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**A Sedimentation Plan to Assess the Impact
of Geothermal Activities to the Aquatic
Ecosystem in The Geysers Calistoga KGRA**

Robert R. Ireland

May 19, 1981

**Lawrence
Livermore
Laboratory**

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SEDIMENT SUBCOMMITTEE REPORT FOR KGRA-ARM TASK FORCE

Abstract

The prevention of sedimentation or siltation in aquatic ecosystems is always a key environmental issue in the development and operation of power plant units. This report describes a field program which will assess the amount of sedimentation in the streams and tributaries of The Geysers-Calistoga Known Geothermal Resource Area (KGRA) due to development-related or other site-specific activities. This sediment plan is one part of a four part venture - the others are water quality, benthic invertebrates and fisheries studies - initiated by the California Energy Commission and involving numerous California organizations. Included in this report are the cost breakdowns for each phase, maps and rationale of the sampling sites, the methodology for the laboratory sample processing, and examples of the type of graphic and tabular output expected.

* _____

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Introduction

Since its first meeting in August, 1979, a group which would soon call itself the KGRA-ARM Task Force has been moving towards the implementation of a comprehensive, cooperative program to evaluate and monitor the chronic and cumulative effects of geothermal development in The Geysers-Calistoga KGRA (for more background on the Task Force, please see Appendix 1). One of the initial decisions of the Task Force was to establish four technical subcommittees to develop detailed programs in four disciplines: water quality, fisheries, benthic invertebrates, and sedimentation.

Sedimentation was chosen as one of the four areas since it is generally agreed that erosion and its ultimate impact upon the aquatic ecosystem is one of the key issues related to development of geothermal energy. Erosion, whether initiated by drilling, road building or natural causes, leads to an increase in the amount of the silt and sediment in the streambed. From a physical standpoint, siltation may impede the reproduction, development and emergence of the aquatic invertebrates essential to a healthy stream. Furthermore, siltation is known to be deleterious to fish spawning success by filling in the interstices of the gravel beds needed for egg development. From a chemical standpoint, most erosion activities add organic matter to the water thereby increasing the oxygen demand. Drastic siltation could even ultimately lead to changes in sediment redox potentials with resultant resolubilization of inertly bound elements - a notable concern in an area such as The Geysers where high natural sediment mercury concentrations are present.

By virtue of the fact that the author was currently conducting an aquatic ecology program in The Geysers focusing upon sediment - water interactions, he was chosen as the committee chairman for the sediment group. This report represents the summation of the sediment subcommittee's recommended program.

The penultimate meeting of our committee was held December 9, 1980 at LLNL. The purpose was to finalize the strategies, costs, goals and implementation of this segment of the overall program. Those in attendance included: Robert Ireland of LLNL, Gerald Boles of the Department of Water Resources (DWR), Robert Karfoil, Dave Longanecker and Lucy McMillan of Pacific Gas and Electric (PG&E), and Lloyd Dillion and Marco Farro of the California Energy Commission (CEC).

Several considerations were inherent in the direction of the sediment plan. First, we wished to orient our data gathering in order to complement the other committees' phases towards meeting their overall goals. This would undoubtedly assist in the integration and interpretation of the data. Secondly, we decided that the data should be able to stand by itself in providing a quantification of the physical impact of development-related siltation. If we could recognize and achieve those two goals, then the data would be that much more amenable for use in the attainment of the Task Force's overall objectives, especially including the assessment of current control measures and the recommendation of any further mitigation procedures.

The rest of this report is broken down into four parts. In each section, the costs and methodology are summarized. The four parts to be discussed in order are:

1. Field sample collection
2. Laboratory analysis
3. Data storage and analysis
4. Report writing

Field Sample Collection

Comparative cost analyses revealed that DWR would be more cost-effective for actual sample collection. Numerous factors were considered in this decision including whether personnel were in-house professionals, union members desirous of overtime, as well as general overhead multipliers, etc. The breakdown of cost to DWR is found in Table 1.

Table 1.

DWR Estimate of Field Sample Collection

A. Sample Collection

15 days/run (run = 41 sites)	x
8 hours/day	x
2 runs/year	x
3 people/run	x
Wages and overhead factors	= \$14,440

B. Expenses

11 days/run	x
2 runs/year	x
3 people/run	x
\$50/day/person	= \$3,300

C. Equipment

= \$1,000
\$18,740

D. Contingency at 10%

1,874

Total (1st year) \$20,614

Forty one (41) sites were chosen within the three drainages of The Geysers KGRA: Big Sulphur Creek, Upper Putah Creek and Kelsey Creek. Costs were not broken down into drainages since some overlap may occur within the same day. Allowances were made considering travel time between sites and the total length of time per run. The location of the forty one sites and the rationale for selecting them are found in Appendix 2.

