Monitoring Results of Alternative Watercourse and Lake Protection Zones in the McKinney Creek Watershed in interior, Northern California.

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Abstract

In 2006, based on existing stream water temperatures and channel and riparian habitat data collected along McKinney Creek, Timber Products Company proposed an alternative Watercourse and Lake Protection Zone. The proposed alternative WLPZ was to maintain 100% of the existing canopy closure from 0 to 50 feet from the bankfull width and 50% canopy closure from 50 to 150 feet. The monitoring design of the alternative WLPZ included comments and suggestions provided by the California Department of Fish and Game and North Coast Regional Water Quality Control Board. Timber harvesting occurred during the fall of 2007, following the peak of summer water temperature, with 2008 as the first post harvest water year. Timber harvesting between 50 and 150 feet from bankfull width resulted in mean canopy closure, measured with a siting tube, being reduced from 67% to 53%. Following timber harvest both watershed and reach level MWAT stream water temperatures decreased and then increased, in 2008 and 2009 respectively. At the reach level, relative to pre-harvest temperatures, post-harvest stream MWAT water temperatures remained unchanged following the alternative WLPZ timber harvest. Monitoring of potential sediment erosion found no sediment transported through the alternative WLPZ to the stream channel. Sediment transported to the alternative WLPZ from roads, skid trails or harvest units was filtered by the alternative WLPZ indicating it was very effective in minimizing potential impacts from surface erosion.

1.0 Introduction

McKinney Creek flows north directly into the Klamath River. McKinney Creek is known prior to 1980 to support anadromous salmonids including coho salmon and steelhead trout in lower reaches of the watershed. Currently, based on opportunistic electro-shocking of lower McKinney Creek by the California Department of Fish and Game, neither coho salmon or steelhead trout are known to occupy the lower reaches of the watershed. In April 2001, a barrier to anadromous salmonid distribution was found in lower McKinney Creek. The natural barrier is located approximately in the NW ¼ of Section 21 and is approximately 2.0 miles upstream from the confluence of McKinney Creek with the Klamath River (Figure 1). The natural barrier was reviewed by Mr. Dennis Maria, DFG and was determined to be a natural and permanent barrier to anadromous salmonid distribution. Consequently, the monitoring of this alternative WLPZ was completed in a Class I non-anadromous stream channel.

Through direct observation or correlation studies many scientific studies have established relationships between riparian habitat conditions and stream channels and forest management activities. Generalized curves have been developed that describe these relationships and the distances at which riparian habitat provide key functions for stream channel habitats including riparian shade (Spence et al, 1996; FEMAT 1993). In general, observational studies have found that riparian shade can potentially influence stream channels equal to one site-potential tree height (Beschta et al. 1987). Yet, cause-and-effect studies like the Alsea Watershed Studies in Oregon have found that effective riparian shade buffers from partially harvested riparian habitats occurs between 25 feet to 100 feet from the stream channel (Brown 1971)) and was verified in an additional cause-and-effect study (Brown 1972). Unfortunately, the cause-and-effect relationships between riparian and stream channel habitats, including riparian shade, and current forest management activities in California is poorly understood.

In 2006, Timber Products Company (Company) summarized regional literature, existing McKinney Creek stream water temperature data and watershed level riparian conditions to better understand both historic and existing riparian habitats and stream water temperatures in the McKinney Creek watershed (Appendix A: McKinney Creek THP 2-06-098-SIS6). The assessment of historic and existing riparian habitats found, based on 2001 aerial photography, a total of 84% of the reaches had over 70% canopy closure as compared to 1964 aerial photography when only 39% of the reaches had over 70% canopy closure. This assessment identified potential legacy impacts including historic mining, historic logging and road building and use of land for agriculture. The assessment identified a total of 1,956 feet of Class I riparian habitat and 4,332 feet of Class II riparian habitat that had been partially harvested in previous timber harvest plans between 1997 and 2005. Following these harvests MWAT stream water temperatures in lower McKinney Creek remained relatively unchanged (Appendix A: McKinney Creek THP 2-06-098-SIS6).

Based on this previous monitoring and results of this watershed level assessment, the Company proposed an alternative WLPZ. The alternative WLPZ was designed to maintain all riparian zone functions including riparian shade, nutrients, filtration of sediments, large wood debris delivery to stream channels and stream bank stabilization. Riparian zone functions specifically monitored as part of this alternative WLPZ included water temperatures, riparian shade and riparian zone filtration of sediments.

2.0 Study Design – Public Agency Recommendations

During the review of the proposed alternative WLPZ the NCRWQCB and DFG provided comments, suggestions and recommendations regarding the monitoring of the alternative WLPZ. In general, both the NCRWQCB and DFG were supportive of the proposed alternative WLPZ timber harvest plan and monitoring and provided specific recommendations to be included into the study design:

(1) Measure pre harvest and post harvest alternative WLPZ canopy closure from the entire alternative WLPZ to document the actual canopy closure reduction from the proposed timber harvest plan units.

(2) Collect summer stream temperatures down stream and upstream of proposed timber harvest plan units that focus on an evaluation of possible temperature impacts from management of Class I WLPZ's

(3) Conduct a field survey for sediment transported to or through the alternative WLPZ after first winter after operations. Document whether sediment was being transported to the Class I stream channel or alternative WLPZ and if so identify the source of the sediment. This would provide valuable compliance and effectiveness monitoring to document whether sediment was being transported to or through the alternative WLPZ or was being trapped prior to entering the stream channel or alternative WLPZ.

(4) Install additional stream temperature monitoring stations immediately upstream of Unit #12 to better isolate stream temperature changes along McKinney Creek.

3.0 Methods: Summarized Monitoring Plan in the McKinney Creek Watershed

Monitoring methods of the alternative WLPZ in the McKinney Creek watershed incorporates the results of the McKinney Creek timber harvest plan, the watershed level channel and riparian assessment, comments and suggestions provided by the NCRWQCB and DFG (Appendix B). Based on the scientific information and the suggestions and recommendations provided by the cooperators, the most appropriate study design was a before-after design. As the name suggests, the before-after design is the simple monitoring of the environment before a known disturbance and after a disturbance. This design can identify cause-and-effect relationships by measuring which components may adversely impact the environment and estimate the magnitude of the change (Smith 2002). In analysis, any difference found between the before and after results is attributed to the disturbance, however, this design is limited due to annual variation in environmental conditions like air temperatures, snow melt, stream flows or stochastic events like floods, debris torrents or wildland fires (Smith 2002).

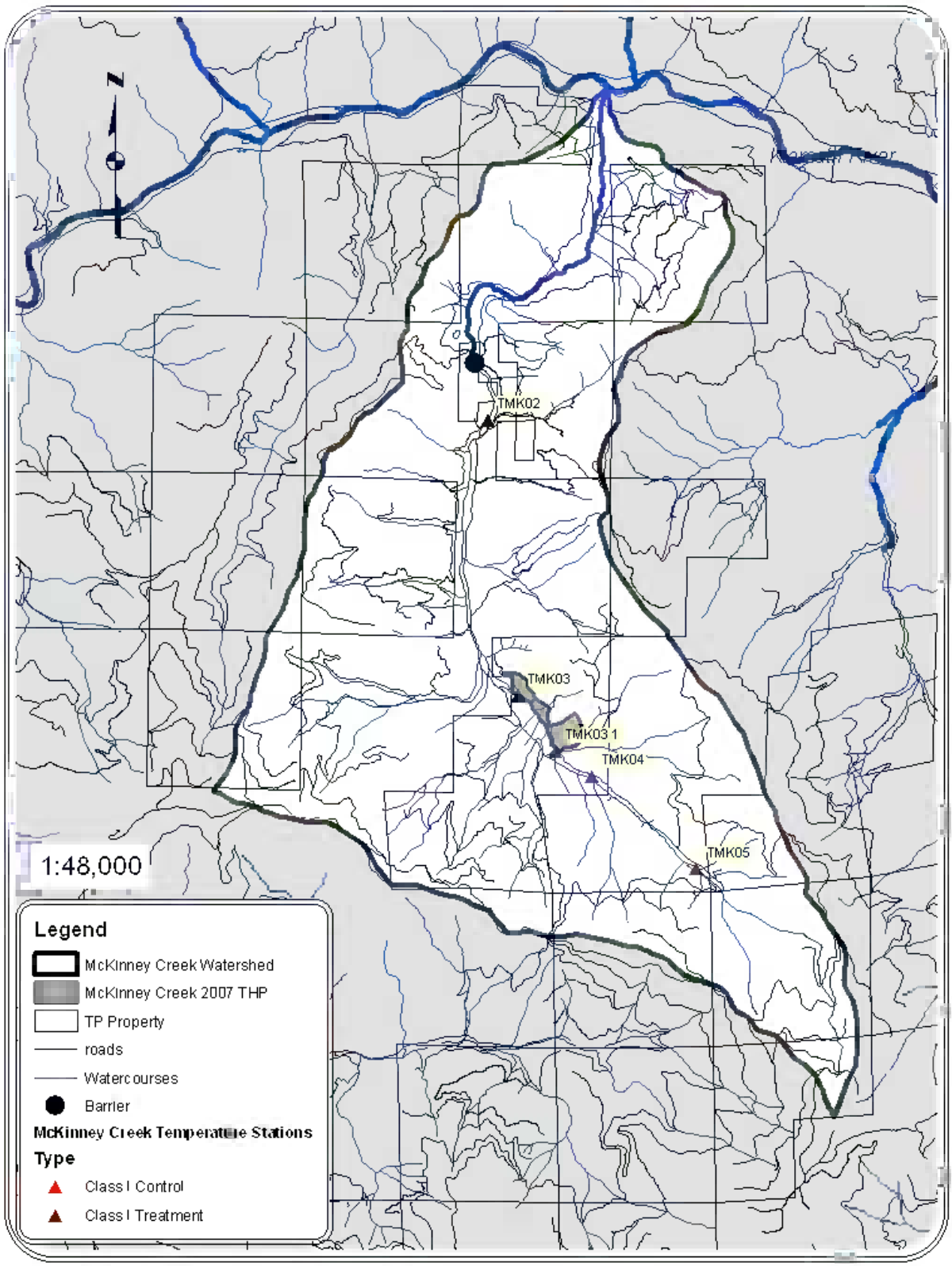
The proposed alternative WLPZ included two different protection zones. And inner zone, from 0 to 50 feet from the bankfull width, 100% of the existing canopy closure would be retained. In other words, this would create a 50 foot no harvest inner zone. The outer zone would be from 50 to 150 feet from bankfull width and 50% canopy closure would be maintained as measured by a sitting tube. This alternative WLPZ was designed to maintain all riparian functions, specifically maintaining existing stream water temperatures. Also, within the outer zone an Equipment Limitation Zone was proposed to maintain understory vegetation, down logs, rocks and forest floor litter to potentially filter sediments before being delivered to the stream channel.

3.1 Stream Water Temperature

The before-and-after design included two stream water temperature sites downstream and three sites upstream of the alternative WLPZ (Figure 1, Appendix C). Site TMK02 has been monitored lower McKinney Creek between 1997 and 2009. For this study, TMK03 was added immediately downstream of the timber harvest units. Site TMK03.1 was added immediately upstream of the timber harvest units to serve as a control and TMK04 and TMK05 were added as additional controls and to provide watershed level water temperature trends (Figure 1, Appendix C). For this study, due to the relative short stream length, we did not collect local microclimate data in the alterative WLPZ.

Water temperatures were measured continuously every one hour interval with electronic recording instruments, which is suitable to detect stream temperature peaks (Lewis et al. 2000). The goal of the field season was to begin on May 15th and end on October 1st. Each instrument was calibrated following calibration protocols (FFFC 1996; USGS 1978). Instruments used in this study were calibrated for accuracy using an EPA certified NIST traceable thermometer, ASTM# 6016. The manufacturer's specifications for accuracy of the instruments, Onset Hobo Temp H8, is stated as +/- 0.2 C at 0C. Additional information collected for each stream water temperature site were those recommended by FFFC (1996) and the USGS (1978). Information collected included date and time of instrument deployment, location name, serial number of instrument, unique location number and personnel. In addition, descriptive information collected for each monitoring site included elevation, tributary basin area, distance to watershed divide and stream summer low flow. And in case of potential equipment malfunction, instantaneous water and air temperatures were recorded on the day of deployment in the field to help identify malfunctions.

Figure 1 Alternative WLPZ and stream water temperature sites along McKinney Creek



3.2 Canopy Closure, Basal area and Trees within alternative WLPZ

Pre harvest and post harvest alternative WLPZ canopy closure, basal area and number of trees were measured to document both the pre and post treatment conditions. At every 100 feet of stream channel a systematic transect perpendicular to each survey plot was measured (Berbach et al. 1999, Zwienicki and Newton 1999). Distances were collected using a cloth tape (Caldwell et al. 1991). Canopy closure, basal area and number of trees were measured within the stream channel, at the mid-point of the inner zone and mid-point of the outer zone. Canopy closure refers to the total canopy overhead that was measured by both a densiometer and siting tube (CWHR 1988). Basal area and the number of trees were measured within a $1/50^{th}$ acre fixed plot centered at the mid-point of the inner zone and mid-point of the outer zone. Due to an existing road located within portions of the alternative WLPZ, two additional survey plots were added per 100 feet of stream length, to more accurately represent canopy closure, basal area or the number of trees.

3.3 Sediment Transported to or through the alternative WLPZ

In general, filtration of sediment from overland flow can occur by physical barriers that trap sediment such as ground vegetation and down woody debris and can occur at distances equal to one site-potential tree height (FEMAT 1993). However, local watershed or channel conditions including geomorphic characteristics such as slope, soil type and vegetative structure and cover can influence effectiveness of filtration of sediment. This study proposed the retention of 100% of all vegetation and conifer and hardwoods trees, down logs, rocks and forest floor litter for filtration within 50 feet of the stream channel, and 50% canopy closure for the remaining 100 feet of zone width. An Equipment Limitation Zone was proposed within the outer zone to maintain understory vegetation, down logs, rocks and forest floor litter to also potentially filter sediments before being delivered to the stream channel.

We conducted a field survey of pre harvest and post harvest conditions in the alternative WLPZ to document sediment transported to or through the alternative WLPZ. Post harvest assessments were conducted following the 1^{st} winter period and 2^{nd} winter as operations were completed. The primary focus of this field survey was to measure sediment transported from overland flow, more concentrated sediment sources like skid trails, road relief culverts, road relief rolling dips, road culvert crossings and small landslides. If any sediment was found to be transported to or through the alternative WLPZ, key metrics were included:

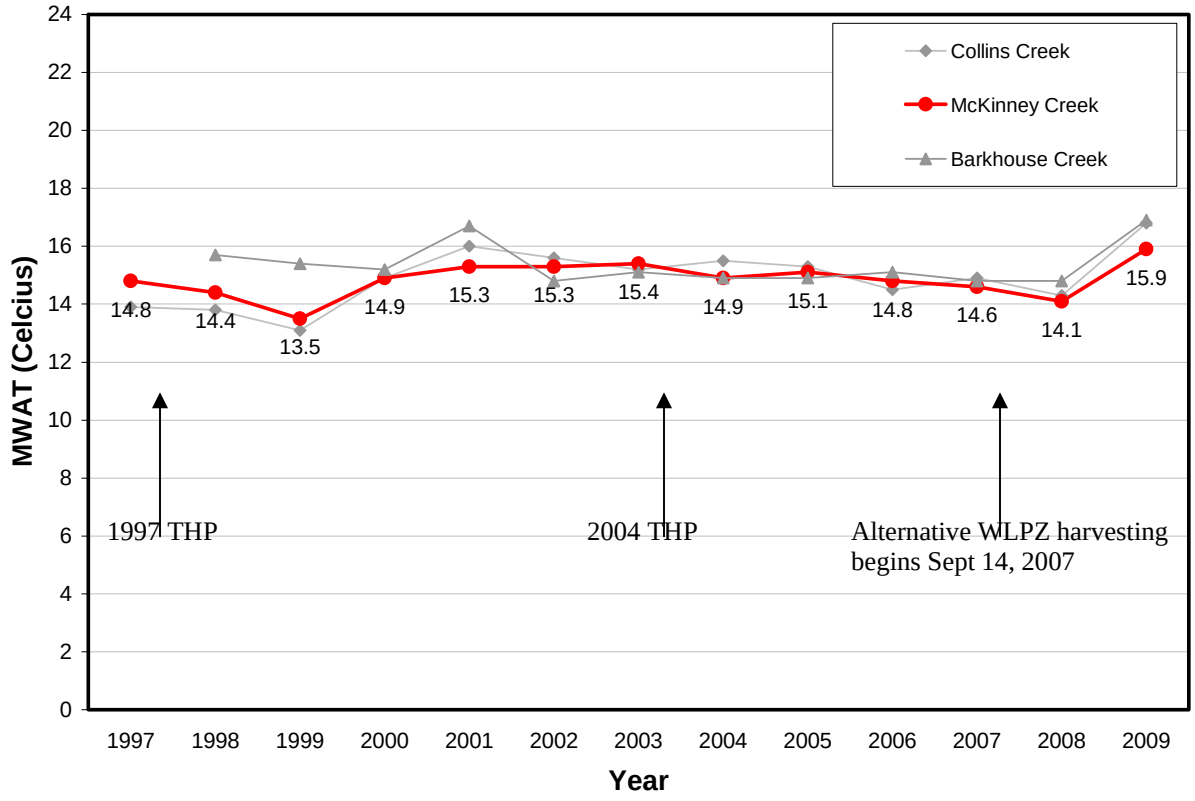
Table 1 Sediment Transport field survey information collected

