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ECOLOGICAL SCIENCES, LLC

Shasta Crayfish Technical Review Committee
2005 Annual Report

Addressing License Articles 409, 410, 412, and 413
Hat Creek Project (FERC No. 2661)
Pit 1 Hydroelectric Project (FERC No. 2687)

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EXECUTIVE SUMMARY

The Federal Energy Regulatory Commission (FERC) licenses for Pacific Gas and Electric Company's (PG&E) Hat Creek Project (FERC No. 2661) and Pit 1 Hydroelectric Project (FERC No. 2687) in northeastern California require the formation of a Technical Review Committee (TRC). The licenses state that the TRC's role is to assist in the design and implementation of the terms and conditions required in the biological opinions related to protection and recovery of the federally and state-listed endangered Shasta crayfish (*Pacifastacus fortis*) in the project areas (Article 410). 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 Recovery Team as 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 TRC and Recovery Team members agreed that TRC actions, including potential barrier locations, would be done where it most benefited the Shasta crayfish and would not be restricted by FERC project boundaries. The TRC oversees the development and implementation of the Shasta crayfish monitoring and management plans (Articles 409 and 412 of both licenses), including the restoration and potential reintroduction of Shasta crayfish into Rock Creek (Hat Creek Article 412) and the recreational management plan for the Hat Creek license (Article 413). The TRC also oversees the development and implementation of a crayfish barrier plan (Pit 1 Article 413) and other license-related activities such as Shasta crayfish surveys along the PG&E levees (Pit 1 Article 407). The major Recovery Team actions include the Sucker Springs Restoration Project and California Department of Fish and Game's Temperature and Genetics studies. This annual report covers TRC and Recovery Team meetings and activities and crayfish monitoring in 2005 and early 2006. It documents the on-going baseline surveys in the Pit 1 Project vicinity, including the determination and quantification of the current distribution and abundance of Shasta crayfish and potential Shasta crayfish habitat. The baseline Hat Creek surveys were completed in 2004. Most of the identified potential Shasta crayfish habitat was associated with large-volume springs that kept the substrate free of fines. Between 2004 and 2006, 73 Shasta crayfish were found, including nine Shasta crayfish in the mainstem Pit River upstream of the Pit River Falls. During this same period, 3678 signal crayfish (*Pacifastacus leniusculus*) and 310 fantail crayfish (*Orconectes virilis*) were collected and exterminated. Shasta crayfish accounted for only 1.8%, whereas signal and fantail crayfish accounted for 90.3% and 7.9%, respectively, of all crayfish encountered.

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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, Figure 1). The licenses for the Hat Creek Project (FERC No. 2661) in Cassel and the Pit 1 Hydroelectric Project (FERC No. 2687) near Fall River Mills were issued on 4 November 2002 and 19 March 2003, respectively. Articles 409 and 412 of both the Hat Creek and Pit 1 licenses require the development of: (1) plans to monitor the habitat and populations of federally and state-listed endangered Shasta crayfish (*Pacifastacus fortis*) in the project areas, and (2) Shasta crayfish management plans (Appendix A). Article 413 of the Hat Creek license requires the development of a recreational management plan to educate the general public and protect Shasta crayfish from recreational activities (Appendix A). 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 (*Pacifastacus leniusculus*). Article 410 of both licenses require 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 related to Shasta crayfish protection and recovery in the project areas (Appendix A). The TRC also serves as a working group for other Shasta crayfish recovery and habitat restoration projects. The TRC was established 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 (Spring Rivers), academia, and PG&E.

In order to address license articles 409, 412, and 413 (Hat Project only), two Shasta Crayfish Management Plans (Plans) were written in consultation with the USFWS, CDFG, Natural Resource Conservation Service (NRCS), and interested stakeholders. The Hat Creek Plan (PG&E 2003a), which includes monitoring, management, and recreational management 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 monitoring and management components, was submitted to the agencies

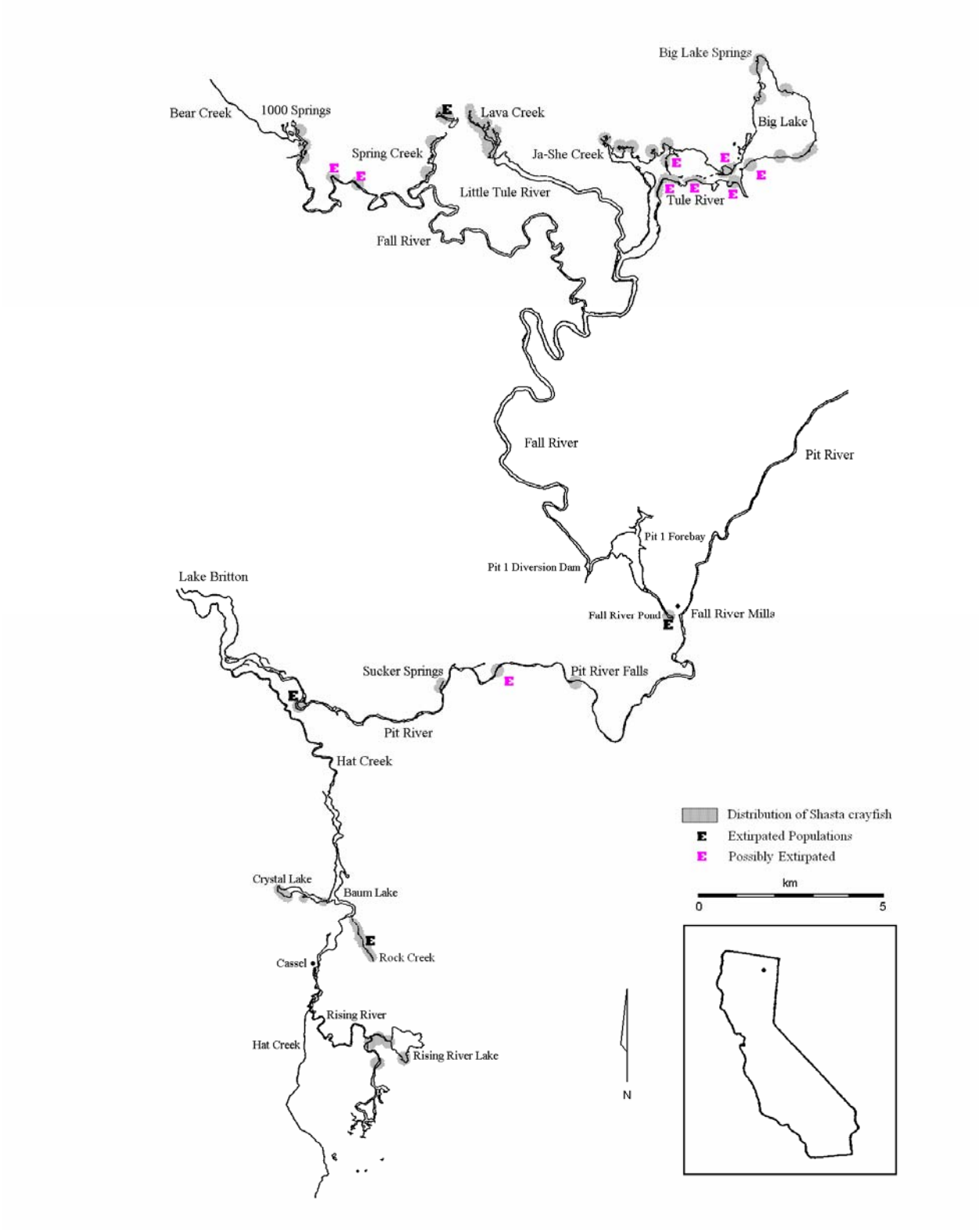

Figure 1 Known distribution of Shasta crayfish (*Pacifastacus fortis*).

on 11 July 2003 and to FERC on 19 September 2003. FERC approved the Pit 1 Plan without modification on 7 July 2004. PG&E is currently working on a Crayfish Barrier Plan to address Article 413 of the Pit 1 license. The Crayfish Barrier Plan needs to include: (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 Plans (PG&E 2003a, 2003b) specify the following three tasks for monitoring Shasta crayfish: (1) map and quantify the existing habitat in the vicinity of the projects in order to delineate habitat areas, (2) collect baseline monitoring data on Shasta crayfish in delineated habitat areas, and (3) monitor Shasta crayfish in delineated habitat areas. Table 1 provides the implementation schedule for these tasks. 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 (Figure 1), which is a springfed tributary to Baum Lake.

This report covers: (1) TRC and Recovery Implementation Team (Recovery Team) activities, and (2) crayfish monitoring from 1 January 2005 through 30 April 2006. TRC and Recovery Team activities, including all meetings and actions in 2005 and early 2006, are documented; activities in early 2005 were also reported in the 2004 TRC Annual Report (Spring Rivers 2005). TRC actions are Shasta crayfish actions specifically required by a FERC license whereas Recovery Team actions are not specifically required by a FERC license. The major projects being carried out under the auspices of the TRC are the Crayfish Barrier Plan (Pit 1 Article 413) and the investigation into the reintroduction of Shasta crayfish into Rock Creek (Hat Creek Article 412). Recovery Team actions include the Sucker Springs Restoration Project (i.e., signal crayfish eradication) and CDFG's Temperature and Genetics studies. The second section of this report documents the on-going baseline surveys in the vicinity of the Pit 1 Project, including the determination and quantification of the current distribution and abundance of Shasta crayfish and potential Shasta crayfish habitat. Baseline Shasta crayfish habitat and distribution surveys for the Hat Creek Plan were completed in 2004 (Spring Rivers 2004, 2005).

Table 1 Schedule of Shasta crayfish surveys from 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 [a]	1	2			5					10					15					20					25					30											
Pit 1 Surveys [b]		1		2		5					10					15					20					25					30					35				40

[a] Surveys for the Hat Creek Project are scheduled for years 1, 2, 5, 10, 15, 20, 25, and 30 of the license.

[b] Surveys for the Pit 1 Project take 2 years each and are scheduled for years 1/2, 3/4, 5/6, 10/11, 15/16, 20/21, 25/26, 30/31, 35/36, and 39/40 of the license.

TRC AND RECOVERY IMPLEMENTATION TEAM ACTIVITIES

The TRC/Recovery Team held meetings on 11 January 2005, 12 April 2005, 19 July 2005, 6 December 2005, and 4 April 2006 (see Appendix B for Meeting Summaries). The TRC also conducted site visits to potential barrier sites on 24 May 2005, 22 February 2006, and 21 March 2006 (see Appendix C for Field Meeting Summaries). 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 to discuss agency concerns related to the project. Construction managers, biologists, and habitat restoration specialists from PG&E and CDFG toured Sucker Springs on 7 September 2005 (Appendix C).

During the April 2005 meeting, the Terms of Reference for the Recovery Team were finalized. The TRC clarified its role as a marriage of two goals: license implementation and species recovery. All TRC and Recovery Team members agreed that TRC actions, including potential barrier locations, would be done where it most benefited the Shasta crayfish and would not be restricted by FERC project boundaries. TRC and Recovery Team members also agreed that unallocated Shasta crayfish license monies (Article 411) could be used for other Recovery Projects such as Sucker Springs Restoration and the investigation into restoring Rock Creek and reintroducing Shasta crayfish.

Crayfish Barrier Plan

During the January 2005 meeting, further discussions on the 20 October 2004 draft of the Crayfish Barrier Plan were held. The draft Crayfish Barrier Plan was revised and submitted to the agencies with the final Crayfish Barrier Flume Study report (Spring Rivers 2005) on 31 January 2005. USFWS and CDFG submitted comments on the 31 January 2005 draft of the Crayfish Barrier Plan in late March/early April 2005 (Appendix D). Both the USFWS and CDFG commented that the 31 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 required in the license article. 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, becomes a concern, CDFG may relocate sculpin above the barriers.

During the April 2005 meeting, the TRC scheduled a barrier field meeting as a first step towards determining the details of barrier construction, materials, and installation required by the license article. 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 at Thousand Springs and Spring Creek on 24 May 2005. Following the field tour, the TRC outlined the steps necessary to produce a barrier plan complete with barrier designs, location specifics, and engineered plans. During the July 2005 meeting, the TRC agreed to move forward on two barrier locations: Thousand Springs and Spring Creek. The TRC requested additional surveys of these areas to determine the current distribution of signal crayfish upstream of the potential barrier locations at Thousand Springs and Spring Creek. The possibility of constructing a smaller, prototype barrier at Sucker Springs was also discussed.

During the December 2005 meeting, the TRC voted to pursue 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 2005). This barrier would protect the predominantly allopatric Shasta crayfish population and pristine habitat at Thousand Springs. The TRC requested that a streambed topography survey of the potential barrier location at Thousand Springs be done in late 2005. The TRC also voted that the second barrier, which would be at Spring Creek, would consist of refacing the existing barrier created by the Spring Creek Road crossing culverts. The Spring Creek Road crossing culverts create a barrier between the signal crayfish in the Fall River and lower Spring Creek and the Shasta crayfish in upper Spring Creek. The upstream face of the Spring Creek Road crossing, however, contained crevices in the concrete underneath the culverts where eradication of signal crayfish was not possible. As part of the Spring Creek barrier project, periodic surveys will be conducted in upper Spring Creek upstream of the Spring Creek Road crossing to remove and control and/or eradicate signal crayfish. PG&E submitted a Crayfish Barrier Plan Update and Action Plan to the TRC and FERC in December 2005 (Appendix E).

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 at Thousand Springs and Spring Creek. The Thousand Springs meeting also involved key ranch personnel. 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 that we meet on site with a PG&E senior construction foremen to discuss the issues. The meeting with the construction foreman was carried out on 21 March 2006. At the April 2006 TRC meeting, one of the key action items identified for the Thousand Springs 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 done on 1–4 May 2006 (Appendix F).

Other Potential Barrier Locations

Other potential barrier locations were also explored including Bowman's Ditch and its headwater springs on Native American and Ahjumawi Lava Springs State Park properties and upper Ja She Creek upstream of the State Park road crossing. One of the potential benefits of a barrier in Ahjumawi Lava Springs State Park is that all parks in the California Department of Parks and Recreation system are being "held in trust for those generations that come after us"—"to the seventh generation and beyond." A barrier at Ahjumawi Lava Springs State Park would be protected into the future.

Spring Rivers surveyed the headwater springs of Bowman's Ditch on Native American property on 5 December 2005. There was some good Shasta crayfish habitat, but the total area of clean lava cobbles and boulders was less than 10 square meters. The rest of the springs surveyed were shallow and/or had flocculent organic/mud substrate. Spring Rivers will survey the springs and ditch on State Park property and Ja She Creek upstream of the State Park road crossing in 2006. This will provide an up-to-date status on both the Shasta crayfish and signal populations and habitat in these areas. This new data will help decide whether installation of a crayfish barrier in Ja She Creek and/or Bowman's Ditch would be beneficial recovery measures.

Funding for another crayfish barrier might be available through conservation grants authorized under section 6 of the Endangered Species Act if the property is State Park land or through Partners for Fish and Wildlife if the property is PG&E land. A barrier in combination with a signal crayfish eradication program could help ensure the future of the Ja She Creek Shasta crayfish population. If sufficient habitat is present, the headwater springs of Bowman's Ditch could be a good refuge site for Shasta crayfish.

Rock Creek Restoration/Reintroduction

During the January 2005 meeting, the results of the detailed topographic survey of the upper Rock Creek meadow (immediately downstream of the present diversion site) completed in late 2004 were reviewed. During the July meeting, CDFG's major question and concern regarding the proposed restoration of approximately 600 feet of the upper meadow of Rock Creek were discussed. The main concern is whether the approximately 600 feet of channel in question is a losing reach, i.e., more water enters the top of the reach than would exit the bottom of the reach. If the reach is a loosing reach then moving the diversion site downstream would result in less water for the Crystal Lake Hatchery, which is unacceptable. The CDFG engineer, George Heise, suggested that either a sand bag test or a percolation test would indicate whether or not it was a losing reach. 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 increase infiltration losses. Percolation testing will be done in 2006 as soon as the ground dries, in order to test the permeability in the area that may be flooded by the proposed new structure.

Big Lake Levee Work

Shasta crayfish have been found in sections of the PG&E levees (Tule River Levee System) along Big Lake and the Tule River (Figure 1). PG&E's Army Corps of Engineers permit and associated USFWS Biological Opinion and Incidental Take Statement cover all levee maintenance activities through 30 April 2008. The USFWS Incidental Take Statement states that no in-water dredging is to take place within Big Lake, Ja She Creek, and the Tule River upstream of the no in-water dredging delineation, which is one-mile upstream of the confluence of the Tule and Little Tule rivers. During the past three summers, extensive beds of aquatic vegetation

in the Tule and Fall rivers have resulted in very high water elevations that have caused one levee failure and continue to threaten the structural integrity of PG&E levees. During August 2005, subsidence and the opening of large holes in areas of the Big Lake levee led PG&E to begin maintenance and repair of the Big Lake levee.

In a September 2005 letter to USFWS, PG&E stated that the levee in the 500-meter planned area of in-water activity (work area), as well as a 100-meter buffer area on either side would be surveyed three times in an effort to find and relocate as many Shasta crayfish as possible to the Big Lake levee cove, which is east of the work area. These activities are covered under the USFWS Incidental Take Statement. Water clarity conditions, however, were very poor during fall 2005 with visibility of 12 inches or less. Spring Rivers surveyed approximately 430 meters of the work area and the buffer on the west side three times. The remaining 70 meters of the work area was surveyed two times and the buffer on the east side of the work area was surveyed once. Two Shasta crayfish were found and relocated to the Big Lake levee cove.

PG&E used primarily small (1.5-inch maximum) gravel substrate on the water-side of the levee to cover an approximately 500-meter section of the Big Lake levee. The smaller substrate was chosen (instead of conventional larger riprap) to minimize the amount of additional crayfish habitat created, because new habitat is more likely to be colonized by non-native crayfish than Shasta crayfish. Gravel was trucked in and placed in piles spaced evenly along the levee. A bulldozer then pushed the gravel onto the water-side of the levee. Both the size of the added substrate and the generally solid band of tules along the water-side of the levee combined to make the gravel placement on the Big Lake levees much less likely to impact Shasta crayfish habitat than the large riprap used along the Tule Lake levees (west of Rat Farm). Most of the gravel that was pushed onto the water-side of the levee was stopped in the shallows at the vegetation so the majority of Shasta crayfish habitat, which is generally on the water-side of the tules, remained unaffected. PG&E can further minimize in-water impacts where the levees are steep by using an excavator to press down the top of the levee to create a gentler slope so that less gravel is dumped into the water.

Sucker Springs Restoration Project

The Sucker Springs Restoration Project proposal was submitted to the TRC for review in early 2005. Additional discussions during the April 2005 TRC meeting and the subsequent CDFG and USFWS field tour of Sucker Springs on 13 April 2005 addressed many of the remaining concerns. The proposal was modified to incorporate changes suggested by USFWS and CDFG and the Sucker Springs Restoration Project was funded. Steve Baumgartner (CDFG) made a site visit with Dan Byrd of the Yreka Screen Shop (Fisheries Habitat Restoration) prior to the July 2005 meeting. At the July 2005 meeting, a field tour of Sucker Springs with construction managers, biologists, and habitat restoration specialists from PG&E, CDFG, and Spring Rivers was arranged for 7 September 2005. Spring Rivers Foundation, a non-profit 501(c)(3) corporation, is the project proponent. CDFG is the lead agency for CEQA/CESA and 1600 permitting for the project. USFWS Partners for Fish and Wildlife drafted a landowner agreement with PG&E and handled the federal permitting. Eradication surveys for non-native signal crayfish are being done in ponds 2, 3, and 4 prior to restoration (see figures attached to the 4 April 2006 meeting summary in Appendix B). Once all permits have been received, the weirs at the downstream ends of ponds 2 and 5, which are remnants of the former Pit River Hatchery, will be repaired or replaced so that they may continue to act as crayfish barriers. The weir at the downstream end of Pond 3 will be removed.

CDFG Temperature Study

In December 2004, CDFG began a temperature growth study with signal crayfish (*Pacifastacus leniusculus*) at the Crystal Lake Fish Hatchery. Fifty young-of-year signal crayfish were placed in two stainless steel troughs with different temperature regimes to determine the effects of temperature on growth rate and survival. Rock Creek water was piped directly into the first trough at 50 °F (10 °C); water in the second treatment was heated to 56 °F (13 °C) to mimic the temperature regime in Sucker Springs Creek. The results to-date show that signal crayfish grew faster in the 56 °F water than in the 50 °F treatment. The size variation of signal crayfish was also greater in the warmer treatment as compared to the 50 °F treatment. Initially, there was differential mortality in two temperature treatments, which could result in density effects because the experiment is being done without replacement. Mortality in both treatments, however,

leveled off after June 2005. In December 2005, there were 26 signal crayfish in the 56 °F water and 23 signal crayfish in the 50 °F water.

Spring Rivers collected four gravid female Shasta crayfish from Crystal Lake on 20 May 2005. Two gravid females were placed in each temperature treatment trough (upstream of the signal crayfish) on that day. Shasta crayfish are provided with fresh trout, periphyton-covered rocks from Crystal Lake, and carrots for food. On 5 August 2005, 49 young-of-year Shasta crayfish were found and replaced in the 56 °F treatment and 50 young-of-year Shasta crayfish (of the 52 young-of-year found) were replaced in the 50 °F treatment. Spring Rivers returned all four adult Shasta crayfish and two young-of-year Shasta crayfish to Crystal Lake on 5 August 2005. CDFG continues to feed and care for the young-of-year Shasta crayfish, but Shasta crayfish in both treatments are still too small to measure. There is no measure of Shasta crayfish mortality, but it appears to be minimal in both treatments.

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 at the Genomic Variation Laboratory of Bernie May, Ph.D. at the University of California, Davis. After discussions with the TRC/Recovery Team and additional research by Spring Rivers, it was determined that a single second walking leg (i.e., pereopod 3) removed at the transverse fracture of the ischium would provide sufficient genetic material while minimizing impact to the Shasta crayfish individual. Genetic sampling is only done on Shasta crayfish greater than or equal to 20 mm total carapace length and no more than 35 crayfish per population are sampled. Although final results from genetic study are expected in a couple of years, there appears to be a fair amount of variation between the populations sampled to date.

METHODS

Survey areas for monitoring crayfish in the vicinity of the projects were selected based on the findings of the comprehensive Shasta crayfish surveys conducted 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). Efforts focused on areas in which Shasta crayfish or potentially suitable Shasta crayfish habitat had been found during earlier surveys. For consistency, the Shasta crayfish

populations and/or site locations named in the Shasta Crayfish Recovery Plan (USFWS 1998) are also used in this report.

In the vicinity of the Pit 1 Project, the baseline habitat mapping and crayfish surveys were done over three years (2004–2006). In 2004, habitat was mapped for areas in upper Fall River, Spring Creek, Ja She Creek, upper Big Lake, and Fall River Pond. Crayfish surveys were done in habitat areas of upper Fall River, upper Big Lake, Tule River Levee System, and Fall River Pond. In 2005 and 2006, the habitat areas in upper Big Lake and the Tule River Levee System were mapped. Crayfish surveys were done in the areas of upper Big Lake and part of Ja She Creek. In addition, the Pit 1 Bypass and Pit 1 reaches of the Pit River from downstream of Big Eddy to Lake Britton were surveyed in 2005. The remaining areas will be mapped and surveyed in 2006.

Habitat Mapping

Shasta crayfish habitat is typified by clean, unembedded lava cobble and boulder substrate on clean or sandy gravel. Water depths and visibility in many of the headwater springs (e.g., parts of Ja She Creek, upper Big Lake, and Crystal Cove) was such that habitat quality assessments and habitat mapping 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. Surveyors measured areas with suitable habitat, assessed habitat quality, and determined and measured specific prime habitat sites. To facilitate habitat area calculations and estimates of crayfish densities, habitat areas were characterized into basic geometric shapes (i.e., square, triangle, and circle) whenever possible. Smaller areas were measured by two divers with a measuring tape; 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.

Habitat was graded on a one-to-three scale. The best quality habitat, designated "prime," consisted of mostly unembedded lava cobble and boulder on gravel that was relatively 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. Relatively unembedded lava cobble and boulder on gravel or sandy gravel that had only minimal accumulation 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 embedded lava cobble and boulder (i.e., in gravel, sand, silt, or organic flocculants) away from cleansing hydraulic influences. Spring areas that lacked larger cobble or boulder habitat were also labeled as marginal.

Crayfish Surveys

Surveys were done by divers using either snorkel or scuba equipment, depending on water depth. Divers first inspected the undisturbed substrate before individually turning over cobbles and boulders to look for crayfish. All crayfish encountered were collected. In order to minimize possible injury or damage, Shasta crayfish were kept separate from introduced crayfish species. Shasta crayfish were either placed in a rigid tube collector or directly into a bucket on board the support boat. Shasta crayfish were released next to the rock where they were found and observed until they moved back underneath the rock. Introduced crayfish were collected into a separate rigid container and destroyed after data collection.

The following data were recorded for each crayfish: (1) species, (2) size measured as total carapace length (TCL) with vernier or dial calipers to the nearest fiftieth 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.

RESULTS

Pit 1 Habitat Mapping

Results of the three-year habitat mapping efforts in the Pit 1 Project vicinity are presented in Table 2 and Appendix G. In total, approximately 26,654 m^2 of potential Shasta crayfish habitat were identified with 14,389 m^2 of prime habitat, 10,308 m^2 of adequate habitat, and 1958 m^2 of marginal habitat. Most of the identified 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 spring influence (e.g., the Tule River Levee System). Spring areas generally have clean or slightly silty gravel and boulder habitat. Most of the levee system, however, was silty and substrate that provided potential habitat (e.g., boulders and earthen clumps) lay on top of a layer of compacted soil and roots, which comprises the levee. Substrate, if any, at the lake bottom was generally embedded in a 6–12 inch layer of silt and did not provide crayfish habitat.

Table 2 Size and quality of Shasta crayfish habitat in the Pit 1 Project vicinity in 2004–2006.

Region	Location	Prime Habitat (m^2)	Adequate Habitat (m^2)	Marginal Habitat (m^2)	Total Habitat (m^2)
Upper Fall River	Thousand Springs Ranch	-	-	-	-
	Fletcher's Bend	264	0	0	264
	Lennihan's Footbridge	216	0	0	216
Spring Creek	Upper and Lower coves	4017	1196	37	5250
Ja She Creek	Ja She Creek headwaters	2755	5243	466	8464
	Crystal Springs, Cove, and Inlet	2572	1091	89	3752
	Tule Coves	50	48	8	106
Upper Big Lake	Big Lake Springs & North Big Lake	410	931	8	1349
	Northeast Big Lake	138	138	0	276
	Northwest Big Lake	0	11	0	11
Tule River Levee System	South shore Big Lake [a]	0	0	1265	1265
	Northeast upper Tule River	-	-	-	-
	South shore upper Tule River [a]	0	0	21	21
	East shore upper Tule River [a]	0	0	0	0
	Horr Pond levees	-	-	-	-
Fall River at FRM	Fall River Pond	3967	900	64	4931
Pit 1 - Big Eddy to PH	Pit River Falls, Canyon spring	ND [b]	750	ND	750
Pit 1 - below PH	Pit River sand pits	ND	ND	ND	ND
	Totals	14,389	10,308	1958	26,655

[a] Habitat measured in year-2 (2005) surveys
[b] ND = No Data, data were not collected for these sites

It was not practical to do a detailed map of habitat in the Pit River, however Shasta crayfish were found from just above Pit River Falls to the last coldwater spring approximately 600 meters upstream on river right with an estimated 750 m^2 of adequate habitat. Several coldwater springs, which enter the Pit River within this section, provided clean substrate and coldwater areas. Warm water springs (i.e., >17 °C) enter the Pit River just upstream of this section.

Pit 1 Crayfish Surveys

Table 3 summarizes the data from the 2003 to 2006 crayfish surveys in the Pit 1 Study Area. Between 2004 and 2006, we found 73 Shasta crayfish, which accounted for 1.8% of all crayfish encountered. More females (n = 35) were encountered than males (n = 24) and there was a higher proportion of juveniles (n = 42) than adults (n = 24). Six young-of-year were found and left in place to avoid accidental harm. The size distributions for Shasta crayfish collected are presented in Figure 2.

Most Shasta crayfish (n = 44) were found at North Big Lake (Big Lake Springs) and one crayfish was found at each Northeast and Northwest Big Lake. A total of nine Shasta crayfish were found along the levee at South Shore Big Lake: five in 2004 and four in 2005. In 2004, we found five (one male, four females) in Big Lake levee cove at the eastern end of the South Shore Big Lake levee, but none were found along the rest of South Shore Big Lake (Figure 1, Spring Rivers 2004). In 2005, we found two female Shasta crayfish approximately 1000 meters west of the cove during crayfish surveys on for the Big Lake levee repair project. Additionally, we found two male Shasta crayfish during later surveys along the levee repair area and relocated them to Big Lake levee cove.

During crayfish surveys of upper Spring Creek conducted in April 2004 and August and November 2005, 59 signal crayfish, including 43 young-of-year, were found throughout most of upper Spring Creek from the culverts to the headwaters. Signal crayfish are now found both in the vicinity and upstream of the main Shasta crayfish population in the headwater springs of Spring Creek.

Crayfish surveys of Thousand Springs conducted in July and August 2004, March, August, and November 2005, and February and May 2006 revealed two signal crayfish (one juvenile, one dead adult male) in and near the fish trap cove and one adult male signal crayfish at the potential barrier site. Thirteen signal crayfish (two young-of-year in 2004, three juveniles and one adult male in 2005, seven juveniles in 2006) were found at the confluence with Hideaway Spring, immediately downstream of the potential barrier site. A male and a gravid female signal crayfish were found on river left just upstream of the footbridge riffle in 2006. Signal crayfish were abundant downstream of the footbridge riffle (RK 39.5).

Table 3 Sex and age class of crayfish by species and location within the Pit 1 study area from January 2004 through April 2006.