Duties performed at the collection site will include: 1) actual removal and packaging of the sediment and water, 2) photographs of the stream for visual documentation of surface fines and 3) measurement of certain basic water quality parameters. These will be discussed in order.

The exact spot where gravel will be sampled will be chosen after careful onsite inspection. Usually this spot will be the gravel riffle at the end of a pool because this area will remain somewhat uniform over time, not be subject to excessive gouging as in the pool, and would be the preferred location for the fish spawning (Figure 1).

The main tool to be used will be the McNeil gravel sampler (see Figure 2). As can be seen from the diagram, the sampler is roughly cylindrical with an internal shelf. One works the sampler into the gravel approximately six inches deep as determined by the weld on the inside. This confines a unit volume, approximately 2.7 liters, of rock, sediment and water. Larger material is extracted by hand and saved by placing it in the internal shelf. This continues until the nubs at the bottom are uncovered. A stainless steel plunger with a compressible O-ring (figure 3) is then forced to the bottom and tightened to prevent water leakage. This allows one to quantitatively remove all the water and silt (fines) remaining within the cylinder. All the gravel, sediment and water are appropriately packaged and labeled for transport back to the lab.

This sampling procedure is repeated five times in the same gravel riff. In the laboratory, the rocks, gravel and water solids will be recombined for each replicate. This mixture will then be processed through a series of six sieves with mesh sizes from 1.5 mm to 0.074 mm.

This is mentioned in this section rather than the next because it helps explain cost factors. Even though sites have been chosen with an eye for accessibility, often a laborious trek out of a steep canyon are unavoidable. It has been the experience of PG&E that a minimum of three people are required to carry the gravel and water back to the vehicle. Moreover, having the proper initial manpower allows the personnel to remove all of the sample thereby saving laboratory and analysis time (and money) which would increase if subsequent subsampling were necessary.

Two other duties were also mentioned as part of the sediment collection schema: photographs and water parameters. Most of the time these phases will be conducted by members of other groups, respectively, the benthic invertebrate team and the water quality team, inasmuch as most of the sampling locations are multiple sites. Most committee members agree that true cost efficacy would result from a coordinated sampling effort of all teams at the same site at the same time. The program manager will be responsible for coordinating this.

In the case of an isolated sediment site, photographs will still be taken. Also, a minimum of water parameters should be noted such as flow, temperature, pH, dissolved oxygen, conductivity and turbidity. The equipment required to perform such tasks should not significantly add to the burden of the three-person team.

Figure 1. Plan view of typical spawning area

(Reprinted from PG&E Report 420-79.41, 1979)

GRAVEL SAMPLER

Figure 2. Gravel sampler

(Reprinted from PG&E Report 420-79.41, 1979)

SEALING PLUNGER INSERT FOR GRAVEL SAMPLER

"O" RING EXPANDS WHEN "T" HANDLE IS TIGHTENED. PLUNGER FITS IN GRAVEL SAMPLER AGAINST STUDS- WITH CORK IN CLEARANCE HOLE MUST HOLD WATER.

Figure 3. Sealing plunger insert for gravel sampler
(Reprinted from PG&E Report 420-79.41, 1979)

Laboratory Analysis

It was apparent that PG&E was the most feasible choice to handle the laboratory analysis of the sediment samples after comparisons of manpower, expertise, and equipment and other factors.

PG&E estimated their laboratory costs to run \$17,678 for one year. This accounts for analyses of two sampling runs of forty-one sites each run with five replicates at each stations. DWR is responsible for ensuring delivery of the samples to PG&E. In the lab, samples will be recombined, weighed and sieved as mentioned previously.

Appendix 3 contains the full directions for the laboratory procedure. Also included is the raw data sheet upon which the proper weights, sizes and other data are hand recorded.

Data Storage and Analysis

PG&E was easily the most practical choice to perform this segment of the sediment because of their expertise and computer facilities with existing software for graphical and statistical displays.

The cost was estimated to be \$1,000 for one year. Most of this money would be used for transferring the handwritten data onto punched computer cards. An additional factor would be the relatively small cost of the computer printouts.

As mentioned previously, the objectives of the sediment plan are to 1) determine whether geothermal development activities are increasing erosional processes which ultimately add to increases in streambed sedimentation and 2) to provide data for the other phases of the Task Force which would serve to enhance their data or interpretation of that data. Towards this end, the capabilities of the existing PG&E computational programs are excellent. Their graphical displays of digested data and statistical tables will certainly facilitate the above goals as well as aid in the writing the final report.