Sediment Erosion Metric	Measurement Method
Date	Pre-harvest, Post-harvest, 1^{st} winter, 2^{nd} winter
Type	Rill, Gully, Channel, Landslide
Size (Volume)	Length x Width x Depth (Cloth tape)
Location	Channel Zone, WLPZ, SOZ, Harvest Unit, Skid Trail, Road
Road Feature Type (if appropriate)	Road related features would be inventoried using our standard quantitative road inventory methods.
Initiation Point	Channel Zone, WLPZ, SOZ, Harvest Unit, Skid Trail, Road
Delivery Point	Wetted Stream Channel, Channel Zone, WLPZ, SOZ, Harvest Unit
Effective Mitigation Measures (if any)	Make qualitative notes regarding waterbars, vegetation, duff layer, coarse soils, topography

4.0 Results: Watershed Level Stream Water Temperatures

Since 1997 stream water temperatures have been collected at one location in the lower McKinney Creek (TMK02) watershed. The results of this watershed level monitoring are described in Figure 2 and Appendix D. Following timber harvesting in 1997 and again in 2004 downstream water temperatures remained relatively unchanged, increasing or decreasing slightly from year to year. Following the September 2007 alternative WLPZ harvest, 2008 summer MWAT water temperatures decreased to 14.1 C. Summer 2009 MWAT water temperatures increased to 15.9 C, apparently, due to 64% lower stream flows (Figure 4). Watersheds immediately adjacent to McKinney Creek, Barkhouse Creek to the east and Collins Creek to west, which had no timber harvesting between 2007 and 2009, experienced similar watershed level MWAT water temperature increases in 2009 (Figure 2). The decrease in stream water temperature in 2008 and increase in 2009 following timber harvest appear to be related to regional changes in stream flows or air temperatures or both.

Figure 2 Upper McKinney Creek (TMK02) (Downstream of Harvest)



4.1 Results: Reach Level Stream Water Temperatures

At the reach level, which includes the entire alternative WLPZ, pre harvest stream water temperatures were collected in 2006 and 2007 at TMK03. Immediately downstream of the alternative WLPZ harvest units MWAT water temperatures ranged from 13.8 C to 14.7 C (Appendix C). Post harvest MWAT water temperatures in 2008 and 2009 ranged from 13.6C to 15.1 C (Appendix C, Figure 3). Similar to results at the watershed level, the reach level MWAT water temperatures decreased in 2008 and increased in 2009. Within the alternative WLPZ reach, the 2007 pre harvest MWAT water temperatures increased from 14.1 C (upstream) to 14.7 C (downstream) or 0.6 C. Following timber harvest, upstream to downstream MWAT water temperatures increased 0.2 C in 2008 and 0.9 C in 2009. At the reach level, relative to pre harvest MWAT temperatures and upstream controls (Figure 3), post harvest MWAT water temperatures remained unchanged following the alternative WLPZ timber harvest.

Figure 3 **McKinney Creek pre and post harvest water temperatures.**

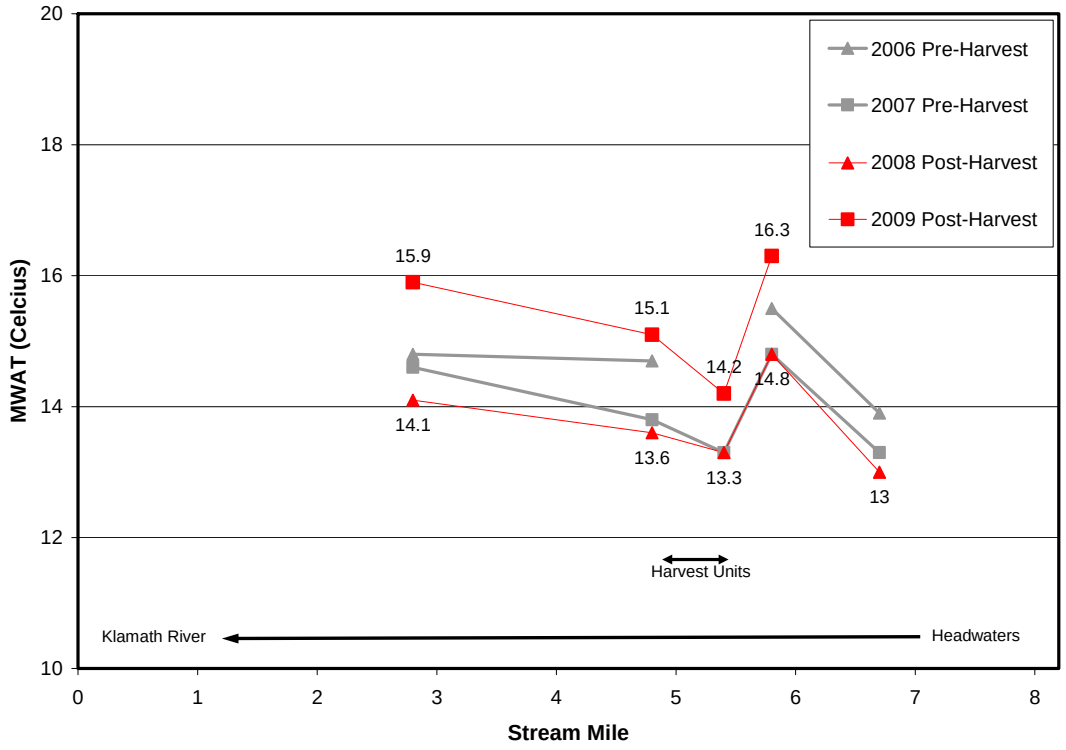
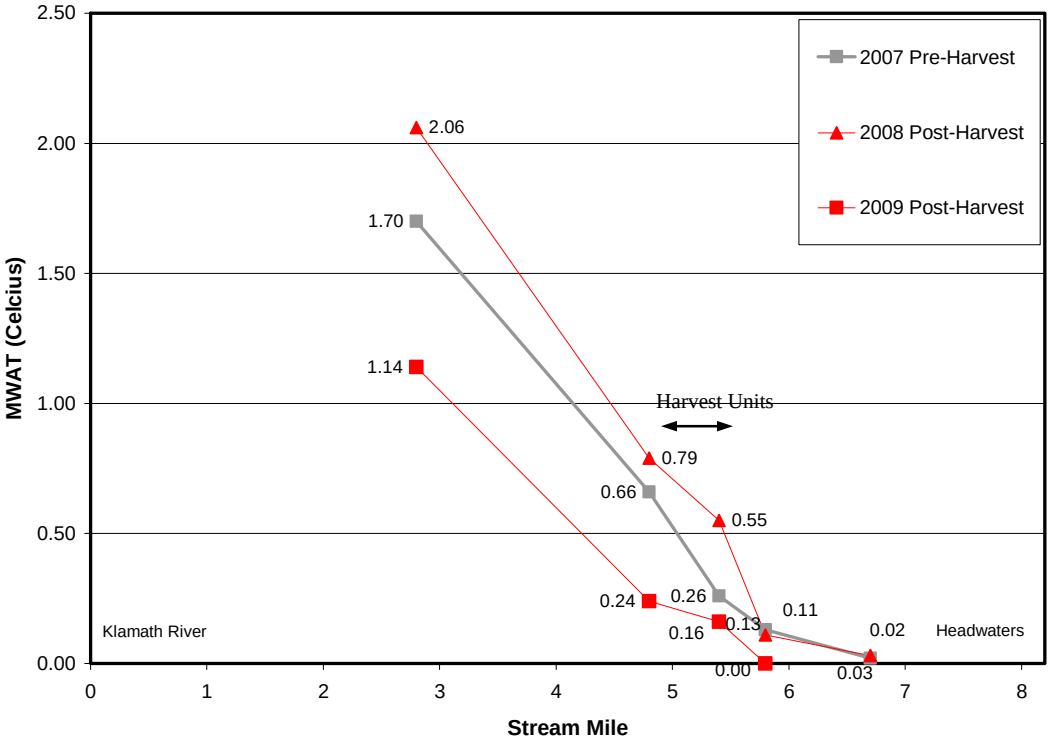


Figure 4 **McKinney Creek pre and post harvest stream flows.**



4.2 Results: Canopy Closure, Basal Area and Trees within alternative WLPZ

Pre harvest field surveys of the stream channel and alternative WLPZ were completed in May of 2007. A total of 3,200 feet of stream channel was surveyed resulting in 32 survey plots along the survey. Stream wetted channel width mean was 7.6 feet ranging from 4 feet to 12 feet. Stream bank full width mean was 13.3 feet ranging from 8 feet to 27 feet. Stream 100-year flood plain width mean was 28.1 feet ranging from 18 feet to 40 feet. Stream channel gradient mean was 4.2% ranging from 1% to 8%. Post harvest field surveys of the stream channel and alternative WLPZ were completed in May and August of 2008

Mean pre harvest alternative WLPZ outer zone canopy closure, as measured with a densitometer, was 83% and ranged from 42% to 100% (Table 2). Mean pre harvest canopy closure measured with a siting tube was 67% and ranged from 11% to 100%. The alterative WLPZ timber harvest reduced mean canopy closure from 67% to 53%.

Table 2 Pre and Post Harvest Canopy Closure for alternative WLPZ

WLPZ Canopy Closure		Number of Plots (n)	Number of Measurements	Pre Harvest Mean (%)	Pre Harvest Range (%)	Post Harvest Mean (%)	Post Harvest Range (%)
Stream Channel	(Densiometer)	32	128	94%	86 - 98%	- - -	- - -
Inner Zone	(Densiometer)	32	128	93%	41 - 100%	- - -	- - -
Outer Zone	(Densiometer)	60	240	83%	42 - 100%	73%	34 – 98%
Stream Channel	(Siting tube)	32	288	86%	56 – 100%	- - -	- - -
Inner Zone	(Siting tube)	32	288	93%	33 – 100%	- - -	- - -
Outer Zone	(Siting tube)	60	540	**67%**	11* - 100%	**53%**	0* – 100%

* = One plot located on road within WLPZ

The fate of all trees measured within 1/50th acre fixed plots was recorded following timber harvest operations. Harvesting of the alternative WLPZ reduced mean trees per acre (tpa) from 167 tpa to 142 tpa (Table 3). Mean basal area acre was reduced from 211 ba to 162 ba. Pre harvest surveys found a total of 197 trees within 1/50th fixed plots. Post harvest 161 or 82% of trees remained unharvested with a mean dbh of 12.3 inches which ranged from 5 to 35 inch dbh. There were 23 trees harvested or 12 % harvested with a mean dbh of 17.3 inches which ranged from 7 to 29 inch dbh. Blow down occurred during the 1st winter following operations accounting for 13 trees or 6% with a mean dbh of 12.9 inches which ranged from 5 to 23 inch dbh. The boundary of the blow down area was measured with a GPS unit and measured 0.35 acres. No blow down has occurred during the 2nd winter following operations. As a comparison, surface erosion surveys also documented wind thrown trees and found 20 trees total dispersed within the entire alternative WLPZ, not just within the 1/50th acre fixed plots. This comparison indicates that wind thrown trees were non-normally distributed and heavily weighted within a few 1/50th acre fixed plots suggesting the fixed plot results may overestimate the amount of wind thrown trees within the entire alternative WLPZ.

Table 3 Pre and Post Harvest Trees/Acre and Basal Area/Acre within WLPZ 1/50th acre fixed plots

WLPZ Canopy Closure	Number of Plots (n)	Measured Trees	Pre Harvest Mean	Pre Harvest Range	Post Harvest Mean	Post Harvest Range
Trees/Acre						
Inner Zone	32	136	209	0 - 600	- - -	- - -
Outer Zone	57	197	**167**	0 – 450	**142**	0 – 400
Basal Area/ Acre						
Inner Zone	32	136	332	0 – 1,186	- - -	- - -
Outer Zone	57	197	**211**	0 – 1,180	**162**	0 to 1,180

Note: All trees > 5" dbh measured within 1/50th acre fixed plot.

4.3 Sediment Transported to and through the WLPZ

Sediment erosion surveys were conducted, both pre and post harvest, to determine whether sediment was being transported to and through the Class I WLPZ. All existing and historic sediment erosion sources were recorded within the Class I stream channel zone, alternative WLPZ, and harvest units immediately adjacent to the alternative WLPZ. Pre harvest sediment erosion surveys were completed on May 21, 2007. A total of 3,200 lineal feet of stream channel were surveyed and found relatively small erosion source (Table 4). Post harvest sediment erosion surveys were conducted May 22, 2008 following the first winter after operations and on April 14, 2009, following the second winter after operations (Table 4).

Post harvest sediment erosion surveys found no new erosion at either site found during pre harvest surveys. Rip rap rock placed at Erosion Survey Point J resulted in an effective control of existing erosion, and is currently preventing any new erosion at this site.

Post harvest sediment erosion surveys found nine new, relatively small, measurable erosion sources (Table 5, Appendix F). Out of the nine sites, two initiated as harvest unit sheet erosion, four initiated as concentrated flow along skid trails, two initiated as sheet erosion along roads within the WLPZ and one initiated from wind throw of WLPZ trees. Total amount of erosion initiated from these nine sites totaled an estimated 0.7 cuyds of sediment. Out of the nine sites, one site delivered <0.1 cuyds of sediment to the channel zone from wind throw of WLPZ trees at Point G. One site delivered sediment to the WLPZ outer zone where sediment routing stopped in the alternative WLPZ outer zone. One site that initiated in the WLPZ inner zone along a road, delivered <0.1 cuyds to the WLPZ inner zone. At the remaining six sites sediment was routed sediment through the harvest unit and filtered at the outer edge of the alternative WLPZ.

In summary, the alternative WLPZ and adjacent harvest units did not initiate any new large landslides or surface erosion. Relatively small, less than 0.2 cuyd sediment sources were found being generated within adjacent harvest units. The alternative WLPZ effectively stopped routing of sediment from road, skid trails and harvest units at 8 of 9 sites and prevented sediment from reaching the channel zone. Results indicate that sediment being transported to the alternative WLPZ or initiated at the outer edge of the alternative WLPZ was effectively trapped prior to entering the channel zone or stream wetted zone and minimized any potential impacts from surface erosion.

Table 5 Pre and Post harvest erosion survey points conducted on 5/21/07, 5/22/08 and 4/14/09

Erosion Survey Point	Description	Initiation Location	Initiation Source	Delivery Zone	Delivery Distance	Erosion (cuyds)
Pre						
J	2 CMP's shotgun erosion	CZ	R	WZ	12	0.9
Post						
A	Survey Start	---	---	---	---	0
B	Rolling dip on road	R	SK	WLPZe	50	0.2
C	3 Blowdown trees	WLPZo	WLPZo	WLPZo	0	0
D	Slight road sheet erosion	R	R	WLPZe	10	<0.1
E	Class III location	---	---	---	---	0
F	Class III, 2 Blowdown trees	WLPZo	WLPZo	WLPZo	0	0
G	14 Blowdown trees	WLPZo	WLPZo	CZ	50	<0.1
H	Rolling dip on road	R	HU	WLPZi	10	<0.1
I	Control point	---	---	---	---	0
J	2 CMP's with RipRap outlet	---	---	---	---	0
K	Rill erosion	HU	HU	WLPZe	35	0.1
L	Rill erosion	HU	SK	WLPZe	12	0.1
M	Rill erosion	HU	SK	WLPZe	20	<0.1
N	Rill erosion	HU	SK	WLPZe	55	<0.1
O	Road sheet erosion	R	R	WLPZo	45	<0.1

CZ = Channel Zone WZ = Wetted Zone WLPZi = WLPZ Inner zone WLPZo = WLPZ Outer zone
WLPZe = WLPZ edge with unit R = Road SK = Skid trail HU = Harvest Unit

5.0 Summary of Results

(1) The harvesting of trees from the outer zone of the alternative WLPZ resulted in a reduction of canopy closure from 67% to 53%.

