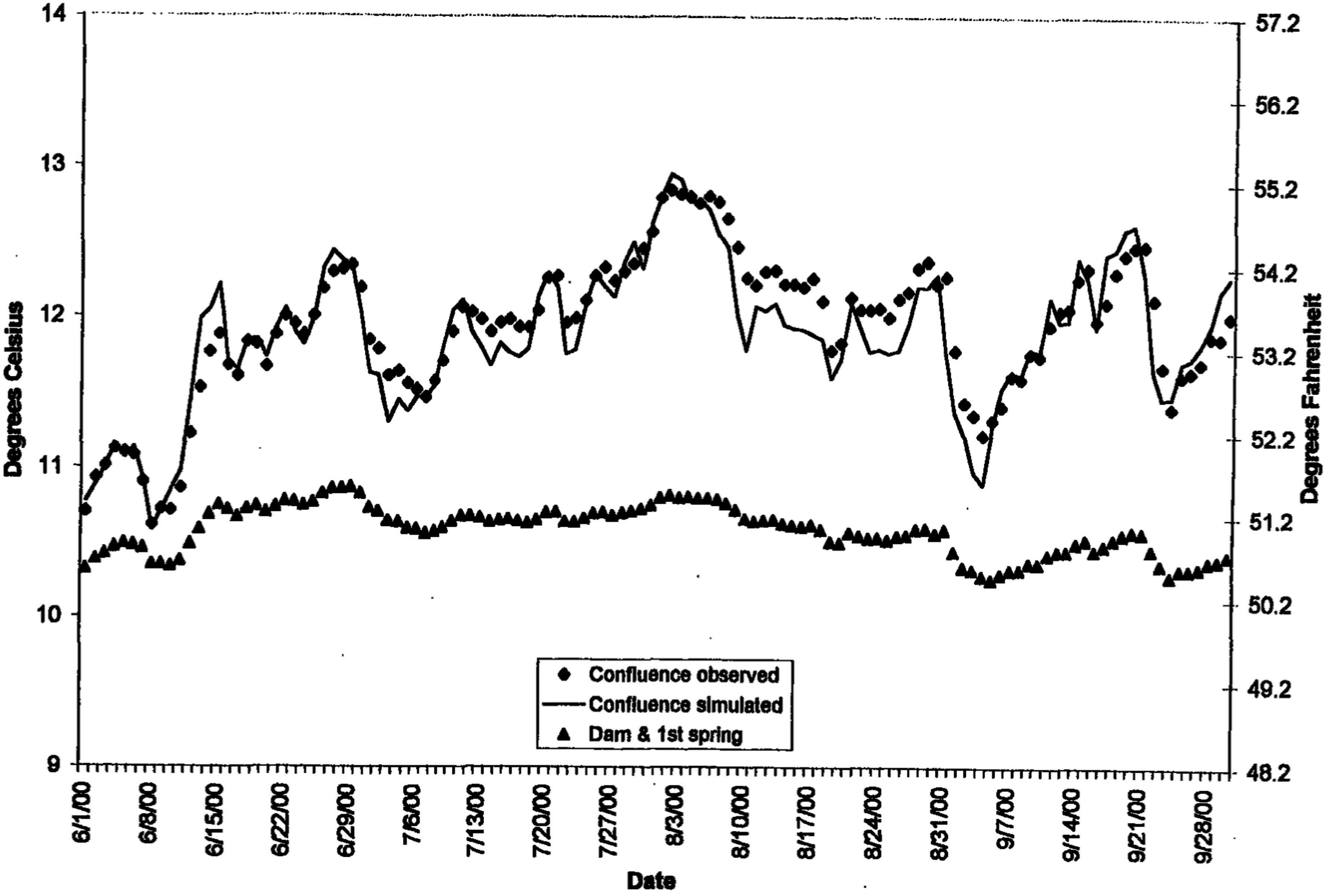

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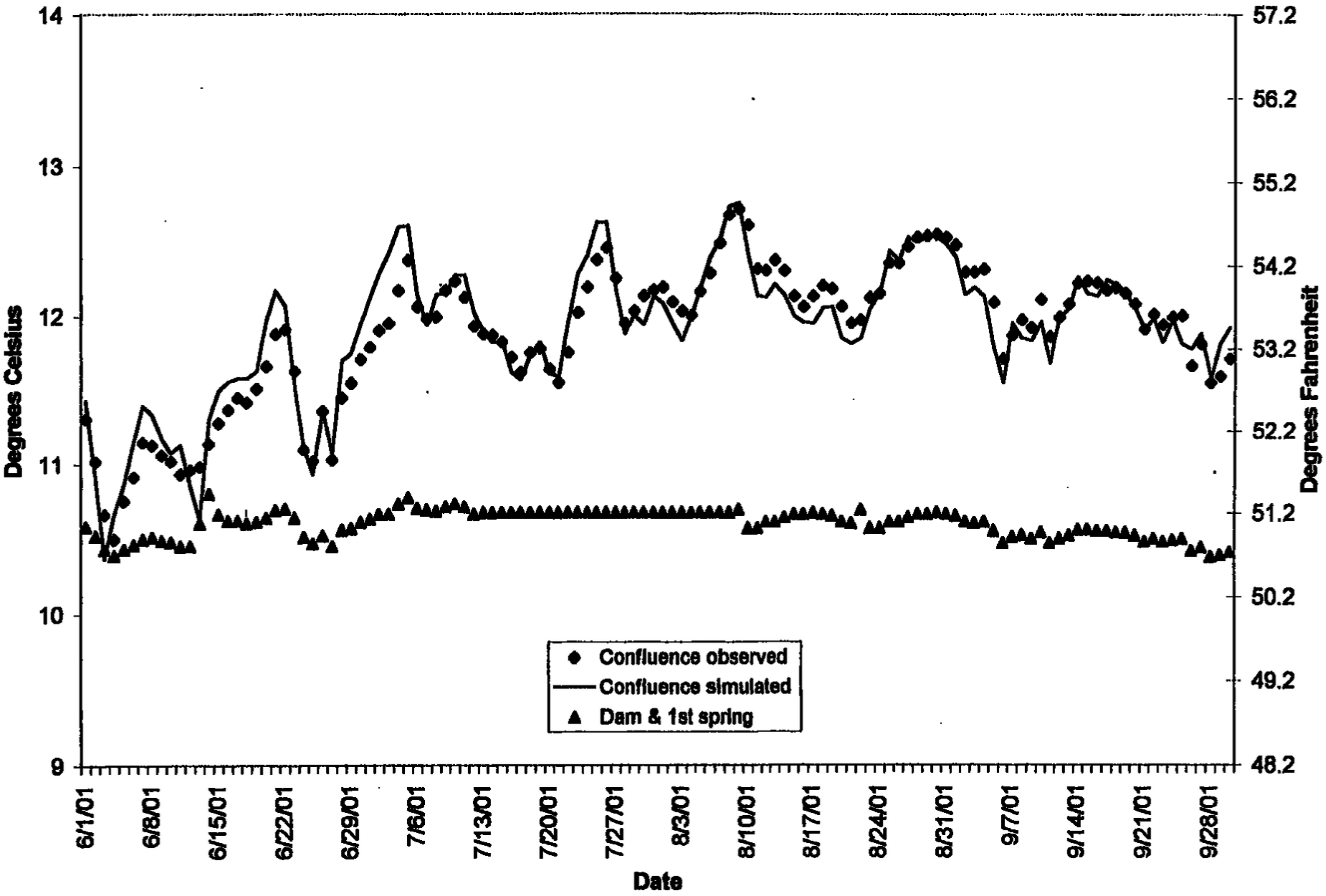

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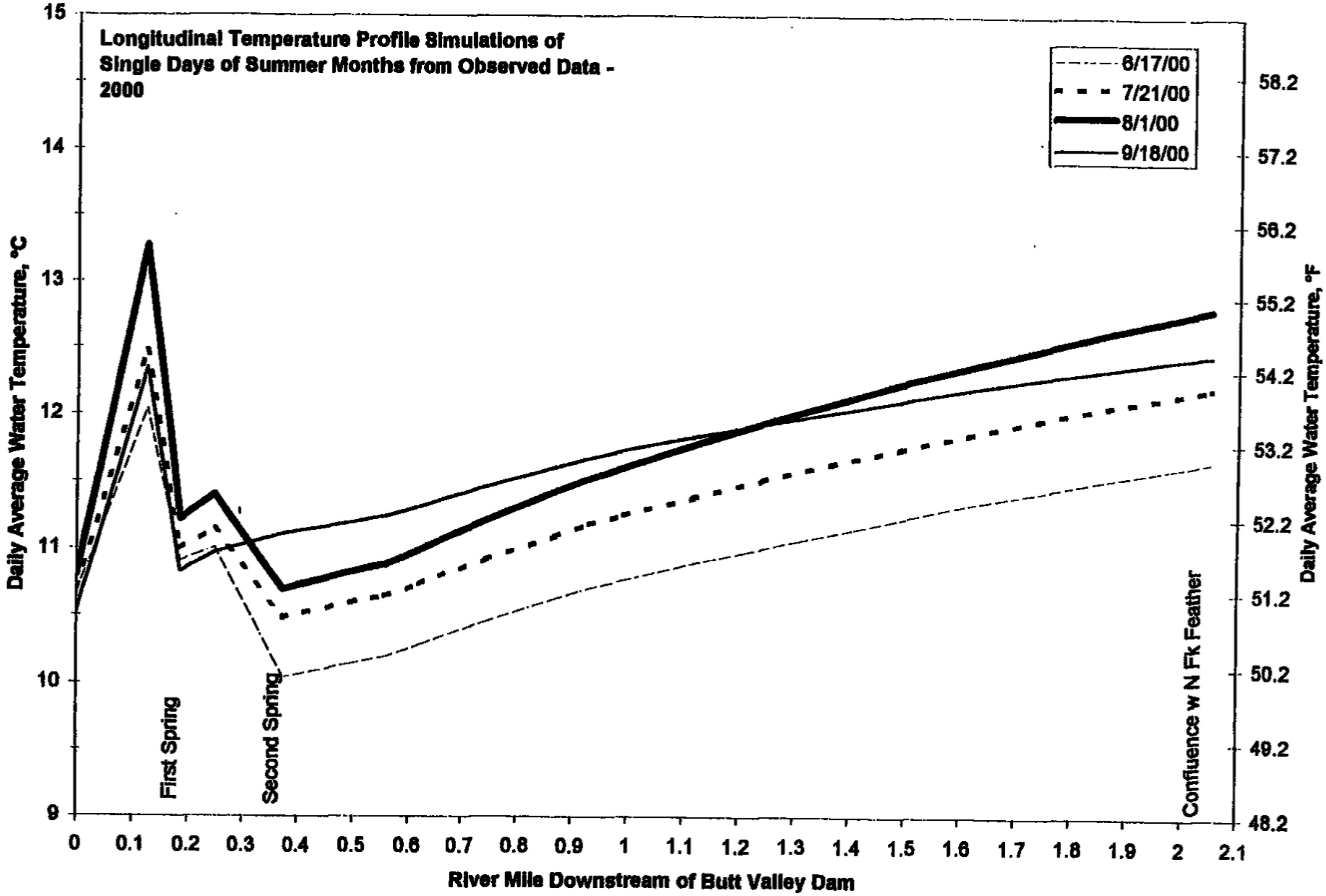

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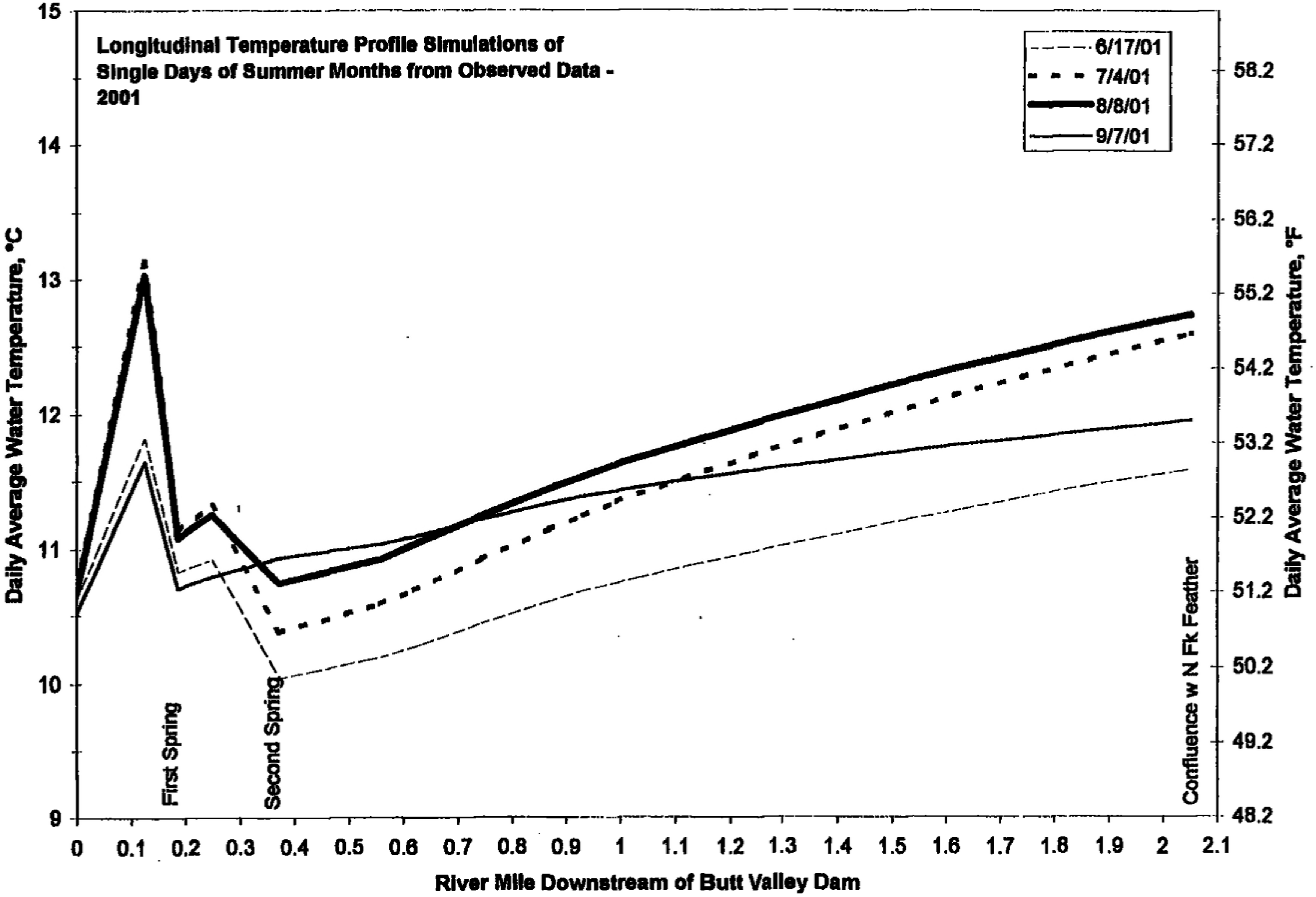

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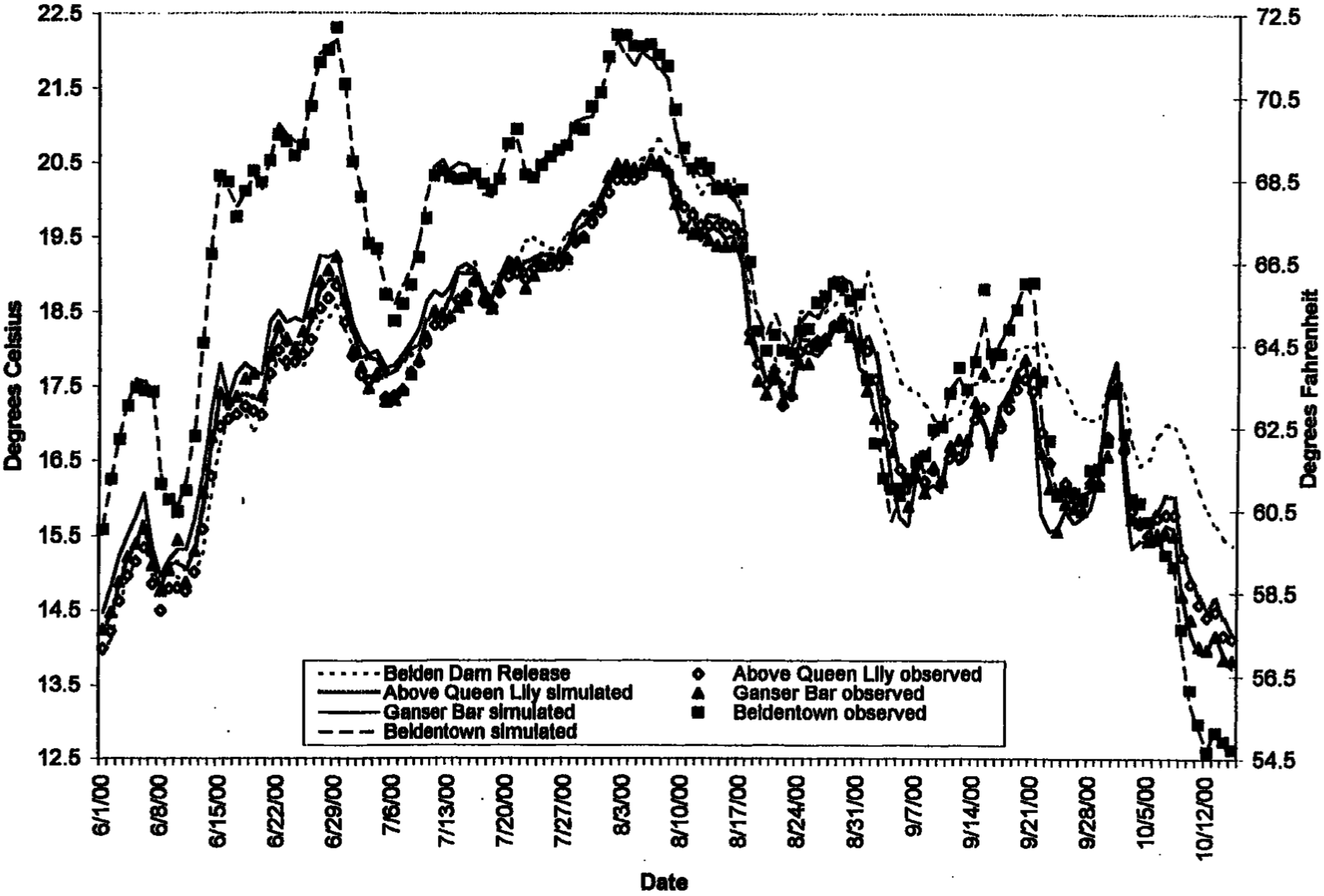

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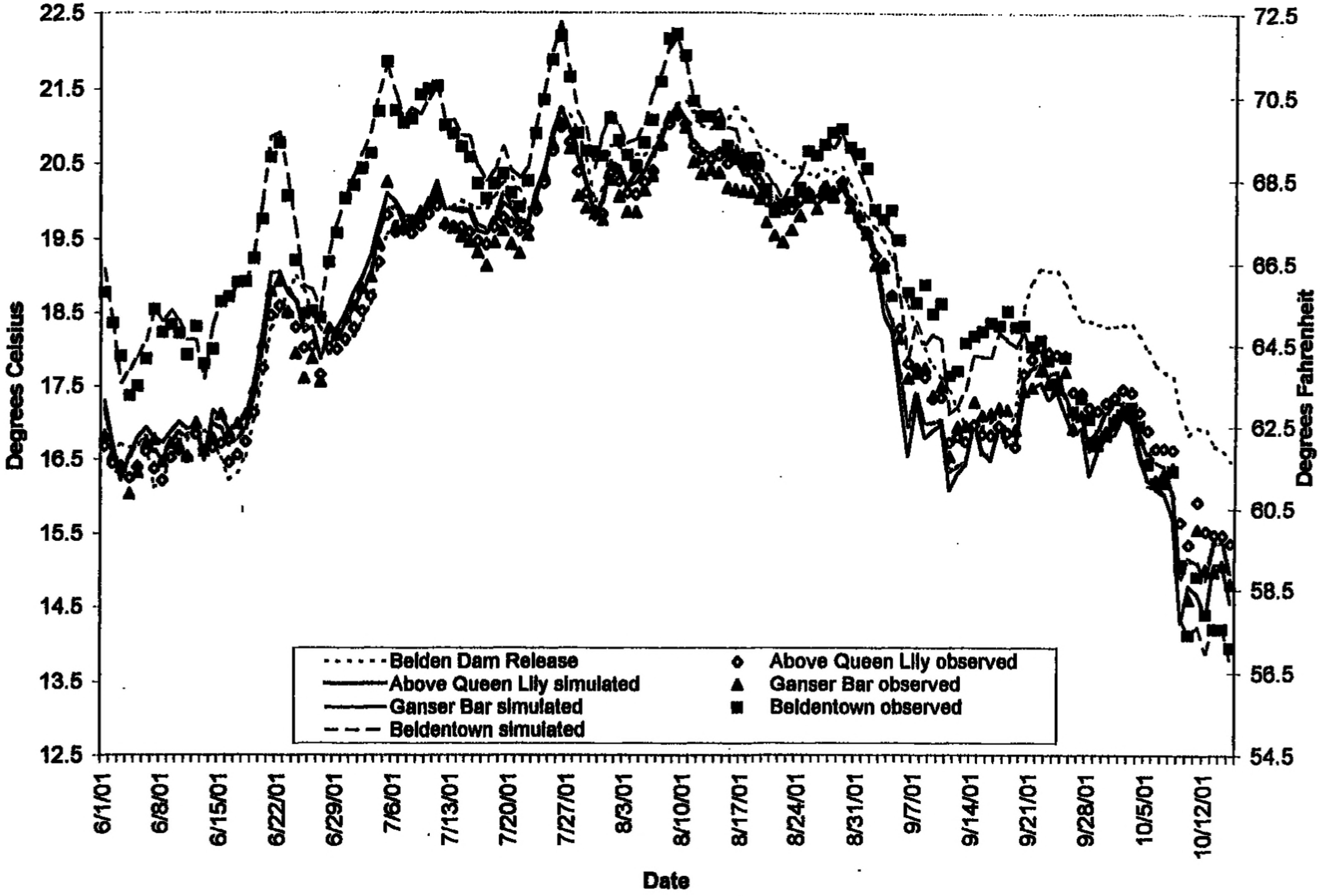

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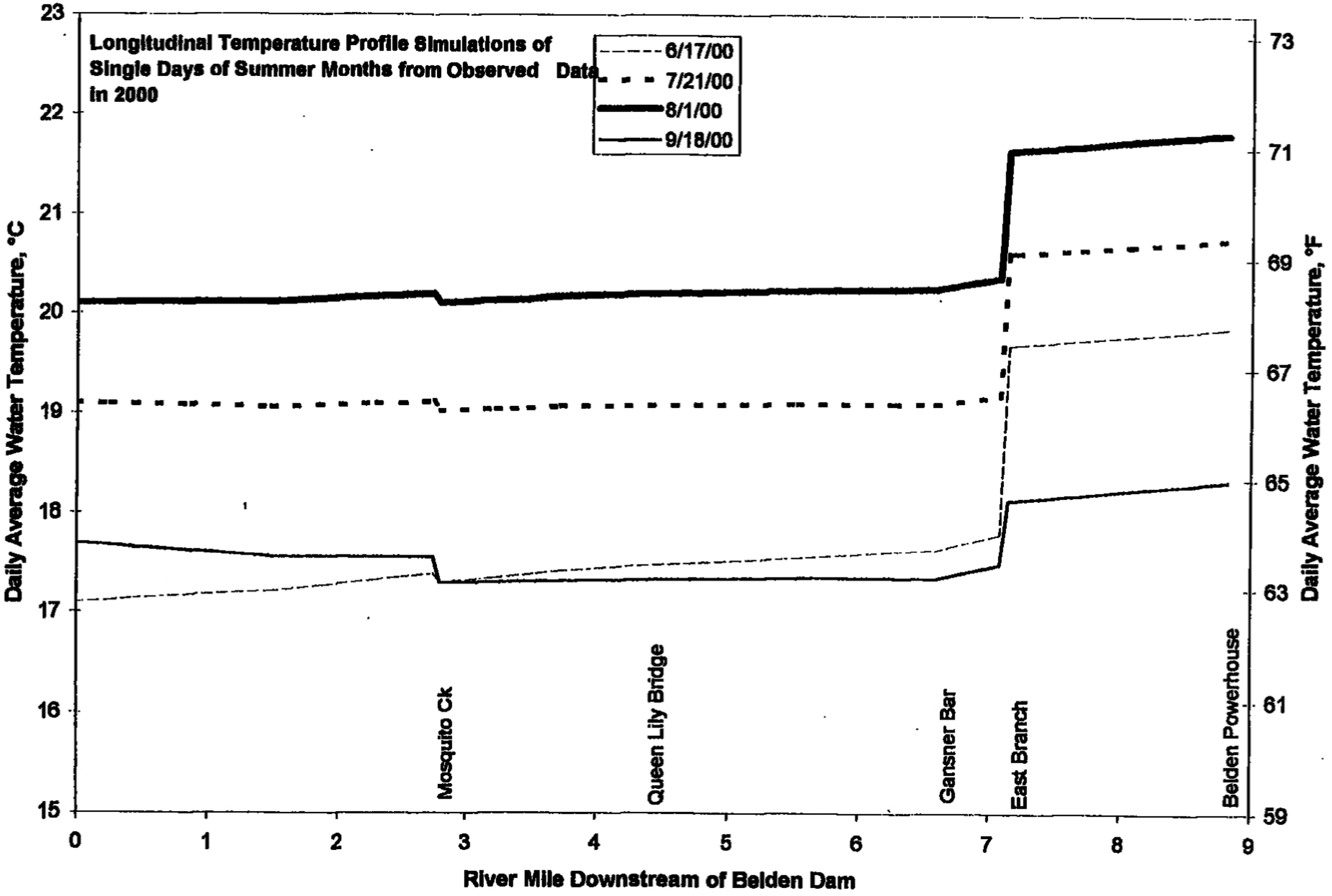

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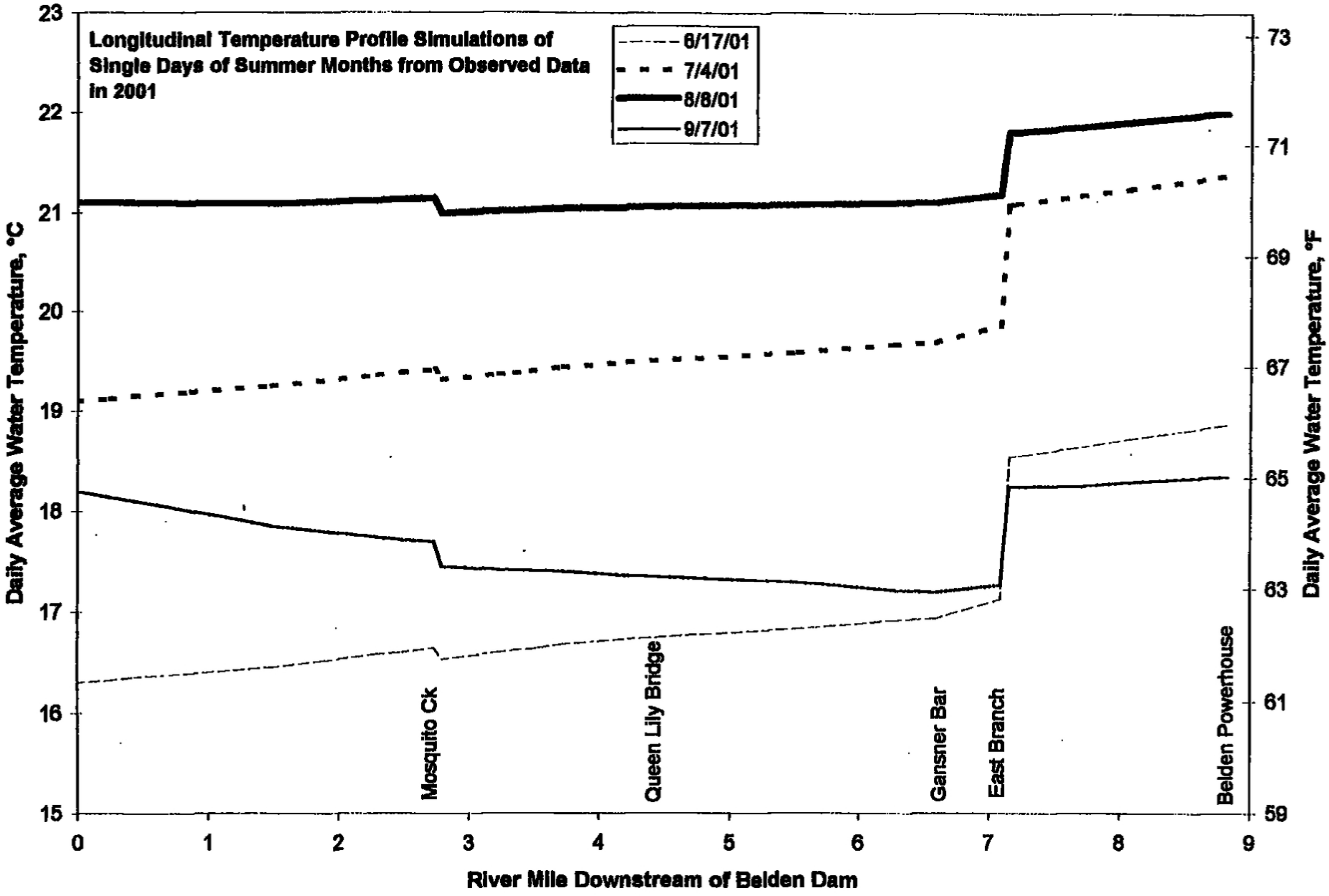

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Table 1. Topographic and vegetative shade attributes used in PG&E's Upper N. Fk. Fearther R. Hydroelectric Project Stream Temperature Model - Seneca Reach.

Top of Reach (location)	Above end Distance (km)	Reach Azimuth (°)	Stream Width (m)	Stream Bank	Topographic Angle (°)	Calculated Tree height (m)	Crown (m)	Offset (m)	Calculated Vegetative Density (%)
Canyon Dam	17.5	+18°	14.93	Right:	32.75	20.96	4.19	3.43	0.79
				Left:	35.25	20.91	4.57	1.90	0.75
Skinner Flat Rd	15.1	-12°	12.65	Right:	41.25	16.56	5.56	2.50	0.64
				Left:	45.50	13.97	5.33	2.50	0.48
Salmon Creek Falls	11.8	-27°	10.92	Right:	37.50	17.26	7.24	1.30	0.87
				Left:	41.00	20.21	6.10	2.06	0.82
Pliocene Creek	10.8	-37°	16.69	Right:	37.50	17.26	7.24	1.30	0.87
				Left:	41.00	20.21	6.10	2.06	0.82
Seneca Bridge	9.3	+58°	11.22	Right:	27.60	9.82	5.49	0.79	0.72
				Left:	25.60	12.83	5.49	0.91	0.77
Butt Creek	2.1	+57.3°	11.92	Right:	38.20	15.24	7.01	2.99	0.69
				Left:	36.40	15.56	6.40	3.29	0.63

Table 3. Maximum and minimum shade values used in PG&E's Upper N. Fk. Fearther R. Hydroelectric Project Stream Temperature Model - Belden Reach. (Woodward-Clyde Consultants, 1986).

Top of Reach (location)	Above end Distance (km)	WCC Original data		
		Stream Width (m)	Shade values:	
			Minimum	Maximum
Belden Dam	14.2	16.00	0.4211	0.5838
	13.8	16.00	0.2758	0.5528
	13.5	16.00	0.3783	0.6414
	12.8	16.00	0.3783	0.6414
	11.8	16.76	0.2262	0.5100
	10.5	14.33	0.1947	0.5330
	10.2	14.33	0.1947	0.5330
	9.0	14.33	0.2415	0.4001
	8.6	14.33	0.1000	0.5940
	8.2	14.33	0.3105	0.4080
	7.4	9.75	0.3616	0.4853
	5.3	18.29	0.3341	0.4910
	4.1	10.06	0.4267	0.5384
	3.6	28.96	0.2099	0.2883
	2.6	23.77	0.1778	0.2619
	1.8	26.21	0.0265	-0.0110
	1.2	21.64	0.0562	0.1385
Belden Powerhouse	0.0			

Table 2. Topographic and vegetative shade attributes used in PG&E's Upper N. Fk. Fearther R. Hydroelectric Project Stream Temperature Model - Butt Creek Reach.

Top of Reach (location)	Above end Distance (km)	Reach Azimuth (°)	Stream Width (m)	Stream Bank	Topographic Angle (°)	Calculated Tree height (m)	Crown (m)	Offset (m)	Calculated Vegetative Density (%)
Butt Valley Dam	3.3	-26°	3.43	Right:	43.50	10.46	4.19	0.76	0.66
				Left:	46.75	17.68	4.57	1.98	0.66
High Gradient Canyon	2.4	-75°	6.02	Right:	48.50	19.69	6.86	1.91	0.51
				Left:	35.75	23.21	6.48	0.91	0.73
Moderate Gradient Canyon	1.8	-8°	6.83	Right:	32.92	22.51	5.99	1.52	0.74
				Left:	37.58	28.79	6.63	1.65	0.71

UPPER NORTH FORK FEATHER RIVER PROJECT

FERC NO. 2105

Attachment E2-D

MITEMP3 Model Calibration and Validation in 2000-2001: Lake Almanor and Butt Valley Reservoir

MITEMP3 Model Calibration and Validation in 2000 - 2001 Lake Almanor and Butt Valley Reservoir, CA

Prepared for

Pacific Gas and Electric Company

Prepared by

Bechtel Corporation
50 Beale Street
San Francisco, California

March 2002

Executive Summary

In 2000 PG&E contracted with Bechtel Corporation to perform a peer review of a numerical reservoir model in connection with PG&E's relicensing work for the Rock Creek-Cresta Project (FERC License No. 1962) and the Upper North Fork Feather River (NFFR) Project (FERC License No. 2105). Key issues to be addressed by the relicensing effort are the effects of project operation on the NFFR stream temperatures and, through the thermal regime established in the project reach, on the local fishery.

As part of a cold water feasibility study conducted in 1985-1986, Woodward Clyde Consultants (WCC) developed MITEMP3 for PG&E's Lake Almanor and Butt Valley Reservoir. A discrepancy in the thermal stratification structure of Lake Almanor between the predictions of the model and the observations of the lake raised concerns about the validity of the model. To address these concerns, an extensive field monitoring program was conducted during 2000-2001 and a peer review, followed by the re-calibration of the MITEMP3 model for two reservoirs, Lake Almanor and Butt Valley Reservoir, were carried out to ensure that a reliable model is available to investigate the feasibility of supplying cold water to the NFFR streams. This report presents the findings of the peer review, the results of the re-calibration, and validation of MITEMP3 for these two reservoirs.

The objectives of the study are as follows:

1) Review the WCC MITEMP3 model and identify the causes of the discrepancies between the predictions of the model and the observations of the thermal structure in Lake Almanor.
2) Re-calibrate the Lake Almanor MITEMP3 model for year 2000 conditions;
3) Validate the Lake Almanor MITEMP3 model for year 2001 conditions;
4) Assess the impacts of spring flows on the water balance and thermal regime of Lake Almanor;
5) Re-calibrate the Butt Valley Reservoir MITEMP3 model for year 2000 conditions;
6) Validate the Butt Valley Reservoir MITEMP3 model for year 2001 conditions.

The MITEMP3 model is generally applicable for the simulation of a stratified lake or reservoir provided that the one-dimensional assumptions are met. The characteristics of Lake Almanor and Butt Valley Reservoir make them amenable to analysis using one-dimensional models.

The model production runs performed by WCC in 1986 (WCC, 1986) inadvertently had a conversion error in model input that resulted in a significant overestimate of the cold water volume available both in Lake Almanor and Butt Valley Reservoir

The re-calibrated and validated MITEMP3 model was used to predict the temperature profiles and the temperatures of water released from the outlets (i.e., Prattville Intake, Caribou 1 and 2 intake structures) for various combinations of meteorological, hydrological, structural modification, and operational scenarios. These simulation runs were carried out under a separate contract and the results are reported in the Exhibit E of Draft Application for New License for FERC 2105 (PG&E, April 2002).

Lake Almanor Model

Lake Almanor has numerous springs that are an important source of cold water in the dry summer months. The water balance for the entire lake suggests that the total spring flow in year 2000, an "average" water year, was about 255 cfs.

The Lake Almanor model was calibrated with the year 2000 data covering the period from April to September. The model correctly predicted the formation of a thermocline in late spring, the strengthening of thermal stratification during the summer, and a diminishing temperature gradient in the fall. The model simulations replicated the measured thermocline elevation, as well as the temperatures of epilimnion and hypolimnion waters (Figures 4.12 – 4.16). The mean bias and the maximum difference between simulated and measured Butt Valley tailrace temperatures (outflow from Lake Almanor) are 0.08°C and 1.4°C, respectively (Figure 4.17 and Table 4.1).

According to the water balance calculation, the estimated spring flow for the year 2001, a "dry" year, was 201 cfs. The Lake Almanor model performed well for the year 2001 validation period, provided that the light extinction coefficient was reduced to reflect the reduction in the suspended sediments in the reservoir due to the reduced inflows (Figures 4.29 – 4.32). The mean bias and the maximum difference between simulated and measured Butt Valley tailrace temperatures are 0.04°C and 1.1°C, respectively (Figure 4.33 and Table 4.1).

Butt Valley Reservoir Model

No significant source of spring flows was identified for Butt Valley Reservoir. The water balance for the entire reservoir suggested that the relation between power load and turbine flow adopted for Caribou 1 and Caribou 2 Powerhouses may underestimate the actual flow through the units. A 7% increase added to the calculated outflow was found to produce the best match between simulated and measured reservoir surface levels. This adjustment was applied to subsequent simulation runs.

Butt Valley Reservoir does not have enough storage volume to cause significant long-term thermal stratification because its retention time is relatively short, on the order of one to two weeks, as opposed to the nine-month retention time for Lake Almanor. Due to solar heating, the temperature of water leaving Caribou 2 Powerhouse is 1-2°C warmer than that entering the reservoir.

The Butt Valley Reservoir model was re-calibrated with the year 2000 data covering the period from April to September. The model predicted a weak thermocline in late spring, which quickly dissipated during the summer. The agreement between simulated and measured temperature profiles is, in general, satisfactory (Figures 5.6 – 5.9). The mean bias and the maximum difference between simulated and measured Caribou 1 tailrace temperatures are –0.18°C and 2.8°C, respectively. The mean bias and the maximum difference between simulated and measured Caribou 2 tailrace temperatures are 0.01°C and 1.4°C, respectively (Figure 5.10 and Table 5.1). These values were obtained after removing abnormalities in observed Caribou 2 tailrace temperatures.

The Butt Valley Reservoir model performed satisfactorily for the year 2001 validation period, provided that the light extinction coefficient was reduced to reflect the reduction in the suspended sediments in a "dry" year (Figures 5.15 – 5.17). The mean bias and the maximum difference between simulated and measured Caribou 1 tailrace temperatures are 0.89°C and 4.6°C, respectively (Figure 5.18 and Table 5.1). The biggest discrepancies between the simulated results of the model and the observations occurred in periods when the reservoir was thermally stratified and the flow through the Caribou 1 Powerhouse was small. Under these conditions, Caribou 1 intake, located in the deep part of the reservoir, is likely to draw cold water selectively and the model, by withdrawing water over the full depth, conservatively over-estimates the temperature of water released from Caribou 1 Powerhouse. As Caribou 1 started full operation in early summer, the cold water was rapidly depleted. The reservoir became well mixed during the critical months from summer to fall, and hence the Caribou 1 Intake draws water uniformly from the water column as predicted by the model. For the period when the withdrawal is likely to be uniform, the mean bias and the maximum difference for the Caribou 1 tailrace temperatures are much reduced from 0.89°C and 4.6°C to 0.01°C and 0.9°C, respectively (Table 4.1). Because the withdrawal of coldwater is associated with small discharge rates and because the volume of cold water in Butt Valley is small, the selective withdrawal of cold water from Caribou 1 Intake offers limited benefit to the reaches downstream. The mean bias and the maximum difference between simulated and measured Caribou 2 tailrace temperatures are -0.73°C and 1.9°C, respectively, after the removal of abnormalities in observed Caribou 2 tailrace temperatures (Figure 5.18 and Table 5.1).

The re-calibrated MITEMP3 model has been applied to two reservoirs of contrasting characteristics and subject to different environmental conditions of years 2000 and 2001. In each case, the model reproduced the general thermal structure, as well as the elevation of thermocline and the temperatures of epilimnion and hypolimnion waters. The model can be used as a predictive tool in support of reservoir operations under existing intake conditions. If this model is to be used to "forecast" the release water temperatures for proposed withdrawal alternatives, the model results should be subject to cautious interpretation and verification, following completion of the physical and numerical model studies being conducted in 2002 at the University of Iowa, Iowa City.

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1. Introduction

1.1 Background

The Upper North Fork Feather River (NFFR) Project and the Rock Creek-Cresta Project are located on the North Fork Feather River watershed in northeastern California and are currently operated by Pacific Gas and Electric Company (PG&E) under FERC License Numbers 2105 and 1962, respectively. While the FERC 2105 Project is still in the process of being relicensed, a FERC 1962 license is being issued in October 2001. Key issues to be addressed by both the relicensing applications are the effects of project operation on the NFFR stream temperatures and, through the thermal regime established in the project reach, on the local fishery.

Lake Almanor is the first in a succession of reservoirs for major hydroelectric generation projects that utilize the water resources of the NFFR and its tributaries for hydroelectric power generation. Water released from Lake Almanor powers the generators at the Butt Valley, Caribou 1 and 2, Belden, Oak Flat, Rock Creek, Cresta, and Poe powerhouses owned by PG&E and the Oroville Project (FERC No. 2100) owned by the State of California Department of Water Resources (DWR). Lake Almanor receives major inflows from the NFFR at Chester (annual flow of approximately 288 cfs), the Hamilton Branch Powerhouse (annual inflow of 109 cfs) and Hamilton Branch (annual average of 85 cfs). Various minor tributaries and groundwater springs also contribute inflows to Lake Almanor. The temperatures of the outflows of Lake Almanor and Butt Valley Reservoir dominate the thermal regime in the NFFR streams. Modeling tools are being developed to assess the impact of the operating scenarios of these hydroelectric facilities on the NFFR stream temperatures.

In 1985-1986, PG&E conducted a study to assess the amount of cold water in Lake Almanor and the feasibility of withdrawing this cold water through proposed modification to the Prattville intake structure. As part of the study, PG&E contracted with Woodward Clyde Consultants (WCC) to develop temperature models for reservoirs and streams in the Rock Creek-Cresta project reach. The study concluded that cold water was available and a "skimmer" structure at the Prattville Intake could reduce temperatures in the Project reaches by approximately 2 - 4°C, with the larger temperature change corresponding to extreme meteorological conditions. The model tool developed for the reservoirs is a one-dimensional numerical model, MITEMP3, a modified version of MITEMP. A series of model production runs were conducted to demonstrate the advantage of the 'skimmer' structure relative to the existing intake conditions in reducing the NFFR stream temperatures.

In 2000, as part of the FERC 2105 relicensing effort, the results of the WCC's model production runs were peer reviewed. Discrepancies between the predictions of the model and the observations of the thermal structure of Lake Almanor raised concerns regarding the validity of the MITEMP3 model. To address these concerns, PG&E carried out an extensive field monitoring program during 2000-2001 and contracted with Bechtel Corporation to identify the sources of the problems, to correct them, and to re-establish the creditability of the MITEMP3 model for Lake Almanor and Butt Valley Reservoir. This report presents the findings of the review and the results of re-calibration and validation.

1.2 Objectives

The objectives of the study are as follows:

1) Review the WCC's MITEMP3 model and identify the causes of the discrepancies in the thermal structure between the predictions of the model and the observations in Lake Almanor;
2) Re-calibrate the Lake Almanor model for year 2000 conditions;
3) Validate the Lake Almanor model for year 2001 conditions;
4) Assess the impacts of spring flows on the water balance and thermal regime of Lake Almanor;
5) Re-calibrate the Butt Valley Reservoir model for year 2000 conditions;
6) Validate the Butt Valley Reservoir model for year 2001 conditions.

The re-calibrated MITEMP3 model was used to predict the temperature profiles in Lake Almanor and Butt Valley Reservoir, and the temperatures of water released from the outlets (i.e., Prattville Intake, Caribou 1 and 2 intake structures) for various combinations of meteorological, hydrological, structural modification, and operational scenarios. These simulation runs were carried out under a separate contract and the results are provided in the Exhibit E of Draft Application for New License for FERC 2105 (PG&E, April 2002).

1.3 Report Organization

Section 2 of this report summarizes the characteristics of the two reservoirs that are pertinent to the calibration of the model. The main features of the MITEMP3 model, a review of WCC's model results, model setup, assumptions, and limitations are discussed in Section 3. Sections 4 and 5 present the results of model re-calibration and validation for Lake Almanor and Butt Valley Reservoir, respectively. Finally, Section 6 presents the conclusions.

2. Project Description

2.1 Lake Almanor

Lake Almanor and Butt Valley Reservoir are part of the Upper NFFR system. Lake Almanor is the primary storage reservoir for the upper NFFR. It stores surface runoff and snow melt in the spring and releases water from storage for electricity generation in the summer and fall. At a normal maximum water surface elevation of 4494 feet (PG&E datum), Lake Almanor has a storage capacity of 1,142,000 acre-feet and a surface area of 27,000 acres. Three main sources of surface inflow are the NFFR at Chester, the Hamilton Branch, and the Hamilton Branch powerhouse. In a "typical" year, the combined inflow can reach a maximum of about 1700 cfs in April or May, and decrease to a base flow of about 240 cfs in the summer. The NFFR flow alone makes up 70-80% of the total inflow. Numerous sources of groundwater feed springs that flow into Lake Almanor but the flow could not been quantified. Groundwater springs are not expected to change appreciably from season to season. They appear to be a significant source of cold water during the dry summer months.

Lake Almanor has two regulated outflows: one through a low-level outlet in the Canyon Dam Intake tower, which releases water to the NFFR below Canyon Dam to support fish and wildlife in the Seneca Reach; another through the Prattville Intake, which releases water to Butt Valley Powerhouse for electricity generation. While the fish-water release through the Canyon Dam is maintained at 35 cfs, the flow through the Butt Valley powerhouse is highly intermittent and can be as high as 2100 cfs when electricity generation reaches its peak, mostly in the summer months. At this flow rate, Lake Almanor has a retention time of nine months. Not surprisingly, Lake Almanor has a distinct annual cycle of stratification.

Starting in the spring, the lake surface begins to rise from a low water level following an increase in inflows from snowmelt. Heated by solar radiation, inflows tend to have a temperature higher than that of the lake water, and hence enter the reservoir near the surface. The temperature difference from surface to bottom becomes more pronounced in the next four to five months, building up a thermal stratification with a temperature difference of about 10°C and an epilimnion layer up to 30-40 feet deep. Surface processes such as the exchange of sensible heat, evaporation, and wind mixing promote convective mixing in the epilimnion, resulting in a fairly uniform epilimnion temperature and a strong vertical temperature gradient at its base. Below the thermocline, the hypolimnion water heats up slowly due to the absorption of solar radiation and turbulent diffusion. This gradual temperature rise is partly offset by cold spring water inflows. In the fall the cooling of the epilimnion eventually weakens the stratification. The lake overturns and ultimately returns to a well-mixed state.

Numerous groundwater springs were observed in the Lake Almanor area. The largest among these is Big Springs, located in a cove to the west of the Hamilton Branch. Flows seep through the ground all year round, both above and below the water line.

Historically, Big Springs flowed into an incised channel, joined the historic Hamilton Branch channel, and flowed 10 miles south before joining NFFR above the Canyon Dam. In 1924 and prior to the completion of Canyon Dam, a channel was excavated to intercept water from Big Springs and Hamilton Branch and conveyed the water to the Prattville Intake. All of these channels are now under water, and are believed to help convey cold water from the Hamilton Branch to the Prattville Intake. These channels are shown in Figure 2.1.

2.2 Butt Valley Reservoir

Butt Valley Reservoir serves as the afterbay to Butt Valley Powerhouse and the forebay for the Caribou 1 and 2 Powerhouses. At a normal operating level of 4132 feet (PG&E datum), the reservoir has a storage capacity of 49,897 acre-feet and a surface area of 1,600 acres. The reservoir receives the majority of its inflows from Butt Valley Powerhouse and a minor contribution from Butt Creek below Lake Almanor. In a "typical" year, the natural stream flow in Butt Creek peaks at about 350 cfs in the spring but decreases to a base flow of about 50 cfs in the summer.

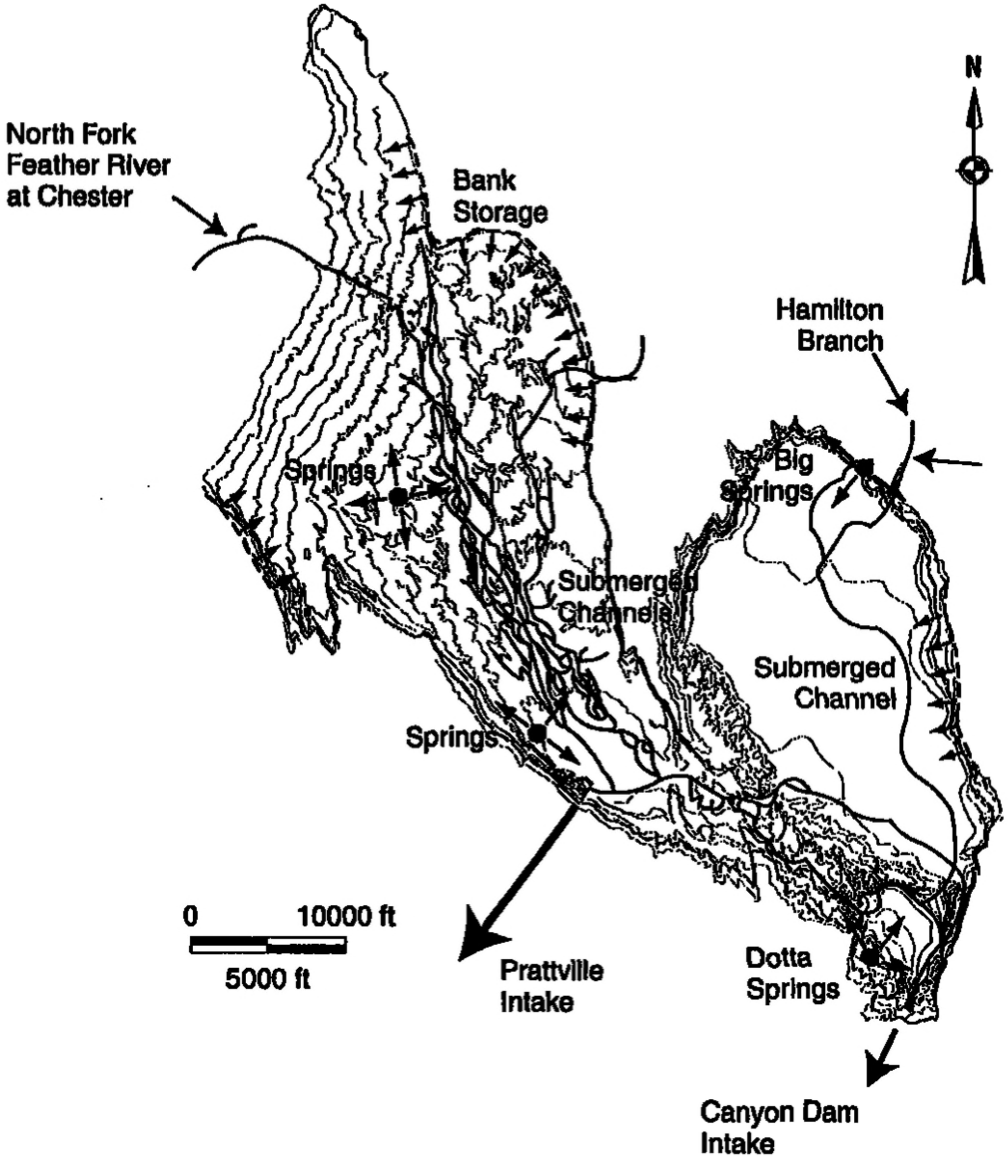
Water in Butt Valley Reservoir is discharged through two intake structures to the Caribou 1 and 2 Powerhouses, and thence to the Belden Reservoir downstream. The outflows are intermittent as the demand for electricity varies. The combined outflow is on the order of 2200 cfs in the summer. At this flow rate, the retention time of Butt Valley Reservoir is approximately ten days.

Because of its small volume, the reservoir water level rises and falls appreciably as a result of unbalanced inflow and outflow. The temperature difference from top to bottom of the water column ranges from 8 to 10°C in June, but reduces to 3°C or less, in August. Unlike Lake Almanor, Butt Valley Reservoir is not stably stratified, except for the spring and early summer months. The shallow water depth, the lack of cold spring flows to the reservoir, and the short retention time all suggest that Butt Valley Reservoir does not store a significant amount of cold water.

The PG&E datum is used throughout this report. Since the USGS datum has been used widely in references related to this project, the relationship between two elevation reference systems is given as follows:

Elevation in feet (USGS datum) = Elevation in feet (PG&E datum) + 10.2 feet

Figure 2.1 Historic Big Meadow Topography Map (1927)



3. MITEMP3 Model Description

3.1 Overview

MITEMP is a one-dimensional numerical model for natural lakes and man-made impoundments. A detailed description of the MITEMP model is given in "Mathematical Predictive Models for Cooling Ponds and Lakes (Octavio *et al.*, 1980)". This model divides the body of water into a series of horizontal layers. Thermal energy is computed on a layer-by-layer basis for any required length of time. Between two adjacent layers, diffusion and convection act to smooth out temperature gradients. Physical processes considered include surface heat transfer, internal heat absorption, the entrance mixing of inflows, withdrawal dynamics, turbulent diffusion, overturning and mixing (Figure 3.1). The time scales associated with these processes range from one year to a day or shorter.

Each physical process can be "calibrated" by adjusting one or more empirical parameters (within the reasonable ranges) to produce the best match between the simulation results and the field measurements. Once calibrated, these process-based parameters should function for a variety of conditions. Since 1970s, the MITEMP model has been applied to numerous projects ranging from natural lakes to cooling ponds. If calibrated for specific site conditions, the model has produced reasonable results as long as the basic assumptions hold, e.g. that significant temperature gradients exist only in the vertical direction.

The principal outputs of the MITEMP model are the vertical temperature distributions and outflow temperatures for a prescribed withdrawal strategy.

3.2 Review of WCC's MITEMP3 Model

MITEMP3 model used for this study is based upon the 1988 version of MITEMP, with minor changes. In 1985-1986, WCC expanded the MITEMP's withdrawal options to include any prescribed, non-Gaussian, withdrawal profiles. This change was necessary to model the flow through the existing Prattville Intake, believed to be uniform from the base elevation of the approach channel to the reservoir surface, and the flow through the modified intake designed to selectively withdraw cold water from the deep part of the reservoir. The WCC MITEMP3 was calibrated using the field data for the period from June 3 to July 20, 1986 and validated for the period from July 9 to August 12, 1985.

In 2000, Bechtel Corporation reviewed the WCC MITEMP3 model in light of the extensive set of temperature measurements collected by PG&E in 2000 and 2001. Special attention was paid to the following questions. Are the calibration and validation procedures adopted sufficiently rigorous to ensure the predictability of the model over a range of conditions? Are model results in good agreement with the field measurements conducted in 1985, 1986, and 2000? Are the model predications for the production runs consistent with what is known of the thermal structure of the lake?

Although the WCC MITEMP3 model results were in reasonable agreement with the measurements conducted in 1985 and 1986, this model failed to replicate the year 2000 conditions, suggesting an inadequate calibration. For the production runs, the model did not adequately predict the well-documented thermal stratification in the summer months. Specifically, the model significantly under-estimated the thickness of the surface layer and hence over-predicted the volume of cold water available for downstream release.

Two unrelated reasons are believed to be responsible for the unsatisfactory model performance. First, the simulation period was too short and began too late in the annual cycle of the lake, excluding the period when the lake develops a thermal stratification from a well-mixed state. Hence the model was not calibrated for the full range of hydrodynamic conditions for which it was required to make predictions. Second, the light extinction coefficient, a parameter describing the decay rate of the transmitted short-wave radiation into water column, was inadvertently increased ten times for all production runs when the system of units was converted from the SI system to the English system. The net effect was that the solar radiation would only penetrate approximate 0.5 m of water, instead of 5 m as observed in Lake Almanor, eliminating the source of heat responsible for development of stable thermal stratification in the lake.

The WCC MITEMP3 and the 1988 version MITEMP (the original model developed by MIT) were run for the year 2000 conditions using the WCC calibration parameters that did not include the error in the light extinction coefficient. Results are essentially identical, suggesting that the modifications made by WCC do not substantially change the functions and capabilities of MITEMP. The review concluded that the WCC MITEMP3 should be re-calibrated using the data covering a stratification cycle and validated using the data from another year.

3.3 Modifications

In 2000, PG&E contracted with Bechtel Corporation to re-calibrate MITEMP3 using the extensive field data collected in 2000 and 2001 in Lake Almanor. In the process, the following modifications were made to the MITEMP3 model:

1) Added the groundwater springs to the inflows into Lake Almanor.
2) Replaced the constant light extinction coefficient with a seasonally adjusted one, reflecting the high turbidity levels observed in late spring.
3) Used calibration and validation periods spanning a full cycle of stratification, starting from late spring and lasting through the critical summer months. This approach ensures that the model parameters were fully tested for the period of greatest concern.
4) Modified the algorithm for adjusting the turbulent diffusivity in the presence of an unstable density gradient, which was found to cause numerical instability.
5) Corrected inconsistent declaration of variables.

3.4 Assumptions

Central to the MITEMP3 model are several assumptions, mostly related to the use of a one-dimensional model to describe the thermal structure in the reservoir:

1) The temperature gradient is predominantly in the vertical direction. The variation in the horizontal direction is minimal.
2) Inflows are allowed initially to mix with the ambient water. Once diluted, inflows are inserted at an elevation at which the mixed inflow water spreads horizontally without causing thermal instability. The initial mixing is designed to represent some of the near-field, three-dimensional effects.
3) Although inflow and outflow occur locally, effects are "communicated" instantaneously to the entire computational "layer" at which these inflow and outflow take place.
4) The meteorological conditions imposed over the surface of the lake are spatially homogeneous, despite micro-climatic variations that inevitably occur.
5) The withdrawal scheme is based upon a prescribed flow distribution. The validity of this assumption should be tested using the principles of stratified flows and field observations.

Because of its large size, Lake Almanor has a thermal structure strongly influenced by surface heat transfer but relatively unresponsive to daily flows. Sustained winds, which are of sufficient magnitude to cause seiching and wind-induced circulation, are also absent from the site (UC Davis, February 2002). These two factors make Lake Almanor amenable to analysis using one-dimensional models.

In 1985, PG&E conducted velocity measurements in the vicinity of Prattville Intake. Temperature profiles were also collected in front of the Prattville, Caribou 1, and Caribou 2 intake structures. Based on these observations, it was assumed that these intake structures draw water uniformly from the full depth of the water column in the vicinity of the intake.

3.5 Limitations

A one-dimensional model such as MITEMP3 cannot simulate three-dimensional effects due to seiching, longitudinal temperature/pressure gradients, or the near-field effect in the vicinity of the intake structure. The temperature measurements at various locations throughout Lake Almanor have not produced any evidence of seiching or large-scale circulation. These temperature profiles indicate that the thermal structure of the lake is indeed one-dimensional. For Butt Valley Reservoir, this assumption was also justified by field measurements.

At a time step of 24 hours, the time resolution of the model is limited to changes lasting a day or longer. This time step balances the need to model essential processes relevant to the withdrawal of cold water against computational effort. The diurnal heating and cooling cycle of the surface water, which primarily affects the top three to five feet of water but has no lasting effect on either the depth of thermocline or the temperature of water in hypolimnion, will not be reproduced using a time step of one day.

MITEMP3 model has been calibrated for the existing intake configurations. Should these structures be modified to draw a greater amount of cold water, the withdrawal scheme used in the model would need to be modified, provided the characteristics of the modified intake structures are fully understood. Data for modifying the withdrawal scheme will be obtained with a physical and numerical modeling study being conducted (2002) at the University of Iowa.

3.6 Model Setup

The MITEMP3 model requires six types of input: meteorology, inflow, lake characteristics, outflow, initial conditions, and computational grids.

Meteorology. Meteorological data include air temperature, wind speed, relative humidity, cloud cover, and solar radiation. Among these, hourly air temperature, wind speed, and relative humidity were collected by the U.S. Forest Service at Chester, California on the western shore of Lake Almanor and published by the California Data Exchange Center of California Department of Water Resources (http://cdec.water.ca.gov). Solar radiation was measured by PG&E at the Prattville Intake site. The percentage of cloud cover, CC, was computed using the following equation:

$$CC = \sqrt{\frac{1-\frac{S}{S_0}}{0.65}}; \qquad \text{Equation (3.1)}$$

where S is the measured solar radiation, S_0 is the clear sky solar radiation adjusted for the latitude and altitude of the site (Becker, 1979). When not measured, the solar radiation was calculated using the clear sky solar radiation and the historical mean cloud cover.

In addition to solar radiation, PG&E also measured air temperature, wind speed, and relative humidity at Prattville. The air temperature and wind speed at Prattville tend to have a more narrow range than those at Chester. The meteorology station at Prattville may have been sheltered by local topography from prevailing winds and therefore, is not representative of conditions on Lake Almanor. For this reason, air temperature, wind speed, and relative humidity at Chester Station were used for model inputs.

Inflow. Inflow quantity, temperature, and the entrance mixing ratio are required inputs. PG&E has installed gaging stations on major tributaries to Lake Almanor and Butt Valley Reservoir and provided both flows and water temperatures. The entrance mixing ratio depends on the bottom slope of the streambed and how rapidly the stream channel expands before entering the lake. A large expansion angle and a steep bottom slope lead to greater mixing and a higher entrance mixing ratio.

Precipitation for the simulation period was small and was not accounted for; the monthly cumulative rainfall for April and May was on the order of 2 inches or less and dropped to zero from June to September.

Lake Characteristics. The lake bathymetry information consists of the surface area and the corresponding lake length for selected elevations. This information was developed using the topographic maps and data provided by PG&E.

The transfer of heat by evaporation, conduction, long wave radiation from the water vapor in the sky and back radiation from the water surface are immediately absorbed by the water at the surface. The surface water, on the other hand, absorbs only a portion of solar radiation (typically thirty to forty percent of the incident solar radiation). The reminder penetrates considerable depths to warm up the hypolimnion water. Two calibration parameters are required here: the light extinction coefficient and the surface absorption of solar radiation. Short wave radiation penetrates water depths according to an exponentially-decay function (the Beer's law), with the light extinction coefficient, η, as the rate of decay. Its value depends on the color and clarity of the water. Empirically, this coefficient has been found to correlate with the secchi depth, D, i.e.,

$$\eta = \frac{\alpha}{D} \qquad \text{Equation (3.2)}$$

where α is a constant. Poole and Atkins (1929) found that a typical range for α is 1.1 to 1.7. For Lake Almanor, the secchi depth has low readings (or high light extinction coefficients) in the spring when inflows bring suspended sediments to the lake and again in late summer when biologic activities are most vigorous.

Outflows. All outflows considered are regulated releases. Besides the outflow quantity, MITEMP3 also requires information on the withdrawal elevation and flow distribution over the depth (uniform vs. selective). In some cases, the water available for withdrawal is further constrained by the topographic features in the vicinity of the intake. Hence, the withdrawal scheme was determined from a careful examination of intake configuration, local topographic features, and velocity measurements, if at all possible.

Initial conditions. Water temperature profile and water surface elevation are required to initialize the computation. Ideally, the simulation should commence when the lake is still in a well-mixed state.

Computational grid. MITEMP3 uses a uniform grid system, defined by the grid spacing (1.52 m) and a reference elevation at the bottom of the lake.

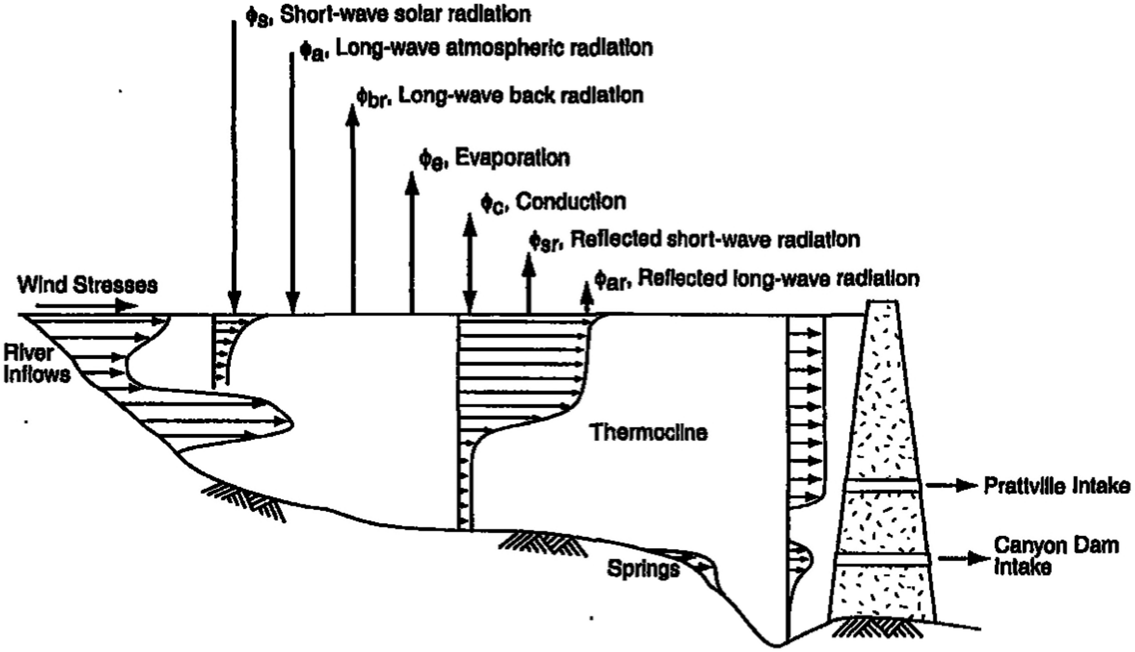
The MITEMP3 simulation was carried out using a 24-hour time step. Meteorological and inflow data at a shorter time interval were first averaged to obtain daily values.

The MITEMP3 model was calibrated as follows:

1. Without the spring flows, run the model for the entire simulation period. The spring flow rate required to achieve water balance was determined from the difference between the observed and simulated water levels.
2. Adjust within a relatively narrow range the light extinction coefficient to match the observed thermocline depth. The initial values were chosen based on the secchi depth readings (see Equation (3.2) above).
3. Adjust the percentage of absorption of solar radiation by surface water within a relatively narrow range to produce a desired temperature gradient at the thermocline elevation.
4. Adjust the entrance mixing ratio for the inflows to match the hypolimnion temperature.

The primary calibration parameters are the light extinction coefficient, the surface absorption, the entrance mixing ratio, and to a lesser extent, the vertical diffusion coefficient. These parameters are site specific and were adjusted ("calibrated") using the PG&E field measurements. Sensitivity analyses were performed to "fine-tune" these parameters to obtain the "best match" between the predicted and observed thermal structure.

Figure 3.1 Physical Processes for Stratified Reservoirs as Applied to Lake Almanor



4. Lake Almanor Model

The Lake Almanor model was calibrated for the period from April 6 to September 30, 2000 and validated for the period from April 24 to August 7, 2001. Two types of temperature measurements were used extensively: the temperature profiles in the lake and the time series of the outflow temperatures. A water balance calculation was performed to determine the probable spring flow quantity.

The lake model encompasses the body of Lake Almanor with both Hamilton (eastern) and Chester (western) lobes. Although calibrated and run separately, the Lake Almanor model and the Butt Valley Reservoir model are hydraulically connected by the Butt Valley turbine flow through Prattville Intake.

Figures 4.1 – 4.5 show the meteorological conditions for year 2000. The average air temperature increased from 8°C in spring to about 20°C in summer while the daily average wind speed remained in the 2 to 2.5 m/s range. Relative humidity was higher in spring (70%) and dropped to about 35% in summer. The percentage cloud cover varied from 60-90% to 30-40% for the same period, further modulating the solar radiation.

Lake Almanor has three major inflows: NFFR at Chester, Hamilton Branch, and the Hamilton Branch Powerhouse. Year 2000 was close to an "average" water year. The NFFR inflow reached 1400 cfs in mid April (Figure 4.6). From April 6 to May 16 the NFFR inflow was not monitored. The flow quantity was obtained using water balance. The flows in Hamilton Branch and the Hamilton Branch Powerhouse were as high as 180 cfs and 200 cfs for the same period, respectively (Figures. 4.7 and 4.8). In the summer months, the combined inflow from these three sources was in the order of 250 cfs. Among the three inflows, the NFFR has a small entrance mixing ratio due to the gradual expansion of the river channel at the mouth. Both Hamilton Branch and the Hamilton Branch Powerhouse inflows have a larger entrance mixing ratio due to the rapid expansion of the inflows upon entering the lake.

Lake Almanor has two outlets one at Prattville Intake and one at Canyon Dam Intake. The daily average outflows for year 2000 are shown in Figure 4.9. The Canyon Dam release flow was maintained at 35 cfs throughout the year, while the Butt Valley Powerhouse flow increased from zero in spring to about 2000 cfs in summer and depending on the demand for electricity, could fluctuate from hour to hour.

The invert of the Prattville Intake is located at elevation 4410 ft. However, the accessibility to the water in the deep, eastern lobe is restricted by a broad and flat plain, which has an elevation ranging from 4427 ft to 4429 ft. This is a submerged area known as Big Meadow prior to construction of Canyon Dam. Cutting through this flat area is a narrow channel connecting the eastern lobe and Prattville Intake. The channel bottom elevation is approximately 4422 ft. This channel was excavated and improved to convey water from the Big Springs area before Canyon Dam was raised in 1924. The capacity of the channel appears to be insufficient for the quantity of cold water desired and water from outside the channel and at higher elevations may have to be drawn into the intake to meet lower outflow temperature requirements. On March 7, 2001, PG&E made velocity measurements in front of Prattville Intake. Results indicate that the withdrawal velocity was fairly uniform in the first 40 ft of water depth, down to elevation 4436 ft. For modeling purposes, it was assumed that Prattville Intake withdraws water uniformly from elevation 4436 ft to the surface.

The Canyon Dam Intake tower has two groups of gates. The invert of the lower gates, from which fish-water is currently released, is situated at elevation 4422 ft. The upper gates have an invert elevation of 4467 ft and are not operated except during higher flow releases. The MITEMP3 model assumed the withdrawal velocity profile at Canyon Dam Intake is Gaussian with the maximum velocity at an elevation of 4421 ft.

The table below summarizes the light extinction coefficient for years 2000 and 2001. Thirty-five percent of solar radiation was assumed to be absorbed at the surface.

Lake Almanor Light Extinction Coefficient

Month	Secchi Depth[1], m		Light Extinction Coefficient, m^{-1}	
	1982-1995	2001	2000	2001
March	2.2	2.9		
April	2.9	3.0	0.22	0.21
May	2.9		0.25	0.21
June	4.5	8.4	0.25	0.21
July	5.7	6.1	0.20	0.20
August	5.1		0.25	
September	6.6	4.2	0.19	

[1] Average value based upon secchi depth measurements provided by the California Department of Water Resources.

4.1 Calibration

The water temperature profile measured on April 6, 2000 was used to initialize the calibration run. This temperature distribution is fairly uniform, with only 3°C difference from surface to bottom.

For the year 2000, the total spring flow was estimated to be 255 cfs, giving a mean bias and the maximum difference between simulated and measured water surface levels of –0.05 ft and 0.3 ft, respectively (Figure 4.10). The spring water temperature was assumed to be 8°C, based upon several temperature readings at Big Springs obtained when the lake level was low enough to expose spring water inflows. This spring water temperature is expected to remain constant throughout the year. It was further assumed that the majority of the spring flows comes from the Big Springs area. The existing cold water channel, i.e., the historic Hamilton Branch and Big Springs natural channel, provides a pathway for the spring water to reach the deep part of Lake Almanor, causing little mixing with ambient water along the way. Based upon these assumptions, the groundwater springs were treated as a single inflow with a low entrance mixing ratio. These assumptions gave reasonable results in the model but remain to be verified by the three-dimensional model and additional field data.

PG&E collected synoptic temperature profiles at eight stations distributed throughout Lake Almanor on five days. Figure 4.11 is a location map of these temperature stations. The comparisons of simulated and measured profiles for June 22, July 20, August 17, September 9, and September 28 are shown in Figures 4.12 – 4.16. The overall agreement is very good in terms of the thermocline elevation and the temperatures of epilimnion and hypolimnion waters. Note that most of the field temperature data were collected around the noon hour, with the measured temperature profiles showing a heated surface layer three to four feet deep. This warm surface layer only lasted through the warmest hours of the day and should be ignored when comparing the measurements and the model results because the latter represent only daily averages.

Figure 4.17 is a plot of the outflow temperatures at the Butt Valley Powerhouse tailrace and the NFFR below Canyon Dam. The measured temperatures are also plotted as symbols. It has been observed that when the Butt Valley outflow is small, the temperature sensor, placed at the confluence of the Butt Valley tailrace and Butt Creek below Lake Almanor, had a tendency to show a lower temperature, more in line with that of Butt Creek rather than with those in front of Prattville Intake. To filter out these "contaminated" readings, the outflow temperatures shown are averages weighted with the Butt Valley turbine flow.

The agreement between simulation results and measurements is satisfactory for the Butt Valley tailrace but is not quite as good for the NFFR below Canyon Dam (MITEMP3 appeared to underestimate the water temperature from May to July). It was noted that the measured water temperature in the NFFR below Canyon Dam was higher than that in the hypolimnion layer as revealed by the temperature profile in front of the intake tower. It was suggested, and later confirmed by PG&E operators, that there was a small leak in the upper gates of the Canyon Dam intake, causing warm epilimnion water to mix with the released cold water and raising the outflow temperature by approximately 0.5°C. Based upon the temperatures corresponding to the upper and lower gates elevations, the leakage flow was estimated to be on the order of two to three cfs. No effort was made to incorporate the leakage from the upper gates in the MITEMP3 model.

Table 4.1 summarizes the mean bias, the probable difference on 50% confidence, and the maximum difference between simulated and measured temperatures. The probable difference on 50% confidence is defined as 0.6745 times the standard deviation. For the Butt Valley tailrace, the mean bias and the maximum difference are 0.08°C and 1.4°C, respectively. For the NFFR below Canyon Dam, the mean bias and the maximum difference are –0.16°C and 0.7°C, respectively.

4.2 Validation

The meteorological conditions for the year 2001 are shown in Figures 4.18 – 4.22. The inflow and outflow time series are shown in Figures 4.23 – 4.26. The year 2001 was a dry year. The peak flow in the NFFR at Chester, for example, was only 350 cfs, compared with 1400 cfs in year 2000. Due to power generation requirements in 2001, the water level in Lake Almanor was drawn down to an unusually low level in early spring, resulting in a much-reduced cold water supply for the rest of the season. The light extinction coefficient for the period from April to June was reduced as well, reflecting the reduction in suspended sediments. Other model parameters remained unchanged. This set of parameters is believed to be representative of dry year conditions.

A combined spring flow of 201 cfs gave a good prediction of the lake level in the year 2001 simulation period (Figure 4.27). This reduction in spring flows may be due to a lower water table.

The initial temperature profile used to initialize the year 2001 validation run was taken on April 24, 2001. At that time, the temperature difference between surface and bottom was 5°C.

The model was run for the period from April 24 to August 7, 2001. During this period, the lake temperature profiles were collected at nine stations on four days. Figure 4.28 shows a location map of PG&E's temperature stations. The simulated temperature profiles were compared with the measured profiles on June 6, July 10, July 24, and August 9 (Figures 4.29 – 4.32). The simulation terminated on August 7 due to lack of inflow information at the time of model testing. Hence on Figure 4.32 the comparison was made between the simulated temperature profile for August 7 and the measured profile for August 9. With the exception of the epilimnion water temperature on June 6 and July 10, the model was able to predict satisfactorily the elevation of thermocline and the hypolimnion temperature, two critical factors in determining the amount of cold water in the lake.

Figure 4.33 shows the temperature of the outflows from Lake Almanor. The mean bias and the maximum difference are 0.04°C and 1.1°C for Butt Valley tailrace and –0.66°C and 1.3°C for the NFFR below Canyon Dam (Table 4.1). MITEMP3 under-predicted the temperature of water in the NFFR below Canyon Dam, hence the large bias. The under-prediction is attributed to the observed leakage from the upper gates of the Canyon Dam Intake tower. No correction was made to include this leakage in the model simulation.

Table 4.1 Lake Almanor: Comparison of Observations and Model Predictions

Period	Output	Mean Bias[1]	Probable Difference on 50% Confidence[2]	Maximum Difference
Year 2000 Calibration	Water Surface Elevation, ft	-0.05	0.1	0.3
	Butt Valley Tailrace Temperature[3, 4], °C	0.08	0.3	1.4
	NFFR below Canyon Dam - Seneca Reach, °C	-0.16	0.2	0.7
Year 2001 Validation	Water Surface Elevation, ft	0.07	0.04	0.2
	Butt Valley Tailrace Temperature[3], °C	0.04	0.3	1.1
	NFFR below Canyon Dam - Seneca Reach[5], °C	-0.66	0.2	1.3

Notes:

[1] Bias = MITEMP3 prediction - field measurement

[2] Probable difference on 50% confidence = 0.6745 x the standard deviation

[3] Measured water temperature at Butt Valley tailrace is flow-weighted.

[4] From August 16 to 19, 2000 Butt Valley Powerhouse operation was interrupted. The measured water temperature for this period is not used for statistical analysis.

[5] Measured water temperature in NFFR below Canyon Dam during the IFIM test period from May 12 to 16, 2001 is not used for statistical analysis.

Figure 4.1 Year 2000 Air Temperature at Chester

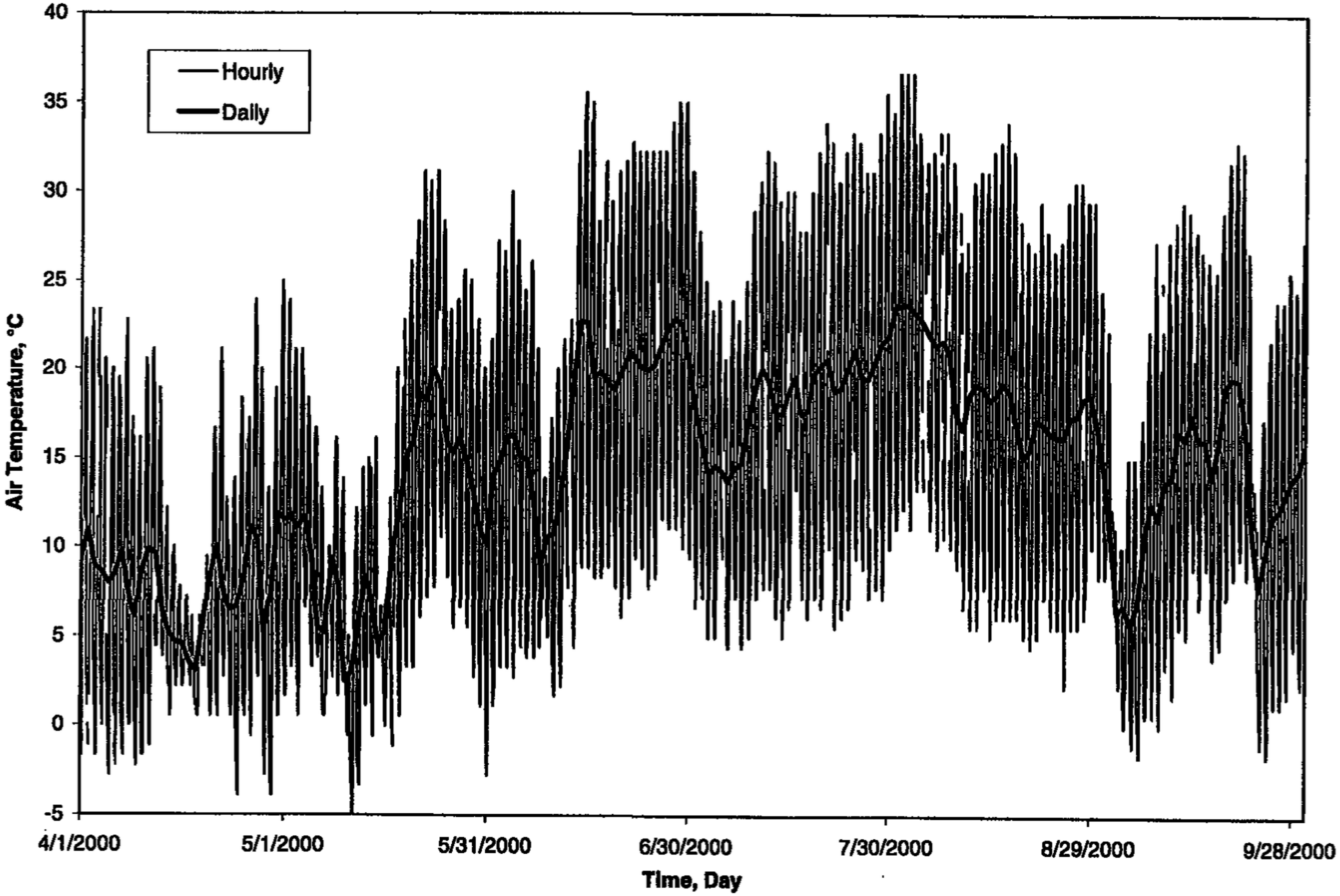


Figure 4.2 Year 2000 Wind Speed at Chester

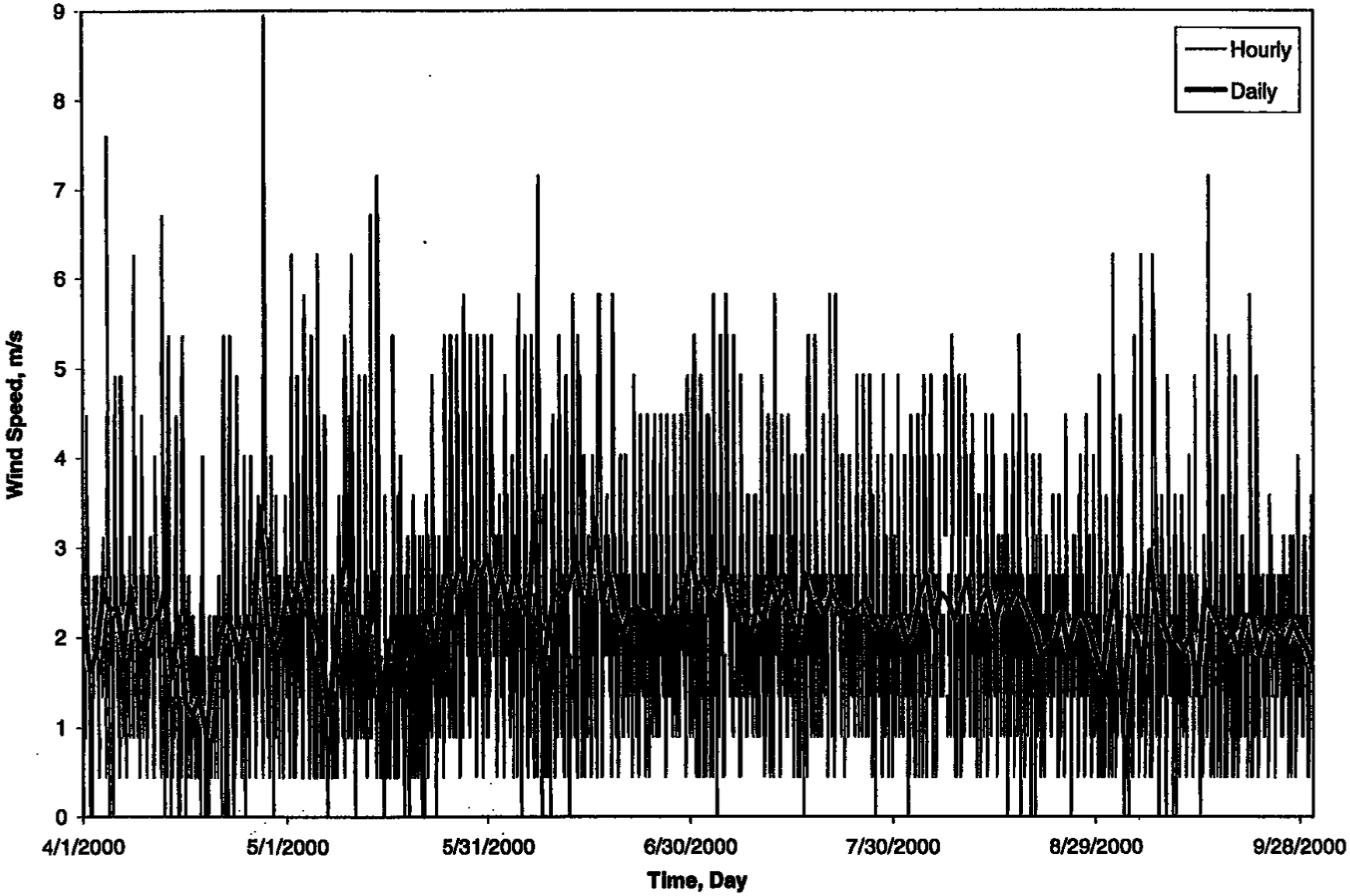


Figure 4.3 Year 2000 Relative Humidity at Chester

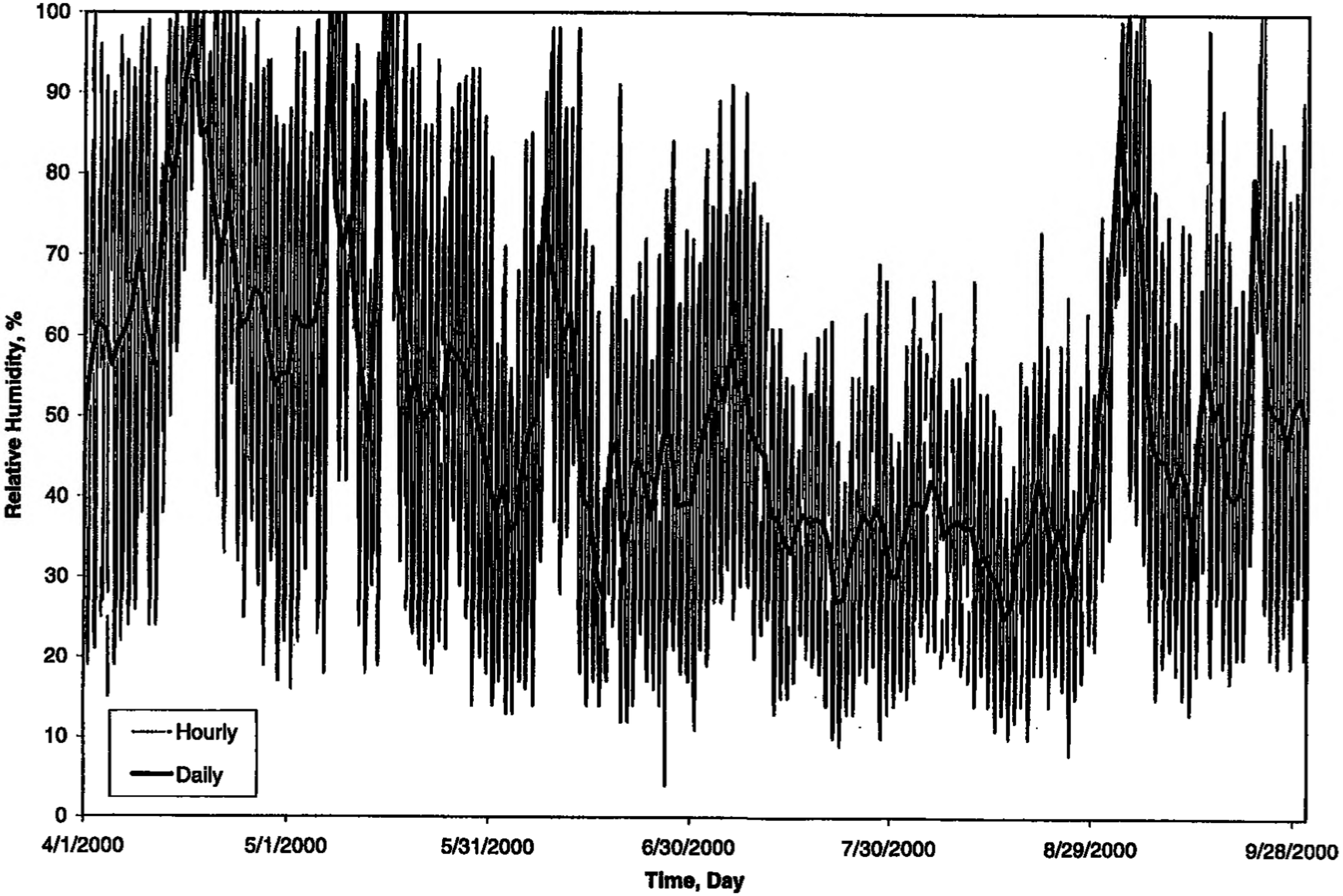


Figure 4.4 Year 2000 Solar Radiation at Prattville

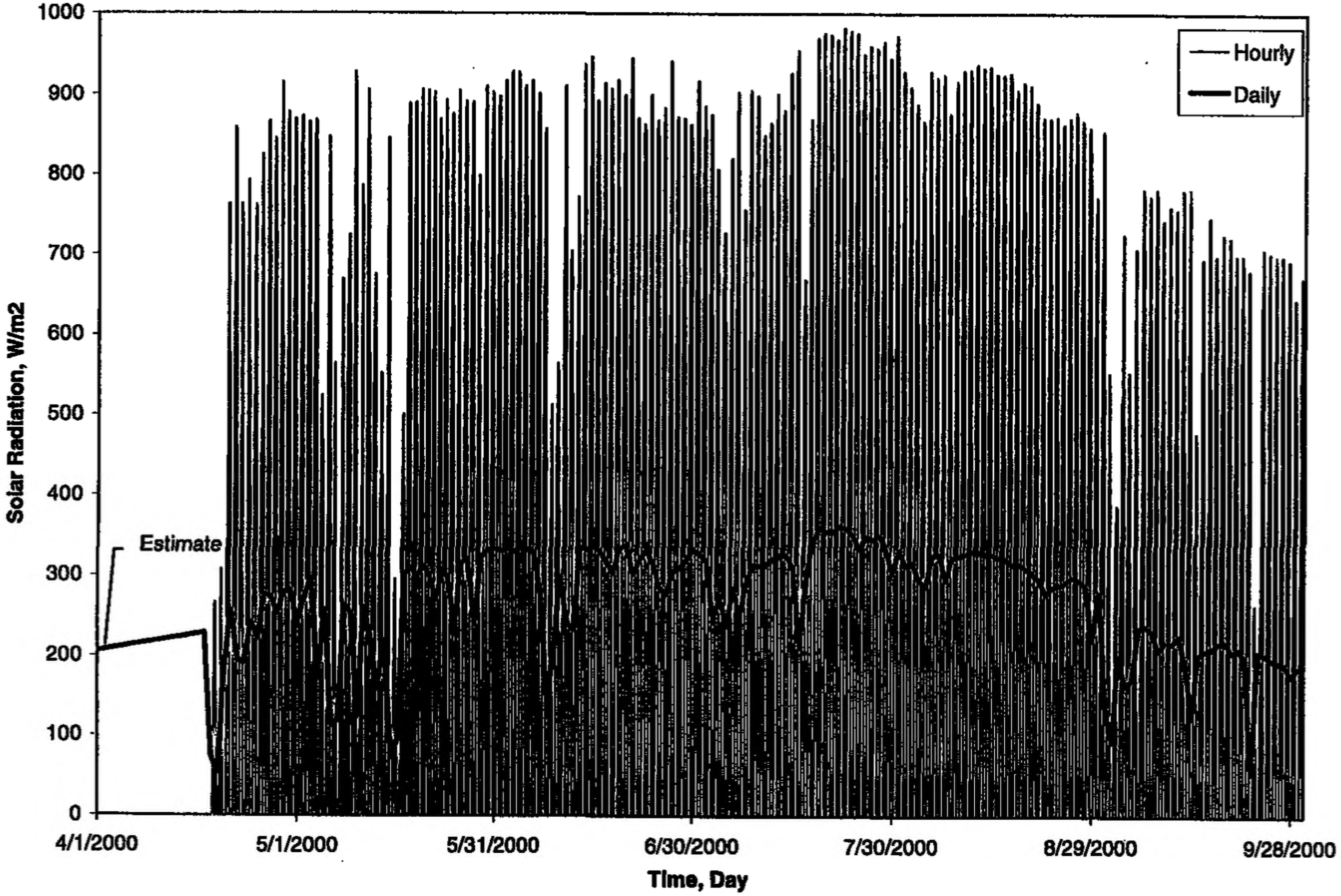


Figure 4.5 Year 2000 Cloud Cover at Prattville

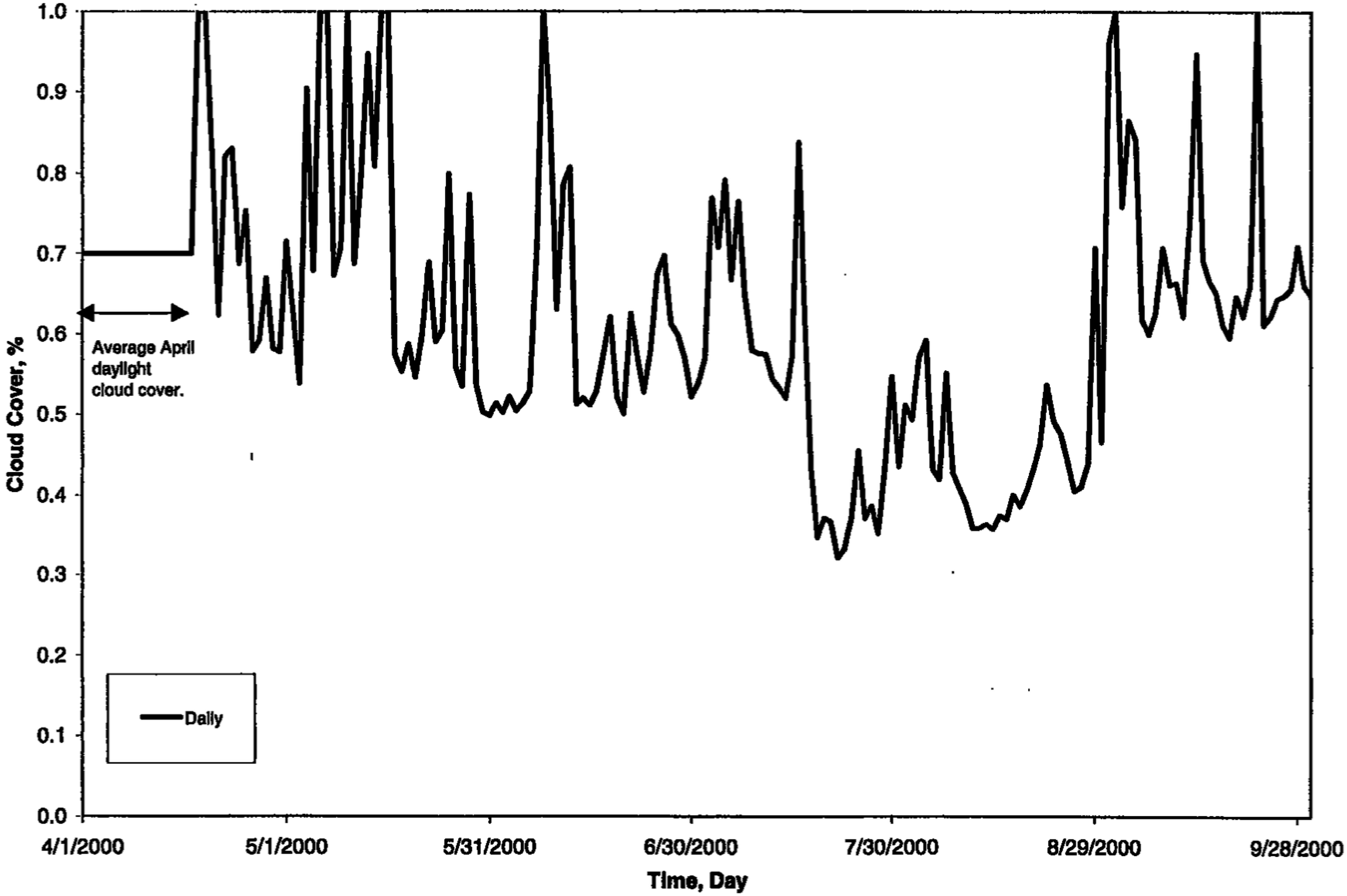
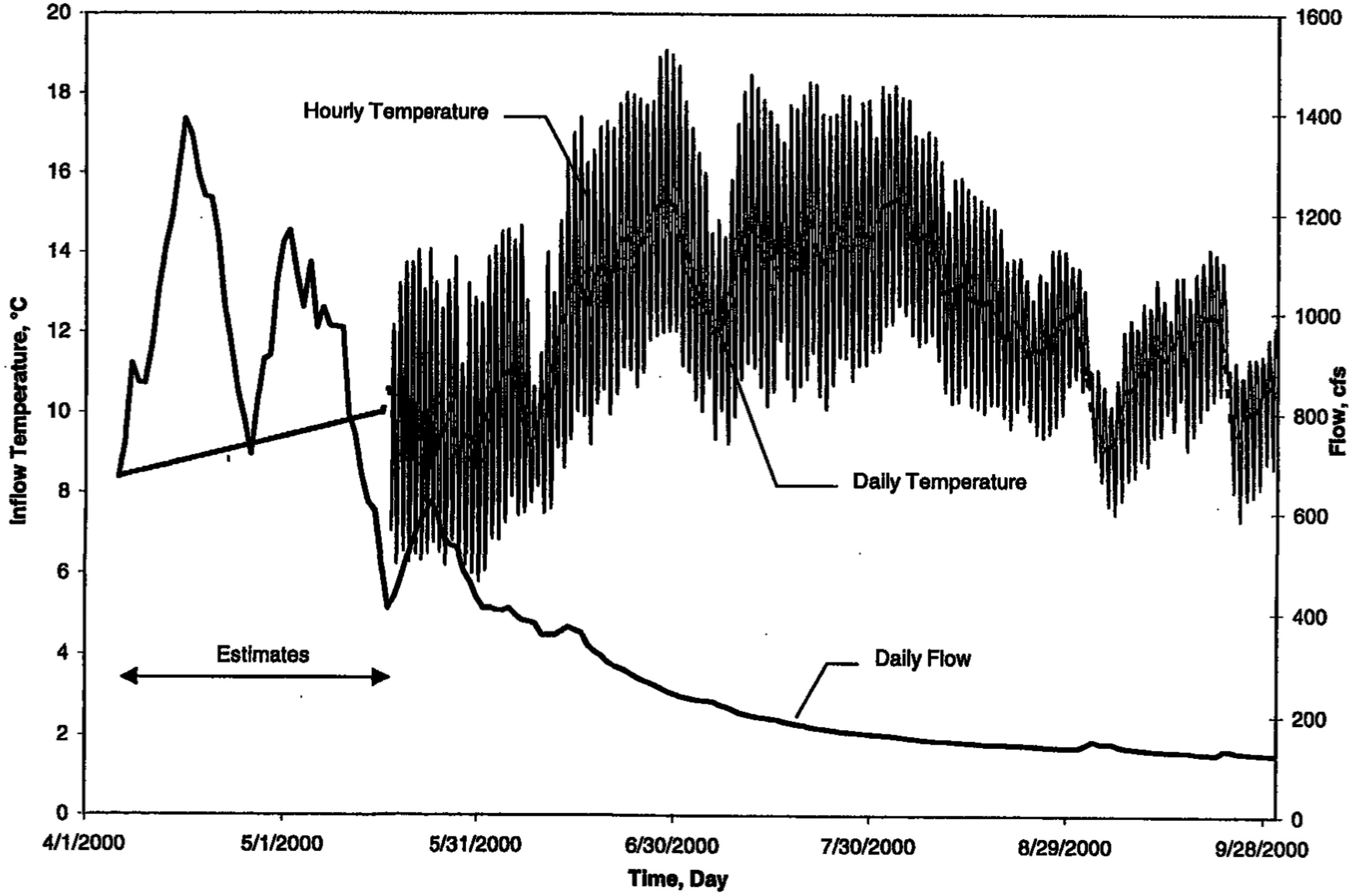