	Shasta crayfish						Signal crayfish						Fantail crayfish					
Region and Location	**M**	**F**	**Adult**	**Juv**	**YOY**[1]	**Total**	**M**	**F**	**Adult**	**Juv**	**YOY**[1]	**Total**	**M**	**F**	**Adult**	**Juv**	**YOY**[1]	**Total**
Upper Fall River																		
Thousand Springs Ranch[2]	0	0	0	0	0	0	403	453	534	473	20	1027	0	0	0	0	0	0
Fletcher's Bend	0	0	0	0	0	0	151	210	91	270	66	427	0	0	0	0	0	0
Lennihan's Footbridge	0	0	0	0	0	0	41	44	43	42	14	99	0	0	0	0	0	0
Spring Creek																		
Upper and lower coves	-	-	-	-	-	-	10	8	7	9	43	59	-	-	-	-	-	-
Ja She Creek																		
Ja She Creek headwaters	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crystal Springs, Cove, Inlet	3	1	2	2	0	4	643	845	1257	274	140	1671	0	0	0	0	0	0
Tule Coves	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Upper Big Lake																		
Big Lake Springs & North Big Lake[3]	14	24	8	31	5	44	149	181	223	115	20	358	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[4]	3	6	7	2	0	9	2	1	2	1	0	3	4	6	11	0	0	11
Northeast upper Tule River	0	0	0	0	0	0	0	0	0	0	0	0	3	1	3	1	0	4
South shore upper Tule River	0	0	0	0	0	0	5	1	2	4	0	6	24	15	37	2	0	39
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	2	3	2	3	0	5	12	15	26	1	0	27
Fall River at FRM																		
Fall River Pond	0	0	0	0	0	0	2	6	5	3	0	8	142	87	216	13	0	229
Pit 1 - Big Eddy to PH (Pit River Falls, Canyon spring)	3	3	5	7	2	14	7	2	3	6	0	9	4	8	11	1	0	12
Pit 1 - below PH (sand pits)	0	0	0	0	0	0		M	A	N	Y		0	0	1	0	0	1
Totals	24	35	24	42	7	**73**	1418	1757	2171	1204	303	**3678**	189	132	305	18	0	**323**

[1] YOY = young-of-year
[2] Thousand Springs Ranch data do not include Shasta crayfish surveys in the upper coves
[3] Totals include two Shasta crayfish juveniles (not caught) and eight signal crayfish juveniles (killed) and therefore not sexed
[4] Data for Shasta crayfish (not for signal and fantail crayfish) include data from 2005 levee repair surveys

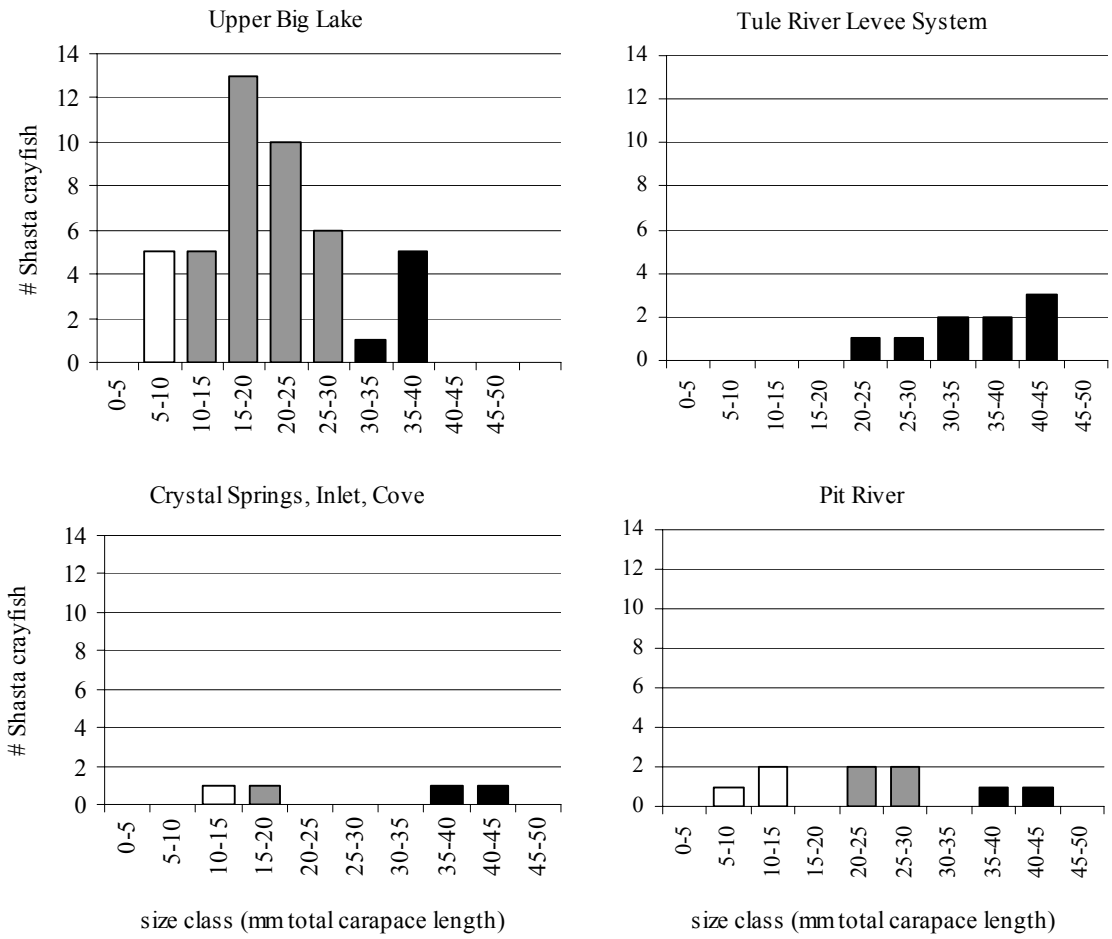

Figure 2 Shasta crayfish carapace size class distribution by location in the Pit 1 study area in 2004–2006. Bar colors represent age classes: young-of-year (white), juvenile (gray), and adult (black).

During the 2005 surveys of the Pit River from downstream of Big Eddy to upstream of Lake Britton, Shasta crayfish were found from the top of the Pit River Falls to approximately 600 meters upstream. Shasta crayfish were found on river left from Pit River Falls to approximately 400 meters upstream and on river right for approximately 100 meters from the coldwater spring downstream. Shasta crayfish were found in a one-to-two meter strip of the lower velocity edgewater, although efforts focused on these areas because the rest of the channel including the thalweg could not be surveyed. Shasta crayfish were found among gravels and under cobbles and small boulders. Habitat under large boulders, which made up a large portion of the substrate in the Pit River, could not be surveyed. At the upstream most area, we found young-of-year and

juvenile Shasta crayfish. We found Shasta crayfish throughout most of this section, but in low numbers.

Between 2004 and 2006, we collected and exterminated 3678 signal crayfish, which accounted for 90.3% of all crayfish collected. More females (n = 1757) were collected than males (n = 1418). There was a higher proportion of adults (n = 2171) than juveniles (n = 1204) with 303 young-of-year collected or killed in place. The size distributions for signal crayfish captured are presented in Figure 3.

Between 2004 and 2006, 323 fantail crayfish (*Orconectes virilis*) were collected and exterminated; fantail crayfish accounted for 7.9% of all crayfish collected. More males (n = 189) were collected than females (n = 132) and there was a higher proportion of adults (n = 305) than juveniles (n = 18). No young-of-year were found. Size distributions for fantail crayfish are presented in Figure 4. Table 4 provides a summary of the number and density of crayfish by species and area.

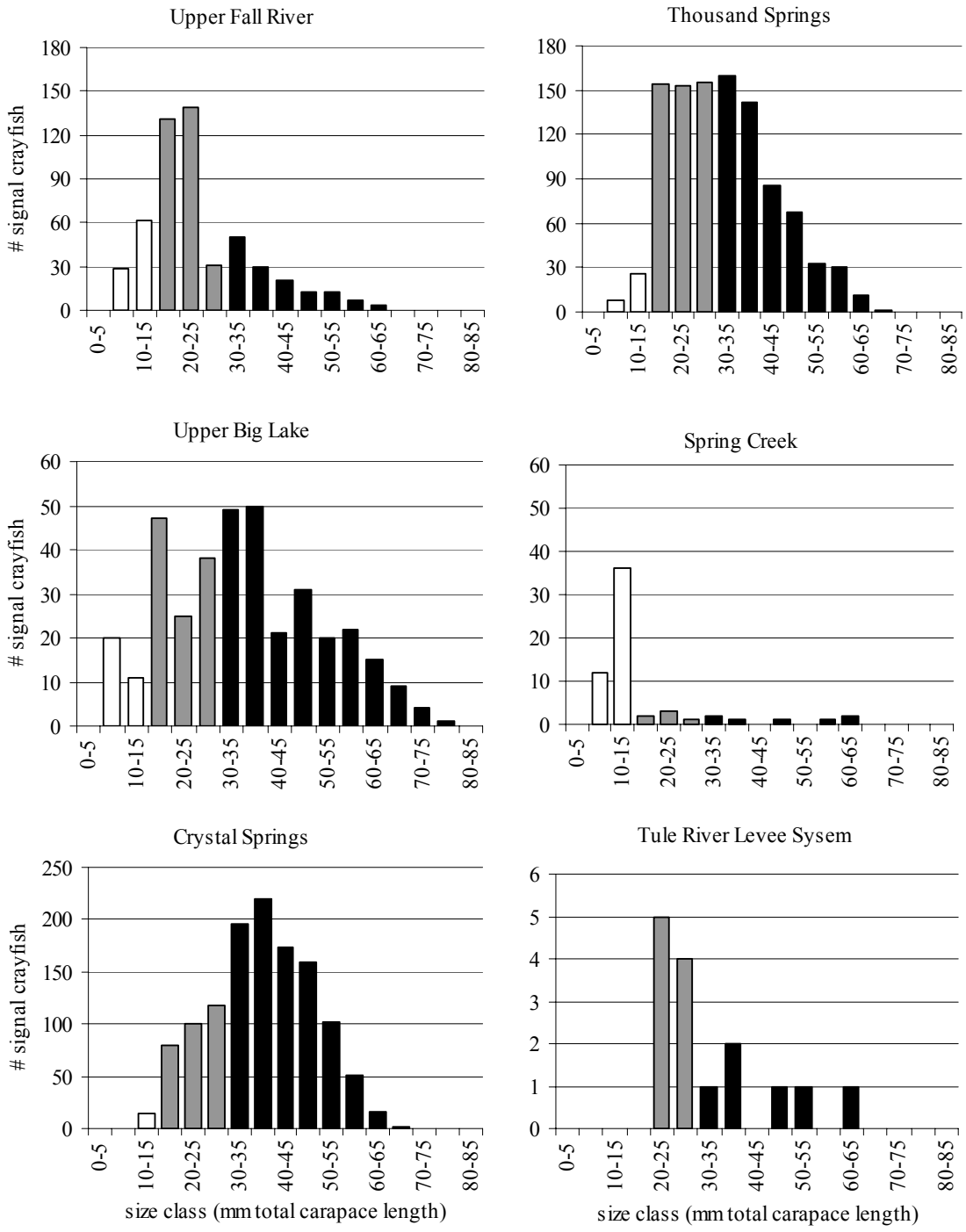

Figure 3 Signal crayfish carapace size class distribution by location in the Pit 1 study area in 2004–2006. Bar colors represent age classes: young-of-year (white), juvenile (gray), and adult (black).

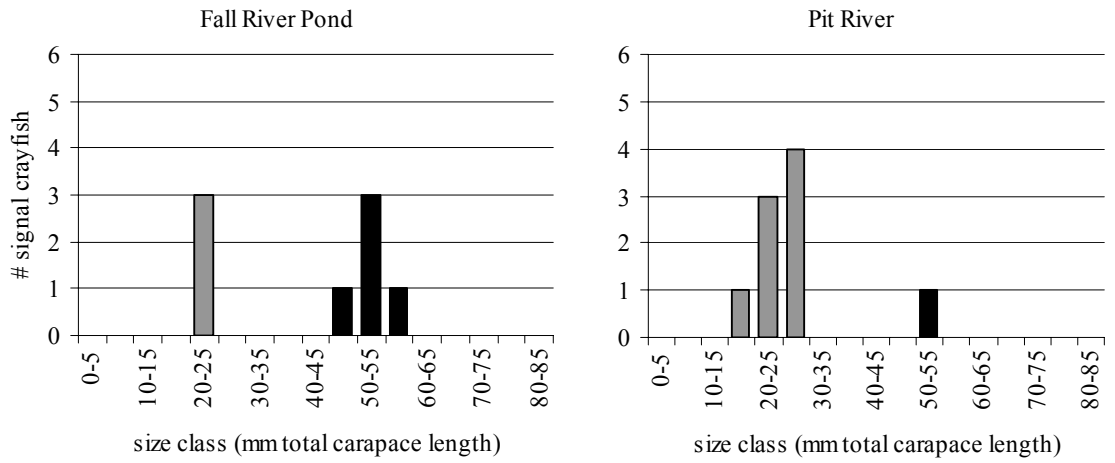

Figure 3 (continued).

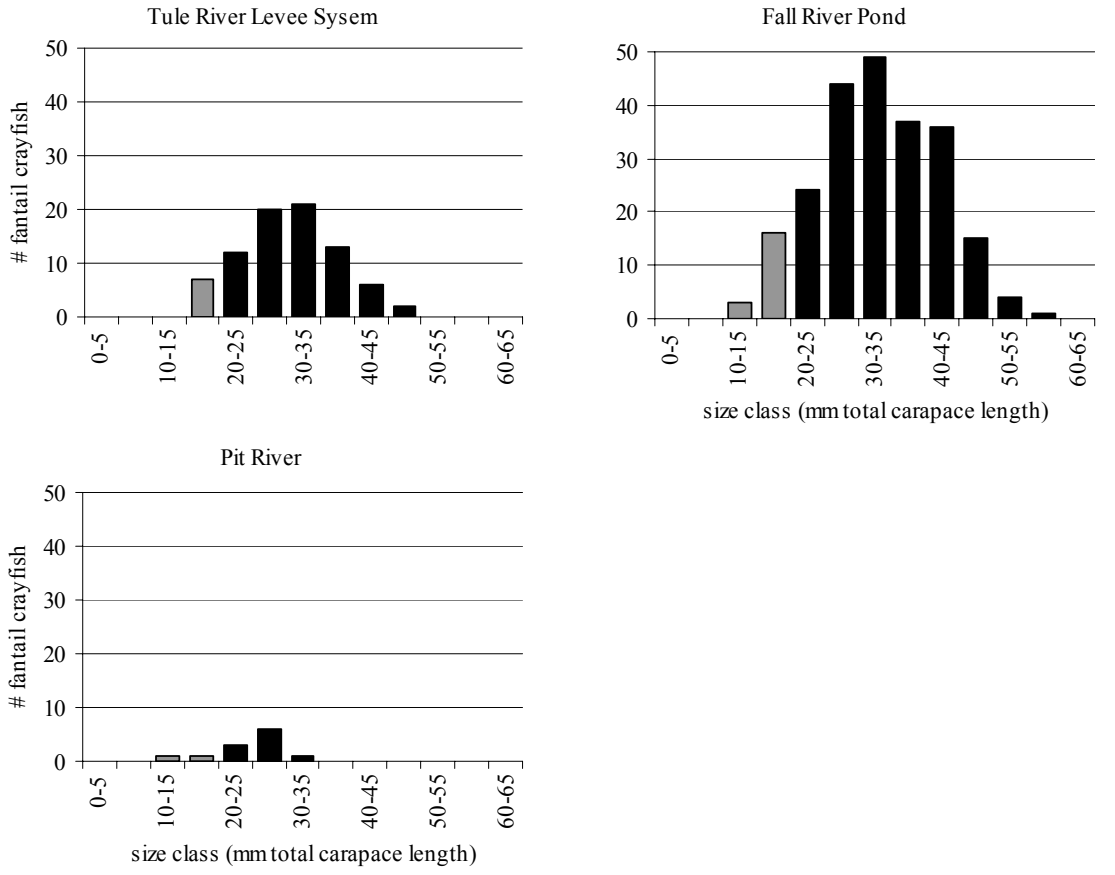

Figure 4 Fantail crayfish carapace size class distribution by location in the Pit 1 study area in 2004. Bar colors represent age classes: young-of-year (white), juvenile (gray), and adult (black).

Table 4 Total crayfish numbers, percentage by species, and estimated densities for each surveyed location from 2004 to 2006.

Region and Location	Shasta crayfish				Signal crayfish				Fantail crayfish			
	# of Crayfish	Percent of Species	Total Area (m^2)	Crayfish Density (#/m^2)	# of Crayfish	Percent of Species	Total Area (m^2)	Crayfish Density (#/m^2)	# of Crayfish	Percent of Species	Total Area (m^2)	Crayfish Density (#/m^2)
Upper Fall River												
Thousand Springs Ranch [1]	-	-	-	-	1027	100%	-	-	0	0%	-	0.000
Fletcher's Bend	0	0%	264	0.000	427	100%	264	1.617	0	0%	264	0.000
Lennihan's Footbridge	0	0%	216	0.000	98	100%	216	0.454	0	0%	216	0.000
Spring Creek												
Upper and lower coves	-	-	5250	-	59	-	5250	0.011	-	-	5250	-
Ja She Creek												
Ja She Creek headwaters	-	-	8463	-	-	-	8463	-	-	-	8463	-
Crystal Springs, Cove, Inlet	4	0%	3752	0.001	1671	100%	3752	0.445	0	0%	3752	0.000
Tule Coves	-	-	106	-	-	-	106	-	-	-	106	-
Upper Big Lake												
Big Lake Springs & North Big Lake [2]	44	11%	1349	0.033	358	90%	1349	0.265	0	0%	1349	0.000
Northeast Big Lake	1	25%	276	0.004	3	75%	276	0.011	0	0%	276	0.000
Northwest Big Lake	1	33%	11	0.091	2	67%	11	0.182	0	0%	11	0.000
Tule River Levee System												
South shore Big Lake	9	39%	1265	0.007	3	13%	1265	0.002	11	48%	1265	0.009
Northeast upper Tule River	0	0%	-	-	0	0%	-	-	4	100%	-	-
South shore upper Tule River	0	0%	21	0.000	6	13%	21	0.286	39	87%	21	1.857
East shore upper Tule River	0	0%	0	0.000	1	100%	0	-	0	0%	0	-
Horr Pond levees	0	0%	-	-	5	16%	-	-	27	84%	-	-
Fall River at FRM												
Fall River Pond	0	0%	4931	0.000	8	3%	4931	0.002	229	97%	4931	0.046
Pit 1 - Big Eddy to PH												
Pit River Falls, Canyon spring	14	40%	750	0.012	9	26%	750	0.012	12	34%	750	0.016
Pit 1 - below PH												
Pit River sand pits	0	0%	-	-	-	-	-	-	-	-	-	-

[1] Thousand Springs Ranch does not include the upper coves

DISCUSSION

The purpose of these monitoring surveys was to map, quantify, and delineate existing Shasta crayfish habitat in the vicinity of the Hat Creek and Pit 1 projects and to collect baseline data on Shasta crayfish populations in these areas. The baseline data will enable us to monitor population trends for Shasta crayfish and non-native crayfish, including distribution, abundance, density, and species composition over the 30-year term of the Hat Creek Project license (2003–2032) and the 40-year term of the Pit 1 Project license (2004–2043). Although the data are not directly comparable (because of differences in objectives and methods of earlier surveys), Table 5 summarizes data on number, density, estimated population size, and species composition from these on-going surveys and previous surveys by Daniels in 1978 (unpublished data in letter dated 7/13/95, Daniels 1978, Daniels 1980, Eng and Daniels 1982), Light and Clarke and Light and Myrick in the summers of 1990 and 1991 for Professor Don Erman of U.C. Berkeley (Light 1990, 1991 unpublished notes, Light 1991, Light et al. 1991, Erman et al 1993), and Ellis for PG&E in 1993 (Ellis 1994). Although assessments of population trends from these different data should be done with care, there are some trends that can be discerned.

Only general comparisons of past and current Shasta crayfish populations in the Pit 1 Project vicinity are possible at this time. In 1978, Daniels found mainly Shasta crayfish in the Pit 1 Project vicinity, but did find fantail crayfish in the mainstem Pit River (Table 5). 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 1994. Fantail crayfish are now found throughout much of the upper 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. Shasta crayfish were found at Fletcher's bend and Lennihan's footbridge in the mainstem upper Fall River in the early 1990s, but have not been found during surveys since 1993, including intensive surveys in 2004. Shasta crayfish are still present and reproducing near the Pit River Falls.

Table 5 Available data on number, density, estimated population size, and species composition from previous and current surveys in the Pit 1 Project vicinity.

	Region and Location	1978 [a]	1990, 1991, 1992 [b]	2001 [c]	2004–2006 [d]
Upper Fall River	Thousand Springs – Fish trap cove	20 Shasta 0.75 Shasta/m^2	21–230 Shasta		
	Thousand Springs – below the cove	5 Shasta 0.23 Shasta/m^2	11–24 Shasta		263 signal
	Fletcher's Bend		4–11 Shasta 0 Shasta (1995) 0–6 signal		427 signal (100%) 1.617 signal/m^2
	Lennihan's Footbridge		11–13 Shasta 0–6 signal		98 signal (100%) 0.454 signal/m^2
Spring Creek	Upper coves	50 Shasta Population size: 600–1000 0.79 Shasta/m^2	9–466 Shasta Population size: 4640 ± 627 4951 ± 103 0.83 Shasta/m^2		59 signal 0.011 signal /m^2
	Lower coves	8 Shasta Population size: 10–50 0.50 Shasta/m^2	17 Shasta		
Ja She Creek	Ja She Creek headwaters	0 Shasta (at bridge)	33 Shasta 1 signal (at bridge)	62 Shasta 364 signal	
	Crystal Springs, Cove, Inlet	1 Shasta molt 0.04 Shasta/m^2	11 Shasta	17 Shasta 315 signal	4 Shasta (0%) 0.001 Shasta /m^2 1671 signal (100%) 0.445 signal /m^2
	Tule Coves		16 Shasta 8 signal	13 Shasta 39 signal	
Upper Big Lake	Big Lake Springs	12 Shasta 1.00 Shasta/m^2	39 Shasta	61 Shasta	36 Shasta (92%) 0.028 Shasta /m^2
	North Big Lake		32 Shasta	49 Shasta 10 signal	3 signal (8%) 0.002 signal/m^2
	Northeast Big Lake	10 Shasta 1.11 Shasta/m^2	5 Shasta	6 signal	1 Shasta (25%) 0.004 Shasta /m^2 3 signal (75%) 0.011 signal/m^2
	Northwest Big Lake		7 Shasta	3 Shasta 12 signal	1 Shasta (33%) 0.088 Shasta /m^2 2 signal (76%) 0.175 signal/m^2

Table 5 (continued).

	Region and Location	1978 [a]	1990, 1991, 1992 [b]	2001 [c]	2004–2006 [d]
Tule River Levee System	South shore Big Lake	30 Shasta 3.56 Shasta/m^2	0–9 Shasta		9 Shasta (39%) 0.007 Shasta /m^2 3 signal (13%) 0.002 signal /m^2 11 fantail (48%) 0.009 fantail /m^2
	Northeast upper Tule River	30 Shasta 1.20 Shasta/m^2	5 Shasta 1 signal	5 signal 5 fantail	4 fantail (100%)
	South shore upper Tule River		0–3 Shasta 0–7 signal		6 signal (13%) 0.286 signal /m^2 39 fantail (87%) 1.857fantail /m^2
	East shore upper Tule River		Shasta molts 11 signal		1 signal (100%) No habitat identified
	Horr Pond levees		7 Shasta	26 signal 5 fantail	5 signal (16%) 27 fantail (84%)
Fall River Pond	Fall River Pond	1 Shasta 0.15 Shasta/m^2	0–many signal 0–most fantail		8 signal (3%) 0.002 signal /m^2 229 fantail (97%) 0.046 fantail /m^2
Pit 1 - Big Eddy to PH	Pit River Falls		4 Shasta (1995) many fantail		14 Shasta (40%) 0.019 Shasta /m^2 9 signal (26%) 0.012 signal /m^2 12 fantail (34%) 0.016 fantail /m^2
	Pit River - Canyon spring	0 Shasta	0 Shasta present signal 0 fantail		
Pit 1 - below PH	Pit River sand pits	8 Shasta 0.44 Shasta/m^2 271 fantail 3.11 fantail/m^2	abundant signal 0 fantail		many signal 1 fantail

[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] Ahjumawi Lava Springs State Park Survey (Spring Rivers 2001)
[d] this study

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APPENDIX A—FERC LICENSE ARTICLES PERTAINING TO SHASTA CRAYFISH FOR THE HAT CREEK AND PIT 1 PROJECTS

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.

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 (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.

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.

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 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 by the Commission that the plan is approved. Upon Commission approval, the licensee shall implement the plan, including any changes required by the Commission.

FERC License Article 412 requires the development of a Shasta crayfish management plan for the project area. The article is quoted from the license verbatim and shown in italic typeface below:

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 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 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.

APPENDIX B—TRC MEETING SUMMARIES FROM 11 JANUARY 2005, 12 APRIL 2005, 19 JUNE 2005, 6 DECEMBER 2005, AND 4 APRIL 2006

Shasta Crayfish Technical Review Committee
January 2005 Meeting Summary

The following is a summary of the Crayfish Technical Review Committee meeting held on January 11, 2005.

1. Rhonda Shiffman of PG&E made introductions and outlined the progress since the last TRC meeting, including.
    - PG&E filed for a second extension of time (until December 31, 2005) for filing the Pit 1 Crayfish Barrier Plan on 12/20/04.
2. Harry McQuillen of USFWS Recovery Branch gave a presentation on Recovery Implementation Teams
    - Recovery Team Objectives are to:
        i. Reduce or eliminate threats to listed species
        ii. Restore self-sustaining wild populations
        iii. Remove species from list
    - Recovery Teams Roles and Responsibilities include:
        i. act in an Advisory capacity to USFWS and make recommendations to USFWS; USFWS has final deciding authority
        ii. make recommendation in the best interest of the species
        iii. are not regulatory
        iv. are the only entity that USFWS can legally ask for advise
        v. are exempt from Federal Advisory Committee Act (FACA) by Section 4 of the Endangered Species Act
    - Recovery Team Rules of Behavior:
        i. biases and egos don't help
        ii. use of the Team to promote your own agenda or further your own career rather than furthering the recovery of the species is inappropriate
        iii. don't embarrass the Team, your organization/agency, or the FWS
        iv. no one person has any more say than anyone else
        v. participate and have fun making a difference for the species
    - Recovery teams can be structured with working groups or technical teams and subcommittees that are formed/disbanded as needed
        i. Technical teams can include people not on the Recovery Team
    - Avoid potential conflicts of interest
    - No compensation for Recovery Team
    - Importance of Open Communication
3. Shasta crayfish Recovery Plan (1998) is becoming out-of-date. USFWS operates on the most current information available.
4. Of the 104 listed species managed by the Sacramento Field Office of USFWS
        i. 6 species (+1 species presumed extinct) chosen as focus species in 2002
        ii. 6 more species, including Shasta crayfish, chosen as focus species in 2005
        iii. These 12 species get 90% of the Recovery dollars
        iv. Shasta crayfish will get more attention because it is a focus species
5. Harry handed out draft Terms of Reference for the Shasta Crayfish Recovery Team
    - The group was asked to review the Terms of Reference and provide Harry with comments by March 1st.
    - Upon review, the Terms of Reference can be finalized at the next meeting on April 12, 2005.

6. Recovery Team leader or leaders were discussed. Suggested options included Maria as single team leader or Maria and Rhonda as co-leaders.
7. Rhonda brought up the potential need to consult with the Pacific Forest and Watershed Lands Stewardship Council (Lands Stewardship Council) regarding various decisions or projects that would affect areas, such as Sucker Springs and Rock Creek, which are part of the 140,000 acres of watershed lands being managed by the Lands Stewardship Council.
8. Maria gave a presentation summarizing the Crayfish Barrier Flume Study that was conducted at UC Davis. The final report of the study will be sent to the TRC before the end of January. The major results of the Crayfish Barrier Flume Study were:
    - An overhanging barrier design was found to be a successful barrier to crayfish in both flowing and still water conditions.
    - Although a broad range of designs was tested for sediment passage in the flume, some sediment accumulated at all barriers at higher bedload supply rates.
    - Trout easily moved upstream of the overhanging barrier.
    - Although the overhanging barrier was not found to be an impassable barrier to sculpin (i.e., riffle and prickly sculpin), it did appear to present a behavioral barrier.
9. Maria summarized the changes in the revised draft Crayfish Barrier Plan, which will be sent to the TRC by the end of January. Additional information pertaining to sculpin passage issues was presented, including:
    - Riffle sculpin (*Cottus gulosus*) and prickly sculpin (*Cottus asper*) (34 to 75 mm total length) were able to pass the overhanging drop barrier, but showed little inclination to do so unless chased by a net or harassed by a crayfish.
    - Barrier was not an impassable physical obstacle, but did appear to present a behavioral barrier to sculpin.
    - Genetic exchange would likely be common in a downstream direction, but may be limited in an upstream direction although conditions of low food availability, overcrowding, or predation risk may provide motivation for sculpin to cross barriers.
    - Less than 1% of the area occupied by the rough sculpin would potentially be affected by the installation of crayfish barriers, based on GIS calculations of the areal extent of the rough sculpin distribution in the Fall River drainage above and below the potential barrier locations.
10. Jeff gave a presentation on the detailed topographic survey of upper Rock Creek meadow (immediately downstream of the present diversion site) that was completed in late 2004.
    - Surveyed 17 Valley transects that were interconnected in a grid to allow spatial modeling.
    - Surveyed wetted channel cross-section, water depths, and water surface elevations.
    - These data, which were collected to allow hydrologic modeling, have not been sent out to the engineers yet.
    - The only possible spill-around spot was located where the pipeline exits the historic channel. This spot could easily be built up to prevent spill over.
    - The Rock Creek Restoration Project has the potential to be a great win-win situation with Crystal Lake Hatchery retaining all of its water while creating a successful habitat restoration and refugia for the Shasta crayfish.
    - Steve and Randy brought up that there are still unanswered questions and unknowns about the proposed Rock Creek Restoration Project.
11. Steve gave an update on CDFG's Section 6-funded genetics study
    - DFG has applied for additional Section 6 money to continue the genetic study
    - Steve will provide the TRC with copies of the Section 6 proposal for the study
    - Results from genetic study are expected in a couple of years

- Potential options for sampling of genetic material include either the walking legs (pair) or the pleopods (pair), which are the swimmerets (abdominal appendages).
- Maria will research what sampling will be less invasive.

12. Potential Grant-Funded Projects (Maria Ellis)
    - Dan Strait of USFWS Partners for Fish and Wildlife called right before the meeting to give an update. Northeastern California was not chosen as a focus area by Partners for Fish and Wildlife. Focus areas will be getting more than 50% of the funding and a full-time staff person. The rest of the funding (<50%), which is still a significant amount of money, will be open to competition as before. Dan is pretty confident that the Sucker Springs Restoration Project will be funded by Partners for Fish and Wildlife for 2005. Maria will be submitting a proposal for the Sucker Springs Restoration Project by the end of January/beginning of February. Partners for Fish and Wildlife will be selecting projects to fund in March.
    - The Sucker Springs restoration project, as proposed, would be funded as a partnership between USFWS Partners for Fish and Wildlife, USFWS Recovery Program, Spring Rivers, and PG&E. Maria will send the proposal to the TRC.
    - Pacific Forest and Watershed Lands Stewardship Council (Lands Stewardship Council). Propose to write draft Management Plan Proposals for both Sucker Springs and Rock Creek habitat restoration projects to inform the Council of ongoing Shasta crayfish recovery efforts.
13. Maria discussed the status of Pit 1 2004/2005 baseline surveys and the 2005 Work Plan being conducted under the "Shasta Crayfish Management Plan" for the Pit 1 Project and Year-2 monitoring surveys of Crystal and Baum lakes for the Hat Creek Project.
    - The baseline surveys and habitat mapping for Hat Creek were completed in 2003 and the first year monitoring surveys were completed in 2004.
    - The Pit 1 baseline surveys and habitat mapping for the Pit 1 Project, which were started in 2004, will be completed in 2005, including the Pit River from Big Eddy to Lake Britton.
    - Additional research related to the potential Rock Creek habitat restoration project:
        - Provide more detailed data to engineers and run hydraulic model (e.g., HEC RAS) to determine normal depth of flow for a target discharge of 20–25 cfs.
        - Sand bag test of upper Rock Creek meadow
            - Streambed Alteration Permit
14. Summary of PG&E Shasta crayfish funding requirements and expenditures for the Pit 1 and Hat licenses: $30,000 Hat Creek in 2003 and 2004; $65,000 Pit 1 in 2004; and additional funding for TRC activities.
15. Spring Rivers Foundation became a California nonprofit corporation on July 22, 2004. State tax-exempt was received in January 2005. Federal tax-exempt status is still pending; federal processing time, which is usually 120 days, is currently running at 180 days (end of April 2005). Once granted, tax-exempt status would be effective as of July 22, 2004.
16. Next meeting is scheduled for 10:00 am to 3:00 pm on **April 12, 2005** (Tuesday) in Redding in the CDFG conference room.
    - Finalize Terms of Reference for the Shasta Crayfish Recovery Team.
    - Discuss Pit 1 Crayfish Barrier Plan

Action Items:

What	Who	When
Shasta Crayfish TRC Meeting Summary Notes	Maria/Rhonda	ASAP
Research options for sampling of genetic material	Spring Rivers/Maria	Jan. 2005
Crayfish Barrier Flume Study Final Report to TRC	Spring Rivers/Maria	Jan. 2005
Revised draft Crayfish Barrier Plan to TRC	Spring Rivers/Maria	Jan. 2005
Review Terms of Reference for Shasta crayfish Recovery Team; provide comments to Harry McQuillen/USFWS	TRC	March 2005
Comments on the draft Crayfish Barrier Plan on or before April 1, 2005.	TRC	April 1, 2005
Study Design for overland travel by signal crayfish to TRC	Spring Rivers/Maria	March 2005
Resurvey potential barrier sites	Spring Rivers	March 2005
Arrange field meeting for PG&E's Field Engineer, Rob Bowers, to look at the proposed barrier sites	PG&E/Chris	March 2005
Sucker Springs Restoration Project Proposal to Partners for Fish and Wildlife and USFWS Recovery Branch	Spring Rivers	February 2005
Sucker Springs Restoration Project Proposal to TRC	Spring Rivers	March 2005
CDFG Section 6 Proposal to TRC	Steve Baumgartner	March 2005
TRC/Recovery Implementation Team Meeting	TRC	April 12, 2005

Attendees:

Rhonda Shiffman	PG&E Hydro
Kathy Brown	USFWS Endangered Species
Dave Longanecker	PG&E TES
Woody Elliot	CA Dept of Parks and Recreation
Maria Ellis	Spring Rivers
Jeff Cook	Spring Rivers
Annie Manji	CDFG
Harry McQuillen	USFWS Recovery
Randy Benthin	CDFG
Steve Baumgartner	CDFG
Shane Overton	CDFG

Shasta Crayfish Technical Review Committee
April 2005 Meeting Summary

The following is a summary of the Shasta crayfish Technical Review Committee meeting held in Redding on April 12, 2005.

b. Rhonda Shiffman of PG&E made introductions and outlined the progress since the last TRC meeting, including.
   - Adoption of Maria and Rhonda as co-leaders of the Recovery Implementation Team
   - Draft Crayfish Barriers Plan (revised) sent for review to TRC/Recovery Implementation Team
   - Final Crayfish Barrier Flume Study Report sent to TRC/Recovery Implementation Team

2. Harry McQuillen of USFWS Recovery Branch clarified that the TRC represents agencies and companies and the Recovery Implementation Team represents the species. Harry also stated that it was important to keep TRC and Recovery Team business separate and that for the Recovery Team to function well, biases need to be checked at the door.
3. Harry went over the Terms of Reference with the TRC and Recovery Implementation Team. He stated that he incorporated the few changes sent to him by the TRC and Recovery Team.
   i. Harry stated that a USFWS editor had suggested the following edit in the 2nd paragraph, 6th sentence: Change "performed" to "considered and evaluated" in "The USFWS incorporated TRC members into a Recovery Implementation Team for the Shasta crayfish to allow recovery work to be performed outside of the FERC project boundaries, to provide technical advice, and to expedite USFWS funding of restoration projects."
      - Dave Longanecker and Maria Ellis stated that it was important to state that license monies could be spent and recovery implementation actions could be performed outside of the FERC project boundaries. One of the important steps taken by the TRC was to agree that TRC actions, including potential barrier locations, would be done where it most benefited the species and would not be restricted by FERC project boundaries. Rhonda stated that the TRC was a marriage of two goals: license implementation and species recovery. All TRC and Recovery Team members agreed that it was important that work be done that was in the best interest of the Shasta crayfish, regardless of FERC boundaries.
      - TRC and Recovery Team members agreed that unallocated Shasta crayfish license monies could be used for other Recovery Projects such as Sucker Springs and exploring the possibility of restoring Rock Creek and reintroducing Shasta crayfish.
      - Harry said that he would talk to the editor about keeping the original wording of performed.

   ii. Harry stated that a USFWS editor had suggested the following edit in the 3rd paragraph, 1st sentence: Change "appoint" to "establish" in "The ESA authorizes USFWS to appoint recovery teams to assist in the development and implementation of recovery plans."
4. Rhonda provided a summary of the Pacific Forest and Watershed Lands Stewardship Council (Council).
   i. The Council can not fund projects that are license requirements or PG&E mitigation.
   ii. Funding for the Council is 100 million with 30 million for youth education program, 60 million rehabilitation and improvements, and 10 million for planning.
   iii. Agencies can approach the Council to purchase lands and for endowment monies to manage the lands.
   iv. Proposals to the Council should include the full package of restoration and management costs and leverage monies.
   v. Groups such as Pacific Forest Trust and TNC can hold conservation easements.
   vi. Plan development: Although the Council has already made one disposition, it will probably be about 1.5 to 2 years before the Council considers disposition of most land.

