DOCKETED	
Docket Number:	79-AFC-05C
Project Title:	Compliance - Application for Certification for PG&E Geysers Unit 16 (78-NOI-6)
TN #:	250877
Document Title:	2022 Annual Compliance Report - Quicksilver (U16)
Description:	N/A
Filer:	Haley DeLong
Organization:	Geysers Power Company, LLC
Submitter Role:	Applicant
Submission Date:	6/30/2023 1:37:42 PM
Docketed Date:	6/30/2023

CALPINE

GEYSERS POWER COMPANY, LLC

10350 SOCRATES MINE ROAD

MIDDLETOWN, CA 95461

GPC-23-090

June 30, 2023

Keith Winstead, Compliance Project Manager
Energy Facilities Siting and Environmental Protection Division
California Energy Commission
1516 Ninth Street, MS-15
Sacramento, California 95814-5512

Subject: 2022 Annual Compliance Report – Unit 16 (Quicksilver) Power Plant (79-AFC-05C)

Dear Mr. Winstead:

In fulfillment of the Compliance Plan's annual reporting requirement, Geysers Power Company, LLC hereby submits the 2022 Annual Compliance Report (ACR) for Unit 16 (Quicksilver), Docket Number 79-AFC-05C, as required by Condition COM-5.

If you have any comments or questions, please contact me at (707) 431-6062.

Sincerely,

Saima Baig

Saima Baig
EHS Manager
Calpine Corporation

Geysers Quicksilver Plant (Unit 16)
79-AFC-05C
2022 Annual Compliance Report to the California Energy Commission
January 2022-December 2022 Reporting Period

EXECUTIVE SUMMARY

Section 25532 of the Public Resources Code provides that the California Energy Commission (CEC) shall establish a monitoring system to assure that any facility certified by the CEC is constructed and operated in compliance with air, water quality, public health, safety, and other applicable regulations, guidelines, and conditions adopted or established by the CEC.

On December 4, 1979, Pacific Gas and Electric Company (PG&E) filed an Application for Certification (AFC) for Geysers Power Plant Unit 16. In granting the AFC, the CEC issued the "Final Commission Decision Document for Geysers Power Plant Unit 16." In November 1999, the CEC license was transferred from PG&E to Geysers Power Company, LLC (GPC or Project Owner). The license requires GPC to be responsible for administering and monitoring various Conditions for Certification as contained in the Final Commission Decision, in accordance with the Compliance Plan for Unit 16, including submitting an Annual Report that summarizes compliance tasks conducted during the previous year.

Two amendments to the Final Decision have been approved by the CEC, resulting in the inclusion of additional on-going compliance tasks for reporting in the Annual Compliance Report.

First, on December 10, 2018, the CEC Final Decision was amended to revise the Air Quality Conditions of Certification and approved the installation of the wet down system permanent diesel engine at Grant, Socrates and Quicksilver (TN#: 226127). The new Air Quality and Worker Safety Conditions of Certification requires on-going reporting of certain monitoring and other activities at Grant.
Second, on November 16, 2020, additional Compliance Conditions of Certification were adopted for Unit 19 (TN#: 235706): GEN-1, COM-1 through 11, and FIRE PROTECTION-1 through 5. Condition COM-5 requires submission of Periodic and Annual Compliance Reports and details specific reporting requirements that should be included in each Annual Compliance Report (ACR). The following sections of this ACR corresponds with the reporting requirements set forth in Condition COM-5. The conditions with annual reporting requirements that are included as part of this ACR are summarized below:

Technical Area	Conditions with Annual Reporting Requirements
Air Quality	AQ-5C, AQ-5E, AQ-E3E, AQ-SC2, AQ-SC3
Biological Resources	BR 1-3
Compliance	COM-5
Fire Protection	Fire Protection-3
Public Health	PH 6-1
Water Quality, Hydrology and Water Resources	WQ 11-10

Geysers Quicksilver Plant (Unit 16)
79-AFC-05C
2022 Annual Compliance Report to the California Energy Commission
January 2022-December 2022 Reporting Period

In accordance with Condition Compliance-5, the Project Owner reports as follows:

1. Updated Compliance Matrix

A copy of the updated compliance matrix showing the status of all conditions of certification (with the exception of fully satisfied conditions) is included as an attachment under COMPLIANCE-5.

2. Summary of current project operating status and explanation of any significant changes to facility operating status during the year

Quicksilver is currently operational and was operational during the 2022 reporting period with the exception of the following outage periods:

Event	Summary	Start	Actual End
Forced Outage	Unit Relayed	2/8/2022 4:08	2/8/2022 10:51
Forced Outage	Unit relayed due to LRVC (vac pump) bearing failure	2/27/2022 0:31	2/27/2022 12:15
Forced Outage	Forced outage	3/3/2022 13:12	3/3/2022 20:52
Forced Derate	LRVP bearing issue	4/4/2022 15:25	5/3/2022 4:00
Planned Outage (BOP)	Unit separated for planned outage	5/3/2022 4:00	6/15/2022 10:50
Planned Outage (BOP)	Overspeed T.T.	6/15/2022 6:56	6/15/2022 10:49
Forced Outage	4160V metering trouble	8/19/2022 12:22	8/19/2022 18:49
Planned Outage (BOP)	Unit separated for planned outage	11/2/2022 5:00	11/2/2022 18:35

Geysers Quicksilver Plant (Unit 16)
79-AFC-05C
2022 Annual Compliance Report to the California Energy Commission
January 2022-December 2022 Reporting Period

3. Required Annual Compliance Report Documents

The following documents are required by specific conditions to be submitted along with the ACR:

Condition of Certification	Submittal Title
AQ-5C	**Attachment AQ-5C:** Summary of H_2S source test results for the 2022 calendar year. The 2022 AB2588 Air Toxics "Hot Spots" Emission Inventory Report (electronic .tra file) was provided to LCAQMD on 4/26/2023.
AQ-5E	The gland steam seal system annual test was not conducted during 2022 due to the system being out of service during the year.
AQ-E3E	**Attachment AQ-E3E**: Engine operating data summary for the 2022 calendar year.
AQ-SC2	**Attachment AQ-SC2:** Copy of the Annual Throughput Report submitted to LCAQMD for the operating period October 1, 2021 through September 30, 2022.
AQ-SC3 / COM-5	**Attachment COM-5:** Compliance Matrix This Annual Compliance Report is being submitted to the CEC in accordance with AQ-SC3 and COM-5. An updated Compliance Matrix is attached in accordance with COM-5.
BR 1-3	**Attachment BR 1-3a:** Aquatic Monitoring Report **Attachment BR 1-3b:** Guzzler Inspection Report
PH 6-1	**Attachment PH 6-1:** Table of quarterly radon-222 concentration analyses in non-condensable gases during the 2022 calendar year
FIRE PROTECTION - 3	Inspection, Testing, and Maintenance (ITM) reports are submitted to the CEC under confidential designation. ITM reports are not provided as part of this ACR.
WQ 11-10	**Attachment WQ 11-10:** 2022 Geysers Power Plant Units Recycled Water Use Report. A copy of the report is attached.

Geysers Quicksilver Plant (Unit 16)
79-AFC-05C
2022 Annual Compliance Report to the California Energy Commission
January 2022-December 2022 Reporting Period

4. Cumulative List of All Known Post-Certification Changes Approved by the CEC or CPM

- Order Approving Settlement, Order No. 20-1116-2 – 11/16/2020 – CEC TN 235706
- Order Approving Petition to Amend the Facility license (install permanent emergency diesel generator engine for cooling tower wet-down system) Order No. 18-210-2 – 12/10/2018 – CEC TN 226127
- Approval of Petition to Use Reclaimed Wastewater and Approval of Verification Changes – 3/12/2004 – CEC TN 31107
- Commissioner Order Approving Ownership Transfer from PG&E to Geysers Power Company – 4/14/1999 – CEC TN 11770

5. Submittal deadlines not met

There were no late submittals in 2022 associated with power plant operations.

6. Filings Submitted to or Permits Issued by Other Governmental Agencies

- Authority to Construct Permit Application – Quicksilver Unit 16 Spring 2022 Overhaul Projects – Submitted to the LCAQMD and CEC on 2/23/22
- Authority to Construct Permit Application for Temporary/Seasonal Use Engine for Emergency Backup Power at the Unit 16 Pond – Submitted to the LCAQMD on 7/6/22
- Notification of CARB PERP Rental Engines for PSPS Backup Power in LCAQMD
- Quarterly Compliance Reports submitted to LCAQMD/CEC
- Criteria Pollutant Year 2022 Emission Inventory for GPC Plants submitted to CEC
- 2022 PSD H2S Abatement System Performance Results: Geysers Power Company LLC's Sonoma, Lake View, Grant, Quicksilver and Calistoga Power Plants submitted to CEC & LCAQMD
- Lake County AB2588 Air Toxics "Hot Spots" Emission Inventory Report for the Inventory Year 2022 submitted to LCAQMD
- Monthly submission of completed hazardous waste manifests to DTSC.
- Annual Hazardous Waste Report submitted to DTSC.
- Sulfur Hexafluoride (SF6) Geothermal Resource Tracer Testing Exemption- Progress Report submitted to CARB
- Guzzler and Sediment Pond inspection pictures submitted to CEC
- BC/WFF aquatic monitoring report submitted to CEC

7. Projection of Scheduled Compliance Activities for Next Year

- AQ-5C: Perform annual comprehensive testing of incoming steam, condensate, circulating water and cooling tower stack shall be tested for H_2S, ammonia, arsenic, boron, hexavalent chrome, mercury, radon 222, and particulates as appropriate.
- AQ-5E: Perform annual source testing of Gland Steam Seal System

- Biological Resources 1-3: Continued implementation and maintenance as outlined in Wildlife Mitigation Plan and Monitoring Program
- Compliance-5: Evaluate Site Contingency Plan for unplanned facility closure
- Fire Protection-3: Perform inspections, testing, and maintenance of fire systems
- Public Health 2-1: Perform quarterly sampling and analysis of radon-222 concentrations in noncondensable gases entering the power plant in the incoming steam line, or vent off-gas line, or H_2S abatement off-gas line

8. Additions to the Compliance Record

- Basis of Design (BOD) Fire Protection and Life Safety Systems document (dated August 7, 2021).
- On-going logging of monitoring and calibration of H_2S monitoring devices, continuous strip chart record and appropriate sampling line, and other additions pursuant to AQ-5A.
- On-going analyses of results of source tests and other tests requested by the LCAQMD or CEC pursuant to the AQ conditions of certification.
- 2022 Geysers Power Plant Units Recycled Water Use Report to the State WRCB-Division of Drinking Water.

9. Evaluation of the Site Contingency Plan

No modifications were made to the Site Contingency Plan during the 2022 reporting period.

10. Listing of complaints, notices of violations, official warnings, and citations

No complaints, notices of violations, official warnings or citations received during the 2022 reporting period.

CONDITION OF CERTIFICATION
AQ-5C

Attachment AQ-5C: Summary of H2S source test results for the 2022 calendar year

Geysers Quicksilver Plant (Unit 16) 79-AFC-05C
2022 Annual Compliance Report to the California Energy Commission
January 2022-December 2022

Summary of H2S Source Test Results for the 2022 Calendar Year

Geysers Quicksilver Plant (Unit 16) 79-AFC-05 , Condition AQ-5C		
Month	**Test Date**	**Measured H_2S Emissions (Kg/hr)***
January	**1/11/2022**	**1.1**
February	**2/2/2022**	**1.3**
March	**3/10/2022**	**0.9**
April	**4/26/2022**	**0.4**
May	**Out of Service**	**--**
June	**6/17/2022**	**0.1**
July	**7/26/2022**	**0.4**
August	**8/25/2022**	**0.4**
September	**9/21/2022**	**0.6**
October	**10/18/2022**	**0.7**
November	**11/9/2022**	**2.2**
December	**12/13/2022**	**12**

*Unit 16 allowable H_2S emissions = 2.3 Kg/hr

CONDITION OF CERTIFICATION
AQ-E3E

Attachment AQ-E3E: Engine operating data summary for the 2022 calendar year

Geysers Quicksilver Plant (Unit 16) 79-AFC-05C
2022 Annual Compliance Report to the California Energy Commission
January 2022-December 2022

Cooling Tower Wet-down Diesel Engine-Driven Pump Operating Data

CEC Licensed Facilities in Lake County

January 1, 2022 - December 31, 2022

Facility	*Ultra Low Sulfur Diesel Fuel Use (Gallons)[1]*	*Engine Use (Total Hours)*	*Engine Use by Category*	*Engine Use by Category (Hours)*
Quicksilver (Unit 16) License: 79-AFC-05C Condition: AQ-E3E	123.7	10.1	Testing/Maintenance	10.1
			Emergency Use	0.0

[1]Fuel use estimated using manufacturer's fuel consumption rating (12.3 gal/hr) x total hours of engine operation

CONDITION OF CERTIFICATION
AQ-SC2

Attachment AQ-SC2: Copy of the Annual Throughput Report submitted to LCAQMD for the operating period October 1, 2021 through September 30, 2022

Geysers Quicksilver Plant (Unit 16) 79-AFC-05C
2022 Annual Compliance Report to the California Energy Commission
January 2022-December 2022

CALPINE

GEYSERS POWER COMPANY, LLC

10350 SOCRATES MINE ROAD

MIDDLETOWN, CA 95461

707.431.6000

GPC-22-040

October 26, 2022

Keith Winstead, Compliance Project Manager
California Energy Commission,
1516 Ninth Street, MS-15
Sacramento, CA 95814-5512
Keith.Windstead@energy.ca.gov

Subject: **2022 Annual Power Plant Emissions and Throughput Report**

Dear Mr. Winstead:

Enclosed is a copy of the annual power plant production and throughput report requested by the Lake County Air Quality Management District in a letter dated September 1, 2022. These data are presented for the period of operations from October 1, 2021 through September 30, 2022 for the Quicksilver (Unit 16) Geothermal Power Plant.

Please call me at (707) 431-6858 if you have any questions.

Sincerely,

Haley DeLong
Air Program Manager

Attachments

Geothermal Power Plant Emissions/Throughput Worksheet

Geysers Power Company, LLC
c/o Calpine Corporation
10350 Socrates Mine Rd.
Middletown, CA 95461

2022

		Normal Production			Stretford Bypass		Steam Stacking/Venting	
Source	**Permit #**	**Number of Hours in Production**	**Average H_2S Emissions (lb/hr)**	**H_2S Emissions (lb/yr)**	**Number of Stretford Bypass Events**	**Stretford Bypass Emissions (H_2S-lb/yr)**	**Number of Steam Stacking Events**	**Steam Stacking Emissions (H_2S-lb/yr)**
Unit 16 Geothermal Power Plant	A/C 2015-24	7695.5	1.8	13,575	0	0	0	0

Covering the latest twelve (12) month period from October 1, 2021 to September 30, 2022

Print Name: Haley DeLong Phone: (707) 431-6858

Submitted by: Haley DeLong Date: 10/26/22

CONDITION OF CERTIFICATION
AQ-SC3 / COM-5

Attachment COM-5: Compliance Matrix

Geysers Quicksilver Plant (Unit 16) 79-AFC-05C
2022 Annual Compliance Report to the California Energy Commission
January 2022-December 2022

Technical Area	No.	Facility Status	Condition of Certification	Compliance Verification	Status	2022 Annual Compliance Report
AQ	1A	Operations/ Ongoing	The emissions limitations contained below shall apply during normal power plant operation, outages, and/or curtailments. All equipment shall be regularly maintained in good working order and operated in a manner to prevent or minimize air emissions.	The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	GPC is in compliance, records available upon request.
AQ	1B	Operations/ Ongoing	Hydrogen Sulfide (H2S) emissions from the project shall not exceed five (5.0) pounds per hour on a combined basis, and meet an annual performance criterion not to exceed seven and one-half (7.5) pounds per hour for an aggregate of not more than 72 hours per year.	The project owner shall verify compliance by adhering to all testing and monitoring requirements.	Ongoing	GPC is in compliance.
AQ	1C	Operations/ Ongoing	The H2S content in the sweet gas from the Stretford shall not exceed 10 ppmv, prior to dilution in the cooling tower or as specified in an LCAQMD-approved performance plan under Section 655.	The project owner shall verify compliance by operating a continuous compliance monitor as required in AQ-5B.	Ongoing	Any H2S levels above 10 ppmv are reported in the quarterly reports.
AQ	1D	Operations/ Ongoing	The H2S concentration from the Gland Steam Seal System vent shall not exceed 250 ppmw, and the H2S emission rate shall not exceed 0.1 lbs/hr.	The project owner shall verify compliance by adhering to all testing and monitoring requirements.	Ongoing	GPC is in compliance
AQ	1E	Operations/ Ongoing	The project owner shall install and maintain cooling tower drift elimination rated at 0.002 % or better. In the event of generalized atmospheric conditions or localized dangerous contamination of such a nature as to constitute an emergency creating a danger to the health and welfare of the citizens of Lake County, the Air Pollution Control Officer (APCO) will take immediate action by requiring the project owner to reduce H2S or other emissions, or to discontinue emissions entirely. In the event emissions are discontinued entirely, a hearing shall be held by the Lake County Air Quality Management District (LCAQMD) Hearing Board, as soon as practical after such action has been taken, to determine whether such discontinuance shall continue, and under what conditions.	The project owner shall verify compliance by adhering to all testing and monitoring requirements.	Ongoing	GPC is in compliance. GPC provides test results to the LCAQMD and the CPM in the quarterly compliance reports.
AQ	1G	Operations/ Ongoing	Visible emissions shall not exceed the values listed below for more than three (3) minutes in any one (1) hour: •Ringelmann 0.5 (10% opacity) for combustion emissions engine exhaust; and •Ringelmann 1 (20% opacity) for road and construction dust emissions.	The project owner shall perform a Visible Emissions Evaluation to determine compliance as requested by the LCAQMD or CPM. The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	No request has been made to perform testing
AQ	2A	Operations/ Ongoing	The project owner shall maintain and operate the power plant, emissions abatement systems, and associated ancillary equipment as described in submitted specifications and drawings and subsequent permit modifications in accordance with good operating practices and procedures to meet the emissions limit in 1: Emissions. The power plant and abatement system components shall be adequately maintained and winterized.	The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	GPC is in compliance. Winterization inspections performed annually, records available upon request.
AQ	2B	Operations/ Ongoing	The project owner shall coordinate plant operations with the steam supplier and follow the mutually developed plan to limit H2S emissions during plant operation to the H2S emission limitation in 1: Emissions, and in the case of a power plant outage, to meet the limitation within 15 minutes or as near to 15 minutes as possible, but in no case longer than 60 minutes after the cessation of power generation. This plan, involving the operation of the turbine bypass system, shall be annually reviewed and modified as necessary with the approval of the APCO.	The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	GPC is in compliance. Records available upon request.
AQ	2E	Operations/ Ongoing	The project owner shall comply with the requirements of the Air Toxics "Hot Spots" Information and Assessment Act (AB2588) as specified in Sections 44300 - 44394 of the California Health and Safety Code.	The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	Submittal of the AB2588 report submitted to LCAQMD on 4/20/22 fulfills this condition.
AQ	2F	Operations/ Ongoing	Within 180 days of commercial operation, the project owner shall apply for a Permit to Operate, and prove compliance with these conditions.	The project owner shall submit the Permit to Operate to the CPM as required in AQ-SC1. The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Complete	Site access and records are available on request.
AQ	3A	Operations/ Ongoing	Notification The LCAQMD shall be notified pursuant to Rule 510, upon breakdown and/or loss of emissions control from this facility. In the event that emissions exceed the allowable limit, the project owner shall notify the LCAQMD within one (1) hour and shall advise the LCAQMD: 1) the cause of the exceedance; 2) actions taken or proposed to achieve compliance; and 3) estimate of emissions and duration of noncompliance.	In the event that emissions exceed the allowable limit, the project owner shall notify the CPM by the close of the next business day. The project owner shall report breakdowns to the CPM in the quarterly compliance reports.	Ongoing	GPC is in compliance, all breakdown incidents are reported to LCAQMD and the CPM in the quarterly compliance reports.

Technical Area	No.	Facility Status	Condition of Certification	Compliance Verification	Status	2022 Annual Compliance Report
AQ	3B	Operations/ Ongoing	Reports The project owner shall maintain records of the plant and abatement system operation, testing to show compliance with the emission limits, and provide a summary on a quarterly basis. The quarterly summary shall detail; 1) hours of operation; 2) any periods of abatement equipment malfunctions, reason for malfunction and corrective action; 3) types and amounts of chemicals used for condensate treatment; 4) periods of scheduled and unscheduled outages and the cause of outages, if known; 5) a summary of continuous emissions monitoring records for plant operation and monitor maintenance; 6) results of source tests, and 7) the dates and hours of any H2S emissions in excess of the limitation in 1: Emissions.	The project owner shall submit the quarterly reports to the CPM within 45 days of the end of each quarter. The project owner shall make the site and records available for inspection by representatives of the District, ARB, U.S. EPA, and Energy Commission upon request.	Ongoing	GPC is in compliance. Quarterly compliance reports are submitted to LCAQMD and the CPM.
AQ	4A	Operations/ Ongoing	Power Plant and Abatement The project owner shall submit an application for, and receive an, Authority to Construct Permit prior to any significant deletions, additions, modifications of, or operational changes to, the constructed power plant, automated (computerized) management system, and AECS equipment.	The project owner shall provide the CPM with applications and permits issued according to AQ-SC1. The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	An ATC application was submitted to the LCAQMD for the 2022 Spring Overhaul Project and forwarded to the CEC on April 6, 2022. The ATC was issued by the LCAQMD on April 26, 2022.
AQ	5A	Operations/ Ongoing	Upon a determination by the APCO that continuous monitors or monitoring systems are available to quantify plant cooling tower emissions, the project owner shall install and operate a continuous emissions monitor system to verify compliance with emissions limits contained in 1: Emissions. Until such time as continuous emissions monitors are installed and operational, the project owner shall conduct monthly H2S source testing of the cooling tower stacks or as specified in an accepted performance plan under Section 655. The monthly test shall conform to source tests submitted to meet AFC Condition (K) and DOC Condition 11A.	The project owner shall submit the testing results to the CPM in the quarterly compliance report. The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	Continuous monitoring systems are installed at Unit 16 and monthly H2S source tests are submitted in the quarterly reports.
AQ	5B	Operations/ Ongoing	The project owner shall maintain a continuous H2S monitor and record of gas flow on the Stretford treated gas stream. Such equipment shall be maintained in calibration and records of calibration shall be available to the LCAQMD upon request.	The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	GPC is in compliance, records available upon request.
AQ	5C	Operations/ Ongoing	The project owner shall annually conduct a comprehensive emissions test. The incoming steam, condensate, circulating water and cooling tower stack shall be tested for H2S, ammonia, arsenic, boron, hexavalent chrome, mercury, radon 222, and particulates as appropriate. The APCO or CPM may request analysis for additional components and testing at other process points upon reasonable request and in a manner necessary to comply with AB 2588 or other applicable law(s). The annual test plan shall be submitted for LCAQMD review and approval 45 days prior to the planned test. The results of the test shall be provided to the LCAQMD within 60 days of the completion of the test, or as soon as practicable.	The project owner shall provide the CPM a copy of the approved annual test plan. The project owner shall summarize compliance in the Annual Compliance Report. The CPM shall provide the project owner with any requests for analysis of additional components or other process points at least 60 days prior to the next scheduled test or other timeframe as agreed upon between the project owner and CPM. The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	GPC fulfills this condition through submittal of the AB2588 Air Toxics "Hot Spots" Emission Inventory Report. The 2022 report was prepared in CARB's HARP reporting software and the electronic file was provided to LCAQMD on 4/26/2023. The constituents are reported as drift in the report. H2S is tested monthly and reported in the quarterly reports. The monthly H2S test results are provided as attachment AQ-5C.
AQ	5D	Operations/ Ongoing	The project owner shall fund, participate in, or cause to be performed ambient monitoring for H2S, wind speed and direction, temperature and rainfall at a location within the Anderson Springs area approved by the APCO for the operational life of the plant. The project owner shall participate in, fund, or cause to be performed, additional ambient monitoring as reasonably requested by the APCO upon determination that plant emissions are an air quality concern. The H2S and meteorological data shall be immediately available to the LCAQMD and data reports, in a format acceptable to the LCAQMD, shall be submitted on a quarterly basis. A joint monitoring effort on an equitable basis with other developers such as GAMP shall be acceptable. Upon written request of the APCO or CPM, the project owner shall install, operate and maintain a meteorological monitoring station at the power plant site. It shall be located, the results reported, and access to data provided as determined by the APCO.	If the project owner does not participate in GAMP, the project owner shall submit to the LCAQMD and CPM, for their review and approval, a detailed ambient monitoring plan.	Ongoing	GPC participates in GAMP.
AQ	5E	Operations/ Ongoing	Source testing of the Gland Steam Seal System, as approved by the APCO, shall be performed annually unless waived in writing by the APCO.	The project owner shall submit the annual testing results or waiver to the CPM in the following quarterly or annual periodic compliance report. The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	GPC is in compliance. The annual gland steam seal system was not tested in 2022 due to the gland steam seal system being out of service.
AQ	6A	Operations/ Ongoing	The project owner shall provide safe access to the plant records, logbooks, equipment, and sampling ports, for the purpose of inspection and testing by the LCAQMD, its representatives, the Energy Commission, or the California Air Resources Board. Should the plant be secured by locks or gates, the LCAQMD shall be provided keys, combinations or other means to gain immediate access for purpose of testing or inspection.	The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	GPC is in compliance

Technical Area	No.	Facility Status	Condition of Certification	Compliance Verification	Status	2022 Annual Compliance Report
AQ	E1A	Operations/ Ongoing	All equipment shall be regularly maintained in good working order pursuant to manufacturer's guidelines and operated in a manner to prevent or minimize air emissions. The Lake County Air Quality Management District(LCAQMD) shall be notified pursuant to Rule 510, regarding equipment breakdown.	The project owner shall notify the CPM of breakdowns in the quarterly compliance reports. The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	GPC verifies compliance by adhering to all testing, monitoring, and reporting requirements.
AQ	E1B	Operations/ Ongoing	Visible emissions from E1 shall not exceed Ringelmann 0.5 (10% opacity) from the engine exhaust stack for more than three (3) minutes in any one (1) hour.	The project owner shall perform a Visible Emissions Evaluation to determine compliance as requested by the LCAQMD or CPM. The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	No request has been made to perform testing
AQ	E2A	Operations/ Ongoing	E1 shall only operate to power emergency standby cooling tower wet-down pump use when commercial line power is not available because of an emergency or line maintenance outage. The project owner shall develop or utilize an engine maintenance plan per manufacturer's specifications and/or the National Emission Standard for Hazardous Air Pollutants (NESHAP) for Reciprocating Internal Combustion Engines (RICE) and New Source Performance Standards (NSPS).	The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	The engine is operated only for emergency use. Testing and maintenance is limited in accordance to RICE and NESHAP regulations. Records Available upon request
AQ	E2B	Operations/ Ongoing	Testing and maintenance operations for E1 is allowed for up to 50 hours per 12-month period.	The project owner shall maintain logs as required in Records and Reporting. The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	GPC is in compliance, records available upon request.
AQ	E2C	Operations/ Ongoing	Should total hours of operation for E1 exceed usage hours that result in a prioritization score of 10 or above, a Health Risk Assessment and/or additional emission reductions may be required.	The project owner shall perform a Health Risk Assessment or reduce emissions as requested by the LCAQMD or CPM. The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	No request has been made to perform a Health Risk Assessment during the reporting period.
AQ	E2D	Operations/ Ongoing	Diesel fuel utilized shall be California Low Sulfur Diesel containing less than 15 ppmw sulfur.	The project owner shall maintain logs as required in Records and Reporting. The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	GPC contracts with vendors who only supply CARB diesel fuel. Records are available upon request.
AQ	E2E	Operations/ Ongoing	The project owner shall comply with the requirements of the Air Toxics "Hot Spots" Information and Assessment Act as specified in Sections 44300 - 44394 of the California Health and Safety Code as well as the ATCM for Stationary Compression Ignition Engines.	The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	2022 AB2588 annual update files were exported from HARP and provided to LCAQMD on 4/26/2023.
AQ	E2F	Operations/ Ongoing	Within 180 days of initial operation, the project owner shall apply for a Permit to Operate, and prove compliance with these conditions.	The project owner shall submit the Permit to Operate to the CPM according to AQ-SC1. The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Complete	Site access and records are available on request.
AQ	E3A	Operations/ Ongoing	The project owner shall maintain a log for E1 (all logs can be hard copy or digital) meeting the requirements of the NESHAP for RICE and NSPS which contains at a minimum, the facility name, location, engine information, fuel used, emission control equipment, maintenance conducted on the engine, and documentation that the engine meets the emission standards.	The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	GPC is in compliance, records available upon request.
AQ	E3B	Operations/ Ongoing	The project owner shall maintain a log for E1 of usage that shall document hours of operation, and initial startup hours. The project owner shall maintain a log of engine maintenance to show compliance with maintenance plan and NSPS requirements.	The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	GPC is in compliance, records available upon request.
AQ	E3C	Operations/ Ongoing	The project owner shall document fuel usage by retention of fuel purchase records or by other methods that adequately show fuel use for this engine. Log entries shall be retained for a minimum of 36 months, with 24 months of the most recent entries retained / accessible on-site. The log shall meet all requirements of the ATCM for Stationary Compression Ignition Engines.	The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	GPC is in compliance. Records available upon request.