(2) At the watershed level, a decrease in MWAT water temperature in 2008 and increase in 2009 following the alternative WLPZ timber harvest appear to be related to regional changes in stream flows or air temperatures or both.

(3) At the reach level, relative to pre harvest MWAT water temperatures and upstream controls, post harvest MWAT water temperatures remained unchanged following the alternative WLPZ timber harvest.

(4) There was no sediment transported through the alternative WLPZ to the stream channel. Sediment transported to the alternative WLPZ from roads, skid trails or harvest units was very small and was filtered, indicating the alternative WLPZ was very effective in minimizing potential impacts from surface erosion.

(5) Post harvest blow down of riparian trees in the channel and inner and outer zones was isolated to a relatively small portion of the alternative WLPZ.

6.0 Limitations of Results

It should be noted that this investigation has identified some preliminary cause-and-effect relationships between riparian and stream channel habitats and current forest management activities in California. And these results have been measured during, the most acute potential impacts from timber harvesting. However, due to the relatively short study period and limited sample size, one sample reach, generalization of the results should be limited to stream channels with similar geomorphic and ecological conditions and timber harvests with similar silvicultural prescriptions.

7.0 References

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Appendix C: Summary of Water Temperature Monitoring Sites (See Water Quality Map)

Monitoring Site #	UTM North	UTM East	Elev (meter) (feet)	Timber Harvest Unit #	Monitoring Years	Stream Class	Control or Treatment
TMK02	4628806	507876	784 m (2,611 ft)	Baseline	1997 to 2008	Class I	Baseline
TMK03	4626033	508209	899 m (2,994 ft)	Downstream Unit #11,12,13	2006 to 2008	Class I	Downstream Treatment
TMK03.1	4625481	508598	933 m (3,107 ft)	Upstream Unit #11,12,13	2007 to 2008	Class I	Upstream Treatment
TMK04	4625230	508971	960 m (3,197 ft)	Upstream Unit #11,12.13	2006 to 2008	Class I	Upstream Control
TMK05	4624308	510038	1065 m (3,546 ft)	Upstream Unit #11,12,13	2006 to 2008	Class I	Upstream Control

Appendix D: McKinney Creek (TMK02) (Downstream of harvest)

Calendar Year	Sampling Period	7-day MWAT Period	Diurnal Fluctuation C	MMAT[1] C° and F°	MWAT[1] C° and F°
1997	6/12 to 11/13	8/4 to 8/10	3.5	16.4 (61.8F)	14.8 (58.9F)
1998	5/21 to 11/30	7/21 to 7/27	2.8	15.8 (60.8F)	14.4 (58.2F)
1999	5/27 to 12/6	8/24 to 8/30	2.7	14.5 (58.4F)	13.5 (47.3F)
2000	6/2 to 9/8	7/28 to 8/3	3.4	16.3 (59.1F)	14.9 (59.1F)
2001	7/9 to 10/9	8/7 to 8/13	3.9	17.1 (63.1F)	15.3 (59.8F)
2002	6/27 to 10/9	7/10 to 7/16	3.7	16.9 (62.8F)	15.3 (59.8F)
2003	6/3 to 9/22	7/27 to 8/2	2.8	16.7 (62.4F)	15.1 (59.5F)
2004	6/1 to 9/21	7/22 to 7/28	3.2	16.4 (61.8F)	14.9 (59.1F)
2005	6/6 to 9/26	8/2 to 8/8	3.3	16.6 (62.2F)	15.1 (59.5F)
2006	5/10 to 10/24	7/21 to 7/27	2.5	16.1 (61.3F)	14.8 (58.9F)
2007	5/10 to 10/26	7/22 to 7/28	3.0	16.1 (61.3F)	14.6 (58.6F)
2008	5/22 to 10/13	8/11 to 8/17	3.5	15.7 (60.6F)	14.1 (57.6F)
2009	4/14 to 10/13	7/26 to 8/1	4.0	17.7 (64.2F)	15.9 (60.9F)

1 MWAT is the Maximum Weekly Average Temperature, MMAT = Maximum Weekly Maximum Temperature

Appendix E: McKinney Creek

Calendar Year	Sampling Period	7-day MWAT Period	Diurnal Fluctuation	MMAT[1] C° and F°	MWAT[1] C° and F°
TMK03 Immediately Downstream Harvest					
2006	5/30 to 10/24	7/22 to 7/28	1.9	15.6	14.7
2007	5/10 to 10/26	7/21 to 7/27	2.2	14.7	13.8
2008	5/22 to 10/16	8/13 to 8/19	2.4	14.7	13.6
2009	4/14 to 10/13	7/26 to 8/1	2.8	16.3	15.1
TMK03.1 Immediately Upstream Harvest					
2006	No data	No data	No data	No data	No data
2007	5/10 to 10/26	7/21 to 7/27	1.8	14.1	13.3
2008	5/22 to 10/16	8/11 to 8/17	2.4	14.5	13.3
2009	4/14 to 10/13	7/26 to 8/1	2.6	15.4	14.2
TMK04 Upstream Harvest					
2006	5/30 to 10/24	7/21 to 7/27	1.9	16.3	15.5
2007	5/10 to 10/26	7/23 to 7/29	2.4	15.9	14.8
2008	5/22 to 10/16	8/11 to 8/17	2.8	16.0	14.8
2009*	4/14 to 10/13	7/26 to 8/1	2.1	17.1	16.3
TMK05 Upstream Harvest					
2006	5/30 to 10/24	7/21 to 7/27	1.0	14.4	13.9
2007	5/10 to 10/26	7/22 to 7/28	0.7	13.1	12.8
2008	5/22 to 10/16	8/11 to 8/17	0.6	13.3	13.0
2009**	4/14 to 10/13	Dewatered			

* Dewatered after MWAT period. **Dewatered during MWAT period

1 MWAT is the Maximum Weekly Average Temperature, MMAT = Maximum Weekly Maximum Temperature

Appendix A: McKinney Creek

Appendix B: McKinney Creek

Class I Watercourse Regarding 936.9 (f): The current THP (outside of the Coastal Anadromy Zone) will have the following protection measures for a single Class I watercourse with a confined channel (Howard Creek).
As per 936.9 (v) Site-specific measures or non standard operational provisions; the RPF is proposing site specific measures in place of standard zone widths and overstory canopy cover described in 936.9 (f) (4). Both RPF site specific evaluation and written concurrence as a result of pre-consultation with DFG on October 27, 2010 will follow in subsequent pages.

The minimum WLPZ delineation and timber operations in Class I WLPZ's in locations outside the coastal anadromy zone where confined channels are present is 100-feet slope distance.

- Single-Tree Selection shall be the silvicultural system selected as the harvesting system
- Sanitation-Salvage is prohibited within the WLPZ
- The post-harvest stand shall have a minimum 50% overstory canopy; The post harvest canopy may be composed of both conifers and hardwood species and shall have at least 25% existing overstory conifer canopy
- The post-harvest stand shall retain the 7-largest conifer trees (live or dead) on each acre of the area that encompasses the core zone
- Large trees retained shall be those most conducive to recruitment to provide for the beneficial functions of riparian zones (e.g., trees that lean towards the channel, have an unimpeded fall path toward the watercourse, are in advanced decay, on unstable areas, or have undermined roots)

- 14CCR § 936.5(e)"B", The WLPZ shall be clearly identified on the ground by the RPF who prepared the plan, or his supervised designee, with a combination of blue/blue & white striped flagging along the perimeter of the zone prior to the preharvest inspection.

- 14CCR § 936.5(e) "D", To ensure the retention of shade canopy filter strip properties and the maintenance of wildlife values described in 14CCR § 936.4(b), a base mark shall be placed below the cut-line of the harvest trees within the zone. An RPF or his supervised designee will complete such marking in advance of the preharvest inspection.

Contrasting 936.9 Table 3,

Watercourse & Lake Protection Zone (WLPZ) widths				
Class I Confined / Outside	Channel Zone	Core / Inner Zone	Inner / Outer Zone	Total WLPZ
Slope Class 0%-30%	Variable	50-feet	50-feet	100-feet
Silviculture	No Harvest	No Harvest	Selection	
Overstory Canopy	Retain All Trees	Retain All Trees	50% overstory canopy	

Pertaining to 936.4 (a)(2), as part of the field examination the RPF has concluded there is one Class I watercourse with potential spawning and rearing habitat for anadramous salmonids & no Class II watercourses that can feasibly be restored to a Class I. Regarding 936.4 (a)(1), as part of this field examination, the RPF... shall evaluate areas near, and areas with the potential to directly impact, watercourses and lakes for sensitive conditions including, but not limited to, ... wherein the values set forth in 14 CCR § 936.4(b) are *impaired*. The modern requirements of 14 CCR § 936.9 precede other sections of the Forest Practice Rules. The proposed THP meets the current goal as timber operations were planned and shall be conducted to protect, maintain, and contribute to the restoration of properly functioning salmonid habitat and listed salmonid species. The habitat condition, including example photographs, is described in subsequent sections of the timber harvest plan.

936.9 (v): "Site-specific measures or nonstandard operational provisions"

(1) "In consideration of the spatial variability of the forest landscape, the RPF may propose site-specific measures or nonstandard operational provisions in place of any of the provisions contained in this section. Site specific plans may be submitted when, in the judgment of the RPF, such measures or provisions offer a more effective or more feasible way of achieving the goals and objectives set forth in 14 CCR 916 [936.9, 956.9], subsections (a) and (c), and would result in effects to the beneficial functions of the riparian zone equal to or more favorable than those expected to result from the application of the operational provisions required under 14 CCR 916.9 [936.9, 956.9]."

(2) "Measures or provisions proposed pursuant to 14 CCR 916.9 [936.9, 956.9], subsections (v) shall only be approved when the plan incorporates an evaluation of the beneficial functions of the riparian zone as set forth in subsection (3) below. In the event of measures limited in applicability to specific sites, the submitter may instead of an evaluation, obtain written concurrence from DFG prior to plan submittal. RPF's may request a pre-consultation for the site specific plan and the Director may agree and request staff from responsible agencies."

(3) "The evaluation of the beneficial functions of the riparian zone shall be included... and shall include the following components scaled appropriately to the scope of the proposed measure(s) or provision(s) and the beneficial functions potentially affected."

Pre-consultation:

A pre-consultation for the alternative practice was requested by the RPF and accommodated by Department of Fish and Game (DFG) Environmental Scientist, Stacy Stanish. The on-site meeting was held on October 27th, 2010. In attendance were Henry T. James, (SPI) RPF; Stacy Stanish, (DFG); and Adam Wyman, (CAL FIRE) Tehama/Glenn Unit Forester. Harvest unit #2111 was visited, which has the greatest length (1500') and area (3.6-acres) of WLPZ implementing the proposed alternative practice. The alternative practice will apply to two harvest units (#2111 & #2116) along a Class I portion of Howard Creek for a total stream reach of 2700-feet and approximately 6-acres.

Discussions were held surrounded by a variety of habitat elements which focused on how to best achieve the goal of the rule to protect, maintain and contribute to restoration of properly functioning salmonid habitat. It was agreed, given the proximity to the source spring, that maintaining those resources providing sediment protections would be of greatest importance and that a lesser amount would be required to maintain stream temperature. The call to increase available sunlight inputs to stimulate the growth and health of hardwood species within the streamside region was identified as many species are present although in a suppressed state. Selective harvest would target objectives to promote a mix of conifer and hardwood species for nutrient input, provide structural diversity and more rapidly growing trees. It was established for this site that retaining habitat components nearest the watercourse would be the most beneficial for streamside bank protection, large wood recruitment, retaining large trees, sediment filtration and terrestrial wildlife habitat.

The proposed alternative practice provides both an expanded core zone for near stream retention, as well as a broadened area of canopy opening selection harvest. The alternative practice presents the opportunity for a more efficient harvest operation and also provides greater clarity to the licensed timber operator (LTO). Rather than a series of parallel zones of varying widths (30', 40', 30', and 25') and retention prescriptions (All, 70%, 50% and None); two equal zones are identified (50' each) by the RPF, one for full retention and one employing traditional watercourse zone selective harvest techniques (50%). Please refer to Section V of the THP for correspondence from Stacy Stanish, DFG.

(1) The standard rule states:

936.9 (f) (4) Class I watercourses with confined channels outside watersheds in the coastal anadromy zone:
The following are the minimum requirements for WLPZ delineation and timber operations in Class I WLPZ's in locations outside of watersheds in the coastal anadromy zone where confined channels are present. WLPZ width is 100 feet slope distance, with an additional 25 foot ELZ depending on the silvicultural system applied contiguous to the WLPZ. Three zones are established within the WLPZ's: The Core Zone is nearest to the water, the Inner Zone is the middle zone contiguous to the Core Zone, and the Outer Zone is furthest from the water and contiguous to the Inner Zone. Graphic depiction of the zones and the abbreviated descriptions of the silvicultural prescriptions and operational requirements are shown in Figure 6. Table 3 specifies the enforceable standards to be used for protection of Class I watercourses for the area outside the coastal anadromy zone:

(A) Core Zone: The minimum width of the Core Zone shall be 30 feet measured from the watercourse transition line or lake transition line. No timber operations are permitted in this zone except for those listed in 14 CCR § 916.9 [936.9, 956.9], subsection (e) (1) (A)-(F), or those approved pursuant to 14 CCR § 916.9 [936.9, 956.9], subsection (v). Sanitation-Salvage is prohibited except as provided in 14 CCR § 916.9 [936.9, 956.9], subsections (s), (t), and (u).

(B) Inner Zone: The minimum width of the Inner Zone shall be 40 feet measured from the landward edge of Core Zone. Timber operations are permitted in this zone when conducted to meet the goals of this section, including those for the Inner Zone in 14 CCR § 916.9 [936.9, 956.9], subsection (c) (2), pursuant to 14 CCR § 916.9 [936.9, 956.9], subsections (e) (1) (A)-(F) or pursuant to 14 CCR § 916.9 [936.9, 956.9], subsection (v). Harvesting prescriptions should focus on practices that use thinning from below. Silvicultural systems for harvesting are limited to the use of commercial thinning or single tree selection modified to meet the following requirements:

1. When commercial thinning is used, the QMD of conifer trees greater than 8 inches dbh in the preharvest project area shall be increased in the postharvest stand.
2. Sanitation-Salvage is prohibited except as provided in 14 CCR § 916.9 [936.9, 956.9], subsections (s), (t), and (u).
3. Postharvest stand shall have a minimum 70% overstory canopy cover. The postharvest canopy may be composed of both conifers and hardwood species and shall have at least 25% overstory conifer canopy.
4. Postharvest stand shall retain the 7 largest conifer trees (live or dead) on each acre of the area that encompasses the Core and Inner Zones.
5. Large trees retained to meet 14 CCR § 916.9 [936.9, 956.9], subsections (f)(4)(B)(1.) and (3.) above that are the most conducive to recruitment to provide for the beneficial functions of riparian zones (e.g., trees that lean towards the channel, have an unimpeded fall path toward the watercourse, are in an advanced state of decay, are located on unstable areas or downslope of such unstable areas, or have undermined roots) are to be given priority to be retained as future recruitment trees.

(C) Outer Zone: The minimum width of the Outer Zone shall be 30 feet measured from the landward edge of the Inner Zone. When evenaged regeneration methods, seed tree removal, shelterwood removal, alternative prescriptions declared under 14 CCR § 913.6 [933.6, 953.6], subsection (b)(3) as most related to any evenaged silvicultural system, variable retention, or rehabilitation will be utilized contiguous to watercourse and lake protection zones, an additional 25 foot ELZ is required contiguous to the Outer Zone. Timber operations are permitted in the Outer Zone when conducted to meet the goals of this section, including those for the Outer Zone in 14 CCR § 916.9 [936.9, 956.9], subsection (c) (3) and (5) pursuant to 14 CCR § 916.9 [936.9, 956.9], subsection (e) (1) (A)-(F), or pursuant to 14 CCR § 916.9 [936.9, 956.9], subsection (v). Silvicultural systems for harvesting are limited to the use of commercial thinning or single tree selection modified to meet the following requirements:

1. Postharvest stand shall have a minimum 50% overstory canopy cover. The postharvest canopy may be composed of both conifers and hardwood species and shall have at least 25% overstory conifer canopy.
2. Priority shall be given to retain wind firm trees.