Appendix 4 contains numerous examples of the type of graphic and tabular output which PG&E has already produced with sediment data.

Report Writing

The writing of the sediment report was mutually decided to be a small group effort consisting of LLNL, PG&E and DWR. This trio will convene to collectively interpret the data, summarize the trends and recommend what future courses of action should occur. This report will then be available to the program manager for his coordination decisions and incorporation into the comprehensive report.

The effort of writing the report as determined by both PG&E and DWR will require approximately half a man-month. This translates to dollars as : PG&E, \$4,862; DWR, \$2,326 for a total of \$7,188 as of December, 1980.

LLNL was not planning to charge for the report writing. We have been involved since the inception of the Task Force as an interested and independent party with our own funding sources. Though these sources have since evaporated, it is still to our mutual benefit to continue participating in the Task Force toward parallel and/or common goals concerning the aquatic ecology in The Geysers KGRA. Without funding, however, the level of our commitment is uncertain at this time.

Cost Summary

<u>Responsibility</u>	<u>Cost</u>			
	<u>1st Year</u>		<u>2nd Year</u>	
	<u>DWR</u>	<u>PG&E</u>	<u>DWR</u>	<u>PG&E</u>
I. Field sample collection - DWR	\$20,614		\$23,706	
II. Lab analysis - PG&E		\$17,678		\$20,330
III. Data storage and analysis - PG&E		1,000		1,150
IV. Report writing - DWR, PG&E, LLNL	<u>2,326</u>	<u>4,862</u>	<u>2,675</u>	<u>5,591</u>
Individual Total	\$22,940	\$23,540	\$26,381	\$27,071
Year Total	\$46,480		\$53,542	
Two-Year Total	\$96,022			

NOTE:

1. First year costs are estimates offered in December, 1980. Since this program may not get underway until Fall, 1981, it would not be unreasonable to assume that all costs would increase 15% for the first year and subsequent years.
2. Second year figures are in fact merely 115% of first year figures.
3. This should be negotiable and left to the agency and the program manager.

For questions regarding this report, contact:

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Appendix 1.

Background of the KGRA-ARM Task Force

Appendix 1. Background of the KGRA-ARM Task Force

(Excerpt from KGRA-ARM Review Draft, Sept. 11, 1980)

In August 1979, representatives of the California Energy Commission (CEC), North Coast Regional Water Quality Control Board (NCRWQCB), California Department of Fish and Game (CDF&G), Pacific Gas and Electric Company (PGandE), and Union Oil Company of California began a series of meetings to investigate the many, varied and largely uncoordinated aquatic resource monitoring programs in the Geysers-Calistoga KGRA and to determine whether a comprehensive, cooperative program could be developed which would be more efficient and cost effective.

After the task force members* concluded that a better monitoring program could be developed, it prepared a "Statement of Purpose" for distribution to the management of those organizations represented by the task force. The statement summarized the problems leading to the effort to improve monitoring, outlined the objectives of a more comprehensive approach, and began to establish the foundation of a water quality and aquatic biology monitoring program. The management generally concurred with the principles in the statement.

The task force then established four technical subcommittees to develop detailed programs in four disciplines: water quality, fisheries, benthic invertebrates, and sedimentation. The task force believed that these four areas would be the ones most likely affected by development and the ones from which data could be used to analyze impacts.

*The group, collectively known as The Geysers-Calistoga KGRA Aquatic Resources Monitoring Task Force or KGRA-ARM Task Force, now also includes the Central Valley Regional Water Quality Control Board (CVRWQCB), California Department of Water Resources (DWR), U.S. Geological Survey (USGS), U.S. Bureau of Land Management (USBLM), G.R.I.P.S. Commission, Lawrence Livermore Laboratory (LLL), Sacramento Municipal Utility District (SMUD), Northern California Power Agency (NCPA), and Aminoil USA.

The sections which follow are a compilation of programs developed by the subcommittees. For each program, the sampling and analysis techniques are specified, representative sampling stations are established, and the cost of sampling and analysis is estimated. While the specific programs are considered reasonable ones to study impacts from development in the KGRA in light of limited resources, they are subject to comment and revision. The final program will take into account any comments by parties interested in monitoring the KGRA and the personnel and funding available to implement the program.

Objectives

As identified in the Task Force's "Statement of Purpose," the objectives of this monitoring program are:

- o To evaluate cumulative impacts on aquatic resources due to full-field geothermal development, as well as other types of development in the study area.
- o To evaluate the effectiveness of measures used to protect aquatic resources from the impacts of developing geothermal power plants, steam fields, and roads in the study area.
- o To coordinate ongoing and proposed monitoring programs in The Geysers-Calistoga KGRA in order to reduce redundancy, to reduce unnecessary financial and personnel expenditures, and to promote flow of information among interested agencies and persons in The Geysers-Calistoga KGRA.