Technical Area	No.	Facility Status	Condition of Certification	Compliance Verification	Status	2022 Annual Compliance Report
AQ	E3D	Operations/ Ongoing	The project owner shall maintain a non-resettable hour meter for each engine capable of displaying 9,999 hours.	The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	GPC is in compliance.
AQ	E3E	Operations/ Ongoing	The project owner shall furnish an annual record of fuel use (gallons) and owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request engine use (hours), breaking down hours of testing, maintenance, and emergency use, and in a format acceptable to the LCAQMD, within 15 days of request, and by October 31st of each year.	The content and format of the annual record submitted by the project owner to the LCAQMD shall be approved by the LCAQMD. The project owner shall provide the CPM a summary of the type of fuel used and engine use (hours) breaking down hours of testing, maintenance, and emergency use, to the CPM in the annual compliance report. The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	See attachment AQ-E3E for a summary of engine operating information for the reporting period.
AQ	E4A	Operations/ Ongoing	Emergency Engine The project owner shall apply for and receive an Authority to Construct permit prior to the addition of new equipment or modification of permitted equipment.	The project owner shall provide the CPM with applications and permits issued according to AQ-SC1. The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	GPC is in compliance.
AQ	E5A	Operations/ Ongoing	The project owner shall provide safe access to the plant records, logbooks, equipment, and sampling ports, for the purpose of inspection and testing by the LCAQMD, its representatives, the Energy Commission, or the California Air Resources Board. Should the plant be secured by locks or gates, the LCAQMD shall be provided keys, combinations or other means to gain immediate access for purpose of testing or inspection.	The project owner shall perform monitoring and testing as requested by the LCAQMD or CPM, the project owner shall make the site and records available for inspection by representatives of the District, ARB, U.S. EPA, and Energy Commission upon request.	Ongoing	GPC is in compliance.
AQ	E6A	Operations/ Ongoing	Emergency Engine The permit for the emergency engine shall be posted at the equipment site and be available for the project owner's reference and LCAQMD staff inspection. If locks or unmanned gates are used to secure the project area, the LCAQMD or its representative will be given free access of entry for the purposes of monitoring or inspecting during normal business hours or periods of emergency engine use.	The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	GPC is in compliance.
AQ	F1A	Operations/ Ongoing	The total ROG, PM10, SOx or NOx emission rate for this facility shall not exceed 25 tons per 12-month period. The emission rate(s) determination shall be consistent with the methodology and assumptions used to evaluate the application(s) under which the LCAQMD permit(s) was/were issued.	The project owner shall perform a source test to verify compliance with the emission rate(s) upon request of the District. The project owner shall make the site and records available for inspection by representatives of the District, ARB, and Energy Commission upon request.	Ongoing	GPC is in compliance.
AQ	SC1	Operations/ Ongoing	The project owner shall provide the compliance project manager (CPM) copies of any Lake County Air Quality Management District-(LCAQMD or District) issued project air permit for the facility. The project owner shall submit any request or application for a new project air permit or project air permit modification to the CPM.	The project owner shall submit any request or application for a new project air permit or project air permit modification to the CPM at the time of its submittal to the permitting agency. The project owner shall provide the CPM a copy of all issued air permits, including all modified air permits, to the CPM within 30 days of finalization.	Ongoing	Applications submitted to the LCAQMD and LCAQMD issued air permits are forwarded to the CPM.
AQ	SC2	Operations/ Ongoing	The project owner shall provide the CPM with copies or summaries of the quarterly and annual reports submitted to the District or ARB. The project owner shall submit to the CPM in the required quarterly reports a summary of any notices of violation and reports, and complaints relating to the project.	The project owner shall provide the reports to the CPM within the timeframes required in the conditions of certification.	Ongoing	See attachment AQ SC-2 for a copy of the Annual Throughput Report submitted to LCAQMD and CEC. For the Quarterly Reports, the CPM is provided with a copy at the time of submittal to LCAQMD.

Technical Area	No.	Facility Status	Condition of Certification	Compliance Verification	Status	2022 Annual Compliance Report
AQ	SC3	Operations/ Ongoing	The project owner shall provide the CPM with an Annual Compliance Report demonstrating compliance with all the conditions of certification as required in the General Provisions of the Compliance Plan for the facility.	The project owner shall provide the Annual Compliance Report to the CPM within 45 calendar days after the end of the reporting period or a later date as approved by the CPM.	Ongoing	GPC is in compliance.
Biological Resources	1-2	Operations/ Ongoing	Project owner will implement the biological protection measures outlined in the NOI, pp. 23, 116-117, 156-161, Appendix D, Section 7, Appendix E, pp. E-54 to E-56, Appendix I, pp. 4-1 to 4-2; AFC, pp. 6-26, 6-30 to 6-32; and Responses to Data Requests of April 9, 1980, and April 30, 1980. These measures include: • The use of native species of shrubs and trees whenever possible for revegetation. • The construction of a retention barrier surrounding Unit 16 to contain accidental spills of condensate and chemicals in storage areas. • No construction within 500 feet of streams, in order to protect riparian areas, except in areas of creek crossings and fill areas as designated in construction plans or as required by the AFC approval. • The construction of the cooling tower for Unit 16 to meet a 0.002 percent drift design as an expected measure to reduce boron drift impacts on surrounding vegetation. • Evaluation of fish populations and stream sediments if a spill occurs at Unit 16. • Planning of construction to avoid mass grading during the months of December, January, and February. However, if weather conditions are favorable and PG&E desires to carry out operations during the wet season (November, December, January, February, and March), they will notify the Lake County Building Department and receive its concurrence. Extra effort to control erosion and sedimentation will be initiated during this time period, and these measures will be specified in the notification to the county. In addition, PG&E will notify the CEC and CDFandG of such construction activities and the erosion control measures to be implemented. • The use of temporary erosion control measures during construction. • The use of long-term erosion measures. • Revegetation will be used to control erosion, including punched straw seed bed preparation, hydroseeding, slope stepping, and, if necessary, establishment of an irrigation system for vegetation on cut and fill slopes and the sedimentation ponds. These efforts will be continued as needed for the duration of the project. • Revegetation shall be performed at the beginning of or just prior to the wet season, October through April, to aid in seedling survival. • Construction of sedimentation ponds at the end of the power plant site drainage system and at the disposal fill area. These ponds will be maintained for the operational life of the power plant.	Project owner will submit semiannual compliance statements, verifying compliance at biological protection measures associated with power plant construction. These statements will be submitted to the California Department of Fish and Game and the CEC starting six months after the start of construction and continuing until one year after the start of commercial operations. Starting one year after commercial operation, annual compliance statements will be re submitted to the CDFandG and the CEC/for a period of three years, at which time, monitoring and reporting may be continued for a period agreed to by project owner and the CEC staff, or in the absence of such agreement and upon submission to the Commission itself, for a period as directed by the Commission. In the event of a spill at Unit 16, an early assessment by the project owner biologist on the immediate effects to fish populations and other stream organisms will be made and reported to the CEC and CDFandG. This will be followed by submittal of a summary report within two weeks of the spill if adverse effects occurred to biological resources.	Ongoing	GPC is in compliance.
Biological Resources	1-3	Operations/ Ongoing	Project owner shall implement the measures of the CEC-CPM approved Wildlife Mitigation Plan and Monitoring Program. This plan shall discuss wildlife food planting, vegetation, wildlife ponds, wildlife habitat, erosion control, and chaparral management. Any changes or alternatives to the content of the Wildlife Mitigation Plan and Monitoring Program must be approved by the CEC-CPM. Project owner's biologist shall provide a progress report of the measures identified above to the CEC-CPM and the California Department of Fish and Game in annual compliance reports.	Prior to implementation of alternatives to the Wildlife Mitigation Plan and Monitoring Program, project owner will submit any proposed alternatives to the CEC-CPM for approval. project owner shall submit annual compliance statements to the CEC-CPM.	Ongoing	GPC is in compliance - see attachments BR 1-3a: Aquatic Monitoring and 1-3b: Guzzler Inspection Report.
Biological Resources	1-10	Operations/ Ongoing	At the time the power plant is to be deactivated project owner will include in the decommissioning plan a biological resources element identifying mitigation and compensation measures.	Project owner will submit the biological resources element of the decommissioning plan to the CEC and CDFandG for a determination of adequacy and acceptability.	Ongoing	Not applicable - Unit 16 is still operational.
COM	1	Operations/ Ongoing	Unrestricted Access The project owner shall ensure that the CPM, responsible staff, and delegate agencies are granted unrestricted access to the facility site, related facilities, project-related staff, and the records maintained on-site for the purpose of conducting facility audits, surveys, inspections, or general or closure-related site visits. Although the CPM will normally schedule site visits on dates and times agreeable to the project owner, the CPM reserves the right to make unannounced visits at any time, whether such visits are by the CPM in person or through representatives from staff, delegated agencies, or consultants.	N/A	Ongoing	GPC is in compliance.

Technical Area	No.	Facility Status	Condition of Certification	Compliance Verification	Status	2022 Annual Compliance Report
COM	2	Operations/ Ongoing	Compliance Record The project owner shall maintain electronic copies of all project files and submittals on-site, or at an alternative site approved by the CPM for the operational life and closure of the project. The files shall also contain at least: 1.the facility's Application for Certification, if available; 2.all amendment petitions, staff approvals and CEC orders; 3.all site-related environmental impact and survey documentation; 4.all appraisals, assessments, and studies for the project; 5.all finalized original and amended design plans and "as-built" drawings for the entire project; 6.all citations, warnings, violations, or corrective actions applicable to the project, and 7.the most current versions of any plans, manuals, and training documentation required by the conditions of certification or applicable LORS. Staff and delegate agencies shall, upon request to the project owner, be given unrestricted access to the files maintained pursuant to this condition.	N/A	Ongoing	GPC is in compliance.
COM	3	Operations/ Ongoing	Compliance Verification Submittals A cover letter or email from the project owner or an authorized agent is required for all compliance submittals and correspondence pertaining to compliance matters. The cover letter or email's subject line shall identify the project by the docket number for the compliance phase, cite the appropriate condition of certification number(s), and give a brief description of the subject of the submittal. When submitting supplementary or corrected information, the project owner shall reference the date of the previous submittal and the condition(s) of certification applicable. All reports and plans required by the project's conditions of certification shall be submitted in a searchable electronic format (.pdf, MS Word or Excel, etc.) and include standard formatting elements such as a table of contents identifying by title and page number each section, table, graphic, exhibit, or addendum. All report and/or plan graphics and maps shall be adequately scaled and shall include a key with descriptive labels, directional headings, a distance scale, and the most recent revision date. The project owner is responsible for the content and delivery of all verification submittals to the CPM and notification that the actions required by the verification were satisfied by the project owner or an agent of the project owner. All submittals shall be accompanied by an electronic copy on an electronic storage medium, or by e-mail, as agreed upon by the CPM. If hard copy submittals are required, they should be addressed as follows: Compliance Project Manager Geysers Energy Project (Docket Number) California Energy Commission 1516 Ninth Street (MS-2000)	N/A	Ongoing	GPC is in compliance.
COM	4	Pre-con	Monthly Compliance Report During the construction of approved project modifications requiring construction of 6 months or more, the project owner or authorized agent shall submit an electronic searchable version of the MCR to the CPM within ten (10) business days after the end of each reporting month. No MCR shall be required for maintenance and repair activities, regardless of duration. MCRs shall be submitted each month until construction is complete, and the final certificate of occupancy is issued by the DCBO. MCRs shall be clearly identified for the month being reported. The MCR shall contain, at a minimum: 1.A summary of the current project construction status, a revised/updated schedule if there are significant delays, and an explanation of any significant changes to the schedule; 2.Construction submittals pending approval, including those under review, and comments issued, and those approved since last MCR; 3.A projection of project compliance activities (compliance submittals, etc.) scheduled during the next (2) two months; the project owner shall notify the CPM as soon as any changes are made to the project construction schedule that would affect compliance with conditions of certification; 4.A listing of incidents (safety, etc.), complaints, inspections (status and those requested), notices of violation, official warnings, trainings administered, and citations received during the month; a list of any incidents that occurred during the month, a description of the actions, taken to date to resolve the issues; and the status of any unresolved actions noted in the previous MCRs; 5.Documents required by specific conditions (if any) to be submitted along with each MCR. Each of these items shall be identified in the transmittal letter, as well as the conditions they satisfy, and submitted as attachments to the MCR; 6.A list of conditions (if any) that have been satisfied during the reporting period, and adscription or reference to the actions that satisfied the condition; and 7.A listing of the month's additions to the Compliance Record	N/A	Ongoing	GPC is in compliance. Monthly compliance reports were submitted as part of the effort to recommission the fire protection systems. This effort concluded in November 2022.

Technical Area	No.	Facility Status	Condition of Certification	Compliance Verification	Status	2022 Annual Compliance Report
COM	5	Operations/ Ongoing	Periodic and Annual Compliance Reports The project owner shall continue to submit searchable electronic ACRs to the CPM, as well as other PCRs required by the various technical disciplines. ACRs shall be completed for each year of commercial operation and are due each year on a date agreed to by the CPM. Other PCRs (e.g. quarterly reports), may be specified by the CPM. The searchable electronic copies may be filed on an electronic storage medium or by e-mail, subject to CPM approval. Each ACR must include the AFC number, identify the reporting period, and contain the following: 1.an updated list showing the status of all conditions of certification (fully satisfied conditions do not need to be included in the matrix after they have been reported as completed); 2.a summary of the current project operating status and an explanation of any significant changes to facility operating status during the year; 3.documents required by specific conditions to be submitted along with the ACR; each of these items shall be identified in the transmittal letter with the conditions it satisfies, and submitted as an attachment to the ACR; 4.a cumulative list of all known post-certification changes approved by the CEC or the CPM; 5.an explanation for any submittal deadlines that were missed, accompanied by an estimate of when the information will be provided; 6.a listing of filings submitted to, or permits issued by, other governmental agencies during the year; 7.a projection of project compliance activities scheduled during the next year; 8.a listing of the year's additions to the Compliance Record; 9.an evaluation of the Site Contingency Plan, including amendments and plan updates; and 10.a listing of complaints, incidents, notices of violation, official warnings, and citations received during the year, a description of how the issues were resolved, and the status of any unresolved complaints.	N/A	Ongoing	GPC is in compliance. The ACR due date agreed upon with the CPM for the 2021 reporting year and thereafter is June 30th following the reporting year
COM	6	Operations/ Ongoing	Confidential Information Any information that the project owner designates as confidential shall be submitted to the CEC's Executive Director with an application for confidentiality, pursuant to Title 20, California Code of Regulations, section 2505(a).	N/A	Ongoing	GPC is in compliance.
COM	7	Operations/ Ongoing	Annual Energy Facility Compliance Fee Pursuant to the provisions of section 25806 (b) of the Public Resources Code, the project owner shall continue paying an annual compliance fee which is adjusted annually, due by July 1 of each year in which the facility retains its certification.	N/A	Ongoing	GPC is in compliance.
COM	8	Operations/ Ongoing	Amendments and Staff Approved Project Modifications The project owner shall petition the CEC, pursuant to Title 20, California Code of Regulations, section 1769, to modify the design, operation, or performance requirements of the project or linear facilities, or to transfer ownership or operational control of the facility. Section 1769 details the required contents for a Petition to Amend a CEC Decision. A project owner is required to submit a five thousand ($5,000) dollar fee for every Petition to Amend a previously certified facility, pursuant to Public Resources Code section 25806(e). If the actual amendment processing costs exceed $5,000.00, the total Petition to Amend reimbursement fees owed by a project owner will not exceed seven hundred fifty thousand dollars ($750,000), adjusted annually.	N/A	Ongoing	GPC is in compliance.
COM	9	Operations/ Ongoing	Incident-Reporting Requirements Within 24 hours of its occurrence, the project owner shall report to the CPM any safety-related incident. Such reporting shall include any incident that has resulted in death to a person; an injury or illness to a person requiring overnight hospitalization; a report to Cal/OSHA, OSHA, or other regulatory agency; or damage to the property of the project owner or another person of more than $50,000. If not initially provided, a written report also will be submitted to the CPM within five business days of the incident. The report will include copies of any reports concerning the incident that have been submitted to other governmental agencies.	N/A	Ongoing	GPC is in compliance.
COM	10	Operations/ Ongoing	Non-Operation and Restoration Plans If the facility ceases operation temporarily because it is physically unable to operate (excluding maintenance or repair) for longer than three (3) months (or other CPM-approved date), the project owner shall notify the CPM. Notice of planned non-operation, excluding maintenance or repair, shall be given at least two (2) weeks prior to the scheduled date. Notice of unplanned non-operation shall be provided no later than one (1) week after non-operation begins.	N/A	Ongoing	GPC is in compliance.

Technical Area	No.	Facility Status	Condition of Certification	Compliance Verification	Status	2022 Annual Compliance Report
COM	11	Operations/ Closure	Facility Closure Planning The project owner shall coordinate with the CEC to plan and prepare for eventual permanent closure and license termination by filing a Facility Closure Plan. The Facility Closure Plan shall be filed 90 days before the commencement of closure activities or at such other time agreed to between the CPM and the project owner. The Facility Closure Plan shall include the information set forth in Title 20, California Code of Regulations, section 1769, but shall not be subject to the fee set forth in Public Resources Code section 25806(e).	N/A	Ongoing	GPC is in compliance.
FIRE PROTECTION	1	Operations/ Ongoing	The project owner shall notify and submit design drawings to the compliance project manager (CPM) for any planned modifications that would materially change the design, operation, or performance of the fire protection or fire alarm systems.	At least 15 business days before the start of any construction that materially changes the design, operation or performance made to the fire protection or fire alarm systems, the project owner shall submit a complete set of design drawings to the CPM for review and approval, and to the DCBO for plan check against the applicable LORS and construction inspection.	Ongoing	During 2022, GPC was working through the recommissioning of the fire system based on the BOD which was approved on December 5, 2022.
FIRE PROTECTION	2	Operations/ Ongoing	The project owner shall maintain and update, as appropriate, the fire protection Basis of Design documents and appendices to ensure that the fire protection and fire alarm systems are documented and accurately depicted on drawings for the project site.	The project owner shall provide the CPM with an updated Basis of Design document within 30 days of completing any changes to fire protection or fire alarm systems that result in changes to the Basis of Design.	Ongoing	The Basis of Design was approved by the CEC on December 5, 2022. There have been no modifications that required an update to the BOD.
FIRE PROTECTION	3	Operations/ Ongoing	The project owner shall ensure that all required inspections, testing, and maintenance (ITM) are performed on the project's fire protection systems as specified and in the frequencies set forth in Title 19, California Code of Regulations, section 904(a) and on the project's fire alarm systems as specified in the applicable edition of the National Fire Protection Association (NFPA) 72 National Fire Alarm and Signaling Code.	The project owner shall provide to the CPM copies of the completed ITM reports for the project's fire protection systems and fire alarm systems within 15 days of receiving the ITM reports. The ITM reports shall be submitted quarterly for the first two years following approval of this condition, then all ITM reports shall be submitted annually thereafter.	Ongoing	ITM reports are submitted to the CEC under confidential designation. The 2022 ITM reports were submitted on a quarterly basis for 2022, and will be submitted annually hereafter.
FIRE PROTECTION	4	Operations/ Ongoing	Whenever deficiencies or failures are identified in any of the ITM reports for the project's fire protection or fire alarm systems, the project owner shall provide the CPM with a summary of the following information from the ITM reports required by FIRE SAFETY-3: (a)A summary of all deficiencies or failures identified; (b)The corrective action the project owner has taken, or plans to take, to address each identified deficiency or failure; and (c)The completion date or an estimated completion date to implement the corrective action.	The project owner shall provide the CPM with the information from (a)-(c) within 15 days of receiving the ITM reports.	Ongoing	GPC is in compliance. The required information was submitted with the quarterly 2022 ITM reports under confidential designation.
FIRE PROTECTION	5	Operations/ Ongoing	In the case of a fire protection system impairment, as defined in the latest applicable edition of NFPA-25, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems, California Edition, that would prevent the proper functioning of any portion of the fire protection or fire alarms systems during a fire event, the project owner shall inform the CPM of the impairment along with the following information: (a)The date discovered; (b)The location of the impairment; (c)A short description, including a photograph (if applicable), of the impairment and its cause (if known), and a description of the actions to be taken to protect life and safety until the impairment is corrected; (d)The corrective action outlining how the impairment was repaired, including any engineering drawings or inspections, not already provided to the CPM or the DCBO; (e)The date the impairment was repaired; and (f)Before and after photographs (if applicable) showing the completed impairment repair.	The project owner shall provide the CPM with information from (a)-(c) within two business days of the discovery of an impairment, or within a time as approved by the CPM. The project owner shall provide the CPM with information from (d)-(f) within 5 days of correction of the impairment.	Ongoing	GPC prepared a reporting procedure document for the fire protection system impairment program in May 2022. GPC followed this procedure and provided the proper fire protection system impairment notifications to the CEC during the reporting period.

Technical Area	No.	Facility Status	Condition of Certification	Compliance Verification	Status	2022 Annual Compliance Report
GEN	1	Operations/ Ongoing	Whenever material modifications to the facility are planned, the project owner shall design, construct, and inspect project modifications in accordance with the applicable version of the California Building Standards Code (CBSC), also known as Title 24, California Code of Regulations, which encompasses the California Building Code (CBC), California Administrative Code, California Electrical Code, California Mechanical Code, California Plumbing Code, California Energy Code, California Fire Code, California Code for Building Conservation, California Reference Standards Code, and all other applicable engineering laws, ordinances, regulations and standards (LORS) in effect at the time initial design plans are submitted to the chief building official (CBO) for review and approval (the CBSC in effect is the edition that has been adopted by the California Building Standards Commission and published at least 180 days previously). The project owner shall ensure that the provisions of the above applicable codes are enforced during the construction, addition, alteration, or demolition of the modifications. Where, in any specific case, different applicable sections of the code specify different materials, methods of construction or other requirements, the most restrictive shall govern. Where there is a conflict between a general requirement and a specific requirement, the specific requirement shall govern. The project owner shall ensure that all contracts with contractors, subcontractors, and suppliers clearly specify that all work performed, and materials supplied comply with the codes listed above.	Within 30 days following receipt of the certificate of occupancy (if one is required by the CBO) for any material project modification completed after the effective date of this condition, the project owner shall submit to the compliance project manager (CPM) a statement of verification, signed by the responsible design engineer, attesting that all designs, construction, installation, and inspection requirements of the applicable LORS and the CEC's decision have been met in the area of facility design. The project owner shall also provide the CPM a copy of the certificate of occupancy within 30 days of receipt from the CBO. Once the certificate of occupancy has been issued, the project owner shall inform the CPM at least 30 days prior to any construction, addition, alteration, or demolition to be performed on any portion(s) of the completed facility that requires CBO approval for compliance with the above codes. The CPM will then determine if the CBO needs to approve the work.	Ongoing	On 4/18/22, GPC submitted a Petition to Amend questionnaire to replace the original 16 steam turbine rotor.
Geotechnical/ Structural Engineering	15-15	Operations/ Ongoing	The as-graded and as-build plans shall be maintained as permanent records	Project owner shall identify the person or office to contact for CEC examination of such records.	Ongoing	All As-Built plans are available in the Compliance Record.
Geotechnical/ Structural Engineering	15-16	Operations/ Ongoing	If notified by either a responsible CB0 or by CEC that any proposed design plans or specifications or any substantial revisions thereof are not acceptable, project owner shall not proceed with any construction based on such plans and specifications.	Upon notification that the original design plans are unacceptable, project owner shall prepare and submit revised design plans to the responsible CB0 or CEC. In its periodic compliance reports to the CEC, project owner shall indicate any dates of construction shutdown resulting from the no acceptance of original design plans and specifications.	Ongoing	GPC did not receive notification that any design plans are unacceptable during the reporting period.
Noise	5-3	Operations/ Ongoing	Within 90 days after the plant reaches its rated power generation capacity and construction is complete, PG&E shall conduct a noise survey at the nearest sensitive receptor and at 500 feet from the generating station. The survey will cover a 2a-hour period with results reported in terms of Lx (x=10, 50, and 90), Leq and Ldn levels. PG&E shall prepare a report of the survey that will be used to determine the plant's conformance with county standards. In the event that county standards are being exceeded, the report shall also contain a mitigation plan and a schedule to correct the noncompliance. No future noise surveys of off-site operational noise are required unless the public registers complaints or the noise from the project is suspected of increasing due to a change in the operation of the facility.	Within 30 days of the noise survey, project owner shall submit its report to the Lake County Air Pollution Control District.	Ongoing	No complaints were received during the reporting period.

Technical Area	No.	Facility Status	Condition of Certification	Compliance Verification	Status	2022 Annual Compliance Report
Noise	5-4	Operations/ Ongoing	Within 180 days after the start of commercial operation, project owner shall prepare a noise survey report for the noise-hazardous areas in the facility. The survey shall be conducted by an acoustician in accordance with the provisions of 8 CAC, Article 105. The survey results will be used to determine the magnitude of employee noise exposure. If employee complaints of excessive noise arise during the life of the project, Cal/DOSH, Department of Industrial Relations, shall make a compliance determination.	project owner shall notify Cal/DOSH and the CEC of the availability of the report.	Ongoing	No complaints were received during the reporting period.
Public Health	6-1	Operations/ Ongoing	Project Owner shall quarterly sample and analyze radon-222 concentrations in noncondensable gases entering the power plant in incoming steam line, vent off-gas line, or H2S abatement off-gas line. This sampling program will comply with the most recent California Department of Health Services, Radiologic Health Service (CDHS/RHS) requirements for radon-222 monitoring and reporting. In addition, this radon-222 steam monitoring program will be conducted quarterly for a period of two (2) years after the scheduled date of commercial operation and annually thereafter. If monitoring results indicate that the radon-222 release from Unit 16 is well within applicable standards, the monitoring program may be modified, reduced in scope, or eliminated provided project owner obtains the permission of CDHS/RHS. As new information and techniques become available, with concurrence of project owner and CDHS/RHS, changes may be made to the program or the methods employed in monitoring radon-222.	During the first year of commercial operation, project owner shall provide CDHS/RHS with the results of the quarterly sampling within 30 days of the end of the quarter. After the first year of commercial operation, project owner shall provide CDHS/RHS with an annual report summarizing quarterly sampling results. The annual report will comply in format and content with the most recent CDHS/RHS reporting requirements.	Ongoing	See attachment Public Health 6-1 for table of quarterly analysis.
Public Health	6-2	Operations/ Ongoing	If the radon-222 concentration exceeds 3.0 picocuries per liter (pCi/1) in the cooling tower exhaust, project owner must inform the CDHS/RHS with a special report.	project owner shall provide a written report to CDHS/RHS of sample results within 30 days of confirming an exceedance of 3.0 pCi/1 radon-222 in the cooling tower exhaust.	Ongoing	See the attached table referenced in Public Health 6-1. There was no exceedance of 3.0 pCi/l during the reporting period.
Public Health	6-3	Operations/ Ongoing	If the radon-222 concentrations exceed 6.0 pCi/1 in the cooling tower exhaust, project owner shall notify the CDHS/RHS and the CEC by telegram or telephone upon confirmation of the sample result. Confirmation includes reanalyzing the sample by project owner or another qualified laboratory. The confirmation procedures used shall be the same as the routine analysis, but may include sending samples to CDHS/RHS or other qualified laboratories for analysis. Sample result confirmation must be accomplished in the quickest manner possible and should take less than five calendar days.	Project Owner shall notify CDHS/PHS and the CEC within 24 hours of confirming the sample results. Project Owner shall provide a special report to CDHS/PHS and the CEC outlining corrective actions taken.	Ongoing	See the attached table referenced in Public Health 6-1. There was no exceedance of 6.0 pCi/l during the reporting period.
Safety	9-2	Operations/ Ongoing	On-site worker safety inspections shall be conducted by the California Division of Occupational Safety and Health (Cal/DOSH) during construction and operation of the facility or when an employee complaint has been received. Cal/DOSH shall notify the CEC in writing in the event of a violation that could involve DOSH action affecting the construction or operation schedule.	Project owner shall note any Cal/DOSH inspections in its periodic compliance reports	Ongoing	GPC is in compliance. No Cal/OSHA inspections were performed during the reporting period
Soils	8-3	Operations/ Ongoing	PG&E shall annually measure the amount of sediment accumulated in the sedimentation basins. This information will be used to evaluate the success of the erosion control plan. The accumulated sediment will be estimated by adequate measuring techniques (e.g., staff gauge). Sediment quantities will be verified when sediment is removed. The sediment basins should not be fuller than 60 percent of actual capacity prior to each winter season. The basins will be cleaned as necessary.	The initial measurement shall be taken one year after the start of site preparation, and subsequent measurements shall be taken at one-year intervals thereafter. PG&E shall submit an annual written report to the Central Valley Regional Water Quality Control Board and the CEC beginning one year after the start of commercial operation and continuing for a period of three years, at which time, monitoring and reporting may be continued for a period agreed to by PG&E and the CEC staff, or in the absence of such agreement and upon submission to the Commission itself, for a period as directed by the Commission. Included in each annual report will be a summary of required maintenance and repairs to the erosion control/sediment containment system.	Ongoing	An annual containment inspection is conducted as part of a preventative maintenance program. No major findings or repairs were completed during the reporting period.
Solid Waste Management	10-1	Operations/ Ongoing	10-1PG&E shall ensure that any hazardous waste hauler employed has a certificate of registration from the California Department of Health Services, Hazardous Materials Management Section.	PG&E shall keep a letter on file verifying that hazardous waste haulers have DOHS certificates of registration.	Ongoing	All waste haulers are in compliance and on file in the DTSC database.

