PACIFIC GAS AND ELECTRIC COMPANY

Hat Creek Hydroelectric Project, FERC No. 2661
Pit 1 Hydroelectric Project, FERC No. 2687

Shasta Crayfish Technical Review Committee Summary Report

May 2009

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Shasta Crayfish Technical Review Committee Summary Report

Addressing License Articles 409, 410, 411, 412, and 413
Hat Creek Hydroelectric Project (FERC No. 2661, USFWS Biological Opinion 1-1-02-F-0182)
Pit 1 Hydroelectric Project (FERC No. 2687, USFWS Biological Opinion 1-1-00-F-0210)
Upper Fall River Crayfish Barrier Project (USFWS Biological Opinion 1-1-07-F-0333)
PG&E's USFWS Recovery Permit TE-755945-3
Spring Rivers' USFWS Recovery Permit TE-806679-3

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Executive Summary

The Federal Energy Regulatory Commission (FERC) licenses for Pacific Gas and Electric Company's (PG&E) Hat Creek Hydroelectric Project (FERC No. 2661) and Pit 1 Hydroelectric Project (FERC No. 2687) require the formation of a technical review committee (TRC) to oversee certain management activities for the endangered Shasta crayfish (*Pacifastacus fortis*). Consequently, the Shasta Crayfish TRC, which consists of representatives from both federal and state agencies, academia, PG&E and other members of the private sector, was formed in April 2003. As stated in both licenses, the TRC's role is to assist in the design and implementation of the terms and conditions required in the biological opinions for the protection and recovery of the Shasta crayfish in the two project areas. In addition to license implementation, the TRC expanded its role to include species recovery throughout the range of the Shasta crayfish. As a result, the United States Fish and Wildlife Service formed the Shasta Crayfish Recovery Team, which is comprised of a subset of TRC members. TRC actions are defined as Shasta crayfish actions specifically required by a FERC license, whereas Recovery Team actions are not specifically required by a FERC license. All members agreed that TRC actions would be done where it most benefited the Shasta crayfish and would not be restricted by FERC project boundaries.

This document summarizes all Shasta crayfish TRC and/or Recovery Team activities between April 2003 and April 2009 and provides recommendations for future activities.

TRC Activities

TRC actions include TRC/Recovery team meetings, crayfish monitoring and habitat delineation, removal or eradication of non-native signal crayfish (*Pacifastacus leniusculus*) and non-native fantail crayfish (*Orconectes virilis*), implementation of the Crayfish Barrier Plan, development and installation of Shasta crayfish interpretive and education signs, and investigations into the reintroduction of Shasta crayfish into Rock Creek. As part of this document, the 2008 annual monitoring data includes the completion of the second crayfish monitoring survey in the Pit 1 Project vicinity, non-native crayfish eradication surveys related to the Crayfish Barrier Plan, and verification and correction of delineated crayfish habitat data.

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Both Crayfish Barrier Plan projects were completed in 2007. A crayfish barrier was designed and installed in the upper Fall River just downstream of the large Shasta crayfish population at Thousand Springs. Subsequently, annual signal crayfish eradication surveys have been conducted upstream of the barrier to reduce or eliminate that non-native, invasive species. The second project was the improvement of the Spring Creek Road crossing, where culverts create velocity barriers to signal crayfish that occur downstream in lower Spring Creek and Fall River. The crossing was improved by filling in crevices and gaps surrounding the culverts thereby eliminating habitat being used by signal crayfish. Annual surveys to remove signal crayfish have also been conducted in Spring Creek upstream of the culverts.

In 2008 interpretive and education signs were designed and installed at several locations in the Hat Creek and Pit 1 project areas that are commonly visited by the public. The signs contain information about the status of the Shasta crayfish and the threat posed by the illegal use of crayfish as bait.

A proposed plan for the partial restoration of Rock Creek and subsequent reintroduction of Shasta crayfish into Rock Creek was described to the TRC in June 2004. The plan involves the movement of the California Department of Fish and Game's (CDFG) Crystal Lake Fish Hatchery diversion structure downstream about 600 feet, so that a section of Rock Creek suitable for Shasta crayfish would be re-watered. Topographic mapping of the stream channel, percolation tests, and measurements of existing stream flow at the top and bottom of the proposed restoration reach were conducted between 2003 and 2006 to address concerns that the amount of water available for diversion at the new location would be reduced. A genetic management plan and a written proposal for the proposed Rock Creek Restoration and Shasta crayfish Reintroduction Project need to be developed in 2009.

Crayfish monitoring surveys began in 2003 with the baseline Hat Creek survey, which was conducted between September 2003 and February 2004. The second Hat Creek survey was done between November 2004 and February 2005, and the third survey was done between January and April 2007. The baseline survey in the Pit 1 Project vicinity was conducted between March 2004

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and February 2007. The second Pit 1 survey was conducted between April 2007 and March 2009.

In the Pit 1 Project vicinity, 786 Shasta crayfish, 5903 signal crayfish, and 350 fantail crayfish, were collected during the baseline survey. During the second monitoring survey, 550 Shasta crayfish, 6097 signal crayfish, and 117 fantail crayfish were collected. Shasta crayfish accounted for 11.2% of all crayfish encountered in the baseline survey and 8.1% of all crayfish encountered in the second survey. Non-native signal crayfish and fantail crayfish accounted for 83.9% and 5.0% of all crayfish encountered in the baseline survey, respectively. Non-native signal crayfish and fantail crayfish accounted for 90.1% and 1.7% of all crayfish encountered in the second survey, respectively. The two largest populations of Shasta crayfish were found in Spring Creek and at Thousand Springs in the upper Fall River drainage.

During the Hat Creek surveys, Shasta crayfish were only found in Crystal Lake. Totals of 162, 272, and 132 Shasta crayfish were found in the first, second, and third surveys, respectively. Within Crystal Lake, Shasta crayfish accounted for 13% of the crayfish captured in the first survey and 14% in the second and third surveys; non-native signal crayfish accounted for the remaining 87% or 86%. The age-class distribution showed an shift towards adults from 2003 to 2007. Most of the Shasta crayfish were found in the spring areas of Southwestern Crystal Lake. The number of Shasta crayfish found at Crystal Lake Outflow decreased from 23 to 7 to 2 over the years. Shasta crayfish were least abundant in Middle Cove with two crayfish found in the first and second surveys, and none in the third survey.

A comparison of results from the two surveys in the Pit 1 Project vicinity and the three surveys in the Hat Creek Project vicinity with results from earlier surveys (1978 and the 1990s) indicates a substantial decline in Shasta crayfish distribution and abundance. Shasta crayfish were found at 25 locations in the Pit 1 and Hat project vicinities during the earlier surveys. The most recent survey confirmed Shasta crayfish present at 15 locations, with fewer than 10 Shasta crayfish found at eight of these locations. Introduced signal crayfish have continued to expand their range since the late 1970s and are now widespread and abundant throughout most of the area.

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The fantail crayfish has expanded its range in the upper Tule River and Big Lake drainage since being introduced there in 1993.

Recovery Team Activities

Recovery Team actions include the Sucker Springs Restoration Project and California CDFG's temperature and genetics studies.

The Sucker Springs Restoration Project involves the re-establishment of a natural channel, removal of non-native crayfish, and construction of crayfish barriers to maintain an allopatric subpopulation of Shasta crayfish. To date, most of the unnatural features that were part of the old hatchery facilities have been removed from the stream channel. Extensive efforts to remove non-native crayfish have been conducted annually since 2003 and will continue until successful. Work planned for 2009 also includes the installation of crayfish barriers upstream of two existing weirs at the downstream ends of ponds 4 and 5.

Two ongoing Recovery Team projects are being conducted by CDFG. One is a temperature study, which produced results on the growth of signal crayfish but has yet to be successful with Shasta crayfish. The other is a study of the genetics of the various Shasta crayfish subpopulations that is being conducted by the University of California, Davis and Spring Rivers. Results to date have shown that each of the various subpopulations can be placed into one of three regional groups.

Recommendations

The Shasta Crayfish TRC/Recovery Team Year 5 Review Workshop was held on 22 April 2009. The first five and six years of monitoring for the Pit 1 and Hat Creek projects, respectively were reviewed. The observed decline in Shasta crayfish numbers and the recovery actions needed, were discussed. The Shasta crayfish plans have been and will continue to be adapted as needed, based on input from the TRC. The recommendations and changes are documented in the annual reports. Projected TRC and Recovery Team activities for 2009 and current recommendations are provided.

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TRC Activities and Recommendations

1. Eliminate the summer flushing flows in the Pit 1 Bypass Reach due to the possibility that the license-required summer flushing flows may be resulting in take of the endangered Shasta crayfish.
2. Continue snorkel surveys of the Upper Fall River barrier at least twice a year to inspect the barrier and to monitor for the presence of debris and/or algal growth that could compromise the barrier.
3. Develop a written proposal to reintroduce Shasta crayfish to Rock Creek. Article 412 of the Hat Creek Project license requires PG&E to develop a Shasta Crayfish Management Plan that includes formulation of a plan to re-introduce Shasta crayfish into Rock Creek. Prior to implementation of a Rock Creek Reintroduction Plan:
   a. Develop a Rock Creek Restoration Plan to restore historical Shasta crayfish habitat, including measures to ensure that the water needs for the Crystal Lake Fish Hatchery continue to be met.
   b. Consult Genetic Management Plan to help determine source population for potential reintroductions of Shasta crayfish into Rock Creek.
4. Continue with the Pit 1 and Hat Creek crayfish monitoring surveys according to the schedule and methods described in this report. If no Shasta crayfish have been found during at least two consecutive surveys including the baseline crayfish monitoring surveys, the site can be eliminated from the next round of surveys. For instance, Fletcher's Bend, Lennihan's Footbridge, Northeast Upper Tule River, South Shore Upper Tule River, East Shore Upper Tule River, Horr Pond Levees, and Baum Lake will not be surveyed during the third Pit 1 surveys starting in 2009 or the fourth Hat survey in 2012.
5. Conduct the Rising River survey, upon receipt of landowner permission.
6. Continue with the biannual non-native crayfish eradication surveys of Thousand Springs and Spring Creek according to the schedule and methods described in this report.

Recovery Team Activities and Recommendations

1. Begin implementation of non-native signal crayfish suppression measures and refugia investigations as outlined in the scope of work for the 2008 Director's Deferred funding.
2. Develop a CDFG Section 6 proposal to:
   a. Conduct Mitochondrial DNA work on existing Shasta crayfish genetic samples.
   b. Develop a Genetic Management Plan to help determine source populations for potential reintroductions of Shasta crayfish into Rock Creek and elsewhere.
   c. Investigate potential refugia
3. Continue with eradication of signal crayfish in Sucker Springs Creek. Review and modify methods, as necessary, to improve effectiveness.
4. Install crayfish barriers, similar in design to the upper Fall River crayfish barrier, adjacent to and upstream from the Pond 4 weir and the Pond 5 weir in Sucker Springs Creek.
5. Develop a proposal to reintroduce a relatively small number of Shasta crayfish upstream of the CDFG diversion structure on Rock Creek in 2009 as an experiment in lieu of the temperature study in the raceways at Crystal Lake Fish Hatchery.

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   a. Consult Genetic Management Plan to help determine source population for potential reintroductions of Shasta crayfish into Rock Creek.

6. Continue and expand the CDFG Genetic Study
   a. Collect genetic samples from Shasta crayfish in Rising River once landowner permission is obtained and send to UC Davis Genomic Variability Laboratory.
   b. Conduct Mitochondrial DNA work on existing Shasta crayfish genetic samples.
   c. Develop a Genetic Management Plan to help determine source populations for potential reintroductions of Shasta crayfish into Rock Creek and elsewhere.

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Introduction

The Federal Energy Regulatory Commission (FERC) issued licenses for two Pacific Gas and Electric Company (PG&E) hydroelectric projects in northeastern California (Shasta County) within the past seven years. The licenses for the Hat Creek Hydroelectric Project (FERC No. 2661) and the Pit 1 Hydroelectric Project (FERC No. 2687) were issued on 4 November 2002 and 19 March 2003, respectively. Both licenses contain Articles designed to monitor and protect the federally and state-listed endangered Shasta crayfish (*Pacifastacus fortis*), which exists in both project areas (Figure 1). The licenses include measures to protect Shasta crayfish from non-native, invasive crayfish. The non-native signal crayfish (*Pacifastacus leniusculus*), which is both a competitor and predator of the Shasta crayfish, is considered the greatest threat to the continued existence of the Shasta crayfish (Ellis 1999). The non-native fantail crayfish (*Orconectes virilis*) is also found within the range of the Shasta crayfish.

In both the Hat Creek and Pit 1 licenses (Appendix A), Article 409 requires the development of a plan to monitor the habitat and populations of Shasta crayfish in the project area. Article 412 of each license requires the development of a Shasta crayfish management plan, including provisions to fund non-native signal crayfish removal. Article 413 of the Hat Creek license and Article 416 of the Pit 1 license require the development of recreational management plans to educate the public about the status of Shasta crayfish, including potential threats from recreational activities. Article 413 of the Pit 1 license requires the development of a plan to construct and maintain a minimum of two exclusion barriers to protect Shasta crayfish habitat from invasion by signal crayfish. Article 410 of each license requires PG&E to establish a technical review committee (TRC) to assist PG&E in the design and implementation of the terms and conditions required in the biological opinions for Shasta crayfish protection and recovery in the two project areas.

The TRC was established in April 2003 in coordination with the United States Fish and Wildlife Service (USFWS), California Department of Fish and Game (CDFG), and other resource agencies and interested stakeholders. The TRC consists of representatives from USFWS, CDFG, California Department of Parks and Recreation (CDPR), Spring Rivers Ecological Sciences LLC

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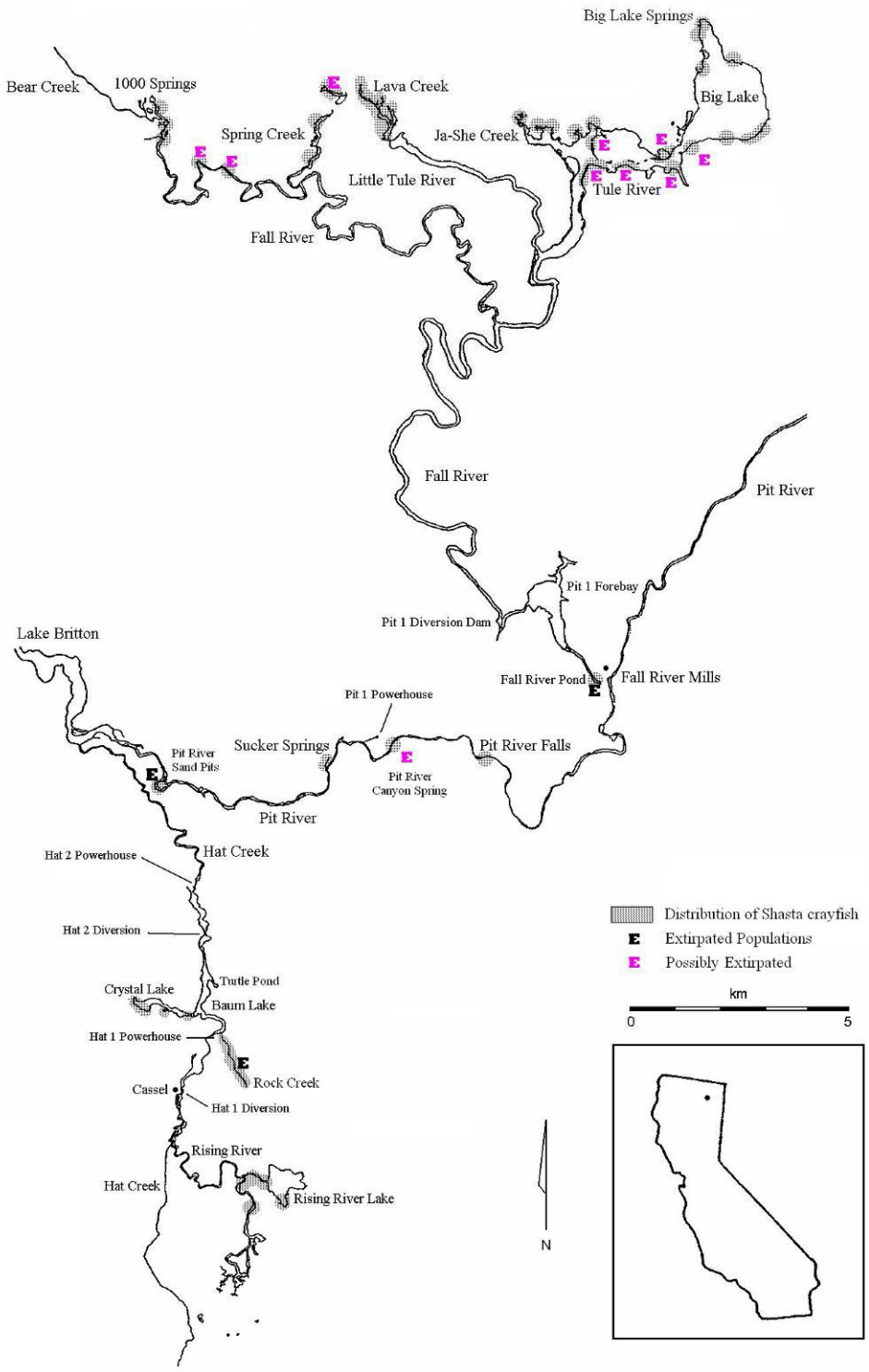

Figure 1 Known distribution of the Shasta crayfish (*Pacifastacus fortis*).

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(Spring Rivers), academia, and PG&E. In addition to helping PG&E implement the terms and conditions of the license, the TRC also serves as a working group for other Shasta crayfish recovery projects. As a result, the USFWS formed the Shasta Crayfish Recovery Team (Recovery Team), which is comprised of a subset of TRC members. TRC actions are defined as Shasta crayfish actions specifically required by a FERC license, whereas Recovery Team actions are not specifically required by a FERC license.

To address the requirements of Articles 409 and 412 in each project licenses, a Shasta Crayfish Management Plan (Plan) was written in consultation with the USFWS, CDFG, Natural Resources Conservation Service (NRCS), and interested stakeholders. The Hat Creek Plan (PG&E 2003a), which includes crayfish monitoring and management and recreational management (Article 413) components, was submitted to the agencies on 14 February 2003. Comments from the agencies were addressed before the Hat Creek Plan was submitted to FERC on 30 April 2003. FERC approved the Hat Creek Plan without modification on 21 August 2003. The Pit 1 Plan (PG&E 2003b), which includes crayfish monitoring and management components, was submitted to the agencies for comment on 11 July 2003 and to FERC on 19 September 2003. FERC approved the Pit 1 Plan without modification on 7 July 2004.

On 8 December 2006, PG&E submitted the final Crayfish Barrier Plan (PG&E 2006) to FERC, as specified in Article 413 of the Pit 1 license. FERC approved the Crayfish Barrier Plan on 8 March 2007. The Crayfish Barrier Plan includes four required elements: (1) provisions to fund the design and construction of two crayfish barriers; (2) detailed design drawings and map locations of the exclusion barriers; (3) a schedule for construction and initial performance testing; and (4) a monitoring and reporting schedule for long-term evaluation of barrier effectiveness.

The two Shasta crayfish management plans (PG&E 2003a, 2003b) specify the following three monitoring tasks: (1) map and quantify the existing habitat in the Project areas; (2) collect baseline data on Shasta crayfish in delineated habitat areas; and (3) monitor Shasta crayfish in delineated habitat areas over the length of the license. The crayfish monitoring surveys began with the baseline Hat Creek survey, which was done between September 2003 and February

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2004. The second Hat Creek survey was conducted between November 2004 and February 2005. The baseline survey in the Pit 1 Project vicinity was conducted between March 2004 and February 2007. Table 1 provides the implementation schedule for these tasks over the course of the two licenses. This schedule was revised and approved during the May 2007 TRC meeting because the Pit 1 baseline crayfish monitoring survey took three years to complete. In addition, the plans call for the removal of non-native crayfish found during the monitoring surveys. The Hat Creek Plan calls for formulation of a plan to reintroduce Shasta crayfish to Rock Creek, which is a spring-fed tributary to Baum Lake (Figure 1).

Both the Hat Creek and Pit 1 licenses (Appendix A) and Shasta crayfish management plans (PG&E 2003a, 2003b) specify that habitat and populations of Shasta crayfish will be monitored within the respective Project areas. During the 3 May 2007 meeting, however, the TRC approved the inclusion of all known Shasta crayfish locations (e.g., Rising River, Rainbow Spring, Lava Creek, Thousand Springs, etc.) in the study area for the surveys outlined in the Shasta crayfish management plans. The expansion of the study areas resulted in no additional monetary requirements, facilitated sample collection for the genetic study, and provided consistency with the Crayfish Barrier Plan, which included a barrier location outside the Pit 1 Project area. The additional survey sites will be scheduled when there are monitoring funds available, for instance during years when regular monitoring surveys are not scheduled (e.g., 2008 through 2011 for Hat Creek; see Table 1).

Articles 411 and 412 of both the Hat Creek and Pit 1 licenses require PG&E to establish Shasta crayfish management funds to cover the cost of monitoring, non-native crayfish removal, and other TRC-approved Shasta crayfish activities. The annual amounts for crayfish surveys (Article 411) and non-native crayfish removal (Article 412) are adjusted annually from the original amounts stated in the licenses (2003 dollars for Hat and 2004 dollars for Pit 1) based on the Consumer Price Index as specified in the license. During years in which monitoring surveys are not scheduled (e.g., years 3 and 4 of the Hat Creek license), the annual management funds are used for other TRC-approved Shasta crayfish projects, such as the Sucker Springs Creek Restoration Project. Shasta crayfish management funds that are not spent during the year roll over to subsequent years. Beginning in 2008, barrier non-native crayfish control funding and

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Table 1 Schedule[a] of Shasta crayfish surveys included in the Hat Creek and Pit 1 Shasta crayfish management plans

YEAR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Hat license year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30											
Pit license year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Hat Surveys[b]	1	2			5					10					15					20					25					30											
Pit Surveys[c]		1			4		6				10					15					20					25					30					35				39	

[a] Schedule was revised because the initial baseline Pit 1 Project surveys took 3 years. It was approved during the 3 May 2007 TRC meeting.
[b] Surveys for the Hat Creek Project are scheduled for years 1, 2, 5, 10, 15, 20, 25, and 30 of the license.
[c] Baseline Pit 1 Project surveys took 3 years; future surveys will take 1-2 years each and are scheduled for years 4/5, 6/7, 10/11, 15/16, 20/21, 25/26, 30/31, 35/36, and 39/40 of the license.

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implementation included the Spring Creek barrier project (i.e., Spring Creek Road Crossing Cavity-Filling Project). Appendix B provides a summary of the Shasta crayfish management funds, including barrier non-native crayfish control, for both licenses through 1 April 2009.

This document includes the monitoring data for 2008 and early 2009 and a summary of all monitoring efforts since license implementation began in 2003. Activities performed in 2008 and the winter of 2009 include: (1) TRC/Recovery team meetings, (2) Rock Creek site visits with PG&E, USFWS, and other potential partners, (3) completion of the second Pit 1 crayfish monitoring survey, and (4) verification and correction of delineated crayfish habitat. This document reports and provides the multi-year summaries for all monitoring efforts under: (1) TRC actions, including crayfish monitoring surveys, the Crayfish Barrier Plan (Pit 1 Article 413), and the investigation into the reintroduction of Shasta crayfish into Rock Creek (Hat Creek Article 412); and (2) Recovery Team actions, including the Sucker Springs Restoration Project and CDFG's temperature and genetics studies.

Technical Review Committee Activities

2008 Meetings

The TRC and Recovery Team held joint meetings on 9 April 2008 and 24 September 2008 (see Appendix C for Meeting Agendas and Summaries). On 22 July 2008, Spring Rivers personnel met with USFWS, Bureau of Land Management (BLM), and Ducks Unlimited (DU) personnel (Kathy Brown, the USFWS Conservation Partnerships Program Coordinator; Dominic Bachman, USFWS Partners for Fish and Wildlife Private Lands Biologist; John Ranlett, DU Regional Biologist-Intermountain West; and Harry McQuillen, BLM Cosumnes River Preserve Manager) to tour Rock Creek and Sucker Springs Creek and to discuss potential partnership and funding opportunities for Shasta crayfish restoration projects. In addition, Spring Rivers personnel met with PG&E personnel at Rock Creek on 6 October 2008 and 18 March 2009 to familiarize them with the site and issues related to potential habitat restoration.

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Summary of Past Meetings

During the first Shasta crayfish TRC meeting, which was held on 16 April 2003, the draft TRC protocol, draft Hat Creek Shasta Crayfish Management Plan, and funding were discussed. It was decided that the TRC would handle Shasta Crayfish Management Plan issues for both the Hat Creek and Pit 1 projects. The revised TRC Protocol, describing the purpose, goals, objectives, and commitments of the TRC for both the Hat Creek and Pit 1 Projects, was filed with FERC on 26 May 2004. During a 7 October 2003 field meeting, the TRC visited Crystal Lake and Rock Creek and were given an overview of the status of Shasta crayfish in the Pit 1 Project area and the status of the Pit 1 Shasta Crayfish Management Plan.

Two TRC meetings were held in 2004. During the 14 April 2004 TRC meeting, USFWS suggested that the TRC incorporate members into a recovery implementation team, which would allow recovery work to be performed outside of FERC project boundaries and also expedite USFWS funding of restoration projects. USFWS agreed to write a letter indicating that PG&E can use license monies allocated for Shasta crayfish anywhere within the species' range to best benefit Shasta crayfish, as opposed to only within project boundaries. During the 26 October 2004 TRC meeting, USFWS announced that a Shasta Crayfish Recovery Team had been formed that was comprised of eight members of the TRC. In addition, the TRC also conducted a site visit to Rock Creek on 9 June 2004, so that engineers from CDFG (George Heise) and the private sector (Chuck Schlumpberger), as well as other agency personnel, could review the proposed plan to move the intake structure for the Crystal Lake Hatchery approximately 600 feet downstream to restore potential Shasta crayfish habitat in the upper Rock Creek meadow.

In 2005, four joint meetings of the TRC and Recovery Team were held on 11 January, 12 April, 19 July, and 6 December. The TRC also conducted a site visit to potential barrier sites on 24 May 2005. Two additional field meetings were held at Sucker Springs Creek to discuss the Sucker Springs Restoration Project. CDFG and USFWS personnel toured Sucker Springs Creek on 13 April 2005. Construction managers, biologists, and habitat restoration specialists from PG&E and CDFG toured Sucker Springs on 7 September 2005.

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In 2006, the TRC and Recovery Team met on 4 April, 3 August, and 2 November. The TRC also conducted site visits to potential barrier sites on 22 February 2006 and 21 March 2006. A Recovery Team meeting that included members Dan Strait of USFWS Partners for Fish and Wildlife and Maria Ellis and other Spring Rivers personnel was held at Sucker Springs Creek on 5 December 2006 to discuss the Sucker Springs Restoration Project.

In 2007, the TRC and Recovery Team held meetings on 3 May and 25 September. During the May meeting, the TRC approved the inclusion of all known Shasta crayfish locations outside of Project areas (e.g., Rising River, Rainbow Spring, Lava Creek, Thousand Springs, etc.) in the study area for the surveys outlined in the Hat Creek and Pit 1 Shasta crayfish monitoring plans.

Crayfish Barriers

As required by the Pit 1 license, PG&E developed and implemented a Crayfish Barrier Plan (PG&E 2006) to construct and maintain a minimum of two exclusion barriers to protect Shasta crayfish and their habitat from invasion by signal crayfish and other non-native crayfish species. Decisions about the locations, designs, construction methods, and materials of the proposed barriers were made based on the results of the Crayfish Barrier Flume Study (Spring Rivers 2005a) and numerous field meetings and consultations with engineers, construction experts, landowners, federal and state agencies, the TRC, and the Recovery Team. The Crayfish Barrier Flume Study, which was funded by CDPR, USFWS, and Spring Rivers, was conducted at the J. Amorocho Hydraulics Laboratory and the Center for Aquatic Biology and Aquaculture at the University of California, Davis from January 2002 through July 2004 (Spring Rivers 2005a). To determine the locations of potential barriers, highest priority was given to sites that would prevent the upstream migration of non-native crayfish into allopatric Shasta crayfish populations or sites where there was a possibility that allopatry could be restored upstream of a barrier. The upper Fall River at Thousand Springs and Spring Creek were considered the two highest priority barrier locations because of the relatively large size of the Shasta crayfish populations and the relatively few non-native signal crayfish found in the vicinity or upstream of the potential barrier locations in the 2006 surveys.

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PG&E worked with the TRC and Recovery Team to develop a Crayfish Barrier Plan (PG&E 2006) that would provide the greatest benefit to the species. The Upper Fall River Crayfish Barrier Project benefits the Shasta crayfish in the upper Fall River at Thousand Springs by creating a barrier to upstream migration of the non-native signal crayfish. The Spring Creek Road Crossing Cavity-Filling Project protects Shasta crayfish by eliminating potential refugia for signal crayfish and by capturing signal crayfish, with the goal of reducing and controlling their numbers or eradicating them. Potential refuges for non-native crayfish were eliminated by filling the voids, gaps, and cavities in the upstream face of the Spring Creek Road Crossing. The capture efforts seek to either eradicate or control non-native crayfish populations in Spring Creek upstream of the Spring Creek Road Crossing. The Spring Creek Road Crossing Cavity-Filling Project is an extension of a project completed in 2000 that replaced the deteriorating culverts of the original road crossing at Spring Creek in order to create a barrier to the upstream movement of signal crayfish from Fall River.

PG&E requested four extensions (i.e., 31 December 2004, 31 December 2005, 31 August 2006, 10 December 2006) for filing the Crayfish Barrier Plan, which was originally due within one year of license issuance (i.e., March 19, 2004). Between 20 October 2004 and 31 January 2005, PG&E submitted two drafts of the Crayfish Barrier Plan and the final Crayfish Barrier Flume Study report to the TRC. Discussions on the plan, including the potential effects to rough sculpin, were held during the TRC meetings in October 2004, January 2005, and April 2005. Both USFWS and CDFG commented that the January 2005 draft of the Crayfish Barrier Plan lacked the detailed design drawings and map locations of the exclusion barriers and a schedule for construction and initial performance testing, as required by the license. USFWS emphasized the importance of having an engineer from PG&E work out the final details of barrier construction, materials, and installation. Both USFWS and CDFG reiterated the importance of extending the barrier onto the stream banks to prevent the overland travel of non-native crayfish and requested additional details as to the design and evaluation of overland barriers. CDFG stated that if genetic isolation of rough sculpin, a fully protected species, appears to be occurring, CDFG may relocate sculpin above the barriers.

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During May 2005, engineers from PG&E and CDFG met with other USFWS, CDFG, PG&E, and Spring Rivers personnel, landowners, and managers to tour the potential barrier sites in the upper Fall River at Thousand Springs and in Spring Creek to determine and discuss the details of barrier construction, materials, and installation. Following the field tour, the TRC outlined the steps necessary to produce a barrier plan complete with barrier designs, location specifics, and engineering plans. During the July 2005 meeting, the TRC agreed to move forward on the two barrier locations. The TRC requested additional surveys of these areas to determine the current distribution of signal crayfish upstream of the potential barrier locations. The possibility of constructing a smaller, prototype barrier at Sucker Springs Creek was also discussed.