5. Sucker Springs Restoration Project
    i. CDFG stated concerns about Pit River flooding and signal crayfish moving back into Sucker Springs Creek even if the eradication is successful. Significant flooding of the Pit River occurred in 1964, 1986, and 1997, an approximately 10 to 15-year recurrence interval.
    ii. Native American issues: Potential contacts: Dave Wooton (BIA-ESA), Jim Holeman/Alison MacDougall (PG&E), Jessica Jim/Michelle Berditschevsky (Pit River Tribes)
    iii. Timeline and Permits: USFWS Section 7, CEQA (probably mitigated negative declaration), CDFG 1600 Streambed Alteration, Army Corps Nationwide 27, 401 Certification, CDFG CESA EIR/Negative Declaration, Cultural Resources
        - Mandatory significance with endangered species, rough sculpin authorization of take, month-long public review.
    iv. Roofing sealant such as bithathane (Bituthene®, Grace Ice and Water Shield®) might be used to seal cracks in the cement.
    v. Major issues with the Sucker Springs Restoration Project are:
        1. Someone could move signal crayfish in at any time—always a risk, nothing we can do.
        2. Potential flooding—(1) survey parking area between Pit River and Sucker Springs to determine Pit River surface water elevation that would impact Sucker Springs upstream of Pond 5 weir, and (2) add fill to parking area again (CDFG increased the elevation of the parking area after the 1986 flood).
        3. Signal crayfish possibly living "underground" in the springs, especially in Pond 3.
    vi. Need to show financial activity, 3-4 years funding, good for both Recovery Branch and Partners.
    vii. Entire process is open for review and revision.
    viii. Need to spell out detailed needs if we are going to proceed with the Sucker Springs Restoration Project.
    ix. Keep Weir 2 in place and seal.
    x. The 6-month no-signal crayfish period is arbitrary. A breeding season or two would be more useful.
    xi. CDFG reserve opinion until they look at Sucker Springs. Need concensus to move forward. Need to identify milestones that need to be met to continue to move forward
    xii. CDFG and USFWS to tour Sucker Springs and other sites on April 13th.
    xiii. CDFG 1600 Permit needs a detailed proposal with formal project description, design, and material installation. Current proposal does not include many things discussed at this meeting, such as education, fencing, raising road bed.
    xiv. Land Stewardship Council grant to acquire Sucker Springs or BLM.
    xv. PG&E management—business reasons to do Sucker Springs—high value, low risk example of collaborative success, good PR.
    xvi. Final Plan with conceptual design but not final engineering design.
6. Crayfish Barrier Plan
    i. CDFG—rough sculpin issue is probably workable.
    ii. Overland travel experiment not necessary. Use overhanging wings to stop potential overland travel.
    iii. Barrier field meeting for PG&E and CDFG engineers, USFWS, CDFG, and PG&E personnel, and landowners to visit Thousand Springs and Spring Creek on May 24, 2005.
    iv. Bowman's Ditch is a potential site located on State Park property with headwaters on Mike property,
    v. Barrier locations need easement in perpetuity

vi. PG&E would formally approach landowners for long-term commitment.
vii. Barrier Plan steps
    1. Engineer/biologist tour with landowner present (minimize size of tour)
    2. Following tour get PG&E land agent Mike Drury involved.
    3. Engineers physical draft of plans (Auto Cad) with laydown areas etc.
    4. Prepare proposal
    5. Review proposal and plans with landowners
    6. Review proposal and plans with TRC
    7. Opportunity to amend plan based on landowner and TRC comments

7. Steve Baumgartner of CDFG provided copies of their Section 6 proposals for the Shasta crayfish genetics and temperature Studies.
    i. Steve presented growth and survival data for juvenile signal crayfish raised at the Crystal Lake Fish Hatchery in 50 °F (10 °C) Rock Creek water and 56 °F (13 °C) water similar in temperature to Sucker Springs Creek.
    ii. Crayfish grew faster in warmer water.
    iii. CDFG needs 2 to 10 Shasta crayfish to repeat the growth and survival studies with that species.
8. Next meeting is scheduled for 10:00 am to 3:00 pm on July 19, 2005 (Tuesday) in Burney.

Action Items:

What	Who	When
Shasta crayfish TRC meeting summary notes	Maria/Rhonda	ASAP
Resurvey potential barrier sites for crayfish	Spring Rivers	2005
CDFG and USFWS site visit to Sucker Springs Creek	CDFG/USFWS	April 13, 2005
Field meeting for PG&E and CDFG engineers and agency personnel to look at the proposed barrier sites		May 24, 2005
Proposal and Engineers Plans for barrier sites	PG&E/CDFG	June 2005
TRC/Recovery Implementation Team meeting	TRC/Recovery Team	July 19, 2005

Attendees:

Rhonda Shiffman	PG&E Hydro
Dave Longanecker	PG&E TES
Chris Herrala	PG&E Hydro
Harry McQuillen	USFWS Recovery
Kathy Brown	USFWS Endangered Species
Dan Strait	USFWS Partners for Fish and Wildlife
Woody Elliot	CA Dept of Parks and Recreation
Annie Manji	CDFG
Randy Benthin	CDFG
Steve Baumgartner	CDFG
Theo Light	Shippensburg University of PA
Maria Ellis	Spring Rivers Ecological Sciences, LLC

Shasta Crayfish Technical Review Committee
July 2005 Meeting Summary

The following is a summary of the Shasta crayfish Technical Review Committee meeting held in Burney on July 19, 2005.

I. Introductions were made by Rhonda Shiffman (PG&E).
   A. Maria Ellis (Spring Rivers) outlined the events/progress since the last TRC meeting, including.
      1) CDFG and USFWS field tour of Sucker Springs on April 13, 2005
      2) Barrier Field Tour May 24, 2005
      3) Sucker Springs Restoration Project funded and Agency changes to proposal
      4) Separation of TRC and Recovery Team Actions: TRC Actions are specifically required by a FERC license whereas Recovery Team Actions are not specifically required by a FERC license.
         a) Rhonda stated that because Article 412 asks PG&E to identify alternatives to combate the rapid decline of Shasta crayfish in the project area, enhancements aside of those specified in the license may also be considered to be license related.

II. Recovery Team Projects
   A. Sucker Springs Restoration Project
      1) Dan Strait (USFWS Partners for Fish and Wildlife) gave an update on the project, which he described as an example of adaptive management. Dan gave a brief review of changes resulting from the agency tour on April 13th.
         a) Because of concerns that signal crayfish could be living in the springs, Pond 2 Weir will be left in place and fortified. Pond 3 Weir will still be removed and Pond 5 Weir will be fortified.
      2) Steve Baumgartner (CDFG) made a site visit with Dan Byrd of the Yreka Screen Shop (Fisheries Habitat Restoration). Dan felt that the weirs were definitely repairable and could be filled from the inside.
      3) Steve will organize a Sucker Springs field meeting with Dan, Zeke (Mike Zanin), Maria, and any other interested parties.
      4) Steve will be the lead on CEQA/CESA and 1600 permitting.
         a) In terms of CEQA, if a listed species can or will be affected then there is a mandatory significance finding so a negative declaration could be used but not a categorical exemption.
         b) CDFG will waive 1600 streambed alteration fee ($875)
      5) Dave Longanecker (PG&E) expressed concerned about signal crayfish moving out of barriers during removal or fortification work.
         a) Maria stated that crayfish escaping out of a weir would go into the pond downstream of the weir and could be collected in a beach seine stretched across the channel or by hand.
      6) Partners for Fish and Wildlife is working on a cooperative agreement with Spring Rivers Foundation; this agreement has a revised project description in it. Dan will e-mail the cooperative agreement to the TRC/Recovery Team.

7) Partners for Fish and Wildlife is working on a landowner agreement with PG&E. Dan will send the landowner agreement to Rhonda soon for PG&E's execution.
8) Partners for Fish and Wildlife will do the Section 7 ESA consultation.
9) USFWS already has a Nationwide 27 permit that will cover the project.
10) Dan will contact Dennis Heiman of the Regional Water Quality Control Board to work on the Water Quality Certification.
11) PG&E management has agreed to provide in-kind and matching contributions.
12) Cultural Resource Issues
    a) Rhonda will ask Alison MacDougall, the PG&E archeologist, about Sucker Springs.
    b) USFWS has a Section 106 programattic agreement with SHPO (State Historic Preservation Officer) so legally in compliance.
    c) Plan to consult with Native Americans soon to get involvement in the early phases of the project. Plan to have Native American observers.
    d) Spring Rivers was told by Morningstar Wilson that Joey Silvas was the Native American to contact about Sucker Springs Creek.
13) Maria has some background information that might be useful for permitting and can provide additional written descriptions, etc. as needed for permits
14) Rhonda will acquire budget order number for Zeke's work at Sucker Springs

B. CDFG Temperature Study
1) Signal crayfish continue to grow faster in the 56 °F water as compared to the 50 °F Rock Creek water. This experiment began in December 2004.
2) There is differential mortality in two temperature-treatment tanks, need to check which temperature treatment had higher mortality.
3) Study is being done without replacement so potential density effects. Density in tanks is pretty low so density effects may be minimal.
4) Four gravid female Shasta crayfish from Crystal Lake were placed in the tanks (2 in each temperature treatment) on May 20, 2005.
5) One female Shasta crayfish molted a few days ago.
6) Shasta crayfish are being fed fresh trout, periphyton-covered rocks from Crystal Lake, and carrots.
    a) Steve has observed Shasta crayfish eating trout but not carrots. The carrots do appear to have been nibbled on or at least they change appearance after being in the water for a while.
7) Would like to continue the experiment until reproduction.
    a) Maria pointed out that Shasta crayfish reproduce at 4 or 5 years of age.
    b) Need to check the time frame given in the biological opinion (BO) for temperature study.
8) Suggestions were made to add ± standard deviation to mean TCL in Temperature Study figure and to do a separate figure (or add a second y-axis) showing mortality by month for the Temperature Study.
9) Spring Rivers will return adult Shasta crayfish and any young-of-year (YOY) Shasta crayfish over the 100 YOY needed for the temperature study (50 YOY per temperature treatment.

III. Technical Review Committee (TRC) Projects

A. Barrier Plan

1) Ken Leung, the PG&E engineer assigned to the Barrier Project, conveyed his thoughts to Rhonda after the Barrier Field Tour in May.
    a) Ken thinks that the streambanks upstream of a barrier at Thousand Springs will be inundated.
    b) A hydraulic analysis will determine the extent of backwater and the incremental upstream inundation to address Peter Stents' concerns.
    c) Sediment may build up behind barriers even if bedload supply is low, which will create a maintenance issue that if not addressed would defeat the utility of the barrier.
    d) It will be difficult to build a barrier with no contiguous seams.
    e) Ken estimates that a barrier is likely to cost much more than the $150,000 allocated in the license, particularly because it will be built under wet and not dry conditions.
2) CDFG notes on Barrier Tour from George Heise
    a) George has been swamped, there are only three CDFG engineers state-wide.
    b) Steve will contact George to remind him that we are waiting for his notes from the barrier tour.
    c) Steve will send George's barrier tour notes out to the group as soon as he gets them.
3) Harry McQuillen's (USFWS) May 25th email summarized courses of action and discussion points from the barrier tour:
    a) Harry listed the landowner Peter Stent's concerns about constructing a barrier at Thousand Springs.
    b) Harry listed the action items that should be done in order to explore or construct a barrier at Thousand Springs.
    c) Harry thought that it made much more sense to try to eradicate signal crayfish upstream of the Spring Creek Road crossing culverts than to build another barrier at Spring Creek.
    d) Harry was interested in at least determining the extent of the distribution and abundance of signal crayfish in upper Spring Creek.
4) Spring Creek
    a) Already has a barrier in place at the Spring Creek Road crossing culverts, which separates the signal crayfish in the Fall River and lower Spring Creek from upper Spring Creek
    b) No one liked the looks of the potential barrier location in upper Spring Creek, especially the engineers from CDFG and PG&E.
    c) Need to determine the distribution and abundance of signal crayfish in upper Spring Creek (upstream of the Spring Creek Road crossing culverts).
    d) Spring Rivers will survey upper Spring Creek in order to determine the distribution and abundance of signal crayfish and e-mail a memo summarizing the results of the survey to the group before the next meeting.
5) Prototype barrier at Sucker Springs Creek
    a) Smaller (shorter) barrier—easier to construct and monitor
    b) Could put barrier anywhere in Pond 5—if put in the middle of Pond 5 it would divide the eradication area into two parts.
6) Changing barrier requirement in the FERC Pit 1 License?
    a) PG&E wants to satisfy FERC and do what is best for the species.

b) Kathy Brown (USFWS) stated that if the group decides that barriers won't work then the USFWS would need to change the BO for the FERC Pit 1 License because that is the basis for the license requirement. The project description in the BO would need to be revised to say that barriers are not feasible.
c) We don't have enough information to make a decision on barrier feasibility at this point.

7) The group decided that if a barrier at Thousand Springs is still considered feasible based on George's comments, then we should do the streambed topography survey of Thousand Springs.
8) Rhonda will consult with FERC about the Pit 1 Barrier Plan filing.
9) Need to keep Peter Stent and Spring Creek landowners/managers in the loop.

B. Rock Creek—proposed restoration of approximately 600 feet of the upper meadow
A major question is whether the approximately 600 feet of channel in question is a losing reach, i.e., more water enters the top of the reach than would exit the bottom of the reach. This would result in less water for the Crystal Lake Hatchery, which is unacceptable.

1) A sand bag test would determine whether or not it was a losing reach. Sandbag the bottom of reach and allow water to fill to height of proposed new diversion point. Would need to allow approximately half the water to continue downstream so that the lower channel is not dewatered.
2) Would need a CDFG 1600 Permit. Probably would not need an Army Corps permit because the amount of fill (sand bags) would be below the threshold for a Nationwide (NW). Would need a 401 Water Quality Certification or waiver.
3) Steve would need a project description in order to work on a CDFG 1600 permit.
4) Target sand bag study for summer 2006 and start permitting now.
5) Target draft of project description for next meeting. The project description needs to include substantiation that lower Rock Creek would not be dewatered.

C. Kathy brought up the proposed Fall River dredging project and the potential effects on Shasta crayfish. Mike Dean of CDFG has been contacting her for an opinion on the potential effects of the project on Shasta crayfish.

1) Rough sculpin, which are a fully protected species by the state, are a bigger issue in terms of dredging. Since rough sculpin are present in the Fall River and would be affected by dredging, Steve thought it was unlikely that the dredging project could proceed.

IV. Next meeting is scheduled for 10:00 am to 3:00 pm on October 25, 2005 (Tuesday) in Sacramento at USFWS.

1) Try not to schedule Sacramento meetings in the winter.
2) A phone meeting may be arranged to talk about some potential issues, such as the Thousand Springs topography survey, prior to the next meeting.

Action Items:

What	Who	When
Shasta crayfish TRC meeting summary notes	Maria/Rhonda	July
1. E-mail Sucker Springs cooperative agreement to TRC/Recovery Team 2. E-mail Sucker Springs landowner agreement to Rhonda 3. Contact Dennis Heiman re: Water Quality Certification for Sucker Springs 4. Section 7 ESA consultation for Sucker Springs	Dan Strait/ USFWS Partners for Fish and Wildlife	Before next meeting
1. Arrange Sucker Springs field meeting with Dan Byrd and Zeke 2. Request George Heise's barrier tour summary 3. E-mail George Heise's barrier tour summary to group 4. Work on CEQA/CESA and 1600 permitting for Sucker Springs 5. Add ± standard deviation to mean TCL and add second y-axis or do separate figure showing mortality by month for the Temperature Study. 6. Check BO time frame for temperature study.	Steve Baumgartner/ CDFG	Before next meeting
1. Talk with Alison MacDougall regarding cultural monitoring/consultation at Sucker Springs 2. Acquire budget order number for Zeke's work at Sucker Springs 3. Consult FERC about Crayfish Barrier filing	Rhonda Shiffman/ PG&E	Before next meeting
1. Survey Spring Creek for signal crayfish 2. E-mail Spring Creek survey results to group 3. Return adult Shasta crayfish and any young-of-year (YOY) Shasta crayfish over the 100 YOY needed for the Temperature Study (50 YOY per temperature treatment). 4. Provide assistance/written materials for Sucker Springs permitting 5. Work on written project description for Rock Creek 6. Keep Peter Stent and Spring Creek Ranch landowners/managers in the loop	Maria Ellis/ Spring Rivers	Before next meeting
Decide on Thousand Spring channel topography survey once George Heise's barrier tour summary has been received.	TRC/Recovery Team	Before next meeting
TRC/Recovery Implementation Team meeting	TRC/Recovery Team	Oct. 25, 2005

Attendees:

Rhonda Shiffman	PG&E Hydro
Dave Longanecker	PG&E TES
Mike Zanin (Zeke)	PG&E Shasta Hydro
Kathy Brown	USFWS Endangered Species
Dan Strait	USFWS Partners for Fish and Wildlife
Randy Benthin	CDFG
Steve Baumgartner	CDFG
Glenn Yoshioka	CDFG Species Conservation & Recovery
Theo Light	Shippensburg University of PA
Maria Ellis	Spring Rivers Ecological Sciences, LLC

Shasta Crayfish Technical Review Committee
December 2005 Meeting Summary

The following is a summary of the Shasta crayfish Recovery Team and Technical Review Committee meeting held in Sacramento on December 6, 2005.

[Additional information to meeting discussions is shown in square brackets.]

I. Rhonda Shiffman (PG&E) reviewed the agenda for the meeting, which was divided into Recovery Team projects (not required by FERC in PG&E Project licenses) and Technical Review Committee projects (required by FERC in PG&E Project licenses).

II. Recovery Team—Sucker Springs Restoration Project

A. Maria Ellis (Spring Rivers) provided a verbal and written summary of the Sucker Springs Creek Engineering Field Meeting on September 7, 2005, which was attended by Steve Baumgartner and Dan Byrd of CDFG, Mike (Zeke) Zanin and Rhonda Shiffman of PG&E, and Maria Ellis and Jeff Cook of Spring Rivers.

B. Steve Baumgartner (CDFG) gave an overview of the CEQA/CESA and 1600 streambed alteration permit process.

1) Bruce Webb, who heads the Fish and Game Code 1600 (Streambed Alteration) department, has been to the site and wants to work with us to streamline the process.
2) The 1600 and CEQA/CESA permitting will all be done in the same office. The 1600 permit application will trigger the CEQA/CESA process as well because of the presence of listed species.
3) Unfortunately, Fish and Game can no longer waive permit fees. Fees for the 1600 just increased in November 2005.
4) Rough sculpin, which is a fully protected species, will be the major determinant of how the project gets done and what steps will be necessary.
5) Steve asked Maria whether the rough sculpin is found throughout all ponds in Sucker Springs. Maria said she would double check but thought that rough sculpin were found throughout the tributary. Dave Longanecker (PG&E) stated that he doesn't think that rough sculpin were found in the fast water downstream of the hatchery ponds when PG&E electroshocked years ago.
6) Spring Rivers Foundation is the Project Proponent.
7) Spring Rivers is currently working on the 1600 permit application. The original project budget included money for permitting, including fees. Steve will review the permit application before Spring Rivers submits it to the department.
8) PG&E is still the landowner of Sucker Springs Creek. The Pacific Forest and Watershed Land Stewardship Council holds a conservation easement on the property. EDAW has been hired to research all the watershed lands held in the conservation easement.

C. Dan Strait (USFWS Partners for Fish and Wildlife) provided an update on the Section 7 ESA consultation, the Army Corps Nationwide 27 permit, and the Section 106 programmatic agreement with the State Historic Preservation Officer (SHPO).

1) The Section 7 ESA consultation was completed and signed on September 14, 2005. It is an Intra-Service Section 7 Biological Evaluation with the determination of may affect, but is not likely to adversely affect species (Shasta crayfish).

2) The Project automatically qualifies for an Army Corps Nationwide 27 permit, because the landowner has signed a long-term agreement with USFWS. This non-notification permit requires that the Project comply with all federal laws, cultural resources evaluation, and have a signed agreement with USFWS. California still requires that the Project be certified by the Water Board (some states do not require this, but California does).
3) USFWS signed a Section 106 programmatic agreement with SHPO 6 to 7 years ago. Sucker Springs was designated as an Appendix A project, which are passive undertakings with little or no likelihood of having a significant effect on historic properties. Sucker Springs is considered so altered from historic conditions it is unlikely that cultural resources would be impacted by the Project. If sensitive cultural resources are found then the project would need to be re-evaluated.

D. Spring Rivers has completed a draft of the Water Quality Certification application. Dennis Heiman has been the contact with the Regional Water Quality Control Board. Rhonda asked to be notified if Dennis sends the application on to Jim Canaday at the State Water Quality Control Board because she has a good working relationship with Mr. Canaday.
E. Need to talk to Alison McDougal, PG&E's cultural resources specialist, about Native American involvement and observers. Alison has a good rapport with the Pit River tribes. Maria can contact Alison directly to be apprised as to any potentially sensitive sites and to consult about appropriate Native American involvement and observers.
F. Are there any permits required by Shasta County? [Upon further post-meeting research—the Project will need a County Grading Permit based on the area of land disturbed.]
G. Rhonda stated that it was probably time to prepare a revised budget for the Sucker Springs Restoration Project.
H. Maria provided an update of the Sucker Springs Eradication surveys. Signal crayfish [mostly young-of-year (YOY) and juveniles] are still found during surveys of ponds 4 & 3; a few signal crayfish have been found in Pond 2 as well. [During 2005, 377 signal crayfish (40 adult, 142 juvenile, 195 YOY) were found in Pond 4, 128 signal crayfish (20 adult, 44 juvenile, 64 YOY) were found in Pond 3, and 7 signal crayfish (5 adult, 2 juvenile) were found in Pond 2.]
   1) During experimental trials in a wading pool, electrofishing has not been successful in either creating taxis or killing crayfish. [Existing literature (Westman et al. 1978, Rabeni et al. 1997) reports that electrofishing is an effective means of sampling crayfish. The 1978 paper states that higher voltage (~ 500 to 700 volts), non-pulsating (i.e., smooth) current creates galvanotaxis with crayfish. Modern electroshockers tend to overload over 400 volts.]
   2) Glenn Yoshioka (CDFG) asked whether the anode was within 10 to 12 inches of the crayfish. Maria said that it had been.
I. Theo Light (Shippensburg University) asked about potential effects of high water events on Sucker Springs.
   1) High water events in the Pit River do back water up into Sucker Springs.
   2) The barriers will still be effective even if there is no flow or reverse flow.
   3) The lateral wings that will be installed on the Pond 5 barrier should keep crayfish from moving around the barrier at high water.
   4) The lowest point of land between the Pit River and Sucker Springs is the road right before the gate into the fenced area of Sucker Springs.

5) After high water events, we will need to survey Sucker Springs to see if any signal crayfish got in.

III. Recovery Team—CDFG Temperature Study Update

A. Steve Baumgartner provided an update on the CDFG Temperature Study.
1) Steve handed out a figure of the mean monthly juvenile signal crayfish length with 95% confidence intervals.
2) Signal crayfish continue to grow faster in the 56 degree F water.
3) Mortality in the two temperature treatments leveled off after June. Only 2 or 3 signal crayfish have died in each treatment since June. Fifty young-of-year (YOY) signal crayfish were placed in each temperature treatment in December 2004; now there are 26 signal crayfish in the 56 °F water and 23 signal crayfish in the 50 °F water.
4) Steve pointed out that the size variation of signal crayfish in the warmer treatment was greater than in the 50 °F treatment.
5) Maria commented that the variation in size is more than 8mm in length, which is impressive (from less than 11 mm TCL to greater than 19 mm TCL). This variation is what makes it so difficult to distinguish age classes of crayfish.
6) [Two gravid female Shasta crayfish from Crystal Lake were placed in each temperature treatment on May 20, 2005. On August 5, 2005, 49 YOY Shasta crayfish were found and replaced in the 56 °F treatment and 50 YOY Shasta crayfish (of the 52 YOY found) were replaced in the 50 °F treatment. Spring Rivers returned all four adult Shasta crayfish and two YOY Shasta crayfish to Crystal Lake on August 5, 2005.]
7) Steve has been feeding and caring for the YOY Shasta crayfish, but has not counted or measured them due to their small size. Maria agreed with Steve that it is best not to handle the YOY crayfish when they are very small.

IV. TRC—Big Lake Levee Work

A. Rhonda provided a brief history of the Pit 1 Levee system, including PG&E's earlier attempts to get the levees from the Project area and to give the McArthur Swamp and levees to the California Waterfowl Association.
1) PG&E's Army Corps of Engineers permit and associated USFWS Biological Opinion and Incidental Take Statement cover all levee maintenance activities through April 30, 2008.
2) The USFWS Incidental Take Statement states that no in-water dredging is to take place within Big Lake, Ja She Creek, and the Tule River upstream of the no in-water dredging delineation, which is one-mile upstream of the confluence of the Tule and Little Tule rivers.

B. Maria showed pictures of the work currently being done on the Big Lake levees.
1) PG&E is using primarily small (1.5-inch maximum) gravel substrate on the water-side of the levee to buttress an approximately 500-meter section of the Big Lake levee.
2) Smaller substrate was chosen (instead of conventional larger rip rap) in order to minimize the amount of crayfish habitat created.
3) Gravel was trucked in and placed in piles spaced evenly down the levee. A dozer then pushes the gravel onto the water-side of the levee.
4) Both the size of the added substrate and the generally solid band of tules along the water-side of the levee combine to make the gravel placement on the Big Lake

levees much less likely to impact Shasta crayfish habitat than the large rip rap used along the Tule Lake levees (west of Rat Farm). Most of the gravel that is pushed onto the water-side of the levee is stopped in the shallows at the vegetation so the majority of Shasta crayfish habitat, which is generally on the water-side of the tules, remains unaffected.

5) A PG&E soils/geologist is going to determine how the stabilizing abilities of the gravel material compare to larger rip rap.
6) In the September 2005 letter to USFWS, PG&E stated that the levee in the planned area of in-water activity (work area), as well as a 100-meter buffer area on either side would be surveyed three times in an effort to find and relocate as many Shasta crayfish as possible to Big Lake levee cove, which is east of the work area. These activities are covered under the USFWS Incidental Take Statement.
7) Water clarity conditions, however, were very poor this fall with visibility of no more than 12 inches and often only a few inches. Spring Rivers surveyed approximately 550 meters, which comprised all but 70 meters of the work area, three times. The rest of the area was surveyed two times. Two Shasta crayfish were found and relocated to the Big Lake levee cove.
8) PG&E can further minimize in-water impacts where the levees are steep by using an excavator to press down the top of the levee to create a gentler slope so that less gravel is dumped into the water.

V. TRC—Bowman's Ditch and Springs on Native American and State Park properties

A. Spring Rivers surveyed the springs on Native American property on December 5, 2005. There was some good Shasta crayfish habitat, but the total area of clean lava cobbles and boulders was less than 10 square meters. The rest of the springs surveyed were shallow and/or had flocculent organic/mud substrate.
B. [The springs and ditch on State Park property need to be surveyed as well.]

VI. TRC—Crayfish Barriers

A. Article 413 of the Pit 1 License requires a plan to construct and maintain a minimum of two exclusion barriers to protect Shasta crayfish habitat from invasion by signal crayfish. The plan needs to 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.
B. Steve handed out a recent e-mail from George Heise outlining his informal thoughts from the May 24, 2005 Barrier Field Meeting.
   1) George is still planning to write a memorandum outlining his thoughts, concerns, and ideas from the May 24, 2005 Barrier Field Meeting.
   2) Steve will continue to remind George that the TRC/Recovery Team would like to see a memorandum outlining George's thoughts, concerns, and ideas from the May 24, 2005 Barrier Field Meeting.
C. Maria showed schematic maps of Spring Creek and Thousand Springs showing all locations where signal crayfish have been found as well as the distribution of Shasta crayfish.

1) Crayfish surveys of upper Spring Creek were done in April 2004 and July, August, and November 2005. [During these surveys, a total of 81 signal crayfish, including 55 YOY, were found in Spring Creek upstream of the culverts.]
2) Crayfish surveys of Thousand Springs and the upper Fall River were done in July and August 2004 and in March, August, and November 2005. Two signal crayfish (1 juvenile, 1 dead adult male) were found in or near the fish trap cove upstream of the potential barrier site in 2005 [and six signal crayfish (2 YOY in 2004, 3 juveniles and 1 adult male in 2005) were found at the confluence with Hideaway Springs downstream of the potential barrier site]. Signal crayfish are abundant in the upper Fall River downstream of the footbridge riffle (RK 39.5).

D. Comments from the TRC
1) The cost of a single barrier is likely to be much greater than the $150,000 maximum for two barriers given in the license.
2) A significant amount of eradication surveys can be done for the cost of a single barrier.
3) Rhonda stated that eradication surveys are an expense project, whereas barrier installation is a capital project. PG&E has been budgeting for a capital project not an expense project.
4) Rhonda also stated that if the cost of a single barrier were significantly greater than the $150,000 maximum for two barriers given in the license (for example $500,000 for a single barrier), PG&E would probably reject it. The TRC would have to push to try to get PG&E to cover costs that are so much greater than required by the license.
5) Woody Elliot (State Parks) expressed concern about the status/upkeep etc. of the barriers in the future. We need to have conservation easements with landowners. Ahjumawi Lava Springs State Park and other parks in the California Department of Parks and Recreation system are being "held in trust for those generations that come after us"—"to the seventh generation and beyond." A barrier at Ahjumawi would be protected into the future.

E. TRC Action Plan for Thousand Springs
1) A barrier at Thousand Springs upstream of the Bear Creek confluence may still makes sense—this is still a crucial measure.
2) A topographic survey of the streambed at Thousand Springs should be done before the end of the year.
3) Increase the frequency and intensity of eradication surveys.
4) Need to experiment with potential barrier materials and biofouling etc.

F. TRC Action Plan for Spring Creek
1) The culverts at the Spring Creek Road crossing are an existing barrier.
2) A lot of eradication can be done for the price of a barrier

G. Crayfish Barrier Plan Update and Action Plan
1) Maria will write a Crayfish Barrier Plan Update and Action Plan for review by the TRC/Recovery Plan ASAP. It will include a table with actions and schedule for Thousand Springs and Spring Creek.
2) Rhonda needs to submit the Crayfish Barrier Plan Update and Action Plan to FERC by December 31, 2005.