Figure 4.6 Lake Almanor Year 2000: NFFR at Chester



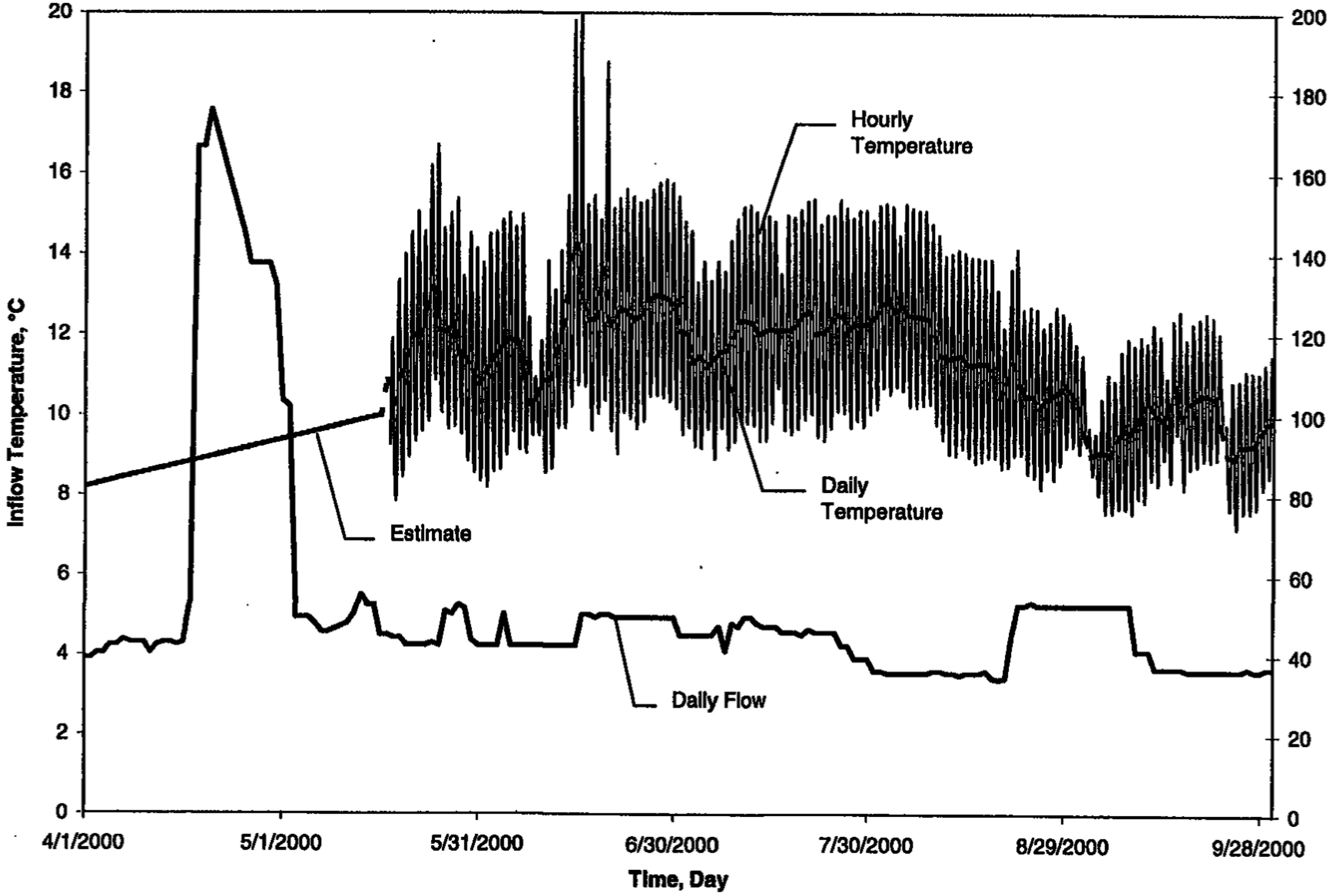


Figure 4.7 Lake Almanor Year 2000: Hamilton Branch

Figure 4.8 Lake Almanor Year 2000: Hamilton Branch Powerhouse

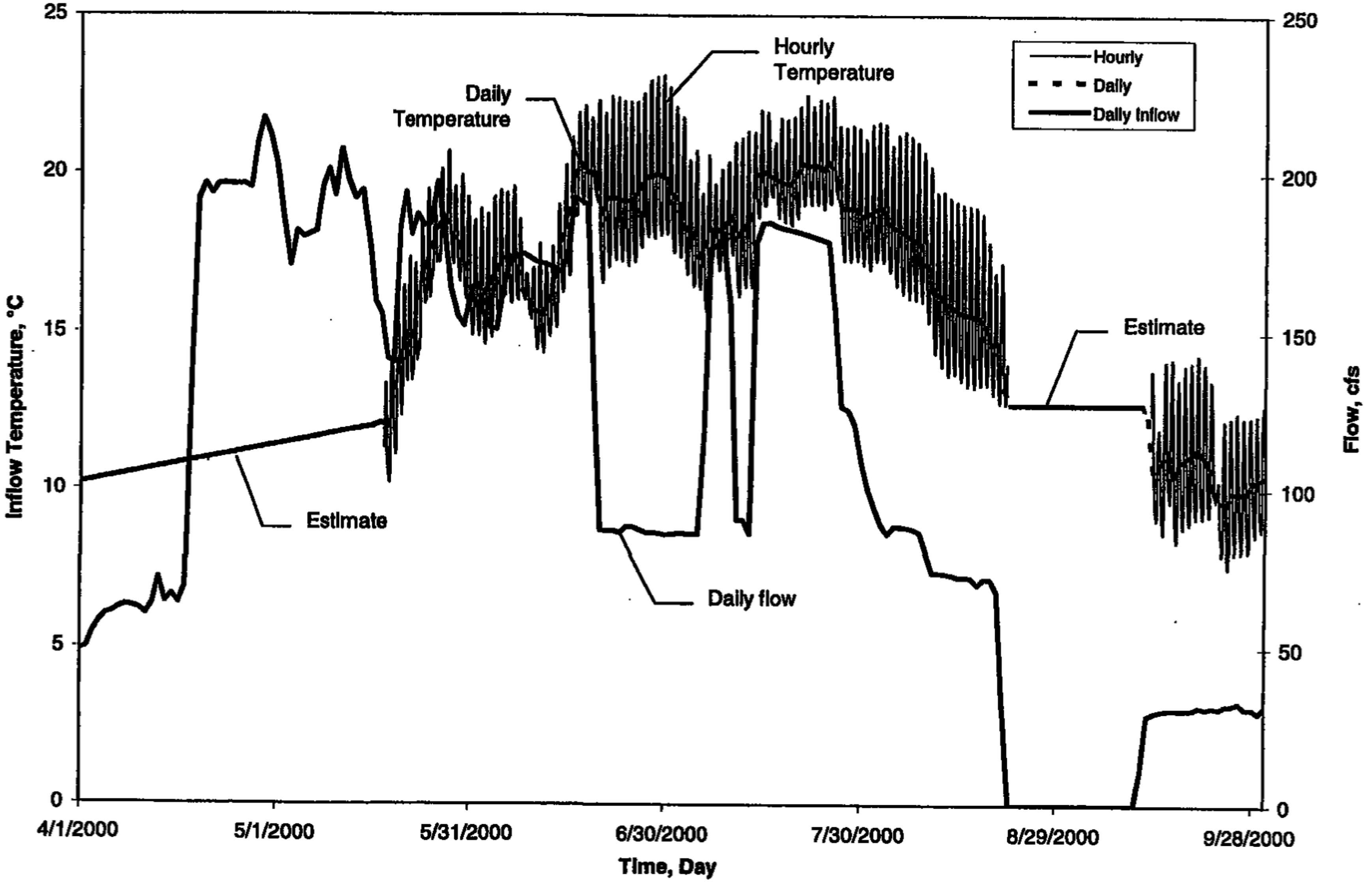


Figure 4.9 Lake Almanor Year 2000: Butt Valley Powerhouse and NFFR below Canyon Dam

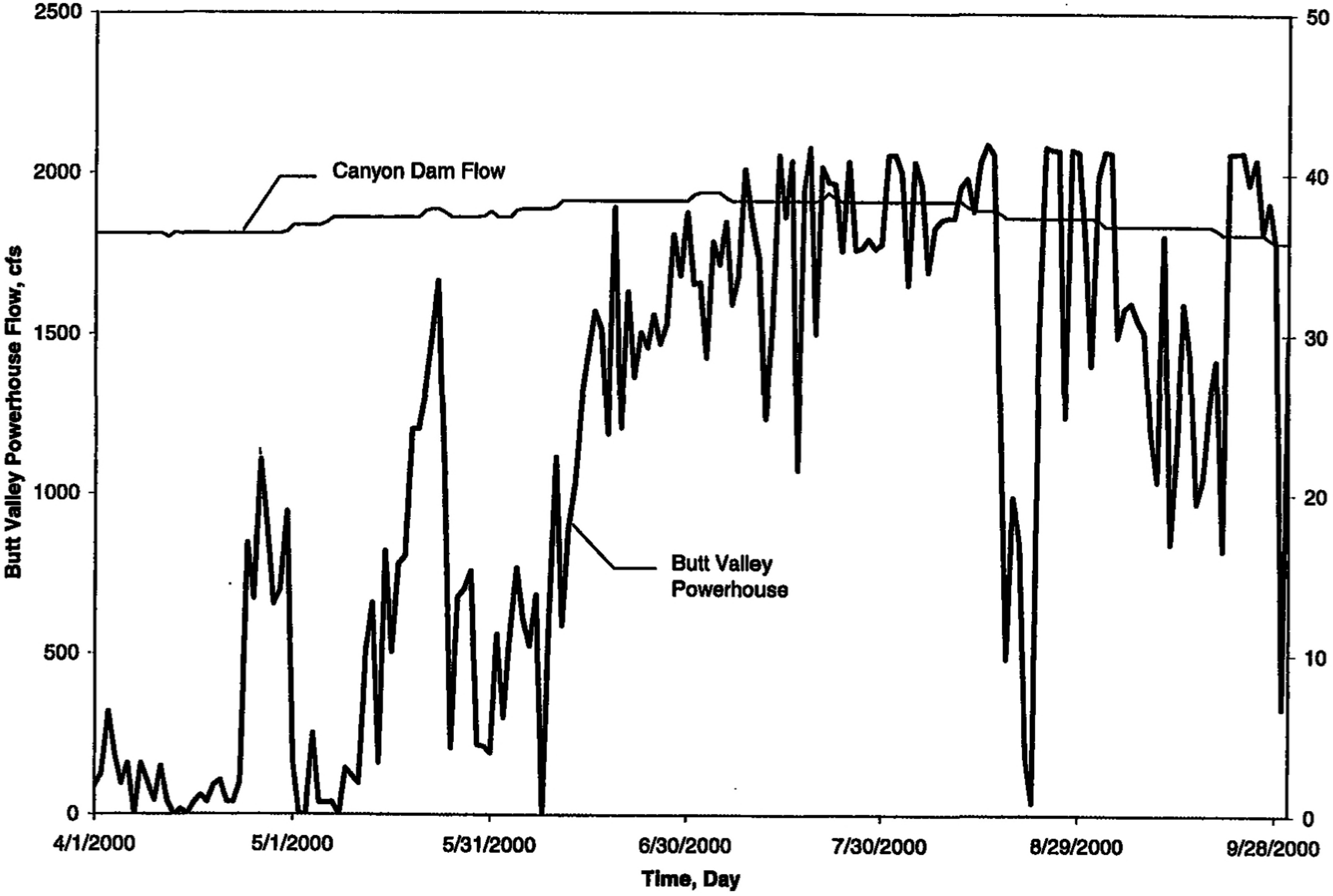


Figure 4.10 Lake Almanor Year 2000: Water Surface Elevation

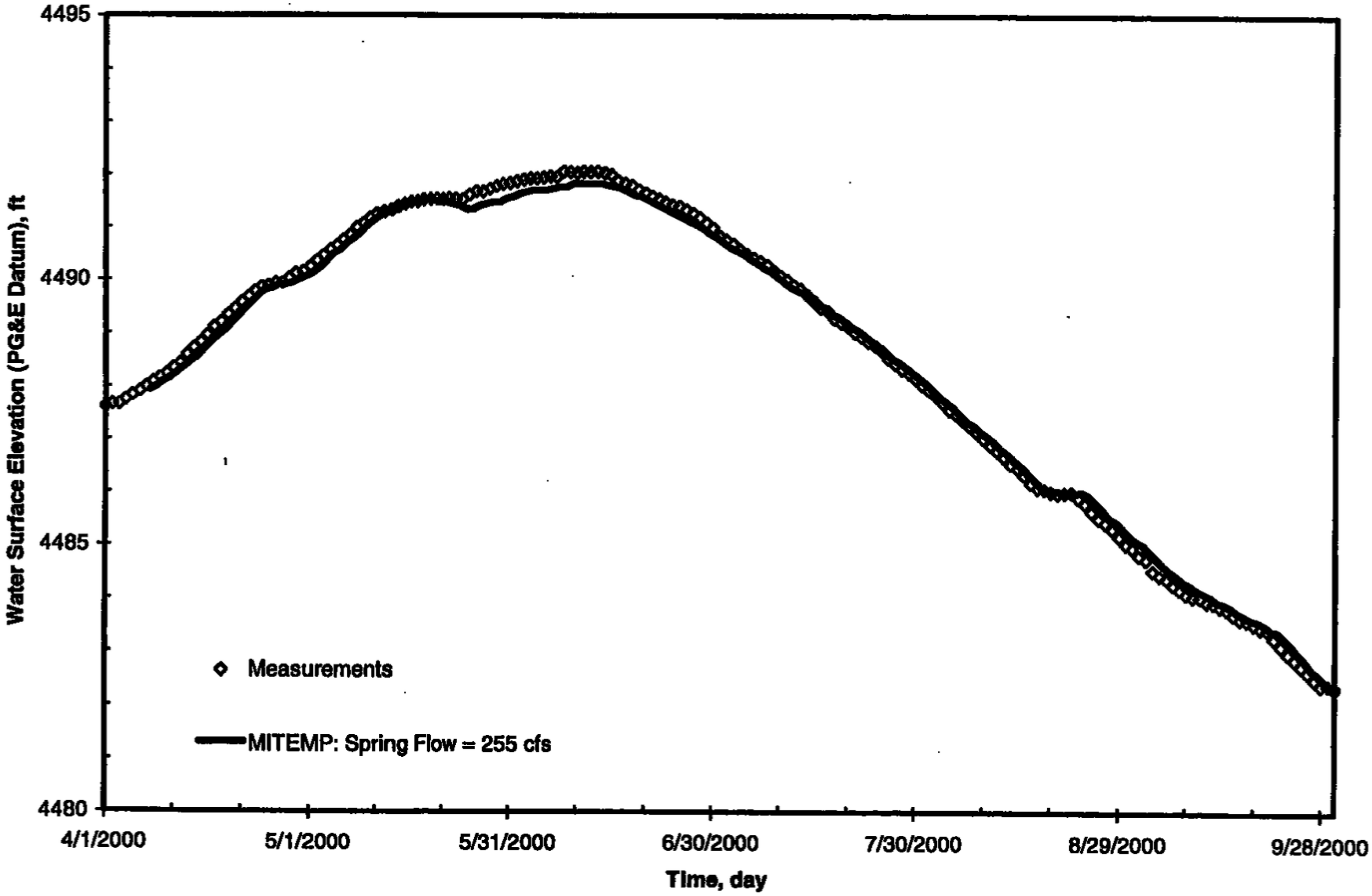


Figure 4.11 Lake Almanor Year 2000: PG&E Temperature Stations

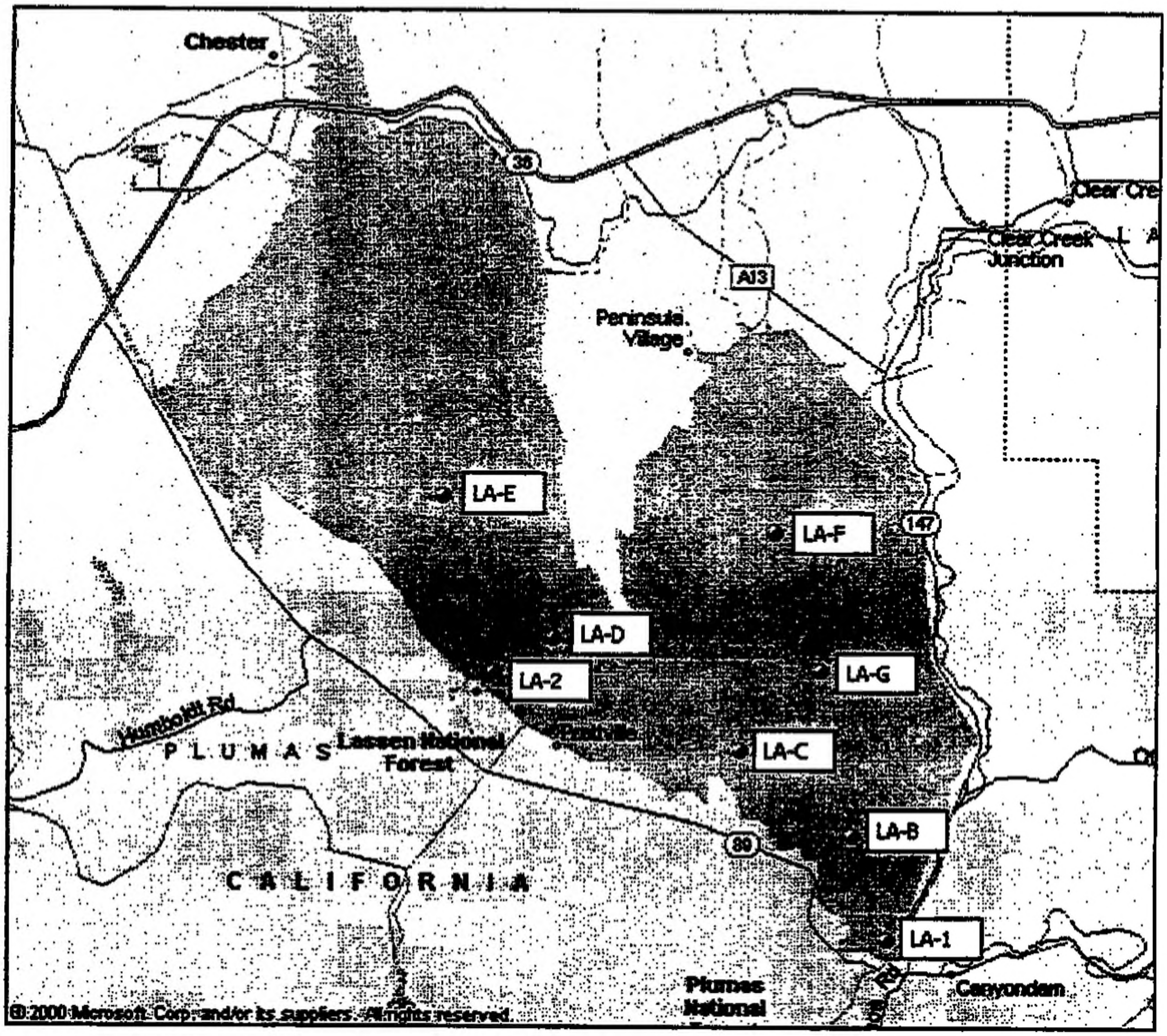


Figure 4.12 Lake Almanor Temperature Profiles June 22, 2000

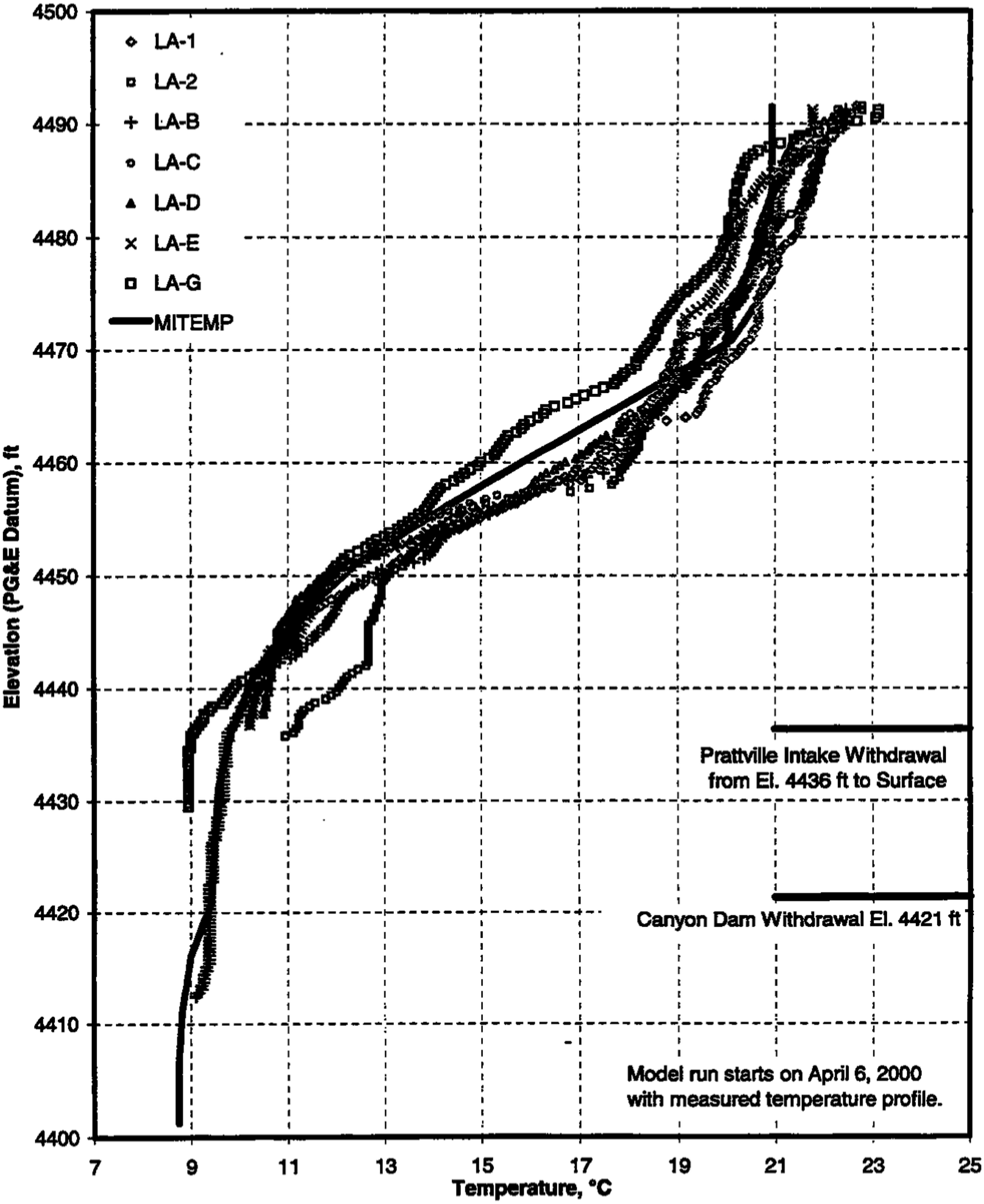
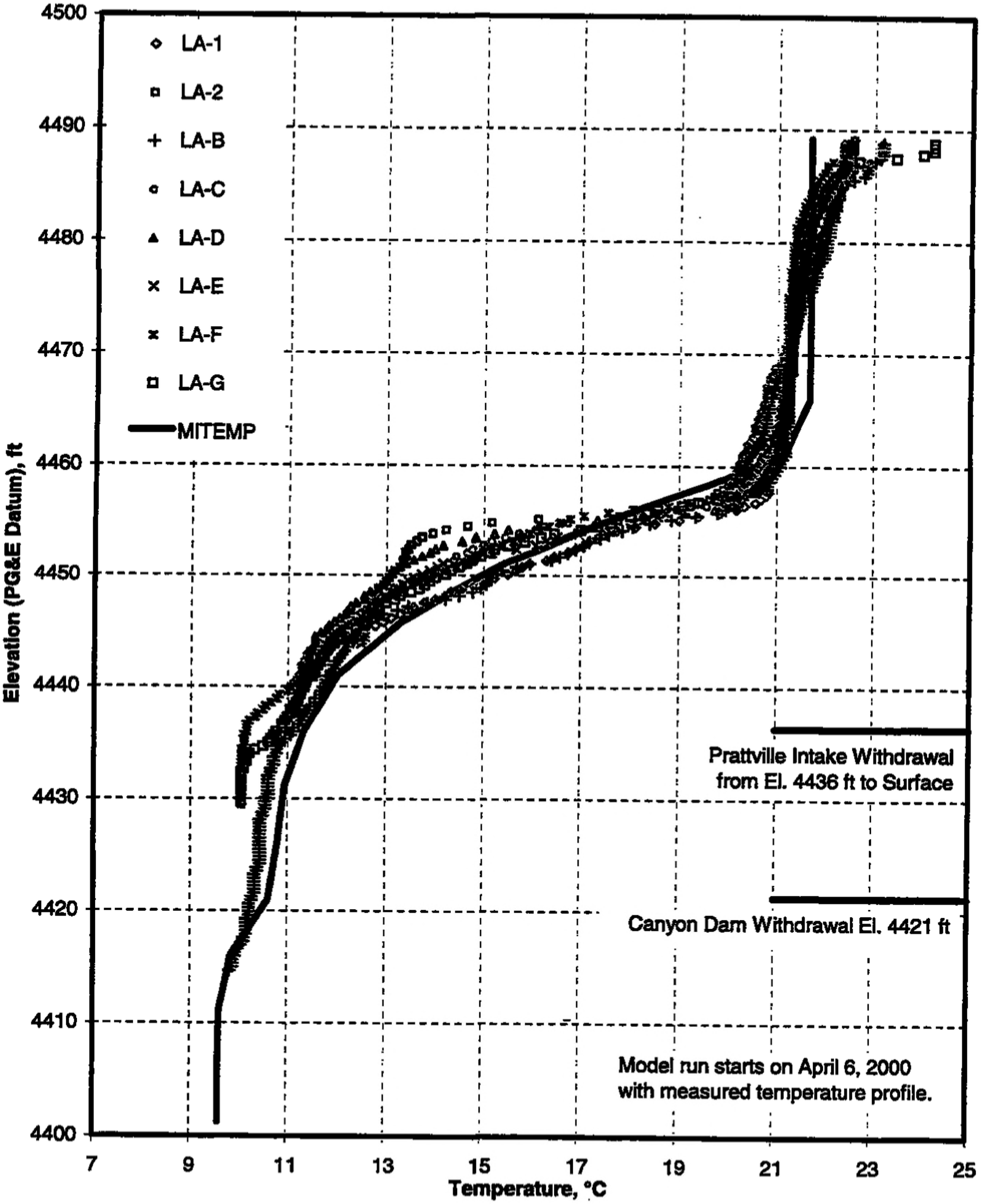


Figure 4.13 Lake Almanor Temperature Profiles July 20, 2000



Prattville Intake Withdrawal from El. 4436 ft to Surface

Canyon Dam Withdrawal El. 4421 ft

Model run starts on April 6, 2000 with measured temperature profile.

Figure 4.14 Lake Almanor Temperature Profiles August 17, 2000

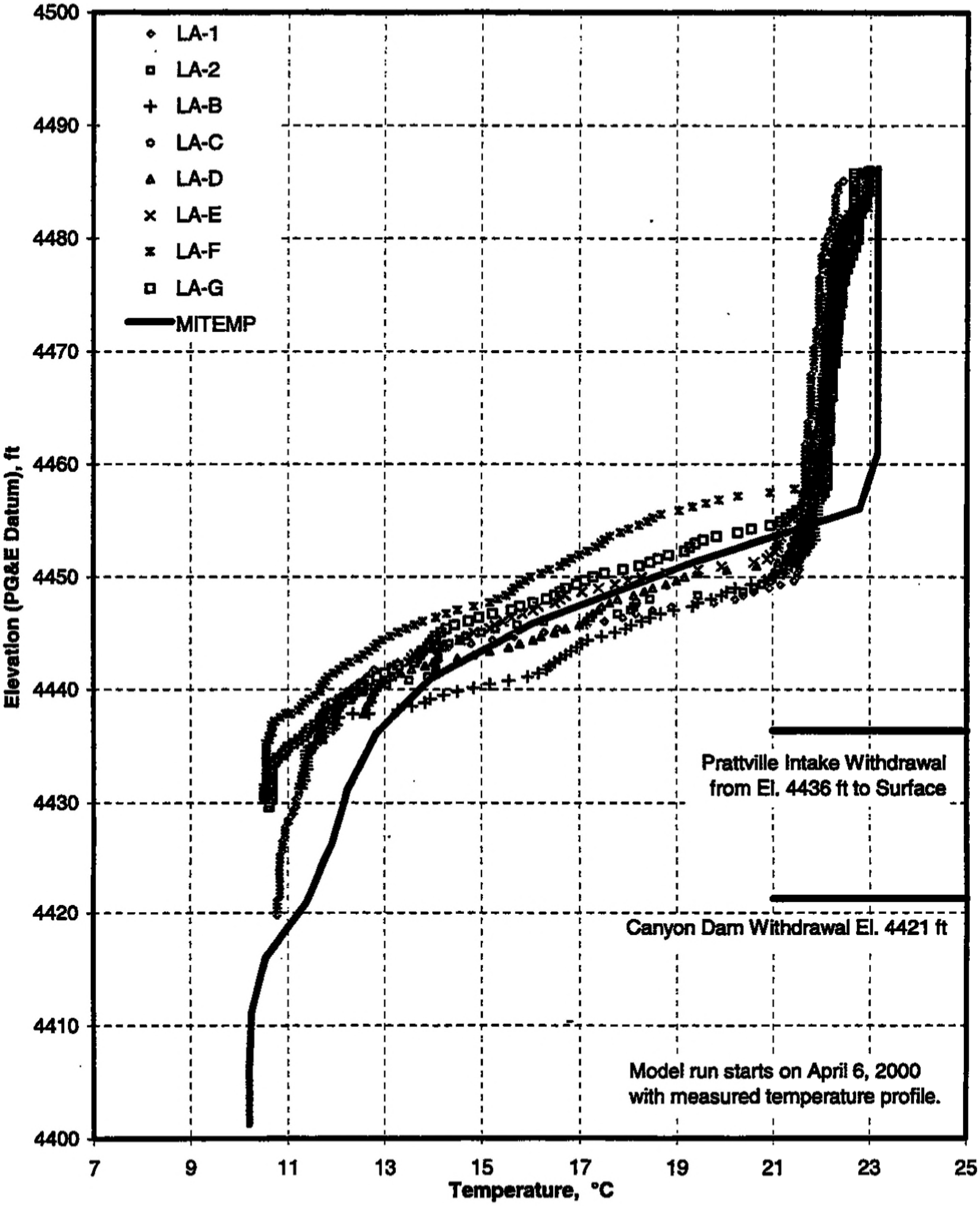


Figure 4.16 Lake Almanor Temperature Profiles September 28, 2000

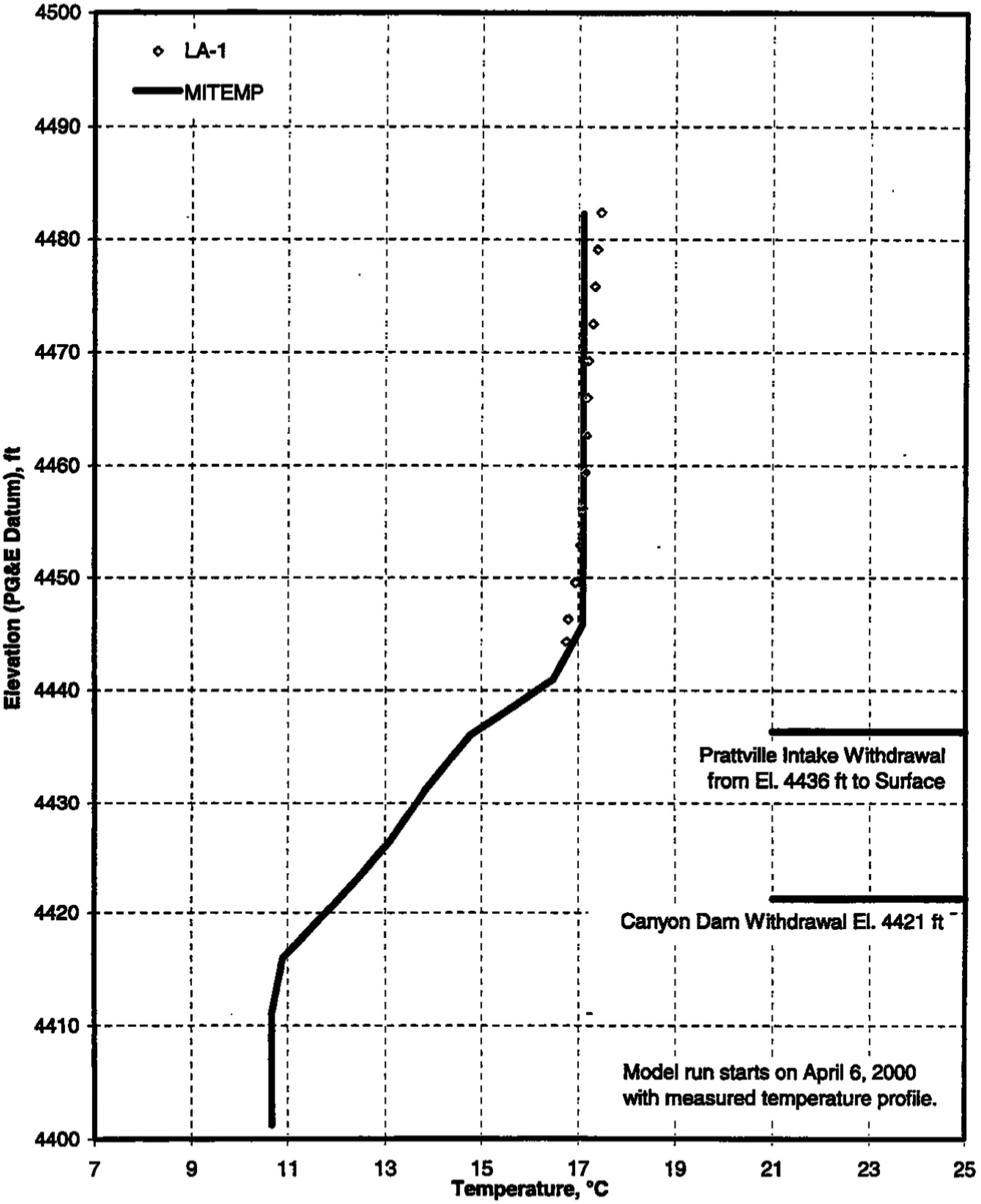


Figure 4.17 Lake Almanor Year 2000: Outflow Temperatures

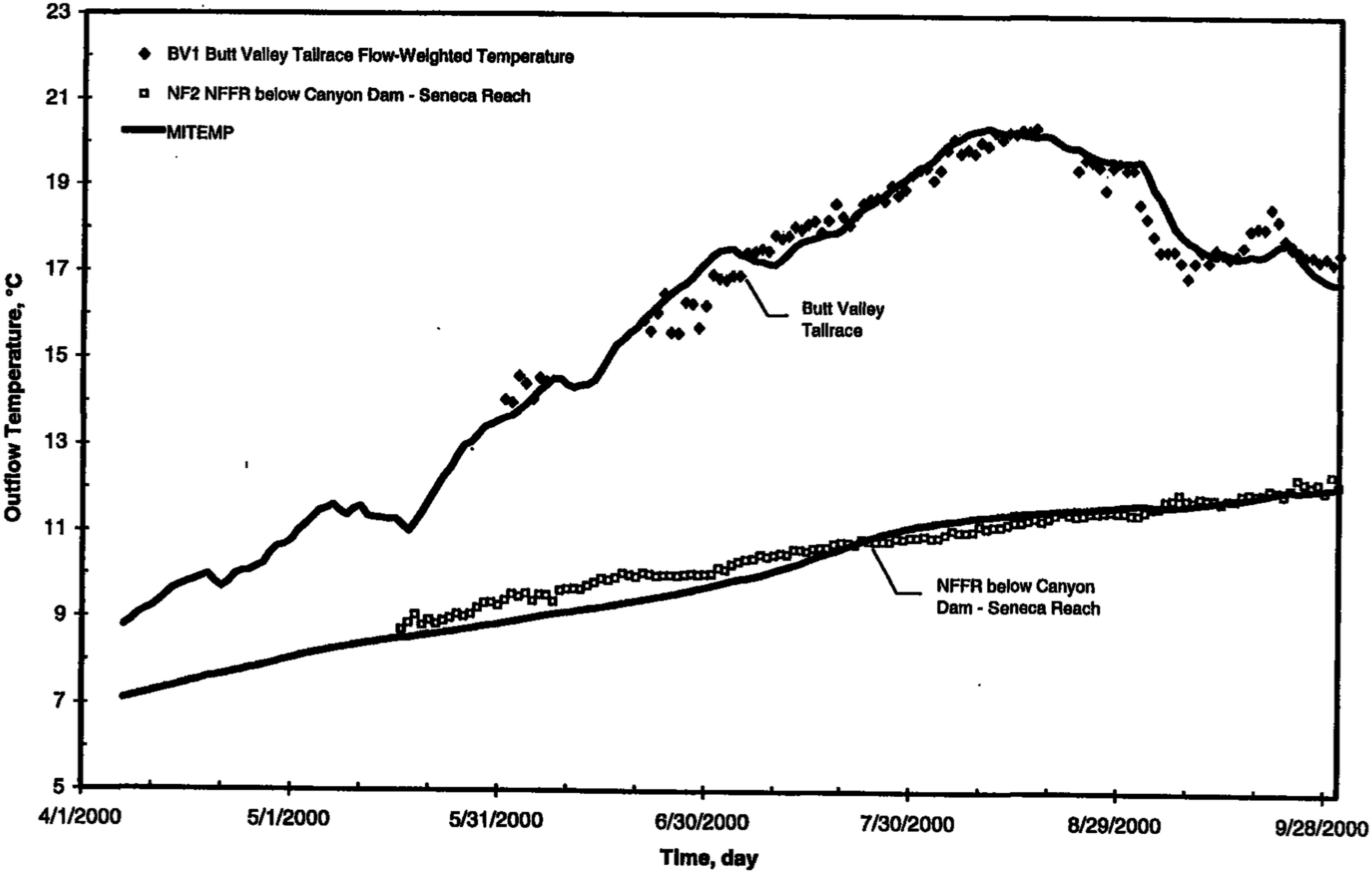


Figure 4.18 Year 2001 Air Temperature

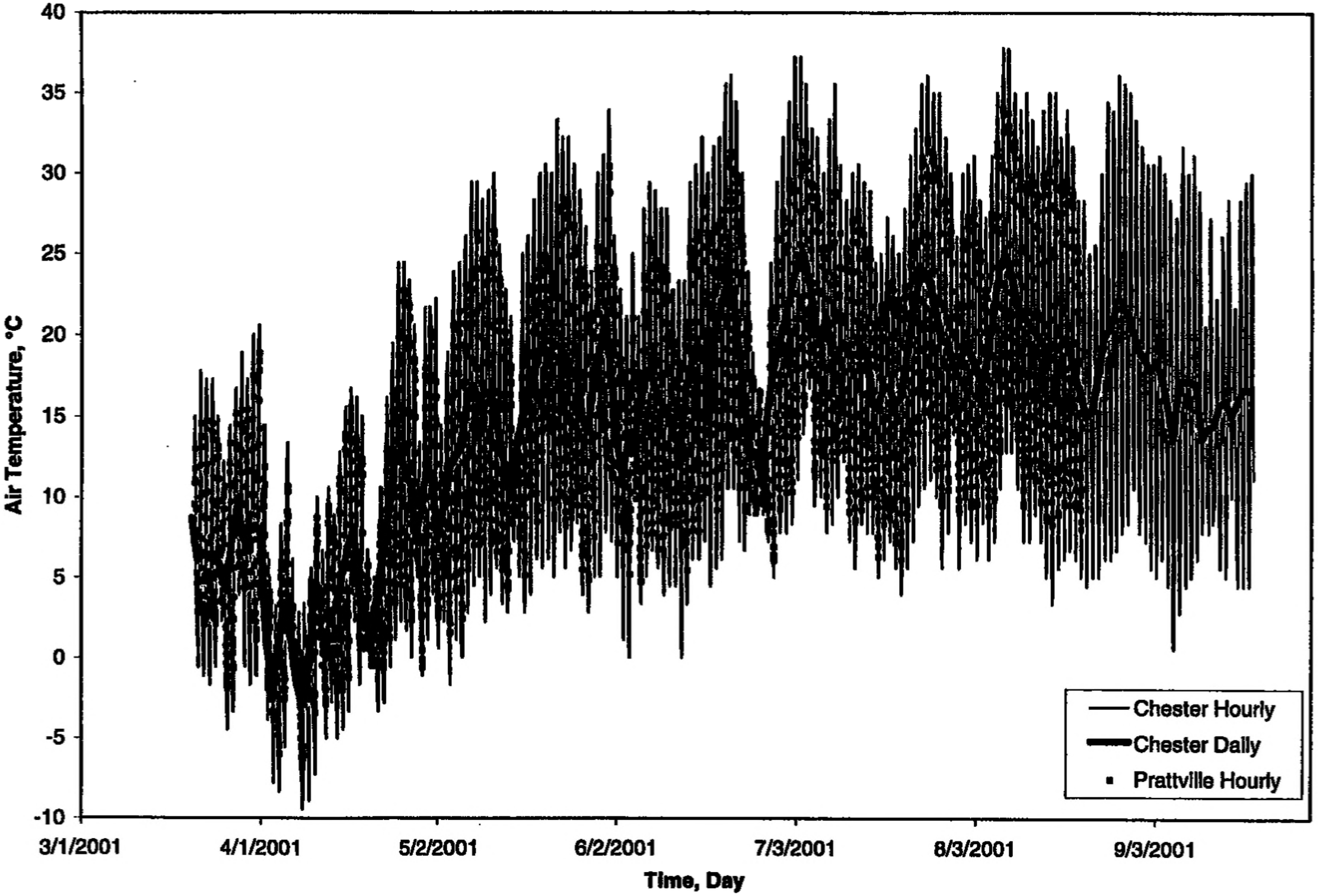


Figure 4.19 Year 2001 Wind Speed

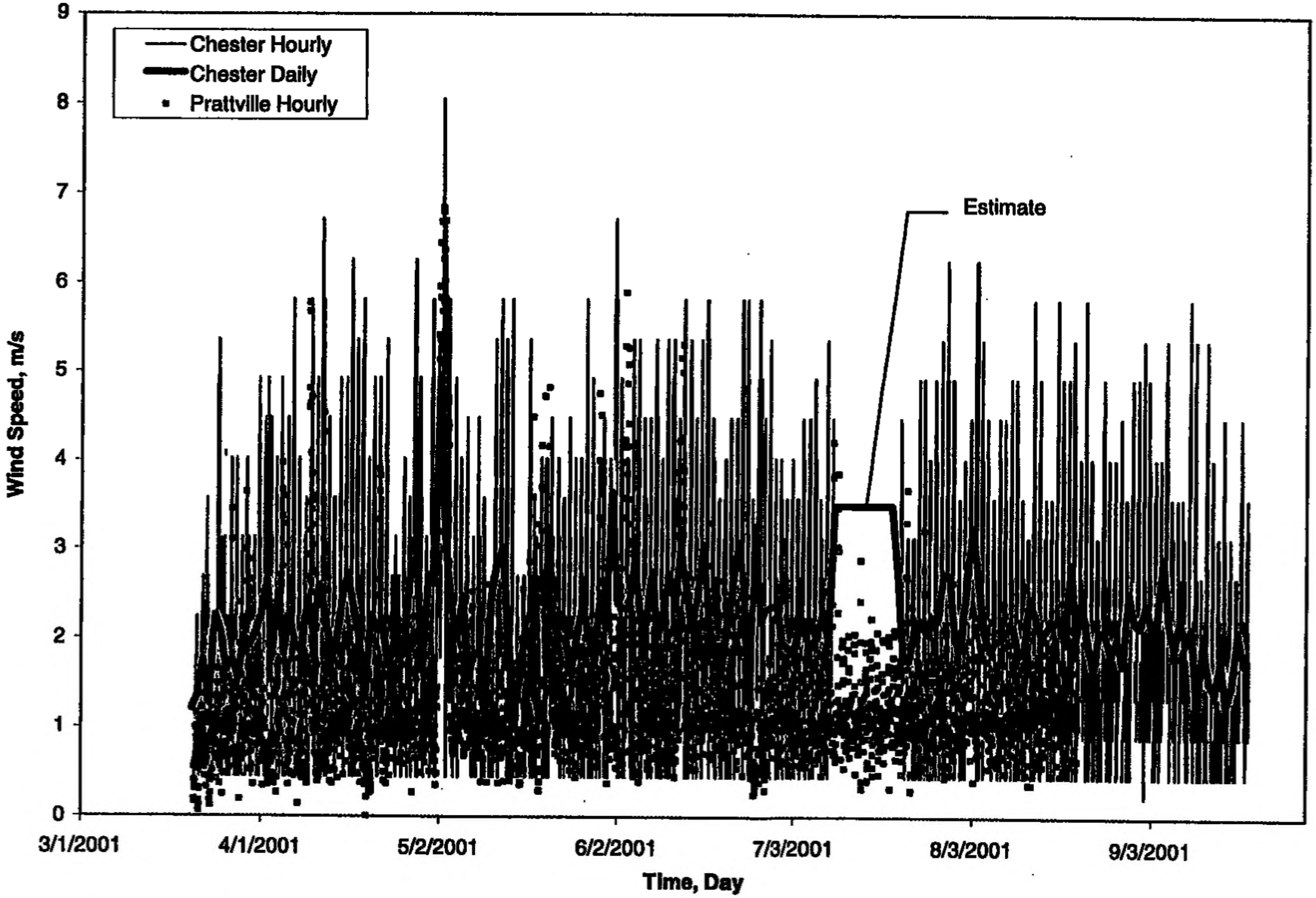


Figure 4.20 Year 2001 Relative Humidity

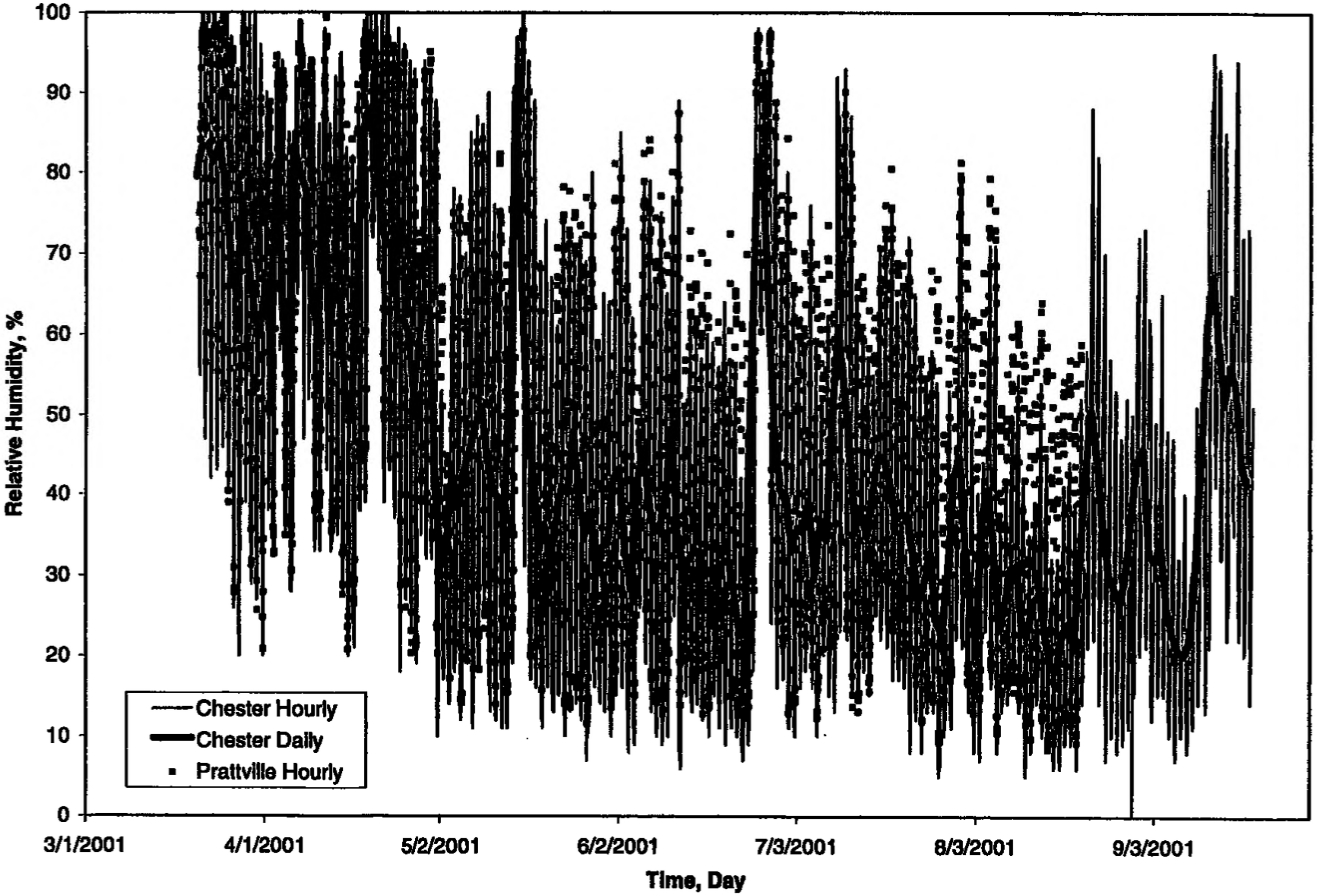


Figure 4.21 Year 2001 Solar Radiation at Prattville

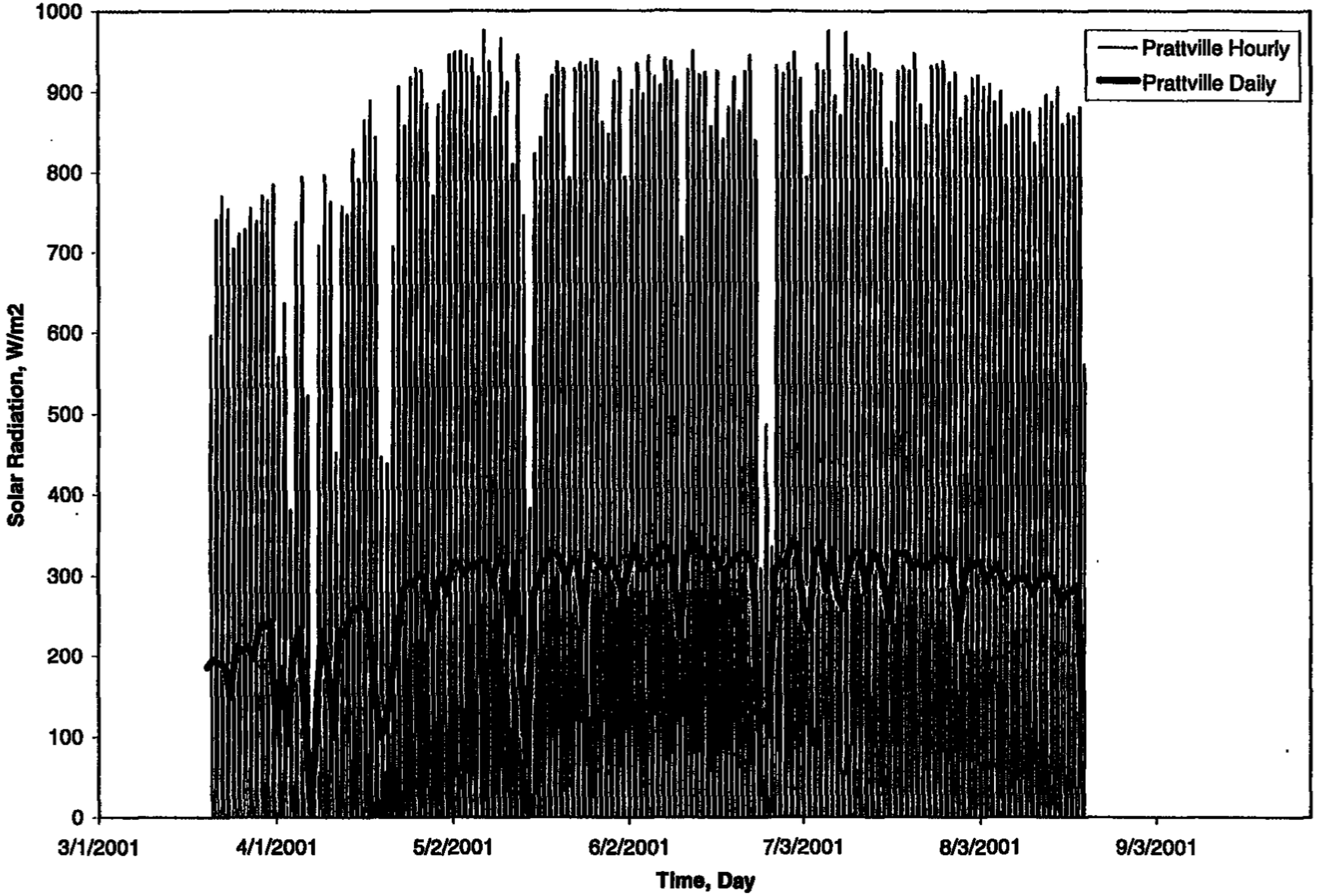


Figure 4.22 Year 2001 Cloud Cover at Prattville

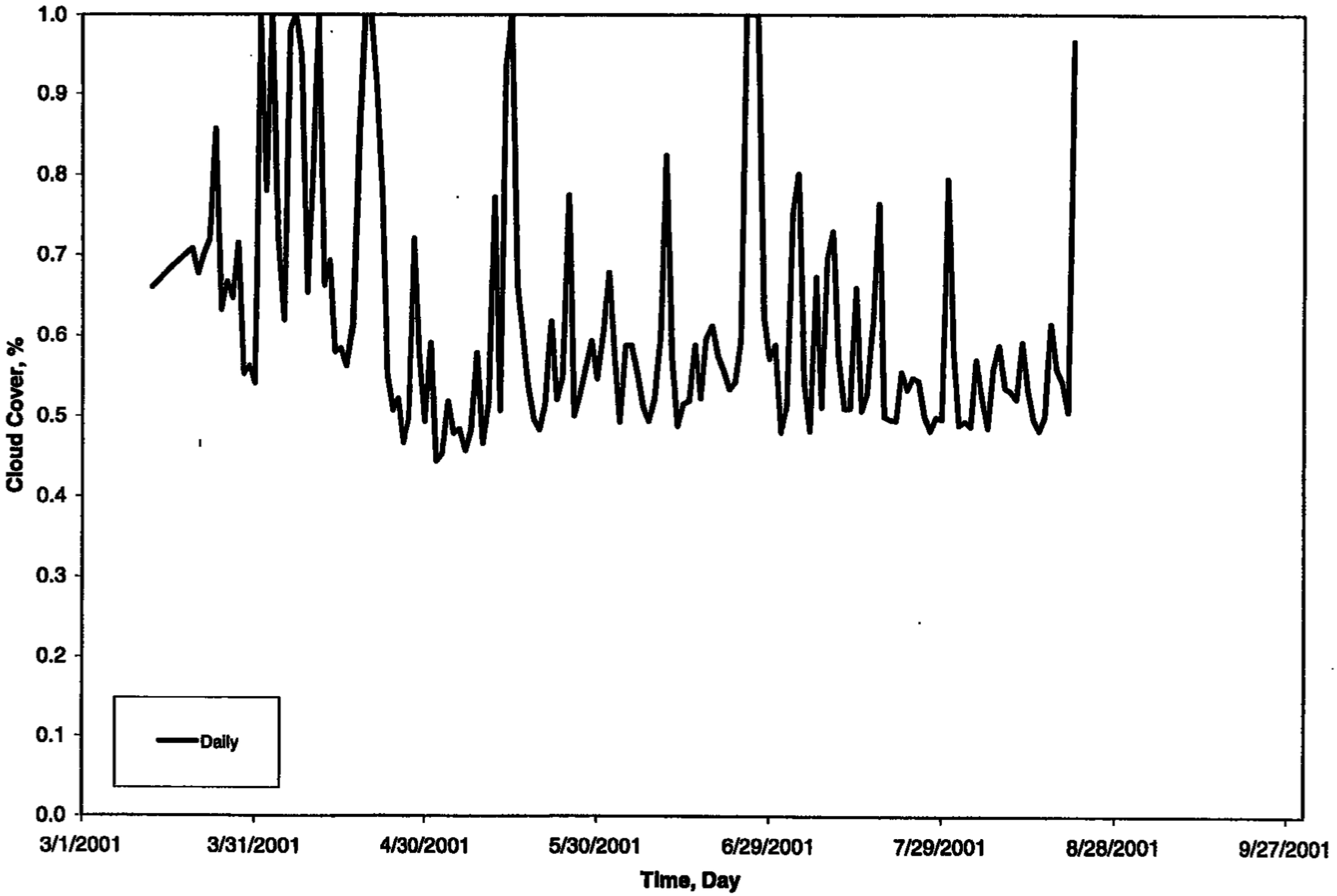
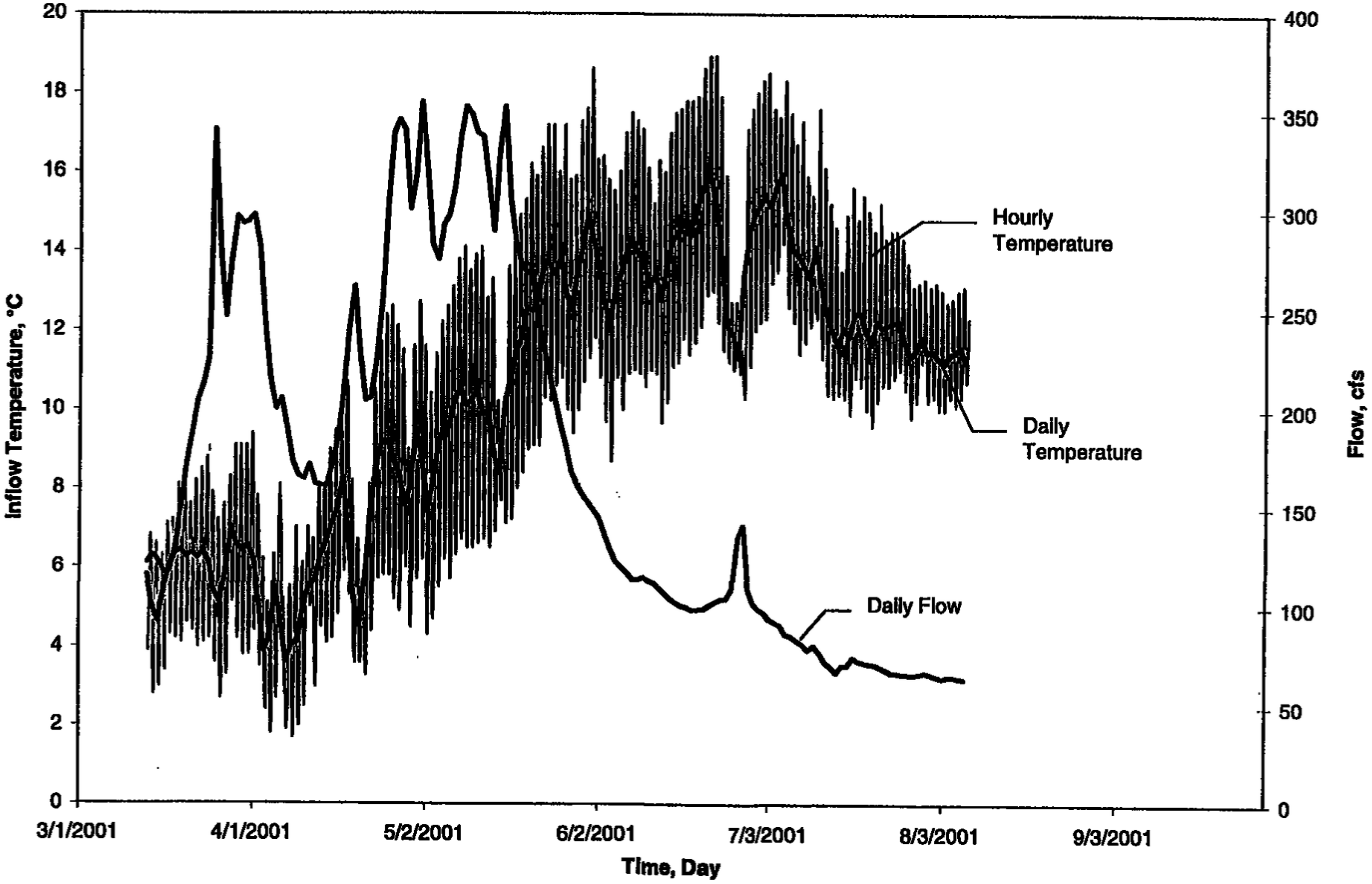


Figure 4.23 Lake Almanor Year 2001: NFFR at Chester



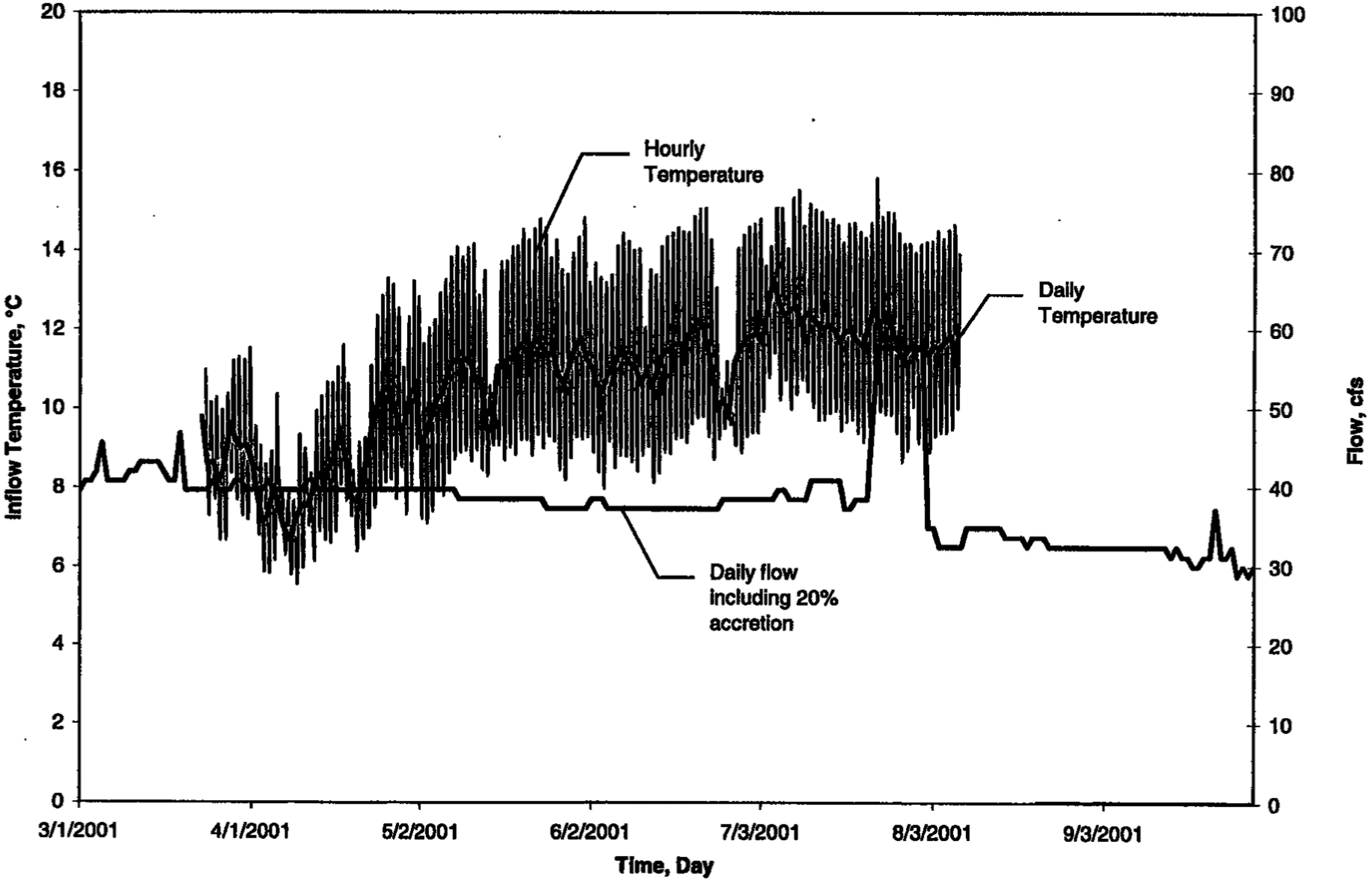
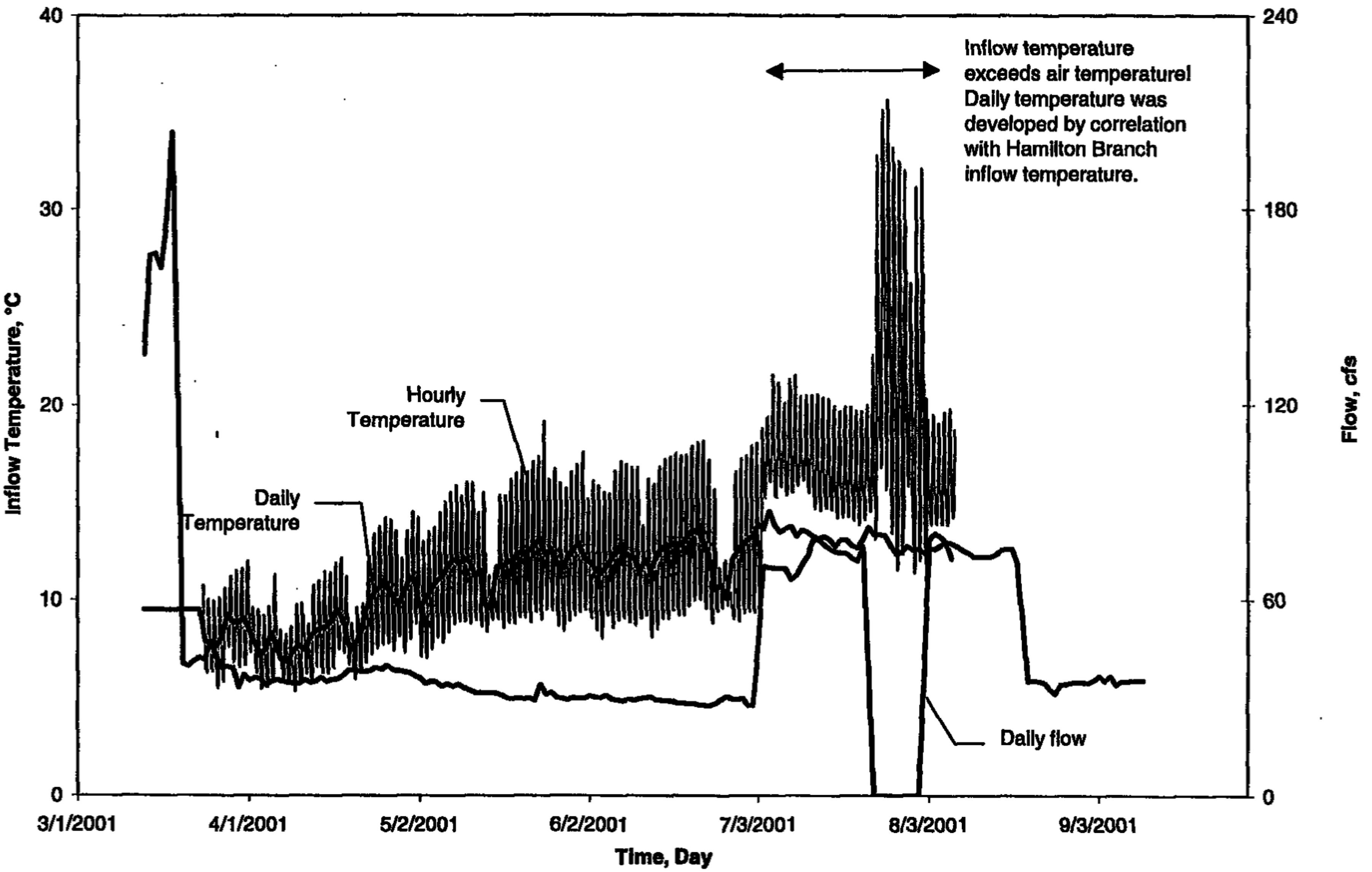


Figure 4.24 Lake Almanor Year 2001: Hamilton Branch
Hourly Temperature
Daily Temperature
Daily flow including 20% accretion
Inflow Temperature, °C
Flow, cfs
Time, Day
20
18
16
14
12
10
8
6
4
2
0
100
90
80
70
60
50
40
30
20
10
0
3/1/2001
4/1/2001
5/2/2001
6/2/2001
7/3/2001
8/3/2001
9/3/2001

Figure 4.25 Lake Almanor Year 2001: Hamilton Branch Powerhouse



Inflow temperature exceeds air temperature! Daily temperature was developed by correlation with Hamilton Branch inflow temperature.

Figure 4.26 Lake Almanor Year 2001: Butt Valley Powerhouse and NFFR below Canyon Dam

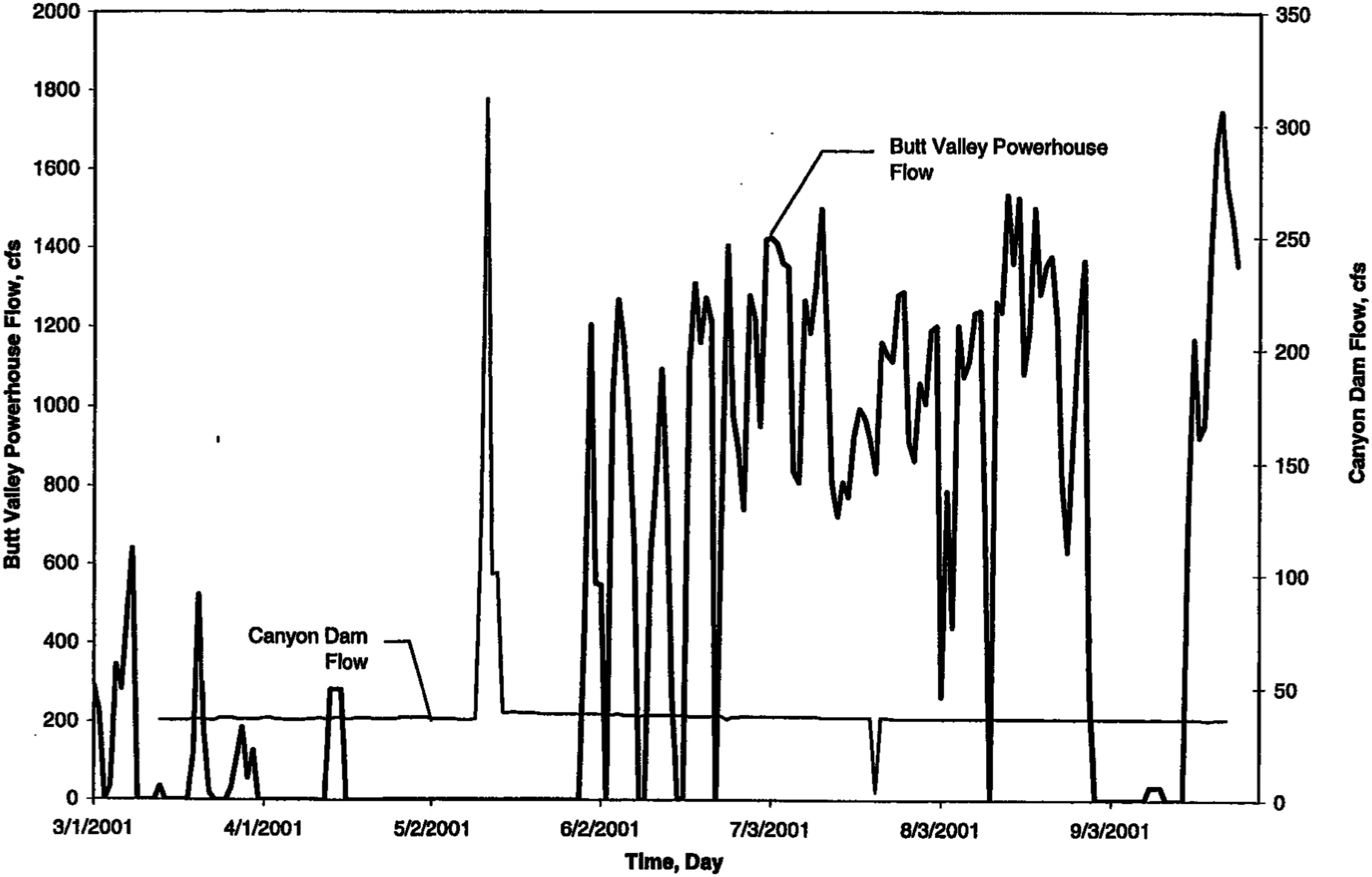


Figure 4.27 Lake Almanor Year 2001: Water Surface Elevation

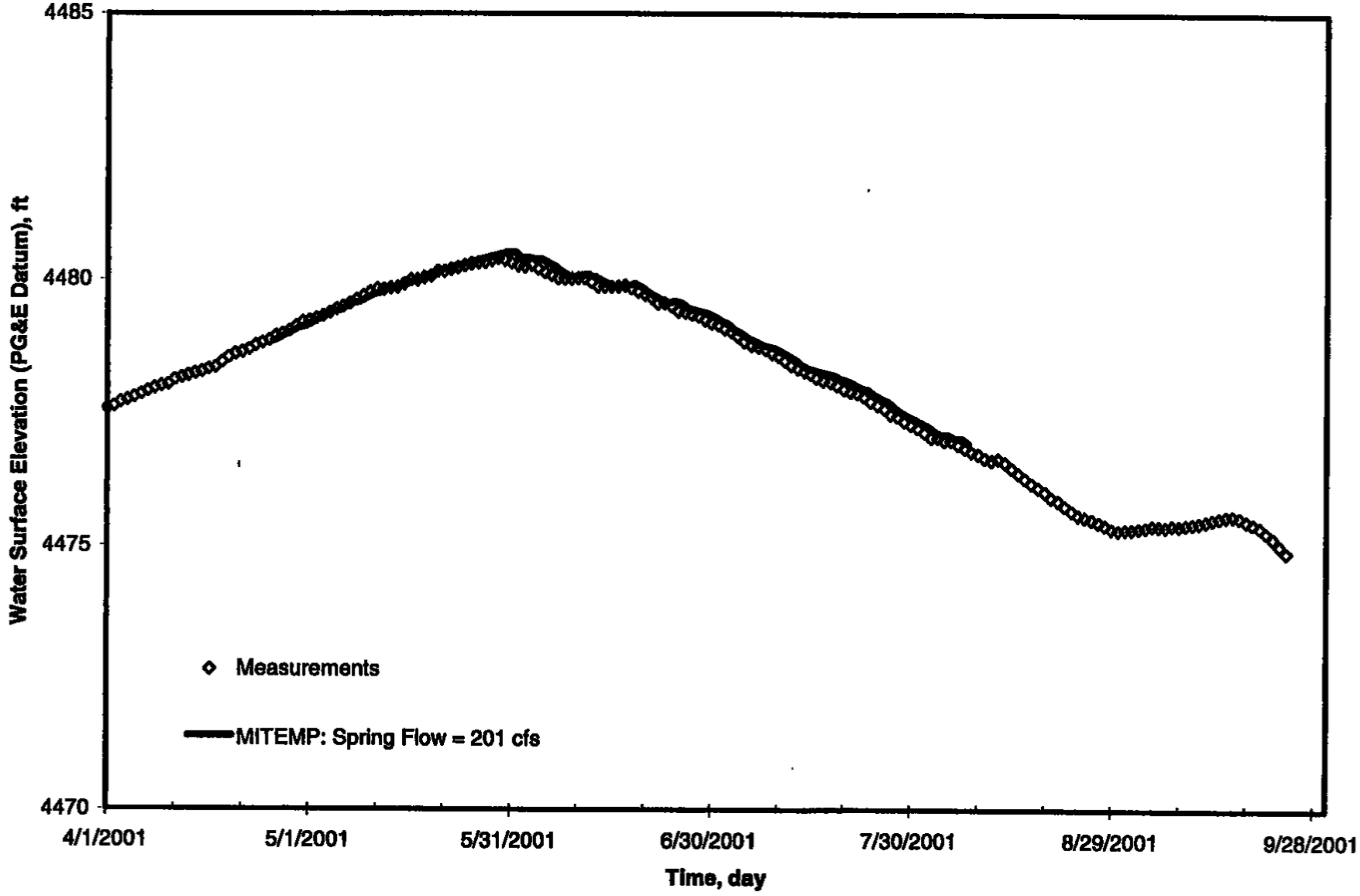


Figure 4.28 Lake Almanor Year 2001: PG&E Temperature Stations

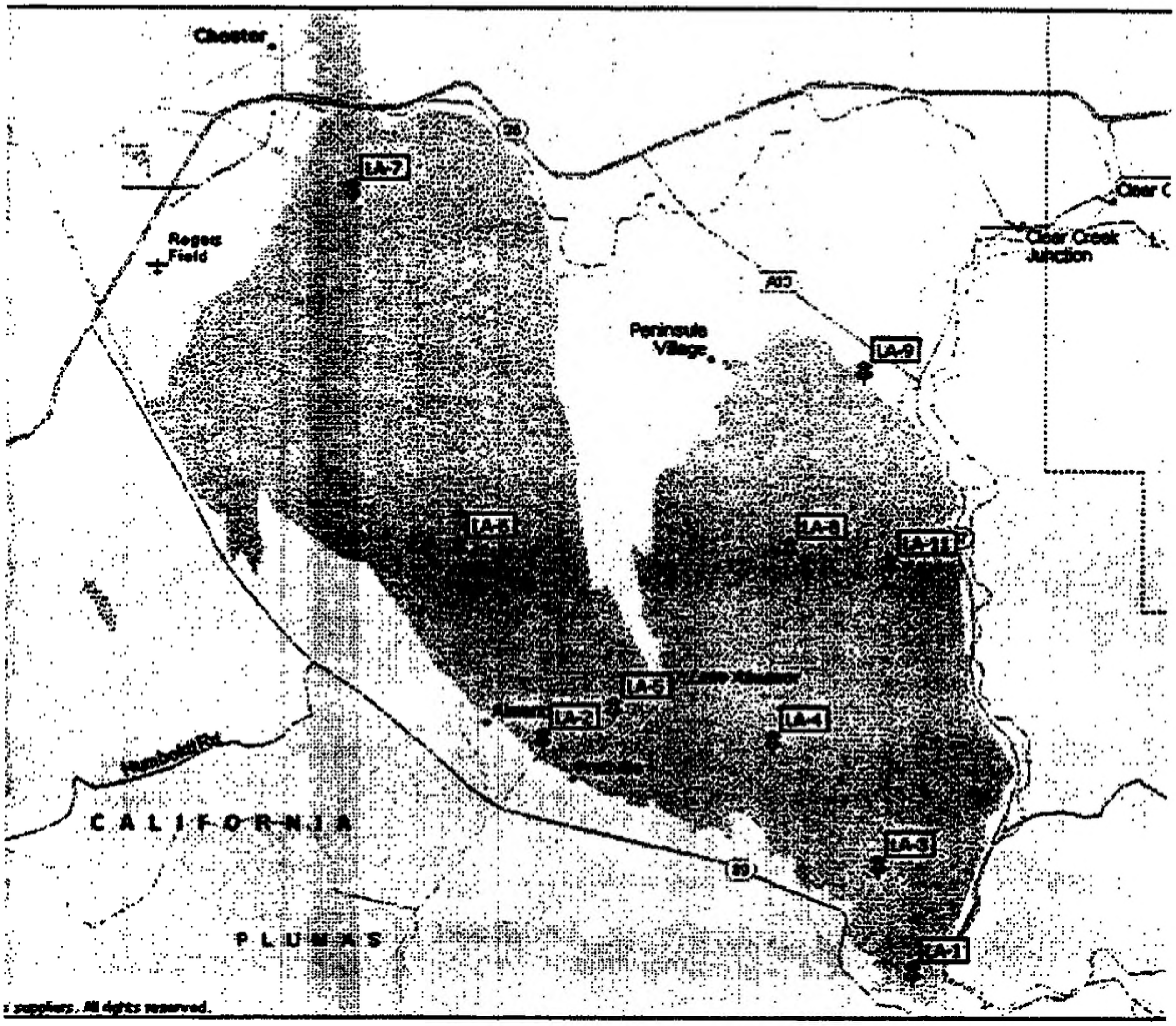


Figure 4.29 Lake Almanor Temperature Profiles June 6, 2001

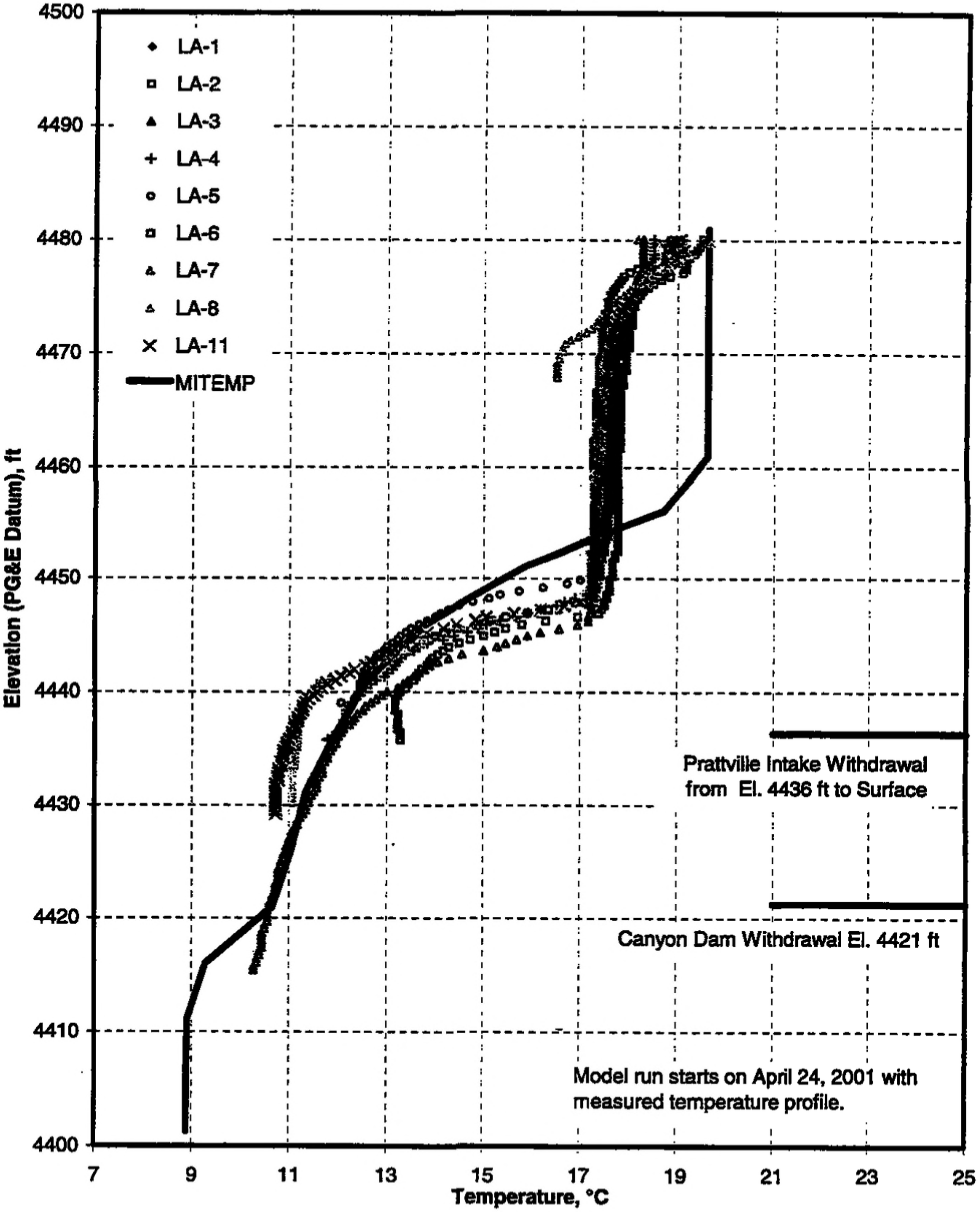


Figure 4.30 Lake Almanor Temperature Profiles July 10, 2001

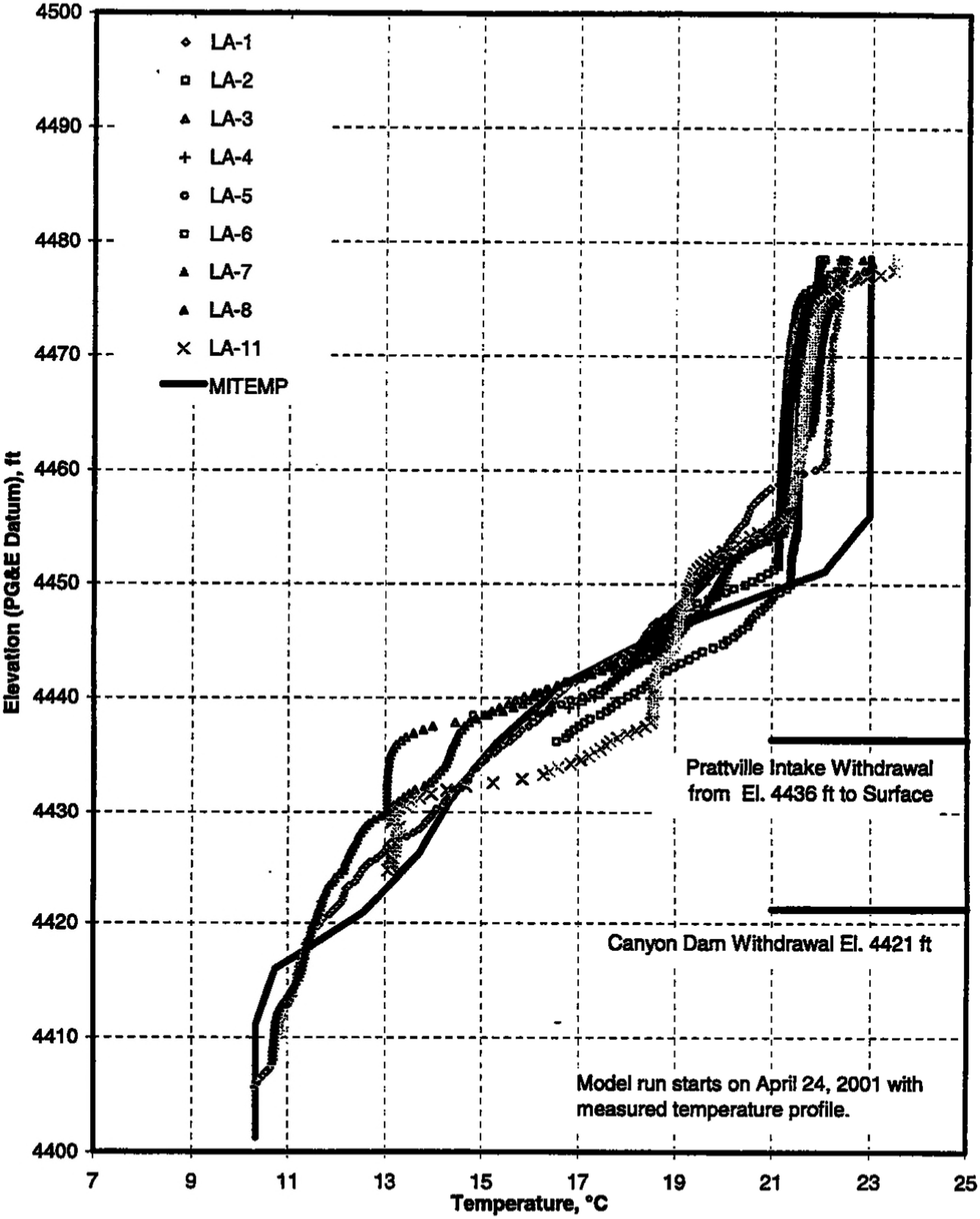


Figure 4.31 Lake Almanor Temperature Profiles July 24, 2001

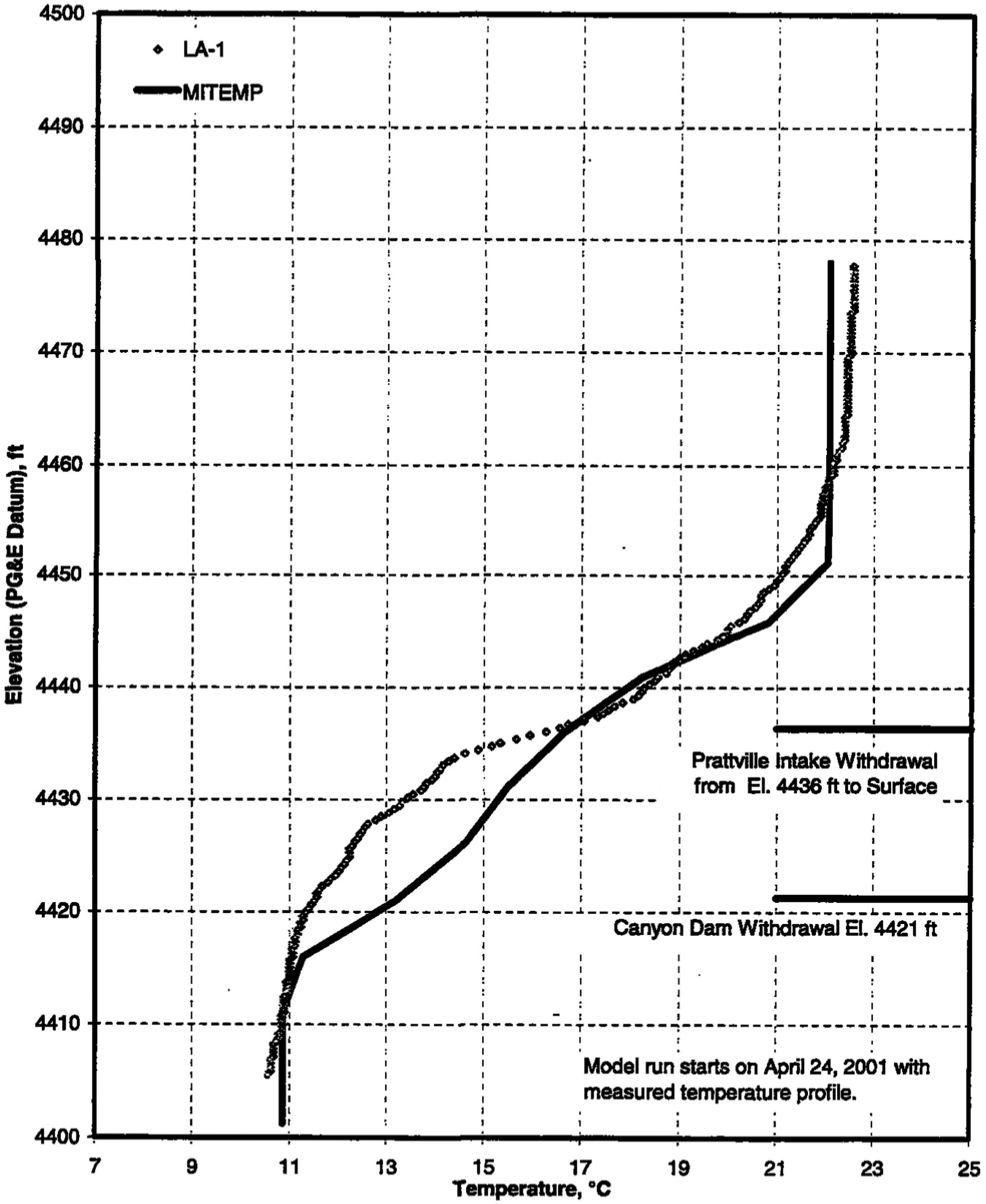


Figure 4.32 Lake Almanor Temperature Profiles August 9, 2001

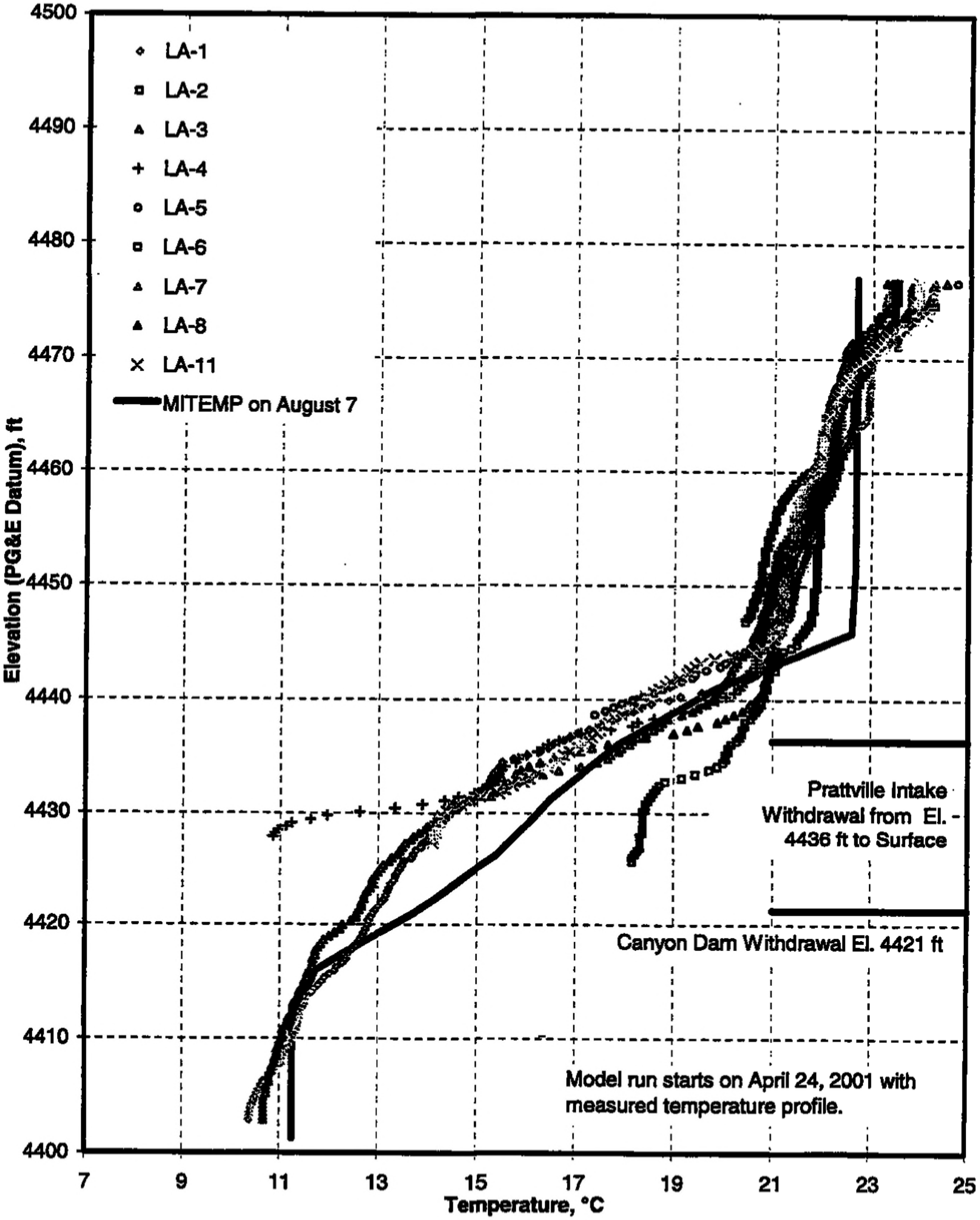
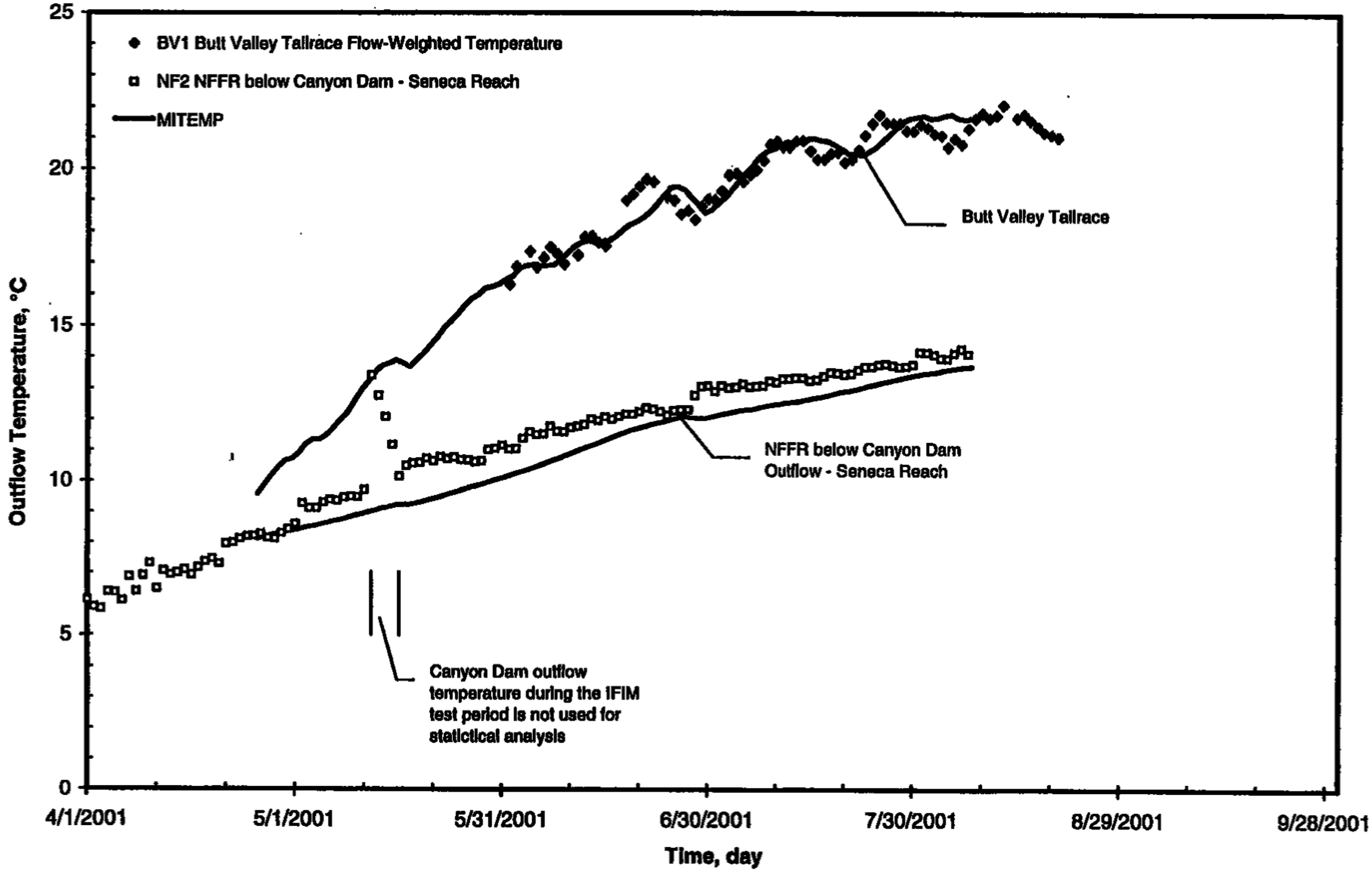


Figure 4.33 Lake Almanor Year 2001: Outflow Temperatures



5. Butt Valley Reservoir Model

The Butt Valley reservoir model includes the reservoir in its entirety.