In addition, the results of the monitoring program are expected to expedite the regulatory process by providing information that clarifies some of the

uncertainty regarding the impacts of geothermal development on aquatic resources and by providing a standardized monitoring program to be used in steamfield and power plant permits.

Appendix 2.

Sediment Sampling Sites and Rationale

Appendix 2. Sediment sampling sites and rationale

Numbering of sampling sites proceed upstream from a chosen point within the watershed. For now, this is merely arbitrary convenience but, in the future, all sites will be labeled by PG&E with the exact mileage from that chosen point in order to specifically define that sampling location (for example, BSC 10.3 means 10.3 miles upstream from the point)

Many sites have been chosen to correspond with the other committees' (water quality, fisheries, benthic) stations in order to facilitate both the sampling endeavor and the data homogeneity. This is noted in brackets beneath the sampling site descriptions and on the figures (B = benthic invertebrates, F = fisheries, S=sediment, W =water quality).

BIG SULPHUR CREEK DRAINAGE

This numbering system starts at the confluence of Big Sulphur Creek (BSC) with the Russian River.

A total of twenty(20) sites are located in the BSC drainage.

Refer to Figure 1A for further explanation.

<u>Site</u>	<u>Rationale</u>
Big Sulphur Creek: BSC 1 (S)	This is the farthest downstream site and will serve as the ultimate integrator of the BSC drainage prior to the Russian River confluence. Additionally, this will double as a convenient reference point since a PG&E gauging station is located here which continually monitors and records flow and total suspended solids (TSS) in the water column.

- BSC 2 (S) Approximately one mile below the confluence of Little Sulphur (LSC) Creek. Chosen to assess the mixing of LSC and BSC. Also a prior LLNL sampling site with good accessibility.
- BSC 3 (S) Located just below Squaw Creek (SQC). Isolates the contribution of SQC to BSC prior to input for LSC. Good accessibility.
- BSC 4 (S) Prior to the input from SQC, this site represents the lower end of the geothermally active area and also reflects any input from the many outcroppings of abandoned mercury mines which line the upstream canyon. A previous LLNL station with reasonable seasonal access.
- BSC 5 (S) This site is immediately after the main cluster of active geothermal power units. The difference between BS 4 and BS 5 will reflect the degree of settling out downstream. Also a previous LLNL station.
- BSC 6 (BSW) Immediately prior to the main cluster of units and the bridge across BSC. The difference between BS 5 and BS 6 will detect input from these sources. A prior LLNL station.
- BSC 7 (BSW) This site is chosen for several reasons: one; it is immediately below the Unit 14 tributary; two, it reflects input from Hot Springs Creek (HSC), a natural geothermal tributary; three, this site corresponds to an existing PG&E sediment sampling station.
- BSC 8 (S) Immediate above HSC and Unit 14 tributary but below the bridge crossing BSC. The difference between BS 7 and BS 8 will isolate these two inputs.

BSC 9 (BSW) Situated upstream from the bridge. The difference between BS 8 and BS 9 will detect erosional influences from this crossing. Easy access.

BSC 10 (S) This site is immediately downstream from the confluence of Little Geysers Creek (LGC), a natural geothermal tributary and BSC. The site will serve as an integrater of the headwaters of BSC since often LGC will exceed the flow of BSC in this area for the last few dry months of summer. Also chosen since this corresponds to a previous LLNL site and is an area of benthic invertebrate investigation performed by the University of California, Berkeley.

BSC 11 (BFSW) Situated above LGC, this site will isolate the input from the tributary when compared to BSC 10. The site is located below Pine Flat bridge, proposed Unit 18, the Socrates mine tributary and the Socrates mine processing area. It also corresponds to previous LLNL and PG&E sites and is easily accessible.

BSC 12 (BFSW) This site will serve as a "clean" comparison station for the time being. In the future this site may be impacted by the NCPA 1 unit. The difference between BS 11 and BS 12 will detect inputs from those influences mentioned in site BS 11. This is a previous LLNL station.

Little Sulphur Creek: LSC 1 (S) This site has been newly added to serve as a "control" station inasmuch as LSC drains a substantial area with vegetative and geologic similarity to BSC. This site will serve as background or baseline data until any future development ensues.

Squaw Creek: Located immediately upstream from its confluence with BSC,
 SQC 1 this site on Squaw Creek assesses the ultimate input of
 (BFSW) SC to BSC.