VII. TRC—Shasta crayfish in the Pit River upstream of the Pit River Falls (Pit 1 Bypass)

A. Shasta crayfish were found in the mainstem Pit River upstream of the Pit River Falls during surveys this fall. In 1995, Maria found four Shasta crayfish upstream of the Pit River Falls while surveying for freshwater mussels. [On October 6, 2005, 14 Shasta crayfish were found in the 800 meter reach of the mainstem Pit River between the coldwater springs on river right (north) at river kilometer (RK) 87.1 and the Pit River Falls (RK 86.3).] Both signal crayfish (*Pacifastacus leniusculus*) and fantail crayfish (*Orconectes virilis*) were found in this area as well. [Both signal and fantail crayfish were approximately twice as abundant as Shasta crayfish in this area.]

VIII. TRC—Rock Creek Restoration

A. In George Heise's summary of the June 9, 2004 site visit to Rock Creek (dated July 15, 2004), he stated that ground permeability in the areas that may be flooded from the proposed new structure could be checked for the potential to increase filtration losses by percolation testing similar to the test for septic leach fields.
   1) George also requested a more detailed topographic survey of Rock Creek. [This was done in December 2004.]
   2) Maria asked the TRC if they would recommend percolation testing as a means of finding out whether moving the diversion would result in increase filtration losses.
   3) The TRC agreed that percolation testing would be a good next step.

IX. Next meeting is scheduled for 10:00 am to 3:00 pm on April 11, 2005 (Tuesday) at the CDFG office in Redding.

A. Phone meetings may be arranged to discuss potential issues before the next meeting.

Attendees:

Rhonda Shiffman	PG&E Hydro
Dave Longanecker	PG&E TES
Kathy Brown	USFWS Endangered Species
Dan Strait	USFWS Partners for Fish and Wildlife
Woody Elliot	CA Dept of Parks and Recreation
Steve Baumgartner	CDFG
Glenn Yoshioka	CDFG Species Conservation & Recovery
Theo Light	Shippensburg University of PA
Maria Ellis	Spring Rivers Ecological Sciences, LLC

Action Items:

What	Who	When
Shasta crayfish TRC meeting summary notes	Maria/Rhonda	ASAP in Dec.
E-mail Crayfish Barrier Plan Update to TRC/Recovery Team	Maria/Rhonda	ASAP in Dec.
Review and Comment on Crayfish Barrier Plan Update	TRC/Recovery Team	ASAP in December
File Crayfish Barrier Plan Update with FERC	Rhonda Shiffman	by Dec 31st
Talk with Alison MacDougall regarding cultural monitoring/consultation at Sucker Springs	Rhonda/Maria	Before April meeting
5. E-mail/mail Sucker Springs agreements and permits to TRC/Recovery Team (i.e., cooperative agreement, Section 7 ESA consultation, Army Corps Nationwide 27 permit, and Section 106 programmatic agreement with SHPO)	Dan Strait/ USFWS Partners for Fish and Wildlife	December
7. Review 1600 permit application for Sucker Springs	Steve Baumgartner/ CDFG	December
8. Monitor 1600 and CEQA/CESA permitting 9. Keep reminding George Heise that we would like his barrier tour summary 10. E-mail George Heise's barrier tour summary to group		Before April meeting
7. Conduct Thousand Spring channel topography survey 8. Finish draft 1600 streambed alteration permit and send to Steve for review 9. Finish draft water quality certification permit and send to Dave for review 10. Submit 1600 streambed alteration permit and fee to CDFG 11. Submit water quality certification permit and fee to Regional Water Quality Control Board 12. Submit County Grading permit and fee to Shasta County 13. Verify distribution of rough sculpin in Sucker Springs	Maria Ellis/ Spring Rivers	December
14. Prepare a scope and budget for eradication surveys upstream of Spring Creek Road crossing (including safety measures in the vicinity of the culverts). 15. Test potential barrier materials for biofouling etc. 16. Signal crayfish eradication surveys in 1000 Springs and Spring Creek 17. Revise budget for Sucker Springs Restoration Project 18. Survey springs and Bowman ditch on State Park property 19. Survey detached headwater pools on Ja She Creek 20. Determine the change in water surface elevation upstream of the barrier, if installed 21. Do Percolation Testing at Rock Creek 22. Keep Peter Stent and Spring Creek Ranch landowners/ managers in the loop	Maria Ellis/ Spring Rivers	Before April meeting
1. Prepare preliminary design of Thousand Springs barrier 2. Determine method, design, and cost for adding a smooth concrete face around the upstream end of the culverts to remove any potential crayfish refuge	PG&E Engineers	Mid 2006
Submit revised draft Crayfish Barrier Plan with preliminary designs to TRC/Recovery Team	PG&E	July 2006
TRC/Recovery Implementation Team meeting	TRC/Recovery Team	April 11, 2006

Shasta Crayfish Technical Review Committee
April 2006 Meeting Summary

The following is a summary of the Shasta Crayfish Recovery Team and Technical Review Committee meeting held in Redding on April 4, 2006.

I. Rhonda Shiffman (PG&E) reviewed the agenda for the meeting
II. TRC—Thousand Springs Ranch (TSR) Crayfish Barrier
   A. Maria Ellis (Spring Rivers) briefly summarized the 22 February field meeting with Ed Hudson, senior civil engineer with Devine Tarbell and Associates (DTA), and Ken Leung, senior civil engineer with PG&E. The meeting summary was e-mailed to the TRC on 3 April.
   B. Ken Leung (PG&E engineer) provided some additional details about the DTA proposal for the initial design and construction plan for the TSR barrier. From the design and engineering perspectives, a barrier needs to both meet the biological objectives and minimize disturbance to the existing channel and aesthetics.
   C. Ed Hudson (DTA engineer) gave a PowerPoint presentation on the conceptual layout of a barrier at TSR including: (1) general requirements; (2) conceptual alternatives being considered for a crayfish barrier (i.e., post and barrier, concrete footing in fabric with stainless steel barrier attached on the downstream side, pre-cast anchor blocks with stainless steel barrier attached on the downstream side, and a partial pipe section attached to a concrete footer); and (3) shore construction with the use of coffer dams. The PowerPoint presentation is being e-mailed to the TRC with the meeting summary.
   D. Comments
      1) The best barrier would be (a) 100% effective at blocking crayfish migration, (b) have a minimally invasive design (both to the channel and surrounding area during construction and visually after installation), and (c) could be removed leaving little or no trace (i.e., if the barrier was no longer functioning or necessary or if the landowner would like it to be removed). Each alternative had different pros and cons. It could be possible to use a combination of alternatives. A couple of pros and cons for use of pre-cast anchor blocks are:
         a) A crane, which would probably be necessary for installation of the pre-cast anchor blocks, was considered pretty invasive.
         b) Pre-cast concrete can be painted or dyed to blend in better.
      2) The two major issues in barrier installation will be: (1) sealing it to the bottom of the channel so that crayfish cannot crawl or burrow underneath the barrier foundation; and (2) the downstream face of the barrier must be seamless or without contiguous seams that would allow a crayfish to crawl over it.
         a) Theo Light (Shippensburg University of PA) is most concerned about crayfish burrowing. Recent literature from Great Britton shows that signal crayfish do burrow.
         b) Foot of barrier should extend 8–12 inches into the substrate to prevent crayfish from burrowing underneath.
         c) Suggestions to help seal the foundation to the substrate included: (1) removal of loose cobbles and boulders prior to installation of foundation; (2) grout the bottom where there is a space between the foundation and substrate or where there are cracks/crevices in the bedrock; (3) trench along barrier line to create a notch for the foot of the barrier in order to grout it into the substrate better.

d) The erosion mats (i.e., concrete footing in fabric) used in the second alternative would conform to the substrate more than pre-cast anchor blocks. More information on erosion mats can be found at http://armorform.com/page3.html and http://www.geostarcorporation.com/hsproducts.html

⇒ Harry McQuillen (USFWS) would like Steve Baumgartner (CDFG) to ask the CDFG Section 1600 permitting unit within CDFG if a wet concrete could be used to create a smooth base along the surface of the channel. The group thought that this was unlikely due to water quality issues and the caustic, alkaline nature of lime, which is used in concrete for solidification.

3) A more detailed survey of the substrate in the vicinity of the potential barrier site is needed.

⇒ Survey the substrate so that a detailed map of the substrate in the area between Rick's transect location and the confluence with Bear Creek can be compiled, including the depth of finer substrate, the presence/absence of crevices and cracks in the bedrock, and water depth.

4) Barrier installation will need to involve fairly detailed and tedious construction, i.e., like dental work.

5) An epoxy coating that meets EPA standards for safe drinking water could be applied on site.

6) The barrier probably will not result in a significant increase in the water level elevation upstream.

7) The wing dams on shore would angle downstream \ | ↑ | / and would not need to be any longer than 15 to 20 feet and could possibly be shorter.

8) It is important that the headwaters of the Fall River remain non-navigable in order to minimize the chance of introduction of non-native crayfish upstream of the barrier.

a) Periodic surveys and removal downstream of the barrier would help control the signal crayfish population and lower the invasion rate.

9) Bear Creek flooding is an issue for the potential introduction of non-native crayfish upstream of the barrier. Need to incorporate measures to keep signal crayfish out of Bear Creek.

a) A berm along the river-right side of Fall River between Fall River and Bear Creek was suggested. How high would the berm need to be? Would it be an eye-sore? Harry doesn't think a berm is the answer.

⇒ Write up a risk assessment for Bear Creek flooding and introducing non-native crayfish upstream of the barrier. Include steps to minimize the introduction of signal crayfish into Bear Creek and hence into the upper Fall River.

10) PG&E will check on whether PG&E can sole source the construction of the barrier or do it in-house

11) PG&E would own the barrier not the landowner.

12) TSR Barrier will undoubtedly need an EIS/EIR.

E. TRC Action Plan for Thousand Springs Barrier

⇒ PG&E will put together a matrix with each alternative outlining pros and cons and estimated cost. If one of the alternative stands out as superior to the others state so and why.

⇒ Conference call with TRC in order to decide/agree on best alternative.

⇒ Start writing the plan for the TSR barrier now.

III. TRC—Spring Creek Culvert Refacing Project

A. Maria gave a brief overview of the basic construction plan for refacing the upstream side of the Spring Creek Road crossing and culverts as outlined in the 21 March field meeting summary with Clay Lavigne, Senior Construction Foreman with PG&E Hydro, which was e-mailed to the TRC on 3 April.
B. Rough sculpin are likely to be the only major biological issue. Harry suggested that once the lower portion of the form was in place, snorkel surveys could be done to remove all rough sculpin so that no take would occur, which would simplify the process.
C. The TSR and Spring Creek Barrier projects should be permitted separately.
D. It might be possible to tier the Spring Creek Culvert Refacing Project off the original Spring Creek Culvert Replacement project completed in 2000. Otherwise, ACOE would be NEPA lead and CDFG would be CEQA lead because of the rough sculpin.
E. Maria will put together a brief project description from the 21 March meeting summary and make pdf files of all the 1999–2000 permits pertaining to the original project and e-mail it to Harry and Steve. Harry will initiate an informal consultation with ACOE and Steve will run it by the 1600/CEQA office.

IV. TRC—Rock Creek Restoration
A. As soon as the ground dries out a bit, percolation testing will be done to test the ground permeability in the areas that may be flooded from the proposed new structure in order to determine the potential for increase filtration losses if the diversion was moved downstream.

V. TRC—Shasta Crayfish Survey Update
A. Ja She Creek upstream of the State Park road crossing will be resurveyed this spring. This will provide an up-to-date status on both the Shasta crayfish and signal populations in this area. This new data will help decide whether installation of a crayfish barrier in Ja She Creek would be a beneficial recovery measure.
1) Harry said that funding for another crayfish barrier might be available through Section 6 funding if the property is State Park land or through Partners for Fish and Wildlife if the property is PG&E land.
2) A Barrier in combination with a signal crayfish eradication program could help ensure the future of the Ja She Creek Shasta crayfish population. Eradication is needed for recovery; control of signal crayfish numbers is not a recovery criterion.
3) Need to document the substrate to determine the relative ease of signal crayfish removal and/or eradication.
B. Partners for Fish and Wildlife really likes partnerships involving Native American Tribal Lands. Spring Rivers surveyed Bowman's Springs on the Native American property on December 5, 2005. There was some good Shasta crayfish habitat, but the total area of clean lava cobbles and boulders was less than 10 square meters. The rest of the springs surveyed were shallow and/or had flocculent organic/mud substrate. Bowman's Springs and Ditch on State Park property still need to be surveyed.

VI. Recovery Team—Sucker Springs Restoration Project
A. Permitting Status
1) 1600 Streambed Alteration Permit (and CEQA/CESA) received on 4/25/06
2) Water Quality Certification—filed application with Regional Water Quality Control Board
3) Section 7 ESA consultation, Army Corps Nationwide 27 permit, Section 106 programmatic agreement with the State Historic Preservation Officer (SHPO)—Completed

⇒ Spring Rivers will talk to Alison McDougal, PG&E's cultural resources specialist, to be apprised as to any potentially sensitive sites and to consult about appropriate Native American involvement and observers. Further consultation with SHPO may be required.

B. Maria provided an update of the Sucker Springs Eradication surveys. She showed three figures, which are attached to this summary.

C. Ron Jackman, bald eagle biologist contracted by PG&E, has found bald eagles using Pond 5 of Sucker Springs this winter and early spring while the Pit River has been so high and discolored.
   1) Kathy and Harry talked about how the use of Sucker Springs by bald eagles will likely have some effect on permitting.
   2) Maria suggested that we not restore (bring in the streambanks and revegetate) Pond 5 to allow for eagle foraging.
      ⇒ Maria said that she would find out how far the nest was from the Project. The nest, which is upstream of the Pit 1 Powerhouse tailrace, is 0.56 miles from the Sucker Springs Ponds. It is also not in the line-of-sight and there are a lot of trees separating the nest from the ponds, which Mark Jenkins (PG&E biologist) says is good.

VII. Recovery Team—CDFG Genetic and Temperature Studies Update

A. Steve Baumgartner provided an update on the CDFG Genetic Study being conducted by Bernie May, Ph.D. at University of California, Davis Genomic Variation Laboratory.
   1) Jessica Petersen, a doctoral student in Bernie May's lab, reports that there appears to be a fair amount of variation between the populations sampled to date.
   2) Of all the species that have been worked on in the Genomic Variation Lab, Shasta crayfish have been the most challenging species to find markers on.

B. Steve Baumgartner provided an update on the CDFG Temperature Study.
   1) Signal crayfish continue to grow faster in the 56 degree F water as compared to the 50 °F treatment.
   2) Shasta crayfish in both treatments are still too small to measure. There is no measure of Shasta crayfish mortality, but it appears to be minimal.

VIII. Next meeting is scheduled for 10:00 am to 3:00 pm on November 1, 2006 (Wednesday) at the CDFG office in Redding.

A. Conference call to discuss barrier alternatives tentatively set for May 10th at 10:00 am.

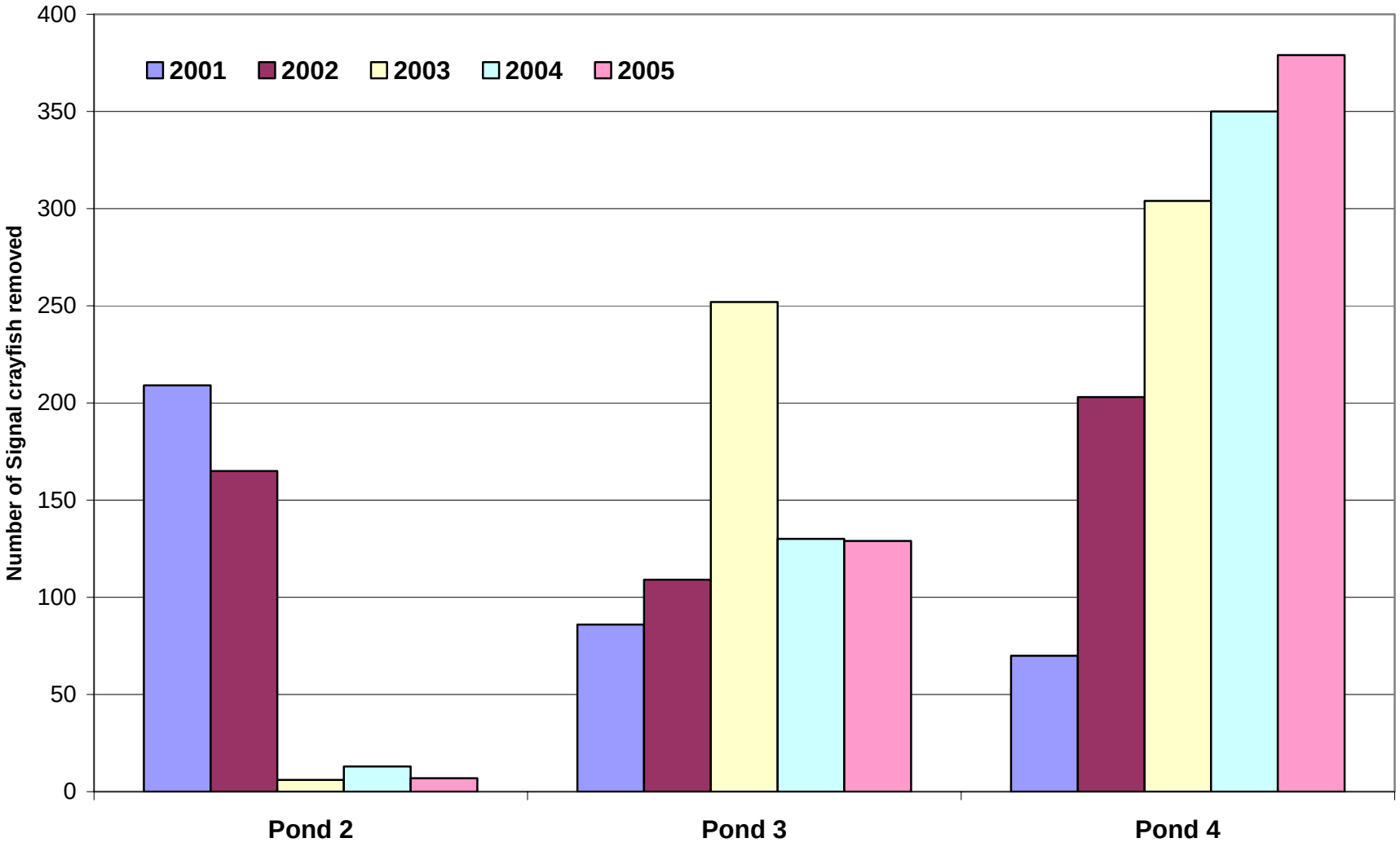
Attendees:

Rhonda Shiffman	PG&E Hydro
Dave Longanecker	PG&E TES
Jason Vann	PG&E TES
Kathy Brown	USFWS Endangered Species
Harry McQuillen	USFWS Conservation Partnership
Woody Elliot	CA Dept of Parks and Recreation
Steve Baumgartner	CDFG
Glenn Yoshioka	CDFG Species Conservation & Recovery
Theo Light	Shippensburg University of PA
Maria Ellis	Spring Rivers Ecological Sciences, LLC
Ed Hudson	Devine Tarbell and Assoc. Engineer
Ken Leung	PG&E Hydro Engineer

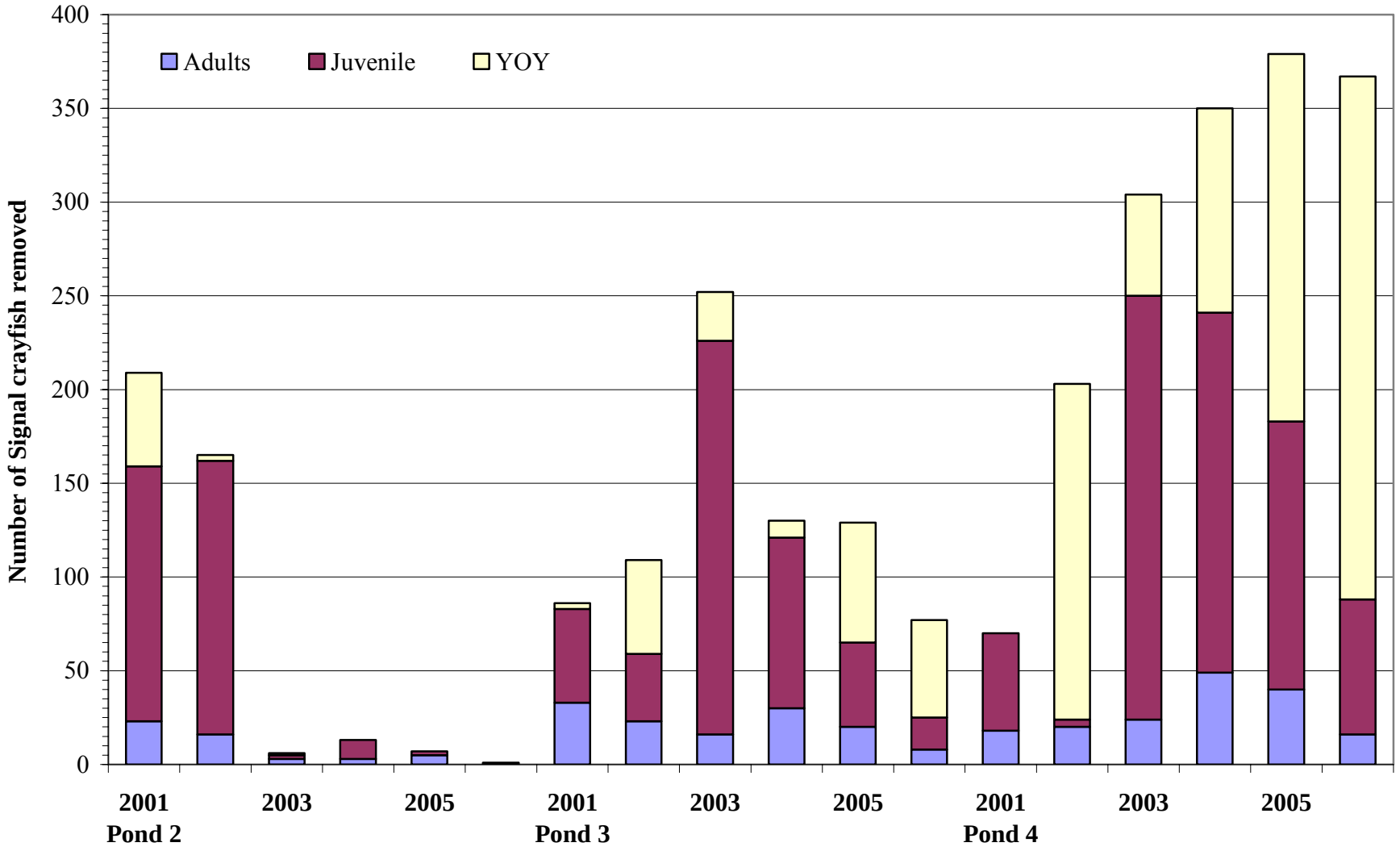
Action Items:

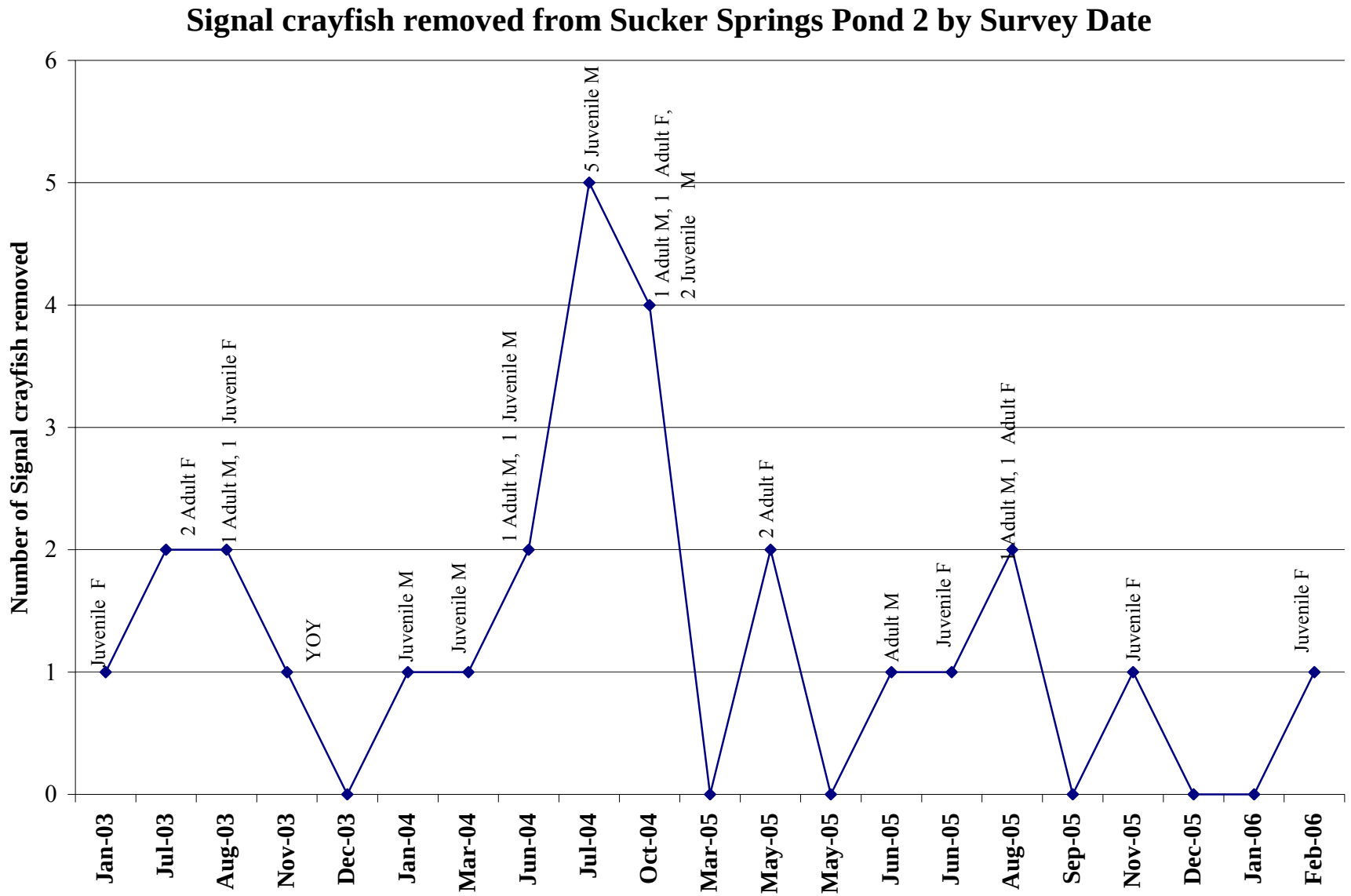
Project	Task	Who	When
	Shasta crayfish TRC meeting summary notes	Maria Ellis	ASAP
	E-mail DTA presentation, erosion mat references, Sucker Spring Eradication figures to TRC/Recovery Team	Maria Ellis	ASAP
Sucker Springs	Talk with Alison MacDougall regarding cultural monitoring/consultation at Sucker Springs	Maria Ellis	ASAP
TSR Barrier	Contact Peter Stent about TSR substrate survey	Maria Ellis	ASAP
TSR Barrier	Compile and provide DTA with detailed map of the TSR substrate between Rick's transect location and the confluence with Bear Creek, including the depth of finer substrate, the presence/absence of crevices and cracks in the bedrock, and water depth.	Spring Rivers	ASAP
TSR Barrier	Confirm with CDFG1600 permitting staff if a wet concrete can be used to create a smooth base along the surface of the Fall River channel.	Steve Baumgartner	ASAP
TSR Barrier	Put together a matrix with each TSR Barrier alternative outlining pros and cons and estimated cost. If one of the alternative stands out as superior to the others state so and why.	Ed Hudson, DTA (Ken Leung)	May
TSR Barrier	Conference call with TRC in order to decide/agree on best alternative for TSR barrier.	Rhonda Shiffman/TRC	May
TSR Barrier	Start writing the plan for the TSR barrier	Maria Ellis/ Rhonda Shiffman	May
TSR Barrier	Confirm if PG&E can do the construction of the TSR barrier in-house? Also, verify if PG&E can sole source it?	Rhonda Shiffman	May
TSR Barrier	Write a risk assessment for Bear Creek flooding and introducing non-native crayfish upstream of the TSR barrier. Include steps to minimize the introduction of signal crayfish into Bear Creek and hence into the upper Fall River.	Maria Ellis—1st draft	May/June
Crayfish Barrier Plan	Submit revised draft Crayfish Barrier Plan with preliminary designs to TRC/Recovery Team and FERC for 60-day review.	PG&E	June 20, 2006
Spring Creek Refacing	Start permitting for Spring Creek Culvert Refacing Project Prepare a scope and budget for eradication surveys upstream of Spring Creek Road crossing (including safety measures in the vicinity of the culverts).	Maria Ellis	May/June
Barrier	Signal crayfish eradication surveys at TSR and Spring Creek Keep Peter Stent and Spring Creek Ranch landowners/ managers in the loop	Maria Ellis/ Spring Rivers	Continue
Crayfish Barrier Plan	TRC/Recovery Team submit comments on the revised draft Crayfish Barrier Plan	PG&E	by August 19, 2006
Crayfish Barrier Plan	File revised Crayfish Barrier Plan with FERC	PG&E	August 31, 2006
Sucker Springs	Revise budget for Sucker Springs Restoration Project	Maria Ellis	2006
Rock Creek	Do Percolation Testing at Rock Creek	Spring Rivers	2006
Pit 1 License /Barriers	Survey springs and Bowman ditch on State Park property Survey Ja She Creek including detached headwater pools	Spring Rivers	2006
	TRC/Recovery Implementation Team meeting	TRC/Recovery Team	November 1, 2006

Number of Signal crayfish removed from Sucker Springs by Pond and Year



Life Stage of Signal crayfish removed from Sucker Springs by Pond and Year




Signal crayfish removed from Sucker Springs Pond 2 by Survey Date
Number of Signal crayfish removed
0
1
2
3
4
5
6
Juvenile F
2 Adult F
1 Adult M, 1 Juvenile F
YOY
Juvenile M
Juvenile M
1 Adult M, 1 Juvenile M
5 Juvenile M
1 Adult M, 1 Adult F, 2 Juvenile M
2 Adult F
Adult M
Juvenile F
1 Adult M, 1 Adult F
Juvenile F
Juvenile F
Jan-03
Jul-03
Aug-03
Nov-03
Dec-03
Jan-04
Mar-04
Jun-04
Jul-04
Oct-04
Mar-05
May-05
May-05
Jun-05
Jun-05
Aug-05
Sep-05
Nov-05
Dec-05
Jan-06
Feb-06

APPENDIX C—BARRIER FIELD MEETINGS ON 24 MAY 2005, 22 FEBRUARY 2006, AND 21 MARCH 2006 AND SUCKER SPRINGS CREEK FIELD MEETING ON 7 SEPTEMBER 2005

Barrier Field Tour
May 24, 2005

The agenda and attendees of the May 24, 2005 (10:00 am to approximately 3:00 pm) Barrier Field Tour of potential barrier sites on the upper Fall River at Thousand Springs Ranch and on Spring Creek on Spring Creek Ranch is provided. The May 25, 2005 e-mail from Harry McQuillen of USFWS that summarizes the courses of action and discussion points is also provided.

Crayfish Barrier Sites Field Tour Agenda

1000 Meet at the Ranch Office at Thousand Springs Ranch
1015 Potential barrier site in Fall River upstream of the Bear Creek confluence
1200 Lunch at Thousand Springs Ranch
1300 Drive to Spring Creek Ranch and look at the potential barrier site on Spring Creek
1500 Field tour completed

Attendees:

Rhonda Shiffman	PG&E Hydro
Dave Longanecker	PG&E TES
Ken Leung	PG&E Senior Civil Engineer
Harry McQuillen	USFWS Recovery
Lori Rinek	USFWS
Annie Manji	CDFG
Randy Benthin	CDFG
Steve Baumgartner	CDFG
George Heise	CDFG Hydraulic Engineer
Maria Ellis	Spring Rivers Ecological Sciences, LLC
Jeff Cook	Spring Rivers Ecological Sciences, LLC
Peter Stent	Landowner Thousand Springs Ranch
Rick Poore	StreamWise
Mary Rickert	Manager, Spring Creek Ranch

From: Harry_McQuillen@fws.gov
Sent: Wednesday, May 25, 2005 4:45 PM
To: Maria Ellis; Jeff Cook; sbaumgartner@dfg.ca.gov; rbenthin@dfg.ca.gov; RxSm@pge.com; DRL3@pge.com; AManji@dfg.ca.gov
Cc: Lori_Rinek@fws.gov; Kathy_Brown@fws.gov

Subject: 1000 Springs ranch/Spring Creek site visit: courses of action, discussion points, etc.