Butt Valley Reservoir has two major inflows: Butt Valley Powerhouse flow and Butt Creek below Lake Almanor. The Butt Valley Powerhouse flow was obtained from the relationship between power load and turbine flow. During the peak electricity generation period in the summer, the Butt Valley Powerhouse flow can be as high as 2100 cfs. During the period of no power generation, however, Butt Valley powerhouse still maintains a "motor" flow of about 35 cfs, which was accounted for in the MITEMP3 model by increasing the estimated Butt Valley Powerhouse flow by 35 cfs whenever the daily average fell below 300 cfs. (The "motor" flow was not included in the Lake Almanor model since it was not expected to impact the water balance for this large lake.) The flow in Butt Creek below Lake Almanor is not regulated and can be as high as 300 cfs in April and drop to 50 cfs in the summer (Figure 5.1). Both inflows were modeled with small entrance mixing ratios due to the slowly expanding nature of the entrance channel into the lake. No significant spring flows were identified for this reservoir.

Water in Butt Valley Reservoir is discharged through two intake structures one for Caribou 1 and a second for Caribou 2 Powerhouse and thence to the Belden Forebay downstream. Outflows were determined by PG&E using power load-flow relationships for these two units. A sensitivity analysis was conducted to determine the most probable bias in the outflow estimates. A constant 7% increase added to both Caribou 1 and 2 flows was found to yield the best prediction for the Butt Valley Reservoir water level for both years 2000 and 2001. The adjusted flow rate is shown in Figure 5.2 for Caribou 1 Powerhouse and in Figure 5.3 for Caribou 2 Powerhouse. The outflows were intermittent as dictated by the demand for electricity. The combined outflow reached a peak at 2200 cfs in the summer.

The invert elevation of Caribou 1 Intake is at 4067 ft. In 1986, Woodward Clyde Consultants compared the outflow temperature at the Caribou 1 tailrace and the temperature profiles in the reservoir. It appeared that the Caribou 1 intake withdrew water uniformly over the depth. Upon inspecting the topographic map in the vicinity of the intake structure, it was assumed that Caribou 1 Intake withdraws water uniformly from elevation 4085 ft to surface in the current version of MITEMP3.

The Caribou 2 Intake conduit is located in a shallow cove area. Although the invert is situated at an elevation of 4093 ft, the channel entrance limits the accessibility to the reservoir storage above elevation 4100 ft. In the reservoir model, it was assumed that water is drawn uniformly from elevation 4100 ft to the surface.

Due to the geographic proximity of two reservoirs, the meteorological data used for the Lake Almanor model were also applied to Butt Valley Reservoir. Figures 4.1 – 4.5 show the daily average conditions for the year 2000.

The table below shows the light extinction coefficient for years 2000 and 2001. The reduced value for the light extinction coefficient in year 2001 reflects the reduction in the suspended sediments due to a lower runoff. Thirty-five percent of solar radiation was assumed to be absorbed at the surface.

Butt Valley Reservoir Light Extinction Coefficient

Month	Secchi Depth[1], m		Extinction Coefficient, m^{-1}	
	1982-1995	2001	2000	2001
March	N/A			
April	N/A		0.44	0.40
May	N/A		0.44	0.40
June	N/A		0.43	0.31
July	N/A	6.6	0.35	0.31
August	N/A	6.6	0.30	0.31
September	N/A		0.28	

[1]Average value based upon secchi depth measurements provided by PG&E.

5.1 Calibration

The water temperature profile measured on April 6, 2000 was used to initialize the calibration run. The initial temperature distribution has a 6°C temperature difference from surface to bottom.

Figure 5.4 shows the simulated water surface level for the calibration period. The mean bias and the maximum difference between simulated and measured water surface levels are –0.01 ft and 4.1 ft, respectively (Table 5.1).

PG&E operated three temperature stations, arranged along the axis of the reservoir (Figure 5.5). A comparison of simulated and measured temperature profiles for June 22, July 20, August 17, and September 28 are shown in Figures 5.6 – 5.9. The model did a reasonable job of predicting water temperature and temperature gradient. The most significant discrepancy occurred on April 17 when the model over-estimated the surface temperature by approximately 1.2°C.

The simulated outflow temperatures of the Caribou 1 and 2 tailrace are shown in Figure 5.10. The measured outflow temperatures, weighted by their respective flow rates to "filter out" temperature readings on days when the units were not in operation, also appear in the same graph as symbols.

The discrepancy between simulated and measured Caribou 2 tailrace temperatures was at first glance puzzling, considering the good agreement between the temperature profiles for the same period. A close inspection suggests that measured water temperatures at Caribou 2 tailrace in June, July, and September were unrealistically high. Take June 22, 2000 for example. The difference between the measurement and the simulation is 1.3°C.

The measured outflow temperature is 19.8°C (Figure 5.10). The temperature profiles collected on the same day shows an average temperature of approximately 18.5°C for the water column between elevation 4100 ft and the surface (Figure 5.6). This temperature is in close agreement with the computed outflow temperature but less than the measured tailrace temperature. On September 28, 2000, both measured and simulated temperature profiles show a uniform temperature of 17°C over the full depth. Yet the Caribou 2 temperature sensor gave a temperature of 19.5°C (Figure 5.9). The difference is 2.5°C. Based upon these observations, it was suspected that the Caribou 2 temperature sensor malfunctioned in two periods in year 2000, as indicated in Figure 5.10. Following discussion with PG&E, it was found that the Caribou 2 sensor was installed in a valve house on the penstock due to difficulties in directly placing the temperature recorder in the tailrace. PG&E confirmed that during the two periods in question debris clogged the valve house.

The mean bias and the maximum difference for the Caribou 1 tailrace temperature are –0.18°C and 2.8°C, respectively (Table 5.1). Excluding the periods in which the Caribou 2 tailrace temperature is in question, the mean bias and the maximum difference for the Caribou 2 tailrace temperatures are 0.01°C and 1.4°C, respectively.

5.2 Validation

The same water temperature profile used for the year 2000 calibration run was used to initialize the validation run. There is a 6°C temperature difference from surface to bottom.

The meteorological conditions for the year 2001 are shown in Figures 4.18 – 4.22. The inflow and outflow time series are given in Figures 5.11 – 5.13. The year 2001 was a dry year and this condition is reflected in the flow in Butt Creek below Lake Almanor; the peak flow was only 120 cfs, compared with 300 cfs in year 2000. The light extinction coefficient for the period from April to June was reduced, reflecting the decreased sediment loads into the reservoir. Other model parameters remained unchanged. This set of parameters is believed to be representative of the "dry" year conditions.

With this adjustment, the reservoir model was re-run for the period from April 1 to August 7, 2001. Figure 5.14 shows the predicted, as well as the measured, reservoir level. The mean bias and the maximum difference are 0.86 ft and 2.2 ft, respectively.

The predicted temperature profiles were compared with the measured on June 6, July 11, and August 20 (Figures 5.15 – 5.17). Overall, the model is able to predict both water temperature and vertical temperature gradient with good accuracy. June 6, 2001 is an exception; the model predicted a thermocline elevation that is 5 ft too high. Fine-tuning the light extinction coefficient for the months of April and May may reduce the difference. The adjustment is not warranted, however, in the absence of any temperature measurements for the same period.

The outflow temperatures are shown in Figure 5.18. For the months of June and July, the measured Caribou 2 outflow temperature is approximately 1.5°C higher than the model prediction, despite the good agreement between simulated and measured temperature profiles for the same period. It appears that as in year 2000, the measured outflow temperature is inconsistent with the measured profiles and may be too high due to debris problems at the location of the Caribou 2 temperature sensor. If this period of unusually high temperature is excluded, the mean bias and the maximum difference between simulated and measured Caribou 2 tailrace temperatures are –0.20°C and 1.0°C, respectively.

Two features of the Caribou 1 outflow temperature time series are worth commenting. First, the measured outflow temperature at the Caribou 1 tailrace was reduced by 0.4°C on the recommendation of PG&E personnel. This adjustment was necessary, following a field validation, to compensate for the time lag and warming of water between the Caribou 1 flow and the temperature sensor installed in a fire water supply line. Second, on days when the MITEMP3 model grossly overestimated the Caribou 1 outflow temperature (see open symbols in Figure 5.18), the daily average flow rate through Caribou 1 Intake was always less than 60 cfs. It was further noted that on June 6 and July 11, the measured (as well as simulated) temperature profiles showed a moderate degree of thermal stratification. The actual flow rate fell short of the estimated critical flow rate necessary to maintain a uniform withdrawal, suggesting that Caribou 1 Intake withdrew water selectively, contrary to the uniform withdrawal assumption made in the model. Selective withdrawal would result in a lower (in this case, 4-5°C lower) temperature than that of an assumed uniform withdrawal. On the days when the turbine flow was high or the thermal stratification was weak, the simulated outflow temperature was again in good agreement with the measured Caribou 1 tailrace temperature, suggesting the uniform withdrawal assumption a reasonable one. Further modifications to the MITEMP3 model are needed in order to fully reproduce this flow-dependent withdrawal phenomenon.

Selective withdrawal is not observed for Caribou 2 Intake, located at a higher elevation where thermal stratification is less pronounced. The assumption of uniform withdrawal for Caribou 2 Intake remains valid.

The mean bias and the maximum difference between simulated and measured Caribou 1 tailrace temperatures are 0.89°C and 4.6°C, respectively (Table 5.1). Excluding the period suspected of selective withdrawal, the mean bias and the maximum difference become 0.01°C and 0.9°C, in line with the MITEMP3 performance for Lake Almanor.

Table 5.1 Butt Valley Reservoir: Comparison of Observations and Model Predictions

Period	Output	Mean Bias[1]	Probable Difference on 50% Confidence[2]	Maximum Difference
Year 2000 Calibration	Water Surface Elevation, ft	-0.01	1.0	4.1
	Caribou #1 Tailrace Temperature[3], °C	-0.18	0.5	2.8
	Caribou #2 Tailrace Temperature[3], °C (Including Abnormal High Temperature Measurements)	*-1.16*	*0.9*	*6.0*
	Caribou #2 Tailrace Temperature[3, 4], °C (Excluding Abnormal High Temperature Measurements)	0.01	0.4	1.4
	Combined Outflow Temperature, °C (Including All Temperature Measurements)	*-0.90*	*0.7*	*4.1*
Year 2001 Validation	Water Surface Elevation, ft	0.86	0.5	2.2
	Caribou #1 Tailrace Temperature[3], °C (Including Selective Withdrawal Period)	*0.89*	*0.9*	*4.6*
	Caribou #1 Tailrace Temperature[3], °C (Excluding Selective Withdrawal Period)	0.01	0.3	0.9
	Caribou #2 Tailrace Temperature[3], °C (Including Abnormal High Temperature Measurements)	*-0.73*	*0.4*	*1.9*
	Caribou #2 Tailrace Temperature[3, 4], °C (Excluding Abnormal High Temperature Measurements)	-0.20	0.3	1.0
	Combined Outflow Temperature[3], °C (Including All Temperature Measurements)	*-0.42*	*0.3*	*1.6*

Notes:

[1] Bias = MITEMP3 prediction - field measurement

[2] Probable difference on 50% confidence = 0.6745 x standard deviation

[3] Measured water temperature at Caribou #1, and Caribou #2 tailrace is flow-weighted.

[4] Measured water temperature that exceeds the reasonable range may be subject to instrument error and is not used for statistical analysis.

Figure 5.1 Butt Valley Reservoir Year 2000: Butt Creek below Lake Almanor

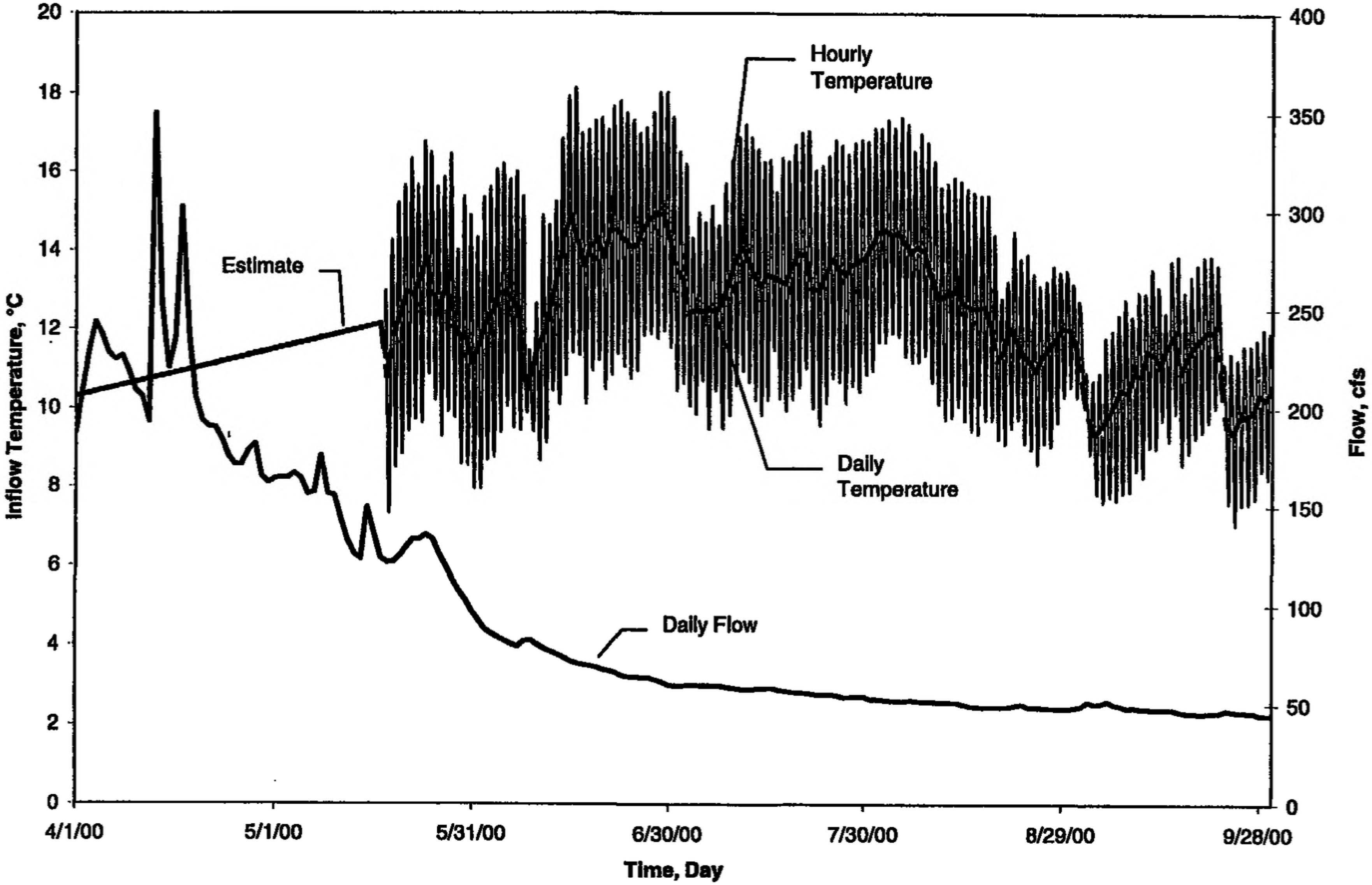


Figure 5.2 Butt Valley Reservoir Year 2000: Caribou 1 Powerhouse

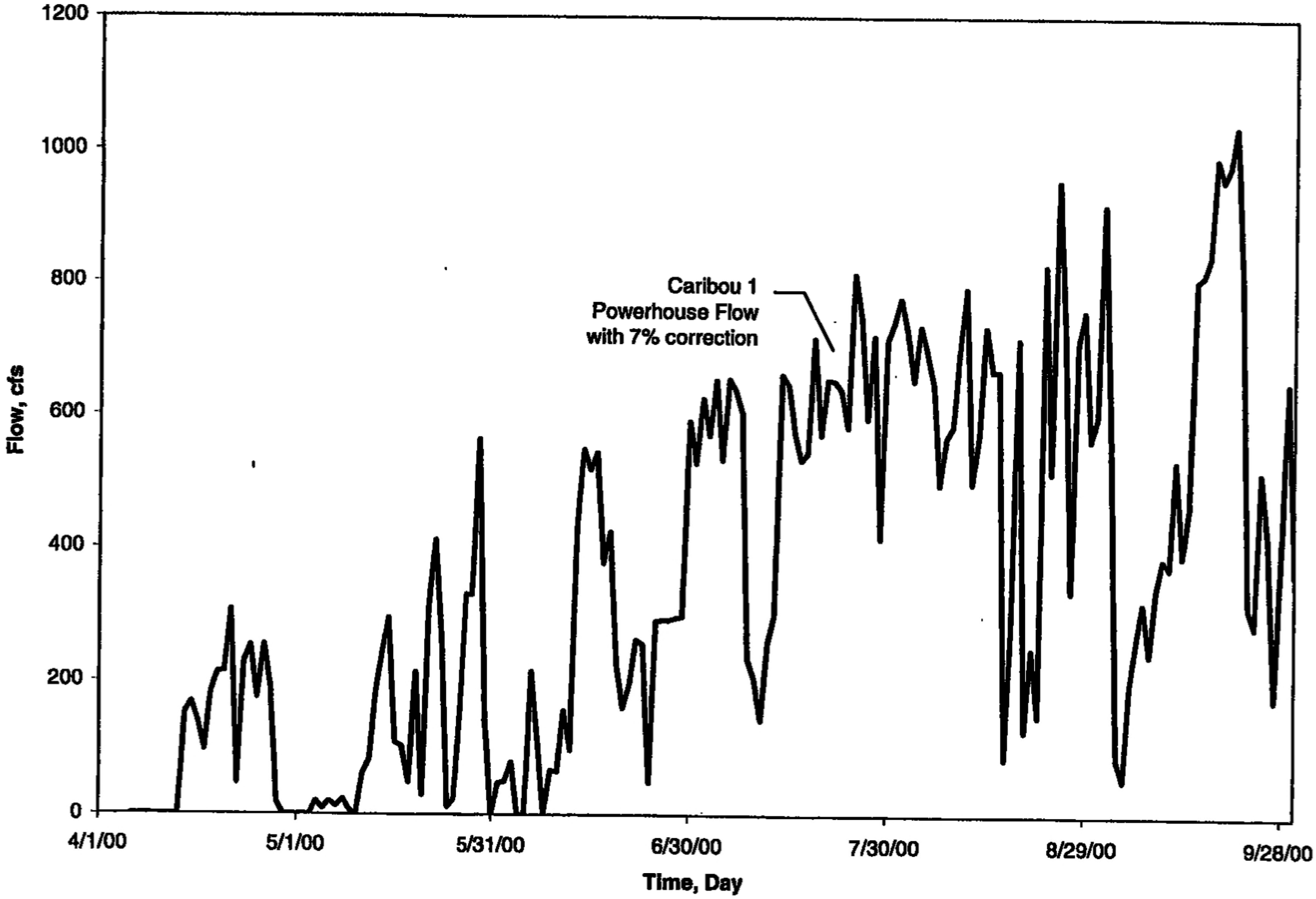


Figure 5.3 Butt Valley Reservoir Year 2000: Caribou 2 Powerhouse

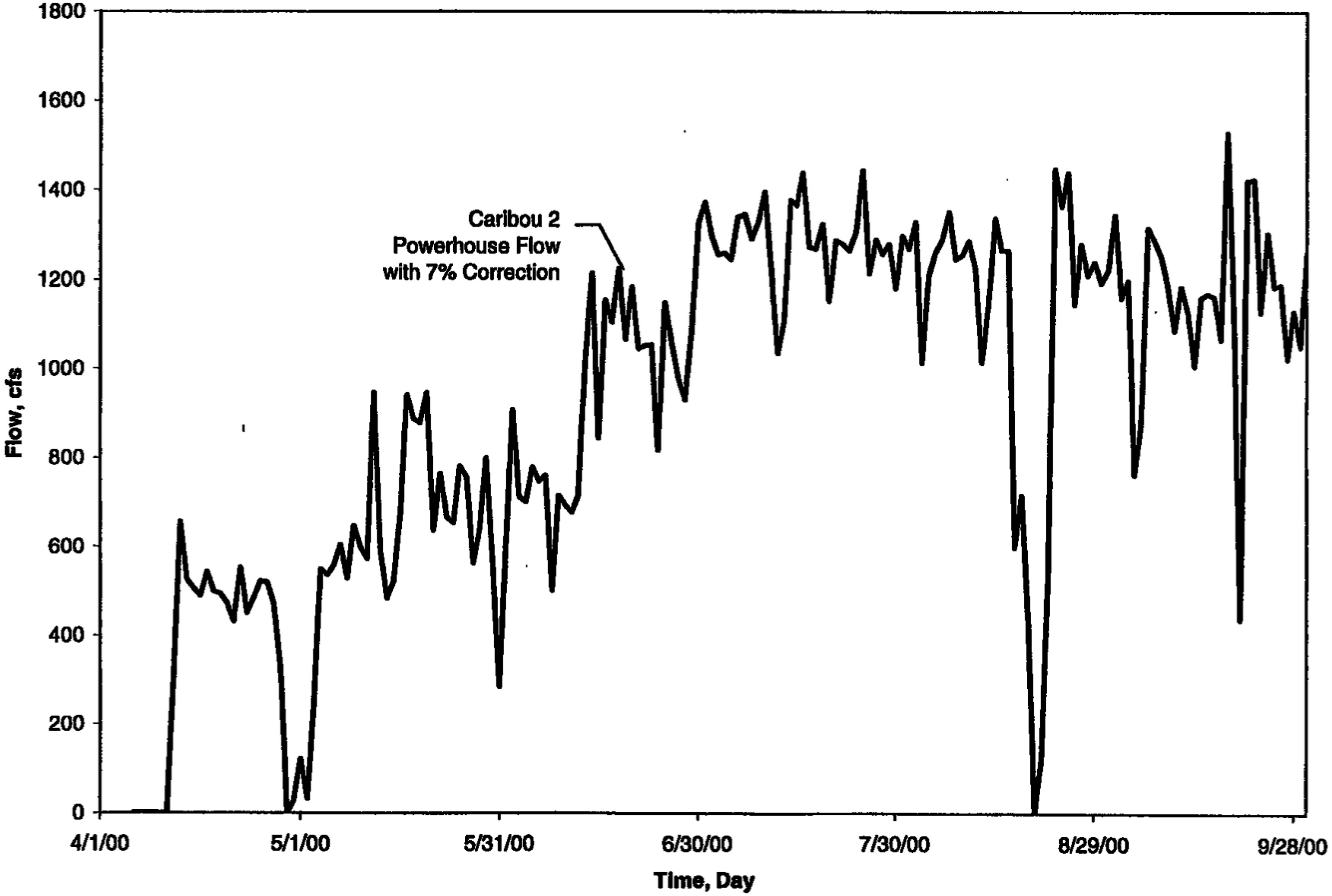


Figure 5.4 Butt Valley Reservoir Year 2000: Water Surface Elevation

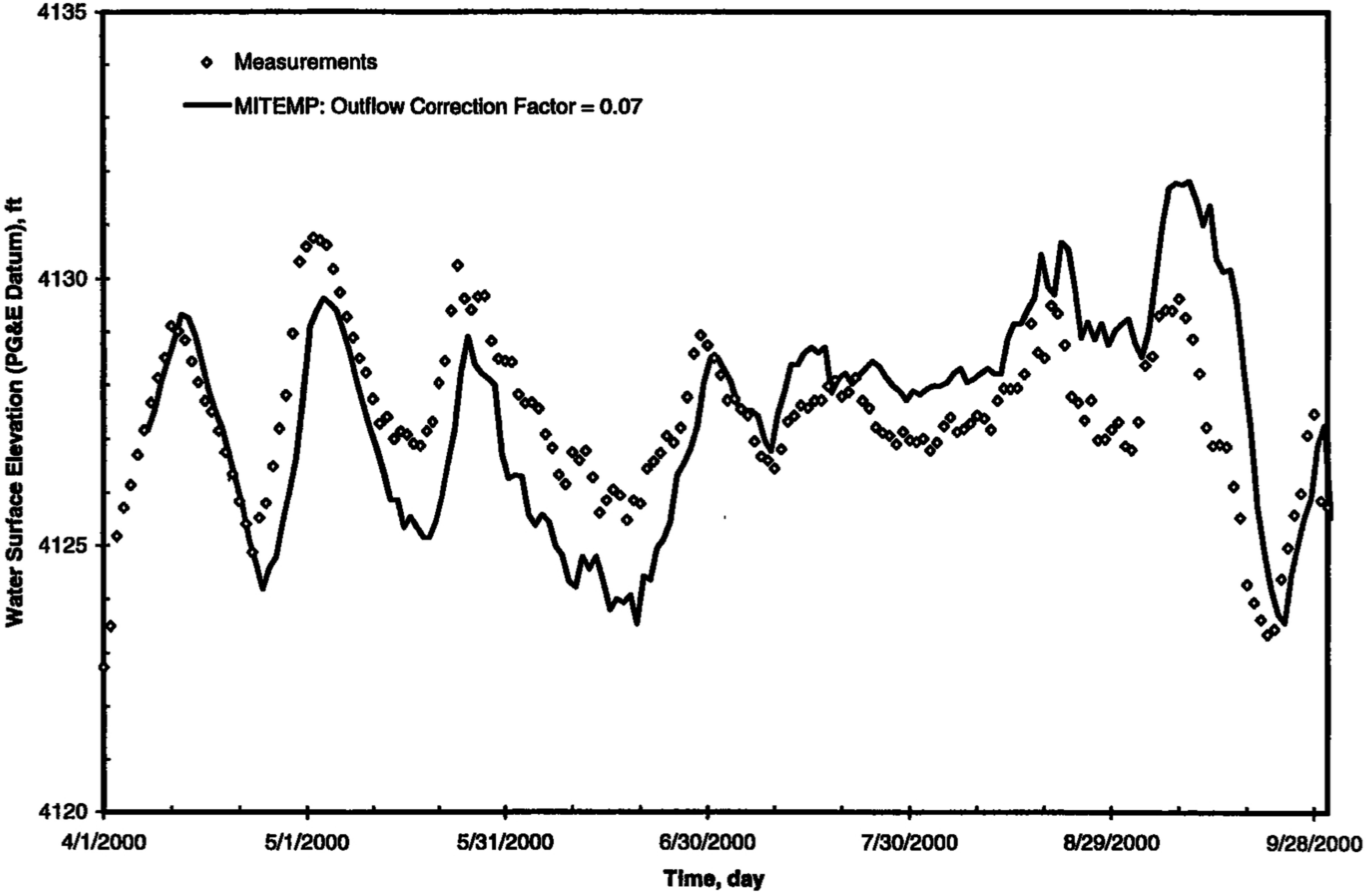


Figure 5.5 Butt Valley Reservoir 2000-2001: PG&E Temperature Stations

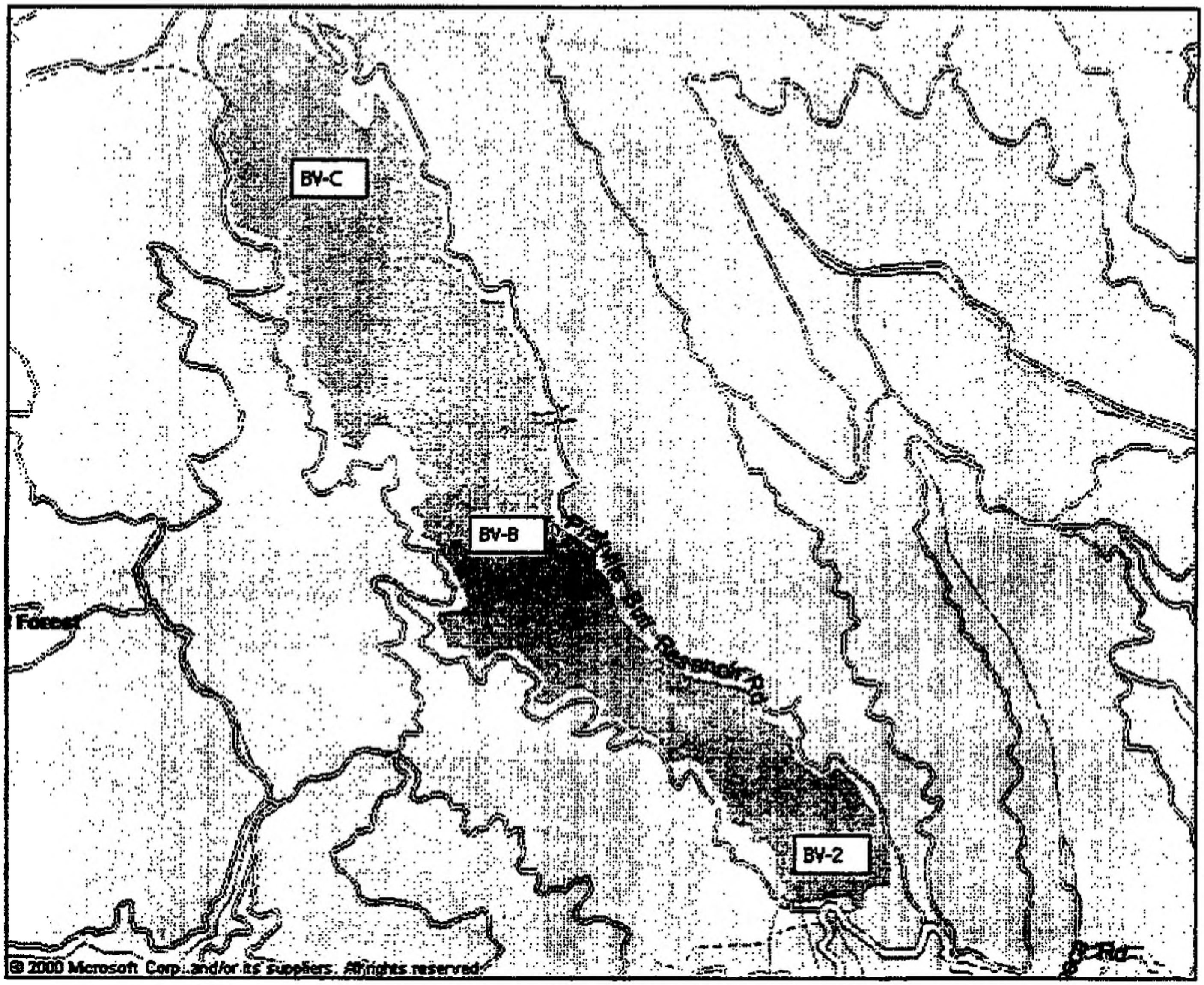


Figure 5.6 Butt Valley Reservoir Temperature Profiles June 22, 2000

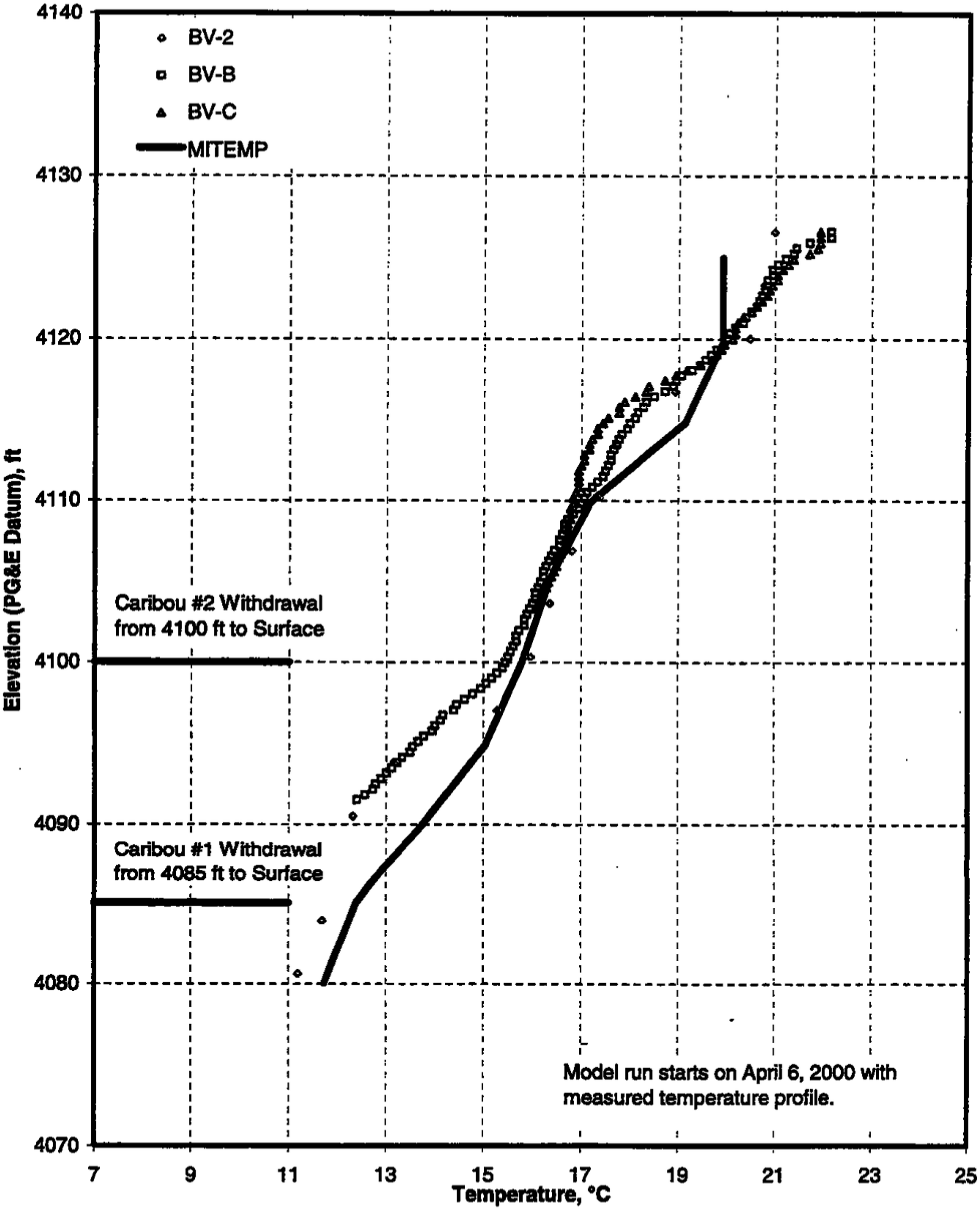


Figure 5.7 Butt Valley Reservoir Temperature Profiles July 20, 2000

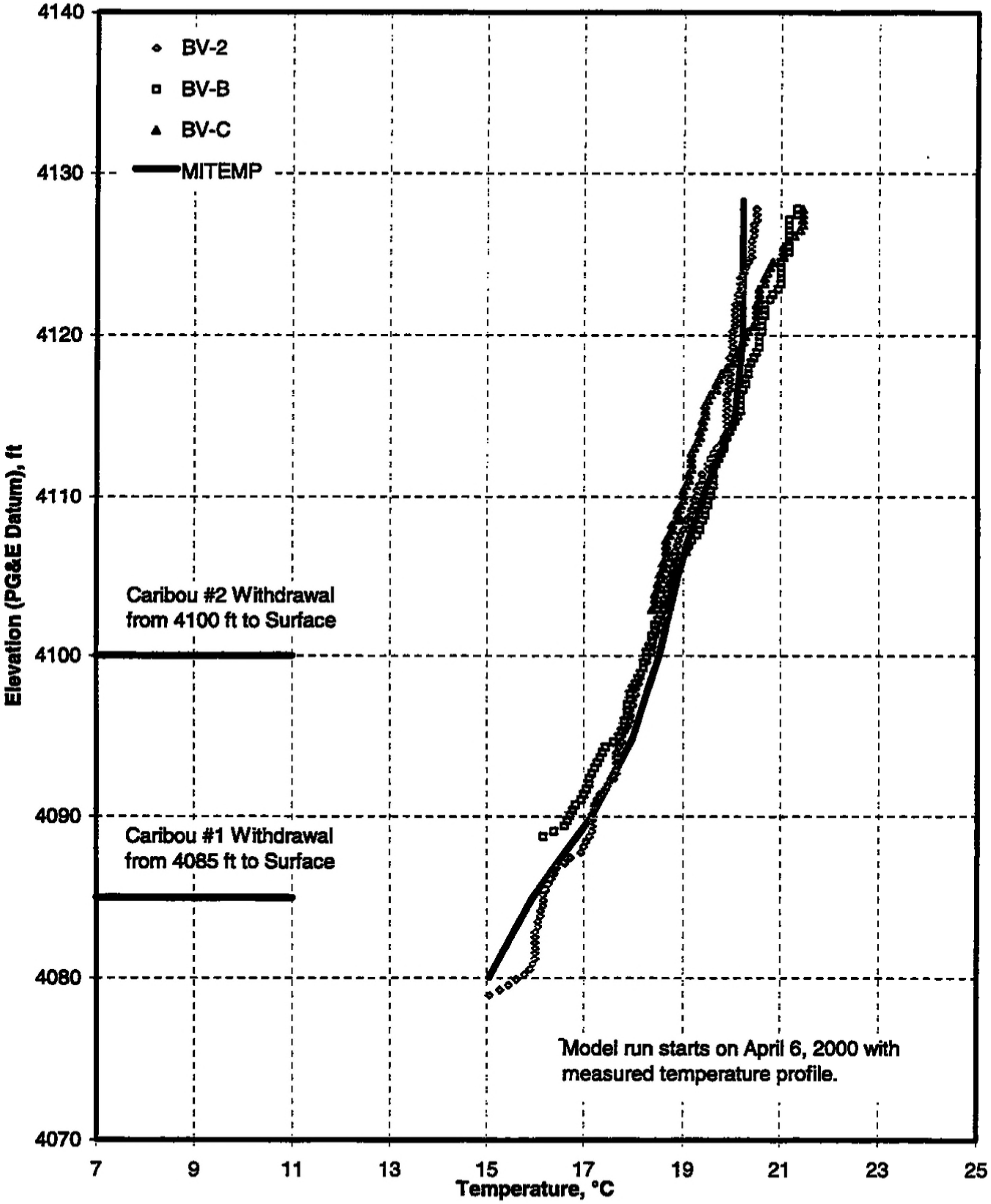


Figure 5.8 Butt Valley Reservoir Temperature Profiles August 17, 2000

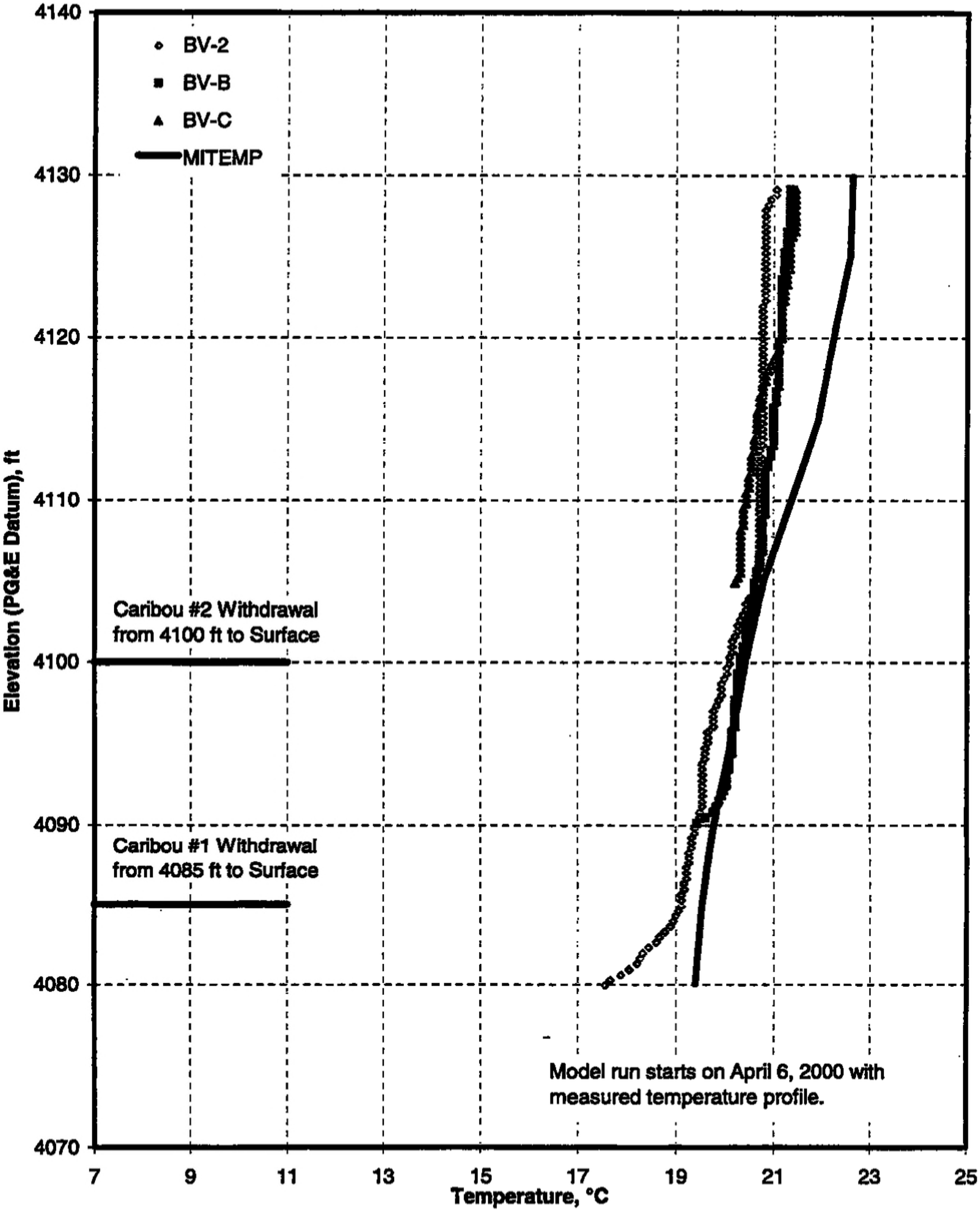


Figure 5.9 Butt Valley Reservoir Temperature Profiles September 28, 2000

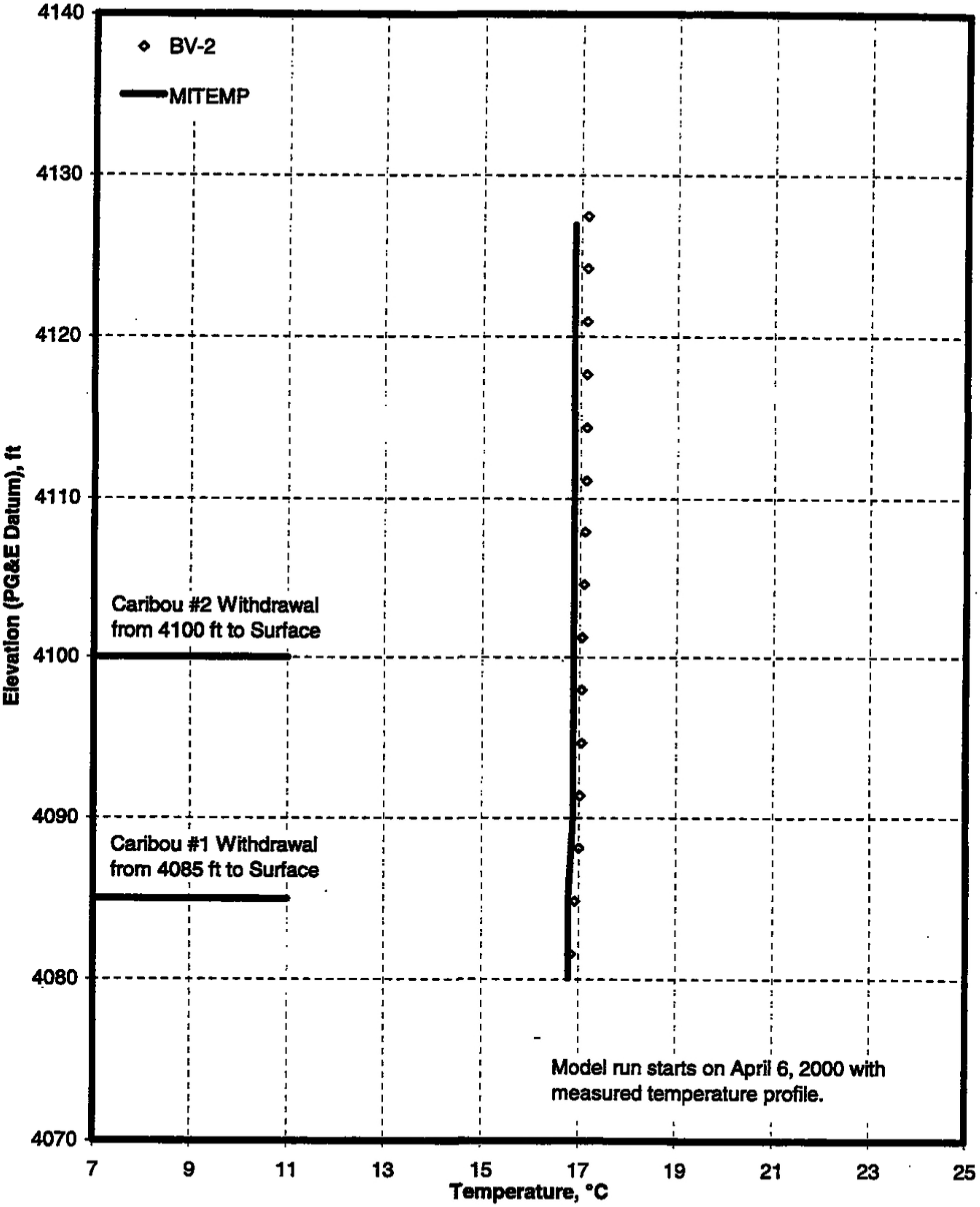


Figure 5.10 Butt Valley Reservoir Year 2000: Outflow Temperatures

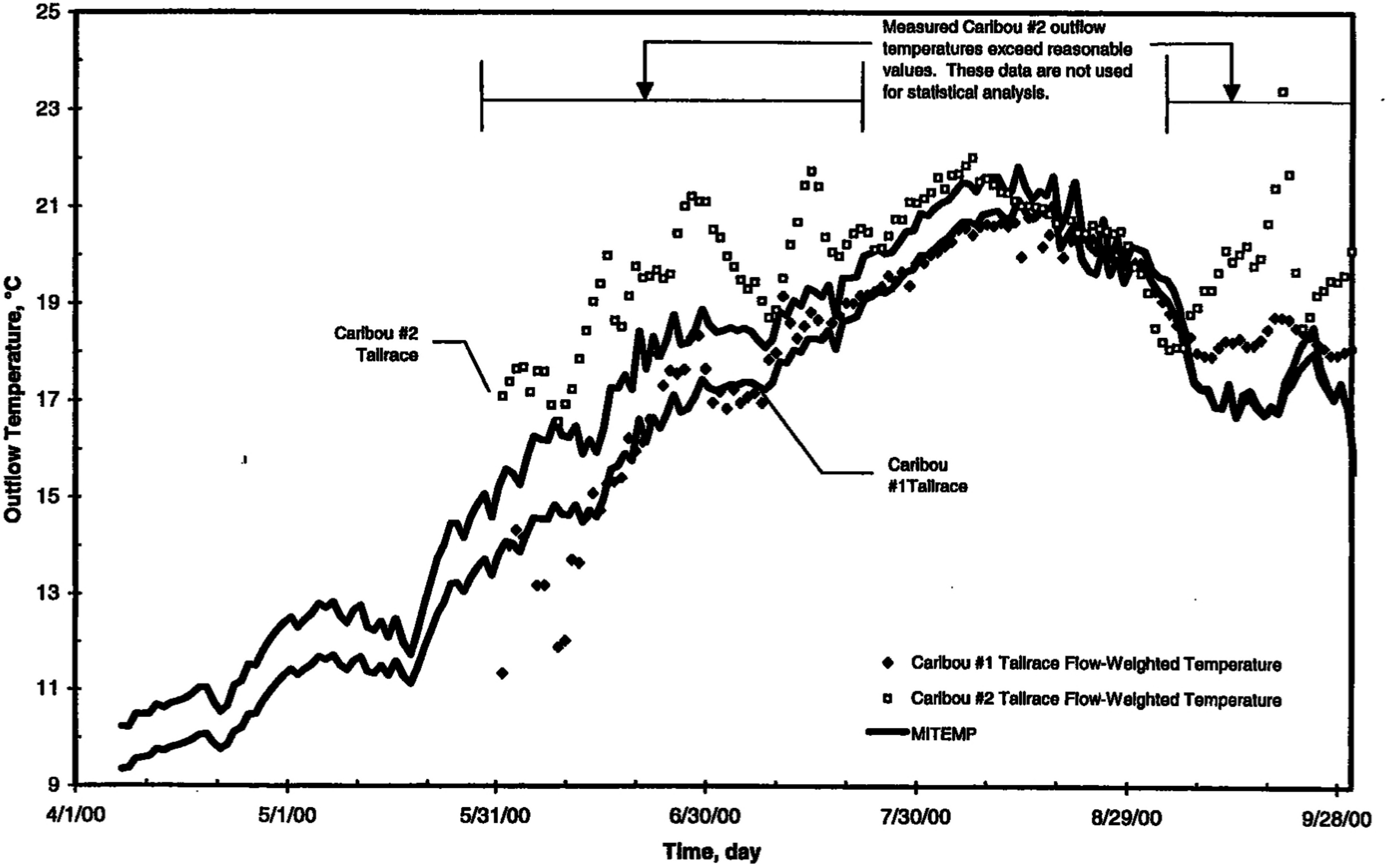


Figure 5.11 Butt Valley Reservoir Year 2001: Butt Creek below Lake Almanor

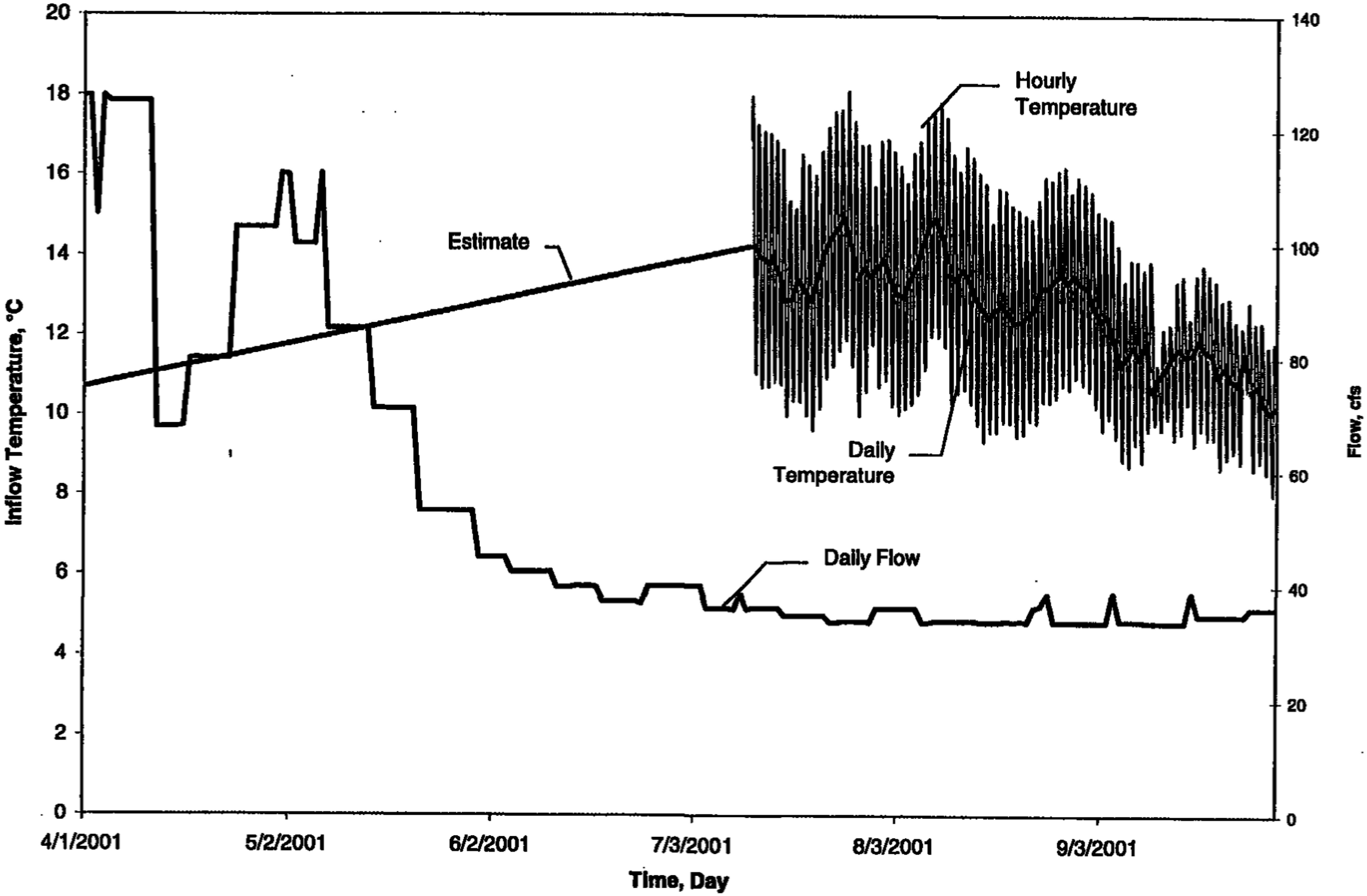


Figure 5.12 Butt Valley Reservoir Year 2001: Caribou 1 Powerhouse

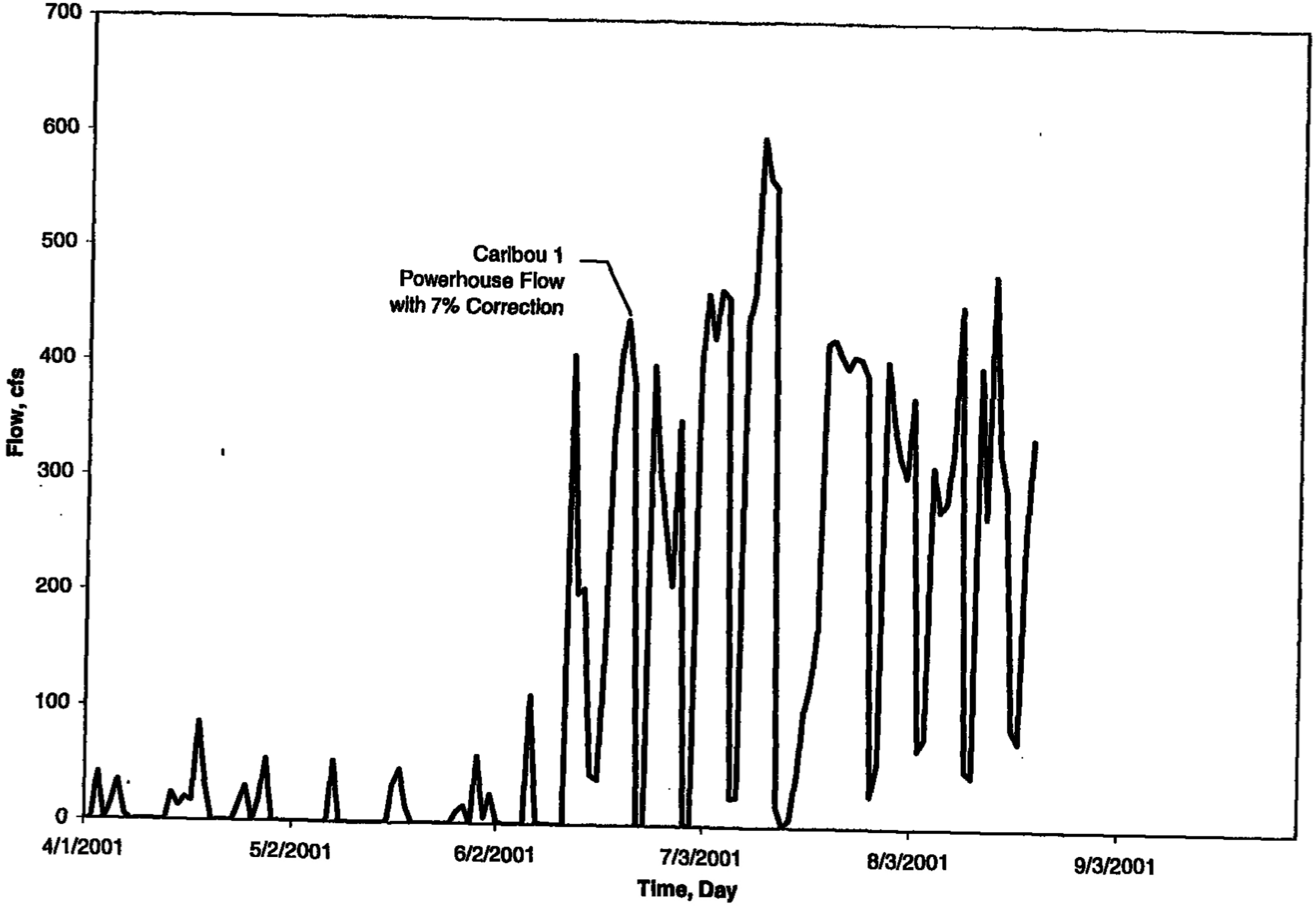


Figure 5.13 Butt Valley Reservoir Year 2001: Caribou 2 Powerhouse

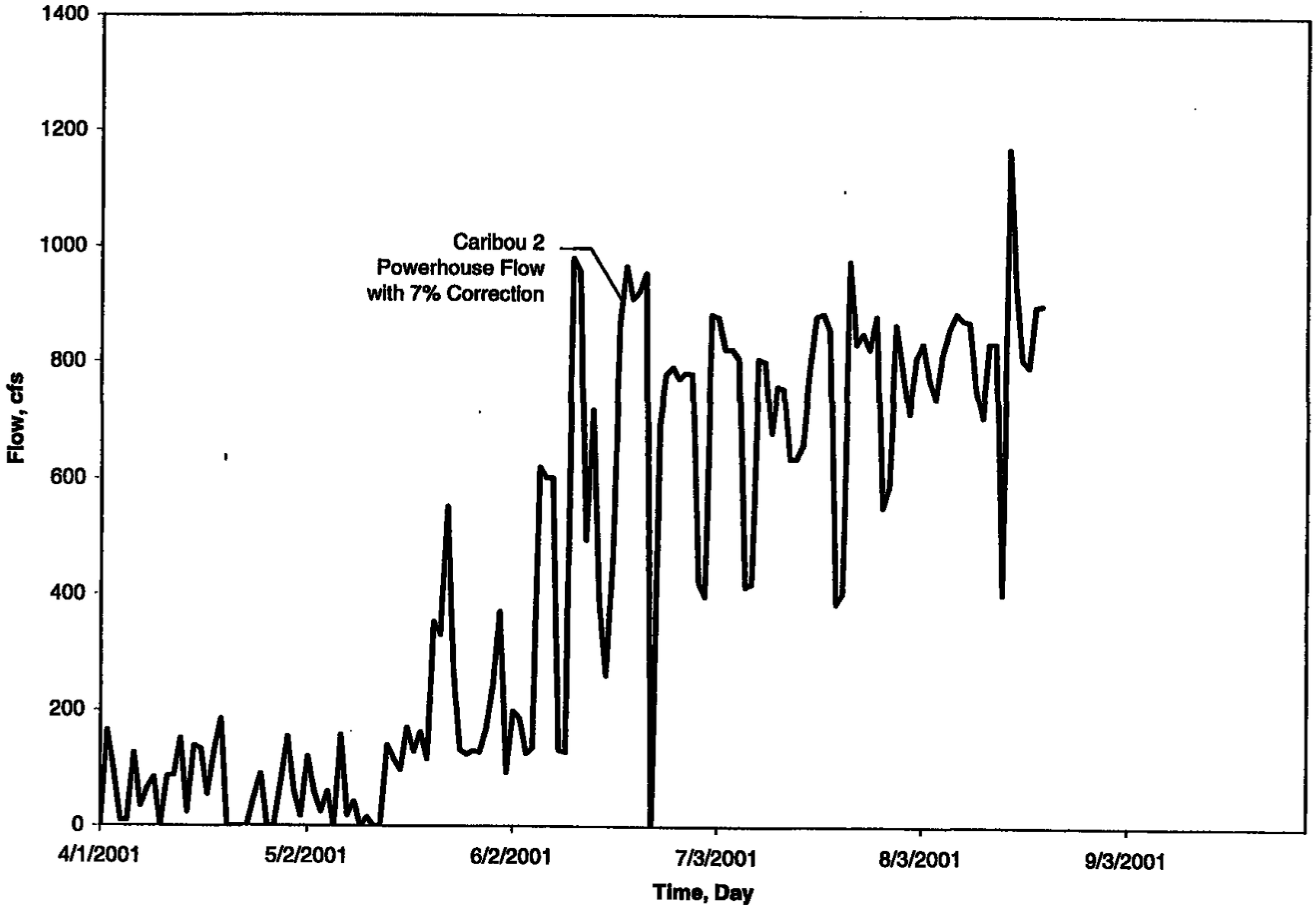


Figure 5.14 Butt Valley Reservoir Year 2001: Water Surface Elevation

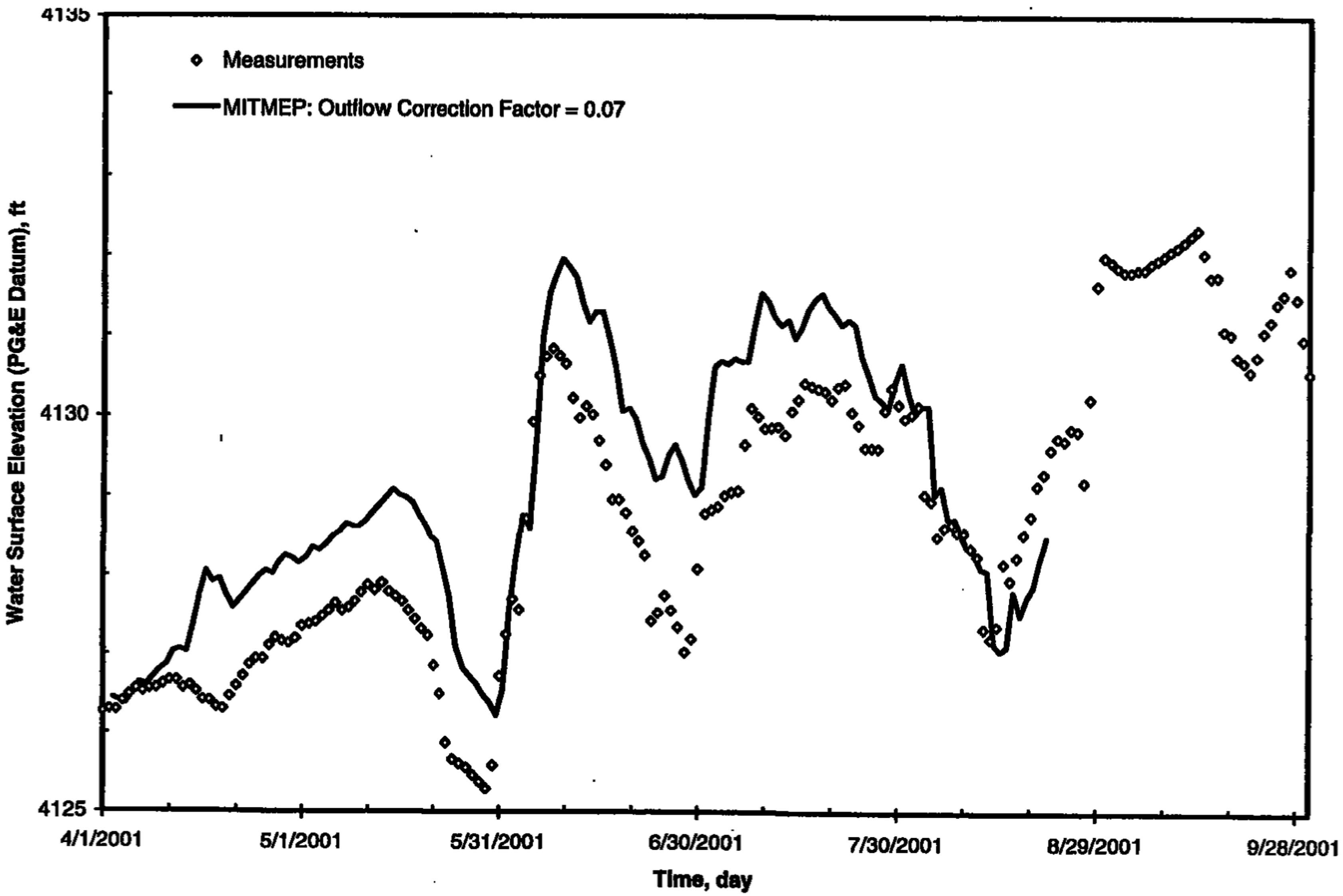


Figure 5.15 Butt Valley Reservoir Temperature Profiles June 6, 2001

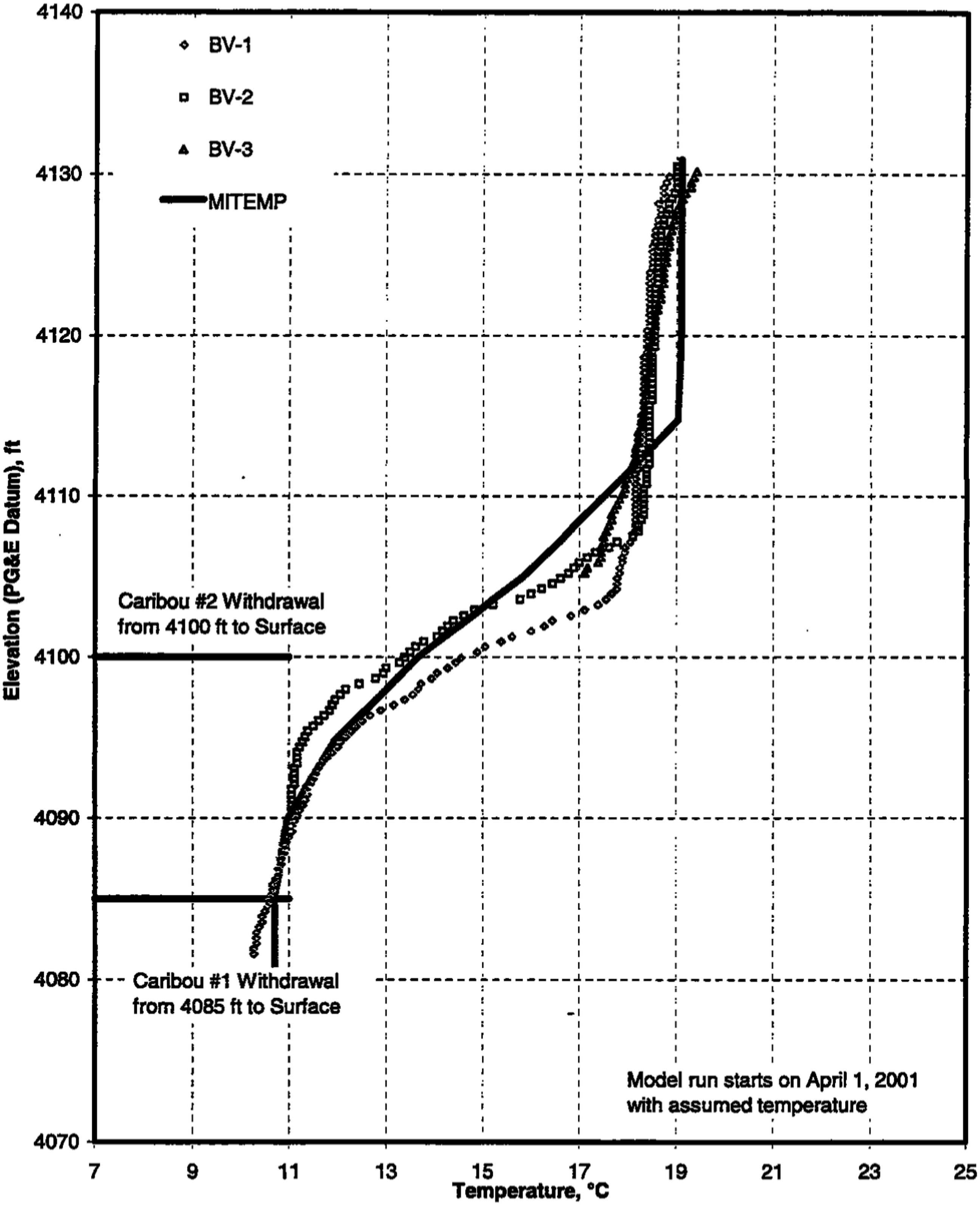


Figure 5.16 Butt Valley Reservoir Temperature Profiles July 11, 2001

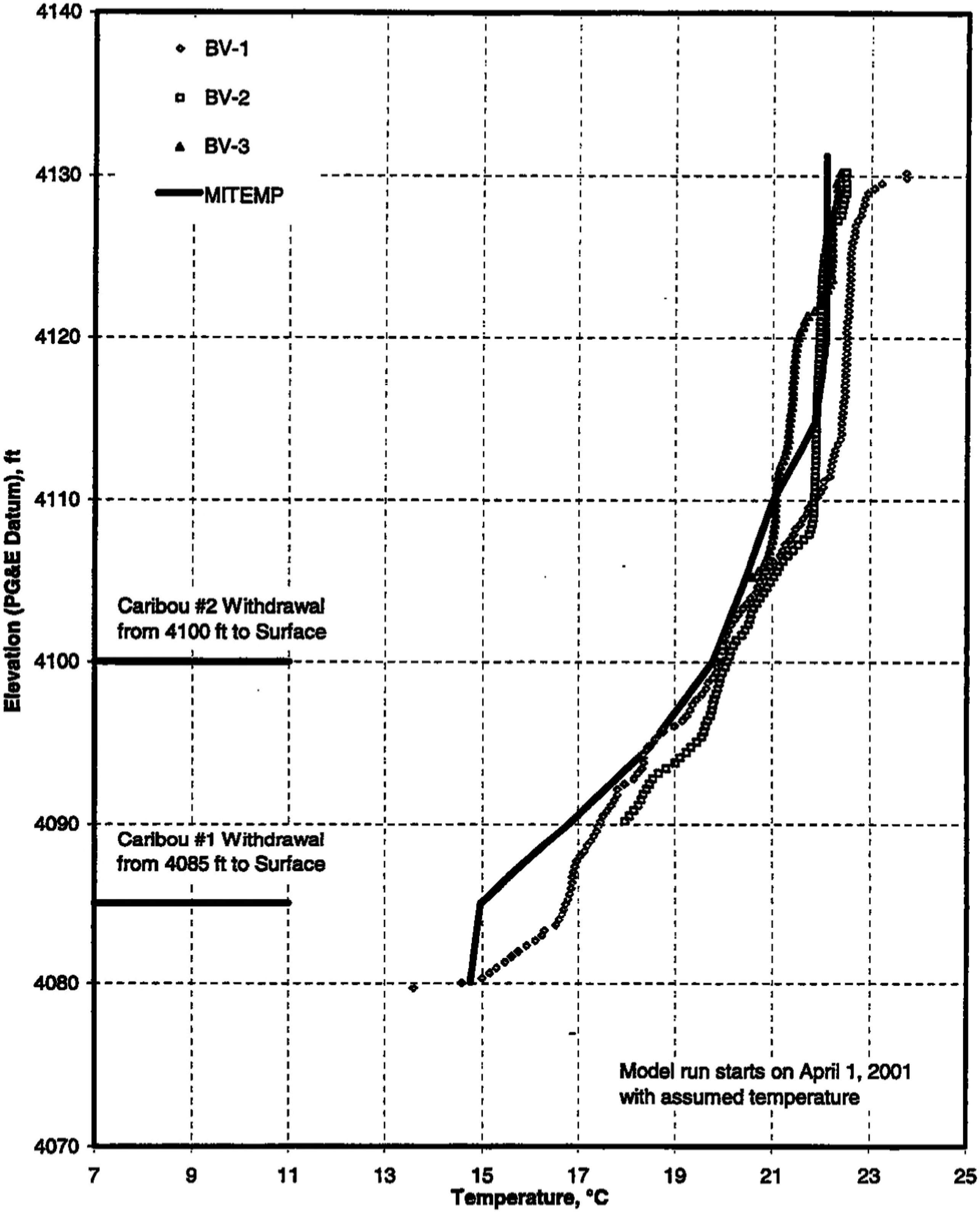


Figure 5.17 Butt Valley Reservoir Temperature Profiles August 20, 2001

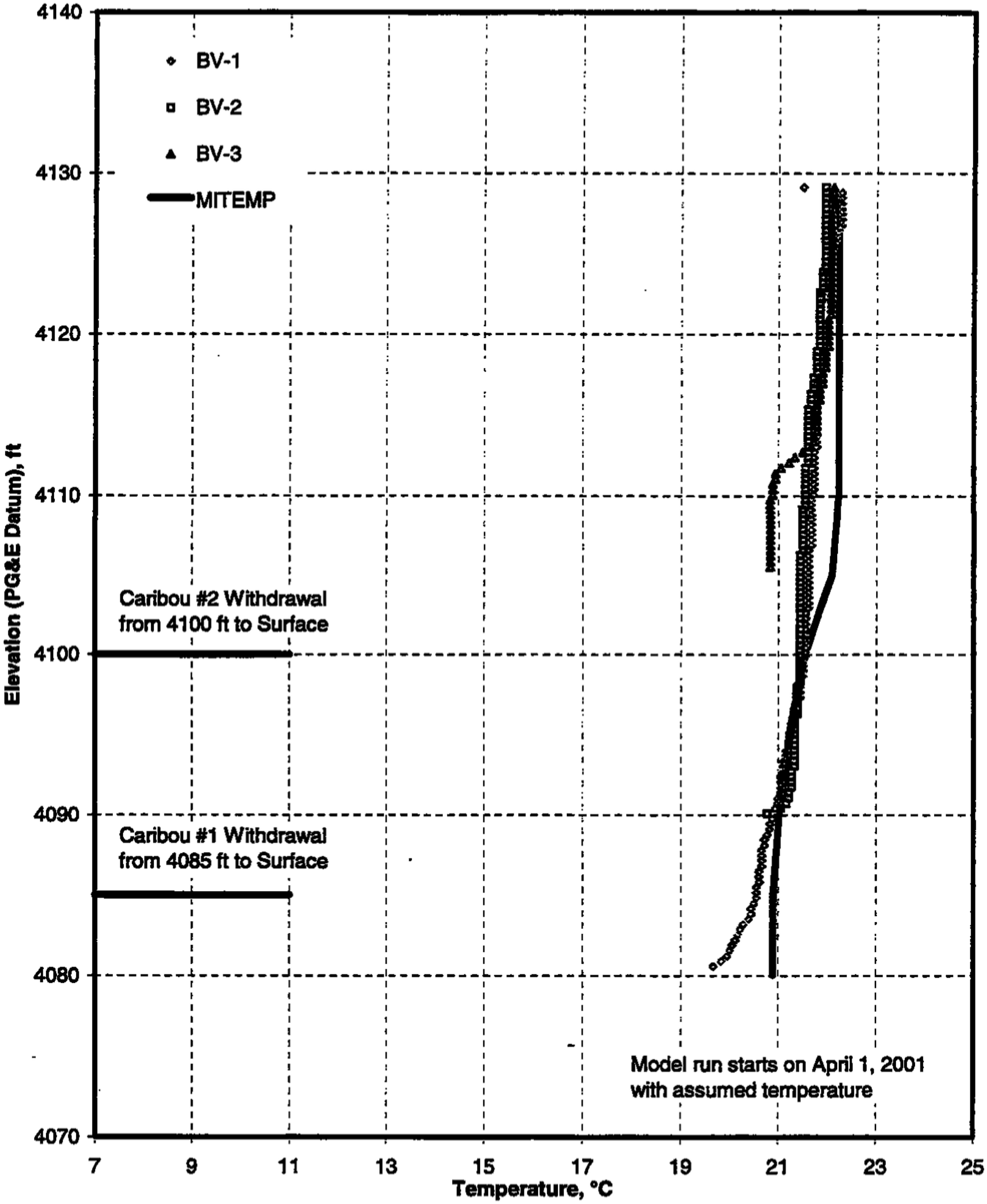
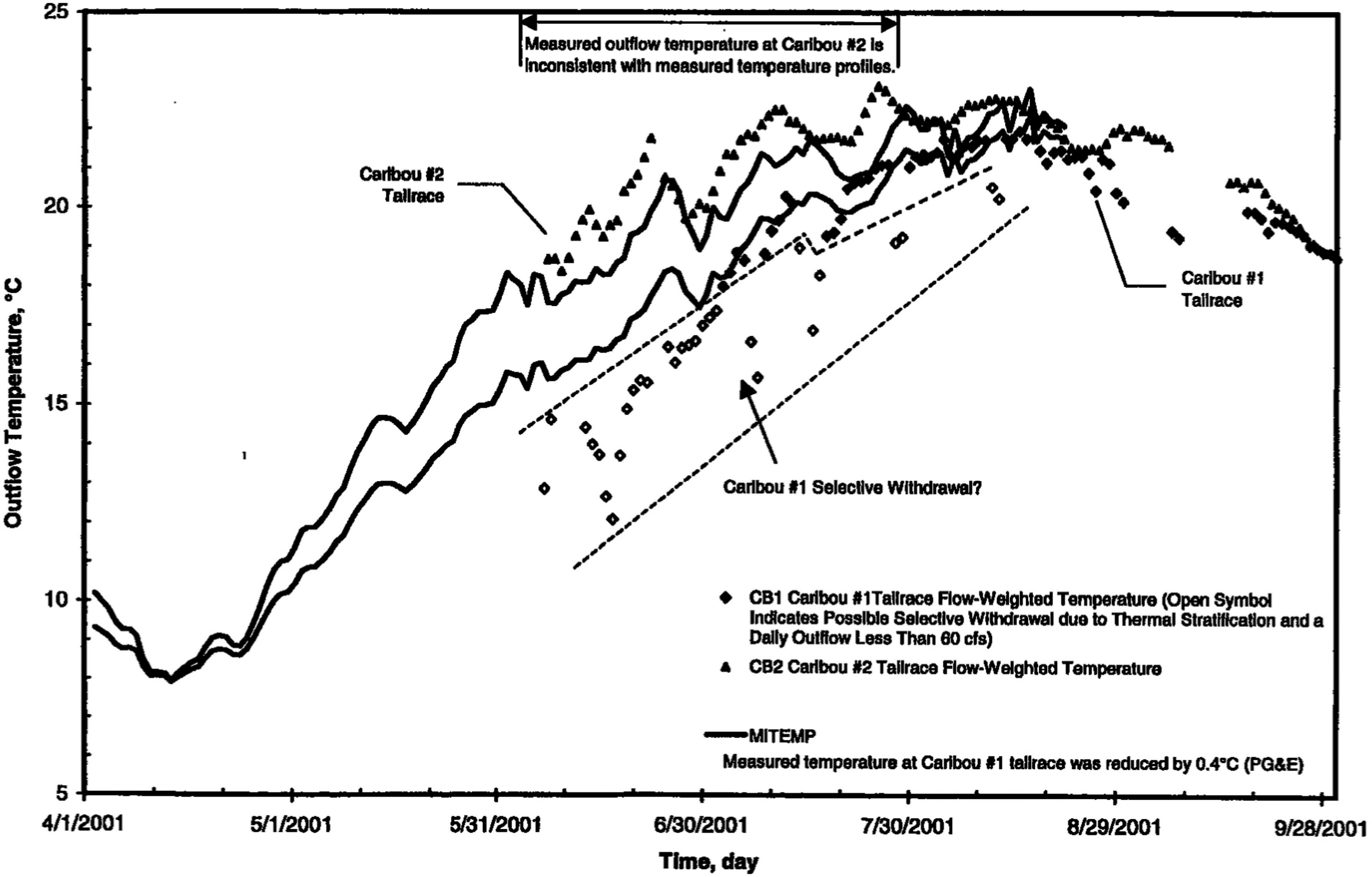


Figure 5.18 Butt Valley Reservoir Year 2001: Outflow Temperatures



6. Conclusions

The one-dimensional reservoir temperature model, MITEMP3 developed by WCC in 1985-1986 was peer reviewed, re-calibrated with the extensive year 2000 data set and validated with the year 2001 data set. The findings and conclusions are summarized as follows:

1) The MITEMP3 model is generally valid for the simulation of a stratified lake provided that the one-dimensional assumptions are met. The characteristics of Lake Almanor and Butt Valley Reservoir make them amenable to analysis using one-dimensional models.

2) The model production runs performed by WCC in 1986 (December, 1986) inadvertently had a conversion error in model input (the light extinction coefficient) that resulted in a significant overestimate of the cold water volume available both in Lake Almanor and Butt Valley Reservoir.

3) A seasonally adjusted light extinction coefficient permits the simulation to cover the entire thermal stratification cycle, a critical test to ensure the predictability of the model over a long period of time. This coefficient accounts for the collective effects of water quality parameters, such as turbidity and biological activity, on thermal stratification, providing an additional means to bracket the reservoir conditions that vary from one year to the next.

4) A more realistic assessment of the supply of cold water during the critical summer months was obtained by adding spring flows to the Lake Almanor model.

5) The re-calibrated MITEMP3 model simulated the key features of the thermal regime of Lake Almanor: the evolution of the thermal structure, the elevation of the thermocline, and the temperature of epilimnion and hypolimnion waters.

6) The simulated Butt Valley tailrace temperature is in good agreement with the measured temperature. The mean bias and the maximum difference between simulated and measured Butt Valley tailrace temperatures are 0.08°C and 1.4°C in year 2000 and 0.04°C and 1.1°C in year 2001.

7) The re-calibrated Butt Valley Reservoir model predicted temperature profiles in good agreement with the measured ones in both years 2000 and 2001.

8) The mean bias and the maximum difference between simulated and measured Caribou 1 Powerhouse tailrace temperatures are -0.18°C and 2.8°C in year 2000 and 0.89°C and 4.6°C in year 2001. The MITEMP3 model tends to conservatively over-estimate the temperature at the Caribou 1 tailrace when the reservoir is stratified and the turbine flow is low (less than 60 cfs); a condition conducive to selective withdrawal. At present, the MITEMP3 model has not been

programmed to choose a variable withdrawal scheme between selective and uniform withdrawal scheme based upon the prevailing temperature and flow conditions. Additional modifications to MITEMP3 can be made should it become necessary to improve the model predictability for these low-flow conditions.

9) The mean bias and maximum difference between simulated and measured Caribou 2 Powerhouse tailrace temperatures are 0.01°C and 1.4°C in year 2000 and –0.73°C and 1.9°C in year 2001. This accuracy was obtained after removing measurement data that were subject to instrument error.

10) The total spring flow to Lake Almanor was determined to be 255 cfs in an "average" year and 201 cfs in a "dry" year, subject to further verification using field data.

11) It should be emphasized that at present the MITEMP3 model has been calibrated for the existing intake conditions only. If the model is to be used to "forecast" the release water temperatures for proposed withdrawal alternatives, the results should be subject to cautious interpretation and verification after completion of the physical and numerical model studies being conducted in 2002 at the University of Iowa.

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UPPER NORTH FORK FEATHER RIVER PROJECT

FERC NO. 2105

Appendix E2-A

Water Quality of Late Summer Releases from Canyon Dam

Upper North Fork Feather River Project, FERC 2105

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Upper North Fork Feather River Project
FERC No. 2105

Water Quality of Late Summer Releases from Canyon Dam

July-November 2001

Prepared by
Technical and Ecological Services

March 2002

Report No.: 026.11-02.15

Pacific Gas and Electric Company
Technical and Ecological Services
3400 Crow Canyon Road, San Ramon, California 94583

Prepared by:

Elizabeth A. Frantz

Elizabeth A. Frantz
Environmental Technical Specialist

Approved by:

Scott Tu

Scott Tu
Senior Environmental Engineer

Korbin D. Creek

Korbin D. Creek
Supervisor, Land and Water Quality Unit

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1 OBJECTIVES AND SCOPE

To supplement available water quality data and verify assumptions on water resource dynamics in the upper North Fork Feather River (NFFR) Project area, Pacific Gas and Electric Company (the Licensee) developed a special study entitled, "Water Quality of Late Summer Releases from Canyon Dam," following a concern raised by the resource agencies in a field reconnaissance during October 2000. The objectives and scope of this special study, as per collaborative discussions with the resource agencies, are outlined below.

- Quantify how water quality conditions change in time for the epilimnion and hypolimnion of Lake Almanor.
- Quantify water quality and chemical conditions of the Upper NFFR when releases are made from the low-level outlet (existing operation) and those from the upper-level outlet under a 35 cfs release.
- Quantify water quality and chemical conditions of the Upper NFFR and Lake Almanor when releases are made from the low-level outlet at a higher release (200 cfs).
- Determine the spatial extent of water quality impacts associated with the late summer releases from Canyon Dam by different flow releases.
- Provide information for making future resource management decisions.

2 INTRODUCTION

The Upper North Fork Feather River Project (Project) is located on the NFFR watershed in northeastern California in Plumas County approximately 90 miles northeast of Oroville, California. The Project encompasses approximately 30 river-miles of the upper NFFR (Figure 1). The Project is currently operated by the Licensee under Federal Energy Regulatory Commission (FERC) License 2105.

Description of the Watershed

The Project is the first in a chain of major hydroelectric generation projects that develop the power resources for the NFFR and its tributaries. The Project includes Lake Almanor, Butt Valley Reservoir and Butt Valley, Caribou No. 1, Caribou No. 2, Oak Flat and Belden Powerhouses (Figure 2) (Pacific Gas and Electric Company 2000). The unlicensed Hamilton Branch Project is located upstream of Lake Almanor and includes a small powerhouse on the eastern shore of Lake Almanor that uses water taken from Mountain Meadows Reservoir. Downstream of the Project are the Rock Creek, Cresta, and Poe powerhouses owned by Licensee, and the Oroville Project (FERC No. 2100) owned by the State of California Department of Water Resources (DWR). Delivering water to the NFFR downstream of Licensee's Rock Creek Dam is the Licensee's Bucks Creek Powerhouse. Lake Almanor and Lake Oroville are the two largest reservoirs in the watershed

Lake Almanor and its Tributaries

The primary storage reservoir for the Project is Lake Almanor. Lake Almanor was created in various phases between 1913 and 1927 with the construction of a hydraulic fill dam referred to as Canyon Dam. Lake Almanor has a normal maximum water surface elevation of 4,494 ft (Pacific Gas and Electric Company datum, for United States Geological Survey (USGS) datum add 10.2 feet) and a storage capacity of 1,142,000 acre-feet. The Licensee received authorization to maintain Lake Almanor surface elevation at 4,494 feet in 1976 (previously was kept at 4,490 feet). The average residence time in Lake Almanor is estimated to be 291 days (Pacific Gas and Electric Company 2000).

Major tributaries to the lake are the NFFR at the city of Chester with an average flow of approximately 355 cfs (which provides approximately half the annual inflow to the lake), the Hamilton Branch with an average flow of 190 cfs (which provides 20 to 25 percent of the annual inflow), and a number of minor tributaries including Benner, Last Chance, and Bailey creeks (Figure 2). Various submerged springs also contribute inflow to Lake Almanor. Major lake outlets include the Canyon Dam intake which releases water to the NFFR downstream of Lake Almanor at a flow of 35 cfs (69 acre-feet per day which is required by Article 26 of FERC License No. 2105 to provide for sustenance of fish life in the NFFR), and the Prattville intake that diverts water to Butt Valley Reservoir through Butt Valley Powerhouse (which represents the greatest portion of water released from Lake Almanor, 2,200 cfs or 4,356 acre-feet per day).

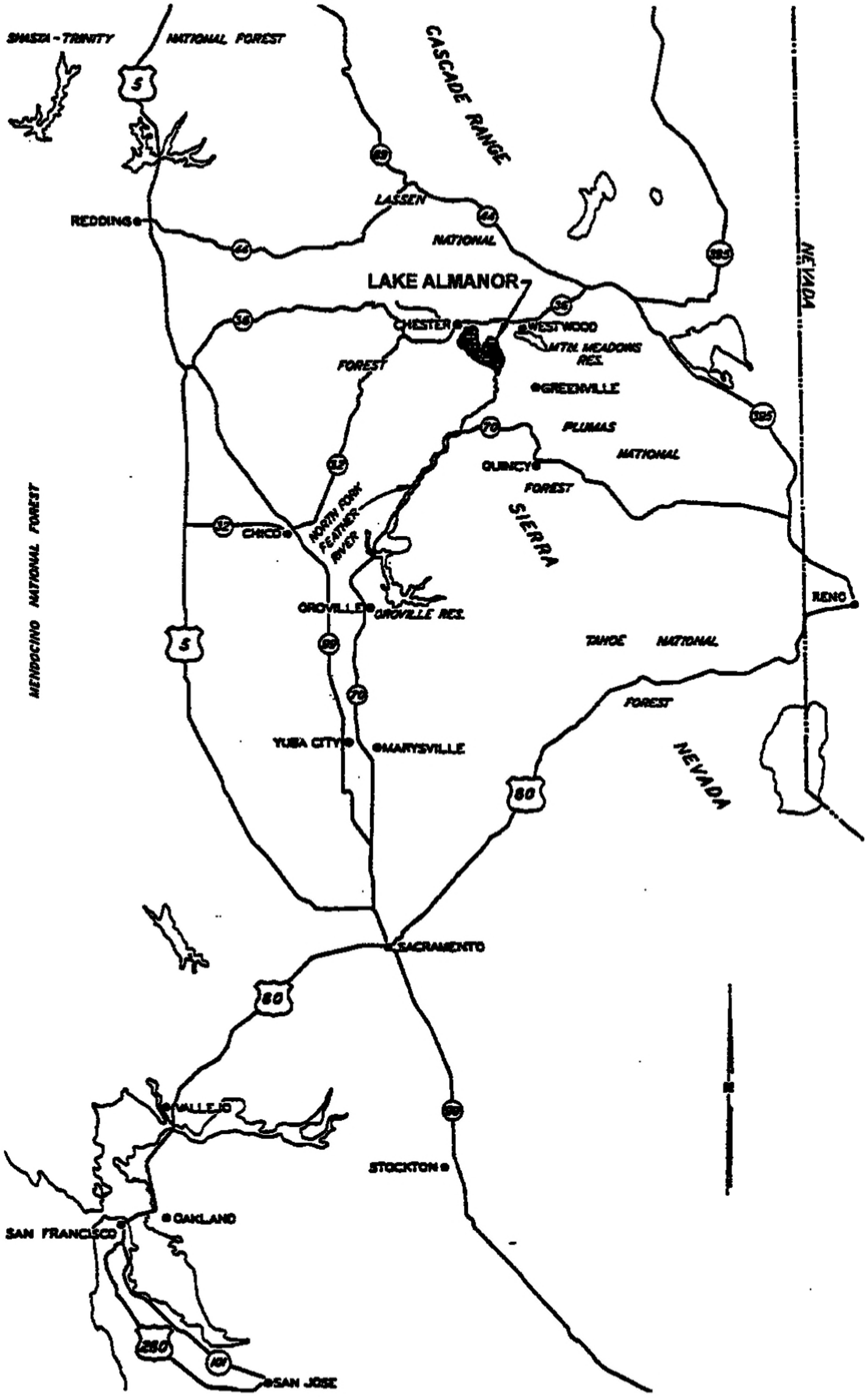


Figure 1. Location of Lake Almanor and the Feather River in California.

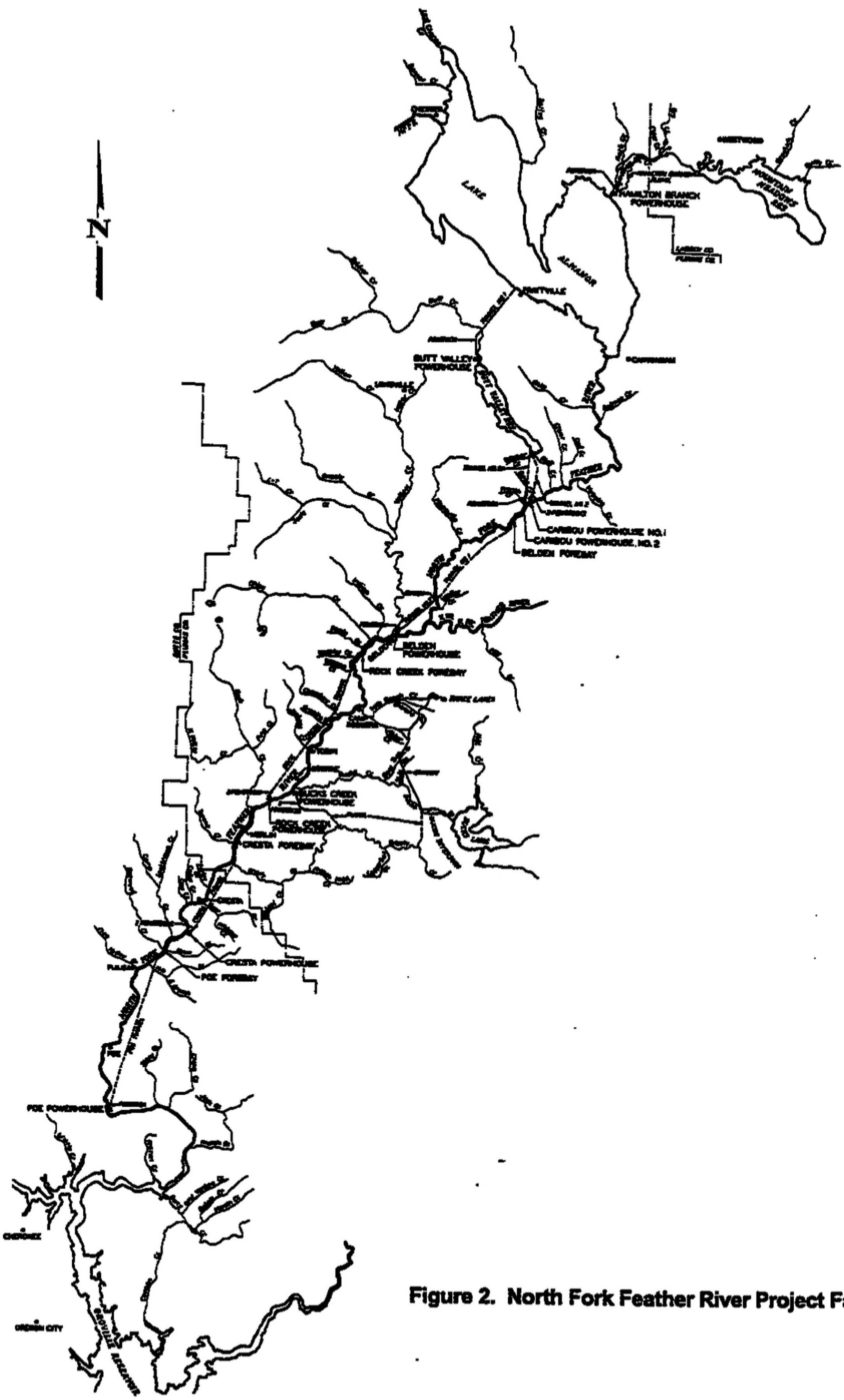


Figure 2. North Fork Feather River Project Facilities

3 HISTORICAL WATER QUALITY

Water quality monitoring programs have been conducted in the NFFR drainage by various agencies (DWR, California Department of Fish and Game [CDFG], U. S. Environmental Protection Agency [US EPA] STORET database, and Pacific Gas and Electric Company published data) over an extended period. The majority of water quality data associated with the Project is derived from past licensing and compliance monitoring efforts conducted in conjunction with Licensee's downstream hydroelectric projects. These monitoring programs include: 1980-82 Water Quality Impacts of Cold Water Releases on the Upper NFFR (Pacific Gas and Electric Company 1982 and 1984) in Appendix A, 1985-86 Rock Creek-Cresta cold Water Feasibility Study (Pacific Gas and Electric Company 1986a, 1986b and 1987), and 1981-85 Rock Creek-Cresta Project Fisheries Management Study (CDFG 1988). Appendix B presents EPA historical profile data collected near the intake tower of Lake Almanor during 1977 and 1978 (US EPA STORET database website; http://www.usepa.gov/storet/).
In addition to the studies conducted as part of the Licensee's NFFR system, the DWR is currently conducting an extensive water quality monitoring program in Lake Almanor. This is a long-term program intended to monitor trends in the water quality of Lake Almanor. Data from this program (see Appendix C) for the period 1989 to 2001 are available as unpublished data from the DWR (2001).