Technical Area	No.	Facility Status	Condition of Certification	Compliance Verification	Status	2022 Annual Compliance Report
Solid Waste Management	10-2	Operations/ Ongoing	The Stretford process wastes include elemental sulfur and the Stretford purge stream. PG&E shall ensure that elemental sulfur is stored in a steam coil heated tank and removed periodically to be sold or to be disposed at a site approved for such wastes. PG&E shall ensure that the Stretford purge stream is either pumped into the overflow structure of the cooling tower basin for reinjection into the steam reservoir or trucked to an approved disposal site. Any sludge which accumulates in the cooling tower will be vacuumed off and hauled by a registered hazardous waste hauler to an approved disposal site.	PG&E shall submit final design plans and "As Built" drawings to the Lake County CBO incorporating these design features. In addition, PG&E shall each month submit completed hazardous waste manifests to DOHS in compliance with Section 66475 of Title 22, CAC.	Ongoing	Any excess Stretford solution is sent to the cooling tower for continued use of a abatement chemical.
Solid Waste Management	10-3	Operations/ Ongoing	Project owner shall ensure that hazardous wastes are taken to a facility permitted by DOHS to accept such wastes. (PG&E has indicated its intention to dispose of wastes generated by Geysers Unit 16 at either the Middletown or Kelseyville approved sites.)	PG&E shall notify the CEC, DOHS, and Solid Waste Management Board of the selected disposal site. Any notice of change in disposal sites will be submitted as changes occur.	Ongoing	GPC is in compliance. No update to changes in approved disposal sites
Solid Waste Management	10-5	Operations/ Ongoing	If hazardous wastes, including Stretford sulfur effluent, are stored on site for more than 60 days, PG&E shall obtain a determination from the DOHS that the requirements of a Hazardous Waste Facility Permit have been satisfied.	PG&E shall notify the CEC if it files an in-lieu application with DOHS for the operation of a Hazardous Waste Facility.	As needed	GPC abides by DTSC Guidance for GPC's generator status.
Transmission Line Safety and Nuisance	13-4	Operations/ Ongoing	In the event of complaints regarding induced currents from vehicles, portable objects, large metallic roofs, fences, gutters, or other objects, project owner shall investigate and take all reasonable measures at its own expense to correct the problem for valid complaints, provided that (a) the object is located outside the right- "of-way, or (b) the object is within the right-of-way and existed prior to right-of-way acquisition. For objects constructed, installed, or otherwise placed within the right-of-way after right-of-way acquisition, project owner shall notify the owner of the object that it should be grounded. In this case, grounding is the responsibility of the property owner. project owner shall advise the property owner of this responsibility in writing prior to signing the right-of-way agreement.	Project owner shall maintain a record of activities related to this paragraph. These records shall be made available to CEC staff upon request.	Ongoing	No complaints received concerning induced currents from the GPC plants during the reporting period.
Transmission Line Safety and Nuisance	16-2	Operations/ Ongoing	PG&E shall maintain the vegetation clearance for conductors and structures on the transmission lines in accordance with Title 14, California Administrative Code, Sections 1250 - 1258 and Public Resources Code, Sections 4292 - 4296.	Within 120 days after completion of construction, PG&E shall submit a statement to the California Department of Forestry and the CEC that the transmission line has been constructed in accordance with applicable requirements. PG&E shall also inspect the transmission line annually to ensure that the line maintains required clearances during the fire season. In the event that noncompliance is determined by the CDF, the CDF shall require PG&E to take measures necessary to correct the noncompliance. If PG&E's corrective measures are unsatisfactory in the opinion of the CDF, the CDF shall inform the CEC and shall recommend a course of action.	Complete	GPC is in compliance with GPC's Transmission Line maintenance program. There aren't any transmission lines at Grant owned by GPC. Inspections are performed by PG&E.
Transmission Line Safety and Nuisance	16-6	Operations/ Ongoing	On-site worker safety inspections shall be conducted by the California Division of Occupational Safety and Health (Cal/DOSH) during construction and operation of the transmission line or when an employee complaint has been received. Cal/DOSH shall notify the CEC in writing in the event of a violation that could involve DOSH actions affecting the transmission line construction or operation schedule.	PG&E shall note any Cal/DOSH inspections in its periodic compliance reports.	Ongoing	No injuries have been reported during the reporting period
Water Quality/ Hydrology/ Water Resources	11-2	Operations/ Ongoing	Project owner shall comply with the "Emergency Accidental Spill and Discharge Control Plan and Procedures, Geysers Power Plant" (revised February 15, 1980).	Verification procedures are identified in the document.	Ongoing	GPC is in compliance with the Spill Prevention, Response, Monitoring, Contingency and Cleanup Plan for Central Valley RWQCB WDR's R5-2002-0010 and 99-042

Technical Area	No.	Facility Status	Condition of Certification	Compliance Verification	Status	2022 Annual Compliance Report
Water Quality/ Hydrology/ Water Resources	11-10	Operations/ Ongoing	Project owner will utilize condensed steam for cooling water purposes, acquire an outside source for freshwater supplies, and utilize annually an estimated 3.6 million gallons (12 acre feet) of water for construction.	PG&E will submit to the CEC documentation showing: a.The source and amount of cooling tower basin start-up water, and b.The source, means (appropriation, purchase), and amount of fresh water supply. Under certain conditions, PG&E or its contractor may need to acquire permits or waivers. This information shall be submitted prior to the commencement of power plant or transmission line switchyard construction. The project owner shall provide the Compliance Project Manager with copies of all local and state water quality permits related to the use and disposal of reclaimed municipal wastewater within thirty (30) days of receipt. In the annual compliance reports. the project owner shall provide the CPM with data on the annual quantity of water reinjected at the facility, and a copy of the report submitted to the California Department of Health Services on the additional uses of recycled water per Provision #2 of the December 5. 2003 California Department of Health Services approval letter.	Ongoing	Recycled water was not utilized for reinjection at this facility during the reporting period. See attached Recycled Water Use Report sent to SWRCB during the reporting period.

CONDITION OF CERTIFICATION
BIOLOGICAL RESOURCES 1-3

Attachment BR 1-3a: Aquatic Monitoring Report

Geysers Quicksilver Plant (Unit 16) 79-AFC-05C
2022 Annual Compliance Report to the California Energy Commission
January 2022-December 2022

BEAR CANYON AND WEST FORD FLAT AQUATIC MONITORING PROGRAM

Annual Report 2022 (BC/WFF XXXV)

Prepared for:
Calpine Corporation

January 2023

BEAR CANYON AND WEST FORD FLAT AQUATIC MONITORING PROGRAM

Annual Report 2022 (BC/WFF XXXV)

Prepared for:
Calpine Corporation

January 2023

1425 N. McDowell Boulevard
Suite 200
Petaluma, CA 94954
707.795.0900
www.esassoc.com

Los Angeles

Oakland

Portland

Sacramento

San Diego

San Francisco

Seattle

Tampa

Woodland Hills

TABLE OF CONTENTS

Bear Canyon and West Ford Flat Aquatic Monitoring Program - Annual Report 2022 (BC/WFF XXXV)

		Page
I.	**Introduction**	**I-1**
II.	**Water Quality**	**II-1**
	II.1 Methods	II-1
	II.2 Results	II-1
	II.3 Discussion	II-16
III.	**Fish Populations**	**III-1**
	III.1 Methods	III-1
	III.2 Results	III-2
	III.3 Discussion	III-6
IV.	**Benthic Macroinvertebrates**	**IV-1**
	IV.1 Methods	IV-1
	IV.2 Results	IV-4
	IV.3 Discussion	IV-7
V.	**Summary and Recommendations**	**V-1**
VI.	**References**	**VI-1**

List of Figures

I.1	Sampling Stations	I-3
III.1	Size Distributions of Rainbow Trout, July 2022	III-19
III.2	Summary of Yearly Age Class Distributions of Rainbow Trout	III-22

List of Tables

I.1	BC/WFF Monitoring Stations and Tasks for 2022	I-2
II.1	Water Quality Analyses Results, April 2022	II-17
II.1	Water Quality Analyses Results, July 2022	II-18
II.3	Water Quality Analyses Results, October 2022	II-19
III.1	Summary of Yearly Fish Population Estimates	III-7
III.2	Summary of Yearly Age Class Distribution of Rainbow Trout	III-13
IV.1	Metrics Results for Benthic Macroinvertebrate Samples, July 2022	IV-9
IV.2	RRIBI Values for Benthic Macroinvertebrate Samples, July 2022	IV-9

I. INTRODUCTION

The Bear Canyon/West Ford Flat (BC/WFF) aquatic monitoring program was initiated in 1988 and is sponsored by Calpine Corporation. The program monitors streams in and around the Bear Canyon and West Ford Flat power plants and steam fields, which are operated by Calpine Corporation, and is required by Lake County Use Permits for the Bear Canyon and West Ford Flat power plants; and by the Central Valley Regional Water Quality Control Board's (RWQCB) Waste Discharge Order No. 99-42 for the Unit 13 and Unit 16 Power Plants and Waste Discharge Order No. 99-043 for the West Ford Flat and Bear Canyon Power Plants. Copies of the report are forwarded to Lake County and the RWQCB. In 1998, monitoring responsibility transferred from the Institute of Chemical Biology (ICB) to Environmental Science Associates (ESA), who presently conduct the program. A complete history of the program and changes made since 1990 is provided in the BC/WFF XXV, 2012-2013 annual report (ESA, 2013).

A further change was implemented with the 2015-2016 report (ESA, 2017). Prior to 2017, the annual BC/WFF monitoring period extended from July of one year through April of the following year. As such, the data collections did not occur within a given calendar year or even within the same water year. At the recommendation of ESA, Calpine elected to change the schedule of reporting such that future annual summary reports would present the results of sample collections conducted within the same calendar year (i.e., April, July, and October of the same year). The actual sampling frequency or timing were not changed; only the monitoring period summarized in the annual reports. To effect this change, the 2015-2016 report (ESA, 2017) summarized the results of BC/WFF monitoring activities conducted during two calendar years, 2015 and 2016. This current report summarizes the monitoring results for the 2022 calendar year.

The 2022 (BC/WFF XXXV) monitoring period examined water quality and fish populations between April and October 2021 at six monitoring stations located both upstream and downstream of Calpine facilities. Benthic macroinvertebrates (BMI) are sampled every three years, and macroinvertebrate data were last reported for July 2019 (ESA, 2020); hence, BMI samples were again collected and analyzed in July 2022 and the results are included in this report.

Since its inception, the BC/WFF program has collected water quality data at six primary monitoring stations: An-2.8, An-4.4, BeC-0.5, CuC-0.1, Gu-0.6, and Gu-2.4 within the Anderson Creek watershed in Lake County (Figure I.1). The locations of the fish and benthic macroinvertebrate survey sites are in some cases slightly offset from the primary water quality sampling stations due to more appropriate habitat conditions (see Table I.1). As a result of recently changed conditions at fish sampling station Gu-1.9 related to the 2015 Valley Fire, particularly the high number of felled Douglas fir trees within the creek bed, this site became inaccessible for sampling and was relocated. Starting in July 2019, fish and macroinvertebrate sampling began upstream from Gu-1.9 to the primary water quality sampling site Gu-2.4. Moreover, significant geomorphic changes (scour and aggradation) occurred at fish and

macroinvertebrate sampling site BeC-0.9 during the 2018-2019 winter season. While BeC-0.9 remains accessible for sampling, fish habitat quality and quantity has been significantly altered to the extent of rendering any comparisons to past fish population estimates at this site irrelevant and potentially misleading. A new fish and macroinvertebrate sampling site (BeC-0.6; Figure I.1) was established approximately 650 ft downstream of the discontinued site in July 2019. Lastly, recent tree fall blocked safe access to sampling site CuC-0.1 in July 2022, preventing the collection of water quality, fish population, and benthic macroinvertebrate samples at this site.

Water quality parameters examined included water temperature, specific conductance, dissolved oxygen, stream flow, and turbidity. Furthermore, samples were collected at all stations and analyzed at an analytical laboratory accredited by the California Environmental Laboratory Accreditation Program (ELAP). Fish population monitoring was conducted at all stations in July using a standard electrofishing protocol.

TABLE I.1

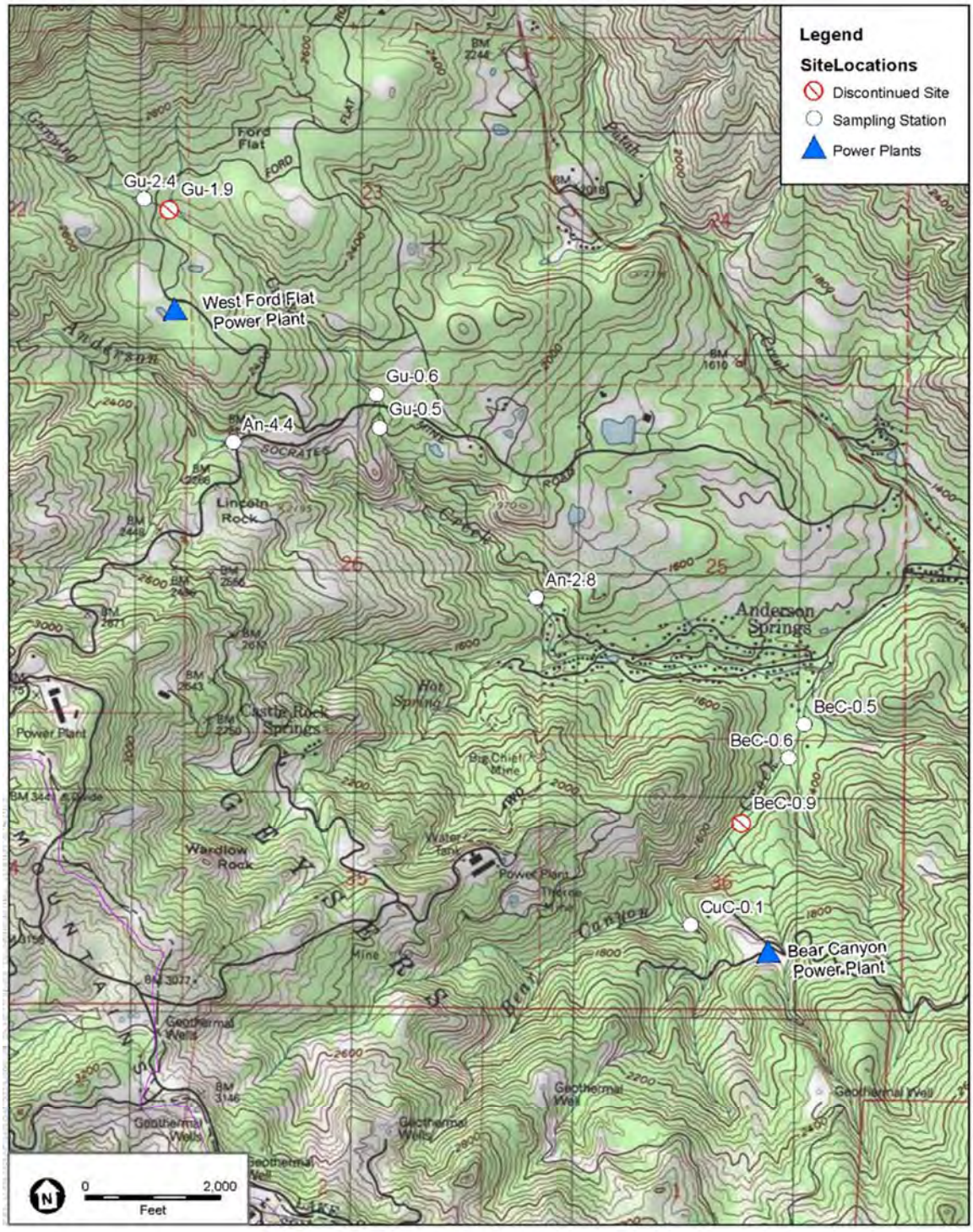
BC/WFF MONITORING STATIONS AND TASKS FOR 2022

Task	An-2.8	An-4.4	Gu-0.5	Gu-0.6	Gu-1.9	Gu-2.4	BeC-0.5	BeC-0.6	BeC-0.9	CuC-0.1
H2O	X	X		X		X	X			X
FISH	X	X	X			X		X		(X)
BMI	X	X	X			X		X		(X)

NOTE: H2O = Water quality, FISH = Fish populations, BMI = Benthic macroinvertebrate populations.

This current report presents and discusses the results of the 2022 BC/WFF monitoring period (i.e., April 2022 through October 2022). Data collected during the previous thirty-four years of BC/WFF monitoring and the preceding Known Geothermal Resources Area – Aquatic Resources Monitoring (KGRA-ARM) study (Karfiol and McMillan, 1983) are also summarized or referenced where appropriate.

On September 12, 2015, the Valley Fire began near Middletown, California, and ultimately burned over 75,000 acres in Lake, Sonoma, and Napa counties. Major areas impacted include Middletown, Hidden Valley, Anderson Springs, and Cobb. The Valley Fire significantly affected Calpine Corporation's BC/WFF operations and infrastructure and extended to all six BC/WFF monitoring program sampling sites. Calpine's West Ford Flat Power plant has been out of operation since the fire.



SOURCE: ESA; USGS

Bear Canyon / West Ford Flat Aquatic Monitoring Program . 980174

Figure I-1
Approximate Locations of Sampling Stations, Discontinued Sites, and Power Plants

II. WATER QUALITY

II.1 Methods

The water quality analyses were conducted according to methodologies described in the KGRA-ARM Program (Karfiol and McMillan, 1983; McMillan, 1985), the Squaw Creek Aquatic Monitoring Program (SCAMP) studies (Jordan *et al.*, 1986, 1987, 1988), and the *Standard Methods for the Examination of Water and Wastewater* (APHA, 1995). The following parameters were measured in the field: temperature, specific conductance, dissolved oxygen, stream flow and hydrogen ion concentration (pH). Furthermore, water samples were collected in the field, preserved if appropriate, and sent to a USEPA-certified analytical laboratory for analysis of the following parameters: total suspended solids, total dissolved solids, turbidity, oil and grease, alkalinity, bicarbonate, carbonate, calcium, magnesium, ammonia, nitrate, sulfate, chloride, total and fecal coliform, aluminum, arsenic, boron, barium, cadmium, chromium, copper, iron, mercury, lead, selenium, vanadium, and zinc. Hardness of the water samples was determined through calculation.

In October 2002, Calpine Corporation staff assumed responsibilities for water quality field measurements and sample collections. During the 2022 monitoring period, Calpine submitted water quality samples to Alpha Analytical Laboratories, Inc., in Ukiah. BC/WFF water quality sample collections for the BC/WFF program were conducted in April, July, and October of 2022. Recent tree fall blocked safe access to sampling site CuC-0.1 in July 2022, preventing the collection of water quality samples at this site during that month.

Tables II.1 through II.3 list the values obtained for the tested parameters during the 2022 monitoring year. It should be noted that Alpha Analytical Laboratories, Inc. has periodically adjusted the reporting limits used for some of the analyses. Reporting limits are the lowest concentration of a given parameter at which the applicable analytical methodology can detect the presence of that constituent (i.e., detection limit). For example, the reporting limit of 0.50 mg/l for chloride indicates that chloride concentrations less than 0.50 mg/l cannot be detected and are reported as “none detected (ND)” by the laboratory. Reporting limits (RL) for each constituent are provided in Tables II.1 through II.3 and should not be confused with regulatory water quality criteria or limits (e.g., acute criterion for chloride is 860 mg/l).

II.2 Results

II.2.1 Physical and Aggregate Properties

Water Temperature

Water temperatures were measured in the field using an Aquacheck Model A51600. Temperature was recorded to the nearest 0.1°C.

Water temperatures naturally fluctuate according to the season and the time of day. High temperatures are critical to aquatic life and reduce the solubility of oxygen, accelerate the metabolism of aquatic organisms, increase the toxicity of heavy metals and alter the species composition within the community (McKee and Wolf, 1963). Rainbow trout (*Oncorhynchus mykiss*) are generally tolerant of a maximum temperature of 24°C according to the USEPA (USEPA, 1986). The preferred temperature range for rainbow/steelhead trout is usually 15 to 18°C, but juveniles regularly persist in water where daytime temperatures reach 26 to 27°C (Moyle, 2002). For example, Kubicek and Price (1976) reported trout at the Geysers to have a maximum temperature tolerance of 26.5°C. However, long-term exposure to temperatures continuously above 24°C is usually lethal (Moyle, 2002).

During the BC/WFF 2022 sampling period, the highest water temperature (18.0°C) was recorded in July at An-2.8 at 11:40. The lowest recorded water temperature was 7.1°C at An-4.4 in April at 09:30. As such, July water temperatures reached the upper end of the preference range of rainbow trout during 2022 BC/WFF sampling but did not exceed the tolerance range.

Specific Conductivity

Specific (temperature compensated) conductivity was measured to the nearest 1 µmhos/cm using an Aquacheck Model A51600.

Specific conductivity is a measure of the capacity of water to conduct an electric current and is a quick method of measuring ion concentration and indicating total dissolved matter and alkalinity. All substances in solution collectively exert osmotic pressure on aquatic organisms. When the osmotic pressure is sufficiently high, water drawn over respiratory membranes and other delicate external organs can cause considerable cell damage. High concentrations of many kinds of pollutants present this danger in addition to any other toxic or corrosive effects they may exhibit (Eckblad, 1978). Streams with mixed fish populations usually have a specific conductance between 150 and 500 µmhos/cm (McKee and Wolf, 1963).

During the BC/WFF 2022 sample period, the lowest conductivity value was 77 µmhos/cm at Gu-2.4 in April. The highest recorded value of 380 µmhos/cm was measured at CuC-0.1 in October. High conductivity values are common in Bear Canyon Creek and Cub Canyon Creek.

Dissolved Oxygen

Dissolved oxygen was measured in the field using an Aquacheck Model A51600. Values were recorded to the nearest 0.1 mg/l.

Dissolved oxygen concentrations vary considerably with water depth, temperature, time of day, flow rate and other natural factors (Eckblad, 1978). Aquatic organisms require dissolved oxygen, and many fish species are limited to a specific concentration range. As discussed by Karfiol and McMillan (1983), and based on the requirements of the fish community, the Central Valley RWQCB (1998) recognized a lower limit of 7.0 mg/l for streams in the Geysers area. Although the USEPA (1986) states 4.0 mg/l as adequate, such a limited amount of dissolved oxygen would have a deleterious effect on salmonids in this area.

The lowest dissolved oxygen concentration of 7.1 mg/l was measured at BeC-0.5 in October. As such, dissolved oxygen concentrations remained above 7 mg/l at all sites on all sampling dates.

Stream Flow

Stream flows were calculated by applying standard cross-sectional area methods (e.g., Platts *et al.*, 1983) using a Marsh-McBirney FLO-MATE Model 2000. Flows are reported to the nearest 0.01 cubic feet per second (cfs).

Water flow in the creeks of the Anderson Creek watershed is largely dependent on rainfall and runoff; there is no snowpack. The higher flows that accompany winter rains flush sediments and debris from the watercourses. Excessive flows can dislocate benthic macroinvertebrates and fish eggs. The rather low summer flows marginally maintain aquatic life in many sections of the watercourses. Reduced summer flows, accompanied by low dissolved oxygen levels and warm water temperatures, can significantly stress fish and other aquatic organisms.

During the 2022 sampling period, the lowest stream flow (0.12 cfs) was measured at CuC-0.1 in October. The highest flow of 2.36 cfs was recorded at An-2.8 in April. Measured streamflow rates in 2022, a thirds consecutive drought year, were generally comparable to flows observed in 2021.

Total Suspended Solids (TSS)

Total suspended solids were measured in mg/l, using standard filtration, drying, and weighing methods (APHA, 1995). The reporting limit for TSS is 1.0 mg/l (Tables II.1 through II.3).

The amount of suspended solids is one measure of watershed erosion. In addition to erosional silt, phytoplankton, zooplankton, and organic detritus are typical components of suspended solids found in natural waters (McMillan, 1985). High concentrations of suspended solids can kill adult fish, smother eggs and fry, reduce primary productivity and alter temperature regimes. Over a period of time, amounts of inert solids in excess of 90 mg/l can be lethal to individual fish, and 270 mg/l may kill 50 percent of some fish populations when exposure is extended for 2 to 12 weeks (McKee and Wolf, 1963).

During the 2022 sampling period, the highest measurement of TSS (6.9 mg/l) was recorded at An-4.4 in April. Most samples throughout the monitoring period contained TSS concentrations in the range of 1-2 mg/l.

Total Dissolved Solids (TDS)

Total dissolved solids were measured in mg/l, using standard filtration, drying, and weighing methods (APHA, 1995). The TDS reporting limit is 10 mg/l (Tables II.1 through II.3).

Total dissolved solids describe, in general terms, the concentrations of dissolved materials in the water which may include a variety of anions (carbonates, sulfates, chlorides, etc.) in combination with metallic cations (calcium, sodium, potassium, etc.) and infers a measure of salinity. The quantity and quality of dissolved solids are major factors determining the variety and abundance of plants and animals in the aquatic system (USEPA, 1986). Waters with more than 500 mg/l

TDS may be unsuitable for irrigation, and 500 mg/l TDS is also the approximate threshold for taste. Common freshwater fish species, however, have been shown to survive 10,000 mg/l dissolved solids (USEPA, 1986).

During 2022, the highest TDS level (210 mg/l) was recorded at CuC-0.1 in April. The lowest level (62 mg/l) was recorded at Gu-2.4 in October.

Turbidity

Turbidity of water samples was determined by the analytical laboratory. The reporting limit for turbidity levels was 0.10 nephelometric turbidity units (NTU) (Tables II.1 through II.3).

Turbidity is a measure of an optical property of water (Thurston *et al*., 1979) and is attributable to suspended and colloidal organic and inorganic matters that affect the penetration of light. For stream water designated for domestic use, the upper limit of 250 NTU has been recommended by McKee and Wolf (1963), who also indicated that turbidity levels over 400 NTU may be harmful to some fish life stages. The effects of high turbidity on aquatic organisms are similar to those of suspended solids.

During the 2022 sampling period, all measured turbidity values were well below the recommended criterion of 250 NTU. The highest recorded turbidity reading was 1.7 NTU, measured at Gu-2.4 in July.

Oil and Grease

Water samples were analyzed for oil and grease by the partition-gravimetric method (APHA, 1995). The reporting limit for the oil and grease analysis is 5.0 mg/l (Tables II.1 through II.3).

Chemicals collectively referred to as oils and greases are not definitive chemical categories, but include thousands of organic compounds with varying physical, chemical, and toxicological properties (USEPA, 1986). Petroleum-based oils and greases are hazardous to aquatic life in even trace amounts while those of animal and vegetable origin are generally nontoxic to most organisms. Because of the difficulty in determining the origin of oil and grease substances, and therefore their toxicity, there are currently no oil and grease criteria for toxicity.

During the 2022 sampling period, the highest oil and grease concentration of 14 mg/l was recorded at Gu-2.4 in July. Oil and grease measurements at this sampling site did not exceed the 5.0 mg/l reporting limit in April or October (Tables II.1 through II.3) and thus there does not appear to be a persistent source of oil and grease contamination.