Hello Everyone:

Thanks for a great site visit yesterday. I am summarizing what I thought were the courses of action and/or discussion points from yesterday's visit.
If I am incorrect, please correct me. I am also adding my version of a timeline on when we can expect things to happen---much of which is based on other recovery actions we have going around the state---although it is subject to how well things go (i.e., permitting).

One important note---Randy reiterated numerous times the need for us all to be on the same page all the time. Since we all have managers holding us accountable, it is important to keep everyone in the loop every step of the way. I agree completely, so if I forgot someone from this email that was on the site visit, please forward it to them (i.e., I don't have email addresses for George, Ken, Peter, etc.).

Thousand Springs Ranch
The landowner has a list of needs that will need to be addressed prior to/during the project. Peter stated he "would like to see things remain the same" at the ranch. Specifically, Peter stated to me that he wants:

1) to make sure that his lawn was not flooded,
2) to make sure the vegetation along the embankment is not affected by increased water depths,
3) to make sure the vegetation, paths, etc. are not destroyed too much during construction,
4) to make sure the aesthetics of the ranch reamin intact (i.e., does not want to see a bright, shiny stainless steel barrier in the middle of the river),
5) to make sure the trout spawning areas are not affected by the installation and mainenance of the barrier,
6) to make sure the rough sculpin, squaw fish et al. are not isolated or affected by the barrier,
7) to know how many people will be coming to the ranch during and after construction of the barrier and,
8) to have some assurance that the barrier can be removed if it does not work, or if he decides to walk away from the project.

Next steps:

1) map the topography of the streambed (Jeff/Rick??)
2) design a barrier that will work at the site (Ken/George??)
3) test materials at Thousand Springs Ranch and test barrier design in real-world environment (Spring Rivers ES??)
4) review by all (especially Peter) and make a decision to proceed (All)
5) permitting (NEPA, CEQA, Section 7, CESA, 404, 401, R&H10, SHA, etc.) (CDFG & FWS)

6) Review and final decision to proceed (FWS and CDFG)
7) Install barrier (All)

Timeline: # 1-6 over the course of next year with installation of barrier (#7) summer 2006

Spring Creek

Proposed barrier site appears more difficult than at Thousand Springs Ranch. Is it logical to put in a barrier when there is essentially a barrier (culverts) directly downstream? Jeff mentioned that 2 years ago there were only "tens" of signals upstream from the culverts; status is unknown now. The following suggested course of action is based on that conversation with Jeff, Steve, myself, et al.:

1) survey Spring Creek above the culverts and estimate how much work it would take for full-scale eradication of signals above culverts (Spring Rivers ES),
2) If the survey results indicate we can eradicate signals upstream of the culverts, prepare a scope of work and budget for full-scale eradication and reinforcement/modification of culverts, including appropriate safety equipment or actions for working around the culverts (Spring Rivers ES).
3) Conduct full-scale eradication of signals upstream of culverts and reinforce/modify culverts as barrier (Spring Rivers ES)
4) If eradication is successful, explore the possibility of installing a barrier about 50 m upstream of culverts as a "safety net" in case signals are accidentally reintroduced to the upstream side of the culverts.

Timeline: 1-3 over the course of the next year, with demonstration of at least one (??) full breeding cycle without signals upstream.

If eradication is not possible, begin preliminary design(s) for barrier installation. Barrier should not be installed prior to Thousand Springs Ranch barrier so we can learn from our mistakes (if any).

Hopefully this is close to what everyone else understood, if not, please let me know so we can discuss.

Thanks Harry

Summary of 22 February 2006 Crayfish Barrier Field Meeting at Thousand Springs Ranch and Spring Creek Road Crossing

From: Jeff Cook
Date: 7 March 2006 (revised 10 March 2006)

Participants: Jeff Nibert and Ken Leung (PG&E), Ed Hudson (Devine Tarbell and Associates), Jim Gilligan and Gary Welsh (Thousand Springs Ranch), Maria Ellis and Jeff Cook (Spring Rivers)

Topics for Discussion:

- Barrier design concerns, including
    - In-water and out-of-water portions
    - Design to protect against muskrat , beaver, and other animal damage
- Possible materials
- Construction issues
- Placement considerations
- Possible impacts of the barrier on hydraulics and water surface elevation upstream
- Maintenance considerations, including
    - Barrier stability and cleaning
- Spring Creek Culvert re-facing

Participants met at the Thousand Springs Ranch office at 9:00 AM. After introductions, participants proceeded to the main house parking area. For purposes of orientation (for Jeff Nibert and Ed Hudson, who had not seen the site before), the bathymetry/topography map and cross-sectional profile of the channel near the proposed location of the barrier was reviewed. Schematics of the channel cross-section, including typical bed composition, and conceptual barrier design (included as attachments below) were also reviewed and discussed.

Ken asked questions about the channel bottom material and noted that the presence of the bedrock sill, exposed and at shallow depth, could pose problems for the construction of the type of foundation/footer shown in the schematic (Attachment C). From the design and engineering perspectives, a barrier should both meet the biological objectives and minimize disturbance to the existing channel and aesthetics. He proposed an alternative design that would use an **erosion mat** (i.e., shallow concrete armoring mat) laid on top of the streambed in place of the subsurface foundation. According to Ken and Ed, these are something like large tubes of a rubberized material that are rolled into place and then pump-filled with some sort of mortar or concrete material. This would result in a flattened sausage-shaped structure that conforms to the streambed surface and provides a gravity anchoring system without extensive foundation excavation in water. Where the tube would sit on solid rock or any uneven surfaces, a mortar material could be injected between the tube and the surface to create a tight seal; this application could be done in a precision manner into just the locations needed. Presumably this could work both for the tube and the barrier face. Where the erosion mat would sit on sand/gravel, mortar would not be necessary. It is likely to be necessary in these locations, however, to bury the edge of the barrier deeply enough into the substrate to ensure that crayfish could not burrow underneath it. A significant potential advantage of this type of foundation is that it could be more easily removed than a buried foundation in the event that the barrier proves to be either unsuccessful or unsuitable in the eyes of the property owner at some time in the future.

Ken raised another alternative subsequent to the field meeting that could work in areas where the channel bed is comprised of bedrock. This alternative would involve bolting the barrier plate to 2" to 3" steel posts that could be attached directly into the bedrock. Holes could be drilled into the bedrock (using hydraulic or pneumatic drills) and posts fixed into the bedrock with grout. The base of the barrier plate would be trimmed to fit the creek bed and sealed with grout material to keep disturbance to the creek bed at a minimum. The streambed in the area currently being considered for barrier placement is a combination of bedrock, boulder, and finer material (i.e., gravel and sand). It seems possible that this method could be used in combination with the erosion mat, i.e., a composite foundation could be created with erosion mat over softer material and overlapping onto the bedrock surface and then posts over the bedrock where the mat would not be necessary.

Prior to installation of any barrier design, the barrier site would be prepared by divers removing rocks and other loose debris. Surveys for crayfish could be done at this time as well in order to move all Shasta crayfish from the immediate area to upstream of the barrier location. If necessary, surfaces could be smoothed somewhat to accommodate the erosion mat by using an air hammer to chip off high points.

The barrier (i.e., the smooth, vertical face that would prevent crayfish passage) could then be attached to the downstream side of the erosion mat. Attachment could be done by drilling and bolting the face onto the erosion mat foundation.

Ken and Ed agreed that the change in water surface elevation that would result from the placement of a barrier with a one-foot height above the bed would not be substantial or significant: perhaps on the order of a couple of inches, definitely less than half a foot. Additionally, the barrier would not affect or compound the effects of the increased water surface elevation that occurs when Bear Creek floods. Under normal flow conditions, the change in water surface elevation would only increase velocity over the barrier, which would have no negative impacts on barrier effectiveness. Jeff Cook raised the issue that we would not want a velocity increase that could result in an increase in scour at the foot of the structure and undermine its stability. Ken and Ed did not believe that would occur. Because there would not be much of an increase in the water surface elevation upstream of the barrier, increased flow velocities would not be focused at the toe of the barrier.

The group moved out to the water and looked at prime crayfish habitat in the headwater cove and then at the barrier location. The high water mark from this year's flood runoff (early January 2006) had been marked on the lawn and this elevation above the normal water surface prompted discussion of the need to extend the barrier far enough above the water surface to provide protection against upstream migration of non-native crayfish under flood conditions. The peninsula between the Fall River headwater pool and Bear Creek is low and becomes completely inundated even by moderate flood flows. The engineers discussed the possibility of putting up a low berm upon which we could extend the barrier on that side. The extension of a barrier wing along the near bank would pose no problems. In both cases the wing would be run in a downstream slant after clearing the water's edge. We discussed that once the barrier was outside of a typical flood height, it would not need to extend up a foot; six inches would be ample because crayfish cannot reach as high out of water as they can in the water. The out-of-water barrier wings could be easily camouflaged with natural vegetation. The downstream sides of these surfaces would need to be maintained free of vegetation, however, to ensure that vegetation (including grasses, sedges, etc.) could not form "bridges" that could allow crayfish to cross over the barrier.

The need to design the barrier to minimize the potential for muskrat activities to compromise barrier integrity was raised. Muskrat burrows underneath the out-of-water portions of the barrier could provide conduits for crayfish to breach the barrier. Additionally, burrowing activity could structurally

destabilize the barrier. We discussed the incorporation of bank-protection measures into the barrier design at and near the water surface. Jim Gilligan said that they had had reasonable success with their efforts using lava cobbles to revet the banks in front of the main house. A similar effort, in combination with some sort of buried screening under the barrier could be effective.

Because beaver are commonly observed at Thousand Springs, beaver activity was discussed with reference to the possibility that beavers might attempt to use the barrier as a foundation for a dam. It was agreed that while the possibility exists, this kind of beaver activity would be easy to detect and disassemble before it became a problem. None of the participants felt that this possibility would develop into a constant nuisance condition.

Different materials were discussed, including stainless steel, coated stainless steel, plastic lumber, and ultra-high molecular weight polyethylene (UHMW). Gary Welsh of Thousand Springs Ranch suggested UHMW as a potentially better alternative to the plastic lumber, which apparently floats and has almost no structural strength.

The suitability of bank conditions for the barrier was discussed. There was concern that the depth at the cross-section location might be insufficient. Water clarity exacerbated the perception that the barrier would be fully submerged through only about one-third of the channel width at the cross-section location. We discussed moving the barrier location upstream toward the house by approximately 20 ft to get into deeper water and more vertical banks, or setting it diagonal across the channel at a location further downstream. A review of the cross-section depth data, however, showed that there is plenty of depth at any location in the general area for the barrier to be feasible. In the cross-section location, water does not reach one foot of depth until seven feet away from the bank on the near shore (river left) side; otherwise the barrier would be completely submerged. Maria pointed out that there appeared to be some bank retreat at the cross-section location (likely the result of muskrat activity). We discussed the options of either building the bank out 7 to 10 feet in order to allow for a near-vertical drop into greater than 1-foot deep water, or excavating the low-sloping bank to achieve the same effect at the present bank location.

The long-term maintenance of the barrier was discussed. The general plan at this time would be to have divers inspect the condition of the barrier once or twice a year during crayfish surveys. Any necessary cleaning would be done at that time. Any structural maintenance needs would be noted and arrangements would be made following the inspections.

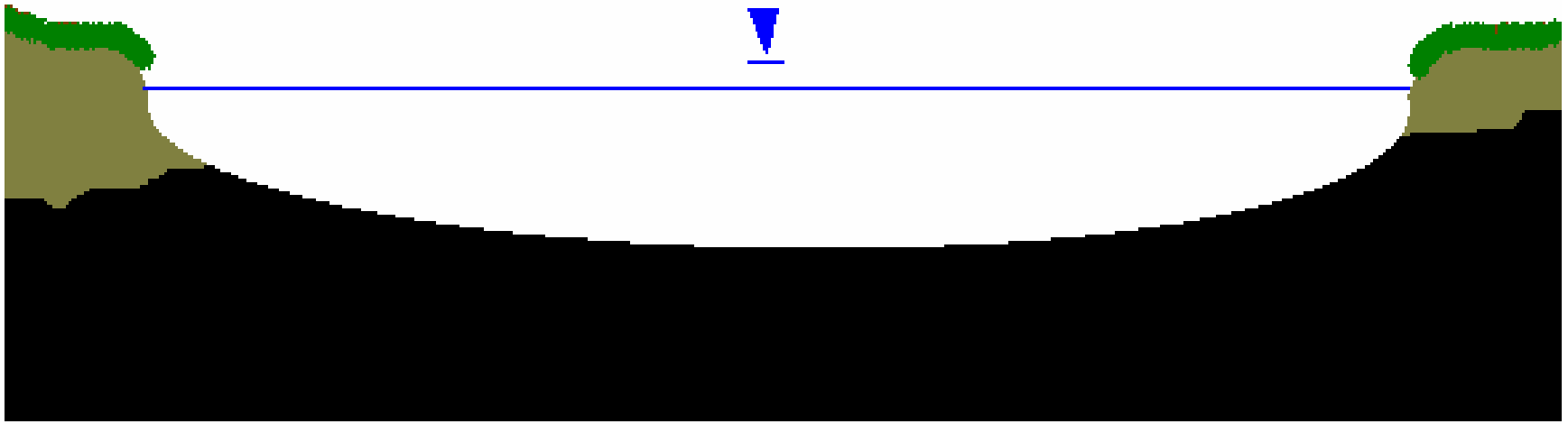
Spring Creek Culverts

Following the meeting at Thousand Springs Ranch, the entire group minus the Thousand Springs Ranch representatives, drove to the Spring Creek Road crossing to discuss the possible re-facing of the culvert foundation in order to eliminate the crayfish habitat that currently exists in the cavities underneath the culverts. After some discussion, Ken said that this was not an engineering problem, but a construction matter with the major concerns being: constructability, concrete mix design, dewatering, and water quality impacts. He recommended that we bring in some of PG&E's construction experts, such as Tom Carrier or Clay Lavigne. Jeff Nibert is following up on these contacts.

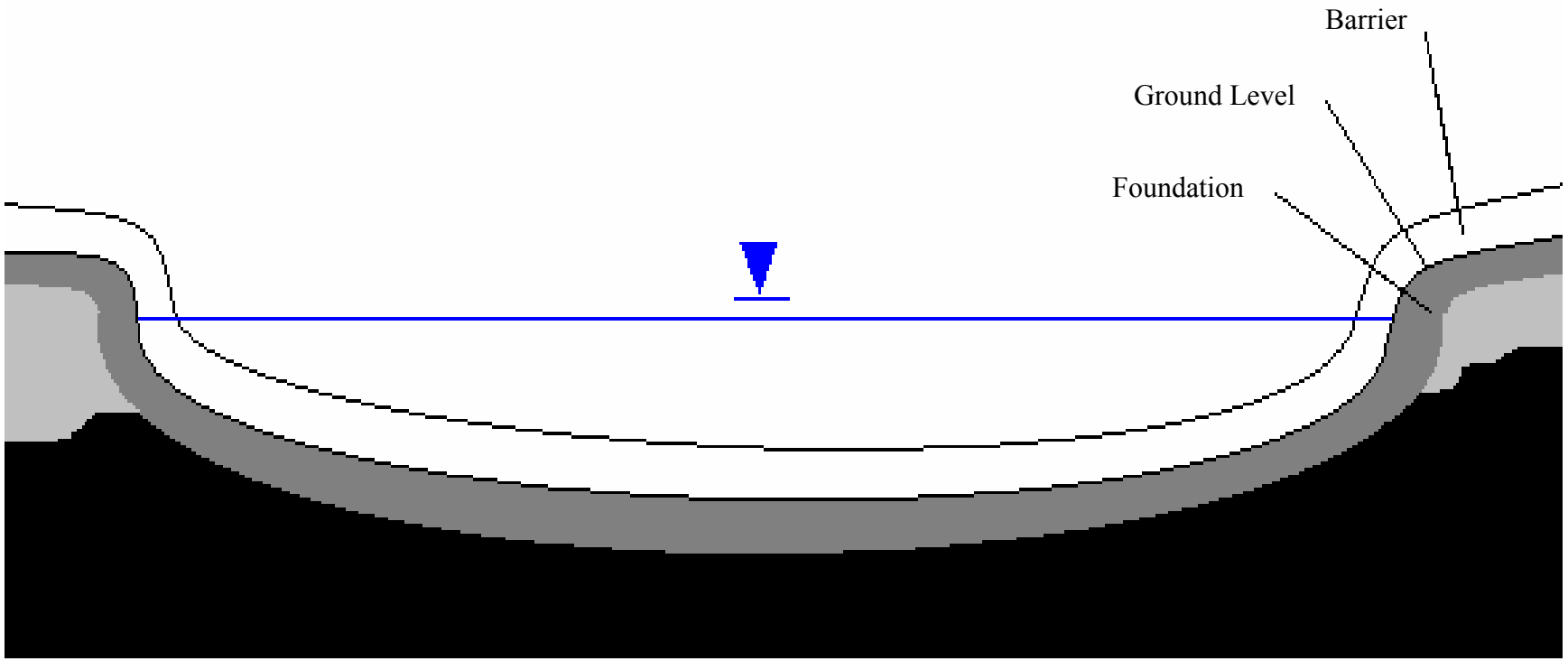
Action Items

Action	Time Frame	Responsible Party
Prepare Barrier Design Proposal	Mid March	Ed Hudson, DTA
Contact PG&E construction experts	Mid March	Jeff Nibert
Conference call w/ Peter Stent to review design proposal	Before April 4 TRC meeting	Maria Ellis, Ed Hudson, Ken Leung

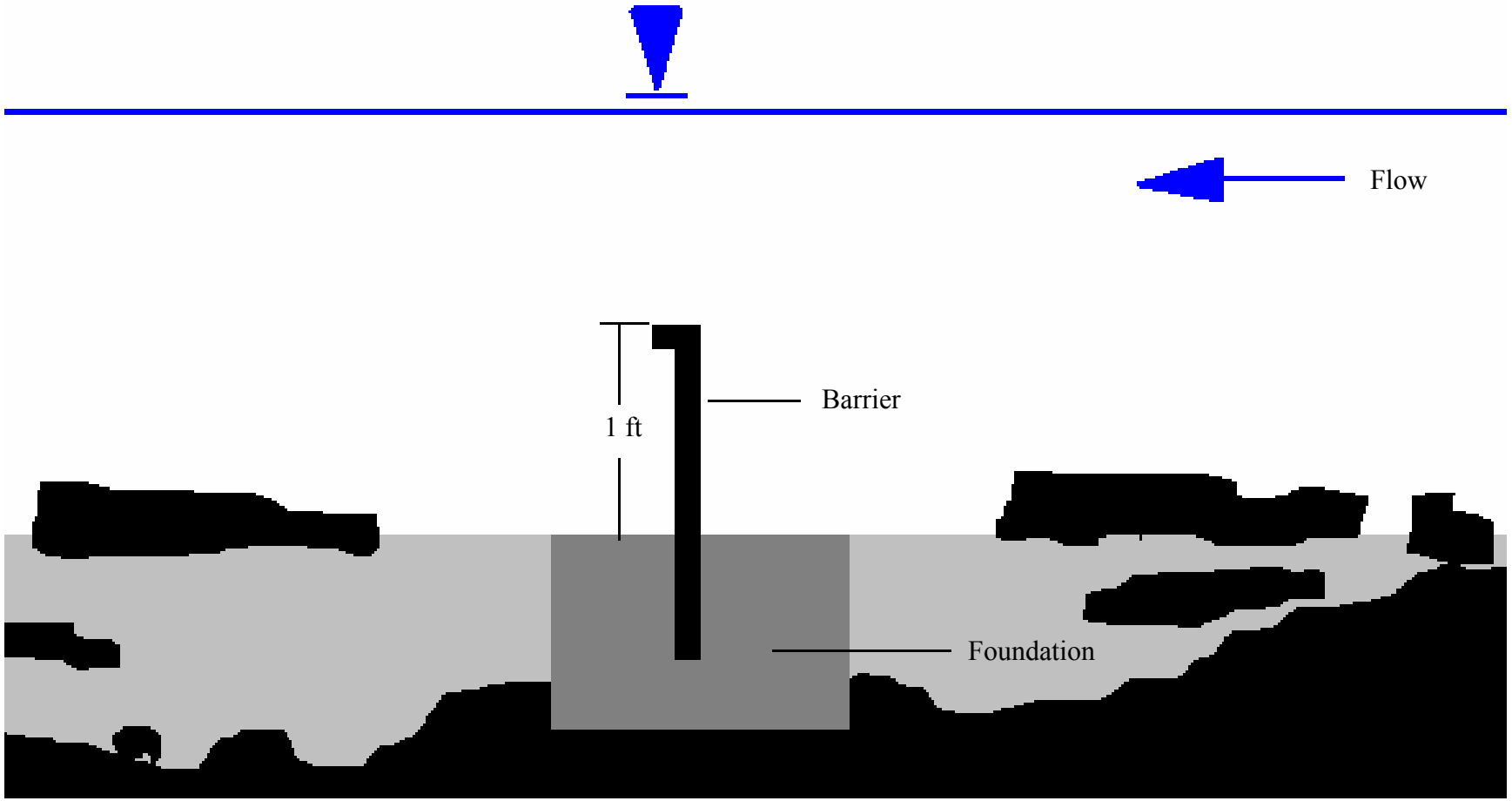
A. River Cross-Section



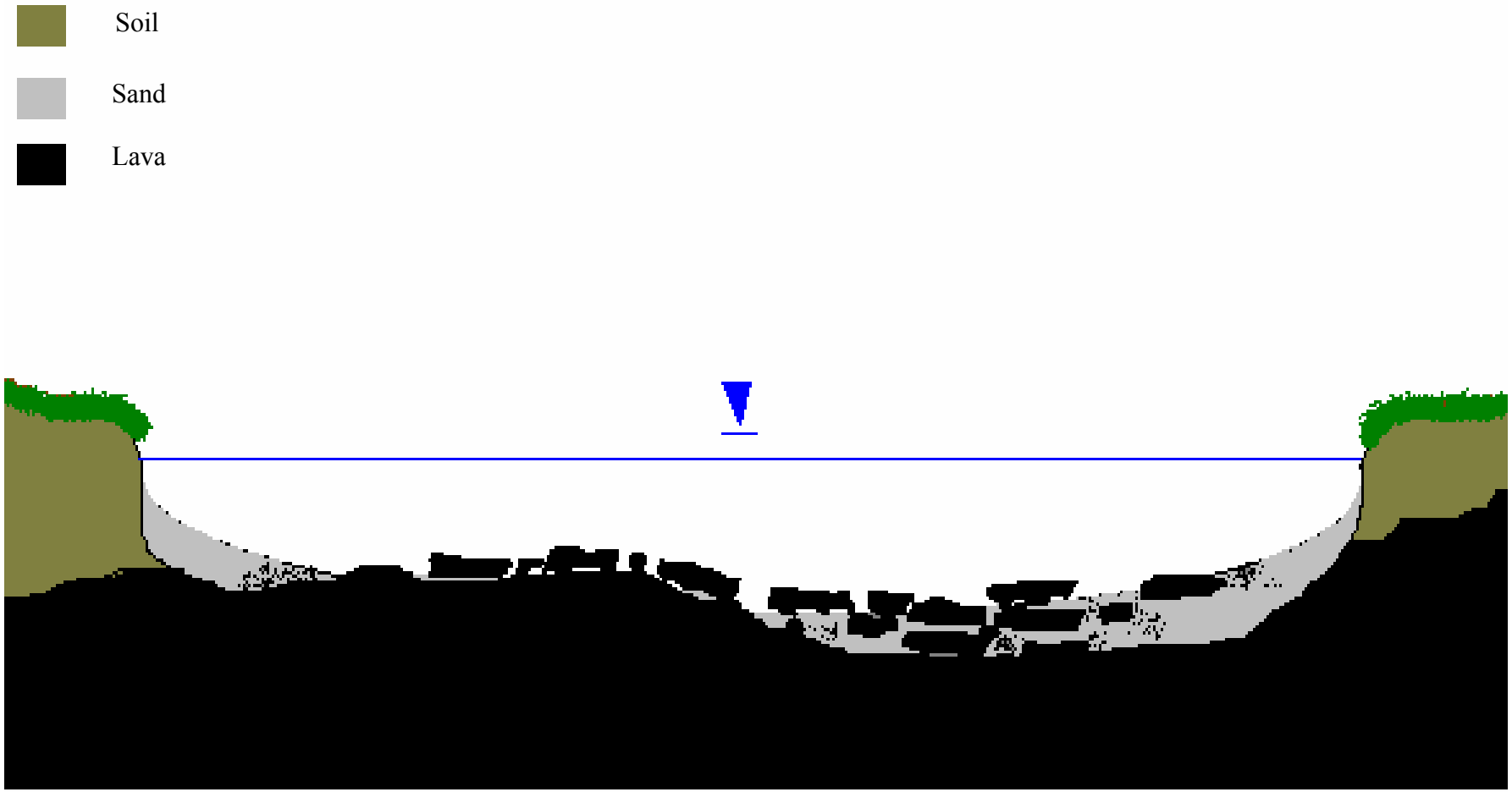
B. Barrier Schematic



C. Barrier/Foundation Cross-Section



D. Substrate Schematic



Summary of 21 March 2006 Crayfish Barrier Field Meeting at Spring Creek Road Crossing

From: Jeff Cook **Date**: 31 March 2006

Participants: Clay LaVigne (PG&E), Maria Ellis and Jeff Cook (Spring Rivers)

Objective: Discuss re-facing the upstream side of the Spring Creek culverts

Maria and Jeff met Clay at the intersection of Cassel Road and Highway 299 and caravanned to the site. Maria and Jeff gave an encapsulated history of the project (i.e., the culvert replacement in 2000), including the rationale, design, execution, and end-result configuration. Clay asked the following four (paraphrased) questions to help him understand conditions around the culverts and what the construction effort would need to account for (Maria and Jeff's answers for each question are included in italics).

1. What are the characteristics of the dominant substrate? *The dominant substrate under the pipes is diatomaceous earth. It is soft, slick, and pliable, but cohesive and relatively resistant to erosion*.
2. How much open space is there between the pipes and the substrate? *The actual freeboard between the pipes and the substrate has not been measured. It is enough for a (slender) adult male diver in a drysuit with BC and tank to squirm underneath. Perhaps 20–24 inches*.
3. Are there larger cobbles or boulders under the pipes? *Most of the rocky substrate (cobbles and boulders) has been removed. Substrate is generally clean under the pipes*.
4. Could boulders (such as the ones lying against the river-right pipe) be removed to facilitate the effort? *All boulders can be removed from around the pipes, whether underneath or lying on the pipe. Prior to construction, any remaining large substrate would be removed*.

Jeff described an idea to cut and frame a plywood form that would slide down over the top of the pipes and could be driven down into the diatomaceous substrate (pilings to support the bottom of the forms could also be driven in to the substrate. Then, in order to close up the form underneath the pipe we could use some sort of inflatable bladder. Clay mentioned that there are such bladders that could be inflated with air or water. Water might be a better option because it would not be buoyant. Clay described some potential shortcomings of such an idea, including the potential difficulties in working with bladders. In addition, the upstream face of the concrete would not be clean once the bladder was removed. This is the key issue for this project; we are trying to remove any nooks and crannies that non-native signal crayfish could use for a refuge.

Clay came up with an alternative plan that would involve using a multi-piece frame that could be constructed around each of the pipes, fastened together with plates between the pipes, and supported on the bottom with pilings driven into the substrate. Initially, we were discussing forms cut out of plywood, but Clay suggested that the forms could be steel and designed to be left in place to form the slick face. For ease of fabrication, installation, and cost effectiveness,

10 or 12 gauge galvanized mild steel[1] sheeting could be used for the formwork. The construction would require industrial divers to install the forms, but could be done without diverting flows or putting up coffer dams. Clay recommended that the depth (from the old concrete face to the new face) should be 12 inches.

Prior to securing the forms to the substrate and around the culverts, a reinforcement framework would be constructed of #4, grade 60, ½ inch rebar. The framework would be constructed on 12-inch centers each way and each face that would be exposed to air, water, or soil.

Once the forms are installed, filling with concrete would be straight-forward. Displaced, concrete-laden water from within the form would be pumped out either into a settling pond or into a 4000-gallon water truck. In the former scenario, a nearby landowner (either Spring Creek Ranch or Dennis Jacobsen) would have to be willing to accept concrete-laden water into a settling pond, which seems unlikely. In the latter, the water could be sprayed over a dirt road, including in the project vicinity as long as conditions were otherwise dry so that there would be no runoff back to the stream. As long as out-pumping keeps pace with concrete pouring (and an appropriate concrete mixture is used to ensure a quick set up time under the submerged conditions), there should be very limited leakage and effects on water quality should be minimal in both magnitude and duration.

We need to resolve permitting issues, specifically around the question of whether an Army Corps permit would be necessary because of the amount of fill that would be added. Clay recommended that we talk with Rhonda and Allison about ACOE permits. It appears that we got a Nationwide 14 Permit for the culvert replacement project, which was completed in 2000. A definition of the conditions under which NWP 14 is appropriate is included (Attachment A). Based on the definition, the blanket application of NWPs, and the fact that we went through the process for the original project, I would think this would be the way to go.

In addition to an ACOE permit, we will need some or all of the following:

- Streambed Alteration Agreement (DFG)
- Water Quality Certification (RWQCB)
- CEQA compliance (likely a mitigated negative declaration)
- Informal Section 7 Consultation (USFWS)

[1] **Mild steel** is the most common form of steel as its price is relatively low while it provides material properties that are acceptable for many applications. Mild steel has medium carbon contents (up to 0.3%) and is therefore neither extremely brittle nor ductile. when heated it becomes malleable, and so can be forged. It is also often used where large amounts of steel need to be formed, for example as structural steel.

Attachment A: Definition for Nationwide Permit 14 (NWP 14) Applicability

14. Road Crossings. Fills for roads crossing waters of the United States (including wetlands and other special aquatic sites) provided the activity meets all of the following criteria:

a. The width of the fill is limited to the minimum necessary for the actual crossing;

b. The fill placed in waters of the United States is limited to a filled area of no more than 1/3 acre. Furthermore, no more than a total of 200 linear feet of the fill for the roadway can occur in special aquatic sites, including wetlands;

c. The crossing is culverted, bridged, or otherwise designed to prevent the restriction of, and to withstand, expected high flows and tidal flows, and to prevent the restriction of low flows and the movement of aquatic organisms;

d. The crossing, including all attendant features, both temporary and permanent, is part of a single and complete project for crossing of a water of the United States; and,

e. For fills in special aquatic sites, including wetlands, the permittee notifies the District Engineer in accordance with the "Notification" general condition. The notification must also include a delineation of affected special aquatic sites, including wetlands.

This NWP may not be combined with NWP 18 or NWP 26 for the purpose of increasing the footprint of the road crossing. Some road fills may be eligible for an exemption from the need for a Section 404 permit altogether (see 33 CFR 323.4). Also, where local circumstances indicate the need, District Engineers will define the term "expected high flows" for the purpose of establishing applicability of this NWP (Sections 10 and 404).