(D) Preferred Management Practices in the Inner and Outer Zone:
When timber operations are considered pursuant to 14 CCR §§ 916.3 [936.3, 956.3], subsection (c) and 916.4 [936.4, 956.4], subsection (d), the following Preferred Management Practices should be considered for inclusion in the Plan by the RPF and by the Director:

1. Preflagging or marking of any skid trails before the preharvest inspection;
2. Heavy equipment should be limited to slopes less than 35% with low or moderate EHR;
3. Use feller-bunchers or hydraulic heel boom loaders which do not drag/skid logs through the zone;
4. Minimize turning of heavy equipment which would result in increased depth of ground surface depressions; and
5. Use mechanized harvesting equipment which delimbs harvested trees on pathway over which heavy equipment would travel.

(2) Explain and describe each proposed practice:

The proposed practice is to utilize an alternative to (Table 3) 14 CCR 936.9 (f) (4) that site specifically would provide more effective resource benefits, as well as more feasible implementation. Please refer to Item 26 under Class I watercourses for a widths and protection measures table; and a comparison table provided under item 3 below.

(3) Explain how the proposed practice differs from the standard practice:

The proposed alternative practice specifically applies to two Class I segments of Howard Creek located in T28N R02E Sections 24 and 25. Please refer to the comparison table provided below which illustrates the differences between the standard rule and the proposed alternative practice.

Comparison Table

Proposed Alternative Practice

Class I	Channel Zone	Core / Inner Zone	Inner / Outer Zone	ELZ	Total
Slope Class 0%-30%	Variable	50-feet	50-feet	N/A	100-feet
Silviculture	No Harvest	No Harvest	Selection		
Overstory Canopy	Retain All Trees	Retain All Trees	50% overstory canopy		

Standard Rule

Class I	Channel Zone	Core Zone	Inner Zone	Outer Zone	ELZ	Total
Slope Class 0%-30%	Variable	30-feet	40-feet	30-feet	25-feet	125-feet
Silviculture	No Harvest	No Harvest	Selection	Selection		
Overstory Canopy	Retain All Trees	Retain All Trees	70% overstory canopy	50% overstory canopy		

(4) The specific location where it will be applied:

As shown on the Howard Springs THP Silviculture Maps the alternative practice will only apply to two harvest units (#2111 and #2116) which border Class I portions of Howard Creek below Howard Springs. Harvest unit #2111 includes approximately 1500-feet of stream length and 3 ½-acres, while unit #2116 includes 1200-feet of stream reach and 2 ½-acres. Watercourse and lake protection zones (WLPZ's) along Class II portions of Howard Creek above Howard Springs will utilize standard rule widths and protection measures outlined under 936.9 (g) Table 4.

(5) Provide in THP Section III an explanation and justification:
The Howard Springs THP area has been managed for timber production for more than 140-years. Early forest harvesting involved sawmills, roads and railways located upon main watercourses (Howard Creek), large block land clearing, machinery that pulled harvested logs through the topsoil and minimal consideration was given to fish and wildlife issues. Recent decades have included the utilization of efficient and low impact harvest technologies, as well as the employment of many regulations designed to protect fish and wildlife habitat values. Most notable among these rules are the Watercourse and Lake Protection Zones (WLPZ's), which establish buffers to provide and maintain important habitat elements near streams.

These "standard" streamside measures requiring 75 to 100-foot buffer widths with selective harvest (50% canopy cover) to the stream bank have been in effect for decades of past timber harvest operations in the McCarty Creek watershed and are largely responsible for their current vigorous condition. Current rules regarding watersheds with Listed Anadramous Salmonids can run counter to the goals of the Forest Practices Act, because they may unnecessarily remove lands from higher production potential without increasing environmental protections or habitat benefits.

Please refer to section III for additional information and justification for the proposed alternative practice.

THP Item #27(j), Site Specific Measures

Alternative Practice proposed to **936.9 (f) (4),** Class I watercourse with confined channels outside watersheds in the coastal anadromy zone

As previously stated, The Howard Springs THP area has been managed for timber production for more than 140-years. Early forest harvesting involved sawmills, roads and railways located upon main watercourses (Howard Creek), large block land clearing, machinery that pulled harvested logs through the topsoil and minimal consideration was given to fish and wildlife issues. Recent decades have included the utilization of efficient and low impact harvest technologies, as well as the employment of many regulations designed to protect fish and wildlife habitat values. Most notable among these rules are the Watercourse and Lake Protection Zones (WLPZ's), which establish buffers to provide and maintain important habitat elements near streams.

Standard streamside measures requiring 75 to 100-foot buffer widths with selective harvest (50% canopy cover) to the stream bank have been in effect for decades of past timber harvest operations in the McCarty Creek watershed and are largely responsible for their current vigorous condition. Current rules regarding watersheds with Listed Anadramous Salmonids can run counter to the goals of the Forest Practices Act, because they may unnecessarily remove lands from higher production potential without increasing environmental protections or habitat benefits.

As per 14 CCR 897(e), "Based on site-specific conditions where, in the judgment of the RPF, the application of the rules pertaining to how a timber operation will be conducted will not achieve the intent of the Act and rules, and where the RPF can describe a practice(s) which will meet or exceed the intent of the Act and rules, the RPF may prescribe alternative practice(s) in lieu of those in the rules."
Regarding the Intent of the Act 14 CCR 897(a), "RPF's who prepare plans shall consider the range of feasible silvicultural systems...seeking to avoid or substantially lessen significant adverse effects on the environment from timber harvesting."

The proposed practice is to utilize an alternative to (Table 3) 14 CCR 936.9 (f) (4) that site specifically would provide more effective resource benefits, as well as more feasible implementation. The proposal will provide both an expanded core zone **for near stream retention,** as well as a broadened area of canopy opening selective harvest. **The alternative practice presents the opportunity for a more efficient harvest operation and also provides greater** clarity to the licensed timber operator **(LTO). Rather than a series of parallel zones of varying widths (30', 40', 30', and 25') and retention prescriptions (All, 70%, 50% and None); two equal zones are identified (50' each) by the RPF, one for full retention and one employing traditional watercourse zone selective harvest techniques (50%).**

The forestlands in the THP area are zoned for timber production (TPZ). The Timberland Productivity Act restricts the use of lands zoned TPZ to growing and harvesting timber and compatible uses, and establishes a presumption that timber harvesting is expected to and will occur on such land.

Considering 14 CCR 897(b)(1), "The goal of forest management on a specific ownership shall be the production or maintenance of forests which are healthy and naturally diverse with a mixture of trees and understory plants, **in which trees are grown primarily for the production of high quality timber products and which meet the following objectives:"**

- **(A) Achieve a balance of growth and harvest over time...**
- **(B) Maintain** functional wildlife habitat **in sufficient condition for continued use...**
- **(C) Retain or recruit late and diverse seral stage** habitat components for wildlife concentrated in the watercourse and lake zones **and as appropriate to provide for functional connectivity between habitats.**
- **(D) Maintain growing stock, genetic diversity and soil productivity.**

Implementation of the Howard Springs THP as proposed will provide a mosaic of habitats in the McCarty Creek state planning watershed. A mixture of successional stages closely interspersed will provide a functional mix of wildlife habitat. Variety in plant species composition will provide for diversity in cover and reproductive habitat for all known wildlife species likely to utilize these planning watersheds. Selective (uneven-aged) harvest plans implemented over previous decades would cover thousands of acres, as well as the entirety of miles of watercourse reaches within the planning watersheds with no significant adverse impacts. By contrast, the Howard Springs THP proposes harvest upon 372-acres or approximately 3% of the watershed assessment area.

THP Item #27(j), Site Specific Measures

The "standard" practice Watercourse and Lake Protection measures which were implemented in numerous past projects provide tangible evidence of their capacity to provide protection for water temperature, large woody debris, filtration of materials, upslope stability, bank & channel stabilization, spawning & rearing habitat, as well as vegetation structure and diversity. This field evidence has been validated by on-going studies on Sierra Pacific timberlands researching the potential effects from timber harvesting adjacent to Class I watercourse.

The harvest areas in the Howard Springs THP requiring Class I watercourse protection occur on slopes ranging between 5 and 30% upon Cohasset and Lyonsville loam soils, which are deep and well drained. Scientific research documents studying potential significant effects from clearcut timber harvesting adjacent to a watercourse follow in the THP or have been provided to keep on file at the CAL FIRE office in Redding. The comparability of the Millseat Creek, Bailey Creek and Judd Creek studies to the treatments proposed in the current THP can be summarized within the following table:

Field of Study	Relevance
Biology	Equivalent bird, mammal, fish and insect species
Botany	Indistinguishable overstory, understory and riparian vegetation Sierran-Mixed Conifer (SMC) and Ponderosa Pine (PPN) habitats
Geology	Cohasset (Olympic) and Lyonsville soil series Loam / clay loam and sandy gravelly loam developed from volcanic parent materials
Geomorphology	Sierra Nevada east to west running Class I watercourses (Spring-fed)
Topography	Gentle stream gradient (often <10%) and moderate side slopes (often <30%)
Meteorology	Identical weather patterns and significant storm events (rainfall, rain on snow, drought)
Hydrology	Comparable channel sizes, stability, peak flow events, streamside vegetation and LWD amounts
Canopy	Similar pre-harvest existing canopy cover (proposed 50% vertical retention) examined with multiple instruments
Width	Variable protection zones studied; harvesting to (175', 100', 75', 50' and stream bank) Proposed 50-foot core zone retaining habitat elements near the watercourse Proposed 50-foot outer zone with Selective harvest increasing solar inputs and hardwood vigor
History	Greater than 125-years of lumbering, sawmills, railroads, flumes, ditches and ranching Road building, transportation of forest products
Watershed	Ownership pattern, road densities and fire history Large state planning watersheds; long east to west & narrower south to north
Management	The same family owned private timberland owner and land-use objectives Ground-based whole tree harvesting using mechanical logging equipment
Silviculture Regeneration	Clearcut harvest regeneration method and site preparation methods; protective vegetative cover remaining Hand planting of tree seedlings; stocking levels Habitat Retention Areas

The effect of forest management operations on water temperature, water quality, soil erosion, sediment transport and species distribution and diversity has been the subject of numerous research studies on Sierra Pacific Industries timberlands, as well as complimentary articles. In general, for riparian zones in good condition and where disturbance to the soil is low to moderate research has shown that **buffer zones of 100-feet or less are adequate to protect aquatic resources.** Results from three local studies performed in Tehama and Shasta Counties, California on Millseat Creek, Bailey Creek, and Judd Creek, support the findings of previous studies. These three experiments examined the change in response variables of water temperature, the near stream microclimate, water quality, large wood, macro invertebrates, shade producing canopy cover, and soil erosion to varying riparian buffer widths (0 ft. to 175-feet.) adjacent to upslope clearcut harvest units. These local studies began in 1999 and have continuously collected data over a period of years to demonstrate that buffer widths 50 feet to 100 feet provide adequate protection to aquatic resources. Two of the studies did not have experimental forestland designation and therefore could not harvest below a 75-foot buffer. The following discussion focuses on these three local experiments, their results, how they relate to the proposed alternative practice for a reduced buffer width and where these results can be found.

THP Item #27(j), Site Specific Measures

JUDD CREEK

One study, the Southern Exposure Research project, (On file with CAL FIRE, Northern Region) is located on Judd Creek, a Class I watercourse located just 5-miles north of the proposed timber harvest plan. The objective of this study was to detect the cumulative impacts on stream temperature, near-stream microclimate, canopy cover, water quality and the response of aquatic organisms following harvesting of multiple clearcut units adjacent to a Class I watercourse. The research project, while designed to be a "worst case scenario" in order to test the minimum protections permitted under the California Forest Practice Rules, found no deleterious effects from harvesting to a legal minimum of a 100 ft. width WLPZ. Results from this Ph.D. dissertation are pertinent to the proposed alternative practice for variable buffer widths because they provide regional information collected from an experiment that was performed locally, and which employed similar forest management practices that are proposed in this alternative practice[1].

This study examines the effects of two riparian buffer widths on microclimate variables, shade-producing canopy cover, and the temperature of stream water in multiple clearcut harvest units adjacent to a fish bearing (Class I) stream in northern California. Data collected before and after timber harvest operations in years 2000, 2001, and 2002 was analyzed to determine changes in response variables to wider (175 ft.) or narrower (100 ft.) riparian buffers. Angular canopy cover was measured to be 85% at mid-stream and no less than 80% within the riparian buffer regardless of buffer width. Vertical canopy cover was measured to be 50% within the riparian buffer for each harvest unit following the first phase of timber operations. **Microclimate results show that edge effects from the adjacent upslope clearcut harvest units had no discernible impact within 40-feet of the stream bank.** No difference in the extent of microclimate edge effects within the riparian zone was found for either the 175 ft. buffer or the 100 ft. buffer under very warm summer conditions. This study found that two separate timber harvest operations, conducted in summer 2000 and summer 2001, resulted in only minor (±1.5 °C) changes in the water temperature pattern along the experimental reach. **The monthly maximum water temperature never exceeded 21.1 °C before or after harvest throughout the study area.** In this experiment, no practical difference in the canopy cover, near-stream microclimate, or water temperature patterns were found between the wider 175-ft. and the narrower 100-ft. buffers. The lack of change in response variables was likely due to the very small measurable reduction in shade-producing canopy cover mid-stream and within the riparian buffer. Only minimal changes in the near stream microclimate and water temperature occurred despite the fact that 35% of the merchantable tree volume within the riparian buffer was removed during summer 2000 timber harvest operations. Results from this study show that 100-ft. vegetative buffers that maintain at least 50% vertical or 80% angular canopy cover minimize potential negative impacts to the temperature of stream water and the near-stream microclimate from adjacent upslope clearcut harvest operations.

After hearing testimony in October 2001, the BOF bestowed *experimental forestland* to the Judd Creek research area. In addition, the BOF granted the research area an exemption from the California Environmental Quality Act (CEQA). Since receiving the *experimental forestland designation* the riparian buffer width was further reduced to 100 ft. and then to 50 ft. from the bank in years 2002 and 2003. Following the publication of her Ph.D. dissertation Dr. James continued to further reduce the riparian buffer width along Judd Creek and collect data on the response variables along Judd Creek. **Results from all data collected in the study show that 50-foot vegetative buffers that maintain at least 50% vertical or 80% angular canopy cover minimize potential negative impacts to the temperature of stream water and the near-stream microclimate from adjacent upslope clearcut harvest operations.**

[1] James 2003 Ph.D. Thesis University of California at Berkeley 2003: Southern Exposure Research Project: A Study Evaluating the Effectiveness of Riparian Buffers in Minimizing Impacts of Clearcut Timber Harvest Operations on Shade-Producing Canopy Cover, Microclimate, and Water Temperature along a Headwater Stream in Northern California by Cajun Elaine James, Doctor of Philosophy in Wildland Resource Science, University of California, Berkeley, Professor Joe McBride, Chair. Spring 2003 This dissertation is available **on file at CDF** Office, Redding

THP Item #27(j), Site Specific Measures

MILLSEAT CREEK STUDY

An abbreviated version of the Millseat Creek study site, methodology and results were submitted to the CAL FIRE in Redding September 2010. This was included in a document written by Dr. Cajun James in January 2001 as part of her expert testimony for EPIC vs. Tuttle. The results in the document submitted show that **no negative impact to environmental resources should result as an effect of the alternative practice proposed regarding buffer width along the classified watercourses of this project.**

BAILEY CREEK STUDY

The Bailey Creek experimental study design contains similar methodologies to both the Southern Exposure Research site along Judd Creek and the Millseat Creek study. Pre-harvest data collection began along Bailey Creek in 2001 and the logging treatments were performed in September 2002. Similar to the Judd Creek study, three clearcut units were harvested upslope of Bailey Creek. As in the Millseat Creek study, 75-foot riparian buffers that maintained 50% vertical (80% angular canopy) cover were retained. **Results from this study found no negative impacts to the temperature of stream water, and the near stream microclimate from adjacent upslope clearcut harvest operations.** (Submitted to CAL FIRE September 2010)

COMPLIMENTARY STUDIES

Several other scientists have collaborated on the design of the three studies discussed above and have conducted complimentary studies. The results of these studies offer conclusive information that the buffer widths requested in the alternative proposal will cause no harm to environmental resources. Following is a brief discussion of each of these studies.