Alkalinity

Total alkalinity was determined by titration (APHA, 1995) and reported in mg/l as calcium carbonate equivalents. The reporting limit for alkalinity is 5.0 mg/l (Tables II.1 through II.3).

Alkalinity is the sum total of components in the water that tend to elevate the pH (*i.e.,* buffering capacity) of the water above a value of about 4.5. Alkalinity levels above 600 mg/l may be harmful to irrigated crops, and those above approximately 400 mg/l may be a problem to human health (USEPA, 1986). Alkalinity is important to aquatic life because it buffers pH changes and

reduces the toxicity of some heavy metals (McMillan, 1985). There is no maximum criterion for aquatic life, but the USEPA (1986) has established a minimum level of 20 mg/l.

During 2022, as during previous monitoring periods, Gunning Creek stations had the lowest alkalinity levels, ranging from 40 to 45 mg/l. Alkalinity was highest at CuC-0.1; 200 mg/l in April and October. Alkalinity measurements never dropped below the recommended minimum level during the sample period.

Bicarbonate

Bicarbonate was determined by titration (APHA, 1995) and reported in mg/l (as calcium carbonate equivalents). The reporting limit for bicarbonate is 5.0 mg/l (Tables II.1 through II.3).

Bicarbonates may reach water by many natural sources, including absorption of carbon dioxide from the air and decomposition of organic material. Bicarbonates tend to reach an equilibrium with carbonates, and the amount of bicarbonates is dependent on the pH of the water and the concentration of carbonates. In general, bicarbonates are seldom considered to be detrimental, although excessive amounts add to the salinity and total solids of water (McKee and Wolf, 1963). There are no universal standards, but bicarbonate levels of less than 150 mg/l are desirable in drinking water (Hibbard, 1935).

During 2022, bicarbonate levels ranged from 49 mg/l at Gu-2.4 in April to 240 mg/l at CuC-0.1 in April and October.

Carbonate

Carbonate was determined by titration (APHA, 1995) and reported in mg/l (as calcium carbonate equivalents). The reporting limit for carbonate is 5.0 mg/l (Tables II.1 through II.3).

The amount of carbonate in water is a function not only of the substances added but also of the temperature, pH, cations, and other dissolved salts; many carbonates are quite insoluble in water (McKee and Wolf, 1963). There are no generally accepted standards, but on the basis of taste considerations it is desirable for drinking waters to have less than 44 mg/l carbonate.

Carbonate concentrations never exceeded the 5 mg/l reporting limit during the 2022 monitoring period.

Hardness

During the 2021 sampling period, hardness was not analyzed by the analytical laboratory. However, hardness can be computed by multiplying the concentrations of the two primary cations responsible for hardness (Ca, Mg) by a constant to obtain equivalent calcium carbonate concentrations and then summing the equivalents (APHA, 1995). The following calculation was used to determine hardness from the reported calcium and magnesium concentrations:

$$\text{Hardness} = 2.497\ [\text{Ca, mg/l}] + 4.116\ [\text{Mg, mg/l}].$$

Calculated values are expressed in mg/l calcium carbonate and the reporting limit is 1.0 mg/l (Tables II.1 through II.3).

Hardness is dependent primarily on the amount of calcium and magnesium in the water. Samples containing zero to 75 mg/l are classed as soft water, and those with 150 to 300 mg/l are considered hard water (USEPA, 1986). In terms of hardness, good quality domestic waters generally register below 250 mg/l. Water above 500 mg/l is undesirable because of precipitation and scale (Hach, 1983). Hard water tends to precipitate toxic metals as insoluble compounds; and, thus, may reduce negative effects on fish populations and other aquatic organisms. No water quality standards have been established for hardness; however, calculation of hardness allows for more accurate determination of toxicity criteria for some metals. Toxic effects of some metals may be lessened by increased water hardness.

Water hardness calculated during 2022 ranged from a low of 29 mg/l at Gu-2.4 in April to a high of 224 mg/l at CuC-0.1 in October. Waters in Bear Canyon and Cub Canyon creeks are relatively hard, and waters in Anderson and Gunning creeks are relatively soft.

Ammonia

The amount of total ammonia (ionized + unionized), based on ammonia-nitrogen, of the water samples was determined using the automated phenate method (APHA, 1995) and values are reported in milligrams of nitrogen per liter (mg N/l). The reporting limit for this analysis is 0.10 mg N/l (Tables II.1 through II.3).

Ammonia concentrations in water samples naturally occur as a product of organic decomposition. In the Geysers drainages, ammonia may also be contributed by natural geothermal surface activity and industrial geothermal activities, principally cooling tower drift (Ireland and Carter, 1980). The revised USEPA (1999a) criteria for protection of aquatic life are based on the pH and temperature of the water. For waters where early life stages of fish are present, the water temperature is below 14°C, and the pH is 8.0, the chronic criterion (30-days average) is 2.43 mg N/l. The acute criterion (1-hour average) for waters at a pH of 8.0 and containing salmonids is 5.62 mg N/l. Please refer to other pH and temperature-specific criteria in USEPA (1999a). The BC/WFF water quality monitoring involves the collection of one-time grab samples. Thus, neither the 1-hour nor the 30-day average concentrations can be determined.

During 2022, none of the collected samples exceeded the 0.20 mg N/l ammonia reporting limit. Thus, neither the acute nor the chronic criterion was exceeded in the non-averaged grab samples.

The KGRA-ARM study reported values of ammonia in 1981-82 and 1982-83 that ranged from less than 0.02 mg N/l at Anderson, Cub Canyon, and Bear Canyon creeks to 2.0 mg N/l at Gunning Creek. Levels of ammonia for the BC/WFF study were high in 1990-91 (above 1.0 mg N/l) and again in 1992-93 (above 2.0 mg N/l). In October 2006, ammonia concentrations of 3.6 and 2.4 mg N/l were observed at An-4.4 and Gu-0.6, respectively. Ambient water conditions at the time of sample collection included a pH value of 8.0 and water temperature below 14°C. Thus, while the acute criterion of 5.62 mg N/l was not exceeded, the chronic criterion of 2.43 mg N/l was exceeded at An-4.4 and reached at Gu-0.6. A similar result was recorded at Gu-0.6 during the summer of the 2005-2006 monitoring year. The reasons for these unusually high levels of ammonia were not evident, but since April 2007, ammonia concentrations at all sampling sites have been well below established criteria.

Nitrate

Nitrate was measured by an ion chromatography method (APHA, 1995). Levels are reported in milligrams of nitrogen per liter (mg N/l). The reporting limit for this analysis is 1.0 mg N/l (Tables II.1 through II.3).

Nitrates that occur in water are often normal decomposition products of organic materials. Nitrate is also the common form in which nitrogen is added as fertilizer to agricultural crops and revegetation projects. Nitrates may also be present in geothermal steam as a result of ammonia oxidation (McMillan, 1985). The nitrate criterion for domestic water is 10.0 mg N/l (USEPA, 1986). However, tested fish species have proven tolerant of levels that are higher than would be expected in any freshwater body; thus, no criteria are recommended (USEPA, 1986).

During 2022, none of the collected nitrate samples exceeded the 1.0 mg N/l reporting limit.

Sulfate

Sulfate was measured by an ion chromatography method (APHA, 1995). Levels are reported in mg/l and the reporting limit for this analysis is 0.5 mg/l (Tables II.1 through II.3).

Sulfates appear in natural streams in a wide range of concentrations, often because of mineral leaching and the oxidation of sulfurous material associated with mining operations. Sulfate is common in geothermal steam and may also be produced during hydrogen sulfide abatement (McMillan, 1985). According to Ireland and Carter (1980) geothermal units are implicated as significant contributors to the input of sulfate into aquatic systems, and the most probable transport process is cooling tower drift. The USEPA has not set a freshwater criterion, but most waters with healthy populations of game fish have less than 90 mg/l (McKee and Wolf, 1963).

Levels of sulfates during the 2022 sampling year ranged from a high of 11.0 mg/l at BeC-0.5 in April and October to a low of less than the 0.50 mg/l detection limit at Gu-0.6 and Gu-2.4 in July and October. On average, Bear Canyon and Cub Canyon Creek typically contain the highest sulfate levels during a given sampling period, while Gunning Creek consistently contains the lowest levels. Sulfate concentrations recorded during this period were all well below the upper threshold suggested for healthy fish populations.

Chloride

Chloride concentrations were measured by an ion chromatography method (APHA, 1995). Levels are reported in mg/l and the reporting limit for this analysis is 0.50 mg/l (Tables II.1 through II.3).

Chloride is present in nearly all water supplies, usually as a metallic salt. In drinking water, chloride concentrations in excess of 250 mg/l give a salty taste. Chlorides in drinking water are not usually harmful until high concentrations are reached, and large amounts may act corrosively on metal pipes and be harmful to plant life. The USEPA (1988) acute criterion for chloride in freshwater is 860 mg/l and the chronic criterion is 230 mg/l.

Levels of chloride during the 2022 sampling period ranged from a low of 1.1 mg/l at Gu-2.4 in October to a high of 2.7 mg/l at BeC-0.5 in April and July.

Hydrogen Ion Concentration (pH)

Hydrogen ion concentrations (pH) was measured in the field using an Aquacheck Model A51600. Measured values were recorded to the nearest 0.1 pH unit.

The logarithm of the reciprocal of the hydrogen ion concentration is known as pH; consequently, a change of one pH unit represents a tenfold increase in hydrogen ion concentration. The solubility of metals in sediments and suspended material and the toxicity of many compounds are affected by pH. The USEPA (1999) has established a pH range of 6.5 to 9.0 for the protection of freshwater aquatic life.

During 2022, the pH of tested waters ranged from 7.8 at Gu-0.6 in July to 8.6 at CuC-0.1 in April. Neither the lower nor the upper USEPA criterion was surpassed.

II.2.2 Coliform Bacteria

The coliform bacteria, organisms commonly found in human (and other mammalian) feces, comprise all of the aerobic and facultative anaerobic, gram-negative, non-endospore forming, and rod-shaped bacteria which ferment lactose with gas formation within 48 hours at 35°C (APHA, 1995). These organisms are used in the water quality analysis as indicative of fecal waste pollution, because some coliform bacteria are not enteric (found in the digestive system) but are found in plant and soil samples. Therefore, fecal coliform counts are often made to distinguish between the two.

Total coliform and fecal coliform bacteria were measured using multiple tube fermentation techniques as described in Standard Methods (APHA, 1995) and reported as the most probable number (MPN) of bacteria per 100 ml of water sample. The reporting limit for the coliform analysis is 1.8 MPN (Tables II.1 through II.3). Treated or chlorinated drinking water should contain no coliform bacteria per 100 ml of sample (APHA, 1985); coliform bacteria in untreated water samples are to be expected.

Total Coliform

Total coliform levels during the 2022 sampling period ranged from a low of 6.8 MPN at Gu-0.6 in October to highs equaling or exceeding the upper reporting limit of 1,600 MPN at An-2.8, An-4.4 and BeC-0.5 in April, Gu-0.6 in July, and CuC-0.1 in October.

Fecal Coliform

Fecal coliform levels during the 2022 sampling period varied from a low of “none detected” at most sites in April to a high of 350 MPN at BeC-0.5 in July.

High fecal coliform counts, coupled with the high total coliform count, occurred at BeC-0.5 during the dry seasons of 2000 and 2001 (ESA, 2001; ESA 2002). This problem was not evident in 2002 and coliform counts at this site were lower still in July 2002 – April 2003. However, elevated coliform levels in Bear Canyon Creek were again evident in July and October 2003. In 2004, 2005, 2006, no such elevated levels were observed, but high concentrations were again observed in July 2007. High total and fecal coliform counts were once again evident at BeC-0.5 in November 2016 and July 2017, but not in 2018. High fecal coliform counts occurred again in

Bear Canyon Creek in July 2019, 2021, and 2022. Leaking residential septic systems and/or wildlife use (e.g., black bear and deer) are the probable causes of occasionally high coliform levels in the monitored streams.

II.2.3 Element Concentrations

The concentrations of 15 chemical elements in collected water samples were analyzed using inductively coupled plasma (ICP) atomic emission spectrometry and ICP mass spectrometry. Grab samples from midstream and mid-depth were preserved on ice and mailed to the analytical laboratory within 24 hours for acid preservation and analysis. Results are reported in milligrams per liter (mg/l) unless otherwise stated. The reporting limits for each parameter, as well as the results of the individual analyses, are presented in Tables II.1 through II.3. Where appropriate, comparisons have been made to selected elements for stations on Anderson, Gunning, and Bear Canyon creeks in the KGRA-ARM report (McMillan, 1985) for the sampling years 1981-82 and 1982-83.

Calcium (Ca)

Calcium is an essential macronutrient for both plants and animals. It is the fifth most common element and is considered to be nontoxic. Calcium is present in most natural water at concentrations from zero to several hundred milligrams (APHA, 1985). Calcium is customarily added to water as it passes through or over calcium-rich geologic formations. Calcium contributes substantially to the hardness of water. Large amounts of calcium salts may precipitate in pipes and boilers as an undesirable scale. There are no established water quality standards for this element.

During 2022, calcium levels ranged from 6.8 mg/l at Gu-2.4 in April to 27 mg/l at BeC-0.5 in July and October, as well as at CuC-0.1 in October.

Among the streams monitored, Gunning Creek typically contains the least calcium, while Bear Canyon Creek and Cub Canyon Creek contain the most.

Magnesium (Mg)

Magnesium is an essential macronutrient for plants and animals and is the eighth most abundant earth element. It is a common constituent of water and contributes significantly to hardness properties. Natural concentrations in surface water may range from zero to several hundred milligrams per liter. Concentrations in excess of 125 mg/l can have a cathartic and diuretic effect on humans (APHA, 1985).

During 2022, magnesium levels ranged from a low of 2.9 mg/l at Gu-2.4 in April to a high of 38 mg/l at CuC-0.1 in October.

In general, the amounts of magnesium in the surface waters of the study area are typically low in Gunning Creek, moderate in Andersen Creek, and higher in Bear Canyon and Cub Canyon creeks.

Aluminum (Al)

Aluminum is the third most abundant metallic element in the earth's crust. The element is not known to have a nutritional function in organisms and may be toxic to life in high concentrations and acidic environments (Lepp, 1981). McKee and Wolf (1963) suggest an upper limit of 0.07 mg/l for the protection of fish and their ova, and the USEPA (2006) recommends a chronic criterion of 0.087 mg/l and an acute criterion of 0.75 mg/l. However, USEPA (2006) also notes that "many high-quality waters in the U.S. contain more than 0.087 mg/l aluminum."

During the 2022 sampling period, the highest recorded aluminum concentration of 0.300 mg/l occurred at An-4.4 in April. As such, the USEPA-recommended acute criterion was not exceeded during the monitoring period. However, the sampling frequency used for the BC/WFF program is insufficient for a determination of compliance with, or exceedance of, the chronic criterion.

The KGRA-ARM study showed values in 1981-1982 and 1982-1983 that ranged from less than 0.006 mg/l of aluminum on Gunning Creek to 4.0 mg/l on Anderson Creek. Since 1990, aluminum levels have, for the most part, decreased substantially at all BC/WFF stations. Slight increases in aluminum concentrations (as high as 0.285 mg/l) were detected during 1994-1995 on Bear Canyon and Cub Canyon creeks. Gunning Creek also had elevated aluminum concentrations during 2005-2006, and again in July 2013, 2014, and 2016. Anderson Creek had elevated aluminum concentrations during the 2005-2006, 2006-2007, 2007-2008, 2011-2012, 2012-2013, and 2016 monitoring periods, and again in 2022. The reasons for the occasional observed increases in aluminum concentrations at BC/WFF stations are unclear.

Arsenic (As)

Arsenic seldom occurs in drinking water above 0.010 mg/l (APHA, 1985). Arsenic is naturally found in the Geysers environment, and it is present in steam condensate, cooling water and cooling tower sludge (McMillan, 1985; Borgias, 1982). Arsenic is a known carcinogen and a poison. Poisoning in humans may occur from arsenic accumulation in the body at low intake levels. Although water hardness does not affect arsenic toxicity, higher temperatures may increase toxicity. According to the USEPA (1986) aquatic life may be adversely affected if the one-hour average of arsenic (III) concentration exceeds 0.360 mg/l more than once every three years. The analytical method used does not distinguish between the different forms of arsenic, therefore detected levels are assumed to be the most toxic form, arsenic (III). California State Department of Health Services (CSDOH) (1977) states a maximum contaminant level for arsenic of 0.050 mg/l in drinking water.

During the 2022 monitoring period, recorded arsenic concentrations never exceeded the 0.002 mg/l reporting limit. Thus, the USEPA criterion was not exceeded.

The KGRA-ARM study showed values of arsenic in 1981-1982 and 1982-1983 that ranged from less than 0.002 mg/l on Anderson, Gunning, and Bear Canyon creeks to a high of 0.004 mg/l on Bear Canyon Creek. Although arsenic levels were relatively high for the BC/WFF study in 1990 and 1991 (up to 0.05 mg/l) for Anderson, Bear Canyon and Cub Canyon creeks, recorded concentrations have generally been low since 1992.

Barium (Ba)

Barium is a yellowish-white metal of the alkaline earth group. It occurs in nature chiefly as barite and witherite, both of which are highly insoluble salts. Many of the salts of barium are soluble in both water and acid, and soluble barium salts are reported to be poisonous (USEPA, 1986). However, barium ions generally are thought to be rapidly precipitated or removed from solution by absorption and sedimentation (McKee and Wolf, 1963). The fatal dose of barium for humans is reported to be 550 to 600 mg (USEPA, 1986). The acceptable barium limit for human health is 2 mg/l, but concentrations would have to exceed 50 mg/l before toxicity to aquatic life would be expected (USEPA, 1986).

During 2022, the highest recorded barium concentration was 0.110 mg/l at An-4.4 in April and July. Therefore, all measured barium concentrations were well below the USEPA recommendation for aquatic life.

In the past, barium concentrations were typically less than the 0.10 mg/l reporting limit. However, the use of a significantly lower reporting limit (0.002 mg/l) by Alpha Analytical Laboratories, Inc. has resulted in consistently measurable barium concentrations.

Boron (B)

Boron is commonly associated with natural geothermal waters and the production of geothermal steam. Although small amounts of boron are essential for plant growth, concentrations in irrigation water in excess of 0.5 mg/l may harm sensitive species; yet, 0.75 mg/l is safe for most plants (Marshack, 1985). Localized boron toxicity to woody vegetation as a result of steam fallout was documented at the Geysers during the early years of geothermal development (Malloch *et al*., 1979). However, continued boron drift monitoring has shown a steady decrease in boron concentrations in plants surrounding geothermal power plants (LandWatch, 2003). Furthermore, 20 years of monitoring have revealed no significant impacts to nearby vegetation (LandWatch, 2003). Boron is not generally considered to be a health hazard to humans and animals (Nolte and Associates, 1985). Drinking water concentrations of less than 0.1 mg/l are generally considered innocuous (APHA, 1985).

During 2022, the highest reported boron concentration of 0.64 mg/l occurred at An-2.8 in July. Therefore, all measured boron concentrations were generally lower than the amount safe for plants although the April concentration at An-2.8 may be considered harmful to sensitive plant species.

Cadmium (Cd)

Cadmium is highly toxic to humans and other animals. A concentration of 0.002 mg/l has been found to be lethal to certain fish, and minute quantities of cadmium are suspected of causing certain cancers and adverse changes in human arteries and kidneys (APHA, 1985). Drinking waters in the U.S. have a mean of about 0.008 mg/l cadmium. USEPA (1986) human health criterion for the ingestion of water containing cadmium is 0.010 mg/l. The criteria for the protection of aquatic organisms are dependent on hardness. For example, at a water hardness of 100 mg/l calcium carbonate the 4-day average of total recoverable cadmium should not exceed

1.1 µg/l (=0.0011 mg/l), and at a hardness of 200 mg/l cadmium should not exceed 2.0 µg/l (=0.002 mg/l) more than once every three years (USEPA, 1986).

During the 2022 sampling year, recorded cadmium concentrations never exceeded the 0.0004 mg/l reporting limit. Therefore, established cadmium criteria were never exceeded.

The KGRA-ARM study showed cadmium levels for 1981-1982 and 1982-1983 that ranged from less than 0.003 mg/l to less than 0.001 mg/l in Anderson, Gunning, and Bear Canyon creeks. For the BC/WFF study, stations on Anderson, Gunning and Bear Canyon creeks frequently had cadmium levels above 0.01 mg/l in 1988 and 1989. However, from 1989 through 2022, cadmium levels have been well below 0.01 mg/l.

Chromium (Cr)

Chromium is a toxic metal and a suspected carcinogen. Hexavalent chromium is more toxic to humans and aquatic life than is the trivalent form. Chromium may occur in natural water in both forms but is usually found in the hexavalent state. The method used for the analysis of chromium did not distinguish between molecular species; thus, values reported for BC/WFF reflect total chromium. According to Marshack (1985) criteria for hexavalent chromium should be used when chromium valence is not known. For the protection of freshwater organisms, the concentration of hexavalent chromium should not exceed 0.016 mg/l on a one-hour average, and 0.011 mg/l on a four-day average, more than once every three years (USEPA, 1986).

During 2022, the analytical laboratory used a 0.0005 mg/l reporting limit for the July and October sample, but a higher limit of 0.002 mg/l in April. Chromium concentrations in July and October ranged from a low of 0.0006 mg/l at Gu-0.6 in October to a high of 0.0026 mg/l at CuC-0.1 in October. All April samples were below the 0.002 mg/l detection limit. BC/WFF water quality monitoring involves the collection of one-time grab samples. Thus, neither the one-hour nor the four-day average concentrations can be determined. However, the October sample at CuC-0.1 may have exceeded one or both criteria for the protection of freshwater organisms if the recorded concentration persisted for a one-hour or four-day period.

In 1994-1995, the criterion was surpassed at An-2.8 (0.013 mg/l) and BeC-0.5 (0.027 mg/l) in October.

Copper (Cu)

Copper is an essential micronutrient for both plants and animals. Copper salts, in quantities exceeding physiological demands, are also used to control algal growths in water supplies. The recommended USEPA (1986) criterion for protection of freshwater aquatic life is dependent on water hardness. For example, the one-hour average concentration of copper should not exceed 0.018 mg/l at a hardness of 100 mg/l calcium carbonate and 0.034 mg/l at a hardness of 200 mg/l; the four-day average concentration of copper should not exceed 0.012 mg/l at a hardness of 100 mg/l calcium carbonate and 0.021 mg/l at a hardness of 200 mg/l, respectively. The USEPA (1986) drinking water standard, based on taste and odor, is 1.0 mg/l.

During 2022, none of the samples exceeded the 0.002 mg/l detection limit. BC/WFF water quality monitoring involves the collection of one-time grab samples. Thus, neither the one-hour nor the four-day average concentrations can be determined. Nevertheless, the criteria for the protection of freshwater organisms were never exceeded at the time of sampling.

The KGRA-ARM study showed levels of copper for 1981-82 and 1982-83 that ranged from less than 0.002 mg/l on Anderson, Gunning and Bear Canyon creeks to 0.008 mg/l on Anderson Creek. In the BC/WFF study copper levels were fairly high in 1989, reaching levels above 0.01 mg/l on Anderson Creek. Copper levels were lower (never greater than 0.008 mg/l) from 1991 through early 1993 at all stations. In mid-1993, there was a single occurrence of an elevated copper level (0.018 mg/l) on Anderson Creek, though subsequent recorded concentrations from late 1993 through 2022 have not exceeded 0.01 mg/l.

Iron (Fe)

Iron is an essential macronutrient for both plants and animals. This element occurs universally in natural waters, commonly in minor amounts. Iron can enter watercourses by leaching of natural deposits, from iron-bearing industrial wastes or emissions, and from acidic mine wastes (Hach, 1983). Iron compounds are sometimes used in hydrogen sulfide abatement associated with geothermal energy production. Iron precipitates can be detrimental to aquatic life (McMillan, 1985). A maximum level of 1 mg/l has been set by the USEPA (1986) for the protection of freshwater aquatic life, and on the basis of taste and aesthetics an upper limit of 0.300 mg/l has been recommended for domestic water supplies.

During 2022, the analytical laboratory used a 0.05 mg/l reporting limit for the July and October samples, but a higher limit of 0.2 mg/l in April. The highest iron concentration of 0.37 mg/l was recorded at An-4.4 in April. Thus, all obtained values were below the USEPA criterion for the protection of aquatic life.

The KGRA-ARM study reported values for iron in 1981-82 and 1982-83 that ranged from 0.03 mg/l on Gunning Creek to 2.0 mg/l on Anderson Creek. Although iron levels were relatively high during the 1990-91 BC/WFF sampling period (high of 0.711 mg/l), values have generally remained below 0.5 mg/l since 1992.

Lead (Pb)

Lead is a toxic element that accumulates in animals. Lead is present in geothermal steam condensates (Borgias, 1982) and may be added to water supplies via lead-rich geologic deposits. Lead tends to be precipitated by numerous substances, effectively reducing levels found in flowing water. Natural waters seldom have more than 0.02 mg/l, although lead values up to about 0.4 mg/l have been reported (APHA, 1985). Lead toxicity in the aquatic environment is influenced by pH, alkalinity, and hardness. McKee and Wolf (1963) have reported lead poisoning in humans to be caused by drinking water with as low as 0.042 mg/l lead. The lead criteria for protection of freshwater aquatic life as proposed by the USEPA (1986) are dependent on water hardness and duration of exposure. For example, at a hardness of 100 mg/l calcium carbonate, the concentration of lead should not exceed 0.082 mg/l on a one-hour average, and 0.0032 mg/l on a four-day average, more than once every three years. At a hardness of 200 mg/l, the criteria

increase to 0.200 and 0.0077 mg/l, respectively. A lead concentration of 0.050 mg/l has been established for domestic water supplies (USEPA, 1986).

During 2022, none of the water samples contained lead levels above the 0.001 mg/l reporting limits. Although BC/WFF water quality monitoring uses non-averaged grab sampling, the lead criteria for protection of freshwater aquatic life are unlikely to have been exceeded.

The KGRA-ARM study showed lead values in 1981-82 and 1982-83 that ranged from less than 0.001 mg/l on Anderson, Gunning and Bear Canyon creeks to 0.002 mg/l on Gunning Creek. Although lead levels were relatively high in the BC/WFF study for much of 1988 and 1990 (>0.05 mg/l), levels have remained low from 1990 through 2022.

Mercury (Hg)

Organic and inorganic mercury salts are very toxic (APHA, 1985), and mercury is naturally associated with geothermal surface waters. In the past, mercury mining occurred in many places in the Geysers region, including the Anderson Creek drainage. Mercury is present in geothermal steam condensate, cooling water and cooling tower sludge (McMillan, 1985). The USEPA (1986) criteria for the protection of freshwater organisms are dependent on duration of exposure. For example, the concentration of mercury (II) should not exceed 0.0024 mg/l on a one-hour average and 0.00012 mg/l on a four-day average, more than once over a three-year period. The analytical method used does not distinguish between the different forms of mercury, therefore detected levels are assumed to be the most toxic form, mercury (II). CSDOH (1977) states that 0.002 mg/l mercury is the maximum contaminant level for water used continually for drinking or culinary purposes.

During the 2022 sampling period, mercury concentrations did not exceed 0.0002 mg/l reporting limit. The 1-hour criterion for the protection of freshwater organisms was not exceeded during the sampling period. However, as the reporting limit for mercury analysis is slightly higher than the four-day average criterion, and due to the non-averaging grab sample nature of the monitoring program, compliance with the four-day average criterion could not be determined.

Brown and Caldwell Consulting (1985) reported a single occurrence of an elevated mercury level (0.0048 mg/l) on Gunning Creek. The KGRA-ARM report showed values for 1981-1982 and 1982-1983 that ranged from less than 0.0001 mg/l on Anderson and Bear Canyon creeks to a high of 0.0005 mg/l on Bear Canyon Creek.

Selenium (Se)

Excessive selenium may present a health hazard to humans. Selenium has been reported to affect normal embryo development in domestic animals (USEPA, 1980), and it may similarly affect fish and wildlife (Davis *et al*., 1988). Tissue concentrations of selenium in excess of 2 mg/l may cause toxic effects in sensitive species of fish. However, small quantities of selenium are beneficial, and its role as an essential micronutrient is assumed for humans and other animals. For selenium, the USEPA (1986) has established a drinking water standard of 10 µg/l (=0.010 mg/l) for the protection of public health. However, the analytical methods employed did not distinguish

elemental selenium from the more toxic selenite form of selenium. The aquatic life criterion for exposure to selenite is 35 µg/l (=0.035 mg/l) as a 24-hour average.

During 2022, none of the water samples contained selenium levels above the 0.008 mg/l reporting limit. Although BC/WFF water quality monitoring uses non-averaged grab sampling, the selenium criterion for protection of freshwater aquatic life is unlikely to have been exceeded.