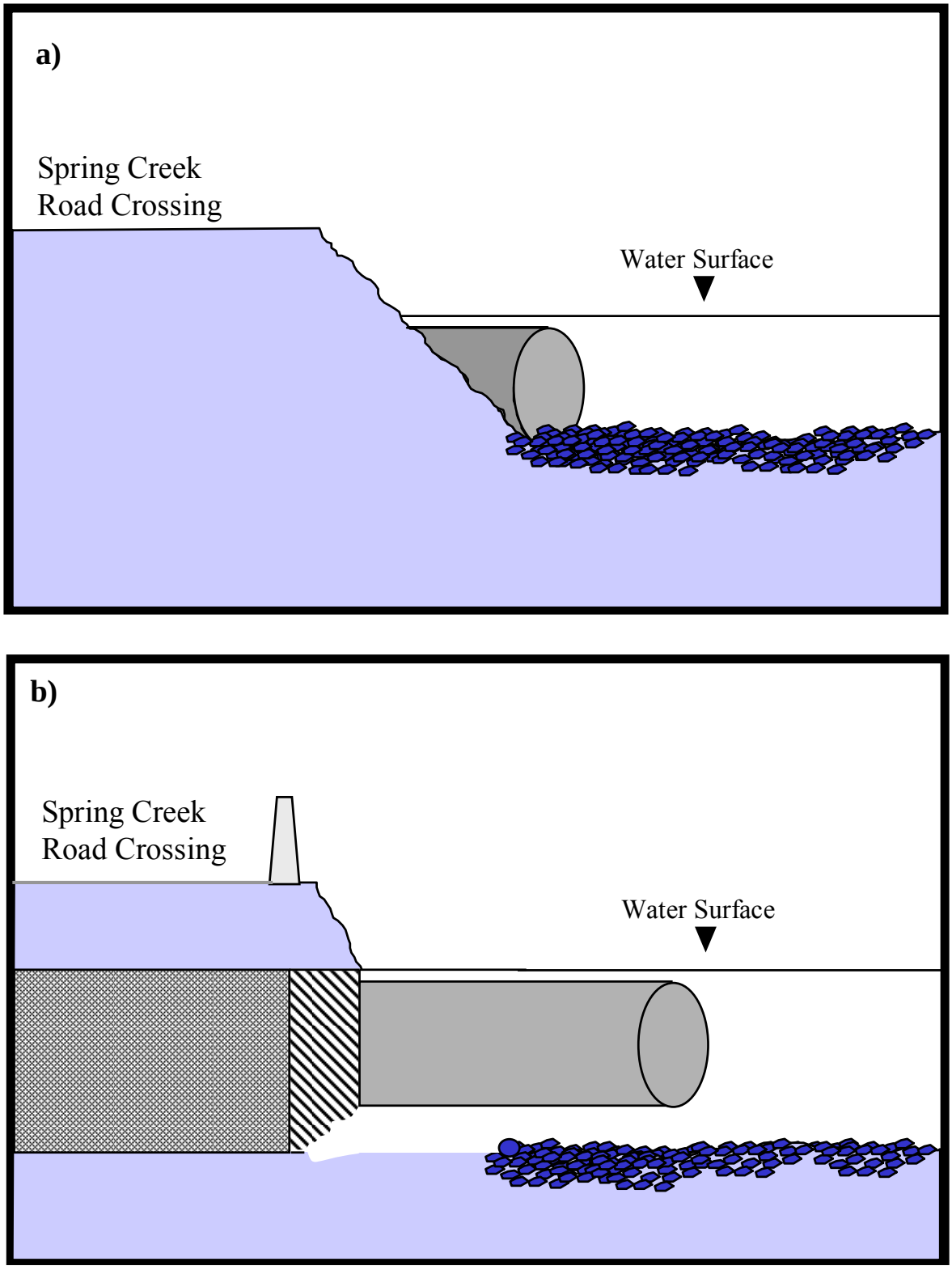


Figure 1 Culverts at Spring Creek Road crossing (a) prior to replacement in 2000 and (b) after replacement.

Sucker Springs Creek
Engineering Field Meeting Summary
September 7, 2005

The following is a summary of the Engineers Field Meeting at Sucker Springs Creek on September 7, 2005.

1. The meeting started at approximately 2:00 PM
2. Present initially were: Dan Byrd and Steve Baumgartner of CDFG, Mike (Zeke) Zanin of PG&E Shasta Hydro, and Maria Ellis and Jeff Cook of Spring Rivers. Rhonda Shiffman of PG&E Hydro joined the group at approximately 3:00 PM following another field meeting she was attending in the area.
3. Maria and Jeff described the general conceptual design of the project and the rationale behind it to Dan, Steve, and Zeke as follows: (1) reinforce the downstream most weir (i.e., at the downstream end of Pond 5 to re-establish a barrier to upstream migration of signal crayfish from the Pit River; (2) ensure that the weirs at the downstream ends of ponds 2 and 4 are intact and act as barriers to upstream migration from ponds 3 and 5, respectively; (3) remove the weir at the downstream end of Pond 3; (4) complete the eradication of signal crayfish from ponds 2, 3, and 4; (5) begin restoring the channel to approximately pre-disturbance conditions starting from the upstream end (i.e., pond 2); (6) when no signal crayfish have been found in ponds 2, 3, and 4 for at least one breeding season, remove the weir at the downstream end of Pond 2; and (7) when ponds 2, 3, and 4 have been restored, remove the barrier at the downstream end of Pond 1. The weir between ponds 4 and 5 and at the downstream end of pond 5 will be left in place to prevent constant repopulation of signal crayfish from the Pit River.
4. Pond 5 was the first stop on the site tour where the discussion focused around how to reinforce the downstream weir. Maria and Jeff described the condition of the weir, i.e., the concrete is rotting with tunnels through it that create refuge for signal crayfish and allow them to move out of lower Sucker Springs Creek through the weir into Pond 5. It was agreed that the weir would need to be rebuilt rather than repaired; pouring good concrete into bad concrete would not be a long-term fix. This could be done in sections by using temporary coffer dams (such as gravity blocks and sandbags) to isolate sections of the weir and divert all the flow first to one side and then the other of the channel. In addition to gravity blocks and sandbags, visquene plastic could be used and sump pumps can be employed to draw the water elevation down (it is unlikely that sections could be dewatered, given the substrate porosity and numerous springs).
5. The question was raised regarding how the work could be done and Steve mentioned that having heavy machinery in the water could make the state permitting, specifically the 1600 streambed alteration permit, onerous. Equipment in the channel should be avoided.
6. Zeke thought the use of a 40,000 lb class excavator would give enough reach to keep the machine perched on the bank out of the channel. Depending on the structural strength of the weir at the downstream end of Pond 5, a hydraulic hammer attachment could be used on the excavator to break things up and then a rock bucket could be used to remove the concrete.
7. The next discussion topic was about the structure of the weirs: how the present ones were constructed and the desired construction for the replacement of the Pond 5 weir. Zeke and Dan asked if the weir had a footing wall or cut-off wall, which would improve the stability of weir (by balancing the mass of the structure and the forces on it) and increase the

effectiveness of the weir as a barrier by limiting the potential for crayfish to tunnel underneath the weir. Jeff mentioned that based on Spring Rivers' observations of flow beginning to siphon through the substrate and underneath the weir between ponds 2 and 3, he didn't think there was a cut-off wall on that weir.

8. Zeke asked about the license nexus to this project. Maria and Steve explained that the Sucker Springs Project was not required by the license, but that it is being accommodated by the license, in that the TRC is a license requirement and PG&E is actively involved and supportive of the activities of the TRC.
9. Some discussion ensued about land ownership and the role of the Pacific Forest and Watershed Lands Stewardship Council relative to the Sucker Springs Project. At the moment there is no direct connection, although members of the council were given a brief presentation about Sucker Springs during a September 28th 2004 tour of watershed lands in the Intermountain Area.
10. There was also discussion about the need to bring in the Pit River Tribe soon so that they will be involved. It was agreed that Allison McDougall should be brought in and have her coordinate with the Tribe.
11. Next, the group went up to the weir between ponds 2 and 3 to talk about channel reconstruction and weir removal. Work on the upper weirs and banks should be easily done from the side of the channel, including any use of heavy equipment (e.g., excavator). Because of the possibility of signal crayfish holding underneath the aprons of the weirs, we will likely want to do the weirs in sections with coffer dams to isolate the crayfish when the sections are pulled. Other minor logistical issues of construction and design were also discussed.
12. The meeting ended at approximately 3:30.

Written by Jeff Cook, reviewed by Maria Ellis, Zeke Zanin, and Dan Byrd

Action Items:

What	Who	When
Write project description (for the weir rehabilitation and removal portions of project)	Maria/Jeff	ASAP
Begin work on 1600 permit	Steve B. (w/ input from SRES)	ASAP
Talk to Allison McDougall and get the Pit River Tribe involved, i.e., site tour and briefing of conceptual design	Maria/Zeke	ASAP

Attendees:

Rhonda Shiffman	PG&E Hydro
Steve Baumgartner	CDFG Region 1
Dan Byrd	CDFG Yreka Screen Shop
Mike (Zeke) Zanin	PG&E Shasta Hydro
Maria Ellis	Spring Rivers Ecological Sciences, LLC
Jeff Cook	Spring Rivers Ecological Sciences, LLC

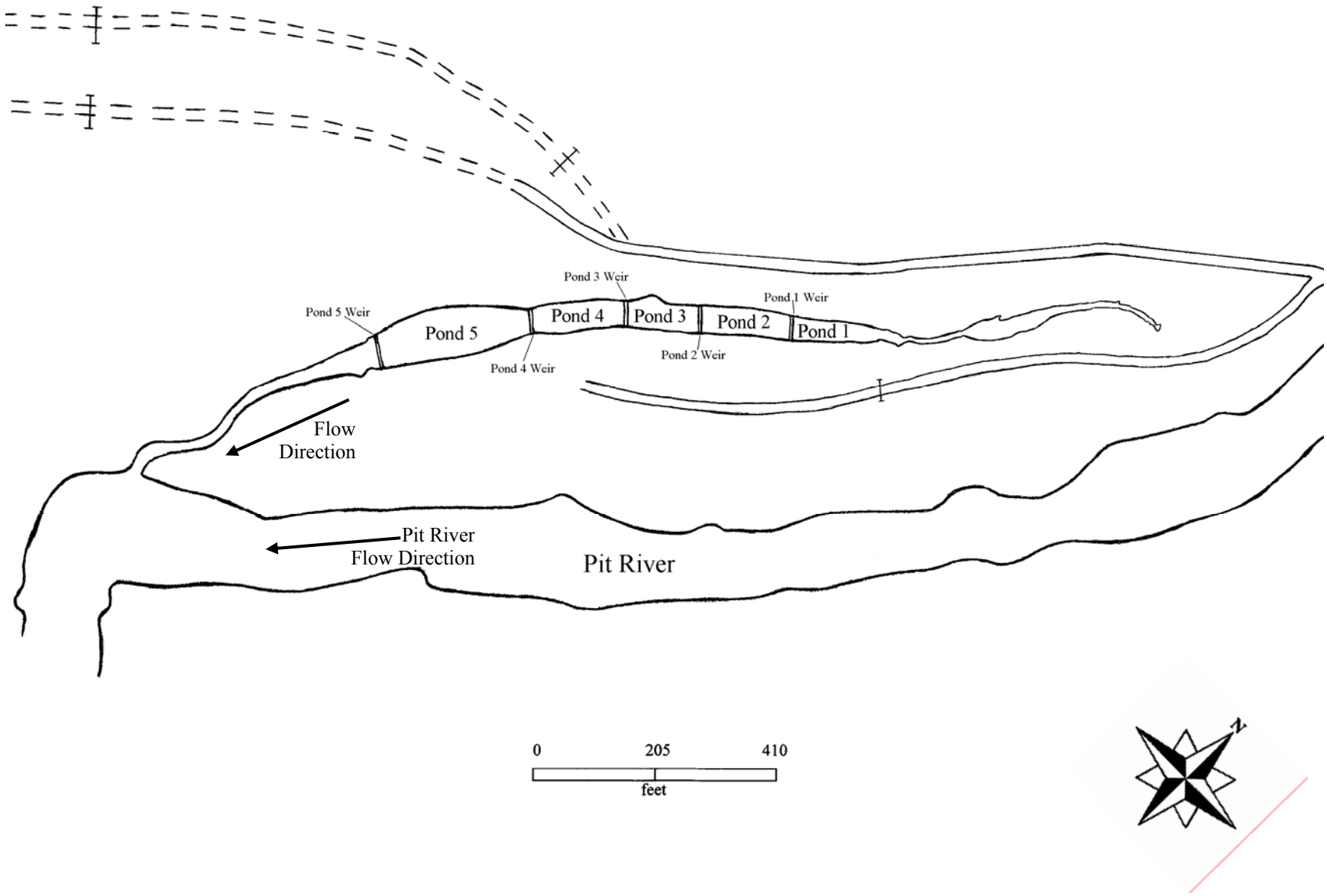


Figure 1 Schematic of Sucker Springs Creek showing remnant hatchery ponds and weirs.

APPENDIX D—USFWS AND CDFG COMMENTS ON THE 31 JANUARY 2005 DRAFT OF THE CRAYFISH BARRIER PLAN

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825-1846

In Reply Refer To:
1-1-05-TA-0812

MAR 2 2 2005

Ms. Rhonda B. Shiffman
Pacific Gas and Electric Company
Mail Code N11C
Post Office Box 770000
San Francisco, California 94177

Dear Ms. Shiffman:

Subject: Comments on the Draft Crayfish Barrier Plan for the Pit No. 1 Hydroelectric Project, Federal Energy Regulatory Commission Number 2687, Shasta County, California

This is in response to your February 1, 2005 request for comments from the U.S. Fish and Wildlife Service (Service) on the January 2005 Draft Crayfish Barrier Plan (Draft Plan). The Crayfish Barrier Plan is being prepared in response to the Service's October 25, 2002 biological opinion (Service file 1-1-00-F-0210) (Pit BO), and Article 413 of the Federal Energy Regulatory Commission's (FERC) license issued to Pacific Gas and Electric (PG&E), to operate the Pit 1 Hydroelectric Project (FERC Project No. 2687). These documents required the development and funding of a plan to construct and maintain a minimum of two exclusion barriers to protect habitat for the Shasta crayfish (*Pasifastacus fortis*), a state and federally endangered species. It is the intent of PG&E to develop an adaptive plan that will be implemented with the guidance of the multi-agency Shasta Crayfish Technical Review Committee (TRC) and the Shasta Crayfish Recovery Team, groups whose members include the California Department of Fish and Game, the Service, PG&E, California Department of Parks and Recreation, and academia.

The Service supports your efforts in developing the Draft Plan. The final Crayfish Barrier Plan will implement recovery actions for the Shasta crayfish, with the potential of protecting remaining allopatric populations of the Shasta crayfish from the invasion by non-native crayfish, particularly the signal crayfish (*Pacifastacus leniusculus*). On December 14, 2004, the Service provided initial comments via email on the October 2004 version of the Draft Plan. Those comments were incorporated into the January 2005 version. The Service has additional comments based on further review of the Draft Plan.

Specific to potential crayfish barrier locations (Section 3.1), the Service believes that site priority should also take into account maximum length of the barrier to be constructed. Because the

barriers to be installed have only undergone lab testing, it may be advantageous to build the first barrier at a site that has a narrower width than other sites. As stated in the Draft Plan, the first barrier will be a "learning process". Engineering, construction, monitoring and maintenance time and costs should be lower for a smaller barrier and may be more adaptable to modifications if necessary.

Specific to crayfish barrier design (Section 3.2) and construction (Section 3.4), the proposed basic design for the barriers will be an overhanging drop barrier with a 12-inch vertical section. This design was chosen based on the January 2005 *Crayfish Barrier Flume Study* prepared by Spring Rivers Ecological Sciences, Cassel, California. The Service is concerned with the lack of specificity on how these barriers will be constructed and installed, and what materials will be used during construction. Article 413 and the Pit BO state that the Licensee would submit detailed design drawings. It was the Service's expectation that the detailed design drawings section of a Crayfish Barrier Plan would include engineered specifications addressing the concerns stated above. The Service believes that it is imperative that PG&E utilize the services of an engineer to flush out the final details of barrier construction, materials and installation. The Service also recommends that the Draft Plan address details on extending the barrier to the stream banks to prevent the overland travel of non-native crayfish, and include an evaluation and recommendation of types of overland barriers for consideration.

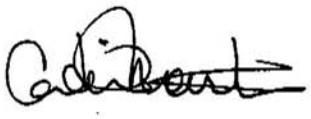
Specific to the performance testing schedule following barrier installation (Section 3.4), the Draft Plan states that biannual monitoring and maintenance surveys will begin in the fall following installation. Because the proposed barriers to be installed have only undergone lab testing, the Service believes that additional monitoring and surveys should occur in the first year. We recommend that PG&E propose a schedule that outlines a comprehensive schedule for the first year that adequately addresses monitoring and maintenance activities, starting shortly after installation. The Service envisions that comprehensive monitoring and surveys would occur in a phased approach, with the most intensive work occurring in the first three months, perhaps twice a week, and then stepped down to twice a month intervals and finally to every other month. If results of the first year monitoring and surveys are acceptable to the TRC and Recovery Team, then biannual surveys for the next four years, as outlined in the Draft Plan, would be appropriate (Section 3.5). The Service also believes that the use of underwater video cameras may be useful during the performance testing period to monitor the effectiveness of the barriers, and recommends that PG&E include it as an option in the final Crayfish Barrier Plan.

Specific to plan implementation and funding (Section 3.6), the Draft Plan states that the design and construction of two crayfish barriers, as required by Article 413 and the Pit BO, will in all likelihood exceed $150,000. In order to evaluate the adequacy of the funding that the Service recommended in the Pit BO, and to be able to comment on the scope and priority of expenditures that will occur, the Service would like to see a detailed budget of approximate costs of designing and constructing the two barriers.

In our Pit BO, the Service requested an "implementable plan". We sincerely appreciate the work to date that has gone into the Draft Plan, and hope that it will soon be finalized and that implementation will begin as soon as possible. We appreciate your continued cooperation and

participation in the conservation of listed and sensitive species. We look forward to working with you and the rest of the TRC and Recovery Team on the implementation of FERC's license for the Pit No. 1 Project in relation to the recovery of the Shasta crayfish. Please address any questions or concerns regarding this response to Kathy Brown or Roberta Gerson, Branch Chief, at (916) 414-6600.

Sincerely,



Catrina Martin
Deputy Assistant Field Supervisor

cc:
Steve Baumgartner, Associate Biologist, CDFG, Redding, California
Annie Manji, FERC Coordinator, CDFG, Redding, California
Maria Ellis, Spring River Ecological Sciences, Cassel, California
Harry McQuillen, Recovery Branch, SFWO

State of California – The Resources Agency **ARNOLD SCHWARZENEGGER, Governor**

DEPARTMENT OF FISH AND GAME

http://www.dfg.ca.gov

601 Locust Street
Redding, CA 96001
(530) 225-2300

April 8, 2005

Ms. Rhonda B. Shiffman
Pacific Gas & Electric Co.
Mail Code NIIC, Post Office Box 770000
San Francisco, CA 94177

Ms. Maria Ellis
Spring Rivers Ecological Sciences
Post Office box 153
Cassel, CA 96016-0153

Dear Ms. Shiffman and Ms. Ellis:

Thank you for the opportunity to provide comments on the Crayfish Barrier Flume Study Final Report (Flume Study) and the Draft Barrier Plan for the Pit No. 1 Hydroelectric Project, Federal Energy Regulatory Commission (FERC) Project No. 2687 (Barrier Plan). In reviewing these documents, the Department of Fish and Game considers crayfish barriers as one potential "tool" in the suite of solutions for protection of the State and federally endangered Shasta crayfish. We envision functional barriers working in concert with other control and enhancement measures such as nonnative crayfish removal, captive breeding, and the establishment of refugia for the conservation and recovery of Shasta crayfish.

On March 19, 2003, FERC issued a new license for Pacific Gas and Electric Company's (Licensee) Pit No.1 Hydroelectric Project, FERC No. 2687. Article 413 requires the Licensee to prepare a plan for FERC approval to construct and maintain a minimum of two exclusion barriers to protect Shasta crayfish habitat from invasion by nonnative signal crayfish. In response to the necessity of finding a reliable means of halting the upstream migration of signal crayfish into the habitat of the few remaining allopatric populations of Shasta crayfish, the Crayfish Barrier Flume Study (Spring Rivers 2005) was undertaken at the University of California at Davis (UCD). The Draft Barrier Plan utilizes the information derived from the Crayfish Barrier Flume Study to fulfill the FERC directive.

The main goal of the Crayfish Barrier Flume Study was to develop and test barrier designs that prohibit the upstream migration of nonnative crayfish, and allow fish and sediment passage. Initially, acoustic and electrical barriers were considered but information derived from an extensive literature search indicated these types of barriers are unproven or cost prohibitive. Three basic barrier designs were then physically evaluated at UCD in the Sacramento River sediment model flume and a smaller acrylic flume. The three designs utilizing different combinations of physical and velocity barriers tested in the flume study include the overhanging drop barrier, a modified Torlesse vortex-tube sediment trap barrier, and a constriction barrier.

Ms. Rhonda B. Shiffman and Ms. Maria Ellis
April 8, 2005
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The test flow regime was representative of the 1 to 3 feet per second velocities seen at potential barrier sites and also included a no flow test to mimic still water. The trials began with no flow and then increased by approximately 1 foot per second every 10 minutes until flows reached a maximum velocity of approximately 3 feet per second. Flows were then decreased in a similar stepwise manner back to no flow.

Each of the three barriers tested in the flume study were evaluated based on blockage or passage crayfish, sediment movement, and relative impacts to three species of fish. The vortex-tube designs were not successful in halting crayfish passage or moving sediment more than six inches downstream from the barrier and therefore should not be given further consideration. The constriction barrier prevented trout from moving upstream but passed sediment effectively only when the design occupied approximately two-thirds or more of the water column. This design was also shown to be a complete barrier to sculpin. Based on these results, the constriction barrier should not be considered as a viable design. The Department concurs with the report's findings that there are no locations where either a vortex tube or constriction barrier should be considered.

Of the several different designs tested, the most successful barrier against upstream crayfish movement in both still and flowing water was the overhanging physical barrier with a vertical wall. This design was successful in preventing crayfish from moving upstream in the flume study. A serious concern with the design aspect of the overhanging physical barrier is that it must extend onto each streambank sufficiently to prevent overland travel of nonnative crayfish. The overhanging physical barrier did not present a barrier to trout in the flume study but did present a behavioral barrier to two species of sculpin. Since sculpin are benthic fish, they would not cross the overhanging barrier unless coaxed by a dip net. Although this barrier design was able to pass sediment, it failed to move it downstream away from the barrier and be self-cleaning. This limits the application of the overhanging physical barrier to those sites with negligible bedload sediment which include Spring Creek and upper Fall River upstream of the Bear Creek confluence.

After reviewing the fish passage tests involving rainbow trout (*Oncorhynchus mykiss*) riffle sculpin, (*Cottus gulosus*) and prickly sculpin (*C. asper*), we concur with the behavioral findings of the study. We believe the riffle sculpin and the prickly sculpin were adequate surrogates in the fish passage tests for the rough sculpin (*C. asperrimus*), a fully protected species, the Department must consider. Section 5515 of the California Fish and Game Code states "…the Department may authorize the taking of fully protected species for necessary scientific research, including efforts to recover fully protected, threatened, or endangered species." According to the information provided by the Licensee, less than 1% of potential rough sculpin habitat would be

isolated by the construction of two barriers. If genetic isolation of rough sculpin becomes a concern, the Department may relocate sculpin above the barriers.

The "Construction and Performance Testing" section of the Barrier Plan states, "…barriers will be anchored into the streambed in concrete footers." In order to pour or install an effective concrete footer impervious to crayfish, the stream may have to be diverted, and the streambed may have to be substantially altered. Detailed construction plans including materials as outlined in Article 413 are necessary for the Department to assess the possible impacts of the structure and its construction on aquatic resources. The construction section also states "The first year of monitoring and maintenance after barrier installation will be used as a field test of the crayfish barrier design as specified in the Recovery Plan (USFWS 1998)." The Recovery Plan is very vague in addressing monitoring and maintenance, and states "…a field test of the crayfish barrier design should be conducted along with a one-year monitoring/maintenance period during which different eradication methods can be employed upstream from the barrier to measure its effectiveness." Additionally, the Department requires information relative to the inspection and maintenance of the barriers for algae growth and debris accumulation. It is essential for the Department to know who will be responsible for the inspection and maintenance schedule and how frequently the inspections will be made prior to barrier construction.

The Barrier Plan states the construction and design of two crayfish barriers will likely exceed the $150,000 provided for in Article 413. We agree with this conclusion. In order for this process to move forward in an expeditious manner the Licensee should complete a detailed budget that includes line items for design, construction, and monitoring. In addition, significant engineering should be completed prior to applying for any construction permits.

The Draft Crayfish Barrier Plan is a concise summary of the findings of the Crayfish Barrier Flume Study and addresses License Article 413 of the Pit No. 1 Hydroelectric Project No. 2687. The flume study focused on the major barrier issues including fish passage, bedload transport, as well as aquatic and overland travel of signal crayfish. The results narrowed the viable options to the overhead physical barrier design. The Department appreciates the "moving target" and adaptive management aspects of this project, however, specific construction materials and methods have not been provided to enable Department staff to make an assessment of barrier design, construction, efficacy and monitoring. Installation of barriers should only proceed when these issues are resolved and an effective and functional design is approved by the Department and the United States Fish and Wildlife Service.

Ms. Rhonda B. Shiffman and Ms. Maria Ellis
April 8, 2005
Page Four

We appreciate the scope and complexity of this project and encourage the Licensee to continue to work expeditiously toward the goal of Shasta crayfish recovery. Please direct any comments or question to Associate Fisheries Biologist Steve Baumgartner by phone at (530) 225-2370, E-mail at sbaumgartner@dfg.ca.gov or mail at the letterhead address.

Sincerely,

Gary B. Stacey
Fisheries Program Manager

cc: Mr. Harry McQuillen and Ms. Kathy Brown
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Mr. Dave Longanecker
Pacific Gas and Electric
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Mr. Woody Elliot
Department of Parks & Recreation
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Mr. Theo Light
Department of Biology
Shippensburg University
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Ms. Becky Miller
Habitat Conservation Programs Branch
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Redding, CA 96001

APPENDIX E— CRAYFISH BARRIER PLAN UPDATE AND ACTION PLAN SUBMITTED TO FERC IN DECEMBER 2005

CRAYFISH BARRIER PLAN UPDATE

December 15, 2005

BACKGROUND

Article 413 of the license for Pacific Gas and Electric Company (PG&E)'s Pit No. 1 Hydroelectric Project (FERC No. 2687), which was issued by the Federal Energy Regulatory Commission (FERC or Commission) on March 19, 2003, requires the development of a Crayfish Barrier Plan. PG&E must submit to the Commission 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 plan must be prepared in consultation with the United States Fish and Wildlife Service (USFWS) and California Department of Fish and Game (CDFG) and shall allow a minimum of 60 days for USFWS and CDFG to comment and to make recommendations before the plan is filed with the Commission.

PG&E's intent has been to develop a reasonable and adaptive plan within the Shasta Crayfish Technical Review Committee (TRC) and the Recovery Implementation Team for the Shasta crayfish (Recovery Team) to fine tune and direct the implementation of the plan. An adaptive plan is desirable because some aspects of the plan, such as the specific locations of the barriers, are contingent on the upstream-most location of non-native crayfish—which is a moving target. In addition, other aspects, such as the specific materials to be used, will depend on suitability, availability, and cost. PG&E has asked the TRC and Recovery Team, which also includes members of USFWS, CDFG, California Department of Parks and Recreation (CDPR), academia, and interested stakeholders within the potentially affected areas, to guide these decisions based on the most current information available.

PROGRESS TO-DATE

PG&E transmitted a first draft of the Crayfish Barrier Plan to the Shasta crayfish TRC and Recovery Team on October 20, 2004. The plan was reviewed and discussed during the October 26, 2004 TRC meeting. During the meeting, CDFG expressed concern as to the potential effects of barriers on the state-listed threatened rough sculpin (*Cottus asperrimus*), which is a fully protected species. USFWS submitted the only written comments received on this first draft. Further discussions on the Crayfish Barrier Plan, particularly on the potential effects to rough sculpin, occurred during the January 11, 2005 TRC/Recovery Team meeting. Based on these discussions and comments, the draft Crayfish Barrier Plan was revised and submitted to the agencies with the 1st draft comments on February 1, 2005 (Appendix A). Both USFWS and CDFG submitted written comments on the plan in late March/early April 2005 (Appendix B). During the April 12, 2005 TRC/Recovery Team meeting (Appendix C), the plan and comments were discussed and steps were outlined to help finalize the plan, including a proposed field meeting to evaluate potential barrier sites.

Potential barrier locations are prioritized based on multiple factors, including: Shasta crayfish population size, Shasta crayfish habitat quality and size, absence and/or ease of eradication of non-native crayfish, access to site for barrier installation and maintenance, landowner cooperation, and existing protection of site (e.g., on-site monitoring, public access). Although signal crayfish have invaded most of the Fall River drainage, Thousand Springs and upper Spring Creek were chosen as the highest priority sites for a barrier due to the large size and allopatric (i.e., single species) status of the Shasta crayfish populations based on earlier surveys. A barrier field meeting for PG&E and CDFG engineers, USFWS, CDFG, Spring Rivers, and PG&E personnel, and landowners to visit Thousand Springs and upper Spring Creek was held on May 24, 2005 (Appendix D). As outlined in the meeting summary provided by Harry McQuillen of USFWS, the potential barrier location at Thousand Springs was considered to be more feasible than at the upper Spring Creek site. During the more detailed discussion of the barrier field meeting and plan at the July 19, 2005 meeting (Appendix E), the TRC and Recovery Team stated that it was important to determine the extent and distribution of non-native crayfish in upper Spring Creek and Thousand Springs.

Recent Surveys

Spring Creek and Thousand Springs were originally chosen as the highest priority barrier sites because of the large size of the Shasta crayfish populations, the pristine condition of the habitat, and the absence of non-native crayfish. Since the comprehensive crayfish surveys done by PG&E in the early 1990s, however, the distribution of non-native signal crayfish has expanded throughout most of the midreaches of the Pit River drainage, including the Fall River subdrainage. The distribution of non-native fantail crayfish (*Orconectes virilis*) has also expanded during this time. By 2003, a few signal crayfish were found at the location of the downstream-most Shasta crayfish population (i.e., Indian Fish Trap) in upper Spring Creek (Figure 1) and a large signal crayfish population was found in the upper Fall River approximately 300 meters downstream of Thousand Springs (RK 39.5, Figure 2).

Crayfish surveys of upper Spring Creek were conducted in April 2004 and July, August, and November 2005. During these surveys, 81 signal crayfish, including 55 YOY, were found throughout most of upper Spring Creek from the culverts to the headwaters as shown in Figure 1. Signal crayfish are now found both in the vicinity and upstream of the main Shasta crayfish population in the headwater springs (RK 3.0—RK 3.3) of Spring Creek.

Crayfish surveys of Thousand Springs and the upper Fall River were conducted in July and August 2004 and in March, August, and November 2005. Two signal crayfish (1 juvenile, 1 dead adult male) were found in or near the fish trap cove upstream of the potential barrier site in 2005 and six signal crayfish (2 YOY in 2004, 3 juveniles and 1 adult male in 2005) were found at the confluence with Hideaway Springs as shown in Figure 2. Signal crayfish were abundant in the upper Fall River downstream of the footbridge riffle (RK 39.5). Signal crayfish are currently invading Thousand Springs.

Recent surveys in both Spring Creek and Thousand Springs support earlier observations that non-native crayfish are continuing to expand their distribution into the headwater springs that support Shasta crayfish. This continual change in the distribution of non-native crayfish severely

limits the potential for isolating and maintaining natural refugia for Shasta crayfish by the use of barriers.

ACTION PLANS

During the December 6, 2005 TRC/Recovery Team meeting, the group reviewed all data and tentatively agreed on plans of action for upper Spring Creek and Thousand Springs. The plans include current status, proposed actions, and tentative schedule for each location. Although the presence of non-native signal crayfish in both upper Spring Creek and Thousand Springs greatly increases the complexity of the situation, the TRC and Recovery Team stated that protecting these Shasta crayfish populations is still a high priority, but that different approaches are appropriate at each site. The TRC and Recovery Team felt that the emphasis should be on eradication and/or population control of signal crayfish in upper Spring Creek because a barrier already exists at Spring Creek at the road crossing culverts and signal crayfish have been found throughout upper Spring Creek,. This concurs with Harry McQuillen's suggestion for Spring Creek in his May 25, 2005 e-mail (Appendix D). At Thousand Springs, however, only two signal crayfish have been found upstream of the potential barrier site. In addition, the barrier site appears more feasible than the Spring Creek site due to shallower depth and ease of access. Consequently, the TRC and Recovery Team felt that installation of a barrier at this site is still a viable and potentially effective means of protecting the Thousand Springs Shasta crayfish population.

PG&E will submit a revised draft Crayfish Barrier Plan, which incorporates these action plans, to the TRC and Recovery Team by June 2006. The TRC, Recovery Team, engineers, and landowners will be given 60 days to review the plan and preliminary designs. Upon Commission approval, PG&E shall implement the plan, including any changes required by the Commission.

Spring Creek Plan

Current Status:

- The culverts at the Spring Creek Road crossing are effective barriers that prevent the upstream migration of signal crayfish from lower Spring Creek.
- There is a space underneath the upstream end of the culverts that provides a refuge for crayfish and cannot be surveyed by divers.
- Signal crayfish have been found in low numbers (81 signal crayfish including 55 YOY) in upper Spring Creek upstream of the culverts between the road crossing and the headwater springs of Spring Creek.
- The potential barrier location at the narrowest part of the Spring Creek channel upstream of the road crossing is problematic due to depth, width, and other factors (e.g., cattle grazing, wetlands).