During the December 2005 meeting, the TRC voted in favor of pursuing the construction of a barrier across the channel of the upper Fall River at Thousand Springs, above the confluence of Bear Creek, utilizing the basic design criteria specified in the Barrier Flume Study (Spring Rivers 2005a). The TRC requested that a streambed topography survey of the potential barrier location be done in late 2005. The TRC also voted in favor of the second barrier at Spring Creek, but that it would consist of refacing the existing barrier created by the Spring Creek Road crossing culverts. The TRC also included periodic surveys to remove and control, or eradicate, signal crayfish in Spring Creek upstream of the Spring Creek Road crossing. PG&E submitted a Crayfish Barrier Plan Update and Action Plan to the TRC and FERC in December 2005.

On 22 February 2006, a field meeting was held to familiarize the PG&E project manager and engineer and PG&E's consulting engineer with the proposed barrier locations in the upper Fall River at Thousand Springs and in Spring Creek and to meet with key ranch personnel at Thousand Springs Ranch. The site visits gave the engineers an opportunity to assess the overall site conditions and facilitate plan development. At the Spring Creek site, PG&E's engineer was able to determine that the key issues were related to construction, not engineering. He recommended an on-site meeting with a PG&E construction foreman to discuss the issues. The meeting with the construction foreman and Spring Rivers was carried out on 21 March 2006. At the April 2006 TRC meeting, one of the key action items identified for the upper Fall River barrier was for the engineers to produce a matrix that would list and evaluate the various barrier options. In order for this to be done, a detailed substrate mapping and depth-probing effort was

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done on 1–4 May 2006. The survey produced a data grid covering 210 linear feet of the Fall River channel from bank to bank at a 10-ft by 10-ft resolution. Data collected at the center of each square of the grid included water depth and the depth of the substrate overburden (i.e., sand, gravel, and cobble) covering the bedrock (Figure 2).

Based on the substrate mapping, the following three barrier alternatives were devised. An evaluation matrix of these barrier alternatives is shown in Table 2.

Post-and-Plate Barrier. This barrier would be a stainless steel plate that would have its top edge 1 foot above the bottom of the river. The barrier would be supported by posts drilled and grouted into the bedrock bottom. The plate would be welded to the posts. Where the overburden is less than, or equal to, 1 foot deep, the bottom edge of the barrier would be sealed to the bedrock by a hydrophilic waterstop material, grout, or other filler material. Where the overburden is greater than 1 foot, the barrier plate would be buried a minimum of 1 foot into the overburden instead of being sealed to the bedrock.

Pre-cast, Anchor Blocks with Plate Barrier. This barrier would be a stainless steel plate with its top 1 foot above the bottom of the river. The plate would be held in place by bolts in pre-cast concrete blocks about 8 inches high, 12 inches deep, and 6 feet long. The bottom would be sealed by a hydrophilic waterstop material, grout, or other filler material.

Cast-in-place Concrete Anchor with Plate Barrier. This barrier would be a stainless steel plate that would have its top 1 foot above the bottom of the river. The plate would be attached with bolts to a concrete-filled tube. The concrete tube would be about 6 inches high and 14 inches wide and extend the entire width of the river. The tube would be placed in the water and then concrete would be pumped into it. Bolts would be drilled into the concrete after it is cured.

At the 3 August 2006 meeting, the TRC decided that the post-and-plate barrier was the preferred alternative, based on overall cost, ease of construction, installation, and removal, if necessary. The substrate survey data were then used to select the best possible alignment for the barrier (Figure 2). The alignment was selected to maximize the amount of exposed bedrock, while minimizing the length of the structure and the steepness of the bank at the barrier interface.

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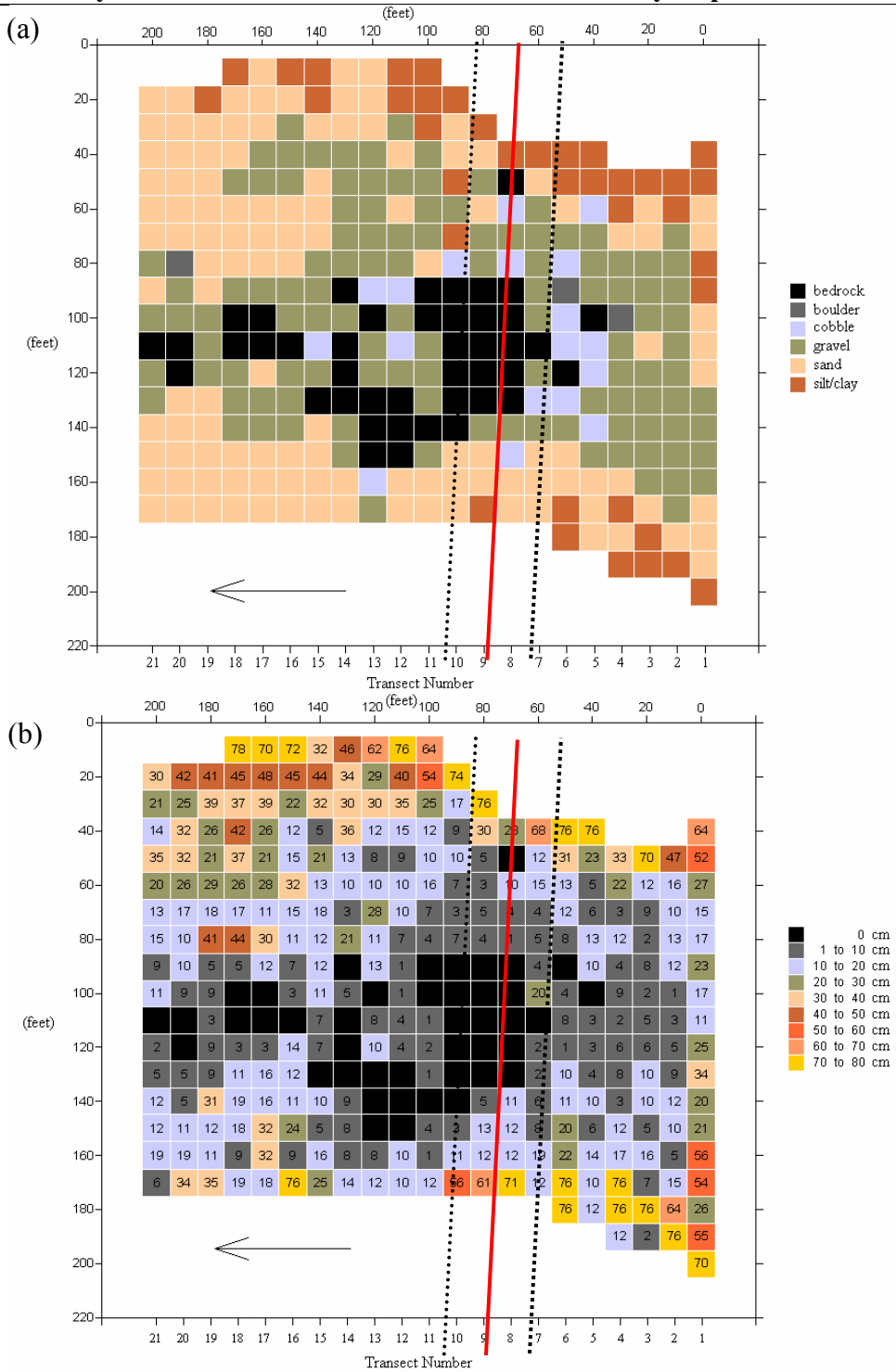

Figure 2 **Substrate at the upper Fall River barrier location mapped in the center of each 10-foot square survey grid: (a) substrate type and (b) depth range (square color) and measured depth (number) of overburden on bedrock in centimeters. Red line indicates barrier allignment. Dashed lines delineate the 15-foot work area. Arrow indicates flow direction.**

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Table 2 Evaluation matrix of barrier design alternatives for the upper Fall River.

Barrier Type	Post-and-Plate	Pre-Cast Anchor Blocks	Concrete Footing in Fabric
Barrier Material(s)	Stainless Steel	Concrete, Stainless Steel	Concrete, Plastic Fabric, Stainless Steel
Ease of Installation	Small crew with minimum equipment and small material size.	Requires crane or barge and precise alignment of blocks.	Requires concrete truck, pump truck, and method to anchor tube.
Water Quality Concerns	Minimum impact while drilling post holes. Use non-toxic grout.	Minimum impacts during drilling bolts.	Potential impact from accident with concrete placement.
Sealing Bottom	Seal bottom of plate against rock with waterstop or grout.	More difficult than post-and-plate barrier due to block next to plate.	Depends on tube following bottom contour; may leave voids that need filling.
Removable	Cut plates from posts and cut posts at bottom.	Requires crane to lift out blocks.	Concrete in tube would have to be broken into small pieces and removed.
Cost	Probably lowest cost.	Higher than post-and-plate with crane or barge costs depending on alignment problems.	Higher than post-and-plate with concrete on site and pump truck.
Time to Construct	Probably 2 weeks.	Shortest time 1-2 weeks if able to align block easily.	Over 3 weeks total. Needs concrete cure for drilling.

At the 3 August 2006 meeting, the TRC also agreed to a two-phase approach for implementation of the Crayfish Barrier Plan. The upper Fall River barrier would be constructed in 2007 and the Spring Creek barrier refacing would likely be completed in 2008. Non-native crayfish eradication would continue in both areas. PG&E agreed to initiate some of the permitting for the barriers once the plan was submitted to FERC for final approval. Significant funding of permitting or any other activity, however, would occur after FERC approval of the plan. The final Crayfish Barrier Plan was submitted to FERC and the agencies on 8 December 2006.

FERC approved the Crayfish Barrier Plan on 8 March 2007, with the following modification. The Shasta Crayfish Technical Review Committee annual reports would provide: (1) updates on PG&E's efforts to secure funding, (2) a proposed schedule for accomplishing the Spring Creek Road culvert cavity filling, and (3) a proposed schedule for biannual eradication/control surveys of non-native crayfish in Spring Creek. The plan outlined the design and methods for the construction of a barrier in the upper Fall River at Thousand Springs (Upper Fall River Crayfish

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Barrier Project) and the repair of an existing barrier in Spring Creek (Spring Creek Road Crossing Cavity-Filling Project). All permitting and compliance issues related to the Endangered Species Act, National Historic Preservation Act, National Environmental Policy Act, California Environmental Quality Act, Clean Water Act, and the California Endangered Species Act, were addressed prior to construction.

In 2007, the crayfish barrier in upper Fall River was constructed, and the barrier in Spring Creek was refaced and the substrate in the vicinity of the upstream end of the culverts was moved. PG&E provided the USFWS with a post-construction report titled "Non-Native Crayfish Barrier Post-Construction Report Benefiting Shasta Crayfish" (Spring Rivers 2007b), which documented the results of the pre-construction surveys and project actions in fulfillment of the reporting requirements under the USFWS Biological Opinion and Incidental Take Statement (1-1-07-F-0333) for the Upper Fall River Crayfish Barrier Project.

Monitoring and maintenance surveys for the Upper Fall River barrier began immediately after the barrier was installed in August 2007 and will continue for the life of the barrier or until the landowner and/or TRC/Recovery Team decides that the barrier and/or its maintenance is no longer needed or functional. Snorkel surveys of the barrier were done to ensure the integrity of the barrier and to monitor for the presence of debris and/or algal growth that could compromise the barrier. In addition to snorkel surveys, Thousand Spring Ranch personnel also monitor for the presence of debris or any other disturbances to the barrier. Because no build-up of algae or debris was observed on the stainless steel surface of the barrier during the initial, more frequent monitoring, a biannual monitoring schedule was adopted. Table 3 provides a summary of the upper Fall River barrier inspection, including dates, persons conducting the inspection, and details pertaining to cleaning, debris loading, algal growth, or other pertinent barrier information.

To streamline reporting, PG&E requested and USFWS agreed to a change in the deadline for reporting on post-construction monitoring, including the eradication surveys, from the 1st of January to the 31st of May each year (Appendix D). The extension allows the monitoring results to be included in the annual reports for the TRC. The 2008 eradication survey data are reported in the Crayfish Monitoring, Non-Native Crayfish Eradication Surveys section of this report.

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Table 3 Upper Fall River barrier inspection summary.

Date	Inspector(s)	Comments
August 27, 2007	Stalcup, Breedveld	Surface clean and free of debris
August 28, 2007	Stalcup, Breedveld	Surface clean and free of debris
September 27, 2007	Stalcup, Breedveld	Surface clean and free of debris
February 28, 2008	Stalcup, Breedveld	Surface clean and free of debris
July 24, 2008	Stalcup, Breedveld	Surface clean and free of debris
January 26, 2009	Stalcup, Breedveld	Surface clean and free of debris, snails

Rock Creek Reintroduction

Pursuant to the Hat Creek Shasta Crayfish Monitoring and Management Plan, investigations to assess the feasibility of the restoration of Rock Creek and subsequent reintroduction of Shasta crayfish began in 2003. Reliable anecdotal evidence exists that Shasta crayfish inhabited Rock Creek up until 1950, when the majority of the flow was diverted near the upper end of its perennially wetted channel to supply CDFG's Crystal Lake Fish Hatchery. The stream was subsequently rotenoned in 1962 and 1963 (Schafer 1968).

Reintroduction of Shasta crayfish into Rock Creek would involve rewatering some portion of the channel, which still retains suitable cobble and boulder substrate, to restore natural crayfish habitat. In order to do that, however, several concerns need to be addressed, including: (1) insure that CDFG's water needs for the Crystal Lake Fish Hatchery continue to be met, (2) a high level of confidence that a reintroduced Shasta crayfish population would be viable and protected from invasion by non-native crayfish, and (3) the source population for the reintroduction needs to be determine based on appropriate criteria.

In 2003, a longitudinal profile was surveyed along Rock Creek from the headwater springs above the hatchery intake to the mouth of Rock Creek at Baum Lake. Slope was surveyed following standard methods (e.g., Moffitt and Bouchard 1982). The locations and elevations of key features along the length of the channel were surveyed and noted, including the hatchery diversion intake structure and the drop-structure barrier near the lower end of the channel (Figure 3). Potential Shasta crayfish habitat was assessed, and a snorkel survey was done to verify that Rock Creek was free of any crayfish species. Channel widths in two areas of potential Shasta crayfish habitat in the upper meadow and the low-gradient portion of the lower

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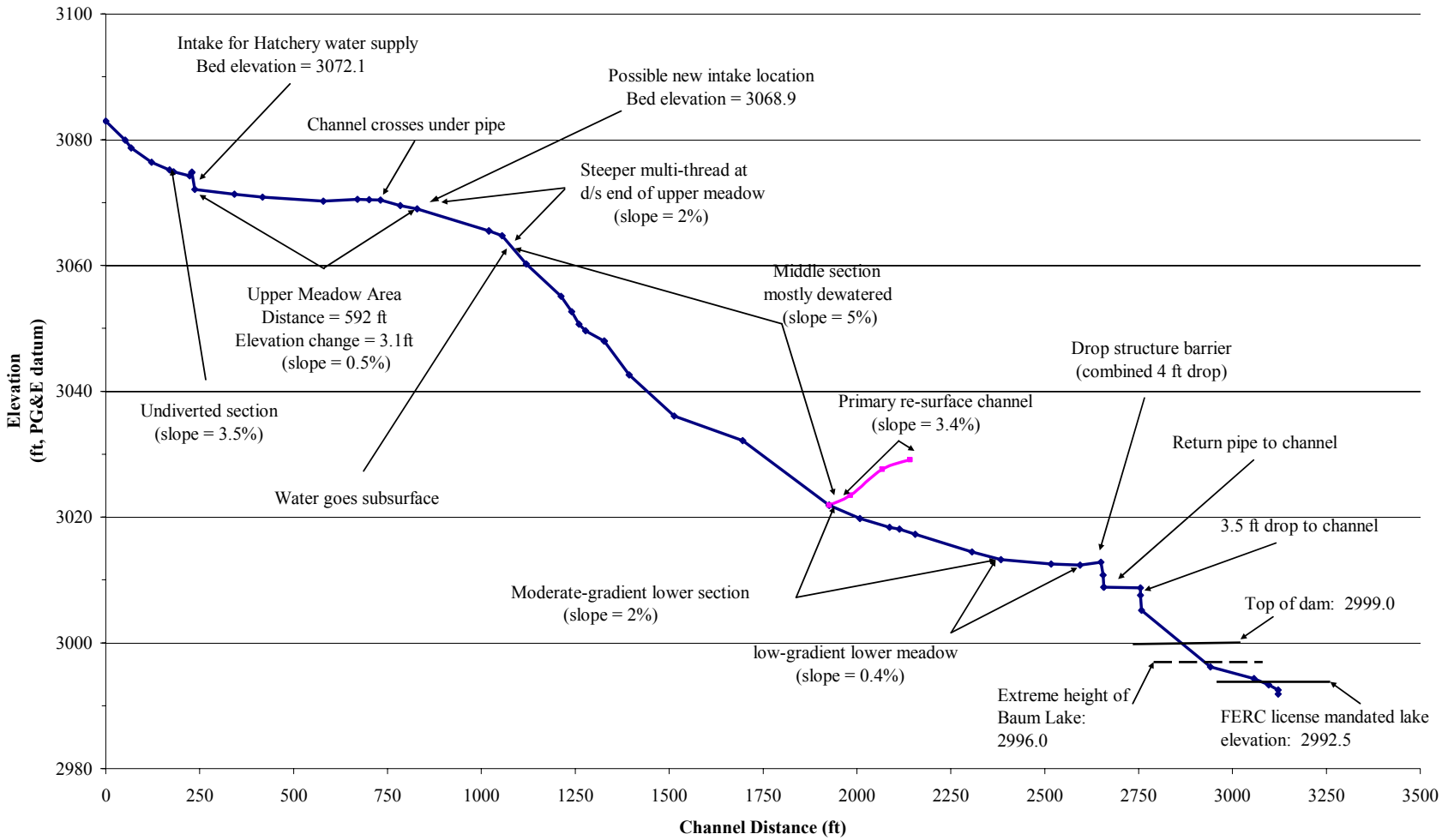

Figure 3 **Longitudinal profile of Rock Creek from the headwater springs above the hatchery intake to the mouth of Rock Creek at Baum Lake. The locations and elevations of key features along the length of the channel are noted, including the hatchery diversion intake structure, upper meadow, possible location for a new intake structure, low-gradient lower meadow, and the drop-structure barrier near the lower end of the channel.**

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meadow in Rock Creek (Figure 3) were measured to assess the amount of habitat that might be recreated with water released back into the channel.

The upper Rock Creek meadow is a low-gradient reach that has good potential as a restoration site. In December 2004, this upper meadow was mapped from the current hatchery diversion intake structure downstream to the location of a proposed replacement hatchery diversion intake structure. A total of 17 transects were established perpendicular to a 550-foot longitudinal transect approximately parallel to the Rock Creek channel but upslope of the channel on river right (Spring Rivers 2005b). Twelve transects were established at 50-ft intervals along the longitudinal transect and four additional cross-sections were established at possible spillover areas. At the location of the proposed new hatchery diversion intake structure, one final transect was established perpendicular to the channel. Transects were surveyed following standard methods (e.g., Moffitt and Bouchard 1982). The locations and elevations of key features on each transect were surveyed and noted, including potential spillover areas and the hatchery water supply pipe. Elevations along all transects were tied to a common elevation datum to facilitate plotting the elevation data in a three-dimensional grid.

Figure 4 is a topographic map (6-inch contour interval) of the upper Rock Creek meadow from the current hatchery intake structure to the proposed new hatchery diversion intake structure at the downstream end of the meadow. This map was generated from the 2004 topographic data. All Rock Creek transects are included in the 2004 Annual Report to the TRC (Spring Rivers 2005b). In the upper 350 feet of the mapped area, Rock Creek is confined to its current channel with no possible spill-over areas. The hatchery water-supply pipe follows the old channel in the upper portion, but exits the channel between the 400-ft and 450-ft transects. In this area the natural historic bank on the east side of Rock Creek (i.e., left side of Figure 4) was low, which made this the logical location for the pipeline to be diverted from the channel. In order to divert it, a notch was excavated through the natural bank berm to allow the pipeline to pass without excessive elevation gain. This notch in the historic bank berm is the only location through which Rock Creek water could possibly spill out of the natural historic channel, if natural flows were to be returned to the channel. The notch in the berm, which is slightly wider than the width of the pipe, would be filled as part of the potential restoration of the upper Rock Creek meadow.

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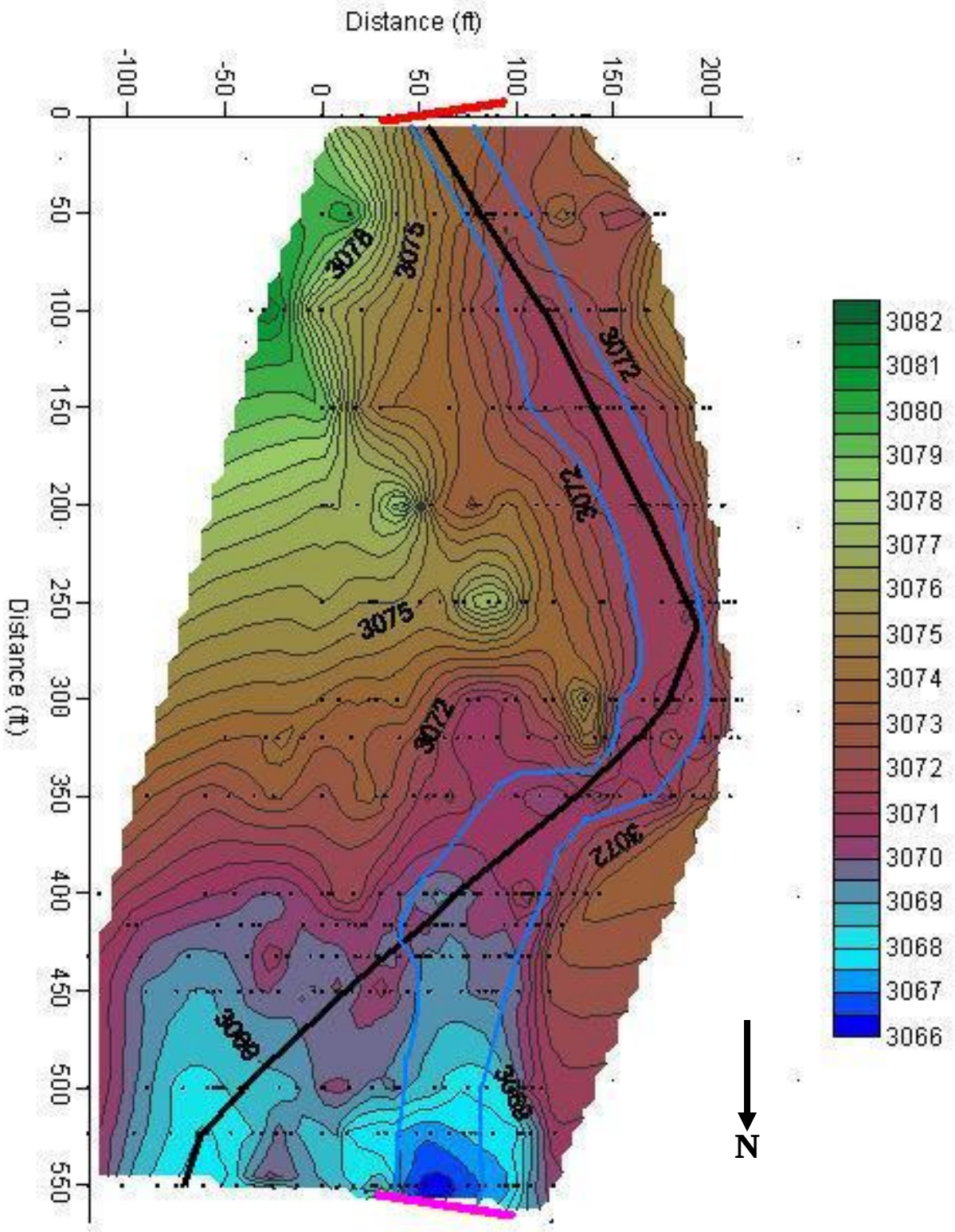

Figure 4 **Color-coded contour map of the upper Rock Creek basin, with transect data points (black dots) and hatchery water supply pipe (black line). The historic channel is outlined in blue. Each color represents a 6-inch elevation change.**

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Based on the 2003 and 2004 topographical surveys of Rock Creek, TRC discussions of restoration and reintroduction of Shasta crayfish began to focus on the upper meadow of Rock Creek. The approximately 600-foot-long, low-gradient (0.5 % slope) meadow stretches from just below the present CDFG hatchery diversion structure to a substantial break in slope where Rock Creek enters a steep, cascading section. The average width of the remnant channel in the potential restoration section was about 23 feet. Restoration would involve relocating the diversion structure from its present location to one approximately 600 feet downstream and restoring flow to the channel through the upper meadow. This would create approximately 13,550 sq ft (1259 m^2) of Shasta crayfish habitat. Based on the calculated mean density of 0.83 Shasta crayfish per square meter observed in upper Spring Creek (Light et al. 1995), the restored Rock Creek meadow area potentially could support more than 1000 Shasta crayfish. This estimated carrying capacity could be conservative given that Daniels (1980) found densities as high as 6.89 Shasta crayfish per meter at Crystal Lake Outflow and Ellis (1999) recorded as many as 25 Shasta crayfish under a single rock in the fish trap cove at Thousand Springs.

During a July 2005 meeting, CDFG voiced a major concern that the upper meadow of Rock Creek could be a losing reach (i.e., less water would exit the bottom of the reach than enters the top of the reach). If the reach is a losing reach, then moving the diversion site downstream would result in less water for the Crystal Lake Fish Hatchery, which would be unacceptable to CDFG. CDFG engineer, George Heise, suggested that a sand bag test or percolation test would indicate whether it was a losing reach (see Appendix E for the 15 July 2004 CDFG Memorandum prepared by George Heise on the proposal to relocate the Crystal Lake Hatchery water supply diversion point). During the December 2005 meeting, the TRC recommended that percolation testing be done in the upper meadow area of Rock Creek to determine whether moving the diversion downstream would result in less water available for diversion to the hatchery.

In early June 2006, the feasibility of conducting a standard percolation test in the Rock Creek reach targeted for restoration was assessed. Test holes were dug in the floodplain away from the Rock Creek channel to qualitatively assess soil moisture and percolation potential. These holes could only be dug approximately 6 to 12 inches into the soil before striking bedrock. Ground-

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water was encountered 4 to 6 inches below the soil surface and remained in the holes as standing water. By August, both holes remained moist, although standing water was no longer present.

In early August 2006, flow was measured at two locations in Rock Creek to assess whether any of the existing low flow (i.e., less than 1 cubic foot per second [cfs]) in the channel was being lost to the potential restoration channel. One location was in the upper half of the upper meadow, and the other was near the lower end. Several factors combined to make these measurements difficult and to create a worst-case scenario for assessing potential water loss within the reach. These factors included: (1) the very low discharge in the channel below the hatchery diversion; (2) the broad, shallow configuration of the current wetted channel and the coarseness of the substrate; (3) the split upper channel, which made it necessary to measure flow in both channels; (4) a small percentage of flow at the lower location that was seeping around the measurement transect; and (5) the time of year (August), when evapotranspiration losses would be relatively high.

The discharge at the upper end of the channel (i.e., the combined discharge of the two split channels) was 0.63 cfs. The discharge at the lower transect was 0.54 cfs. The specifications of the flow meter state an accuracy of ±2% of the measured value, plus or minus the zero stability of the sensor (0.05 ft/s). The difference between the upper and lower discharges was 0.09 cfs. Thus, although the flow measurement at the lower end of the reach was less than the upper measurement, the difference was less than the margin of error for the measurements and may not be real. Based on the measurements made under summer conditions in 2006 and the accuracy of those measurements, it cannot be concluded that the Rock Creek channel is a losing reach.

During TRC discussions in November 2006, a conference call between CDFG engineer George Heise, CDFG biologist Steve Baumgartner, and Spring Rivers biologists Maria Ellis and Jeff Cook was suggested, but has not occurred. The proposed objective of the call was to provide the opportunity for: (1) a discussion of site assessment methods (e.g., for hydrologic testing); (2) the establishment of criteria and thresholds for moving forward (e.g., acceptable percolation rates); and (3) a discussion of conceptual designs for a new diversion dam, intake structure, and other facilities that would be necessary for the project.

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Shasta Crayfish Interpretive and Education Signs

In compliance with Article 413 of the Hat Creek license and Article 416 of the Pit 1 license, PG&E developed interpretive and education (I&E) signs to be installed at designated locations. The Hat Creek I&E sign was developed to educate the general public and protect Shasta crayfish from recreational activities (Figure 5). Copies of the sign were installed at the Hat Creek recreation sites, which include the Baum Lake parking lot and the Cassel Campground at Hat 1 Canal in 2008. The Pit 1 I&E sign was developed for educating the general public about the status of the Shasta crayfish and the bald eagle, including information on potential threats from recreational activities (Figure 6). Copies of the Pit 1 I&E sign were installed at the Pit recreation sites, which include the Rat Farm (Big Lake) Access, the Tule-Fall River Access, the Fall River Lake Day Use Area, the Fall River Pond Access, and the Pit River Access in 2008.

In 2009, PG&E will be installing a permanent version of CDFG's sign that needed to be replaced annually at the outflow of Crystal Lake. The sign posts the CDFG regulation prohibiting fishing in the Crystal Lake Outflow from November 16th through the last Friday in April (Figure 7).

Crayfish Monitoring

Survey areas for monitoring crayfish in the vicinity of the projects were selected based on the findings of the comprehensive Shasta crayfish surveys done for PG&E in the early 1990s (Ellis and Hesseldenz 1993, Ellis 1996, 1999), as well as earlier surveys (Daniels 1980, Eng and Daniels 1982). For consistency, names for the Shasta crayfish populations and site locations designated in the Shasta Crayfish Recovery Plan (USFWS 1998) were also used in this report. Efforts focused on areas in which Shasta crayfish, or potentially suitable Shasta crayfish habitat, had been found during earlier surveys. In addition, 14.2 kilometers of the mainstem Pit River were surveyed in 2005 to map the distribution of Shasta crayfish. This spring-influenced reach of the mainstem Pit River consists of the lower Pit 1 Bypass Reach downstream of Big Eddy to the Pit 1 Powerhouse and the Pit River Reach between the Pit 1 Powerhouse and Lake Britton. In earlier surveys, Shasta crayfish were found at two locations in the lower Pit 1 Bypass Reach (i.e., Pit River Falls in 1995 and Pit River Canyon Spring in 1980 and 1995) and at one location in the Pit River Reach (i.e., Pit River Sand Pits in 1978) (Figure 1, Ellis 1996).