Results of the cold water feasibility studies indicated that cold water released from the low-level outlet of the intake tower (hypolimnion of Lake Almanor) at Canyon Dam significantly reduced instream temperatures in the NFFR downstream of Canyon Dam during periods of thermal stratification in Lake Almanor. The colder water temperatures were more suitable for optimum trout growth and productivity. Results of the water quality tests during these studies, however, indicate that water quality of the upper NFFR was degraded by the low-level cold water releases from the hypolimnion of Lake Almanor (Pacific Gas and Electric Company 1982 and 1984).

Dissolved oxygen and pH levels were reduced in the hypolimnion of Lake Almanor, and an objectionable odor (hydrogen sulfide/rotten egg odor) was noticeable in the NFFR near Canyon Dam. In addition, discoloration of sediments in the upper NFFR (in late summer and early fall sampling periods) was reported in 1980 and 1981 after cold water releases were made. At that time, the weir known as NF30 (also known as the mineral spring, MS-38), which is located approximately 20 feet to the left of Canyon Dam when you look at the dam from the road, had not been constructed yet (a concrete box enclosing the spring was constructed in 1997 [Geomatrix Consultants 1997]), and large quantities of iron and manganese precipitates were covering the ground in the surrounding area near the existing weir. These releases may have contributed to the iron and manganese precipitates that were observed in the NFFR just below Canyon Dam in the 1980s. After 1997, the concrete box that enclosed the mineral spring effectively contained a majority of the precipitates within the box. There were still some precipitates observed on the ground, but they did not flow into the upper NFFR as they may have done prior to 1997.

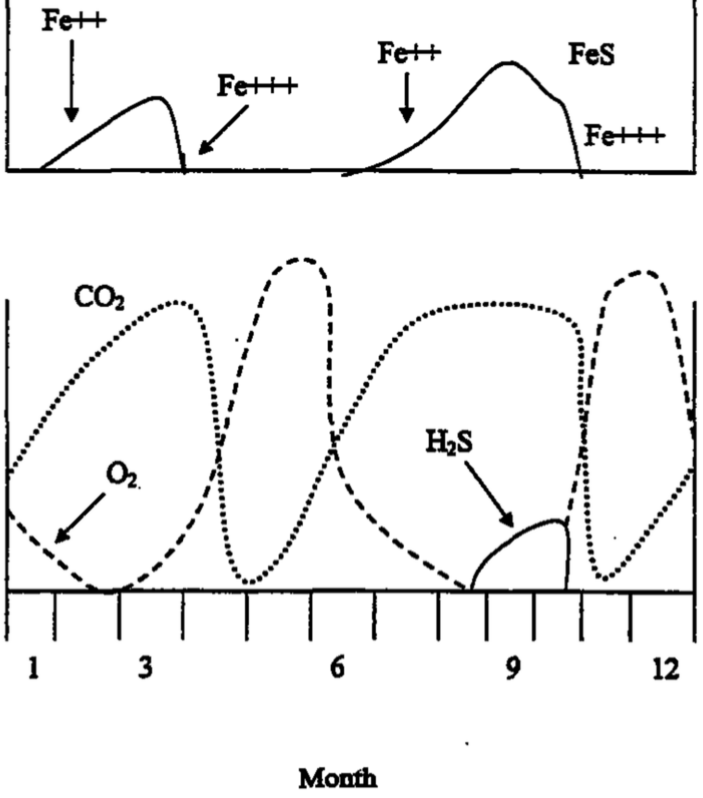
Physical and Chemical Processes That Occur in Lake Almanor

Historical data indicate that Lake Almanor exhibits thermal stratification associated with deep semi-productive lakes (see Appendix C for historical temperature and dissolved oxygen profiles for Lake Almanor [DWR 2001]). These data also indicate that with the onset of thermal stratification in the lake, the hypolimnion will become anoxic (devoid of dissolved oxygen) due to natural processes occurring within the lake (decomposition of organic material). As production in the upper layers of the lake (the epilimnion) increases through the summer, the amount of organic material that rains down to the hypolimnion will increase. Dissolved oxygen consumed by the decomposition of this organic material was not being replenished in the hypolimnion due to existence of the thermocline that prevents mixing of the oxygen-rich epilimnion and the oxygen-poor hypolimnion. As a result of the reduced conditions in the hypolimnion, certain transition metals (iron and manganese), which have been locked in the sediments as insoluble complexes (oxides and hydroxides) in the presence of oxygen, will go back into solution in their reduced and soluble states.

Iron and manganese concentrations will continue to increase through the summer in the hypolimnion as long as oxygen is not present and the pH is less than approximately 7.5 units (Cole 1975). Sulfate is reduced to sulfide under these conditions in the hypolimnion as well. Figure 3 shows a schematic representation of the processes that occur in the anoxic and reduced zone of the hypolimnion of a dimictic, eutrophic lake. There is a slight lag between the time when the oxygen concentrations in the hypolimnion reach levels less than 1 mg/L and when the concentrations of the reduced metals (iron and manganese) begin to increase along with the increase in sulfide concentrations. The concentrations of these constituents in the hypolimnion tend to reach a maximum late in the summer or early fall (during late September and early October).

The onset of winter storms will force these processes to reverse. The cooler air temperatures and the windy conditions will force the dissolution of the thermocline. The lake will become isothermal (i.e., completely uniform in temperature and fully mixed). Dissolved oxygen concentrations will increase in the hypolimnion with the reintroduction of oxygen into the deeper layers of the lake. In the presence of oxygen, iron and manganese will form insoluble iron and manganese oxides and hydroxides that will precipitate out of solution and settle in the sediments. Sulfide will be oxidized back into sulfate. This process is referred to as lake overturn. Historical data collected from Lake Almanor indicate that these processes are occurring seasonally in the lake (Figures 4 and 5 and Appendix C).

Figure 3. Schematic Presentation of Events due to Anoxic and Reduced Conditions in the Hypolimnion of Dimictic and Eutrophic Lake



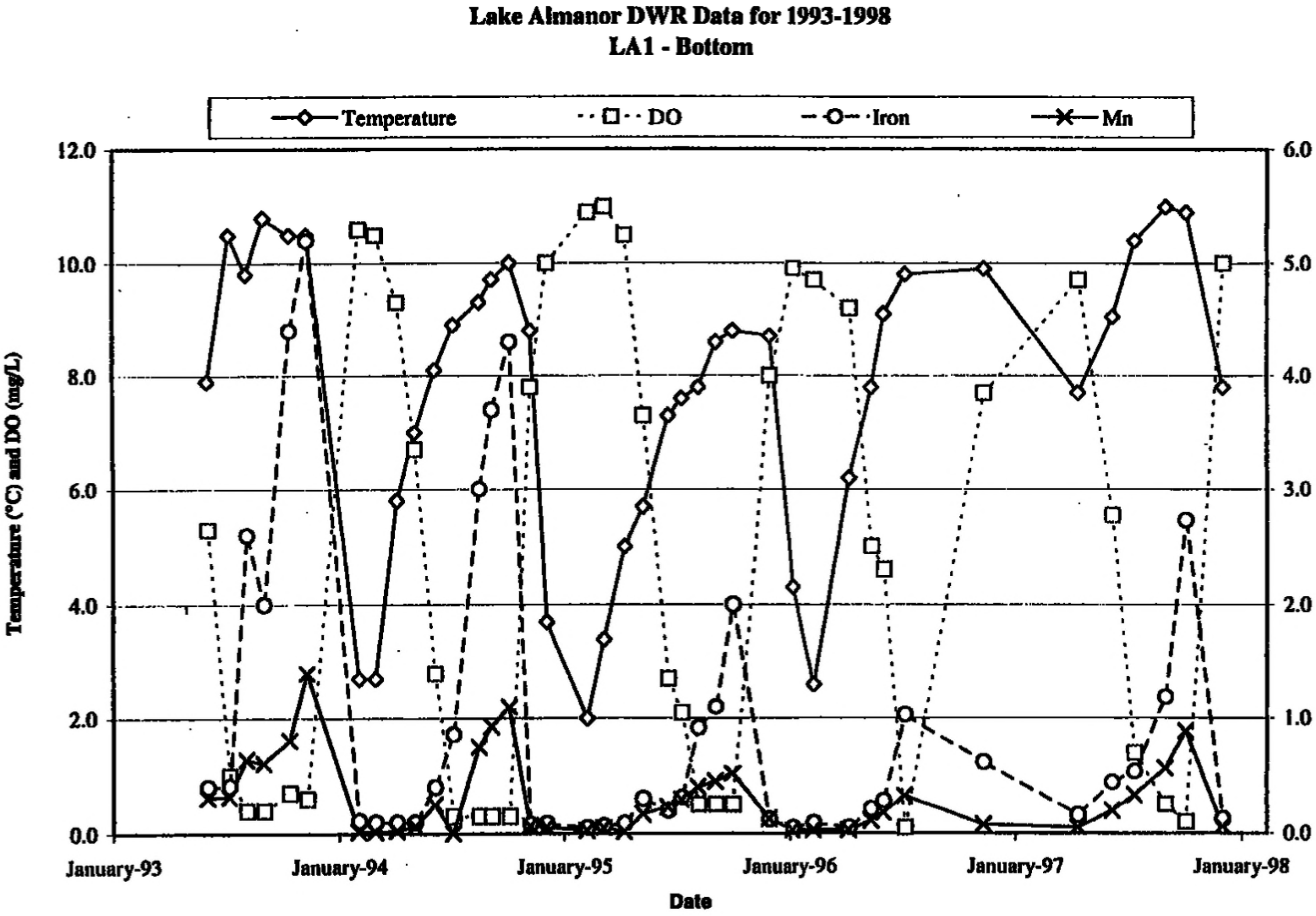


Figure 4. Trends for Temperature, Dissolved Oxygen, Sulfide, Iron, and Manganese in the Hypolimnion of Lake Almanor during 1993 through 1998 (DWR 2001).

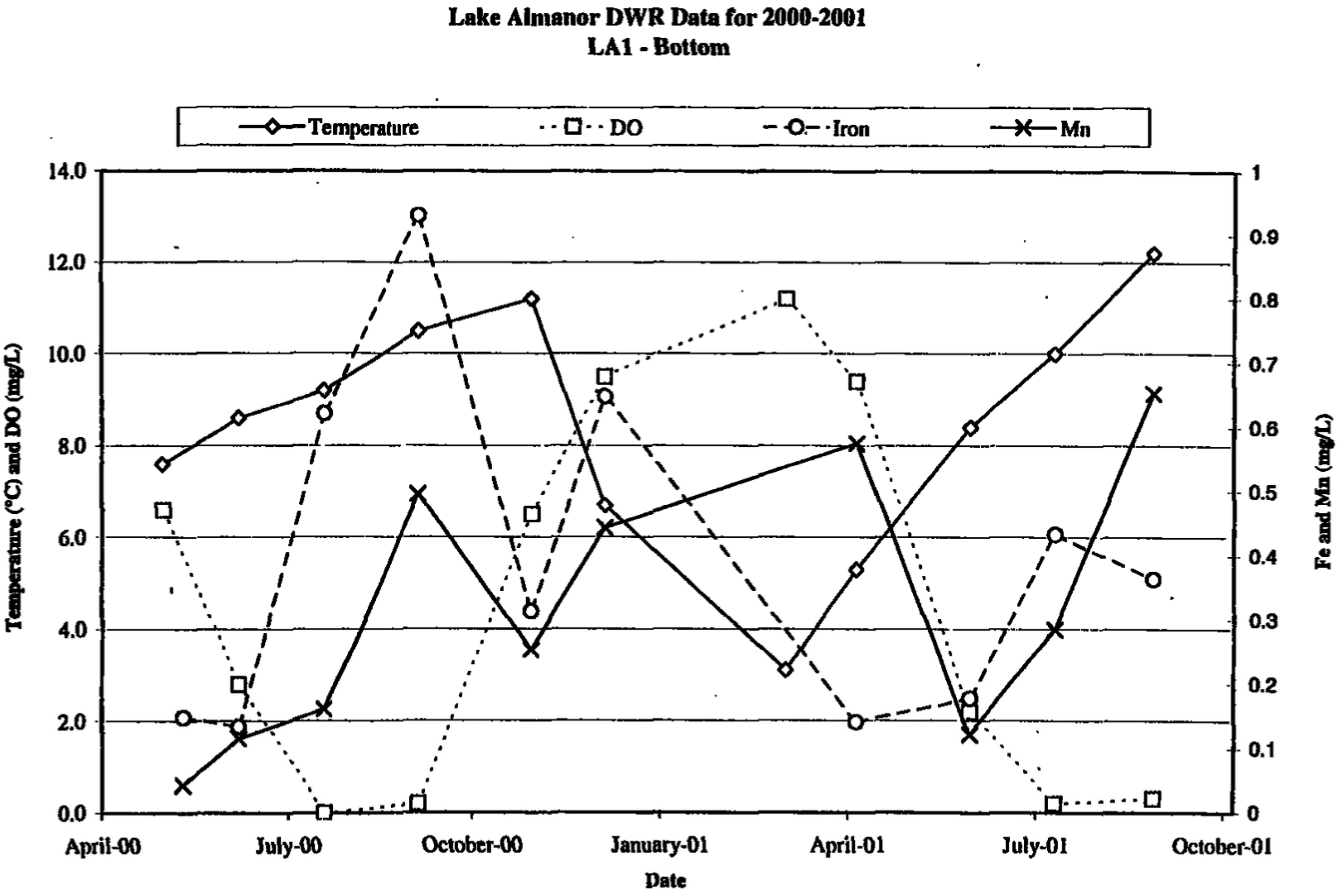


Figure 5 Trends for Temperature, Dissolved Oxygen, Sulfide, Iron, and Manganese in the Hypolimnion of Lake Almanor during 2000 and 2001 (DWR 2001).

4 PROJECT BACKGROUND

Sampling Approach

Samples were collected once during July, August, and September, three times in October, and once during November. During July, August, and September, anaerobic conditions were developing in the hypolimnion of Lake Almanor with the onset of thermal stratification. These sampling efforts were used to document the effects on water quality at downstream stations of the upper NFFR as Lake Almanor became more stratified. During this phase of the study, all water releases were made from the lower gate of the intake tower at a flow of 35 cfs.

The first sampling effort in October was used to determine baseline conditions in both Lake Almanor and the upper NFFR when an odor was present. The second sampling effort in October was used to determine the effects on water quality at downstream stations in the upper NFFR when water was released from the upper gate of the intake tower (gate invert of 4,467 feet [Pacific Gas and Electric Company datum]), which withdrew water from the epilimnion of the lake. The third sampling event in October was used to determine the effects on water quality at downstream stations in the upper NFFR when releases were made from the lower gate of the intake tower at a higher flow release, 200 cfs. Lake Almanor was still stratified during this phase of the study and reduced conditions were still present in the hypolimnion of the lake.

A final sampling effort in November was conducted in order to verify the thermal and chemical changes that would occur with the overturn of the lake, and the effects these changes would have on downstream stations of the upper NFFR when releases were made from the lower gate of the intake tower at a flow of 35 cfs.

Station Locations

Eight water quality sampling locations were used to determine water quality in the upper NFFR and in Lake Almanor during the study (Figure 6 and Table 1). Two of the stations were located in Lake Almanor near the intake tower at depths of 1 meter (within the epilimnion) and approximately 20 meters (within the hypolimnion). Six stations were located on the upper NFFR below Canyon Dam. Station NF2-38 was located at the outlet structure of Canyon Dam; MS-38 was the mineral spring, also known as weir NF30, located east of Canyon Dam; station NF2A-38 was located approximately 0.25 river miles downstream of Canyon Dam near the gaging station; station SF-38 was located approximately 1.4 river miles downstream of Canyon Dam near Skinner Flat; station NF3-38 was located approximately 4.9 river miles downstream of Canyon Dam near the Seneca Bridge; and station NF4-38 was located approximately 10 river miles downstream of Canyon Dam near the gaging station above Caribou Powerhouse. Precipitate and algae scrapings were also collected from stations on the upper NFFR and the mineral spring whenever red/orange precipitates were visible.

Four sediment samples were also collected from Lake Almanor during one month (August) of the study. These stations were located at the intake tower (S1-38), approximately 1.4 miles above the intake tower in the east lobe (S2-38), approximately 4.0 miles above the intake tower in the east lobe (S3-38), and approximately 4.3 miles above Prattville intake in the western lobe of Lake Almanor (S4-38).

Monitoring Parameters

Several general physical and chemical water quality indicators were monitored at each station. Table 2 presents a list of the parameters and rationale for their selection. This study concentrated on the factors related to the possible degradation of upper NFFR waters due to releases of hypolimnetic waters from Lake Almanor. Temperature, pH, dissolved oxygen (DO), and turbidity measurements were collected *in situ* with a HydroLab DataSonde ® (3 or 4a) water analyzer. The HydroLab was calibrated in the laboratory before each use. All other monitoring parameters were measured by Basic Laboratory in Redding, California. A stainless steel Ekman ® dredge and a plastic Van dorn ® bottle sampler were used to collect analytical laboratory sediment and water samples, respectively from the lake. Dissolved and total silver concentrations were also measured in the water quality samples, precipitate/algae scrapings, and in the lake sediment samples in order to determine the effects of cloud seeding within the study area. Results of the silver measurements and cloud seeding procedures are discussed and presented in the Exhibit E of the Draft Application Report, FERC 2105. Samples collected for chemical analyses were preserved and analyzed according to the methods listed in Table 2.

Figure 6. Sampling Station Locations in Lake Almanor and the Upper North Fork Feather River

Table 1. Lake Almanor and NFFR Sampling Station Locations

Station Name	Latitude	Longitude	Depth	Type of Sample
LA1-U-38	40° 10.618N	121° 5.289W	3 feet	Lake Water
LA1-L-38	40° 10.618N	121° 5.289W	65-70 feet	Lake Water
NF2A-38	40° 10.151N	121° 5.557W	1.5 feet	NFFR Water
MS-38	40° 10.360N	121° 5.457W	1.5 feet	Mineral Spring
NF2-38	40° 10.346N	121° 5.467W	1.5 feet	NFFR Water
SF-38	40° 9.323N	121° 5.651W	1.5 feet	NFFR Water
NF3-38	40° 7.012N	121° 5.030W	1.5 feet	NFFR Water
NF4-38	40° 8.806N	121° 5.124W	1.5 feet	NFFR Water
S1-38	40° 10.595N	121° 05.308W	73 feet	Lake Sediment
S2-38	40° 11.857N	121° 05.512W	81 feet	Lake Sediment
S3-38	40° 13.999N	121° 06.260W	47 feet	Lake Sediment
S4-38	40° 16.267N	121° 11.193W	23 feet	Lake Sediment

Table 2

Monitoring Parameters Included in the Late Summer Release from Canyon Dam Investigation

Sample Matrix	Monitoring Parameter	Units	Reporting Limit	Method of Measurement	Rationale
Water	*In Situ*				
	Temperature	°C	0.1	Hydrolab [1]	Thermal stratification in lakes during summer months is responsible for the development of anaerobic conditions in the hypolimnion. Temperature also has a significant impact on the well being of aquatic life.
	pH	units	0.1	Hydrolab [1]	pH changes can adversely affect fish and plant life. pH changes can also affect the dissolution of metals in the water column in conjunction with varying dissolved oxygen concentrations.
	Dissolved Oxygen	mg/L	0.1	Hydrolab [1]	Dissolved Oxygen (DO) concentrations can have a strong impact on aquatic life. Low DO concentrations are associated with the bottom waters (hypolimnion) of thermally stratified reservoirs.
	Turbidity	NTU	0.2	Hydrolab [1]	High turbidity is undesirable from a domestic users standpoint. Increased turbidity levels may indicate increased production in lakes. Increased turbidity in downstream river stations may indicate degraded water quality due to precipitation of dissolved metals released from the hypolimnetic waters.

Table 2 (Continued)

Sample Matrix	Monitoring Parameter	Units	Reporting Limit	Method of Measurement	Rationale
Water	*Certified Laboratory*[2]				
	Color	units	5	US EPA 2120	Increased color may be an indication of water quality deterioration.
	Threshold Odor	T. O. N.	2	US EPA 2150	Increased odor may be an indication of water quality deterioration. Sulfide has a "rotten egg" odor. Sulfate is reduced to sulfide under low DO concentrations in hypolimnetic waters.
	Dissolved Iron	µg/L	50	US EPA 6010A	Under anaerobic conditions such as those caused by thermal stratification, ferrous iron (Fe II) will go into solution from the sediments.
	Dissolved Manganese	µg/L	1	US EPA 6010A	Under anaerobic conditions such as those caused by thermal stratification, manganese will go into solution from the sediments in its soluble and reduced form (Mn II).
	Dissolved Silver	µg/L	1	US EPA 6010A	Cloud seeding practices have occurred in the project area. Silver is a product of this practice and elevated levels may be detrimental to aquatic life.
	Ammonia Nitrogen	mg/L	0.05	US EPA 4500 NH3	Thermal stratification can affect the nitrogen cycle in reservoirs and in downstream waters. As the hypolimnion becomes de-oxygenated, the water becomes denitrified and ammonia is produced.

Table 2 (Continued)

Sample Matrix	Monitoring Parameter	Units	Reporting Limit	Method of Measurement	Rationale
Water	*Certified Laboratory*[2]				
	Total Suspended Solids	mg/L	2	US EPA 2540 D	High total suspended solids (TSS) can be detrimental to aquatic life. Some types of releases can cause an increase in TSS or turbidity below the dam.
	Total Dissolved Solids	mg/L	2	US EPA 2540	High total dissolved solids (TDS) is undesirable for irrigation. TDS may increase in a reservoir as a result of evaporation and long detention time.
	Total Organic Carbon	mg/L	1	US EPA 5310	Total organic carbon (TOC) is useful in assessing the potential oxygen-demanding load of organic material on a receiving stream.
	Sulfide-Low level	μg/L	1.7	US EPA 4500 SE	Hydrogen sulfide is produced in anoxic waters by the reduction of sulfate. Sulfide is a noxious substance and can be toxic to aquatic life and is undesirable from an aesthetic standpoint.
Lake Sediments	*Certified Laboratory*[2]				
	Sulfate	mg/Kg	1.2	US EPA 4500 SO4	Sulfate is reduced to sulfide under anaerobic conditions in the hypolimnion.

Table 2 (Continued)

Sample Matrix	Monitoring Parameter	Units	Reporting Limit	Method of Measurement	Rationale
Lake Sediments	*Certified Laboratory*[2]				
	Sulfide	mg/Kg	1.18	US EPA 4500 S	Hydrogen sulfide is produced in anoxic waters by the reduction of sulfate. Sulfide is a noxious substance and can be toxic to aquatic life and is undesirable from an aesthetic standpoint.
	Total Iron	mg/Kg	10	US EPA 6010A	Total iron was measured in the lake sediments to determine the potential source and magnitude of dissolved iron to the hypolimnetic waters.
	Total Manganese	mg/Kg	1	US EPA 6010A	Total manganese was measured in the lake sediments to determine the potential source and magnitude of dissolved manganese to the hypolimnetic waters.
	Total Silver	mg/Kg	4	US EPA 6010A	Total silver was measured in lake sediments to determine the potential effects of cloud seeding on the lake system.
	Total Organic Carbon	%	0.03	ASA #9 Methods of Soil Analysis PII 29-3.5.2	Total organic carbon was measured as an indicator for productivity in the lake sediments.

Table 2 (Continued)

Sample Matrix	Monitoring Parameter	Units	Reporting Limit	Method of Measurement	Rationale
Precipitate/Algae Scrapings	*Certified Laboratory*[2]				
	Total Iron	mg/Kg	10	US EPA 6010A	Total iron was measured in precipitate and algae scrapings when they were present to determine the iron loading potential of the mineral spring to the river system.
	Total Manganese	mg/Kg	1	US EPA 6010A	Total manganese was measured in precipitate and algae scrapings when they were present to determine the manganese loading potential of the mineral spring to the river system.
	Total Silver	mg/Kg	4	US EPA 6010A	Total silver was measured to determine the potential effects of cloud seeding on the project area.

1 = Hydrolab DataSonde ® (3 or 4a) water analyzer. The HydroLab was calibrated in the laboratory before each use.
2 = Basic Laboratory, 2218 Railroad Ave., Redding, CA 96001 (California D.O.H.S. Cert. # 1677)

5 RESULTS AND DISCUSSION

Table 3 shows *in situ* results for Lake Almanor and the upper NFFR water quality stations for the sampling period July through November 2001. Table 4 shows analytical laboratory results for Lake Almanor and the upper NFFR water quality stations for the sampling period. Table 5 shows analytical laboratory results for the sediment samples collected from Lake Almanor during the August 2001 sampling event.

Lake Almanor

Lake Almanor was thermally stratified during the summer and fall of 2001 (Figure 7). Lake overturn had occurred by the November 2001 sampling event. DO concentrations were near zero (<1 mg/L) in the hypolimnion of Lake Almanor during the summer (Table 3). The thermocline prevented the oxygen rich epilimnion (average DO concentration was 7.8 mg/L) from mixing with the hypolimnion. Summer algae production allowed for organic material to settle at the bottom of the lake. Dissolved oxygen was consumed during the decomposition of this organic material in the hypolimnion.

With the depletion of oxygen in the hypolimnion, transition metals (iron and manganese) dissolved back into the waters overlying the sediments. The concentration of these metals slowly accumulated through summer, reaching a maximum concentration around October 10, 2001 for iron (4,020 µg/L) and October 18, 2001 for manganese (1,980 µg/L) (Figures 8 and 9). Manganese will go into solution earlier than iron during summer stagnation, but will be precipitated later than iron during overturn (Cole 1975). Sulfide started to accumulate in the hypolimnion, reaching a maximum concentration (504 µg/L) during the September 2001 monitoring event (Figure 10). Figure 11 shows the progression of water quality changes that were occurring in the hypolimnion of Lake Almanor during the monitoring program. By late September, early October, iron, manganese and sulfide had accumulated to maximum levels.

Table 3

In situ Field Data Collected from Lake Almanor and the Seneca Reach of the NFFR for the Late Summer Release Investigation

Sample Location	Date	Time	Depth (meters)	Temperature (°C)	Dissolved Oxygen (DO) (mg/L)	DO Saturation (%)	pH (units)	Turbidity (NTU)	Conductivity (µmhos/cm)	Gage Height (feet)
LA1-U-38	7/10/01	---	0.2	23.6	---	---	---	---	---	NA
LA1-U-38	8/8/01	12:05	0.9	23.0	7.2	99	8.5	1	100	NA
LA1-U-38	9/11/01	13:36	1.0	20.8	6.5	82	7.7	1	100	NA
LA1-U-38	10/10/01	13:30	1.0	17.5	6.6	80	7.8	8	111	NA
LA1-U-38	10/17/01 (1)	9:00	1.3	16.1	6.5	78	7.5	<1	110	NA
LA1-U-38	10/18/01 (2)	8:40	1.0	15.8	7.0	82	7.7	4	110	NA
LA1-U-38	11/14/01	12:30	1.1	11.7	6.9	73	7.7	6	100	NA
LA1-L-38	7/10/01	---	22.3	10.3	---	---	---	---	---	NA
LA1-L-38	8/8/01	12:13	19.8	10.7	0.2	2	7.0	4	98	NA
LA1-L-38	9/11/01	13:45	21.0	11.5	0.3	5	7.0	2	104	NA
LA1-L-38	10/10/01	13:20	19.9	11.0	0.4	4	7.1	9	130	NA
LA1-L-38	10/17/01 (1)	8:32	20.8	11.1	0.3	3	6.6	1	132	NA
LA1-L-38	10/18/01 (2)	8:23	21.2	11.0	0.5	5	7.1	7	136	NA
LA1-L-38	11/14/01	10:48	20.4	11.4	4.8	50	7.4	8	104	NA
MS-38	7/10/01	12:36	NA	12.1	1.9	19	7.0	4	242	0.11
MS-38	8/7/01	12:55	NA	11.5	1.3	17	6.9	7	220	0.12
MS-38	9/11/01	11:30	NA	11.0	1.9	19	6.8	<1	216	0.12
MS-38	10/10/01	11:30	NA	10.5	2.0	20	6.8	<1	240	0.1
MS-38	10/17/01 (1)	9:50	NA	10.5	2.1	22	6.8	<1	241	0.11
MS-38	10/18/01 (2)	9:36	NA	10.3	2.4	25	6.9	<1	241	0.11
MS-38	11/14/01	11:34	NA	10.8	2.9	21	6.9	35*	222	0.11

Table 3 (Continued)

Sample Location	Date	Time	Depth (meters)	Temperature (°C)	Dissolved Oxygen (DO) (mg/L)	DO Saturation (%)	pH (units)	Turbidity (NTU)	Conductivity (µmhos/cm)	Gage Height (feet)
Weir NF25	7/10/01	---	---	---	---	---	---	---	---	---
Weir NF25	8/7/01	13:20	NA	12.1	0.7	---	6.9	<1	174	0.25
Weir NF25	9/11/01	11:35	NA	12.0	1.1	12	6.8	<1	179	0.25
Weir NF25	10/10/01	11:34	NA	11.9	2.0	23	6.8	5	205	0.25
Weir NF25	10/17/01	10:18	NA	11.9	0.7	7	6.8	<1	206	0.25
Weir NF25	10/18/01	9:48	NA	11.8	0.7	6	6.8	<1	207	0.25
Weir NF25	11/14/01	11:47	NA	11.8	0.8	7	6.9	7	193	0.24
NF2-38	7/10/01	12:55	NA	13.3	8.2	87	7.2	2	147	NA
NF2-38	8/7/01	13:17	NA	13.8	7.9	89	7.3	2	99	NA
NF2-38	9/11/01	11:35	NA	15.1	7.4	99	7.4	8	100	NA
NF2-38	10/10/01	11:43	NA	15.6	7.3	84	7.6	8	116	NA
NF2-38	10/17/01 (1)	10:10	NA	15.8	8.3	97	7.6	<1	113	NA
NF2-38	10/18/01 (2)	9:53	NA	15.8	8.6	100	7.8	10	111	NA
NF2-38	11/14/01	11:51	NA	11.6	9.4	100	7.6	5	106	NA
NF2A-38	7/10/01	12:02	NA	14.0	9.5	102	7.8	2	118	NA
NF2A-38	8/7/01	12:10	NA	14.3	7.4	86	7.5	3	100	NA
NF2A-38	9/11/01	10:55	NA	14.9	7.6	90	7.5	4	103	NA
NF2A-38	10/10/01	10:45	NA	15.6	8.1	95	7.7	7	117	NA
NF2A-38	10/17/01 (1)	10:48	NA	15.8	8.4	98	7.7	7	115	NA
NF2A-38	10/18/01 (2)	10:20	NA	15.7	8.6	100	7.8	9	112	NA
NF2A-38	11/14/01	10:45	NA	11.6	9.6	101	7.9	8	105	NA

Table 3 (Continued)

Sample Location	Date	Time	Depth (meters)	Temperature (°C)	Dissolved Oxygen (DO) (mg/L)	DO Saturation (%)	pH (units)	Turbidity (NTU)	Conductivity (µmhos/cm)	Gage Height (feet)
SF-38	7/10/01	11:20	NA	14.9	10.3	114	8.4	1	118	NA
SF-38	8/7/01	11:22	NA	15.0	7.9	92	8.5	2	108	NA
SF-38	9/11/01	10:00	NA	14.0	8.4	95	8.1	<1	110	NA
SF-38	10/10/01	10:00	NA	13.4	8.6	96	8.0	<1	124	NA
SF-38	10/17/01 (1)	11:23	NA	14.7	9.1	104	8.2	<1	124	NA
SF-38	10/18/01 (2)	10:56	NA	15.5	9.1	105	8.0	7	113	NA
SF-38	11/14/01	9:50	NA	11.1	10.4	108	8.2	5	112	NA
NF3-38	7/10/01	10:21	NA	14.1	11.0	119	8.2	1	118	NA
NF3-38	8/7/01	10:30	NA	14.3	8.6	94	8.2	1	121	NA
NF3-38	9/11/01	9:06	NA	13.5	9.3	101	8.1	<1	122	NA
NF3-38	10/10/01	9:15	NA	10.9	9.3	96	7.6	1	136	NA
NF3-38	10/17/01 (1)	12:05	NA	12.9	9.7	104	8.2	<1	136	NA
NF3-38	10/18/01 (2)	11:41	NA	14.6	9.7	106	8.1	28	117	NA
NF3-38	11/14/01	9:05	NA	10.0	10.6	106	8.1	3	124	NA
NF4-38	7/10/01	8:53	NA	14.4	8.6	93	8.3	1	---	NA
NF4-38	8/7/01	8:55	NA	14.0	7.8	84	8.1	1	159	NA
NF4-38	9/11/01	8:00	NA	13.2	8.3	88	8.1	<1	158	NA
NF4-38	10/10/01	8:16	NA	9.9	10.1	95	7.8	<1	177	NA
NF4-38	10/17/01 (1)	13:07	NA	12.3	9.5	96	8.2	<1	178	NA
NF4-38	10/18/01 (2)	12:45	NA	12.5	10.1	104	8.1	60	141	NA
NF4-38	11/14/01	7:55	NA	9.7	10.4	101	8.0	1	166	NA

--- = Not Reported during this sampling event.
NA = Not applicable to this station.
(1) = Special test (Upper gate used with flow of 35 cfs).
(2) = Special test (Lower gate used with flow of 200 cfs).
* = Turbidity is usually lower, appears to be due to lots of particulate algae in the containment.

Table 4

Analytical Laboratory Results for Lake Almanor and the Seneca Reach of the NFFR for the Late Summer Release Investigation

Station	Date	Color (units)	Odor (T.O.N.)	Sulfide (µg/L)	TDS (mg/L)	TSS (mg/L)	TOC (mg/L)	NH3 (mg/L)	Diss-Fe (µg/L)	Diss-Mn (µg/L)	Diss-Ag (µg/L)	Total-Mn (mg/KgW)	Total-Fe (mg/KgW)	Total-Ag (mg/KgW)	% Solids (%)
LA1-U-38	7/10/01	<5	<2	<2.6	58	3	2.8	0.13	<50	3	---	---	---	---	---
LA1-U-38	8/8/01	<5	<2	<1.7	67	<3	2.3	<0.05	<50	1	<1	---	---	---	---
LA1-U-38	9/11/01	5	<2	3.3	81	<2	2.0	<0.05	<50	<1	<1	---	---	---	---
LA1-U-38	10/10/01	5	<2	1.8	63	<2	2.2	<0.05	<50	4	<1	---	---	---	---
LA1-U-38	10/17/01 (1)	5	2	2.3	54	<2	2.5	<0.05	<50	2	<1	---	---	---	---
LA1-U-38	10/18/01 (2)	10	4	<1.7	71	5	1.8	<0.05	<50	4	<1	---	---	---	---
LA1-U-38	11/14/01	15	<2	1.7	57	4	1.6	0.08	<50	6	<1	---	---	---	---
LA1-L-38	7/10/01	10	<2	<2.6	50	4	1.7	0.38	131	217	---	---	---	---	---
LA1-L-38	8/8/01	15	<2	<1.7	63	54	1.2	<0.05	<50	184	<1	---	---	---	---
LA1-L-38	9/11/01	25	<2	504	74	7	2.8	0.12	1,990	841	<1	---	---	---	---
LA1-L-38	10/10/01	100	4	221	64	12	2.8	0.56	4,020	1,160	<1	---	---	---	---
LA1-L-38	10/17/01 (1)	40	2	265	59	21	3.1	0.39	3,840	1,610	<1	---	---	---	---
LA1-L-38	10/18/01 (2)	60	2	186	70	8	1.6	0.22	2,120	1,980	<1	---	---	---	---
LA1-L-38	11/14/01	15	<2	3.1	67	4	1.4	0.10	55	8	<1	---	---	---	---
MS-38	7/10/01	20	<2	10.2	112	7	<1.0	0.4	3,860	2,900	---	349 *	7,370 *	<4.0*	1.7
MS-38	8/8/01	30	<2	8.1	123	11	1.0	<0.05	3,700	3,230	<1	419 *	11,300 *	<4.0*	---
MS-38	9/11/01	10	<2	2.0	132	7	1.2	<0.05	3,280	2,820	<1	1,410*	20,100*	<4.0*	---
MS-38	10/10/01	50	<2	5.9	123	8	1.0	0.08	3,400	2,950	<1	687*	11,700*	<4.0*	---
MS-38	10/17/01 (1)	60	<2	11.9	116	4	1.9	0.07	3,500	3,020	<1	3,210*	25,600*	<4.0*	6
MS-38	10/18/01 (2)	30	<2	6.3	137	5	<1.0	0.06	3,600	3,090	<1	6,210*	30,800*	<4.0*	8.1
MS-38	11/14/01	15	<2	12.0	75	7	<1.0	0.10	3,560	3,070	<1	3,600*	28,700*	<4.0*	5.1

Table 4 (Continued)

Station	Date	Color (units)	Odor (T.O.N.)	Sulfide (μg/L)	TDS (mg/L)	TSS (mg/L)	TOC (mg/L)	NH3 (mg/L)	Diss-Fe (μg/L)	Diss-Mn (μg/L)	Diss-Ag (μg/L)	Total-Mn (mg/KgW)	Total-Fe (mg/KgW)	Total-Ag (mg/KgW)	% Solids (%)
NF2-38	7/10/01	10	<2	<2.6	60	<3	1.4	0.24	<50	28	---	---	---	---	---
NF2-38	8/8/01	20	<2	<1.7	62	5	1.4	<0.05	<50	36	<1	---	---	---	---
NF2-38	9/11/01	5	<2	<1.7	64	5	1.9	<0.05	122	755	<1	---	---	---	---
NF2-38	10/10/01	25	4	8.6	61	<2	2.1	<0.05	273	524	<1	---	---	---	---
NF2-38	10/17/01 (1)	10	<2	1.7	64	<2	3.5	<0.05	<50	7	<1	---	---	---	---
NF2-38	10/18/01 (2)	10	<2	<1.7	74	<2	1.3	<0.05	<50	8	<1	---	---	---	---
NF2-38	11/14/01	15	<2	<1.7	73	<2	1.3	0.16	68	16	<1	---	---	---	---
NF2A-38	7/10/01	5	<2	<2.6	52	<3	1.9	0.15	<50	24	---	---	---	---	---
NF2A-38	8/8/01	15	3	<1.7	59	4	1.8	<0.05	<50	44	3	---	---	---	---
NF2A-38	9/11/01	5	<2	<1.7	70	6	1.6	<0.05	157	663	<1	---	---	---	---
NF2A-38	10/10/01	20	<2	3.4	68	4	2.2	<0.05	198	316	<1	---	---	---	---
NF2A-38	10/17/01 (1)	10	<2	2.0	59	<2	3.0	<0.05	<50	16	<1	---	---	---	---
NF2A-38	10/18/01 (2)	10	<2	<1.7	75	5	1.6	<0.05	<50	23	<1	---	---	---	---
NF2A-38	11/14/01	15	<2	<1.7	73	4	1.2	0.11	57	10	<1	---	---	---	---
SF-38	7/10/01	<5	<2	<2.6	65	<3	1.6	0.16	<50	3	---	---	---	---	---
SF-38	8/8/01	5	<2	<1.7	65	<3	1.1	<0.05	<50	5	<1	---	---	---	---
SF-38	9/11/01	7	<2	<1.7	77	<2	1.4	<0.05	140	57	<1	---	---	---	---
SF-38	10/10/01	15	<2	1.5	79	<2	1.8	<0.05	105	73	<1	---	---	---	---
SF-38	10/17/01 (1)	5	<2	1.7	60	<2	2.5	<0.05	<50	2	<1	---	---	---	---
SF-38	10/18/01 (2)	10	2	<1.7	73	11	1.8	<0.05	<50	14	<1	---	---	---	---
SF-38	11/14/01	5	<2	<1.7	82	<2	<1.0	<0.05	<50	3	<1	---	---	---	---

Table 4 (Continued)

Station	Date	Color (units)	Odor (T.O.N.)	Sulfide (µg/L)	TDS (mg/L)	TSS (mg/L)	TOC (mg/L)	NH3 (mg/L)	Diss-Fe (µg/L)	Diss-Mn (µg/L)	Diss-Ag (µg/L)	Total-Mn (mg/KgW)	Total-Fe (mg/KgW)	Total-Ag (mg/KgW)	% Solids (%)
NF3-38	7/10/01	<5	<2	<2.6	73	<3	<1.0	0.25	<50	<1	---	---	---	---	---
NF3-38	8/8/01	5	<2	<1.7	73	<3	<1.0	<0.05	<50	3	<1	---	---	---	---
NF3-38	9/11/01	<5	<2	<1.7	88	<2	1.4	<0.05	<50	2	<1	---	---	---	---
NF3-38	10/10/01	10	<2	0.7	80	<2	1.4	<0.05	<50	2	<1	---	---	---	---
NF3-38	10/17/01 (1)	5	<2	<1.7	74	<2	2.0	<0.05	<50	2	<1	---	---	---	---
NF3-38	10/18/01 (2)	200	4	<1.7	77	29	2.4	<0.05	<50	12	<1	---	---	---	---
NF3-38	11/14/01	7	<2	<1.7	81	<2	1.0	0.07	<50	2	<1	---	---	---	---
NF4-38	7/10/01	<5	<2	<2.6	97	<3	<1.0	0.18	<50	1	---	---	---	---	---
NF4-38	8/8/01	5	<2	2.8	103	<3	<1.0	<0.05	<50	5	<1	---	---	---	---
NF4-38	9/11/01	<5	<2	<1.7	98	<2	1.4	<0.05	<50	2	<1	---	---	---	---
NF4-38	10/10/01	5	<2	<1.7	122	9	1.4	<0.05	<50	3	<1	---	---	---	---
NF4-38	10/17/01 (1)	5	<2	<1.7	98	<2	2.1	<0.05	<50	3	<1	---	---	---	---
NF4-38	10/18/01 (2)	60	4	<1.7	92	75	3.6	<0.05	<50	9	<1	---	---	---	---
NF4-38	11/14/01	5	<2	<1.7	101	<2	<1.0	<0.05	<50	4	<1	---	---	---	---

Non-detects were reported as less than the reporting limit
--- = Not sampled for this constituent
* = Precipitate sample collected at this station
(1) = Special test, release from upper gate at 35 cfs
(2) = Special test, release from lower gate at 200 cfs

Table 5

Lake Almanor Sediment Sample Analytical Results for the Late Summer Release Investigation

		Station Name			
		S1-38	**S2-38**	**S3-38**	**S4-38**
Date		8/8/01	8/8/01	8/8/01	8/8/01
Time		11:55	11:36	11:10	10:40
Latitude		40° 10.595N	40° 11.857N	40° 13.999N	40° 16.267N
Longitude		121° 05.308W	121° 05.512W	121° 06.260W	121° 11.193W
Lake Depth	(feet)	73.0	80.5	47.0	23.3
Constituent	**Units**				
Total Organic Carbon (TOC)	(mg/Kg-W)	17,000	21,400	12,300	31,500
Sulfate (SO_4^{2-})	(mg/Kg-W)	2.61	7.86	9.63	<1.2
Sulfide	(mg/Kg-W)	4.45	40.2	1.47	2.39
Total Iron	(mg/Kg-W)	8,540	3,320	2,400	2,850
Total Manganese	(mg/Kg-W)	154	70	72.4	79.3
Total Silver	(mg/Kg-W)	<4.0	<4.0	<4.0	<4.0

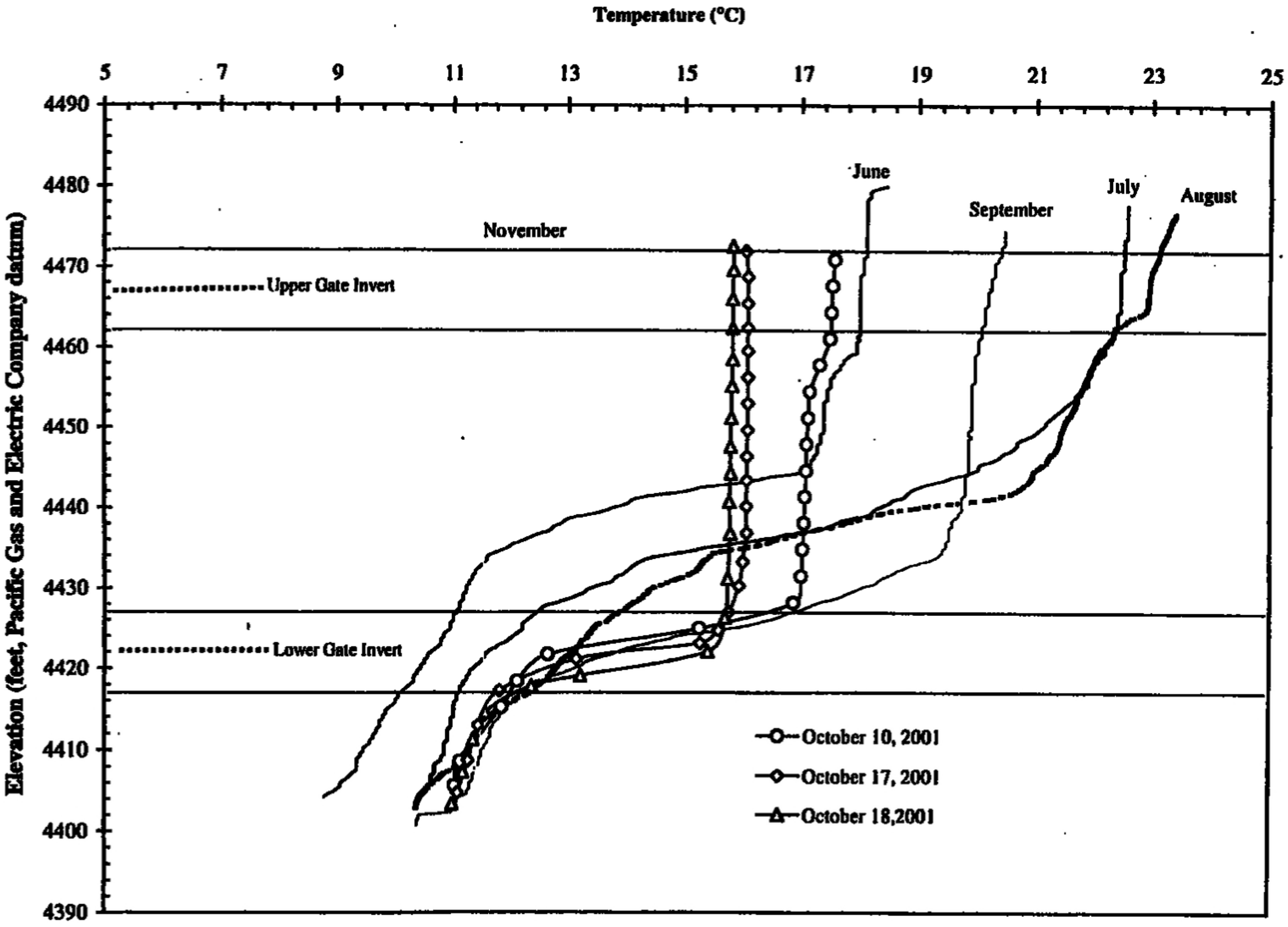


Figure 7. Temperature Profiles in Lake Almanor during the Period July 2001 through November 2001.

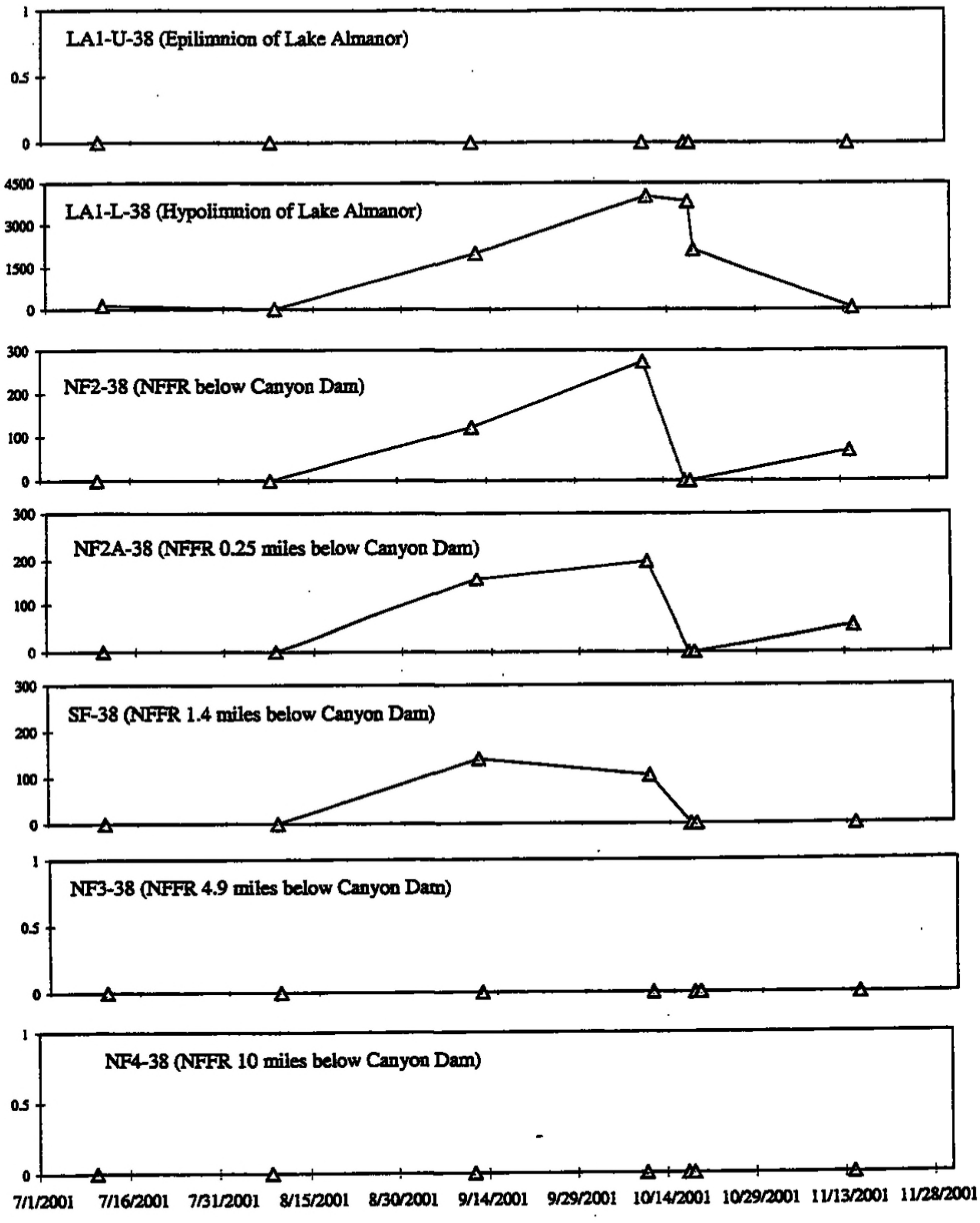


Figure 8. Iron Concentrations Detected in Lake Almanor and the Upper NFFR during the Monitoring Program.

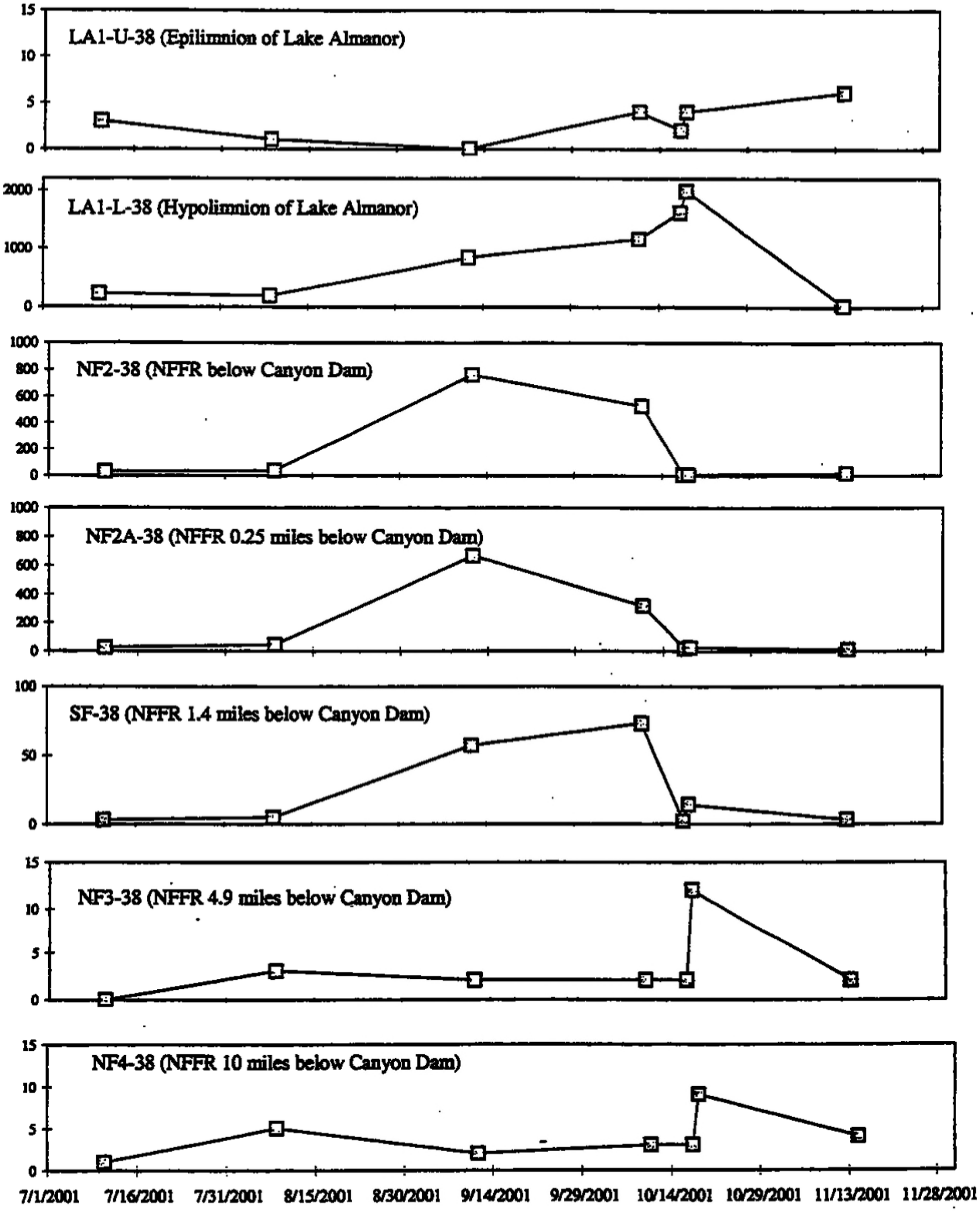


Figure 9. Manganese Concentrations Detected in Lake Almanor and the Upper NFFR during the Monitoring Program.

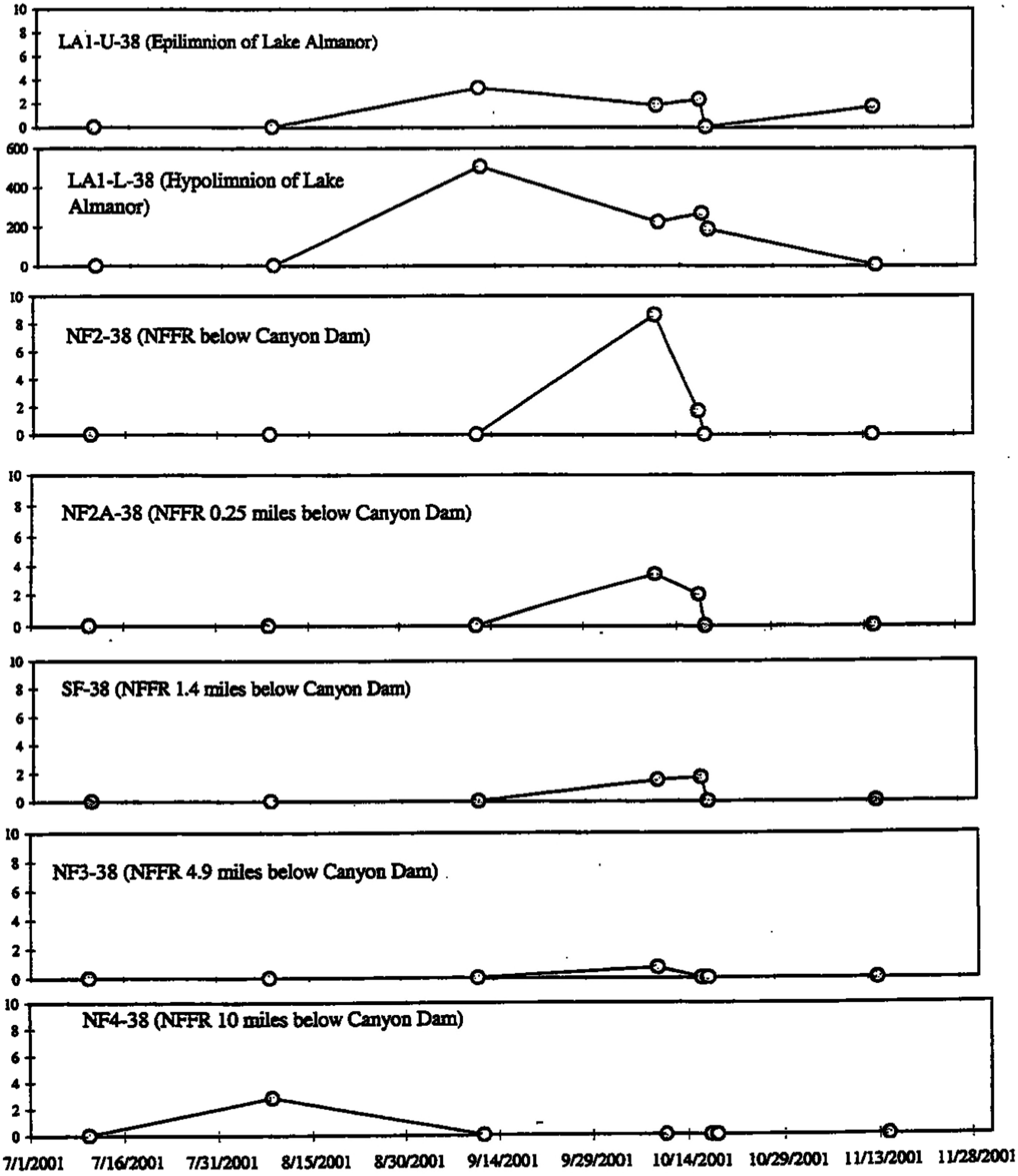


Figure 10. Sulfide Concentrations Detected in Lake Almanor and the Upper NFFR during the Monitoring Program.

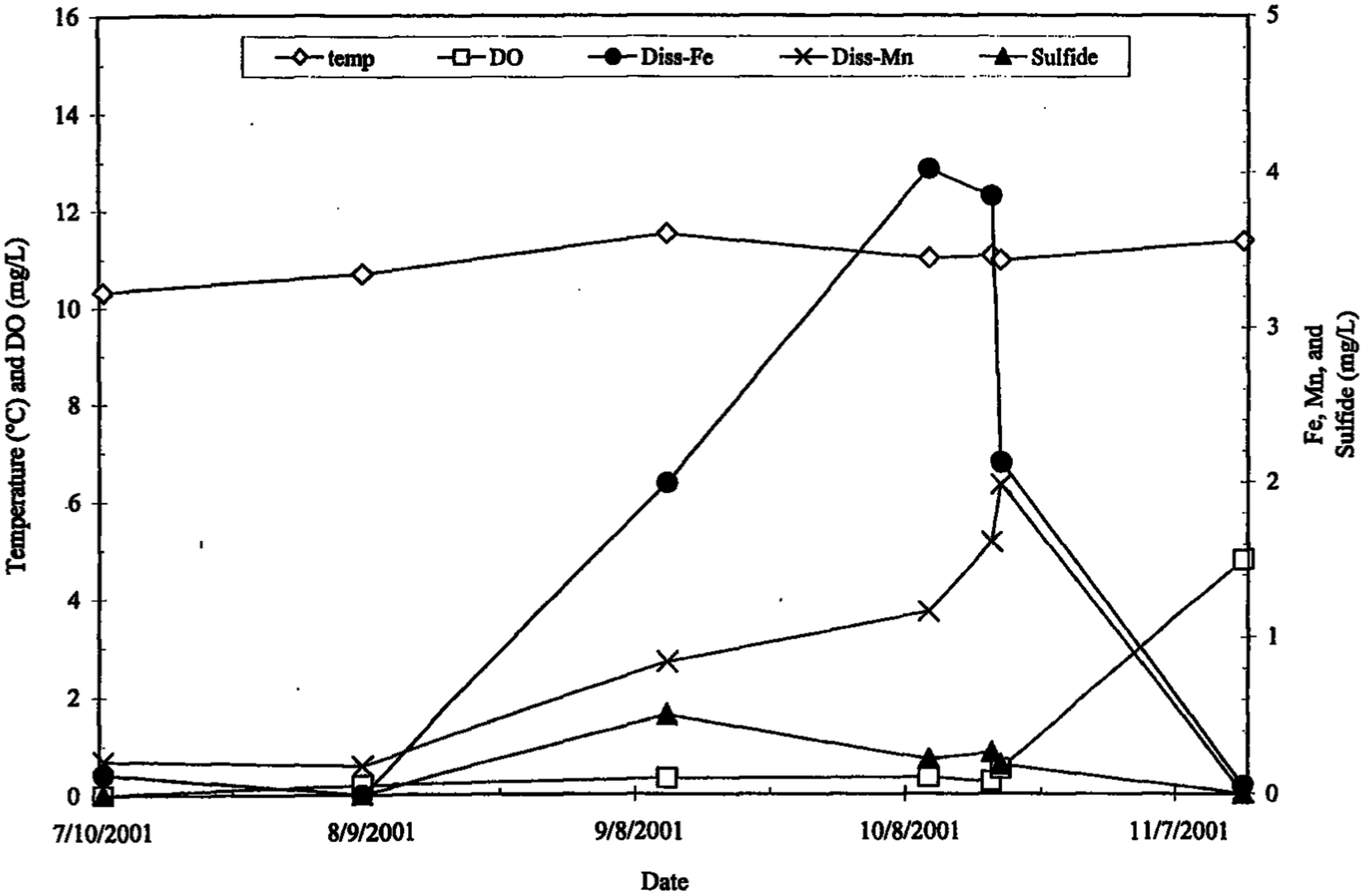


Figure 11. Concentrations of Selected Analytes in the Hypolimnion of Lake Almanor during the Monitoring Program.

Detectable concentrations of dissolved manganese were present in the epilimnion of Lake Almanor during every month except September of the monitoring program. Iron was not detected above the reporting limit (<50 mg/L) in the epilimnion during the monitoring program. A possible explanation for these occurrences is that internal wave action caused by summer gales allowed pockets of the hypolimnetic water to be mixed into the overlying waters, thus allowing manganese to be mixed into the upper layers of the lake (Moss 1980). Manganese tends to precipitate out of solution later than iron when lake overturn occurs. Thus, more manganese compared to iron may be mixed into the epilimnion during this period and more manganese may be lost in lake outflows (Cole 1975). The hypolimnion is not as effective a trap for manganese as it is for iron. The highest concentration of manganese detected in the epilimnion of Lake Almanor was 6 µg/L during the November monitoring event (lake overturn).

As the summer progressed into fall, cooler temperatures and stronger wind conditions forced the upper layers of the lake to mix with the bottom layers, dissipating the thermocline. This process allowed oxygen to penetrate deeper into the lake. Iron and manganese will precipitate out of solution in the presence of oxygen (manganese stays in solution slightly longer than iron). During the November 2001 sampling event, iron, manganese, and sulfide concentrations in the hypolimnion of Lake Almanor were greatly reduced in the presence of oxygen (Figure 11 and Table 4). Oxygen levels had increased up to 4.8 mg/L in the hypolimnion of Lake Almanor as a result of lake overturn (DO levels had previously been <1 mg/L, Table 3).

Sediment samples collected from Lake Almanor in August 2001 showed that at depth in the lake (near the intake tower and approximately 1.47 miles from the intake tower), high concentrations of total iron and manganese were present in the sediments. There was a large reserve for the dissolved metals within the sediments. Sulfide and sulfate were also present at substantial concentrations in the sediments. The levels of these constituents will remain constant within the sediments unless there is significant nutrient input from catchment areas (i.e., increased production in the epilimnion due to external loading) or increased loss through outflow (i.e., through the intake tower and Canyon Dam). Only the surface of the mud (first few centimeters) will be involved in the chemical processes, which release soluble iron, manganese, and sulfide to the overlying water. The vast reserves of metal precipitates below the surface of the mud will remain trapped within the sediment below the surface layer (Moss 1980).

Mineral Spring (MS-38) Weir NF30

Water quality results for the mineral spring are shown in Tables 3 and 4. *In situ* measurements were also collected at weir NF25 (for comparison purposes and was indicative of a groundwater spring source), which is located next to the outlet structure. Both weirs are characterized by low DO concentrations (averaging 2.1 mg/L for MS-38 and 1.0 mg/L for weir NF25, respectively), relatively stable pH values (averaging 6.9 units for MS-38 and 6.8 units for weir NF25, respectively), and high conductivity measurements (averaging 232 µmhos/cm and 194 µmhos/cm for MS-38 and weir NF25, respectively). Each weir is enclosed by a concrete box that allows spill to overflow one end of the box. The mineral spring was full of an orange/red floc material during the entire monitoring program. This material spilled over the edge of the box and onto the ground extending over a number of feet toward the river, but never reached the river during the monitoring program. Weir NF25 had a few different types of green algae growing in it. The average temperature for the mineral spring was approximately 11.0°C. The average temperature for weir NF25 was 11.9°C.

Dissolved iron and manganese were measured in the water collected from the mineral spring during the monitoring program. The concentrations of dissolved iron and manganese were significant and did not fluctuate greatly from month to month at station MS-38, unlike the concentrations in the hypolimnion of Lake Almanor. The average concentrations were 3,557 µg/L and 3,011 µg/L, respectively for iron and manganese. Algae and precipitate scrapings were also collected in the vicinity of the mineral spring during the monitoring program. The concentrations of total iron and total manganese were measured in these samples. In general, the concentrations for total iron and manganese tended to increase through October 18, 2001 and then decreased slightly in November. The concentrations were high for total iron and total manganese, averaging 19,367 mg/Kg and 2,269 mg/Kg, respectively.

Seneca Reach of the North Fork Feather River

The water quality of the upper NFFR was influenced by the quality of water that was released from the intake tower through Canyon Dam. During the monitoring program, the lower gate of the intake tower (gate invert 4,422 feet) was used during normal operating conditions at a flow of 35 cfs.

During July and August, dissolved iron and manganese were beginning to accumulate in their soluble and reduced states (Fe 2+ and Mn 2+) in the hypolimnion of Lake Almanor. Sulfide concentrations were not detectable during July and August in the hypolimnion (Figure 11 and Table 4). Dissolved iron was not detected in any of the river water quality stations during July and August (<50 µg/L in Figure 8). Dissolved manganese was detected at all of the NFFR water quality stations by the August sampling event and remained detectable through the entire monitoring program (Figure 9). Sulfide was detected at station NF4-38 during the August sampling event at a concentration of 2.8 µg/L but was not detected at any of the other stations until October 10, 2001 (Figure 10). The August sulfide measurement at station NF4-38 may have been due to localized conditions in the vicinity of the station that allowed for the production of sulfide. Immediately upstream of the old gaging station (approximately ¼ to ½ mile from the station) near Caribou Powerhouse, there is a natural spring with geothermal characteristics. It is close to the first foot bridge and generates enough water that the area is always wet and a slight sulfide odor has been present in the past (Tim Sagraves, personal communication).

During the September monitoring event, dissolved iron, manganese, and sulfide concentrations in the hypolimnion had increased significantly from the August concentrations (the sulfide concentration was at a maximum). These increases for iron and manganese were evident in the water quality results for the stations on the upper NFFR. Iron was detected in the upper NFFR as far downstream as station SF-38 near Skinner Flat (approximately 1.4 river miles from Canyon Dam). Dissolved iron was not detected during the monitoring program at stations NF3-38 (approximately 4.9 river miles from Canyon Dam) and NF4-38 (approximately 10 river miles from Canyon Dam). In all cases, the dissolved iron concentrations were below the California drinking water standards, which are applicable "at the tap," and include a secondary maximum contaminant level (MCL) of 300 ppb (California Code of Regulations [CCR] Title 22). Dissolved iron concentrations in the Seneca Reach of the NFFR were also well below the instantaneous maximum criterion of 1,000 ppb for freshwater aquatic life (US EPA [National Recommended Water Quality Criteria-Correction] 1999). The criterion for manganese includes a California drinking water standard secondary MCL of 50 ppb (CCR Title 22). This criterion was exceeded at stations NF2A-38, NF2-38, and SF-38 (extending approximately 1.4 river miles downstream of Canyon Dam) during September and early October; however, this criterion is applicable "at the tap" and does not strictly apply here.

Sulfide was not detected above the reporting limit until the October 10, 2001 sampling event in the upper NFFR. A possible explanation for lack of detection of sulfide during the September monitoring event (when sulfide concentrations were at a maximum in the hypolimnion) could be that the water that was drawn into the lower gate of the intake tower during that month actually came from the thermocline (Figure 7). This water would be characterized by rapidly changing DO concentrations and temperatures.

The presence of oxygen in this layer would inhibit the persistence of sulfide within the layer. Just below the thermocline however, sulfide was at a maximum concentration, but this water was not being accessed as much at the time due to the low lake elevation (4,473 ft.) and resultant low thermocline elevation. Some of the hypolimnetic water was being accessed through the lower gate as is evident by the iron and manganese results. These constituents were able to stay in solution longer than sulfide under variable dissolved oxygen conditions. Sulfide exceeded the US EPA (1999) instantaneous maximum criterion of 2 ppb for freshwater aquatic life as far downstream as station NF2A-38 (approximately 0.25 river miles downstream of Canyon Dam) during early October. Sulfide also exceeded this criterion during August at station NF4-38, however, this exceedance was most likely the result of localized conditions within the vicinity of the station as explained previously.

Lake Almanor had completely overturned by the November 2001 sampling event. As a result, the concentrations of sulfide, iron, and manganese were significantly reduced in the hypolimnion of Lake Almanor. The concentrations of these constituents in the upper NFFR were also significantly reduced by this time. Dissolved iron concentrations were non-detectable (<50 μg/L) in the upper NFFR by the November 2001 sampling event. Conversely, dissolved manganese concentrations, were still detectable above the reporting limit (<1 μg/L) in November, but were significantly reduced compared to previous months.

Mitigation Measures under Variable Gate Operations

There were two test flow releases during the monitoring program. The first test release occurred on October 17, 2001 and involved switching to the upper gate (gate invert 4,467 feet) at a flow of 35 cfs. These release conditions were maintained for 7 hours prior to sampling to ensure that the water that was collected from the NFFR was representative of the water that was being released from the dam outlet. After all water quality samples were collected, release operations were switched back to the lower gate. On the following day (October 18, 2001) the flow was increased to 200 cfs and samples were collected from the river after approximately 4 hours. Release operations were then switched back to a flow of 35 cfs from the lower gate for the remainder of the monitoring period.

A slight hydrogen sulfide odor was noticeable near the outlet of Canyon Dam on the upper NFFR by October 10, 2001. This was the indicator that was used to determine when to change the gate operations of the intake tower to mitigate the odor problem, which had been more noticeable during 2000. The hydrogen sulfide odor was noticeable from the road above the dam during 2000 (Pacific Gas and Electric Company Personnel).

The concentrations of dissolved iron and manganese that were detected at upper NFFR water quality stations were reduced to non-detectable levels for iron, and to less than 17 µg/L for manganese after switching the 35 cfs release flow to the upper gate. Prior to the gate switch, iron and manganese levels were as high as 273 µg/L for iron and 524 µg/L for manganese in the upper NFFR. Sulfide concentrations also decreased at most of the upper NFFR stations as a result of the gate switch.

Dissolved oxygen concentrations in the upper NFFR water quality stations tended to increase slightly after this gate switch (Table 3). Temperatures in the upper NFFR stations also exhibited a slight increase. The largest increase (2.4°C) occurred at station NF4-38. The water that was released from the upper gate of the intake tower at this time was approximately 5°C warmer than the water that would have been released from the lower gate of the intake tower. Another noticeable trend in temperatures in the upper NFFR was that the temperatures measured at downstream stations tended to be colder than the temperatures measured closer to the outlet structure. The water at the station near the outlet structure on the upper NFFR (NF2-38) was 15.8°C on October 17, 2001. The temperature measured at station NF4-38 on the same day was 12.3°C. There was noticeable cooling due to combined effects; the cooler air temperature and the accretion flow between the outlet structure and Caribou Powerhouse. This accretion flow was most likely due to natural spring sources and a number of small creeks located below the Skinner Flat water quality station. Butt Creek provides cool water at a flow of approximately 15 cfs to the upper NFFR just before Caribou Powerhouse.

The water quality conditions in the upper NFFR improved as a result of the gate switch to the upper gate at a flow of 35 cfs. The concentrations of iron, manganese, and sulfide decreased significantly at most stations. Turbidity measurements did not change significantly during the test and dissolved oxygen levels remained above 8.0 mg/L at all the upper NFFR stations.

During the second test flow release (switch to lower gate at 200 cfs), the conditions in the hypolimnion were still reduced and iron and manganese were present at concentrations of 2,120 µg/L (slightly reduced from previous months) and 1,980 µg/L (a maximum for manganese), respectively.

Dissolved iron was not detected above the reporting limit (<50 µg/L) at any of the water quality stations on the upper NFFR during this test flow release. Dissolved manganese was detected at all the water quality stations on the upper NFFR at slightly increased concentrations compared to concentrations measured on and before October 10, 2001. During this sampling event, the manganese concentration in the hypolimnion of Lake Almanor was at a maximum. When flow releases are made from the lower gate of the intake tower, soluble manganese is more likely to be discharged in the lake outflow. The high flow release from the lower gate reduced the dilution effect of downstream tributaries. The highest concentration of manganese was measured at station NF2A-38 (23 µg/L) during this sampling event. Sulfide was not detected at any of the upper NFFR water quality stations during this test flow release even though the concentration of sulfide was 186 µg/L in the hypolimnion of Lake Almanor at the time. The flushing and thorough mixing action of the water as it passed through the dam provided sufficient aeration to prevent sulfide from remaining in the water.

Another affect of increasing the flow to 200 cfs was an increase in turbidity measurements in the upper NFFR. The highest measurements occurred at stations NF3-38 and NF4-38. The sediment at many of the water quality stations consisted of fine silty clay-like materials. These fine materials (washload) were easily suspended by higher velocities in the NFFR. The increase in washload was expected to be short-lived and was a transitory process as flow stabilized. Total suspended solids measurements during this monitoring event were also significantly higher than in previous months at stations SF-38, NF3-38, and NF4-38.

Effects of Varying Lake Elevations

As mentioned previously, the odor problem was not as evident during the 2001 monitoring program as it was during 2000. One major difference between these two years was lake elevation. During September 2000, the elevation of Lake Almanor was approximately 10 feet higher than it was during the 2001 monitoring period (4,483 feet versus 4,473 feet). Figure 12 shows the percentage of times that Lake Almanor has had an historic elevation between 4,494 feet and 4,464 feet for the years 1976 through 2001. The 50% time case represents the average lake elevation for the given month.

Figure 13 shows temperature profiles during several months in 2000 (DWR 2001). Water was released from the lower gate of the intake tower (gate invert 4,422 ft) at a flow of 35 cfs during 2000. The water that would be drawn into this gate is represented by a band of water that extends both above and below the gate invert elevation of 4,422 ft. The approximate width of this band is 9 ft., with about half the water supplied from above and half the water supplied from below the gate invert (Bechtel 2002). As shown in Figure 13, this band of water that would be drawn into the lower gate consisted of hypolimnetic water below the thermocline. When compared to Figure 7, it is evident that the thermocline was approximately 10 ft. higher during 2000 compared to 2001. As a result of this elevation difference, water that was drawn into the lower gate during 2000 and during 2001 would be thermally and chemically different.

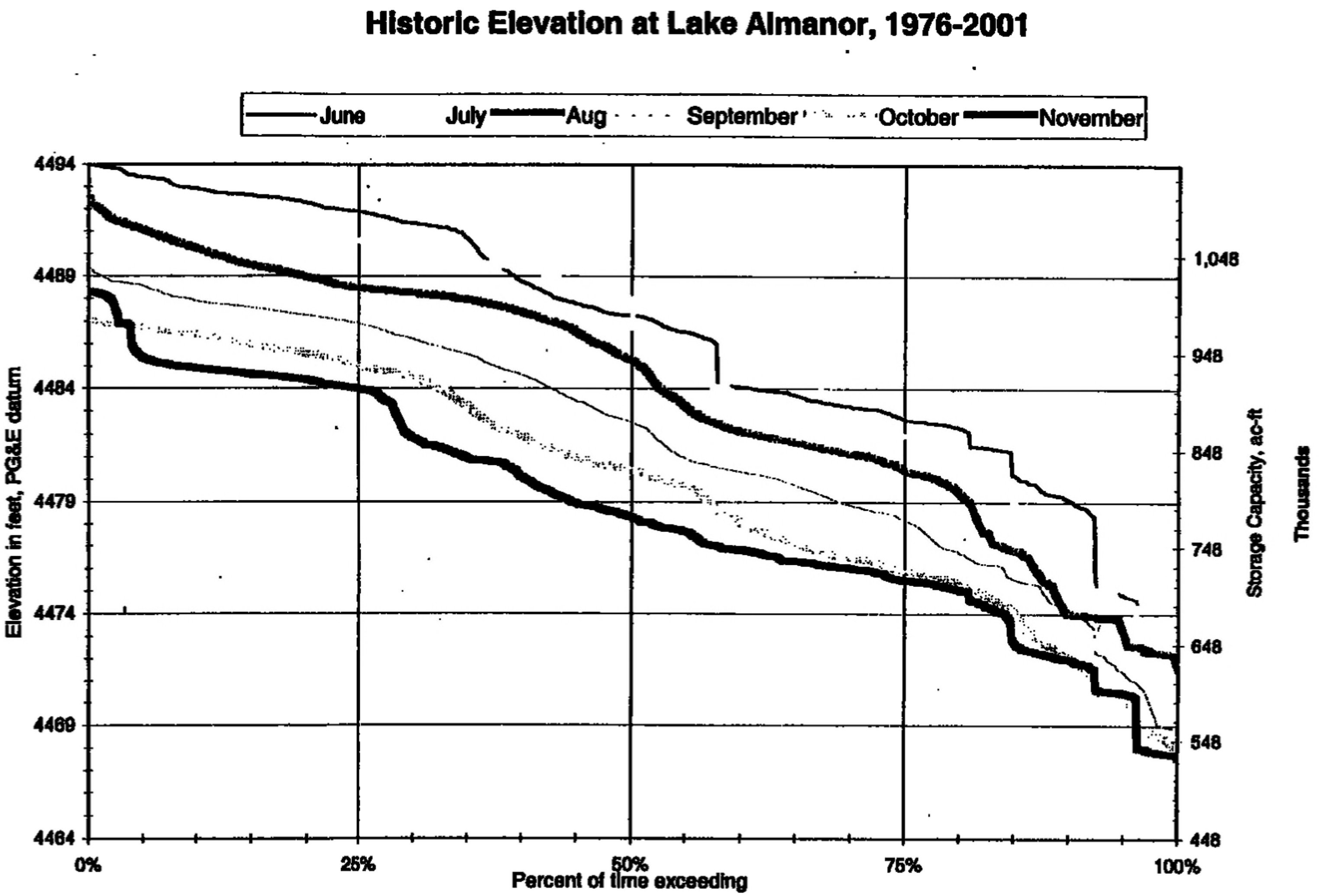


Figure 12. Historical Elevations in Lake Almanor from 1976 through 2001.

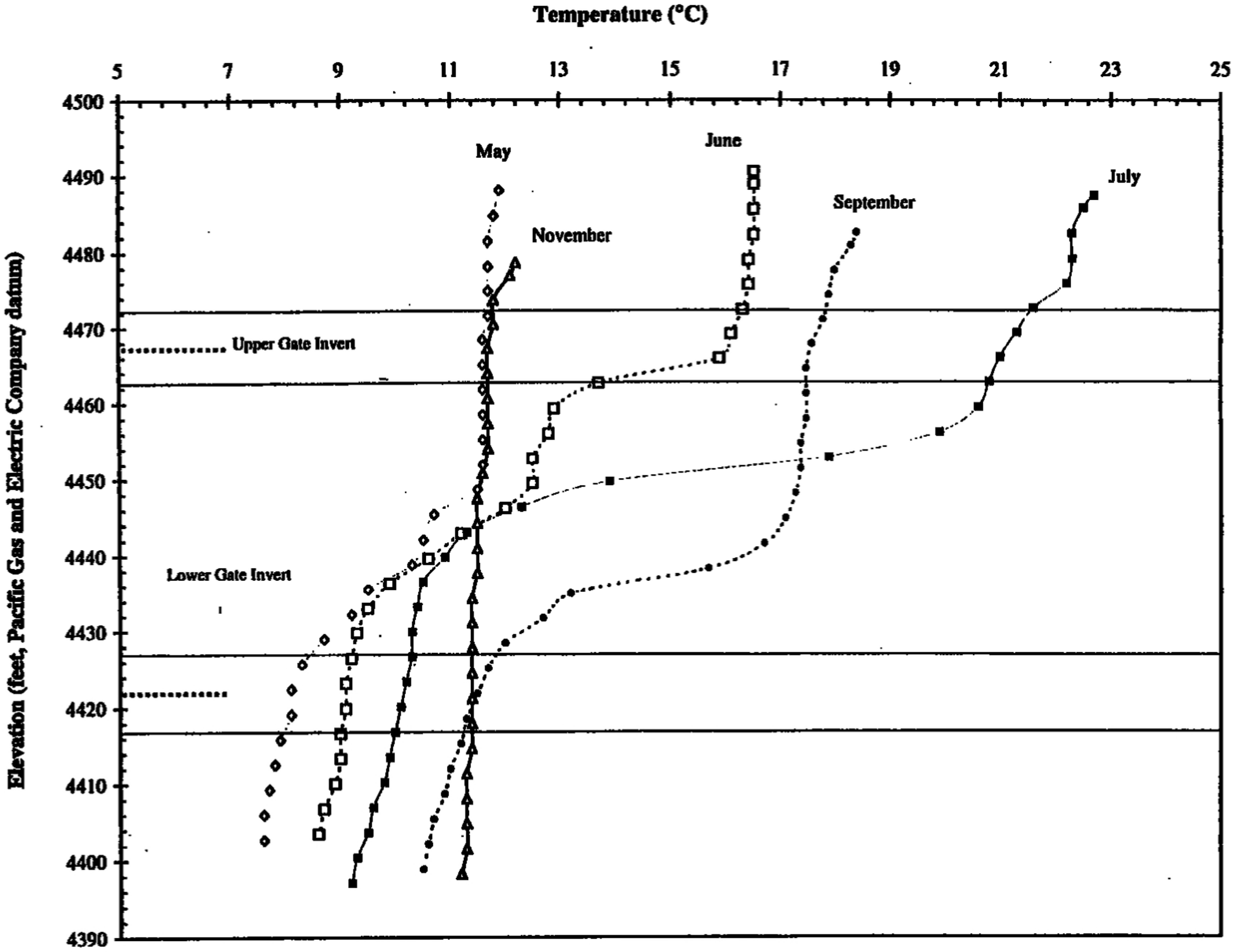


Figure 13. Temperature Profiles in Lake Almanor during 2000 (DWR 2001)

During 2000, the water that was drawn into the lower gate would have consisted of hypolimnetic water with reduced conditions (i.e., elevated dissolved iron, manganese, and sulfide concentrations). During 2001, the water that was drawn into the lower gate was a combination of hypolimnetic water and water from the thermocline. Thus, this water would have higher dissolved oxygen concentrations prior to passing through the gate resulting in a decrease in the concentration of sulfide, which would result in a less noticeable odor coming from the dam.

It can be concluded that during years when lake elevation is low, the odor and precipitate problem may not be as noticeable as it would in years when the lake elevation is high. In the years when lake elevation is high (i.e., stronger odor present and elevated levels of dissolved iron and manganese present in the hypolimnion), it may be possible to switch gate operations and use the upper gate of the intake tower (gate invert 4,467 ft.) for water releases as long as the temperature does create adverse impacts to aquatic life. However, as was stated previously, small springs and creeks do provide cooler water to the lower reaches of the upper NFFR. Therefore, temperature at the downstream stations may not be an issue when releases are made from the upper gate of the intake tower. Gate operations could be switched back to using the lower gate when the lake overturns and oxygen is again present in the hypolimnion. Lake overturn typically occurs by November.

6 CONCLUSION

The Licensee monitored water quality conditions in Lake Almanor and the Seneca Reach of the NFFR from mid summer through early November 2001. This monitoring effort was associated with the occurrence of late season odor and suspected changes in trace metal concentrations in the NFFR below Canyon Dam. These conditions occurred as a direct result of flow releases that were made from the low-level outlet of Canyon Dam, and accessed water from the hypolimnion of Lake Almanor.

Data from this investigation indicate that elevated levels of sulfide, dissolved iron and manganese, existed in the hypolimnion of Lake Almanor during the late summer and early fall of 2001. The mineral spring at the toe of Canyon Dam produced a nearly constant small discharge of high iron and manganese water year-long. The dissolved iron and manganese were present in the hypolimnion of Lake Almanor at levels exceeding their respective regulatory criteria (including Title 22 and secondary MCLs, which are water quality standards for aesthetics and taste). This data also indicated that while elevated levels of both iron and manganese were present in the NFFR immediately downstream of Canyon Dam (within 1.5 miles of the release), these constituents were not present at levels above background throughout the rest of the Seneca Reach. Dissolved iron was never measured above the regulatory criteria in the NFFR during this investigation. Dissolved manganese was measured above the regulatory criteria between September and October in the river immediately below Canyon Dam. This condition did not extend beyond approximately 1.5 miles downstream and concentrations were at or near the criteria level.

Problems associated with elevated sulfide are essentially aesthetic, and are related primarily to odor issues. While this condition does exist as a result of hypolimnetic processes, the rapid re-aeration of water as it passes below the dam returns concentrations to near non-detectable levels immediately downstream of the dam.

It can be concluded that during years when the water surface elevation in Lake Almanor is low, the odor and precipitate problem may not be as noticeable as it would in years when the lake elevation is high. In the years when lake elevation is high (i.e., stronger odor present and elevated levels of dissolved iron and manganese present in the hypolimnion that reach their peak concentrations in late summer), switching operations to use the upper gate of the intake tower (gate invert 4,467 ft.) for water releases might be considered as mitigation for the odor problem as long as the water temperature of the release does not cause adverse impacts to aquatic resources in the NFFR. Gate operations could be switched to the upper cause adverse impacts to aquatic resources in the NFFR. Gate operations could be switched to the upper gate on September 15 with small probability of causing adverse impacts to aquatic resources downstream of Canyon Dam. Gate operations could be switched back to normal (using the lower gate) after the lake turns over (on or after November 1) and oxygen is again present in the hypolimnion.