The KGRA-ARM study showed selenium values for 1981-82 and 1982-83 that ranged from less than 0.002 mg/l on Anderson, Gunning and Bear Canyon creeks to a high of 0.004 mg/l on Bear Canyon Creek. For the BC/WFF study, selenium levels on Anderson, Gunning and Bear Canyon creeks were relatively high in 1988, 1989, and 1990 (greater than 0.15 mg/l), but values remained low from 1991 through 2021. In October 2009, one selenium sample exceeded the lower reporting limit (0.0094 mg/l at BeC-0.5), but the level was not high enough to exceed the drinking water standards (ESA, 2010).

Vanadium (V)

Vanadium is a common element in soils, and some of its compounds may benefit humans by reducing dental caries and blood cholesterol levels (McMillan, 1985). However, vanadium pentoxide, which has been used in hydrogen sulfide abatement at the Geysers, can cause gastrointestinal and respiratory disturbances (APHA, 1985). Although vanadium is present in geothermal sludge (Borgias, 1982), it is not known if this element is present in cooling tower drift. In the U.S., drinking water supplies have a mean concentration of 0.006 mg/l. Fish may be adversely affected by as little as 4.8 mg/l in soft water and 30 mg/l in hard water (McKee and Wolf, 1963). The USEPA's estimated permissible ambient goal, based on health, is 0.007 mg/l (USEPA, 1986).

During 2022, none of the samples exceeded the 0.003 mg/l reporting limit for vanadium. Thus, vanadium levels remained well below the levels that could affect fish during all sampling events.

Zinc (Zn)

Zinc is an element essential for human growth and for many aquatic organisms. The mean zinc concentration in U.S. drinking waters is 1.33 mg/l; when in concentrations greater than 5 mg/l it affects taste. Acute toxicity of aquatic organisms has been demonstrated in concentrations as low as 0.090 mg/l, and a 24-hour criterion of 0.047 mg/l has been suggested for the protection of freshwater organisms (USEPA, 1986). In the Geysers region, additional zinc may be added to surface waters by deterioration of galvanized iron, runoff from mine tailings, input from hot springs and fallout from geothermal steam.

None of the 2022 water samples contained zinc levels above the 0.02 mg/l reporting limit. Therefore, the USEPA criterion of 0.047 mg/l for the protection of freshwater organisms was not exceeded.

The KGRA-ARM study showed zinc concentrations in 1981-1982 and 1982-1983 that ranged from less than 0.001 mg/l on Anderson, Gunning and Bear Canyon creeks to 0.06 mg/l on Gunning Creek. Zinc levels for the BC/WFF study were sporadically above 0.04 mg/l in 1988-89

on Anderson, Bear Canyon, and Gunning creeks, and also in 1990 on Bear Canyon and Gunning creeks. Levels of zinc above 0.1 mg/l were reached in 1988 on Gunning Creek and in 1992 on Bear Canyon and Cub Canyon creeks. During late 1994, zinc levels exceeded 0.1 mg/l on Anderson, Gunning, Bear Canyon, and Cub Canyon creeks.

II.3 Discussion

As during prior years, the results of the 2022 BC/WFF water quality analyses are again reflective of the relatively undisturbed conditions in the Anderson Creek watershed. All sampled parameters were below applicable water quality criteria established by the USEPA.[1] The Valley Fire burned much of the BC/WFF sampling area in September 2015. Nevertheless, no significant long-term, post-fire water quality effects are apparent from the available data.

After 35 years of BC/WFF water quality sampling, the current laboratory analyses of total suspended solids, total dissolved solids, turbidity, oil and grease, alkalinity, bicarbonate, carbonate, calcium, magnesium, ammonia, nitrate, sulfate, chloride, total and fecal coliform, aluminum, arsenic, boron, barium, cadmium, chromium, copper, iron, mercury, lead, selenium, vanadium, and zinc no longer appear to be warranted. Long-term geothermal operations in the Anderson Creek watershed have been documented to have little to no effect on these parameters. Moreover, the currently permitted schedule of three grab sampling events per year would be highly unlikely to detect short-term effects of accidental releases of pollutants. We therefore recommend that sampling for these parameters be eliminated from the BC/WFF program. Furthermore, we recommend that the frequency of field measurements of parameters such as streamflow, dissolved oxygen concentration, water temperature, and conductivity be reduced to once a year and be conducted concurrent with fish surveys. Physical water quality measurements provide important information about the habitat quality conditions fish are exposed to at the time of the surveys.

[1] Water quality criteria testing performed by Alpha Analytical Labs, Inc., used standard USEPA testing methodologies. These include the methodology for metals by EPA 200 Series Methods; conventional chemistry parameters by APHA/EPA Methods; Aluminum by total ICP 200.7 EPA; Chromium by total ICP 200.7 EPA; pH by SM4500; Solids by TSS-SM2540D.

TABLE II.1

WATER QUALITY ANALYSES RESULTS, APRIL 2022

Parameter	RL	An-2.8	An-4.4	Gu-0.6	Gu-2.4	BeC-0.5	CuC-0.1	Mean
Date	---	4/12	4/12	4/12	4/12	4/12	4/12	---
Time	---	1130	0930	1045	1000	1115	0845	---
Air Temp (°C)	**0.1**	3.3	5.0	12.2	5.0	12.8	5.6	**7.3**
Water Temp (°C)	**0.1**	9.1	7.1	8.0	8.5	7.3	9.4	**8.2**
Conduct. (µmhos/cm)	**1**	180	180	83	77	280	320	**187**
DO Conc. (mg/l)	**0.1**	10.3	11.8	9.6	9.2	8.9	11.1	**10.2**
DO Sat. (%)	**1**	90	99	82	80	81	99	**89**
Flow (cfs)	**0.01**	2.36	0.41	1.25	0.66	0.88	0.40	**0.99**
TSS (mg/l)	**1.0**	1.1	6.9	1.9	1.2	ND	ND	**1.9**
TDS (mg/l)	**10**	120	120	84	68	160	210	**127**
Turbidity (NTU)	**0.10**	0.79	4.0	0.61	0.72	1.4	0.44	**1.33**
Oil & Grease (mg/l)	**5.0**	1.4	ND	ND	ND	ND	5.0	**ND**
Alkalinity (mg/l)	**5.0**	82	92	42	40	140	200	**99**
Bicarbonate (mg/l)	**5.0**	100	110	51	49	180	240	**122**
Carbonate (mg/l)	**5.0**	ND	ND	ND	ND	ND	ND	**ND**
Hardness (mg/l)	**1**	80	86	31	29	156	192	**96**
Ca (mg/l)	**1.0**	14	18	7.3	6.8	23	21	**15**
Mg (mg/l)	**1.0**	11	10	3.2	2.9	24	34	**14**
Ammonia (mg/l)	**0.20**	ND	ND	ND	ND	ND	ND	**ND**
Nitrate (mg N/l)	**1.0**	ND	ND	ND	ND	ND	ND	**ND**
Sulfate (mg/l)	**0.50**	9.4	7.2	0.73	0.56	11.0	5.8	**5.8**
Chloride (mg/l)	**0.50**	1.7	1.8	1.4	1.2	2.7	2.4	**1.9**
pH (pH units)	**0.1**	8.4	8.2	7.9	7.9	8.2	8.6	**8.2**
Total Coliform (MPN)	**1.8**	>1600	540	220	920	1600	110	**>831**
Fecal Coliform (MPN)	**1.8**	94	ND	ND	4.5	ND	ND	**16**
Al (mg/l)	**0.040**	0.066	0.300	0.041	0.061	0.064	ND	**0.089**
As (mg/l)	**0.002**	ND	ND	ND	ND	ND	ND	**ND**
Ba (mg/l)	**0.002**	0.051	0.089	0.018	0.010	0.068	0.055	**0.049**
B (mg/l)	**0.200**	ND	ND	ND	ND	ND	ND	**ND**
Cd (mg/l)	**0.0004**	ND	ND	ND	ND	ND	ND	**ND**
Cr (mg/l)	**0.0020**	ND	0.0020	ND	ND	ND	0.0027	**ND**
Cu (mg/l)	**0.002**	ND	ND	ND	ND	ND	ND	**ND**
Fe (mg/l)	**0.200**	ND	0.370	ND	ND	ND	ND	**ND**
Pb (mg/l)	**0.001**	ND	ND	ND	ND	ND	ND	**ND**
Hg (mg/l)	**0.0002**	ND	ND	ND	ND	ND	ND	**ND**
Se (mg/l)	**0.008**	ND	ND	ND	ND	ND	ND	**ND**
V (mg/l)	**0.003**	ND	ND	ND	ND	ND	ND	**ND**
Zn (mg/l)	**0.02**	ND	ND	ND	ND	ND	ND	**ND**

NOTE: RL = Reporting Limit; ND = None Detected at RL; NA = Not Available; --- = Not Applicable.

TABLE II.2

WATER QUALITY ANALYSES RESULTS, JULY 2022

Parameter	RL	An-2.8	An-4.4	Gu-0.6	Gu-2.4	BeC-0.5	CuC-0.1	Mean
Date	---	7/13	7/13	7/13	7/13	7/13	NA	---
Time	---	1140	0940	1040	1010	1110	NA	---
Air Temp (°C)	**0.1**	26.1	20.0	21.1	20.6	23.9	NA	**22.3**
Water Temp (°C)	**0.1**	18.0	15.7	14.3	13.0	17.4	NA	**15.7**
Conduct. (µmhos/cm)	**1**	140	190	86	82	310	NA	**162**
DO Conc. (mg/l)	**0.1**	8.8	8.9	9.3	9.7	8.0	NA	**8.9**
DO Sat. (%)	**1**	94	91	93	93	85	NA	**91**
Flow (cfs)	**0.01**	0.80	0.48	0.65	1.10	0.27	NA	**0.66**
TSS (mg/l)	**1.0**	1.9	1.3	2.9	5.6	1.0	NA	**2.5**
TDS (mg/l)	**10**	130	140	93	91	200	NA	**131**
Turbidity (NTU)	**0.10**	1.6	0.33	4.0	1.7	0.34	NA	**1.59**
Oil & Grease (mg/l)	**5.0**	ND	ND	ND	14	ND	NA	**ND**
Alkalinity (mg/l)	**5.0**	72	96	45	41	170	NA	**85**
Bicarbonate (mg/l)	**5.0**	88	120	55	50	210	NA	**105**
Carbonate (mg/l)	**5.0**	ND	ND	ND	ND	ND	NA	**ND**
Hardness (mg/l)	**1**	65	91	33	32	187	NA	**82**
Ca (mg/l)	**1.0**	12	20	7.8	7.6	27	NA	**15**
Mg (mg/l)	**1.0**	8.5	10	3.4	3.2	29	NA	**11**
Ammonia (mg/l)	**0.50**	ND	ND	ND	ND	ND	NA	**ND**
Nitrate (mg N/l)	**1.0**	ND	ND	ND	ND	ND	NA	**ND**
Sulfate (mg/l)	**0.50**	2.1	6.8	ND	ND	10.0	NA	**3.8**
Chloride (mg/l)	**0.50**	1.6	1.7	1.3	1.2	2.7	NA	**1.7**
pH (pH units)	**0.1**	8.3	8.0	7.8	7.9	7.9	NA	**8.0**
Total Coliform (MPN)	**1.8**	350	540	>1600	540	920	NA	**>790**
Fecal Coliform (MPN)	**1.8**	23	170	ND	7.8	350	NA	**110**
Al (mg/l)	**0.010**	0.040	0.040	0.150	0.110	0.044	NA	**0.077**
As (mg/l)	**0.002**	ND	ND	ND	ND	ND	NA	**ND**
Ba (mg/l)	**0.002**	0.048	0.110	0.021	0.011	0.093	NA	**0.057**
B (mg/l)	**0.200**	0.64	ND	ND	ND	ND	NA	**ND**
Cd (mg/l)	**0.0004**	ND	ND	ND	ND	ND	NA	**ND**
Cr (mg/l)	**0.0005**	0.0013	0.0009	0.0012	0.0007	0.0014	NA	**0.0011**
Cu (mg/l)	**0.002**	ND	ND	ND	ND	ND	NA	**ND**
Fe (mg/l)	**0.050**	ND	0.078	0.120	0.110	0.120	NA	**0.086**
Pb (mg/l)	**0.001**	ND	ND	ND	ND	ND	NA	**ND**
Hg (mg/l)	**0.0002**	ND	ND	ND	ND	ND	NA	**ND**
Se (mg/l)	**0.008**	ND	ND	ND	ND	ND	NA	**ND**
V (mg/l)	**0.003**	ND	ND	ND	ND	ND	NA	**ND**
Zn (mg/l)	**0.02**	ND	ND	ND	ND	ND	NA	**ND**

NOTE: RL = Reporting Limit; ND = None Detected at RL; NA = Not Available; --- = Not Applicable.

TABLE II.3

WATER QUALITY ANALYSES RESULTS, OCTOBER 2022

Parameter	RL	An-2.8	An-4.4	Gu-0.6	Gu-2.4	BeC-0.5	CuC-0.1	Mean
Date	---	10/20	10/20	10/20	10/20	10/20	10/20	---
Time	---	1240	1055	1140	1120	1215	0930	---
Air Temp (°C)	**0.1**	26.1	17.8	26.1	25.6	18.3	14.4	**21.4**
Water Temp (°C)	**0.1**	14.9	13.1	12.7	12.5	13.8	13.7	**13.5**
Conduct. (µmhos/cm)	**1**	140	200	90	80	330	380	**203**
DO Conc. (mg/l)	**0.1**	9.9	9.4	9.2	9.8	7.1	7.7	**8.9**
DO Sat. (%)	**1**	95	90	87	93	84	96	**91**
Flow (cfs)	**0.01**	0.88	0.36	1.10	1.63	0.34	0.12	**0.74**
TSS (mg/l)	**1.0**	1.5	5.7	ND	1.8	ND	ND	**1.5**
TDS (mg/l)	**10**	100	120	87	62	160	200	**122**
Turbidity (NTU)	**0.10**	0.95	0.65	0.60	1.1	ND	ND	**0.55**
Oil & Grease (mg/l)	**5.0**	ND	ND	ND	ND	ND	ND	**ND**
Alkalinity (mg/l)	**5.0**	63	89	44	41	160	200	**100**
Bicarbonate (mg/l)	**5.0**	77	110	54	50	190	240	**120**
Carbonate (mg/l)	**5.0**	ND	ND	ND	ND	ND	ND	**ND**
Hardness (mg/l)	**1**	57	88	34	31	179	224	**102**
Ca (mg/l)	**1.0**	11	19	8.0	7.4	27	27	**17**
Mg (mg/l)	**1.0**	7.1	9.8	3.5	3.1	27	38	**15**
Ammonia (mg/l)	**0.50**	ND	ND	ND	ND	ND	ND	**ND**
Nitrate (mg N/l)	**1.0**	ND	ND	ND	ND	ND	ND	**ND**
Sulfate (mg/l)	**0.50**	1.8	6.0	ND	ND	11	9.9	**4.8**
Chloride (mg/l)	**0.50**	1.4	1.8	1.2	1.1	2.3	2.2	**1.7**
pH (pH units)	**0.1**	8.3	8.2	7.9	7.9	7.9	8.5	**8.1**
Total Coliform (MPN)	**1.8**	540	240	6.8	350	240	>1600	**>496**
Fecal Coliform (MPN)	**1.8**	7.8	33	ND	6.8	79	79	**34**
Al (mg/l)	**0.010**	0.016	0.097	0.011	0.030	0.014	0.110	**0.046**
As (mg/l)	**0.002**	ND	ND	ND	ND	ND	ND	**ND**
Ba (mg/l)	**0.002**	0.041	0.110	0.017	0.010	0.085	0.085	**0.058**
B (mg/l)	**0.200**	ND	0.200	ND	ND	0.220	0.260	**ND**
Cd (mg/l)	**0.0004**	ND	ND	ND	ND	ND	ND	**ND**
Cr (mg/l)	**0.0005**	0.0011	0.0014	0.0006	0.0010	0.0014	0.0026	**0.0014**
Cu (mg/l)	**0.002**	ND	ND	ND	ND	ND	ND	**ND**
Fe (mg/l)	**0.050**	0.100	0.270	0.059	0.088	0.240	0.230	**0.165**
Pb (mg/l)	**0.001**	ND	ND	ND	ND	ND	ND	**ND**
Hg (mg/l)	**0.0002**	ND	ND	ND	ND	ND	ND	**ND**
Se (mg/l)	**0.008**	ND	ND	ND	ND	ND	ND	**ND**
V (mg/l)	**0.003**	ND	ND	ND	ND	ND	ND	**ND**
Zn (mg/l)	**0.02**	ND	ND	ND	ND	ND	ND	**ND**

NOTE: RL = Reporting Limit; ND = None Detected at RL; NA = Not Available; --- = Not Applicable.

III. FISH POPULATIONS

The study of fish populations in conjunction with water quality measurement is a particularly valuable component of a monitoring program for several reasons. Physical and chemical water parameters vary significantly between samplings; as a consequence, extreme conditions may not be recorded. Fish, however, are continuously exposed to variations in water quality and are indicators of the long-term "health" of a stream. Collection of fish population data over several years from different stations in the project area helps to identify places that support year-round breeding populations of both game and non-game species.

The Anderson Creek watershed is located in the Mayacmas Mountains of southwestern Lake County and forms a tributary to upper Putah Creek, which flows into Lake Berryessa. Thus, the Anderson Creek watershed is not accessible to anadromous salmonids such as steelhead (*Oncorhynchus mykiss*).

III.1 Methods

Fish monitoring was conducted during the month of July, as directed by Lake County agencies, because previous KGRA-ARM data (Karfiol and McMillan, 1983) were also collected in July and because that period was deemed late enough in the trout's reproductive season to estimate spawning success for the entire year (McKean *et al.*, 1998). Sampling procedures are those described in Karfiol and McMillan (1983) and Jordan *et al.* (1986) and are standard for fisheries research. The process involved the placement of blocking nets on the upstream and downstream ends of a 30-meter stretch of stream. Fish populations were surveyed using a standard multi-pass depletion method. Statistical population estimates were calculated using the Microfish 3.0 computer program (Van Deventer and Platts, 1988). Since the projected total population is an estimate, the number of fish actually captured may be lower. The statistical treatment of the data is necessary since it is not always possible to catch all fish in a particular reach of the stream. As a consequence, reporting only the number actually caught could underestimate the number of fish present in a given reach. It should be noted that riffle sculpins (*Cottus gulosus*) do not have swim bladders and thus typically remain on the bottom of the stream where they are difficult to capture. As such, population estimates for this species tend to be somewhat unreliable.

Rainbow trout were measured using fork length while the total length was used for California roach (*Lavinia symetricus*), Sacramento sucker (*Catostomus occidentalis*) and riffle sculpin. Age classes of rainbow trout were determined by correlating length of the captured fish with growth patterns described in Karfiol and McMillan (1983). Thus, individuals measuring less than 85 millimeters (mm) are categorized as young-of-the-year while those measuring 85 mm or greater are yearling-or-older. It should be noted, however, that using fixed size (i.e., 85 mm) to separate age classes is somewhat inaccurate as it does not account for site-specific or yearly differences in growth rates. For example, the bimodal size distribution evident at An-2.8 in July 2022 suggests

that fish up to 90 mm were likely young-of-the-year fish at this particular site. However, age assessments using bimodal distributions are typically more reliable with larger sampling sizes and thus this method may at times prove inconclusive when few individuals are present or most individuals fall into only one size class. Given that the 85 mm age class cut-off has been used in BC/WFF sampling for the previous 34 years, this approach is retained for the 2022 results discussed below.

III.2 Results

BC/WFF fish surveys for the 2022 monitoring period were conducted on July 27 and 28. The locations of two long-term sampling sites (Gu-1.9 and BeC-0.9) were moved in 2019, as described in more detail below. Rainbow trout were captured at five of the six sampling stations. Sampling station CuC-0.1 could not be surveyed in July 2022 due to a lack of safe access. However, rainbow trout have not been captured at CuC-0.1 since 2010. Riffle sculpins were present at An-2.8, and BeC-0.6. In the past, California roach were only captured at BeC-0.9 and in 2022 this species was again only present at the relocated site (BeC-0.6). Sacramento suckers, a species that is occasionally present in low numbers at stations An-2.8 and BeC-0.9 (see Table III.1), were not captured in 2022.

Table III.1 shows the population estimates for fish found at the six BC/WFF stations in July 2022 and summarizes population data for all previous sampling years. Table III.2 presents the numbers and percentages of young-of-the-year and yearling-and-older rainbow trout collected at all BC/WFF stations sampled in July 2022, as well as prior years. Fish length histograms for rainbow trout captured in 2022 are presented in Figure III.1, while Figure III.2 shows trends in total abundance and young-of-the-year abundance over the duration of the monitoring project.

An-2.8

The July 2022 rainbow trout population estimate was 75, more than double the 2021 estimate of 35, and almost 40% higher than the long-term station average of 54 (Table III.1). The 2021 population estimate was the lowest since 2002 and the 2022 estimate therefore reflects a substantial recovery. The number of trout captured in July 2022 was 68, of which 57 individuals (84%) were young-of-the-year and 11 individuals (16%) were yearling-and-older. The 2000 estimate of 116 was the highest value for rainbow trout surveys conducted at this station since 1980. The lowest population estimate was 17 in 1991.

A total of 53 riffle sculpins were captured at An-2.8 in July 2022. The average sculpin population estimate for this site is 29. Estimates for this species have always fluctuated widely since the early 1980's (Table III.1), partially due to the difficulty inherent in sampling this species with standard electrofishing methods.

It should be noted that in 2018, a single bullfrog (*Lithobates catesbeianus*) larva was captured at Station An-2.8 in the lower Anderson Creek watershed. Bullfrogs are an introduced species and their large size, high mobility, generalized eating habits, and huge reproductive capabilities, have made them extremely successful invaders and a threat to Californian biodiversity. Bullfrogs have been linked to the decline of sensitive aquatic species such as California red-legged frogs (*Rana*

draytonii) and are also known to feed on foothill yellow-legged frogs (*Rana boylii*) and juvenile trout. This was the first and only time that the authors of this report have observed a bullfrog in the Anderson Creek watershed during two decades of survey work. Due to the great threat this species poses to native aquatic species, the captured bullfrog larva was destroyed.

An-4.4

The rainbow trout population estimate for July 2022 was 5, a 55% decrease from the 2021 estimate of 11 (Table III.1) and well below the long-term station average of 33. Of the 5 individuals captured, only one (20%) was a young-of-the-year fish and 4 (80%) were yearling-and-older trout. Population estimates at An-4.4 have ranged from 5 in 2008 and 2022 to 76 in 1979. After this site contained the lowest population estimate recorded since the inception of the BC/WFF monitoring program in 2008, the rainbow trout population rebounded drastically in 2009 and 2010, maintained an above-average size in 2011, but gradually declined over the next eight years. The 2020 population estimate appeared to mark a positive reversal in this trend, but continued drought conditions in 2021 and 2022 likely contributed to a continued decline in trout abundance. Qualitatively, habitat availability within the sampling reach has decreased since 2011, with the lower half of the reach now consisting of a braided network of shallow channels, although a more distinct channel offering greater habitat availability has been developing since 2020.

Gu-0.5

The July 2022 population estimate for rainbow trout at Gu-0.5 was 11, a slight decrease (15%) from the 2021 estimate of 13 and the lowest estimate ever recorded at this site. Of the 11 trout captured in 2022, seven (64%) were young-of-the-year fish, and four (36%) were yearling-and-older. After experiencing a slow but steady decline in yearly population estimates from 2011 through 2015 (Figure II.2), the Gu-0.5 trout population recovered to near-average numbers in 2016 and 2017 and exceeded the long-term average in 2018 and 2020. However, populations numbers have again declined significantly during the past two drought years. The highest recorded estimate of 69 occurred in 1979. The long-term average for this site is 33.

Gu-2.4

As a result of changed conditions at Station Gu-1.9 related to the 2015 Valley Fire, particularly the high number of fallen Douglas fir trees within the creek bed, this site was inaccessible for fish sampling in 2018. In addition, a visual survey of the site in 2018 revealed no fish, suggesting that this site may no longer support rainbow trout. Due to these conditions, the fish survey reach was relocated in July 2019 from Gu-1.9 to the associated long-term water quality sampling site Gu-2.4, located a short distance upstream. A culverted stream crossing is located between sampling sites Gu-1.9 and Gu-2.4, but this culvert appears passable to fish under some hydraulic conditions. Gu-2.4 is characterized by slightly steeper channel topography than Gu-1.9, and the boulder-dominated step-run habitats present more challenging conditions for trout than the riffle-pool habitat sequences that were prevalent at Gu-1.9. Therefore, fish survey results at Gu-2.4 may not be directly comparable to past population estimates at Gu-1.9.

In July 2022, the rainbow trout population estimate for Gu-2.4 was 8, identical to the 2021 estimate. Of the 8 trout captured, four (50%) were young-of-the-year fish and four (50%) were

yearling-and-older fish, indicative of improved spawning success compared to 2021 when no young-of-the-year fish were observed at Gu-2.4.

In 2016, the first year of sampling following the 2015 Valley Fire, only two trout were captured at Gu-1.9. In 2017, no rainbow trout were captured at Gu-1.9, and a 2018 visual survey of approximately 300 ft of channel upstream of the sampling site did not reveal any fish either. These data appeared to indicate that the fish population in this reach of Gunning Creek had become extirpated in the aftermath of the 2015 Valley Fire. Moreover, the California Fish Passage Assessment Database (PAD) identifies a natural partial fish passage barrier ("Gunning Creek Falls") located approximately 1,200 ft downstream of Gu-1.9 (and approximately 3,700 ft upstream of Gu-0.5). Although characterized as a "partial" barrier (i.e., fish passage may be possible during some hydraulic conditions) these falls may prevent natural reintroduction of trout into upper Gunning Creek and Gu-1.9 in the future. The presence of two trout at the relocated sampling site Gu-0.5 in July 2019 suggest that a remnant population of rainbow trout remained in upper Gunning Creek, and the continued presence of a small population through 2022 provides an encouraging sign that this stream reach supports a self-sustaining population.

BeC-0.6

During the 2018-2019 high flow season, a large, deep pool that used to comprise the majority of historic sampling site BeC-0.9 had become filled with sediment and/or its downstream hydraulic control had been scoured out, leaving minimal, shallow aquatic habitat in its place. Sampling in these significantly altered geomorphic condition would have rendered comparisons to past fish surveys misleading and therefore inappropriate. The sampling site was therefore relocated approximately 0.3 kilometers (1,000 ft) downstream to a new sampling site (BeC-0.6) for the July 2019 surveys. Sampling site BeC-0.6 was selected because it contains habitat features (e.g., large pool) that approximate past conditions at BeC-0.9. However, trout population estimates at BeC-0.9 and BeC-0.6 are likely not directly comparable, as indicated below.

The July 2022 rainbow trout population estimate for BeC-0.6 was 33, a slight (18%) increase over the 2021 estimate of 28 (Table III.1). Of the 32 trout caught at BeC-0.6 in 2022, 29 (91%) were young-of-the-year while 3 (9%) were yearling-or-older fish. This age class structure is similar to 2020 and 2021 when 90% and 100% of the sample populations, respectively, consisted of young-of-the-year trout. High proportions of young-of-the-year fish at BeC-0.6/BeC-0.9 since 2018 (Table III.2) suggest that Bear Canyon Creek serves as a major reproduction and nursery ground for rainbow trout in the Anderson creek watershed. In past sampling years, population estimates at BeC-0.9/BeC-0.6 have exhibited large variations, ranging from 7 in 1982 to 124 in 1999, with a long-term average population estimate of 38. The likely cause of these large variations in population size is habitat variation. The majority of the BeC-0.9 sampling reach consisted of one large pool that underwent cycles of scouring and deposition, resulting in considerable variation in habitat quantity and quality within this reach. In 2020 through 2022, BeC-0.6 presented similar habitat conditions with one long, deep glide/pool. Low baseflows during drought conditions (e.g., 2014 and 2015) also affected the low-gradient BeC-0.9 site where water temperatures were typically higher than at other sampling sites located in the upper watershed (e.g., An-4.4 and Gu-1.9). The predominance of California roach at BeC-0.6 in 2021 and 2022 (see below) suggests similar conditions.

The July 2022 population estimate for riffle sculpin was 16, a slight (14%) increase over the 2021 estimate of 14. Population estimates for riffle sculpins vary significantly in Bear Canyon Creek from year to year (Table III.1), partially due to the difficultly inherent in sampling this species with standard electrofishing methods. In previous years, the estimates at BeC-0.9 ranged from 7 in 1995 to 101 in 1975 with a long-term station average of 27.