Action Plan:

Task	Schedule
1. Prepare a scope and budget for eradication surveys upstream of Spring Creek Road crossing (including safety measures in the vicinity of the culverts).	Early 2006
2. Increase frequency and intensity of eradication surveys	Begin in early 2006
3. Determine method, basic design, and cost for adding a smooth concrete face around the upstream end of the culverts to remove any potential crayfish refuge	Before April TRC meeting
4. Review by TRC, Recovery Team, engineers, and landowner and decide whether or not to proceed	April 2006
5. Prepare preliminary design and construction plan	Mid 2006
6. Preliminary design and construction plan review by TRC, Recovery Team, engineers, and landowner	July 2006
7. Prepare final detailed design and construction plan	2006
8. Permitting	2006/2007
9. Install a smooth concrete face around the upstream end of the culverts	2007

Thousand Springs Plan

Current Status:

- Only two signal crayfish have been found upstream of the potential barrier location immediately upstream of the Bear Creek confluence.
- The potential barrier site appears more feasible than the Spring Creek site due to shallower depth and ease of access.

Action Plan:

Task	Schedule
1. Perform bathymetric survey of streambed topography of the Fall River headwater pool from the potential barrier location upstream of the Bear Creek confluence	December 2005
2. Increase frequency and intensity of eradication surveys	Begin in early 2006
3. Test materials for biofouling etc.	Before April meeting
4. Determine the change in water surface elevation upstream of the barrier, if installed	Before April meeting
5. Review by TRC, Recovery Team, engineers, and landowner and decide whether or not to proceed with barrier	April 2006
6. Prepare preliminary design of Thousand Springs barrier	Mid 2006
7. Preliminary design review by TRC, Recovery Team, engineers, and landowner	July 2006
8. Prepare final detailed design of Thousand Springs barrier	2006
9. Permitting	2006/2007
10. Explore conservation easements and/or other agreements to address landowner and agency concerns (e.g., barrier removal, barrier protection in perpetuity)	2006/2007
11. Install barrier upon FERC approval	Fall 2007

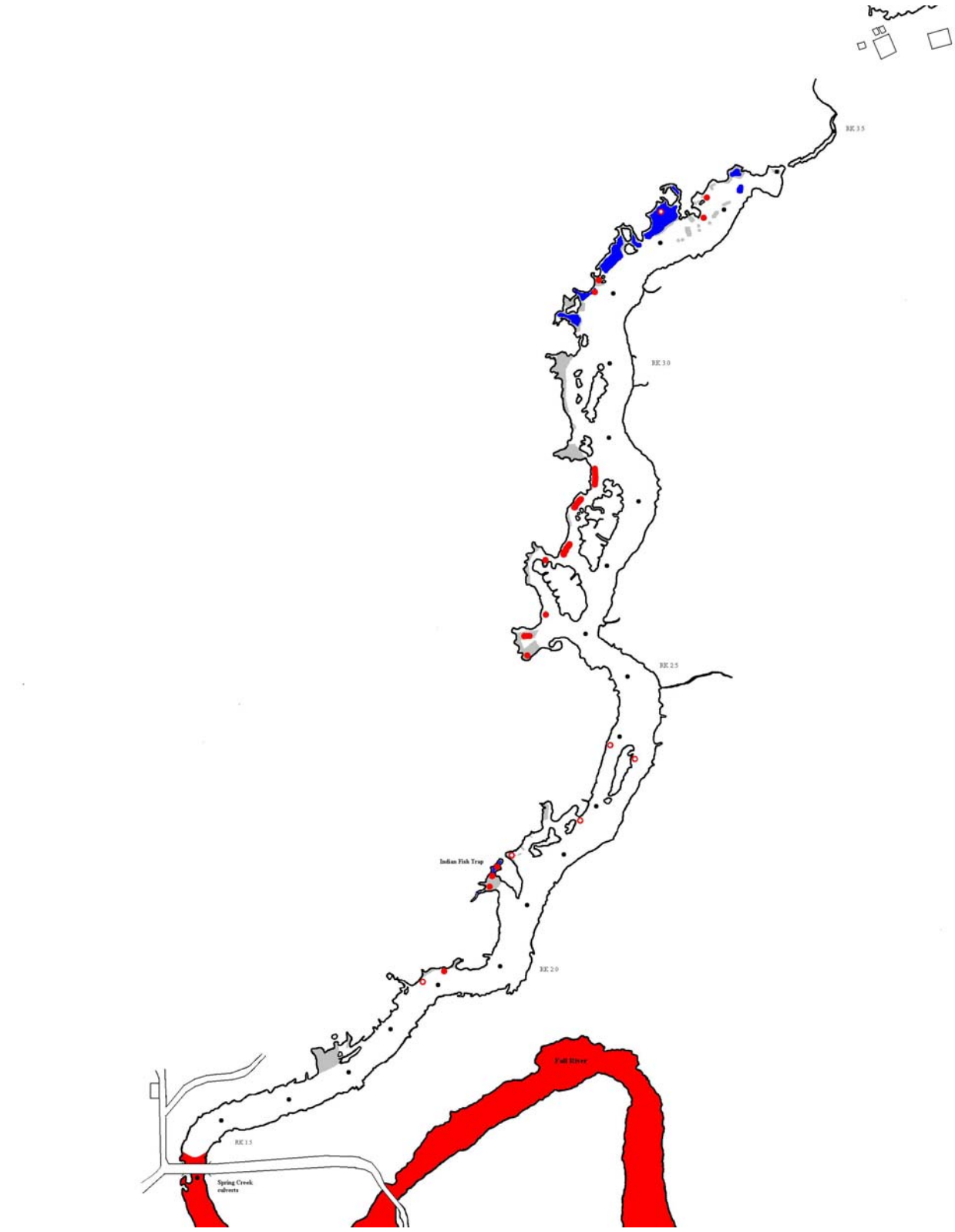

Figure 1 Distribution of non-native signal crayfish in the upper Spring Creek as of November 2005.

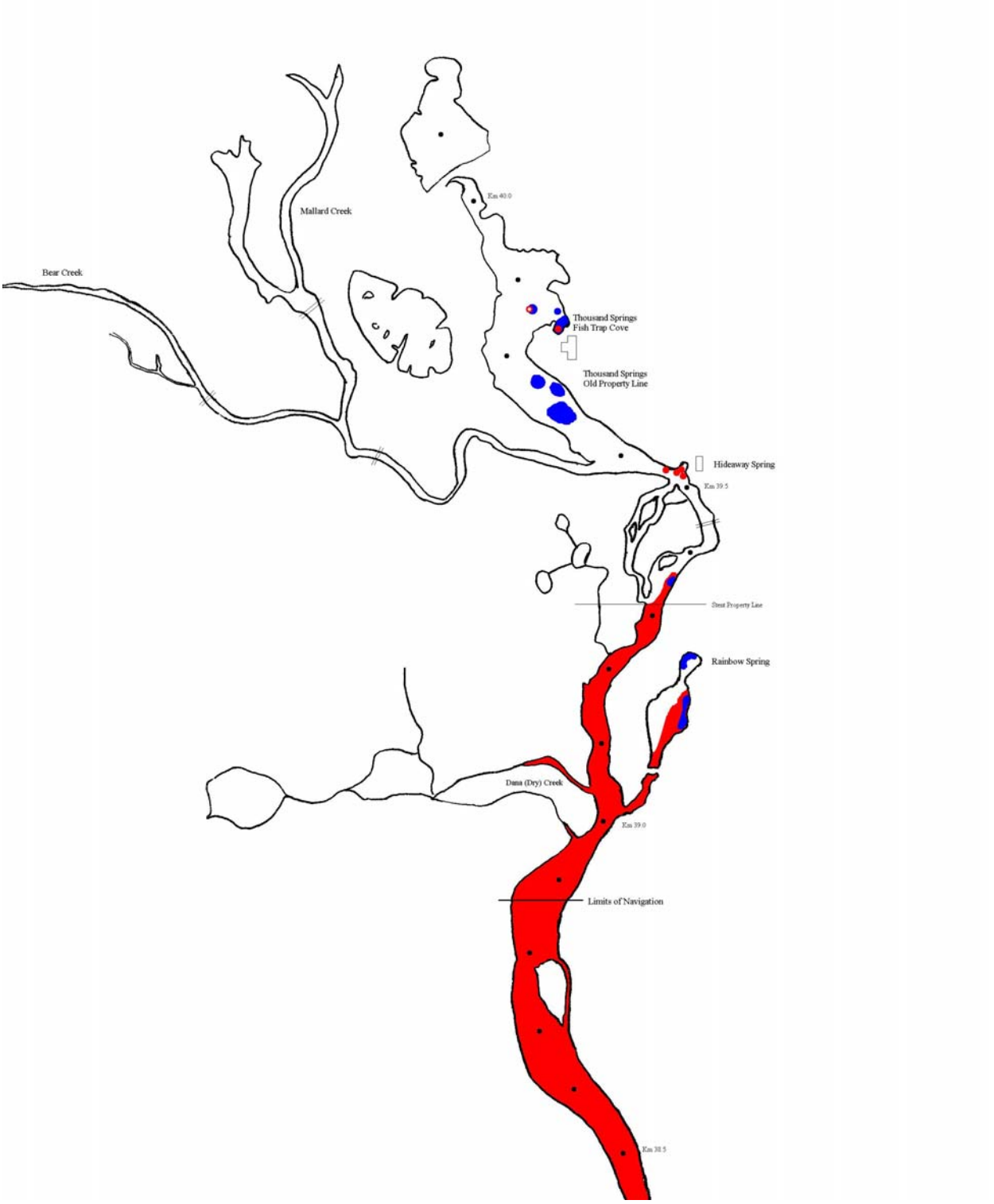

Figure 2 Distribution of non-native signal crayfish in the upper Fall River as of November 2005. Thousand Springs refers to the section of upper Fall River upstream of the Bear Creek confluence.

APPENDIX F— SUBSTRATE MAPPING AT THE THOUSAND SPRINGS RANCH CRAYFISH BARRIER SITE

SPRING RIVERS

ECOLOGICAL SCIENCES, LLC

Substrate Mapping at the Thousand Springs Ranch

Crayfish Barrier Site

May 10, 2006

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INTRODUCTION

As part of the on-going feasibility assessment of a physical crayfish barrier on the upper Fall River at Thousand Springs Ranch, a detailed substrate mapping and depth survey was conducted in 200 feet of Fall River channel just upstream of the confluence with Bear Creek (Figure 1). This reach has been identified as the best probable location for such a barrier in the upper Fall River. The survey was conducted to assess streambed conditions and help determine the optimal location for the installation of a barrier foundation, based on bottom composition and substrate depth within this reach.

METHODS

Data Collection

The substrate depth and mapping survey was conducted on 1–4 May 2006. A measuring tape was stretched and secured on the right bank of the Fall River from 200 ft upstream of Bear Creek to its confluence, establishing a longitudinal axis for the surveys (measurements were done from the upstream end of the line to the Bear Creek confluence). The azimuth of this longitudinal axis was determined. Starting at zero, flags were placed every 10 feet along this longitudinal axis to aid in compass sighting. Transects perpendicular to the longitudinal axis were established across the channel at the 10-foot intervals (a total of 21 cross-sectional transects). Steel rebar headpins were driven on both sides of the channel at each transect location. Starting at the upstream end, a tagline (graduated in 2-foot increments) was stretched between the re-bar stakes (zeroed at the longitudinal axis on river right) to serve as the transect line. Survey stations were set at 10-foot intervals along the transect lines. This established a 10x10-foot grid across 200 linear feet of river channel.

The locations of the right and left banks and edges of water were recorded to the nearest foot at every transect. Substrate surveys were done with two divers using scuba or snorkel gear. A data recorder anchored in a boat nearby assisted the surveyors. The depth of water was measured to

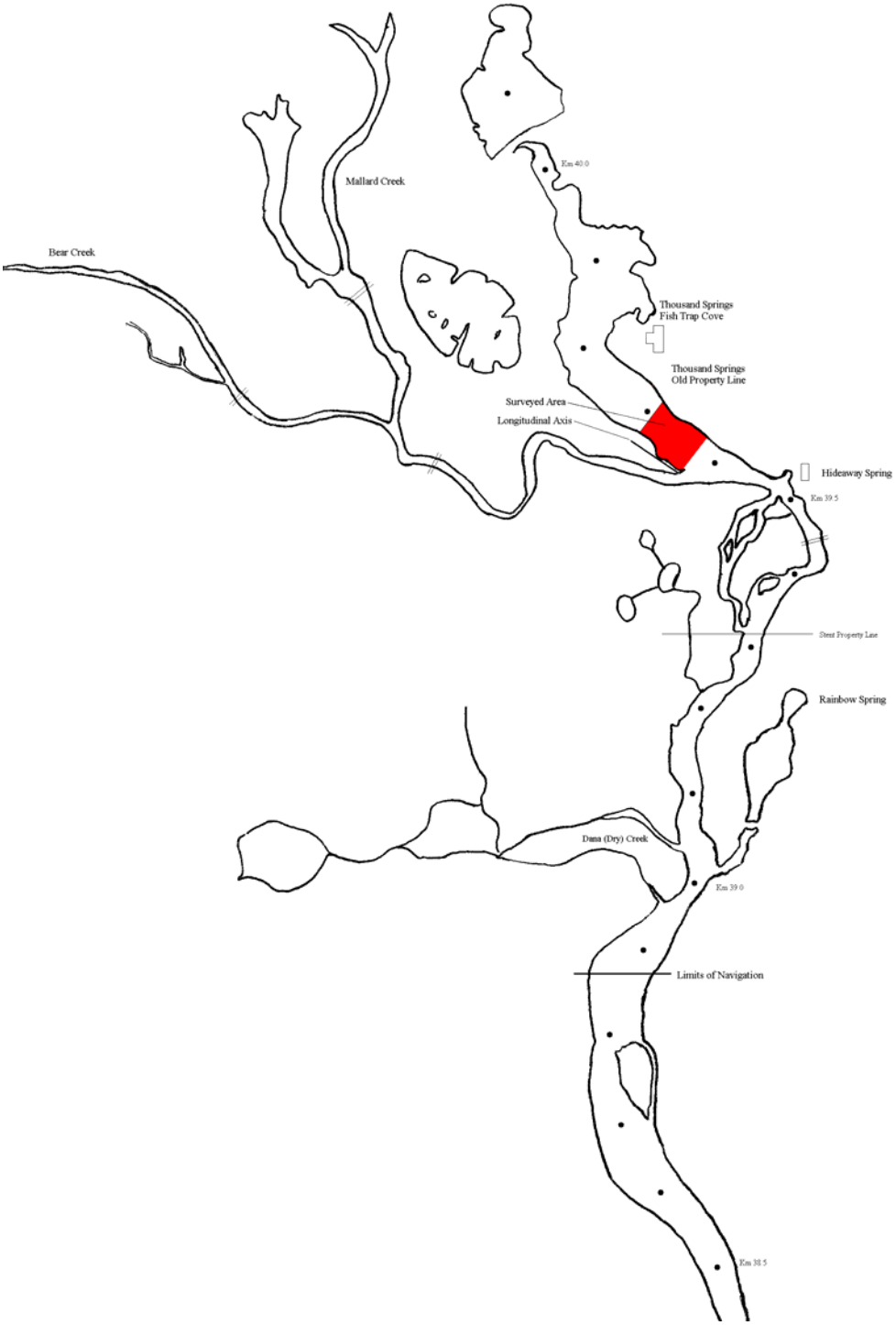

Figure 1 Substrate survey location (shaded) on the upper Fall River

the nearest 50th of a foot using a surveyors rod. The dominant surface substrate was determined, using standardized categories of substrate sizes, as follows:

Silt	≤0.062 mm	(<0.0024 in)
Sand	0.062–2.0 mm	(0.0024–0.08 in)
Gravel	2–64 mm	(0.08–2.5 in)
Cobble	64–256 mm	(2.5–10.1 in)
Boulder	256–2048 mm	(10.1–80 in)
Bedrock	>2048 mm	(>80 in)

Except when the surface substrate was bedrock, the depth of the substrate down to an impenetrable level (which was assumed to be bedrock) was measured. Along transect 1 this was done by driving a 3/8-inch rebar into the substrate until it could not be driven farther. Along the remainder of the transects depth probing was done by forcing a narrow (1/4 inch) smooth steel rod (with a handle at the top) into the substrate material until an impenetrable layer was encountered. In both cases the rod was then grasped at the substrate surface level and removed. The length of rod that had been driven beneath the surface was measured to the nearest centimeter.

Analysis

Data from the survey were entered into a spreadsheet and imported into two different graphics software programs (i.e., Surfer® and Graphis®) that provide both two-dimensional and three-dimensional data displays. Using the water surface elevation at each transect as a constant, we were able to plot the streambed surface as defined by the depth of water (i.e., the distance below the horizontal water surface elevation). From the streambed surface we subtracted the depth of substrate through which we were able to drive the probe (if any) to determine the surface of the underlying bedrock.

RESULTS

Figure 1 is a graphical representation of the surface substrate composition data. Each square represents an individual data point (data were collected at the center of each square). The black squares show where bedrock was exposed at the surface. All other squares had some penetrable substrate on top of bedrock. Figure 2 shows the depths of substrate at each of the data points. Figures 3, 4, and 5 are different three-dimensional representations showing the streambed surface and the underlying bedrock surface.

Channel depth was greatest in the upper portion of the surveyed area (Figures 3, 4, and 5). There was at least one location of exposed bedrock on every transect with the exception of transects 1 through 4 and transect 19 (Figure 1). The exposed bedrock did not have a lot of cracks or fractures. Bedrock was exposed and/or depth to bedrock was very shallow through the left-central portions of transects 7–14, and 17–21 (Figures 1, 2, 3, and 4).

DISCUSSION

The area between transects 8 and 12 provided the maximum amount of exposed bedrock or bedrock with shallow substrate cover (Figure 2). This area could work well with an erosion-mat or other type of foundation that would lie directly on bedrock. If the objective is to bury the bottom of the barrier a safe distance (i.e., 8–12 inches to bedrock) into the substrate until it reaches bedrock, the best locations for a barrier are within the upper 30 feet of the surveyed grid (between transects 1 and 4) or between transects 15 and 16 (Figure 2).

There was a methodological difference with depth probing at transect 1 compared to the rest of the transects (see Methods). Because depth probing at most transects was not done with the aid of a hammer, depth to hard bedrock may be slightly underestimated along transects 2 through 21. Depths along transect 1 might better represent the depths achievable with something like sheet-pile that is driven into the substrate. Still, the optimal substrate depth of 8–12 inches (20.3–30.5 cm) may be difficult to attain completely across any of the transect locations (Figure 2).

If a sheet-pile foundation option is considered, however, it could be possible to create a barrier that was not perfectly linear, but could include angled turns to follow optimal substrate depths across the channel. More detailed substrate depth surveys, for example in the upper 30 feet of the grid and in the vicinity of transects 15 and 16, could permit us to home in on a location with optimal (or workable) substrate depths.

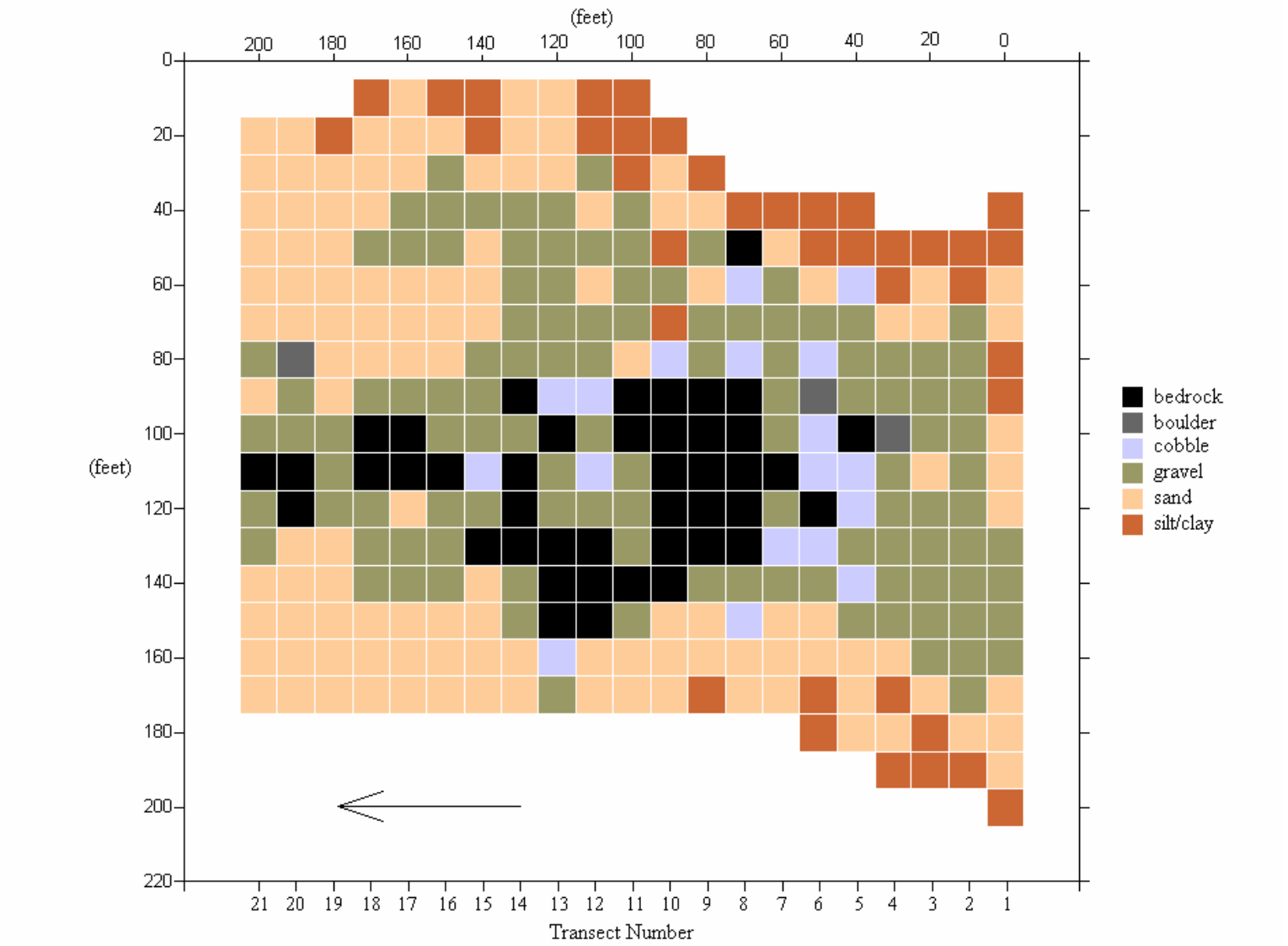

Figure 1 Substrate types at the centers of each square in the survey grid. Arrow indicates flow direction

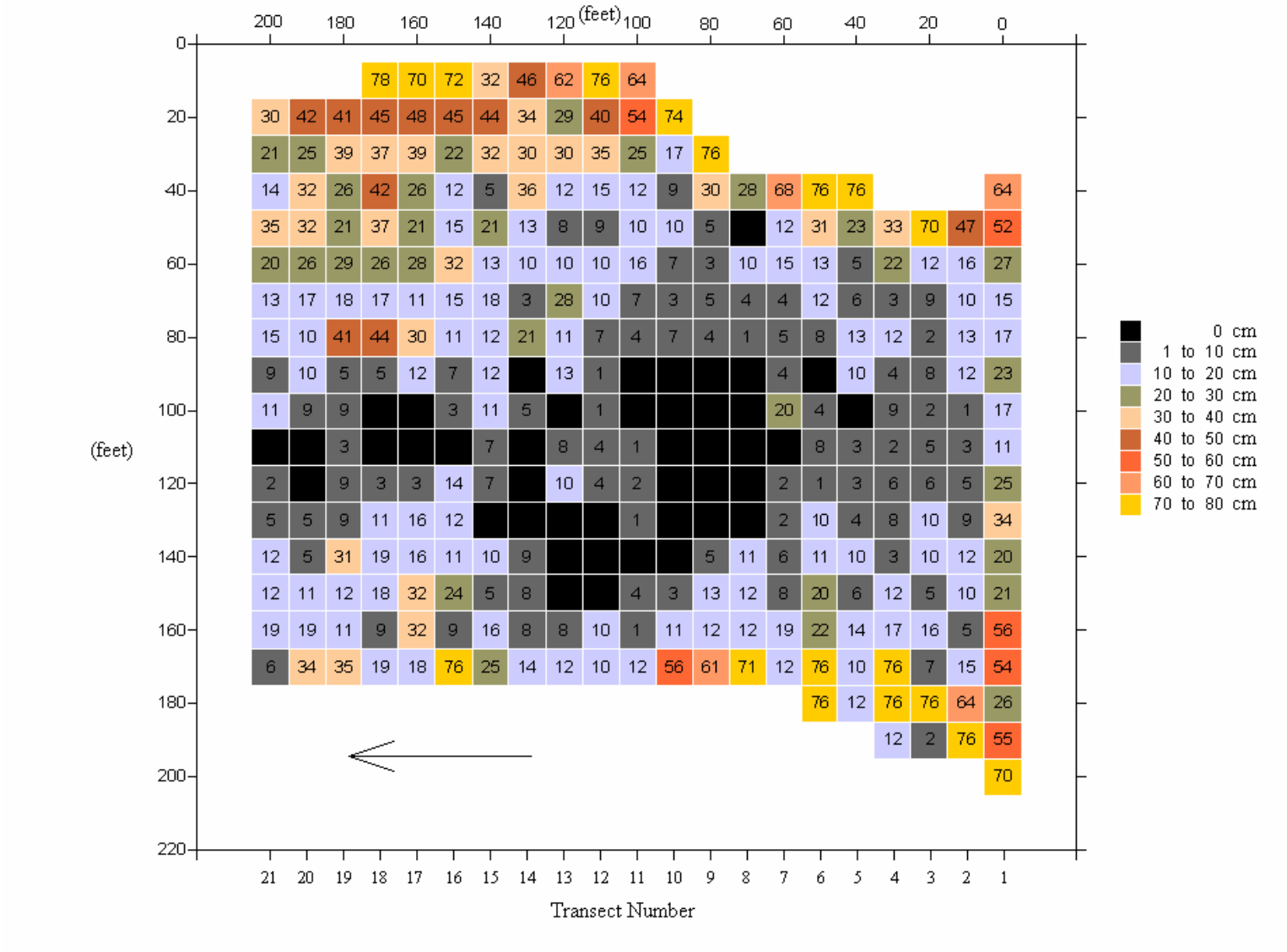

Figure 2 Depth of substrate to bedrock in the survey grid. Square color indicate depth range; numbers are actual measured depths at the centers of each square. Arrow indicates flow direction

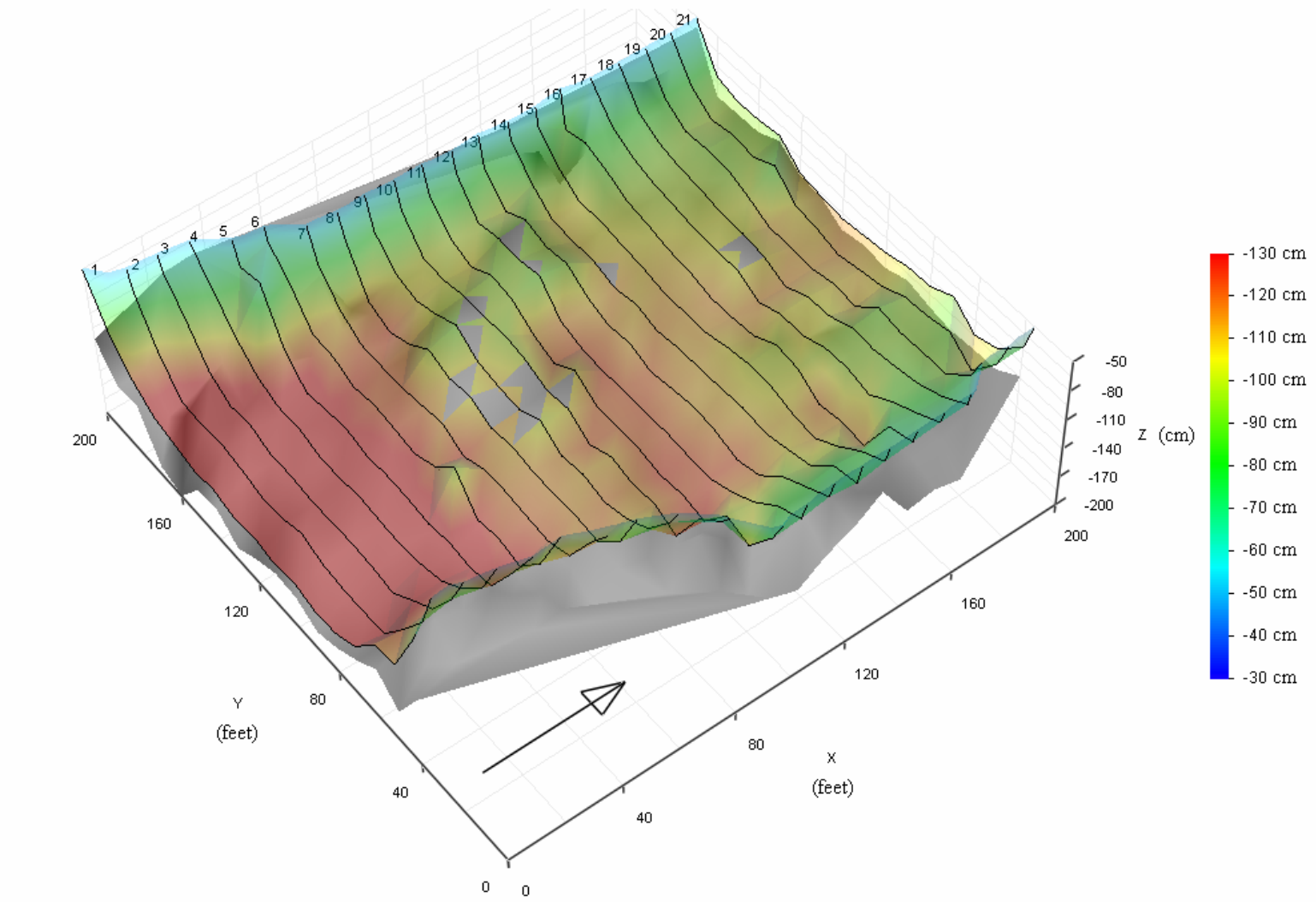

Figure 3 Three-dimensional view of the streambed and subsurface bedrock layers. Perspective is from above the upstream river-right corner (arrow indicates flow direction). Gray represents the exposed or underlying bedrock layer. Color spectrum indicates depth of the streambed below the water surface

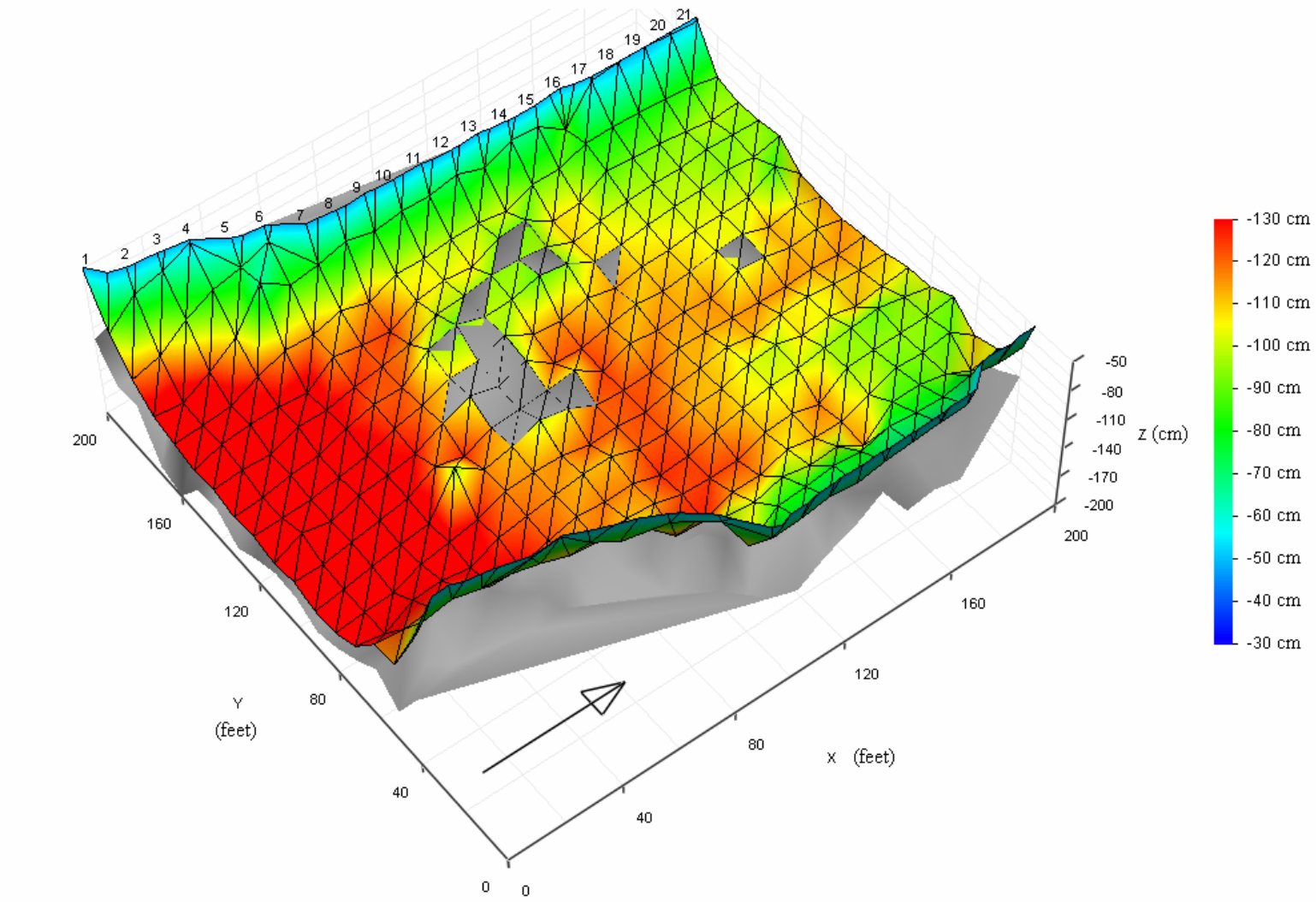

Figure 4 Three-dimensional view of the streambed and subsurface bedrock layers. Perspective is from above the upstream river-right corner (arrow indicates flow direction). Gray represents the exposed or underlying bedrock layer. Color spectrum indicates depth of the streambed below the water surface