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Appendix A

PACIFIC GAS AND ELECTRIC COMPANY HISTORICAL WATER QUALITY DATA FOR THE NFFR/LAKE ALMANOR

Appendix A1
Water Quality Impacts of Cold Water Releases on the Upper NFFR*
June 4 through October 5, 1981

Temperature (degrees C)

Date	LA-1	LA-2	FR-1
6/4/81	17.9	9.3	18.3
6/22/81	17.7	10.2	19.3
7/13/81	21.1	11.3	19.6
7/20/81	21.4	11.1	12.5
8/5/81	21.6	11.4	12.5
8/24/81	21.3	12.2	13
9/14/81	21.5	12.1	12.5
10/5/81	—	—	13.9

Dissolved Oxygen (mg/L)

Date	LA-1	LA-2	FR-1
6/4/81	8	4.5	7.7
6/22/81	7.8	3.5	8
7/13/81	7.8	0.4	8.2
7/20/81	8.6	0.6	9.2
8/5/81	7.9	1.2	9.2
8/24/81	7.5	0.6	8.6
9/14/81	6.7	0.9	7.7
10/5/81	---	—	8.6

pH (units)

Date	LA-1	LA-2	FR-1
6/4/81	8.5	7.2	8.4
6/22/81	8.4	7.1	8.4
7/13/81	8.2	7.1	7.9
7/20/81	8.4	7.2	7.2
8/5/81	8.4	7.2	7.2
8/24/81	8.0	7.2	7.2
9/14/81	8.0	7.0	7.2
10/5/81	—	—	7.2

Specific Conductance (µmhos/cm)

Date	LA-1	LA-2	FR-1
6/4/81	85	70	83
6/22/81	80	70	82
7/13/81	83	72	80
7/20/81	87	75	75
8/5/81	99	83	82
8/24/81	95	100	75
9/14/81	92	85	87
10/5/81	—	—	83

Turbidity (NTU)

Date	LA-1	LA-2	FR-1
6/4/81	5.1	2.0	3.8
6/22/81	2.3	2.4	2.2
7/13/81	2.5	5.9	2.5
7/20/81	2.1	2.8	2.6
8/5/81	3.4	4.2	3.9
8/24/81	1.3	4.7	3.2
9/14/81	1.1	5.1	3.7
10/5/81	—	—	2.0

Color (APHA)

Date	LA-1	LA-2	FR-1
6/4/81	8	8	8
6/22/81	8	8	6
7/13/81	11	11	8
7/20/81	5	11	11
8/5/81	6	6	12
8/24/81	9	9	10
9/14/81	4	18	18
10/5/81	—	—	9

* Data from Pacific Gas and Electric Company Report No. 026.11-82.7
--- = No boat available, Lake Almanor not sampled
LA-1 = Lake Almanor near intake structure at 4465 ft elevation
LA-2 = Lake Alamanor near intake structure at 4420 ft elevation
FR-1 = North Fork Feather River below Canyon Dam

Appendix A1
Water Quality Impacts of Cold Water Releases on the Upper NFFR*
June 4 through October 5, 1981

Odor

Date	LA-1	LA-2	FR-1
6/4/81	1	1	0
6/22/81	1	1	1
7/13/81	4	4	4
7/20/81	2	4	4
8/5/81	1	1	1
8/24/81	4	4	4
9/14/81	4	4	4
10/5/81	—	—	2

Total Suspended Solids (mg/L)

Date	LA-1	LA-2	FR-1
6/4/81	<5.0	<5.0	12.0
6/22/81	<5.0	<5.0	<5.0
7/13/81	8.0	6.0	8.0
7/20/81	0.8	0.8	<0.8
8/5/81	<2.0	3.0	<2.0
8/24/81	1.2	8.3	4.0
9/14/81	<0.5	2.0	4.8
10/5/81	—	—	10.0

Total Dissolved Solids (mg/L)

Date	LA-1	LA-2	FR-1
6/4/81	59	59	62
6/22/81	57	61	59
7/13/81	59	58	55
7/20/81	54	59	60
8/5/81	58	66	61
8/24/81	61	62	66
9/14/81	61	62	67
10/5/81	—	—	69

Calcium Hardness (mg-$CaCO_3$/L)

Date	LA-1	LA-2	FR-1
6/4/81	21	23	23
6/22/81	24	24	26
7/13/81	22	23	23
7/20/81	26	24	23
8/5/81	22	22	24
8/24/81	22	24	24
9/14/81	24	24	24
10/5/81	—	—	24

Magnesium Hardness (mg-$CaCO_3$/L)

Date	LA-1	LA-2	FR-1
6/4/81	22	26	20
6/22/81	16	17	15
7/13/81	16	17	18
7/20/81	11	15	18
8/5/81	19	20	19
8/24/81	20	19	19
9/14/81	17	18	19
10/5/81	—	—	19

Total Hardness (mg-$CaCO_3$/L)

Date	LA-1	LA-2	FR-1
6/4/81	43	49	43
6/22/81	40	41	41
7/13/81	38	40	41
7/20/81	37	39	41
8/5/81	41	42	43
8/24/81	42	43	43
9/14/81	41	42	43
10/5/81	—	—	43

* Data from Pacific Gas and Electric Company Report No. 026.11-82.7

— = No boat available, Lake Almanor not sampled
LA-1 = Lake Almanor near intake structure at 4465 ft elevation
LA-2 = Lake Alamanor near intake structure at 4420 ft elevation
FR-1 = North Fork Feather River below Canyon Dam

Appendix A1
Water Quality Impacts of Cold Water Releases on the Upper NFFR*
June 4 through October 5, 1981

Total Alkalinity (mg-$CaCO_3$/L)

Date	LA-1	LA-2	FR-1
6/4/81	50	51	50
6/22/81	51	54	54
7/13/81	52	54	52
7/20/81	51	54	56
8/5/81	53	55	57
8/24/81	52	56	58
9/14/81	54	56	56
10/5/81	---	---	56

Iron (µg/L)

Date	LA-1	LA-2	FR-1
6/4/81	<10	350	120
6/22/81	<10	<10	<10
7/13/81	<10	100	10
7/20/81	<10	10	<10
8/5/81	<10	<10	<10
8/24/81	<10	<10	<10
9/14/81	<10	<10	<10
10/5/81	---	---	<10

Manganese (µg/L)

Date	LA-1	LA-2	FR-1
6/4/81	<10	250	50
6/22/81	<10	240	<10
7/13/81	<10	650	<10
7/20/81	<10	190	80
8/5/81	<10	500	430
8/24/81	<10	410	280
9/14/81	<10	180	<10
10/5/81	---	---	<10

Sulfide (µg/L)

Date	LA-1	LA-2	FR-1
6/4/81	<100	<100	<100
6/22/81	<100	<100	<100
7/13/81	<100	<100	<100
7/20/81	<100	<100	<100
8/5/81	<100	<100	<100
8/24/81	<100	<100	<100
9/14/81	<100	200	<100
10/5/81	---	---	<100

Sulfate (mg/L)

Date	LA-1	LA-2	FR-1
6/4/81	1.2	<1.0	1
6/22/81	<1.0	<1.0	<1.0
7/13/81	<1.0	<1.0	<1.0
7/20/81	<1.0	<1.0	<1.0
8/5/81	<1.0	2	1
8/24/81	<1.0	<1.0	<1.0
9/14/81	<1.0	<1.0	<1.0
10/5/81	---	---	<1.0

Total Ammonia (mg-N/L)

Date	LA-1	LA-2	FR-1
6/4/81	0.73	0.67	0.28
6/22/81	0.07	0.27	0.09
7/13/81	0.03	0.53	0.03
7/20/81	0.04	0.42	0.39
8/5/81	0.02	0.46	0.42
8/24/81	0.09	0.54	0.51
9/14/81	0.02	0.66	0.56
10/5/81	---	---	0.44

* Data from Pacific Gas and Electric Company Report No. 026.11-82.7

--- = No boat available, Lake Almanor not sampled

LA-1 = Lake Almanor near intake structure at 4465 ft elevation

LA-2 = Lake Alamanor near intake structure at 4420 ft elevation

FR-1 = North Fork Feather River below Canyon Dam

Appendix A1
Water Quality Impacts of Cold Water Releases on the Upper NFFR*
June 4 through October 5, 1981

Unionized Ammonia (mg-NH_3/L)

Date	LA-1	LA-2	FR-1
6/4/81	0.09	<0.02	0.03
6/22/81	<0.02	<0.02	<0.02
7/13/81	<0.02	<0.02	<0.02
7/20/81	<0.02	<0.02	<0.02
8/5/81	<0.02	<0.02	<0.02
8/24/81	<0.02	<0.02	<0.02
9/14/81	<0.02	<0.02	<0.02
10/5/81	—	—	<0.02

Nitrate (mg-N/L)

Date	LA-1	LA-2	FR-1
6/4/81	0.20	0.24	0.23
6/22/81	0.04	0.06	0.05
7/13/81	<0.01	<0.01	<0.01
7/20/81	0.12	0.12	0.14
8/5/81	0.23	0.14	0.17
8/24/81	0.04	0.03	0.05
9/14/81	<0.01	<0.01	<0.01
10/5/81	—	—	0.01

Phosphorous (mg-P/L)

Date	LA-1	LA-2	FR-1
6/4/81	0.010	<0.010	<0.010
6/22/81	<0.010	<0.010	<0.010
7/13/81	0.020	0.170	0.010
7/20/81	0.030	0.030	0.030
8/5/81	0.030	0.090	0.060
8/24/81	0.080	0.030	0.030
9/14/81	<0.010	0.022	0.019
10/5/81	—	—	<0.010

Phosphate (mg-PO_4/L)

Date	LA-1	LA-2	FR-1
6/4/81	<0.03	<0.03	<0.03
6/22/81	<0.03	<0.03	<0.03
7/13/81	<0.03	0.06	<0.03
7/20/81	<0.03	<0.03	<0.03
8/5/81	0.03	0.03	0.06
8/24/81	0.03	0.02	0.02
9/14/81	<0.03	<0.03	<0.03
10/5/81	—	—	<0.03

Total Organic Carbon (mg-C/L)

Date	LA-1	LA-2	FR-1
6/4/81	5	<5	<5
6/22/81	<5	<5	<5
7/13/81	3	<3	<3
7/20/81	<3	<3	<3
8/5/81	3	2	2
8/24/81	3	3	3
9/14/81	3	3	3
10/5/81	—	—	3

* Data from Pacific Gas and Electric Company Report No. 026.11-82.7
— = No boat available, Lake Alamnor not sampled
LA-1 = Lake Almanor near intake structure at 4465 ft elevation
LA-2 = Lake Alamanor near intake structure at 4420 ft elevation
FR-1 = North Fork Feather River below Canyon Dam

Appendix A2
Lake Almanor and Upper NFFR Temperature and Water Quality Investigation*
June through October (1980 – 1982)

Date	Parameter	Station FR-1	FR-2	FR-3
6/11/80	Temperature	14.4	11.8	13.3
6/25/80	Temperature	13.9	15.0	14.4
7/24/80 (1)	Temperature	12.1	17.2	15.3
8/21/80	Temperature	11.8	16.5	16.1
9/10/80	Temperature	11.7	12.5	14.2
10/2/80	Temperature	11.8	13.2	11.2
6/3/81	Temperature	18.3	19.0	17.1
6/23/81	Temperature	19.3	14.7	15.8
7/14/81 (1)	Temperature	19.6	15.8	15.2
7/20/81	Temperature	12.5	—	—
8/6/81	Temperature	12.5	12.2	13.0
8/24/81	Temperature	13.0	15.2	14.9
9/14/81	Temperature	12.5	15.2	15.8
10/5/81	Temperature	13.9	12.5	11.5
6/2/82	Temperature	14.9	14.2	13.2
6/22/82	Temperature	17.5	17.3	17.1
7/20/82	Temperature	18.0	16.5	15.8
8/18/82	Temperature	20.8	19.2	17.9
9/13/82	Temperature	18.3	14.5	15.0
6/11/80	DO	9.0	9.6	9.6
6/25/80	DO	9.1	9.0	9.3
7/24/80 (1)	DO	9.6	9.0	9.0
8/21/80	DO	8.8	9.9	9.6
9/10/80	DO	7.6	9.4	9.5
10/2/80	DO	8.3	9.2	9.8
6/3/81	DO	7.7	8.7	8.3
6/23/81	DO	8.0	9.0	9.0
7/14/81 (1)	DO	8.2	8.8	9.3
7/20/81	DO	9.2	—	—
8/6/81	DO	9.2	9.9	9.6
8/24/81	DO	8.6	9.1	9.2
9/14/81	DO	7.7	8.7	9.1
10/5/81	DO	8.6	9.2	9.7
6/2/82	DO	9.0	9.0	9.6
6/22/82	DO	8.4	8.6	8.6
7/20/82	DO	8.6	9.6	9.8

Appendix A2
Lake Almanor and Upper NFFR Temperature and Water Quality Investigation*
June through October (1980 – 1982)

		Station		
Date	**Parameter**	**FR-1**	**FR-2**	**FR-3**
8/18/82	DO	7.9	7.3	8.5
9/13/82	DO	7.4	8.2	7.9
6/11/80	pH	7.7	7.7	7.7
6/25/80	pH	7.6	7.9	7.7
7/24/80 (1)	pH	7.6	7.8	7.6
8/21/80	pH	7.2	8.0	8.0
9/10/80	pH	7.3	8.0	8.0
10/2/80	pH	7.2	7.8	7.9
6/3/81	pH	8.4	8.1	8.3
6/23/81	pH	8.4	7.6	8.1
7/14/81 (1)	pH	7.9	7.8	7.9
7/20/81	pH	7.2	—	—
8/6/81	pH	7.2	7.6	7.6
8/24/81	pH	7.2	8.2	8.0
9/14/81	pH	7.2	8.0	7.6
10/5/81	pH	7.2	8.0	8.0
6/2/82	pH	7.6	7.9	8.2
6/22/82	pH	7.8	7.9	7.8
7/20/82	pH	7.8	8.1	8.1
8/18/82	pH	8.2	8.4	8.2
9/13/82	pH	7.8	7.8	8.0
6/11/80	Conductivity	96	123	163
6/25/80	Conductivity	70	100	105
7/24/80 (1)	Conductivity	87	113	150
8/21/80	Conductivity	78	90	140
9/10/80	Conductivity	82	102	135
10/2/80	Conductivity	78	91	124
6/3/81	Conductivity	83	105	140
6/23/81	Conductivity	82	99	137
7/14/81 (1)	Conductivity	80	100	135
7/20/81	Conductivity	75	—	—
8/6/81	Conductivity	82	96	131
8/24/81	Conductivity	75	92	119
9/14/81	Conductivity	87	105	138
10/5/81	Conductivity	83	100	125

Appendix A2
Lake Almanor and Upper NFFR Temperature and Water Quality Investigation*
June through October (1980 - 1982)

		Station		
Date	Parameter	FR-1	FR-2	FR-3
6/2/82	Conductivity	69	90	125
6/22/82	Conductivity	75	95	132
7/20/82	Conductivity	70	92	110
8/18/82	Conductivity	125	108	197
9/13/82	Conductivity	78	101	132
6/11/80	Turbidity	3.4	2.0	0.80
6/25/80	Turbidity	1.3	1.4	1.1
7/24/80 (1)	Turbidity	0.92	2.0	1.5
8/21/80	Turbidity	0.90	5.4	4.9
9/10/80	Turbidity	1.1	1.1	7.2
10/2/80	Turbidity	1.8	1.0	1.8
6/3/81	Turbidity	3.8	0.95	1.3
6/23/81	Turbidity	1.1	2.3	1.8
7/14/81 (1)	Turbidity	0.80	1.2	1.8
7/20/81	Turbidity	2.6	—	—
8/6/81	Turbidity	3.9	3.6	4.0
8/24/81	Turbidity	3.3	2.1	2.0
9/14/81	Turbidity	2.8	1.8	1.2
10/5/81	Turbidity	2.0	1.5	1.2
6/2/82	Turbidity	2.0	1.5	1.5
6/22/82	Turbidity	0.98	1.5	0.93
7/20/82	Turbidity	0.59	0.68	1.0
8/18/82	Turbidity	0.65	0.70	1.1
9/13/82	Turbidity	0.60	—	—

* = Data from Pacific Gas and Electric Company Report No. 026.11-83.1
(1) = Low level releases were made on or immediately after these sampling periods
Temperature (degrees C)
DO = Dissolved Oxygen (mg/L)
pH (units)
Conductivity (µmhos/cm)
Turbidity (NTU)
FR-1 = Water quality station below Canyon Dam
FR-2 = Water quality station above Seneca
FR-3 = Water quality station above Caribou Powerhouse

Appendix B

EPA STORET HISTORICAL
WATER QUALITY DATA
FOR
LAKE ALMANOR

STORET Historical Data for Lake Almanor
Lake Almanor at Intake Tower near Dam
Latitude: 40 deg. 10 min. 40 sec. N
Longitude: 121 deg. 5 min. 6 sec. W

Sampling Date	Elevation (feet)	Depth (feet)	Depth (meters)	Temperature (deg C)	DO (mg/L)	DO % Saturation (%)	Specific Conductance (µmhos/cm)	pH (units)	Fe Dissolved (µg/L)	Mn Dissolved (µg/L)	Sulfate (mg/L as SO4)
4/14/77	4473.3	0	0.0	10.3	10	104.3	110	7.9	---	---	---
4/14/77	4470.3	3	0.9	10.3	10	104.3	110	7.8	---	---	---
4/14/77	4467.3	6	1.8	9.9	10.1	105.3	110	7.8	---	---	---
4/14/77	4460.3	13	4.0	9.5	10.2	103.6	110	7.8	---	---	---
4/14/77	4457.3	16	4.9	9.4	10.2	103.6	110	7.8	---	---	---
4/14/77	4454.3	19	5.8	9.4	10.2	103.6	110	7.8	---	---	---
4/14/77	4451.3	22	6.7	9.3	10.2	103.6	110	7.8	---	---	---
4/14/77	4447.3	26	7.9	9.1		---	110	7.8	---	---	---
4/14/77	4444.3	29	8.8	8.9		---	110	7.8	---	---	---
4/14/77	4441.3	32	9.8	8.6		---	110	7.8	---	---	---
4/14/77	4437.3	36	11.0	8.3	10.2	101.0	110	7.8	---	---	---
4/14/77	4434.3	39	11.9	8.1		---	110	7.8	---	---	---
4/14/77	4431.3	42	12.8	8	8.8	87.1	110	7.8	---	---	---
4/14/77	4428.3	45	13.7	7.6		---	110	7.7	0	0	0.6
4/14/77	4424.3	49	14.9	7.1		---	110	7.7	---	---	---
4/14/77	4421.3	52	15.8	6.7		---	110	7.6	---	---	---
4/14/77	4418.3	55	16.8	6.5		---	110	7.6	---	---	---
4/14/77	4414.3	59	18.0	6.4		---	110	7.5	---	---	---
4/14/77	4411.3	62	18.9	6.7	9.5	91.7	110	7.5	0	10	1.2
4/14/77	4411.3	62	18.9	6.4		---	110	7.5	---	---	---
4/14/77	4408.3	65	19.8	6.2		---	110	7.5	---	---	---
4/14/77	4405.3	68	20.7	6		---	110	7.5	---	---	---
4/14/77	4401.3	72	21.9	5.9		---	110	7.4	---	---	---
5/31/77	4473.58	1	0.3	17.8	9.1	112.9	110	8.2	---	---	---
5/31/77	4471.58	3	0.9	16.8	9.4	114.2	110	8.2	---	---	---
5/31/77	4468.58	6	1.8	16	9.3	109.6	110	8.2	---	---	---

STORET Historical Data for Lake Almanor
Lake Almanor at Intake Tower near Dam
Latitude: 40 deg. 10 min. 40 sec. N
Longitude: 121 deg. 5 min. 6 sec. W

Sampling Date	Elevation (feet)	Depth (feet)	Depth (meters)	Temperature (deg C)	DO (mg/L)	DO % Saturation (%)	Specific Conductance (µmhos/cm)	pH (units)	Fe-Diss (µg/L)	Mn-Diss (µg/L)	Sulfate (mg/L as SO4)
5/31/77	4465.58	9	2.7	15.5	9.2	106.3	111	8.1	---	---	---
5/31/77	4461.58	13	4.0	15.3	9.2	106.3	111	8	---	---	---
5/31/77	4458.58	16	4.9	14.4	8.8	99.7	111	7.9	---	---	---
5/31/77	4455.58	19	5.8	13.3	8.9	98.9	111	7.9	---	---	---
5/31/77	4452.58	22	6.7	12.6	8.6	95.6	111	7.8	---	---	---
5/31/77	4448.58	26	7.9	12.1	8.9	97.1	111	7.7	---	---	---
5/31/77	4445.58	29	8.8	11.9	8.8	96.0	111	7.6	---	---	---
5/31/77	4442.58	32	9.8	11.8	8.9	97.1	111	7.6	---	---	---
5/31/77	4438.58	36	11.0	11.6	8.7	94.9	111	7.5	---	---	---
5/31/77	4435.58	39	11.9	11.4	8.6	91.3	111	7.5	---	---	---
5/31/77	4432.58	42	12.8	11	8.3	88.1	111	7.4	---	---	---
5/31/77	4429.58	45	13.7	10.7	8.1	86.0	111	7.3	---	---	---
5/31/77	4425.58	49	14.9	10.1	7.6	79.2	111	7.2	---	---	---
5/31/77	4422.58	52	15.8	9.8	7.2	75.1	111	7.1	---	---	---
5/31/77	4419.58	55	16.8	9.5	6.4	65.0	112	7	---	---	---
5/31/77	4415.58	59	18.0	9.3	6.1	62.0	112	7	---	---	---
5/31/77	4412.58	62	18.9	9.1	5.9	59.9	112	6.9	---	---	---
5/31/77	4409.58	65	19.8	9	5.6	56.9	112	6.8	---	---	---
5/31/77	4406.58	68	20.7	8.8	5.7	57.9	112	6.8	---	---	---
5/31/77	4402.58	72	21.9	8.5	3.8	37.6	114	6.7	---	---	---
6/1/77	4409.62	65	19.8	9.3	4.8	48.7	111	7.3	---	---	0.3
6/1/77	4408.62	66	20.1	9.3	4.8	48.8	111	7.3	---	---	0.3
9/28/77	4442.89	26	7.9	---	---	---	123	8	20	10	1.2
9/28/77	4426.89	42	12.8	14.6	0	0	120	7.1	60	500	1
9/28/77	4425.89	43	13.1	14.6	0	0	120	7.1	60	500	1

STORET Historical Data for Lake Almanor
Lake Almanor at Intake Tower near Dam
Latitude: 40 deg. 10 min. 40 sec. N
Longitude: 121 deg. 5 min. 8 sec. W

Sampling Date	Elevation (feet)	Depth (feet)	Depth (meters)	Temperature (deg C)	DO (mg/L)	DO % Saturation (%)	Specific Conductance (µmhos/cm)	pH (units)	Fe-Diss (µg/L)	Mn-Diss (µg/L)	Sulfate (mg/L as SO4)
9/28/77	4409.89	59	18.0	12.5	0	0	123	6.9	1500	1300	1.2
6/20/78	4485.1	3	0.9	18.7	9.1	114.1	94	8.6	---	---	---
6/20/78	4482.1	6	1.8	18	9.1	112.9	94	8.7	---	---	---
6/20/78	4479.1	9	2.7	17.7	9.1	112.9	94	8.7	---	---	---
6/20/78	4475.1	13	4.0	17.6	9.2	114.1	94	8.7	---	---	---
6/20/78	4472.1	16	4.9	17.4	9.2	111.7	94	8.7	---	---	---
6/20/78	4469.1	19	5.8	17.1	9.2	111.7	94	8.7	---	---	---
6/20/78	4466.1	22	6.7	16.9	9	109.3	94	8.7	---	---	---
6/20/78	4462.1	26	7.9	16.8	8.9	108.1	94	8.6	---	---	---
6/20/78	4459.1	29	8.8	16.7	8.7	105.7	94	8.6	---	---	---
6/20/78	4456.1	32	9.8	16.5	8.4	99.0	94	8.4	---	---	---
6/20/78	4452.1	36	11.0	14	6	68.0	95	7.8	---	---	---
6/20/78	4449.1	39	11.9	13.4	5.5	61.1	95	7.7	---	---	---
6/20/78	4446.1	42	12.8	13	4.9	54.5	96	7.6	---	---	---
6/20/78	4443.1	45	13.7	12.7	4.6	51.1	95	7.6	---	---	---
6/20/78	4439.1	49	14.9	12.5	4.6	50.2	96	7.5	---	---	---
6/20/78	4436.1	52	15.8	12.3	4.5	49.1	97	7.5	---	---	---
6/20/78	4433.1	55	16.8	11.9	4	43.6	97	7.5	---	---	---
6/20/78	4429.1	59	18.0	11.7	4	43.6	98	7.4	---	---	---
6/20/78	4426.1	62	18.9	11.6	4	43.6	98	7.4	---	---	---
6/20/78	4423.1	65	19.8	11.3	3.7	39.3	99	7.4	---	---	---
6/20/78	4416.1	72	21.9	10.8	3.5	37.2	100	7.4	---	---	---
6/20/78	4410.1	78	23.8	10.6	3.3	35.0	101	7.4	---	---	---
6/20/78	4403.1	85	25.9	10.4	2.7	28.2	101	7.3	---	---	---
6/20/78	4400.1	88	26.8	10.1	1.6	16.7	103	7.3	---	---	---

STORET Historical Data for Lake Almanor
Lake Almanor at Intake Tower near Dam
Latitude: 40 deg. 10 min. 40 sec. N
Longitude: 121 deg. 5 min. 6 sec. W

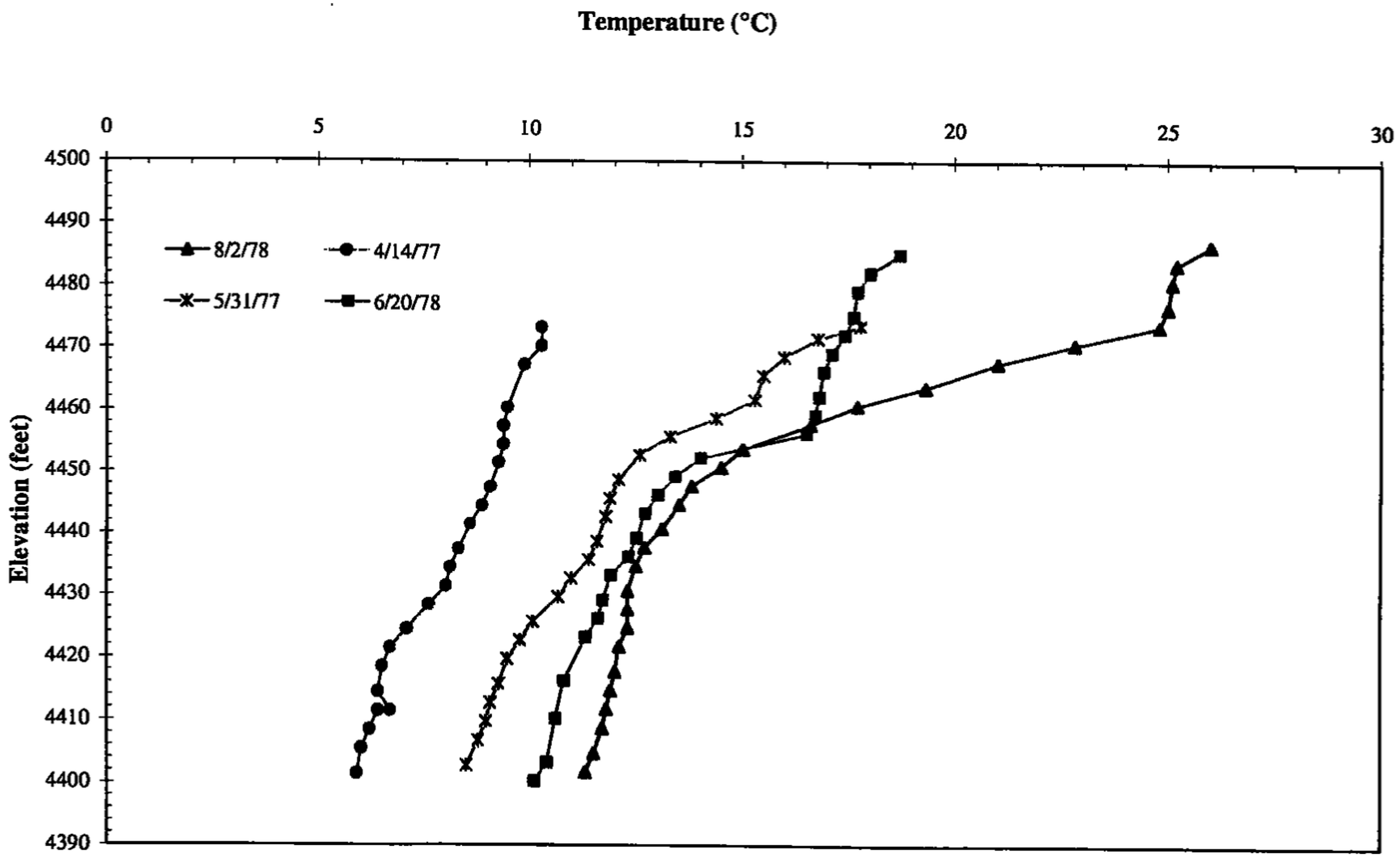
Sampling Date	Elevation (feet)	Depth (feet)	Depth (meters)	Temperature (deg C)	DO (mg/L)	DO % Saturation (%)	Specific Conductance (µmhos/cm)	pH (units)	Fe-Diss (µg/L)	Mn-Diss (µg/L)	Sulfate (mg/L as SO4)
8/2/78	4486.58	3	0.9	26	7.3	104.9	105	8.8	---	---	---
8/2/78	4483.58	6	1.8	25.2	7.3	102.4	105	8.8	---	---	---
8/2/78	4480.58	9	2.7	25.1	7.2	101.0	105	8.8	---	---	---
8/2/78	4476.58	13	4.0	25	7.3	102.4	105	8.8	---	---	---
8/2/78	4473.58	16	4.9	24.8	7.3	102.4	105	8.8	---	---	---
8/2/78	4470.58	19	5.8	22.8	8.1	109.7	103	9	---	---	---
8/2/78	4467.58	22	6.7	21	7.8	102.1	102	8.9	---	---	---
8/2/78	4463.58	26	7.9	19.3	6.6	82.7	102	8.5	---	---	---
8/2/78	4460.58	29	8.8	17.7	4.9	60.8	102	8.1	---	---	---
8/2/78	4457.58	32	9.8	16.6	3.8	46.2	103	7.7	---	---	---
8/2/78	4453.58	36	11.0	15	2.1	24.3	105	7.6	---	---	---
8/2/78	4450.58	39	11.9	14.5	1.8	20.4	107	7.4	---	---	---
8/2/78	4447.58	42	12.8	13.8	1.5	17.0	108	7.4	---	---	---
8/2/78	4444.58	45	13.7	13.5	1.3	14.4	109	7.3	---	---	---
8/2/78	4440.58	49	14.9	13.1	1.1	12.2	109	7.3	---	---	---
8/2/78	4437.58	52	15.8	12.7	1.1	12.2	111	7.2	---	---	---
8/2/78	4434.58	55	16.8	12.5	1.1	12.0	112	7.2	---	---	---
8/2/78	4430.58	59	18.0	12.3	1.1	12.0	112	7.2	---	---	---
8/2/78	4427.58	62	18.9	12.3	1.1	12.0	113	7.2	---	---	---
8/2/78	4424.58	65	19.8	12.3	1.1	12.0	113	7.2	---	---	---
8/2/78	4421.58	68	20.7	12.1	1.1	12.0	112	7.2	---	---	---
8/2/78	4417.58	72	21.9	12	1.1	12.0	114	7.1	---	---	---
8/2/78	4414.58	75	22.9	11.9	1.1	12.0	115	7.1	---	---	---
8/2/78	4411.58	78	23.8	11.8	1.1	12.0	116	7.1	---	---	---
8/2/78	4408.58	81	24.7	11.7	1.1	12.0	117	7.1	---	---	---
8/2/78	4404.58	85	25.9	11.5	1.1	12.0	116	7.1	---	---	---
8/2/78	4401.58	88	26.8	11.3	1.1	12.0	120	7.1	---	---	---

STORET Historical Data for Lake Almanor
Lake Almanor at Intake Tower near Dam
Latitude: 40 deg. 10 min. 50 sec. N
Longitude: 121 deg. 5 min. 6 sec. W

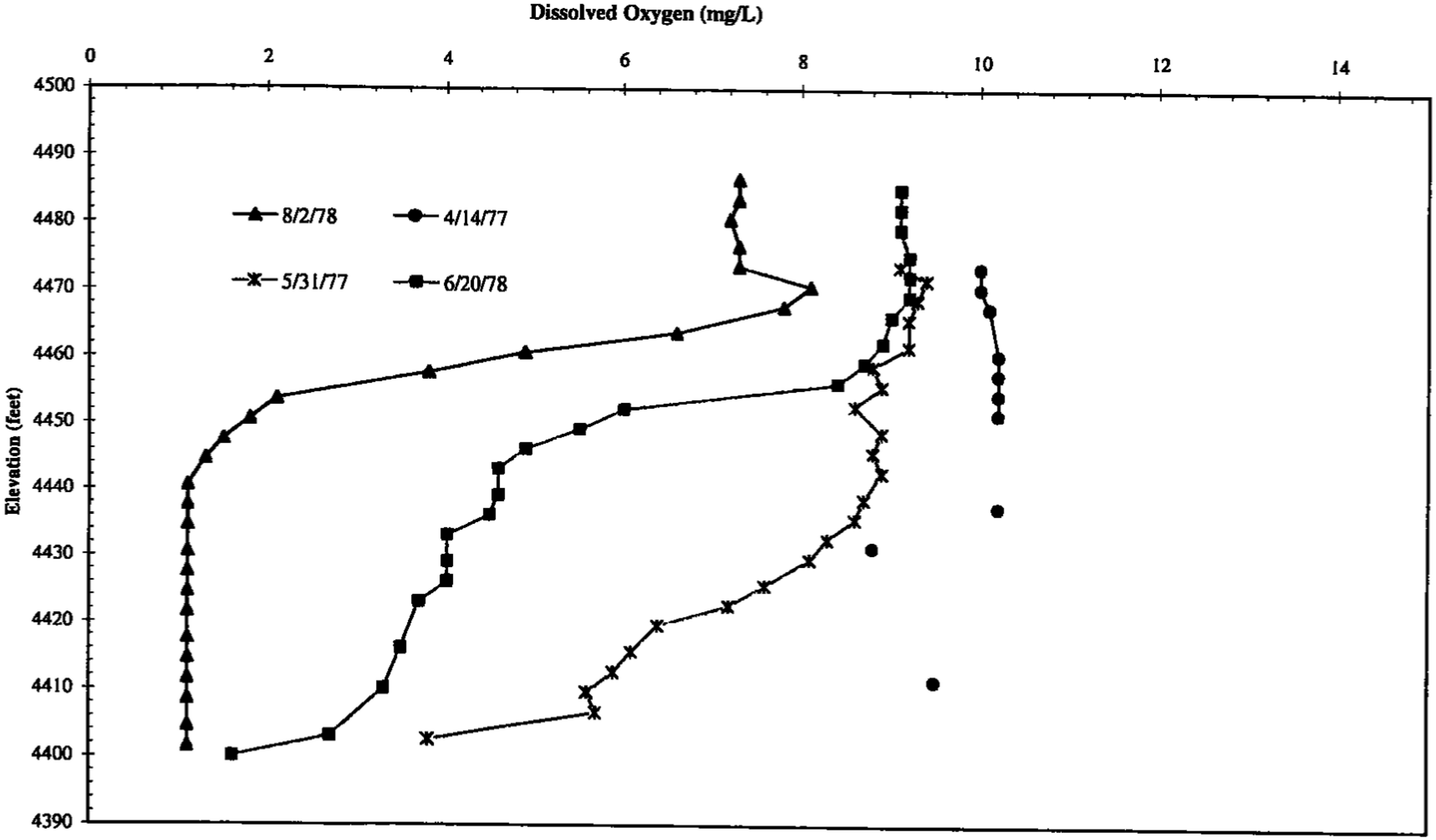
Sampling Date	Elevation (feet)	Depth (feet)	Depth (meters)	Temperature (deg C)	DO (mg/L)	DO % Saturation (%)	Specific Conductance (µmhos/cm)	pH (units)	Fe-Diss (µg/L)	Mn-Diss (µg/L)	Sulfate (mg/L as SO4)

STORET data from EPA website http://www.epa.gov/storet/

4/14/77 Lake surface elevation was 4473.3 ft (PG&E datum)
5/31/77 Lake surface elevation was 4474.58 ft (PG&E datum)
6/1/77 Lake suface elevation was 4474.62 ft (PG&E datum)
9/28/77 Lake surface elevation was 4468.89 ft (PG&E datum)
6/20/78 Lake surface elvation was 4488.1 ft (PG&E datum)
8/2/78 Lake surface elevation was 4489.58 ft (PG&E datum)



Historical Temperature Profiles for Lake Almanor near the Intake Tower



Historical Dissolved Oxygen Profiles for Lake Almanor near the Intake Tower

APPENDIX C

LONG-TERM DWR WATER QUALITY DATA FOR LAKE ALMANOR NEAR THE INTAKE TOWER

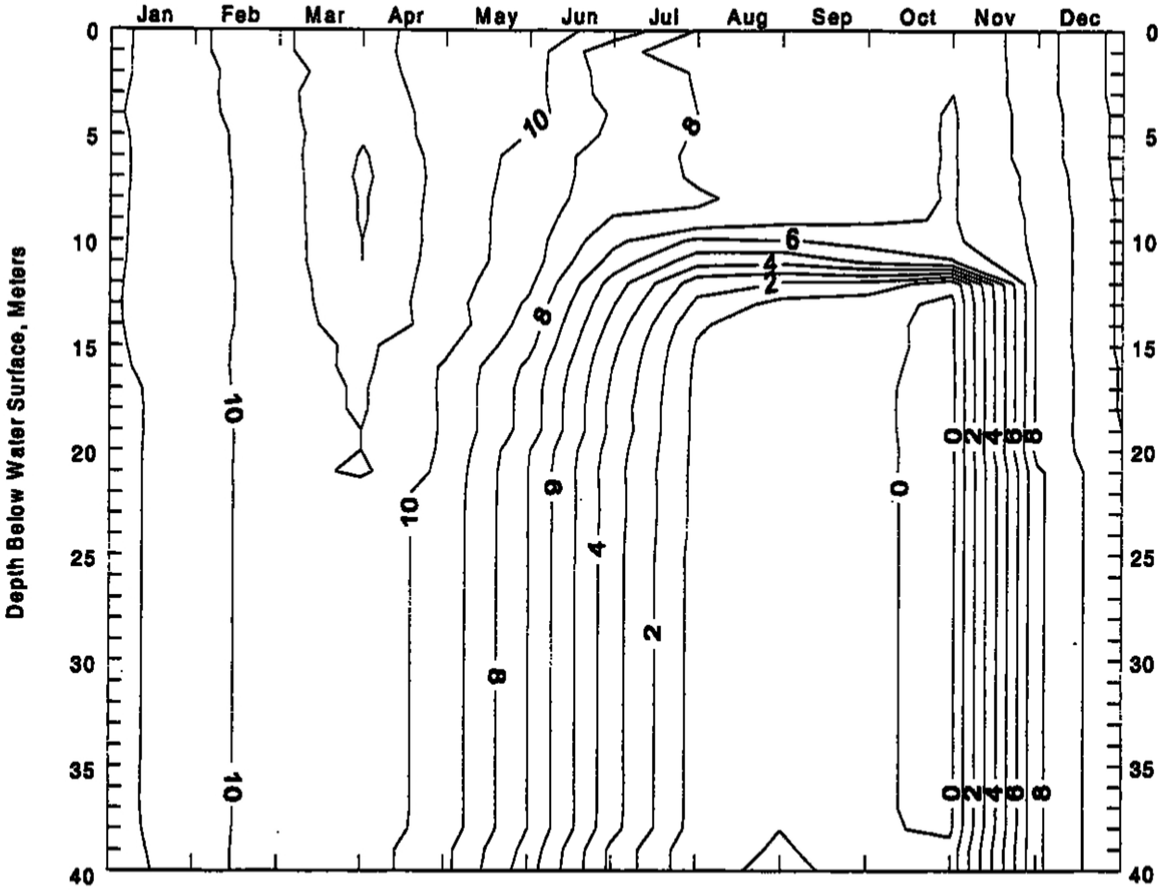


Figure 1. Dissolved oxygen in Lake Almanor in 1994, mg/L (DWR 2001).

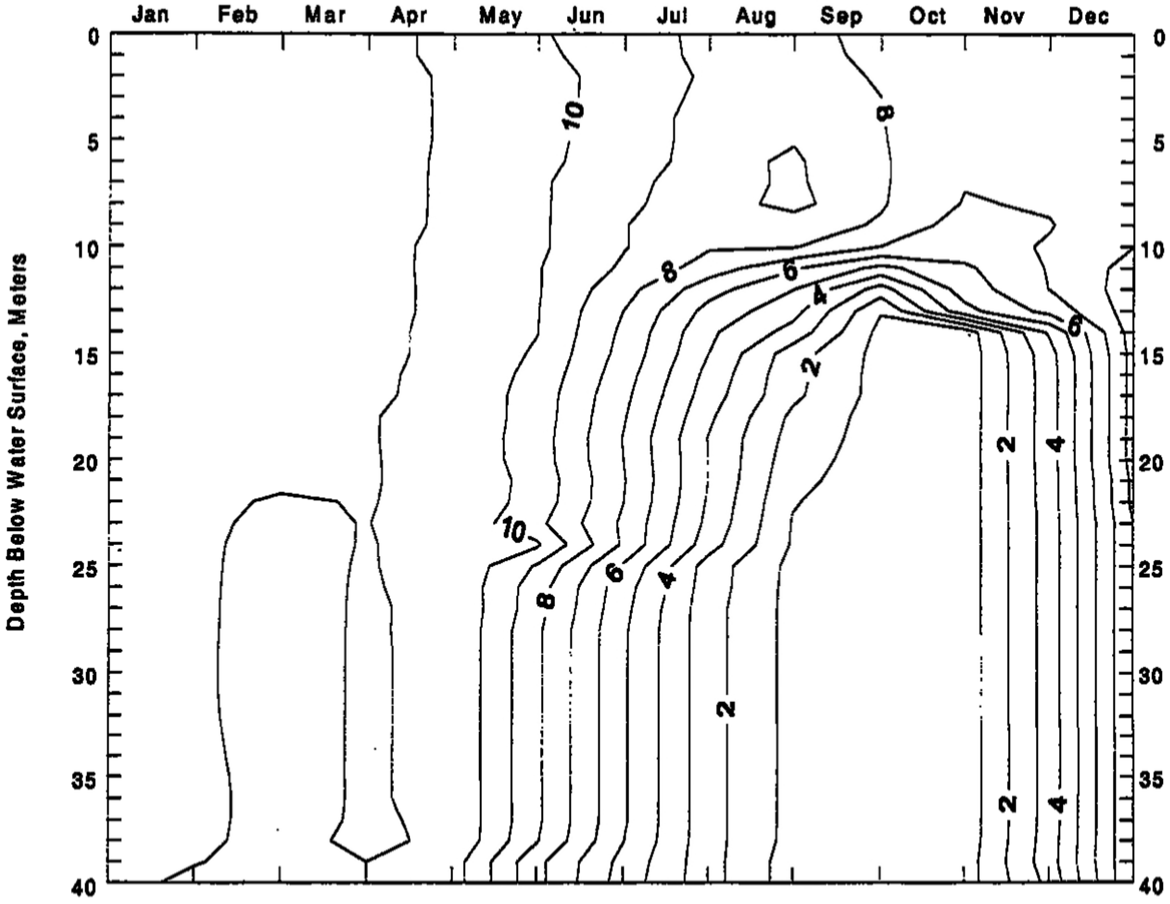


Figure 2. Dissolved oxygen in Lake Almanor in 1995, mg/L (DWR 2001).

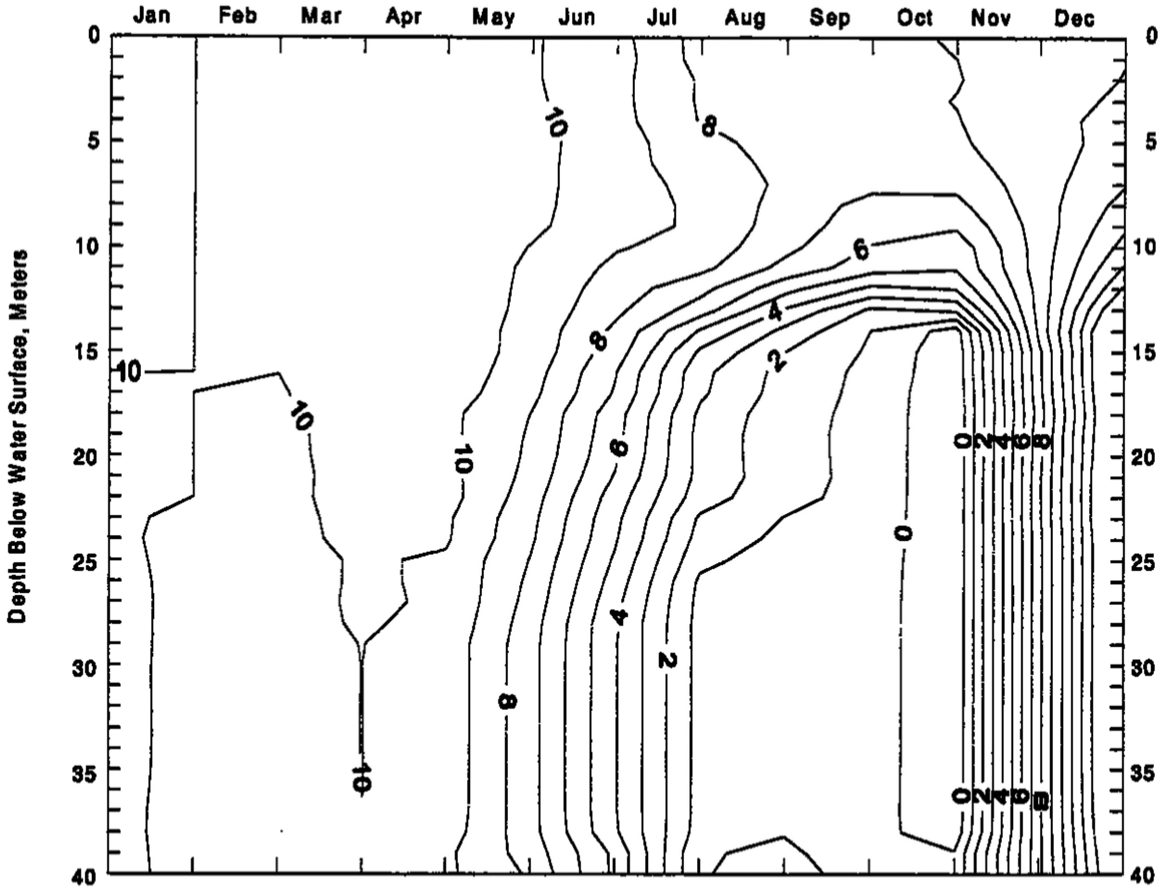


Figure 3. Dissolved oxygen in Lake Almanor in 1996, mg/L (DWR 2001).

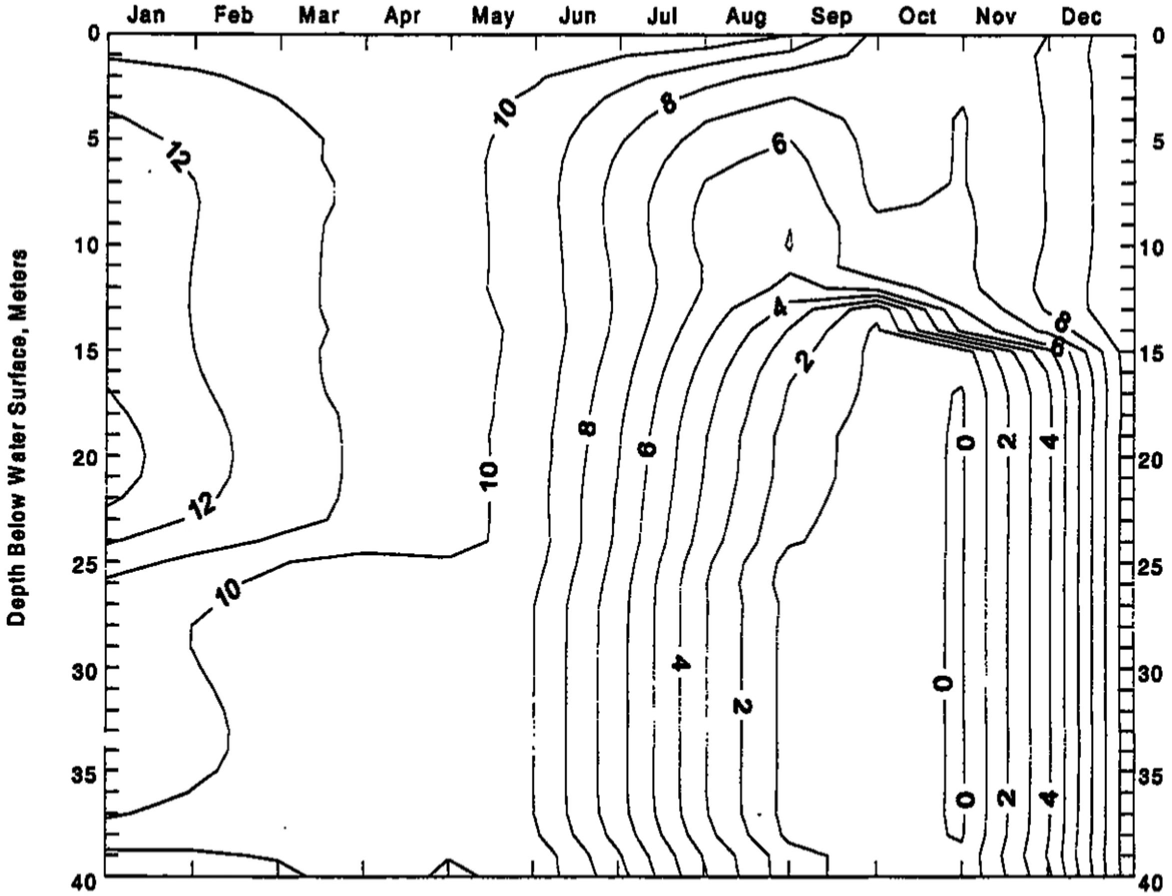


Figure 4. Dissolved oxygen in Lake Almanor in 1997, mg/L (DWR 2001).

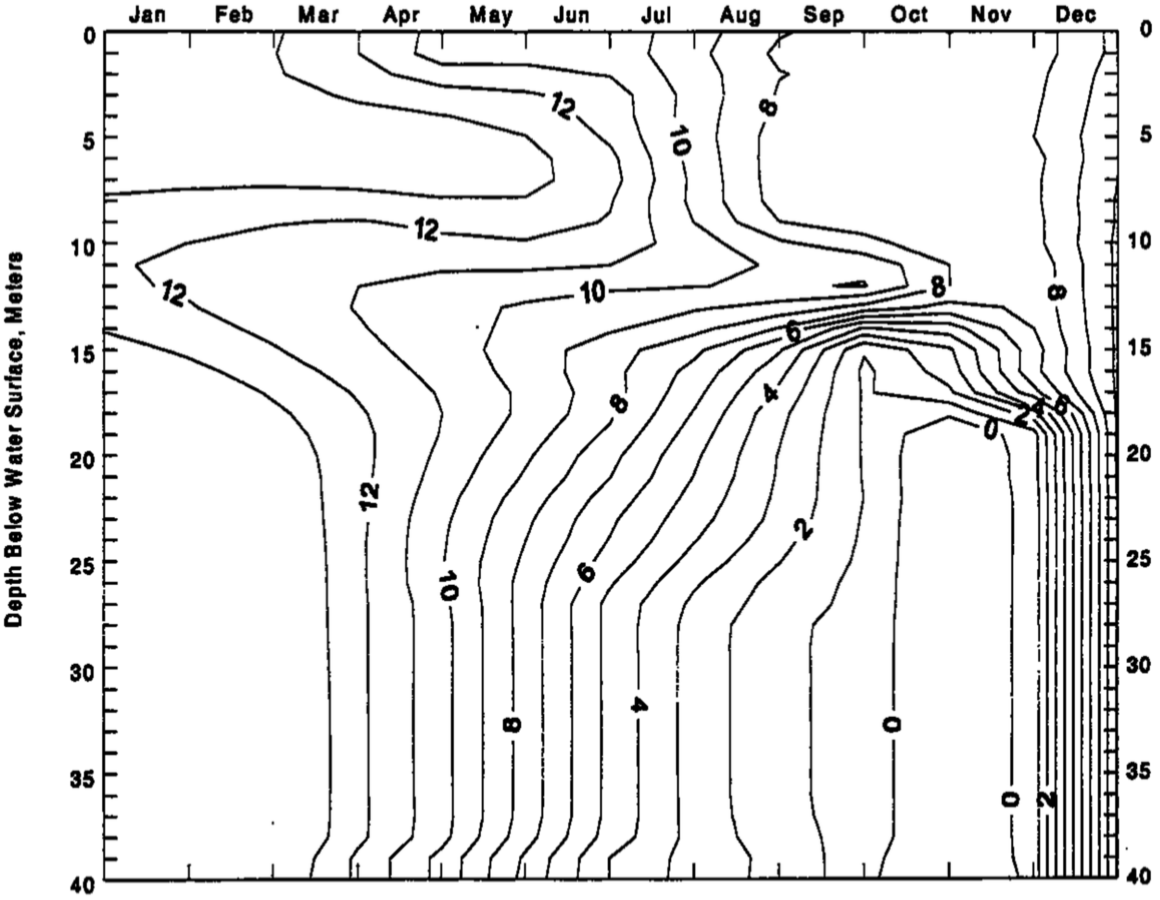


Figure 5. Dissolved oxygen in Lake Almanor in 1998, mg/L (DWR 2001).

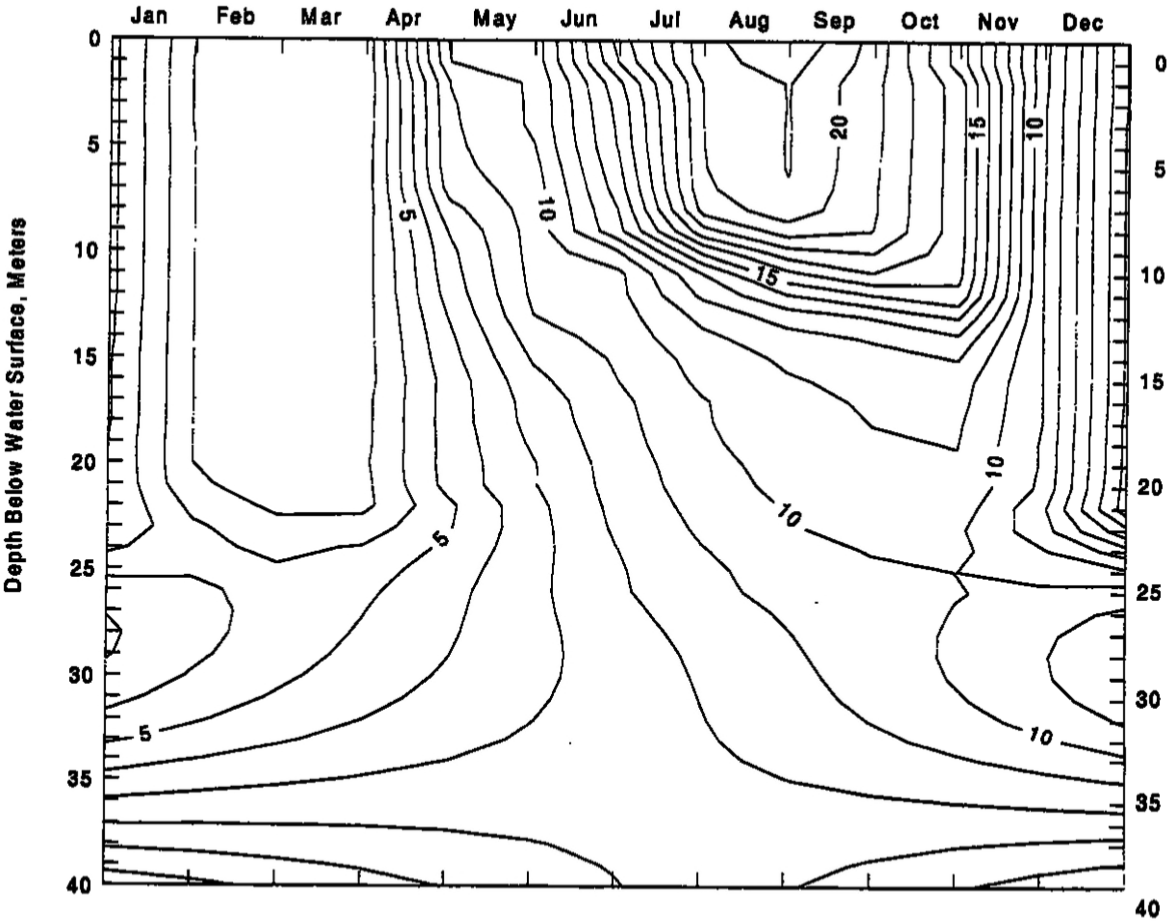


Figure 6. Annual temperature stratification in Lake Almanor in 1994, °C
(DWR 2001)

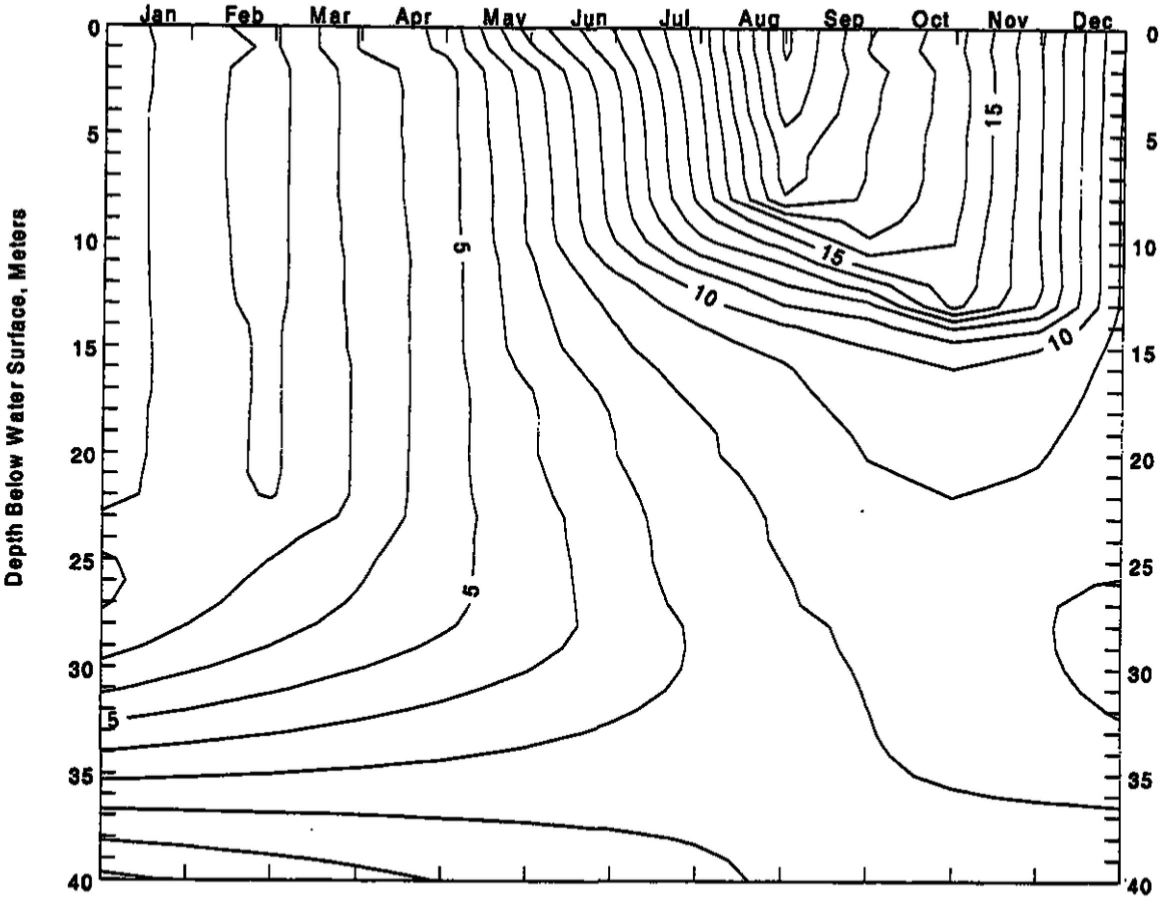


Figure 7. Annual temperature stratification in Lake Almanor in 1995, °C (DWR 2001).

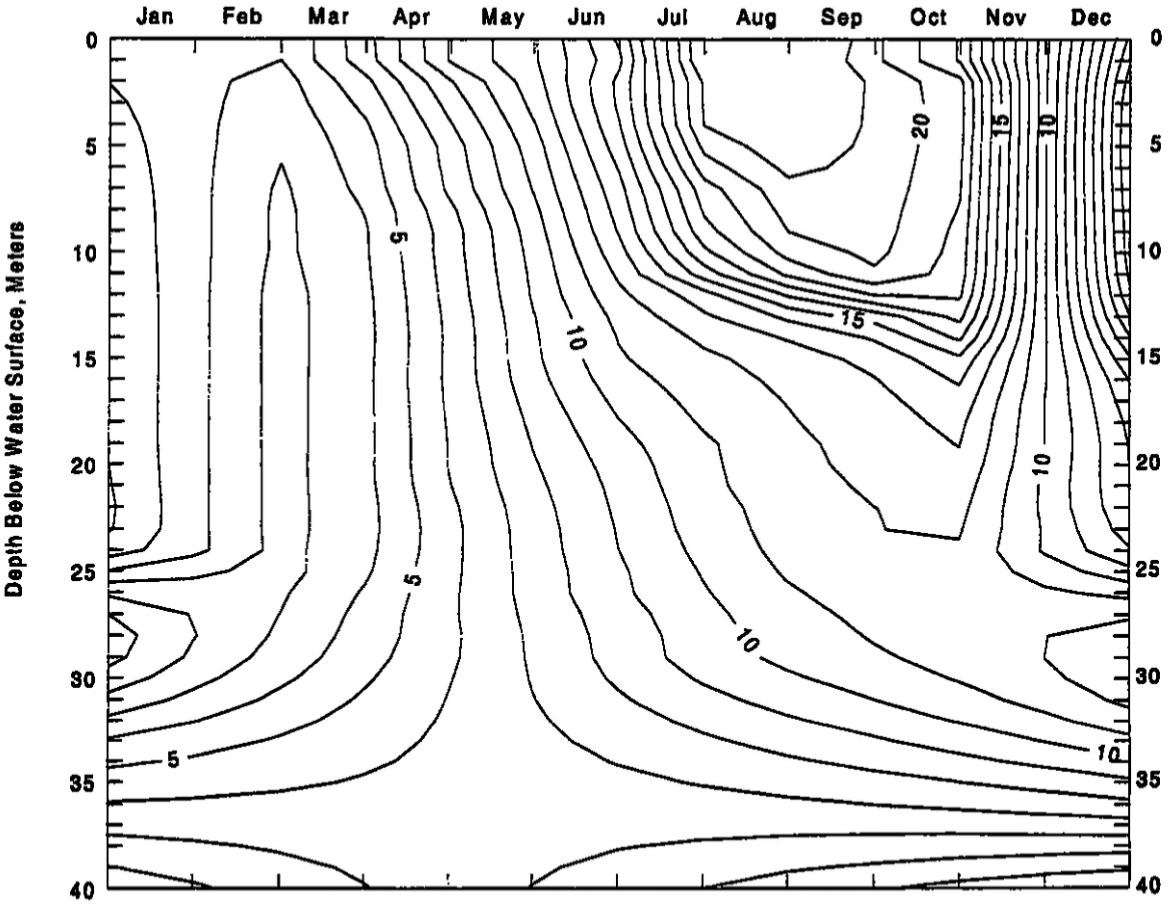


Figure 8. Annual temperature stratification in Lake Almanor in 1996, °C (DWR 2001).

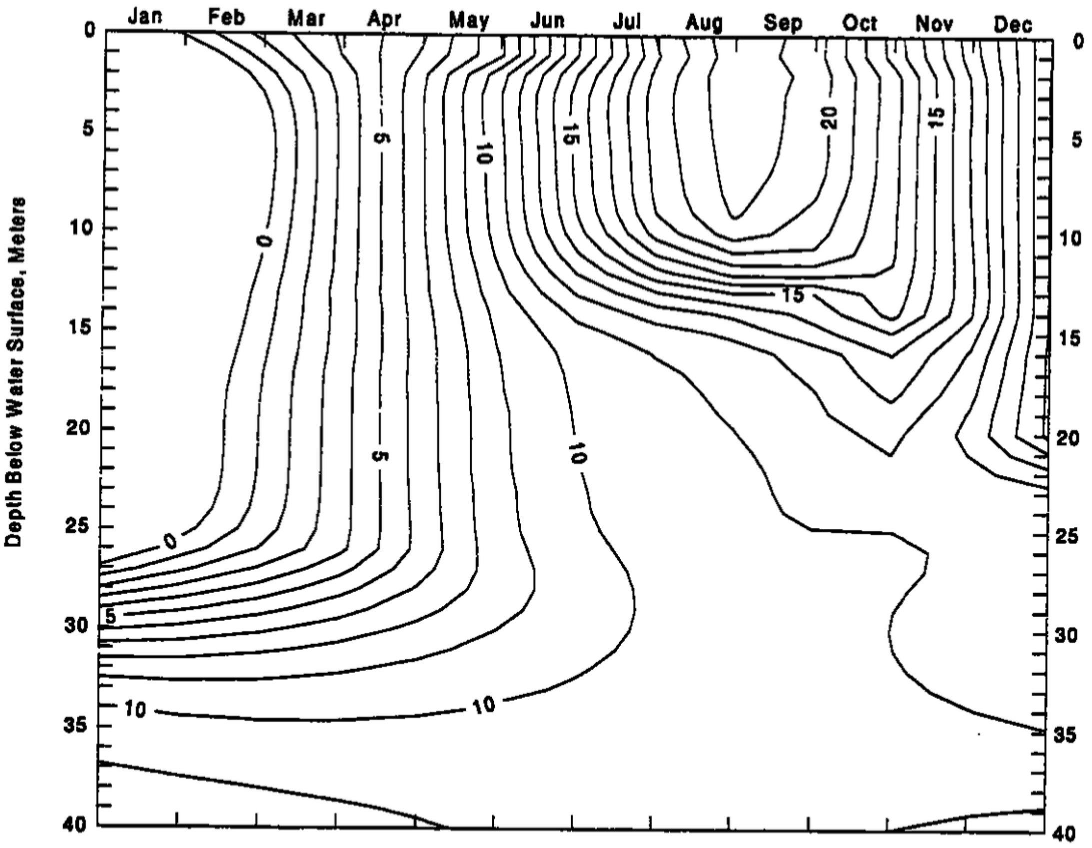


Figure 9. Annual temperature stratification in Lake Almanor in 1997, °C (DWR 2001).

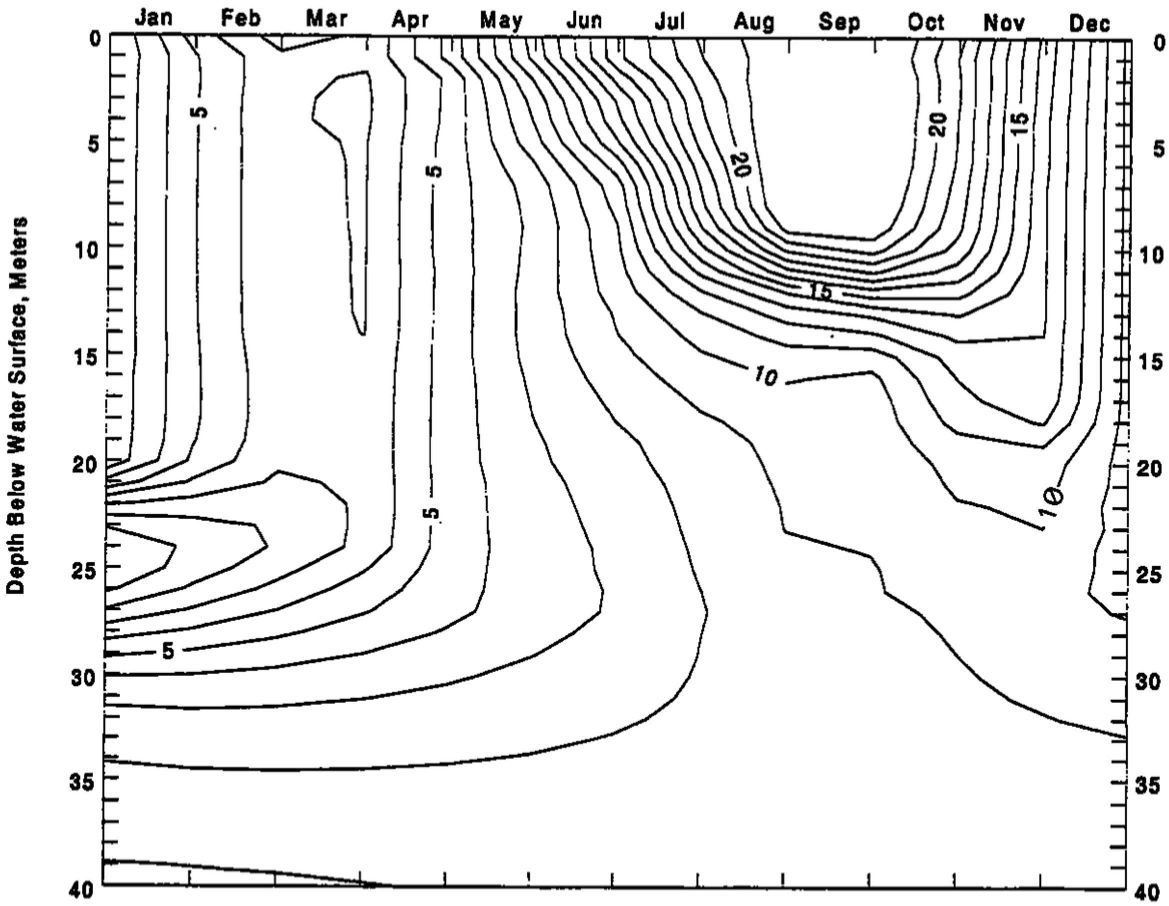


Figure 10. Annual temperature stratification in Lake Almanor in 1998, °C (DWR 2001).

DWR data for 2000 and 2001
Lake Almanor near the Intake Tower

Station Number	Station Name	Locality Used - AB Station Number	Date	Time (PST)	Depth (meters)	elevation (feet)	Secchi (meters)	Temp (degrees C)	Temp (degrees F)	D.O. (ppm)	pH (field)	EC (field) (umhos/cm)	Alkalinity (lab) (mg/L)	Turbidity (lab, NTU)
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	0.5	4489.6	3.3				8.6	86	50	2.1
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	1.0	4488.0		11.9	53.4	9.4				
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	2.0	4484.7		11.8	53.2	9.4				
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	3.0	4481.4		11.7	53.1	9.4	8.5	79	47	2.1
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	4.0	4478.1		11.7	53.1	9.4				
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	5.0	4474.8		11.7	53.1	9.4				
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	6.0	4471.6		11.7	53.1	9.4	8.4	79	48	2.1
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	7.0	4468.3		11.6	52.9	9.3				
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	8.0	4465.0		11.6	52.9	9.3				
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	9.0	4461.7		11.6	52.9	9.3	8.5	83	50	2.0
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	10.0	4458.4		11.6	52.9	9.3				
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	11.0	4455.2		11.6	52.9	9.3				
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	12.0	4451.9		11.6	52.9	9.3	8.4	83	48	2.2
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	13.0	4448.6		11.5	52.7	9.2				
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	14.0	4445.3		10.7	51.3	8.6				
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	15.0	4442.0		10.5	50.9	8.4	7.8	83	47	2.6
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	16.0	4438.7		10.3	50.5	8.3				
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	17.0	4435.5		9.5	49.1	7.9				
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	18.0	4432.2		9.2	48.6	7.7	7.5	84	50	2.4
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	19.0	4428.9		8.7	47.7	7.5				
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	20.0	4425.6		8.3	46.9	7.2				
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	21.0	4422.3		8.1	46.6	7.0	7.3	80	48	2.3
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	22.0	4419.1		8.1	46.6	7.0				
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	23.0	4415.8		7.9	46.2	7.0				
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	24.0	4412.5		7.8	46.0	6.9	7.4	83	48	2.5
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	25.0	4409.2		7.7	45.9	6.7				
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	26.0	4405.9		7.6	45.7	6.6				
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	27.0	4402.7		7.6	45.7	6.6	7.4	83	49	2.7
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	0.5	4490.4	4.8	16.5	61.7	8.5	8.4	97	49	1.2
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	1.0	4488.8		16.5	61.7	8.5				
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	2.0	4485.5		16.5	61.7	8.4				
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	3.0	4482.2		16.5	61.7	8.5	8.1	93	50	1.4
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	4.0	4478.9		16.4	61.5	8.4				
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	5.0	4475.6		16.4	61.5	8.5				
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	6.0	4472.4		16.3	61.3	8.5	8.1	92	50	1.3
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	7.0	4469.1		16.1	61.0	8.6				
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	8.0	4465.8		15.9	60.6	8.4				
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	9.0	4462.5		13.7	56.7	8.4	7.8	93	50	1.9
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	10.0	4459.2		12.9	55.2	8.3				
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	11.0	4456.0		12.8	55.0	8.2				
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	12.0	4452.7		12.5	54.5	7.8	7.4	95	47	1.9
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	13.0	4449.4		12.5	54.5	7.9				
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	14.0	4446.1		12.0	53.6	7.8				
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	15.0	4442.8		11.2	52.2	6.7	7.2	95	53	1.9
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	16.0	4439.6		10.6	51.1	5.7				
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	17.0	4436.3		9.9	49.8	4.8				
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	18.0	4433.0		9.5	49.1	4.0	7.1	97	52	2.6
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	19.0	4429.7		9.3	48.7	3.6				
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	20.0	4426.4		9.2	48.6	3.3				
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	21.0	4423.2		9.1	48.4	3.4	7.1	96	52	2.6
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	22.0	4419.9		9.1	48.4	3.3				
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	23.0	4416.6		9.0	48.2	3.4				
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	24.0	4413.3		9.0	48.2	3.4	7.0	98	51	3.1

DWR data for 2000 and 2001
Lake Almanor near the Intake Tower

Station Number	Station Name	Locally Used Station Identifier	Date	Time (PST)	Depth (meters)	Elevation (feet)	Secchi (meters)	Temp (degrees C)	Temp (degrees F)	D.O. (ppm)	pH (field)	EC (field) (umhos/cm)	Alkalinity (lab) (mg/L)	Turbidity (lab, NTU)
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	25.0	4410.0		8.9	48.0	3.4				
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	26.0	4406.7		8.7	47.7	3.3				
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	27.0	4403.5		8.6	47.5	2.8	7.0	97	53	4.0
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	0.5	4487.4	8.4	22.7	72.9	7.8	7.6	99	47	0.7
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	1.0	4485.7		22.5	72.5	7.7				
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	2.0	4482.4		22.3	72.1	7.5				
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	3.0	4479.2		22.3	72.1	7.7	7.5	95	46	0.6
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	4.0	4475.9		22.2	72.0	7.6				
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	5.0	4472.6		21.6	70.9	7.9				
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	6.0	4469.3		21.3	70.3	7.6	7.5	95	47	0.6
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	7.0	4466.0		21.0	69.8	7.8				
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	8.0	4462.8		20.8	69.4	7.8				
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	9.0	4459.5		20.6	69.1	7.9	7.5	94	47	0.7
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	10.0	4456.2		19.9	67.8	8.2				
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	11.0	4452.9		17.9	64.2	7.4				
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	12.0	4449.6		13.9	57.0	4.1	6.7	95	47	0.8
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	13.0	4446.3		12.3	54.1	1.6				
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	14.0	4443.1		11.3	52.3	0.2				
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	15.0	4439.8		10.9	51.6	0.0	6.4	98	48	1.3
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	16.0	4436.5		10.5	50.9	0.0				
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	17.0	4433.2		10.4	50.7	0.0				
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	18.0	4429.9		10.3	50.5	0.0	6.2	99	49	1.6
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	19.0	4426.7		10.3	50.5	0.0				
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	20.0	4423.4		10.2	50.4	0.0				
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	21.0	4420.1		10.1	50.2	0.0	6.1	99	48	1.8
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	22.0	4416.8		10.0	50.0	0.0				
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	23.0	4413.5		9.9	49.8	0.0				
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	24.0	4410.3		9.8	49.6	0.0	6.1	100	49	2.3
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	25.0	4407.0		9.6	49.3	0.0				
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	26.0	4403.7		9.5	49.1	0.0				
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	27.0	4400.4		9.3	48.7	0.0	7.3	94	46	0.7
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	28.0	4397.1		9.2	48.6	0.0				
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	0.5	4482.5	6.9	18.4	65.1	7.4	7.4	97	52	0.5
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	1.0	4480.9		18.3	64.9	7.4				
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	2.0	4477.6		18.0	64.4	7.5				
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	3.0	4474.3		17.9	64.2	7.5	7.4	97	51	0.4
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	4.0	4471.0		17.8	64.0	7.6				
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	5.0	4467.8		17.6	63.7	7.5				
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	6.0	4464.5		17.5	63.5	7.5	7.4	97	53	0.7
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	7.0	4461.2		17.5	63.5	7.4				
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	8.0	4457.9		17.5	63.5	7.4				
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	9.0	4454.6		17.4	63.3	7.2	7.4	96	49	0.7
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	10.0	4451.4		17.4	63.3	7.2				
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	11.0	4448.1		17.3	63.1	7.2				
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	12.0	4444.8		17.1	62.8	6.5	7.1	97	50	0.6
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	13.0	4441.5		16.7	62.1	5.7				
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	14.0	4438.2		15.7	60.3	3.0				
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	15.0	4434.9		13.2	55.8	0.5	6.8	98	50	0.7
A5L01071051	LK ALMANOR NR DM.	LA-01	09/07/00	1230	16.0	4431.7		12.7	54.9	0.4				
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	17.0	4428.4		12.0	53.6	0.3				

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DWR data for 2000 and 2001
Lake Almanor near the Intake Tower

Station Number	Station Name	Locally Used Station Identifier	Date	Time (PST)	Depth (meters)	elevation (feet)	Secchi (meters)	Temp (degrees C)	Temp (degrees F)	D.O. (ppm)	pH (field)	EC (field) (umhos/cm)	Alkalinity (lab) (mg/L)	Turbidity (lab, NTU)
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	18.0	4425.1		11.7	53.1	0.3	6.7	100	50	1.4
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	19.0	4421.8		11.6	52.7	0.3				
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	20.0	4418.5		11.3	52.3	0.3				
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	21.0	4415.3		11.2	52.2	0.3	6.7	100	50	1.5
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	22.0	4412.0		11.0	51.8	0.3				
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	23.0	4408.7		10.9	51.6	0.2				
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	24.0	4405.4		10.7	51.3	0.2	6.6	104	51	2.7
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	25.0	4402.1		10.6	51.1	0.2				
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	26.0	4398.9		10.5	50.9	0.2	6.5	111	52	5.5
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	0.5	4478.6	2.3	12.2	54.0	7.5	8.2	98	50	0.9
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	1.0	4477.0		12.1	53.8	7.5				
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	2.0	4473.7		11.8	53.2	7.6				
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	3.0	4470.4		11.8	53.2	7.7	8.1	97	50	0.9
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	4.0	4467.2		11.7	53.1	7.6				
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	5.0	4463.9		11.7	53.1	7.7				
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	6.0	4460.6		11.7	53.1	7.9	7.9	99	52	1.0
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	7.0	4457.3		11.7	53.1	7.9				
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	8.0	4454.0		11.7	53.1	7.7				
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	9.0	4450.8		11.6	52.9	7.6	7.8	99	50	1.4
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	10.0	4447.5		11.5	52.7	7.8				
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	11.0	4444.2		11.5	52.7	7.9				
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	12.0	4440.9		11.5	52.7	7.8	7.8	96	51	0.8
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	13.0	4437.6		11.5	52.7	7.7				
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	14.0	4434.4		11.4	52.5	7.7				
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	15.0	4431.1		11.4	52.5	7.7	7.8	98	50	0.8
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	16.0	4427.8		11.4	52.5	7.8				
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	17.0	4424.5		11.4	52.5	7.9				
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	18.0	4421.2		11.4	52.5	7.9	7.8	99	49	0.8
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	19.0	4418.0		11.4	52.5	7.9				
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	20.0	4414.7		11.4	52.5	7.3				
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	21.0	4411.4		11.3	52.3	7.1	7.7	99	50	1.3
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	22.0	4408.1		11.3	52.3	7.0				
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	23.0	4404.8		11.3	52.3	6.8				
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	24.0	4401.5		11.3	52.3	6.7				
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	25.0	4398.3		11.2	52.2	6.5	7.7	98	49	1.5
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	0.5		4.4	7.0	44.6	9.4	8.3	101	53	1.2
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	1.0			7.0	44.6	9.4				
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	2.0			6.9	44.4	9.7				
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	3.0			6.9	44.4	9.6	8.3	100	50	1.1
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	4.0			6.9	44.4	9.5				
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	5.0			6.9	44.4	9.4				
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	6.0			6.9	44.4	9.3	8.2	100	49	1.3
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	7.0			6.9	44.4	9.4				
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	8.0			6.9	44.4	9.2				
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	9.0			6.9	44.4	9.4	8.2	100	48	1.6
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	10.0			6.9	44.4	9.5				
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	11.0			6.9	44.4	9.5				
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	12.0			6.8	44.2	9.5	8.2	100	47	1.2
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	13.0			6.8	44.2	9.6				
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	14.0			6.8	44.2	9.5				

DWR data for 2000 and 2001
Lake Almanor near the Intake Tower

Station Number	Station Name	Locally Used Station Identifier	Date	Time (PST)	Depth (meters)	elevation (feet)	Secchi (meters)	Temp (degrees C)	Temp (degrees F)	D.O. (ppm)	pH (field)	EC (field) (umhos/cm)	Alkalinity (lab) (mg/L)	Turbidity (lab, NTU)
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	15.0			6.8	44.2	9.4	8.2	100	47	1.2
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	16.0			6.8	44.2	9.4				
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	17.0			6.8	44.2	9.5				
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	18.0			6.8	44.2	9.5	8.2	100	48	1.3
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	19.0			6.8	44.2	9.5				
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	20.0			6.8	44.2	9.5				
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	21.0			6.8	44.2	9.5	8.2	100	48	1.6
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	22.0			6.8	44.2	9.5				
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	23.0			6.8	44.2	9.5				
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	24.0			6.7	44.1	9.5				
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	25.0			6.7	44.1	9.5	8.2	100	48	1.7
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	0.0	4476.2	2.9	3.3	37.9	11.6	7.8	101	53	0.9
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	1.0	4472.9		3.2	37.8					
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	2.0	4469.7		3.2	37.8					
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	3.0	4466.4		3.2	37.8	11.5	7.8	101	52	0.9
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	4.0	4463.1		3.2	37.8					
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	5.0	4459.8		3.2	37.8					
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	6.0	4456.5		3.1	37.6	11.5	7.8	101	53	0.8
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	7.0	4453.3		3.1	37.6					
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	8.0	4450.0		3.1	37.6					
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	9.0	4446.7		3.1	37.6	11.4	7.8	101	53	1.0
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	10.0	4443.4		3.1	37.6					
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	11.0	4440.1		3.1	37.6					
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	12.0	4436.8		3.1	37.6	11.5	7.8	101	53	0.9
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	13.0	4433.6		3.1	37.6					
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	14.0	4430.3		3.1	37.6					
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	15.0	4427.0		3.1	37.6	11.3	7.8	101	53	0.9
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	16.0	4423.7		3.1	37.6					
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	17.0	4420.4		3.1	37.6					
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	18.0	4417.2		3.1	37.6	11.3	7.8	101	53	0.9
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	19.0	4413.9		3.1	37.6					
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	20.0	4410.6		3.1	37.6					
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	21.0	4407.3		3.1	37.6	11.2	7.8	101	53	1.2
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	22.0	4404.0		3.1	37.6					
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	23.0	4400.8		3.1	37.6					
A5L01071051	LK ALMANOR NR DM	LA-01	03/08/01	1300	24.0	4397.5		3.1	37.6	11.2	7.7	101	53	1.3
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	0.0	4478.1	3.5	7.8	46.0	10.0	8.0	102	53	1.1
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	1.0	4474.8		7.8	46.0	10.0				
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	2.0	4471.6		7.8	46.0	9.9				
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	3.0	4468.3		7.7	45.9	9.8	8.0	101	54	1.0
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	4.0	4465.0		7.6	45.7	9.8				
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	5.0	4461.7		7.5	45.5	9.8				
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	6.0	4458.4		7.4	45.3	9.8	8.1	101	53	1.0
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	7.0	4455.2		7.4	45.3	9.8				
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	8.0	4451.9		7.4	45.3	9.8				
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	9.0	4448.6		7.4	45.3	9.7	8.1	101	53	0.9
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	10.0	4445.3		7.3	45.1	9.8				
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	11.0	4442.0		7.3	45.1	9.8				
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	12.0	4438.8		7.3	45.1	9.7	8.1	101	53	0.9
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	13.0	4435.5		7.2	45.0	9.7				

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DWR data ... 2000 and 2001
Lake Almanor near the Intake Tower

Station Number	Station Name	Locally Used Station Identifier	Date	Time (PST)	Depth (meters)	elevation (feet)	Secchi (meters)	Temp (degrees C)	Temp (degrees F)	D.O. (ppm)	pH (field)	EC (field) (Umhos/cm)	Alkalinity (lab) (mg/L)	Turbidity (lab, NTU)
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	14.0	4432.2		7.1	44.8	9.5				
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	15.0	4428.9		7.0	44.6	9.6	8.1	101	55	0.9
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	16.0	4425.6		6.9	44.4	9.6				
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	17.0	4422.4		6.8	44.2	9.6				
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	18.0	4419.1		6.7	44.1	9.5	8.0	101	54	0.9
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	19.0	4415.8		6.7	44.1	9.6				
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	20.0	4412.5		6.2	43.2	9.7				
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	21.0	4409.2		6.1	43.0	9.3	7.9	101	53	0.9
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	22.0	4406.0		5.9	42.6	9.6				
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	23.0	4402.7		5.5	41.9	9.4				
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	24.0	4399.4		5.4	41.7	9.4				
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	25.0	4396.1		5.3	41.5	9.4	7.9	101	54	1.0
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	0.0	4480.0	7.4	19.2	66.6	7.9	8.3	104	54	0.5
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	1.0	4476.7		19.2	66.6	7.9 (w)				
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	2.0	4473.4		19.2	66.6	7.8				
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	3.0	4470.1		18.8	65.8	8.0	8.3	104	55	0.5
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	4.0	4466.9		18.5	65.3	8.0				
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	5.0	4463.6		18.5	65.3	8.0				
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	6.0	4460.3		18.3	64.9	8.0	8.3	104	54	0.5
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	7.0	4457.0		17.9	64.2	8.0				
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	8.0	4453.7		17.8	64.0	8.1				
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	9.0	4450.5		17.6	63.7	8.0	8.3	104	54	0.5
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	10.0	4447.2		17.2	63.0	8.0				
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	11.0	4443.9		16.6	61.9	8.1				
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	12.0	4440.6		14.4	57.9	8.4	8.1	104	54	0.7
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	13.0	4437.3		12.7	54.9	8.1				
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	14.0	4434.1		12.1	53.8	8.0				
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	15.0	4430.8		11.7	53.1	7.8	N/A	N/A	54	0.9
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	16.0	4427.5		11.3	52.3	7.4				
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	17.0	4424.2		10.9	51.6	7.1				
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	18.0	4420.9		10.6	51.1	7.1	7.7	103	54	
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	19.0	4417.7		10.0	50.0	5.9				
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	20.0	4414.4		9.8	49.6	5.4				
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	21.0	4411.1		9.5	49.1	5.3	7.5	105	54	1.7
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	22.0	4407.8		9.2	48.6	5.2				
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	23.0	4404.5		9.0	48.2	4.8				
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	24.0	4401.2		8.8	47.8	4.4			54	1.8
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1330	25.0	4398.0		8.4	47.1	2.2	7.6	104		
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	0.0	4478.0	8.0	21.9	71.4	7.9 (w)	8.4	107	57	0.5
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	1.0	4474.7		21.9	71.4	8.0				
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	2.0	4471.4		21.8	71.2	7.9				
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	3.0	4468.1		21.8	71.2	8.0	8.4	108	57	0.5
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	4.0	4464.9		21.5	70.7	8.0				
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	5.0	4461.6		21.3	70.3	8.1				
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	6.0	4458.3		21.2	70.2	8.2	8.4	110	55	0.6
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	7.0	4455.0		21.1	70.0	8.3				
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	8.0	4451.7		21.0	69.8	8.4				
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	9.0	4448.5		20.9	69.6	8.4	8.4	107	56	0.5
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	10.0	4445.2		20.3	68.5	8.3				
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	11.0	4441.9		18.4	65.1	8.1				

Station Number	Station Name	Locally Used Station Identifier	Date	Time (PST)	Depth (meters)	Elevation (feet)	Secchi (meters)	Temp (degrees C)	Temp (degrees F)	D.O. (ppm)	pH (field)	EC (field) (umhos/cm)	Alkalinity (lab) (mg/L)	Turbidity (lab, NTU)
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	12.0	4438.6		16.4	61.5	6.8	8.3	105	56	0.7
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	13.0	4435.3		15.1	59.2	5.3				
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	14.0	4432.1		14.1	57.4	4.3				
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	15.0	4428.8		13.6	56.5	3.9	7.8	107	55	0.9
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	16.0	4425.5		13.1	55.6	4.1				
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	17.0	4422.2		12.6	54.7	3.6				
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	18.0	4418.9		12.3	54.1	3.4	7.8	106	54	1.0
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	19.0	4415.7		11.8	53.2	3.3				
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	20.0	4412.4		11.5	52.7	2.9				
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	21.0	4409.1		11.2	52.2	2.2	7.6	107	55	1.4
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	22.0	4405.8		10.9	51.6	1.6				
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	23.0	4402.5		10.6	51.1	1.0				
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	24.0	4399.2		10.2	50.4	0.4	7.6	109		
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	25.0	4396.0		10.0	50.0	0.2			57	4.5
A5L01071051	LK ALMANOR NR DM	LA-01	09/06/01	1420	0.0	4475.3	4.7	21.5	70.7	7.5	8.5	118	61	0.7
A5L01071051	LK ALMANOR NR DM	LA-01	09/06/01	1420	1.0	4472.1		21.5	70.7	7.5				
A5L01071051	LK ALMANOR NR DM	LA-01	09/06/01	1420	2.0	4468.8		21.4	70.5	7.5				
A5L01071051	LK ALMANOR NR DM	LA-01	09/06/01	1420	3.0	4465.5		21.4	70.5	7.5	8.4	107	59	0.8
A5L01071051	LK ALMANOR NR DM	LA-01	09/06/01	1420	4.0	4462.2		20.8	69.4	7.8				
A5L01071051	LK ALMANOR NR DM	LA-01	09/06/01	1420	5.0	4458.9		20.8	69.4	7.8				
A5L01071051	LK ALMANOR NR DM	LA-01	09/06/01	1420	6.0	4455.7		20.8	69.4	7.7	8.3	107	60	0.9
A5L01071051	LK ALMANOR NR DM	LA-01	09/06/01	1420	7.0	4452.4		20.8	69.4	7.6				
A5L01071051	LK ALMANOR NR DM	LA-01	09/06/01	1420	8.0	4449.1		20.7	69.3	7.6				
A5L01071051	LK ALMANOR NR DM	LA-01	09/06/01	1420	9.0	4445.8		20.7	69.3	7.6	8.3	108	59	0.8
A5L01071051	LK ALMANOR NR DM	LA-01	09/06/01	1420	10.0	4442.5		20.6	69.1	7.6				
A5L01071051	LK ALMANOR NR DM	LA-01	09/06/01	1420	11.0	4439.3		20.5	68.9	7.3				
A5L01071051	LK ALMANOR NR DM	LA-01	09/06/01	1420	12.0	4436.0		20.5	68.9	7.3	8.1	107	58	1.0
A5L01071051	LK ALMANOR NR DM	LA-01	09/06/01	1420	13.0	4432.7		20.4	68.7	7.2				
A5L01071051	LK ALMANOR NR DM	LA-01	09/06/01	1420	14.0	4429.4		17.9	64.2	0.5				
A5L01071051	LK ALMANOR NR DM	LA-01	09/06/01	1420	15.0	4426.1		16.2	61.2	0.4	6.8	108	56	3.2
A5L01071051	LK ALMANOR NR DM	LA-01	09/06/01	1420	16.0	4422.8		15.1	59.2	0.4				
A5L01071051	LK ALMANOR NR DM	LA-01	09/06/01	1420	17.0	4419.6		14.1	57.4	0.4				
A5L01071051	LK ALMANOR NR DM	LA-01	09/06/01	1420	18.0	4416.3		13.4	56.1	0.4	6.6	109	55	3.0
A5L01071051	LK ALMANOR NR DM	LA-01	09/06/01	1420	19.0	4413.0		12.6	54.7	0.3				
A5L01071051	LK ALMANOR NR DM	LA-01	09/06/01	1420	20.0	4409.7		12.2	54.0	0.3	6.6	112	55	2.9

DWR data for 2000 and 2001
Lake Alamnor near the Intake Tower

Station Number	Station Name	Locally Used Station Identifier	Date	Time (PST)	Depth (meters)	Dissolved Ca (mg/L)	Dissolved Mg (mg/L)
A5L01071051	LK ALMANOR NR DM	LA-01	05/08/00	1000	0.5	8	4
A5L01071051	LK ALMANOR NR DM	LA-01	05/08/00	1000	27.0	8	4
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	0.5	10	5
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	25.5	10	5
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	0.5	9	5
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	25.5	9	5

Station Number	Station Name	Locally Used Station Identifier	Date	Time (PST)	Depth (meters)	Dissolved Na (mg/L)	Dissolved K (mg/L)
A5L01071051	LK ALMANOR NR DM	LA-01	05/08/00	1000	0.5	4	1.1
A5L01071051	LK ALMANOR NR DM	LA-01	05/08/00	1000	27.0	4	1.1
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	0.5	4	1.3
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	25.5	4	1.3
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	0.5	4	1.3
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	25.5	4	1.2

Station Number	Station Name	Station Identifier	Date	(PST)	(meters)	Dissolved SO4 (mg/L)	Dissolved Cl (mg/L)
A5L01071051	LK ALMANOR NR DM	LA-01	05/08/00	1000	0.5	2	<1
A5L01071051	LK ALMANOR NR DM	LA-01	05/08/00	1000	27.0	2	<1
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	0.5	<1.0	<1
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	25.5	<1.0	<1
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	0.5	<1	<1
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	25.5	<1	<1

DWR data for 2000 and 2001
Lake Alamnor near the Intake Tower

Station Number	Station Name	Station Identifier	Date	(PST)	(meters)	Dissolved Hardness (as CaCO3 mg/L)	Dissolved B (mg/L)
A5L01071051	LK ALMANOR NR DM	LA-01	05/08/00	1000	0.5	36	
A5L01071051	LK ALMANOR NR DM	LA-01	05/08/00	1000	27.0	36	
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	0.5	46	
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	25.5	46	
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	0.5	43	<0.1
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	25.5	43	<0.1

DWR data for 2000 and 2001
Lake Almanor near the Intake Tower

Station Number	Station Name	Locally Used Station Identifier	Date	Time (PST)	Depth (meters)	Al (µg/L)	Ag (µg/L)	As (µg/L)	Cu (µg/L)	Total Fe (µg/L)	Total Mn (µg/L)
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	0.5	63.5		0.258		62.9	12.2
A5L01071051	LK ALMANOR NR DM	LA-01	05/11/00	1000	27.0	50.9		0.333		149	42.5
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	0.5	29.5		0.269		30.8	5.94
A5L01071051	LK ALMANOR NR DM	LA-01	06/08/00	0900	30.0	62.2		0.325		134	116
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	0.5	14.3		0.307		12.0	2.78
A5L01071051	LK ALMANOR NR DM	LA-01	07/21/00	1100	28.0	13.2		0.849		621	162
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	0.5	15.4		0.32		19.3	9.94
A5L01071051	LK ALMANOR NR DM	LA-01 Dup	09/07/00	1230	0.5	14.2		0.315		16.0	9.53
A5L01071051	LK ALMANOR NR DM	LA-01	09/07/00	1230	26.0	10.8		0.858		931	496
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	0.5	7.5		0.521		124	71.7
A5L01071051	LK ALMANOR NR DM	LA-01	11/02/00	1045	25.0	13.3		0.661		313	253
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	0.5	13.5		0.353		41.8	19.5
A5L01071051	LK ALMANOR NR DM	LA-01 Dup	12/08/00	1030	0.5	11:2		0.316		39.1	20.2
A5L01071051	LK ALMANOR NR DM	LA-01	12/08/00	1030	25.0	366		0.534		648	44.3
A5L01071051	LK ALMANOR NR DM	LA-01 Dup	04/12/01	1330	0.5	29	<0.002		0.27	35.3	9.16
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	0.5	28.7	<0.002		0.26	35.3	9.04
A5L01071051	LK ALMANOR NR DM	LA-01	04/12/01	1330	25.0	61.3	<0.002		0.32	141	57.5
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1320	0.5	15.2	<0.003	0.250	0.34	12.6	4.60
A5L01071051	LK ALMANOR NR DM	LA-01	06/07/01	1320	25.0	34.5	<0.003	0.393	0.29	178	122
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	0.5	17.1	<0.002	0.283	0.23	13.2	5.06
A5L01071051	LK ALMANOR NR DM	LA-01	07/19/01	1415	25.0	12.1	<0.002	0.622	0.16	433	285
A5L01071051	LK ALMANOR NR DM	LA-01 Dup	07/19/01	1415	0.5	13.1	<0.002	0.278	0.23	12.4	5.16
A5L01071051	LK ALMANOR NR DM	LA-01	09/06/01	1420	0.5	11.6	0.003	0.374	0.29	24.6	10.9
A5L01071051	LK ALMANOR NR DM	LA-01	09/06/01	1420	21.1	11	<0.001	0.887	0.32	364	653
A5L01071051	LK ALMANOR NR DM	LA-01 Dup	09/06/01	1420	0.5	12	<0.001	0.413	0.31	24.1	11.1

Appendix D

CERTIFIED ANALYTICAL REPORTS
AND
CHAIN-OF-CUSTODY DOCUMENTATION

BASIC
LABORATORY

Report To:	PG&E 3400 CROW CANYON RD. SAN RAMON, CA 94583
Attention:	ELIZABETH GUENTHER
Project Name:	NFFR / LAKE ALMANOR
Sample Description:	WATER TESTING

Lab No:	200107280
Date:	07/25/01
Phone:	(925) 866-5472
Date Sampled:	07/10/01
Date Received:	07/10/01

AMENDED

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Method:	***Test:***	***Units***	***NF4***	***NF3***	***SF***	***NF2a***	***MS***	***NF2***	***LA1-U***	***LA1-L***	***Reporting Limit:***	***Date Analyzed***
4500 S	Sulfide	ug/l	n	n	n	n	10.2	n	n	n	2.6	07/20/01
2540	Total Dissolved Solids	mg/l	97	73	65	52	112	60	58	50	5	07/13/01
2540 D	Total Suspended Solids	mg/l	n	n	n	n	7	n	3	4	3	07/12/01
5310	Total Organic Carbon	mg/l	n	n	1.6	1.9	n	1.4	2.8	1.7	1.0	07/16/01
4500 NH3	Ammonia @ N	mg/l	0.18	0.25	0.16	0.15	0.40	0.24	0.13	0.38	0.05	07/17/01
6010A	Dissolved Iron	ug/l	n	n	n	n	3660	n	n	131	50	07/18/01
6010A	Dissolved Manganese	ug/l	1	n	3	24	2900	28	3	217	1	07/18/01
2120	Color	units	n	n	n	5	20	10	n	10	5	07/11/01
2150	Odor	T.O.N.	n	n	n	n	n	n	n	n	2	07/11/01

Comments: California D.O.H.S. Cert. #1677.
n - Not detected at the reporting limit.
Amended on 08/08/01 to include QA/QC information as requested per the client.

Reported by: JB Hawley

Report To:	PG&E 3400 CROW CANYON RD. SAN RAMON, CA 94583	***Lab No:***	200107280QAQC
		Date:	07/25/01
		Phone:	(925) 866-5472
		Date Sampled:	07/10/01
Attention:	ELIZABETH GUENTHER	***Date Received:***	07/10/01
Project Name:	NFFR / LAKE ALMANOR		
Sample Description:	WATER TESTING / QAQC	***AMENDED***	

Page 2 of 3

Method:	***Test:***	***Units***	***Method Blank***	***Duplicate % RPD***	***Spike %Recovery***	***LCS % Recovery***	***Reporting Limit:***	***Date Analyzed***
4500 S	Sulfide	ug/l	n	0.0	91.8	91.8	2.6	07/20/01
2540	Total Dissolved Solids	mg/l	n	3.0	81.6	81.6	5	07/13/01
2540 D	Total Suspended Solids	mg/l	n	0.0	82.0	82.0	3	07/12/01
5310	Total Organic Carbon	mg/l	n	+/-RLS	95.0	95.0	1.0	07/18/01
4500 NH3	Ammonia @ N	mg/l	n	0.0	95.3	95.3	0.05	07/17/01
6010A	Dissolved Iron	ug/l	n	0.0	96.8	96.8	50	07/18/01
6010A	Dissolved Manganese	ug/l	n	1.4	94.6	94.6	1	07/18/01

Comments: California D.O.H.S. Cert. #1677.
n - Not detected at the reporting limit.
Amended on 08/08/01 to include QA/QC information as requested per the client.

Reported by: Hawley

BASIC
LABORATORY

Report To: PG&E
3400 CROW CANYON RD.
SAN RAMON, CA 94583

Attention: ELIZABETH GUENTHER

Lab No: 200107280
Date: 07/25/01
Phone: (925) 866-5472
Date Sampled: 07/10/01
Date Received: 07/10/01

Project Name: NFFR / LAKE ALMANOR
Sample Description: PRECIPITATE

AMENDED

Page 3 of 3

TEST:	**Total Iron**	**Total Manganese**	**Silver**	**%Solids**
METHOD:	6010A	6010A	6010A	2540
UNITS:	mg/kgW	mg/kgW	mg/kgW	%
REPORTING LIMIT:	10.0	1.0	4.0	0.02
DATE ANALYZED:	07/18/01	07/18/01	07/18/01	07/13/01
Sample ID				
MS	7370	349	n	1.7
Method Blank	n	n	n	
Duplicate % RPD	2.1	2.3	0.0	0.7
Spike % Recovery	81.0	80.0	91.8	
LCS % Recovery	88.0	86.5	82.8	

Comments: California D.O.H.S. Cert. #1677.
n - Not detected at the reporting limit.
Amended on 08/08/01 to include QA/QC information as requested per the client.

Reported by: JE Hawley

6 Samp

BASIC LABORATORY CHAIN OF CUSTODY RECORD

2218 Railroad Avenue, Redding, CA 96001 (530) 243-7234 FAX 243-7494

CLIENT NAME: S+E

ADDRESS: 3400 Crow Canyon Rd.
[illegible] Ramon, CA 94583

PROJECT NAME: NFFR/Lake Almanor

PROJECT #:

LAB #: 20010728C

REQUESTED COMP. DATE: 7/25/01

SAMP: 8

TURN AROUND TIME: STD ☒ RUSH ☐

PAGE ___ OF ___

PROJECT MANAGER: Elizabeth Guenther

PHONE: 925-866-5972

FAX: 925-866-5681

E-MAIL:

INVOICE TO: PGE (invoice desk)
3400 Crow Canyon Rd, San Ramon

CWA 3500032917

SPECIAL MAIL ☐ E-MAIL ☐ FAX ☐

REP:

I.D.#

SYSTEM #:

CUST. SEAL

ICE

QC = 1 [✓ 2] 3 4

ANALYSES REQUESTED

DATE	TIME	WATER	COMP	SOIL	SAMPLE DESCRIPTION	# OF BOTTLES	Color, Odor, TSS, TDS*	Dissolved Fe, Mn*	Ammonia Nitrogen	TOC	SO4 (Field)*	Total Fe, Mn, Ag	% Solids				LAB ID	REMARKS
7/10	8:53	X			NF4		1	1	1	1	1						1	* Field
7/10	10:21	X			NF3		1	1	1	1	1						2	filtered
7/10	11:20	X			SF		1	1	1	1	1						3	
7/10	12:02	X			NF2a		1	1	1	1	1						4	
7/10	12:36	X			MS		1	1	1	1	1		one				5	
'0	12:55	X			NF2		1	1	1	1	1						6	
7/10	13:41	X			LA1-U		1	1	1	1	1						7	
7/10	13:53	X			LA1-L		1	1	1	1	1						8	
7/10	12:36			X	MS-Precip							1	D				9	

PRESERVATIONS HNO₃ ☐ H₂SO₄ ☐ NaOH ☐ ZnAce/NaOH ☐ HCL ☐ Nathio ☐

SAMPLED BY: Elizabeth Guenther	DATE/TIME: 7/10/01	RELINQUISHED BY: Elizabeth Guenther	DATE/TIME: 7/10/01 16:58
RECEIVED BY:	DATE/TIME:	RELINQUISHED BY:	DATE/TIME:
RECEIVED BY:	DATE/TIME:	RELINQUISHED BY:	DATE/TIME:
RECEIVED BY LAB: Julie McNeall	DATE/TIME: 7/10/01 5:05 pm	SAMPLE SHIPPED VIA: UPS POST BUS FED-EX OTHER ______	

INSTRUCTIONS, TERMS, CONDITIONS ON BACK.

BASIC
LABORATORY

Report To:	PG&E 3400 CROW CANYON RD. SAN RAMON, CA 94583	***Lab No:***	200108238
		Date:	08/22/01
		Phone:	(925) 866-5472
		Date Sampled:	08/07/01
Attention:	ELIZABETH GUENTHER	***Date Received:***	08/07/01
Project Name:	NFFR / LAKE ALMANOR		
Sample Description:	WATER TESTING		

Method:	***Test:***	***Units***	***MS***	***NF2A***	***NF2***	***NF4***	***SE***	***NF3***	***Reporting Limit:***	***Date Analyzed***
4500 SE.	Sulfide	ug/l	8.1	n	n	2.8	n	n	1.7	08/20/01
2540	Total Dissolved Solids	mg/l	123	59	62	103	65	73	5	08/10/01
2540 D	Total Suspended Solids	mg/l	11	4	5	n	n	n	3	08/09/01
5310	Total Organic Carbon	mg/l	1.0	1.8	1.4	n	1.1	n	1.0	08/14/01
4500 NH3	Ammonia @ N	mg/l	n	n	n	n	n	n	0.05	08/10/01
6010A	Dissolved Iron	ug/l	3700	n	n	n	n	n	50	08/20/01
6010A	Dissolved Manganese	ug/l	3230	44	36	5	5	3	1	08/20/01
6010A	Dissolved Silver	ug/l	n	3	n	n	n	n	1	08/20/01
2120	Color	units	30	15	20	5	5	5	5	08/08/01
2150	Odor	T.O.N.	n	3	n	n	n	n	2	08/08/01

Comments: California D.O.H.S. Cert. #1677.
n - Not detected at the reporting limit.