California roach were not observed at BeC-0.6 in 2019 but were the dominant species in 2020 with a population estimate of 84. The July 2022 population estimate of 35 was comparable to the 2021 estimate of 36. California roach, a native species adapted to slow, warm water and large pools, were regularly present at BeC-0.9, frequently undergoing large population fluctuations (Table III.1), ranging from none caught in 1988 and 1996 to 128 in 1994. The long-term average population estimate at this site is 19. The new BeC-0.6 sampling provided less favorable roach habitat than BeC-0.9 in 2019, but conditions in 2020 through 2022 have been more similar to those historically observed at BeC-0.9.

No Sacramento suckers were captured at BeC-0.6 in July 2022. The species had been present at BeC-0.9 in low numbers from 2008 through 2010 after its previous absence from that site since 1992 (Table III.1).

CuC-0.1

Safe access to sampling site CuC-0.1 was prevented by a large oak tree that had recently fallen across, and severely damaged, the staircase leading down the excessively steep slope. As such, no fish surveys were conducted at this site in July 2022.

No rainbow trout have been captured at CuC-0.1 since 2010 (Table III.1). The average for this site is 8 (after ten years with no trout) and previous population estimates ranged from 0 in 2004 to 55 in 1999. Riffles sculpins have been absent from CuC-0.1 since 2019.

The primary substrate type at this sampling location is bedrock and geomorphologic changes over the past years have resulted in marginal trout habitat. Water depths in July are typically less than one inch in most places, the width of the wetted channel averages about 3 to 6 inches, and the depths in the two primary pools that used to support trout during the summer low-flow period have decreased considerably. Furthermore, the only portion of the survey reach containing spawning-size gravels may be too small to support rainbow trout spawning activities. It should be noted, however, that foothill yellow-legged frogs (*Rana boylii*), rough-skinned newts (*Taricha granulosa*), and California giant salamander (*Dicamptodon ensatus*) larvae are regularly observed at this sampling site, indicative of the high-quality aquatic habitat for native amphibians in Cub Canyon Creek.

III.3 DISCUSSION

During the course of a year many factors may induce population fluctuations, such as changes in water quality and flow, passage of natural barriers by trout, habitat availability, spawning success, production of food (benthic macroinvertebrates) and influx of foreign materials or sediments. Direct cause and effect relationships are difficult to establish since fish populations, even in an

undisturbed area, can fluctuate due to natural variations in either the biotic or abiotic components of the ecosystem.

Compared to 2021, the 2022 rainbow trout population estimates decreased at two sampling sites (An-4.4, Gu-0.5), increased at two sites (An-2.8, BeC-0.6), and remained constant at one site (Gu-2.4). One site (CuC-0.1) was not sampled in 2022. The largest decrease in the trout population estimate occurred at An-4.4 while trout abundance increased by more than 100% further downstream at An-2.8. In the past, California roach consistently outnumbered rainbow trout, but abundances of the two species were comparable in 2022.

As discussed in previous annual summary reports, historic BC/WFF fish survey data suggest that the timing of high flow events plays a far more significant role in young-of-the year abundances (and therefore subsequent yearling-and-older abundances) than the overall water year type (e.g., wet versus dry year). With the occurrence of the September 2015 Valley Fire, an additional variable has been added to the analysis of fish population trends. However, a comparison of pre-fire (2015) to post-fire (2016) population data did not reveal any clear trends, possibly because long-term drought-related effects may have confounded these trends (ESA, 2017). In fact, the overall trout abundance (i.e., the total of all sampling site population estimates) increased by 27% from 2015 to 2016, and length-frequency analysis of the fish data indicated that large fish (i.e., yearling-and-older) were more common in 2016 than 2015, suggesting a relatively high year-over-year survival rate (ESA, 2017).

Subsequently, overall trout abundance estimates declined in 2018 to what at the time represented the lowest ever recorded (111 individuals) since the inception of the BC/WFF program and remained very low (118 individuals) in 2019. In 2020, the abundance estimate increased to 148 individuals, but remained below the long-term average of 180 at that time. However, the 2021 total abundance estimate of 67 marked by far the lowest trout population recorded in 35 years of BC/WFF monitoring. Severe drought conditions through California in 2021 appeared to have significantly depressed local trout populations. In 2022, the total trout estimate increased to 99 but remains well below the current long-term average of 174 during continued drought conditions.

TABLE III.1

SUMMARY OF YEARLY FISH POPULATION ESTIMATES

Station	Year	Rainbow Trout	California Roach	Sacramento Sucker	Riffle Sculpin
An-2.8	1980	77	0	0	81
	1983	20	0	1	36
	1988	31	0	0	32
	1989	25	0	0	10
	1990	25	0	0	19
	1991	17	0	0	14
	1992	34	0	0	30
	1993	18	0	0	36
	1994	44	0	0	28
	1995	27	0	0	17
	1996	27	0	0	12
	1997	70	0	0	24
	1998	37	0	0	28
	1999	92	0	0	12
	2000	116	0	0	42
	2001	78	0	0	39
	2002	30	0	0	15
	2003	42	0	0	17
	2004	40	0	0	33
	2005	46	0	0	37
	2006	46	0	0	16
	2007	39	0	0	12
	2008	46	0	0	17
	2009	55	0	0	24
	2010	79	0	0	16
	2011	101	0	0	28
	2012	58	0	0	16
	2013	60	0	0	35
	2014	74	0	0	15
	2015	44	0	0	42
	2016	91	0	0	88
	2017	88	0	0	44
	2018	48	0	0	28
	2019	84	0	0	44
	2020	70	0	0	5
	2021	35	0	0	31
	2022	75	0	0	53
	Average	***54***	***0***	***0***	***29***
An-4.4	1975	33	0	0	0
	1978	18	0	0	0
	1979	76	0	0	0
	1980	64	0	0	0

TABLE III.1 (CONTINUED)

SUMMARY OF YEARLY FISH POPULATION ESTIMATES

Station	Year	Rainbow Trout	California Roach	Sacramento Sucker	Riffle Sculpin
An-4.4	1982	13	0	0	0
(Cont.)	1983	19	0	0	0
	1988	28	0	0	0
	1989	30	0	0	0
	1990	41	0	0	0
	1991	35	0	0	0
	1992	32	0	0	0
	1993	35	0	0	0
	1994	67	0	0	0
	1995	27	0	0	0
	1996	31	0	0	0
	1997	53	0	0	0
	1998	27	0	0	0
	1999	64	0	0	0
	2000	53	0	0	0
	2001	47	0	0	0
	2002	39	0	0	0
	2003	32	0	0	0
	2004	42	0	0	0
	2005	46	0	0	0
	2006	29	0	0	0
	2007	58	0	0	0
	2008	5	0	0	0
	2009	18	0	0	0
	2010	44	0	0	0
	2011	41	0	0	0
	2012	30	0	0	0
	2013	27	0	0	0
	2014	24	0	0	0
	2015	23	0	0	0
	2016	15	0	0	0
	2017	32	0	0	0
	2018	19	0	0	0
	2019	8	0	0	0
	2020	26	0	0	0
	2021	11	0	0	0
	2022	5	0	0	0
	Average	***33***	***0***	***0***	***0***
Gu-0.5	1975	53	0	0	0
	1979	69	0	0	0
	1982	24	0	0	0
	1983	28	0	0	0

TABLE III.1 (CONTINUED)

SUMMARY OF YEARLY FISH POPULATION ESTIMATES

Station	Year	Rainbow Trout	California Roach	Sacramento Sucker	Riffle Sculpin
Gu-0.5	1988	21	0	0	0
(Cont.)	1989	17	0	0	0
	1990	30	0	0	0
	1991	33	0	0	0
	1992	16	0	0	0
	1993	20	0	0	0
	1994	40	0	0	0
	1995	13	0	0	0
	1996	23	0	0	0
	1997	46	0	0	0
	1998	33	0	0	0
	1999	50	0	0	0
	2000	68	0	0	0
	2001	23	0	0	0
	2002	28	0	0	0
	2003	47	0	0	0
	2004	41	0	0	0
	2005	41	0	0	0
	2006	39	0	0	0
	2007	30	0	0	0
	2008	28	0	0	0
	2009	23	0	0	0
	2010	41	0	0	0
	2011	51	0	0	0
	2012	35	0	0	0
	2013	28	0	0	0
	2014	12	0	0	0
	2015	17	0	0	0
	2016	36	0	0	0
	2017	31	0	0	0
	2018	44	0	0	0
	2019	24	0	0	0
	2020	41	0	0	0
	2021	13	0	0	0
	2022	11	0	0	0
	Average	***33***	***0***	***0***	***0***
Gu-1.9	1975	25	0	0	0
	1978	40	0	0	0
	1979	24	0	0	0
	1982	16	0	0	0
	1983	15	0	0	0
	1988	44	0	0	0

TABLE III.1 (CONTINUED)

SUMMARY OF YEARLY FISH POPULATION ESTIMATES

Station	Year	Rainbow Trout	California Roach	Sacramento Sucker	Riffle Sculpin
Gu-1.9	1989	26	0	0	0
(Cont.)	1990	34	0	0	0
	1991	36	0	0	0
	1992	22	0	0	0
	1993	36	0	0	0
	1994	38	0	0	0
	1995	18	0	0	0
	1996	37	0	0	0
	1997	34	0	0	0
	1998	40	0	0	0
	1999	47	0	0	0
	2000	29	0	0	0
	2001	13	0	0	0
	2002	26	0	0	0
	2003	35	0	0	0
	2004	52	0	0	0
	2005	44	0	0	0
	2006	31	0	0	0
	2007	29	0	0	0
	2008	24	0	0	0
	2009	21	0	0	0
	2010	40	0	0	0
	2011	29	0	0	0
	2012	24	0	0	0
	2013	28	0	0	0
	2014	17	0	0	0
	2015	13	0	0	0
	2016	2	0	0	0
	2017	0	0	0	0
	2018	NA	NA	NA	NA
Gu-2.4	2019	2	0	0	0
	2020	11	0	0	0
	2021	8	0	0	0
	2022	8	0	0	0
	Average	***25***	***0***	***0***	***0***
BeC-0.9	1975	51	5	0	101
	1979	60	43	12	51
	1980	35	34	0	19
	1982	7	6	0	30
	1983	33	2	0	13
	1988	15	0	0	13
	1989	57	9	2	31

TABLE III.1 (CONTINUED)

SUMMARY OF YEARLY FISH POPULATION ESTIMATES

Station	Year	Rainbow Trout	California Roach	Sacramento Sucker	Riffle Sculpin
BeC-0.9	1990	18	8	0	20
(Cont.)	1991	9	19	0	37
	1992	18	36	1	34
	1993	12	4	0	42
	1994	28	128	0	41
	1995	23	2	0	7
	1996	32	0	0	8
	1997	53	37	0	13
	1998	62	4	0	34
	1999	110	19	0	31
	2000	54	8	0	20
	2001	58	8	0	17
	2002	17	24	0	33
	2003	17	15	0	22
	2004	10	9	0	13
	2005	22	6	0	22
	2006	22	9	0	10
	2007	37	5	0	14
	2008	55	14	3	39
	2009	27	9	1	14
	2010	10	14	1	7
	2011	59	7	0	36
	2012	30	4	0	13
	2013	N/A	N/A	N/A	N/A
	2014	29	2	0	20
	2015	16	2	0	26
	2016	56	17	0	25
	2017	60	28	0	35
	2018	68	76	0	27
BeC-0.6	2019	124	0	0	68
	2020	24	84	0	9
	2021	28	36	0	14
	2022	33	35	0	16
	Average	***38***	***19***	***1***	***27***
CuC-0.1	1975	6	0	0	0
	1979	7	0	0	0
	1982	6	0	0	0
	1983	3	0	0	0
	1988	2	0	0	0
	1989	5	0	0	0
	1990	8	0	0	0
	1991	25	0	0	0

TABLE III.1 (CONTINUED)

SUMMARY OF YEARLY FISH POPULATION ESTIMATES

Station	Year	Rainbow Trout	California Roach	Sacramento Sucker	Riffle Sculpin
CuC-0.1	1992	31	0	0	0
(Cont.)	1993	45	0	0	0
	1994	19	0	0	0
	1995	5	0	0	0
	1996	12	0	0	0
	1997	22	0	0	0
	1998	14	0	0	0
	1999	55	0	0	0
	2000	10	0	0	0
	2001	13	0	0	0
	2002	2	0	0	0
	2003	1	0	0	0
	2004	0	0	0	0
	2005	2	0	0	0
	2006	3	0	0	0
	2007	10	0	0	0
	2008	4	0	0	0
	2009	1	0	0	2
	2010	1	0	0	0
	2011	0	0	0	0
	2012	0	0	0	0
	2013	0	0	0	0
	2014	0	0	0	0
	2015	0	0	0	0
	2016	0	0	0	6
	2017	0	0	0	1
	2018	0	0	0	6
	2019	0	0	0	2
	2020	0	0	0	0
	2021	0	0	0	0
	2022	N/A	N/A	N/A	N/A
	Average	***8***	***0***	***0***	***0***

NOTE: Data presented for dates prior to 1998 are adapted from McKean *et al.* (1998).

TABLE III.2

SUMMARY OF YEARLY AGE CLASS DISTRIBUTION OF RAINBOW TROUT

Station	Date	Young-of-the-Year	%	Yearling-and-Older	%
An-2.8	1980	70	92	6	8
	1983	14	70	6	30
	1988	23	79	6	21
	1989	19	76	6	24
	1990	16	64	9	36
	1991	10	63	6	37
	1992	24	75	8	25
	1993	9	60	6	40
	1994	8	20	33	80
	1995	21	78	6	22
	1996	18	67	9	33
	1997	61	94	4	6
	1998	26	72	10	28
	1999	59	84	11	16
	2000	79	89	10	11
	2001	60	83	12	17
	2002	19	70	8	30
	2003	35	83	7	17
	2004	28	72	11	28
	2005	26	65	14	35
	2006	34	74	12	26
	2007	24	65	13	35
	2008	39	85	7	15
	2009	45	90	5	10
	2010	56	80	14	20
	2011	57	69	26	31
	2012	31	55	25	45
	2013	46	81	11	19
	2014	51	76	16	24
	2015	34	79	9	21
	2016	61	80	15	20
	2017	51	77	15	23
	2018	36	77	11	23
	2019	66	87	10	13
	2020	39	66	20	34
	2021	23	68	11	32
	2022	57	84	11	16
An-4.4	1983	13	68	6	32
	1988	13	46	15	54
	1989	15	50	15	50
	1990	25	61	16	39
	1991	24	68	11	32

TABLE III.2 (CONTINUED)

SUMMARY OF YEARLY AGE CLASS DISTRIBUTION OF RAINBOW TROUT

Station	Date	Young-of-the-Year	%	Yearling-and-Older	%
An-4.4	1992	24	75	8	25
(Cont.)	1993	16	47	18	53
	1994	39	68	18	32
	1995	3	14	18	86
	1996	12	40	18	60
	1997	41	80	10	20
	1998	12	46	14	54
	1999	48	79	13	21
	2000	34	69	15	31
	2001	28	61	18	39
	2002	20	57	15	43
	2003	16	50	16	50
	2004	19	53	17	47
	2005	22	50	22	50
	2006	14	48	15	52
	2007	35	64	20	36
	2008	0	0	5	100
	2009	14	78	4	22
	2010	21	49	22	51
	2011	27	73	10	29
	2012	16	53	14	47
	2013	21	78	6	22
	2014	0	0	22	100
	2015	15	65	8	35
	2016	7	50	7	50
	2017	27	93	2	7
	2018	2	11	17	89
	2019	8	100	0	0
	2020	19	83	4	17
	2021	8	73	3	27
	2022	1	20	4	80
Gu-0.5	1983	11	44	14	56
	1988	14	70	6	30
	1989	5	29	12	71
	1990	19	67	11	33
	1991	12	36	21	64
	1992	10	62	6	38
	1993	8	44	10	56
	1994	17	45	21	55
	1995	5	38	8	62
	1996	13	57	10	43
	1997	25	66	13	34

TABLE III.2 (CONTINUED)

SUMMARY OF YEARLY AGE CLASS DISTRIBUTION OF RAINBOW TROUT

Station	Date	Young-of-the-Year	%	Yearling-and-Older	%
Gu-0.5	1998	18	64	10	36
(Cont.)	1999	28	62	17	38
	2000	31	62	19	38
	2001	6	26	17	74
	2002	12	50	12	50
	2003	24	53	21	47
	2004	25	64	14	36
	2005	24	60	16	40
	2006	21	55	17	45
	2007	14	48	15	52
	2008	15	63	9	37
	2009	11	48	12	52
	2010	27	66	14	34
	2011	31	65	17	35
	2012	15	44	19	56
	2013	22	79	6	21
	2014	1	8	11	92
	2015	10	59	7	41
	2016	18	60	12	40
	2017	22	76	7	24
	2018	21	51	20	49
	2019	11	58	8	42
	2020	15	43	20	57
	2021	8	62	5	38
	2022	7	64	4	36
Gu-1.9	1983	7	50	7	50
	1988	23	53	20	47
	1989	3	15	17	85
	1990	17	50	17	50
	1991	22	63	13	37
	1992	4	18	18	82
	1993	22	63	13	37
	1994	25	66	13	34
	1995	4	22	14	78
	1996	22	63	13	37
	1997	17	52	16	48
	1998	15	52	14	48
	1999	31	71	13	29
	2000	22	76	7	24
	2001	2	17	10	83
	2002	21	81	5	19
	2003	21	66	11	34

TABLE III.2 (CONTINUED)

SUMMARY OF YEARLY AGE CLASS DISTRIBUTION OF RAINBOW TROUT

Station	Date	Young-of-the-Year	%	Yearling-and-Older	%
Gu-1.9	2004	31	63	18	37
(Cont.)	2005	23	54	20	46
	2006	16	53	14	47
	2007	20	69	9	31
	2008	14	61	9	39
	2009	10	48	11	52
	2010	22	58	16	42
	2011	12	44	15	56
	2012	8	35	15	65
	2013	16	70	7	30
	2014	7	41	10	59
	2015	11	85	2	15
	2016	0	0	2	100
	2017	0	0	0	0
	2018	NA	NA	NA	NA
Gu-2.4	2019	1	50	1	50
	2020	11	100	0	0
	2021	0	0	8	100
	2022	4	50	4	50
BeC-0.9	1975	42	91	4	9
	1979	42	74	15	26
	1980	34	97	1	3
	1982	2	29	5	71
	1983	28	90	3	10
	1988	14	93	1	7
	1989	39	78	11	22
	1990	13	72	5	28
	1991	24	100	0	0
	1992	14	78	4	22
	1993	6	55	5	45
	1994	11	50	11	50
	1995	19	90	2	10
	1996	21	68	10	32
	1997	39	85	7	15
	1998	50	85	9	15
	1999	75	79	20	21
	2000	40	80	10	20
	2001	44	81	10	19
	2002	14	82	3	18
	2003	8	53	7	47
	2004	6	60	4	40
	2005	18	82	4	18

TABLE III.2 (CONTINUED)

SUMMARY OF YEARLY AGE CLASS DISTRIBUTION OF RAINBOW TROUT

Station	Date	Young-of-the-Year	%	Yearling-and-Older	%
BeC-0.9	2006	10	50	10	50
(Cont.)	2007	20	57	15	43
	2008	35	83	7	17
	2009	18	72	7	28
	2010	5	50	5	50
	2011	43	83	9	17
	2012	15	58	11	42
	2013	N/A	N/A	N/A	N/A
	2014	18	72	7	28
	2015	9	56	7	44
	2016	10	25	30	75
	2017	33	70	14	30
	2018	59	94	4	6
BeC-0.6	2019	96	97	3	3
	2020	18	90	2	10
	2021	28	100	0	0
	2022	29	91	3	9
CuC-0.1	1975	0	0	6	100
	1979	0	0	7	100
	1982	0	0	6	100
	1983	0	0	3	100
	1988	0	0	2	100
	1989	4	80	1	20
	1990	6	87	2	13
	1991	21	84	4	16
	1992	29	94	2	6
	1993	40	89	5	11
	1994	9	47	10	53
	1995	0	0	5	100
	1996	11	92	1	8
	1997	22	100	0	0
	1998	10	71	4	29
	1999	43	78	12	22
	2000	4	40	6	60
	2001	8	62	5	38
	2002	0	0	2	100
	2003	1	100	0	0
	2004	0	0	0	0
	2005	2	100	0	0
	2006	0	0	3	100
	2007	7	70	3	30
	2008	0	0	4	100

TABLE III.2 (CONTINUED)

SUMMARY OF YEARLY AGE CLASS DISTRIBUTION OF RAINBOW TROUT

Station	Date	Young-of-the-Year	%	Yearling-and-Older	%
CuC-0.1	2009	0	0	1	100
(Cont.)	2010	0	0	1	100
	2011	0	0	0	0
	2012	0	0	0	0
	2013	0	0	0	0
	2014	0	0	0	0
	2015	0	0	0	0
	2016	0	0	0	0
	2017	0	0	0	0
	2018	0	0	0	0
	2019	0	0	0	0
	2020	0	0	0	0
	2021	0	0	0	0
	2022	NA	NA	NA	NA

NOTE: Data presented for dates prior to 1998 are adapted from McKean *et al.* (1998).

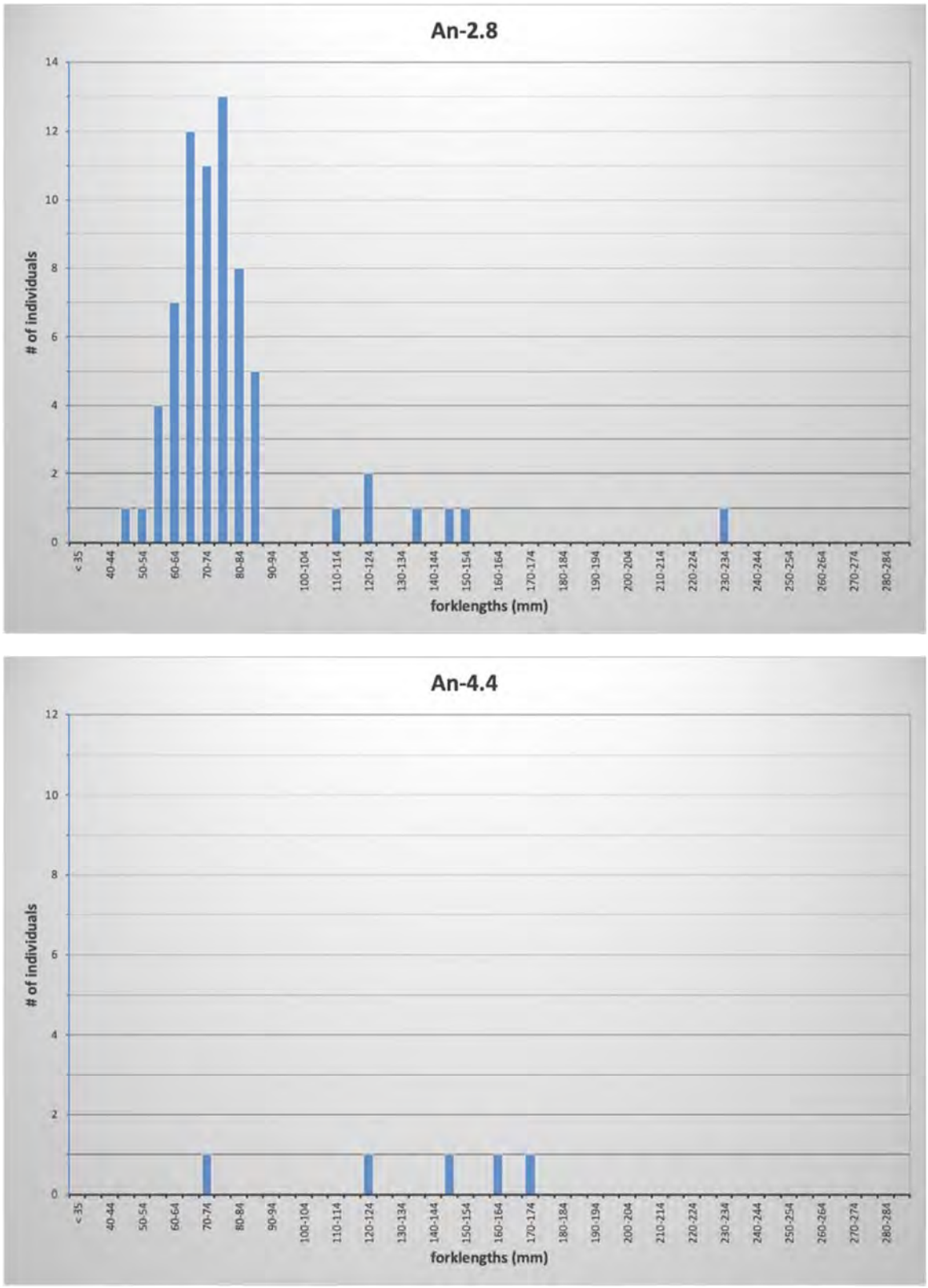


Figure III-1. Size Distributions of Rainbow Trout, July 2022

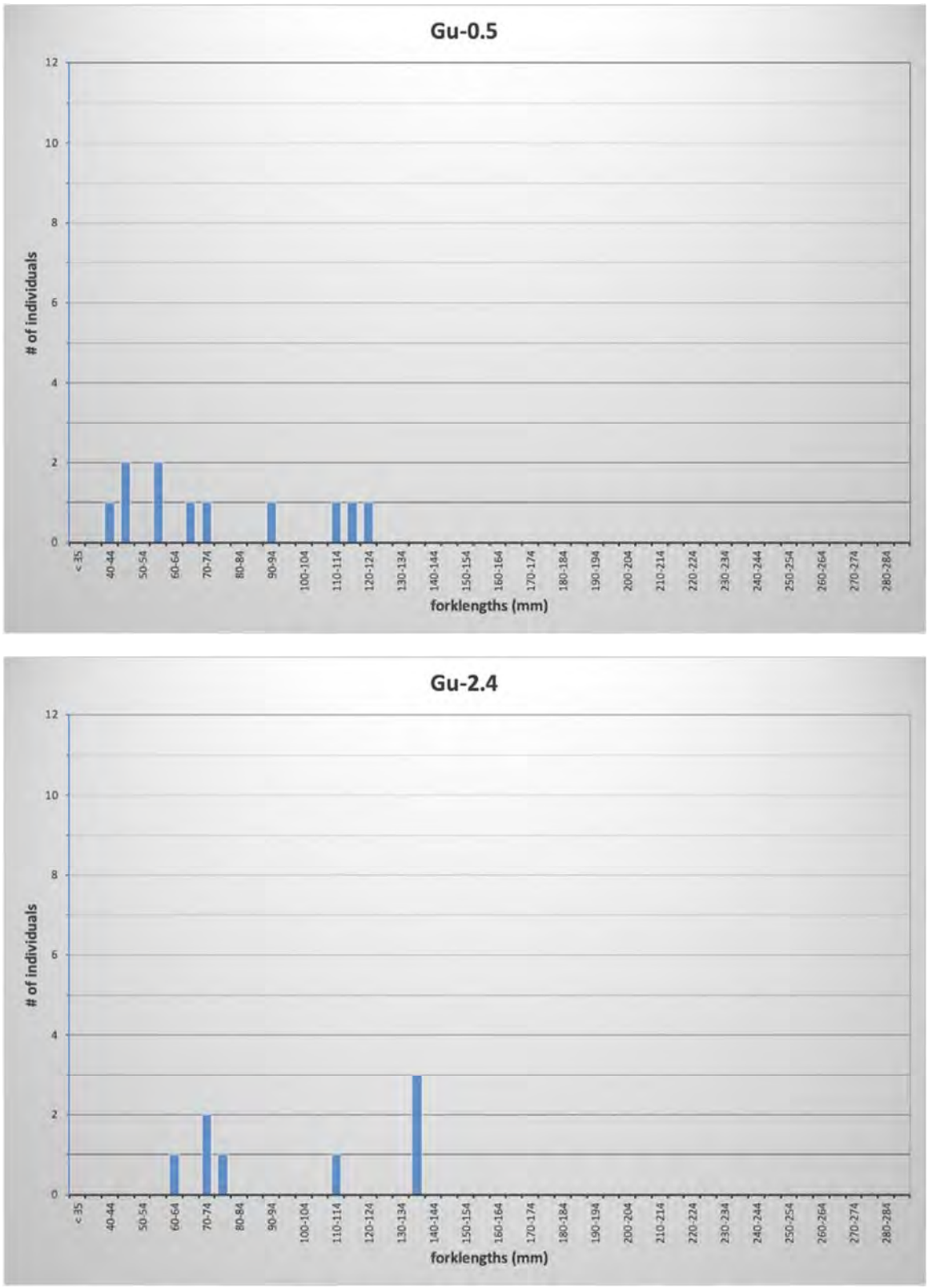
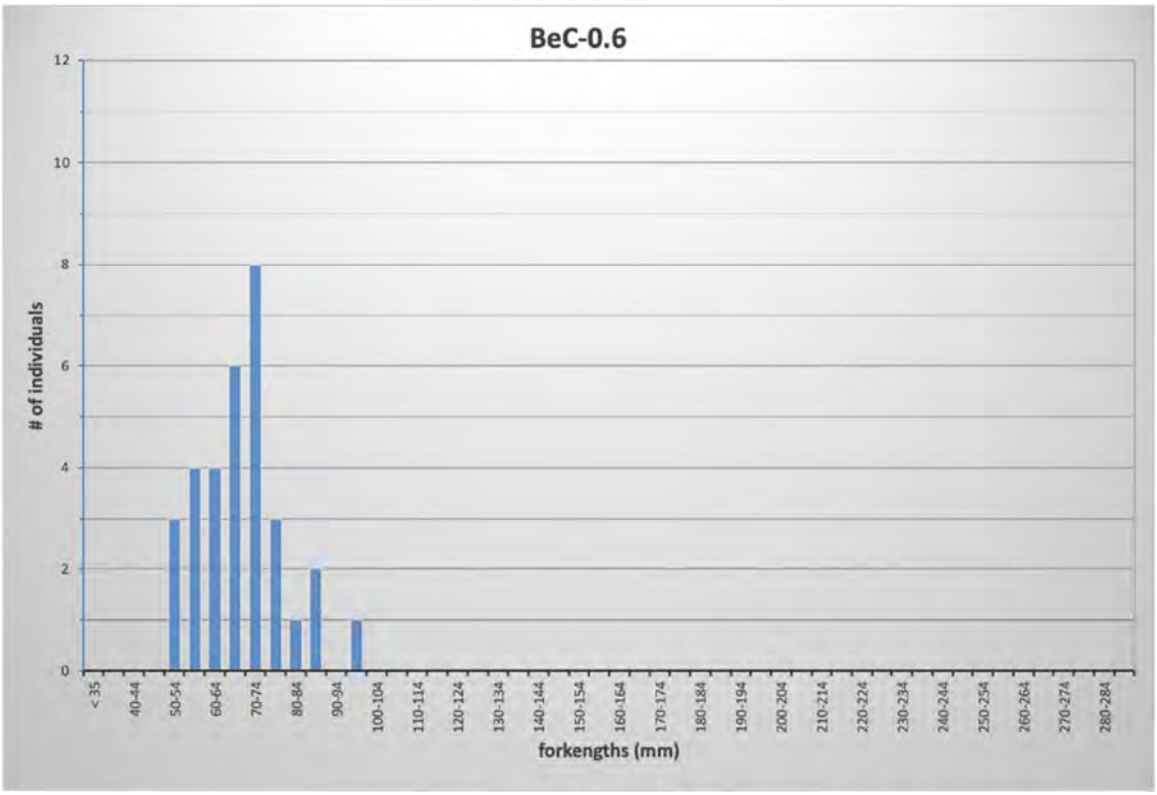


