ASSESSMENT OF THE PERAZZO MEADOWS WATERSHED
A Tributary to the Little Truckee River, California

(With emphasis on factors affecting salmonid habitat)

A Study Prepared by
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For

The Feather River Chapter Trout Unlimited
And
The USDA Forest Service, Tahoe National Forest

November 2013

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Purposes of this Document

- A compendium, a gathering of the work of many people over many years into one document.
- Knowledge base to help strategize LCT recovery efforts.
- Baseline data to monitor trend over time, with emphasis on aquatic habitat conditions and populations
- A great cure for insomnia if you keep it on your nightstand (K. Roby)

ACKNOWLEDGEMENTS

The following individuals have given freely the fruits of their professional labors and are due full credit for the efforts and expertise.

Major contributions to the sections of fish monitoring and stream temperature were made by **Deborah Urich** of the Tahoe NF. She and her crews collected and synthesized much of that information over several years. **Mr. Derek Bloomquist** deserves thanks for an excellent and timely study of fish populations in Cold Stream. **David Shaw, Beth Christman, Randy Westmoreland, Paul Honeywell, Ken Roby**, and **Amber Coates** also contributed data and/or consultation just when it was needed. My thanks go out to **Cindy Noble** and **Bill Copren** from Trout Unlimited for initiating and shepherding this project.

Organizations in support of this effort include the Feather River and Sagebrush Chapters of Trout Unlimited, Truckee River Watershed Council, Sierra County Fire Safe and Watershed Council, and the Tahoe National Forest.

Organization of the Report

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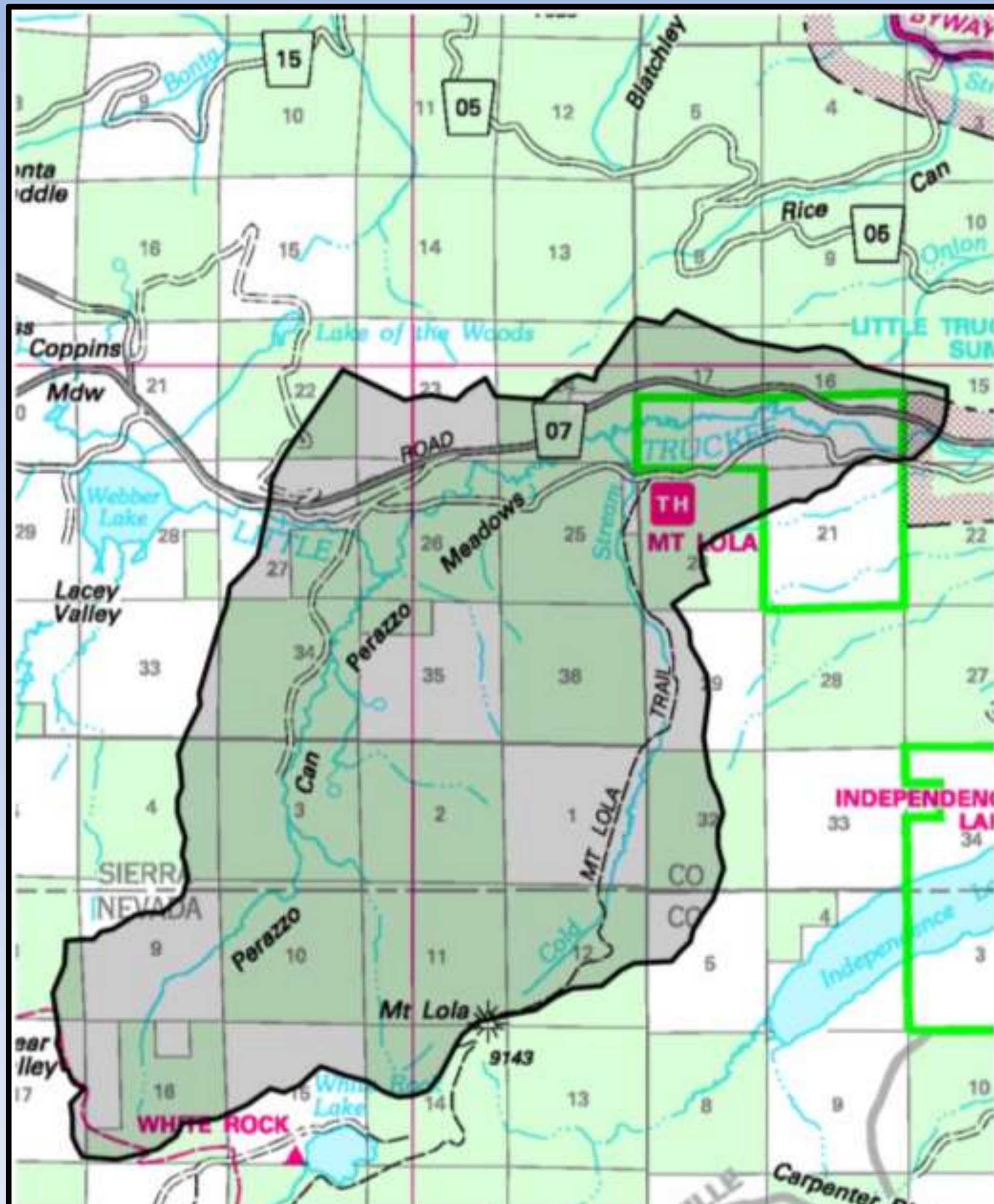