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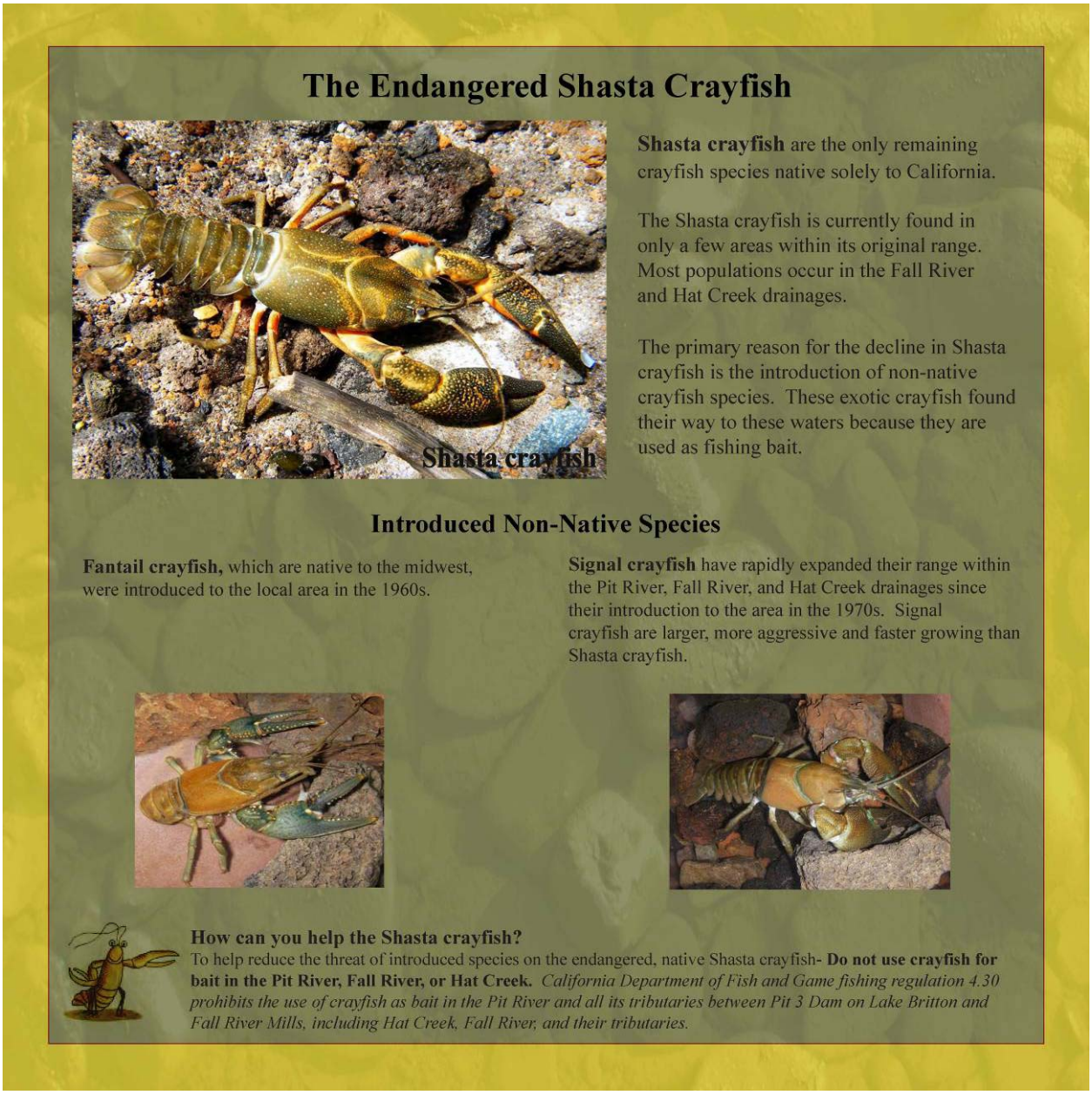

Figure 5 Hat Creek Shasta crayfish interpretive and education sign.

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Figure 6 Pit 1 Shasta crayfish and bald eagle interpretive and education sign.

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Figure 7 Crystal Lake Outflow sign posting the CDFG regulation prohibiting fishing in the Crystal Lake Outflow from November 16th through the last Friday in April.

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For both projects, the initial baseline crayfish monitoring survey included detailed mapping of Shasta crayfish habitat, as well as surveys for all crayfish species. Each crayfish survey done for the subsequent crayfish monitoring was of equal effort to the baseline survey. Subsequent crayfish monitoring surveys, however, relied on the Shasta crayfish habitat mapping results from the baseline survey. If changes in habitat were noted during subsequent crayfish monitoring surveys, Shasta crayfish habitat mapping results were revised as necessary based on these observations. Shasta crayfish habitat was surveyed once during each crayfish monitoring survey.

Between monitoring surveys, some changes were made in the geographic area surveyed based on either the TRC decision to include sites outside the FERC Project boundaries or the results of previous surveys. The baseline surveys for both projects focused on habitat and populations of Shasta crayfish within the Project boundaries; however, the TRC decided that subsequent surveys would include all known Shasta crayfish locations. As a consequence, the second Pit 1 monitoring surveys added Rainbow Spring, Lava Creek, and Thousand Springs to the sites within the Pit 1 Project boundaries that were surveyed during the baseline survey. Similarly, Rising River will be included in future Hat Creek monitoring surveys, if landowner permission is received. Rising River was not surveyed during the first three Hat Creek surveys. In addition, the intent of the crayfish monitoring surveys is to initially include all sites where Shasta crayfish have ever been found, as well as some other potential Shasta crayfish habitat. If Shasta crayfish are not found during at least two consecutive surveys at a site, however, the site is removed from the next round of surveys. The need to revisit these sites in future years will be determined by the TRC/Recovery Team.

Habitat Mapping

Shasta crayfish habitat is typified by unembedded lava cobble and boulder substrate on gravel or a mixture of sand and gravel with minimal fine material (Ellis 1999). Non-native signal and fantail crayfish are also found in typical Shasta crayfish habitat. Because of less restrictive habitat requirements, non-native signal and fantail crayfish are also found in other areas with more fine material or where lava substrate is sparse or absent. To delineate existing Shasta crayfish habitat at each location, a site reconnaissance was done to map and measure habitat areas. Areas of habitat were identified, delineated, and measured by surveyors, snorkelers, and scuba divers using survey measuring tapes. Water depths and visibility in many of the headwater

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springs (e.g., parts of Ja She Creek, upper Big Lake, Crystal Springs, and Cove Crystal Lake) were such that habitat mapping and habitat quality assessments could be done looking through the water surface, using polarized glasses, from a boat or shore. Waters with greater depths and poorer visibility were surveyed using scuba or snorkeling equipment. Where water visibility was limited and depths were greater than approximately 2.5 ft, scuba gear was required to survey effectively and efficiently. Polygons representing individual habitat areas were drawn onto large-scale base maps. Smaller areas were measured by two divers; large areas, where divers would be out of visual range of each other, were measured on the surface by a diver and a person in a support boat or on shore. If additional habitat was found during crayfish surveys it was also mapped and added to the habitat calculations.

During the mainstem Pit River survey in 2005, habitat was only mapped where Shasta crayfish were found. Shasta crayfish were only found in an approximately 600-meter reach (i.e., Pit River Falls) upstream of the Pit River Falls downstream from where the coldwater (i.e., 13–14 °C) springs on river right begin. This section of river provided an estimated 750 m^2 of adequate habitat. Several springs with temperatures less than 15 ºC enter the Pit River within this section and provide coldwater areas with clean substrate. Warmer springs (i.e., 17–19 °C) enter the Pit River just upstream of this section.

In Rock Creek, potential Shasta crayfish habitat locations were calculated from channel length measurements taken with a hip chain and an average of measured channel widths. Both the upper and lower meadows had low-gradient channel reaches that would provide potential Shasta crayfish habitat if re-watered. Because the proposed restoration would utilize the natural instream flow of Rock Creek, only the larger upper meadow site is being considered for restoration so that Rock Creek could remain as the Crystal Lake Hatchery water source.

Habitat was graded as prime, adequate, or marginal based on observations from earlier studies (Ellis and Hesseldenz 1993, Ellis and Cook 1998, Ellis 1999). The best quality habitat, designated “prime,” consisted of mostly unembedded lava cobble and boulder on gravel that was mostly free of fine material (i.e., fine sand and silt). Prime habitat was generally associated with areas of spring inflow or upwelling or other flowing water that kept the substrate free of fines.

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Relatively unembedded lava cobble and boulder on gravel, or sand and gravel, that contained only minimal amounts of fine material was designated "adequate" habitat. Adequate habitat was usually located farther away from spring inflow or other water currents that minimized the accumulation of fine sediment. The lowest quality potential habitat was designated "marginal." Marginal habitat generally consisted of lava cobble and boulder embedded in gravel, sand, silt, or organic flocculants. Marginal habitat generally occurred in areas with little or no current. Spring inflow or upwelling areas that lacked larger cobble or boulder habitat were also designated as marginal. Within a location, Shasta crayfish were generally found in the higher quality (i.e., prime or adequate) habitat areas. Marginal habitat was mostly used by Shasta crayfish in locations that lacked better quality habitat.

Pit 1 Habitat Mapping

Shasta crayfish habitat mapping and the baseline crayfish monitoring survey within the Pit 1 Project vicinity were done over an approximately three-year period from March 2004 to February 2007 (Spring Rivers 2004, 2005b, 2006, 2007a). The second monitoring survey for the Pit 1 Project was conducted between 2007 and 2009 (this report).

Table 4 presents the results of the habitat surveys in the Pit 1 Project vicinity. There was a total of approximately 34,987 m^2 of potential Shasta crayfish habitat identified, including 22,543 m^2 of prime and 10,477 m^2 of adequate habitat. Most of the habitat was associated with voluminous springs (e.g., Spring Creek, Ja She Creek headwaters, and North Big Lake), while little habitat was identified away from springs (e.g., Tule River Levee System). Spring areas generally had clean or slightly silty gravel and boulder habitat. Substrate along most of the levee system, however, was silty with only limited marginal habitat provided by boulders and earthen clumps on top of the compacted soil and roots on the levee face. The sparse substrate on the bottom of Big Lake and the Tule River was generally embedded in a 6–12 inch layer of silt and consequently did not provide Shasta crayfish habitat.

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Table 4 Size and quality of Shasta crayfish habitat in the Pit 1 Project vicinity as identified, mapped, and verified between 2004 and 2009.

		Habitat (m^2)			
Region	Location	Prime	Adequate	Marginal	Total Prime & Adequate
Upper Fall River	1000 Springs Fish Trap Cove	836	0	0	836
	1000 Springs Old Property Line	480	6	0	486
	Fletcher's Bend	264	0	0	264
	Lennihan's Footbridge	216	0	0	216
Spring Creek	Upper coves	9083	470	37	9553
	Lower coves	1054	726	0	1780
Ja She Creek	Ja She Creek headwaters	3237	5270	463	8507
	Crystal Springs Cove	2610	1083	89	3693
	Tule Coves	118	93	20	211
Upper Big Lake	Big Lake Springs	177	0	0	177
	North Big Lake (excl. Springs)	363	955	8	1318
	Northeast Big Lake	138	138	0	276
	Northwest Big Lake	0	11	0	11
Tule River Levee System	South shore Big Lake	0	0	1265	0
	Northeast upper Tule River			0	0
	South shore upper Tule River	0	0	21	0
	East shore upper Tule River	0	0	0	0
	Horr Pond levees	0	75	0	75
Fall River at FRM	Fall River Pond	3967	900	64	4867
Pit 1 Bypass – Big Eddy to Powerhouse (PH)	Pit River Falls		750		750 [a]
	Pit River Canyon Spring	ND	ND		ND
Pit River below PH	Pit River Sand Pits	ND	ND		ND

[a] Estimated value based on aerial photographs; ND = Not Determined

Hat Creek Habitat Mapping

The baseline crayfish monitoring survey within the Hat Creek Project vicinity, which included Shasta crayfish habitat mapping, was completed in 2003 (Spring Rivers 2004). The second monitoring survey for the Hat Creek Project was completed in 2004 (Spring Rivers 2005b), and the third survey was completed in 2007 (Spring Rivers 2008).

Table 5 reports the locations, relative quality, and estimated areas of Shasta crayfish habitat in Crystal Lake and Baum Lake, and the estimated area of potential habitat that could be restored in the upper meadow of Rock Creek. Crystal Lake had a total of 3908 m^2 of potential habitat with a

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total of 663 m^2 of prime and 1115 m^2 of adequate habitat between Southwestern, Middle Cove, and the outflow area of Crystal Lake. A total of 1259 m^2 of potentially prime habitat would be available in the upper meadow, if this section of the Rock Creek channel were re-watered and restored. The low-gradient portion of the lower meadow (392 m^2) is not being considered for restoration.

Table 5 Size and quality of Shasta crayfish habitat in the Hat Creek Project vicinity as identified, mapped, and verified between 2003 and 2009.

		Habitat (m^2)			
Region	Location	Prime	Adequate	Marginal	Total Prime & Adequate
Crystal Lake	Southwest	401	529	2069	930
	Middle	24	586	1226	610
	Outflow	238	0	613	238
Baum Lake	Crystal Inflow	0	207	225	207
	West	0	195	175	195
	Turtle Pond	0	42	0	42
Rock Creek [a]	Rock Creek	1259	0	0	1259

[a] Potential habitat if the upper meadow is restored. Does not include the low-gradient portion of the lower meadow (392 m^2).

Crayfish Surveys

During crayfish monitoring surveys, habitat areas were surveyed for crayfish by snorkelers and/or scuba divers who first inspected the undisturbed substrate before turning over individual cobbles and boulders. Snorkel/scuba hand removal surveys for crayfish result in little bias in terms of gender or age class as compared to other sampling methods such as trapping (Abrahamsson 1971, Westman et al. 1978, Ellis 1999). All crayfish encountered, regardless of species, were collected, except Shasta crayfish too small to be handled safely. To minimize possible injury, Shasta crayfish were kept separate from introduced crayfish species in either a rigid tube collector or in a bucket with water. After data collection, Shasta crayfish were released next to the rock where they were found and observed until they moved back underneath the rock. Non-native crayfish were collected and destroyed after data collection.

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The following data were recorded for each collected crayfish: (1) species, (2) size measured as total carapace length (TCL) with vernier or dial calipers to the nearest tenth of a millimeter, (3) sex of crayfish greater than approximately 12 mm TCL, (4) general condition (e.g., reproductive state, missing appendages, and molt state), and (5) area or zone of capture. Crayfish less than 10 to 12 mm TCL cannot be reliably sexed and were therefore grouped as young of year (YOY). Shasta crayfish reach sexual maturity at approximately 27 mm TCL, whereas signal crayfish reach sexual maturity at approximately 30 mm TCL (Ellis 1999). Fantail crayfish can reach sexual maturity at approximately 19 mm TCL (Spring Rivers unpublished data). Shasta crayfish between 10 and 27 mm TCL were categorized as juveniles, and those greater than 27 mm TCL were categorized as adults. Signal crayfish between 12 and 30 mm TCL were categorized as juveniles, and those greater than 30 mm TCL were categorized as adults. Fantail crayfish between 10 and 19 mm TCL were categorized as juveniles, and those greater than 19 mm TCL were categorized as adults.

Crayfish densities were calculated for the monitoring surveys based on the number of individuals found within each survey site. Because the vast majority of Shasta crayfish were found in areas classified as either prime or adequate habitat in most sites, the total area of prime and adequate habitat was used for density calculations. The Shasta crayfish sites along the Tule River Levee System, however, were the exception because only marginal habitat was present. Crayfish densities for all species found at South Shore Big Lake and South Shore Upper Tule River were calculated using the total area of marginal habitat present at each site.

Pit 1 Crayfish Surveys

The baseline monitoring survey for the Pit 1 Hydroelectric Project took place between March 2004 and February 2007. The Fall River drainage sites included: Upper Fall River (i.e., Fletcher's Bend, Lennihan's Footbridge), Spring Creek, Ja She Creek (i.e., Ja She Creek headwaters, Crystal Springs Cove [including Crystal Springs, Crystal Cove, Crystal Inlet], Tule Coves), Upper Big Lake (i.e., Big Lake Springs, North Big Lake, Northeast Big Lake, Northwest Big Lake), Tule River Levee System (i.e., South shore Big Lake, Northeast upper Tule River, South shore upper Tule River, East shore upper Tule River, Horr Pond levees), and Fall River at Fall River Mills (i.e., Fall River Pond). In addition, the mainstem Pit River in the Pit 1 Bypass

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Reach downstream of Big Eddy (i.e., Pit River Falls, Canyon Spring) and in the Pit 1 Reach from the Pit 1 Powerhouse downstream to Lake Britton (i.e., Pit River Sand Pits) were surveyed in 2005, as part of the baseline survey.

The second monitoring survey took place between March 2007 and March 2009, and included the following three additional sites: Rainbow Spring, Lava Creek, and Thousand Springs. South Shore Upper Tule River, East Shore Upper Tule River, Fall River Pond, and the Pit River Sand Pits were omitted from the second survey, because no Shasta crayfish were found during the baseline survey and at least one previous survey. The third survey is scheduled for 2009 and 2010. Crayfish sex and age class composition for the baseline and second monitoring surveys are presented in Table 6 and Table 7, respectively.

During the Pit 1 baseline monitoring survey, 786 Shasta crayfish were collected, which accounted for 11.2% of all crayfish encountered (Table 6). The two largest populations of Shasta crayfish were found in Spring Creek and at Thousand Springs in the upper Fall River drainage. Within the Fall River drainage (in order of numerical abundance), Shasta crayfish were also collected in Ja She Creek, Big Lake Springs, Rainbow Spring, North Big Lake, South Shore Big Lake near the Big Lake Levee Cove, Tule Coves, and Crystal Springs Cove. A single Shasta crayfish was also found at Northeast Big Lake and at Northwest Big Lake. In the mainstem Pit River, 21 Shasta crayfish were found upstream of the Pit River Falls. For all locations combined, slightly more females (n = 342) were encountered than males (n = 303), for a sex ration of 53:47. There was a higher proportion of juveniles (n = 354) than adults (n = 348). In addition, 84 YOY were observed and left in place to avoid accidental harm from handling.

During the second monitoring survey, 550 Shasta crayfish were collected, accounting for 8.1% of all crayfish encountered in the Pit 1 Study Area (Table 7). Again, the two largest Shasta crayfish populations were found at Thousand Springs and Spring Creek in the upper Fall River drainage. Within the Fall River drainage (in order of abundance), Shasta crayfish were also collected in Ja She Creek, Lava Creek, Big Lake Springs, Rainbow Springs, North Big Lake, Crystal Springs Cove, Tule Coves, and Northwest Big Lake. Although Shasta crayfish were found at Northeast Big Lake and South Shore Big Lake during the baseline survey, none were

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Table 6 Number of crayfish, by species, sex[a], and age class[b], encountered in the Pit 1 Project vicinity during the baseline monitoring survey (2004–2007).

	Shasta crayfish						Signal crayfish						Fantail crayfish					
Region and Location	**M**	**F**	**Adult**	**Juv**	**YOY**	**Total**	**M**	**F**	**Adult**	**Juv**	**YOY**	**Total**	**M**	**F**	**Adult**	**Juv**	**YOY**	**Total**
Upper Fall River																		
Thousand Springs above barrier	129	128	152	117	11	280	9	9	8	6	10	24	0	0	0	0	0	0
Thousand Springs below barrier	0	0	0	2	0	2	605	673	770	678	70	1518	0	0	0	0	0	0
Rainbow Spring	4	12	3	14	2	19	8	15	9	14	0	23	0	0	0	0	0	0
Fletcher's Bend	0	0	0	0	0	0	152	210	91	270	89	450	0	0	0	0	0	0
Lennihan's Footbridge	0	0	0	0	0	0	41	44	43	42	27	112	0	0	0	0	0	0
Spring Creek																		
Upper coves	108	127	118	145	53	316	18	17	21	12	43	76	0	0	0	0	0	0
Lower coves	6	18	13	13	0	26	25	28	26	27	8	61	0	0	0	0	0	0
Ja She Creek																		
Ja She Creek headwaters	28	18	31	18	5	54	645	741	1218	168	0	1386	0	0	0	0	0	0
Crystal Springs Cove	3	1	2	2	0	4	670	896	1307	333	151	1791	0	0	0	0	0	0
Tule Coves	2	4	4	4	0	8	22	29	30	22	0	52	0	0	0	0	0	0
Upper Big Lake																		
Big Lake Springs	10	22	5	26	5	36	3	0	2	1	0	3	0	0	0	0	0	0
North Big Lake (excl. Springs)	5	2	4	5	0	9	146	181	247	88	20	355	0	0	0	0	0	0
Northeast Big Lake	0	1	1	0	0	1	1	2	1	2	0	3	0	0	0	0	0	0
Northwest Big Lake	1	0	1	0	0	1	2	0	1	1	0	2	0	0	0	0	0	0
Tule River Levee System																		
South shore Big Lake	3	6	8	1	0	9	2	1	2	1	0	3	3	6	9	0	0	9
Northeast upper Tule River	0	0	0	0	0	0	0	0	0	0	0	0	3	1	4	1	0	5
South shore upper Tule River	0	0	0	0	0	0	11	7	12	6	0	18	28	32	58	2	0	60
East shore upper Tule River	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0
Horr Pond levees	0	0	0	0	0	0	1	3	2	5	0	7	17	15	31	2	0	33
Fall River at FRM																		
Fall River Pond	0	0	0	0	0	0	2	6	5	3	0	8	143	87	216	14	0	230
Pit 1 - Big Eddy to PH																		
Pit River Falls	4	3	6	7	8	21	7	2	4	6	0	10	4	8	11	1	0	12
Canyon Spring	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pit 1 - below PH (Sand Pits)	0	0	0	0	0	0		M	A	N	Y		0	0	1	0	0	1
Totals	303	342	348	354	84	**786**	2370	2865	3799	1686	418	**5903**	198	149	330	20	0	**350**

[a] M=male, F=female [b] Juv=juvenile, YOY=young of year

NOTE: Sex totals may differ from adult and juvenile totals, because not all adults and juveniles were sexed.

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Table 7 Number of crayfish, by species, sex[a], and age class[b], encountered in the Pit 1 Project vicinity during the second monitoring survey (2007–2009).

	Shasta crayfish						Signal crayfish						Fantail crayfish					
Region and Location	**M**	**F**	**Adult**	**Juv.**	**YOY**	**Total**	**M**	**F**	**Adult**	**Juv.**	**YOY**	**Total**	**M**	**F**	**Adult**	**Juv.**	**YOY**	**Total**
Upper Fall River																		
Thousand Springs above barrier	99	115	102	132	16	250	23	17	16	24	62	102	0	0	0	0	0	0
Thousand Springs below barrier	0	0	0	0	0	0	20	12	9	20	9	38	0	0	0	0	0	0
Rainbow Spring	3	3	7	1	0	8	67	86	100	53	0	153	0	0	0	0	0	0
Fletcher's Bend	0	0	0	0	0	0	19	18	7	29	54	90	0	0	0	0	0	0
Lennihan's Footbridge	0	0	0	0	0	0	26	42	21	47	54	122	0	0	0	0	0	0
Lava Creek	12	23	33	12	0	45	155	200	174	181	113	468	0	0	0	0	0	0
Spring Creek																		
Upper coves	30	31	21	46	27	94	111	114	71	229	10	310	0	0	0	0	0	0
Lower coves	7	5	0	12	1	13	121	163	84	334	17	435	0	0	0	0	0	0
Ja She Creek																		
Ja She Creek headwaters	17	33	36	40	6	82	755	828	1229	550	4	1783	0	0	0	0	0	0
Crystal Springs Cove	1	2	3	1	0	4	591	889	1253	471	24	1748	0	0	0	0	0	0
Tule Coves	2	0	2	0	0	2	24	48	45	53	5	103	1	0	1	0	0	1
Upper Big Lake																		
Big Lake Springs	9	21	15	22	4	41	42	51	61	48	0	109	0	0	0	0	0	0
North Big Lake (excl. Springs)	2	3	4	4	0	8	180	260	319	195	76	590	0	0	0	0	0	0
Northeast Big Lake	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Northwest Big Lake	1	1	2	0	0	2	3	5	6	2	0	8	0	0	0	0	0	0
Tule River Levee System																		
South shore Big Lake	0	0	0	0	0	0	1	2	2	1	0	3	24	35	59	0	0	59
Northeast upper Tule River	0	0	0	0	0	0	1	1	0	2	0	2	4	7	10	4	0	14
South shore upper Tule River	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
East shore upper Tule River	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Horr Pond levees	0	0	0	0	0	0	2	2	0	4	0	4	11	9	20	0	0	20
Fall River at FRM																		
Fall River Pond	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pit 1 - Big Eddy to PH																		
Pit River Falls	1	0	1	0	0	1	-	-	-	-	-	29	-	-	-	-	-	23
Canyon Spring	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pit 1 - below PH (Sand Pits)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Totals	184	237	226	270	54	**550**	2141	2738	3397	2243	428	**6097**	40	51	90	4	0	**117**

[a] M=male, F=female [b] Juv=juvenile, YOY=young of year

NOTE: Sex totals may differ from adult and juvenile totals, because not all adults and juveniles were sexed.

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found at these sites during the second monitoring survey. In the mainstem Pit River upstream of the falls, only one dead Shasta crayfish was found. More females (n = 237) were encountered than males (n = 184) for a sex ration of 56:44. Juveniles (n = 270) outnumbered adults (n = 226). In addition, 54 YOY were observed and left in place to avoid accidental harm. The size distributions for Shasta crayfish are presented in Figure 8.

During the baseline monitoring survey, 5903 signal crayfish were collected and exterminated at all survey locations combined (Table 6). Signal crayfish accounted for 83.9% of all crayfish encountered. More females (n = 2865) were collected than males (n = 2370). There was a higher proportion of adults (n = 3799) than juveniles (n = 1686) or YOY (418).

During the second monitoring survey, 6097 signal crayfish were collected and exterminated at all survey locations combined (Table 7). Signal crayfish accounted for 90.1% of all crayfish collected. More females (n = 2738) were found than males (n = 2141). There was a higher proportion of adults (n = 3397) than juveniles (n = 2243) or YOY (n = 428). The size distributions for signal crayfish by location are presented in Figure 9.

During the baseline survey, 350 fantail crayfish were collected and exterminated (Table 6). Fantail crayfish accounted for 5.0% of all crayfish collected. More males (n = 198) were encountered than females (n = 149), and there was a higher proportion of adults (n = 330) than juveniles (n = 20). No YOY were found.

During the second survey, 117 fantail crayfish were collected and exterminated (Table 7). Fantail crayfish accounted for 1.7% of all crayfish collected. More females (n = 51) were collected than males (n = 40), and there was a higher proportion of adults (n = 90) than juveniles (n = 4). No YOY were found. Size distributions for fantail crayfish are presented in Figure 10.

During the second Pit 1 survey, four sites were omitted because Shasta crayfish were not found during the two previous surveys. Fall River Pond and the Pit River Sand Pits were omitted, because Shasta crayfish had not been found since 1978. South Shore Upper Tule River and East Shore Upper Tule River were omitted, because only a few Shasta crayfish and/or molts were

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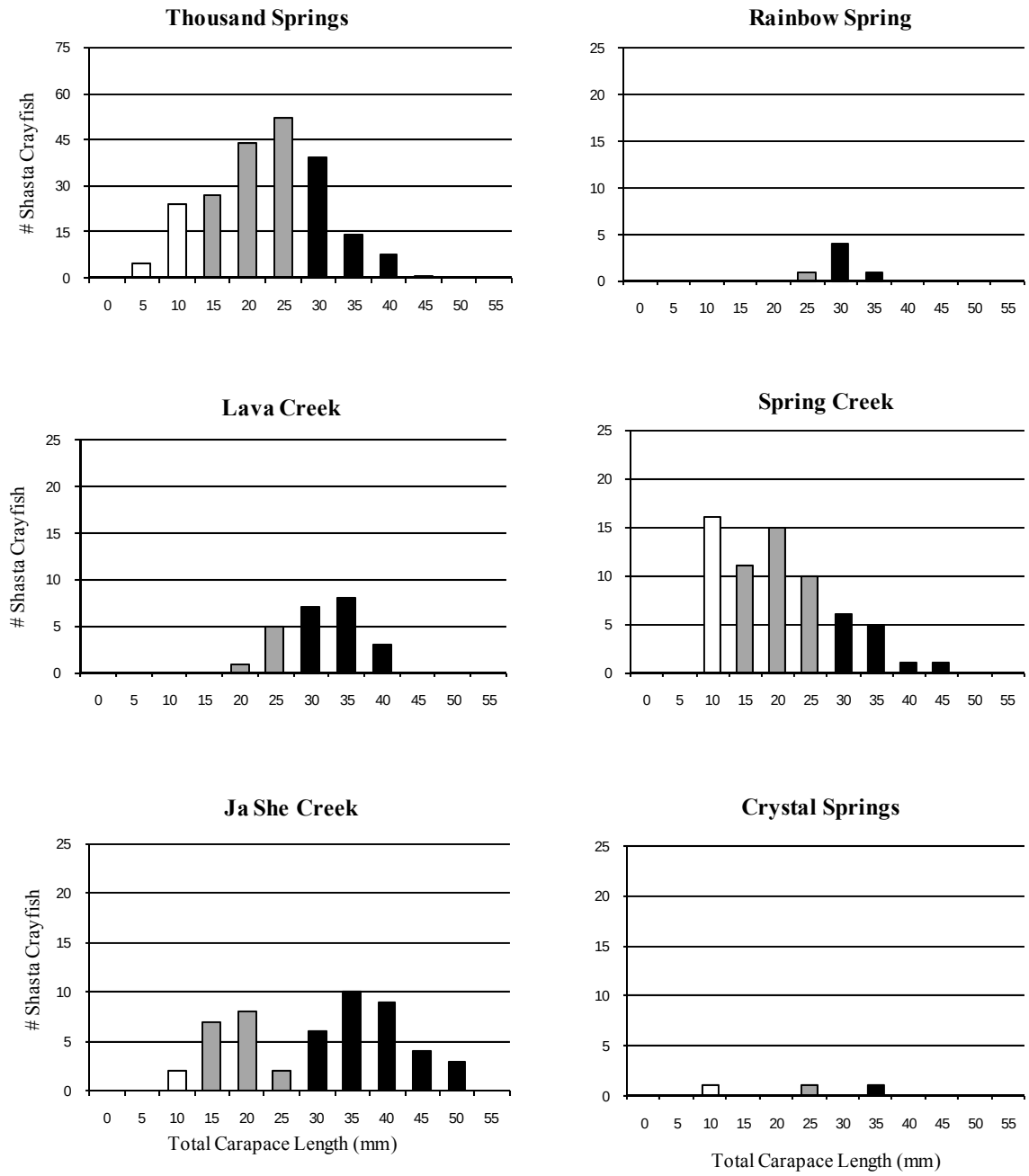

Figure 8 Shasta crayfish size-class distributions by location in the Pit 1 study area in 2007–2008. Bar shades represent age classes: young of year (white), juvenile (gray), and adult (black).