Reported by: Hawley

BASI

LABORATOR

Report To:	PG&E 3400 CROW CANYON RD. SAN RAMON, CA 94583
Attention:	ELIZABETH GUENTHER
Project Name:	NFFR / LAKE ALMANOR
Sample Description:	WATER TESTING / QAQC

Lab No:	200108238QAQC
Date:	08/22/01
Phone:	(925) 866-5472
Date Sampled:	08/07/01
Date Received:	08/07/01

Page 2 of 3

Method:	***Test:***	***Units***	***Method Blank***	***Duplicate % RPD***	***Spike %Recovery***	***LCS % Recovery***	***Reporting Limit:***	***Date Analyzed***
4500 SE.	Sulfide	ug/l	n	6.9	79.7	100	1.7	08/20/01
2540	Total Dissolved Solids	mg/l	n	6.3		99.0	5	08/10/01
2540 D	Total Suspended Solids	mg/l	n	5.0		83.0	3	08/09/01
5310	Total Organic Carbon	mg/l	n	0.0	92.2	94.0	1.0	08/14/01
4500 NH3	Ammonia @ N	mg/l	n	0.0	86.3	106	0.05	08/10/01
6010A	Dissolved Iron	ug/l	n	2.5	115	106	50	08/20/01
6010A	Dissolved Manganese	ug/l	n	1.7	114	111	1	08/20/01
6010A	Dissolved Silver	ug/l	n	0.0	115	111	1	08/20/01

Reported by: Hawley

BASIC

LABORATORY

Report To:	PG&E 3400 CROW CANYON RD. SAN RAMON, CA 94583	***Lab No:***	200108238
		Date:	08/22/01
		Phone:	(925) 866-5472
		Date Sampled:	08/07/01
Attention:	ELIZABETH GUENTHER	***Date Received:***	08/07/01
Project Name:	NFFR / LAKE ALMANOR		
Sample Description:	PRECIPITATE	***Page 3 of 3***	

TEST:	***Total*** ***Iron***	***Total*** ***Manganese***	***Total*** ***Silver***
METHOD:	6010A	6010A	6010A
UNITS:	mg/kgW	mg/kgW	mg/kgW
REPORTING LIMIT:	10.0	1.0	4.0
DATE ANALYZED:	08/13/01	08/13/01	08/13/01
Sample ID			
MS Precipitate	11300	419	n
Method Blank	n	n	n
Duplicate % RPD	0.6	0.4	0.0
Spike % Recovery	104	108	108
LCS % Recovery	93.9	96.5	95.8

Comments: California D.O.H.S. Cert. #1677.
n - Not detected at the reporting limit.
mg/kgW.- Wet weight.

Reported by: Hawley

BASIC LABORATORY CHAIN OF CUSTODY RECORD

2218 Railroad Avenue, Redding, CA 96001 (530) 243-7234 FAX 243-7494

CLIENT NAME: PGE Elizabeth Guenther

PROJECT NAME: NFFR / Lake Almanor

PROJECT #:

LAB #: 20010823

ADDRESS: 3400 Crow Canyon Rd
San Ramon CA 94583

REQUESTED COMP. DATE: 8/22/01

SAMP: 7

TURN AROUND TIME: STD ☒ RUSH ☐

PAGE 1 OF 1

PROJECT MANAGER:

PHONE: 925-866-5492

FAX: 925-866-5681

E-MAIL: eago@pge.com

INVOICE TO: PGE

PO#: CWA 3500032917

SPECIAL MAIL ☐ E-MAIL ☐ FAX ☒

REP:

I.D.#

SYSTEM #:

CUST. SEAL

ICE

QC = 1 [✓ 2] 3 4

ANALYSES REQUESTED

DATE	TIME	WATER	COMP	SOIL	SAMPLE DESCRIPTION	# OF BOTTLES	Color/odor/TSS/TDS	diss. Fe/Mn/and Silver	Ammonia Nitrogen	TOC	Sulfide* (Special test-ppb)	Total Fe, Mn, Silver	LAB ID	REMARKS
8/7	12:55	X			MS	5	X	X	X	X	X		1	diss Fe, Mn, Siln
8/7	12:10	X			NF2a	5	X	X	X	X	X		2	samples were
8/7	13:17	X			NF2	5	X	X	X	X	X		3	field filtered
8/7	13:07				MS precipitate	1						X	4	
8/7	8:55	X			NF4	5	X	X	X	X	X		5	Sulfide samples
8/7	11:22	X			SF	5	X	X	X	X	X		6	were field
8/7	10:30	X			NF3	5	X	X	X	X	X		7	filtered
														*ULTRALOW LEVEL
								these were field filtered			these were field filtered			

PRESERVATIONS HNO$_3$ ☑ H$_2$SO$_4$ ☑ NaOH ☐ ZnAce/NaOH ☑ HCL ☐ Nathio ☐

SAMPLED BY: Elizabeth Guenther	DATE/TIME: 8/7/01	RELINQUISHED BY: Elizabeth Guenther	DATE/TIME: 8/7/01 16:22
RECEIVED BY:	DATE/TIME:	RELINQUISHED BY:	DATE/TIME:
RECEIVED BY:	DATE/TIME:	RELINQUISHED BY:	DATE/TIME:
RECEIVED BY LAB: Julie McNeall	DATE/TIME: 8/7/01 4:22 pm	SAMPLE SHIPPED VIA: UPS POST BUS FED-EX OTHER ____	

INSTRUCTIONS, TERMS, CONDITIONS ON BACK.

BASIC
LABORATORY

Report To: PG&E
3400 CROW CANYON RD.
SAN RAMON, CA 94583

Attention: ELIZABETH GUENTHER

Project Name: FEATHER RIVER / LAKE ALMANOR

Sample Description: WATER TESTING

Lab No: 200108290
Date: 08/28/01
Phone: (925) 866-5472
Date Sampled: 08/08/01
Date Received: 08/08/01

Page 1 of 3

Method:	Test:	Units	LA1-L	LA1-U	Reporting Limit:	Date Analyzed
4500 S	Sulfide	ug/l	n	n	1.7	08/20/01
2540	Total Dissolved Solids	mg/l	63	67	5	08/10/01
2540 D	Total Suspended Solids	mg/l	54	n	3	08/09,10/01
5310	Total Organic Carbon	mg/l	1.2	2.3	1.0	08/14/01
4500 NH3	Ammonia @ N	mg/l	n	n	0.05	08/17/01
6010A	Iron - Dissolved	ug/l	n	n	50	08/20/01
6010A	Manganese - Dissolved	ug/l	184	1	1	08/20/01
6010A	Silver - Dissolved	ug/l	n	n	1	08/20/01
2120	Color	units	15	n	5	08/09/01
2150	Odor	T.O.N.	n	n	2	08/09/01

Comments: California D.O.H.S. Cert. #1677.
n - Not detected at the reporting limit.

Reported by: JB Hawley

BASIC
ABORATORY

Report To:	PG&E 3400 CROW CANYON RD. SAN RAMON, CA 94583	***Lab No:***	200108290
		Date:	08/28/01
		Phone:	(925) 866-5472
		Date Sampled:	08/08/01
Attention:	ELIZABETH GUENTHER	***Date Received:***	08/08/01
Project Name:	FEATHER RIVER / LAKE ALMANOR		
Sample Description:	SOIL TESTING		

Page 2 of 3

Method:	***Test:***	***Units***	***S1***	***S2***	***S3***	***S4***	***Reporting Limit:***	***Date Analyzed***
*	Total Organic Carbon	mg/kgW	17000	21400	12300	31500	0.03	08/10/01
4500 SO4	Sulfate	mg/kgW	2.61	7.86	9.63	n	1.20	08/21/01
4500S	Sulfide	mg/kgW	4.45		1.47	2.39	1.18	08/23/01
4500S	Sulfide	mg/kgW		40.2			2.14	08/23/01
6010A	Iron - Total	mg/kgW	8540	3320	2400	2850	10.0	08/14/01
6010A	Manganese - Total	mg/kgW	154	70.0	72.4	79.3	1.0	08/14/01
6010A	Silver - Total	mg/kgW	n	n	n	n	4.0	08/14/01

Comments:

California D.O.H.S. Cert. #1677.
n - Not detected at the reporting limit.
* - ASA #9 Methods of Soil Analysis PII 29-3..5.2
mg/kgW - Wet weight

Reported by: JE Hawley

200108290.xls

BASIC
ABORATORY

Report To:	PG&E 3400 CROW CANYON RD. SAN RAMON, CA 94583	***Lab No:***	200108290QAQC
		Date:	08/28/01
		Phone:	(925) 866-5472
Attention:	ELIZABETH GUENTHER	***Date Sampled:***	08/08/01
		Date Received:	08/08/01
Project Name:	FEATHER RIVER / LAKE ALMANOR		
Sample Description:	WATER TESTING / QAQC		

Page 3 of 3

Method:	*Test:*	*Units*	*Method Blank*	*Duplicate % RPD*	*Spike %Recovery*	*LCS % Recovery*	*Reporting Limit:*	*Date Analyzed*
4500 S	Sulfide	ug/l	n	6.9	79.7	100	1.7	08/20/01
4500 SO4	Sulfate	mg/l	n	4.3	91.6	110	0.4	08/21/01
2540	Total Dissolved Solids	mg/l	n	4.6		99.0	5	08/10/01
2540 D	Total Suspended Solids	mg/l	n	0.0		92.6	3	08/09,10/01
5310	Total Organic Carbon	mg/l	n	0.0	92.2	94.0	1.0	08/14/01
4500 NH3	Ammonia @ N	mg/l	n	0.0	103	87.1	0.05	08/17/01
6010A	Iron - Dissolved	ug/l	n	2.7	108.	106	50	08/20/01
6010A	Manganese - Dissolved	ug/l	n	1.6	114	111	1	08/20/01
6010A	Silver - Dissolved	ug/l	n	0.0	111	111	1	08/20/01

Comments: California D.O.H.S. Cert.#1677
n - Not detected at the reporting limit.

Reported by: JHawley

8888

BASIC LABORATORY CHAIN OF CUSTODY RECORD

2218 Railroad Avenue, Redding, CA 96001 (530) 243-7234 FAX 243-7494

CLIENT NAME: PGE

RESS:
3400 Crow Canyon Rd
San Ramon CA 94583

PROJECT NAME: Feather River/Lake Almanor

PROJECT #:

LAB #: 20010829C

REQUESTED COMP. DATE: 8/23/01

SAMP: 6

TURN AROUND TIME: STD ☒ RUSH ☐

PAGE 1 OF 1

PROJECT MANAGER: Elizabeth Guenther

PHONE: 925-866-5492

FAX: 925-866-5681

E-MAIL: eag4@pge.com

INVOICE TO: Elizabeth Guenther
PGE

PO#: CWA 3500032917

SPECIAL MAIL ☐ E-MAIL ☐ FAX ☐

REP:

I.D.#

SYSTEM #:

CUST. SEAL

ICE

QC = 1 [✓ 2] 3 4

ANALYSES REQUESTED

DATE	TIME	WATER	COMP	SOIL	SAMPLE DESCRIPTION	# OF BOTTLES	Dissolved Mn, Fe, Silver	Sulfide (special kit)	TOC	Ammonia Nitrogen	Color, odor, TSS, TDS	Total Mn, Fe, Silver	TOC, Sulfide, Sulfate				LAB ID	REMARKS
8/8	12:13	X			LA1-L	5	X	X	X	X	X						1	Sulfide water
8/8	12:00	X			LA1-U	5	X	X	X	X	X						2	Samples were
8/8	11:55			X	S1	2						X	X				3	field filtered
8/8	11:40			X	S2	2						X	X				4	
8/8	11:10			X	S3	2						X	X				5	dissolved Mn, Fe
8/8	10:40			X	S4	2						X	X				6	Silver water"
																		Samples were
																		field filtered

field filtered ↑
field filtered ↑

PRESERVATIONS HNO₃ ☐ H₂SO₄ ☐ NaOH ☐ ZnAce/NaOH ☐ HCL ☐ Nathio ☐

SAMPLED BY: Elizabeth Guenther	DATE/TIME: 8/8/01	RELINQUISHED BY: Elizabeth Guenther	DATE/TIME: 8/8 15:16
RECEIVED BY:	DATE/TIME:	RELINQUISHED BY:	DATE/TIME:
EIVED BY:	DATE/TIME:	RELINQUISHED BY:	DATE/TIME:
RECEIVED BY LAB: Julie McNeal	DATE/TIME: 8/8/01 3:15pm	SAMPLE SHIPPED VIA: UPS POST BUS FED-EX OTHER	

INSTRUCTIONS, TERMS, CONDITIONS ON BACK.

BASIC LABORATORY, INC.

JAN 1 5 200

Report To:	PG&E 3400 CROW CANYON RD. SAN RAMON, CA 94583	***Lab No:***	200109276
		Date:	10/03/01
		Phone:	(925) 866-5472
Attention:	ELIZABETH FRANTZ	***Fax:***	(925) 866-5681
		Date Sampled:	09/11/01
Project Name:	NFFR / LAKE ALMANOR	***Date Received:***	09/11/01
Sample Description:	WATER TESTING		

Amended

Page 1 of 3

Method:	***Test:***	***Units***	***LA1-L***	***LA1-U***	***MR (WATER)***	***NF2***	***NF2A***	***SF***	***NF4***	***NF3***	***Reporting Limit:***	***Date Analyzed***
4500 S.E.	Sulfide	ug/l	604	3.3	2.0	n	n	n	n	n	1.7	10/02/01
2540	Total Dissolved Solids	mg/l	74	81	132	64	70	77	98	88	2	09/12/01
2540 D	Total Suspended Solids	mg/l	7	n	7	5	6	n	n	n	2	09/13/01
5310	Total Organic Carbon	mg/l	2.8	2.0	1.2	1.9	1.6	1.4	1.4	1.4	1.0	09/26/01
4500 NH3	Ammonia @ N	mg/l	0.12	n	n	n	n	n	n	n	0.05	09/12/01
6010A	Iron - Dissolved	ug/l	1990	n	3280	122	157	140	n	n	50	09/13/01
6010A	Manganese - Dissolved	ug/l	841	n	2820	755	663	57	2	2	1	09/13/01
6010A	Silver - Dissolved	ug/l	n	n	n	n	n	n	n	n	1	09/13/01
2120	Color	units	25	5	10	5	5	7	n	n	5	09/12/01
2150	Odor	T.O.N.	n	n	n	n	n	n	n	n	2	09/12/01

Comments: California D.O.H.S. Cert. #1677.
n - Not detected at the reporting limit.
Amended on 1/14/02 to show corrected Dissolved Silver results for sample 1 and Name change.

Reported by:

Report To: PG&E
3400 CROW CANYON RD.
SAN RAMON, CA 94583

Attention: ELIZABETH FRANTZ

Project Name: NFFR / LAKE ALMANOR

Sample Description: WATER TESTING

Lab No: 200109276
Date: 10/03/01
Phone: (925) 866-5472
Fax: (925) 866-5681
Date Sampled: 09/11/01
Date Received: 09/11/01

Amended

Page 2 of 3

Method:	Test:	Units	Method Blank	Duplicate % RPD	Spike %Recovery	LCS % Recovery	Reporting Limit:	Date Analyzed
4500 S.E.	Sulfide	ug/l	n	1.1	111	91.8	1.7	10/02/01
2540	Total Dissolved Solids	mg/l	n	7.5		97.6	2	09/12/01
2540 D	Total Suspended Solids	mg/l	n	12.0		93.0	2	09/13/01
5310	Total Organic Carbon	mg/l	n	+/-RLS	97.7	97.0	1.0	09/26/01
4500 NH3	Ammonia @ N	mg/l	n	0.0	75.0	107	0.05	09/12/01
6010A	Iron - Dissolved	ug/l	n	7.7	108	104	50	09/13/01
6010A	Manganese - Dissolved	ug/l	n	7.8	120	104	1	09/13/01
6010A	Silver - Dissolved	ug/l	n	≤RL	104	104	1	09/13/01

Comments: California D.O.H.S. Cert. #1677.
n - Not detected at the reporting limit.
≤ - Less than or equal to the reporting value.
Amended on 1/14/02 to show corrected Dissolved Silver results for sample 1 and Name change.

Reported by:

Report To:	PG&E 3400 CROW CANYON RD. SAN RAMON, CA 94583	**Lab No:**	200109276
		Date:	10/03/01
		Phone:	(925) 866-5472
		Fax:	(925) 866-5681
Attention:	ELIZABETH FRANTZ	**Date Sampled:**	09/11/01
		Date Received:	09/11/01
Project Name:	NFFR / LAKE ALMANOR		
Sample Description:	PRECIPITATE		

Amended **Page 3 of 3**

TEST:	***Total Iron***	***Total Manganese***	***Total Silver***
METHOD:	6010A	6010A	6010A
UNITS:	mg/kgW	mg/kgW	mg/kgW
REPORTING LIMIT:	10.0	1.0	4.0
DATE ANALYZED:	09/20/01	09/20/01	09/20/01
Sample ID			
MS (Precipitate)	20100	1410	n
Method Blank	n	n	n
Duplicate % RPD	3.7	3.3	≤RL
Spike % Recovery	>=4xSPK	83.0	87.9
LCS % Recovery	93.0	93.1	92.6

Comments: California D.O.H.S. Cert. #1677.

n - Not detected at the reporting limit.

mg/kgW - Wet weight.

≥ - Greater than or equal to the reporting limit.

≤ - Less than or equal to the reporting value.

Amended on 1/14/02 to show corrected Dissolved Silver results for sample 1 and Name change.

Reported by:

BASIC LABORATORY CHAIN OF CUSTODY RECORD

2218 Railroad Avenue, Redding, CA 96001 (530) 243-7234 FAX 243-7494 Other

CLIENT NAME: Elizabeth Guenther PGE

PROJECT NAME: NFFR/Lake Almanor

PROJECT #:

LAB #: 20010927G

ADDRESS: 3400 Crow Canyon Rd
San Ramon CA 94583

REQUESTED COMP. DATE: 9/26/01

SAMP: 9

TURN AROUND TIME: STD ☒ RUSH ☐

PAGE 1 OF 1

PROJECT MANAGER:

PHONE: 925-866-5476

FAX:

E-MAIL: eag@pge.com

INVOICE TO: Elizabeth Guenther

PO#:

SPECIAL MAIL ☐ E-MAIL ☒ FAX ☐

REP:

I.D.#

SYSTEM #:

CUST. SEAL

ICE

QC = 1 [✓ 2] 3 4

* ANALYSES REQUESTED

DATE	TIME	WATER	COMP	SOIL	SAMPLE DESCRIPTION	# OF BOTTLES	TOC	Sulfide (special test)*	*dissolved Mn, Fe, Ag	Ammonia	Color/color/TDS/TSS	Total P, Fe, Mn, Ag					LAB ID	REMARKS
9/11		X			LA1-L		X	X	X	X	X						1	
9/11		X			LA1-U		X	X	X	X	X						2*	* field
9/11		X			MS (water)		X	X	X	X	X						3	filtered
9/11					MS precipitate							X					4	
		X			NF2		X	X	X	X	X						5	
		X			NF2a		X	X	X	X	X						6	
		X			SF		X	X	X	X	X						7	
		X			[redacted] NF4		X	X	X	X	X						8	
		X			NF3		X	X	X	X	X						9	

PRESERVATIONS HNO₃ ☐ H₂SO₄ ☐ NaOH ☐ ZnAce/NaOH ☐ HCL ☐ Nathio ☐

SAMPLED BY: Elizabeth Guenther	DATE/TIME: 9/11/01	RELINQUISHED BY: Elizabeth Guenther	DATE/TIME: 9/11/01 16:34
RECEIVED BY:	DATE/TIME:	RELINQUISHED BY:	DATE/TIME:
RECEIVED BY:	DATE/TIME:	RELINQUISHED BY:	DATE/TIME:
RECEIVED BY LAB: Vern Dallin 9/11/01	DATE/TIME: 4:35	SAMPLE SHIPPED VIA: UPS POST BUS FED-EX OTHER	

INSTRUCTIONS, TERMS, CONDITIONS ON BACK

B/ :
LABORATORY

Report To: PG&E
3400 CROW CANYON RD.
SAN RAMON, CA 94583

Attention: ELIZABETH GUENTHER

Project Name: UNFFR / LAKE ALMANOR

Sample Description: WATER TESTING

Lab No: 0110366
Date: 10/25/01
Phone: (925) 866-5472
Fax: (925) 866-5681
Date Sampled: 10/10/01
Date Received: 10/10/01
PO Number: CWA3500032917

Page 1 of 3

Method:	Test:	Units	NF4	NF3	SF	NF2a	MS	NF2	LA1-U	LA1-L	Reporting Limit:	Date Analyzed
4500 SE	Sulfide	ug/l	n	0.7	1.5	3.4	5.9	8.6	1.8	221	1.7	10/22/01
2540	Total Dissolved Solids	mg/l	122	80	79	68	123	61	63	64	2	10/10/01
2540 D	Total Suspended Solids	mg/l	9	n	n	4	8	n	n	12	2	10/15/01
5310	Total Organic Carbon	mg/l	1.4	1.4	1.8	2.2	1.0	2.1	2.2	2.8	1.0	10/23/01
4500 NH3	Ammonia @ N	mg/l	n	n	n	n	0.08	n	n	0.56	0.05	10/15/01
6010A	Dissolved Iron	ug/l	n	n	105	198	3400	273	n	4020	50	10/16/01
6010A	Dissolved Manganese	ug/l	3	2	73	316	2950	524	4	1160	1	10/16/01
6010A	Dissolved Silver	ug/l	n	n	n	n	n	n	n	n	1	10/16/01
2120	Color	units	5	10	15	20	50	25	5	100	5	10/11/01
2150	Odor	T.O.N.	n	n	n	n	n	4	n	4	2	10/11/01

Comments: California D.O.H.S. Cert. #1677.
n - Not detected at the reporting limit.

Reported by:

BASIC
LABORATORY

Report To: PG&E
3400 CROW CANYON RD.
SAN RAMON, CA 94583

Attention: ELIZABETH GUENTHER

Project Name: UNFFR / LAKE ALMANOR

Sample Description: WATER TESTING / QAQC

Lab No: 0110366
Date: 10/25/01
Phone: (925) 866-5472
Fax: (925) 866-5681
Date Sampled: 10/10/01
Date Received: 10/10/01
PO Number: CWA3500032917

Page 2 of 3

Method:	***Test:***	***Units***	***Method Blank***	***Duplicate % RPD***	***Spike %Recovery***	***LCS % Recovery***
4500 Se	Sulfide	ug/l	n	0.0	93.5	100
2540	Total Dissolved Solids	mg/l	n	0.7		97.9
2540 D	Total Suspended Solids	mg/l	n	0.0		84.0
5310	Total Organic Carbon	mg/l	n	+/=RLS	101	108
4500 NH3	Ammonia @ N	mg/l	n	0.0	95.7	96.1
6010A	Dissolved Iron	ug/l	n	0.0	98.4	98.6
6010A	Dissolved Manganese	ug/l	n	0.8	102	102
6010A	Dissolved Silver	ug/l	n	0.0	104	102
2120	Color	units				
2150	Odor	T.O.N.				

Comments: California D.O.H.S. Cert. #1677.
n - Not detected at the reporting limit.

Reported by:

BASIC
LABORATORY

Report To:	PG&E 3400 CROW CANYON RD. SAN RAMON, CA 94583	***Lab No:***	0110366
		Date:	10/25/01
		Phone:	(925) 866-5472
		Fax:	(925) 866-5681
Attention:	ELIZABETH GUENTHER	***Date Sampled:***	10/10/01
		Date Received:	10/10/01
Project Name:	UNFFR / LAKE ALMANOR	***PO Number:***	CWA3500032917
Sample Description:	PRECIPITATE	***Page 3 of 3***	

	Total Iron	Total Manganese	Total Silver
TEST:			
METHOD:	6010A	6010A	6010A
UNITS:	mg/kgW	mg/kgW	mg/kgW
REPORTING LIMIT:	10.0	1.0	4.0
DATE ANALYZED:	10/15/01	10/15/01	10/15/01
Sample ID			
MS	11700	687	n
Method Blank	n	n	n
Duplicate % RPD	2.5	5.4	0.0
Spike % Recovery	120	78.0	93.8
LCS % Recovery	88.3	90.1	90.2

Comments: California D.O.H.S. Cert. #1677.
n - Not detected at the reporting limit.

Reported by:

0110366.xls

PG&E

BASIC LABORATORY CHAIN OF CUSTODY RECORD

2218 Railroad Avenue, Redding, CA 96001 (530) 243-7234 FAX 243-7494

CLIENT NAME: Elizabeth Guenther

RESS: 3400 Crow Canyon Rd
San Ramon CA 94583

PROJECT MANAGER:

PHONE: 925-866-5492

FAX: 925-866-5681

E-MAIL: EAGO@pge.com

INVOICE TO:

PO#: CWA 350003291

SPECIAL MAIL ☐ E-MAIL ☒ FAX ☐

PROJECT NAME: UNFFR Lake Almanor

PROJECT #:

LAB #: 01103166

REQUESTED COMP. DATE: 10/25/01

SAMP: 9

TURN AROUND TIME: STD ☒ RUSH ☐

PAGE 1 OF 1

REP:

I.D.#

SYSTEM #:

CUST. SEAL

ICE

QC = 1 [✓ 2] 3 4

ANALYSES REQUESTED

DATE	TIME	WATER	COMP	SOIL	SAMPLE DESCRIPTION	# OF BOTTLES	Sulfide (low level)*	Dissolved - Mn, Fe, Ag*	Odor, Color, TSS, TDS	NH3	TOC	total - Mn, Fe, Ag					LAB ID	REMARKS
10/10	8:16	X			NF4	5	X	X	X	X	X						1	
10/10	9:15	X			NF3	5	X	X	X	X	X						2	* field
10/10	10:00	X			SF	5	X	X	X	X	X						3	filtered
10/10	10:45	X			NF2a	5	X	X	X	X	X						4	sulfide
10/10	11:30	X			MS	5	X	X	X	X	X						5	and dissolved
10/10	11:43	X			NF2	5	X	X	X	X	X						6	metals
10/10	13:30	X			LA1-U	5	X	X	X	X	X						7	
10/10	13:20	X			LA1-L	5	X	X	X	X	X						8	
10/10	11:56				MS (precipitate)	1						X					9	

PRESERVATIONS HNO3 ☐ H2SO4 ☒ NaOH ☐ ZnAce/NaOH ☐ HCL ☐ NaThio ☐

SAMPLED BY: E. Guenther	DATE/TIME: 10/10/01	RELINQUISHED BY: E. Guenther	DATE/TIME: 10/10/01 16:11
RECEIVED BY:	DATE/TIME:	RELINQUISHED BY:	DATE/TIME:
EIVED BY:	DATE/TIME:	RELINQUISHED BY:	DATE/TIME:
SEIVED BY LAB: Julie McNeale	DATE/TIME: 10/10/01 4:10 pm.	SAMPLE SHIPPED VIA: UPS POST BUS FED-EX OTHER ______	

RUCTIONS, TERMS, CONDITIONS ON BACK.

BA
LABORATORY

Report To:	PG&E 3400 CROW CANYON RD. SAN RAMON, CA 94583	***Lab No:***	0110531
		Date:	11/02/01
		Phone:	(925) 866-5472
Attention:	ELIZABETH GUENTHER	***Fax:***	(925) 866-5681
		Date Sampled:	10/17/01
Project Name:	UNFFR / LAKE ALMANOR	***Date Received:***	10/17/01
Sample Description:	WATER TESTING		

Page 1 of 3

Method:	***Test:***	***Units***	***NF4***	***NF3***	***NF2***	***NF2A***	***SE***	***MS***	***LAI-L***	***LAI-U***	***Reporting Limit:***	***Date Analyzed***
4500 S.E.	Sulfide	ug/l	n	n	1.7	2.0	1.7	11.9	265	2.3	1.7	10/31/01
2540	Total Dissolved Solids	mg/l	98	74	64	59	60	116	59	54	2	10/22/01
2540 D	Total Suspended Solids	mg/l	n	n	n	n	n	4	21	n	2	10/18/01
5310	Total Organic Carbon	mg/l	2.1	2.0	3.5	3.0	2.5	1.9	3.1	2.5	1.0	10/25/01
4500 NH3	Ammonia @ N	mg/l	n	n	n	n	n	0.07	0.39	n	0.05	10/19/01
6010A	Iron - Dissolved	ug/l	n	n	n	n	n	3500	3840	n	50	10/26/01
6010A	Manganese - Dissolved	ug/l	3	2	7	16	2	3020	1610	2	1	10/26/01
6010A	Silver - Dissolved	ug/l	n	n	n	n	n	n	n	n	1	10/26/01
2120	Color	units	5	5	10	10	5	60	40	5	5	10/19/01
2150	Odor	T.O.N.	n	n	n	n	n	n	2	2	2	10/19/01

Comments: California D.O.H.S. Cert. #1677.
n - Not detected at the reporting limit.

Reported by:

0110531.xls

BA[illegible]
LABORATORY

Report To:	PG&E 3400 CROW CANYON RD. SAN RAMON, CA 94583	**Lab No:**	0110531
		Date:	11/02/01
		Phone:	(925) 866-5472
		Fax:	(925) 866-5681
Attention:	ELIZABETH GUENTHER	**Date Sampled:**	1017/01
		Date Received:	10/17/01
Project Name:	UNFFR / LAKE ALMANOR		
Sample Description:	WATER TESTING		

Page 2 of 3

Method:	**Test:**	**Units**	**Method Blank**	**Duplicate % RPD**	**Spike %Recovery**	**LCS % Recovery**	**Reporting Limit:**	**Date Analyzed**
4500 S.E.	Sulfide	ug/l	n	+/-RLS	77.2	87.1	1.7	10/31/01
2540	Total Dissolved Solids	mg/l	n	1.0		96.5	2	10/22/01
2540 D	Total Suspended Solids	mg/l	n	0.0		106	2	10/18/01
5310	Total Organic Carbon	mg/l	n	2.3	102	108	1.0	10/25/01
4500 NH3	Ammonia @ N	mg/l	n	3.4	99.1	101	0.05	10/19/01
6010A	Iron - Dissolved	ug/l	n	0.0	108	105	50	10/26/01
6010A	Manganese - Dissolved	ug/l	n	0.0	110	106	1	10/26/01
6010A	Silver - Dissolved	ug/l	n	0.0	110	106	1	10/26/01

Comments: California D.O.H.S. Cert. #1677.
n - Not detected at the reporting limit.

Reported by:

BASIC

LABORATORY

Report To:	PG&E 3400 CROW CANYON RD. SAN RAMON, CA 94583	***Lab No:***	0110531
		Date:	11/02/01
		Phone:	(925) 866-5472
		Fax:	(925) 866-5681
Attention:	ELIZABETH GUENTHER	***Date Sampled:***	10/17/01
		Date Received:	10/17/01
Project Name:	UNFFR / LAKE ALMANOR		
Sample Description:	PRECIPITATE	***Page 3 of 3***	

TEST:	***Total <u>Iron</u>***	***Total <u>Manganese</u>***	***Total <u>Silver</u>***	***<u>% Solids</u>***
METHOD:	6010A	6010A	6010A	2540
UNITS:	mg/kgW	mg/kgW	mg/kgW	%
REPORTING LIMIT:	10.0	1.0	4.0	0.02
DATE ANALYZED:	10/29/01	10/29/01	10/29/01	10/22/01
<u>Sample ID</u>				
MS Precipitate Scrapings	25600	3210	n	6.0
Method Blank	n	n	n	
Duplicate % RPD	0.6	0.4	0.0	5.5
Spike % Recovery	87.0	96.8	100	
LCS % Recovery	90.7	89.6	90.4	

Comments: California D.O.H.S. Cert. #1677.
n - Not detected at the reporting limit.
mg/kgW - Wet weight.

Reported by:

BASIC LABORATORY CHAIN OF CUSTODY RECORD

2218 Railroad Avenue, Redding, CA 96001 (530) 243-7234 FAX 243-7494

CLIENT NAME: Elizabeth Guenther
PG&E

ADDRESS: 3400 Crow Canyon Rd
San Ramon CA 94583

PROJECT NAME: UNFFR
Lake Almanor

PROJECT #:

LAB #: 0110531

REQUESTED COMP. DATE: 11/1/01

TURN AROUND TIME: STD ☒ RUSH ☐

 # SAMP: 9

PAGE 1 **OF** 1

PROJECT MANAGER: Elizabeth Guenther

PHONE: 925-866-5472

FAX: 925-866-5681

E-MAIL: EAG0@pge.com

INVOICE TO: Elizabeth Guenther

PO# CWA 3500032917

SPECIAL MAIL ☐ **E-MAIL** ☒ **FAX** ☒

REP:

I.D.#

SYSTEM #:

CUST. SEAL

ICE

QC = 1 [✓ 2] 3 4

ANALYSES REQUESTED

DATE	TIME	WATER	COMP	(Solid)	SAMPLE DESCRIPTION	# OF BOTTLES	TSS, TDS, color (alk.)	Diss. Fe, Mn, Ag *	Sulfide (only/unfilt) *	NH3	TOC	Total Fe, Mn, Ag	% Solids				LAB ID	REMARKS
10/17	13:10	X			NF4		X	X	X	X	X						1	* held
10/17	12:05	X			NF3		X	X	X	X	X						2	filtered
10/17	10:07	X			NF2		X	X	X	X	X						3	samples
10/17	10:46	X			NF2a		X	X	X	X	X						4	
10/17	11:23	X			SF		X	X	X	X	X						5	
10/17	9:56	X			MS		X	X	X	X	X						6	
10/17	9:15	X			LAI-L		X	X	X	X	X						7	
10/17	9:00	X			LAI-U		X	X	X	X	X						8	
10/17	10:04	—		X	MS- precipitate scrapings							X	X				9	

PRESERVATIONS HNO₃ ☐ H₂SO₄ ☐ NaOH ☐ ZnAce/NaOH ☐ HCL ☐ Nathio ☐

SAMPLED BY: Elizabeth Guenther	**DATE/TIME:** 10/17/01	**RELINQUISHED BY:** Elizabeth Guenther	**DATE/TIME:** 10/17/01 16:14
RECEIVED BY:	**DATE/TIME:**	**RELINQUISHED BY:**	**DATE/TIME:**
RECEIVED BY:	**DATE/TIME:**	**RELINQUISHED BY:**	**DATE/TIME:**
RECEIVED BY LAB: [illegible] 10/17/01	**DATE/TIME:** 4:15	**SAMPLE SHIPPED VIA:** UPS POST BUS FED-EX OTHER ________	

INSTRUCTIONS, TERMS, CONDITIONS ON BACK.

BASIC
LABORATORY

Report To:	PG&E 3400 CROW CANYON RD. SAN RAMON, CA 94583	***Lab No:***	0110557
		Date:	11/07/01
		Phone:	(925) 866-5472
Attention:	ELIZABETH GUENTHER	***Fax:***	(925) 866-5681
		Date Sampled:	10/18/01
Project Name:	UNFFR / LAKE ALMANOR	***Date Received:***	10/18/01
		P.O. Number:	CWA3500032917
Sample Description:	WATER TESTING		

Method:	***Test:***	***Units***	***LA1-U***	***LA1-L***	***NF2***	***MS***	***NF2a***	***SF***	***NF3***	***NF4***	***Reporting Limit:***	***Date Analyzed***
4500 SE	Sulfide	ug/l	n	186	n	6.3	n	n	n	n	1.7	11/05/01
2540	Total Dissolved Solids	mg/l	71	70	74	137	75	73	77	92	2	10/23/01
2540 D	Total Suspended Solids	mg/l	5	8	n	5	5	11	29	75	2	10/19/01
5310	Total Organic Carbon	mg/l	1.8	1.6	1.3	n	1.6	1.8	2.4	3.6	1.0	11/01/01
4500 NH3	Ammonia @ N	mg/l	n	0.22	n	0.06	n	n	n	n	0.05	10/19/01
6010A	Iron - Dissolved	ug/l	n	2120	n	3600	n	n	n	n	50	10/26/01
6010A	Manganese - Dissolved	ug/l	4	1960	8	3090	23	14	12	9	1	10/26/01
6010A	Silver - Dissolved	ug/l	n	n	n	n	n	n	n	n	1	10/26/01
2120	Color	units	10	60	10	30	10	10	200	60	5	10/19/01
2150	Odor	T.O.N.	4	2	n	n	n	2	4	4	2	10/19/01

Comments: California D.O.H.S. Cert. #1677.
n - Not detected at the reporting limit.

Reported by:

BASIC
ABORATORY

Report To:	PG&E 3400 CROW CANYON RD. SAN RAMON, CA 94583	***Lab No:*** ***Date:*** ***Phone:***	0110557 11/07/01 (925) 866-5472
		Fax:	(925) 866-5681
Attention:	ELIZABETH GUENTHER	***Date Sampled:***	10/18/01
		Date Received:	10/18/01
Project Name:	UNFFR / LAKE ALMANOR	***P.O. Number:***	CWA3500032917
Sample Description:	PRECIPITATE		

Page 2 of 4

Method:	***Test:***	***Units***	***MS-Precipitate***	***Reporting Limit:***	***Date Analyzed***
6010A	Total Iron	mg/kgW	30800	10.0	10/29/01
6010A	Total Manganese	mg/kgW	6210	1.0	10/29/01
6010A	Total Silver	mg/kgW	n	4.0	10/29/01
2540	% Solids	%	8.1	0.02	10/22/01

Comments: California D.O.H.S. Cert. #1677.
n - Not detected at the reporting limit.
mg/kgW - Wet weight

Reported by:

0110557.xls

BASIC
ABORATORY

Report To: PG&E
3400 CROW CANYON RD.
SAN RAMON, CA 94583

Attention: ELIZABETH GUENTHER

Project Name: UNFFR / LAKE ALMANOR

Sample Description: WATER TESTING / QAQC

Lab No: 0110557
Date: 11/07/01
Phone: (925) 866-5472
Fax: (925) 866-5681
Date Sampled: 10/18/01
Date Received: 10/18/01
P.O. Number: CWA35000329

Page 3 of 4

Method:	***Test:***	***Units***	***Method Blank***	***Duplicate % RPD***	***Spike %Recovery***	***LCS % Recovery***	***Reporting Limit:***	***Date Analyzed***
4500 S	Sulfide	ug/l	n	0.0	103	99.1	1.7	11/05/01
2540	Total Dissolved Solids	mg/l	n	1.4		96.5	2	10/23/01
2540 D	Total Suspended Solids	mg/l	n	0.0		106	2	10/19/01
5310	Total Organic Carbon	mg/l	n	0.0	95.4	98.8	1.0	11/01/01
4500 NH3	Ammonia @ N	mg/l	n	0.0	99.1	101	0.05	10/19/01
6010A	Iron - Dissolved	ug/l	n	0.0	108	105	50	10/26/01
6010A	Manganese - Dissolved	ug/l	n	0.0	110	106	1	10/26/01
6010A	Silver - Dissolved	ug/l	n	0.0	110	106	1	10/26/01

Comments: California D.O.H.S. Cert.#1677
n - Not detected at the reporting limit.

Reported by:

BASIC
ABORATORY

Report To:	PG&E 3400 CROW CANYON RD. SAN RAMON, CA 94583	**Lab No:**	0110557
		Date:	11/07/01
		Phone:	(925) 866-5472
		Fax:	(925) 866-5681
Attention:	ELIZABETH GUENTHER	**Date Sampled:**	10/18/01
		Date Received:	10/18/01
Project Name:	UNFFR / LAKE ALMANOR	**P.O. Number:**	CWA3500032917
Sample Description:	PRECIPITATE		

Page 4 of 4

Method:	Test:	Units	Method Blank	Duplicate % RPD	Spike %Recovery	LCS % Recovery	Reporting Limit:	Date Analyzed
6010A	Total Iron	mg/kgW	n	0.6	87.0	90.7	10.0	10/29/01
6010A	Total Manganese	mg/kgW	n	0.4	96.8	89.6	1.0	10/29/01
6010A	Total Silver	mg/kgW	n	0.0	100	90.4	4.0	10/29/01
2540	% Solids	%		5.5			0.02	10/22/01

Comments: California D.O.H.S. Cert. #1677.
n - Not detected at the reporting limit.
mg/kgW. - Wet weight

Reported by:

0110557.xls

BASIC LABORATORY CHAIN OF CUSTODY RECORD

2218 Railroad Avenue, Redding, CA 96001 (530) 243-7234 FAX 243-7494

CLIENT NAME: Elizabeth Guenther TEE
PROJECT NAME: UNFFR/Lake Almanor
PROJECT #:
LAB #: 011055?

ADDRESS: 3460 Crow Canyon Rd
San Ramon CA 94583
REQUESTED COMP. DATE: 11/12/01
SAMP: 9
TURN AROUND TIME: STD ☒ RUSH ☐
PAGE 1 OF 1

PROJECT MANAGER: Elizabeth Guenther
PHONE: 925-866-5472
FAX: 925-866-5681
E-MAIL: EAG@TEE.COM
INVOICE TO: Elizabeth Guenther
PO#: CWA 3500058917
SPECIAL MAIL ☐ E-MAIL ☒ FAX ☒

REP:
I.D.#
SYSTEM #:
CUST. SEAL
ICE
QC = 1 [✓ 2] 3 4

ANALYSES REQUESTED

DATE	TIME	WATER	COMP	Prep	SAMPLE DESCRIPTION	# OF BOTTLES	TSS, TDS, cation, (alk)	NH3	TOC	* Sulfide (low level)	* Diss. Mn, Fe, As, Ag	Total Mn, Fe, Ag	% solids				LAB ID	REMARKS
10/18	850	X			LA1-LL		X	X	X	X	X						1	* field
10/18	900	X			LA1-L		X	X	X	X	X						2	filtered
10/18	933	X			NF2		X	X	X	X	X						3	
10/18	937	X			MS		X	X	X	X	X						4	
10/18	1017	X			NF2a		X	X	X	X	X						5	
10/18	1057	X			SF		X	X	X	X	X						6	
10/18	1141	X			NF3		X	X	X	X	X						7	
10/18	1245	X			NF4		X	X	X	X	X						8	
10/18	945			X	MS-precipitate	[illegible]						X	X				9	

PRESERVATIONS HNO$_3$ ☐ H$_2$SO$_4$ ☐ NaOH ☐ ZnAce/NaOH ☐ HCL ☐ Nathio ☐

SAMPLED BY: E. Guenther
DATE/TIME: 10/18/01
RELINQUISHED BY: Elizabeth Guenther
DATE/TIME: 10/18/01 15:50

RECEIVED BY:
DATE/TIME:
RELINQUISHED BY:
DATE/TIME:

RECEIVED BY:
DATE/TIME:
RELINQUISHED BY:
DATE/TIME:

RECEIVED BY LAB:
DATE/TIME: 10/18/01 3:50
SAMPLE SHIPPED VIA: UPS POST BUS FED-EX OTHER ____

INSTRUCTIONS, TERMS, CONDITIONS ON BACK

BASIC LABORATORY, INC.

Report To:	PG&E 3400 CROW CANYON RD. SAN RAMON, CA 94583	***Lab No:***	0111441
		Date:	11/29/01
		Phone:	(925) 866-5472
		Fax:	(925) 866-5681
Attention:	ELIZABETH GUENTHER	***Date Sampled:***	11/14/01
		Date Received:	11/14/01
Project Name:	UNFFR / LAKE ALMANOR	***P.O. No.:***	CWA3500032917
Sample Description:	WATER TESTING		

Page 1 of 3

Method:	***Test:***	***Units***	***NF4***	***NF3***	***SF***	***NF2a***	***NF2***	***MS***	***LA1-L***	***LA1-U***	***Reporting Limit:***	***Date Analyzed***
4500 S.E.	Sulfide	ug/l	n	n	n	n	n	12.0	3.1	1.7	1.7	11/16/01
2540	Total Dissolved Solids	mg/l	101	81	82	73	73	75	67	67	2	11/19/01
2540 D	Total Suspended Solids	mg/l	n	n	n	4	n	7	4	4	2	11/19/01
5310	Total Organic Carbon	mg/l	n	1.0	n	1.2	1.3	n	1.4	1.6	1.0	11/28/01
4500 NH3	Ammonia @ N	mg/l	n	0.07	n	0.11	0.16	0.10	0.10	0.08	0.05	11/15/01
6010A	Iron - Dissolved	ug/l	n	n	n	57	68	3560	65	n	50	11/21/01
6010A	Manganese - Dissolved	ug/l	4	2	3	10	16	3070	8	6	1	11/21/01
6010A	Silver - Dissolved	ug/l	n	n	n	n	n	n	n	n	1	11/21/01
2120	Color	units	5	7	5	15	15	15	15	15	5	11/15/01
2150	Odor	T.O.N.	n	n	n	n	n	n	n	n	2	11/15/01

Comments: California D.O.H.S. Cert. #1677.
n - Not detected at the reporting limit.

Reported by:

0110531.xls

BASIC LABORATORY, INC.

Report To:	PG&E 3400 CROW CANYON RD. SAN RAMON, CA 94583		***Lab No:***	0111441
			Date:	11/29/01
			Phone:	(925) 866-5472
			Fax:	(925) 866-5681
Attention:	ELIZABETH GUENTHER		***Date Sampled:***	11/14/01
			Date Received:	11/14/01
Project Name:	UNFFR / LAKE ALMANOR		***P.O. No.:***	CWA3500032917
Sample Description:	WATER TESTING			

Method:	***Test:***	***Units***	***Method Blank***	***Duplicate % RPD***	***Spike %Recovery***	***LCS % Recovery***	***Reporting Limit:***	***Date Analyzed***
4500 S.E.	Sulfide	ug/l	n	0.0	106	105	1.7	11/16/01
2540	Total Dissolved Solids	mg/l	n	1.0		83.8	2	11/19/01
2540 D	Total Suspended Solids	mg/l	n	9.0		107	2	11/19/01
5310	Total Organic Carbon	mg/l	n	0.0	104	95.0	1.0	11/28/01
4500 NH3	Ammonia @ N	mg/l	n	0.0	109	105	0.05	11/15/01
6010A	Iron - Dissolved	ug/l	n	0.7	>RL	91.2	50	11/26/01
6010A	Manganese - Dissolved	ug/l	n	1.8	>RL	106	1	11/26/01
6010A	Silver - Dissolved	ug/l	n	0.0	96.5	107	1	11/26/01
2120	Color	units					5	11/15/01
2150	Odor	T.O.N.					2	11/15/01

Comments: California D.O.H.S. Cert. #1677.
n - Not detected at the reporting limit.

Reported by:

Report To: PG&E
3400 CROW CANYON RD.
SAN RAMON, CA 94583

Attention: ELIZABETH GUENTHER

Project Name: UNFFR / LAKE ALMANOR

Sample Description: PRECIPITATE

Lab No: 0111441
Date: 11/29/01
Phone: (925) 866-5472
Fax: (925) 866-5681
Date Sampled: 11/14/01
Date Received: 11/14/01
P.O. No.: CWA3500032917

Page 3 of 3

TEST:	**Total Iron**	**Total Manganese**	**Total Silver**	**% Solids**
METHOD:	6010A	6010A	6010A	2540
UNITS:	mg/kgW	mg/kgW	mg/kgW	%
REPORTING LIMIT:	10.0	1.0	4.0	0.02
DATE ANALYZED:	11/26/01	11/26/01	11/26/01	11/20/01
Sample ID				
MS Precipitate Scrapings	28700	3600	n	5.1
Method Blank	n	n	n	
Duplicate % RPD	0.7	1.6	0.0	5.5
Spike % Recovery	80.0	89.0	96.5	
LCS % Recovery	91.2	90.6	90.5	

Comments: California D.O.H.S. Cert. #1677.
n - Not detected at the reporting limit.
mg/kgW - Wet weight.

Reported by:

BASIC LABORATORY CHAIN OF CUSTODY RECORD

2218 Railroad Avenue, Redding, CA 96001 (530) 243-7234 FAX 243-7494

CLIENT NAME: Elizabeth Guenther (PG&E)	PROJECT NAME: NFFR/ Lake Almanor	PROJECT #:	LAB #: 0171441
ADDRESS: 3400 Crow Canyon Rd San Ramon, CA 94583	REQUESTED COMP. DATE: TURN AROUND TIME: STD ☒ RUSH ☐		# SAMP: 9 PAGE 1 OF 1
PROJECT MANAGER: Elizabeth Guenther			REP:
PHONE: 925-866-5495	FAX: 925-866-5681	E-MAIL: EAEG@pge.com	LD# SYSTEM #:
INVOICE TO: Elizabeth Guenther	PO#: CWA 350003291		CUST. SEAL ICE
SPECIAL MAIL ☒	E-MAIL ☒	~~FAX~~	QC = 1 [✓ 2] 3 4

ANALYSES REQUESTED

DATE	TIME	WATER	COMP	precip	SAMPLE DESCRIPTION	# OF BOTTLES	TSS, TDS, odor, Color	NH3	TOC	Sulfide (low level) *	Diss. Fe, Mn, Ag *	Total Fe, Mn, Ag	% Solids				LAB ID	REMARKS
11/14	7:55	X			NF4	5	X	X	X	X	X		–					* Field
11/14	9:05	X			NF3	5	X	X	X	X	X							filtered
11/14	9:50	X			SF	5	X	X	X	X	X							samples
11/14	10:45	X			NF2a	5	X	X	X	X	X							
11/14	11:50	X			NF2	5	X	X	X	X	X							
11/14	11:34	X			MS	5	X	X	X	X	X							
14	13:15	X			LA1-L	5	X	X	X	X	X							
11/13	13:05	X			LA1-U	5	X	X	X	X	X							
11/13	11:34			X	MS (precipitate)	1						X	X					

bottles are labeled 11/13 should be 11/14
GG

PRESERVATIONS HNO₃ ☒ H₂SO₄ ☒ NaOH ☒ (ZnAc/NaOH) ☒ HCL ☐ Nathio ☐

SAMPLED BY: Elizabeth Guenther	DATE/TIME: 11/13/01	RELINQUISHED BY: Elizabeth Guenther	DATE/TIME: 11/15/01 16:00
RECEIVED BY:	DATE/TIME:	RELINQUISHED BY:	DATE/TIME:
RECEIVED BY:	DATE/TIME:	RELINQUISHED BY:	DATE/TIME:
RECEIVED BY LAB:	DATE/TIME: 11/15/01 4:00	SAMPLE SHIPPED VIA: UPS POST BUS FED-EX OTHER ____	

INSTRUCTIONS, TERMS, CONDITIONS ON BACK

UPPER NORTH FORK FEATHER RIVER PROJECT

FERC NO. 2105

Appendix E2-B

Summary of 2000 and 2001 Hourly Water Temperature Data from NFFR Project

Appendix E2-B

Summary of 2000 and 2001 Hourly Water Temperature Data from NFFR Project

Station	Year	Month	Hourly Temperatures [1] max	min	mean	Data Days
NFFR at Chester (NF1A)	2000	June	19.1	6.1	12.6	30
	2000	July	18.5	9.2	13.9	31
	2000	Aug	18.2	9.4	13.0	31
	2000	Sept	14.1	7.3	10.8	30
	2001	June	18.9	8.7	13.8	30
	2001	July	18.5	9.6	12.9	31
	2001	Aug	16.5	10.0	11.5	31
	2001	Sept	12.8	10.3	11.3	30
Hamilton Branch at Road bridge (HB1)	2000	June	20.8	8.2	12.2	30
	2000	July	15.4	8.9	12.1	31
	2000	Aug	15.3	8.2	11.4	31
	2000	Sept	12.6	7.2	9.7	30
	2001	June	15.1	8.0	11.1	30
	2001	July	16.1	8.6	12.1	31
	2001	Aug	15.2	8.6	11.5	31
	2001	Sept	13.4	7.9	10.1	30
Hamilton Branch Powerhouse (HB2)	2000	June	23.1	14.3	18.2	30
	2000	July	22.6	15.6	19.1	31
	2000	Aug	21.6	12.7	16.6	21
	2000	Sept	14.3	7.5	10.5	19
	2001	June	18.1	8.1	12.1	30
	2001	July	21.5	9.4	16.5	23
	2001	Aug	20.6	8.9	14.0	30
	2001	Sept	15.2	7.9	12.1	30
Lake Almanor at Canyon Dam near surface (LA1-S)	2000	June	24.8	14.2	20.1	25
	2000	July	23.9	19.8	21.7	31
	2000	Aug	24.8	19.8	22.2	31
	2000	Sept	20.5	17.2	18.3	30
	2001	June	23.9	17.4	19.5	25
	2001	July	24.6	19.2	21.9	31
	2001	Aug	24.3	20.4	22.0	31
	2001	Sept	23.1	18.1	20.3	30
Lake Almanor at Canyon Dam near bottom (LA1-B)	2000	June	10.7	8.7	10.0	25
	2000	July	12.8	9.9	11.1	31
	2000	Aug	13.4	11.0	12.1	31
	2000	Sept	16.9	11.8	14.9	30
	2001	June	13.6	11.0	11.9	25
	2001	July	15.0	11.2	13.1	31
	2001	Aug	15.3	12.6	13.8	31
	2001	Sept	19.9	12.7	14.6	30

Appendix E2-B (Continued)

			Daily Temperatures [1]			Data
Station	Year	Month	max	min	mean	Days
NFFR below Canyon Dam (NF2)	2000	June	10.7	8.8	9.8	30
	2000	July	11.3	9.6	10.6	31
	2000	Aug	12.2	10.5	11.2	31
	2000	Sept	13.1	11.2	11.9	30
	2001	June	14.1	10.4	12.0	30
	2001	July	15.2	11.7	13.4	31
	2001	Aug	16.2	13.1	14.3	31
	2001	Sept	17.4	13.4	15.3	30
NFFR at Seneca Bridge (NF3A)	2000	June	15.8	8.5	12.6	30
	2000	July	15.6	10.2	13.1	31
	2000	Aug	15.9	10.6	13.2	31
	2000	Sept	14.1	9.5	12.1	30
	2001	June	16.8	9.8	13.5	30
	2001	July	17.6	12.2	15.0	31
	2001	Aug	17.6	12.6	15.2	31
	2001	Sept	16.3	12.3	14.5	30
NFFR above Butt Creek (NF3B)	2000	June	—	—	—	—
	2000	July	—	—	—	—
	2000	Aug	—	—	—	—
	2000	Sept	—	—	—	—
	2001	June	19.0	10.5	14.4	30
	2001	July	19.9	12.9	16.0	31
	2001	Aug	19.6	13.1	15.9	31
	2001	Sept	17.8	12.1	14.5	30
NFFR above Caribou PH (NF4)	2000	June	17.8	9.6	13.8	30
	2000	July	17.2	11.4	14.3	31
	2000	Aug	17.5	11.4	14.3	31
	2000	Sept	15.0	10.0	12.6	30
	2001	June	18.1	10.3	14.1	30
	2001	July	19.0	12.4	15.5	31
	2001	Aug	18.8	12.7	15.4	31
	2001	Sept	17.1	11.7	14.1	30
Butt Valley Powerhouse [Corrected] (BV1)	2000	June	17.3	13.0	15.6	17
	2000	July	19.6	15.4	18.1	31
	2000	Aug	20.7	17.1	19.8	30
	2000	Sept	19.2	16.1	17.7	30
	2001	June	20.8	16.1	18.5	25
	2001	July	22.1	18.9	20.7	31
	2001	Aug	22.5	20.3	21.3	29
	2001	Sept	19.8	17.6	18.7	14

Appendix E2-B (Continued)

			Daily Temperatures [1]			
Station	**Year**	**Month**	**max**	**min**	**mean**	**Data Days**
Butt Valley Res. at Caribou Intake Near surface (BV2-S)	2000	June	23.7	16.6	20.0	24
	2000	July	22.8	18.6	20.6	31
	2000	Aug	23.7	19.3	21.2	31
	2000	Sept	20.7	17.3	18.4	30
	2001	June	23.3	18.6	20.3	25
	2001	July	24.6	19.9	22.4	31
	2001	Aug	24.1	21.1	22.4	31
	2001	Sept	22.9	18.4	20.6	30
Butt Valley Res. at Caribou Intake Near bottom (BV2-B)	2000	June	11.2	9.8	10.5	24
	2000	July	15.3	11.0	12.9	31
	2000	Aug	17.3	14.2	16.1	31
	2000	Sept	17.6	16.4	16.8	30
	2001	June	11.8	9.1	10.3	25
	2001	July	16.6	11.3	14.0	31
	2001	Aug	19.1	16.2	17.8	31
	2001	Sept	19.9	17.1	17.9	30
Butt Creek above Butt Valley Reservoir (BC1)	2000	June	18.2	7.9	13.4	30
	2000	July	17.2	9.4	13.3	31
	2000	Aug	17.4	8.6	12.6	31
	2000	Sept	13.9	7.0	10.6	30
	2001	June	18.5	8.6	13.4	30
	2001	July	19.4	9.7	14.3	31
	2001	Aug	18.1	9.4	13.5	31
	2001	Sept	16.4	8.1	11.5	30
Butt Creek below Butt Valley Reservoir (BC2)	2000	June	11.5	10.0	10.6	30
	2000	July	11.9	10.4	10.7	31
	2000	Aug	11.4	10.3	10.6	31
	2000	Sept	11.0	10.0	10.4	30
Excludes flow test period	2001	June	11.3	10.1	10.6	30
	2001	July	11.3	10.4	10.7	13
	2001	Aug	11.2	10.4	10.6	9
	2001	Sept	11.2	10.2	10.5	30
Butt Creek at Mouth (BC3)	2000	June	13.8	9.4	11.5	30
	2000	July	14.1	10.6	12.0	31
	2000	Aug	14.3	11.1	12.3	31
	2000	Sept	13.5	10.5	11.9	30
	2001	June	13.5	9.3	11.2	30
	2001	July	14.0	10.5	12.0	31
	2001	Aug	14.2	11.0	12.3	31
	2001	Sept	13.6	10.8	12.0	30

Appendix E2-B (Continued)

			Daily Temperatures [1]			Data
Station	**Year**	**Month**	**max**	**min**	**mean**	**Days**
Caribou No. 1 Powerhouse [corrected] (CARB1)	2000	June	18.7	11.6	15.4	20
	2000	July	19.8	13.7	18.0	31
	2000	Aug	20.7	17.9	19.9	30
	2000	Sept	19.5	17.3	17.9	28
	2001	June	17.1	11.2	15.2	14
	2001	July	21.8	14.5	19.7	24
	2001	Aug	22.4	19.4	21.5	24
	2001	Sept	20.2	18.5	19.4	14
Caribou No. 2 Powerhouse [corrected] (CARB2)	2000	June	22.0	15.1	17.5	14
	2000	July	22.8	17.9	20.2	31
	2000	Aug	22.7	19.3	21.0	30
	2000	Sept	19.6	17.4	18.4	6
	2001	June	22.1	17.8	19.9	22
	2001	July	23.7	19.8	22.0	31
	2001	Aug	23.2	21.1	22.2	30
	2001	Sept	22.1	18.6	20.3	22
Belden Reservoir At Intake (BD1)	2000	June	20.5	14.6	17.5	30
	2000	July	20.9	17.7	19.2	31
	2000	Aug	21.8	18.9	20.3	31
	2000	Sept	19.4	17.1	18.0	30
	2001	June	21.1	18.0	19.2	26
	2001	July	22.6	19.7	21.3	31
	2001	Aug	22.8	21.1	21.9	31
	2000	Sept	21.7	18.1	19.8	30
NFFR below Belden Dam (NF5)	2000	June	19.0	13.6	16.4	30
	2000	July	20.3	17.5	18.8	31
	2000	Aug	21.1	17.1	19.5	31
	2000	Sept	19.2	16.8	17.6	30
	2001	June	19.3	15.7	17.2	30
	2001	July	21.5	18.0	19.9	31
	2001	Aug	21.6	19.4	20.7	31
	2001	Sept	20.0	16.0	18.2	30
Mosquito Creek At mouth (MC1)	2000	June	17.3	9.6	13.0	30
	2000	July	15.8	11.9	13.4	19
	2000	Aug	—	—	—	0
	2000	Sept	12.6	9.8	11.1	9
	2001	June	15.4	10.5	12.7	30
	2001	July	16.4	12.2	14.1	31
	2001	Aug	16.0	12.3	13.8	31
	2001	Sept	14.9	10.9	12.6	30

Appendix E2-B (Continued)

			Daily Temperatures [1]			Data
Station	**Year**	**Month**	**max**	**min**	**mean**	**Days**
NFFR near	2000	June	21.0	12.6	16.4	30
Queen Lily	2000	July	22.0	16.3	18.5	31
Campground	2000	Aug	22.6	16.2	19.1	31
(NF6)	2000	Sept	20.0	14.5	16.7	30
	2001	June	20.7	14.9	17.1	30
	2001	July	23.0	17.0	19.7	31
	2001	Aug	23.8	18.9	20.3	31
	2001	Sept	21.4	15.0	17.6	30
NFFR near	2000	June	22.2	11.9	17.6	21
Gansner Bar	2000	July	23.0	15.4	18.6	31
(NF7)	2000	Aug	23.4	15.8	19.0	31
	2000	Sept	20.1	13.2	16.6	30
	2001	June	22.0	14.0	17.3	30
	2001	July	23.9	16.4	19.7	31
	2001	Aug	23.9	17.9	20.2	31
	2001	Sept	22.0	14.8	17.5	30
East Branch	2000	June	25.9	13.8	19.8	30
NFFR at mouth	2000	July	24.3	16.9	21.3	31
(EB1)	2000	Aug	25.2	17.5	20.9	31
	2000	Sept	20.3	14.3	17.2	30
	2001	June	24.7	16.6	20.5	30
	2001	July	25.6	19.6	22.8	31
	2001	Aug	25.1	18.9	22.0	31
	2001	Sept	22.8	15.6	18.9	30
NFFR at Belden	2000	June	24.8	13.5	19.0	30
Town Bridge	2000	July	23.9	16.2	20.2	31
(NF8)	2000	Aug	24.6	16.5	20.0	31
	2000	Sept	20.4	14.3	17.1	30
	2001	June	23.5	15.1	18.7	30
	2001	July	24.8	17.6	20.9	31
	2001	Aug	24.7	17.8	20.8	31
	2001	Sept	22.8	15.0	18.3	30
Belden	2000	June	19.8	15.0	17.4	30
Powerhouse	2000	July	20.4	17.5	18.9	31
(BD2)	2000	Aug	21.2	18.9	20.1	30
	2001	Sept	19.2	16.9	17.8	30
	2001	June	21.2	17.8	19.3	23
	2001	July	22.8	19.4	21.5	31
	2001	Aug	23.1	21.2	22.2	31
	2000	Sept	22.7	18.1	20.4	30

Appendix E2-B (Continued)

Station	Year	Month	Daily Temperatures [1] max	min	mean	Data Days
Yellow Creek	2000	June	19.2	9.2	14.3	30
Near mouth	2000	July	18.0	12.2	15.0	31
(YC1)	2000	Aug	18.9	12.3	15.0	23
	2000	Sept	—	—	—	0
	2001	June	19.2	11.3	14.7	30
	2001	July	20.3	13.5	16.4	31
	2001	Aug	19.3	13.2	15.8	31
	2000	Sept	17.2	11.2	13.6	30

1. Hourly values are based on hourly average data, month statistics represent the maximum, minimum, and mean based on these hourly average temperatures.

UPPER NORTH FORK FEATHER RIVER PROJECT

FERC NO. 2105

Appendix E2-C

Comparison of Regulatory Criteria and 2000 UNFFR Project Water Quality Data

Appendix E2-C

Comparison of Regulatory Criteria and 2000 UNFFR Project Water Quality Data

Table 1	Comparison of regulatory criteria and 2000 UNFFR Project water quality data (metals are expressed as *total* metals).
Table 1B	Comparison of hardness-based regulatory criteria and 2000 UNFFR Project data for metals (expressed as *total* metals)
Table 2	UNFFR Relicensing (FERC 2105) – 2000 Water Quality Monitoring Program Results (metals expressed as *total* metals)
Table 3	UNFFR Relicensing (FERC 2105) – California Toxics Rule (CTR), Inland Surface Waters, Human Health (30-day average), units are expressed as micrograms per liter [ppb])
Table 4	UNFFR Relicensing (FERC 2105) Freshwater Criteria Translator for Dissolved Metals (from the *Metals Tanslator: Guidance for Calculating a Total Recoverable Permit Limit From a Dissolved Criterion*, USEPA Document 823-B-96-007, June 1996)

Appendix E2-C.

Table 1. Comparison of regulatory criteria and 2000 UNFFR Project water quality data (metals are expressed as *total* metals).

Station NF1B – North Fork Feather River at Chester.

	Water Quality Parameter Statistics				California Toxics Rule (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection[1]			USEPA National Recommended Ambient Water Quality Criteria Freshwater Aquatic Life Protection[2]			CA Dept. Health Services CCR-Title 22 Drinking Water Standard[3]		RWQCB-CVR Basin Plan Objectives[4]
	Mean	Median	Minimum	Maximum	4-Day[4]	1-Hour[4]	Max[4]	4-Day[4]	1-Hour[4]	Max[4]	Primary MCL	Secondary MCL	
Water Temperature (°C)	8.1	9.8	2.1	12.2									
Dissolved Oxygen (mg/L)	10.1	10.2	8.0	12.2									>7
Specific Conductance (mS/cm)	68	74	44	82								900 (μmhos/cm)	150
pH (Standard Units)	7.7	7.8	7.1	8.0						6.5-9.0			6.5-8.5
Total Dissolved Solids (mg/L)	43	45	28	52								500	
Fecal Coliform	11	8	<2	26									200/400[5]
Arsenic (mg/L)	*<0.0032*	*<0.0032*	*<0.0032*	*<0.0032*	0.15	0.34		0.15	0.34		0.05		
Barium (mg/L)	0.0076	0.0076	0.0064	0.0085							1.0		
Cadmium (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.005		
Chromium (mg/L)	*<0.00047*	*<0.00047*	*<0.00047*	*<0.00047*							0.05		
Copper (mg/L)	*<0.0004*	*<0.0004*	*<0.0004*	*<0.0004*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		1.3	1.0	
Iron (mg/L)	0.0871	0.0545	*<0.0028*	0.2700						1.0		0.3	
Lead (mg/L)	*<0.0013*	*<0.0013*	*<0.0013*	*<0.0013*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.015		
Manganese (mg/L)	0.00205	*<0.00046*	*<0.00046*	0.01000								0.05	
Mercury (mg/L)	0.00022	<0.0002	<0.0002	0.00029				0.00077	0.0014		0.002		
Selenium (mg/L)	*<0.0042*	*<0.0042*	*<0.0042*	*<0.0042*	0.005	0.020		0.005			0.05		
Silver (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*			See Table 1B					0.10	
Zinc (mg/L)	0.0021	*<0.0013*	*<0.0013*	0.0058	See Table 1B	See Table 1B		See Table 1B	See Table 1B			5.0	
Ammonia - Total (mg/L)[6]	*<0.1*	*<0.1*	*<0.1*	*<0.1*				3.0	6.2				
Chloride (mg/L)	1.5	1.5	0.2	3.0				230	860			250	
Nitrate, as NO3 (mg/L)	0.61	0.10	0.10	3.14							45		
Sulfate (mg/L)	1.8	1.6	0.8	3.1								250	
Alkalinity - Total (mg/L)	41	40	26	60				≥20					

1. USEPA 40 CFR Part 131, Water Quality Standards; Establishment on Numeric Criteria for Priority Toxic Pollutants for the State of California [*California Toxics Rule*].
2. USEPA National Ambient Water Quality Criteria, Freshwater Aquatic Life Protection Recommended Criteria.
3. For DHS MCL's to apply, the watershed must be designated MUN in the Basin Plan. For example, Lake Almanor is not designated as having existing domestic or municipal water supply, but the North Fork Feather River is listed as a municipal water supply.
4. Fourth Edition of the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins.
5. Fecal Coliform limit is a monthly geometric mean of < 200 / 100 mL, and no more than 10% of the monthly observations above 400 /100 mL.
6. Ammonia concentration range based on the median pH and median temperature measurements made in UNFFR Project during the 2000 sampling program.

Appendix E2-C.

Table 1. Comparison of regulatory criteria and 2000 UNFFR Project water quality data (metals are expressed as *total* metals).

Station HB1 – Hamilton Branch at Highway A13 bridge.

	Water Quality Parameter Statistics				California Toxics Rule (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection[1]			USEPA National Recommended Ambient Water Quality Criteria Freshwater Aquatic Life Protection[2]			CA Dept. Health Services CCR-Title 22 Drinking Water Standard[3]		RWQCB-CVR Basin Plan Objectives[3]
	Mean	Median	Minimum	Maximum	4-Day[4]	1-Hour[4]	Max[4]	4-Day[4]	1-Hour[4]	Max[4]	Primary MCL	Secondary MCL	
Water Temperature (°C)	8.8	9.0	6.2	11.5									
Dissolved Oxygen (mg/L)	9.7	9.5	8.6	11.0									>7
Specific Conductance (mS/cm)	109.2	109.6	90.6	119.2								900 (μmhos/cm)	150
pH (Standard Units)	8.0	8.1	7.6	8.2						6.5-9.0			6.5-8.5
Total Dissolved Solids (mg/L)	70	70	58	76								500	
Fecal Coliform	7	2	<2	23									200/400[5]
Arsenic (mg/L)	<0.0032	<0.0032	<0.0032	<0.0032	0.15	0.34		0.15	0.34		0.05		
Barium (mg/L)	0.00128	<0.00039	<0.00039	0.00570							1.0		
Cadmium (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.005		
Chromium (mg/L)	*<0.00047*	*<0.00047*	*<0.00047*	*<0.00047*							0.05		
Copper (mg/L)	*<0.0004*	*<0.0004*	*<0.0004*	*<0.0004*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		1.3	1.0	
Iron (mg/L)	0.0371	*<0.0028*	*<0.0028*	0.1400						1.0		0.3	
Lead (mg/L)	*<0.0013*	*<0.0013*	*<0.0013*	*<0.0013*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.015		
Manganese (mg/L)	0.00346	<0.00046	<0.00046	0.01000								0.05	
Mercury (mg/L)	0.0002	*<0.0002*	*<0.0002*	0.0004				0.00077	0.0014		0.002		
Selenium (mg/L)	*<0.0042*	*<0.0042*	*<0.0042*	*<0.0042*	0.005	0.020		0.005			0.05		
Silver (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*			See Table 1B					0.10	
Zinc (mg/L)	0.0020	*<0.0013*	*<0.0013*	0.0052	See Table 1B	See Table 1B		See Table 1B	See Table 1B			5.0	
Ammonia - Total (mg/L)[6]	*<0.1*	*<0.1*	*<0.1*	*<0.1*				3.0	6.2				
Chloride (mg/L)	1.3	1.3	0.2	2.5				230	860			250	
Nitrate, as NO3 (mg/L)	2.2	0.5	0.1	8.0							45		
Sulfate (mg/L)	0.6	0.2	0.2	1.7								250	
Alkalinity - Total (mg/L)	64	65	52	70				≥20					

1. USEPA 40 CFR Part 131, Water Quality Standards; Establishment on Numeric Criteria for Priority Toxic Pollutants for the State of California [*California Toxics Rule*].
2. USEPA National Ambient Water Quality Criteria, Freshwater Aquatic Life Protection Recommended Criteria.
3. For DHS MCL's to apply, the watershed must be designated MUN in the Basin Plan. For example, Lake Almanor is not designated as having existing domestic or municipal water supply, but the North Fork Feather River is listed as a municipal water supply.
4. Fourth Edition of the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins.
5. Fecal Coliform limit is a monthly geometric mean of < 200 / 100 mL, and no more than 10% of the monthly observations above 400 /100 mL.
6. Ammonia concentration range based on the median pH and median temperature measurements made in UNFFR Project during the 2000 sampling program.

Appendix E2-C.

Table 1. Comparison of regulatory criteria and 2000 UNFFR Project water quality data (metals are expressed as *total* metals).

Station HB2 – Hamilton Branch Powerhouse at penstock head-works.

	Water Quality Parameter Statistics				California Toxics Rule (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection[1]			USEPA National Recommended Ambient Water Quality Criteria Freshwater Aquatic Life Protection[2]			CA Dept. Health Services CCR-Title 22 Drinking Water Standard[3]		RWQCB-CVR Basin Plan Objectives[3]
	Mean	Median	Minimum	Maximum	4-Day[4]	1-Hour[4]	Max[4]	4-Day[4]	1-Hour[4]	Max[4]	Primary MCL	Secondary MCL	
Water Temperature (°C)	12.7	11.7	5.4	19.9									
Dissolved Oxygen (mg/L)	9.8	9.9	7.5	12.3									>7
Specific Conductance (mS/cm)	106.2	102.9	85.6	130.9								900 (μmhos/cm)	150
pH (Standard Units)	8.2	8.2	7.3	8.8						6.5-9.0			6.5-8.5
Total Dissolved Solids (mg/L)	68	66	55	84								500	
Fecal Coliform	2	2	<2	4									200/400[5]
Arsenic (mg/L)	*<0.0032*	*<0.0032*	*<0.0032*	*<0.0032*	0.15	0.34		0.15	0.34		0.05		
Barium (mg/L)	0.0095	0.0105	0.0055	0.0110							1.0		
Cadmium (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.005		
Chromium (mg/L)	*<0.00047*	*<0.00047*	*<0.00047*	*<0.00047*							0.05		
Copper (mg/L)	*<0.0004*	*<0.0004*	*<0.0004*	*<0.0004*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		1.3	1.0	
Iron (mg/L)	0.0768	0.0670	*<0.0028*	0.1500						1.0		0.3	
Lead (mg/L)	*<0.0013*	*<0.0013*	*<0.0013*	*<0.0013*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.015		
Manganese (mg/L)	0.01002	0.00910	<0.00046	0.02500								0.05	
Mercury (mg/L)	*<0.0002*	*<0.0002*	*<0.0002*	*<0.0002*				0.00077	0.0014		0.002		
Selenium (mg/L)	*<0.0042*	*<0.0042*	*<0.0042*	*<0.0042*	0.005	0.020		0.005			0.05		
Silver (mg/L)	0.00037	*<0.00036*	*<0.00036*	0.00040			See Table 1B					0.10	
Zinc (mg/L)	0.0017	*<0.0013*	*<0.0013*	0.0038	See Table 1B	See Table 1B		See Table 1B	See Table 1B			5.0	
Ammonia - Total (mg/L)[6]	*<0.1*	*<0.1*	*<0.1*	*<0.1*				3.0	6.2				
Chloride (mg/L)	0.8	0.8	0.2	1.3				230	860			250	
Nitrate, as NO3 (mg/L)	1.5	0.1	0.1	8.0							45		
Sulfate (mg/L)	0.7	0.8	0.2	1.5								250	
Alkalinity - Total (mg/L)	61	60	50	70				≥20					

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1. USEPA 40 CFR Part 131, Water Quality Standards; Establishment on Numeric Criteria for Priority Toxic Pollutants for the State of California [*California Toxics Rule*].
2. USEPA National Ambient Water Quality Criteria, Freshwater Aquatic Life Protection Recommended Criteria.
3. For DHS MCL's to apply, the watershed must be designated MUN in the Basin Plan. For example, Lake Almanor is not designated as having existing domestic or municipal water supply, but the North Fork Feather River is listed as a municipal water supply.
4. Fourth Edition of the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins.
5. Fecal Coliform limit is a monthly geometric mean of < 200 / 100 mL, and no more than 10% of the monthly observations above 400 /100 mL.
6. Ammonia concentration range based on the median pH and median temperature measurements made in UNFFR Project during the 2000 sampling program.

Appendix E2-C.

Table 1. Comparison of regulatory criteria and 2000 UNFFR Project water quality data (metals are expressed as *total* metals).

Station LA1 (Surface) – Lake Almanor near Canyon Dam Intake.

	Water Quality Parameter Statistics				California Toxics Rule (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection[1]			USEPA National Recommended Ambient Water Quality Criteria Freshwater Aquatic Life Protection[2]			CA Dept. Health Services CCR-Title 22 Drinking Water Standard[3]		RWQCB-CVR Basin Plan Objectives[3]
	Mean	Median	Minimum	Maximum	4-Day[4]	1-Hour[4]	Max[4]	4-Day[4]	1-Hour[4]	Max[4]	Primary MCL	Secondary MCL	
Water Temperature (°C)	17.1	19.7	8.8	22.0									
Dissolved Oxygen (mg/L)	7.7	7.1	5.8	9.6									>7
Specific Conductance (mS/cm)	93.2	93.9	86.2	98.2								900 (µmhos/cm)	150
pH (Standard Units)	8.1	8.2	7.5	8.3						6.5-9.0			6.5-8.5
Total Dissolved Solids (mg/L)	60	60	55	63								500	
Fecal Coliform	<2	<2	<2	<2									200/400[5]
Arsenic (mg/L)	*<0.0032*	*<0.0032*	*<0.0032*	*<0.0032*	0.15	0.34		0.15	0.34		0.05		
Barium (mg/L)	0.0081	0.0080	0.0073	0.0093							1.0		
Cadmium (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.005		
Chromium (mg/L)	*0.00129*	*<0.00047*	*<0.00047*	*0.00540*							0.05		
Copper (mg/L)	*<0.0004*	*<0.0004*	*<0.0004*	*<0.0004*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		1.3	1.0	
Iron (mg/L)	0.0234	0.0169	*<0.0028*	0.0530						1.0		0.3	
Lead (mg/L)	*<0.0013*	*<0.0013*	*<0.0013*	*<0.0013*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.015		
Manganese (mg/L)	0.00823	0.00473	<0.00046	0.02800								0.05	
Mercury (mg/L)	*<0.0002*	*<0.0002*	*<0.0002*	*<0.0002*				0.00077	0.0014		0.002		
Selenium (mg/L)	*<0.0042*	*<0.0042*	*<0.0042*	*<0.0042*	0.005	0.020		0.005			0.05		
Silver (mg/L)	<0.00036	*<0.00036*	*<0.00036*	<0.00036			See Table 1B					0.10	
Zinc (mg/L)	0.0023	*<0.0013*	*<0.0013*	0.0052	See Table 1B	See Table 1B		See Table 1B	See Table 1B			5.0	
Ammonia - Total (mg/L)[6]	*<0.1*	*<0.1*	*<0.1*	*<0.1*				3.0	6.2				
Chloride (mg/L)	0.7	0.8	0.2	1.4				230	860			250	
Nitrate, as NO3 (mg/L)	0.2	0.1	0.1	0.9							45		
Sulfate (mg/L)	2.5	1.0	0.2	9.3								250	
Alkalinity - Total (mg/L)	50	50	48	50				≥20					

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1. USEPA 40 CFR Part 131, Water Quality Standards; Establishment on Numeric Criteria for Priority Toxic Pollutants for the State of California [*California Toxics Rule*].
2. USEPA National Ambient Water Quality Criteria, Freshwater Aquatic Life Protection Recommended Criteria.
3. For DHS MCL's to apply, the watershed must be designated MUN in the Basin Plan. For example, Lake Almanor is not designated as having existing domestic or municipal water supply, but the North Fork Feather River is listed as a municipal water supply.
4. Fourth Edition of the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins.
5. Fecal Coliform limit is a monthly geometric mean of < 200 / 100 mL, and no more than 10% of the monthly observations above 400 /100 mL.
6. Ammonia concentration range based on the median pH and median temperature measurements made in UNFFR Project during the 2000 sampling program.

Appendix E2-C.

Table 1. Comparison of regulatory criteria and 2000 UNFFR Project water quality data (metals are expressed as *total* metals).

Station LA1 (Bottom) – Lake Almanor near Canyon Dam Intake.

	Water Quality Parameter Statistics				California Toxics Rule (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection[1]			USEPA National Recommended Ambient Water Quality Criteria Freshwater Aquatic Life Protection[2]			CA Dept. Health Services CCR-Title 22 Drinking Water Standard[3]		RWQCB-CVR Basin Plan Objectives[3]
	Mean	Median	Minimum	Maximum	4-Day[4]	1-Hour[4]	Max[4]	4-Day[4]	1-Hour[4]	Max[4]	Primary MCL	Secondary MCL	
Water Temperature (°C)	11.2	11.2	7.4	16.8									
Dissolved Oxygen (mg/L)	5.5	4.9	0.7	9.8									>7
Specific Conductance (mS/cm)	92.1	92.3	85.3	97.6								900 (μmhos/cm)	150
pH (Standard Units)	7.3	7.2	6.9	8.1						6.5-9.0			6.5-8.5
Total Dissolved Solids (mg/L)	152	59	55	622								500	
Fecal Coliform	<2	<2	<2	<2									200/400[5]
Arsenic (mg/L)	*0.0065*	*<0.0032*	*<0.0032*	*0.023*	0.15	0.34		0.15	0.34		0.05		
Barium (mg/L)	0.0082	0.0090	<0.00039	0.0120							1.0		
Cadmium (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.005		
Chromium (mg/L)	*<0.00047*	*<0.00047*	*<0.00047*	*<0.00047*							0.05		
Copper (mg/L)	*<0.0004*	*<0.0004*	*<0.0004*	*<0.0004*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		1.3	1.0	
Iron (mg/L)	0.0934	0.0374	*<0.0028*	0.3200						1.0		0.3	
Lead (mg/L)	*<0.0013*	*<0.0013*	*<0.0013*	*<0.0013*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.015		
Manganese (mg/L)	0.05224	0.03900	<0.00046	0.17000								0.05	
Mercury (mg/L)	*<0.0002*	*<0.0002*	*<0.0002*	*<0.0002*				0.00077	0.0014		0.002		
Selenium (mg/L)	*<0.0042*	*<0.0042*	*<0.0042*	*<0.0042*	0.005	0.020		0.005			0.05		
Silver (mg/L)	0.00037	*<0.00036*	*<0.00036*	0.00044			See Table 1B					0.10	
Zinc (mg/L)	0.0040	*0.0032*	*<0.0013*	0.0075	See Table 1B	See Table 1B		See Table 1B	See Table 1B			5.0	
Ammonia - Total (mg/L)[6]	*<0.1*	*<0.1*	*<0.1*	*<0.1*				3.0	6.2				
Chloride (mg/L)	0.6	0.4	0.2	1.6				230	860			250	
Nitrate, as NO3 (mg/L)	0.1	0.1	0.1	0.1							45		
Sulfate (mg/L)	0.65	0.75	0.20	1.00								250	
Alkalinity - Total (mg/L)	50	50	49	50				≥20					

1. USEPA 40 CFR Part 131, Water Quality Standards; Establishment on Numeric Criteria for Priority Toxic Pollutants for the State of California [*California Toxics Rule*].
2. USEPA National Ambient Water Quality Criteria, Freshwater Aquatic Life Protection Recommended Criteria.
3. For DHS MCL's to apply, the watershed must be designated MUN in the Basin Plan. For example, Lake Almanor is not designated as having existing domestic or municipal water supply, but the North Fork Feather River is listed as a municipal water supply.
4. Fourth Edition of the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins.
5. Fecal Coliform limit is a monthly geometric mean of < 200 / 100 mL, and no more than 10% of the monthly observations above 400 /100 mL.
6. Ammonia concentration range based on the median pH and median temperature measurements made in UNFFR Project during the 2000 sampling program.

Appendix E2-C.

Table 1. Comparison of regulatory criteria and 2000 UNFFR Project water quality data (metals are expressed as *total* metals).

Station NF2 – North Fork Feather River below Canyon Dam.

	Water Quality Parameter Statistics				California Toxics Rule (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection[1]			USEPA National Recommended Ambient Water Quality Criteria Freshwater Aquatic Life Protection[2]			CA Dept. Health Services CCR-Title 22 Drinking Water Standard[3]		RWQCB-CVR Basin Plan Objectives[3]
	Mean	Median	Minimum	Maximum	4-Day [4]	1-Hour[4]	Max[4]	4-Day [4]	1-Hour[4]	Max[4]	Primary MCL	Secondary MCL	
Water Temperature (°C)	10.1	10.1	7.7	12.1									
Dissolved Oxygen (mg/L)	9.2	9.2	7.3	10.7									>7
Specific Conductance (mS/cm)	94.8	94.4	89.1	100.9								900 (µmhos/cm)	150
pH (Standard Units)	7.4	7.4	7.1	7.8						6.5-9.0			6.5-8.5
Total Dissolved Solids (mg/L)	61	61	57	65								500	
Fecal Coliform	*<2*	*<2*	*<2*	*2*									200/400[5]
Arsenic (mg/L)	*0.0035*	*<0.0032*	*<0.0032*	*0.0052*	0.15	0.34		0.15	0.34		0.05		
Barium (mg/L)	0.0146	0.0115	0.0076	0.0340							1.0		
Cadmium (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.005		
Chromium (mg/L)	*0.00439*	*<0.00047*	*<0.00047*	*0.02400*							0.05		
Copper (mg/L)	*<0.0004*	*<0.0004*	*<0.0004*	*<0.0004*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		1.3	1.0	
Iron (mg/L)	0.4698	0.2540	*<0.0028*	1.7000						1.0		0.3	
Lead (mg/L)	*<0.0013*	*<0.0013*	*<0.0013*	*<0.0013*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.015		
Manganese (mg/L)	0.4530	0.2500	0.0190	1.7000								0.05	
Mercury (mg/L)	<0.0002	*<0.0002*	*<0.0002*	<0.0002				0.00077	0.0014		0.002		
Selenium (mg/L)	*<0.0042*	*<0.0042*	*<0.0042*	*<0.0042*	0.005	0.020		0.005			0.05		
Silver (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*			See Table 1B					0.10	
Zinc (mg/L)	0.0017	<0.0013	<0.0013	0.0035	See Table 1B	See Table 1B		See Table 1B	See Table 1B			5.0	
Ammonia - Total (mg/L)[6]	*<0.1*	*<0.1*	*<0.1*	*<0.1*				3.0	6.2				
Chloride (mg/L)	1.4	1.5	0.8	2.0				230	860			250	
Nitrate, as NO3 (mg/L)	*<0.1*	*<0.1*	*<0.1*	*<0.1*							45		
Sulfate (mg/L)	0.7	0.8	0.2	1.3								250	
Alkalinity - Total (mg/L)	58	58	50	70				≥20					

1. USEPA 40 CFR Part 131, Water Quality Standards; Establishment on Numeric Criteria for Priority Toxic Pollutants for the State of California [*California Toxics Rule*].
2. USEPA National Ambient Water Quality Criteria, Freshwater Aquatic Life Protection Recommended Criteria.
3. For DHS MCL's to apply, the watershed must be designated MUN in the Basin Plan. For example, Lake Almanor is not designated as having existing domestic or municipal water supply, but the North Fork Feather River is listed as a municipal water supply.
4. Fourth Edition of the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins.
5. Fecal Coliform limit is a monthly geometric mean of < 200 / 100 mL, and no more than 10% of the monthly observations above 400 /100 mL.
6. Ammonia concentration range based on the median pH and median temperature measurements made in UNFFR Project during the 2000 sampling program.

Appendix E2-C.

Table 1. Comparison of regulatory criteria and 2000 UNFFR Project water quality data (metals are expressed as *total* metals).

Station BC1 - Butt Creek above Butt Valley Reservoir.

	Water Quality Parameter Statistics				California Toxics Rule (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection[1]			USEPA National Recommended Ambient Water Quality Criteria Freshwater Aquatic Life Protection[2]			CA Dept. Health Services CCR-Title 22 Drinking Water Standard[3]		RWQCB-CVR Basin Plan Objectives[3]
	Mean	Median	Minimum	Maximum	4-Day[4]	1-Hour[4]	Max[4]	4-Day[4]	1-Hour[4]	Max[4]	Primary MCL	Secondary MCL	
Water Temperature (°C)	7.8	8.6	3.8	11.1									
Dissolved Oxygen (mg/L)	10.0	9.8	9.3	11.2									>7
Specific Conductance (mS/cm)	130.3	139.0	77.5	146.7								900 (µmhos/cm)	150
pH (Standard Units)	7.8	8.0	7.3	8.2						6.5-9.0			6.5-8.5
Total Dissolved Solids (mg/L)	83	89	50	94								500	
Fecal Coliform	31	26	2	80									200/400[5]
Arsenic (mg/L)	*0.0035*	*<0.0032*	*<0.0032*	*0.0052*	0.15	0.34		0.15	0.34		0.05		
Barium (mg/L)	0.0068	0.0066	0.0061	0.0080							1.0		
Cadmium (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.005		
Chromium (mg/L)	*<0.00047*	*<0.00047*	*<0.00047*	*<0.00047*							0.05		
Copper (mg/L)	*<0.0004*	*<0.0004*	*<0.0004*	*<0.0004*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		1.3	1.0	
Iron (mg/L)	0.1733	0.0920	*<0.0028*	0.4400						1.0		0.3	
Lead (mg/L)	*<0.0013*	*<0.0013*	*<0.0013*	*<0.0013*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.015		
Manganese (mg/L)	0.0437	0.0365	0.0130	0.0970								0.05	
Mercury (mg/L)	*<0.0002*	*<0.0002*	*<0.0002*	*<0.0002*				0.00077	0.0014		0.002		
Selenium (mg/L)	*<0.0042*	*<0.0042*	*<0.0042*	*<0.0042*	0.005	0.020		0.005			0.05		
Silver (mg/L)	*0.00039*	*<0.00036*	*<0.00036*	*0.0005*			See Table 1B					0.10	
Zinc (mg/L)	*<0.0013*	*<0.0013*	*<0.0013*	*<0.0013*	See Table 1B	See Table 1B		See Table 1B	See Table 1B			5.0	
Ammonia - Total (mg/L)[6]	*<0.1*	*<0.1*	*<0.1*	*<0.1*				3.0	6.2				
Chloride (mg/L)	1.1	1.1	*<0.2*	2.0				230	860			250	
Nitrate, as NO3 (mg/L)	0.2	*<0.1*	*<0.1*	0.7							45		
Sulfate (mg/L)	2.3	2.4	0.6	3.9								250	
Alkalinity - Total (mg/L)	73	80	45	80				≥20					

1. USEPA 40 CFR Part 131, Water Quality Standards; Establishment on Numeric Criteria for Priority Toxic Pollutants for the State of California [*California Toxics Rule*].
2. USEPA National Ambient Water Quality Criteria, Freshwater Aquatic Life Protection Recommended Criteria.
3. For DHS MCL's to apply, the watershed must be designated MUN in the Basin Plan. For example, Lake Almanor is not designated as having existing domestic or municipal water supply, but the North Fork Feather River is listed as a municipal water supply.
4. Fourth Edition of the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins.
5. Fecal Coliform limit is a monthly geometric mean of < 200 / 100 mL, and no more than 10% of the monthly observations above 400 /100 mL.
6. Ammonia concentration range based on the median pH and median temperature measurements made in UNFFR Project during the 2000 sampling program.

Appendix E2-C.

Table 1. Comparison of regulatory criteria and 2000 UNFFR Project water quality data (metals are expressed as *total* metals).

Station BV1 – Butt Valley Powerhouse Tailrace.

	Water Quality Parameter Statistics				California Toxics Rule (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection[1]			USEPA National Recommended Ambient Water Quality Criteria Freshwater Aquatic Life Protection[2]			CA Dept. Health Services CCR-Title 22 Drinking Water Standard[3]		RWQCB-CVR Basin Plan Objectives[3]
	Mean	Median	Minimum	Maximum	4-Day[4]	1-Hour[4]	Max[4]	4-Day[4]	1-Hour[4]	Max[4]	Primary MCL	Secondary MCL	
Water Temperature (°C)	14.7	16.6	7.7	20.2									
Dissolved Oxygen (mg/L)	8.0	7.9	6.3	10.2									>7
Specific Conductance (mS/cm)	91.5	90.8	86.6	97.0								900 (µmhos/cm)	150
pH (Standard Units)	7.7	7.7	7.3	8.0						6.5-9.0			6.5-8.5
Total Dissolved Solids (mg/L)	59	59	56	62								500	
Fecal Coliform	5	<2	<2	17									200/400[5]
Arsenic (mg/L)	*<0.0032*	*<0.0032*	*<0.0032*	*<0.0032*	0.15	0.34		0.15	0.34		0.05		
Barium (mg/L)	0.0086	0.0084	0.0080	0.0093							1.0		
Cadmium (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.005		
Chromium (mg/L)	*<0.00047*	*<0.00047*	*<0.00047*	*<0.00047*							0.05		
Copper (mg/L)	*<0.0004*	*<0.0004*	*<0.0004*	*<0.0004*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		1.3	1.0	
Iron (mg/L)	0.0696	0.0710	*<0.0028*	0.1600						1.0		0.3	
Lead (mg/L)	*<0.0013*	*<0.0013*	*<0.0013*	*<0.0013*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.015		
Manganese (mg/L)	0.0437	0.0365	0.0130	0.0970								0.05	
Mercury (mg/L)	<0.0002	*<0.0002*	*<0.0002*	<0.0002				0.00077	0.0014		0.002		
Selenium (mg/L)	*<0.0042*	*<0.0042*	*<0.0042*	*<0.0042*	0.005	0.020		0.005			0.05		
Silver (mg/L)	*0.000383333*	*<0.00036*	*<0.00036*	*0.0005*			See Table 1B					0.10	
Zinc (mg/L)	0.0044	<0.0013	<0.0013	0.0200	See Table 1B	See Table 1B		See Table 1B	See Table 1B			5.0	
Ammonia - Total (mg/L)[6]	*<0.1*	*<0.1*	*<0.1*	*<0.1*				3.0	6.2				
Chloride (mg/L)	1.6	1.4	0.4	3.3				230	860			250	
Nitrate, as NO3 (mg/L)	0.5	<0.1	<0.1	2.7							45		
Sulfate (mg/L)	1.2	1.1	<0.2	2.0								250	
Alkalinity - Total (mg/L)	51	50	45	60				≥20					

1. USEPA 40 CFR Part 131, Water Quality Standards; Establishment on Numeric Criteria for Priority Toxic Pollutants for the State of California [*California Toxics Rule*].
2. USEPA National Ambient Water Quality Criteria, Freshwater Aquatic Life Protection Recommended Criteria.
3. For DHS MCL's to apply, the watershed must be designated MUN in the Basin Plan. For example, Lake Almanor is not designated as having existing domestic or municipal water supply, but the North Fork Feather River is listed as a municipal water supply.
4. Fourth Edition of the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins.
5. Fecal Coliform limit is a monthly geometric mean of < 200 / 100 mL, and no more than 10% of the monthly observations above 400 /100 mL.
6. Ammonia concentration range based on the median pH and median temperature measurements made in UNFFR Project during the 2000 sampling program.

Appendix E2-C.

Table 1. Comparison of regulatory criteria and 2000 UNFFR Project water quality data (metals are expressed as *total* metals).

Station BV2 (Surface) - Butt Valley Reservoir near Caribou Powerhouse Unit 1 intake structure.

	Water Quality Parameter Statistics				California Toxics Rule (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection[1]			USEPA National Recommended Ambient Water Quality Criteria Freshwater Aquatic Life Protection[2]			CA Dept. Health Services CCR-Title 22 Drinking Water Standard[3]		RWQCB-CVR Basin Plan Objectives[3]
	Mean	Median	Minimum	Maximum	4-Day[4]	1-Hour[4]	Max[4]	4-Day[4]	1-Hour[4]	Max[4]	Primary MCL	Secondary MCL	
Water Temperature (°C)	16.5	18.7	7.9	21.0									
Dissolved Oxygen (mg/L)	8.3	8.2	6.0	10.6									>7
Specific Conductance (mS/cm)	95.9	95.7	89.7	101.3								900 (µmhos/cm)	150
pH (Standard Units)	7.7	7.7	7.5	7.9						6.5-9.0			6.5-8.5
Total Dissolved Solids (mg/L)	61	61	57	65								500	
Fecal Coliform	*<2*	*<2*	*<2*	*<2*									200/400[5]
Arsenic (mg/L)	*<0.0032*	*<0.0032*	*<0.0032*	*<0.0032*	0.15	0.34		0.15	0.34		0.05		
Barium (mg/L)	0.0079	0.0080	0.0069	0.0089							1.0		
Cadmium (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.005		
Chromium (mg/L)	*0.00206*	*<0.00047*	*<0.00047*	*0.01000*							0.05		
Copper (mg/L)	*<0.0004*	*<0.0004*	*<0.0004*	*<0.0004*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		1.3	1.0	
Iron (mg/L)	0.0436	0.0254	*<0.0028*	0.1300						1.0		0.3	
Lead (mg/L)	*<0.0013*	*<0.0013*	*<0.0013*	*<0.0013*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.015		
Manganese (mg/L)	0.0167	0.0175	0.0110	0.0210								0.05	
Mercury (mg/L)	0.00025	*<0.0002*	*<0.0002*	0.00051				0.00077	0.0014		0.002		
Selenium (mg/L)	*<0.0042*	*<0.0042*	*<0.0042*	*<0.0042*	0.005	0.020		0.005			0.05		
Silver (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*			See Table 1B					0.10	
Zinc (mg/L)	0.0018	<0.0013	<0.0013	0.0044	See Table 1B	See Table 1B		See Table 1B	See Table 1B			5.0	
Ammonia - Total (mg/L)[6]	*<0.1*	*<0.1*	*<0.1*	*<0.1*				3.0	6.2				
Chloride (mg/L)	0.7	0.8	0.2	1.4				230	860			250	
Nitrate, as NO3 (mg/L)	0.5	*<0.1*	*<0.1*	2.3							45		
Sulfate (mg/L)	0.5	0.4	*<0.2*	1.0								250	
Alkalinity - Total (mg/L)	50	50	50	50				≥20					

1. USEPA 40 CFR Part 131, Water Quality Standards; Establishment on Numeric Criteria for Priority Toxic Pollutants for the State of California [*California Toxics Rule*].
2. USEPA National Ambient Water Quality Criteria, Freshwater Aquatic Life Protection Recommended Criteria.
3. For DHS MCL's to apply, the watershed must be designated MUN in the Basin Plan. For example, Lake Almanor is not designated as having existing domestic or municipal water supply, but the North Fork Feather River is listed as a municipal water supply.
4. Fourth Edition of the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins.
5. Fecal Coliform limit is a monthly geometric mean of < 200 / 100 mL, and no more than 10% of the monthly observations above 400 /100 mL.
6. Ammonia concentration range based on the median pH and median temperature measurements made in UNFFR Project during the 2000 sampling program.

Appendix E2-C.

Table 1. Comparison of regulatory criteria and 2000 UNFFR Project water quality data (metals are expressed as *total* metals).

Station BV2 (Bottom) - Butt Valley Reservoir near Caribou Powerhouse Unit 1 intake structure.