MACRO-INVERTEBRATES

As part of the studies implemented at both Judd Creek and Millseat Creek; Dr. Morgan Hannaford examined the response of macro-invertebrates to the variable riparian buffer widths. Dr. Hannaford examined the following biotic metrics and indices; richness, composition, functional feeding groups and tolerance. He found **no negative impact to the macro-invertebrate community** at either Millseat Creek or Judd Creek when the riparian buffer was reduced to 75-feet. (Submitted to CAL FIRE September 2010)

LARGE WOOD AND SOIL EROSION

Dr. Lee Benda performed several studies within the Judd Creek Watershed that provide information that show **no negative impact would result to future large wood recruitment or soil erosion in the proposed alternative practice to reduce riparian buffers along Howard Creek.** Dr. Benda examined the effect of timber harvest operations along Judd Creek and how these practices affected large wood recruitment and whether or not the timber harvest operations along Judd Creek contributed to surface erosion and sediment to the stream. He performed three studies: Large Wood Recruitment, Erosion Pin Study as well as a Sediment Budget. In his report titled "Erosion Study: Judd Creek Basin, Southern Cascades, California" Dr. Benda's summarizes the following:

Future Large Wood Recruitment Management for Non-landslide Areas:

- Over 50% of all key pieces resulted from bank erosion
- **50% of in-stream wood originates from within 10-feet of the channel banks**
- **90% of all wood is introduced into stream from within 60-feet**
- Wood introduced by bank erosion is the dominant process that creates key pieces of large wood into the creek

Did Timber Harvest Operations along Judd Creek Contribute to Surface Erosion and Sediment to the Creek?

- Surface erosion in harvest units was found to be negligible to non-existent.
- In 90% of the Erosion Pin Study sites erosion did not occur, in fact, soil expansion occurred at these sites.
- Erosion did occur at 10% of sites that were always *bare ground,* although the sediment never reached the stream channel. The sediment was captured by surface roughness elements within 10 feet.
- Results from sediment budget found that surface erosion from road segments within 200 feet of a stream is predicted to be a major source of forestry related erosion and historic post fire erosion dominated the long-term erosion rates. In conclusion, forest management related erosion is a very small component <5% when compared to other nature erosion processes.

THP Item #27(j), Site Specific Measures

WATER TEMPERATURE

Dr. Bruce Krumland's presentation compares the temperature of water between upstream and downstream control blocks were made before and after timber harvest operations that reduced the riparian buffer. These empirical results were also compared with the predicted change in water temperature that was calculated by George Brown's 1967 Water Temperature Model. For all three creeks Brown's model predicted a water temperature change < 0.5 degrees Celsius due to timber harvest operations that reduced the buffer to 75feet or 100 feet, and empirical results were always less. **Timber harvest operations did not result in statistically significant increases in water temperature.** The measured changes in water temperature were very small and of the same magnitude as the sensor detection limits.

CONCLUSION

Harvest activities were studied within the Class I WLPZ in all of the preceding research studies projects along watercourses comparable to and within the current timber harvest plan area. Each study concluded that timber harvest operations with a similar streamside buffer to the proposed alternative resulted in no negative impacts to stream temperature, near stream micro-climate, macro-invertebrate richness, large wood recruitment, or soil erosive properties. Utilizing a 100-foot watercourse and lake protection zone with 50-foot of core retention and 50-feet of adjacent modified selection retaining 50% vertical canopy will prevent deleterious interference with the watershed condition and provide equal protection of the beneficial uses of water outlined in 14 CCR 936.9. Near stream habitat elements will remain in place, while increased solar inputs will benefit hardwood vigor and improve nutrient availability. Please refer to Section V for additional information and references cited.

Water Quality Monitoring Project in the Judd Creek Watershed
Based upon the Engebretsen Timber Harvest Plan (2-04-084-TEH)
MSG Joint Project between CDF, CVRWQCB and SPI

Cooperating Investigators

Cajun James PhD (Research and Monitoring Manager) for Sierra Pacific Industries; Morgan Hannaford PhD (Aquatic Entomology); Lee Benda PhD (Geomorphology); Bruce Krumland PhD (Statistics and Biometrics); Pete Cafferata (Hydrology) for Cal Fire; and Drew Coe (Engineering Geologist) for CVRWQQB.

Background:

To determine the potential impacts of timber management practices on water quality the Board of Forestry and Fire Protection (BOF) through the Monitoring Study Group (MSG) has established cooperative research projects with various landowners (Campbell Timberlands, Mendocino County RCD and Sierra Pacific Industries (SPI)). This watershed scale experiment enlisted cooperation between SPI, the California Department of Forestry and Fire Protection and the Central Valley Regional Water Quality Control Board. A watershed-scale Timber Harvest Plan (THP) named Engebretsen (# 2-04-084-TEH) was specifically prepared for this research project.

The project is located within the Judd Creek State Planning Watershed, California (5509.630101). This small to moderately sized watershed covers 6,350-acres and is 11.02-miles in length from the headwaters of Judd Creek to it's confluence with the North Fork of Antelope Creek. The Judd Creek watershed assessment area is a combination of private and pubic forestland ownership. Private landowners include Sierra Pacific Industries (72%) as well as a private ranch (16%). The United States Forest Service (12%) manages the remaining land within the watershed.

The stream gradient, annual rainfall, soil type, aspect, slope and land use history of the Judd Creek watershed is typical of the characteristics of most headwater watersheds owned by Sierra Pacific Industries in the mixed conifer forests of northern California. Headwater watersheds that are similar to Judd Creek comprise approximately 80% of the 1.2 million acres that Sierra Pacific Industries currently owns in the area regulated by the Central Valley Regional Water Quality Control Board. Therefore, results from this research project will provide valuable and applicable information to determine potential impacts of similar timber harvest operations on water quality for inland California headwaters watersheds.

The Engebretsen THP was written by Steve DeBonis, Registered Professional Forester (RPF #2756) to address the research and monitoring goals of Dr. Cajun James and provided the opportunity to effectively measure potential impacts of forest management practices at the watershed scale. The plan was approved in November 2004 and includes 41 clear-cut harvest units (ranging from 10 to 26 acres), 2.9-miles of new road construction, landing construction, the abandonment of 1.7-miles of seasonal roads, the abandonment of selected landings within watercourse zones, the removal of corrugated metal pipes, installation of rocked fords and a number of segments of road surface rocking.

The Engebretsen THP harvested 835-acres or 13% of the entire Judd Creek watershed, accounting for 18% of all SPI lands within this watershed. When harvest operations on the THP were completed in 2009, approximately 1,105-acres or 17% of the area within the Judd Creek watershed had received even-aged management treatment within a 10-year period. The Judd Creek watershed is currently on the high end of the intensive management spectrum as all harvest units within the last decade were clear cut and therefore approach the purported 25% threshold that may produce increases in peak flows during rain on snow events (McGurk and Cafferata 1991).

Previous studies have occurred within or near the Judd Creek watershed and therefore baseline data is available for a variety of parameters to provide support to the Engebretsen THP research. Within the Judd Creek watershed, the Southern Exposure THP (2-00-092 TEH) involved a research project that was purposely designed to examine the effectiveness of different riparian buffer widths for protecting water quality. Ted James (RPF# 2569) wrote the Southern Exposure THP, signed on June 29, 2000 after being granted special "Experimental Forestland" status by the California Board of Forestry. Special designation was required for this timber harvest plan by the BOF because the watercourse and lake protection zone (WLPZ) buffer widths along the Class I stream (Judd Creek) proposed for harvest were less than the widths prescribed in the California Forest Practice Rules, January 2000 edition. A series of harvests were conducted that reduced the buffer widths at increments of 175', 100', 50', and finally to the stream-bank. Dr. Cajun James has collected baseline data for the buffer studies as part of the Southern Exposure THP in T29N R02E Sections 8 and 9 and at the confluence with Antelope Creek (James, 2003) since 1999. The following parameters have been recorded to date; water temperature, discharge, turbidity, suspended sediment, near stream microclimate, precipitation, canopy cover, ph, conductivity and dissolved oxygen. The Southern Exposure THP had sensors deployed within the Judd Creek watershed and with the addition of the watershed level Engebretsen THP; additional monitoring devices were deployed throughout the watershed (Figure 1). Dr. Morgan Hannaford collaborated with Dr. James during both of these studies to examine the response of macro invertebrates to timber harvest operation upland of Judd Creek. Additionally, Dr. Lee Benda constructed a sediment budget and a large wood budget for the Judd Creek watershed in conjunction with the Southern Exposure project.

The Engebretsen THP included six phases over an eight-year time frame for this cooperative Water Quality Monitoring project within the Judd Creek watershed (Figure 2).

Phase 1 Begins in November 2004 with the signed approval of the Engebretsen THP by Cal Fire.

Phase 2 Two-years of baseline monitoring throughout the entire watershed 2005-2006.

Phase 3 All road construction treatments were performed in 2007.

Phase 4 2008 a one-year monitoring period to collect data after the road treatments was performed.

Phase 5 Spring-Fall 2009, all 41 harvest units were logged and the biomass was chipped and hauled.

Phase 6 Currently in progress and will be completed following winter 2011. Phase 6 involves three years 2009-2011 of monitoring the results of both road treatments and harvesting.

Water Temperature and Turbidity Results

Water temperature and turbidity results are available from the water quality station downstream of both the Southern Exposure and Engebretsen Timber Harvest plans. The location of this water quality station captures the entire drainage system of the Judd Creek watershed and would record any measurable cumulative effects from the two timber harvest plans upstream of this location. In stream measurements were recorded during each hour of every day (0, 15, 30, 45 minute data) since the water quality station was installed in December 2000. Equipment deployed in the field to collect continuous monitoring data consists of YSI 6820 multi-parameter Sonde (http://www.ysi.com/productsdetail.php?6820-V2-4), YSI 6026 optical NTU sensor, YSI 6560 temperature sensor and Waterlog H-350 XL data logger and gas bubbler (http://www.waterlog.com/Products/H-350XL/350XL.html). Laboratory calibration, field maintenance and Sonde swap visits occur monthly in accordance with USGS recommendations.

Bjornn and Reiser (1991) discuss studies of lethal temperature ranges for fish and document that 23.9 degrees Celsius is the established lethal temperature for Steelhead. As shown in Figure 3 the average daily water temperature over the last 10 years has never exceeded 20.67 °C, which is below the lethal temperature of 23.9 °C reported by Bjornn and Reiser (1991).

Results of the maximum daily turbidity measured at a continuous water quality station immediately downstream of the Southern Exposure and Engebretsen Timber Harvest Plans are shown in Figure 4 and below in Table 1. To date 4,129 days of turbidity data has been collected over the last decade from December 2000 to August 2010. Approximately 85.88 % of the days had maximum turbidity less than 24 NTU's where little to no impact to fish are known to occur and 8.04% of days had maximum turbidity values fall with in the range between 25-50 NTU's identified by Sigler et al. (1984) where reduced growth may occur and Steelhead emigrated in laboratory stream studies. The remaining 6.08% or 251 out of 4,129 days had maximum turbidity levels that exceeded 50 NTU's with the highest recorded daily NTU of 866. Recorded turbidity along Judd Creek responded quickly to rainfall events within the watershed. Although yearly flow rates have changed over the decade along Judd Creek, the maximum flow of 120 cfs was recorded during the 2005 and 2006 water year. Typically average yearly peak flows range from 20 cfs to 60 cfs. Turbidity did spike downstream in one location not associated with a rainfall event. This spike in turbidity occurred locally where a culvert was replaced by a ford during road construction that was performed from August 20, 2007 to August 30, 2007 as part of the Engebretsen THP. Following initial winter rains in October 2007 turbidity measured downstream at a continuous monitoring station returned to pre-project values (Figure 5).

Table 1

NTU's	Maximum Daily NTU Number of Days	%Max NTU Days out of 4129 Total Days
0 to 24	3546	85.88
25 to 50	332	8.04
51 to 100	145	3.51
101 to 200	72	1.74
201 to 300	15	0.36
301 to 400	10	0.24
401 to 500	3	0.07
501 to 600	4	0.10
601 to 700	0	0.00
701 to 800	1	0.02
801 to 900	1	0.02

Field inspections and in-stream water quality data measured during implementation and completion of both projects collected throughout the last decade demonstrate there were no negative impacts to water quality that resulted from multiple timber harvest operations in the Judd Creek Watershed.

Howard Flat THP (2-04-180-TEH)

Near the Judd Creek watershed the Howard Flat THP (2-04-180-TEH) was approved on March 2nd, 2005. The Howard Flat THP was located within both the Panther Spring (5509.630202) and McCarty Creek (5509.630203) state planning watersheds and was prepared by Ted James (RPF #2569).

The Howard Flat THP proposed to harvest a total of 508-acres, which represented 2% of the combined watersheds (25,513-acres). Clearcut harvest actually completed included 487-acres from 23 individual units. The plan additionally involved 1 ¼-miles of new seasonal road construction; 1 ½-miles of new mainline seasonal road construction; less than ¼-mile of road abandonment; landing construction; landing abandonment; two bridge installations over Howard Creek; one bridge and one arch-pipe installation over Middle Fork of Antelope Creek; Corrugated Metal Pipe removals (CMP); one arch-pipe abandonment; a number of CMP installations; numerous rocked ford dip installations and over 1-mile total road surface rocking. Sierra Pacific Industries (SPI) ownership within the combined watersheds is 52% (13,238-acres); public ownership (USFS) is 40% (10,155-acres) and State & small private owners total 8% (2,138-acres). The THP included two alternative practices: one pertaining to WLPZ buffer zone width; and one pertaining to overstory canopy retention within Class I watercourse protection zones in a watershed with threatened and impaired values (currently – listed anadramous salmonids). Pre-harvest predictions of potential water temperature increases were made using Brown's water temperature model on individual watercourse segments. SPI research data from both Millseat Creek (Shasta County) and Judd Creek 2000-2004 (Tehama County) regarding canopy measurements and maximum water temperatures were included as part of four appendices to the timber harvest plan. A final completion and stocking report for the Howard Flat THP was signed on July 13, 2010. Numerous agency inspections, forester field observations and water quality monitoring reports exhibit no significant negative impacts to water quality as a result of the timber harvest and associated alternative practices.

Deadhorse Falls THP (2-05-115-TEH) and Shelton Ridge THP (2-06-109-TEH)

Adjacent to the Judd Creek watershed and within the Deadhorse Creek watershed (5509.630103) both the Deadhorse Falls THP (2-05-115-TEH) and Shelton Ridge THP (2-06-109-TEH) represent a completed and an active timber harvest plan within the same watershed as the proposed Maidenhair THP. Both THP's were prepared by Steve DeBonis (RPF #2756) and were approved on January 25, 2006 and January 12, 2007 respectively.

The Deadhorse Falls THP harvested a total of 797-acres, which represented 5% of the watershed (16,179-acres). Clearcut harvest included 588-acres from 29 individual units representing 4% of the watershed in evenaged management. The plan additionally involved 1-mile of new road construction; one new bridge installation over Deadhorse creek (100N); and one rock ford with fish ladder installation replacing a corrugated metal pipe on Deadhorse Creek. Sierra Pacific Industries (SPI) ownership within the watershed is 56% (9,088-acres) and public ownership (USFS) is 42% (6,863-acres). Two harvest units had watercourse and lake protection zone (WLPZ) buffers of 75-100 feet along 4,137 lineal feet of Class I streams. The plan was logged and chipped between May and November 2009. A completion report was signed by CalFire on November 23, 2009.

The Shelton Ridge THP proposes harvesting a total of 916-acres, which represents an additional 6% of the planning watershed. To date, 700-acres of the timber harvest plan has been harvested between March and August 2010. Clearcut harvest included 550-acres from 28 individual units representing 3% of the watershed in evenaged management. The plan also involved 2.7-miles of new road construction; 1/3-mile of road abandonment; one CMP installation; a number of rocked fords and road surface rocking near classified watercourses. Ownership in the watershed is the same as stated above.

Maidenhair Timber Harvest Plan (2-10-031-TEH)

To further confirm no negative impacts would result from the proposed "Maidenhair" Timber Harvest Plan (2-10-031 TEH) water temperature recording devices were installed in ten locations from September 4, 2010 to September 20, 2010 (Figure 6). These devices were installed to document the water temperature downstream of four completed timber harvest plans and one active THP that all had riparian buffers widths narrower than those required by the current 2010 California Forest Practice Rules and have harvested to 85% angular canopy closure within the WLPZ. These four operations are all located adjacent to or in the watershed encompassing the proposed "Maidenhair" Timber Harvest Plan. These devices were deployed within four additional Class I Watercourses (North Fork of Antelope Creek, Deadhorse Creek, Middle Fork of Antelope Creek and Howard Creek) for 16 days to specifically identify any potential negative impacts from completed THP's "Southern Exposure" (2-00-092-TEH), "Engebretsen" (2-04-084-TEH), "Howard Flat" (2-04-180-TEH), and "Deadhorse Falls" (2-05-115-TEH); as well as active THP "Shelton Ridge" (2-06-109-TEH). Water Temperature results in Figure 7 correspond to the ten recent water temperature devices deployed to identify potential negative impacts from the four previously completed timber harvest plans and one active THP (Figure 6).