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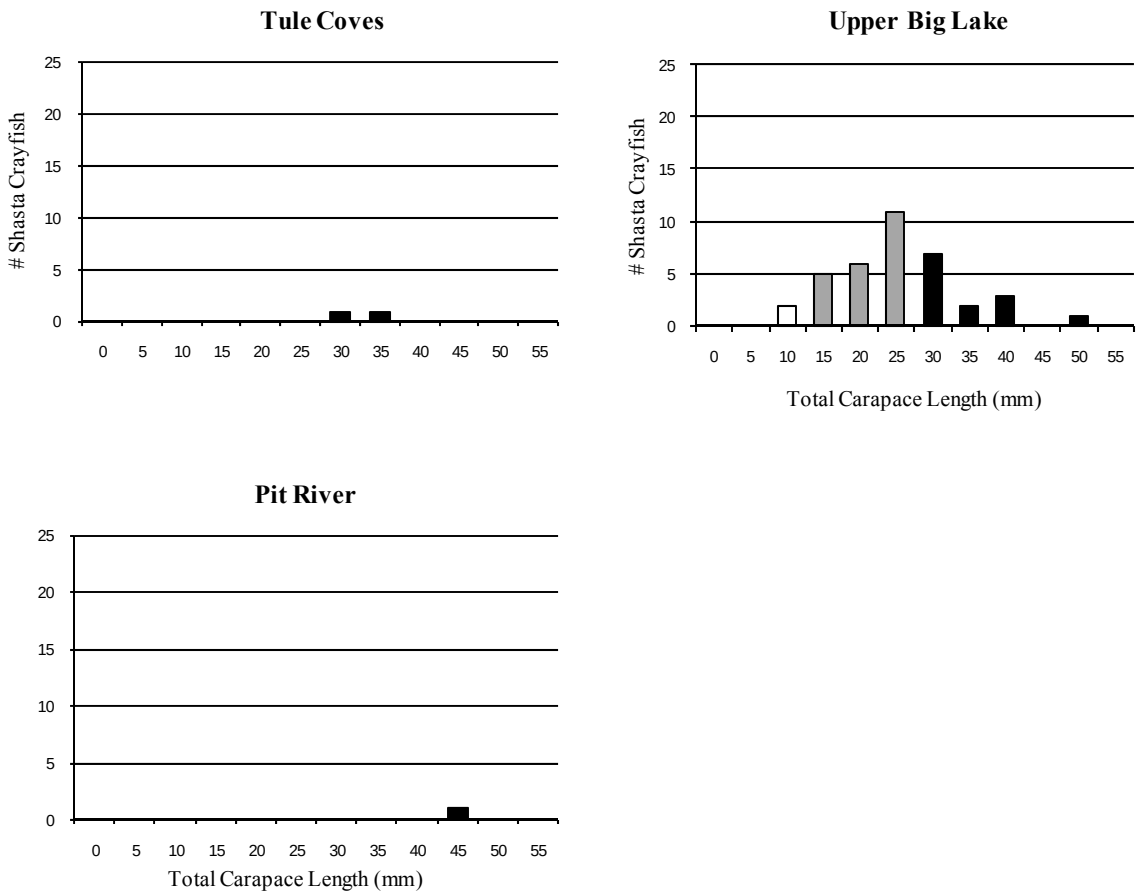

Figure 8 (continued) Shasta crayfish size-class distributions by location in the Pit 1 study area in 2007–2008. Bar shades represent age classes: young of year (white), juvenile (gray), and adult (black).

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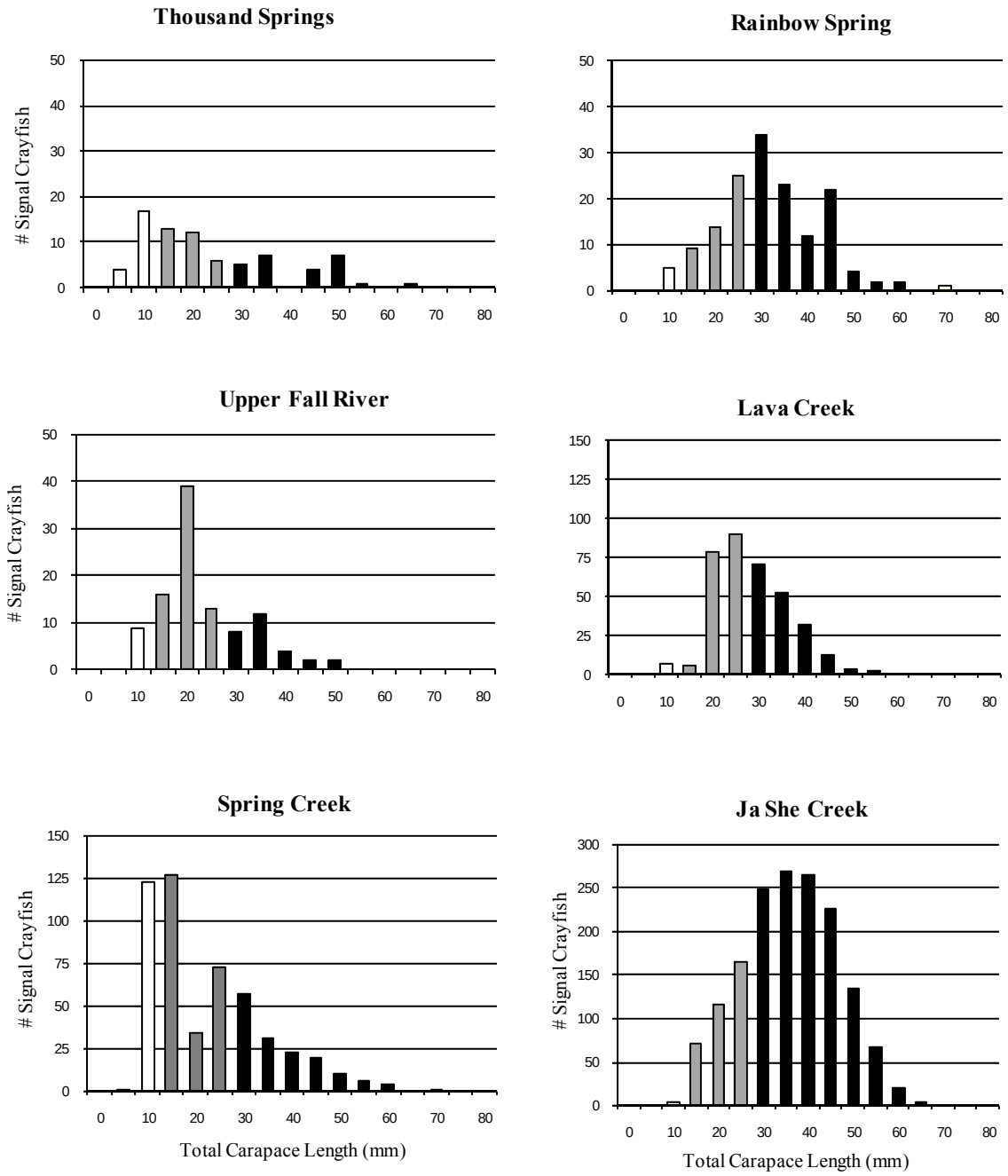

Figure 9 Signal crayfish size-class distributions by location in the Pit 1 study area in 2007–2008. Bar shades represent age classes: young of year (white), juvenile (gray), and adult (black).

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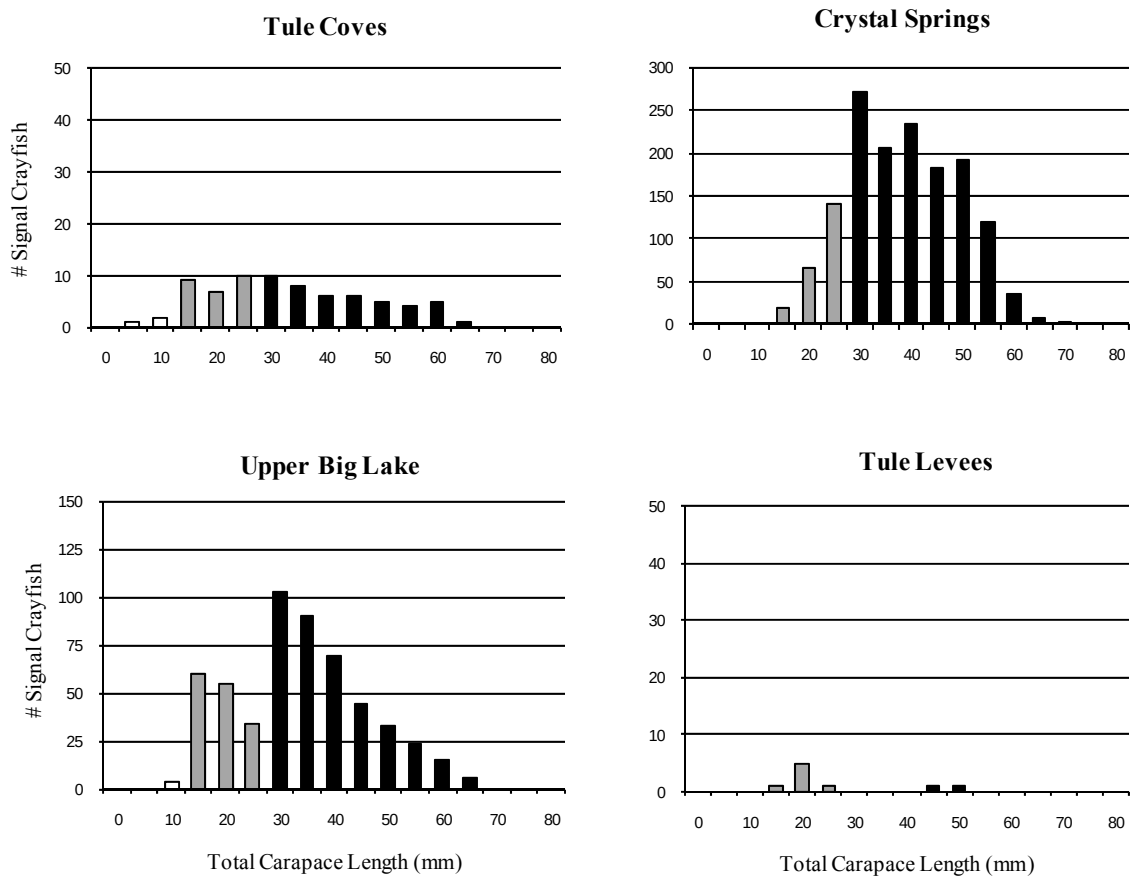

Figure 9 (continued) Signal crayfish size-class distributions by location in the Pit 1 study area in 2007–2008. Bar shades represent age classes: young of year (white), juvenile (gray), and adult (black).

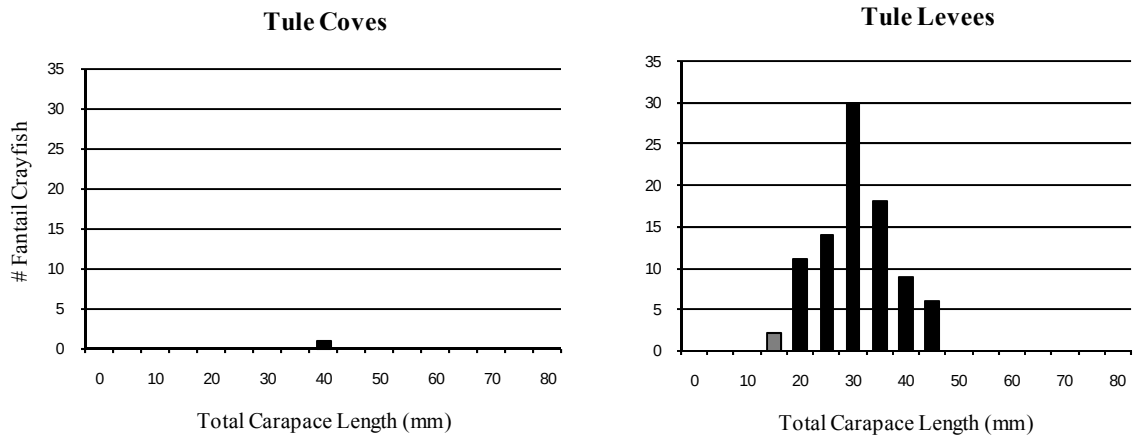

Figure 10 Fantail crayfish size-class distributions by location in the Pit 1 study area in 2007–2008. Bar shades represent age classes: young of year (white), juvenile (gray), and adult (black).

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found during the 1990–1992 surveys and none were found in later surveys. In contrast, several Shasta crayfish were found during the 1990–1992 surveys at Horr Pond Levee, Fletcher's Bend, and Lennihan's Footbridge so they were included in the second survey.

Hat Creek Crayfish Surveys

The first three surveys for the Hat Creek Hydroelectric Project took place in 2003 (between September 2003 and February 2004), 2004 (between November 2004 and February 2005), and 2007 (between January and April 2007). In 2004, the Crystal Lake Outflow was surveyed by a University of California Davis team on July 20-22 (Pintor unpublished data), as well as, by Spring Rivers on November 19 and December 1 and 3. Surveys were done in areas of Crystal and Baum lakes where Shasta crayfish, or potentially suitable Shasta crayfish habitat, had been found during earlier surveys. Within Crystal Lake, the Southwest, Middle Cove, and Outflow areas were surveyed. In Baum Lake, the Crystal Inflow and the spring-fed area west of Crystal Inflow (i.e., West Baum Lake) were surveyed all three years. Turtle Pond, the spring-fed pond on the east side of Baum Lake (Figure 1) was surveyed in 2003, but not in subsequent years because very little suitable habitat was found. Rock Creek was surveyed in 2003 to verify that no crayfish were present. The next survey is scheduled for 2012.

Crayfish sex and age class composition for the three surveys are presented in Table 8. Shasta crayfish were only found in Crystal Lake during the Hat Creek surveys. Totals of 162, 272, and 132 Shasta crayfish were found in 2003, 2004, and 2007, respectively. Within Crystal Lake, Shasta crayfish accounted for 13% of the crayfish captured in 2003 and 14% in 2004 and 2007. The sex ratio (male:female) among years varied somewhat: 54:46 in 2003, 52:48 in 2004, and 51:49 in 2007. The age-class distribution (adult:juvenile:YOY) showed an increased shift towards more adults and fewer juveniles and YOY in Crystal Lake over the years: 49:47:4 in 2003, 59:36:6 in 2004, and 72:27:1 in 2007. Berried females (i.e., carrying eggs) were mainly found in Southwest Crystal Lake during all years; one female from Crystal Lake Outflow had a single egg in 2007. During these surveys, which were all done in the winter months, approximately half of the females were berried in 2004 (50%) and 2007 (52%) as compared to only 22% in 2003. Southwest Crystal Lake supported the majority of the Crystal Lake population (85% in 2003, 97% in 2004, and 98% in 2007) and most of the berried females. The

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number of Shasta crayfish found at the Crystal Lake Outflow decreased from 23 to 7 to 2 over the years. Shasta crayfish were least abundant in Middle Cove, with two crayfish found in 2003 and 2004, and none in 2007. Figure 11 shows the size distribution of Shasta crayfish found during the 2003, 2004, and 2007 Crystal Lake surveys.

Table 8 Crayfish species, sex [a], and age class [b] composition in the Hat Creek Study Area during the first three surveys (2003, 2004, and 2007).

Region		Shasta crayfish						Signal crayfish					
Location	Year	M	F [c]	Adult	Juv	YOY	Total	M	F	Adult	Juv	YOY	Total
Crystal Lake													
Southwest	2003	73	58 (13)	67	65	5	**137**	41	39	35	45	33	**113**
	2004	126	117 (59)	154	94	15	**263**	86	66	69	83	64	**216**
	2007	65	62 (32)	94	35	1	**130**	65	68	34	129	11	**174**
Middle Cove	2003	1	1 (0)	2	0	0	**2**	60	56	33	83	7	**123**
	2004	1	1 (0)	2	0	0	**2**	99	81	65	115	37	**217**
	2007	0	0 (0)	0	0	0	**0**	51	67	27	127	0	**154**
Outflow	2003	10	13 (0)	9	14	0	**23**	582	626	679	529	12	**1220**
	2004 [d]	3	4 (0)	7	0	0	**7**	570	715	718	569	40	**1327**
	2007	0	1 (1)	2	0	0	**2**	192	188	121	324	12	**457**
Baum Lake													
Crystal Inflow	2003	0	0	0	0	0	**0**	76	96	135	37	0	**172**
	2004	0	0	0	0	0	**0**	129	96	153	72	58	**283**
	2007	0	0	0	0	0	**0**	103	79	153	39	1	**193**
West	2003	0	0	0	0	0	**0**	98	95	166	27	0	**193**
	2004	0	0	0	0	0	**0**	631	406	981	56	4	**1041**
	2007	0	0	0	0	0	**0**	197	219	402	16	0	**418**
Turtle Pond	2003	0	0	0	0	0	**0**	1	5	3	3	0	**6**
	2004	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Rock Creek	2003	0	0	0	0	0	**0**	0	0	0	0	0	**0**

[a] M=male, F=female; [b] Juv=juvenile, YOY=young of year
[c] Number in parentheses indicates the number of females with eggs
[d] Combined data from UC Davis (20-22 Jul) and Spring Rivers (19 Nov, 1 & 3 Dec) Crystal Lake Outflow surveys.
NOTE: Totals by sex may differ from adult/juvenile totals, because sex was not determined for all crayfish.

Signal crayfish were found throughout the survey areas of Crystal and Baum lakes. During the 2003, 2004, and 2007 surveys, 6307 signal crayfish were captured and destroyed (Table 8). Signal crayfish accounted for 92% of all crayfish captured during the Hat surveys in 2003 and 2004 and 91% in 2007. The overall sex ratio was reasonably equal: 2981 males, 2902 females, and 279 of undetermined sex. Annual sex ratios were 48:52 in 2003, 53:47 in 2004, and 49:51 in 2007. The size distribution of signal crayfish by location from the 2007 survey is presented in Figure 12. The overall age class distribution of the sample was skewed towards adults: 3548 adults, 2071 juveniles, and 268 YOY. Annual age class distributions were 58:40:3 in 2003,

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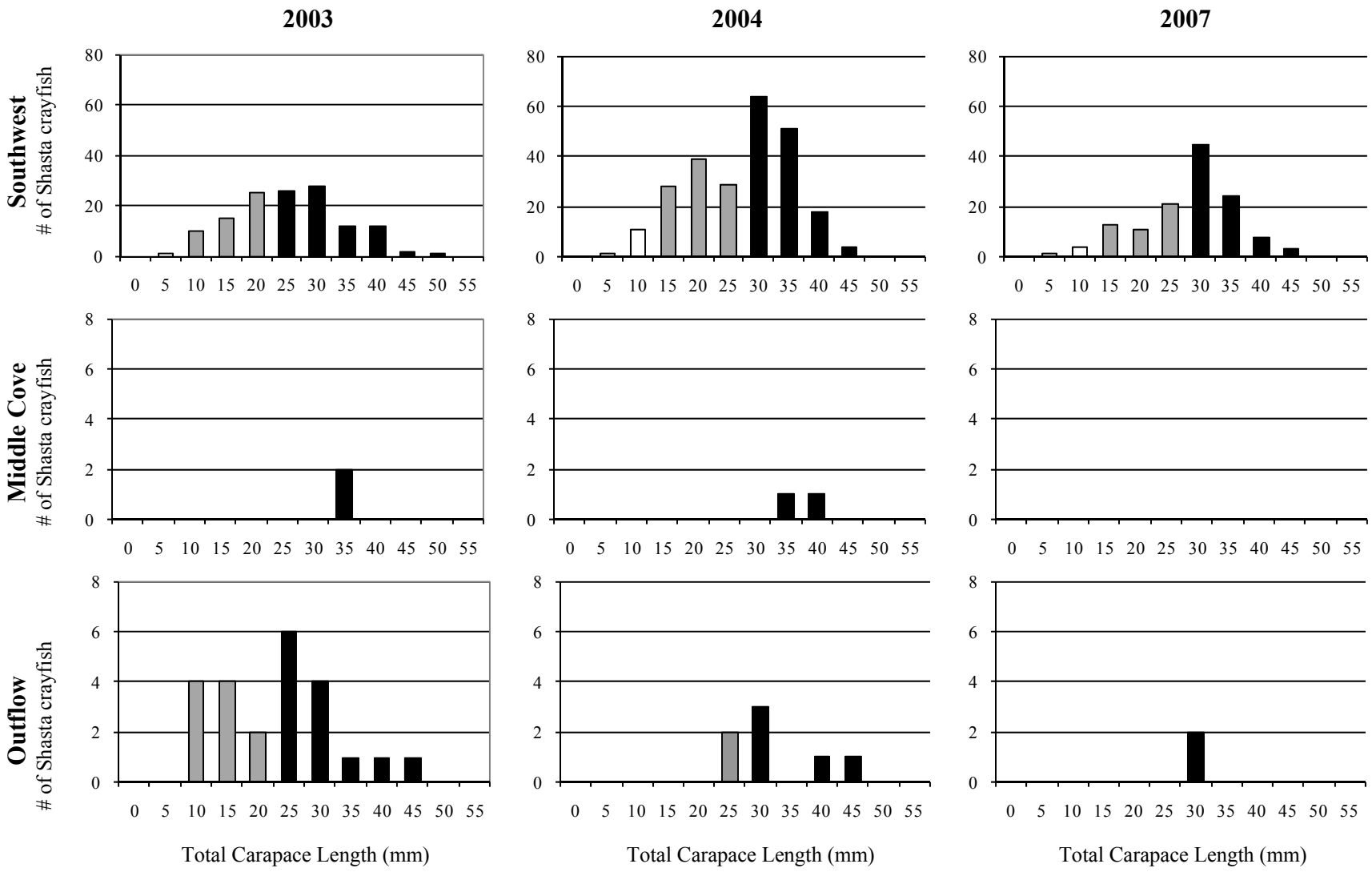

Figure 11 Size distribution of Shasta crayfish from Crystal Lake regions during the 2003, 2004, and 2007 surveys.

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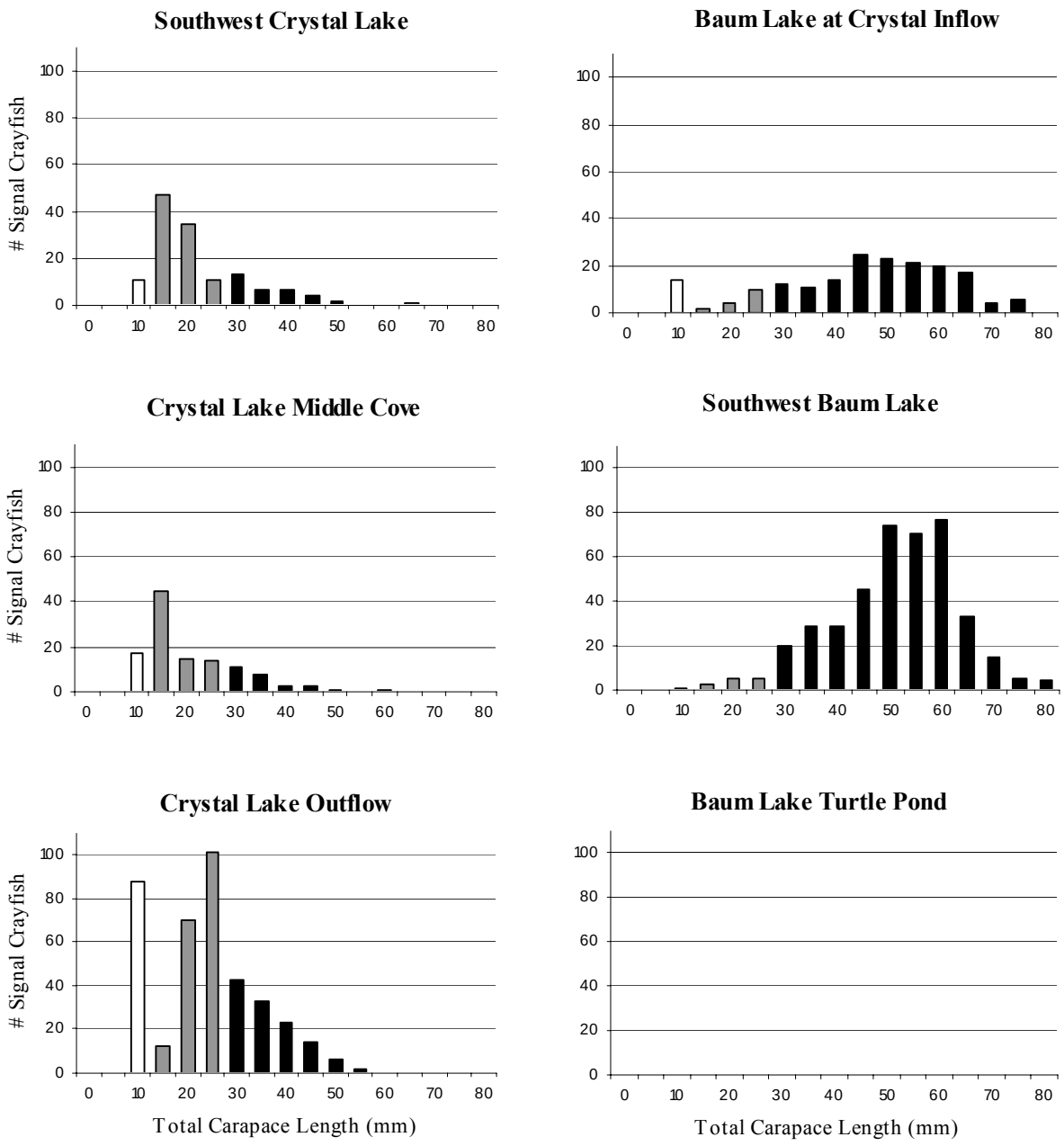

Figure 12 Size distribution of signal crayfish from Crystal Lake and Baum Lake during the 2007 survey.

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64:29:7 in 2004, and 53:45:2 in 2007. The largest number of signal crayfish was encountered at Crystal Lake Outflow (Table 6), but the highest density was observed at West Baum Lake. No crayfish of any species were found in Rock Creek in 2003, during the only survey of that location.

Non-Native Crayfish Eradication Surveys

In addition to the crayfish monitoring surveys, non-native crayfish eradication surveys were conducted at Thousand Springs and Spring Creek. These surveys focused solely on eradication of invasive crayfish and were in addition to the crayfish monitoring surveys done in Thousand Springs (second survey only) and Spring Creek (baseline and second survey). These non-native crayfish eradication surveys were conducted in Thousand Springs and Spring Creek as part of the Pit 1 Plan (PG&E 2003b) as required by Articles 412 and 413 of the license and the Crayfish Barrier Plan (PG&E 2006). One or more surveys to eradicate non-native crayfish were done at Thousand Springs annually between 2004 and 2009 and at Spring Creek in 2003, 2005, 2006, and 2008. Eradication surveys followed the same methods as the crayfish monitoring surveys, but focused more on areas where non-native crayfish had previously been found and included more marginal habitat often used by non-native crayfish. Similar effort was applied to each eradication survey in terms of time and area surveyed, so that trends in numbers and species composition could be discerned.

The number of Shasta crayfish observed during eradication surveys was generally estimated and recorded. The Shasta crayfish encountered during these surveys were not collected, however, and the data were not used in crayfish density calculations. Non-native crayfish were collected and destroyed after data collection on individuals.

Figure 13 shows the number of signal crayfish captured and removed from Thousand Springs during eradication surveys upstream of the current barrier location each year since 2003. Signal crayfish were first found in Thousand Springs upstream of the barrier location in 2005. A total of 126 signal crayfish have been captured and removed from Thousand Springs upstream of the current barrier location since 2005. The increase in the number of signal crayfish in early 2009 was due to 53 YOY found in Fish Trap Cove.

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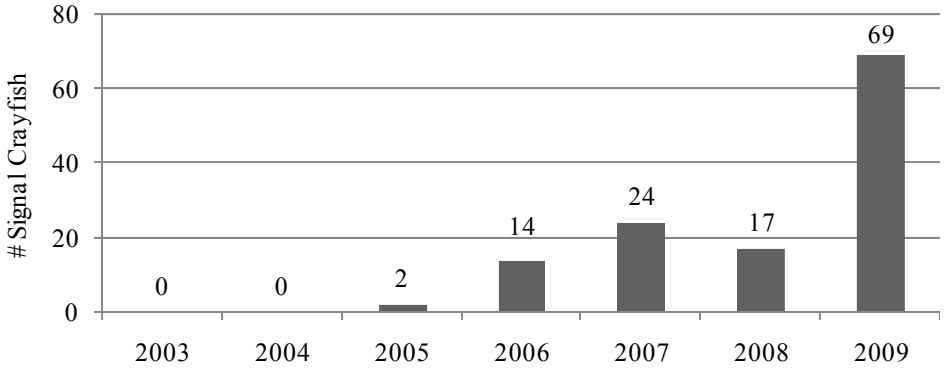

Figure 13 Number of signal crayfish found upstream of the Thousand Springs barrier location since 2003. Data for 2009 only includes January and February surveys.

Figure 14 shows the number of signal crayfish captured and removed from Spring Creek upstream of the Spring Creek Road crossing each year since 2003. Signal crayfish were first found upstream of the culverts in 1997, before the Spring Creek Road crossing was replaced in 2000 (Ellis and Cook 2001). Signal crayfish were first found further upstream in the upper coves of headwaters of Spring Creek in 2003. A total of 897 signal crayfish have been captured and removed from Spring Creek upstream of the Spring Creek Road crossing since 2003.

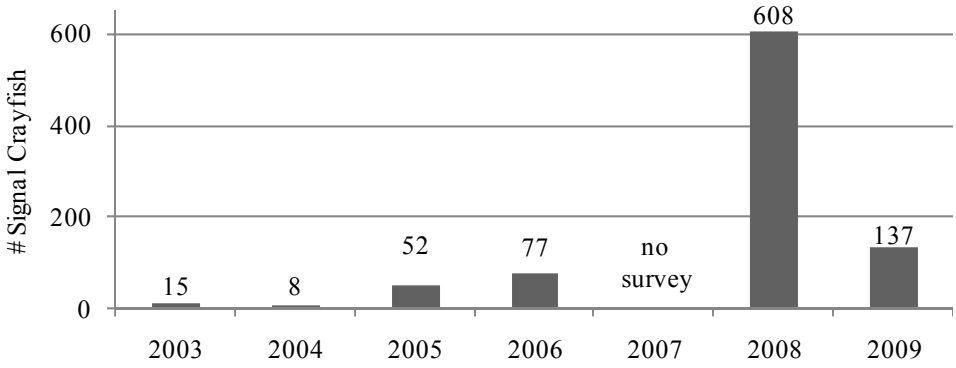

Figure 14 Number of signal crayfish found upstream of the Spring Creek Road crossing since 2003. Data for 2009 only includes surveys through February.

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Shasta Crayfish Population Status

Survey objectives, methods, and effort intensity of the crayfish monitoring surveys conducted for both Projects have been consistent. These surveys were fairly consistent with crayfish monitoring surveys conducted by Ellis since 1990 and by Daniels in 1978, but were not necessarily consistent with the objectives, methods, and effort intensity of the earliest surveys (i.e., 1898 through 1986). Consequently, the following discussion is divided into two parts: (1) the potential effects of the new license by comparing baseline with subsequent crayfish monitoring surveys; and (2) the trends during the last few decades by comparing the crayfish monitoring surveys under the current license with those conducted under the previous license by Ellis between 1990 and 2001 and by Daniels in 1978, as well as some general comparison of past and present Shasta crayfish populations since the first survey in 1898.

Current License

Between the baseline (786 Shasta crayfish) and second (550 Shasta crayfish) Pit 1 monitoring surveys, there was a 30% decline in the number of Shasta crayfish found even with the addition of three Shasta crayfish monitoring sites (i.e., Rainbow Spring, Lava Creek, and Thousand Springs). Shasta crayfish accounted for 11.2% of all crayfish encountered in the baseline survey, but only 8.1% in the second survey. Signal crayfish increased percent species composition from 83.9% in the baseline survey to 90.1% in the second survey. Fantail crayfish decreased percent species composition from 5.0% in the baseline survey to 1.7% in the second survey.

During both Pit 1 surveys, the two largest populations of Shasta crayfish were found in Spring Creek and at Thousand Springs in the upper Fall River drainage. Based on the relative abundance of juvenile to adult Shasta crayfish, recruitment at most of the Pit 1 sites appears good. Between the baseline and second surveys, declines in the numbers of Shasta crayfish were observed at several sites. For instance Shasta crayfish were found at Northeast Big Lake and South Shore Big Lake during the baseline survey, but were not found at these sites during the second monitoring survey. The most dramatic decline occurred in the mainstem Pit River upstream of the Pit River Falls. During the 2005 survey of the mainstem Pit River, Shasta crayfish were only found in the approximately 600 meter-long reach of the Pit River that is influenced by cold springs just above the Pit River Falls. Since the new license flow regime was

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implemented, a significant decline in Shasta crayfish numbers has been observed in this 600-meter reach. In October 2005, a total of 21 Shasta crayfish (6 adults, 7 juveniles, and 8 YOY) were found in this 600-meter reach, but only one adult male Shasta crayfish was found in September 2008 (Spring Rivers 2009b). During this same period, both non-native crayfish species increased in abundance. Between 2005 and 2008, the number of signal crayfish almost tripled (10 in 2005, 29 in 2008) and the number of fantail crayfish almost doubled (12 in 2005, 23 in 2008) in this reach (Spring Rivers 2009b).