SQC 2 This site is located just downstream from Unit 11 and the
 (BFSW) bridge crossing SQC. In comparison with site SQC3, this
 should measure the influence of these two sources.

SQC 3 Located above Unit 11 and the bridge, this will isolate
 (FS) these sources when compared with SQC2. Also serves as a
 downstream station for input from Unit 17. Corresponds
 to a previous PG&E station.

SQC 4 This site is located above Unit 17 and will be compared
 (S) with SQC3. This also serves as a "clean" comparison
 station for all of Squaw Creek.

Cobb Creek: Cobb Creek is a clean, spring-fed, year round spring
 CC1 originating at the ridgeline. It carves a valley between
 (BS) Unit 12 and Units 9 and 10 and would be subject to runoff
 from these sources.

CC 2 Located above the road and units 9 & 10, this site should
 (BS) serve as a "clean" comparison station. In the future,
 however, this site may be affected by the proposed SMUD
 unit. Both CC 1 and CC 2 are prior LLNL stations. Site
 CC 2 has reasonable access.

Little Geysers Creek: As noted previously, LGC is a natural thermal tributary
 LGC 1 which often becomes the main headwater flow of BSC in the
 (BSW) late summer. Drainage from proposed unit 18 will
 probably affect LGC. It is important to assess this
 creek prior to its confluence with BSC because of this.
 This is also a previous LLNL station.

Figure 2 A Big Sulphur Creek drainage. Sediment sampling stations.

UPPER PUTAH CREEK DRAINAGE

The reference point for the future mileage numbering system will be where the bridge crosses Putah Creek downstream from the last sampling station on Putah Creek.

A total of thirteen (13) sites are located in the Upper Putah Creek (UPC) drainage.

See Figure IB for further explanation.

<u>Site</u>	<u>Rationale</u>
Upper Putah Creek: UPC 1 (BS)	This site will be used to assess the collective input from this short but rather steep and complex network draining the UPC region.
UPC 2 (BFSW)	This site should serve as a "control" inasmuch as no geothermal drilling or building is occurring upstream from here. Comparison of UPC1 and UPC2 should reflect that impact to Putah Creek which is still quantifiable after input from the integrated Anderson Creek network.
Anderson Creek: ANC 1 (BSW)	Located immediately after the town of Anderson Springs, this site will gauge the collective input from the network of creeks prior to the town, the influence of the town itself, and that of Bear Canyon Creek and its tributaries prior to dilution in Putah Creek.
ANC 2 (BSW)	This site is located just prior to input from Hot Spring Creek and the town of Anderson Springs. The location should integrate Anderson Creek and Gunning Creek. This is also a prior PG&E sediment station.

ANC 3 This is an especially important location inasmuch as it
(BFS) will help gauge the amount of erosional activity
 attributable to the Socrates Mine road just upstream and
 the tributary (tributary 13-1) originating at Unit 13.
 Comparison with ANC 4 will isolate these inputs. This is
 also a former PG&E location.

ANC 4 Will serve as a "control" site for background when
(BSW) comparing to site ANC 3.

13-1 This tributary evidently has no official name and has
(S) been dubbed 13-1 by PG&E because of its source.
 Comparison with sites ANC 3 and ANC 4 will isolate the
 road effects from erosional effects stemming from Unit 13.

Gunning Creek: This station is a former PG&E sediment site located just
GC 1 below the Socrates Mine road and is designed to assess
(BFS) that influence by comparison with site GC 2.

GC 2 As noted above, this site will isolate the road effect.
(BFSW) It will also be used to compare natural erosional
 activity during the course of Gunning Creek between sites
 GC 2 and GC 3.

GC 3 This is considered to be a "clean" site, since no man made
(SW) activity is occurring above here.

Hot Spring This site is located just prior to its confluence with
Creek: Anderson Creek. Sediment sampling here will provide data
H 1 on the input from Hot Spring Creek, a natural thermal
(S) tributary, and from the well pads upcanyon from this site.

Bear Canyon

Creek:

BCC 1

(BFSW)

BCC 2

(BSW)

This site is located downstream from Unit 16 and all the

Bear Canyon Creek tributaries.

This site should serve as a "clean" comparison station

for Bear Canyon Creek. Comparison of BCC 1 and BCC 2

should isolate erosional inputs due to unit 16 activities.

Figure 2B Upper Putah Creek drainage. Sediment sampling stations.

KELSEY CREEK DRAINAGE

The reference point for the future mileage numbering system will ultimately be where Kelsy Creek enters Clear Lake.

See Figure IC for further explanation.

A total of eight (8) sites are located in the Kelsey Creek (KC) drainage.