	Water Quality Parameter Statistics				California Toxics Rule (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection[1]			USEPA National Recommended Ambient Water Quality Criteria Freshwater Aquatic Life Protection[2]			CA Dept. Health Services CCR-Title 22 Drinking Water Standard[3]		RWQCB-CVR Basin Plan Objectives[3]
	Mean	Median	Minimum	Maximum	4-Day[4]	1-Hour[4]	Max[4]	4-Day[4]	1-Hour[4]	Max[4]	Primary MCL	Secondary MCL	
Water Temperature (°C)	12.4	13.5	6.1	17.3									
Dissolved Oxygen (mg/L)	4.1	2.4	0.4	10.3									>7
Specific Conductance (mS/cm)	99.4	99.3	85.3	119.2								900 (µmhos/cm)	150
pH (Standard Units)	7.0	7.0	6.8	7.4						6.5-9.0			6.5-8.5
Total Dissolved Solids (mg/L)	64	63	55	76								500	
Fecal Coliform	*<2*	*<2*	*<2*	*<2*									200/400[5]
Arsenic (mg/L)	*<0.0032*	*<0.0032*	*<0.0032*	*<0.0032*	0.15	0.34		0.15	0.34		0.05		
Barium (mg/L)	0.0118	0.0095	0.0078	0.0220							1.0		
Cadmium (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.005		
Chromium (mg/L)	*<0.00047*	*<0.00047*	*<0.00047*	*<0.00047*							0.05		
Copper (mg/L)	*<0.0004*	*<0.0004*	*<0.0004*	*<0.0004*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		1.3	1.0	
Iron (mg/L)	0.2427	0.1200	*0.0440*	0.7900						1.0		0.3	
Lead (mg/L)	*<0.0013*	*<0.0013*	*<0.0013*	*<0.0013*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.015		
Manganese (mg/L)	0.2605	0.1450	0.0160	0.7100								0.05	
Mercury (mg/L)	<0.0002	*<0.0002*	*<0.0002*	<0.0002				0.00077	0.0014		0.002		
Selenium (mg/L)	*<0.0042*	*<0.0042*	*<0.0042*	*<0.0042*	0.005	0.020		0.005			0.05		
Silver (mg/L)	*0.000365*	*<0.00036*	*<0.00036*	*0.00039*			See Table 1B					0.10	
Zinc (mg/L)	0.0025	0.0013	0.0013	0.0071	See Table 1B	See Table 1B		See Table 1B	See Table 1B			5.0	
Ammonia - Total (mg/L)[6]	*<0.1*	*<0.1*	*<0.1*	*<0.1*				3.0	6.2				
Chloride (mg/L)	1.1	1.1	0.2	2.1				230	860			250	
Nitrate, as NO3 (mg/L)	*<0.1*	*<0.1*	*<0.1*	*<0.1*							45		
Sulfate (mg/L)	0.8	1.0	0.2	1.1								250	
Alkalinity - Total (mg/L)	51	50	48	60				≥20					

1. USEPA 40 CFR Part 131, Water Quality Standards; Establishment on Numeric Criteria for Priority Toxic Pollutants for the State of California [*California Toxics Rule*].
2. USEPA National Ambient Water Quality Criteria, Freshwater Aquatic Life Protection Recommended Criteria.
3. For DHS MCL's to apply, the watershed must be designated MUN in the Basin Plan. For example, Lake Almanor is not designated as having existing domestic or municipal water supply, but the North Fork Feather River is listed as a municipal water supply.
4. Fourth Edition of the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins.
5. Fecal Coliform limit is a monthly geometric mean of < 200 / 100 mL, and no more than 10% of the monthly observations above 400 /100 mL.
6. Ammonia concentration range based on the median pH and median temperature measurements made in UNFFR Project during the 2000 sampling program.

Appendix E2-C.

Table 1. Comparison of regulatory criteria and 2000 UNFFR Project water quality data (metals are expressed as *total* metals).

Station BC3 - Butt Creek above North Fork Feather River.

	Water Quality Parameter Statistics				California Toxics Rule (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection[1]			USEPA National Recommended Ambient Water Quality Criteria Freshwater Aquatic Life Protection[2]			CA Dept. Health Services CCR-Title 22 Drinking Water Standard[3]		RWQCB-CVR Basin Plan Objectives[3]
	Mean	Median	Minimum	Maximum	4-Day[4]	1-Hour[4]	Max[4]	4-Day[4]	1-Hour[4]	Max[4]	Primary MCL	Secondary MCL	
Water Temperature (°C)	10.6	11.1	8.6	12.0									
Dissolved Oxygen (mg/L)	9.4	9.3	8.4	10.3									>7
Specific Conductance (mS/cm)	174.5	176.0	159.0	183.5								900 (µmhos/cm)	150
pH (Standard Units)	8.0	8.0	7.6	8.2						6.5-9.0			6.5-8.5
Total Dissolved Solids (mg/L)	112	113	102	118								500	
Fecal Coliform	*<2*	*<2*	*<2*	*<2*									200/400[5]
Arsenic (mg/L)	*<0.0032*	*<0.0032*	*<0.0032*	*<0.0032*	0.15	0.34		0.15	0.34		0.05		
Barium (mg/L)	0.0045	0.0052	*<0.00039*	0.0057							1.0		
Cadmium (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.005		
Chromium (mg/L)	*<0.00047*	*<0.00047*	*<0.00047*	*<0.00047*							0.05		
Copper (mg/L)	*<0.0004*	*<0.0004*	*<0.0004*	*<0.0004*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		1.3	1.0	
Iron (mg/L)	*<0.0028*	*<0.0028*	*<0.0028*	*<0.0028*						1.0		0.3	
Lead (mg/L)	*<0.0013*	*<0.0013*	*<0.0013*	*<0.0013*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.015		
Manganese (mg/L)	<0.00046	<0.00046	<0.00046	<0.00046								0.05	
Mercury (mg/L)	0.00023	*<0.0002*	*<0.0002*	0.00036				0.00077	0.0014		0.002		
Selenium (mg/L)	*<0.0042*	*<0.0042*	*<0.0042*	*<0.0042*	0.005	0.020		0.005			0.05		
Silver (mg/L)	*0.000421667*	*0.000405*	*<0.00036*	*0.00052*			See Table 1B					0.10	
Zinc (mg/L)	*<0.0013*	*<0.0013*	*<0.0013*	*<0.0013*	See Table 1B	See Table 1B		See Table 1B	See Table 1B			5.0	
Ammonia - Total (mg/L)[6]	*<0.1*	*<0.1*	*<0.1*	*<0.1*				3.0	6.2				
Chloride (mg/L)	1.2	1.3	0.2	2.0				230	860			250	
Nitrate, as NO3 (mg/L)	1.4	*<0.1*	*<0.1*	8.0							45		
Sulfate (mg/L)	3.0	3.0	2.8	3.4								250	
Alkalinity - Total (mg/L)	105	100	87	150				≥20					

1. USEPA 40 CFR Part 131, Water Quality Standards; Establishment on Numeric Criteria for Priority Toxic Pollutants for the State of California [*California Toxics Rule*].
2. USEPA National Ambient Water Quality Criteria, Freshwater Aquatic Life Protection Recommended Criteria.
3. For DHS MCL's to apply, the watershed must be designated MUN in the Basin Plan. For example, Lake Almanor is not designated as having existing domestic or municipal water supply, but the North Fork Feather River is listed as a municipal water supply.
4. Fourth Edition of the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins.
5. Fecal Coliform limit is a monthly geometric mean of < 200 / 100 mL, and no more than 10% of the monthly observations above 400 /100 mL.
6. Ammonia concentration range based on the median pH and median temperature measurements made in UNFFR Project during the 2000 sampling program.

Appendix E2-C.

Table 1. Comparison of regulatory criteria and 2000 UNFFR Project water quality data (metals are expressed as *total* metals).

Station NF4 – North Fork Feather River above Caribou Powerhouse.

	Water Quality Parameter Statistics				California Toxics Rule (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection[1]			USEPA National Recommended Ambient Water Quality Criteria Freshwater Aquatic Life Protection[2]			CA Dept. Health Services CCR-Title 22 Drinking Water Standard[3]		RWQCB-CVR Basin Plan Objectives[3]
	Mean	Median	Minimum	Maximum	4-Day[4]	1-Hour[4]	Max[4]	4-Day[4]	1-Hour[4]	Max[4]	Primary MCL	Secondary MCL	
Water Temperature (°C)	10.7	11.6	6.8	14.0									
Dissolved Oxygen (mg/L)	9.4	8.8	8.6	11.2									>7
Specific Conductance (mS/cm)	159.9	163.6	128.1	171.3								900 (µmhos/cm)	150
pH (Standard Units)	8.0	8.1	7.5	8.2						6.5-9.0			6.5-8.5
Total Dissolved Solids (mg/L)	102	105	82	110								500	
Fecal Coliform	4	3	<2	8									200/400[5]
Arsenic (mg/L)	*0.00395*	*<0.0032*	*<0.0032*	*0.0077*	0.15	0.34		0.15	0.34		0.05		
Barium (mg/L)	0.0213	0.0210	0.0150	0.0300							1.0		
Cadmium (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.005		
Chromium (mg/L)	*<0.00047*	*<0.00047*	*<0.00047*	*<0.00047*							0.05		
Copper (mg/L)	*<0.0004*	*<0.0004*	*<0.0004*	*<0.0004*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		1.3	1.0	
Iron (mg/L)	0.1250	0.0925	*<0.0028*	0.3900						1.0		0.3	
Lead (mg/L)	*<0.0013*	*<0.0013*	*<0.0013*	*<0.0013*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.015		
Manganese (mg/L)	0.0528	0.0320	0.0180	0.1600								0.05	
Mercury (mg/L)	<0.0002	*<0.0002*	*<0.0002*	<0.0002				0.00077	0.0014		0.002		
Selenium (mg/L)	*<0.0042*	*<0.0042*	*<0.0042*	*<0.0042*	0.005	0.020		0.005			0.05		
Silver (mg/L)	*0.000393333*	*<0.00036*	*<0.00036*	*0.00056*			See Table 1B					0.10	
Zinc (mg/L)	0.0018	<0.0013	<0.0013	0.0040	See Table 1B	See Table 1B		See Table 1B	See Table 1B			5.0	
Ammonia - Total (mg/L)[6]	*<0.1*	*<0.1*	*<0.1*	*<0.1*				3.0	6.2				
Chloride (mg/L)	1.6	1.6	0.7	2.1				230	860			250	
Nitrate, as NO3 (mg/L)	0.7	*<0.1*	*<0.1*	3.5							45		
Sulfate (mg/L)	3.0	3.3	0.2	4.0								250	
Alkalinity - Total (mg/L)	85	90	68	90				≥20					

1. USEPA 40 CFR Part 131, Water Quality Standards; Establishment on Numeric Criteria for Priority Toxic Pollutants for the State of California [*California Toxics Rule*].
2. USEPA National Ambient Water Quality Criteria, Freshwater Aquatic Life Protection Recommended Criteria.
3. For DHS MCL's to apply, the watershed must be designated MUN in the Basin Plan. For example, Lake Almanor is not designated as having existing domestic or municipal water supply, but the North Fork Feather River is listed as a municipal water supply.
4. Fourth Edition of the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins.
5. Fecal Coliform limit is a monthly geometric mean of < 200 / 100 mL, and no more than 10% of the monthly observations above 400 /100 mL.
6. Ammonia concentration range based on the median pH and median temperature measurements made in UNFFR Project during the 2000 sampling program.

Appendix E2-C.

Table 1. Comparison of regulatory criteria and 2000 UNFFR Project water quality data (metals are expressed as *total* metals).

Station CARB1 – Caribou No.1 Powerhouse tailrace.

	Water Quality Parameter Statistics				California Toxics Rule (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection[1]			USEPA National Recommended Ambient Water Quality Criteria Freshwater Aquatic Life Protection[2]			CA Dept. Health Services CCR-Title 22 Drinking Water Standard[3]		RWQCB-CVR Basin Plan Objectives[3]
	Mean	Median	Minimum	Maximum	4-Day[4]	1-Hour[4]	Max[4]	4-Day[4]	1-Hour[4]	Max[4]	Primary MCL	Secondary MCL	
Water Temperature (°C)	16.0	17.2	9.1	19.5									
Dissolved Oxygen (mg/L)	7.7	7.4	6.8	9.3									>7
Specific Conductance (mS/cm)	99.3	98.9	94.5	102.5								900 (μmhos/cm)	150
pH (Standard Units)	7.8	7.9	7.6	8.0						6.5-9.0			6.5-8.5
Total Dissolved Solids (mg/L)	63	63	60	65								500	
Fecal Coliform	*<2*	*<2*	*<2*	*<2*									200/400[5]
Arsenic (mg/L)	*<0.0032*	*<0.0032*	*<0.0032*	*<0.0032*	0.15	0.34		0.15	0.34		0.05		
Barium (mg/L)	0.0090	0.0095	0.0077	0.0098							1.0		
Cadmium (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.005		
Chromium (mg/L)	*<0.00047*	*<0.00047*	*<0.00047*	*<0.00047*							0.05		
Copper (mg/L)	*0.00158*	*<0.0004*	*<0.0004*	*0.00630*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		1.3	1.0	
Iron (mg/L)	0.1006	0.0930	*<0.0028*	0.2500						1.0		0.3	
Lead (mg/L)	*<0.0013*	*<0.0013*	*<0.0013*	*<0.0013*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.015		
Manganese (mg/L)	0.0788	0.0510	0.0180	0.1800								0.05	
Mercury (mg/L)	0.00022	*<0.0002*	*<0.0002*	0.00028				0.00077	0.0014		0.002		
Selenium (mg/L)	*<0.0042*	*<0.0042*	*<0.0042*	*<0.0042*	0.005	0.020		0.005			0.05		
Silver (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*			See Table 1B					0.10	
Zinc (mg/L)	0.0167	0.0210	<0.0013	0.0280	See Table 1B	See Table 1B		See Table 1B	See Table 1B			5.0	
Ammonia - Total (mg/L)[6]	*<0.1*	*<0.1*	*<0.1*	*<0.1*				3.0	6.2				
Chloride (mg/L)	1.3	1.2	0.7	2.0				230	860			250	
Nitrate, as NO3 (mg/L)	*<0.1*	*<0.1*	*<0.1*	*<0.1*							45		
Sulfate (mg/L)	1.2	1.0	1.0	1.5								250	
Alkalinity - Total (mg/L)	52	50	50	60				≥20					

1. USEPA 40 CFR Part 131, Water Quality Standards; Establishment on Numeric Criteria for Priority Toxic Pollutants for the State of California [*California Toxics Rule*].
2. USEPA National Ambient Water Quality Criteria, Freshwater Aquatic Life Protection Recommended Criteria.
3. For DHS MCL's to apply, the watershed must be designated MUN in the Basin Plan. For example, Lake Almanor is not designated as having existing domestic or municipal water supply, but the North Fork Feather River is listed as a municipal water supply.
4. Fourth Edition of the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins.
5. Fecal Coliform limit is a monthly geometric mean of < 200 / 100 mL, and no more than 10% of the monthly observations above 400 /100 mL.
6. Ammonia concentration range based on the median pH and median temperature measurements made in UNFFR Project during the 2000 sampling program.

Appendix E2-C.

Table 1. Comparison of regulatory criteria and 2000 UNFFR Project water quality data (metals are expressed as *total* metals).

Station CARB2 – Caribou No.2 Powerhouse tailrace.

	Water Quality Parameter Statistics				California Toxics Rule (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection[1]			USEPA National Recommended Ambient Water Quality Criteria Freshwater Aquatic Life Protection[2]			CA Dept. Health Services CCR-Title 22 Drinking Water Standard[3]		RWQCB-CVR Basin Plan Objectives[3]
	Mean	Median	Minimum	Maximum	4-Day[4]	1-Hour[4]	Max[4]	4-Day[4]	1-Hour[4]	Max[4]	Primary MCL	Secondary MCL	
Water Temperature (°C)	18.5	19.9	8.9	24.5									
Dissolved Oxygen (mg/L)	7.8	7.6	6.5	10.1									>7
Specific Conductance (mS/cm)	97.0	96.4	94.4	100.8								900 (µmhos/cm)	150
pH (Standard Units)	7.8	7.8	7.7	7.9						6.5-9.0			6.5-8.5
Total Dissolved Solids (mg/L)	62	62	60	65								500	
Fecal Coliform	*<2*	*<2*	*<2*	*<2*									200/400[5]
Arsenic (mg/L)	*<0.0032*	*<0.0032*	*<0.0032*	*<0.0032*	0.15	0.34		0.15	0.34		0.05		
Barium (mg/L)	0.0091	0.0087	0.0077	0.0120							1.0		
Cadmium (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.005		
Chromium (mg/L)	*<0.00047*	*<0.00047*	*<0.00047*	*<0.00047*							0.05		
Copper (mg/L)	*<0.0004*	*<0.0004*	*<0.0004*	*<0.0004*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		1.3	1.0	
Iron (mg/L)	0.0571	0.0520	*<0.0028*	0.1500						1.0		0.3	
Lead (mg/L)	*<0.0013*	*<0.0013*	*<0.0013*	*<0.0013*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.015		
Manganese (mg/L)	0.0622	0.0210	0.0170	0.2300								0.05	
Mercury (mg/L)	0.00023	*<0.0002*	*<0.0002*	0.00035				0.00077	0.0014		0.002		
Selenium (mg/L)	*<0.0042*	*<0.0042*	*<0.0042*	*<0.0042*	0.005	0.020		0.005			0.05		
Silver (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*			See Table 1B					0.10	
Zinc (mg/L)	<0.0013	<0.0013	<0.0013	<0.0013	See Table 1B	See Table 1B		See Table 1B	See Table 1B			5.0	
Ammonia - Total (mg/L)[6]	*<0.1*	*<0.1*	*<0.1*	*<0.1*				3.0	6.2				
Chloride (mg/L)	1.6	1.4	0.8	3.0				230	860			250	
Nitrate, as NO3 (mg/L)	0.2	*<0.1*	*<0.1*	0.7							45		
Sulfate (mg/L)	0.9	1.0	*<0.2*	1.5								250	
Alkalinity - Total (mg/L)	52	50	50	60				≥20					

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1. USEPA 40 CFR Part 131, Water Quality Standards; Establishment on Numeric Criteria for Priority Toxic Pollutants for the State of California [*California Toxics Rule*].
2. USEPA National Ambient Water Quality Criteria, Freshwater Aquatic Life Protection Recommended Criteria.
3. For DHS MCL's to apply, the watershed must be designated MUN in the Basin Plan. For example, Lake Almanor is not designated as having existing domestic or municipal water supply, but the North Fork Feather River is listed as a municipal water supply.
4. Fourth Edition of the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins.
5. Fecal Coliform limit is a monthly geometric mean of < 200 / 100 mL, and no more than 10% of the monthly observations above 400 /100 mL.
6. Ammonia concentration range based on the median pH and median temperature measurements made in UNFFR Project during the 2000 sampling program.

Appendix E2-C.

Table 1. Comparison of regulatory criteria and 2000 UNFFR Project water quality data (metals are expressed as *total* metals).

Station NF5 – North Fork Feather River below Belden Dam.

	Water Quality Parameter Statistics				California Toxics Rule (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection[1]			USEPA National Recommended Ambient Water Quality Criteria Freshwater Aquatic Life Protection[2]			CA Dept. Health Services CCR-Title 22 Drinking Water Standard[3]		RWQCB-CVR Basin Plan Objectives[3]
	Mean	Median	Minimum	Maximum	4-Day[4]	1-Hour[4]	Max[4]	4-Day[4]	1-Hour[4]	Max[4]	Primary MCL	Secondary MCL	
Water Temperature (°C)	15.2	17.1	8.5	20.4									
Dissolved Oxygen (mg/L)	8.5	8.0	7.2	10.5									>7
Specific Conductance (mS/cm)	110.1	105.7	98.2	140.1								900 (µmhos/cm)	150
pH (Standard Units)	7.8	7.8	7.6	7.9						6.5-9.0			6.5-8.5
Total Dissolved Solids (mg/L)	70	68	63	90								500	
Fecal Coliform	*2*	*<2*	*<2*	*4*									200/400[5]
Arsenic (mg/L)	*<0.0032*	*<0.0032*	*<0.0032*	*<0.0032*	0.15	0.34		0.15	0.34		0.05		
Barium (mg/L)	0.0106	0.0097	0.0078	0.0170							1.0		
Cadmium (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.005		
Chromium (mg/L)	*<0.00047*	*<0.00047*	*<0.00047*	*<0.00047*							0.05		
Copper (mg/L)	*<0.0004*	*<0.0004*	*<0.0004*	*<0.0004*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		1.3	1.0	
Iron (mg/L)	0.0604	0.0635	*<0.0028*	0.1500						1.0		0.3	
Lead (mg/L)	*<0.0013*	*<0.0013*	*<0.0013*	*<0.0013*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.015		
Manganese (mg/L)	0.0543	0.0655	0.0150	0.0800								0.05	
Mercury (mg/L)	<0.0002	*<0.0002*	*<0.0002*	<0.0002				0.00077	0.0014		0.002		
Selenium (mg/L)	*<0.0042*	*<0.0042*	*<0.0042*	*<0.0042*	0.005	0.020		0.005			0.05		
Silver (mg/L)	*0.000423333*	*<0.00036*	*<0.00036*	*0.00074*			See Table 1B					0.10	
Zinc (mg/L)	0.0060	0.0030	<0.0013	0.0190	See Table 1B	See Table 1B		See Table 1B	See Table 1B			5.0	
Ammonia - Total (mg/L)[6]	*<0.1*	*<0.1*	*<0.1*	*<0.1*				3.0	6.2				
Chloride (mg/L)	1.3	1.3	0.6	2.0				230	860			250	
Nitrate, as NO3 (mg/L)	1.5	*<0.1*	*<0.1*	4.8							45		
Sulfate (mg/L)	1.9	1.4	1.0	4.8								250	
Alkalinity - Total (mg/L)	59	60	50	74				≥20					

1. USEPA 40 CFR Part 131, Water Quality Standards; Establishment on Numeric Criteria for Priority Toxic Pollutants for the State of California [*California Toxics Rule*].
2. USEPA National Ambient Water Quality Criteria, Freshwater Aquatic Life Protection Recommended Criteria.
3. For DHS MCL's to apply, the watershed must be designated MUN in the Basin Plan. For example, Lake Almanor is not designated as having existing domestic or municipal water supply, but the North Fork Feather River is listed as a municipal water supply.
4. Fourth Edition of the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins.
5. Fecal Coliform limit is a monthly geometric mean of < 200 / 100 mL, and no more than 10% of the monthly observations above 400 /100 mL.
6. Ammonia concentration range based on the median pH and median temperature measurements made in UNFFR Project during the 2000 sampling program.

Appendix E2-C.

Table 1. Comparison of regulatory criteria and 2000 UNFFR Project water quality data (metals are expressed as *total* metals).

Station NF7 – North Fork Feather River near Gansner Bar.

	Water Quality Parameter Statistics				California Toxics Rule (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection[1]			USEPA National Recommended Ambient Water Quality Criteria Freshwater Aquatic Life Protection[2]			CA Dept. Health Services CCR-Title 22 Drinking Water Standard[3]		RWQCB-CVR Basin Plan Objectives[3]
	Mean	Median	Minimum	Maximum	4-Day[4]	1-Hour[4]	Max[4]	4-Day[4]	1-Hour[4]	Max[4]	Primary MCL	Secondary MCL	
Water Temperature (°C)	15.5	17.6	8.0	20.1									
Dissolved Oxygen (mg/L)	9.0	8.6	7.4	11.4									>7
Specific Conductance (mS/cm)	133.9	131.6	116.2	161.0								900 (μmhos/cm)	150
pH (Standard Units)	8.1	8.1	7.8	8.4						6.5-9.0			6.5-8.5
Total Dissolved Solids (mg/L)	86	84	74	103								500	
Fecal Coliform	3	4	2	4									200/400[5]
Arsenic (mg/L)	<0.0032	<0.0032	<0.0032	<0.0032	0.15	0.34		0.15	0.34		0.05		
Barium (mg/L)	0.0113	0.0105	0.0093	0.0170							1.0		
Cadmium (mg/L)	<0.00036	<0.00036	<0.00036	<0.00036	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.005		
Chromium (mg/L)	<0.00047	<0.00047	<0.00047	<0.00047							0.05		
Copper (mg/L)	<0.0004	<0.0004	<0.0004	<0.0004	See Table 1B	See Table 1B		See Table 1B	See Table 1B		1.3	1.0	
Iron (mg/L)	0.0547	0.0289	<0.0028	0.1800						1.0		0.3	
Lead (mg/L)	<0.0013	<0.0013	<0.0013	<0.0013	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.015		
Manganese (mg/L)	0.0221	0.0205	0.0056	0.0390								0.05	
Mercury (mg/L)	<0.0002	<0.0002	<0.0002	<0.0002				0.00077	0.0014		0.002		
Selenium (mg/L)	<0.0042	<0.0042	<0.0042	<0.0042	0.005	0.020		0.005			0.05		
Silver (mg/L)	0.000378333	<0.00036	<0.00036	0.00047			See Table 1B					0.10	
Zinc (mg/L)	<0.0013	<0.0013	<0.0013	<0.0013	See Table 1B	See Table 1B		See Table 1B	See Table 1B			5.0	
Ammonia - Total (mg/L)[6]	<0.1	<0.1	<0.1	<0.1				3.0	6.2				
Chloride (mg/L)	1.4	1.5	0.6	2.0				230	860			250	
Nitrate, as NO3 (mg/L)	0.2	0.1	0.1	0.7							45		
Sulfate (mg/L)	3.1	3.0	1.7	6.0								250	
Alkalinity - Total (mg/L)	69	70	60	84				≥20					

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1. USEPA 40 CFR Part 131, Water Quality Standards; Establishment on Numeric Criteria for Priority Toxic Pollutants for the State of California [*California Toxics Rule*].
2. USEPA National Ambient Water Quality Criteria, Freshwater Aquatic Life Protection Recommended Criteria.
3. For DHS MCL's to apply, the watershed must be designated MUN in the Basin Plan. For example, Lake Almanor is not designated as having existing domestic or municipal water supply, but the North Fork Feather River is listed as a municipal water supply.
4. Fourth Edition of the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins.
5. Fecal Coliform limit is a monthly geometric mean of < 200 / 100 mL, and no more than 10% of the monthly observations above 400 /100 mL.
6. Ammonia concentration range based on the median pH and median temperature measurements made in UNFFR Project during the 2000 sampling program.

Appendix E2-C.

Table 1. Comparison of regulatory criteria and 2000 UNFFR Project water quality data (metals are expressed as *total* metals).

Station EB1 – East Branch North Fork Feather River above confluence.

	Water Quality Parameter Statistics				California Toxics Rule (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection[1]			USEPA National Recommended Ambient Water Quality Criteria Freshwater Aquatic Life Protection[2]			CA Dept. Health Services CCR-Title 22 Drinking Water Standard[3]		RWQCB-CVR Basin Plan Objectives[3]
	Mean	Median	Minimum	Maximum	4-Day[4]	1-Hour[4]	Max[4]	4-Day[4]	1-Hour[4]	Max[4]	Primary MCL	Secondary MCL	
Water Temperature (°C)	15.9	17.7	4.6	22.7									
Dissolved Oxygen (mg/L)	8.9	8.7	6.6	12.5									>7
Specific Conductance (mS/cm)	174.3	191.9	81.7	212.7								900 (µmhos/cm)	150
pH (Standard Units)	8.3	8.4	7.6	8.8						6.5-9.0			6.5-8.5
Total Dissolved Solids (mg/L)	112	123	53	136								500	
Fecal Coliform	4	2	<2	9									200/400[5]
Arsenic (mg/L)	0.0054	<0.0032	<0.0032	0.0098	0.15	0.34		0.15	0.34		0.05		
Barium (mg/L)	0.02883	0.03000	0.02200	0.03400							1.0		
Cadmium (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.005		
Chromium (mg/L)	*<0.00047*	*<0.00047*	*<0.00047*	*<0.00047*							0.05		
Copper (mg/L)	*<0.0004*	*<0.0004*	*<0.0004*	*<0.0004*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		1.3	1.0	
Iron (mg/L)	0.1585	*0.0685*	*<0.0028*	0.6400						1.0		0.3	
Lead (mg/L)	*<0.0013*	*<0.0013*	*<0.0013*	*<0.0013*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.015		
Manganese (mg/L)	0.0134	0.0125	0.0077	0.0230								0.05	
Mercury (mg/L)	<0.0002	*<0.0002*	*<0.0002*	<0.0002				0.00077	0.0014		0.002		
Selenium (mg/L)	*<0.0042*	*<0.0042*	*<0.0042*	*<0.0042*	0.005	0.020		0.005			0.05		
Silver (mg/L)	*0.00045*	*0.00046*	*<0.00036*	*0.00053*			See Table 1B					0.10	
Zinc (mg/L)	0.0023	*<0.0013*	*<0.0013*	0.0071	See Table 1B	See Table 1B		See Table 1B	See Table 1B			5.0	
Ammonia - Total (mg/L)[6]	*<0.1*	*<0.1*	*<0.1*	*<0.1*				3.0	6.2				
Chloride (mg/L)	3.4	3.9	0.6	4.5				230	860			250	
Nitrate, as NO3 (mg/L)	3.5	0.4	*<0.1*	14							45		
Sulfate (mg/L)	5.5	5.6	3.0	7.4								250	
Alkalinity - Total (mg/L)	86	90	43	100				≥20					

1. USEPA 40 CFR Part 131, Water Quality Standards; Establishment on Numeric Criteria for Priority Toxic Pollutants for the State of California [*California Toxics Rule*].
2. USEPA National Ambient Water Quality Criteria, Freshwater Aquatic Life Protection Recommended Criteria.
3. For DHS MCL's to apply, the watershed must be designated MUN in the Basin Plan. For example, Lake Almanor is not designated as having existing domestic or municipal water supply, but the North Fork Feather River is listed as a municipal water supply.
4. Fourth Edition of the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins.
5. Fecal Coliform limit is a monthly geometric mean of < 200 / 100 mL, and no more than 10% of the monthly observations above 400 /100 mL.
6. Ammonia concentration range based on the median pH and median temperature measurements made in UNFFR Project during the 2000 sampling program.

Appendix E2-C.

Table 1. Comparison of regulatory criteria and 2000 UNFFR Project water quality data (metals are expressed as *total* metals).

Station NF8 – North Fork Feather River above Belden Town Bridge.

	Water Quality Parameter Statistics				California Toxics Rule (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection[1]			USEPA National Recommended Ambient Water Quality Criteria Freshwater Aquatic Life Protection[2]			CA Dept. Health Services CCR-Title 22 Drinking Water Standard[3]		RWQCB-CVR Basin Plan Objectives[3]
	Mean	Median	Minimum	Maximum	4-Day[4]	1-Hour[4]	Max[4]	4-Day[4]	1-Hour[4]	Max[4]	Primary MCL	Secondary MCL	
Water Temperature (°C)	14.3	16.1	5.5	18.4									
Dissolved Oxygen (mg/L)	8.9	8.6	7.4	11.4									>7
Specific Conductance (mS/cm)	149.5	156.4	91.1	184.5								900 (µmhos/cm)	150
pH (Standard Units)	8.0	8.1	7.7	8.2						6.5-9.0			6.5-8.5
Total Dissolved Solids (mg/L)	96	100	58	118								500	
Fecal Coliform	16	6	<2	50									200/400[5]
Arsenic (mg/L)	*0.0038*	*<0.0032*	*<0.0032*	*0.0066*	0.15	0.34		0.15	0.34		0.05		
Barium (mg/L)	0.0217	0.0215	0.0190	0.0240							1.0		
Cadmium (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.005		
Chromium (mg/L)	*<0.00047*	*<0.00047*	*<0.00047*	*<0.00047*							0.05		
Copper (mg/L)	*<0.0004*	*<0.0004*	*<0.0004*	*<0.0004*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		1.3	1.0	
Iron (mg/L)	0.1925	0.0805	*<0.0028*	0.6100						1.0		0.3	
Lead (mg/L)	*<0.0013*	*<0.0013*	*<0.0013*	*<0.0013*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.015		
Manganese (mg/L)	0.0209	0.0195	0.0074	0.0370								0.05	
Mercury (mg/L)	<0.0002	*<0.0002*	*<0.0002*	<0.0002				0.00077	0.0014		0.002		
Selenium (mg/L)	*<0.0042*	*<0.0042*	*<0.0042*	*<0.0042*	0.005	0.020		0.005			0.05		
Silver (mg/L)	*0.00043*	*0.00039*	*<0.00036*	*0.00061*			See Table 1B					0.10	
Zinc (mg/L)	0.0056	<0.0013	<0.0013	0.0190	See Table 1B	See Table 1B		See Table 1B	See Table 1B			5.0	
Ammonia - Total (mg/L)[6]	*0.1*	*<0.1*	*<0.1*	*0.3*				3.0	6.2				
Chloride (mg/L)	2.0	2.0	0.9	3.3				230	860			250	
Nitrate, as NO3 (mg/L)	1.0	0.1	0.1	5.7							45		
Sulfate (mg/L)	4.3	4.5	2.6	5.6								250	
Alkalinity - Total (mg/L)	75	80	49	90				≥20					

1. USEPA 40 CFR Part 131, Water Quality Standards; Establishment on Numeric Criteria for Priority Toxic Pollutants for the State of California [*California Toxics Rule*].
2. USEPA National Ambient Water Quality Criteria, Freshwater Aquatic Life Protection Recommended Criteria.
3. For DHS MCL's to apply, the watershed must be designated MUN in the Basin Plan. For example, Lake Almanor is not designated as having existing domestic or municipal water supply, but the North Fork Feather River is listed as a municipal water supply.
4. Fourth Edition of the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins.
5. Fecal Coliform limit is a monthly geometric mean of < 200 / 100 mL, and no more than 10% of the monthly observations above 400 /100 mL.
6. Ammonia concentration range based on the madian pH and median temperature measurements made in UNFFR Project during the 2000 sampling program.

Appendix E2-C.

Table 1. Comparison of regulatory criteria and 2000 UNFFR Project water quality data (metals are expressed as *total* metals).

Station YC1 – Yellow Creek above Belden Powerhouse tailrace.

	Water Quality Parameter Statistics				California Toxics Rule (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection[1]			USEPA National Recommended Ambient Water Quality Criteria Freshwater Aquatic Life Protection[2]			CA Dept. Health Services CCR-Title 22 Drinking Water Standard[3]		RWQCB-CVR Basin Plan Objectives[3]
	Mean	Median	Minimum	Maximum	4-Day[4]	1-Hour[4]	Max[4]	4-Day[4]	1-Hour[4]	Max[4]	Primary MCL	Secondary MCL	
Water Temperature (°C)	9.9	11.3	2.9	13.6									
Dissolved Oxygen (mg/L)	10.1	10.3	8.7	12.2									>7
Specific Conductance (mS/cm)	118.4	127.9	84.2	136.7								900 (µmhos/cm)	150
pH (Standard Units)	7.8	7.9	7.4	8.1						6.5-9.0			6.5-8.5
Total Dissolved Solids (mg/L)	73	82	36	87								500	
Fecal Coliform	3	4	<2	4									200/400[5]
Arsenic (mg/L)	*<0.0032*	*<0.0032*	*<0.0032*	*<0.0032*	0.15	0.34		0.15	0.34		0.05		
Barium (mg/L)	0.0102	0.0100	0.0082	0.0120							1.0		
Cadmium (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.005		
Chromium (mg/L)	*<0.00047*	*<0.00047*	*<0.00047*	*<0.00047*							0.05		
Copper (mg/L)	*<0.0004*	*<0.0004*	*<0.0004*	*<0.0004*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		1.3	1.0	
Iron (mg/L)	0.0379	0.0249	*<0.0028*	0.1100						1.0		0.3	
Lead (mg/L)	*<0.0013*	*<0.0013*	*<0.0013*	*<0.0013*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.015		
Manganese (mg/L)	<0.00046	<0.00046	<0.00046	<0.00046								0.05	
Mercury (mg/L)	<0.0002	*<0.0002*	*<0.0002*	<0.0002				0.00077	0.0014		0.002		
Selenium (mg/L)	*<0.0042*	*<0.0042*	*<0.0042*	*<0.0042*	0.005	0.020		0.005			0.05		
Silver (mg/L)	*0.00040*	*0.00038*	*<0.00036*	*0.00048*			See Table 1B					0.10	
Zinc (mg/L)	0.0022	<0.0013	<0.0013	0.0067	See Table 1B	See Table 1B		See Table 1B	See Table 1B			5.0	
Ammonia - Total (mg/L)[6]	*0.1*	*<0.1*	*<0.1*	*0.3*				3.0	6.2				
Chloride (mg/L)	1.2	1.4	0.2	2.0				230	860			250	
Nitrate, as NO3 (mg/L)	1.3	0.1	0.1	6.0							45		
Sulfate (mg/L)	1.7	1.7	0.6	2.9								250	
Alkalinity - Total (mg/L)	67	70	50	80				≥20					

1. USEPA 40 CFR Part 131, Water Quality Standards; Establishment on Numeric Criteria for Priority Toxic Pollutants for the State of California [*California Toxics Rule*].
2. USEPA National Ambient Water Quality Criteria, Freshwater Aquatic Life Protection Recommended Criteria.
3. For DHS MCL's to apply, the watershed must be designated MUN in the Basin Plan. For example, Lake Almanor is not designated as having existing domestic or municipal water supply, but the North Fork Feather River is listed as a municipal water supply.
4. Fourth Edition of the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins.
5. Fecal Coliform limit is a monthly geometric mean of < 200 / 100 mL, and no more than 10% of the monthly observations above 400 /100 mL.
6. Ammonia concentration range based on the median pH and median temperature measurements made in UNFFR Project during the 2000 sampling program.

Appendix E2-C.

Table 1. Comparison of regulatory criteria and 2000 UNFFR Project water quality data(metals are expressed as *total* metals).

Station BD2 - Belden Powerhouse Tailrace.

	Water Quality Parameter Statistics				California Toxics Rule (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection[1]			USEPA National Recommended Ambient Water Quality Criteria Freshwater Aquatic Life Protection[2]			CA Dept. Health Services CCR-Title 22 Drinking Water Standard[3]		RWQCB-CVR Basin Plan Objectives[3]
	Mean	Median	Minimum	Maximum	4-Day[4]	1-Hour[4]	Max[4]	4-Day[4]	1-Hour[4]	Max[4]	Primary MCL	Secondary MCL	
Water Temperature (°C)	16.6	18.8	8.4	19.7									
Dissolved Oxygen (mg/L)	8.0	7.9	6.7	10.7									>7
Specific Conductance (mS/cm)	101.0	100.7	97.9	106.7								900 (μmhos/cm)	150
pH (Standard Units)	7.8	7.8	7.7	7.9						6.5-9.0			6.5-8.5
Total Dissolved Solids (mg/L)	65	65	63	68								500	
Fecal Coliform	*<2*	*<2*	*<2*	*<2*									200/400[5]
Arsenic (mg/L)	*0.003775*	*<0.0032*	*<0.0032*	*0.0055*	0.15	0.34		0.15	0.34		0.05		
Barium (mg/L)	0.0093	0.0095	0.0082	0.0100							1.0		
Cadmium (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.005		
Chromium (mg/L)	*<0.00047*	*<0.00047*	*<0.00047*	*<0.00047*							0.05		
Copper (mg/L)	*<0.0004*	*<0.0004*	*<0.0004*	*<0.0004*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		1.3	1.0	
Iron (mg/L)	0.0954	0.0990	*<0.0028*	0.1900						1.0		0.3	
Lead (mg/L)	*<0.0013*	*<0.0013*	*<0.0013*	*<0.0013*	See Table 1B	See Table 1B		See Table 1B	See Table 1B		0.015		
Manganese (mg/L)	0.0528	0.0440	0.0240	0.0910								0.05	
Mercury (mg/L)	<0.0002	*<0.0002*	*<0.0002*	<0.0002				0.00077	0.0014		0.002		
Selenium (mg/L)	*<0.0042*	*<0.0042*	*<0.0042*	*<0.0042*	0.005	0.020		0.005			0.05		
Silver (mg/L)	*<0.00036*	*<0.00036*	*<0.00036*	*<0.00036*			See Table 1B					0.10	
Zinc (mg/L)	0.0178	0.0220	<0.0013	0.0340	See Table 1B	See Table 1B		See Table 1B	See Table 1B			5.0	
Ammonia - Total (mg/L)[6]	*<0.1*	*<0.1*	*<0.1*	*<0.1*				3.0	6.2				
Chloride (mg/L)	1.4	1.6	0.9	2.0				230	860			250	
Nitrate, as NO3 (mg/L)	5.8	3.6	0.1	16							45		
Sulfate (mg/L)	2.2	1.2	0.2	6.0								250	
Alkalinity - Total (mg/L)	54	50	50	60				≥20					

1. USEPA 40 CFR Part 131, Water Quality Standards; Establishment on Numeric Criteria for Priority Toxic Pollutants for the State of California [*California Toxics Rule*].
2. USEPA National Ambient Water Quality Criteria, Freshwater Aquatic Life Protection Recommended Criteria.
3. For DHS MCL's to apply, the watershed must be designated MUN in the Basin Plan. For example, Lake Almanor is not designated as having existing domestic or municipal water supply, but the North Fork Feather River is listed as a municipal water supply.
4. Fourth Edition of the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins.
5. Fecal Coliform limit is a monthly geometric mean of < 200 / 100 mL, and no more than 10% of the monthly observations above 400 /100 mL.
6. Ammonia concentration range based on the median pH and median temperature measurements made in UNFFR Project during the 2000 sampling program..

Appendix E2-C.

Table 1B. Comparison of hardness-based regulatory criteria and 2000 UNFFR Project data for metals (expressed at *total* metals).

Station NF1B - North Fork Feather River at Chester

	Reporting Limits	Detection Limits	Results (mg/L)	California Toxics Rules Criteria (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection		
				4-Day	1-Hour	Max
April 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0006	0.0006	
Copper (mg/L)	0.005	0.00040	ND	0.0020	0.0025	
Lead (mg/L)	0.005	0.0013	ND	0.0003	0.009	
Silver (mg/L)	0.005	0.00036	ND			0.00016
Zinc (mg/L)	0.01	0.0013	ND	0.026	0.026	
Total Hardness, as CaCO3 (mg/L)	1		17			
June 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0007	0.0008	
Copper (mg/L)	0.005	0.00040	ND	0.0024	0.0031	
Lead (mg/L)	0.005	0.0013	ND	0.0004	0.011	
Silver (mg/L)	0.005	0.00036	ND			0.00024
Zinc (mg/L)	0.01	0.0013	ND	0.031	0.031	
Total Hardness, as CaCO3 (mg/L)	1		21			
July 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0009	0.0012	
Copper (mg/L)	0.005	0.00040	ND	0.0033	0.0045	
Lead (mg/L)	0.005	0.0013	ND	0.0007	0.018	
Silver (mg/L)	0.005	0.00036	ND			0.00046
Zinc (mg/L)	0.01	0.0013	ND	0.044	0.043	
Total Hardness, as CaCO3 (mg/L)	1		31			
August 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0009	0.0012	
Copper (mg/L)	0.005	0.00040	ND	0.0032	0.0043	
Lead (mg/L)	0.005	0.0013	ND	0.0007	0.017	
Silver (mg/L)	0.005	0.00036	ND			0.00043
Zinc (mg/L)	0.01	0.0013	ND	0.043	0.042	
Total Hardness, as CaCO3 (mg/L)	1		30			
September 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0009	0.0011	
Copper (mg/L)	0.005	0.00040	ND	0.0031	0.0042	
Lead (mg/L)	0.005	0.0013	ND	0.0006	0.016	
Silver (mg/L)	0.005	0.00036	ND			0.00041
Zinc (mg/L)	0.01	0.0013	ND	0.041	0.041	
Total Hardness, as CaCO3 (mg/L)	1		29			
November 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0009	0.0011	
Copper (mg/L)	0.005	0.00040	ND	0.0031	0.0042	
Lead (mg/L)	0.005	0.0013	ND	0.0006	0.016	
Silver (mg/L)	0.005	0.00036	ND			0.00041
Zinc (mg/L)	0.01	0.0013	0.0058 J	0.041	0.041	
Total Hardness, as CaCO3 (mg/L)	1		29			

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1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
3. "J" Flag is placed in a report in which lab reports results between the MDL and reporting limit. It indicates that the result is estimated. While definitely present, it is below the reporting limit, indicating we do not track the accuracy at these levels.

Appendix E2-C.

Table 1B. Comparison of hardness-based regulatory criteria and 2000 UNFFR Project data for metals (expressed at *total* metals).

Station HB1 - Hamiltion Branch at Highway A13 bridge

	Reporting Limits	Detection Limits	Results (mg/L)	California Toxics Rules Criteria (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection		
				4-Day	1-Hour	Max
April 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0017	
Copper (mg/L)	0.005	0.00040	ND	0.0043	0.0059	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.025	
Silver (mg/L)	0.005	0.00036	ND			0.00078
Zinc (mg/L)	0.01	0.0013	ND	0.057	0.056	
Total Hardness, as CaCO3 (mg/L)	1		42			
June 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0014	0.0021	
Copper (mg/L)	0.005	0.00040	ND	0.0051	0.0073	
Lead (mg/L)	0.005	0.0013	ND	0.0012	0.031	
Silver (mg/L)	0.005	0.00036	ND			0.00112
Zinc (mg/L)	0.01	0.0013	ND	0.068	0.067	
Total Hardness, as CaCO3 (mg/L)	1		52			
July 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0015	0.0025	
Copper (mg/L)	0.005	0.00040	ND	0.0058	0.0083	
Lead (mg/L)	0.005	0.0013	ND	0.0014	0.037	
Silver (mg/L)	0.005	0.00036	ND			0.00143
Zinc (mg/L)	0.01	0.0013	ND	0.077	0.076	
Total Hardness, as CaCO3 (mg/L)	1		60			
August 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0015	0.0023	
Copper (mg/L)	0.005	0.00040	ND	0.0055	0.0078	
Lead (mg/L)	0.005	0.0013	ND	0.0013	0.034	
Silver (mg/L)	0.005	0.00036	ND			0.00127
Zinc (mg/L)	0.01	0.0013	ND	0.072	0.072	
Total Hardness, as CaCO3 (mg/L)	1		56			
September 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0014	0.0021	
Copper (mg/L)	0.005	0.00040	ND	0.0051	0.0073	
Lead (mg/L)	0.005	0.0013	ND	0.0012	0.031	
Silver (mg/L)	0.005	0.00036	ND			0.00112
Zinc (mg/L)	0.01	0.0013	ND	0.068	0.067	
Total Hardness, as CaCO3 (mg/L)	10		52			
November 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0014	0.0022	
Copper (mg/L)	0.005	0.00040	ND	0.0053	0.0075	
Lead (mg/L)	0.005	0.0013	ND	0.0013	0.033	
Silver (mg/L)	0.005	0.00036	ND			0.00120
Zinc (mg/L)	0.01	0.0013	ND	0.070	0.070	
Total Hardness, as CaCO3 (mg/L)	1		54			

1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
3. "J" Flag is placed in a report in which lab reports results between the MDL and reporting limit. It indicates that the result is estimated. While definitely present, it is below the reporting limit, indicating we do not track the accuracy at these levels.

Appendix E2-C.

Table 1B. Comparison of hardness-based regulatory criteria and 2000 UNFFR Project data for metals (expressed at *total* metals).

Station HB2 - Hamiltion Branch Powerhouse (at Header Box)

	Reporting Limits	Detection Limits	Results (mg/L)	California Toxics Rules Criteria (USEPA) Inland Surface Waters		
				Freshwater Aquatic Life Protection		
				4-Day	1-Hour	Max
April 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0011	0.0014	
Copper (mg/L)	0.005	0.00040	ND	0.0037	0.0051	
Lead (mg/L)	0.005	0.0013	ND	0.0008	0.021	
Silver (mg/L)	0.005	0.00036	ND			0.00060
Zinc (mg/L)	0.01	0.0013	ND	0.050	0.049	
Total Hardness, as CaCO3 (mg/L)	1		36			
June 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0011	0.0015	
Copper (mg/L)	0.005	0.00040	ND	0.0040	0.0055	
Lead (mg/L)	0.005	0.0013	ND	0.0009	0.023	
Silver (mg/L)	0.005	0.00036	ND			0.00068
Zinc (mg/L)	0.01	0.0013	ND	0.053	0.053	
Total Hardness, as CaCO3 (mg/L)	1		39			
July 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0013	0.0018	
Copper (mg/L)	0.005	0.00040	ND	0.0046	0.0065	
Lead (mg/L)	0.005	0.0013	ND	0.0011	0.027	
Silver (mg/L)	0.005	0.00036	ND			0.00091
Zinc (mg/L)	0.01	0.0013	ND	0.061	0.061	
Total Hardness, as CaCO3 (mg/L)	1		46			
August 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0017	
Copper (mg/L)	0.005	0.00040	ND	0.0043	0.0059	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.025	
Silver (mg/L)	0.005	0.00036	ND			0.00078
Zinc (mg/L)	0.01	0.0013	ND	0.057	0.056	
Total Hardness, as CaCO3 (mg/L)	1		42			
September 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0011	0.0016	
Copper (mg/L)	0.005	0.00040	ND	0.0041	0.0057	
Lead (mg/L)	0.005	0.0013	ND	0.0009	0.024	
Silver (mg/L)	0.005	0.00036	ND			0.00071
Zinc (mg/L)	0.01	0.0013	ND	0.054	0.054	
Total Hardness, as CaCO3 (mg/L)	10		40			
November 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0017	
Copper (mg/L)	0.005	0.00040	ND	0.0043	0.0059	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.025	
Silver (mg/L)	0.005	0.00036	ND			0.00078
Zinc (mg/L)	0.01	0.0013	ND	0.057	0.056	
Total Hardness, as CaCO3 (mg/L)	1		42			

1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
3. "J" Flag is placed in a report in which lab reports results between the MDL and reporting limit. It indicates that the result is estimated. While definitely present, it is below the reporting limit, indicating we do not track the accuracy at these levels.

Appendix E2-C.

Table 1B. Comparison of hardness-based regulatory criteria and 2000 UNFFR Project data for metals (expressed at *total* metals).

Station LA1-S(urface) - Lake Almanor near Canyon Dam

California Toxics Rules Criteria (USEPA)
Inland Surface Waters
Freshwater Aquatic Life Protection

April 2000

	Reporting Limits	Detection Limits	Results (mg/L)	4-Day	1-Hour	Max
Cadmium (mg/L)	0.002	0.00036	ND	0.0011	0.0014	
Copper (mg/L)	0.005	0.00040	ND	0.0037	0.0051	
Lead (mg/L)	0.005	0.0013	ND	0.0008	0.021	
Silver (mg/L)	0.005	0.00036	ND			0.00060
Zinc (mg/L)	0.01	0.0013	ND	0.050	0.049	
Total Hardness, as CaCO3 (mg/L)	1		36			

June 2000

	Reporting Limits	Detection Limits	Results (mg/L)	4-Day	1-Hour	Max
Cadmium (mg/L)	0.002	0.00036	ND	0.0011	0.0015	
Copper (mg/L)	0.005	0.00040	ND	0.0040	0.0055	
Lead (mg/L)	0.005	0.0013	ND	0.0009	0.023	
Silver (mg/L)	0.005	0.00036	ND			0.00068
Zinc (mg/L)	0.01	0.0013	ND	0.053	0.053	
Total Hardness, as CaCO3 (mg/L)	1		39			

July 2000

	Reporting Limits	Detection Limits	Results (mg/L)	4-Day	1-Hour	Max
Cadmium (mg/L)	0.002	0.00036	ND	0.0013	0.0018	
Copper (mg/L)	0.005	0.00040	ND	0.0046	0.0065	
Lead (mg/L)	0.005	0.0013	ND	0.0011	0.027	
Silver (mg/L)	0.005	0.00036	ND			0.00091
Zinc (mg/L)	0.01	0.0013	ND	0.061	0.061	
Total Hardness, as CaCO3 (mg/L)	1		46			

August 2000

	Reporting Limits	Detection Limits	Results (mg/L)	4-Day	1-Hour	Max
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0017	
Copper (mg/L)	0.005	0.00040	ND	0.0043	0.0059	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.025	
Silver (mg/L)	0.005	0.00036	ND			0.00078
Zinc (mg/L)	0.01	0.0013	ND	0.057	0.056	
Total Hardness, as CaCO3 (mg/L)	1		42			

September 2000

	Reporting Limits	Detection Limits	Results (mg/L)	4-Day	1-Hour	Max
Cadmium (mg/L)	0.002	0.00036	ND	0.0011	0.0016	
Copper (mg/L)	0.005	0.00040	ND	0.0041	0.0057	
Lead (mg/L)	0.005	0.0013	ND	0.0009	0.024	
Silver (mg/L)	0.005	0.00036	ND			0.00071
Zinc (mg/L)	0.01	0.0013	ND	0.054	0.054	
Total Hardness, as CaCO3 (mg/L)	10		40			

November 2000

	Reporting Limits	Detection Limits	Results (mg/L)	4-Day	1-Hour	Max
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0017	
Copper (mg/L)	0.005	0.00040	ND	0.0043	0.0059	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.025	
Silver (mg/L)	0.005	0.00036	ND			0.00078
Zinc (mg/L)	0.01	0.0013	0.0033 J	0.057	0.056	
Total Hardness, as CaCO3 (mg/L)	1		42			

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1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
3. "J" Flag is placed in a report in which lab reports results between the MDL and reporting limit. It indicates that the result is estimated. While definitely present, it is below the reporting limit, indicating we do not track the accuracy at these levels.

Appendix E2-C.

Table 1B. Comparison of hardness-based regulatory criteria and 2000 UNFFR Project data for metals (expressed at *total* metals).

Station LA1 - B(ottom) - Lake Almanor near Canyon Dam

				California Toxics Rules Criteria (USEPA) Inland Surface Waters		
				Freshwater Aquatic Life Protection		
	Reporting Limits	Detection Limits	Results (mg/L)	4-Day	1-Hour	Max
April 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0011	0.0015	
Copper (mg/L)	0.005	0.00040	ND	0.0040	0.0055	
Lead (mg/L)	0.005	0.0013	ND	0.0009	0.023	
Silver (mg/L)	0.005	0.00036	0.00044 J			0.00068
Zinc (mg/L)	0.01	0.0013	0.00044 J	0.053	0.053	
Total Hardness, as CaCO3 (mg/L)	1		39			
June 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0016	
Copper (mg/L)	0.005	0.00040	ND	0.0042	0.0058	
Lead (mg/L)	0.005	0.0013	ND	0.0009	0.024	
Silver (mg/L)	0.005	0.00036	ND			0.00074
Zinc (mg/L)	0.01	0.0013	0.0075 J	0.056	0.055	
Total Hardness, as CaCO3 (mg/L)	1		41			
July 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0013	0.0018	
Copper (mg/L)	0.005	0.00040	ND	0.0046	0.0065	
Lead (mg/L)	0.005	0.0013	ND	0.0011	0.027	
Silver (mg/L)	0.005	0.00036	ND			0.00091
Zinc (mg/L)	0.01	0.0013	0.0033 J	0.061	0.061	
Total Hardness, as CaCO3 (mg/L)	1		46			
August 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0017	
Copper (mg/L)	0.005	0.00040	ND	0.0044	0.0061	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.025	
Silver (mg/L)	0.005	0.00036	ND			0.00081
Zinc (mg/L)	0.01	0.0013	ND	0.058	0.057	
Total Hardness, as CaCO3 (mg/L)	1		43			
September 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0004	0.0003	
Copper (mg/L)	0.005	0.00040	ND	0.0013	0.0015	
Lead (mg/L)	0.005	0.0013	ND	0.0002	0.005	
Silver (mg/L)	0.005	0.00036	ND			0.00007
Zinc (mg/L)	0.01	0.0013	ND	0.017	0.017	
Total Hardness, as CaCO3 (mg/L)	10		10			
November 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0016	
Copper (mg/L)	0.005	0.00040	ND	0.0042	0.0058	
Lead (mg/L)	0.005	0.0013	ND	0.0009	0.024	
Silver (mg/L)	0.005	0.00036	ND			0.00074
Zinc (mg/L)	0.01	0.0013	0.0074 J	0.056	0.055	
Total Hardness, as CaCO3 (mg/L)	1		41			

1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
3. "J" Flag is placed in a report in which lab reports results between the MDL and reporting limit. It indicates that the result is estimated. While definitely present, it is below the reporting limit, indicating we do not track the accuracy at these levels.

Appendix E2-C.

Table 1B. Comparison of hardness-based regulatory criteria and 2000 UNFFR Project data for metals (expressed at *total* metals).

Station NF2 - North Fork Feather River below Canyon Dam

	Reporting Limits	Detection Limits	Results (mg/L)	California Toxics Rules Criteria (USEPA) Inland Surface Waters – Freshwater Aquatic Life Protection		
				4-Day	1-Hour	Max
April 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0017	
Copper (mg/L)	0.005	0.00040	ND	0.0044	0.0061	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.025	
Silver (mg/L)	0.005	0.00036	ND			0.00081
Zinc (mg/L)	0.01	0.0013	ND	0.058	0.057	
Total Hardness, as CaCO3 (mg/L)	1		43			
June 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0017	
Copper (mg/L)	0.005	0.00040	ND	0.0043	0.0059	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.025	
Silver (mg/L)	0.005	0.00036	ND			0.00078
Zinc (mg/L)	0.01	0.0013	0.0035 J	0.057	0.056	
Total Hardness, as CaCO3 (mg/L)	1		42			
July 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0013	0.0020	
Copper (mg/L)	0.005	0.00040	ND	0.0050	0.0070	
Lead (mg/L)	0.005	0.0013	ND	0.0012	0.030	
Silver (mg/L)	0.005	0.00036	ND			0.00105
Zinc (mg/L)	0.01	0.0013	ND	0.066	0.065	
Total Hardness, as CaCO3 (mg/L)	1		50			
August 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0018	
Copper (mg/L)	0.005	0.00040	ND	0.0044	0.0062	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.026	
Silver (mg/L)	0.005	0.00036	ND			0.00084
Zinc (mg/L)	0.01	0.0013	ND	0.059	0.058	
Total Hardness, as CaCO3 (mg/L)	1		44			
September 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0018	
Copper (mg/L)	0.005	0.00040	ND	0.0044	0.0062	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.026	
Silver (mg/L)	0.005	0.00036	ND			0.00084
Zinc (mg/L)	0.01	0.0013	ND	0.059	0.058	
Total Hardness, as CaCO3 (mg/L)	1		44			
November 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0016	
Copper (mg/L)	0.005	0.00040	ND	0.0042	0.0058	
Lead (mg/L)	0.005	0.0013	ND	0.0009	0.024	
Silver (mg/L)	0.005	0.00036	ND			0.00074
Zinc (mg/L)	0.01	0.0013	ND	0.056	0.055	
Total Hardness, as CaCO3 (mg/L)	1		41			

1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
3. "J" Flag is placed in a report in which lab reports results between the MDL and reporting limit. It indicates that the result is estimated. While definitely present, it is below the reporting limit, indicating we do not track the accuracy at these levels.

Appendix E2-C.

Table 1B. Comparison of hardness-based regulatory criteria and 2000 UNFFR Project data for metals (expressed at *total* metals).

Station BC1 - Butt Creek above Butt Valley Reservoir

	Reporting Limits	Detection Limits	Results (mg/L)	California Toxics Rules Criteria (USEPA) Inland Surface Waters		
				Freshwater Aquatic Life Protection		
				4-Day	1-Hour	Max
April 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0011	0.0015	
Copper (mg/L)	0.005	0.00040	ND	0.0038	0.0053	
Lead (mg/L)	0.005	0.0013	ND	0.0008	0.022	
Silver (mg/L)	0.005	0.00036	ND			0.00062
Zinc (mg/L)	0.01	0.0013	ND	0.051	0.050	
Total Hardness, as CaCO3 (mg/L)	1		37			
June 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0016	0.0027	
Copper (mg/L)	0.005	0.00040	ND	0.0063	0.0091	
Lead (mg/L)	0.005	0.0013	ND	0.0016	0.041	
Silver (mg/L)	0.005	0.00036	ND			0.00169
Zinc (mg/L)	0.01	0.0013	ND	0.083	0.082	
Total Hardness, as CaCO3 (mg/L)	1		66			
July 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0019	0.0034	
Copper (mg/L)	0.005	0.00040	ND	0.0076	0.0111	
Lead (mg/L)	0.005	0.0013	ND	0.0020	0.052	
Silver (mg/L)	0.005	0.00036	0.0005 J			0.00245
Zinc (mg/L)	0.01	0.0013	ND	0.100	0.099	
Total Hardness, as CaCO3 (mg/L)	1		82			
August 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0018	0.0030	
Copper (mg/L)	0.005	0.00040	ND	0.0068	0.0100	
Lead (mg/L)	0.005	0.0013	ND	0.0018	0.046	
Silver (mg/L)	0.005	0.00036	0.0004 J			0.00201
Zinc (mg/L)	0.01	0.0013	ND	0.090	0.090	
Total Hardness, as CaCO3 (mg/L)	1		73			
September 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0017	0.0028	
Copper (mg/L)	0.005	0.00040	ND	0.0064	0.0093	
Lead (mg/L)	0.005	0.0013	ND	0.0016	0.042	
Silver (mg/L)	0.005	0.00036	ND			0.00178
Zinc (mg/L)	0.01	0.0013	ND	0.085	0.085	
Total Hardness, as CaCO3 (mg/L)	10		68			
November 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0016	0.0027	
Copper (mg/L)	0.005	0.00040	ND	0.0062	0.0090	
Lead (mg/L)	0.005	0.0013	ND	0.0016	0.040	
Silver (mg/L)	0.005	0.00036	ND			0.00164
Zinc (mg/L)	0.01	0.0013	ND	0.082	0.081	
Total Hardness, as CaCO3 (mg/L)	1		65			

1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
3. "J" Flag is placed in a report in which lab reports results between the MDL and reporting limit. It indicates that the result is estimated. While definitely present, it is below the reporting limit, indicating we do not track the accuracy at these levels.

Appendix E2-C.

Table 1B. Comparison of hardness-based regulatory criteria and 2000 UNFFR Project data for metals (expressed at *total* metals).

Station BV1 - Butt Valley Powerhouse Tailrace

	Reporting Limits	Detection Limits	Results (mg/L)	California Toxics Rules Criteria (USEPA) Inland Surface Waters		
				Freshwater Aquatic Life Protection		
				4-Day	1-Hour	Max
April 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0011	0.0014	
Copper (mg/L)	0.005	0.00040	ND	0.0037	0.0051	
Lead (mg/L)	0.005	0.0013	ND	0.0008	0.021	
Silver (mg/L)	0.005	0.00036	0.00047 J			0.00060
Zinc (mg/L)	0.01	0.0013	0.00047 J	0.050	0.049	
Total Hardness, as CaCO3 (mg/L)	1		36			
June 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0011	0.0016	
Copper (mg/L)	0.005	0.00040	ND	0.0041	0.0057	
Lead (mg/L)	0.005	0.0013	ND	0.0009	0.024	
Silver (mg/L)	0.005	0.00036	ND			0.00071
Zinc (mg/L)	0.01	0.0013	ND	0.054	0.054	
Total Hardness, as CaCO3 (mg/L)	1		40			
July 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0013	0.0018	
Copper (mg/L)	0.005	0.00040	ND	0.0046	0.0065	
Lead (mg/L)	0.005	0.0013	ND	0.0011	0.027	
Silver (mg/L)	0.005	0.00036	ND			0.00091
Zinc (mg/L)	0.01	0.0013	ND	0.061	0.061	
Total Hardness, as CaCO3 (mg/L)	1		46			
August 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0017	
Copper (mg/L)	0.005	0.00040	ND	0.0044	0.0061	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.025	
Silver (mg/L)	0.005	0.00036	ND			0.00081
Zinc (mg/L)	0.01	0.0013	ND	0.058	0.057	
Total Hardness, as CaCO3 (mg/L)	1		43			
September 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0016	
Copper (mg/L)	0.005	0.00040	ND	0.0042	0.0058	
Lead (mg/L)	0.005	0.0013	ND	0.0009	0.024	
Silver (mg/L)	0.005	0.00036	ND			0.00074
Zinc (mg/L)	0.01	0.0013	0.02	0.056	0.055	
Total Hardness, as CaCO3 (mg/L)	10		41			
November 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0017	
Copper (mg/L)	0.005	0.00040	ND	0.0043	0.0059	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.025	
Silver (mg/L)	0.005	0.00036	ND			0.00078
Zinc (mg/L)	0.01	0.0013	ND	0.057	0.056	
Total Hardness, as CaCO3 (mg/L)	1		42			

1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
3. "J" Flag is placed in a report in which lab reports results between the MDL and reporting limit. It indicates that the result is estimated. While definitely present, it is below the reporting limit, indicating we do not track the accuracy at these levels.

Appendix E2-C.
Table 1B. Comparison of hardness-based regulatory criteria and 2000 UNFFR Project data for metals (expressed at *total* metals).

Station BV2-S(urface) - Butt Valley Reservoir near Caribou Powerhouse Unit 1 intake structure

				California Toxics Rules Criteria (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection		
	Reporting Limits	Detection Limits	Results (mg/L)	4-Day	1-Hour	Max
April 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0011	0.0015	
Copper (mg/L)	0.005	0.00040	ND	0.0040	0.0055	
Lead (mg/L)	0.005	0.0013	ND	0.0009	0.023	
Silver (mg/L)	0.005	0.00036	0.00035 J			0.00068
Zinc (mg/L)	0.01	0.0013	0.00035 J	0.053	0.053	
Total Hardness, as CaCO3 (mg/L)	1		39			
June 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0016	
Copper (mg/L)	0.005	0.00040	ND	0.0042	0.0058	
Lead (mg/L)	0.005	0.0013	ND	0.0009	0.024	
Silver (mg/L)	0.005	0.00036	ND			0.00074
Zinc (mg/L)	0.01	0.0013	ND	0.056	0.055	
Total Hardness, as CaCO3 (mg/L)	1		41			
July 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0013	0.0019	
Copper (mg/L)	0.005	0.00040	ND	0.0047	0.0066	
Lead (mg/L)	0.005	0.0013	ND	0.0011	0.028	
Silver (mg/L)	0.005	0.00036	ND			0.00094
Zinc (mg/L)	0.01	0.0013	ND	0.062	0.062	
Total Hardness, as CaCO3 (mg/L)	1		47			
August 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0018	
Copper (mg/L)	0.005	0.00040	ND	0.0044	0.0062	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.026	
Silver (mg/L)	0.005	0.00036	ND			0.00084
Zinc (mg/L)	0.01	0.0013	ND	0.059	0.058	
Total Hardness, as CaCO3 (mg/L)	1		44			
September 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0016	
Copper (mg/L)	0.005	0.00040	ND	0.0042	0.0058	
Lead (mg/L)	0.005	0.0013	ND	0.0009	0.024	
Silver (mg/L)	0.005	0.00036	ND			0.00074
Zinc (mg/L)	0.01	0.0013	ND	0.056	0.055	
Total Hardness, as CaCO3 (mg/L)	10		41			
November 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0018	
Copper (mg/L)	0.005	0.00040	ND	0.0044	0.0062	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.026	
Silver (mg/L)	0.005	0.00036	ND			0.00084
Zinc (mg/L)	0.01	0.0013	0.0044 J	0.059	0.058	
Total Hardness, as CaCO3 (mg/L)	1		44			

1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
3. "J" Flag is placed in a report in which lab reports results between the MDL and reporting limit. It indicates that the result is estimated. While definitely present, it is below the reporting limit, indicating we do not track the accuracy at these levels.

Appendix E2-C.

Table 1B. Comparison of hardness-based regulatory criteria and 2000 UNFFR Project data for metals (expressed at *total* metals).

Station BV2-B(ottom) - Butt Valley Reservoir near Caribou Powerhouse Unit 1 intake structure

	Reporting Limits	Detection Limits	Results (mg/L)	California Toxics Rules Criteria (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection		
				4-Day	1-Hour	Max
April 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0011	0.0015	
Copper (mg/L)	0.005	0.00040	ND	0.0039	0.0054	
Lead (mg/L)	0.005	0.0013	ND	0.0009	0.022	
Silver (mg/L)	0.005	0.00036	0.00039 J			0.00065
Zinc (mg/L)	0.01	0.0013	0.00039 J	0.052	0.052	
Total Hardness, as CaCO3 (mg/L)	1		38			
June 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0017	
Copper (mg/L)	0.005	0.00040	ND	0.0043	0.0059	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.025	
Silver (mg/L)	0.005	0.00036	ND			0.00078
Zinc (mg/L)	0.01	0.0013	ND	0.057	0.056	
Total Hardness, as CaCO3 (mg/L)	1		42			
July 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0013	0.0020	
Copper (mg/L)	0.005	0.00040	ND	0.0050	0.0070	
Lead (mg/L)	0.005	0.0013	ND	0.0012	0.030	
Silver (mg/L)	0.005	0.00036	ND			0.00105
Zinc (mg/L)	0.01	0.0013	ND	0.066	0.065	
Total Hardness, as CaCO3 (mg/L)	1		50			
August 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0017	
Copper (mg/L)	0.005	0.00040	ND	0.0044	0.0061	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.025	
Silver (mg/L)	0.005	0.00036	ND			0.00081
Zinc (mg/L)	0.01	0.0013	ND	0.058	0.057	
Total Hardness, as CaCO3 (mg/L)	1		43			
September 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0013	0.0018	
Copper (mg/L)	0.005	0.00040	ND	0.0046	0.0065	
Lead (mg/L)	0.005	0.0013	ND	0.0011	0.027	
Silver (mg/L)	0.005	0.00036	ND			0.00091
Zinc (mg/L)	0.01	0.0013	0.0071 J	0.061	0.061	
Total Hardness, as CaCO3 (mg/L)	10		46			
November 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0017	
Copper (mg/L)	0.005	0.00040	ND	0.0044	0.0061	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.025	
Silver (mg/L)	0.005	0.00036	ND			0.00081
Zinc (mg/L)	0.01	0.0013	ND	0.058	0.057	
Total Hardness, as CaCO3 (mg/L)	1		43			

1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
3. "J" Flag is placed in a report in which lab reports results between the MDL and reporting limit. It indicates that the result is estimated. While definitely present, it is below the reporting limit, indicating we do not track the accuracy at these levels.

Appendix E2-C.

Table 1B. Comparison of hardness-based regulatory criteria and 2000 UNFFR Project data for metals (expressed at *total* metals).

Station BC3 - Butt Creek above North Fork Feather River

	Reporting Limits	Detection Limits	Results (mg/L)	California Toxics Rules Criteria (USEPA) Inland Surface Waters		
				Freshwater Aquatic Life Protection		
				4-Day	1-Hour	Max
April 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0018	0.0032	
Copper (mg/L)	0.005	0.00040	ND	0.0071	0.0104	
Lead (mg/L)	0.005	0.0013	ND	0.0019	0.048	
Silver (mg/L)	0.005	0.00036	0.00052 J			0.00215
Zinc (mg/L)	0.01	0.0013	0.00052 J	0.094	0.093	
Total Hardness, as CaCO3 (mg/L)	1		76			
June 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0020	0.0036	
Copper (mg/L)	0.005	0.00040	ND	0.0078	0.0115	
Lead (mg/L)	0.005	0.0013	ND	0.0021	0.054	
Silver (mg/L)	0.005	0.00036	ND			0.00261
Zinc (mg/L)	0.01	0.0013	ND	0.103	0.102	
Total Hardness, as CaCO3 (mg/L)	1		85			
July 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0022	0.0042	
Copper (mg/L)	0.005	0.00040	ND	0.0089	0.0133	
Lead (mg/L)	0.005	0.0013	ND	0.0025	0.064	
Silver (mg/L)	0.005	0.00036	0.00045 J			0.00339
Zinc (mg/L)	0.01	0.0013	ND	0.117	0.116	
Total Hardness, as CaCO3 (mg/L)	1		99			
August 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0021	0.0039	
Copper (mg/L)	0.005	0.00040	ND	0.0084	0.0126	
Lead (mg/L)	0.005	0.0013	ND	0.0023	0.060	
Silver (mg/L)	0.005	0.00036	0.00048 J			0.00305
Zinc (mg/L)	0.01	0.0013	ND	0.111	0.110	
Total Hardness, as CaCO3 (mg/L)	1		93			
September 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0020	0.0036	
Copper (mg/L)	0.005	0.00040	ND	0.0079	0.0117	
Lead (mg/L)	0.005	0.0013	ND	0.0021	0.055	
Silver (mg/L)	0.005	0.00036	ND			0.00266
Zinc (mg/L)	0.01	0.0013	ND	0.104	0.103	
Total Hardness, as CaCO3 (mg/L)	10		86			
November 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0019	0.0033	
Copper (mg/L)	0.005	0.00040	ND	0.0073	0.0108	
Lead (mg/L)	0.005	0.0013	ND	0.0019	0.050	
Silver (mg/L)	0.005	0.00036	ND			0.00230
Zinc (mg/L)	0.01	0.0013	ND	0.097	0.096	
Total Hardness, as CaCO3 (mg/L)	1		79			

1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
3. "J" Flag is placed in a report in which lab reports results between the MDL and reporting limit. It indicates that the result is estimated. While definitely present, it is below the reporting limit, indicating we do not track the accuracy at these levels.

Appendix E2-C.

Table 1B. Comparison of hardness-based regulatory criteria and 2000 UNFFR Project data for metals (expressed at *total* metals).

Station NF4 - North Fork Feather River above Caribou Powerhouse

				California Toxics Rules Criteria (USEPA) Inland Surface Waters		
	Reporting Limits	Detection Limits	Results (mg/L)	Freshwater Aquatic Life Protection		
				4-Day	1-Hour	Max
April 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0016	0.0025	
Copper (mg/L)	0.005	0.00040	ND	0.0060	0.0086	
Lead (mg/L)	0.005	0.0013	ND	0.0015	0.038	
Silver (mg/L)	0.005	0.00036	0.00056 J			0.00152
Zinc (mg/L)	0.01	0.0013	0.00056 J	0.079	0.078	
Total Hardness, as CaCO3 (mg/L)	1		62			
June 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0018	0.0032	
Copper (mg/L)	0.005	0.00040	ND	0.0072	0.0105	
Lead (mg/L)	0.005	0.0013	ND	0.0019	0.049	
Silver (mg/L)	0.005	0.00036	ND			0.00220
Zinc (mg/L)	0.01	0.0013	0.004 J	0.095	0.094	
Total Hardness, as CaCO3 (mg/L)	1		77			
July 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0021	0.0038	
Copper (mg/L)	0.005	0.00040	ND	0.0081	0.0120	
Lead (mg/L)	0.005	0.0013	ND	0.0022	0.057	
Silver (mg/L)	0.005	0.00036	ND			0.00282
Zinc (mg/L)	0.01	0.0013	ND	0.107	0.106	
Total Hardness, as CaCO3 (mg/L)	1		89			
August 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0019	0.0034	
Copper (mg/L)	0.005	0.00040	ND	0.0075	0.0110	
Lead (mg/L)	0.005	0.0013	ND	0.0020	0.051	
Silver (mg/L)	0.005	0.00036	ND			0.00240
Zinc (mg/L)	0.01	0.0013	ND	0.099	0.098	
Total Hardness, as CaCO3 (mg/L)	1		81			
September 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0018	0.0030	
Copper (mg/L)	0.005	0.00040	ND	0.0068	0.0099	
Lead (mg/L)	0.005	0.0013	ND	0.0018	0.045	
Silver (mg/L)	0.005	0.00036	ND			0.00196
Zinc (mg/L)	0.01	0.0013	ND	0.089	0.089	
Total Hardness, as CaCO3 (mg/L)	1		72			
November 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0016	0.0027	
Copper (mg/L)	0.005	0.00040	ND	0.0063	0.0091	
Lead (mg/L)	0.005	0.0013	ND	0.0016	0.041	
Silver (mg/L)	0.005	0.00036	ND			0.00169
Zinc (mg/L)	0.01	0.0013	ND	0.083	0.082	
Total Hardness, as CaCO3 (mg/L)	1		66			

1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
3. "J" Flag is placed in a report in which lab reports results between the MDL and reporting limit. It indicates that the result is estimated. While definitely present, it is below the reporting limit, indicating we do not track the accuracy at these levels.

Appendix E2-C.

Table 1B. Comparison of hardness-based regulatory criteria and 2000 UNFFR Project data for metals (expressed at *total* metals).

Station CARB1 - Caribou No.1 Powerhouse tailrace

	Reporting Limits	Detection Limits	Results (mg/L)	California Toxics Rules Criteria (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection		
				4-Day	1-Hour	Max
April 2000						
Cadmium (mg/L)	0.002	0.00036	.			
Copper (mg/L)	0.005	0.00040	.			
Lead (mg/L)	0.005	0.0013	.			
Silver (mg/L)	0.005	0.00036	.			
Zinc (mg/L)	0.01	0.0013	.			
Total Hardness, as CaCO3 (mg/L)	1		.			
June 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0016	
Copper (mg/L)	0.005	0.00040	ND	0.0042	0.0058	
Lead (mg/L)	0.005	0.0013	ND	0.0009	0.024	
Silver (mg/L)	0.005	0.00036	ND			0.00074
Zinc (mg/L)	0.01	0.0013	0.028	0.056	0.055	
Total Hardness, as CaCO3 (mg/L)	1		41			
July 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0013	0.0020	
Copper (mg/L)	0.005	0.00040	0.0063	0.0049	0.0069	
Lead (mg/L)	0.005	0.0013	ND	0.0011	0.029	
Silver (mg/L)	0.005	0.00036	ND			0.00101
Zinc (mg/L)	0.01	0.0013	0.011	0.065	0.064	
Total Hardness, as CaCO3 (mg/L)	1		49			
August 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0018	
Copper (mg/L)	0.005	0.00040	ND	0.0044	0.0062	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.026	
Silver (mg/L)	0.005	0.00036	ND			0.00084
Zinc (mg/L)	0.01	0.0013	0.022	0.059	0.058	
Total Hardness, as CaCO3 (mg/L)	1		44			
September 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0017	
Copper (mg/L)	0.005	0.00040	ND	0.0044	0.0061	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.025	
Silver (mg/L)	0.005	0.00036	ND			0.00081
Zinc (mg/L)	0.01	0.0013	0.021	0.058	0.057	
Total Hardness, as CaCO3 (mg/L)	10		43			
November 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0016	
Copper (mg/L)	0.005	0.00040	ND	0.0042	0.0058	
Lead (mg/L)	0.005	0.0013	ND	0.0009	0.024	
Silver (mg/L)	0.005	0.00036	ND			0.00074
Zinc (mg/L)	0.01	0.0013	ND	0.056	0.055	
Total Hardness, as CaCO3 (mg/L)	1		41			

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1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
3. "J" Flag is placed in a report in which lab reports results between the MDL and reporting limit. It indicates that the result is estimated. While definitely present, it is below the reporting limit, indicating we do not track the accuracy at these levels.

Appendix E2-C.

Table 1B. Comparison of hardness-based regulatory criteria and 2000 UNFFR Project data for metals (expressed at *total* metals).

Station CARB2 - Caribou No. 2 Powerhouse tailrace

	Reporting Limits	Detection Limits	Results (mg/L)	California Toxics Rules Criteria (USEPA) Inland Surface Waters		
				Freshwater Aquatic Life Protection		
				4-Day	1-Hour	Max
April 2000						
Cadmium (mg/L)	0.002	0.00036	.			
Copper (mg/L)	0.005	0.00040	.			
Lead (mg/L)	0.005	0.0013	.			
Silver (mg/L)	0.005	0.00036	.			
Zinc (mg/L)	0.01	0.0013	.			
Total Hardness, as CaCO3 (mg/L)	1		.			
June 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0017	
Copper (mg/L)	0.005	0.00040	ND	0.0043	0.0059	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.025	
Silver (mg/L)	0.005	0.00036	ND			0.00078
Zinc (mg/L)	0.01	0.0013	0.026	0.057	0.056	
Total Hardness, as CaCO3 (mg/L)	1		42			
July 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0013	0.0019	
Copper (mg/L)	0.005	0.00040	ND	0.0047	0.0066	
Lead (mg/L)	0.005	0.0013	ND	0.0011	0.028	
Silver (mg/L)	0.005	0.00036	ND			0.00094
Zinc (mg/L)	0.01	0.0013	ND	0.062	0.062	
Total Hardness, as CaCO3 (mg/L)	1		47			
August 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0018	
Copper (mg/L)	0.005	0.00040	ND	0.0044	0.0062	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.026	
Silver (mg/L)	0.005	0.00036	ND			0.00084
Zinc (mg/L)	0.01	0.0013	ND	0.059	0.058	
Total Hardness, as CaCO3 (mg/L)	1		44			
September 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0017	
Copper (mg/L)	0.005	0.00040	ND	0.0043	0.0059	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.025	
Silver (mg/L)	0.005	0.00036	ND			0.00078
Zinc (mg/L)	0.01	0.0013	ND	0.057	0.056	
Total Hardness, as CaCO3 (mg/L)	10		42			
November 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0016	
Copper (mg/L)	0.005	0.00040	ND	0.0042	0.0058	
Lead (mg/L)	0.005	0.0013	ND	0.0009	0.024	
Silver (mg/L)	0.005	0.00036	ND			0.00074
Zinc (mg/L)	0.01	0.0013	ND	0.056	0.055	
Total Hardness, as CaCO3 (mg/L)	1		41			

1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
3. "J" Flag is placed in a report in which lab reports results between the MDL and reporting limit. It indicates that the result is estimated. While definitely present, it is below the reporting limit, indicating we do not track the accuracy at these levels.

Appendix E2-C.

Table 1B. Comparison of hardness-based regulatory criteria and 2000 UNFFR Project data for metals (expressed at *total* metals).

Station NF5 - North Fork Feather River Below Belden Dam

	Reporting Limits	Detection Limits	Results (mg/L)	California Toxics Rules Criteria (USEPA) Inland Surface Waters — Freshwater Aquatic Life Protection		
				4-Day	1-Hour	Max
April 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0019	0.0033	
Copper (mg/L)	0.005	0.00040	ND	0.0073	0.0108	
Lead (mg/L)	0.005	0.0013	ND	0.0019	0.050	
Silver (mg/L)	0.005	0.00036	0.0007 J			0.00230
Zinc (mg/L)	0.01	0.0013	ND	0.097	0.096	
Total Hardness, as CaCO3 (mg/L)	1		79			
June 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0015	0.0023	
Copper (mg/L)	0.005	0.00040	ND	0.0055	0.0079	
Lead (mg/L)	0.005	0.0013	ND	0.0014	0.035	
Silver (mg/L)	0.005	0.00036	ND			0.00131
Zinc (mg/L)	0.01	0.0013	0.005 J	0.073	0.073	
Total Hardness, as CaCO3 (mg/L)	1		57			
July 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0016	0.0025	
Copper (mg/L)	0.005	0.00040	ND	0.0060	0.0086	
Lead (mg/L)	0.005	0.0013	ND	0.0015	0.038	
Silver (mg/L)	0.005	0.00036	ND			0.00152
Zinc (mg/L)	0.01	0.0013	ND	0.079	0.078	
Total Hardness, as CaCO3 (mg/L)	1		62			
August 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0014	0.0022	
Copper (mg/L)	0.005	0.00040	ND	0.0053	0.0075	
Lead (mg/L)	0.005	0.0013	ND	0.0013	0.033	
Silver (mg/L)	0.005	0.00036	ND			0.00120
Zinc (mg/L)	0.01	0.0013	ND	0.070	0.070	
Total Hardness, as CaCO3 (mg/L)	1		54			
September 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0016	0.0025	
Copper (mg/L)	0.005	0.00040	ND	0.0060	0.0086	
Lead (mg/L)	0.005	0.0013	ND	0.0015	0.038	
Silver (mg/L)	0.005	0.00036	ND			0.00152
Zinc (mg/L)	0.01	0.0013	0.019	0.079	0.078	
Total Hardness, as CaCO3 (mg/L)	1		62			
November 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0015	0.0024	
Copper (mg/L)	0.005	0.00040	ND	0.0057	0.0082	
Lead (mg/L)	0.005	0.0013	ND	0.0014	0.036	
Silver (mg/L)	0.005	0.00036	ND			0.00139
Zinc (mg/L)	0.01	0.0013	0.0086 J	0.076	0.075	
Total Hardness, as CaCO3 (mg/L)	1		59			

1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
3. "J" Flag is placed in a report in which lab reports results between the MDL and reporting limit. It indicates that the result is estimated. While definitely present, it is below the reporting limit, indicating we do not track the accuracy at these levels.

Appendix E2-C.

Table 1B. Comparison of hardness-based regulatory criteria and 2000 UNFFR Project data for metals (expressed at *total* metals).

Station NF7 - North Fork Feather River at Gansnar Bar

	Reporting Limits	Detection Limits	Results (mg/L)		California Toxics Rules Criteria (USEPA) Inland Surface Waters		
					Freshwater Aquatic Life Protection		
					4-Day	1-Hour	Max
April 2000							
Cadmium (mg/L)	0.002	0.00036	ND		0.0019	0.0033	0.00230
Copper (mg/L)	0.005	0.00040	ND		0.0073	0.0108	
Lead (mg/L)	0.005	0.0013	ND		0.0019	0.050	
Silver (mg/L)	0.005	0.00036	0.00047	J			
Zinc (mg/L)	0.01	0.0013	0.00047	J	0.097	0.096	
Total Hardness, as CaCO3 (mg/L)	1		79				
June 2000							
Cadmium (mg/L)	0.002	0.00036	ND		0.0015	0.0023	0.00131
Copper (mg/L)	0.005	0.00040	ND		0.0055	0.0079	
Lead (mg/L)	0.005	0.0013	ND		0.0014	0.035	
Silver (mg/L)	0.005	0.00036	ND				
Zinc (mg/L)	0.01	0.0013	ND		0.073	0.073	
Total Hardness, as CaCO3 (mg/L)	1		57				
July 2000							
Cadmium (mg/L)	0.002	0.00036	ND		0.0016	0.0025	0.00152
Copper (mg/L)	0.005	0.00040	ND		0.0060	0.0086	
Lead (mg/L)	0.005	0.0013	ND		0.0015	0.038	
Silver (mg/L)	0.005	0.00036	ND				
Zinc (mg/L)	0.01	0.0013	ND		0.079	0.078	
Total Hardness, as CaCO3 (mg/L)	1		62				
August 2000							
Cadmium (mg/L)	0.002	0.00036	ND		0.0014	0.0022	0.00120
Copper (mg/L)	0.005	0.00040	ND		0.0053	0.0075	
Lead (mg/L)	0.005	0.0013	ND		0.0013	0.033	
Silver (mg/L)	0.005	0.00036	ND				
Zinc (mg/L)	0.01	0.0013	ND		0.070	0.070	
Total Hardness, as CaCO3 (mg/L)	1		54				
September 2000							
Cadmium (mg/L)	0.002	0.00036	ND		0.0016	0.0025	0.00152
Copper (mg/L)	0.005	0.00040	ND		0.0060	0.0086	
Lead (mg/L)	0.005	0.0013	ND		0.0015	0.038	
Silver (mg/L)	0.005	0.00036	ND				
Zinc (mg/L)	0.01	0.0013	ND		0.079	0.078	
Total Hardness, as CaCO3 (mg/L)	1		62				
November 2000							
Cadmium (mg/L)	0.002	0.00036	ND		0.0015	0.0024	0.00139
Copper (mg/L)	0.005	0.00040	ND		0.0057	0.0082	
Lead (mg/L)	0.005	0.0013	ND		0.0014	0.036	
Silver (mg/L)	0.005	0.00036	ND				
Zinc (mg/L)	0.01	0.0013	ND		0.076	0.075	
Total Hardness, as CaCO3 (mg/L)	1		59				

1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
3. "J" Flag is placed in a report in which lab reports results between the MDL and reporting limit. It indicates that the result is estimated. While definitely present, it is below the reporting limit, indicating we do not track the accuracy at these levels.

Appendix E2-C.

Table 1B. Comparison of hardness-based regulatory criteria and 2000 UNFFR Project data for metals (expressed at *total* metals).

Station EB1 - East Branch North Fork Feather above confluence

	Reporting Limits	Detection Limits	Results (mg/L)	California Toxics Rules Criteria (USEPA) Inland Surface Waters — Freshwater Aquatic Life Protection		
				4-Day	1-Hour	Max
April 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0010	0.0014	
Copper (mg/L)	0.005	0.00040	ND	0.0037	0.0050	
Lead (mg/L)	0.005	0.0013	ND	0.0008	0.020	
Silver (mg/L)	0.005	0.00036	0.00048 J			0.00057
Zinc (mg/L)	0.01	0.0013	0.00048 J	0.049	0.048	
Total Hardness, as CaCO3 (mg/L)	1		35			
June 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0016	0.0027	
Copper (mg/L)	0.005	0.00040	ND	0.0062	0.0090	
Lead (mg/L)	0.005	0.0013	ND	0.0016	0.040	
Silver (mg/L)	0.005	0.00036	0.00051 J			0.00164
Zinc (mg/L)	0.01	0.0013	ND	0.082	0.081	
Total Hardness, as CaCO3 (mg/L)	1		65			
July 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0022	0.0041	
Copper (mg/L)	0.005	0.00040	ND	0.0087	0.0131	
Lead (mg/L)	0.005	0.0013	ND	0.0024	0.062	
Silver (mg/L)	0.005	0.00036	0.00044 J			0.00327
Zinc (mg/L)	0.01	0.0013	ND	0.115	0.114	
Total Hardness, as CaCO3 (mg/L)	1		97			
August 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0021	0.0039	
Copper (mg/L)	0.005	0.00040	ND	0.0083	0.0124	
Lead (mg/L)	0.005	0.0013	ND	0.0023	0.059	
Silver (mg/L)	0.005	0.00036	0.00053 J			0.00299
Zinc (mg/L)	0.01	0.0013	ND	0.110	0.109	
Total Hardness, as CaCO3 (mg/L)	1		92			
September 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0019	0.0034	
Copper (mg/L)	0.005	0.00040	ND	0.0076	0.0111	
Lead (mg/L)	0.005	0.0013	ND	0.0020	0.052	
Silver (mg/L)	0.005	0.00036	ND			0.00245
Zinc (mg/L)	0.01	0.0013	ND	0.100	0.099	
Total Hardness, as CaCO3 (mg/L)	10		82			
November 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0017	0.0028	
Copper (mg/L)	0.005	0.00040	ND	0.0064	0.0093	
Lead (mg/L)	0.005	0.0013	ND	0.0016	0.042	
Silver (mg/L)	0.005	0.00036	ND			0.00178
Zinc (mg/L)	0.01	0.0013	0.0071 J	0.085	0.085	
Total Hardness, as CaCO3 (mg/L)	1		68			

1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
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Appendix E2-C.

Table 1B. Comparison of hardness-based regulatory criteria and 2000 UNFFR Project data for metals (expressed at *total* metals).

Station NF8 - North Fork Feather River above Belden Town Bridge

	Reporting Limits	Detection Limits	Results (mg/L)	California Toxics Rules Criteria (USEPA) Inland Surface Waters — Freshwater Aquatic Life Protection 4-Day	1-Hour	Max
April 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0017	
Copper (mg/L)	0.005	0.00040	ND	0.0043	0.0059	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.025	
Silver (mg/L)	0.005	0.00036	0.00061 J			0.00078
Zinc (mg/L)	0.01	0.0013	0.00061 J	0.057	0.056	
Total Hardness, as CaCO3 (mg/L)	1		42			
June 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0016	0.0025	
Copper (mg/L)	0.005	0.00040	ND	0.0060	0.0086	
Lead (mg/L)	0.005	0.0013	ND	0.0015	0.038	
Silver (mg/L)	0.005	0.00036	0.00041 J			0.00152
Zinc (mg/L)	0.01	0.0013	ND	0.079	0.078	
Total Hardness, as CaCO3 (mg/L)	1		62			
July 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0019	0.0033	
Copper (mg/L)	0.005	0.00040	ND	0.0073	0.0108	
Lead (mg/L)	0.005	0.0013	ND	0.0019	0.050	
Silver (mg/L)	0.005	0.00036	0.00046 J			0.00230
Zinc (mg/L)	0.01	0.0013	ND	0.097	0.096	
Total Hardness, as CaCO3 (mg/L)	1		79			
August 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0017	0.0029	
Copper (mg/L)	0.005	0.00040	ND	0.0066	0.0096	
Lead (mg/L)	0.005	0.0013	ND	0.0017	0.044	
Silver (mg/L)	0.005	0.00036	ND			0.00187
Zinc (mg/L)	0.01	0.0013	ND	0.087	0.087	
Total Hardness, as CaCO3 (mg/L)	1		70			
September 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0018	0.0031	
Copper (mg/L)	0.005	0.00040	ND	0.0070	0.0102	
Lead (mg/L)	0.005	0.0013	ND	0.0018	0.047	
Silver (mg/L)	0.005	0.00036	ND			0.00210
Zinc (mg/L)	0.01	0.0013	0.019	0.093	0.092	
Total Hardness, as CaCO3 (mg/L)	1		75			
November 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0017	0.0029	
Copper (mg/L)	0.005	0.00040	ND	0.0065	0.0095	
Lead (mg/L)	0.005	0.0013	ND	0.0017	0.043	
Silver (mg/L)	0.005	0.00036	ND			0.00182
Zinc (mg/L)	0.01	0.0013	0.0094 J	0.086	0.086	
Total Hardness, as CaCO3 (mg/L)	1		69			

1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
3. "J" Flag is placed in a report in which lab reports results between the MDL and reporting limit. It indicates that the result is estimated. While definitely present, it is below the reporting limit, indicating we do not track the accuracy at these levels.

Appendix E2-C.

Table 1B. Comparison of hardness-based regulatory criteria and 2000 UNFFR Project data for metals (expressed at *total* metals).

Station YC1 - Yellow Creek above Belden Powerhouse tailrace

	Reporting Limits	Detection Limits	Results (mg/L)	California Toxics Rules Criteria (USEPA) Inland Surface Waters, Freshwater Aquatic Life Protection: 4-Day	1-Hour	Max
April 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0017	
Copper (mg/L)	0.005	0.00040	ND	0.0043	0.0059	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.025	
Silver (mg/L)	0.005	0.00036	0.00048 J			0.00078
Zinc (mg/L)	0.01	0.0013	0.00048 J	0.057	0.056	
Total Hardness, as CaCO3 (mg/L)	1		42			
June 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0013	0.0020	
Copper (mg/L)	0.005	0.00040	ND	0.0049	0.0069	
Lead (mg/L)	0.005	0.0013	ND	0.0011	0.029	
Silver (mg/L)	0.005	0.00036	0.00045 J			0.00101
Zinc (mg/L)	0.01	0.0013	ND	0.065	0.064	
Total Hardness, as CaCO3 (mg/L)	1		49			
July 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0017	0.0028	
Copper (mg/L)	0.005	0.00040	ND	0.0064	0.0092	
Lead (mg/L)	0.005	0.0013	ND	0.0016	0.042	
Silver (mg/L)	0.005	0.00036	ND			0.00173
Zinc (mg/L)	0.01	0.0013	ND	0.084	0.083	
Total Hardness, as CaCO3 (mg/L)	1		67			
August 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0015	0.0024	
Copper (mg/L)	0.005	0.00040	ND	0.0056	0.0080	
Lead (mg/L)	0.005	0.0013	ND	0.0014	0.036	
Silver (mg/L)	0.005	0.00036	ND			0.00135
Zinc (mg/L)	0.01	0.0013	ND	0.074	0.074	
Total Hardness, as CaCO3 (mg/L)	1		58			
September 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0015	0.0025	
Copper (mg/L)	0.005	0.00040	ND	0.0058	0.0083	
Lead (mg/L)	0.005	0.0013	ND	0.0014	0.037	
Silver (mg/L)	0.005	0.00036	0.0004 J			0.00143
Zinc (mg/L)	0.01	0.0013	ND	0.077	0.076	
Total Hardness, as CaCO3 (mg/L)	1		60			
November 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0015	0.0023	
Copper (mg/L)	0.005	0.00040	ND	0.0055	0.0079	
Lead (mg/L)	0.005	0.0013	ND	0.0014	0.035	
Silver (mg/L)	0.005	0.00036	ND			0.00131
Zinc (mg/L)	0.01	0.0013	0.0067 J	0.073	0.073	
Total Hardness, as CaCO3 (mg/L)	1		57			

1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
3. "J" Flag is placed in a report in which lab reports results between the MDL and reporting limit. It indicates that the result is estimated. While definitely present, it is below the reporting limit, indicating we do not track the accuracy at these levels.

Appendix E2-C.

Table 1B. Comparison of hardness-based regulatory criteria and 2000 UNFFR Project data for metals (expressed at *total* metals).

Station BD2 - Belden Powerhouse Tailrace

	Reporting Limits	Detection Limits	Results (mg/L)	California Toxics Rules Criteria (USEPA) Inland Surface Waters Freshwater Aquatic Life Protection		
				4-Day	1-Hour	Max
April 2000						
Cadmium (mg/L)	0.002	0.00036	.			
Copper (mg/L)	0.005	0.00040	.			
Lead (mg/L)	0.005	0.0013	.			
Silver (mg/L)	0.005	0.00036	.			
Zinc (mg/L)	0.01	0.0013	.			
Total Hardness, as CaCO3 (mg/L)	1		.			
June 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0017	
Copper (mg/L)	0.005	0.00040	ND	0.0044	0.0061	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.025	
Silver (mg/L)	0.005	0.00036	ND			0.00081
Zinc (mg/L)	0.01	0.0013	0.034	0.058	0.057	
Total Hardness, as CaCO3 (mg/L)	1		43			
July 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0014	0.0021	
Copper (mg/L)	0.005	0.00040	ND	0.0050	0.0071	
Lead (mg/L)	0.005	0.0013	ND	0.0012	0.031	
Silver (mg/L)	0.005	0.00036	ND			0.00108
Zinc (mg/L)	0.01	0.0013	0.0039 J	0.067	0.066	
Total Hardness, as CaCO3 (mg/L)	1		51			
August 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0013	0.0018	
Copper (mg/L)	0.005	0.00040	ND	0.0046	0.0065	
Lead (mg/L)	0.005	0.0013	ND	0.0011	0.027	
Silver (mg/L)	0.005	0.00036	ND			0.00091
Zinc (mg/L)	0.01	0.0013	ND	0.061	0.061	
Total Hardness, as CaCO3 (mg/L)	1		46			
September 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0017	
Copper (mg/L)	0.005	0.00040	ND	0.0044	0.0061	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.025	
Silver (mg/L)	0.005	0.00036	ND			0.00081
Zinc (mg/L)	0.01	0.0013	0.028	0.058	0.057	
Total Hardness, as CaCO3 (mg/L)	10		43			
November 2000						
Cadmium (mg/L)	0.002	0.00036	ND	0.0012	0.0017	
Copper (mg/L)	0.005	0.00040	ND	0.0044	0.0061	
Lead (mg/L)	0.005	0.0013	ND	0.0010	0.025	
Silver (mg/L)	0.005	0.00036	ND			0.00081
Zinc (mg/L)	0.01	0.0013	0.022	0.058	0.057	
Total Hardness, as CaCO3 (mg/L)	1		43			

1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
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Appendix E2-C.