During the Hat Creek surveys, Shasta crayfish were only found in Crystal Lake, primarily in Southwest Crystal Lake. Although the number varied (162 in 2003, 272 in 2004, and 132 in 2007), Shasta crayfish accounted for an almost constant percentage of the crayfish captured in Crystal Lake during each survey (13% in 2003 and 14% in 2004 and 2007). The most important trends were a continued decline in the number of Shasta crayfish in the Crystal Lake Outflow (23 in 2003, 7 in 2004, and 2 in 2007) and in Middle Cove (2 in 2003 and 2004, 0 in 2007). In addition, there was a shift towards more adults and fewer juveniles and YOY in Crystal Lake over the years (49:47:4 in 2003, 59:36:6 in 2004, and 72:27:1 in 2007).

Previous Surveys

Table 9 summarizes all data on the Shasta crayfish surveys in the Pit 1 Project vicinity between 1978 and January 2009. In 1978, Daniels found mainly Shasta crayfish in the Pit 1 Project vicinity, but fantail crayfish were found in the mainstem Pit River including Sand Pits where Shasta crayfish were also found (Table 9). During surveys in the early 1990s, fantail crayfish were only found in Fall River Pond and the Pit 1 Bypass Reach, until one fantail crayfish was found along the South Shore Big Lake levee in November 1993. Fantail crayfish are now found throughout much of the Tule River Levee System. In the 1990s, signal crayfish were present throughout most of the mainstem Pit River and in several areas of the Fall River drainage, but were absent from most of the headwaters of the Fall River drainage. Signal crayfish are now found throughout most of the Fall River drainage, including most of the headwater areas.

Table 10 summarizes all data from Shasta crayfish surveys in the Hat Creek Project vicinity between 1978 and 2007. Since the first surveys Shasta crayfish have generally decreased in their distribution and numbers, while signal crayfish have increased in their distribution and numbers.

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Table 9 Crayfish population characteristics (number, density, estimated population size, and percent composition) from previous and current surveys in the Pit 1 Project vicinity.

Region and Location		1978 [a]	1990, 1991, 1992 [b]	1993 [c] 1997 [d]	2001 [e]	2004–2007 [f,,g]	2007–2009[g, h]
Upper Fall River	Thousand Springs above barrier	**5–20 Shasta** 0.23–0.75 Shasta/m^2	**230 Shasta**			**280 Shasta (92%)** 0.212 Shasta/m^2 24 signal (8%) 0.018 signal/m^2	**250 Shasta (71%)** 0.189 Shasta/m^2 102 signal (29%) 0.077 signal/m^2
	Thousand Springs below barrier		**24 Shasta**			**2 Shasta (<1%)** 1518 signal (>99%)	**0 Shasta (0%)** 38 signal (100%)
	Rainbow Spring	**8 Shasta** **9 Shasta** (1985)	**45 Shasta (88%)** 6 signal (12%)			**19 Shasta (45%)** (*2003 survey*) 23 signal (55%)	**8 Shasta (5%)** 153 signal (95%)
	Fletcher's Bend		**4–11 Shasta (65%)** 0–6 signal (35%)	**4 Shasta (29%)** 0 Shasta (1995) 10 signal (71%)		**0 Shasta (0%)** 450 signal (100%) 1.705 signal/m^2	**0 Shasta (0%)** 90 signal (100%) 0.341 signal/m^2
	Lennihan's Footbridge		**11–13 Shasta (68%)** 0–6 signal (32%)	**1 Shasta (17%)** 5 signal (83%)		**0 Shasta** 112 signal (100%) 0.519 signal/m^2	**0 Shasta (0%)** 122 signal (100%) 0.565 signal/m^2
Spring Creek	Upper coves	**50 Shasta** Pop. size: 600–1000 0.79 Shasta/m^2	**466 Shasta** Population size: 4640 ± 627 0.83 Shasta/m^2			**316 Shasta (70%)** 0.033 Shasta/m^2 76 signal (30%) 0.008 signal/m^2	**94 Shasta (23%)** 0.010 Shasta/m^2 310 signal (77%) 0.032 signal/m^2
	Lower Coves	**8 Shasta** Pop. size: 10–50 0.50 Shasta/m^2	**17 Shasta**			**26 Shasta (30%)** 0.015 Shasta/m^2 61 signal (70%) 0.034 signal/m^2	**13 Shasta (3%)** 0.007 Shasta/m^2 435 signal (97%) 0.244 signal/m^2
Lava Creek	Lava Creek	**47 Shasta** 2.85 Shasta/m^2	**118 Shasta (98%)** 2 signal (1990) (2%)	**12–73 Shasta** (1993–1995) many signal			**45 Shasta (9%)** 468 signal (91%)
	Horr's Northern Pond	**12 Shasta** Pop. size: 50–100 0.12 Shasta/m^2		0 Shasta			

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Table 9 (continued)

Region and Location		1978 [a]	1990, 1991, 1992 [b]	1993 [c] 1997 [d]	2001 [e]	2004–2007 [f,g]	2007–2009 [g, h]
Ja She Creek	Ja She Creek headwaters	0 Shasta (at bridge)	**33 Shasta** 1 signal (at bridge)		**62 Shasta** 364 signal	**54 Shasta (4%)** 0.006 Shasta/m^2 1386 signal (96%) 0.163 signal/m^2	**82 Shasta (4%)** 0.010 Shasta/m^2 1783 signal (96%) 0.210 signal/m^2
Ja She Creek	Crystal Springs Cove	1 Shasta molt 0.04 Shasta/m^2	**11 Shasta**		**17 Shasta** 315 signal	**4 Shasta (<1%)** 0.001 Shasta/m^2 1791 signal (>99%) 0.485 signal/m^2	**4 Shasta (<1%)** 0.001 Shasta/m^2 1748 signal (>99%) 0.473 signal/m^2
Ja She Creek	Tule Coves		**16 Shasta** 8 signal		**13 Shasta** 39 signal	**8 Shasta (13%)** 0.038 Shasta/m^2 52 signal (87%) 0.246 signal/m^2	**2 Shasta (2%)** 0.009 Shasta/m^2 103 signal (97%) 0.488 signal/m^2 1 fantail (1%) 0.005 fantail/m^2
Upper Big Lake	Big Lake Springs	**12 Shasta** 1.00 Shasta/m^2	**39 Shasta**		**61 Shasta**	**36 Shasta (92%)** 0.203 Shasta/m^2 3 signal (8%) 0.017 signal/m^2	**41 Shasta (27%)** 0.232 Shasta/m^2 109 signal (73%) 0.616 signal/m^2
Upper Big Lake	North Big Lake[f]		**32 Shasta**		**49 Shasta** 10 signal	**9 Shasta (2%)** 0.007 Shasta/m^2 355 signal (98%) 0.269 signal/m^2	**8 Shasta (1%)** 0.006 Shasta/m^2 590 signal (99%) 0.448 signal/m^2
Upper Big Lake	Northeast Big Lake	**10 Shasta** 1.11 Shasta/m^2 (East Shore)	**32 Shasta**		0 Shasta 6 signal	**1 Shasta (25%)** 0.004 Shasta/m^2 3 signal (75%) 0.011 signal/m^2	0 Shasta 0 signal
Upper Big Lake	Northwest Big Lake		**7 Shasta**		**3 Shasta** 12 signal	**1 Shasta (33%)** 0.091 Shasta/m^2 2 signal (67%) 0.182 signal/m^2	**2 Shasta (20%)** 0.182 Shasta/m^2 8 signal (80%) 0.727 signal/m^2

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Table 9 (continued)

Region and Location		1978 [a]	1990, 1991, 1992 [b]	1993 [c] 1997 [d]	2001 [e]	2004–2007 [f,g]	2007–2009[g, h]
Tule River Levee System	South Shore Big Lake (only near Big Lake levee cove in 2004–2007)	**30 Shasta** 3.56 Shasta/m^2	**0–9 Shasta**	**2 Shasta (66%)** 1 fantail (33%)		**9 Shasta (43%)** 0.007 Shasta/m^2 3 signal (14%) 0.002 signal/m^2 9 fantail (43%) 0.007 fantail/m^2	**0 Shasta** 3 signal (5%) 0.002 signal/m^2 59 fantail (95%) 0.047 fantail/m^2
	Northeast upper Tule River	**30 Shasta** 1.20 Shasta/m^2	**5 Shasta (83%)** 1 signal (17%)		0 Shasta	**0 Shasta** 0 signal 5 fantail (100%) No habitat identified	**0 Shasta** 2 signal (13%) 14 fantail (88%)
	South shore upper Tule River		**4 Shasta (29%)** 10 signal (71%)	**0 Shasta** 1 signal YOY		**0 Shasta** 18 signal (23%) 0.857 signal/m^2 60 fantail (77%) 2.857 fantail/m^2	
	East shore upper Tule River		Shasta molts 11 signal			**0 Shasta** 1 signal (100%) No habitat identified	
	Horr Pond levee		**7 Shasta**		0 Shasta 26 signal 5 fantail	**0 Shasta** 7 signal (18%) 0.093 signal/m^2 33 fantail (82%) 0.440 fantail/m^2	**0 Shasta** 4 signal (17%) 0.053 signal/m^2 20 fantail (83%) 0.267fantail/m^2
Fall River Pond	Fall River Pond	**1 Shasta** 0.15 Shasta/m^2	0–many signal 0–most fantail			**0 Shasta** 8 signal (3%) 0.002 signal/m^2 230 fantail (97%) 0.047 fantail/m^2	

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Table 9 (continued)

Region and Location		1978 [a]	1990, 1991, 1992 [b]	1993 [c] 1997 [d]	2001 [e]	2004–2007 [f,,g]	2007–2009[g, h]
Mainstem Pit River	Pit River Falls (Pit 1 Bypass)		**4 Shasta** (1995) many fantail			**21 Shasta (49%)** 0.028 Shasta/m^2 10 signals (23%) 0.013 signals/m^2 12 fantail (28%) 0.016 fantail/m^2	**1 Shasta (dead; 2%)** 0.001 Shasta/m^2 29 signals (55%) 0.039 signals/m^2 23 fantail (43%) 0.031 fantail/m^2
	Canyon Spring (Pit 1 Bypass)	1 Shasta (dead)	1 Shasta (dead) signal present 0 fantail				
	Sand Pits (below Pit 1 Power-house and 299 Bridge)	**8 Shasta (3%)** 0.44 Shasta/m^2 297 fantail (97%) 3.11 fantail/m^2	0 Shasta abundant signal 0 fantail			**0 Shasta** many signals 1 fantail	
Sucker Springs	Sucker Springs Creek (all ponds)	**10 Shasta** 0.2 Shasta/m^2	**4 Shasta (<< 1%)** 47 signal (>>99%) Pond 5	**27 Shasta** Pond 3	**53 Shasta**	**3 Shasta (<< 1%)** 2066 signal (>>99%)	**7 Shasta (1%)** 750 signal (99%)

[a] Daniels, June – October 1978 (unpublished data in letter dated 7/13/95, Daniels 1978, Daniels 1980, Eng and Daniels 1982)
[b] Light 1990 unpublished notes, Hesseldenz and Ellis 1991, Light et al. 1991, Erman et al. 1993, Ellis 1996
[c] PG&E Shasta crayfish monitoring along the South Shore Tule River levee on 6 March, 12 August, 31 October 2007 (Spring Rivers unpublished data)
[d] Ahjumawi Lava Springs State Park Survey (Spring Rivers 2001)
[e] PG&E Shasta crayfish monitoring March 2004 – February 2007 (Spring Rivers 2007a)
[f] Habitat and crayfish data were verified and updated in 2009. Crayfish densities were calculated using the total area of prime and adequate habitat except at South shore Big Lake and South shore upper Tule River where the area of marginal habitat, which was the only habitat present, was used.
[g] PG&E Shasta crayfish monitoring March 2007 – March 2009

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Table 10 Crayfish population characteristics (number, density, estimated population size, and percent composition) from previous and current surveys in the Hat Creek Project vicinity.

	Region and Location	1978 [a]	1990 [b]–1991 [c]	1993 [d]	2003 [e, h]	2004 [f, h]	2007 [g, h]
Crystal Lake	Southwest	**12 Shasta** (100%) 0.12 Shasta/m^2	Signals (no scuba)	**31 Shasta** (50%) 31 signal (50%)	**137 Shasta** (55%) 0.147 Shasta/m^2 113 signal (45%) 0.122 signal/m^2	**263 Shasta** (55%) 0.283 Shasta/m^2 216 signal (45%) 0.232 signal/m^2	**130 Shasta** (43%) 0.140 Shasta/m^2 174 signal (57%) 0.187 signal/m^2
	Middle Cove		**~2 Shasta** (33%) 4 signal (67%)	**5 Shasta** (33%) 10 signal (67%)	**2 Shasta** (2%) 0.003 Shasta/m^2 123 signal (98%) 0.202 signal/m^2	**2 Shasta** (1%) 0.003 Shasta/m^2 217 signal (99%) 0.356 signal/m^2	**0 Shasta (0%)** 154 signal (100%) 0.252 signal/m^2
	Outflow	**658 Shasta** (100%) 6.89 Shasta/m^2 Pop. size: 2000–3000 Shasta	**7 Shasta** (13%) population size: 369 ± 135 Shasta 45 signal (87%)		**23 Shasta** (2%) 0.097 Shasta/m^2 1220 signal (98%) 5.126 signal/m^2	**7 Shasta** (0.5%) 0.029 Shasta/m^2 1327 signal (99%) 5.576 signal/m^2	**2 Shasta** (0.4%) 0.008 Shasta/m^2 457 signal (99%) 1.920 signal/m^2
Baum Lake	Baum Lake at Crystal Inflow	**3 Shasta** (1%) 0.09 Shasta/m^2 230 signal (99%) 3.81 signal/m^2	19 signals (100%)	**1 Shasta** (10%) 9 signal (90%)	**0 Shasta (0%)** 172 signal (100%) 0.831 signal/m^2	**0 Shasta (0%)** 283 signal (100%) 1.367 signal/m^2	**0 Shasta (0%)** 193 signal (100%) 0.932 signal/m^2
Rising River	Rising River Road Bridge			**7 Shasta**			
	Rising River footbridge			**7 Shasta**			
	Rising River Lake outflow	**25 Shasta** 2 Shasta/m^2 Pop. size: 100 Shasta	**18 Shasta**	**18 Shasta**			
	Rising River Lake			**5 Shasta**			

[a] Daniels, 12 June – 7 November 1978 (unpublished data in letter dated 7/13/95, Daniels 1978, Daniels 1980, Eng and Daniels 1982)
[b] Clarke and Light, 19, 22, 27 June & 3 July 1990 (Light 1990 unpublished notes, Light 1991, Light et al. 1991, Erman et al. 1993)
[c] Light and Myrick—Summer 1991 (Light 1991 unpublished data, Erman et al. 1993)
[d] Ellis and Cook, 6 August and 21 & 27 October 1993 (Ellis 1994)
[e] PG&E Shasta crayfish monitoring September 2003 – February 2004 (Spring Rivers 2004)
[f] PG&E Shasta crayfish monitoring November 2004 – February 2005 (Spring Rivers 2005b)
[g] PG&E Shasta crayfish monitoring January– April 2007 (Spring Rivers 2008)
[h] Habitat and crayfish data were verified and updated in 2009. Crayfish densities were calculated using the total area of prime and adequate habitat except at South shore Big Lake and South shore upper Tule River where the area of marginal habitat, which was the only habitat present, was used.

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The larger number of Shasta crayfish encountered in Southwest Crystal Lake during the last three surveys (2003 through 2007), compared to earlier surveys (1978, 1990/91, 1993), is due to the use of scuba in the surveys, which improved sampling effectiveness, and therefore direct comparisons cannot be made. During the same period, Shasta crayfish have decreased in numbers in both Middle Cove and Crystal Lake Outflow. In 1978, Daniels (1978, 1980) estimated the size of the Crystal Lake Outflow Shasta crayfish population to be 2000 to 3000 individuals and described it as one of the largest, densest populations that he surveyed. In 2007, only two Shasta crayfish were found at Crystal Lake Outflow. The first signal crayfish was found at Crystal Lake Outflow in November 1978 (Daniels 1980). In 1990–1991, 13% of the crayfish at Crystal Lake Outflow were Shasta crayfish. By 2003 the percentage of Shasta crayfish was less than 2%, and by 2007 it was only 0.4%. In the absence of some reversal in the current trend, it seems likely that Shasta crayfish will be extirpated from all Crystal Lake locations except Southwest Crystal Lake by the next survey in 2012.

Shasta crayfish have been found at 25 locations (as listed in Tables 9 and 10) in the Hat and Pit 1 project vicinities since 1978. The most recent survey confirmed Shasta crayfish present at 15 locations, with fewer than 10 Shasta crayfish at 8 of these locations. There has been a general decline in Shasta crayfish distribution and abundance. At the same time, introduced signal crayfish have continued to expand their range since the late 1970s and are now widespread and abundant throughout almost all Shasta crayfish habitat. Introduced fantail crayfish have expanded their range in the upper Tule River and Big Lake since 1993. In 1978 Shasta crayfish accounted for 100% of the crayfish encountered everywhere but the mainstem Pit River downstream of the Pit 1 Powerhouse. In 2009, Shasta crayfish accounted for less than 10% of the crayfish encountered during the combined surveys for both Projects (Figure 15).

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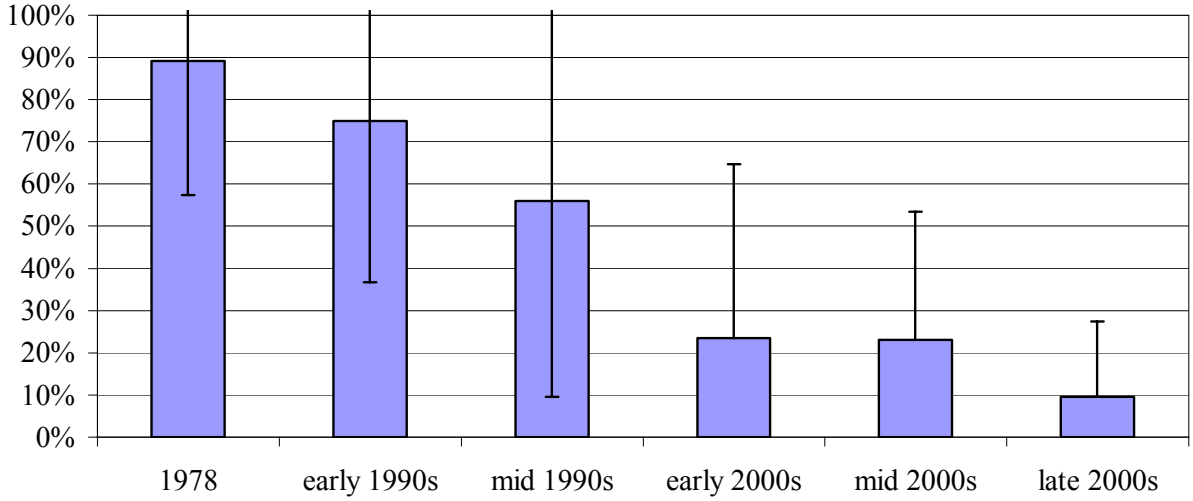

Figure 15 Mean (± standard deviation) percent crayfish species composition represented by Shasta crayfish encountered during all crayfish surveys throughout the species range since 1978.

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Recovery Team Activities

Grant Funding

Spring Rivers Foundation worked together with the USFWS, CDFG, and CDPR to prepare a grant proposal to reduce the numbers of invasive, non-native signal crayfish and to protect Shasta crayfish from extinction. Specifically, the proposal would determine additional locations for barrier construction to prevent further encroachment of signal crayfish in order to ensure that the major populations of Shasta crayfish do not drop below critical thresholds for survival. The proposal was submitted to USFWS for Preventing Extinction Funding on 9 May 2007 and again on 2 April 2008. Although the proposal did not receive Preventing Extinction Funding, it was awarded Director's Deferred Funds on 24 July 2008. The 2008 deferred allocation to protect Shasta crayfish from encroachment of non-native signal crayfish. The proposed project consists of non-native crayfish suppression efforts that target the major population centers of Shasta crayfish in each of the three genetically distinct clusters: (1) Rising River/Crystal Lake, (2) Sucker Springs/Spring Creek/ Ja She Creek, and (3) Rainbow Spring/Thousand Springs. Concurrent with the suppression efforts, the feasibility of additional potential crayfish barrier and refugia locations in each of these genetically distinct clusters will be investigated to prioritize future recovery efforts.

Sucker Springs Restoration Project

The Sucker Springs Creek Restoration Project is a multi-year, cooperative effort by the USFWS Endangered Species Recovery Program, the USFWS Partners for Fish and Wildlife, PG&E, and Spring Rivers Foundation, a non-profit 501(c) (3) corporation dedicated in part to working toward the recovery of Shasta crayfish. The goal of the restoration project is to improve habitat for Shasta crayfish by eliminating non-native signal crayfish and restoring geomorphic features to create more suitable physical habitat for Shasta crayfish. Spring Rivers Foundation is responsible for design and implementation of the restoration work.

In early 2006, all appropriate permits were acquired for stream restoration activities (i.e., CDFG 1600 Streambed Alteration Permit, Water Quality Certification from Regional Water Quality

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Control Board, Section 7 ESA consultation, Army Corps Nationwide 27 permit, and Section 106 programmatic agreement with the State Historic Preservation Officer). As part of the eradication efforts, two decrepit weirs, which provided habitat for signal crayfish and could not be adequately surveyed, were removed in September and October 2006. Before the upper of the two weirs was removed, an aluminum velocity barrier was constructed to halt any signal crayfish from migrating upstream (Spring Rivers 2007b).

The aluminum velocity barrier was originally constructed and installed on 25 and 26 October 2006 by Spring Rivers (Spring Rivers 2007b). It was rebuilt on 16 May 2007 after vandals had removed two stainless steel plates, which had been the integral bank contact points on both sides of the barrier. In addition, a rock V-weir was installed with the initial velocity barrier to stop slope adjustment and prevent destabilization of the velocity barrier. The V-weir was partially successful. When the barrier had to be rebuilt, an additional V-weir was constructed by placing large (~200 mm) cobble from onsite into the gravel bed between the original V-weir and the rebuilt velocity barrier. This additional measure has stopped slope adjustment and prevented destabilization of the velocity barrier.

Since 2006, Spring Rivers, under contract with Spring Rivers Foundation, has removed signal crayfish from Sucker Springs Creek by hand and with baited traps. These efforts continued the work of CDFG (1996–2000) and Spring Rivers (1996–2005), which have kept the number of signal crayfish in Sucker Springs Creek in check for the last 12 years. In 2006, in addition to snorkel surveys of Sucker Springs Creek to hand remove signal crayfish, enclosures were constructed around bank areas that were believed to harbor signal crayfish. These problem bank areas were isolated by constructing a wall of sandbags and thick construction plastic around each area to reduce water flow (Figure 16). The enclosures were left in place through early 2008. During that period, minnow traps baited with sardines were set out in the enclosures to capture signal crayfish. The traps were replenished and checked at least weekly. Trapped Pit sculpin, rough sculpin, and rainbow trout were released outside the enclosures. Once all rough sculpin (a fully protected, state-listed threatened species) were removed from the enclosures, CDFG-approved electrofishing techniques were employed inside the enclosures.

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Figure 16 Several enclosures made with sandbags in Pond 4, with minnow traps deployed inside the walls.

A backpack electrofishing unit (Smith-Root, model LR-24), set at standard fish-collection settings, was used to check for, and remove, any remaining fish inside the enclosures. After all fish were removed, settings were adjusted to more effectively agitate and draw signal crayfish from crevices within the banks. A method of intermittent shocking proved effective at enticing crayfish out of hiding places and into the open. Once in open water, crayfish were shocked to temporarily immobilize them for easy collection with dip nets.

Snorkel and electrofishing surveys showed that some signal crayfish remained in the bank habitat within the enclosures, so an additional method was devised to target them. In October 2007, PG&E provided personnel and a small excavator, to dig trenches into the bank on the upstream and downstream ends within each enclosure and along the front edge of the bank.

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Trenches were dug several feet into the bank and about one foot into the bottom substrate. A single section of plastic-coated, fine (i.e., 20-mesh) stainless-steel screen attached to 2 x 3-inch mesh, galvanized yard fencing was placed in each trench against the bank to entomb remaining signal crayfish. Screens were anchored to the substrate by back-filling the trenches with on-site substrate material. Gravel provided a good anchor medium with minimal interstitial areas for signal crayfish to crawl through. Cobble and boulder were added on top of the gravel, while rebar stakes were used to secure the top of the screens (Figure 17).

Figure 17 Small excavator back-filling the trenches after installation of the single section of screen at an enclosure in Pond 4.

The disturbance created during trench digging displaced many signal crayfish from their bank habitat into the enclosure, from which they were collected during subsequent electrofishing surveys and trapping. More signal crayfish, however, remained among the sandbags of the

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enclosure. In early 2008, before YOY signal crayfish would be free-living, one sandbag enclosure was removed to collect those remaining signal crayfish (Figure 18). Seventeen signal crayfish were collected during deconstruction of the enclosure, and an additional three crayfish in the immediate vicinity were removed during a follow-up snorkel survey. The sandbag enclosure was not reconstructed because the screen now prevented signal crayfish from entering the channel. Reconstruction likely would have provided more signal crayfish habitat that could not have been adequately surveyed. Other sandbag enclosures were deconstructed in early 2008.

Figure 18 Screened bank section after removal of the sandbag enclosure.

In 2008, the various eradication methods used in ponds 2, 3, and 4 resulted in the removal of 192 signal crayfish: 88 adults, 78 juveniles, and 26 YOY. Snorkel surveys in the main channel turned up 153 signal crayfish, while 30 signal crayfish were collected from traps and 9 signal crayfish were shocked. After March 2008, all but one sandbag enclosure was left in place, which

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put a stop to effective electro-fishing. Traps remained in use in areas where crayfish were thought to be in the bank and produced crayfish throughout the year. The sex, size measured as total carapace length (TCL), and general condition (e.g., reproductive state, missing appendages, and molt state) were collected from all crayfish captured by all methods. All signal crayfish were exterminated. Figure 19 shows the number of signal crayfish collected annually during eradication efforts in ponds 2, 3, and 4 at Sucker Springs Creek since 2001.

Sand bag exclusion barriers proved instrumental in drawing signal crayfish out of bank habitat by creating pond-like conditions in which baited traps and electro-fishing worked effectively. Unfortunately, the sand bags also created habitat that could not be surveyed until the barriers were taken down.

On 22 July 2008, Kathy Brown, the USFWS Conservation Partnerships Program Coordinator, presented a sign for Sucker Springs Creek Restoration Project that stated it was a private lands wildlife habitat restorations project completed in partnership with PG&E, Spring Rivers Foundation, USFWS Partners Program, and USFWS Endangered Species Program (Figure 20).

Signal crayfish eradication efforts will continue through 2009. To aid these efforts a secure barrier to halt any migration upstream from Pond 5 is needed. Structural deficiencies in the Pond 4 Weir (at the upstream end of Pond 5) have begun to appear. They include deteriorating concrete and water flowing visibly through the substrate and underneath the weir. Like the other weirs that were removed in 2006, the Pond 4 Weir creates habitat for signal crayfish at the upper end of Pond 5, and it is possible that some of the signal crayfish found recently in the lower end of Pond 4 moved up past the weir (e.g., through the gravel underneath the weir) from Pond 5. The Pond 4 Weir no longer appears to be a secure barrier to upstream migration from Pond 5 so it should be fortified or replaced as soon as possible.

Restoration of the complete channel cannot begin until we can demonstrate that signal crayfish no longer inhabit the restoration area (i.e., no reproduction has occurred for at least one year, and no signal crayfish have been collected for at least one year).

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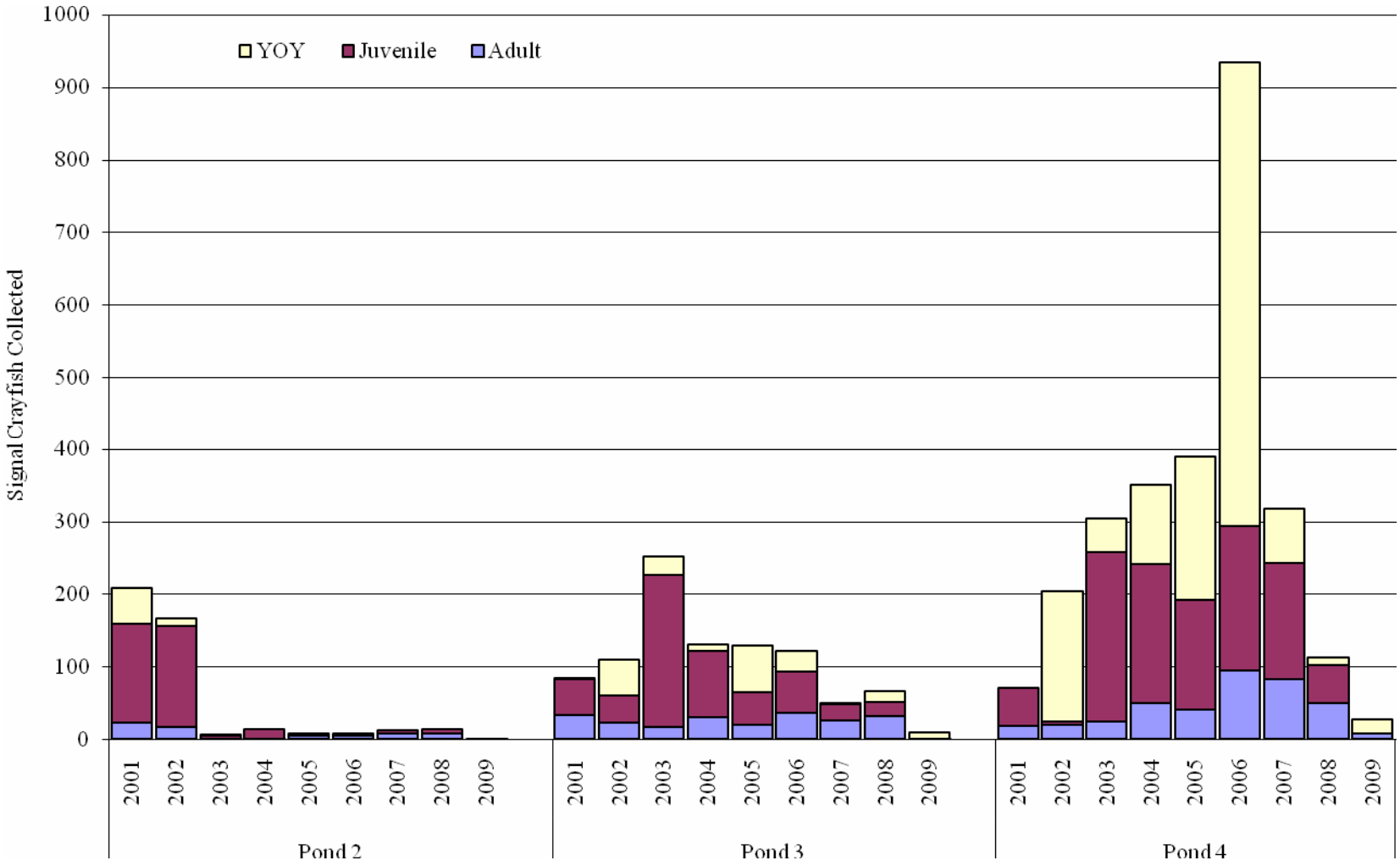

Figure 19 Signal crayfish collected during eradication efforts in ponds 2, 3, and 4 at Sucker Springs Creek since 2001.