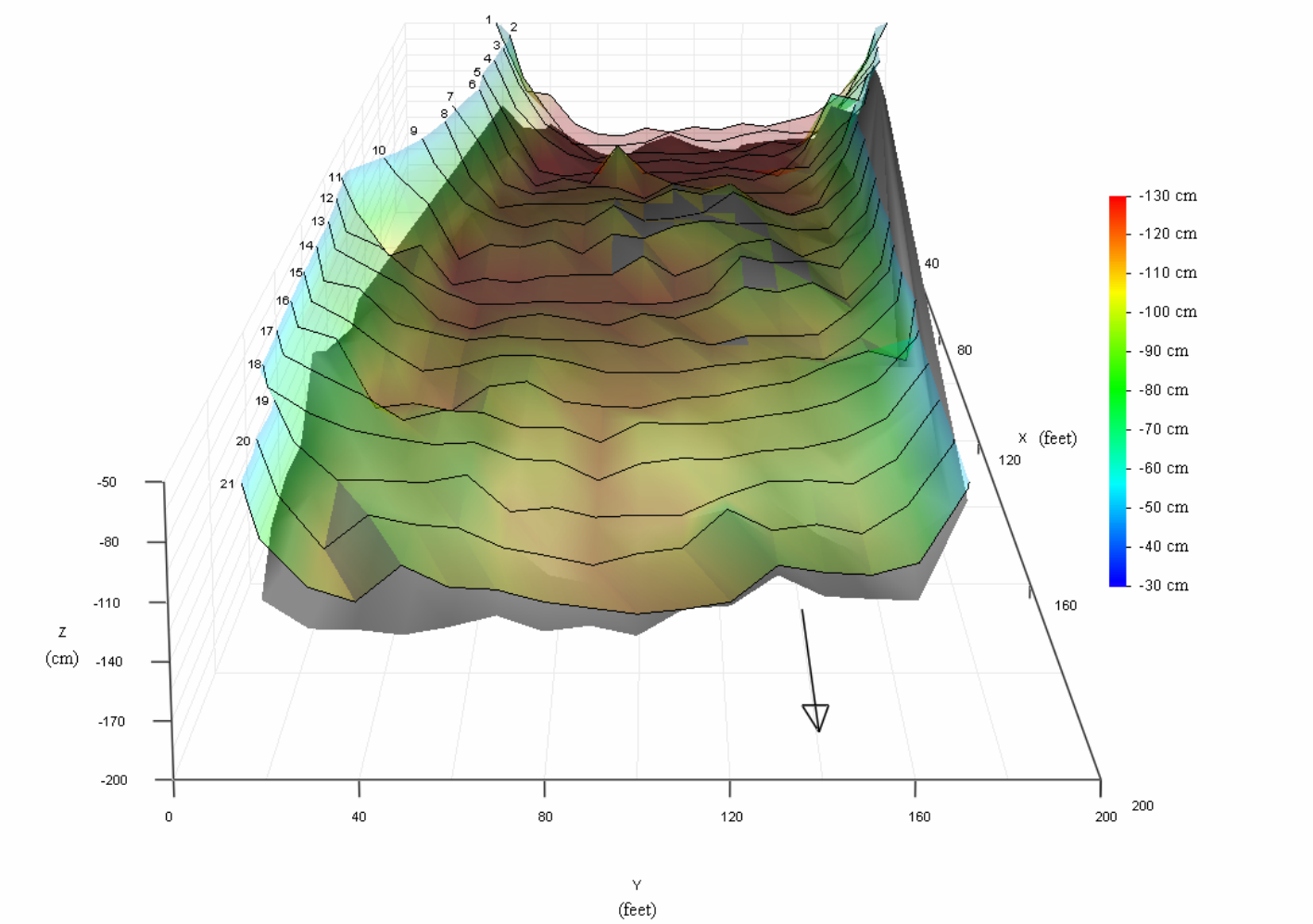

Figure 4 Three-dimensional view of the streambed and subsurface bedrock layers. Perspective from the downstream center of the channel. Gray represents the exposed or underlying bedrock layer. Color spectrum indicates depth of the streambed below the water surface

APPENDIX G—PIT 1 PROJECT HABITAT MAPS

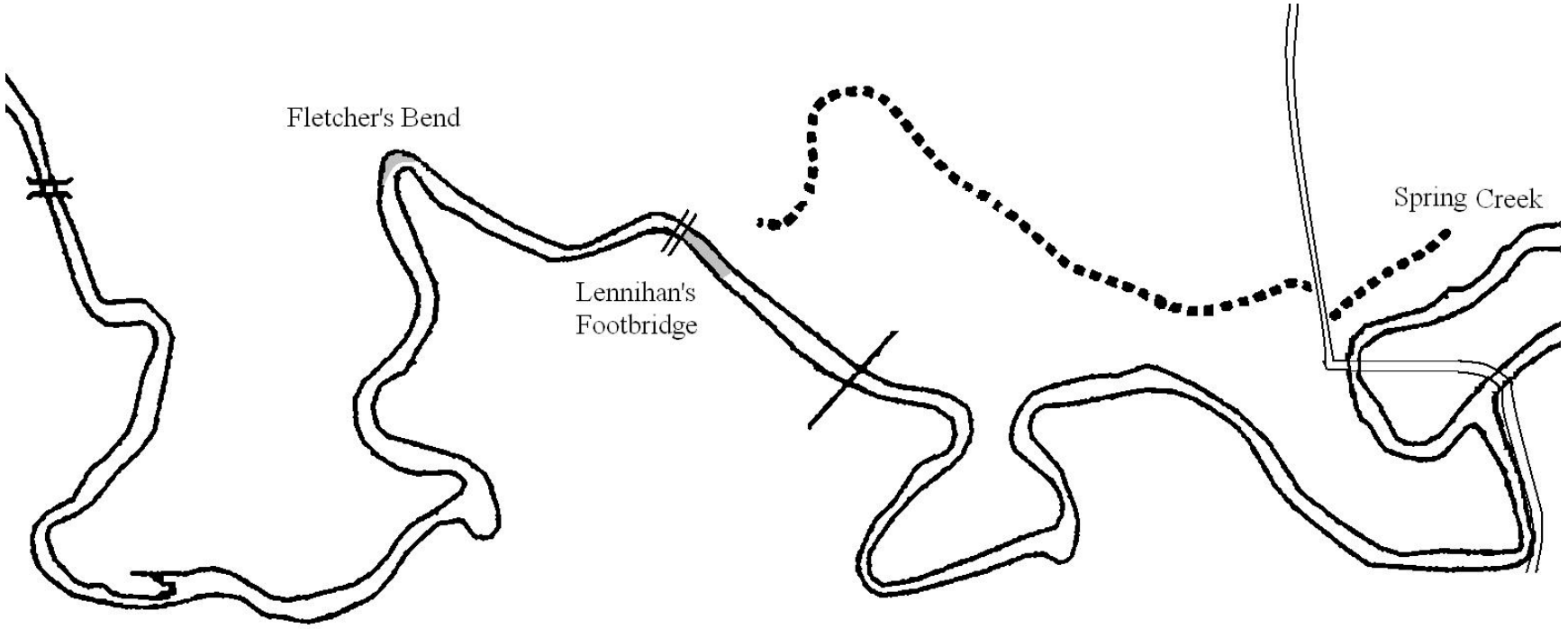

Figure G-1 Areas surveyed and mapped for Shasta crayfish and Shasta crayfish habitat (shaded) at Fletcher's Bend and Lennihan's Footbridge in upper Fall River.

Figure G-2 Areas surveyed and mapped for Shasta crayfish and Shasta crayfish habitat (shaded) in Spring Creek.

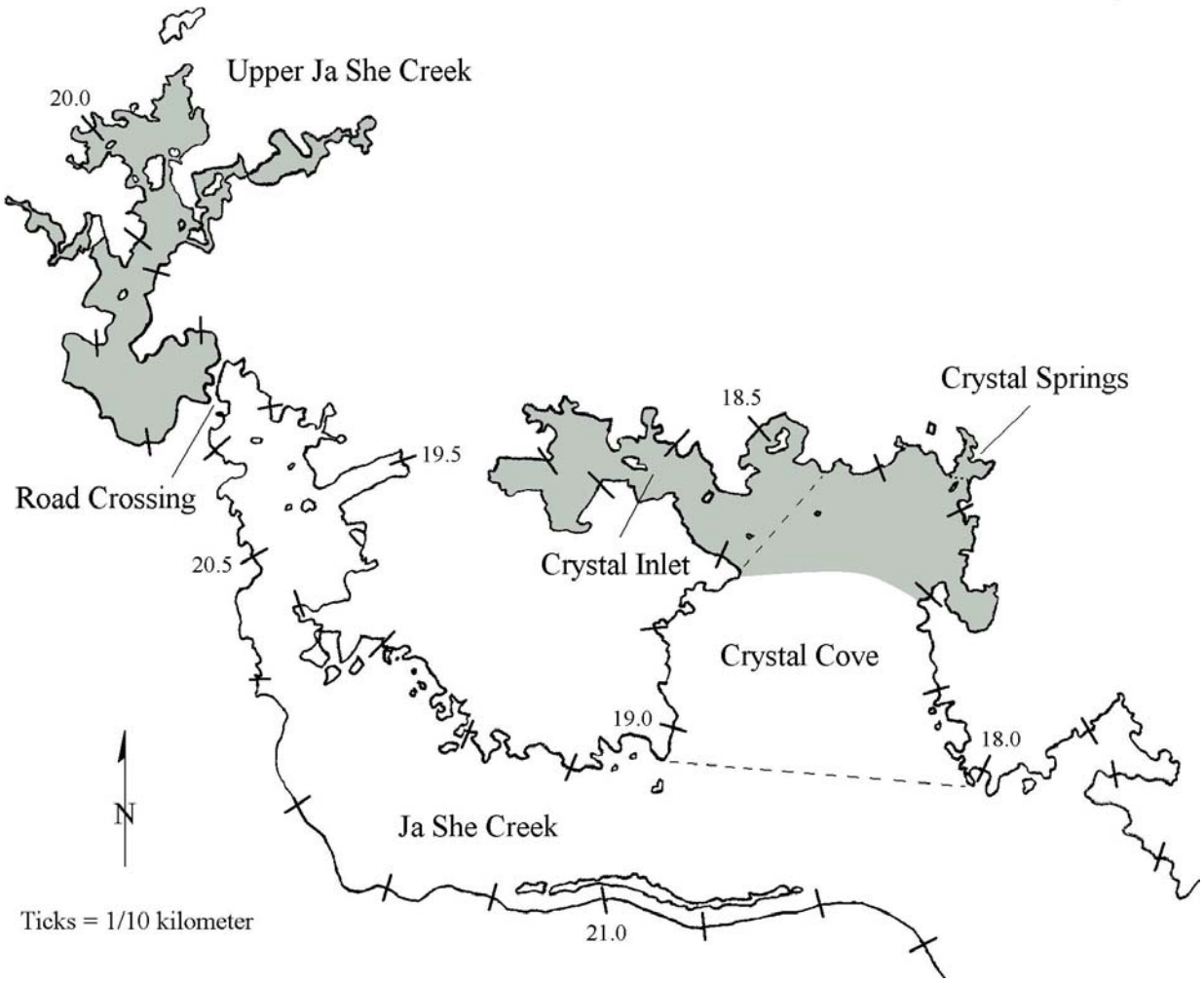

Figure G-3 Areas surveyed and mapped for Shasta crayfish and Shasta crayfish habitat (shaded) in Ja She Creek, Crystal Inlet, Crystal Cove, and Crystal Springs.

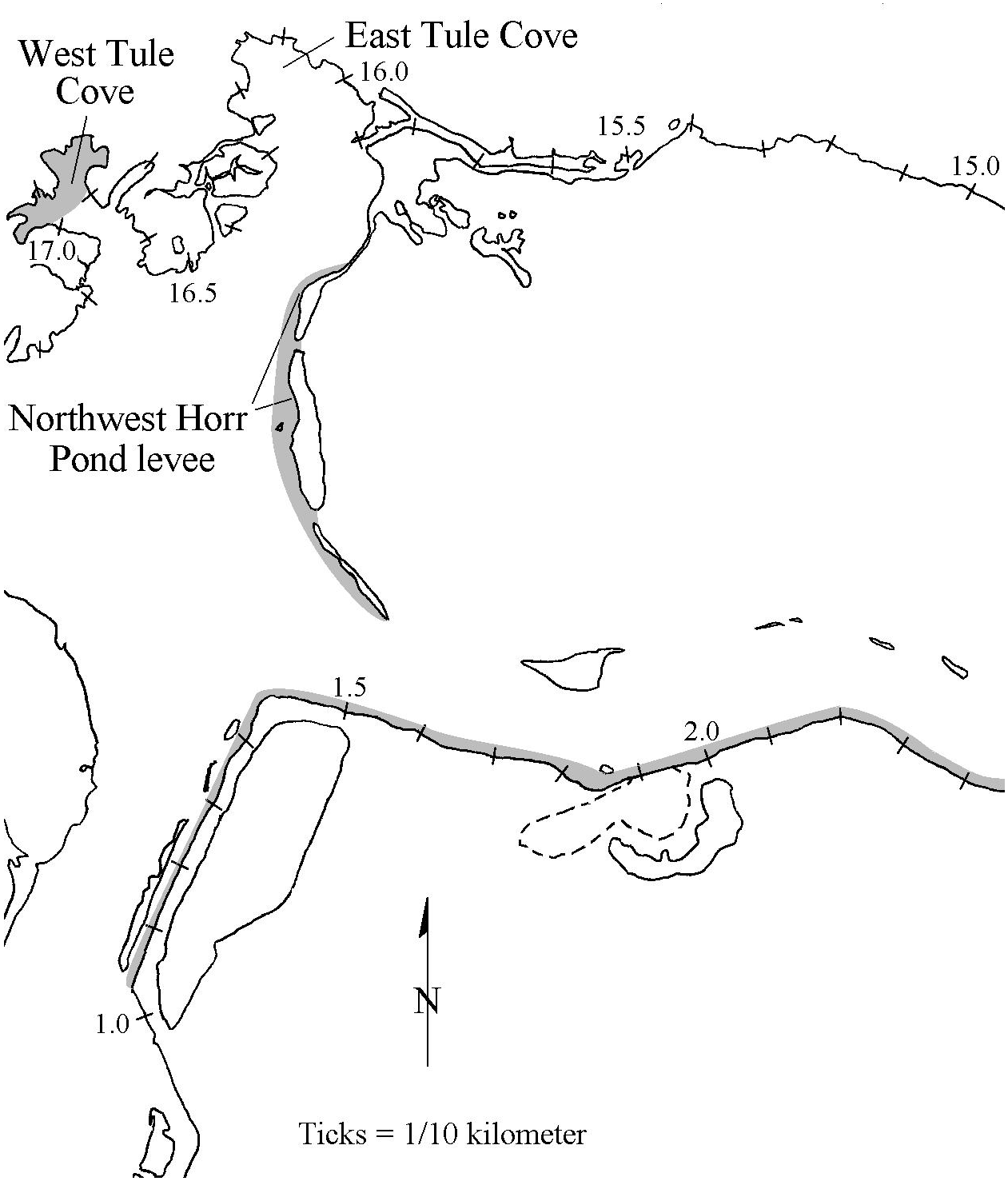

Figure G-4 Areas surveyed and mapped for Shasta crayfish and Shasta crayfish habitat (shaded) in East Tule Cove, West Tule Cove, and along the levees of Horr Pond and Tule River west of Rat Farm.

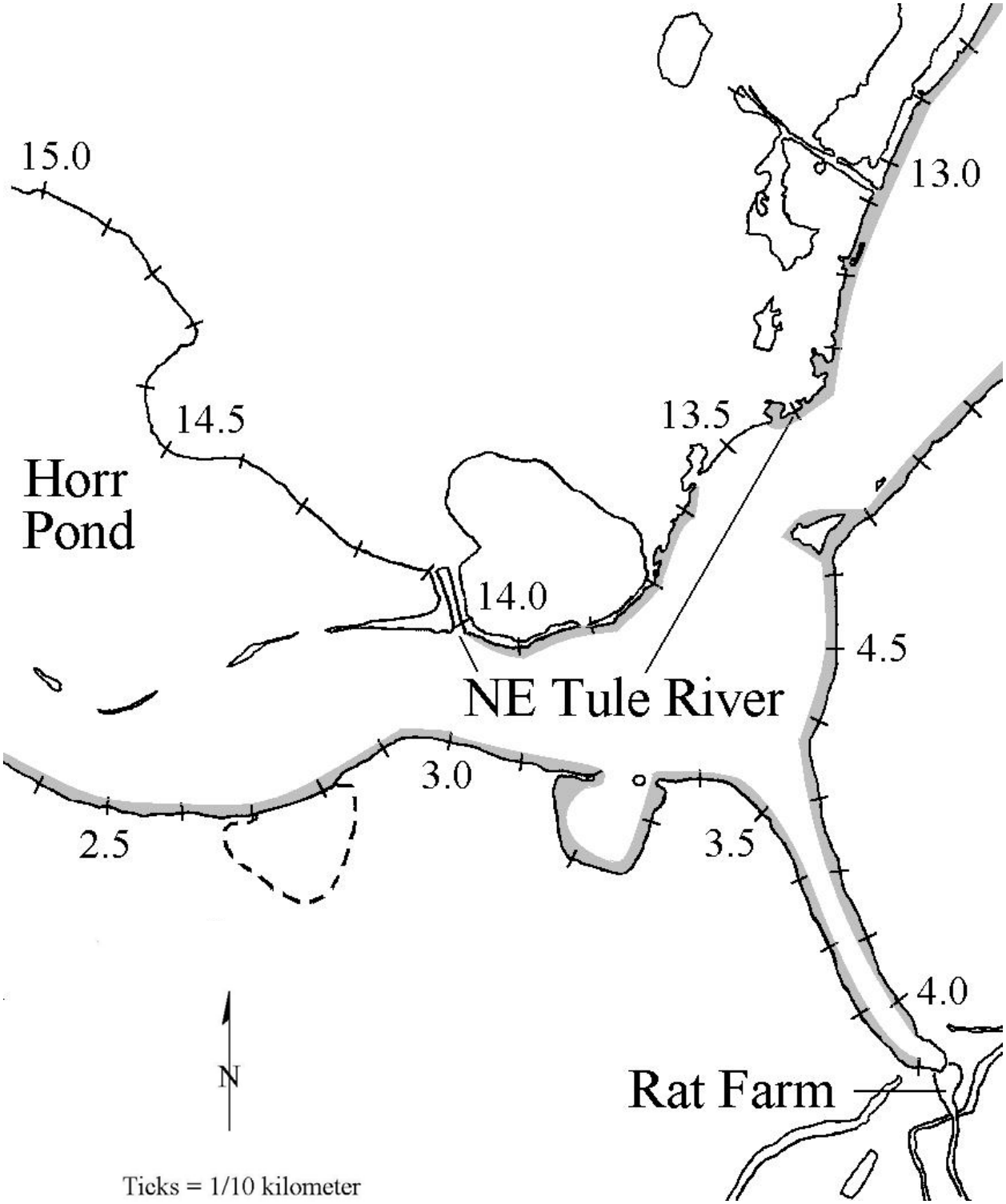

Figure G-5 Areas surveyed and mapped for Shasta crayfish and Shasta crayfish habitat (shaded) along the levees near Rat Farm.

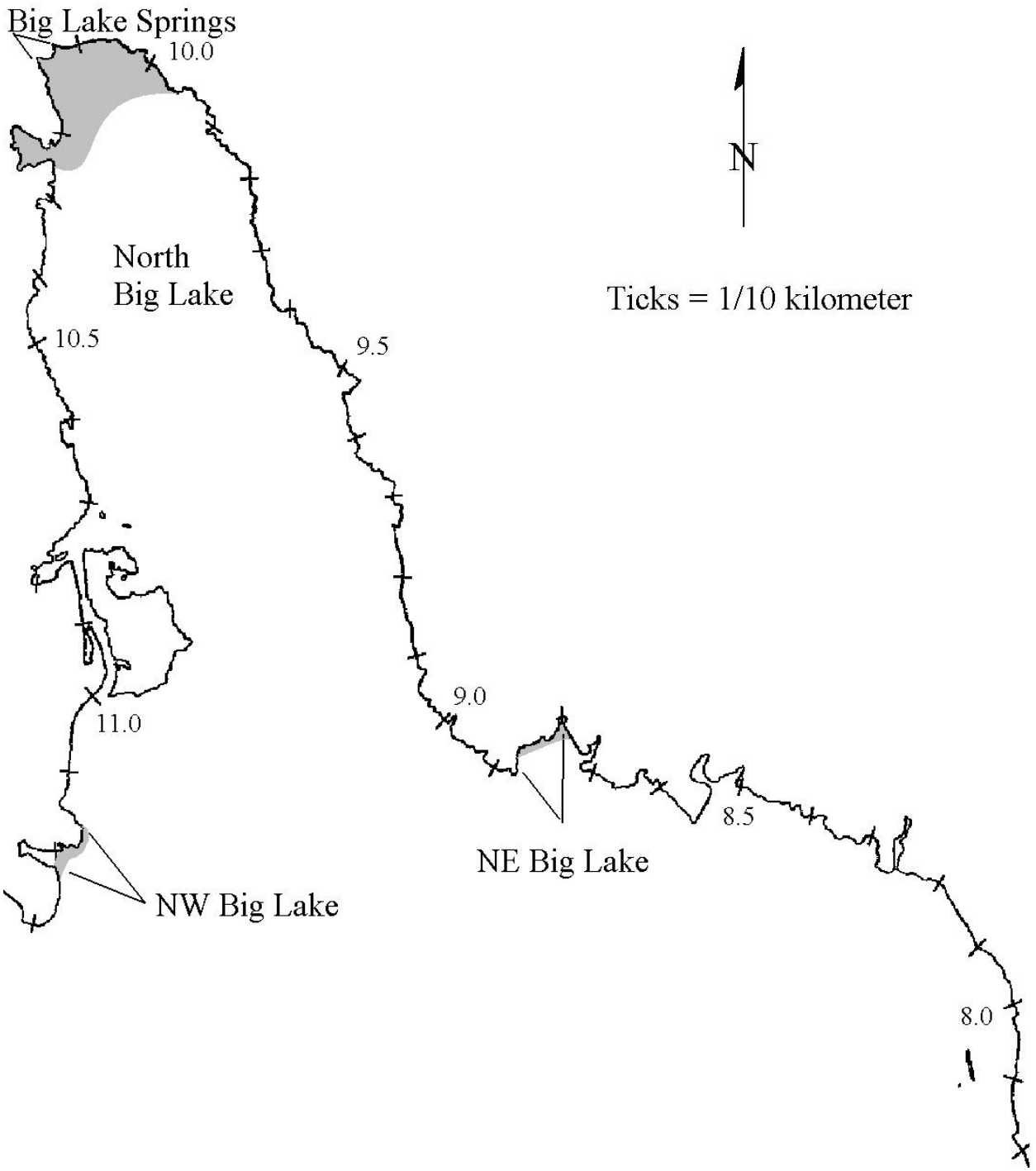

Figure G-6 Areas surveyed and mapped for Shasta crayfish and Shasta crayfish habitat (shaded) in northwest and northeast Big Lake and the big Lake Springs area.

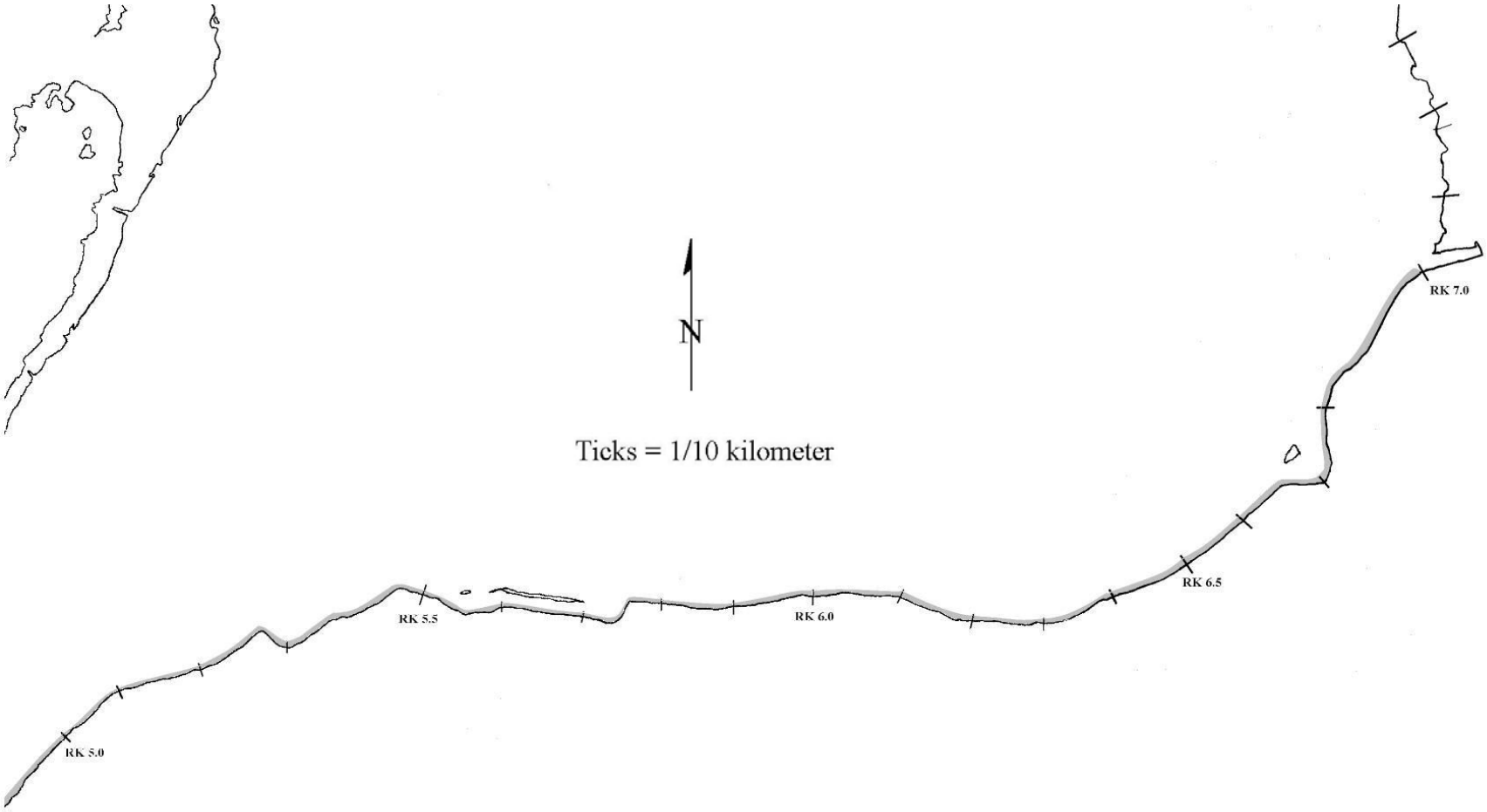

Figure G-7 Areas surveyed and mapped for Shasta crayfish and Shasta crayfish habitat (shaded) along the Big Lake levees east of Rat Farm.

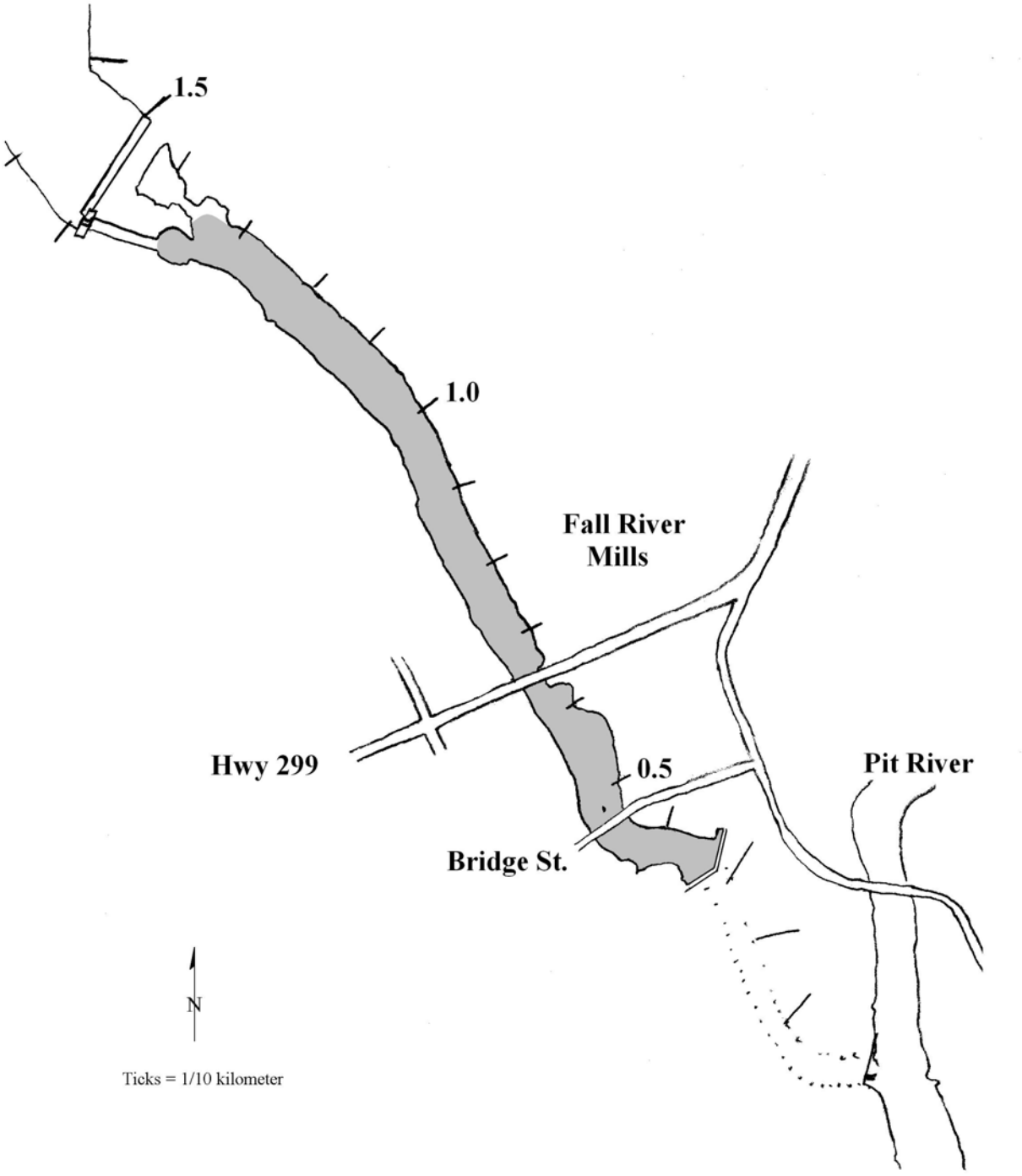

Figure G-8 Areas surveyed and mapped for Shasta crayfish and Shasta crayfish habitat (shaded) in Fall River Pond.