Howard Springs Timber Harvest Plan

The Howard Springs THP proposes to harvest 372-acres and is located entirely within in the McCarty Creek state planning watershed (5509.630203). The THP represents 3% of the watershed area with seventeen (17) harvest units; 1.1-miles of new road construction; approximately ½-mile of road abandonment; landing construction; landing abandonment; road surface rocking; four (4) corrugated metal pipe watercourse crossing improvements and a number of road drainage rocked rolling dip facility installations.

As previously outlined the Howard Flat THP involved two alternative practices, one regarding buffer width and one for canopy retention within the same state planning watershed (McCarty Creek), as well as along the same watercourse (Howard Creek). In addition the Howard Flat THP has completed 487-acres from twenty-three (23) individual units to date. The plan involved 1 ¼-miles of new seasonal road construction; 1 ½-miles of new mainline seasonal road construction; less than ¼-mile of road abandonment; landing construction; landing abandonment; two bridge installations over Howard Creek; Corrugated Metal Pipe removals (CMP); a number of CMP installations; numerous rocked ford dip installations and over 1-mile total road surface rocking making it very analogous to the proposed Howard Springs THP.

The Howard Flat THP implemented standard practice buffer widths (75-100 feet) and canopy retention (50%) retaining greater habitat elements in closer proximity to the watercourse along segments of Howard Creek immediately downstream from the current plan area. A final completion and stocking report for the Howard Flat THP was signed on July 13, 2010. Numerous agency inspections, forester field observations and water quality monitoring reports exhibit no significant negative impacts to water quality as a result of the timber harvest and associated alternative practices.

The Howard Springs THP with identical silvicultural practices proposes a 50-foot core zone and 50-foot outer zone (100-feet) with full canopy retention in the core zone and (50%) canopy retention in the outer zone. Recent stream monitoring to confirm no negative impacts would result from the Maidenhair THP described previously included three (3) stations located upon Howard Creek as shown in Table 2 and Figure 6 (#8, #9 & #10).

Water temperature measured never exceeded 17 °C in any of the ten (10) locations sampled, which is well below the lethal limit of 23.9 °C documented for Steelhead (Bjornn and Reiser 1991). Two additional locations (#11 & #12) are also mapped in Figure 6. At these locations water temperature data has been measured continuously to date since July 2001. Location #11 has temperature sensors installed above where Judd Creek flows into the North Fork of Antelope Creek and Location #12 sensors are installed in the North Fork of Antelope Creek below the confluence with Judd Creek. These two sampling locations are critical sampling points because both are located downstream from all of the implemented timber harvest plans and Location #12 is where the Steelhead and spring run Chinook reside.

Water Temperature results measured over a decade at the confluence of Judd Creek and the North Fork Antelope Creek are shown in (Figure 8 and Figure 9). The maximum average daily water temperature did not exceed 21.03 °C for Judd Creek (Location #11 & Figure 8). The maximum average daily water temperature in the North Fork of Antelope Creek did not exceed 18.94 °C (Location #12 & Figure 9). Water Temperature in the North Fork of Antelope Creek (Location 12) does not approach the established 23.9 °C lethal limit for the Steelhead and Spring Run Chinook that reside there and may actually be in the optimum range for growth for these species. **These long-term data sets show no potential negative effects to aquatic resources have resulted from the multiple harvest plans that occurred upstream.** These water temperature measurements conclude that even with all the combined timber harvest activities within the watersheds no negative impacts at the timber harvest plan scale, the watershed scale, nor further downstream, at the confluence of Judd Creek and the North Fork of Antelope Creek, where the fish species of concern are located, has resulted.

Table 2: Below attributes the timber harvest plans that flow downstream into the ten water temperature sensor device results in Figure 7 and also the two furthest downstream water temperature sampling locations results in Figure 8.

Table 2

Station Number	Location	Timber Harvest Plan (THP) which drains into Water Temperature Monitoring Station
1	North Fork Antelope Creek	Shelton Ridge / Deadhorse Falls
2	Deadhorse Creek	Shelton Ridge / Deadhorse Falls / Maidenhair
3	North Forth Antelope Creek N-Line	Deadhorse Falls
4	Deadhorse Creek 100N4	Deadhorse Falls
5	Deadhorse Creek N-Line	Deadhorse Falls
6	Middle Fork Antelope Creek N-Line	Deadhorse Falls / Maidenhair
7	Tributary of Howard Creek 210N	Howard Flat
8	Howard Creek N-Line	Howard Flat
9	Howard Creek 220N	Howard Flat
10	Howard Creek 190N	Howard Flat
11	Judd Creek above North Fork Antelope	Southern Exposure / Engebretsen
12	North Fork Antelope Creek below the confluence with Judd Creek	Southern Exposure / Engebretsen / Shelton Ridge Deadhorse Falls / Maidenhair

Operational Goal	Potential Benefits and/or Impacts				Howard Springs THP - Evaluation
	Benefit	None	Slight	Significant	
Sediment Loading		X			*History:* Sediment load is not a limiting factor in this watershed. The plan area has deep & well-drained loam soils and gentle topography. *Impacts:* The proposed operations will require some degree of soil disturbance. Soil resource mitigation's shall be adequate protect the beneficial uses of water. These include, proper placement & maintenance of erosion control facilities, lopping of tops, spreading of slash, contour ripping to increase infiltration, retention of >40% protective vegetative cover and timing of operations when saturated soil conditions do not exist. *Benefits:* The proposed installation of surface rocked rolling dips and upgrading four (4) watercourse crossings on Howard Creek will lessen the potential for sediment input. Utilizing 2005 bridge installation and surface rocked approaches at the Middle Fork of Antelope Creek. Installing new roads away from watercourses to eliminate use of existing roads & landings near seasonal streams.
Watercourse Channel & Bank Stability	X	X			*History:* No evidence of slides or mass wasting. *Impacts:* Watercourse protection measures that propose no harvest operations within 50-feet of Class I watercourses and 50-feet of adjacent selective harvest. Class II watercourses protection with 10-foot core zone and 40-65-foot selective harvest zone. Class III ELZ's retaining important habitat elements. *Benefits:* Increased solar energy inputs will improve hardwood vigor and improve nutrient availability.
Salmonid Migratory Route Blockage	X	X			*History:* State planning watershed is listed for potential presence of listed anadramous salmonid species. Although a barrier may be present downstream of the proposed plan area. *Benefits:* Improving capacity and potential fish passage issues by replacing existing watercourse structures with those designed to accommodate 100-year flow events.
Stream Flow	X	X			*Benefits:* Based on research and field observations temporal increases in overall streamflow are anticipated post harvest.
Large Woody Debris	X	X			*History:* Planning area has a history of logging dating back to the 1870's that included a sawmill, infrastructure and homesteads. LWD is not a limiting factor as ample amounts of LWD exist in the streamside zone. Both overstory and understory conifers are future sources of LWD along the watercourse. *Impacts:* All large trees, including those most conducive to recruitment, will be retained within 50-feet of the Class I watercourse. No hardwood species are proposed for harvest. *Benefit:* LWD will be retained where it can provide most benefit. No harvest in core zone may increase conifer mortality.
Vegetation Canopy & Cover Thermal Loading		X			*History:* Thermal loading is not a limiting factor in this watershed. Downstream water monitoring data shows temperatures well within the range preferred by anadramous salmonid species. The fire history of the area includes frequent, low intensity ground fires. Currently ample shade canopy cover exists mid-stream. *Impacts:* No harvest is proposed alongside classified watercourses – vertical canopy and angular canopy will remain.
Peak Flows		X			*History:* Peak flows occur during spring snowmelt and rain-on-snow-events during the winter period. *Impacts:* Rain-on-snow events remain statistically rare and significant peak flow increases are unlikely to occur as a result of the proposed evenaged management. The clearcut harvest condition is temporal. The timely planting and regeneration of these areas will further moderate any increases in peak flow. Grant et, al. (2008) suggests that channel changes from peak flow increases are expected to be minimal in watersheds with these substrate size and characteristics.

Water Quality Monitoring Project in the Judd Creek Watershed Based upon the Engebretsen Timber Harvest Plan (2-04-084-TEH) MSG Joint Project between CDF, CVRWQCB and SPI

Cooperating Investigators

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Although yearly flow rates have changed over the decade along Judd Creek, the maximum flow of 120 cfs was recorded during the 2005 and 2006 water year. Typically average yearly peak flows range from 20 cfs to 60 cfs.

Howard Flat THP (2-04-180-THE)

Near the Judd Creek watershed the Howard Flat THP (2-04-180-TEH) was approved on March 2nd, 2005. The Howard Flat THP was located within both the Panther Spring (5509.630202) and McCarty Creek (5509.630203) state planning watersheds and was prepared by Ted James (RPF #2569).

The Howard Flat THP proposed to harvest a total of 508-acres, which represented 2% of the combined watersheds (25,513-acres). Clearcut harvest actually completed included 487-acres from 23 individual units. The plan additionally involved 1 ¼-miles of new seasonal road construction; 1 ½-miles of new mainline seasonal road construction; less than ¼-mile of road abandonment; landing construction; landing abandonment; two bridge installations over Howard Creek; one bridge and one arch-pipe installation over Middle Fork of Antelope Creek; CMP removals; one arch-pipe abandonment; a number of CMP installations; numerous rocked ford dip installations and over 1-mile total road surface rocking. Sierra Pacific Industries (SPI) ownership within the combined watersheds is 52% (13,238-acres); public ownership (USFS) is 40% (10,155-acres) and State & small private owners total 8% (2,138-acres). The THP included two alternative practices: one pertaining to WLPZ buffer zone width; and one pertaining to overstory canopy retention within Class I watercourse protection zones in a watershed with threatened and impaired values (currently – listed anadramous salmonids). Pre-harvest predictions of potential water temperature increases were made using Brown's water temperature model on individual watercourse segments. SPI research data from both Millseat Creek (Shasta County) and Judd Creek 2000-2004 (Tehama County) regarding canopy measurements and maximum water temperatures were included as part of four appendices to the timber harvest plan. A final completion and stocking report for the Howard Flat THP was signed on July 13, 2010. Numerous agency inspections, forester field observations and water quality monitoring reports exhibit no significant negative impacts to water quality as a result of the timber harvest and associated alternative practices.

Deadhorse Falls THP (2-05-115-TEH) and Shelton Ridge THP (2-06-109-TEH)

Adjacent to the Judd Creek watershed and within the Deadhorse Creek watershed (5509.630103) both the Deadhorse Falls THP (2-05-115-TEH) and Shelton Ridge THP (2-06-109-TEH) represent a completed and an active timber harvest plan within the same watershed as the proposed Maidenhair THP. Both THP's were prepared by Steve DeBonis (RPF #2756) and were approved on January 25, 2006 and January 12, 2007 respectively.

The Deadhorse Falls THP harvested a total of 797-acres, which represented 5% of the watershed (16,179-acres). Clearcut harvest included 588-acres from 29 individual units representing 4% of the watershed in evenaged management. The plan additionally involved 1-mile of new road construction; one new bridge installation over Deadhorse creek (100N); and one rock ford with fish ladder installation replacing a corrugated metal pipe on Deadhorse creek as well. Sierra Pacific Industries (SPI) ownership within the watershed is 56% (9,088-acres) and public ownership (USFS) is 42% (6,863-acres). Two harvest units had watercourse and lake protection zone (WLPZ) buffers of 75-100 feet along 4,137 lineal feet of Class I streams. The plan was logged and chipped between May and November 2009. A completion report was signed November 23, 2009.

The Shelton Ridge THP proposes harvesting a total of 916-acres, which represents an additional 6% of the planning watershed. To date, 700-acres of the timber harvest plan has been harvested between March and August 2010. Clearcut harvest included 550-acres from 28 individual units representing 3% of the watershed in evenaged management. The plan also involved 2.7-miles of new road construction; 1/3-mile of road abandonment; one CMP installation; a number of rocked fords and road surface rocking near classified watercourses. Ownership in the watershed is the same as stated above.

In order to further confirm no negative impacts would result from the proposed "Maidenhair" timber harvest plan (2-10-031 TEH) water temperature recording devices were installed in 10 locations from September 4, 2010 to September 20, 2010(Figure 6). The devices were installed to document the water temperature downstream of four completed timber harvest plans and one active THP that all had riparian buffers widths narrower than those required by the current 2010 California Forest Practice Rules and have harvested to 85% canopy closure within the WLPZ. These four operations are all located adjacent to or in the watershed encompassing the proposed "Maidenhair" Timber Harvest Plan. These devices were deployed within four additional Class I Watercourses (North Fork of Antelope Creek, Deadhorse Creek, Middle Fork of Antelope Creek and Howard Creek) for one week to specifically identify any potential negative impacts from completed THP's "Southern Exposure" (2-00-092-TEH), "Engebretsen" (2-04-084-TEH), "Howard Flat" (2-04-180-TEH), and "Deadhorse Falls" (2-05-115-TEH); as well as active THP "Shelton Ridge" (2-06-109-TEH). Water Temperature results are shown in Table 7 for corresponding to the 10 locations found in Figure 6). Table XX tracks the Timber harvest Plans that flow downstream into 10 locations located in Figure 6.

Table 7		
Station Number	**Location**	**Timber Harvest Plan (THP) which~~Upstream d~~Drains into Water Temperature Monitoring Station~~Location~~**
1	North Fork Antelope Creek	Shelton Ridge / Deadhorse Falls
2	Deadh~~H~~orse Creek	Shelton Ridge / Deadhorse Falls / Maidenhair
3	North Forth Antelope Creek N-Line	Deadhorse Falls
4	Deadh~~H~~orse Creek 100-N-4	Deadhorse Falls
5	Dead~~h~~Horse Creek N-Line	Deadhorse Falls
6	Middle Fork Antelope Creek N-Line	Deadhorse Falls / Maidenhair
7	Tributary of Howard Creek 210N	Howard Flat
8	Howard Creek N-Line	Howard Flat
9	Howard Creek 220N	Howard Flat
10	Howard Creek 190N	Howard Flat
11	Judd Creek above North Fork Antelope	Southern Exposure / Engebretsen
12	North Fork Antelope Creek below the confluence with Judd Creek	Southern Exposure / Engebretsen / Shelton Ridge Deadhorse Falls / Maidenhair

Operational Goal	Potential Benefits and/or Impacts				Maidenhair THP - Evaluation
	Benefit	None	Slight	Significant	
Sediment Loading	X	X			*History:* Sediment load is not a limiting factor in this watershed. The plan area has deep & well-drained loam soils and gentle topography. *Impacts:* The proposed operations will require some degree of soil disturbance. Soil resource mitigation's shall be adequate protect the beneficial uses of water. These include, proper placement & maintenance of erosion control facilities, lopping of tops, spreading of slash, contour ripping to increase infiltration, retention of >40% protective vegetative cover and timing of operations when saturated soil conditions do not exist. *Benefits:* The proposed installation of surface rocked rolling dips (replacing culvert pipe) will lessen the potential for sediment input. Utilizing recent bridge installation and surface rocked approaches at the Middle Fork of Antelope Creek. Installing new roads away from watercourses to eliminate use of historic landings near seasonal streams.
Watercourse Channel & Bank Stability		X			*History:* No evidence of slides or mass wasting. *Impacts:* Watercourse protection measures that propose no harvest operations within 25-50 feet of Class III watercourses and 50-150 feet of Class I & II watercourses. Excluding the use of equipment near any classified watercourses or streambanks.
Salmonid Migratory Route Blockage		X			*History:* State planning watershed is listed for potential presence of listed anadramous salmonid species. Blockage may be present downstream of the proposed plan area. *Benefits:* Existing watercourse crossings have been designed to be 100-year flow capable CMP's, bridges and fords that may eliminate potential fish barriers. In addition, bridge crossings will maintain a more natural channel bottom.
Stream Flow	X	X			*Benefits:* Based on research and observation temporal increases in overall streamflow are anticipated.
Large Woody Debris	X	X			*History:* Planning area has a history of logging dating back to the 1870's, which included a large sawmill and associated infrastructure and town (Lyonsville). LWD is not a limiting factor as ample amounts of LWD exist in the channel. Both overstory and understory hardwoods and conifers are future sources of LWD along the watercourse. *Impacts:* All large trees, including those most conducive to recruitment, will be retained as no harvest will occur along classified watercourses. No hardwood or conifer tree species are proposed for harvest. *Benefit:* No harvest will increase mortality and LWD inputs.
Vegetation Canopy & Cover Thermal Loading		X			*History:* Thermal loading is not a limiting factor in this watershed. Downstream water monitoring data shows temperatures well within the range preferred by anadramous salmonid species. The fire history of the area includes frequent, low intensity ground fires. Currently ample shade canopy cover exists mid-stream. *Impacts:* No harvest is proposed alongside classified watercourses - vertical canopy and angular canopy will remain.
Peak Flows		X			*History:* Peak flows occur during spring snowmelt and rain-on-snow-events during the winter period. *Impacts:* Rain-on-snow events remain statistically rare and significant peak flow increases are unlikely to occur as a result of the proposed evenaged management. The clearcut harvest condition is temporal. The timely planting and regeneration of these areas will further moderate any increases in peak flow.