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Figure 20 Sucker Springs Creek Restoration Project sign presented by USFWS Partners for Fish and Wildlife Program.

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CDFG Temperature Study

The objective of the CDFG Temperature Study at the Crystal Lake Fish Hatchery is to compare the growth of Shasta crayfish and signal crayfish at water temperatures of 50 °F and 56 °F in order to determine if Rock Creek is suitable for a Shasta crayfish reintroduction. CDFG estimates that a three-year rearing period would be necessary to obtain adequate growth data for Shasta crayfish. CDFG began the temperature growth study with signal crayfish in December 2004. Fifty YOY signal crayfish were placed in two stainless steel raceways at the Crystal Lake Fish Hatchery with different temperature regimes to determine the effects of temperature on growth rate and survival. Rock Creek water at a constant 50 °F (10 °C) was piped directly into the first raceway; water in the second treatment was heated to 56 °F (13 °C) to mimic the temperature regime in Sucker Springs Creek. Signal crayfish grew faster (with greater variation in size) in the 56 °F water than in the 50 °F treatment.

On 20 May 2005, Spring Rivers collected four gravid female Shasta crayfish from Southwest Crystal Lake. Two gravid females were placed in each temperature treatment raceway (upstream of the signal crayfish) on that day. Shasta crayfish were provided with fresh trout, periphyton-covered rocks from Crystal Lake, and carrots for food. On 5 August 2005, 49 YOY Shasta crayfish were placed in the 56 °F treatment and 50 YOY Shasta crayfish (of the 52 YOY found) were placed in the 50 °F treatment. Spring Rivers returned all four adult Shasta crayfish and two YOY Shasta crayfish to Crystal Lake on 5 August 2005. The YOY Shasta crayfish in the two water temperature treatment raceways were maintained for more than a year until the Crystal Lake Hatchery experienced an operating failure during the summer of 2006. Algae clogged the 50 °F water input from Rock Creek, resulting in only heated water entering the 56 °F treatment raceway. This resulted in a water temperature of 95 °F for a period of time until the problem was fixed. Consequently, all Shasta crayfish in the 56 °F treatment raceway perished, but the Shasta crayfish in the 50 °F treatment raceway and the signal crayfish appeared unharmed.

In spring 2007, CDFG reinitiated the temperature study after instituting safeguards to prevent an event such as the 2006 operating failure from happening again. On 15 June 2007, two female Shasta crayfish (1 berried and 1 with instars) were collected from Southwest Crystal Lake by

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Spring Rivers. On 3 October 2007, after a failed brood in the hatchery raceway, Spring Rivers returned the two adult females and one surviving YOY to their point of capture.

In spring 2008, CDFG reinitiated the temperature study for a third time. On 7 May 2008, four berried Shasta crayfish were collected from Spring Creek by Spring Rivers. Between 17 and 18 September 2008, the four female Shasta crayfish, which were being held in 50 °F treatment raceway, died. As of the 24 September 2008 TRC/Recovery Team meeting, five YOY Shasta crayfish were still being held in 50 °F treatment raceway at Crystal Lake Fish Hatchery.

In 2009, Spring Rivers personnel will be installing 18 temperature recorders at 10 locations presently inhabited by Shasta crayfish. The recorders will be installed at Thousand Springs, Spring Creek, Ja She creek, Big Lake Springs, Big lake Levee Cove, Pit River Falls, Sucker Springs Creek, Crystal lake, Rock Creek, and Rising River Lake (landowner permission pending). Recorders will be left in place for at least one year. Temperature will be recorded every hour. These data will document the range of water temperatures experienced by extant Shasta crayfish populations.

CDFG Genetics Study

CDFG has received two grants authorized under Section 6 of the Endangered Species Act to do a genetics study on Shasta crayfish. The study is being conducted at the Genomic Variation Laboratory of Bernie May, Ph.D. at the University of California, Davis. The goal is to document potential genetic variability within and among Shasta crayfish subpopulations that have experienced varying degrees of genetic isolation depending on their proximity to one another. After additional research by Spring Rivers and discussions with the TRC, it was determined that a single walking leg (i.e., pereopod 3), removed at the transverse fracture of the ischium, would provide sufficient genetic material while minimizing harm to the donor Shasta crayfish. Spring Rivers has primarily sampled Shasta crayfish during surveys required by the Hat Creek and Pit 1 licenses, although some additional surveys not covered under the licenses have also been conducted. Genetic sampling is only done on Shasta crayfish greater than, or equal to, 20-mm total carapace length. A maximum of 35 crayfish per subpopulation and/or location can be

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sampled during the study. Both field sampling and lab analysis are still ongoing and final results from the genetics study will not be known for a couple of years.

Genetic analyses are based upon genotyping of each individual crayfish sampled at nine microsatellite loci. Microsatellites are co-dominant (i.e., both maternal/paternal alleles can be observed), neutral markers that are employed to uncover population structure. Microsatellites can also be utilized to look for evidence of gene flow, hybridization, and inbreeding. The presence of population structure suggests that those populations found to be significantly different from one another are not randomly admixing, and may have accumulated local adaptations to their specific environment.

In 2007, DNA samples were taken from 24 Shasta crayfish in Lava Creek, five Shasta crayfish in Rainbow Spring, and two Shasta crayfish in Sucker Springs Creek. The small size of these Shasta crayfish populations limited the number of samples that could be obtained. An additional 17 Shasta crayfish from Big Lake were sampled to supplement the 18 samples collected in 2004. The Pit River upstream of Pit River Falls was surveyed on 11 May 2007 to obtain genetic samples from the Pit River Shasta crayfish, but no crayfish were found. On 16 November 2007, the second survey to obtain Shasta crayfish from the Pit River was aborted due to unfavorable survey conditions (i.e., high discharge and low visibility). Spring Rivers is awaiting approval from landowners to survey for Shasta crayfish in Rising River. Table 11 displays the genetics study working data set, which currently includes 235 individuals from nine sampling locations.

Preliminary results indicate that there is a fair amount of variation among the subpopulations sampled to date and that the amount of genetic variability within subpopulations varied by location. Three different genetic clusters have been identified from the samples: 1) Crystal Lake, 2) Big Lake Springs/Ja She Creek/Lava Creek/Spring Creek, and 3) Thousand Springs. The two samples from Sucker Springs Creek fit with the Big Lake Springs/Ja She Creek/Lava Creek/Spring Creek cluster. The five samples from Rainbow Springs show the highest probability of assignment to the Big Lake Springs/Ja She Creek/Lava Creek/Spring Creek cluster, however, some probability is given that three of the five individuals may assign to the Thousand Springs group. The Rainbow Springs individuals may not be clearly assigning

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because: (1) the reference population representative of the diversity found in Rainbow Springs may not be extant, or (2) the results may be reflective of gene flow or perhaps a hybrid zone between the Big Lake Springs and Thousand Springs genetic types.

Table 11 Number of Shasta crayfish sampled for the genetics study by location, 2004-2007.

Population	Number	Date
Big Lake Springs	18	2004
	17	2007
Crystal Lake	35	2004
Thousand Springs – Fish Trap Cove	35	2005
Thousand Springs – Property Line	35	2005
Spring Creek	35	2005
JaShe Creek	35	2006
Lava Creek	24	2007
Sucker Springs	2	2007
Rainbow Springs	5	2007

Crystal Lake had more genetic variation than any other cluster. Genotyping of signal crayfish from Crystal Lake indicated no genetic evidence of hybridization between the species. A summary of the genetics study data, presented at the 9 April 2008 TRC meeting by Jessica Peterson of the UC Davis Genomic Variability Laboratory, is included in Appendix F.

Genetics samples were collected (one each) from Pit River and Sucker Springs Creek during 2008 and winter 2009. Samples were sent to the UC Davis Genomic Variability Laboratory for inclusion in the data set.

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2009 Projected Activities

Technical Review Committee

The first 2009 Shasta Crayfish TRC/Recovery Team meeting was held in Redding on 22 April. The second 2009 meeting will be in Redding on 15 September.

During the April meeting, the Shasta Crayfish TRC/Recovery Team held the Year 5/6 Review Workshop (see Appendix C for meeting agenda and summary). The first five and six years of monitoring for the Pit 1 and Hat Creek projects, respectively were reviewed. The TRC/Recovery Team discussed the decline in Shasta crayfish numbers, both during the monitoring period and compared to historic conditions, and the increasing importance of refuge habitat to preserving the remaining populations. TRC/Recovery Team members expressed the importance of moving forward, without delay, with the Rock Creek reintroduction plan. The group agreed that a genetic management plan would be completed by the UC Davis Genomic Variability Laboratory to determine source populations for potential reintroductions of Shasta crayfish into Rock Creek and elsewhere. It was also agreed that a written proposal for the Rock Creek Restoration Proposal would be done by Spring Rivers in 2009.

During the April 2009 summary review workshop, there was a discussion on the status and precipitous decline of Shasta crayfish observed in the Pit 1 bypass reach since implementation of the flow regime required under the new license. Although the cause of the decline is not known, the following potential factors were discussed: minimum instream flows and their effects on coldwater spring habitat, summer flushing flows, and the increase in non-native crayfish populations. PG&E invited USFWS, CDFG, other interested TRC/Recovery Team members to attend the five-year summary meeting for the Pit 1 Water Quality Monitoring that was held on 11 May 2009 in Sacramento. The purpose of the five-year water quality summary meeting was to meet with the State Water Resources Control Board (SWRCB) and Regional Water Quality Control Board (RWQCB) to discuss whether the beneficial uses identified in the Basin Plan for the Pit River are being reasonably protected. SWRCB could increase minimum instream flows an additional 50 cfs to protect water quality in the bypass reach if it were determined that beneficial uses were not being met (Condition 17 of the SWRCB 401 Certification). PG&E must

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consult with the CDFG, USFWS, and the SWRCB regarding any proposed changes in Project Operation as required by the FERC Order Modifying and Approving the Bald Eagle Compliance Monitoring Plan pursuant to Article 415. Representatives of PG&E, SWRCB, RWQCB, USFWS, CDFG, other interested TRC/Recovery Team members attended the May water quality summary meeting. During the meeting, it was recommended that no increase in base flows be made at this time. The possibility that the planned out-of-season summer flushing flows may be resulting in take of endangered Shasta crayfish was raised by agency personnel during the meeting. At the request of Kim Squires, USFWS , Maria Ellis, Ph.D. of Spring Rivers wrote a letter on 13 May 2009 to USFWS recommending that the summer flushing flows be eliminated (Appendix G).

The third Pit 1 monitoring survey will begin in 2009. The next scheduled survey of the Hat Creek Project vicinity, which will be the fourth survey, is in 2012. Within the Pit 1 and Hat Project vicinities, Shasta crayfish have not been found in the Fall River at Fletcher's Bend or Lennihan's Footbridge, Northeast Upper Tule River, South Shore Upper Tule River, East Shore Upper Tule River, Horr Pond Levees, and Baum Lake since the mid-1990s. The Shasta crayfish found in Baum Lake in 1978 and 1993 may have represented wash downs from Crystal Lake rather than a self-sustaining population. The last Shasta crayfish found in Fall River Pond and at the Pit River Sand Pits was in 1978. These locations are all inhabited by signal crayfish, fantail crayfish, or both non-native species. No Shasta crayfish have been found during at least two consecutive surveys including the baseline crayfish monitoring surveys of these areas and Shasta crayfish are presumed extirpated from these locations. We propose to not survey these areas during the next round of Shasta crayfish surveys. Efforts to obtain permission to survey Rising River will continue, and surveys will begin once permission is obtained.

The biannual non-native crayfish eradication surveys related to the Upper Fall River Crayfish Barrier Project and the Spring Creek Road Crossing Cavity-Filling Project will continue in 2009. The 2009 survey data will be reported in the 2009 Shasta Crayfish Technical Review Committee Annual Report, which is due to the agencies and FERC by 31 May 2010.

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Recovery Team

Eradication efforts and repair/replacement of weirs in Sucker Springs Creek will continue in 2009 with the continued help of PG&E. In 2009, crayfish barriers, which are similar in design to the upper Fall River crayfish barrier, will be installed adjacent to and upstream from the Pond 4 and 5 weirs. The Pond 4 and 5 weirs will be left in place so that the water level can be raised to facilitate snorkel surveys. The following permits, which were obtained in 2005 and 2006 for the initial stages of the Sucker Springs Restoration Project, will cover the installation of these crayfish barriers: CDFG Streambed Alteration Permit (22 May 2005–10 December 2010), State Water Resources Control Board 401 Water Quality Certification Permit (11 May 2006 through Project completion), USFWS Wildlife Extension Agreement (5 December 2005–5 December 2020). Eradication methods will be reviewed and modified, as necessary, to improve effectiveness.

CDFG plans to continue its temperature and genetics studies in 2009. During the 22 April 2009 meeting, the Shasta crayfish TRC/Recovery Team recommended that a relatively small number of Shasta crayfish be introduced upstream of the CDFG diversion structure on Rock Creek in 2009 as an experiment in lieu of the temperature study in the raceways at the Crystal Lake Fish Hatchery. The first three attempts (i.e., 2005–2006, 2007, and 2008) to maintain Shasta crayfish in the raceways for the temperature study at the Crystal Lake Fish Hatchery have been unsuccessful. The rationale for the TRC/Recovery Team recommendation is that an experimental introduction of Shasta crayfish directly into Rock Creek will more directly and expeditiously address whether the reintroduction of Shasta crayfish into Rock Creek is likely to succeed.

Efforts to obtain permission to survey Rising River will continue, and surveys will begin once permission is obtained. If permission can be obtained to survey and collect genetic samples, samples from Shasta crayfish in Rising River will be collected and sent to UC Davis Genomic Variability Laboratory.

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Recommendations

The Shasta crayfish plans have been and will continue to be adapted as needed, based on input from the TRC. The recommendations and changes are documented in the annual reports and the summary report. For instance, the TRC expanded the study area from the FERC Project boundary to the species range. The TRC/Recovery Team will continue to play a guiding role in the direction of Shasta crayfish activities. The following list summarizes current recommendations based on TRC and Recovery Team activities discussed in this report.

TRC Recommendations

1. Eliminate the summer flushing flows in the Pit 1 Bypass Reach due to the possibility that the license-required summer flushing flows may be resulting in take of the endangered Shasta crayfish.
2. Continue snorkel surveys of the Upper Fall River barrier at least twice a year to inspect the barrier and to monitor for the presence of debris and/or algal growth that could compromise the barrier.
3. Develop a written proposal to reintroduce Shasta crayfish to Rock Creek. Article 412 of the Hat Creek Project license requires PG&E to develop a Shasta Crayfish Management Plan that includes formulation of a plan to re-introduce Shasta crayfish into Rock Creek. Prior to implementation of a Rock Creek Reintroduction Plan:
   a. Develop a Rock Creek Restoration Plan to restore historical Shasta crayfish habitat, including measures to ensure that the water needs for the Crystal Lake Fish Hatchery continue to be met.
   b. Consult Genetic Management Plan to help determine source population for potential reintroductions of Shasta crayfish into Rock Creek.
4. Continue with the Pit 1 and Hat Creek crayfish monitoring surveys according to the schedule and methods described in this report. If no Shasta crayfish have been found during at least two consecutive surveys including the baseline crayfish monitoring surveys, the site can be eliminated from the next round of surveys. For instance, Fletcher's Bend, Lennihan's Footbridge, Northeast Upper Tule River, South Shore Upper Tule River, East Shore Upper Tule River, Horr Pond Levees, and Baum Lake will not be surveyed during the third Pit 1 surveys starting in 2009 or the fourth Hat survey in 2012.
5. Conduct the Rising River survey, upon receipt of landowner permission.
6. Continue with the biannual non-native crayfish eradication surveys of Thousand Springs and Spring Creek according to the schedule and methods described in this report.

Recovery Team Recommendations

1. Begin implementation of non-native signal crayfish suppression measures and refugia investigations as outlined in the scope of work for the 2008 Director's Deferred funding.
2. Develop a CDFG Section 6 proposal to:

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   a. Conduct Mitochondrial DNA work on existing Shasta crayfish genetic samples.
   b. Develop a Genetic Management Plan to help determine source populations for potential reintroductions of Shasta crayfish into Rock Creek and elsewhere.
   c. Investigate potential refugia

3. Continue with eradication of signal crayfish in Sucker Springs Creek. Review and modify methods, as necessary, to improve effectiveness.

4. Install crayfish barriers, similar in design to the upper Fall River crayfish barrier, adjacent to and upstream from the Pond 4 weir and the Pond 5 weir in Sucker Springs Creek.

5. Develop a proposal to reintroduce a relatively small number of Shasta crayfish upstream of the CDFG diversion structure on Rock Creek in 2009 as an experiment in lieu of the temperature study in the raceways at Crystal Lake Fish Hatchery.
   a. Consult Genetic Management Plan to help determine source population for potential reintroductions of Shasta crayfish into Rock Creek.

6. Continue and expand the CDFG Genetic Study
   a. Collect genetic samples from Shasta crayfish in Rising River once landowner permission is obtained and send to UC Davis Genomic Variability Laboratory.
   b. Conduct Mitochondrial DNA work on existing Shasta crayfish genetic samples.
   c. Develop a Genetic Management Plan to help determine source populations for potential reintroductions of Shasta crayfish into Rock Creek and elsewhere.

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APPENDIX A—FERC License Articles pertaining to Shasta crayfish for the Hat Creek and Pit 1 Projects

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Hat 1 Project (FERC No. 2661) License Articles pertaining to Shasta Crayfish

Article 409. Pursuant to the terms and conditions of the incidental take statement filed by the U.S. Fish and Wildlife Service, within six months of issuance of the license the licensee shall file with the Commission, for approval, an implementation plan to monitor the habitat and populations of Shasta crayfish in the Project Area. The plan shall include, but shall not be limited to, the following: (1) characterization of suitable Shasta crayfish habitat; (2) provisions to map and quantify amounts of existing (baseline) suitable habitat; (3) quantitative assessment of existing Shasta crayfish populations in the Project Area; (4) methodology for annual monitoring; and (5) annual reporting requirements including progress milestones.

The licensee shall include with the plan, documentation of consultation, copies of comments and recommendations on the completed plan after it has been prepared and provided to the agencies, and specific descriptions of how the agencies' comments are accommodated by the plan. The licensee shall allow a minimum of 60 days for U.S. Fish and Wildlife Service and California Department of Fish and Game to comment and to make recommendations before filing the plan with the Commission. If the licensee does not adopt a recommendation, the filing shall include the licensee's reasons, based on site-specific conditions.

The Commission reserves the right to require changes to the plan. The plan shall not be implemented until the licensee is notified that the plan is approved. Upon Commission approval, the licensee shall implement the plan, including any changes required by the Commission.

Article 410. Pursuant to the terms and conditions of the incidental take statement filed by the U.S. Fish and Wildlife Service, the licensee shall within three months of license issuance, in coordination with the U.S. Fish and Wildlife Service, California Department of Fish and Game, Natural Resources Conservation Service, other resource agencies and interested stakeholders, establish a technical review committee (committee) for the purpose of assisting the licensee in the design and implementation of the terms and conditions required in the biological opinion (primarily focused on Shasta crayfish protection and recovery in the project area). The licensee in coordination with committee members shall establish rules of protocol for conduct of meetings, correspondence, and other communications necessary for committee activities. The licensee in coordination with committee members shall develop written guidance for the committee that describes the purpose, goals, and objectives of the committee. The purpose, goals, and objectives shall be consistent with the Shasta crayfish recovery plan and any new scientific information that may become available. The licensee shall provide to the Commission and the committee by May 31 of each year an annual report of the activities of the committee. The licensee shall provide notice to the Commission within 30 days (but prior to implementing change) of any decisions by the committee that result in changes to project operations that fall outside normal operations as described in the licensed project.

Article 411. Pursuant to the terms and conditions of the incidental take statement filed by the U.S. Fish and Wildlife Service, the licensee shall within three months of license issuance establish an inflation indexed interest bearing account (Funding Account). Within 30 days of establishing the Funding Account, the licensee shall establish a separate interest deposit account

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(Interest Account). Funding Account interest payments shall accrue monthly to the Interest Account. The licensee shall be responsible for management of these accounts and all associated costs. Within 45 days following establishment of the Funding Account, the licensee shall deposit $500,000 in the Funding Account. The Funding Account and Interest Account shall be maintained for the term of the license. The licensee shall not withdraw funds from the Funding Account, and shall retain ownership of the asset value in the Funding Account, but all interest accrued shall be deposited into the Interest Account at the end of each month and shall be available for spending by the technical review committee for purposes of implementing the terms and conditions and conservation measures included in the license for protection and recovery of the Shasta crayfish, exclusive of Article 412. The licensee shall provide documentation of the establishment of these accounts to the Commission and the Service within 100 days of license issuance. In lieu of establishment of the Funding Account and Interest Account, the licensee can make available $30,000 annually, each year for the term of the license, adjusted annually for inflation using the Consumer Price Index, to be spent by the technical review committee for the same purposes as described above.

Article 412. Pursuant to the terms and conditions of the incidental take statement filed by the U.S. Fish and Wildlife Service, the licensee shall file with the Commission within six months of the license issuance, for approval, a comprehensive Shasta crayfish management plan for the Project Area developed in coordination with the California Department of Fish and Game, Natural Resources Conservation Service, U.S. Fish and Wildlife Service and interested stakeholders within the Hat Creek drainage, and approved by the U.S. Fish and Wildlife Service. The plan will identify and examine action alternatives the licensee would implement to combat the rapid decline of Shasta crayfish in the Project Area. The plan shall include provisions to provide or maintain habitat refugia for Shasta crayfish isolated from populations of invasive non-native crayfish in the Project Area, and shall include but not be limited to the following: (1) provisions to fund signal crayfish removal on an annual basis in the amount of at least $10,000, and (2) annual reporting requirements including progress milestones. This plan shall include evaluation of known methods for reducing abundance such as hand removal and other methods that may require pilot testing or further research. Details of fish stocking in the Project Area developed in cooperation with the California Department of Fish and Game to protect and minimize the impacts on Shasta crayfish in the Project Area shall also be included in the Shasta crayfish management plan, and shall include but not be limited to the following: (1) written description and mapping of current locations being stocked and frequency of fish stocking on an annual basis, (2) record of historical stocking, and (3) a list of alternative planting locations. The Shasta crayfish management plan shall also include formulation of a plan to reintroduce Shasta crayfish to the Rock Creek springs area. At minimum this plan should include installation of a crayfish barrier, means to eradicate non-native crayfish above the barrier, and restoring historical Shasta crayfish habitat. This reintroduction plan should include methods to be implemented throughout the term of the license to protect and maintain this reintroduced population in stable condition.

The licensee shall include with the plan, documentation of consultation, copies of comments and recommendations on the completed plan after it has been prepared and provided to the agencies, and specific descriptions of how the agencies' comments are accommodated by the plan. The licensee shall allow a minimum of 60 days for U.S. Fish and Wildlife Service and California

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Department of Fish and Game to comment and to make recommendations before filing the plan with the Commission. If the licensee does not adopt a recommendation, the filing shall include the licensee's reasons, based on site-specific conditions.

The Commission reserves the right to require changes to the plan. The plan shall not be implemented until the licensee is notified that the plan is approved. Upon Commission approval, the licensee shall implement the plan, including any changes required by the Commission.

Article 413. Pursuant to the terms and conditions of the incidental take statement filed by the U.S. Fish and Wildlife Service, the licensee shall file within six months of license issuance with the Commission, for approval, a recreational management plan (Shasta Crayfish). This plan shall include provisions for educating the general public about the status of the Shasta crayfish, information on potential threats from recreational activities, and protective measures to avoid take as part of the recreation planning for the project. The public outreach effort will serve to increase the public's awareness of the causes for species' endangerment. This information shall include an explanation of the fishing regulations restricting the use of crayfish as bait in the Project Area and distribution area of the Shasta crayfish.

The licensee shall include with the plan, documentation of consultation, copies of comments and recommendations on the completed plan after it has been prepared and provided to the agencies, and specific descriptions of how the agencies' comments are accommodated by the plan. The licensee shall allow a minimum of 60 days for U.S. Fish and Wildlife Service and California Department of Fish and Game to comment and to make recommendations before filing the plan with the Commission. If the licensee does not adopt a recommendation, the filing shall include the licensee's reasons, based on site-specific conditions.

The Commission reserves the right to require changes to the plan. The plan shall not be implemented until the licensee is notified that the plan is approved. Upon Commission approval, the licensee shall implement the plan, including any changes required by the Commission.

Pit 1 Project (FERC No. 2687) License Articles pertaining to Shasta Crayfish

Article 409. Pursuant to the terms and conditions of the incidental take statement filed by the U.S. Fish and Wildlife Service, the licensee shall, within six months of license issuance, file for Commission approval, an implementation plan to monitor the habitat and populations of Shasta crayfish in the project area. The plan shall include, but shall not be limited to, the following: (1) characterization of suitable Shasta crayfish habitat; (2) provisions to map and quantify amounts of existing (baseline) suitable habitat; (3) quantitative assessment of existing Shasta crayfish populations in the project area; (4) methodology for annual monitoring; and (5) annual reporting requirements including progress milestones.

The licensee shall include with the plan, a schedule for implementing the plan, for consulting with the U.S. Fish and Wildlife Service and the California Department of Fish and Game, and for filing monitoring reports with the consulted agencies and the Commission, documentation of consultation, copies of comments and recommendations on the completed plan after it has been prepared and provided to the agencies, and specific descriptions of how the agencies' comments

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are accommodated by the plan. The licensee shall allow a minimum of 60 days for the U.S. Fish and Wildlife Service and California Department of Fish and Game to comment and to make recommendations before filing the plan with the Commission. If the licensee does not adopt a recommendation, the filing shall include the licensee's reasons, based on site-specific conditions.

The Commission reserves the right to require changes to the plan. The plan shall not be implemented until the licensee is notified by the Commission that the plan is approved. Upon Commission approval, the licensee shall implement the plan, including any changes required by the Commission.

Article 410. Pursuant to the terms and conditions of the incidental take statement filed by the U.S. Fish and Wildlife Service, the licensee shall within three months of license issuance, in coordination with the U.S. Fish and Wildlife Service, California Department of Fish and Game, California Department of Parks and Recreation, Bureau of Land Management, Natural Resources Conservation Service, other resource agencies and interested stakeholders, establish a technical review committee (committee) for the purpose of assisting the licensee in the design and implementation of the terms and conditions required in the U.S. Fish and Wildlife Service's biological opinion (primarily focused on Shasta crayfish protection and recovery in the project area). The licensee, in coordination with committee members, shall establish rules of protocol for conduct of meetings, correspondence, and other communications necessary for committee activities. The licensee, in coordination with committee members, shall develop written guidance for the committee that describes the purpose, goals, and objectives of the committee. The purpose, goals, and objectives shall be consistent with the Shasta crayfish recovery plan and any new scientific information that may become available. The licensee shall provide to the Commission and the committee, by May 31 of each year, an annual report of the activities of the committee. The licensee shall provide notice to the Commission within 30 days (but prior to implementing change) of any decisions by the committee that result in changes to project operations that fall outside normal operations, as described in the license.

Article 411. Pursuant to the terms and conditions of the incidental take statement filed by the U.S. Fish and Wildlife Service, the licensee shall provide each year, beginning January 1, 2004, for the term of the license, $45,000, adjusted annually per the Consumer Price Index (CPI). These funds shall be for spending by the technical review committee, established pursuant to Article 410, for purposes of implementing the terms and conditions and conservation measures set forth in the biological opinion and incorporated in the license, for protection and recovery of the Shasta crayfish. These funds ($45,000) are distinct from funds required under Article 412 but may be used to supplement funds provided pursuant to Article 412, if approved by the technical review committee.

Article 412. Pursuant to the terms and conditions of the incidental take statement filed by the U.S. Fish and Wildlife Service, within six months of license issuance, the licensee shall file for Commission approval a comprehensive Shasta crayfish management plan for project lands and waters developed in coordination with the U. S. Fish and Wildlife Service, California Department of Fish and Game, California Department of Parks and Recreation, and interested stakeholders within the Pit River drainage, and approved by the U.S. Fish and Wildlife Service. The plan shall identify and examine action alternatives the licensee would implement to combat

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the rapid decline of Shasta crayfish in the project area. The plan shall include provisions to provide or maintain habitat refugia for Shasta crayfish isolated from populations of invasive non-native crayfish in the project area, and shall include but not be limited to the following: (1) provisions to fund signal crayfish removal on an annual basis in the amount of at least $20,000, beginning January 1, 2004, and (2) annual reporting requirements including progress milestones. The funds required in this article for signal crayfish removal are distinct from those required in Article 411 above; however, should signal crayfish removal be deemed no longer necessary (as determined by the technical review committee, established pursuant to Article 410), these funds may be used for implementation of other terms and conditions, if approved by the technical review committee. This plan shall include evaluation of known methods for reducing abundance, such as hand removal and other methods that may require pilot testing or further research. Details of fish stocking in the project area developed in cooperation with the California Department of Fish and Game to protect and minimize the impacts on Shasta crayfish in the project area shall also be included in the Shasta crayfish management plan, and shall include but not be limited to the following: (1) written description and mapping of current locations being stocked and frequency of fish stocking on an annual basis; (2) record of historical stocking; and (3) a list of alternative planting locations.

The licensee shall include with the plan, a schedule for filing any proposed protection and management measures, or any proposed modifications to the project and project operations necessary to protect Shasta crayfish or its critical habitat, documentation of consultation, copies of comments and recommendations on the completed plan after it has been prepared and provided to the agencies, and specific descriptions of how the agencies' comments are accommodated by the plan. The licensee shall allow a minimum of 60 days for the consulted agencies to comment and to make recommendations before filing the plan with the Commission for approval. If the licensee does not adopt a recommendation, the filing shall include the licensee's reasons, based on site-specific conditions.

The Commission reserves the right to require changes to the plan. The plan shall not be implemented until the licensee is notified by the Commission that the plan is approved. Upon Commission approval, the licensee shall implement the plan, including any changes required by the Commission.

Article 413. Pursuant to the terms and conditions of the incidental take statement filed by the U.S. Fish and Wildlife Service, the licensee shall within one year of license issuance file for Commission approval a plan to construct and maintain a minimum of two exclusion barriers to protect Shasta crayfish habitat from invasion by signal crayfish. The plan shall include, but not be limited to, the following: (1) provisions to fund the design and construction of two crayfish barriers, not to exceed $150,000 over 4 years; (2) detailed design drawings and map locations of the exclusion barriers; (3) a schedule for construction and initial performance testing; and (4) a monitoring and reporting schedule for long-term evaluation of barrier performance.

The licensee shall include with the plan, documentation of consultation, copies of comments and recommendations on the completed plan after it has been prepared and provided to the agencies, and specific descriptions of how the agencies' comments are accommodated by the plan. The licensee shall allow a minimum of 60 days for U.S. Fish and Wildlife Service and California

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Department of Fish and Game to comment and to make recommendations before filing the plan with the Commission. If the licensee does not adopt a recommendation, the filing shall include the licensee's reasons, based on site-specific conditions.

The Commission reserves the right to require changes to the plan. The plan shall not be implemented until the licensee is notified by the Commission that the plan is approved. Upon Commission approval, the licensee shall implement the plan, including any changes required by the Commission.