<u>Site</u>	<u>Rationale</u>
Kelsey Creek: KC 1 (BFSW)	This site represents the last station in the geothermal development impact area. It will serve as a gauge of the integrated erosional activities from upper Kelsey Creek, High Valley Creek (HVC), Alder Creek (ALD) and Sulphur Creek (SUL).
KC 2 (BFSW)1	This site is located just prior to the confluence of HVC and KC. Comparison of KC 1 and KC 2 should assess that input due to HVC. Also, this site serves as a downstream marker for siltation possibly generated from NCPA-Shell.
KC 3 (BSF)	Site KC 3 is a very multipurpose station. One, it serves as the upstream site for isolation of any input from the proposed NCPA-Shell Unit. Comparison of KC 2 and KC 3 should assess this. Secondly, this site is a downstream location following possible influences from Sulphur Creek (SUL), Alder Creek (ALD), and Bottle Rock Road.
KC 4 (BSW)	Comparison of site KC 4 with KC 3 should detect any differences stemming from those sources mentioned above. KC 4 by itself will detect whether the upstream towns of Cobb, Forest Lake and Whispering Pines are significantly adding any sedimentation input.

High Valley This site should serve as a gauge of any erosional
Creek: activities which are still present and quantifiable after
HVC 1 running the course of HVC. This will be done by comparison
(BFSW) with previous data from this site and with site HVC 2.

HVC 2 This site will be located immediately below the drainage
(BS) tributary emanating from the proposed DWR-Bottle Rock
unit. This will enable one to determine whether erosional
activities are increasing due to this development, and by
comparison with HVC 1 whether these inputs are still
quantifiable downstream. Good accessibility.

Alder Creek: This site will assess the collective input from Alder and
ALD 1 Lee Creeks just prior to entering Kelsey Creek. Data
(BSW) subtraction of ALD 1 from the difference of KC 3 and KC 4
will also allow us to more accurately assess the influences
of Bottle Rock Road.

ALD 2 This site is located just past the confluence of Alder and
(BS) Lee Creeks. The road from Geyser Rock to Bottle Rock Road
may be a source of siltation as well as some current
upstream well pads and will be noticed at this station.
Comparison of ALD 1 and ALD 2 will allow us to gauge
whether upstream sources are still significant prior to
entering Kelsey Creek.

Figure 2C Kelsey Creek drainage. Sediment sampling locations.

Appendix 3.

Directions for Testing Geysers Sediment Samples

Appendix 3. Directions for Testing Geysers Sediment Samples

1. Set out (5) cubitainers containing fines, and allow to settle undisturbed for approx. 4 hours.
2. Empty (5) bulk samples from sample bags into tared pans. Wash all sample clinging to bag into pan. Place bulk samples in oven to dry overnight.
3. Siphon supernatant from each settled cubitainer into graduated cylinder. Measure and record volume of sample removed before discarding. Be careful not to siphon any of the settled sludge, or stir up the sample.
4. Measure and record remaining slurry and empty into tared pan. Be sure to wash out all of the sludge into the pan. Carefully place pan in oven to dry overnight. Repeat for each sample.
5. Remove bulk samples from oven and allow to cool until luke warm. Record weights of each sample. Do not leave samples out for extended periods (more than 2 hours), as they will absorb water from the air.
6. Split bulk sample over a large No. 4 screen by hand. Record weight of the < No. 4 and > No. 4 portions of sample.
7. For sample portion > No. 4, sieve manually (shake by hand, helping the rocks through the sieves) through 3", 1 1/2", 3/4", 1/2", 3/8", and No. 4 sieves. Record weight of material on each sieve. Check subtotal with known subtotal before discarding this portion of bulk sample. Repeat if large error exists.
8. For portion of sample < No. 4, mechanically shake sample for 10-15 minutes through No. 5T, No. 8, No. 16, No. 20 & No. 30 sieves. Record weights on each sieve, as well as sample portion passing No. 30 sieve. Check subtotal before discarding > No. 30 portion of sample. Retain < No. 30 portion.

9. Remove fines sample from oven and allow to cool until lukewarm. Record weight of sample. Scrape sample into mortar and pestal and carefully pulverize sample as completely as possible.
10. Check field data for volume of fines sample discarded in the field. Perform the following equation to determine sample ratio:

$$\frac{\text{Volume of fines sample in cubitainer}}{\text{Volume of fines sample in cubitainer} + \text{volume discarded in field}} = \text{Sample ratio}$$

11. Multiply < No. 30 portion of bulk sample by sample ratio. Mechanically split bulk sample until you have this weight.
12. Combine pulverized fines sample with the proportioned < No. 30 bulk sample, and mechanically sieve over No. 20, No. 30, No. 50, No. 100, No. 150 T, and No. 200 sieves.