Water Quality Monitoring Proposal for the Judd Creek Watershed

Principal Investigator

Cajun James PhD, Research and Monitoring Manager for Sierra Pacific Industries, P. O. Box 496011 Redding, California 96049-601;(530) 378-8000; email cjames@spi-ind.com.

Other Contributing Investigators

Morgan Hannaford PhD (Aquatic Entomology), Lee Benda PhD (Geomorphology), and Bruce Krumland PhD (Statistics and Biometrics).

Other Cooperators

Pete Cafferata, Forest Hydrologist, California Department of Forestry and Fire Protection, P.O. Box 944246, Sacramento, California; (916) 653-9455.

Background

Throughout the last decade, questions emerged surrounding the effectiveness of forest management practices in California to adequately protect water quality. In order to determine the potential impact of timber management operations on water quality, the Board of Forestry and Fire Protection (BOF) has established cooperative research projects with various landowners. Two such projects were initiated in the year 2003; South Fork of Wages Creek (Campbell Timberlands) and the Garcia River Project (Mendocino County RCD). The proposed monitoring prospectus that follows outlines a cooperative watershed scale experiment between Sierra Pacific Industries, the California Department of Forestry and Fire Protection and the Central Valley Regional Water Quality Board. The materials submitted are a condensed version of a longer monitoring research proposal that will be available by the end of October and will be discussed at the November 10th Monitoring Study Group meeting. These *draft materials* are made available currently to allow for the exchange of ideas and suggestions from other scientists and interested parties. This project will be implemented by Sierra Pacific Industries before winter 2004 and is based on the Judd Creek "Engebretsen" timber harvest plan that is currently in the public review period and is expected to be approved by early October 2004. Peer Review comments and suggestions are welcome and should be submitted to Dr. Cajun James whose contact information is listed above.

Study Area

The proposed research project is located in the Judd Creek Watershed, California Watershed number 5509.630101. This watershed covers 6,350 acres and is 11.02 miles in length from the headwaters of Judd Creek down to the confluence with the North Fork of Antelope Creek. The Judd Creek watershed assessment area is a combination of private and public forestland ownership. Private landowners include Sierra Pacific

Industries (72%) and a private ranch (16%). The United States Forest Service manages the remaining 12% of the watershed.

The stream gradient, annual rainfall, soil type, aspect, slope, and land use history of the Judd Creek watershed is typical of the characteristics of headwaters watersheds owned by Sierra Pacific Industries in mixed-conifer forests of the Southern Cascades. Headwaters watersheds that are similar to Judd Creek comprise 81% of the 1.2 million acres that Sierra Pacific Industries currently owns in the area regulated by the Central Valley Regional Water Quality Control Board. Therefore, results from this monitoring project will contribute valuable information to regulators, forest landowners, and the public on the effect of forest management operations on water quality for inland California headwaters watersheds.

In order to effectively monitor the potential impact of forest management practices it is important to not only select a monitoring watershed that is representative of Sierra Pacific Industries ownership, but to also assess the full range of timber harvest operations that are currently practiced. Therefore, a timber harvest plan, the Judd Creek "Engebretsen", was developed specifically for this monitoring purpose. The plan proposes 41 clear-cut units (ranging from 10 to 26 acres), new road construction, abandonment of older road sections, culvert removals, new landing construction and the abandonment of older landings. The plan would harvest 816 acres or 13% of the entire Judd Creek watershed. This represents almost 18% of SPI lands in this watershed, which places this experiment on the high end of intensive management and potential effects

Baseline Data Available for Inclusion in Monitoring Project

Another reason to locate the monitoring project in the Judd Creek Watershed is because previous studies have been conducted there and baseline data exists for a variety of parameters. Since 1999, Cajun James has collected data for a series of riparian buffer studies in sections 8 and 9 and at the confluence with Antelope Creek. The following parameters were recorded; water temperature, discharge, turbidity, suspended sediment, near stream microclimate, precipitation, canopy cover, and water quality (ph, conductivity, dissolved oxygen). Currently, two water quality-monitoring stations exist in lower Judd Creek that have been collecting data year round since the fall of 2000 as part of these riparian studies. This area in the Judd Creek watershed was designated *experimental forestland status* by the BOF. Dr. Morgan Hannaford has collaborated with Dr. James riparian buffer studies to examine the response of macro invertebrates to timber harvest operations upland of Judd Creek. Dr. Lee Benda has also constructed a sediment budget and a large wood budget for the Judd Creek Watershed in conjunction with the riparian buffer studies.

Monitoring Objective

The objective of this monitoring project is to examine the response of water quality in Judd Creek due to intensive upland forest management activities. Changes in the spatial and temporal variability of stream flow, turbidity, and suspended sediment transport regimes for Judd Creek will be characterized before and after timber harvest operations to determine the effect of timber harvest operations on water quality. In addition, the effect of stream crossing reconstruction, road abandonment, and new road construction on turbidity above and blow treatment sites will be evaluated. Data collected from five water quality stations[1], grab samples and photo points will be included for analysis. Additional baseline data available from other research projects within the watershed will also be used to verify that changes in response variables over time and space resulted from the timber harvest activities implemented in this monitoring project.

Monitoring Timeline and Methodology

- This monitoring project will be implemented over a five-year period and includes six phases beginning in year 2004 and lasting at least through winter 2008. The six phases proposed in this monitoring project are depicted in a flowchart (*Figure A*). Please note that in *Figures 1-6*, each phase of this project is mapped and placement of research equipment is shown. On each map, a solid black and orange line is drawn. This line was mapped to illustrate which direction water will drain within the watershed and help explain equipment placement. The timber harvest units mapped to the right or east of the line will drain into the uppermost water quality station and the timber harvest units mapped to the left or west of the line will drain into the four water quality stations located below the meadow. The water quality station sites were chosen to capture the response of in stream water quality parameters to timber harvest operations in the six phases of this project, located where Judd Creek flows year round, and on Sierra Pacific Industries property.

- In Phase 1, three additional water quality stations will be installed during the fall of 2004. In *Figure1*, red stars represent the location of the two already existing water quality stations and the yellow stars note the proposed new locations.

- In Phase 2, scheduled roadwork will be performed within the Engebretsen THP area during summer 2005 and be concluded by the fall of 2005. In *Figure 2*, proposed roadwork is identified on the map by the following symbols; new road construction (green line), road decommissioning (hatched pink line), culvert removals (orange square), new landing construction (green circle), and the abandonment of older landings (red circle).

[1] Water quality stations include the following equipment: Waterlog data logger, Waterlog gas bubbler, YSI 6280 Multi-Parameter Sonde, Isco suspended sediment sampler.

- In Phase 3, twenty-four units that drain into the lower west side of Judd Creek will be chipped during the summer 2006. In *Figure 3*, the units to be treated in Phase 3 are mapped in gold. Sub-merchantable trees less than or equal to 8 inches in diameter at breast height (DBH) will be chipped. All timber harvest units within this timber harvest plan will be chipped, but because of operational limits, it is not possible to treat all 41 units in a single season. Therefore, mechanical chipping will occur over a two-year period. Mechanical chipping before timber harvest is performed to reduce fire hazard on forestlands in lieu of prescribed burning after harvest. This common forestry practice is increasingly being implemented on Sierra Pacific Industries forestlands because of the risks associated with prescribed burning and because the number of days when prescribed burning is allowed by various agencies has been drastically reduced within the last decade.

- In Phase 4, the twenty-four units chipped in Phase 3 will be clear-cut harvested and seventeen units that drain into the upper east side of Judd Creek will be chipped before harvest in Phase 5. In *Figure 4*, the units harvested are mapped in blue, and the units to be treated with chipping are gold. Phase 4 is scheduled for implementation during the summer of 2007.

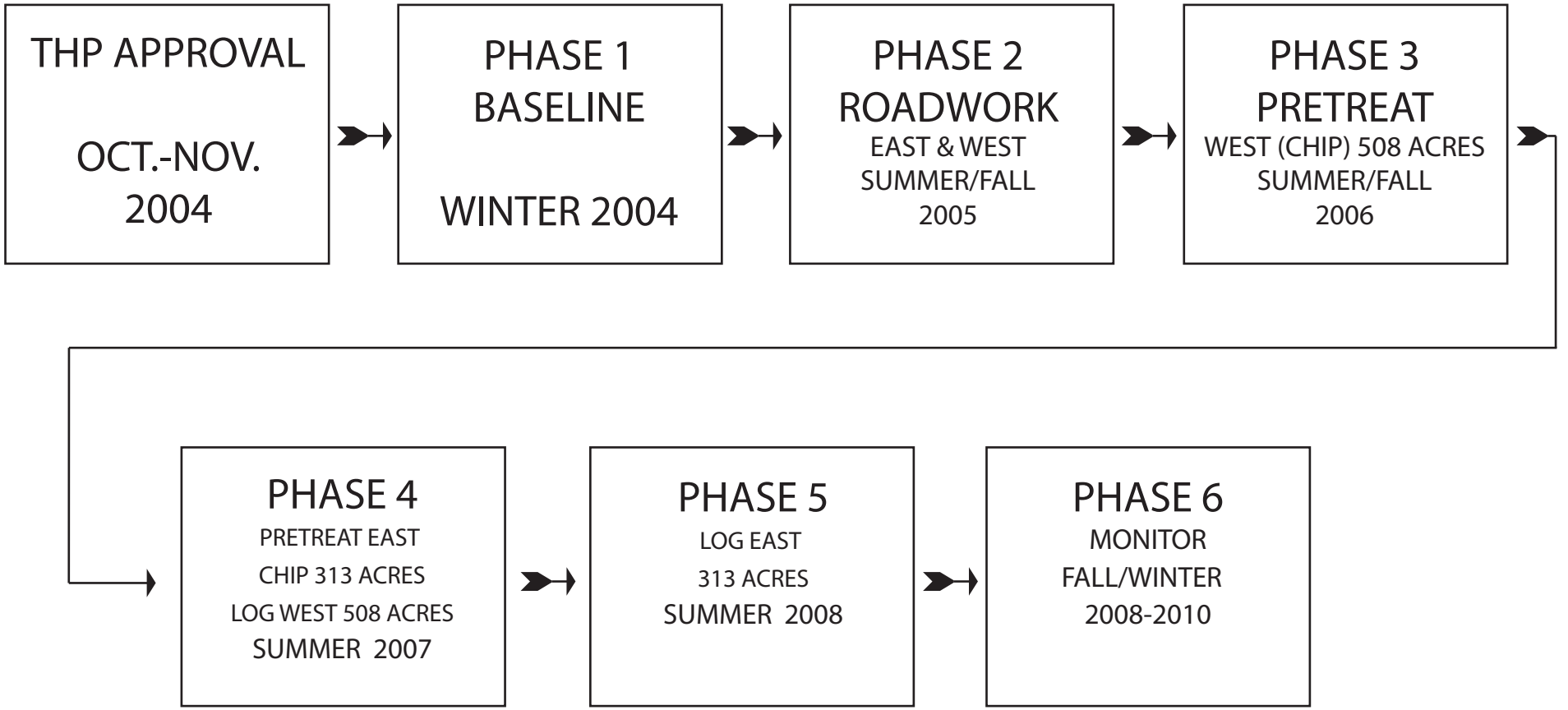
- In Phase 5, the 17 units chipped in Phase 4 will be clear-cut harvested during the summer of 2008. In *Figure 5*, the units to be harvested are mapped in blue and the units that were harvested in the prior year 2007 are now mapped green because they will have been reforested. All treatments are now complete.

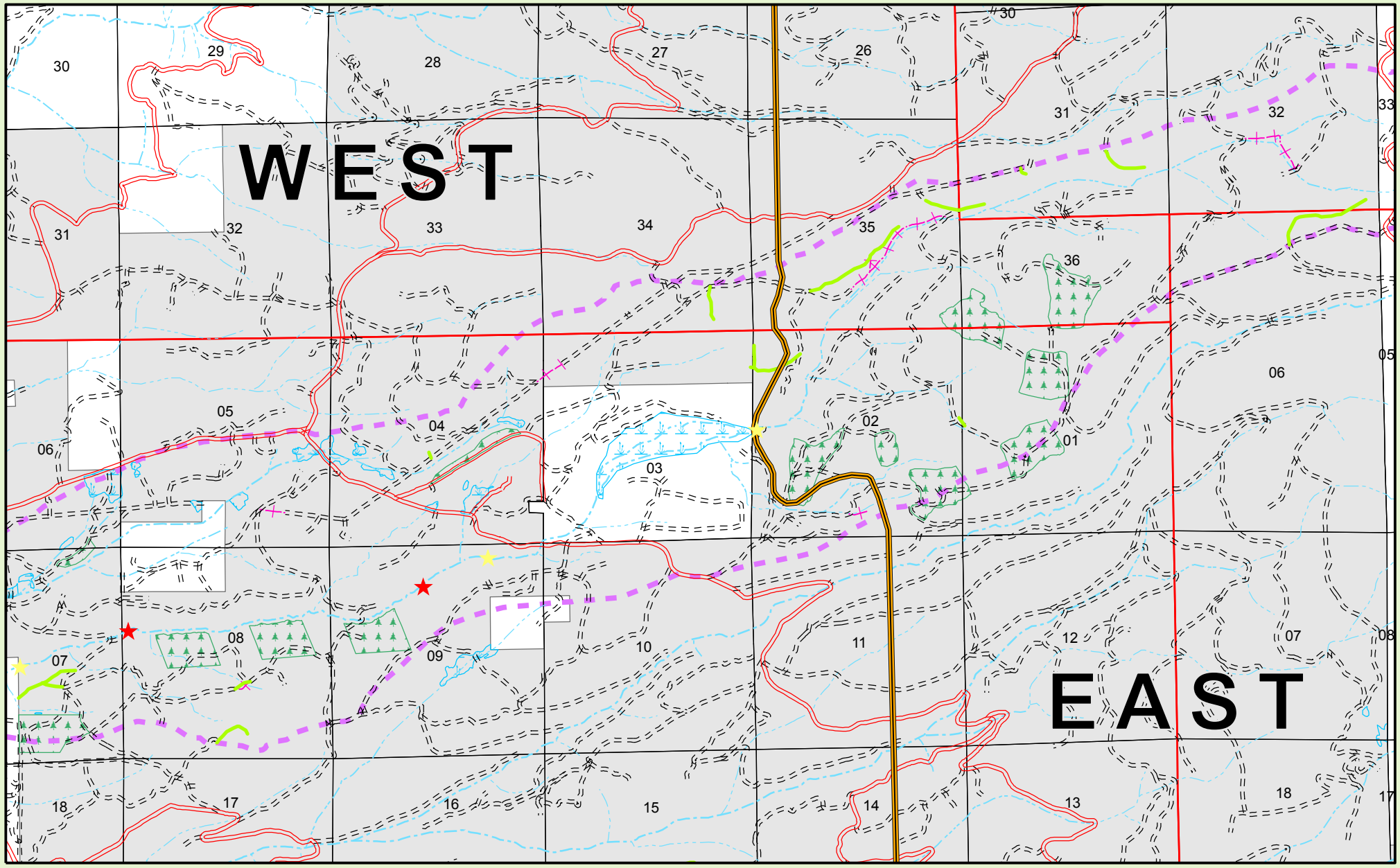
- In Phase 6, all treatments have been implemented and monitoring will continue. In *Figure 6*, all 41 clear-cut harvest units are now mapped in green because they will have been replanted.

Reports to MSG

Each year progress reports will be presented to the MSG and field trips will be arranged if requested.