Figure III-1. Size Distributions of Rainbow Trout, July 2022 (continued)



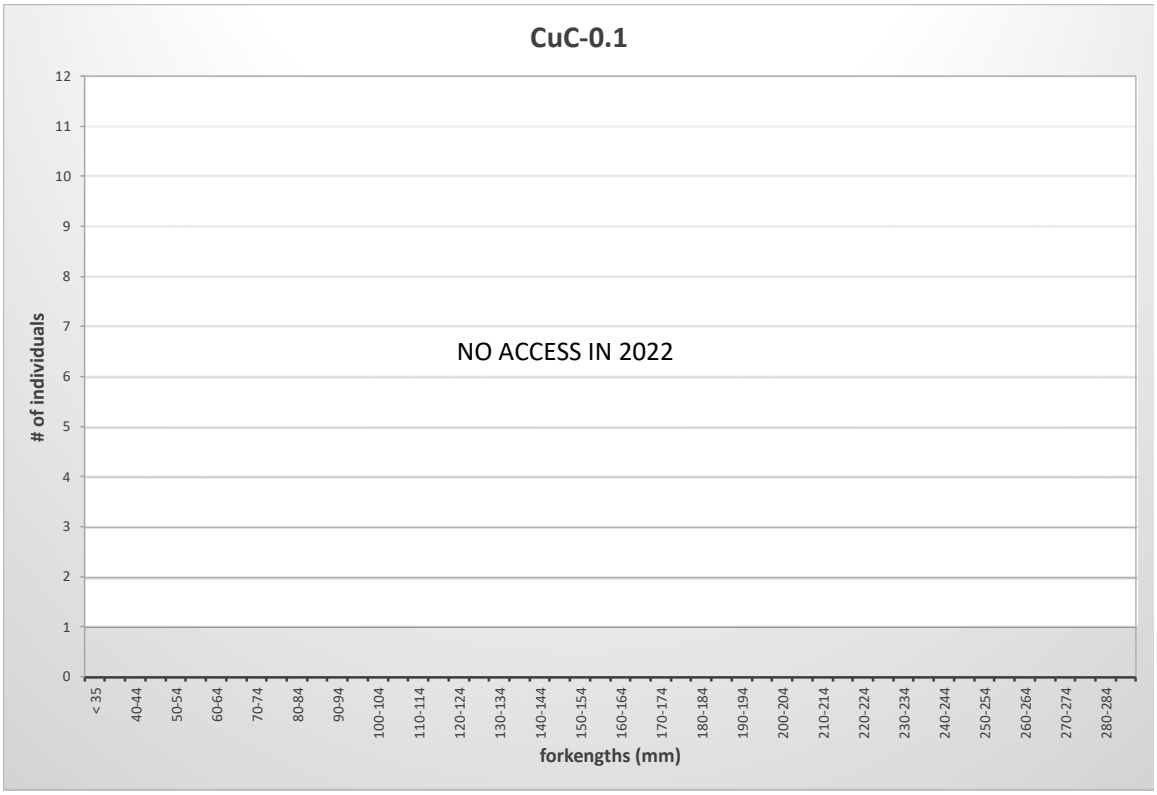


Figure III-1. Size Distributions of Rainbow Trout, July 2022 (continued)

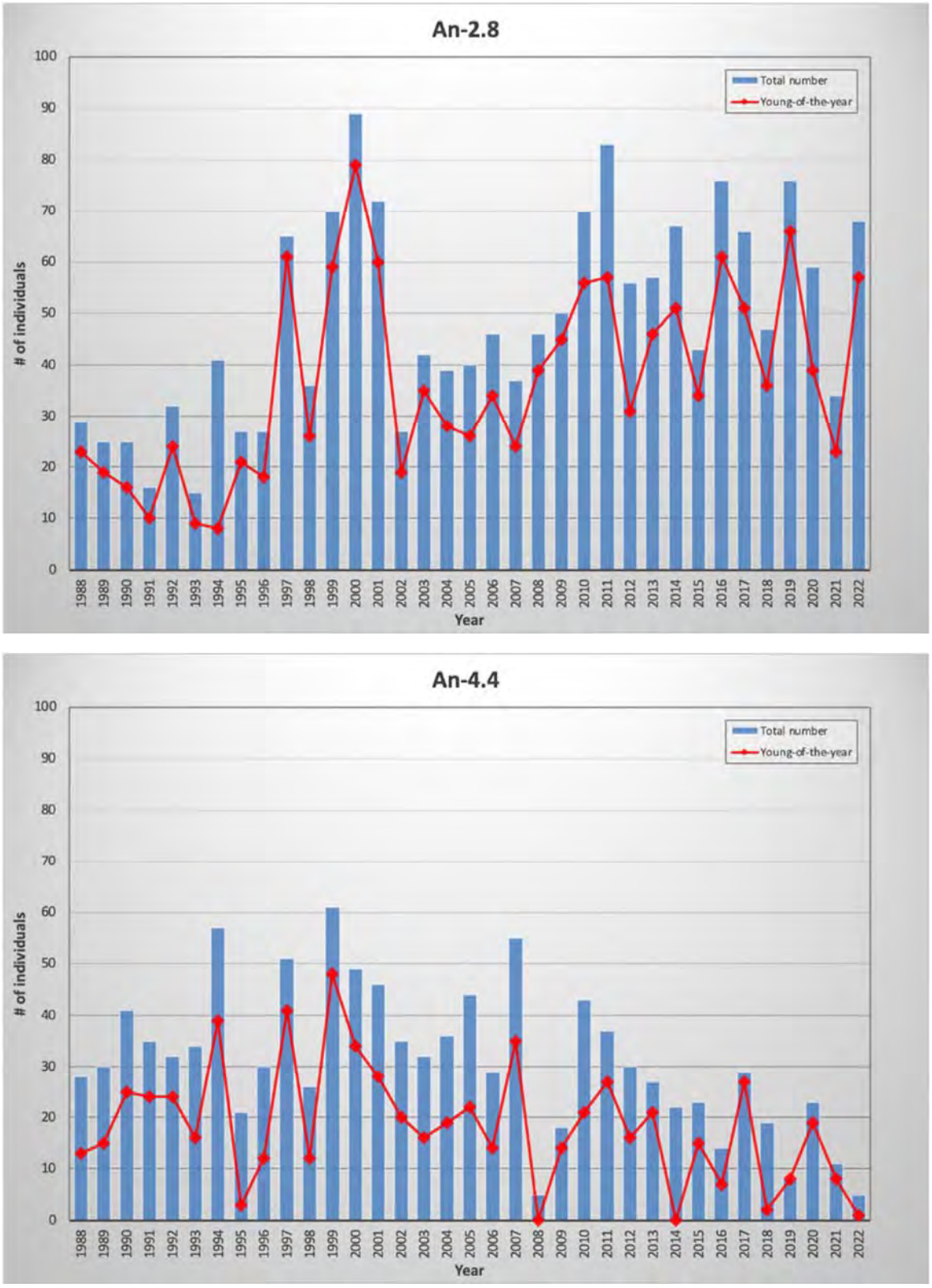


Figure III-2. Summary of Yearly Age Class Distributions of Rainbow Trout

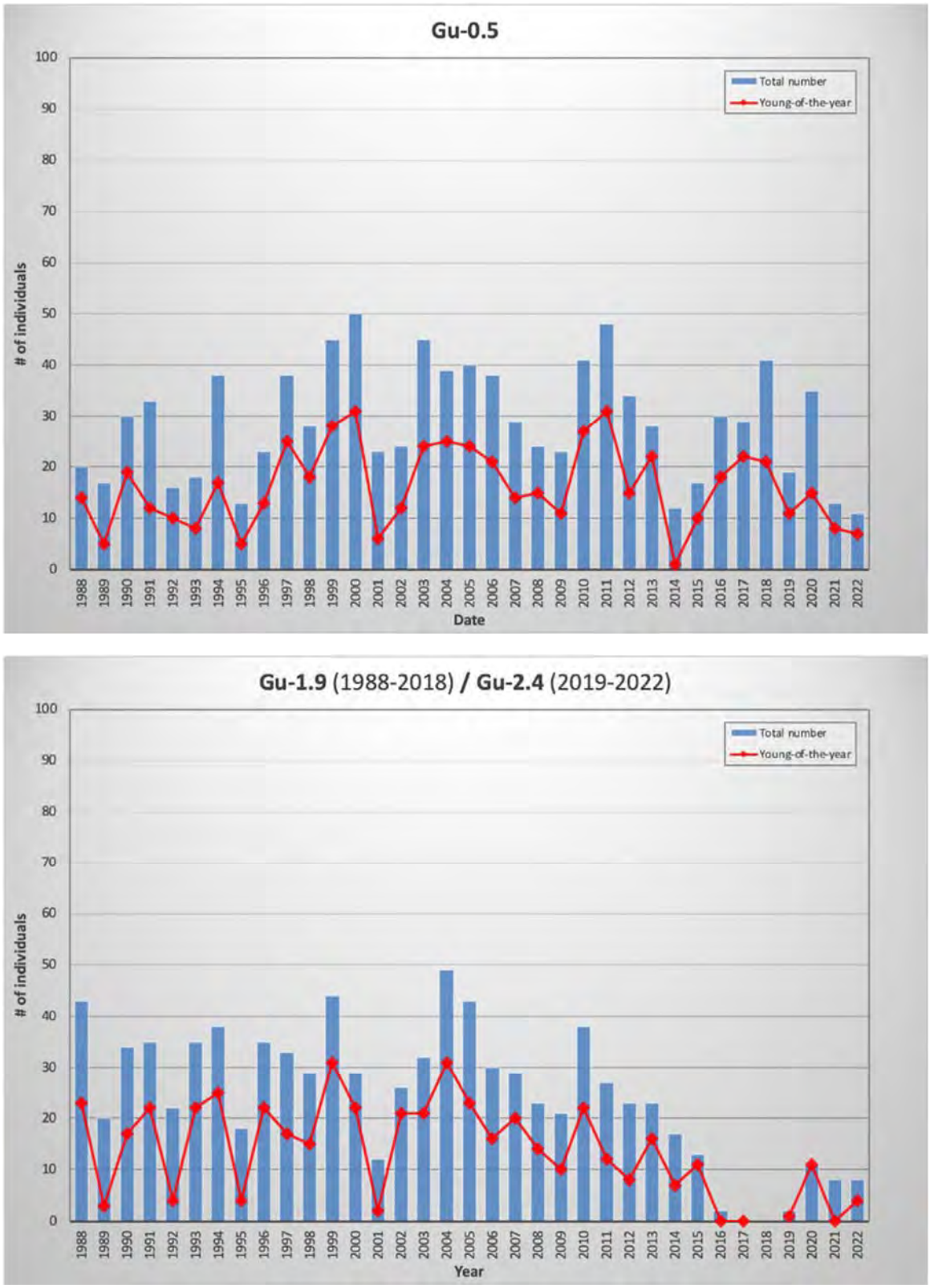


Figure III-2. Summary of Yearly Age Class Distributions of Rainbow Trout (cont.)

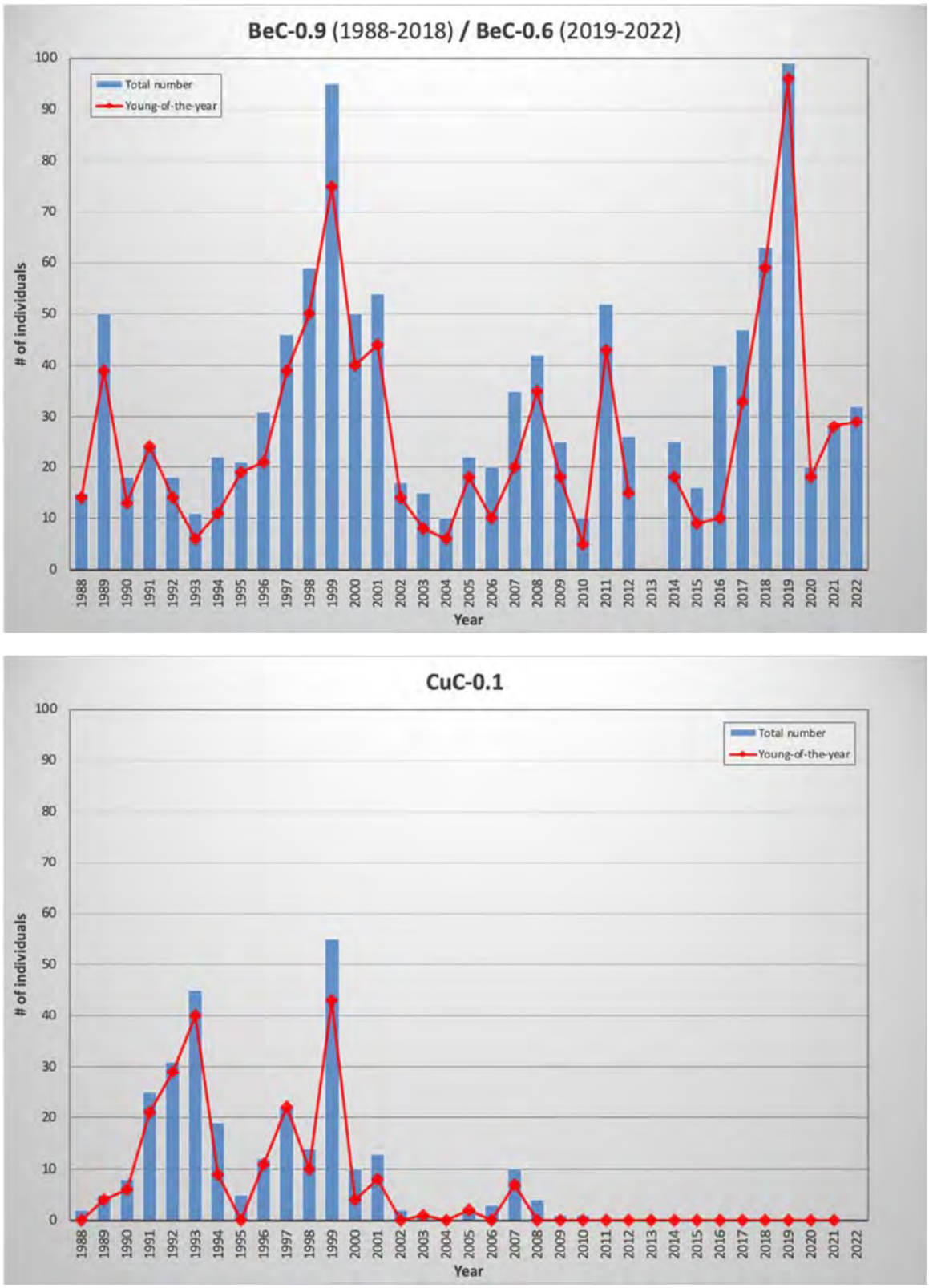


Figure III-2. Summary of Yearly Age Class Distributions of Rainbow Trout (cont.)

IV. BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates (BMI) are those invertebrate animals that can be seen by the unaided eye and can be retained by a U.S. Standard No. 30 sieve (0.595 mm mesh) (Eckblad, 1978). A wide variety of taxa comprise this designation, but chiefly they include the Insecta, Arachnoidea, Ostracoda, Oligochaeta, Turbellaria, Gastropoda, and Bivalvia.

Emphasis in many studies has been given to those benthic macroinvertebrates living on the surface layer of the benthic stratum, and more specifically, those serving as food for fish. Other studies have attempted to equate species diversity and abundance of benthic macroinvertebrates throughout the benthic stratum with changes in water quality (Wilhm and Doris, 1968; Weber, 1973; Cummins, 1975). In either case, the goal has been to identify specific physical and chemical factors as causative agents affecting benthic macroinvertebrate populations. Cummins (1975) has pointed out that such correlations are inherently weak, and usually only indirect relationships can be drawn. However, consistently present (or in some cases absent) taxa with known ecological requirements can, after a sufficient body of data has been accumulated, serve to identify long-term trends in water quality.

During the early years of the BC/WFF monitoring program, BMI samples were collected yearly. However, after seven years of invertebrate data revealed highly fluctuating but consistently healthy BMI populations, the sampling frequency was reduced to once every three years in 1995 in consultation with appropriate agencies. BMI samples were last collected in 2019 (ESA, 2020) and the current report reflects BMI data collected three years later in July 2022.

IV.1 Methods

Since the inception of the BC/WFF monitoring program in 1988, the use of benthic macroinvertebrates in freshwater monitoring has received extensive attention, and both national and State protocols have been developed and refined (Barbour *et al.,* 1999; CDFG, 2003a). Although applying consistent sampling and analysis methodologies during long-term monitoring programs is desirable because it results in more comparable data sets over time, ESA advised Calpine Corporation to modify the BMI methodologies in 2004, bringing sampling and data analysis methods in line with currently accepted standards. Thus, methodologies described in the December 2003 revision of *California Stream Bioassessment Procedure* (CSBP) (CDFG, 2003a) were used for the 2022 sampling event. However, as habitat assessments have never been incorporated into BC/WFF program, the habitat assessment component of the CSBP was not performed in 2022.

When the sampling protocol was updated in 2004, the locations of some of the benthic macroinvertebrate sampling sites were also slightly modified compared to previous surveys to

increase sampling efficiency. BMI samples were subsequently collected at the same sites as the fish surveys (see Section III). Furthermore, the sample collection period was changed from October to July to coincide with the yearly fish surveys.

At each sampling site, a total of three samples were collected from 1 ft^2 substrate areas. Thus, the total area sampled at each site was 3 ft^2. All collected organisms were transferred into plastic containers, preserved in 90% ethanol, and submitted to Aquatic Biology Associates, Inc, Corvallis, OR, for sample composition, subsampling, identification, enumeration, and metrics calculations according to the CSBP Level 1 taxonomic effort (Harrington and Born, 2000). The three samples from each site were combined into one composite sample per site and approximately 500 (±3%) organisms from each composite sample were subsampled, as described in the CSBP (CDFG, 2003a).

Prior to 2004, BC/WFF benthic macroinvertebrate assessments, quantitative (community abundance, diversity, and distribution) and qualitative (indicator taxa) measures were used in presenting and assessing the macroinvertebrates collected throughout the benthic strata. Although these basic measures were retained for analyses conducted since 2004, significantly more measures (metrics) are calculated under the current CSBP protocol. The results of the July 2022 analysis presented below focus primarily on metrics that are used in calculating an Index of Biological Integrity (IBI), or relative biotic condition, for each sampled stream reach. The Russian River Index of Biological Integrity (RRIBI) (Harrington, 1999) used since the 2004 assessment is a regional index developed by CDFG for use in northern California watersheds. The RRIBI applies standardized scores (1 = low biological integrity, 3 = moderate biological integrity, and 5 = high biological integrity) to the mean values of six biological metrics and then uses the total score to describe the biotic condition of the sampled stream reach. A total sample score of 30-24 is indicative of *excellent* biotic conditions, 23-18 of *good* conditions, 17-12 of *fair* conditions, and 11-6 of *poor* conditions. The six metrics used in the RRIBI are further described below. Please refer to Harrington and Born (2000), Harrington (1999), and Barbour *et al.* (1999) for detailed discussions of invertebrate metrics and their use in determining biotic conditions.

Diversity

The number of different taxa present in a sample is an indication of the diversity of the invertebrate community found within a study reach. The diversity of the July 2022 samples was calculated using the Shannon Diversity Index (Shannon, 1948), based on identifications and enumerations to the genus level. Under the RRIBI, a Shannon diversity index value of 3.0 or higher is indicative of *high* diversity (RRIBI score = 5), a value of 2.3-2.9 designates *moderate* diversity (RRIBI score = 3), and value of less than 2.3 represents *low* diversity (RRIBI score = 1) (Harrington, 1999).

Distribution

In past reports, the percent distribution of the dominant orders was used as an indication of the equal or unequal distribution of the major taxa at a given station. The more recent analysis protocols used for the 2016 assessment include a number of different metrics related to describing the taxa compositions of the benthic macroinvertebrate samples. The complete list of these is

presented in Table IV.1. The following distribution-related metrics are used in the RRIBI (Harrington, 1999) calculations:

Taxonomic Richness: The total number of different taxa observed in a sample; values of ≥36 = *high* (RRIBI score = 5), 26-35 = *moderate* (RRIBI score = 3), <26 = *low* (RRIBI score = 1)

% Dominant Taxon: The relative abundance of the most dominant taxon in a sample; values of ≤14 = *high* (RRIBI score = 5), 15-39 = *moderate* (RRIBI score = 3), >39 = *low* (RRIBI score = 1)

Indicator Taxa

An examination of the ecological requirements of the individual taxa is often useful in assessing the "health" of the stream, especially when coupled with an evaluation of community abundance (Knight, 1985). Certain benthic macroinvertebrates are tolerant of a range of environmental conditions, but others have a narrower tolerance and are more sensitive to such disturbances as siltation, low flow, and low oxygen content. Among the taxa sampled, stoneflies are suggested as excellent indicators of water quality because they are always associated with clean and cool flowing water; therefore, they are most intolerant of pollution (Hynes, 1976). Current benthic macroinvertebrate community composition analyses typically focus on three groups of organisms as being representative of relatively unimpaired stream conditions: The orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). The relative abundance of these three sensitive orders (collectively referred to as EPT) provides a useful indication of biotic stream conditions.

Furthermore, the California Aquatic Bioassessment Laboratory Network (CAMLnet) developed the California Tolerance Value (CTV) system that assigns values on a scale of 0 (highly intolerant) to 10 (highly tolerant) to each taxonomic group (CDFG, 2003b). A high proportion of intolerant invertebrates (low CTV values) is indicative of favorable biotic conditions.

The tolerance-related metrics used in the RRIBI (Harrington, 1999) are the following:

EPT Taxa: The number of different taxa within a sample belonging to the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT); values of ≥19 = *high* (RRIBI score = 5), 18-12 = *moderate* (RRIBI score = 3), <12 = *low* (RRIBI score = 1)

Sensitive EPT Index (%): The percentage of EPT taxa with a CTV of 0 to 3; values of ≥54 = *high* (RRIBI score = 5), 17-53 = *moderate* (RRIBI score = 3), <17 = *low* (RRIBI score = 1)

Tolerance Value: A weighted average of CTV values in a sample; values of ≤3.0 = *high* (RRIBI score = 5), 3.1-4.6 = *moderate* (RRIBI score = 3), >4.6 = *low* (RRIBI score = 1)

Abundance

Pre-2004 BC/WFF benthic macroinvertebrate assessments emphasized community abundance, expressed as the total number of organisms found within the total per-site sample area. According to the productivity assessment described in Usinger (1963) and used in previous BC/WFF monitoring reports, streams classified as *rich* contain more than 2,152 organisms/m^2; a designation of *moderate* indicates between 1,076 and 2,152 organisms/m^2; and *low* productivity is indicated by a community abundance of less than 1,076 organisms/m^2. Current assessment protocols, however, put considerably less emphasis on total community abundance as a measure of stream health. The reason for this is that highly polluted stream reaches, such as those downstream of untreated sewage outfalls, may contain vast numbers of invertebrates belonging to relatively few pollution-tolerant taxa (i.e., those with high CTV values). Conversely, a largely unimpaired headwater stream may contain a relatively low total number of individuals. However, if most of these organisms belong to pollution-intolerant taxa (i.e., those with low CTV values), the low abundance would not be viewed as indicative of problems. Thus, the results of community abundance calculations alone may lead to erroneous conclusions about biotic conditions in streams. Although community abundance is presented in Table IV.1, the results are not used in the RRIBI.

IV.2 Results

A summary of all benthic macroinvertebrate metrics calculated for these samples is provided in Table IV.1. Table IV.2 presents the RRIBI scores and ratings for each station.

An-2.8

Diversity, based on the Shannon Diversity Index, at An-2.8 was 3.0 in 2022 (2.6 in 2019), which is classified as a *high* (5) diversity score in the RRIBI scoring system. A total of 46 taxa (44 in 2019) were identified from the subsample, indicative of a RRIBI taxonomic richness value of 5 (*high*). Of this total, 24 taxa (same as in 2019) belonged to the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT) for a RRIBI score of 5 (*high*) for the EPT taxa category. The dominant taxon at this site in 2022 was the moderately sensitive caddisfly genus *Amiocentrus*, which accounted for 15% of the organisms identified in the sample. Thus, the RRIBI score for the dominant taxon category was 3 (*moderate*). A total of 57% (42% in 2019) of all identified organisms belonged to sensitive (CTV $\leq$ 3) EPT taxa for a RRIBI score of 5 (*high*). The tolerance value for this site, based on the weighted average of taxa-specific CTVs, was 3.3 (4.0 in 2019) for a RRIBI score of 3 (*moderate*). The estimated overall abundance of benthic macroinvertebrates at An-2.8 in 2022 was 6,652 organisms/3 ft^2 compared to 18,000 organisms/3 ft^2 in 2019. Abundance estimates can vary widely and are highly dependent on sampling location within the streambed. As noted above, the community abundance metric is not used in the RRIBI.

The total RRIBI for An-2.8 in July 2022 was 26, a significant increase over the 2019 score of 22 and indicative of *excellent* biotic conditions at this site. By comparison, the biotic conditions at this site were determined to be *good* in 2004, *excellent* in 2007 and 2010, and *good* in 2013, 2016, and 2019. Similar to the 2019 results, the 2022 sample contained high taxonomic richness and a high number of EPT taxa. In addition, the scoring for relative abundance of sensitive EPT taxa and overall diversity increased from 2019 to 2022. While the disturbance-tolerant midge family

Chironomidae was the most abundant taxon at An-2.8 in 2016 and 2019, the more sensitive caddisfly genus *Amiocentrus* (CTV of 3) was the dominant taxon in 2022. However, the relative dominance of that taxon maintained the score for this metric at *moderate*. Similarly, the overall weighted tolerance values for the sample also scored *moderate*.