Table 2. UNFFR Relicensing (FERC 2105) – 2000 Water Quality Monitoring Program Results (metals expressed as *total* metals)

Station NF1B - North Fork Feather River at Chester

			Sampling Date					
	Reporting Limits	Detection Limits	April	June	July	August	September	November
Time			10:15	10:50	10:18	11:40	10:18	9:45
In-situ Parameters								
Water Temperature (°C)			3.35	11.47	12.17	11.38	8.31	2.05
Dissolved Oxygen (mg/L)			12.16	7.98	9.47	8.42	11.01	11.63
Specific Conductance (mS/cm)			43.9	53.7	72.5	76.2	81.4	81.5
pH (Standard Units)			7.11	7.7	7.8	7.95	7.85	7.85
Total Dissolved Solids (g/L)			0.0281	0.0343	0.0405	0.0489	0.052	0.0522
Turbidity (NTU)			7	2.7	2.9	1.1	4.6	0.5
Depth (M)			0.5	0.5	0.5	0.5	0.5	0.5
Analytical Parameters								
Total Coliform (MPN/100 ml)			130	110	220	300	90	11
Fecal Coliform (MPN/100 ml)			4	8	26	17	8	<2
Arsenic (mg/L)	0.005	0.0032	ND	ND	ND	ND	ND	ND
Barium (mg/L)	0.005	0.00039	0.0075	0.0064	0.0083	0.0085	0.0077	0.0071
Cadmium (mg/L)	0.002	0.00036	ND	ND	ND	ND	ND	ND
Calcium (mg/L)	0.1	0.0082	4.7	4.7	6.0	6.9	6.6	6.4
Chromium (mg/L)	0.005	0.00047	ND	ND	ND	ND	ND	ND
Copper (mg/L)	0.005	0.00040	ND	ND	ND	ND	ND	ND
Iron (mg/L)	0.1	0.0028	0.270	0.031 J	0.110	0.053 J	ND	0.056 J
Lead (mg/L)	0.005	0.0013	ND	ND	ND	ND	ND	ND
Magnesium (mg/L)	0.1	0.0023	2.0	2.0	2.7	3.2	3.1	3.1
Manganese (mg/L)	0.005	0.00046	0.0100	ND	ND	ND	ND	ND
Mercury (mg/L)	0.0002	0.0002	ND	ND	0.00029	ND	ND	ND
Potassium (mg/L)	1.0	0.1	1.5	1.8	1.9	2.3	2.1	2.0
Selenium (mg/L)	0.005	0.0042	ND	ND	ND	ND	ND	ND
Silver (mg/L)	0.005	0.00036	ND	ND	ND	ND	ND	ND
Sodium (mg/L)	1	0.1	3.1	3.4	4.7	5.8	5.8	5.3
Zinc (mg/L)	0.01	0.0013	ND	ND	ND	ND	ND	0.0058 J
Ammonia - Total (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Boron (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Total Hardness, as CaCO3 (mg/L)	1		17	21	31	30	29	29
Total Phosphorous (mg/L)	0.01		0.04	0.06	0.05	0.05	0.04	0.02
Silica (mg/L)	0.3		23	34	29	31	21	29
Total Kjeldahl Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	ND
Total Organic Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	ND
Chloride (mg/L)	0.2		0.2	1.4	1.0	1.5	3.0	2.1
Nitrate, as NO3 (mg/L)	0.1		ND	ND	ND	ND	3.14	ND
Orthophosphate (mg/L)	0.01		ND	ND	0.13	0.08	ND	0.02
Sulfate (mg/L)	0.2		0.8	1.5	2.0	1.7	1.4	3.1
Chlorophyll-a (mg/L)	0.0005		ND	0.0175	0.0057	0.0015	ND	ND
Alkalinity - Total (mg/L)	10		26	60	40	40	40	40
Alkalinity - Hydroxide (mg/L)	10		ND	ND	ND	ND	ND	ND
Alkalinity - Bicarbonate (mg/L)	10		ND	60	40	40	40	40
Alkalinity - Carbonate (mg/L)	10		ND	ND	ND	ND	ND	ND
MBAS (mg/L)	0.05		ND	ND	ND	0.22	ND	ND
Total Dissolved Solids (mg/L)	10		50	53	70	.	81	59
Total Suspended Solids (mg/L)	1		ND	ND	ND	.	ND	ND
PCB1016 (mg/L)	0.001		.	.	.	.	.	.
PCB1221 (mg/L)	0.001		.	.	.	.	.	.
PCB1232 (mg/L)	0.001		.	.	.	.	.	.
PCB1242 (mg/L)	0.001		.	.	.	.	.	.
PCB1248 (mg/L)	0.001		.	.	.	.	.	.
PCB1254 (mg/L)	0.001		.	.	.	.	.	.
PCB1260 (mg/L)	0.001		.	.	.	.	.	.

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Appendix E2-C.

Table 2. UNFFR Relicensing (FERC 2105) – 2000 Water Quality Monitoring Program Results (metals expressed as *total* metals)

Station HB1 - Hamiltion Branch at Highway A13 bridge

	Reporting Limits	Detection Limits	Sampling Date					
			April	June	July	August	September	November
Time			10:50	11:30	10:45	10:50	10:47	10:15
In-situ Parameters								
Water Temperature (°C)			6.21	11.54	10.81	9.79	8.11	6.26
Dissolved Oxygen (mg/L)			10.96	9.17	9.04	8.55	10.58	9.88
Specific Conductance (mS/cm)			90.6	107.7	107.9	111.2	118.7	119.2
pH (Standard Units)			7.55	8.12	7.98	8.1	8.06	8.22
Total Dissolved Solids (g/L)			0.058	0.0682	0.069	0.0712	0.076	0.0763
Turbidity (NTU)			3.5	2.4	0.8	0.8	4.6	1.4
Depth (M)			0.5	0.5	0.5	0.5	0.5	0.5
Analytical Parameters								
Total Coliform (MPN/100 ml)			11	23	30	4	11	11
Fecal Coliform (MPN/100 ml)			<2	23	11	2	2	2
Arsenic (mg/L)	0.005	0.0032	ND	ND	ND	ND	ND	ND
Barium (mg/L)	0.005	0.00039	ND	0.0057	ND	ND	ND	ND
Cadmium (mg/L)	0.002	0.00036	ND	ND	ND	ND	ND	ND
Calcium (mg/L)	0.1	0.0082	10	12	12	12	12	12
Chromium (mg/L)	0.005	0.00047	ND	ND	ND	ND	ND	ND
Copper (mg/L)	0.005	0.00040	ND	ND	ND	ND	ND	ND
Iron (mg/L)	0.1	0.0028	0.077	0.065	0.140	ND	ND	ND
Lead (mg/L)	0.005	0.0013	ND	ND	ND	ND	ND	ND
Magnesium (mg/L)	0.1	0.0023	4.8	5.3	5.4	6.0	5.6	5.8
Manganese (mg/L)	0.005	0.00046	ND	0.0100	0.0089	ND	ND	ND
Mercury (mg/L)	0.0002	0.0002	ND	ND	0.0004	ND	ND	ND
Potassium (mg/L)	1.0	0.1	1.0 J	1.0	1.0 J	2.2	1.1	1.0 J
Selenium (mg/L)	0.005	0.0042	ND	ND	ND	ND	ND	ND
Silver (mg/L)	0.005	0.00036	ND	ND	ND	ND	ND	ND
Sodium (mg/L)	1	0.1	3.5	3.6	4.0	4.6	4.4	4.3
Zinc (mg/L)	0.01	0.0013	0.0052 J	ND	ND	ND	ND	ND
Ammonia - Total (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Boron (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Total Hardness, as CaCO3 (mg/L)	1		42	52	60	56	52	54
Total Phosphorous (mg/L)	0.01		0.03	0.03	0.02	0.03	0.03	0.02
Silica (mg/L)	0.3		21	27	21	20	15	18
Total Kjeldahl Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	ND
Total Organic Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	ND
Chloride (mg/L)	0.2		0.2	1.3	1.0	1.5	2.5	1.2
Nitrate, as NO3 (mg/L)	0.1		ND	ND	ND	8.0	4.0	0.81
Orthophosphate (mg/L)	0.01		ND	ND	ND	0.03	ND	ND
Sulfate (mg/L)	0.2		ND	ND	1.0	1.7	ND	ND
Chlorophyll-a (mg/L)	0.0005		ND	ND	0.0022	0.0017	ND	ND
Alkalinity - Total (mg/L)	10		52	70	60	60	70	70
Alkalinity - Hydroxide (mg/L)	10		ND	ND	ND	ND	ND	ND
Alkalinity - Bicarbonate (mg/L)	10		52	70	60	60	70	70
Alkalinity - Carbonate (mg/L)	10		ND	ND	ND	ND	ND	ND
MBAS (mg/L)	0.05		ND	ND	ND	ND	ND	ND
Total Dissolved Solids (mg/L)	10		61	74	81	.	93	51
Total Suspended Solids (mg/L)	1		ND	7.4	ND	.	2.1	ND
PCB1016 (mg/L)	0.001		.	.	.	.	.	.
PCB1221 (mg/L)	0.001		.	.	.	.	.	.
PCB1232 (mg/L)	0.001		.	.	.	.	.	.
PCB1242 (mg/L)	0.001		.	.	.	.	.	.
PCB1248 (mg/L)	0.001		.	.	.	.	.	.
PCB1254 (mg/L)	0.001		.	.	.	.	.	.
PCB1260 (mg/L)	0.001		.	.	.	.	.	.

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3. "J" Flag is placed in a report in which lab reports results between the MDL and reporting limit. It indicates that the result is estimated. While definitely present, it is below the reporting limit, indicating we do not track the accuracy at these levels.

Appendix E2-C.

Table 2. UNFFR Relicensing (FERC 2105) – 2000 Water Quality Monitoring Program Results (metals expressed as *total* metals)

Station HB2 - Hamiltion Branch Powerhouse at penstock head-works

	Reporting Limits	Detection Limits	Sampling Date					
			April	June	July	August	September	November
Time			11:15	12:00	11:09	11:07	11:04	10:30
In-situ Parameters								
Water Temperature (°C)			7.45	19.89	19.79	14.83	8.53	5.43
Dissolved Oxygen (mg/L)			11.33	8.53	7.46	7.97	12.25	11.29
Specific Conductance (mS/cm)			97.2	102.3	85.6	103.4	117.9	130.9
pH (Standard Units)			7.31	8.34	8.76	8.07	8.54	8.11
Total Dissolved Solids (g/L)			0.0622	0.0655	0.0547	0.0662	0.0755	0.0835
Turbidity (NTU)			6.3	7.4	4.3	1.7	6.8	2.3
Depth (M)			0.5	0.5	0.5	0.5	0.5	0.5
Analytical Parameters								
Total Coliform (MPN/100 ml)			13	130	30	80	22	80
Fecal Coliform (MPN/100 ml)			4	<2	2	<2	<2	2
Arsenic (mg/L)	0.005	0.0032	ND	ND	ND	ND	ND	ND
Barium (mg/L)	0.005	0.00039	0.0100	0.0110	0.0110	0.0086	0.0055	0.0110
Cadmium (mg/L)	0.002	0.00036	ND	ND	ND	ND	ND	ND
Calcium (mg/L)	0.1	0.0082	11	11	10	12	12	13
Chromium (mg/L)	0.005	0.00047	ND	ND	ND	ND	ND	ND
Copper (mg/L)	0.005	0.00040	ND	ND	ND	ND	ND	ND
Iron (mg/L)	0.1	0.0028	0.140	0.034 J	0.150	0.100	ND	0.034 J
Lead (mg/L)	0.005	0.0013	ND	ND	ND	ND	ND	ND
Magnesium (mg/L)	0.1	0.0023	5.4	4.8	3.9	5.0	5.9	6.4
Manganese (mg/L)	0.005	0.00046	ND	0.0130	0.0250	0.0160	ND	0.0052
Mercury (mg/L)	0.0002	0.0002	ND	ND	0.00023	ND	ND	ND
Potassium (mg/L)	1.0	0.1	1.3	0.9 J	0.3 J	1.9	1.3	0.9 J
Selenium (mg/L)	0.005	0.0042	ND	ND	ND	ND	ND	ND
Silver (mg/L)	0.005	0.00036	0.0004 J	ND	ND	ND	ND	ND
Sodium (mg/L)	1	0.1	3.8	3.3	3.7	4.8	4.9	4.7
Zinc (mg/L)	0.01	0.0013	ND	ND	0.0038 J	ND	ND	ND
Ammonia - Total (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Boron (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Total Hardness, as CaCO3 (mg/L)	1		45	48	46	50	55	58
Total Phosphorous (mg/L)	0.01		0.04	0.05	0.04	0.03	ND	0.03
Silica (mg/L)	0.3		21	20	15	20	14	16
Total Kjeldahl Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	ND
Total Organic Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	ND
Chloride (mg/L)	0.2		0.4	1.2	ND	0.8	0.8	1.3
Nitrate, as NO3 (mg/L)	0.1		ND	ND	ND	8.0	ND	0.68
Orthophosphate (mg/L)	0.01		ND	ND	ND	0.04	ND	ND
Sulfate (mg/L)	0.2		0.6	0.9	1.0	1.5	ND	ND
Chlorophyll-a (mg/L)	0.0005		ND	0.0106	0.0023	0.004	ND	0.0012
Alkalinity - Total (mg/L)	10		56	60	50	60	70	70
Alkalinity - Hydroxide (mg/L)	10		ND	ND	ND	ND	ND	ND
Alkalinity - Bicarbonate (mg/L)	10		56	60	50	60	70	70
Alkalinity - Carbonate (mg/L)	10		ND	ND	ND	ND	ND	ND
MBAS (mg/L)	0.05		ND	ND	ND	ND	ND	0.05
Total Dissolved Solids (mg/L)	10		54	81	71	.	88	50
Total Suspended Solids (mg/L)	1		ND	ND	3.3	.	2	4.9
PCB1016 (mg/L)	0.001		.	.	.	.	.	.
PCB1221 (mg/L)	0.001		.	.	.	.	.	.
PCB1232 (mg/L)	0.001		.	.	.	.	.	.
PCB1242 (mg/L)	0.001		.	.	.	.	.	.
PCB1248 (mg/L)	0.001		.	.	.	.	.	.
PCB1254 (mg/L)	0.001		.	.	.	.	.	.
PCB1260 (mg/L)	0.001		.	.	.	.	.	.

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2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
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Appendix E2-C.

Table 2. UNFFR Relicensing (FERC 2105) – 2000 Water Quality Monitoring Program Results (metals expressed as *total* metals)

Station LA1(Surface) - Lake Almanor near Canyon Dam

	Reporting Limits	Detection Limits	Sampling Date					
			April	June	July	August	September	November
Time			13:00	12:00	12:15	11:30	12:30	9:16
In-situ Parameters								
Water Temperature (°C)			10.43	22.01	22.03	21.95	17.47	8.75
Dissolved Oxygen (mg/L)			9.64	5.76	7.21	7.07	7.07	9.37
Specific Conductance (mS/cm)			86.2	88.8	89.9	98.2	98.2	97.8
pH (Standard Units)			8.22	8.09	8.28	8.25	8.25	7.45
Total Dissolved Solids (g/L)			0.0552	0.0569	0.0575	0.0629	0.0629	0.0626
Turbidity (NTU)			4.3	3.8	2.3	0.4	0.4	6.1
Depth (M)			0	0	0	0	0	0
Analytical Parameters								
Total Coliform (MPN/100 ml)			<2	2	2	<2	4	<2
Fecal Coliform (MPN/100 ml)			<2	<2	<2	<2	<2	<2
Arsenic (mg/L)	0.005	0.0032	ND	ND	ND	ND	ND	ND
Barium (mg/L)	0.005	0.00039	0.0093	0.0079	0.0077	0.0073	0.0080	0.0082
Cadmium (mg/L)	0.002	0.00036	ND	ND	ND	ND	ND	ND
Calcium (mg/L)	0.1	0.0082	9	8	9	9	9	9
Chromium (mg/L)	0.005	0.00047	ND	ND	ND	ND	0.0054	ND
Copper (mg/L)	0.005	0.00040	ND	ND	ND	ND	ND	ND
Iron (mg/L)	0.1	0.0028	0.048 J	ND	0.031 J	ND	ND	0.053 J
Lead (mg/L)	0.005	0.0013	ND	ND	ND	ND	ND	ND
Magnesium (mg/L)	0.1	0.0023	4.7	4.2	4.4	4.7	4.5	4.8
Manganese (mg/L)	0.005	0.00046	ND	ND	ND	0.0090	0.0110	0.0280
Mercury (mg/L)	0.0002	0.0002	ND	ND	ND	ND	ND	ND
Potassium (mg/L)	1.0	0.1	1.5	1.3	1.2	2.6	1.4	1.4
Selenium (mg/L)	0.005	0.0042	ND	ND	ND	ND	ND	ND
Silver (mg/L)	0.005	0.00036	ND	ND	ND	ND	ND	ND
Sodium (mg/L)	1	0.1	4.1	3.3	3.7	4.1	4.1	4.4
Zinc (mg/L)	0.01	0.0013	0.0052 J	ND	ND	ND	ND	0.0033 J
Ammonia - Total (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Boron (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Total Hardness, as CaCO3 (mg/L)	1		36	39	46	42	40	42
Total Phosphorous (mg/L)	0.01		0.01	ND	0.01	0.02	0.02	0.02
Silica (mg/L)	0.3		13	17	13	12	9	11
Total Kjeldahl Nitrogen (mg/L)	0.2		ND	ND	ND	1.1	ND	ND
Total Organic Nitrogen (mg/L)	0.2		ND	ND	ND	1.1	ND	ND
Chloride (mg/L)	0.2		0.6	ND	1.0	1.0	ND	1.4
Nitrate, as NO3 (mg/L)	0.1		ND	ND	ND	0.9	ND	ND
Orthophosphate (mg/L)	0.01		ND	ND	ND	ND	ND	0.013
Sulfate (mg/L)	0.2		0.5	1.0	1.0	9.3	ND	2.7
Chlorophyll-a (mg/L)	0.0005		0.00120	0.02130	0.00080	0.00230	ND	0.00200
Alkalinity - Total (mg/L)	10		48	50	50	50	50	50
Alkalinity - Hydroxide (mg/L)	10		ND	ND	ND	ND	ND	ND
Alkalinity - Bicarbonate (mg/L)	10		48	50	50	50	50	50
Alkalinity - Carbonate (mg/L)	10		ND	ND	ND	ND	ND	ND
MBAS (mg/L)	0.05		ND	ND	ND	ND	ND	ND
Total Dissolved Solids (mg/L)	10		63	71	71	.	69	57
Total Suspended Solids (mg/L)	1		ND	ND	ND	.	2.3	ND
PCB1016 (mg/L)	0.001		.	.	.	.	.	.
PCB1221 (mg/L)	0.001		.	.	.	.	.	.
PCB1232 (mg/L)	0.001		.	.	.	.	.	.
PCB1242 (mg/L)	0.001		.	.	.	.	.	.
PCB1248 (mg/L)	0.001		.	.	.	.	.	.
PCB1254 (mg/L)	0.001		.	.	.	.	.	.
PCB1260 (mg/L)	0.001		.	.	.	.	.	.

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Appendix E2-C.

Table 2. UNFFR Relicensing (FERC 2105) – 2000 Water Quality Monitoring Program Results (metals expressed as *total* metals)

Station LA1(Bottom) - Lake Almanor near Canyon Dam

	Reporting Limits	Detection Limits	Sampling Date					
			April	June	July	August	September	November
Time			13:15	12:00	12:15	11:30	12:30	9:16
In-situ Parameters								
Water Temperature (°C)			7.37	10.26	12.11	12.34	16.75	8.51
Dissolved Oxygen (mg/L)			9.75	2.81	2.76	0.73	6.97	9.79
Specific Conductance (mS/cm)			85.3	87.9	89	97.2	95.5	97.6
pH (Standard Units)			8.05	6.9	7.19	6.89	7.33	7.2
Total Dissolved Solids (g/L)			0.0547	0.0559	0.0569	0.622	0.0611	0.0625
Turbidity (NTU)			4	3	0.7	3.2	6.9	9.5
Depth (M)			16.1	15	13	13	13	14.5
Analytical Parameters								
Total Coliform (MPN/100 ml)			4	4	14	70	50	8
Fecal Coliform (MPN/100 ml)			<2	<2	<2	<2	<2	<2
Arsenic (mg/L)	0.005	0.0032	ND	ND	ND	ND	0.023	ND
Barium (mg/L)	0.005	0.00039	0.0095	0.0085	0.0110	0.0079	ND	0.0120
Cadmium (mg/L)	0.002	0.00036	ND	ND	ND	ND	ND	ND
Calcium (mg/L)	0.1	0.0082	9	8	9	9	ND	9
Chromium (mg/L)	0.005	0.00047	ND	ND	ND	ND	ND	ND
Copper (mg/L)	0.005	0.00040	ND	ND	ND	ND	ND	ND
Iron (mg/L)	0.1	0.0028	0.072 J	ND	0.160	ND	ND	0.320
Lead (mg/L)	0.005	0.0013	ND	ND	ND	ND	ND	ND
Magnesium (mg/L)	0.1	0.0023	4.8	4.3	4.5	4.8	0.11	4.7
Manganese (mg/L)	0.005	0.00046	0.0110	0.0540	0.1700	0.0260	ND	0.0520
Mercury (mg/L)	0.0002	0.0002	ND	ND	0.00024	ND	ND	ND
Potassium (mg/L)	1.0	0.1	1.4	1.4	1.2	2.5	ND	1.3
Selenium (mg/L)	0.005	0.0042	ND	ND	ND	ND	ND	ND
Silver (mg/L)	0.005	0.00036	0.00044 J	ND	ND	ND	ND	ND
Sodium (mg/L)	1	0.1	4.1	3.3	3.7	4.4	2.7	4.1
Zinc (mg/L)	0.01	0.0013	0.0031 J	0.0075 J	0.0033 J	ND	ND	0.0074 J
Ammonia - Total (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Boron (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Total Hardness, as CaCO3 (mg/L)	1		39	41	46	43	ND	41
Total Phosphorous (mg/L)	0.01		0.03	ND	0.03	0.02	ND	0.12
Silica (mg/L)	0.3		13	20	13	15	8	11
Total Kjeldahl Nitrogen (mg/L)	0.2		ND	ND	ND	1.7	ND	ND
Total Organic Nitrogen (mg/L)	0.2		ND	ND	ND	1.7	ND	ND
Chloride (mg/L)	0.2		0.6	ND	1.0	ND	ND	1.6
Nitrate, as NO3 (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Orthophosphate (mg/L)	0.01		ND	ND	ND	ND	ND	0.011
Sulfate (mg/L)	0.2		0.5	1.0	1.0	ND	ND	1.0
Chlorophyll-a (mg/L)	0.0005		0.0019	0.0130	0.0022	0.0028	ND	0.0040
Alkalinity - Total (mg/L)	10		49	50	50	50	50	50
Alkalinity - Hydroxide (mg/L)	10		ND	ND	ND	ND	ND	ND
Alkalinity - Bicarbonate (mg/L)	10		49	50	50	50	50	50
Alkalinity - Carbonate (mg/L)	10		ND	ND	ND	ND	ND	ND
MBAS (mg/L)	0.05		ND	ND	ND	ND	ND	ND
Total Dissolved Solids (mg/L)	10		68	66	63	.	68	ND
Total Suspended Solids (mg/L)	1		ND	ND	2.7	.	5.2	23
PCB1016 (mg/L)	0.001		.	.	.	.	.	.
PCB1221 (mg/L)	0.001		.	.	.	.	.	.
PCB1232 (mg/L)	0.001		.	.	.	.	.	.
PCB1242 (mg/L)	0.001		.	.	.	.	.	.
PCB1248 (mg/L)	0.001		.	.	.	.	.	.
PCB1254 (mg/L)	0.001		.	.	.	.	.	.
PCB1260 (mg/L)	0.001		.	.	.	.	.	.

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Appendix E2-C.

Table 2. UNFFR Relicensing (FERC 2105) – 2000 Water Quality Monitoring Program Results (metals expressed as *total* metals)

Station NF2 - North Fork Feather River below Canyon Dam

			Sampling Date					
	Reporting Limits	Detection Limits	April	June	July	August	September	November
Time			11:50	12:40	11:42	11:40	11:31	11:00
In-situ Parameters								
Water Temperature (°C)			7.7	9.76	10.44	11.38	12.11	9.03
Dissolved Oxygen (mg/L)			9.91	9.3	8.84	7.31	10.74	9.17
Specific Conductance (mS/cm)			89.1	90	93.1	95.6	99.8	100.9
pH (Standard Units)			7.71	7.1	7.15	7.4	7.32	7.75
Total Dissolved Solids (g/L)			0.0568	0.0577	0.0597	0.0613	0.064	0.0645
Turbidity (NTU)			3.9	4.3	1.9	3.6	7.5	2.8
Depth (M)			0.5	0.5	0.5	0.5	0.5	0.5
Analytical Parameters								
Total Coliform (MPN/100 ml)			4	21	30	11	8	7
Fecal Coliform (MPN/100 ml)			2	<2	<2	<2	<2	<2
Arsenic (mg/L)	0.005	0.0032	ND	0.0052	ND	ND	ND	ND
Barium (mg/L)	0.005	0.00039	0.0090	0.0100	0.0130	0.0140	0.0340	0.0076
Cadmium (mg/L)	0.002	0.00036	ND	ND	ND	ND	ND	ND
Calcium (mg/L)	0.1	0.0082	10	9	9	10	10	9
Chromium (mg/L)	0.005	0.00047	ND	ND	ND	ND	0.024	ND
Copper (mg/L)	0.005	0.00040	ND	ND	ND	ND	ND	ND
Iron (mg/L)	0.1	0.0028	0.078 J	0.078 J	0.430	0.530	1.700	ND
Lead (mg/L)	0.005	0.0013	ND	ND	ND	ND	ND	ND
Magnesium (mg/L)	0.1	0.0023	5.5	4.5	4.6	4.8	4.8	4.7
Manganese (mg/L)	0.005	0.00046	0.02	0.18	0.32	0.45	1.7	0.049
Mercury (mg/L)	0.0002	0.0002	ND	ND	ND	ND	ND	ND
Potassium (mg/L)	1.0	0.1	1.4	1.2	1.2	1.4	1.4	1.2
Selenium (mg/L)	0.005	0.0042	ND	ND	ND	ND	ND	ND
Silver (mg/L)	0.005	0.00036	ND	ND	ND	ND	ND	ND
Sodium (mg/L)	1	0.1	5.1	3.5	3.7	4.3	4.1	3.8
Zinc (mg/L)	0.01	0.0013	ND	0.0035 J	ND	ND	ND	ND
Ammonia - Total (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Boron (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Total Hardness, as CaCO3 (mg/L)	1		43	42	50	44	44	41
Total Phosphorous (mg/L)	0.01		0.05	0.11	0.04	0.03	0.03	0.02
Silica (mg/L)	0.3		11	19	15	14	10	11
Total Kjeldahl Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	0.11
Total Organic Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	0.11
Chloride (mg/L)	0.2		1.6	0.8	2.0	1.1	1.7	1.4
Nitrate, as NO3 (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Orthophosphate (mg/L)	0.01		ND	ND	ND	ND	ND	ND
Sulfate (mg/L)	0.2		0.6	1.1	1.0	1.3	ND	ND
Chlorophyll-a (mg/L)	0.0005		0.0007	0.0054	0.0017	0.0063	0.0009	0.0021
Alkalinity - Total (mg/L)	10		56	70	50	50	60	60
Alkalinity - Hydroxide (mg/L)	10		ND	ND	ND	ND	ND	ND
Alkalinity - Bicarbonate (mg/L)	10		ND	70	50	50	60	60
Alkalinity - Carbonate (mg/L)	10		ND	ND	ND	ND	ND	ND
MBAS (mg/L)	0.05		ND	ND	ND	ND	ND	ND
Total Dissolved Solids (mg/L)	10		96	70	66	-	79	22
Total Suspended Solids (mg/L)	1		ND	ND	ND	.	3.8	ND
PCB1016 (mg/L)	0.001		ND	ND	ND	ND	ND	ND
PCB1221 (mg/L)	0.001		ND	ND	ND	ND	ND	ND
PCB1232 (mg/L)	0.001		ND	ND	ND	ND	ND	ND
PCB1242 (mg/L)	0.001		ND	ND	ND	ND	ND	ND
PCB1248 (mg/L)	0.001		ND	ND	ND	ND	ND	ND
PCB1254 (mg/L)	0.001		ND	ND	ND	ND	ND	ND
PCB1260 (mg/L)	0.001		ND	ND	ND	ND	ND	ND

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Appendix E2-C.

Table 2. UNFFR Relicensing (FERC 2105) – 2000 Water Quality Monitoring Program Results (metals expressed as *total* metals)

Station BC1 - Butt Creek above Butt Valley Reservoir

			2000 Sampling					
	Reporting Limits	Detection Limits	April	June	July	August	September	November
Time			9:30	10:20	9:44	9:24	9:22	9:00
In-situ Parameters								
Water Temperature (°C)			3.96	11.14	10.49	9.52	7.59	3.84
Dissolved Oxygen (mg/L)			11.24	9.28	9.53	9.36	10.71	9.99
Specific Conductance (mS/cm)			77.5	135	141.1	144.5	146.7	136.8
pH (Standard Units)			7.27	7.39	8.02	8.17	8.06	7.98
Total Dissolved Solids (g/L)			0.0496	0.0864	0.0909	0.0924	0.0940	0.0874
Turbidity (NTU)			9.5	1.2	0.3	0.3	3.1	0.3
Depth (M)			0.5	0.5	0.5	0.5	0.5	0.5
Analytical Parameters								
Total Coliform (MPN/100 ml)			130	80	80	500	17	8
Fecal Coliform (MPN/100 ml)			2	50	80	50	2	2
Arsenic (mg/L)	0.005	0.0032	ND	0.005	ND	ND	ND	ND
Barium (mg/L)	0.005	0.00039	0.0084	0.0062	0.0069	0.0066	0.0061	0.0057
Cadmium (mg/L)	0.002	0.00036	ND	ND	ND	ND	ND	ND
Calcium (mg/L)	0.1	0.0082	10	16	17	18	17	16
Chromium (mg/L)	0.005	0.00047	ND	ND	ND	ND	ND	ND
Copper (mg/L)	0.005	0.00040	ND	ND	ND	ND	ND	ND
Iron (mg/L)	0.1	0.0028	0.410	ND	0.440	0.140	ND	0.044 J
Lead (mg/L)	0.005	0.0013	ND	ND	ND	ND	ND	ND
Magnesium (mg/L)	0.1	0.0023	3.9	5.9	6.3	6.8	6.4	6.1
Manganese (mg/L)	0.005	0.00046	0.014	ND	0.0120	0.0073	ND	ND
Mercury (mg/L)	0.0002	0.0002	ND	ND	ND	ND	ND	ND
Potassium (mg/L)	1.0	0.1	0.86 J	1.1	1.0	1.3	1.2	1.1
Selenium (mg/L)	0.005	0.0042	ND	ND	ND	ND	ND	ND
Silver (mg/L)	0.005	0.00036	ND	ND	0.0005 J	0.0004 J	ND	ND
Sodium (mg/L)	1	0.1	3.0	4.1	4.5	5.2	5.1	4.6
Zinc (mg/L)	0.01	0.0013	ND	ND	ND	ND	ND	ND
Ammonia - Total (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Boron (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Total Hardness, as CaCO3 (mg/L)	1		37	66	82	73	68	65
Total Phosphorous (mg/L)	0.01		0.02	0.03	0.01	0.00	0.04	0.05
Silica (mg/L)	0.3		21	35	23	27	17	21
Total Kjeldahl Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	0.17
Total Organic Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	0.17
Chloride (mg/L)	0.2		ND	1.2	1.0	0.9	2.0	1.2
Nitrate, as NO3 (mg/L)	0.1		ND	ND	ND	ND	ND	0.68
Orthophosphate (mg/L)	0.01		ND	ND	ND	0.03	ND	ND
Sulfate (mg/L)	0.2		1.1	1.8	3.0	3.2	0.6	3.9
Chlorophyll-a (mg/L)	0.0005		ND	0.0010	0.0019	0.0029	0	0.00062
Alkalinity - Total (mg/L)	10		45	80	80	80	80	70
Alkalinity - Hydroxide (mg/L)	10		ND	ND	ND	ND	ND	ND
Alkalinity - Bicarbonate (mg/L)	10		45	80	80	80	80	70
Alkalinity - Carbonate (mg/L)	10		ND	ND	ND	ND	ND	ND
MBAS (mg/L)	0.05		ND	ND	ND	ND	ND	ND
Total Dissolved Solids (mg/L)	10		98	130	99	.	110	34
Total Suspended Solids (mg/L)	1		ND	ND	ND	.	2.1	ND
PCB1016 (mg/L)	0.001		.	.	.	.	.	.
PCB1221 (mg/L)	0.001		.	.	.	.	.	.
PCB1232 (mg/L)	0.001		.	.	.	.	.	.
PCB1242 (mg/L)	0.001		.	.	.	.	.	.
PCB1248 (mg/L)	0.001		.	.	.	.	.	.
PCB1254 (mg/L)	0.001		.	.	.	.	.	.
PCB1260 (mg/L)	0.001		.	.	.	.	.	.

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Appendix E2-C.

Table 2. UNFFR Relicensing (FERC 2105) – 2000 Water Quality Monitoring Program Results (metals expressed as *total* metals)

Station BV1 - Butt Valley Powerhouse Tailrace

	Reporting Limits	Detection Limits	Sampling Date					
			April	June	July	August	September	November
Time			9:20	9:50	9:27	9:24	9:32	9:00
In-situ Parameters								
Water Temperature (°C)			7.91	16.14	18.86	20.22	17.13	7.71
Dissolved Oxygen (mg/L)			10.24	8.27	6.66	6.25	7.62	8.92
Specific Conductance (mS/cm)			86.6	87.4	88.9	92.6	97	96.7
pH (Standard Units)			7.55	7.3	7.66	7.79	8.01	7.78
Total Dissolved Solids (g/L)			0.0557	0.056	0.059	0.0593	0.0619	0.0621
Turbidity (NTU)			3.4	1.7	0.7	3.1	2.9	2.8
Depth (M)			0.5	0.5	0.5	0.5	0.5	0.5
Analytical Parameters								
Total Coliform (MPN/100 ml)			2	50	13	33	50	4
Fecal Coliform (MPN/100 ml)			<2	<2	<2	17	<2	2
Arsenic (mg/L)	0.005	0.0032	ND	ND	ND	ND	ND	ND
Barium (mg/L)	0.005	0.00039	0.0081	0.0093	0.0091	0.0080	0.0085	0.0083
Cadmium (mg/L)	0.002	0.00036	ND	ND	ND	ND	ND	ND
Calcium (mg/L)	0.1	0.0082	9	9	9	9	9	9
Chromium (mg/L)	0.005	0.00047	ND	ND	ND	ND	ND	ND
Copper (mg/L)	0.005	0.00040	ND	ND	ND	ND	ND	ND
Iron (mg/L)	0.1	0.0028	0.110	0.093 J	0.160	ND	ND	0.049 J
Lead (mg/L)	0.005	0.0013	ND	ND	ND	ND	ND	ND
Magnesium (mg/L)	0.1	0.0023	4.7	4.2	4.3	4.8	4.6	4.8
Manganese (mg/L)	0.005	0.00046	0.0130	0.0970	0.0510	0.0600	0.0190	0.0220
Mercury (mg/L)	0.0002	0.0002	ND	ND	ND	ND	ND	ND
Potassium (mg/L)	1.0	0.1	1.6	1.4	1.3	1.4	1.4	1.3
Selenium (mg/L)	0.005	0.0042	ND	ND	ND	ND	ND	ND
Silver (mg/L)	0.005	0.00036	0.00047 J	ND	ND	ND	ND	ND
Sodium (mg/L)	1	0.1	4.2	3.5	3.8	4.4	4.3	4.2
Zinc (mg/L)	0.01	0.0013	ND	ND	ND	ND	0.02	ND
Ammonia - Total (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Boron (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Total Hardness, as CaCO3 (mg/L)	1		36	40	46	43	41	42
Total Phosphorous (mg/L)	0.01		0.07	0.08	0.02	0.02	0.02	0.04
Silica (mg/L)	0.3		15	19	13	13	9	11
Total Kjeldahl Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	ND
Total Organic Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	ND
Chloride (mg/L)	0.2		0.4	1.3	2.0	1.1	3.3	1.4
Nitrate, as NO3 (mg/L)	0.1		ND	ND	ND	ND	2.7	ND
Orthophosphate (mg/L)	0.01		ND	0.01	ND	ND	ND	ND
Sulfate (mg/L)	0.2		0.6	1.2	1.0	2.0	ND	1.9
Chlorophyll-a (mg/L)	0.0005		ND	ND	0.0007	0.0029	ND	0.00063
Alkalinity - Total (mg/L)	10		49	60	50	50	50	50
Alkalinity - Hydroxide (mg/L)	10		ND	ND	ND	ND	ND	ND
Alkalinity - Bicarbonate (mg/L)	10		49	60	50	50	50	50
Alkalinity - Carbonate (mg/L)	10		ND	ND	ND	ND	ND	ND
MBAS (mg/L)	0.05		ND	ND	ND	ND	ND	ND
Total Dissolved Solids (mg/L)	10		71	52	70	.	74	ND
Total Suspended Solids (mg/L)	1		ND	ND	ND	.	1.6	ND
PCB1016 (mg/L)	0.001		.	.	.	.	.	.
PCB1221 (mg/L)	0.001		.	.	.	.	.	.
PCB1232 (mg/L)	0.001		.	.	.	.		.
PCB1242 (mg/L)	0.001		.	.	.	.	.	.
PCB1248 (mg/L)	0.001		.	.	.	.	.	.
PCB1254 (mg/L)	0.001		.	.	.	.	.	.
PCB1260 (mg/L)	0.001		.	.	.	.	.	.

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Appendix E2-C.
Table 2. UNFFR Relicensing (FERC 2105) – 2000 Water Quality Monitoring Program Results (metals expressed as *total* metals)

Station BV2 (Surface) - Butt Valley Reservoir near Caribou Powerhouse Unit 1 intake structure

	Reporting Limits	Detection Limits	Sampling Date					
			April	June	July	August	September	November
Time			10:00	9:45	10:23	9:20	8:30	11:15
In-situ Parameters								
Water Temperature (°C)			12.32	20.99	20.19	20.6	17.13	7.91
Dissolved Oxygen (mg/L)			9.93	7.53	5.96	7.02	8.84	10.57
Specific Conductance (mS/cm)			89.7	92.9	92.7	101.3	98.5	100.2
pH (Standard Units)			7.68	7.88	7.71	7.83	7.65	7.54
Total Dissolved Solids (g/L)			0.0572	0.0595	0.0593	0.0649	0.0631	0.0641
Turbidity (NTU)			4.3	2.7	1.2	2.8	8.4	7.3
Depth (M)			ND	ND	ND	ND	ND	ND
Analytical Parameters								
Total Coliform (MPN/100 ml)			<2	13	<2	2	2	2
Fecal Coliform (MPN/100 ml)			<2	<2	<2	<2	<2	<2
Arsenic (mg/L)	0.005	0.0032	ND	ND	ND	ND	ND	ND
Barium (mg/L)	0.005	0.00039	0.0089	0.0076	0.0083	0.0069	0.0077	0.0082
Cadmium (mg/L)	0.002	0.00036	ND	ND	ND	ND	ND	ND
Calcium (mg/L)	0.1	0.0082	10	9	9	9	9	9
Chromium (mg/L)	0.005	0.00047	ND	ND	ND	ND	0.01	ND
Copper (mg/L)	0.005	0.00040	ND	ND	ND	ND	ND	ND
Iron (mg/L)	0.1	0.0028	0.130	ND	0.075 J	ND	ND	0.048 J
Lead (mg/L)	0.005	0.0013	ND	ND	ND	ND	ND	ND
Magnesium (mg/L)	0.1	0.0023	4.5	4.4	4.6	4.9	4.5	4.9
Manganese (mg/L)	0.005	0.00046	0.0210	0.0110	0.0130	0.0190	0.0200	0.0160
Mercury (mg/L)	0.0002	0.0002	ND	ND	0.00051	ND	ND	ND
Potassium (mg/L)	1.0	0.1	1.3	1.4	1.3	2.6	1.2	1.4
Selenium (mg/L)	0.005	0.0042	ND	ND	ND	ND	ND	ND
Silver (mg/L)	0.005	0.00036	0.00035 J	ND	ND	ND	ND	ND
Sodium (mg/L)	1	0.1	3.9	3.4	4.0	4.2	4.2	4.3
Zinc (mg/L)	0.01	0.0013	ND	ND	ND	ND	ND	0.0044 J
Ammonia - Total (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Boron (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Total Hardness, as CaCO3 (mg/L)	1		39	41	47	44	41	44
Total Phosphorous (mg/L)	0.01		0.01	ND	0.05	0.02	ND	0.02
Silica (mg/L)	0.3		16	21	14	15	8	12
Total Kjeldahl Nitrogen (mg/L)	0.2		ND	ND	ND	7.6	ND	ND
Total Organic Nitrogen (mg/L)	0.2		ND	ND	ND	7.6	ND	ND
Chloride (mg/L)	0.2		0.6	ND	1.0	1.0	ND	1.4
Nitrate, as NO3 (mg/L)	0.1		ND	ND	ND	ND	2.3	ND
Orthophosphate (mg/L)	0.01		ND	ND	ND	ND	ND	0.011
Sulfate (mg/L)	0.2		0.5	1.0	1.0	ND	ND	ND
Chlorophyll-a (mg/L)	0.0005		ND	0.0026	0.0034	0.0035	ND	0.0018
Alkalinity - Total (mg/L)	10		50	50	50	50	50	50
Alkalinity - Hydroxide (mg/L)			ND	ND	ND	ND	ND	ND
Alkalinity - Bicarbonate (mg/L)	10		50	50	50	50	50	50
Alkalinity - Carbonate (mg/L)	10		ND	ND	ND	ND	ND	ND
MBAS (mg/L)	0.05		ND	ND	ND	ND	ND	ND
Total Dissolved Solids (mg/L)	10		73	13	66	.	74	47
Total Suspended Solids (mg/L)	1		ND	ND	ND	.	1.9	ND
PCB1016 (mg/L)	0.001		.	.	.	.	.	.
PCB1221 (mg/L)	0.001		.	.	.	.	.	.
PCB1232 (mg/L)	0.001		.	.	.	.	.	.
PCB1242 (mg/L)	0.001		.	.	.	.	.	.
PCB1248 (mg/L)	0.001		.	.	.	.	.	.
PCB1254 (mg/L)	0.001		.	.	.	.	.	.
PCB1260 (mg/L)	0.001		.	.	.	.	.	.

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Appendix E2-C.

Table 2. UNFFR Relicensing (FERC 2105) – 2000 Water Quality Monitoring Program Results (metals expressed as *total* metals)

Station BV2 (Bottom) - Butt Valley Reservoir near Caribou Powerhouse Unit 1 intake structure

	Reporting Limits	Detection Limits	Sampling Date					
			April	June	July	August	September	November
Time			10:05	9:45	10:23	9:20	8:30	11:15
In-situ Parameters								
Water Temperature (°C)			6.10	11.19	15.71	17.31	16.84	7.54
Dissolved Oxygen (mg/L)			8.18	1.18	1.11	0.4	3.69	10.26
Specific Conductance (mS/cm)			85.3	93	99.4	119.2	99.1	100.2
pH (Standard Units)			7.30	6.80	6.98	6.94	6.84	7.38
Total Dissolved Solids (g/L)			0.0546	0.0596	0.0636	0.0762	0.0632	0.0641
Turbidity (NTU)			4.8	1.8	8.5	4.3	15.3	9.2
Depth (M)			15.4	14.0	14	14.6	14.6	15
Analytical Parameters								
Total Coliform (MPN/100 ml)			12	2	4	4	<2	2
Fecal Coliform (MPN/100 ml)			<2	<2	<2	<2	<2	<2
Arsenic (mg/L)	0.005	0.0032	ND	ND	ND	ND	ND	ND
Barium (mg/L)	0.005	0.00039	0.0090	0.0100	0.0220	0.0082	0.0140	0.0078
Cadmium (mg/L)	0.002	0.00036	ND	ND	ND	ND	ND	ND
Calcium (mg/L)	0.1	0.0082	10	10	10	9	10	9
Chromium (mg/L)	0.005	0.00047	ND	ND	ND	ND	ND	ND
Copper (mg/L)	0.005	0.00040	ND	ND	ND	ND	ND	ND
Iron (mg/L)	0.1	0.0028	0.120	0.082 J	0.300	0.120	0.790	0.044 J
Lead (mg/L)	0.005	0.0013	ND	ND	ND	ND	ND	ND
Magnesium (mg/L)	0.1	0.0023	4.4	4.4	4.8	4.8	5.2	4.8
Manganese (mg/L)	0.005	0.00046	0.0470	0.5000	0.7100	0.1300	0.1600	0.0160
Mercury (mg/L)	0.0002	0.0002	ND	ND	0.00029	ND	ND	ND
Potassium (mg/L)	1.0	0.1	1.4	1.2	1.4	2.5	1.6	1.3
Selenium (mg/L)	0.005	0.0042	ND	ND	ND	ND	ND	ND
Silver (mg/L)	0.005	0.00036	0.00039 J	ND	ND	ND	ND	ND
Sodium (mg/L)	1	0.1	3.9	3.2	4.0	4.0	7.8	4.0
Zinc (mg/L)	0.01	0.0013	0.0054	ND	ND	ND	0.0071 J	ND
Ammonia - Total (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Boron (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Total Hardness, as CaCO3 (mg/L)	1		38	42	50	43	46	43
Total Phosphorous (mg/L)	0.01		0.02	0.05	0.06	0.03	0.02	0.03
Silica (mg/L)	0.3		15	23	15	15	9	12
Total Kjeldahl Nitrogen (mg/L)	0.2		ND	ND	ND	7.7	ND	1.12
Total Organic Nitrogen (mg/L)	0.2		ND	ND	ND	7.7	ND	1.12
Chloride (mg/L)	0.2		0.7	ND	1.0	1.1	1.2	2.1
Nitrate, as NO3 (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Orthophosphate (mg/L)	0.01		ND	ND	ND	ND	ND	0.04
Sulfate (mg/L)	0.2		1.1	1.0	1.0	ND	ND	1.0
Chlorophyll-a (mg/L)	0.0005		ND	0.0130	ND	0.0041	ND	0.0014
Alkalinity - Total (mg/L)	10		48	60	50	50	50	50
Alkalinity - Hydroxide (mg/L)	10		ND	ND	ND	ND	ND	ND
Alkalinity - Bicarbonate (mg/L)	10		48	60	50	50	50	50
Alkalinity - Carbonate (mg/L)	10		ND	ND	ND	ND	ND	ND
MBAS (mg/L)	0.05		ND	ND	ND	ND	ND	ND
Total Dissolved Solids (mg/L)	10		69	71	92	.	71	33
Total Suspended Solids (mg/L)	1		ND	ND	1.8	.	9.3	ND
PCB1016 (mg/L)	0.001		.	.	.	.	.	.
PCB1221 (mg/L)	0.001		.	.	.	.	.	.
PCB1232 (mg/L)	0.001		.	.	.	.	.	.
PCB1242 (mg/L)	0.001		.	.	.	.	.	.
PCB1248 (mg/L)	0.001		.	.	.	.	.	.
PCB1254 (mg/L)	0.001		.	.	.	.	.	.
PCB1260 (mg/L)	0.001		.	.	.	.	.	.

1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
3. "J" Flag is placed in a report in which lab reports results between the MDL and reporting limit. It indicates that the result is estimated. While definitely present, it is below the reporting limit, indicating we do not track the accuracy at these levels.

Appendix E2-C.

Table 2. UNFFR Relicensing (FERC 2105) – 2000 Water Quality Monitoring Program Results (metals expressed as *total* metals)

Station BC3 - Butt Creek above North Fork Feather River

	Reporting Limits	Detection Limits	Sampling Date					
			April	June	July	August	September	November
Time			9:40	11:48	10:29	10:15	9:54	9:55
In-situ Parameters								
Water Temperature (°C)			8.61	11.99	11.37	11.59	10.9	8.88
Dissolved Oxygen (mg/L)			9.85	9.27	8.39	9.11	9.27	10.25
Specific Conductance (mS/cm)			159	171	181.5	174.7	183.5	177.2
pH (Standard Units)			7.59	7.82	8.05	8.15	8.04	8.06
Total Dissolved Solids (g/L)			0.102	0.11	0.1162	0.112	0.1175	0.1136
Turbidity (NTU)			5.5	2.4	5.2	0.5	0.2	1
Depth (M)			0.5	0.5	0.5	0.5	0.5	0.5
Analytical Parameters								
Total Coliform (MPN/100 ml)			9	34	50	4	30	4
Fecal Coliform (MPN/100 ml)			<2	2	2	<2	2	<2
Arsenic (mg/L)	0.005	0.0032	ND	ND	ND	ND	ND	ND
Barium (mg/L)	0.005	0.00039	0.0052	0.0052	0.0053	0.0057	0.0052	ND
Cadmium (mg/L)	0.002	0.00036	ND	ND	ND	ND	ND	ND
Calcium (mg/L)	0.1	0.0082	22	21	22	24	22	20
Chromium (mg/L)	0.005	0.00047	ND	ND	ND	ND	ND	ND
Copper (mg/L)	0.005	0.00040	ND	ND	ND	ND	ND	ND
Iron (mg/L)	0.1	0.0028	ND	ND	ND	ND	ND	ND
Lead (mg/L)	0.005	0.0013	ND	ND	ND	ND	ND	ND
Magnesium (mg/L)	0.1	0.0023	6.7	6.9	7.3	8.0	7.3	6.9
Manganese (mg/L)	0.005	0.00046	ND	ND	ND	ND	ND	ND
Mercury (mg/L)	0.0002	0.0002	ND	ND	0.00036	ND	ND	ND
Potassium (mg/L)	1.0	0.1	0.8 J	0.9 J	0.7 J	0.9 J	ND	0.7 J
Selenium (mg/L)	0.005	0.0042	ND	ND	ND	ND	ND	ND
Silver (mg/L)	0.005	0.00036	0.00052 J	ND	0.00045 J	0.00048 J	ND	ND
Sodium (mg/L)	1	0.1	5.2	4.9	5.4	6.1	5.8	5.1
Zinc (mg/L)	0.01	0.0013	ND	ND	ND	ND	ND	ND
Ammonia - Total (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Boron (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Total Hardness, as CaCO3 (mg/L)	1		76	85	99	93	86	79
Total Phosphorous (mg/L)	0.01		0.02	0.11	0.06	0.03	0.02	0.03
Silica (mg/L)	0.3		13	26	20	20	13	16
Total Kjeldahl Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	ND
Total Organic Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	ND
Chloride (mg/L)	0.2		0.2	1.3	2.0	1.2	1.1	1.4
Nitrate, as NO3 (mg/L)	0.1		ND	ND	8	ND	ND	ND
Orthophosphate (mg/L)	0.01		ND	ND	ND	0.03	ND	ND
Sulfate (mg/L)	0.2		3.4	3.0	3.0	2.9	3.0	2.8
Chlorophyll-a (mg/L)	0.0005		0.003	ND	ND	0.0023	ND	ND
Alkalinity - Total (mg/L)	10		87	100	150	100	100	90
Alkalinity - Hydroxide (mg/L)	10		ND	ND	ND	ND	ND	ND
Alkalinity - Bicarbonate (mg/L)	10		87	100	150	100	100	90
Alkalinity - Carbonate (mg/L)	10		ND	ND	ND	ND	ND	ND
MBAS (mg/L)	0.05		ND	ND	ND	ND	ND	ND
Total Dissolved Solids (mg/L)	10		120	130	110	.	120	75
Total Suspended Solids (mg/L)	1		ND	ND	ND	.	1.0	<1.0
PCB1016 (mg/L)	0.001		.	.	.	.	.	.
PCB1221 (mg/L)	0.001		.	.	.	.	.	.
PCB1232 (mg/L)	0.001		.	.	.	.	.	.
PCB1242 (mg/L)	0.001		.	.	.	.	.	.
PCB1248 (mg/L)	0.001		.	.	.	.	.	.
PCB1254 (mg/L)	0.001		.	.	.	.	.	.
PCB1260 (mg/L)	0.001		.	.	.	.	.	.

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2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
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Appendix E2-C.
Table 2. UNFFR Relicensing (FERC 2105) – 2000 Water Quality Monitoring Program Results (metals expressed as *total* metals)

Station NF4 - North Fork Feather River above Caribou Powerhouse

			Sampling Date					
	Reporting Limits	Detection Limits	April	June	July	August	September	November
Time			10:30	12:30	11:07	10:54	10:33	10:22
In-situ Parameters								
Water Temperature (°C)			7.12	14.02	13.1	12.63	10.64	6.76
Dissolved Oxygen (mg/L)			10.12	8.84	8.55	8.7	8.83	11.22
Specific Conductance (mS/cm)			128.1	164	170.2	162.9	171.3	163.1
pH (Standard Units)			7.5	8.12	8.12	8.21	8.05	8.09
Total Dissolved Solids (g/L)			0.082	0.105	0.1091	0.1044	0.1097	0.1042
Turbidity (NTU)			13.5	1.7	1.7	1	4.6	0.8
Depth (M)			0.5	0.5	0.5	0.5	0.5	0.5
Analytical Parameters								
Total Coliform (MPN/100 ml)			16	30	80	13	70	2
Fecal Coliform (MPN/100 ml)			2	4	8	2	4	<2
Arsenic (mg/L)	0.005	0.0032	ND	0.0077	ND	ND	ND	ND
Barium (mg/L)	0.005	0.00039	0.0190	0.0300	0.0220	0.0220	0.0200	0.0150
Cadmium (mg/L)	0.002	0.00036	ND	ND	ND	ND	ND	ND
Calcium (mg/L)	0.1	0.0082	17	20	20	20	18	17
Chromium (mg/L)	0.005	0.00047	ND	ND	ND	ND	ND	ND
Copper (mg/L)	0.005	0.00040	ND	ND	ND	ND	ND	ND
Iron (mg/L)	0.1	0.0028	0.140	0.390	0.100	0.085 J	ND	0.032 J
Lead (mg/L)	0.005	0.0013	ND	ND	ND	ND	ND	ND
Magnesium (mg/L)	0.1	0.0023	5.2	6.5	6.9	7.2	6.5	5.9
Manganese (mg/L)	0.005	0.00046	0.0280	0.1600	0.0270	0.0360	0.0480	0.0180
Mercury (mg/L)	0.0002	0.0002	ND	ND	ND	ND	ND	ND
Potassium (mg/L)	1.0	0.1	0.9 J	1.2	ND	1.2	1.3	1.0
Selenium (mg/L)	0.005	0.0042	ND	ND	ND	ND	ND	ND
Silver (mg/L)	0.005	0.00036	0.00056 J	ND	ND	ND	ND	ND
Sodium (mg/L)	1	0.1	4.4	5.8	6.7	7.3	8.9	6.0
Zinc (mg/L)	0.01	0.0013	ND	0.004 J	ND	ND	ND	ND
Ammonia - Total (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Boron (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Total Hardness, as CaCO3 (mg/L)	1		62	77	89	81	72	66
Total Phosphorous (mg/L)	0.01		ND	0.04	0.06	0.02	0.02	0.05
Silica (mg/L)	0.3		13	19	14	16	10	12
Total Kjeldahl Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	ND
Total Organic Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	ND
Chloride (mg/L)	0.2		0.7	1.4	2.0	1.8	1.4	2.1
Nitrate, as NO3 (mg/L)	0.1		ND	ND	ND	ND	3.5	ND
Orthophosphate (mg/L)	0.01		ND	0.01	ND	ND	ND	0.006
Sulfate (mg/L)	0.2		4.0	3.0	4.0	3.0	ND	3.5
Chlorophyll-a (mg/L)	0.0005		ND	ND	0.0005	0.00094	0.00068	ND
Alkalinity - Total (mg/L)	10		68	90	90	80	90	90
Alkalinity - Hydroxide (mg/L)	10		ND	ND	ND	ND	ND	ND
Alkalinity - Bicarbonate (mg/L)	10		68	90	90	80	90	90
Alkalinity - Carbonate (mg/L)	10		ND	ND	ND	ND	ND	ND
MBAS (mg/L)	0.05		ND	ND	ND	ND	ND	ND
Total Dissolved Solids (mg/L)	10		88	110	120	.	100	49
Total Suspended Solids (mg/L)	1		ND	140	ND	.	4.2	<1.0
PCB1016 (mg/L)	0.001		.	.	.	.	.	.
PCB1221 (mg/L)	0.001		.	.	.	.	.	.
PCB1232 (mg/L)	0.001		.	.	.	.	.	.
PCB1242 (mg/L)	0.001		.	.	.	.	.	.
PCB1248 (mg/L)	0.001		.	.	.	.	.	.
PCB1254 (mg/L)	0.001		.	.	.	.	.	.
PCB1260 (mg/L)	0.001		.	.	.	.	.	.

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Appendix E2-C.
Table 2. UNFFR Relicensing (FERC 2105) – 2000 Water Quality Monitoring Program Results (metals expressed as *total* metals)

Station CARB1 - Caribou No.1 Powerhouse tailrace

			Sampling Date					
	Reporting Limits	Detection Limits	April	June	July	August	September	November
Time				13:10	11:43	11:19	10:53	10:45
In-situ Parameters								
Water Temperature (°C)			.	16.1	18.15	19.5	17.22	9.11
Dissolved Oxygen (mg/L)			.	7.94	6.98	7.39	6.76	9.32
Specific Conductance (mS/cm)			.	102.5	98.8	94.5	101.7	98.9
pH (Standard Units)			.	7.61	7.66	7.9	7.9	7.96
Total Dissolved Solids (g/L)			.	0.0652	0.0632	0.0601	0.0651	0.063
Turbidity (NTU)			.	9	4.4	0.6	4.7	1.2
Depth (M)			.	0.5	0.5	0.5	0.5	0.5
Analytical Parameters								
Total Coliform (MPN/100 ml)				4	13	4	2	2
Fecal Coliform (MPN/100 ml)				2	<2	<2	<2	<2
Arsenic (mg/L)	0.005	0.0032	.	ND	ND	ND	ND	ND
Barium (mg/L)	0.005	0.00039	.	0.0082	0.0098	0.0096	0.0095	0.0077
Cadmium (mg/L)	0.002	0.00036	.	ND	ND	ND	ND	ND
Calcium (mg/L)	0.1	0.0082	.	9	9	10	9	9
Chromium (mg/L)	0.005	0.00047	.	ND	ND	ND	ND	ND
Copper (mg/L)	0.005	0.00040	.	ND	0.0063	ND	ND	ND
Iron (mg/L)	0.1	0.0028	.	ND	0.250	0.093 J	0.100	0.057 J
Lead (mg/L)	0.005	0.0013	.	ND	ND	ND	ND	ND
Magnesium (mg/L)	0.1	0.0023	.	4.2	4.6	4.9	4.8	4.6
Manganese (mg/L)	0.005	0.00046	.	0.0250	0.1200	0.1800	0.0510	0.0180
Mercury (mg/L)	0.0002	0.0002	.	ND	0.00028	ND	ND	ND
Potassium (mg/L)	1.0	0.1	.	1.1	1.3	1.5	1.7	1.3
Selenium (mg/L)	0.005	0.0042	.	ND	ND	ND	ND	ND
Silver (mg/L)	0.005	0.00036	.	ND	ND	ND	ND	ND
Sodium (mg/L)	1	0.1	.	3.5	3.9	4.5	6.1	3.9
Zinc (mg/L)	0.01	0.0013	.	0.028	0.011	0.022	0.021	ND
Ammonia - Total (mg/L)	0.1		.	ND	ND	ND	ND	ND
Boron (mg/L)	0.1		.	ND	ND	ND	ND	ND
Total Hardness, as CaCO3 (mg/L)	1		.	41	49	44	43	41
Total Phosphorous (mg/L)	0.01		.	0.05	0.01	ND	ND	0.03
Silica (mg/L)	0.3		.	19	13	14	9	12
Total Kjeldahl Nitrogen (mg/L)	0.2		.	ND	ND	ND	ND	ND
Total Organic Nitrogen (mg/L)	0.2		.	ND	ND	ND	ND	ND
Chloride (mg/L)	0.2		.	0.7	2.0	1.2	1.0	1.4
Nitrate, as NO3 (mg/L)	0.1		.	ND	ND	ND	ND	ND
Orthophosphate (mg/L)	0.01		.	0.01	ND	ND	ND	ND
Sulfate (mg/L)	0.2		.	1.0	1.0	1.5	1.5	1.0
Chlorophyll-a (mg/L)	0.0005		.	0.0125	ND	0.0011	0.0014	0.0034
Alkalinity - Total (mg/L)	10		.	50	50	50	60	50
Alkalinity - Hydroxide (mg/L)	10		.	ND	ND	ND	ND	ND
Alkalinity - Bicarbonate (mg/L)	10		.	50	50	50	60	50
Alkalinity - Carbonate (mg/L)	10		.	ND	ND	ND	ND	ND
MBAS (mg/L)	0.05		.	ND	ND	ND	ND	ND
Total Dissolved Solids (mg/L)	10		.	82	75	.	73	ND
Total Suspended Solids (mg/L)	1		.	3.0	2.2	.	4.6	1.7
PCB1016 (mg/L)	0.001		.	.	.	.	.	.
PCB1221 (mg/L)	0.001		.	.	.	.	.	.
PCB1232 (mg/L)	0.001		.	.	.	.	.	.
PCB1242 (mg/L)	0.001		.	.	.	.	.	.
PCB1248 (mg/L)	0.001		.	.	.	.	.	.
PCB1254 (mg/L)	0.001		.	.	.	.	.	.
PCB1260 (mg/L)	0.001		.	.	.	.	.	.

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Appendix E2-C.
Table 2. UNFFR Relicensing (FERC 2105) – 2000 Water Quality Monitoring Program Results (metals expressed as *total* metals)

Station CARB2 - Caribou No. 2 Powerhouse tailrace

			Sampling Date					
	Reporting Limits	Detection Limits	April	June	July	August	September	November
Time				13:10	11:29	11:26	11:01	10:55
In-situ Parameters								
Water Temperature (°C)			.	24.46	19.94	21.44	17.53	8.88
Dissolved Oxygen (mg/L)			.	7.64	7.6	7.19	6.5	10.06
Specific Conductance (mS/cm)			.	96.3	96.4	94.4	100.8	97.1
pH (Standard Units)			.	7.69	7.68	7.9	7.89	7.82
Total Dissolved Solids (g/L)			.	0.0615	0.0618	0.0603	0.0645	0.0622
Turbidity (NTU)			.	4.4	2	0.3	6.5	1.4
Depth (M)			.	0.5	0.5	0.5	0.5	0.5
Analytical Parameters								
Total Coliform (MPN/100 ml)				2	8	8	23	4
Fecal Coliform (MPN/100 ml)				<2	<2	2	<2	<2
Arsenic (mg/L)	0.005	0.0032	.	ND	ND	ND	ND	ND
Barium (mg/L)	0.005	0.00039	.	0.0120	0.0087	0.0084	0.0087	0.0077
Cadmium (mg/L)	0.002	0.00036	.	ND	ND	ND	ND	ND
Calcium (mg/L)	0.1	0.0082	.	10	9	10	9	9
Chromium (mg/L)	0.005	0.00047	.	ND	ND	ND	ND	ND
Copper (mg/L)	0.005	0.00040	.	ND	ND	ND	ND	ND
Iron (mg/L)	0.1	0.0028	.	0.150	0.078 J	ND	ND	0.052 J
Lead (mg/L)	0.005	0.0013	.	ND	ND	ND	ND	ND
Magnesium (mg/L)	0.1	0.0023	.	4.4	4.6	4.9	4.7	4.6
Manganese (mg/L)	0.005	0.00046	.	0.2300	0.0210	0.0190	0.0240	0.0170
Mercury (mg/L)	0.0002	0.0002	.	ND	0.00035	ND	ND	ND
Potassium (mg/L)	1.0	0.1	.	1.3	1.2	1.4	1.6	1.3
Selenium (mg/L)	0.005	0.0042	.	ND	ND	ND	ND	ND
Silver (mg/L)	0.005	0.00036	.	ND	ND	ND	ND	ND
Sodium (mg/L)	1	0.1	.	3.5	3.9	4.5	6.1	3.9
Zinc (mg/L)	0.01	0.0013	.	0.026 J	ND	ND	ND	ND
Ammonia - Total (mg/L)	0.1		.	ND	ND	ND	ND	ND
Boron (mg/L)	0.1		.	ND	ND	ND	ND	ND
Total Hardness, as CaCO3 (mg/L)	1		.	42	47	44	42	41
Total Phosphorous (mg/L)	0.01		.	0.04	0.03	ND	ND	0.05
Silica (mg/L)	0.3		.	22	13	14	9	12
Total Kjeldahl Nitrogen (mg/L)	0.2		.	ND	ND	ND	ND	ND
Total Organic Nitrogen (mg/L)	0.2		.	ND	ND	ND	ND	ND
Chloride (mg/L)	0.2		.	0.8	3.0	1.1	1.4	1.6
Nitrate, as NO3 (mg/L)	0.1		.	ND	ND	ND	ND	0.73
Orthophosphate (mg/L)	0.01		.	ND	ND	ND	ND	0.009
Sulfate (mg/L)	0.2		.	1.0	1.0	1.5	ND	1.0
Chlorophyll-a (mg/L)	0.0005		.	0.0009	ND	0.00096	0.0072	0.0035
Alkalinity - Total (mg/L)	10		.	50	50	50	60	50
Alkalinity - Hydroxide (mg/L)	10		.	ND	ND	ND	ND	ND
Alkalinity - Bicarbonate (mg/L)	10		.	50	50	50	60	50
Alkalinity - Carbonate (mg/L)	10		.	ND	ND	ND	ND	ND
MBAS (mg/L)	0.05		.	ND	ND	ND	ND	
Total Dissolved Solids (mg/L)	10		.	56	83	.	75	22
Total Suspended Solids (mg/L)	1		.	7.4	ND	.	1.1	ND
PCB1016 (mg/L)	0.001		.	.	.	.	.	.
PCB1221 (mg/L)	0.001		.	.	.	.	.	.
PCB1232 (mg/L)	0.001		.	.	.	.	.	.
PCB1242 (mg/L)	0.001		.	.	.	.	.	.
PCB1248 (mg/L)	0.001		.	.	.	.	.	.
PCB1254 (mg/L)	0.001		.	.	.	.	.	.
PCB1260 (mg/L)	0.001		.	.	.	.	.	.

1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
3. "J" Flag is placed in a report in which lab reports results between the MDL and reporting limit. It indicates that the result is estimated. While definitely present, it is below the reporting limit, indicating we do not track the accuracy at these levels.

Appendix E2-C.

Table 2. UNFFR Relicensing (FERC 2105) – 2000 Water Quality Monitoring Program Results (metals expressed as *total* metals)

Station NF5 - North Fork Feather River Below Belden Dam

	Reporting Limits	Detection Limits	Sampling Date					
			April	June	July	August	September	November
Time			10:50	13:50	12:13	11:53	11:23	11:19
In-situ Parameters								
Water Temperature (°C)			9.40	17.15	19.10	20.38	16.95	8.51
Dissolved Oxygen (mg/L)			9.64	8.08	7.21	7.87	7.87	10.51
Specific Conductance (mS/cm)			140.1	99.2	103.9	98.2	111.8	107.50
pH (Standard Units)			7.65	7.63	7.66	7.88	7.89	7.91
Total Dissolved Solids (g/L)			0.0896	0.0635	0.0666	0.0629	0.0715	0.0688
Turbidity (NTU)			3.3	7.9	2.0	0.7	7.9	2.3
Depth (M)			0.5	0.5	0.5	0.5	0.5	0.5
Analytical Parameters								
Total Coliform (MPN/100 ml)			8	110	240	130	30	17
Fecal Coliform (MPN/100 ml)			<2	4	<2	<2	<2	<2
Arsenic (mg/L)	0.005	0.0032	ND	ND	ND	ND	ND	ND
Barium (mg/L)	0.005	0.00039	0.0170	0.0094	0.0100	0.0091	0.0100	0.0078
Cadmium (mg/L)	0.002	0.00036	ND	ND	ND	ND	ND	ND
Calcium (mg/L)	0.1	0.0082	19	10	11	10	11	10
Chromium (mg/L)	0.005	0.00047	ND	ND	ND	ND	ND	ND
Copper (mg/L)	0.005	0.00040	ND	ND	ND	ND	ND	ND
Iron (mg/L)	0.1	0.0028	0.074 J	ND	0.150	0.080 J	ND	0.053 J
Lead (mg/L)	0.005	0.0013	ND	ND	ND	ND	ND	ND
Magnesium (mg/L)	0.1	0.0023	5.4	4.5	4.9	4.8	4.9	4.4
Manganese (mg/L)	0.005	0.00046	0.0150	0.0800	0.0770	0.0750	0.0560	0.0230
Mercury (mg/L)	0.0002	0.0002	ND	ND	ND	ND	ND	ND
Potassium (mg/L)	1.0	0.1	1.0 J	1.2	1.4	1.3	1.6	1.2
Selenium (mg/L)	0.005	0.0042	ND	ND	ND	ND	ND	ND
Silver (mg/L)	0.005	0.00036	0.0007 J	ND	ND	ND	ND	ND
Sodium (mg/L)	1	0.1	4.6	3.6	4.3	4.5	6.4	4.1
Zinc (mg/L)	0.01	0.0013	ND	0.005 J	ND	ND	0.019	0.0086 J
Ammonia - Total (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Boron (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Total Hardness, as CaCO3 (mg/L)	1		65	44	52	44	47	43
Total Phosphorous (mg/L)	0.01		ND	0.05	0.09	0.03	0.02	0.03
Silica (mg/L)	0.3		14	19	15	14	9	12
Total Kjeldahl Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	ND
Total Organic Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	ND
Chloride (mg/L)	0.2		0.6	0.8	2.0	1.2	1.8	1.4
Nitrate, as NO3 (mg/L)	0.1		ND	ND	4.0	ND	4.8	ND
Orthophosphate (mg/L)	0.01		ND	ND	ND	ND	ND	ND
Sulfate (mg/L)	0.2		4.8	1.0	1.0	1.7	1.4	1.4
Chlorophyll-a (mg/L)	0.0005		0.0011	ND	0.0009	0.0022	ND	0.002
Alkalinity - Total (mg/L)	10		74	60	50	50	60	60
Alkalinity - Hydroxide (mg/L)	10		ND	ND	ND	ND	ND	ND
Alkalinity - Bicarbonate (mg/L)	10		ND	60	50	50	60	60
Alkalinity - Carbonate (mg/L)	10		ND	ND	ND	ND	ND	ND
MBAS (mg/L)	0.05		ND	ND	ND	ND	ND	ND
Total Dissolved Solids (mg/L)	10		.	56	83	.	75	33
Total Suspended Solids (mg/L)	1		<1.0	<1.0	<1.0	.	1.5	<1.0
PCB1016 (mg/L)	0.001		ND	ND	ND	ND	ND	ND
PCB1221 (mg/L)	0.001		ND	ND	ND	ND	ND	ND
PCB1232 (mg/L)	0.001		ND	ND	ND	ND	ND	ND
PCB1242 (mg/L)	0.001		ND	ND	ND	ND	ND	ND
PCB1248 (mg/L)	0.001		ND	ND	ND	ND	ND	ND
PCB1254 (mg/L)	0.001		ND	ND	ND	ND	ND	ND
PCB1260 (mg/L)	0.001		ND	ND	ND	ND	ND	ND

1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
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Appendix E2-C.

Table 2. UNFFR Relicensing (FERC 2105) – 2000 Water Quality Monitoring Program Results (metals expressed as *total* metals)

Station NF7 - North Fork Feather River at Gansnar Bar

	Reporting Limits	Detection Limits	Sampling Date April	 June	 July	 August	 September	 November
Time			11:30	14:26	12:45	12:16	11:50	11:45
In-situ Parameters								
Water Temperature (°C)			9.82	20.06	19.96	20.01	15.25	8.03
Dissolved Oxygen (mg/L)			9.89	7.89	7.43	8.26	8.95	11.40
Specific Conductance (mS/cm)			161	124	125.4	116.2	138.8	137.70
pH (Standard Units)			7.77	7.85	8.07	8.36	8.32	8.14
Total Dissolved Solids (g/L)			0.1030	0.0793	0.0802	0.0742	0.0885	0.0879
Turbidity (NTU)			4.4	2.4	1.0	0.3	1.8	1.7
Depth (M)			0.5	0.5	0.5	0.5	0.5	0.5
Analytical Parameters								
Total Coliform (MPN/100 ml)			59	50	300	300	170	23
Fecal Coliform (MPN/100 ml)			4	2	2	4.	4	4
Arsenic (mg/L)	0.005	0.0032	ND	ND	ND	ND	ND	ND
Barium (mg/L)	0.005	0.00039	0.0170	0.0100	0.0110	0.0095	0.0110	0.0093
Cadmium (mg/L)	0.002	0.00036	ND	ND	ND	ND	ND	ND
Calcium (mg/L)	0.1	0.0082	21	13	12	12	13	13
Chromium (mg/L)	0.005	0.00047	ND	ND	ND	ND	ND	ND
Copper (mg/L)	0.005	0.00040	ND	ND	ND	ND	ND	ND
Iron (mg/L)	0.1	0.0028	0.085 J	ND	0.180	0.055 J	ND	ND
Lead (mg/L)	0.005	0.0013	ND	ND	ND	ND	ND	ND
Magnesium (mg/L)	0.1	0.0023	8.4	5.9	6.0	5.9	6.9	6.1
Manganese (mg/L)	0.005	0.00046	0.0170	0.0240	0.0390	0.0350	0.0120	0.0056
Mercury (mg/L)	0.0002	0.0002	ND	ND	ND	ND	ND	ND
Potassium (mg/L)	1.0	0.1	0.9 J	1.1	1.3	1.2	1.4	1.1
Selenium (mg/L)	0.005	0.0042	ND	ND	ND	ND	ND	ND
Silver (mg/L)	0.005	0.00036	0.00047 J	ND	ND	ND	ND	ND
Sodium (mg/L)	1	0.1	4.5	4.1	4.6	5.0	7.1	4.9
Zinc (mg/L)	0.01	0.0013	ND	ND	ND	ND	ND	ND
Ammonia - Total (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Boron (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Total Hardness, as CaCO3 (mg/L)	1		79	57	62	54	62	59
Total Phosphorous (mg/L)	0.01		0.02	0.05	0.07	0.02	0.02	0.025
Silica (mg/L)	0.3		15	20	15	15	9	12
Total Kjeldahl Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	ND
Total Organic Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	ND
Chloride (mg/L)	0.2		0.6	0.8	2.0	1.2	1.9	1.8
Nitrate, as NO3 (mg/L)	0.1		ND	0.7	ND	ND	ND	ND
Orthophosphate (mg/L)	0.01		ND	ND	ND	ND	ND	ND
Sulfate (mg/L)	0.2		6.0	2.0	3.0	1.7	2.9	3.1
Chlorophyll-a (mg/L)	0.0005		ND	ND	ND	0.0014	ND	ND
Alkalinity - Total (mg/L)	10		84	70	60	60	70	70
Alkalinity - Hydroxide (mg/L)	10		ND	ND	ND	ND	ND	ND
Alkalinity - Bicarbonate (mg/L)	10		84	70	60	60	70	70
Alkalinity - Carbonate (mg/L)	10		ND	ND	ND	ND	ND	ND
MBAS (mg/L)	0.05		ND	ND	ND	ND	ND	ND
Total Dissolved Solids (mg/L)	10		120	91	81	.	84	ND
Total Suspended Solids (mg/L)	1		ND	ND	ND	.	ND	ND
PCB1016 (mg/L)	0.001		.	.	.	.	.	.
PCB1221 (mg/L)	0.001		.	.	.	.	.	.
PCB1232 (mg/L)	0.001		.	.	.	.	.	.
PCB1242 (mg/L)	0.001		.	.	.	.	.	.
PCB1248 (mg/L)	0.001		.	.	.	.	.	.
PCB1254 (mg/L)	0.001		.	.	.	.	.	.
PCB1260 (mg/L)	0.001		.	.	.	.	.	.

1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
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Appendix E2-C.

Table 2. UNFFR Relicensing (FERC 2105) – 2000 Water Quality Monitoring Program Results (metals expressed as *total* metals)

Station EB1 - East Branch North Fork Feather above confluence

	Reporting Limits	Detection Limits	Sampling Date					
			April	June	July	August	September	November
Time			11:50	14:20	13:01	12:37	12:06	11:55
In-situ Parameters								
Water Temperature (°C)			11.25	22.7	21.3	20.36	14.95	4.61
Dissolved Oxygen (mg/L)			9.52	6.62	7.4	8.6	8.71	12.52
Specific Conductance (mS/cm)			81.7	155	201.4	212.7	212.6	182.4
pH (Standard Units)			7.61	8.5	8.81	8.42	8.28	8.13
Total Dissolved Solids (g/L)			0.0525	0.099	0.129	0.1361	0.136	0.1164
Turbidity (NTU)			19.2	9.9	0.8	0.9	5.8	1.4
Depth (M)			0.5	0.5	0.5	0.5	0.5	0.5
Analytical Parameters								
Total Coliform (MPN/100 ml)			500	50	30	130	130	11
Fecal Coliform (MPN/100 ml)			9	<2	2	<2	8	2
Arsenic (mg/L)	0.005	0.0032	ND	0.0096	ND	ND	0.0098	ND
Barium (mg/L)	0.005	0.00039	0.0240	0.0280	0.0330	0.0340	0.0320	0.0220
Cadmium (mg/L)	0.002	0.00036	ND	ND	ND	ND	ND	ND
Calcium (mg/L)	0.1	0.0082	9	16	20	23	20	18
Chromium (mg/L)	0.005	0.00047	ND	ND	ND	ND	ND	ND
Copper (mg/L)	0.005	0.00040	ND	ND	ND	ND	ND	ND
Iron (mg/L)	0.1	0.0028	0.640	0.046 J	0.130	0.041 J	ND	0.091 J
Lead (mg/L)	0.005	0.0013	ND	ND	ND	ND	ND	ND
Magnesium (mg/L)	0.1	0.0023	4.0	6.0	7.7	8.6	7.7	6.0
Manganese (mg/L)	0.005	0.00046	0.0230	0.0097	0.0150	0.0140	0.0110	0.0077
Mercury (mg/L)	0.0002	0.0002	ND	ND	ND	ND	ND	ND
Potassium (mg/L)	1.0	0.1	0.9 J	0.9 J	1.4	1.6	1.6	1.0
Selenium (mg/L)	0.005	0.0042	ND	ND	ND	ND	ND	ND
Silver (mg/L)	0.005	0.00036	0.00048 J	0.00051 J	0.00044 J	0.00053 J	ND	ND
Sodium (mg/L)	1	0.1	3.8	6.7	10.0	13.0	14.0	8.3
Zinc (mg/L)	0.01	0.0013	ND	ND	ND	ND	ND	0.0071 J
Ammonia - Total (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Boron (mg/L)	0.1		ND	ND	0.1	0.2	0.2	0.1
Total Hardness, as CaCO3 (mg/L)	1		35	65	97	92	82	68
Total Phosphorous (mg/L)	0.01		0.04	ND	0.05	0.02	0.02	0.02
Silica (mg/L)	0.3		19	19	16	15	9	12
Total Kjeldahl Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	ND
Total Organic Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	ND
Chloride (mg/L)	0.2		0.6	2.8	4.0	4.5	4.5	3.7
Nitrate, as NO3 (mg/L)	0.1		ND	ND	ND	14	5.94	0.66
Orthophosphate (mg/L)	0.01		ND	ND	ND	ND	ND	ND
Sulfate (mg/L)	0.2		3.0	4.4	7.0	4.7	7.4	6.5
Chlorophyll-a (mg/L)	0.0005		0.0028	ND	ND	0.0022	0.00079	ND
Alkalinity - Total (mg/L)	10		43	90	90	100	100	90
Alkalinity - Hydroxide (mg/L)	10		ND	ND	ND	ND	ND	ND
Alkalinity - Bicarbonate (mg/L)	10		43	90	90	100	100	90
Alkalinity - Carbonate (mg/L)	10		ND	ND	ND	ND	ND	ND
MBAS (mg/L)	0.05		ND	ND	ND	ND	ND	ND
Total Dissolved Solids (mg/L)	10		66	110	130	.	130	50
Total Suspended Solids (mg/L)	1		10	ND	ND	.	1.6	ND
PCB1016 (mg/L)	0.001		.	.	.	.	.	.
PCB1221 (mg/L)	0.001		.	.	.	.	.	.
PCB1232 (mg/L)	0.001		.	.	.	.	.	.
PCB1242 (mg/L)	0.001		.	.	.	.	.	.
PCB1248 (mg/L)	0.001		.	.	.	.	.	.
PCB1254 (mg/L)	0.001		.	.	.	.	.	.
PCB1260 (mg/L)	0.001		.	.	.	.	.	.

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2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
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Appendix E2-C.
Table 2. UNFFR Relicensing (FERC 2105) – 2000 Water Quality Monitoring Program Results (metals expressed as *total* metals)

Station NF8 - North Fork Feather River above Belden Town Bridge

	Reporting Limits	Detection Limits	Sampling Date					
			April	June	July	August	September	November
Time			12:30	10:30	9:10	9:01	8:42	12:12
In-situ Parameters								
Water Temperature (°C)			11.44	18.39	17.86	18	14.36	5.52
Dissolved Oxygen (mg/L)			9.35	8.4	7.4	8.5	8.65	11.37
Specific Conductance (mS/cm)			91.1	140.4	159.2	153.6	184.5	168.1
pH (Standard Units)			7.65	8.02	8.06	8.19	8.04	8.15
Total Dissolved Solids (g/L)			0.0584	0.0899	0.1022	0.0981	0.1182	0.1076
Turbidity (NTU)			17.2	3.8	4.9	0.08	4.2	1.8
Depth (M)			0.5	0.5	0.5	0.5	0.5	5
Analytical Parameters								
Total Coliform (MPN/100 ml)			170	170	240	900	130	17
Fecal Coliform (MPN/100 ml)			50	7	4	<2	30	2
Arsenic (mg/L)	0.005	0.0032	ND	ND	ND	ND	0.0066	ND
Barium (mg/L)	0.005	0.00039	0.0240	0.0220	0.0210	0.0200	0.0240	0.0190
Cadmium (mg/L)	0.002	0.00036	ND	ND	ND	ND	ND	ND
Calcium (mg/L)	0.1	0.0082	11	15	16	16	18	17
Chromium (mg/L)	0.005	0.00047	ND	ND	ND	ND	ND	ND
Copper (mg/L)	0.005	0.00040	ND	ND	ND	ND	ND	ND
Iron (mg/L)	0.1	0.0028	0.610	0.071 J	0.310	0.078 J	ND	0.083 J
Lead (mg/L)	0.005	0.0013	ND	ND	ND	ND	ND	ND
Magnesium (mg/L)	0.1	0.0023	4.5	5.9	6.7	7.2	7.2	6.4
Manganese (mg/L)	0.005	0.00046	0.0220	0.0170	0.0270	0.0370	0.0150	0.0074
Mercury (mg/L)	0.0002	0.0002	ND	ND	ND	ND	ND	ND
Potassium (mg/L)	1.0	0.1	1.0	1.2	1.2	1.4	1.5	1.1
Selenium (mg/L)	0.005	0.0042	ND	ND	ND	ND	ND	ND
Silver (mg/L)	0.005	0.00036	0.00061 J	0.00041 J	0.00046 J	ND	ND	ND
Sodium (mg/L)	1	0.1	3.9	5.8	7.1	8.2	12.0	7.7
Zinc (mg/L)	0.01	0.0013	ND	ND	ND	ND	0.019	0.0094 J
Ammonia - Total (mg/L)	0.1		ND	ND	ND	ND	0.3	ND
Boron (mg/L)	0.1		ND	ND	ND	ND	0.1	0.1
Total Hardness, as CaCO3 (mg/L)	1		42	62	79	70	75	69
Total Phosphorous (mg/L)	0.01		0.03	0.03	0.08	0.02	0.02	0.02
Silica (mg/L)	0.3		18	19	16	14	9	14
Total Kjeldahl Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	ND
Total Organic Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	ND
Chloride (mg/L)	0.2		1.0	0.9	3.0	2.4	1.5	3.3
Nitrate, as NO3 (mg/L)	0.1		ND	ND	ND	ND	5.72	ND
Orthophosphate (mg/L)	0.01		ND	ND	ND	ND	ND	ND
Sulfate (mg/L)	0.2		2.6	4.0	5.0	3.1	5.6	5.5
Chlorophyll-a (mg/L)	0.0005		0.0009	ND	0.001	0.0022	0.008	ND
Alkalinity - Total (mg/L)	10		49	70	80	80	90	80
Alkalinity - Hydroxide (mg/L)	10		ND	ND	ND	ND	ND	ND
Alkalinity - Bicarbonate (mg/L)	10		49	70	80	80	90	80
Alkalinity - Carbonate (mg/L)	10		ND	ND	ND	ND	ND	ND
MBAS (mg/L)	0.05		ND	ND	ND	ND	ND	ND
Total Dissolved Solids (mg/L)	10		71	110	120	.	110	55
Total Suspended Solids (mg/L)	1		ND	ND	ND	.	1.4	ND
PCB1016 (mg/L)	0.001		.	.	.	.	.	.
PCB1221 (mg/L)	0.001		.	.	.	.	.	.
PCB1232 (mg/L)	0.001		.	.	.	.	.	.
PCB1242 (mg/L)	0.001		.	.	.	.	.	.
PCB1248 (mg/L)	0.001		.	.	.	.	.	.
PCB1254 (mg/L)	0.001		.	.	.	.	.	.
PCB1260 (mg/L)	0.001		.	.	.	.	.	.

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Appendix E2-C.

Table 2. UNFFR Relicensing (FERC 2105) – 2000 Water Quality Monitoring Program Results (metals expressed as *total* metals)

Station YC1 - Yellow Creek above Belden Powerhouse tailrace

	Reporting Limits	Detection Limits	Sampling Date					
			April	June	July	August	September	November
Time			12:10	9:10	8:29	8:27	8:13	8:25
In-situ Parameters								
Water Temperature (°C)			7.01	13.64	13.19	12.72	9.92	2.92
Dissolved Oxygen (mg/L)			10.2	8.85	8.67	10.41	10.3	12.18
Specific Conductance (mS/cm)			84.2	102.7	128.1	127.7	136.7	131.1
pH (Standard Units)			7.44	7.82	7.98	8.07	7.66	7.96
Total Dissolved Solids (g/L)			0.0359	0.0659	0.082	0.0817	0.0873	0.0838
Turbidity (NTU)			1.5	2.9	0.8	0.2	0.9	0.2
Depth (M)			0.5	0.5	0.5	0.5	0.5	0.5
Analytical Parameters								
Total Coliform (MPN/100 ml)			70	8	11	11	30	17
Fecal Coliform (MPN/100 ml)			4	4	2	<2	4	4
Arsenic (mg/L)	0.005	0.0032	ND	ND	ND	ND	ND	ND
Barium (mg/L)	0.005	0.00039	0.0082	0.0099	0.0120	0.0100	0.0120	0.0091
Cadmium (mg/L)	0.002	0.00036	ND	ND	ND	ND	ND	ND
Calcium (mg/L)	0.1	0.0082	10	11	13	13	13	13
Chromium (mg/L)	0.005	0.00047	ND	ND	ND	ND	ND	ND
Copper (mg/L)	0.005	0.00040	ND	ND	ND	ND	ND	ND
Iron (mg/L)	0.1	0.0028	0.110	ND	0.047 J	ND	ND	0.062 J
Lead (mg/L)	0.005	0.0013	ND	ND	ND	ND	ND	ND
Magnesium (mg/L)	0.1	0.0023	5.0	5.5	6.1	6.3	6.5	5.9
Manganese (mg/L)	0.005	0.00046	ND	ND	ND	ND	ND	ND
Mercury (mg/L)	0.0002	0.0002	ND	ND	ND	ND	ND	ND
Potassium (mg/L)	1.0	0.1	0.8 J	1.0 J	0.8 J	1.3	1.5	1.1
Selenium (mg/L)	0.005	0.0042	ND	ND	ND	ND	ND	ND
Silver (mg/L)	0.005	0.00036	0.00048 J	0.00045 J	ND	ND	0.0004 J	ND
Sodium (mg/L)	1	0.1	2.8	3.8	4.0	5.0	7.8	4.6
Zinc (mg/L)	0.01	0.0013	0.0012 J	ND	ND	ND	ND	0.0067 J
Ammonia - Total (mg/L)	0.1		ND	ND	ND	ND	0.3	ND
Boron (mg/L)	0.1		ND	ND	ND	ND	ND	ND
Total Hardness, as CaCO3 (mg/L)	1		42	49	67	58	60	57
Total Phosphorous (mg/L)	0.01		0.02	0.05	0.07	0.02	0.04	0.03
Silica (mg/L)	0.3		17	27	18	21	13	19
Total Kjeldahl Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	ND
Total Organic Nitrogen (mg/L)	0.2		ND	ND	ND	ND	ND	ND
Chloride	0.2		0.2	0.6	2.0	1.1	1.6	1.6
Nitrate, as NO3 (mg/L)	0.1		ND	ND	ND	ND	6.04	1.2
Orthophosphate (mg/L)	0.01		ND	ND	ND	0.02	ND	0.009
Sulfate	0.2		0.6	1.0	2.0	1.9	1.5	2.9
Chlorophyll-a	0.0005		0.001	ND	ND	0.0017	ND	0.0011
Alkalinity - Total (mg/L)	10		50	60	70	70	80	70
Alkalinity - Hydroxide	10		ND	ND	ND	ND	ND	ND
Alkalinity - Bicarbonate	10		ND	60	70	70	80	70
Alkalinity - Carbonate	10		ND	ND	ND	ND	ND	ND
MBAS	0.05		ND	ND	ND	ND	ND	ND
Total Dissolved Solids (mg/L)	10		77	95	140	.	76	ND
Total Suspended Solids (mg/L)	1		ND	ND	ND	.	ND	ND
PCB1016 (mg/L)	0.001		.	.	.	.	.	.
PCB1221 (mg/L)	0.001		.	.	.	.	.	.
PCB1232 (mg/L)	0.001		.	.	.	.	.	.
PCB1242 (mg/L)	0.001		.	.	.	.	.	.
PCB1248 (mg/L)	0.001		.	.	.	.	.	.
PCB1254 (mg/L)	0.001		.	.	.	.	.	.
PCB1260 (mg/L)	0.001		.	.	.	.	.	.

1. Method Detection Limit (MDL) is the minimum concentration an analyte can be detected with confidence. It's a statistical measure, three standard deviations of the results of seven standards analyzed in one batch.
2. Reporting Limit is designed to be the concentration at which an analyte can be reported with confidence by the laboratory. Typically 2 to 5 times the MDL, it is typically determined by the lab. The laboratory adjusts reporting limits to account for the differing sensitivity of instruments, for client convenience, and to meet regulatory requirements.
3. "J" Flag is placed in a report in which lab reports results between the MDL and reporting limit. It indicates that the result is estimated. While definitely present, it is below the reporting limit, indicating we do not track the accuracy at these levels.

Appendix E2-C.

Table 2. UNFFR Relicensing (FERC 2105) – 2000 Water Quality Monitoring Program Results (metals expressed as *total* metals)

Station BD2 - Belden Powerhouse Tailrace

			Sampling Date					
	Reporting Limits	Detection Limits	April	June	July	August	September	November
Time			.	9:45	8:56	8:45	8:30	8:45
In-situ Parameters								
Water Temperature (°C)			.	18.8	19.06	19.66	17.17	8.35
Dissolved Oxygen (mg/L)			.	7.99	6.67	7.91	6.82	10.66
Specific Conductance (mS/cm)			.	97.9	100.7	98.5	106.7	101.3
pH (Standard Units)			.	7.71	7.75	7.86	7.84	7.75
Total Dissolved Solids (g/L)			.	0.0626	0.0645	0.0626	0.0682	0.0647
Turbidity (NTU)			.	1.5	2.2	0.1	8.4	0.6
Depth (M)			.	0.5	0.5	0.5	0.5	0.5
Analytical Parameters								
Total Coliform (MPN/100 ml)			.	11	50	30	110	13
Fecal Coliform (MPN/100 ml)			.	<2	<2	<2	<2	2
Arsenic (mg/L)	0.005	0.0032	.	0.0055	ND	ND	0.0051	ND
Barium (mg/L)	0.005	0.00039	.	0.0100	0.010	0.0099	0.0091	0.0082
Cadmium (mg/L)	0.002	0.00036	.	ND	ND	ND	ND	ND
Calcium (mg/L)	0.1	0.0082	.	10	10	10	9	10
Chromium (mg/L)	0.005	0.00047	.	ND	ND	ND	ND	ND
Copper (mg/L)	0.005	0.00040	.	ND	ND	ND	ND	ND
Iron (mg/L)	0.1	0.0028	.	ND	0.110	0.099 J	0.190	0.075 J
Lead (mg/L)	0.005	0.0013	.	ND	ND	ND	ND	ND
Magnesium (mg/L)	0.1	0.0023	.	4.5	4.7	4.9	4.6	4.4
Manganese (mg/L)	0.005	0.00046	.	0.0400	0.0650	0.0910	0.0440	0.0240
Mercury (mg/L)	0.0002	0.0002	.	ND	ND	ND	ND	ND
Potassium (mg/L)	1.0	0.1	.	1.6	0.8 J	2.7	1.5	1.4
Selenium (mg/L)	0.005	0.0042	.	ND	ND	ND	ND	ND
Silver (mg/L)	0.005	0.00036	.	ND	ND	ND	ND	ND
Sodium (mg/L)	1	0.1	.	4.0	3.4	27.0	6.2	4.2
Zinc (mg/L)	0.01	0.0013	.	0.034	0.0039 J	ND	0.028	0.022
Ammonia - Total (mg/L)	0.1		.	ND	ND	ND	ND	ND
Boron (mg/L)	0.1		.	ND	ND	ND	ND	ND
Total Hardness, as CaCO3 (mg/L)	1		.	43	51	46	43	43
Total Phosphorous (mg/L)	0.01		.	0.04	0.13	0.02	0.03	0.02
Silica (mg/L)	0.3		.	20	15	14	9	13
Total Kjeldahl Nitrogen (mg/L)	0.2		.	ND	ND	ND	ND	ND
Total Organic Nitrogen (mg/L)	0.2		.	ND	ND	ND	ND	ND
Chloride (mg/L)	0.2		.	0.9	2.0	1.1	1.6	1.6
Nitrate, as NO3 (mg/L)	0.1		.	3.6	ND	9.2	16	ND
Orthophosphate (mg/L)	0.01		.	ND	0.07	ND	ND	ND
Sulfate (mg/L)	0.2		.	6.0	1.0	2.4	ND	1.2
Chlorophyll-a (mg/L)	0.0005		.	ND	ND	0.0022	ND	0.002
Alkalinity - Total (mg/L)	10		.	50	50	50	60	60
Alkalinity - Hydroxide (mg/L)	10		.	ND	ND	ND	ND	ND
Alkalinity - Bicarbonate (mg/L)	10		.	50	50	50	60	60
Alkalinity - Carbonate (mg/L)	10		.	ND	ND	ND	ND	ND
MBAS (mg/L)	0.05		.	ND	ND	ND	ND	ND
Total Dissolved Solids (mg/L)	10		.	91	73	.	60	ND
Total Suspended Solids (mg/L)	1		.	ND	ND	.	3.2	2.400
PCB1016 (mg/L)	0.001		.	.	.	.	.	.
PCB1221 (mg/L)	0.001		.	.	.	.	.	.
PCB1232 (mg/L)	0.001		.	.	.	.	.	.
PCB1242 (mg/L)	0.001		.	.	.	.	.	.
PCB1248 (mg/L)	0.001		.	.	.	.	.	.
PCB1254 (mg/L)	0.001		.	.	.	.	.	.
PCB1260 (mg/L)	0.001		.	.	.	.	.	.

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Appendix E2-C.

Table 3. UNFFR Relicensing (FERC 2105) – California Toxics Rule (CTR), Inland Surface Waters, Human Health (30-day average), units are expressed as micrograms per liter [ppb])

Inorganic Constituent	**Sources of Drinking Water**	**Other Waters**
	(water + organisms)	**(aquatic organism consumption only)**
Copper	1,300	
Mercury, inorganic	0.050	0.051

Appendix E2-C.
Table 4. UNFFR Relicensing (FERC 2105)
Freshwater Criteria Translator for Dissolved Metals (from *The Metals Translator: Guidance for Calculating a Total Recoverable Permit Limit From a Dissolved Criterion*, USEPA Document 823-B-96-007, June 1996)

Calculation of Default Partition Coefficients [$K_p = K_{PO} \times TSS^{\alpha}$].

	Lakes		Streams	
Metal	K_{PO}	α	K_{PO}	α
Copper	2.85E+06	-0.9000	1.04E+06	-0.7436
Zinc	3.34E+06	-0.6788	1.25E+06	-0.7038
Pb	2.0E+06	-0.5337	2.80E+06	-0.8
Cd	3.52E+06	-0.9246	4.00E+06	-1.1307
Ni	2.21E+06	-0.7578	4.90E-05	-0.5719

Units are as follows: Kp (L/Kg) and for TSS (mg/L)

$F_d = [1 + Kp\ (L/Kg) \times TSS\ (mg/L) \times 10^{-6}\ Kg/mg]^{-1}$

F_d = Fraction that is dissolved (no units)

$C_d = F_d \times C_t$ (same units as C_t)

C_d = dissolved concentration

C_t = total concentration

Example: A level of 0.0063 mg/L was reported for copper at Station CARB1 during July. The corresponding TSS was 2.2 mg/L. Therefore the calculated dissolved fraction is:

$F_d = (1+((1.04E+06 * 2.2^{-0.7436})*2.2*10^{-6}))^{-1} = 0.44$

Therefore the estimated dissolved copper level is: 0.0063 * 0.44 = 0.0028 mg/L.

Range of Calculated Metals Translator (Total Recoverable to Dissolved) based on Observed TSS.

	Lakes		Streams	
Metal	Minimum	Maximum	Minimum	Maximum
Cu	0.20	0.26	0.35	0.49
Zn	0.10	0.23	0.29	0.44
Pb	0.10	0.33	0.18	0.26
Cd	0.18	0.22	0.20	0.25
Ni	0.17	0.31	0.43	0.67