Article 416. Pursuant to the terms and conditions of the incidental take statement filed by the U.S. Fish and Wildlife Service, the licensee shall, within six months of license issuance, file for Commission approval, a recreation management and public outreach plan. The plan shall include, but not be limited to the following: (1) information regarding the location, design, construction, maintenance, and use of the licensee's five proposed forebay recreational areas; (2) information regarding the location, design, construction, and maintenance of the proposed recreational access to the Pit River near Big Eddy, or a comparable site; (3) information regarding how the licensee would maintain the Rat Farm boat launching access area at Big Lake; (4) protective measures to avoid take as part of the recreation planning for the project; and (5) provisions for educating the general public about the status of the Shasta crayfish and the bald eagle, including information on potential threats from recreational activities. The public outreach effort will serve to increase the public's awareness of the causes for species' endangerment. The information provided to the general public shall include an explanation of the fishing regulations restricting the use of crayfish as bait in the project area and distribution area of the Shasta crayfish.

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APPENDIX B—Shasta Crayfish Management Plan Fund Summary

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Shasta Crayfish Management Plan Fund for the Hat Creek (FERC No. 2661) and Pit 1 (FERC No. 2687) Projects

License Article	Annual Fund $	SAP Order #
Hat Creek Survey Article 411	$ 30,000	10211203
Hat Creek Removal Article 412	$ 10,000	10211204
Pit 1 Survey Article 411	$ 45,000	10213521
Pit 1 Removal Article 412	$ 20,000	10213522

Hat Creek License was issued on November 4, 2002. Shasta Crayfish Plan was approved on August 21, 2003. Funding began on January 1, 2003.
Pit 1 License was issued on March 19, 2003. Shasta Crayfish Plan was approved on July 7, 2004. Funding began on January 1, 2004
Based on Article 413 of the Pit 1 License, the Crayfish Barrier Plan was approved on 8 March 2007.
As part of the Barrier Plan, the biannual (2 times per year) crayfish removal surveys for the Spring Creek Barrier project began in 2008 with an annual budget of $35 K.

	---------2003----------		---------2004----------		---------2005----------		---------2006----------		---------2007----------		---------2008----------	
Study/Task	**Principal**	**CPI**	**Principal**	**CPI**	**Principal**	**CPI**	**Principal**	**CPI**	**Principal**	**CPI**	**Principal**	**Estimated CPI**
Hat Surveys	$ 30,000	$ -	$ 30,000	$ 790	$ 30,000	$ 1,842	$ 30,000	$ 2,902	$ 30,000	$ 4,066	$ 30,000	$ 4,773
Hat Removal	$ 10,000	$ -	$ 10,000	$ 266	$ 10,000	$ 614	$ 10,000	$ 967	$ 10,000	$ 1,355	$ 10,000	$ 1,591
Pit 1 Surveys	$ -	$ -	$ 45,000	$ -	$ 45,000	$ 1,525	$ 45,000	$ 3,073	$ 45,000	$ 4,773	$ 45,000	$ 5,930
Pit 1 Removal	$ -	$ -	$ 20,000	$ -	$ 20,000	$ 678	$ 20,000	$ 1,366	$ 20,000	$ 2,121	$ 20,000	$ 2,635
Barrier Crayfish Removal	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 35,000	$ -
Subtotal	$ 40,000	$ -	$ 105,000	$ 1,056	$ 105,000	$ 4,659	$ 105,000	$ 8,308	$ 105,000	$ 12,315	$ 140,000	$ 14,929
Total Annual Budget	$ 40,000		$ 106,056		$ 109,659		$ 113,308		$ 117,315		$ 154,929	
Spring Rivers Invoiced Amount	$ 40,000		$ 105,000		$ 98,310		$ 113,308		$ 117,315		$ -	
Allocated for Spring Creek Barrier	$ -		$ -		$ -		$ -		$ 12,405		$ -	
Balance/Year	$ -		$ 1,056		$ 11,349		$ -		$ (12,405)		$ 154,929	
Balance To Date (04/1/2008)												**$ 154,929**

The annual amounts for Crayfish surveys (Articles 411) and non-native crayfish removal (Articles 412) were adjusted annually from the original amounts stated in the licenses (2003 dollars for Hat and 2004 dollars for Pit 1) based on the CPI (rate of inflation from 2003 for Hat and 2004 for Pit 1 to 2006) as specified in the license. CPI was calculated based on the U.S. Department of Labor Bureau of Labor Statistics Consumer Price Index (CPI) inflation calculator (http://data.bls.gov/cgi-bin/cpicalc.pl).

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APPENDIX C—2008 and April 2009 TRC Meeting Agendas and Summaries

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SHASTA CRAYFISH TECHNICAL REVIEW COMMITTEE
Hat Creek (FERC Project No. 2661) & Pit 1 (FERC Project No. 2687)

April 9, 2008 (Wednesday) - 10:00 am to 2:00 pm
California Department of Fish and Game Region 1 Office Conference Room
601 Locust Street, Redding, CA 96001
(530) 225–2370
CDFG Meeting Host: Steve Baumgartner

AGENDA

Welcome and Introductions (Maria Ellis / Rhonda Shiffman)

I. **TRC Shasta Crayfish Project Updates**

A. Shasta crayfish monitoring

1) Schedule and progress for Hat Creek and Pit 1 Surveys

a) Rising River

2) Shasta Crayfish Management Plan Fund

3) Five-Year Summary Report due in 2009

B. Signal crayfish removal surveys related to the Crayfish Barrier Plan

1) Upper Fall River Crayfish Barrier

2) Biannual Non-native Crayfish Eradication/Control Surveys in upper Spring Creek

C. Rock Creek Restoration

D. Shasta crayfish signs for the Hat Creek and Pit 1 projects

II. **Recovery Team Shasta Crayfish Projects Updates**

A. John Muir Conservation Award (Rhonda Shiffman)

B. Preventing Extinctions Proposals—2007 and 2008 (Amy Fesnock)

C. Section 6 Funding (Glenn Yoshioka)

D. CDFG Temperature Study (Steve Baumgartner)

E. CDFG Genetic Study (summary by Jessica Petersen, UC Davis Genomic Variation Lab)

1) Still need samples from Pit River at Pit River Falls and Rising Rivers

F. Sucker Springs Creek Restoration Project (Maria Ellis)

Establish Action Items / Schedule Next Meeting

Rhonda Shiffman (RxSm@pge.com)
PG&E Environmental Services Department (415) 973–3727

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Shasta Crayfish Technical Review Committee
April 2008 Meeting Summary

The following is a summary of the Shasta Crayfish Technical Review Committee and Recovery Team meeting held in Redding on April 9, 2008.

I. **TRC Shasta Crayfish Project Updates**

A. Reviewed the schedule (Attachment A) and progress for Hat Creek and Pit 1 Surveys. The **Shasta Crayfish Technical Review Committee 2008 Annual Report**, which is due May 31, 2009, will be a Summary Report of the first 6 years of monitoring and other activities for Hat Creek with surveys in 2003 (baseline), 2004, and 2007 and the first 5 years of monitoring and other activities for Pit 1 with surveys in 2004–2006 (baseline) and 2007–2008. The report will also include monitoring and other activities under the Crayfish Barrier Plan and other Shasta crayfish TRC and Recovery Team activities.

B. Rising River will be surveyed as part of the Hat Creek study area as soon as landowner permission is obtained.

C. Shasta crayfish were found during surveys of the Pit 1 Bypass Reach upstream of the Pit River Falls in August 1995 and October 2005, but no Shasta crayfish were found during an 11 May 2007 survey. A 16 November 2007 survey was aborted due to higher water and turbidity issues. The following items were discussed.

1) Could temperature effects related to the three annual flushing flow events first implemented in 2003 under the 2003 FERC license be having a detrimental effect on Shasta crayfish in the Pit 1 Bypass Reach?
2) Install temperature meter in the Pit 1 Bypass Reach upstream of Pit River Falls to monitoring temperature before, during, and after flushing flows.
3) May request clearance for reduced flows (from 150 cfs) in the Pit 1 Bypass or survey after Nov 1 (75 cfs) or Nov 16 (50 cfs) for Shasta crayfish in the Pit River upstream of Pit River Falls (population status and genetic samples).

D. Reviewed the Shasta Crayfish Management Plan Fund (Attachment B). Signal crayfish removal surveys required by the Crayfish Barrier Plan (approved by FERC on March 8, 2007) will be kept as a separate line item from the Pit 1 and Hat Creek removals and will be called Barrier Crayfish Removal.

E. Crayfish Barrier Plan

1) Signal crayfish removal surveys related to the Crayfish Barrier Plan (Barrier Crayfish Removal).
   a) Upper Fall River Crayfish Barrier—continue surveys to remove/control signal crayfish upstream of the Upper Fall River Barrier. A total of 46 signal crayfish (17 males, 13 females, 16 YOY) have been found upstream of the barrier location since 2005 (2 in 2005, 15 in 2006, 24 in 2007, 5 in Feb 2008).
   b) Upper Spring Creek—began the biannual non-native crayfish eradication/control surveys upstream of the Spring Creek Road crossing in 2008. These biannual removal surveys were prescribed in the barrier plan and continue the eradication efforts that began in 2004. A total of 367 signal crayfish (133 males, 153 females, 56 YOY) have been found upstream of the Spring Creek Road crossing since 2004 with 243 in the lower coves and 124 in the upper coves (60 in 2004/2005, 78 in 2006, 176 in 2007, 53 in April 2008).

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c) Need to present crayfish barrier info to larger audience. Amy Fesnock suggested the 2009 Annual Conference of the Western Section of The Wildlife Society on 21-23 January 2009 in Sacramento.

F. Rock Creek Restoration—Hat License Article 412 does not state a deadline. Need to develop a conceptual plan for the Rock Creek Restoration and get buy-in from the agencies.
   1) Estimate the size of the Shasta crayfish population that the restored approximately 600-foot reach of Rock Creek could support.
   2) Need to decide the source population for Shasta crayfish reintroduction—should it be Crystal Lake?
   3) CDFG hatchery water supply considerations were discussed and potential funding as part of the Recovery Team (e.g., Bring Back the Natives).
   4) Region 1 has a new Senior Hatchery Supervisor named Linda Rathburn. Steve Baumgartner will set up a meeting with CDFG, PG&E including a groundwater hydrologist, and Spring Rivers.

G. Shasta crayfish I&E signs are being installed for the Hat Creek and Pit 1 projects.

II. Recovery Team Shasta Crayfish Projects Updates

A. CDFG is working on land acquisition of key conservation properties.

B. John Muir Conservation Award—Thank you everyone!
   1) Submitted a tremendous nomination package with wonderful quotes and support under a very tight schedule.
   2) The John Muir Association was "very impressed with PG&E's and their partners' commitment to conservation and going well beyond what was required in the relicensing permit."
   3) The Green Foothills Committee was the 2008 award recipient.

C. Kathy Brown nominated PG&E for the 2008 USFWS Recovery Champion Award for making a significant contribution to the recovery of endangered and threatened species.
   1) PG&E was honored to be nominated for the award, which was announced in March 2008 and given to a partner with over 30-years experience working with a species.

D. PG&E Annual Richard A. Clarke Environmental Leadership Award
   1) Nominations due in July.

E. Preventing Extinctions Proposal for 2008
   1) Delta smelt and devil's hole pupfish beat out the Shasta crayfish in 2007.
   2) The 2008 Preventing Extinctions Proposal was submitted in early April. Successful proposals will be awarded in June/July.

F. Section 6 Funding (Glenn Yoshioka)
   1) State contracting rules too onerous and therefore not time-effective or feasible to work with private non-profit or for-profit entities.
   2) Need to have matching funds.
   3) Proposed 60K extension for the CDFG UC Davis genetics work for mictochondrial DNA (maternally passed) to show divergence between species/subspecies (phylogeny) using existing samples.

G. Explore Bring Back The Natives grant funding

H. CDFG Temperature Study—CDFG feels is essential to the Rock Creek Restoration project.
   1) Requesting USFWS update BO to allow CDFG to retry experiment in 2008.

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2) Plugged coldwater manifold in 2006 and failed brood with only one young-of-year Shasta crayfish in 2007.
3) Crystal Lake system has been replumbed and revalved in 2007 and 2008 so that the worst-case scenario is cool water.
4) Suggest that Shasta crayfish be collected from Spring Creek instead of Crystal Lake to minimize effects on existing Shasta crayfish populations in the wild.

I. CDFG Genetic Study (written summary by Jessica Petersen, UC Davis Genomic Variation Lab presented by Maria Ellis—Attachment C)
1) Still need samples from Pit River at Pit River Falls and Rising Rivers.
2) Data set includes 235 individuals from nine sampling locations.
3) Three different genetic clusters—Crystal Lake, Big Lake Springs/Ja She Creek/Lava Creek/Spring Creek, and Thousand Springs.
4) Genetic assignment tests place two individuals from Sucker Springs with the Big Lake Springs/Ja She Creek/Lava Creek/Spring Creek cluster
5) To conserve maximum level of genetic diversity, it is essential to maintain all three major genetic clusters.

J. Update on the Sucker Springs Creek Restoration Project
1) Continue snorkel surveys, electroshocking, trapping, of signal crayfish
2) PG&E provided excavators and operators to dig trenches and install plastic-coated, fine (i.e. 20-mesh) stainless-steel screen attached to 2 x 3-inch mesh, galvanized yard fencing around the problem bank areas to entomb remaining signal crayfish.
3) Sand bag enclosures are being removed to capture signal crayfish that are using these areas as habitat.
4) During 2007, 379 signal crayfish were removed from Sucker Springs Creek
5) As of March 2008, 17 YOY have been found in ponds 3 and 4.
6) Both the pond 4 and pond 5 weirs are showing signs of structural deficiencies, such as deteriorating concrete and water flowing visibly through the substrate and underneath the weir, and will need to be replaced.

III. The next meeting will take place on Wednesday, **September 24, 2008** at 10 am at the California Department of Fish and Game Region 1 Office Conference Room in Redding.

IV. **Attendees:**

Rhonda Shiffman	925.415.6330	RxSm@pge.com	PG&E Senior Environmental Consultant
Charles White	415.973.3642	COW1@pge.com	PG&E Hydro License Coordinator
Ruth Sundermeyer	925.415.6376	D5SK@pge.com	PG&E Aquatic Biologist
Amy Fesnock	916.414.6678	amy_fesnock@fws.gov	USFWS Branch Chief, Forest and Foothills Ecosystems
Woody Elliott	530.538.2212	welli@parks.ca.gov	California Department of Parks and Recreation
Steve Baumgartner	530.225.2370	sbaumgartner@dfg.ca.gov	CDFG Region 1 Fishery Biologist
Glenn Yoshioka	916.651.8764	gyoshioka@dfg.ca.gov	CDFG Species Conservation & Recovery
Maria Ellis	530.335.5446	maria@springrivers.com	Spring Rivers Ecological Sciences, LLC

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Action Items from the April 2008 Shasta Crayfish TRC Meeting:

Project	Task	Who	When
Temp Study	Get CDFG support for collecting crayfish from a different source than Crystal Lake	CDFG/ Steve B.	ASAP
Temp Study	Collect 4 female Shasta crayfish from Spring Creek	Spring Rivers CDFG	Early May
Genetics	Obtain landowner permission to survey Rising River	Spring Rivers	ongoing
Genetics	Collect genetic samples from Pit River Falls and Rising River and provide to Jessica	Spring Rivers	ongoing
Genetics	Write Section 6 Proposal for additional genetics funding	CDFG/ Steve B.	2008
Pit 1 Surveys	Install temperature gage in Pit River upstream Pit Falls	Spring Rivers	2008
Barrier/ Crayfish Plan	Continue Barrier non-native crayfish removal surveys in upper Fall River and upper Spring Creek	Spring Rivers	ongoing
Crayfish Plan	Pit 1 and Hat Creek monitoring surveys	Spring Rivers	ongoing
General	Research environmental awards to continue to build ground swell for Shasta crayfish recovery	All	ongoing
Funding	Research funding options including Bring Back the Natives grants	Spring Rivers	ongoing
Sucker Springs	Continue eradication efforts, develop plan to replace or repair pond 4 and 5 weirs	Spring Rivers	ongoing
Rock Creek	Arrange meeting with CDFG, PG&E, and Spring Rivers to develop plan for Rock Creek	CDFG, PG&E, Spring Rivers	2009
Barrier	Barrier Presentation—2009 Annual Conference of the Western Section of The Wildlife Society on 21-23 January 2009 in Sacramento?	Spring Rivers	January 2009

Rhonda Shiffman (RxSm@pge.com)
PG&E Environmental Services Department (925) 415–6330

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SHASTA CRAYFISH TECHNICAL REVIEW COMMITTEE
Hat Creek (FERC Project No. 2661) & Pit 1 (FERC Project No. 2687)

September 24, 2008 (Wednesday) - 10:00 am to 2:00 pm
California Department of Fish and Game Region 1 Office Conference Room
601 Locust Street, Redding, CA 96001
(530) 225–2370
CDFG Meeting Host: Steve Baumgartner

AGENDA

Welcome and Introductions (Maria Ellis / Rhonda Shiffman)
USFWS Introductions (Amy Fesnock)

I. **TRC Shasta Crayfish Project Updates**

A. Shasta crayfish monitoring

1) Status of Hat Creek and Pit 1 Surveys, including Rising River

2) The **Shasta Crayfish Technical Review Committee 2008 Annual Report** will be a Summary Report of the first 6 and 5 years of monitoring and other activities under the Hat Creek and Pit 1 Shasta Crayfish Management Plans, respectively.

B. Signal crayfish removal surveys related to the Crayfish Barrier Plan

1) Upper Fall River Crayfish Barrier

2) Biannual Non-native Crayfish Eradication/Control Surveys in upper Spring Creek

C. Rock Creek Restoration

D. **Review Workshop** for the Hat Creek and Pit 1 Shasta Crayfish Management Plans will be held in April 2009 with the TRC and other interested parties in order to determine future actions.

II. **Recovery Team Shasta Crayfish Projects Updates**

A. PG& Richard A. Clarke Environmental Leadership Award (Rhonda Shiffman)

B. Preventing Extinctions 2008 Proposal—Director's Deferred Funds (Amy Fesnock)

C. Section 6 Funding (Steve Baumgartner)

D. CDFG Temperature Study (Steve Baumgartner)

E. CDFG Genetic Study

1) Pit River at Pit River Falls and Rising Rivers

F. Sucker Springs Creek Restoration Project (Maria Ellis)

Establish Action Items / Schedule Next Meeting

Rhonda Shiffman (RxSm@pge.com)
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SHASTA CRAYFISH TECHNICAL REVIEW COMMITTEE
Hat Creek (FERC Project No. 2661) & Pit 1 (FERC Project No. 2687)

September 24, 2008 (Wednesday) - 10:00 am to 2:00 pm
California Department of Fish and Game Region 1 Office Conference Room
601 Locust Street, Redding, CA 96001
(530) 225–2370
CDFG Meeting Host: Steve Baumgartner

MEETING SUMMARY

I. **Welcome and Introductions** (Maria Ellis / Rhonda Shiffman)
   A. **USFWS Introductions** (Amy Fesnock)
      1) Kim Squires is the new Forest and Foothills Branch Chief. She has been at the U.S. Fish and Wildlife (USFWS) Sacramento Field Office for 4 years.
      2) Josh Hull, Ph.D. is the Recovery Branch Chief for the Endangered Species Program.
      3) Dominic Bachman is the USFWS Partners for Wildlife biologist out of the Modoc National Wildlife Refuge in Alturus.
      4) Amy is leaving USFWS to be the new Threatened and Endangered Species Lead for the Bureau of Land Management (BLM).
   B. PG&E
      1) Rhonda will be stepping down. Her new job in Environmental Services is taking her in new directions.
      2) Charles White, Senior License Coordinator, from Pacific Gas and Electric Company (PG&E) Power Generation Department, will be taking over as co-lead. Ruth Sundermeyer from PG&E's Environmental Services Department will take over as technical coordinator.
      3) At the time of the TRC meeting, Charlie White was on an extended 6-month rotation as the license coordinator for the Pit 1 and Hat Creek Projects. His position is now permanent.

II. **TRC Shasta Crayfish Project Updates**
   A. Status update on the Hat Creek and Pit 1 Shasta crayfish monitoring surveys
      1) Hat Creek was surveyed in 2003/2004 and 2007. The next surveys will be in 2012.
      2) Pit 1 was surveyed in 2004/2005/2006 and is being surveyed in 2007/2008. About four more weeks of surveys will be implemented in the upper Tule River drainage, Pit River above the falls, Spring Creek, and the upper Fall River to complete the 2007/2008 surveys. The next Pit 1 surveys are in 2009/10.
      3) Pit River upstream of the Pit River Falls
         a) Shasta crayfish were first found in the mainstem Pit River upstream of the Pit River Falls in August 13, 1995; four individuals were found. During a more extensive survey of the Pit River above the falls ten years later on October 6, 2005, 14 Shasta crayfish were found as well as 9 signal and 12 fantail crayfish. During a survey on May 11, 2007 no Shasta crayfish were found. A survey on November 16, 2007 was aborted due to high discharge and turbidity. During an extensive survey of the area on September 23, 2008, only 1 dead Shasta crayfish was found.

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b) Concern was raised that the new license-required base flows and flushing flows in the Pit 1 Bypass Reach have changed the temperature regime creating less suitable habitat conditions for Shasta crayfish.
c) Project operations should be reviewed and modifications to the license should be considered.
d) USFWS is implementing its 5-year review for Shasta Crayfish this year, the timing of which coincides with PG&E's review period for the Hat Creek and Pit 1 Shasta Crayfish Management Plans.

B. Status update on the signal crayfish removal surveys related to the Crayfish Barrier Plan
1) Upper Fall River Crayfish Barrier—Prior to installation of the barrier in August 2007, 8 signal crayfish were found upstream of the barrier site. Eradication surveys since the barrier was installed have found 23 signal crayfish. Based on landowner preferences, eradication surveys are done in late January/February and August.
2) Biannual Non-native Crayfish Eradication/Control Surveys in upper Spring Creek began in 2008. A total of 48 signal crayfish were found in the upper coves and 181 signal crayfish were found in the lower coves during the February through April 2008 surveys.

C. The **Shasta Crayfish Technical Review Committee 2008 Report**, which is due May 31, 2009, will be a Summary Report of the first 6 and 5 years of monitoring and other activities under the Hat Creek and Pit 1 Shasta Crayfish Management Plans, respectively.

D. **Review Workshop** for the Hat Creek and Pit 1 Shasta Crayfish Management Plans will be held in April 2009 with the TRC and other interested parties in order to determine future actions and revise the Hat Creek and Pit 1 Shasta Crayfish Management Plans as necessary.
1) A summary of the results of the work conducted between 2003 and 2008 under the Hat Creek Shasta Crayfish Management Plan, including the Shasta crayfish monitoring program, signal crayfish removal program, Rock Creek reintroduction, and recreational management and public outreach efforts will be presented.
2) A summary of the results of the work conducted between 2004 and 2008 under the Pit 1 Shasta Crayfish Management Plan, including the Shasta crayfish monitoring program and the signal crayfish removal program will be presented.
3) The Review Workshop, which was originally scheduled to following Year 5 (2007) of the Hat Creek plan implementation, was rescheduled with TRC approval to follow Year 5 (2008) of implementation of the Pit 1 Shasta Crayfish Management Plan.

E. Rock Creek Restoration
1) To move forward with the Rock Creek Meadow Restoration, a conversation with California Department of Fish and Game (CDFG), PG&E, USFWS, and Spring Rivers is needed to discuss and develop a proposal and reach a conceptual agreement. A PG&E hydrologist will be consulted.
2) Appropriate source population for Rock Creek-possibly Crystal Lake or Rising River. Will look at genetic study.

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III. **Recovery Team Shasta Crayfish Projects Updates**

A. External recognition for the Shasta crayfish TRC and Recovery Team activities.
   1) Rhonda submitted an application for the PG&E Richard A. Clarke Environmental Leadership Award in late July 2008. The 2008 Clarke Award for best group effort went to the "Change a Light Campaign" Core Team of 22 employees that came together during October and November of 2007 to encourage PG&E customers to buy and use compact fluorescent lamps (CFLs).
   2) Kathy Brown, the USFWS Conservation Partnerships Program Coordinator, nominated PG&E for Region 8 (California, Nevada, and Klamath). Through the Recovery Champion Award, the USFWS recognizes employees and partners who are making significant contributions to the recovery of endangered and threatened species. The award, which was announced in March 2008, went to a partner with over 30 years of experience working on species. Although PG&E was not selected for the award, it was an honor to be nominated by the USFWS.
   3) Rhonda submitted a nomination package for the John Muir Conservation Award in November 2007. The Green Foothills Committee was the 2007 award recipient.

B. Preventing Extinctions Proposal—Director's Deferred Funds
   1) The Shasta crayfish 2008 Preventing Extinctions Proposal was funded with Director's Deferred Funds in late July 2008.
   2) Preventing Extinctions RFP are announced annually anytime after March 1.
   3) Should keep applying for Preventing Extinctions funds. Also put us in the running for other funds as occurred in 2008.

C. Section 6 Funding (Steve Baumgartner)
   1) 2003 Section 6 Funding ends 12/31/2008. 2005 Section 6 grant piggybacked on to 2003 grants but with bigger amounts. 2009 Section 6 grant proposal (e.g., refugial sites, genetics) needs to be submitted in the next couple of weeks. May hire personnel to assist. Mitochondrial DNA will provide a better history of gene flow through time. How long ago did lineage diverge?

D. CDFG Temperature Study (Steve Baumgartner)
   1) Steve B. got CDFG support for collecting crayfish from a different source than Crystal Lake. Four gravid female Shasta crayfish were collected from Spring Creek on May 7, 2008.
   2) All four female Shasta crayfish at Crystal Lake Hatchery died around September 17–18, 2008. All crayfish were being held in 50 °F water. Specimens were frozen. Five YOY were still being held in 50 °F water.
   3) CDFG feels the temperature study is important aspect for determining Rock Creek reintroduction and is good information for captive rearing.
   4) Need to ask the question whether the temperature study should continue. Theo asked whether Crystal Lake Hatchery was the appropriate venue for captive rearing experiments.
   5) If Spring Creek Shasta crayfish are used as the source for the temperature study, will people then demand that it be repeated with Crystal Lake crayfish?
   6) Source population should be discussed in the recovery plan. Steve will organize a conference call to discuss source population issues with the TRC/Recovery Team.

E. CDFG Genetic Study
   1) Pit River at Pit River Falls (sample from the 1 dead Shasta found 9/23/08).
   2) Rising River as soon as receive landowner permission.

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3) Jessica has written the final report.

F. Sucker Springs Creek Restoration Project (Maria Ellis)
1) Pond 4 Weir may not be a secure barrier to upstream migration of signal crayfish from Pond 5.
2) Pond 5 Weir is not a secure barrier to upstream migration of signal crayfish from the Pit River.
3) All enclosures were removed from the main pond (formerly ponds 2, 3, and 4) in 2008 except for one at the upstream end of the pond. Trapping continues both inside the enclosure and elsewhere.
4) A total of 145 signal crayfish were collected in 2008.
5) Security and vandalism continue to be an issue at Sucker Springs. "No Trespassing" signs were installed in 2008. The barbed wire fence we installed in May 2007 is routinely bent indicating that people still trespass into Sucker Springs. The secondary access gate at Sucker Springs was vandalized around July 21, 2008. The chain was cut and the lock damaged. A 3/8-inch chain and high security, temper-resistant lock has since been installed.
6) 2009 Plans—Install new crayfish barriers similar in design to the upper Fall River barrier upstream of the Pond 4 and 5 weirs. The Pond 4 and 5 weirs will remain in place for the next few years so that water level can be raised during eradication snorkel surveys. Install permanent fence across channel to connect existing chain link fence sections.

IV. The next meeting will take place on Wednesday, **April 22, 2009** at 10 am at the California Department of Fish and Game Region 1 Office Conference Room in Redding.

Attendees:

Rhonda Shiffman	925.415.6330	RxSm@pge.com	PG&E Senior Environmental Consultant
Charles White	415.973.3642	COW1@pge.com	PG&E Hydro License Coordinator
Ruth Sundermeyer	925.415.6376	D5SK@pge.com	PG&E Aquatic Biologist
Amy Fesnock	916.978.4646	amy_fesnock@blm.gov	BLM Threatened and Endangered Species Lead
Kim Squires	916.414.6654	kim_squires@fws.gov	USFWS Branch Chief, Forest and Foothills Ecosystems
Randy Benthin	530.225.2372	rbenthin@dfg.ca.gov	CDFG Region 1 Senior Fishery Biologist
Steve Baumgartner	530.225.2370	sbaumgartner@dfg.ca.gov	CDFG Region 1 Fishery Biologist
Glenn Yoshioka	916.651.8764	gyoshioka@dfg.ca.gov	CDFG Species Conservation & Recovery
Theo Light	717.477.1093	TSLigh@ship.edu	Shippensburg University, Department of Biology
Jessica Petersen	530.752.6351	jlpetersen@ucdavis.edu	UC Davis Genomic Variation Lab
Maria Ellis	530.335.5446	maria@springrivers.com	Spring Rivers Ecological Sciences, LLC

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Action Items from the September 2008 Shasta Crayfish TRC Meeting:

Project	Task	Who	When
Genetics	Obtain landowner permission to survey Rising River	Spring Rivers	ongoing
Genetics	Collect genetic samples from Pit River Falls and Rising River and provide to Jessica	Spring Rivers	ongoing
Genetics	Write Section 6 Proposal for additional genetics funding	CDFG/ Steve B.	2008
Pit 1 Surveys	Install temperature gage in Pit River upstream Pit Falls	Spring Rivers	2008
Barrier/ Crayfish Plan	Continue Barrier non-native crayfish removal surveys in upper Fall River and upper Spring Creek	Spring Rivers	ongoing
Crayfish Plan	Pit 1 and Hat Creek monitoring surveys	Spring Rivers	ongoing
General	Research environmental awards to continue to build ground swell for Shasta crayfish recovery	All	ongoing
Funding	Research funding options including Bring Back the Natives grants	Spring Rivers	ongoing
Sucker Springs	Continue eradication efforts, develop plan to replace or repair pond 4 and 5 weirs	Spring Rivers	ongoing
Rock Creek	Arrange meeting with CDFG, PG&E, and Spring Rivers to develop plan for Rock Creek	CDFG, PG&E, Spring Rivers	2009
Barrier	Barrier Presentation	Spring Rivers	2009-2010

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REVIEW WORKSHOP AND ANNUAL MEETING
SHASTA CRAYFISH TECHNICAL REVIEW COMMITTEE
Hat Creek (FERC Project No. 2661) & Pit 1 (FERC Project No. 2687)
April 22, 2009 (Wednesday) - 10:00 am to 2:00 pm
California Department of Fish and Game Region 1 Office Conference Room
601 Locust Street, Redding, CA 96001
(530) 225–2370
CDFG Meeting Host: Steve Baumgartner

AGENDA

I. **Welcome and Introductions**

II. **Meeting Purpose and Objectives** (Maria Ellis)
   A. **Shasta Crayfish Technical Review Committee 2008 Report**, due May 31, 2009, is a Summary Report of the first 6 and 5 years of monitoring and other activities under the Hat Creek and Pit 1 Shasta Crayfish Management Plans, respectively.
   B. **Review Workshop** for the Hat Creek and Pit 1 Shasta Crayfish Management Plans with the TRC and other interested parties in order to determine future actions and revise the Hat Creek and Pit 1 Shasta Crayfish Management Plans as necessary.