Record each weight, including the pan. Check subtotal weight before discarding entire sample.

RAW DATA SHEET

FINE SAMPLE

Tare No. _____

- I. (a) Dry wt. of fines sample and tare _____ gm
 (b) Tare wt. _____ gm
 (c) Dry wt. of fine sample _____ gm
- II. (a) Volume of water and fines in cubitainer _____ ml
 (b) Volume of water and fines discarded in sampling _____ ml
 (c) Sample ratio

$$\frac{(a)}{(a) + (b)} = \underline{\hspace{2cm}}$$

BULK SAMPLE

Tare No. _____

- III. (a) Dry wt. of bulk sample and tare _____ gm
 (b) Tare wt. _____ gm
 (c) Dry wt. of bulk sample _____ gm
- IV. (a) Dry wt. of bulk sample passing the No. 30 sieve _____ gm
 (b) Dry wt. of bulk sample not passing the No. 30 sieve _____ gm
 (c) Bulk ratio wt.

$$(IIc \times IVa) \underline{\hspace{2cm}} \text{ gm}$$

 (d) Total ratio wt.

$$(Ic + IVc) \underline{\hspace{2cm}} \text{ gm}$$

Sieve Size	Weight Retained (gm)	Subtotal (gm)	Addl. Weight Retained (gm)	Final Wt. Retained (gm)
3"	_____	_____	_____	_____
1-1/2"	_____	_____	_____	_____
3/4"	_____	_____	_____	_____
1/2"	_____	_____	_____	_____
3/8"	_____	_____	_____	_____
No. 4	_____	_____	_____	_____
5T	_____	=====	_____	_____
8	_____	_____	_____	_____
16	_____	_____	_____	_____
20	_____	_____	_____	_____
30	_____	=====	_____	_____
<u>Subtotal</u>	=====	=====	=====	=====
No. 50	_____	_____	_____	_____
100	_____	_____	_____	_____
150T	_____	_____	_____	_____
200	_____	_____	_____	_____
Pan	_____	_____	_____	_____
<u>Subtotal</u>	=====	_____	_____	=====
<u>TOTAL</u>	_____	_____	_____	=====

Appendix 4.

Examples of Computer Generated Graphic Displays and Tabular Output

Appendix 4: Examples of computer generated graphic displays and tabular output.

PG&E currently has the expertise for computerized sediment data reduction. Computer programs were developed to analyze the particle size data and to produce several types of printouts. Figures 3A-F were copied with permission from PG&E Report 420-80.94. 1980.

Fig. 4 A. Sediment Analysis, General Statistics for Unit . . .

This printout provides the percent weight retained of each particle size for the five replicates sampled at a station on a particular sampling date. ("Mean diameter" refers to the midpoint of the range of particle sizes that would be retained on the corresponding sieve, having passed through the next largest sieve. "Percent difference" is a check for correct transcription of the data.)

Fig. 4 B. Summary of Grain Size Analysis for Geysers Unit . . .

This printout provides the mean percent weight of the particles passing each sieve size for each station on a particular sampling date. ("Diameter" refers to the mesh sizes of the sieves.)

Fig. 4 C. Grain Size Distribution . . .

This printout provides a chart of the grain size distribution for a station on a particular sampling date. (The numbers along the abscissa (76.2, 38.1, . . . 0.074) refer to mesh sizes of the sieves used in the analysis. A point on the curve above a particular mesh size represents the percentage, by weight, of particles in a sample that passed through that sieve.)

Fig. 4 D. Bar Chart of Geomean

This printout provides a graphical comparison of several sampling stations before during, and if available, after construction. The geomean is the average particle size. If the geomean becomes smaller, then the average particle size has decreased indicating erosion and sedimentation processes.

Fig. 4 E. Block Chart of Percentage Fines

This printout provides a visual comparison of the seasonal variations of the percentage of fines and their relationship to the phase of construction. The percentage fines is determined by dividing the weight of the fines (most often considered as ≤ 0.84 mm) by the total weight of the sample. This example seems to indicate that the percentage generally increased after construction began.