An-4.4

Shannon diversity at An-4.4 was 2.6 for an RRIBI score of 3 (*moderate*), a slight improvement over the 2019 diversity rating of 2.3 (also RRIBI score of 3). A total of 38 taxa (46 in 2019) were identified from the subsample, indicative of a RRIBI taxonomic richness value of 5 (*high*). Of this total, 21 taxa (22 in 2019) were members of the EPT orders for a RRIBI score of 5 (*high*) for the EPT taxa category. As in past years, the caddisfly genus *Lepidostoma* was the dominant taxon, accounting for 31% of all organisms identified in the sample. However, unlike previous years, the relative abundance of other taxa increased somewhat, resulting in the observed increase in the Shannon diversity rating. The dominance of the sensitive genus *Lepidostoma* (CTV of 1), accounts for a sensitive EPT index of 67% (RRIBI score of 5) and a tolerance value of 2.9 (RRIBI score of 5). The estimated overall abundance of benthic macroinvertebrates at An-4.4 decreased by 51% from 5,200 organisms/3 ft^2 in 2019 to 2,531 organisms/3 ft^2 in 2022.

The total RRIBI for An-4.4 in July 2022 was 26, indicative of *excellent* biotic conditions and a slight improvement over the 2019 score of 24 (also *excellent*). The 2022 RRIBI score for An-4.4 was comprised of *high* scores for taxonomic richness, EPT taxa, sensitive EPT index, and tolerance, and *moderate* scores for diversity and dominant taxon.

Gu-0.5

The 2022 Shannon diversity value for Gu-0.5 was 2.9 (2.4 in 2019) for a RRIBI score of 3 (*moderate*), the same as in 2019. A total of 58 taxa (35 in 2019) were identified from the subsample, indicative of an RRIBI taxonomic richness value of 5 (*high*). Of this total, 28 taxa (19 in 2019) were members of the EPT orders (RRIBI score of 5). Unlike 2019, when the sensitive caddisfly genus *Lepidostoma* was the dominant taxon at this site, the also sensitive stonefly genus *Malenka* was the dominant taxon in 2022, accounting for 17% of the organisms identified in the sample. This relatively low taxon dominance resulted in an increase in the dominant taxon RRIBI score of 1 (*low*) in 2019 to 3 (*moderate*) in 2022. Due to the slightly lower sensitivity of the dominant taxon *Malenka* (CTV of 2) compared to the 2019 dominant taxon *Lepidostoma* (CTV of 1), the sensitive EPT index at Gu-0.5 decreased slightly from 63% in 2019 to 54% in 2022 but maintained its RRIBI score of 5 (*high*). This lowered sensitivity also increased the overall tolerance value to 2.9 (2.6 in 2019), which accounts for a *moderate* RRIBI score of 3 (5 in 2019). The estimated overall abundance of benthic macroinvertebrates at Gu-0.5 decreased by 43% from 6,541 organisms/3 ft^2 in 2019 to 3,727 organisms/3 ft^2 in 2022.

The total RRIBI for Gu-0.5 in July 2019 was 24, indicative of *excellent* biotic conditions, and an increase compared to the 2019 RRIBI score of 22 (*good* biotic conditions). Previously, biotic conditions fluctuated between *excellent* (2004 and 2010), *good* (2007, 2013, and 2019), and *fair* (2016). The overall 2022 RRIBI score at Gu-0.5 was comprised of *moderate* diversity, dominant taxon, and tolerance, but *high* taxonomic richness, EPT taxa, and sensitive EPT index.

Gu-2.4

The 2022 Shannon diversity value for the relocated upper Gunning Creek site (Gu-2.4) was 2.4 (RRIBI score of 3), identical to the 2019 score. A total of 48 taxa were identified from the subsample (41 in 2019), indicative of *high* taxonomic richness (RRIBI score of 5). Of this total taxon abundance, 25 were EPT taxa, which accounts for a RRIBI score of 5 and represents a 25% increase over the 20 EPT taxa observed in 2019. The dominant taxon, the sensitive caddisfly genus *Lepidostoma*, accounted for 45% of the organisms identified in the sample. This taxon dominance resulted in a decrease in the dominant taxon RRIBI score of 3 (*moderate*) in 2019 to 1 (*low*) in 2022. However, due to the sensitivity of *Lepidostoma* (CTV of 1), the sensitive EPT index at Gu-2.4 increased from was 17% (*moderate* RRIBI score of 3) in 2019 to 61% (*high* RRIBI score of 5) in 2022. The tolerance value of 2.7 accounts for a RRIBI score of 5 (3 in 2019). The estimated overall 2022 abundance of benthic macroinvertebrates in upper Gunning Creek was 3,952 organisms/3 ft^2, comparable to the 3,716 organisms/3 ft^2 estimate in 2019.

The total RRIBI for Gu-2.4 in July 2019 was 24, indicative of *excellent* biotic conditions and an improvement over the 2019 score of 22 (*good* biotic conditions). This marks the first time this site has received an *excellent* score since 2013. Improvements in the sensitive EPT index and tolerance value resulted in the increased rating even though the dominant taxon category decreased from 2019. Prior to the 2015 Valley Fire that devastated the upper Gunning Creek area, Gu-2.4 always had *excellent* biotic conditions, but those fell to *fair* conditions in 2016 before recovering to *good* conditions in 2019 and now back to *excellent* conditions in 2022.

BeC-0.6

The 2022 Shannon diversity value for the relocated Bear Canyon Creek site was 3.1, a substantial improvement over the 2.2 value recorded in 2019 and representative of a *high* RRIBI score of 5. A total of 60 taxa (38 in 2019) were identified from the subsample, the highest taxa abundance of the five sites sampled and equivalent to a RRIBI taxonomic richness value of 5. Of this total, 29 taxa were members of the EPT orders (RRIBI score of 5) in 2022, a marked increase over the 22 taxa (RRIBI score of 5) in 2019. The dominant taxon, the moderately tolerant caddisfly genus *Amiocentrus* (CTV of 3), accounted for 23% of the organisms identified in the sample (RRIBI score of 3). The sensitive EPT index was 40% (RRIBI score of 3) and the tolerance value was 4.1 (RRIBI score of 3), both of which are comparable to biotic conditions noted in 2019. The estimated overall abundance of benthic macroinvertebrates in Bear Canyon Creek decreased by 49% from 11,000 organisms/3 ft^2 in 2019 to 5,607 organisms/3 ft^2 in 2022.

The total RRIBI for BeC-0.6 in July 2022 was 24, indicative of *excellent* biotic conditions. For reference, the 2019 RRIBI score was 20 (*good* biotic conditions). The increase in diversity from a score of 1 in 2019 to a score of 5 in 2022 accounted for the improvement in the biotic conditions rating. Similar to Gu-2.4 discussed above, biotic conditions in Bear Canyon Creek have improved from *fair* in 2016 to *good* in 2019 and now to *excellent* in 2022.

CuC-0.1

As noted above, safe access to sampling site CuC-0.1 was prevented by a large oak tree that had recently fallen across and severely damaged the staircase leading down the excessively steep slope. As such, no benthic macroinvertebrate surveys were conducted at this site in July 2022.

IV.3 Discussion

Benthic macroinvertebrates exhibit a high degree of population fluctuation. Since populations of these organisms are highly interdependent, natural cycles can be very complex. Rainfall is probably the most important factor influencing benthic macroinvertebrate populations in natural streams; water temperature, dissolved oxygen and the ability of a stream to flush silt from benthic substrates are directly correlated with rainfall amounts. McElravy and Resh (1987) found that population abundance of caddisflies in Big Sulphur Creek fluctuated less when rainfall patterns were most nearly the same. This theory is supported by past BC/WFF data which generally show considerable population abundance fluctuations during the late 1980's and early 1990's, while being more uniform during the second half of the 1990's when rainfall was consistently high.

The 2004 switch to the CSBP for sample collections and the RRIBI for data analysis has resulted in the generation of benthic macroinvertebrate data that are not entirely comparable to pre-2004 survey results. Also, the fact that some BMI sampling locations were relocated to existing fish survey sites adds to the non-compatibility of the data with prior BC/WFF data. However, the RRIBI was developed using the results of hundreds of samples and the scoring and rating system allows for relative comparisons of one-time samples to regional conditions. Therefore, we believe that updating BMI assessment methodologies to the current protocols benefited the overall monitoring program more than the ability to compare the current data to past BC/WFF data. At this point in time, a total of a seven sampling events (2004, 2007, 2010, 2013, 2016, 2019, and 2022) have been conducted pursuant to the CSBP (CDFG, 2003a) methodology, and notable trends have emerged from the data.

Compared to 2019, the total RRIBI scores increased at every sampling site in 2022. Similarly, RRIBI scores improved at every site from 2016 to 2019. The 2022 RRIBI ratings improved at four sites and remained constant at one, while one site (CuC-0.1) was not sampled. Overall, all five sampled sites received an *excellent* rating (Table IV.2). Although abundance estimates decreased at most sites between 2019 and 2022, abundance can vary widely and is likely the metric that is most dependent on streamflow as well as sampling location within the streambed. Thus, abundance is not used in RRIBI scoring of biotic conditions. While water years 2016 and 2019 were characterized by near-average precipitation and streamflows, water year 2022 represented the third consecutive drought year in coastal central California. As such, the observed improvements in biotic conditions likely represent gradual recovery of aquatic habitat quality since the 2015 Valley Fire, while low abundances reflect low streamflows during continued drought conditions.

In lower Anderson Creek (An-2.8) improvements in the sensitive EPT index and diversity accounted for the improved score. These improvements were characterized by a shift of the dominant taxon from the tolerant midge family Chironomidae to the moderately sensitive caddisfly genus *Amiocentrus* as well as an increase in taxa diversity. In upper Anderson Creek (An-4.4), a significant decrease in the relative abundance of the most dominant taxon (i.e., increased diversity) accounted for the main improvement.

In Gunning Creek, total RRIBI scores and overall biotic ratings at both sampling sites improved from *good* conditions in 2019 to *excellent* conditions in 2022. EPT taxa rated high at both sites while diversity was moderate at both. The primary differences between the two Gunning Creek sites were the higher dominant taxon score at Gu-0.5, while Gu-2.4 received a higher score for the weighted tolerance value of the sample. At Gu-2.4, the dominance of the sensitive caddisfly genus *Lepidostoma* boosted the tolerance rating but decreased the dominant taxon rating.

In Bear Canyon Creek, biotic conditions improved from *good* to *excellent* on account of an increase in the number of taxa from 38 in 2019 to 60 in 2022, which improved the diversity score from 1 in 2019 to 5 in 2022. All other RRIBI scores at BeC-0.6 remained unchanged from 2019.

TABLE IV.1

METRICS RESULTS FOR BENTHIC MACROINVERTEBRATE SAMPLES, JULY 2022

Metric	An-2.8	An-4.4	Gu-0.6	Gu-2.4	BeC-0.6	CuC-0.1
Taxonomic Richness	**46**	**38**	**58**	**48**	**60**	**--**
EPT Taxa	**24**	**21**	**28**	**25**	**29**	**--**
Ephemeroptera Taxa	7	8	8	8	9	--
Plecoptera Taxa	4	5	6	7	5	--
Trichoptera Taxa	13	8	14	10	15	--
Coleoptera Taxa	7	7	11	6	12	--
EPT Index (%)	73	87	62	75	53	--
Sensitive EPT Index (%)	**57**	**67**	**54**	**61**	**40**	**--**
Shannon Diversity	**3.0**	**2.6**	**2.9**	**2.4**	**3.1**	**--**
Dominant Taxon (%)	**15**	**31**	**17**	**45**	**23**	**--**
Tolerance Value	**3.3**	**2.9**	**3.5**	**2.7**	**4.1**	**--**
Intolerant Organisms (%)	30	49	41	58	13	--
Tolerant Organisms (%)	3.6	1.3	1.3	1.3	7.0	--
% Tolerant Taxa						
Collector-Gatherers (%)	38	59	53	72	50	--
Collector-Filterers (%)	23	7.4	13	2.2	2.8	--
Scrapers (%)	18	13	5.6	7.3	23	--
Predators (%)	7.5	3.4	5.2	5.4	4.5	--
Shredders (%)	8.9	13	20	8.6	12	--
Other (%)	4.2	4.2	3.0	4.4	8.5	--
Estimated Abundance (#/3 ft^2)	6,652	2,531	3,727	3,952	5,607	--

Note: Parameters listed in bold font are those that are used in RRIBI scoring and rating (see Table IV.2)

TABLE IV.2

RRIBI VALUES FOR BENTHIC MACROINVERTEBRATE SAMPLES, JULY 2022

Metric	An-2.8	An-4.4	Gu-0.5	Gu-2.4	BeC-0.6	CuC-0.1
Taxonomic Richness	5	5	5	5	5	--
EPT Taxa	5	5	5	5	5	--
Sensitive EPT Index (%)	5	5	5	5	3	--
Shannon Diversity	5	3	3	3	5	--
Dominant Taxon (%)	3	3	3	1	3	--
Tolerance Value	3	5	3	5	3	--
Total RRIBI Score	**26**	**26**	**24**	**24**	**24**	**--**
RRIBI Rating	**Excellent**	**Excellent**	**Excellent**	**Excellent**	**Excellent**	**--**

V. SUMMARY AND RECOMMENDATIONS

The Bear Canyon/West Ford Flat aquatic monitoring program was initiated in 1988 and is currently in its 35th year. Monitoring activities conducted during 2022 revealed water quality measurements that are reflective of the relatively undisturbed conditions in the Anderson Creek watershed, fish population estimates that are closely correlated to annual hydrology, and benthic macroinvertebrate populations that suggest improving biotic conditions following the 2015 Valley Fire.

Since its inception, the program has periodically undergone a review to assess the continued relevance of the parameters, locations, and frequency of monitoring activities. Considering evidence that normal geothermal operations do not appear to affect water quality in the watershed, we recommend that the laboratory analyses of total suspended solids, total dissolved solids, turbidity, oil and grease, alkalinity, bicarbonate, carbonate, calcium, magnesium, ammonia, nitrate, sulfate, chloride, total and fecal coliform, aluminum, arsenic, boron, barium, cadmium, chromium, copper, iron, mercury, lead, selenium, vanadium, and zinc no longer appear to be warranted. Moreover, the currently permitted schedule of three grab sampling events per year would be highly unlikely to detect short-term effects of accidental releases of pollutants. We therefore recommend that sampling for these parameters be eliminated from the BC/WFF program.

Furthermore, we recommend that the frequency of field measurements of parameters such as streamflow, dissolved oxygen concentration, water temperature, and conductivity be reduced to once a year and be conducted concurrent with fish surveys. Physical water quality measurements provide important information about the habitat quality conditions fish are exposed to at the time of the surveys. Benthic macroinvertebrate populations are an excellent indicator of overall biotic conditions in a stream reach and the current 3-year sampling frequency effectively captures long-term habitat trends.

VI. REFERENCES

American Public Health Association (APHA). 1995. Standard Methods for the Examination of Water and Wastewater. 19th Edition, American Public Health Association, Publication Office, Washington, DC.

American Public Health Association (APHA). 1985. Standard Methods for the Examination of Water and Wastewater. 16th Edition, American Public Health Association, Washington, DC, 1268 p.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B99-002. US Environmental Protection Agency, Office of Water, Washington, D.C.

Borgias, A. P. 1982. The acid solubility of arsenic in cooling tower sludge from the Geysers power plant. Research Report 420-82.82. Department of Engineering Research, Pacific Gas and Electric Company.

Brown and Caldwell Consulting. 1985. Postoperative Environmental Monitoring Summary Report. Published by Brown and Caldwell Consulting Engineers for Santa Fe Geothermal, Middletown.

California Department of Fish and Game (CDFG). 2003a. California Stream Bioassessment Procedure, December 2003 revision, Aquatic Bioassessment Laboratory, Rancho Cordova, CA.

California Department of Fish and Game (CDFG). 2003b. CAMLnet List of California Invertebrate Taxa and Standard Taxonomic Effort, 27 January 2003 revision, Aquatic Bioassessment Laboratory, Rancho Cordova, CA.

California State Department of Health Services (CSDOH). 1977. California domestic water quality and monitoring regulations. TITLE 22, California Administrative Code.

Regional Water Quality Control Board (RWQCB). 1998. The Water Quality Control Plan (Basin Plan) for the California Regional Water Quality Control Board Central Valley Region. Fourth Edition. The Sacramento River Basin and the San Joaquin River Basin.

Davis, E. A., K. J. Maier and A. W. Knight. 1988. The biological consequences of selenium in aquatic ecosystems. California Agriculture Jan-Feb: 18-20 & 29.

Eckblad, J. W. 1978. Aquatic Biology. Wm. C. Brown Company, Dubuque, Iowa, 231 p.

Environmental Science Associates (ESA). 2001. Bear Canyon and West Ford Flat Aquatic Monitoring Program Annual Report 1999-2000 (BC/WFF XII). Prepared for Calpine Corporation.

Environmental Science Associates (ESA). 2002. Bear Canyon and West Ford Flat Aquatic Monitoring Program Annual Report 2000-2001 (BC/WFF XIII). Prepared for Calpine Corporation.

Environmental Science Associates (ESA). 2010. Bear Canyon and West Ford Flat Aquatic Monitoring Program Annual Report 2009-2010 (BC/WFF XXII). Prepared for Calpine Corporation.

Environmental Science Associates (ESA). 2013. Bear Canyon and West Ford Flat Aquatic Monitoring Program Annual Report 2012-2013 (BC/WFF XXV). Prepared for Calpine Corporation.

Environmental Science Associates (ESA). 2017. Bear Canyon and West Ford Flat Aquatic Monitoring Program Annual Report 2015-2016 (BC/WFF XXVIII & XXIX). Prepared for Calpine Corporation.

Environmental Science Associates (ESA). 2020. Bear Canyon and West Ford Flat Aquatic Monitoring Program Annual Report 2019 (BC/WFF XXXII). Prepared for Calpine Corporation.

Hach. 1983. Water Analysis Handbook. Hach Company, Loveland, Colorado, Fascicle 1:1-22.

Harrington, J. and M. Born. 2000. Measuring the Health of California Streams and Rivers. Second edition (revision 4), Sustainable Land Stewardship International Institute, Sacramento, CA.

Hibbard, P. L. 1935. The significance of mineral matter in water. Journal of the American Water Works Association 21:884-896.

Ireland, R. R. and J. L. Carter. 1980. Chemical ecology investigations at the Geysers, California. Transactions of the Geothermal Resources Council 4:675-678.

Jordan, W. P., R. J. Brown, and G. L. Stevens. 1986. Squaw Creek Aquatic Monitoring Program (SCAMP) Annual Report 1984-1985. Published by the Institute of Chemical Biology (USF) for GEO Operator Corporation, Santa Rosa.

Jordan, W. P., R. J. Brown, G. L. Stevens, and K. D. Ward. 1987. Squaw Creek Aquatic Monitoring Program (SCAMP) Annual Report 1985-1986. Published by the Institute of Chemical Biology (USF) for GEOOC, Santa Rosa, and CCPA, Sacramento.

Jordan, W. P., R. J. Brown, K. D. Ward Jennings. 1988. Squaw Creek Aquatic Monitoring Program (SCAMP) Annual Report 1986-1987 and Three-year Summary. Published by the Institute of Chemical Biology (USF) for GEOOC, Santa Rosa, and CCPA, Sacramento.

Karfiol, R. C. and L. E. McMillan (Eds.). 1983. Geysers-Calistoga KGRA-ARM Program 1981-1982 annual report, 2 vols.

Knight, A. 1985. Personal Communication with ICB staff. Department of Land, Air and Water Resources, University of California, Davis.

Kubicek, P. F. and D. G. Price. 1976. An evaluation of water temperature and its effect on juvenile steelhead trout in geothermally active areas of Big Sulphur Creek. Cal-Nev Wildlife Transactions, J. Hoakum (Ed.), pages 1-24.

LandWatch, Incorporated. 2003. 2003 Boron drift monitoring summary for the Calpine Geothermal Power Plant # 19. Prepared for Calpine Corporation.

Lepp. N. W. (ed.). 1981. Effect of heavy metal pollution on plants. Vol. I and II, Applied Science, London.

Malloch, B. S., M. K. Eaton, and N. L. Crane. 1979. Assessment of vegetation stress and damage near the Geysers power plant units. Pacific Gas and Electric, Engineering Research, Report 420-79.3, San Ramon.

Marshack, J. B. 1985. Water Quality Objectives and Hazardous and Designated Levels for Chemical Constituents. Appendix IV, California Regional Water Quality Control Board, Central Valley Region.

McKean, M.E., R.J. Brown, and W.P. Jordan. 1998. Bear Canyon and West Ford Flat Monitoring Report 1997-1998 (BC/WFF X). Published by the Institute of Chemical Biology (USF) for Calpine Geysers Company, Santa Rosa, CA.

McKee, J. E. and H. W. Wolf (Eds.) 1963. Water Quality Criteria (3-a). California State Water Resources Control Board, Sacramento.

McMillan, L. E. (Ed.). 1985. Geysers-Calistoga KGRA-ARM Program 1982-1983 annual report, 2 vols.

Moyle, P. B. 2002. Inland Fishes of California, University of California Press, Berkeley and Los Angeles, CA.

Nolte and Associates. 1985. Draft Environmental Impact Report West Ford Flat (PG&E Unit 19) Project Area, Lake County, California.

Platts, W. S., W. F. Megahan, and G. W. Minshall. 1983. Methods for Evaluating Stream, Riparian, and Biotic Conditions. U.S. Forest Service, Intermountain Forest and Range Experiment Station, Gen. Tech. Report INT-138.

Shannon, C. E. 1948. A mathematical theory of communication. Bell Systems Tech. J. 27:379-423, 623-656.

Thurston, R. V., R. C. Russo, C. M. Fetterrolf, T. A. Edsall and Y. M. Barber (Eds.). 1979. A review of the EPA Redbook: Quality Criteria for Water. Water Quality Section, American Fisheries Society, Bethesda.

U.S. Environmental Protection Agency (USEPA). 1980. Ambient water quality criteria for arsenic (440/5-80-201), cadmium (440/5-80-025), copper (440/5-80-036), lead (440/5-80-057), mercury (440/5-80-058), nickel (440/5-80-060), selenium (440/5-80-070) and zinc (440/5-80-079).

U.S. Environmental Protection Agency (USEPA). 1986. Quality Criteria for Water 1986. EPA 440/5-86-001. Office of Water, Washington, DC.

U.S. Environmental Protection Agency (USEPA). 1988. Ambient Water Quality Criteria for Chloride - 1988. EPA 440/5-88-001. Office of Water, Washington, DC.

U.S. Environmental Protection Agency (USEPA). 1999a. 1999 Update of Ambient Water Quality Criteria for Ammonia. EPA-822-R-99-014. Office of Water, Washington, DC.

U.S. Environmental Protection Agency (USEPA). 1999b. National Recommended Water Quality Criteria - Correction. EPA 822-F-98-005. Office of Water, Washington, DC.

U.S. Environmental Protection Agency (USEPA). 2006. National Recommended Water Quality Criteria. Office of Water, Office of Science and Technology (4304T). 440/9-76-023.

Van Deventer, S. J. and W. S. Platts. 1989. Microcomputer software system for generating population statistics *in* Electrofishing data user's guide for MicroFish 3.0. Gen Tech Rep INT-254. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 29 p.

Wilhm, J. and T. C. Dorris. 1968. Biological parameters for water quality criteria. Bioscience 18:477-481.

Weber, C. I. (Ed.). 1973. Biological field and laboratory methods for measuring the quality of surface waters and effluents. NERC/EPA, Cincinnati.

CONDITION OF CERTIFICATION
BIOLOGICAL RESOURCES 1-3

Attachment BR 1-3b: Guzzler Inspection Report

Geysers Quicksilver Plant (Unit 16) 79-AFC-05C
2022 Annual Compliance Report to the California Energy Commission
January 2022-December 2022

Geysers 2022 Guzzlers and Pond inspections:

Pine Flat Pond – Pond and overflow in good condition

Joe Guzzler – In Good Condition.

Big Sulfur Creek Guzzler – In Good Condition

Unit 20 Guzzler – In Good Condition

U20 Pond Overflow – Overflow functional and Tules now abundant in Pond

D&V Guzzler – In Good Condition

U18 Pond – Overflow and Pond in Good Condition. Some Tules Growing

U17 Pond – Overflow Functional, but Pond is Dry.

U17 Guzzler – In Good Condition. Poison Oak abundant in area.

Injun Mine Sedimentation pond (below white water tank towards U16) was inaccessible due to growth and fallen trees.

Sedimentation Pond Below U16 in Good Condition

Birdsong Meadow fencing Has some barbed wire needing repair – lift top wire.

Guzzler on top of hill near U16 in Good Condition

Sonoma Dams have gravel in top few sections needing to be cleaned to prepare for next rainy season. Gravel appears to be falling in from road above.

CONDITION OF CERTIFICATION
PUBLIC HEALTH 6-1

Attachment PH 2-1: Table of quarterly radon-222 concentration analyses in non-condensable gases during the 2022 calendar year

Geysers Quicksilver Plant (Unit 16) 79-AFC-05C
2022 Annual Compliance Report to the California Energy Commission
January 2022-December 2022

	4Q22	3Q22	2Q22	1Q22	Quicksilver 16	
Date	11/14/22	08/22/22	06/27/22	3/23/22		
Unit	16	16	16	16	16	
[Rn-222] Main Steam Sample (pCi/Kg)	**50896**	**45699**	**40879**	**49850**		
Unit gross load (MW)	**53.4**	**50.7**	**52.8**	**52.6**		
Supply steam flow rate (klb/hr)	**767**	**745**	**842**	**865**		
Supply Steam Flow Rate (Mg/hr)	348	338	382	392		
Steam Rate (lb/kwhr)	**14.40**	**14.70**	**16.00**	**16.10**		
Steam Rate Derived Supply Steam Flow Rate (Mg/hr)	349	338	383	384		
100% Service Cool. Tower Air flow Rate, S.T.P. (GL/hr)	21.40	21.40	21.40	21.40		
Number of Fans in Service	**11**	**11**	**11**	**11**		
Number of Fans	11	11	11	11		
Cool. Tower fract. (cells oper. /cells design)	1.00	1.00	1.00	1.00		
Cooling Tower air flow rate, S.T.P. (GL/hr)	21.40	21.40	21.40	21.40		
Unit daily Cooling Tower air flow (L/day)	5.136E+11	5.136E+11	5.136E+11	5.136E+11		
Unit Rn222 Release Rate (Ci/day)	0.43	0.37	0.38	0.46		
Unit Rn222, Emission Concentration (pCi/L)	**0.83**	**0.72**	**0.73**	**0.89**		
Notes on Color Codes:						
Data from Sample Collection Sheet						
Data from Analytical Laboratory Results						
Data Result						
Data Entry Or Import From Other Source Required						
Maxiumum Value Substiututed in lieu of corrupt data						
Anomolous Source Data Corrupt And Not Used						
Data is Constant or Calculated						
Conversion Const. Mg/klb =						
0.4535924						

CONDITION OF CERTIFICATION
WQ 11-10

Attachment WQ 11-10: 2022 Geysers Power Plant Units Recycled Water Use Report

Geysers Quicksilver Plant (Unit 16) 79-AFC-05C
2022 Annual Compliance Report to the California Energy Commission
January 2022-December 2022

GEYSERS POWER COMPANY, LLC
10350 Socrates Mine Road
Middletown, CA 95461
707.431.6000

GWQ-23-016

January 18, 2023

Email to: dwpdist18@waterboard.ca.gov
District Engineer
State WRCB – Division of Drinking Water
50 D Street, Suite 200
Santa Rosa, CA 95404

Subject: 2022 Geysers Power Plant Units Recycled Water Use Report

District Engineer:

Use of Santa Rosa recycled water first began at Unit 17 on July 22, 2004 where it supports cooling tower basin levels by replacing blowdown water at a rate of 400-500 gpm. When tower basin water levels are sufficiently high, recycled water bypasses the tower and enters the onsite sediment pond, where it mixes with condensate then gravity feeds to the Unit 11 sediment pond prior to reinjection at the OS-16 well. Tabulated below are various uses of recycled water during 2022.

2022 Total	U3 Tower	U17 Tower	U20 Tower	Total SRGRP Gallons Received
Gallons	242,611,230	59,845,951	106,286,902	4,112,220,000

Minor amounts of recycled water were used for incidental purposes as identified in Section 3.2 of the Engineering Report. These uses may consist of dust control, construction, fire-fighting and industrial process water. Additionally, recycled water was used for various drilling activities in Sonoma County during 2022. Appropriate signage and labeling was directed by the User Supervisor for these activities.

If you have any questions, please contact me at (707) 431-6097.

Sincerely,

Peggie King
Calpine-Geysers EHS