III. **Shasta Crayfish TRC Summary Report Presentation** (Maria Ellis)
   A. **Technical Review Committee Activities**
      1) Crayfish Barriers
      2) Rock Creek Restoration
      3) Shasta Crayfish Interpretive and Education Signs
      4) Crayfish Monitoring (Schedule)
         a) Habitat Mapping
         b) Hat Creek Crayfish Surveys—2003/2004 and 2007. Next surveys in 2012.
         c) Pit 1 Crayfish Surveys—2004/05/06 and 2007/08. Next surveys in 2009/10.
         d) Non-Native Crayfish Eradication Surveys
      5) Shasta Crayfish Population Status
   B. **Recovery Team Activities**
      1) Sucker Springs Restoration Project
      2) Grant Funding
         a) Director's Deferred Funds
         b) Preventing Extinctions RFP—2009 due date?
         c) Section 6 Funding
      3) CDFG Temperature Study
      4) CDFG Genetics Study

IV. **Open Discussion—2009 Projected Activities and Future Directions**
   A. Shasta Crayfish Management Plan Fund Summary
   B. Technical Review Committee
   C. Recovery Team

V. **Schedule Next Meeting**

Charles White (COW1@pge.com)
PG&E Senior License Coordinator for the Hat Creek and Pit 1 projects (415) 973-3642

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REVIEW WORKSHOP AND ANNUAL MEETING
SHASTA CRAYFISH TECHNICAL REVIEW COMMITTEE
Hat Creek (FERC Project No. 2661) & Pit 1 (FERC Project No. 2687)

April 22, 2009 (Wednesday) - 10:00 am to 2:00 pm
California Department of Fish and Game Region 1 Office Conference Room
601 Locust Street, Redding, CA 96001
(530) 225–2370
CDFG Meeting Host: Steve Baumgartner

MEETING SUMMARY

I. **Meeting Purpose and Objectives**
   A. The purpose of this summary review workshop is to review the first five and six years of monitoring for the Pit 1 and Hat Creek projects in order to determine future actions and revise the Hat Creek and Pit 1 Shasta Crayfish Management Plans as necessary.
   B. The Shasta Crayfish Technical Review Committee 2008 Summary Report, due May 31, 2009, summarizes the first five and six years of monitoring and other activities under the Pit 1 and Hat Creek Shasta Crayfish Management Plans, respectively.

II. **Shasta Crayfish TRC Summary Report Presentation**

III. **2009 TRC Projected Activities and Future Directions Discussion**
   A. Crayfish Barriers—Continue snorkel surveys of the Upper Fall River barrier at least twice a year to inspect the barrier and to monitor for the presence of debris and/or algal growth that could compromise the barrier.
   B. Rock Creek Restoration
      1) Given the observed decline in Shasta crayfish numbers, both during the monitoring period and compared to historic conditions, the importance of refuge habitat to preserving the remaining populations is increasing.
      2) TRC/Recovery Team members expressed the importance of moving forward, without delay, with the Rock Creek reintroduction plan.
      3) Develop a written proposal to reintroduce Shasta crayfish to Rock Creek. Article 412 of the Hat Creek Project license requires PG&E to develop a Shasta Crayfish Management Plan that includes formulation of a plan to re-introduce Shasta crayfish into Rock Creek. Prior to implementation of a Rock Creek Reintroduction Plan:
         a. Develop a Rock Creek Restoration Plan to restore historical Shasta crayfish habitat, including measures to ensure that the water needs for the Crystal Lake Fish Hatchery continue to be met.
         b. Consult Genetic Management Plan to help determine source population for potential reintroductions of Shasta crayfish into Rock Creek.
   C. Crayfish Monitoring
      1) Continue with the Pit 1 and Hat Creek crayfish monitoring surveys according to the monitoring schedule and methods described in this report.
         a) Hat Creek Crayfish Surveys—2003/2004 and 2007. Next surveys in 2012.
         b) Pit 1 Crayfish Surveys—2004/05/06 and 2007/08. Next surveys in 2009/10.
      2) Conduct the Rising River survey, upon receipt of landowner permission.

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3) Non-Native Crayfish Eradication Surveys—Continue with the biannual non-native crayfish eradication surveys of Thousand Springs and Spring Creek according to the monitoring schedule and methods described in this report.

D. Shasta Crayfish Population Status—the dramatic decline of Shasta crayfish observed in the Pit 1 bypass reach since implementation of the new-license required flow regime was discussed. Although the cause of the decline is not known, the following potential factors were discussed: minimum instream flows and their effect on coldwater spring habitat, summer flushing flows, and increase in non-native crayfish populations.

1) On May 11, 2009, PG&E presented a summary of the results of the first five years of the water quality monitoring to the State Water Resources Control Board (SWRCB) and Regional Water Quality Control Board in Sacramento. As part of Condition 17 of the 401, the SWRCB needs to determine if the beneficial uses identified in the Basin Plan for the Pit River are reasonably protected. If they decide that the beneficial uses are not reasonably protected, the SWRCB can increase flows an additional 50 cfs. Additionally, the *Order Modifying and Approving the Bald Eagle Compliance Monitoring Plan Pursuant To Article 415* requires PG&E to consult with the California Department of Fish and Game, US Fish and Wildlife Service, and the SWRCB regarding any proposed changes in Project Operation.

a) Representatives of PG&E, SWRCB, RWQCB, USFWS, CDFG, other interested TRC/Recovery Team members attended the meeting.

IV. 2009 Recovery Team Projected Activities and Future Directions Discussion

A. Grant Funding

1) 2008 Director's Deferred Funds— Begin implementation of non-native signal crayfish suppression measures and refugia investigations as outlined in the scope of work for the 2008 Director's Deferred funding.
2) Check with Josh Hull in August because there are sometimes extra funds like the Director's Deferred Funds awarded last year.
3) Preventing Extinctions RFP—the 2009 due date has passed.
4) Section 6 Funding proposal due June 1, 2009 for 2010 funding.
   a) Mitochondrial DNA work on existing Shasta crayfish genetic samples
   b) Genetic Management Plan
   c) Refugia investigation

B. Sucker Springs Restoration Project—Eradication efforts and repair/replacement of weirs in Sucker Springs Creek will continue in 2009 with the continued help of PG&E.

1) In 2009, crayfish barriers, similar in design to the upper Fall River crayfish barrier, will be installed adjacent to and upstream of the Pond 4 and 5 weirs.
2) The Pond 4 and 5 weirs will be left in place so that the water level can be raised to facilitate snorkel surveys.

C. CDFG Temperature Study

1) CDFG hatchery and fisheries management have said that they require successful results from the temperature study, in terms of the growth and reproduction of Shasta crayfish, before they will discuss Rock Creek.
   a) Successful growth is probably defined as rearing Shasta crayfish in the 50 °F raceways at the Crystal Lake Fish Hatchery for about three years with measurable growth.
   b) Reproduction is covered by rearing of young of year.

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2) Three attempts (i.e., 2005–2006, 2007, and 2008) to maintain Shasta crayfish in the raceways for the temperature study at the Crystal Lake Fish Hatchery have been unsuccessful.
   a) The reason for the failure of the temperature study in 2007 and 2008 is not known.
   b) Shasta crayfish were reared in both the 50 °F and 56 °F raceways at the Crystal Lake Fish Hatchery for more than a year before the equipment failure in 2006, but Shasta crayfish in both treatments were still too small to measure.
3) Shasta crayfish TRC/Recovery Team members recommended that a relatively small number of Shasta crayfish be introduced upstream of the CDFG diversion structure on Rock Creek in 2009 as an experiment in lieu of the temperature study in the raceways at the Crystal Lake Fish Hatchery.
   a) An experimental introduction of Shasta crayfish directly into Rock Creek will more directly and expeditiously address whether the reintroduction of Shasta crayfish into Rock Creek is likely to succeed.
   b) Need Genetic Management Plan to help determine source population for reintroduction of Shasta crayfish into Rock Creek.

D. CDFG Genetics Study
1) Collect genetic samples from Shasta crayfish in Rising River once landowner permission is obtained and send to UC Davis Genomic Variability Laboratory.
2) Develop a Genetic Management Plan to help determine source populations for potential reintroductions of Shasta crayfish into Rock Creek and elsewhere (UC Davis Genomic Variability Laboratory: Jessica Petersen, Bernie May)
3) Conduct Mitochondrial DNA work on existing Shasta crayfish genetic samples (UC Davis Genomic Variability Laboratory: Jessica Petersen, Bernie May)

V. **Shasta Crayfish Management Plan Fund Summary** (Attachment B)
A. Propose to use some of the unallocated Shasta crayfish management funds from 2008 and 2009 to pay for the installation of crayfish barriers upstream of the Pond 4 and 5 weirs at Sucker Springs Creek in 2009.

VI. **The next meeting will take place on Tuesday, September 15, 2009** at 10 am at the California Department of Fish and Game Region 1 Office Conference Room in Redding.

Attendees:

Charles White	415.973.3642	COW1@pge.com	PG&E Hydro License Coordinator
Ruth Sundermeyer	925.415.6376	D5SK@pge.com	PG&E Aquatic Biologist
Josh Hull	916.414.6742	josh_hull@fws.gov	USFWS Recovery Branch Chief
Kim Squires	916.414.6654	kim_squires@fws.gov	USFWS Forest and Foothills Ecosystems
Steve Baumgartner	530.225.2370	sbaumgartner@dfg.ca.gov	CDFG Region 1 Fishery Biologist
Matt Myers	530.225.3846	mmyers@dfg.ca.gov	CDFG Region 1 Environmental Scientist
Glenn Yoshioka	916.651.8764	gyoshioka@dfg.ca.gov	CDFG Species Conservation & Recovery
Woody Elliot	530.538.2212	welli@parks.ca.gov	CA Dept of Parks and Recreation
Theo Light	717.477.1093	TSLigh@ship.edu	Shippensburg University, Department of Biology
Jessica Petersen	530.752.6351	jlpetersen@ucdavis.edu	UC Davis Genomic Variation Lab
Maria Ellis	530.335.5446	maria@springrivers.com	Spring Rivers Ecological Sciences, LLC

Charles White (COW1@pge.com)
PG&E Senior License Coordinator for the Hat Creek and Pit 1 projects (415) 973-3642

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Action Items from the April 2009 Shasta Crayfish TRC Meeting:

Project	Task	Who	When
	TRC Actions		
Barrier	Continue biennial Upper Fall River barrier inspection snorkel surveys	Spring Rivers	ongoing
Rock Creek	Develop a written proposal to reintroduce Shasta crayfish to Rock Creek	Spring Rivers	2009-2010
Rock Creek	Develop Rock Creek Restoration Plan	Spring Rivers	2009
Crayfish Plan	Pit 1 and Hat Creek monitoring surveys	Spring Rivers	ongoing
Crayfish Plan	Obtain landowner permission to survey Rising River	Spring Rivers	ongoing
Barrier/ Crayfish Plan	Biannual non-native crayfish eradication surveys of Thousand Springs and Spring Creek	Spring Rivers	ongoing
	Recovery Team Actions		
Deferred funds	Begin implementation of non-native signal crayfish suppression measures and refugia exploration funded by the 2008 Director's Deferred allocation	Spring Rivers	2009
Sucker Springs	Continue eradication efforts	Spring Rivers	ongoing
Sucker Springs	Install crayfish barriers, similar in design to the upper Fall River crayfish barrier, adjacent to and upstream of the Pond 4 weir and the Pond 5 weir	Spring Rivers	Summer 2009
Temperature	Install/Maintain temperature gages at ten Shasta crayfish locations	Spring Rivers/CDFG	ongoing
Temperature	Develop a proposal to reintroduce a relatively small number of Shasta crayfish upstream of the CDFG diversion structure on Rock Creek in 2009 as an experiment in lieu of the temperature study in the raceways at Crystal Lake Fish Hatchery	CDFG/ Spring Rivers	2009
Genetics	Collect genetic samples from Pit River Falls and Rising River and provide to Jessica	Spring Rivers	2009
Genetics	Write Section 6 Proposal for additional genetics funding	CDFG/ Steve B.	May 2009
Genetics	Conduct mitochondrial DNA research on samples	CDFG/ UC Davis Genome Lab	2009/2010
Genetics	Develop Genetic Management Plan	CDFG/ UC Davis Genome Lab	2009/2010
Funding	Research funding options including Bring Back the Natives grants	Spring Rivers	ongoing
General	Research environmental awards to continue to build ground swell for Shasta crayfish recovery	All	ongoing

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APPENDIX D—Correspondence with USFWS regarding Barrier Reporting Due Date

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From: Amy_Fesnock@fws.gov [mailto:Amy_Fesnock@fws.gov]
Sent: Monday, March 31, 2008 11:00 AM
To: Maria Ellis
Subject: RE: Shasta Crayfish Technical Review Committee September 2007 Meeting Summary

Hi Maria-

As follow-up to the email below and our phone call this morning -- yes you can make the Barrier report coincide with the other reports, thus pushing its deadline back to May 31 instead of January 1. I don't think we need to amend the BO -- this email should be sufficient.

Thanks-
A

Amy L. Fesnock
Senior Fish and Wildlife Biologist ♦ Forest and Foothills Ecosystems ♦ Endangered Species Division
2800 Cottage Way, Suite W-2605 ♦ Sacramento, CA 95825
916-414-6678 (v) ♦ 916-414-6713 (f) ♦ amy_fesnock@fws.gov

From: Maria Ellis" <Maria@springrivers.com>
Sent: Monday, March 31, 2008 09:20 AM
To: Amy_Fesnock@fws.gov [mailto:Amy_Fesnock@fws.gov]
Subject: RE: Shasta Crayfish Technical Review Committee September 2007 Meeting Summary

Hi Amy,

I hope you are doing well! Glad you will be able to make it either by phone or in person. It would be nice to see you in person, but I understand that your schedule may not allow it. Plus saving 6 hours of travel has a fair amount of appeal.

I have been meaning to get in touch with you for a while but have been swamped with Pit 345 stuff. Here is my download of questions / things I wanted to talk to you about:

When are the Preventing Extinction grant proposals due? Should we revamp our previous proposal to make it more competitive?

Has the Chief of the Recovery branch position been filled?

I want to change the reporting deadline on the Crayfish Barrier BO to coincide with the rest of the Shasta crayfish reporting deadlines (May 31). We already fulfilled the reporting requirements for 2007 so I am looking to change the reporting deadline for the 2008 survey year from January 1, 2009 to May 31, 2009. I should have requested this earlier before you did the last amendment—I apologize but at least there is no big hurry. How do I go about doing so now?

Thanks!
Maria

Maria J. Ellis, Ph.D.
Spring Rivers Ecological Sciences, LLC ♦ maria@springrivers.com ‖ www.springrivers.com
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APPENDIX E—15 July 2004 CDFG Memorandum —Proposal to relocate water supply Diversion Point for Crystal Lake Hatchery

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Department of Fish and Game
State of California

Memorandum

Date : July 15, 2004

To : Mr. Steve Baumgartner
Northern California North Coast Region

From : George Heise
Fisheries Engineering
NAFWB

Subject : **Proposal to Relocate Water Supply Diversion Point for Crystal Lake Hatchery**

At your request, on June 9, 2004, I attended a site meeting at the Crystal Lake hatchery diversion on Rock Springs Creek to evaluate the possibility of relocating the diversion structure approximately 700 feet downstream. The purpose for the proposed relocation of the diversion structure is to restore full stream flow through a meadow reach of the creek and establish or restore Shasta Crayfish habitat in Rock Springs Creek, in which crayfish currently do not exist. The meeting was attended by representatives of DFG Region 1 Redding office, Crystal Lake Hatchery staff, Marie Ellis and Jeff Cook of Spring Rivers Ecological Services, and their engineer, Charles Schlumpberger.

The primary issues to address are:

Can the diversion be moved to the lower end of the meadow and still be made to function hydraulically.

What are the risks to the hatchery water supply in terms of potential loss of water?

What are the constructability issues?

What are the maintenance issues?

This memo assumes that those who read it are familiar with the structure, the site, and proposal. The following are my observations of the site and opinions on the issues related to the relocation of the diversion.

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Existing Division Structure

The existing diversion structure is located approximately 100 feet upstream of the meadow on Rock Springs Creek. It is composed of a concrete weir with a crest length of approximately 25 feet traversing the stream channel, which spills through a grating/trashrack and into a wet well. I estimate the top of the weir to be approximately 4.5 to 5 feet above the stream thalweg. A four foot diameter culvert exits the wet well and transitions into a two foot diameter smooth steel pipe. The steel pipe traverses the meadow at a low gradient (0.5%) adjacent to the stream channel. At the end of the meadow, the pipeline increases in slope and continues on to the hatchery.

Hatchery personnel indicated that diversion to the hatchery is approximately 24 cfs at normal production levels, less when fish have been stocked for the year. On the day of the site visit, I estimated the flow depth at the weir to be about 5 inches, which equates to a flow of approximately 20 cfs across the 25 foot weir. A small amount of leakage, perhaps 2 cfs or so, was leaking past or though the diversion structure into the downstream channel. The rest of the flow was diverted into the four foot metal pipe.

Existing Diversion Structure & Pipeline

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Hydraulic Aspects of Diversion Dam Relocation

At the existing diversion dam, the upstream water elevation has been elevated approximately 4.5 to 5 feet above the invert (bottom) of the pipe in order to provide the necessary energy for diversion of the stream flow into the pipe. The increase in water depth is composed of the following components: 2 feet to fill the 2 foot diameter pipe; approximately 1 foot for velocity head (converting standing water to moving water); approximately 1 foot to account for minor losses (entrance, contraction, and friction losses); and 6 inches for flow depth across the upstream weir.

A similar increase in water elevation above the invert elevation of the pipeline would be needed to divert at the lower end of the meadow. This increase in water elevation for diversion is relative to the invert of the pipe near the new point of diversion, and not the stream bottom. If the stream bottom is lower than the pipe invert, then the water surface would have to be increased by a corresponding amount. If the stream bottom is higher, then the opposite would be true. It may be possible to reduce the increase in upstream water elevation needed for diversion by changing the intake design and improving the hydraulics of the structure. The reduction would probably not amount to more than about a foot of head, though.

The profile of the stream channel from the existing diversion structure to the proposed location shows a bed elevation change of only 3.1 feet. Therefore, if the water surface were raised by 4 feet at the proposed intake location, the backwater effect would be experienced all the way to the existing structure. One way to minimize the increase in water elevation at the proposed location would be to lower the conveyance pipe by burying it a trench through the meadow and connecting to the existing pipe farther down the slope.

Pipeline through the Meadow

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Proposed Diversion Site

Risk to the Hatchery Water Supply

There are three potential conditions that could result in a reduction of water for diversion to the hatchery.

The first risk is unintentional diversion of flow from the stream channel to alternate flow paths through the meadow. The topography of the meadow, relative to the stream channel, had not been documented as of the site visit. The relative elevation of the two seems minimal, perhaps only a few feet in places. If the water elevation in the stream needs to be raised by 3 feet or more to divert at the proposed location, then there will be a risk of loosing a portion of the flow through low points in the stream bank.

The second risk is due to increased infiltration. Relocation of the diversion would provide a greater wetted channel area and increase the depth of water in the channel. Both of these conditions could result in an increase in infiltration to the ground water or underflow, and therefore result reduction of water available for diversion to the hatchery. On the other hand, the water that is passing through the existing diversion could be captured at a new diversion at the end of the meadow. I can not speculate whether capturing the leakage at the existing diversion would be sufficient to offset an increase in infiltration resulting from relocation of the diversion.

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The third risk is an increase in evapotransporation resulting from an expanding riparian zone. Providing stream flow through the length of the meadow may encourage an expansion of the riparian plant community and its water usage.

A more significant aspect of an increase in riparian vegetation is the potential for the vegetation to block the channel and increase the depth of flow, possible causing diversion of flow to the meadow.

Constructability

Access for construction is available along the road to existing diversion. Construction would be of average difficulty and could probably be accomplished with typical construction equipment and techniques. Fish screening structures of average complexity range from $5,000 to $10,000 per cfs diverted. If $5,000/cfs is applied to this structure the cost would be around $100,000.

Maintenance

There could be an increase in the debris loading of a new diversion structure because of the increased channel length through the meadow. This may necessitate more frequent cleaning of the structure. There may be other maintenance and cleaning issues depending on how the structure is designed and how it fits into the existing channel. If the riparian vegetation along the channel becomes too thick and raises the water elevation to an unacceptable level, then some management and removal of vegetation would be needed.

Discussion and Recommendations

Meeting the hydraulic conditions needed for the diversion may be difficult at the proposed site at the lower end of the meadow. To raise the water elevation to the height needed for the diversion could cause lateral flow to the meadow, and/or backwater, velocity and depth conditions in the channel that are unsuitable for the crayfish. If the proposed diversion structure were recessed into the stream channel it would require the replacement of a longer section of the pipeline and tie in farther down slope. In this case, the pipeline would be below ground level and would have to be trenched in.

The potential for loss of water due to increased infiltration is a significant uncertainty. The more the water surface in the channel is raised, the greater the potential loss.

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These may be the primary reasons that the existing diversion was located in a well defined channel section upstream of the meadow. If further investigation of this proposal is to be made, I recommend that a topographic survey of the affected portion of the stream channel and meadow be conducted in sufficient detail to address the issue of flow from the stream channel to the meadow. I also recommend that an evaluation be made of the potential for increased infiltration losses. This could be evaluated by checking the ground permeability (similar to the test for septic leach fields) for areas that may be flooded from the proposed new structure.

cc: Department of Fish and Game
Don Koch, Reg. Manager R1

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APPENDIX F—Genetics Study Summary Prepared for 9 April 2008 TRC Meeting

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Shasta Crayfish – Conservation Genetics Study
April 2008 Update

Jessica Petersen and Bernie May
University of California Davis, Genomic Variation Laboratory

Progress: Since the Shasta Crayfish Technical Review Committee and Recovery Team meeting in September 2007, five samples have been added to the data set. The working data set now includes 235 individuals from nine sampling locations (Table 1).

Population	Number	Date
Big Lake Springs	18	2004
	17	2007
Crystal Lake	35	2004
Thousand Springs – Fish Trap Cove	35	2005
Thousand Springs – Property Line	35	2005
Spring Creek	35	2005
JaShe Creek	35	2006
Lava Creek	24	2007
Sucker Springs	2	2007
Rainbow Springs	5	2007

Table 1. Sampling effort for Shasta crayfish.

Results: Bayesian cluster analysis in STRUCTURE indentifies three major genetic clusters within the collection sites (Figure 1). These clusters represent 1) Big Lake Springs, Spring Creek, JaShe Creek, and Lava Creek (red), 2) Thousand Springs – Fish Trap Cove and Property Line, and 3) Crystal Lake.

Assignment testing of the Sucker Springs samples suggests that, of the genetic samples we have, they are most closely related to those within the Big Lake Springs, etc. cluster. However, assignment of the Rainbow Springs samples is more challenging. Using GeneClass2, all five samples show the highest probability of assignment to the Big Lake Springs, etc. cluster. However, some probability is given that three of the five individuals may assign to the Thousand Springs group. This is visually observed in the STRUCTURE output and also suggested in the likelihood based assignment program, Whichrun. Two potential reasons these individuals are not clearly assigning are: 1) we may not have a reference population remaining that is representative of the diversity that is found in Rainbow Springs, or 2) the results may be reflective of gene flow or perhaps a hybrid zone between the Big Lake Springs and Thousand Springs genetic types.

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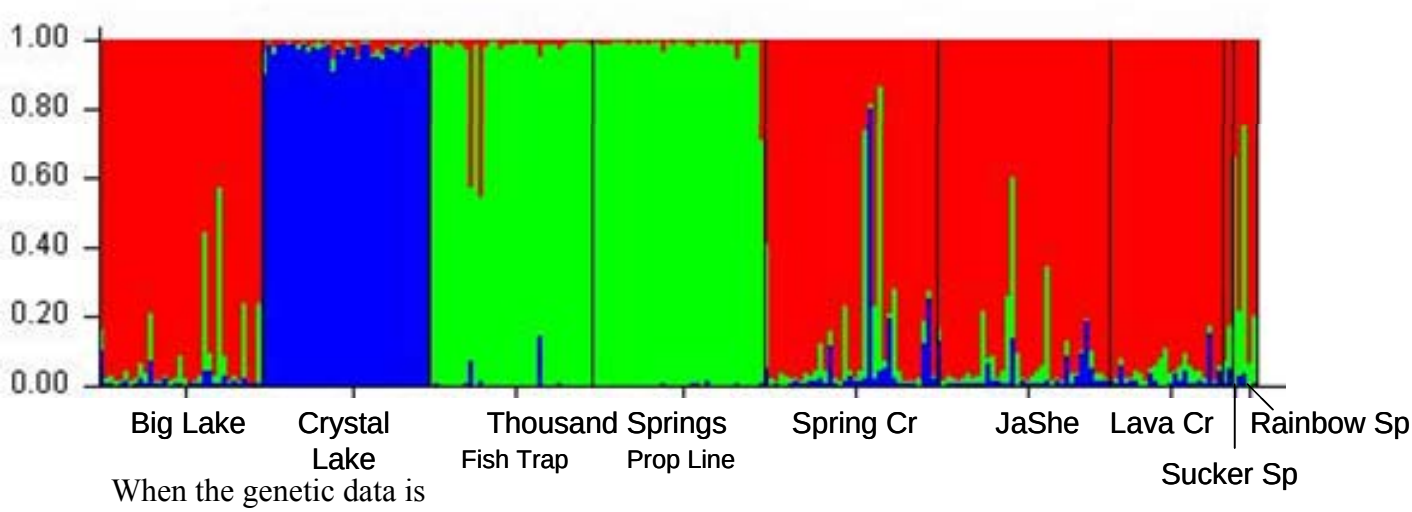
Figure 1. STRUCTURE clustering output illustrating the Big Lake Springs, etc. cluster (red), Crystal Lake (blue), and Thousand Springs (green).



When the genetic data is examined on a finer scale, it is of note that pairwise F_{ST} values show further genetic structuring (significance tested using Fisher's exact test) (Table 1). Based upon these data, each location should be treated as a distinct collection. The two samples from Big Lake Springs collected three years apart did not show any significant difference from one another.

	Big Lake Springs	Crystal Lake	1000 Sp - Fish Trap	1000 Sp - Prop Line	Spring Creek	JaShe Creek
Crystal Lake	0.13					
1000 Sp - Fish Trap	0.15	0.26				
1000 Sp - Prop Line	0.18	0.29	0.03			
Spring Creek	0.03	0.13	0.11	0.14		
JaShe Creek	0.02	0.13	0.15	0.17	0.02	
Lava Creek	0.02	0.13	0.16	0.17	0.02	0.02

Table 1. Pairwise F_{ST} values for each sampling location. F_{ST} values can range from zero (populations identical) to 1 (populations entirely different). A value of 0.25 is generally considered to show moderate to high population differentiation. All values reported indicate a significant difference between locations.

Genetic Management Recommendations: To conserve a maximum level of genetic diversity, it is essential to maintain collections of all three major genetic clusters. Because genetic structuring based upon sampling location is observed within the clusters, translocations between these sites should be avoided whenever possible. In the case where population supplementation or the establishment of a refuge is determined to be necessary to maintain viable collections, organisms should only be translocated between locations within the same major genetic cluster.

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APPENDIX G —13 May 2009 Letter to USFWS regarding the potential effects of planned summer flushing flows on Shasta crayfish

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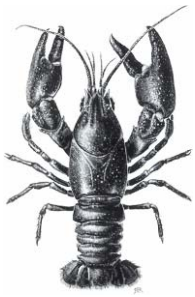

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May 13, 2009

Kim Squires
Senior Fish and Wildlife Biologist
Forest and Foothills Branch
US Fish and Wildlife Service
2800 Cottage Way, Room W-2605
Sacramento, CA 95825

Dear Kim,

I am writing to express concern about the status of the federally and state-listed endangered Shasta crayfish, *Pacifastacus fortis*, in the mainstem Pit River upstream of Pacific Gas and Electric Company's (PG&E's) Pit 1 Hydroelectric Project (FERC Project No. 2687). Shasta crayfish are known to occur in an approximately 600 meter-long reach of the mainstem Pit River that is influenced by colder temperature springs just above the Pit River Falls in the Pit 1 bypass reach. These coldwater springs cool the mainstem water temperature and create coldwater refugia, which are key factors in the ability of the lower Pit 1 bypass reach to support coldwater species such as Shasta crayfish.

As part of the Federal Energy Regulatory Commission (FERC) license for the project that was issued on March 19, 2003, the State Water Resources Control Board (SWRCB) 401 Water Quality Certification requires PG&E to release flushing flows through Fall River Pond and hence the Pit 1 bypass reach for two consecutive weekend days three times annually in May/June, July, and August (Condition 13) and to monitor the effectiveness of these flushing flows for five years after issuance of the new license (Condition 14). PG&E has been implementing these summer flushing flows annually since 2003; the stated purpose of the flushing flows is to control surface aquatic vegetation in Fall River Pond.

On 22 April 2009, the Shasta Crayfish Technical Review Committee and Shasta Crayfish Recovery Team met to review the first five and six-years of monitoring for the Pit 1 and Hat Creek projects. During this summary review workshop, the status and precipitous decline of Shasta crayfish observed in the Pit 1 bypass reach was discussed. On 11 May 2009, a five-year summary meeting for the Pit 1 Water Quality Monitoring was held with the State Water Board and Regional Water Quality Control Board. Staff from U.S. Fish and Wildlife Service and California Department of Fish and Game also attended. The following conditions pertaining to Shasta crayfish were discussed:

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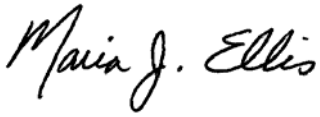
- Summer flushing flows can reduce or eliminate the coldwater refugia, depending on size, that are formed by coldwater springs.
- Summer flushing flows can result in mainstem daily minimum temperatures that are 21 ºC or higher.
- Flushing flows do not appear to be necessary to control nuisance aquatic vegetation in Fall River Pond
- The volume of spring accretion flow to the Pit 1 bypass reach is estimated at more than 100 cubic feet per second.
- The area of the Pit 1 Bypass where Shasta crayfish exist is one that is influenced by the coldwater springs in the Pit 1 bypass reach.
- Shasta crayfish numbers have plummeted in the reach from 2005 to 2008. In October 2005, a total of 21 Shasta crayfish (6 adults, 7 juveniles, and 8 young-of-year) were found in this 600-meter reach, but only one adult male Shasta crayfish was found in September 2008.
- Numbers of the two non-native crayfish species: signal crayfish (*Pacifastacus leniusculus*) and fantail crayfish (*Orconectes virilis*) in the reach have increase during the same period. Between 2005 and 2008, the number of signal crayfish (10 in 2005, 29 in 2008) almost tripled and the number of fantail crayfish (12 in 2005, 23 in 2008) almost doubled in this reach.
- Shasta crayfish are not adapted to short-term fluctuations in temperature.
- Both non-native crayfish species are more tolerant of a wider temperature range as well as temperature fluctuations than Shasta crayfish.
- Non-native crayfish can be both competitors and predators of Shasta crayfish.

While these conditions alone are not conclusive, they reflect a downward trend for Shasta crayfish in the bypass reach of the Pit River and raise the possibility that the summer flushing flows may be resulting in take of an endangered species.

Given the above information and concerns, the potential take of an endangered species related to planned out-of-season summer flushing flows for measures that are not demonstrably necessary to control aquatic vegetation in Fall River Pond does not seem appropriate. As discussed at the meeting, it is my opinion that the summer flushing flows should be eliminated.

Sincerely,



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