SEDIMENT ANALYSIS GENERAL STATISTICS FOR
UNIT 13, STATION 5
6/76

SIEVE SIZE	MEAN DIAMETER (MM)	PERCENT WEIGHT RETAINED					STD. DEV.	VAR.	MEAN	DER. MEAN	LOWER C.L.	UPPER C.L.
		A	B	C	D	E						
3 IN.	101.600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0	0.0
1 1/2 IN.	57.140	8.9	0.0	0.0	7.8	0.0	4.6	21.4	3.4	2.8	-2.0	10.3
3/4 IN.	28.590	21.2	0.9	4.2	10.9	17.1	9.4	89.0	12.7	10.9	0.7	30.7
1/2 IN.	15.890	8.2	1.9	13.6	12.7	17.4	5.9	34.9	10.8	10.0	2.8	21.3
3/8 IN.	11.100	8.0	7.2	16.1	8.2	17.7	5.1	25.6	11.5	11.0	5.3	18.9
NO. 4	7.139	12.8	33.5	33.2	15.7	23.1	9.6	92.7	23.7	22.6	11.6	39.0
NO. 5T	4.059	2.7	7.8	6.5	2.7	2.8	2.5	6.1	4.6	4.4	1.5	8.1
NO. 8	2.859	9.3	23.4	14.5	9.1	7.1	6.8	43.1	12.7	12.1	5.2	21.9
NO. 16	1.774	11.5	14.3	6.3	10.0	6.1	3.5	12.3	9.7	9.4	5.2	14.9
NO. 20	1.014	4.1	2.6	1.0	3.3	1.7	1.2	1.5	2.6	2.5	0.9	4.4
NO. 30	.714	3.5	1.8	0.6	2.8	1.4	1.2	1.3	2.1	2.0	0.5	3.7
NO. 50	.443	3.2	1.7	0.5	2.8	1.4	1.1	1.2	2.0	1.9	0.5	3.6
NO. 100	.222	1.7	1.1	0.4	1.4	0.9	0.5	0.3	1.1	1.1	0.4	1.9
NO. 150T	.126	0.6	0.6	0.2	0.5	0.5	0.2	0.0	0.5	0.5	0.3	0.7
NO. 200	.088	0.3	0.3	0.1	0.2	0.2	0.1	0.0	0.3	0.3	0.2	0.4
PAN		3.1	2.3	2.1	2.1	2.0	0.6	0.2	2.4	2.4	1.7	3.0
TOTAL		100.0	100.0	100.0	100.0	99.9						
DIFFERENCE		1.4	.2	33.6	.8	1.2						
SUM OF FUR 1-10		5141.4	5048.0	5209.4	5011.5	3432.7						
ADJUSTED TOTAL WEIGHT		5142.8	5048.2	5176.7	5012.3	3431.6						
PERCENT DIFFERENCE		.02		.85	.01	.03						

Figure 4 A.

SUMMARY OF GRAIN SIZE ANALYSIS FOR GEYSERS UNIT 13 SEDIMENT STUDY
FOR THE 5/76 PERIOD

PERCENT PASSING BY WEIGHT **

SIEVE SIZE *	DIAMETER (MM)	STATION 5		STATION 6		STATION 7	
		MEAN	DEV	MEAN	DEV	MEAN	DEV
3 IN.	76.199	100.0	0.0	97.5	6.6	92.5	10.3
1 1/2 IN.	38.029	96.6	4.6	89.1	8.6	79.7	15.0
3/4 IN.	19.029	83.0	13.3	70.9	3.6	59.0	13.4
1/2 IN.	12.699	73.1	16.1	59.9	5.2	48.2	10.6
3/8 IN.	9.519	61.6	17.2	52.1	6.5	39.7	8.4
NO. 4	4.759	37.9	11.8	37.9	7.2	24.8	6.6
NO. 5T	3.359	33.4	10.5	35.2	7.0	22.2	6.2
NO. 8	2.359	20.6	7.2	26.4	6.1	14.0	4.8
NO. 16	1.189	10.9	4.5	16.4	4.2	7.0	3.0
NO. 20	.839	8.4	3.3	12.7	2.9	5.0	2.2
NO. 30	.589	6.3	2.1	9.2	1.6	3.4	1.6
NO. 50	.296	4.3	1.1	5.5	0.6	1.9	0.8
NO. 100	.148	3.1	0.6	3.7	0.3	1.3	0.6
NO. 150T	.103	2.6	0.5	3.2	0.2	1.1	0.5
NO. 200	.073	2.4	0.5	2.8	0.2	1.0	0.5
PAN		-0.0	0.0	-0.0	0.0	-0.0	0.0

* SIEVE SIZES ARE U.S. STANDARD SIEVE SIZES EXCEPT WHERE
FOLLOWED BY A 'T', WHICH INDICATES A TYLER SCREEN SIZE.

** ARITHMETIC MEANS AND STANDARD DEVIATIONS OF (MAX) 5 SAMPLES.

Figure 4 B

Figure 4 C

JASON SPRING UNIT=13

BAR CHART OF GLOMER

MEAN

Figure 4 D

STATION=5

BLOCK CHART OF PCTFINES

Figure 4 E

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