JUDD CREEK
MSG TIMELINE





Legend

- Sierra Pacific Industries
- Watershed Boundary
- Plantation < 5 years
- Wet Area
- Road Proposed to be Abandoned
- Proposed Road
- Permanent Road
- Seasonal Road
- Class 1 Watercourse
- Class 2 Watercourse
- Class 3 Watercourse
- Existing Sonde
- Proposed Sonde

Judd Creek Monitoring Study Group

Draft Experimental Design

Phase 1 Baseline Winter 2004

N W E S

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Growing Forests For Our Future

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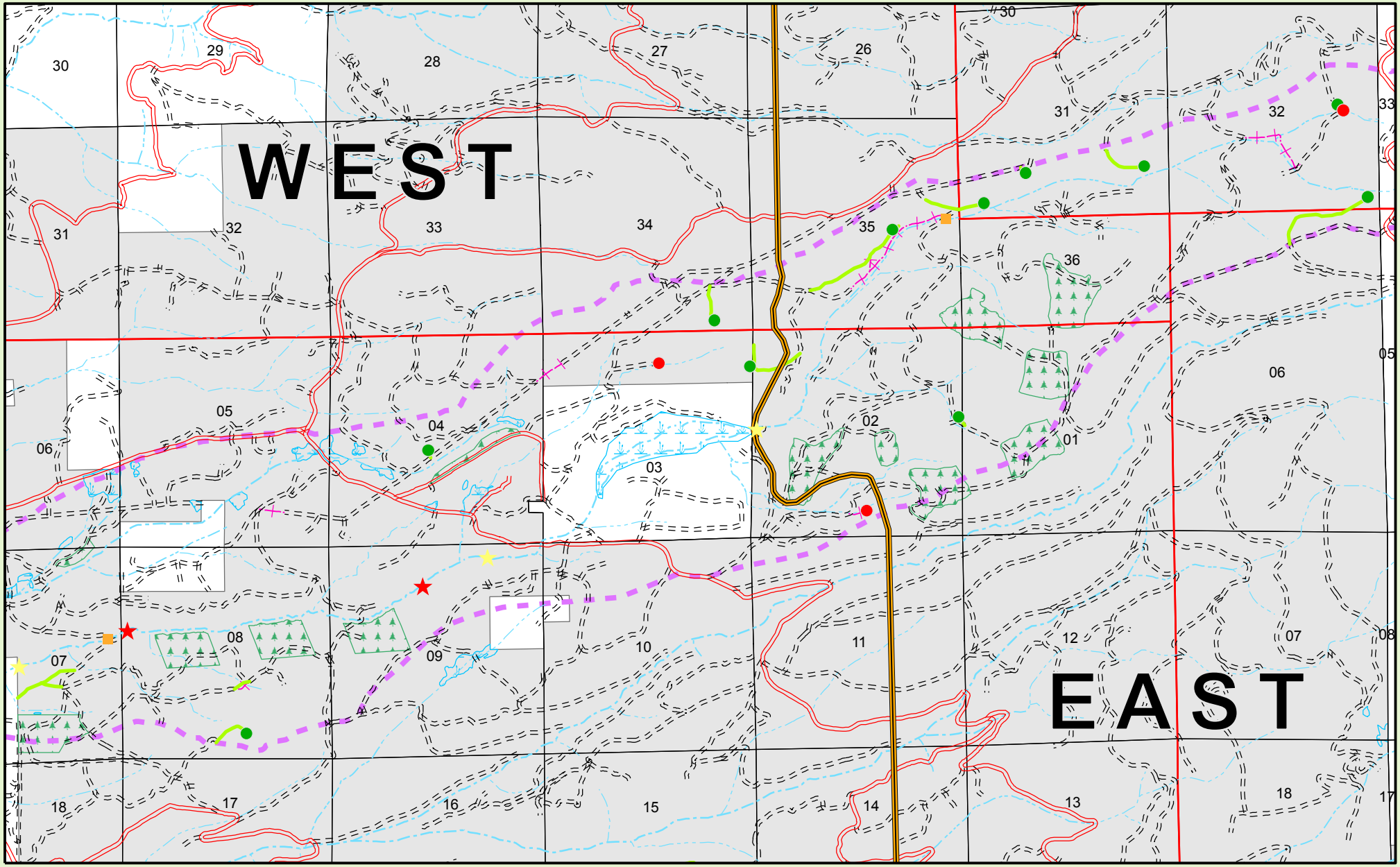

Legend

- Sierra Pacific Industries
- Watershed Boundary
- Plantation < 5 years
- Wet Area
- Road Proposed to be Abandoned
- Proposed Road
- Permanent Road
- Seasonal Road
- Class 1 Watercourse
- Class 2 Watercourse
- Class 3 Watercourse
- Existing Sonde
- Proposed Sonde
- Abandoned Landing
- Proposed Landing
- Culvert Removal/ Photo Point

Judd Creek Monitoring Study Group

Draft Experimental Design

Phase 2 Road Work Summer / Fall 2005

N W E S

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Growing Forests For Our Future

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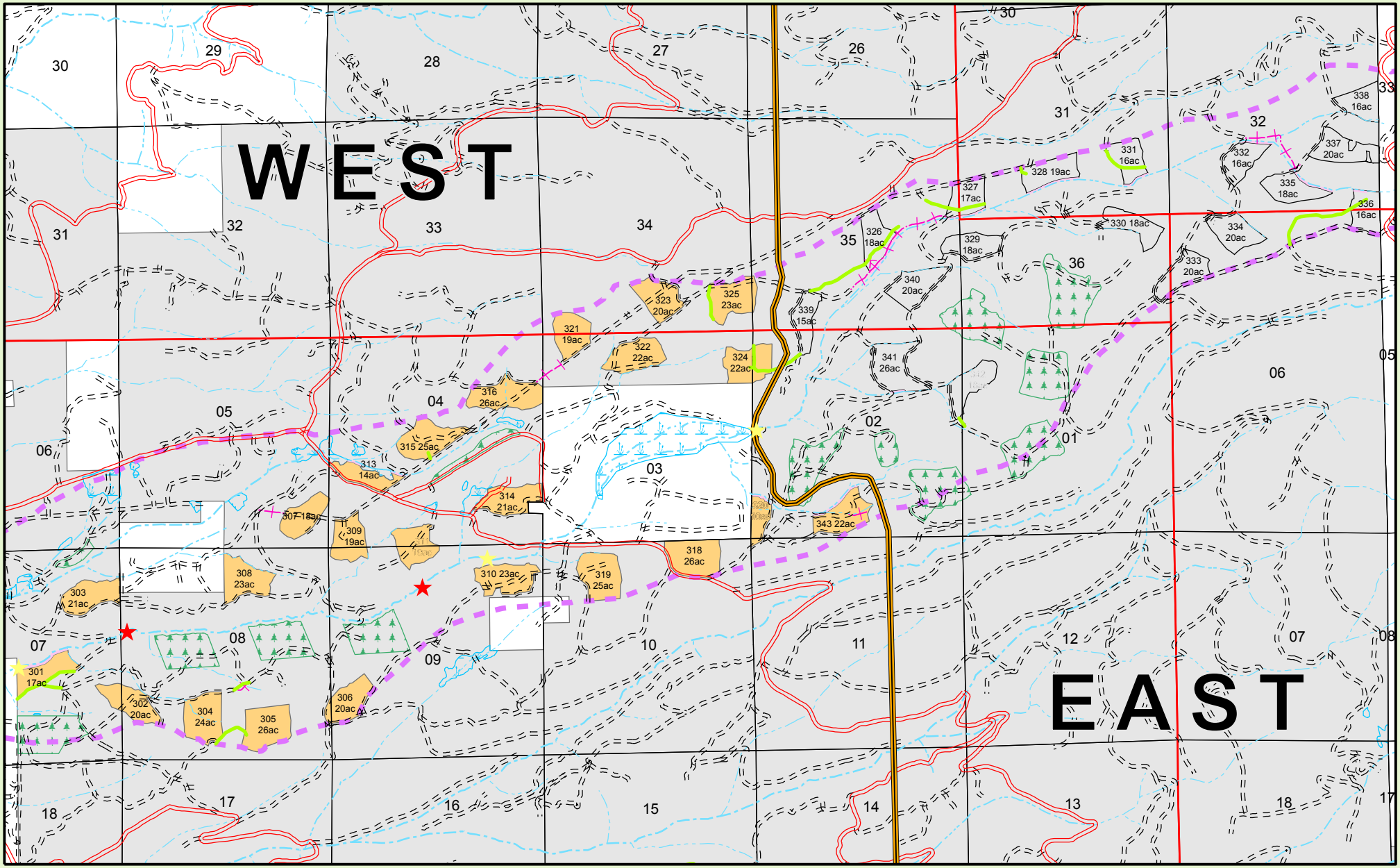
Feet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Legend
Sierra Pacific Industries
Watershed Boundary
Plantation < 5 years
Wet Area
Road Proposed to be Abandoned
Proposed Road
Permanent Road
Seasonal Road
Class 1 Watercourse
Class 2 Watercourse
Class 3 Watercourse
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East Units No Treatment
West Units Chip
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Draft Experimental Design
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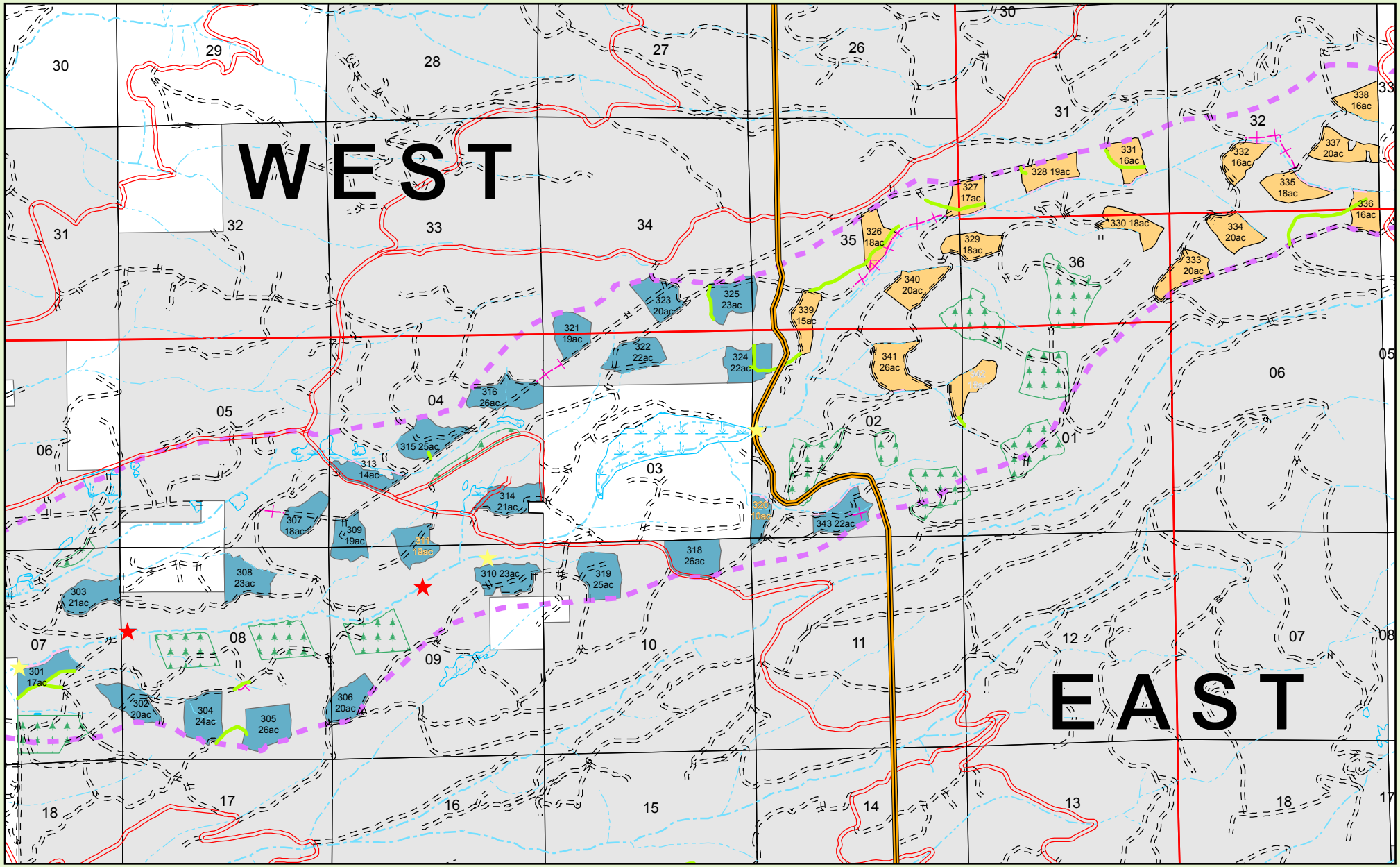
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Watershed Boundary
Plantation < 5 years
Wet Area
Road Proposed to be Abandoned
Proposed Road
Permanent Road
Seasonal Road
Class 1 Watercourse
Class 2 Watercourse
Class 3 Watercourse
Existing Sonde
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East Units Chip
West Units Log
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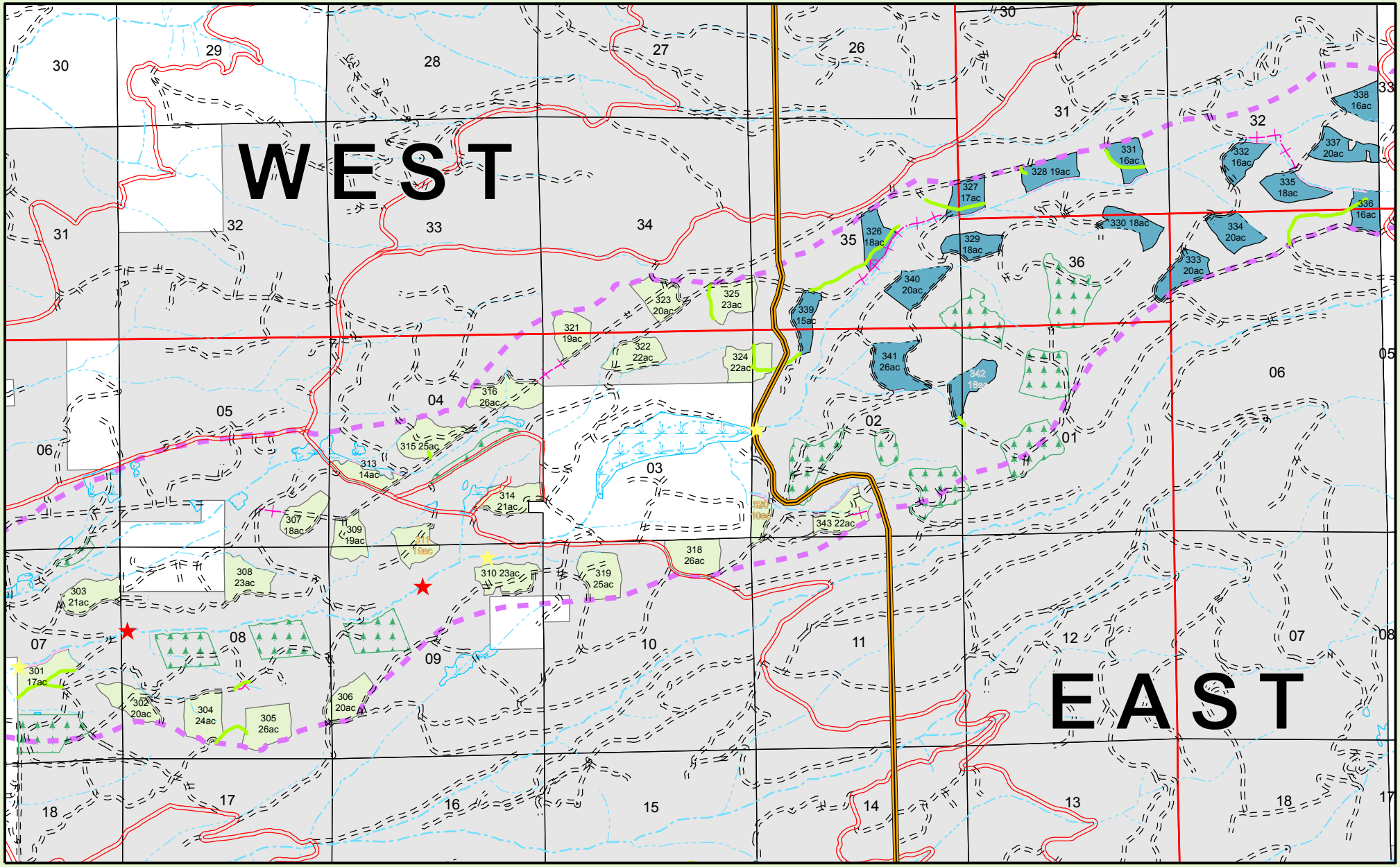
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Sierra Pacific Industries
Watershed Boundary
Plantation < 5 years
Wet Area
Road Proposed to be Abandoned
Proposed Road
Permanent Road
Seasonal Road
Class 1 Watercourse
Class 2 Watercourse
Class 3 Watercourse
Existing Sonde
Proposed Sonde
Log East Units
West Units Completed
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Judd Creek Monitoring Study Group
Draft Experimental Design
Phase 5 Log East Summer 2008
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