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Cold
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9143
WHITE ROCK
White Lake
Carpenter

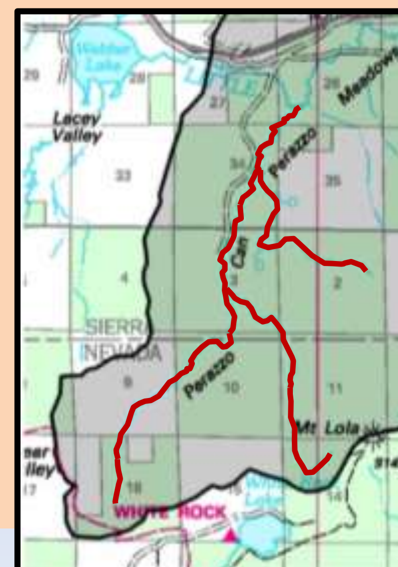
A NOTE ABOUT PLACE NAMES USED IN THIS REPORT

Perazzo Meadows Watershed: Refers to the watershed area above the Sierra Valley Water Company diversion (10 S 732671mE, 4374913mN) but excluding the area above Webber Falls.

LTR/Webber Lake Branch: Refers to the Little Truckee River segment draining from Webber Lake and terminating at the confluence with the *LTR/Perazzo Branch* (10 S 725460mE, 4373116mN). Below this confluence, the channel is referred to simply as the Little Truckee River (LTR).

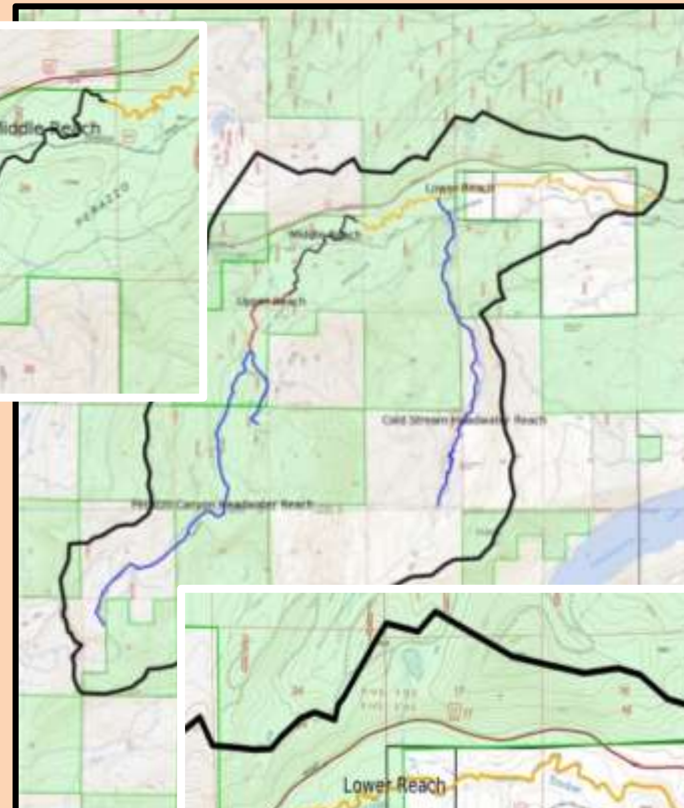
Perazzo Canyon: Refers to the watershed area above the *Upper Meadow* including Toms Valley and two unnamed tributaries.

LTR/Perazzo Branch: Refers to the LTR segment originating in upper *Perazzo Canyon* and terminating at the confluence with the *LTR/Webber Lake Branch* (10 S 725460mE, 4373116mN).



A NOTE ABOUT PLACE NAMES USED IN THIS REPORT

Meadow Reaches



Upper Meadow Reach: Refers to *LTR/Perazzo Branch* beginning at terminus of *Perazzo Canyon* and ending at the confluence with *LTR/Webber Lake Branch*. This is the site of phase 1 of the stream restoration project.

Middle Meadow Reach: Refers to the LTR from the end of the Upper Meadow Reach to a point (10 S 726583mE, 4374422mN) where the channel emerges from a relatively rocky, confined reach. This point is about 0.6 stream miles downstream from the bridge on the Henness Pass Road.

Lower Meadow Reach: Refers to the LTR from the end of the Middle Meadow Reach down to the SVWC diversion structure. Includes the confluence of Cold Stream. This is the site of phase 2 of the stream restoration project.

Headwater Reaches: All channels above the Meadow Reaches

Most of the data in this report are summarized by these stream reach designations

Section 1.2 Description of the Study Area

- Most of you know this already. This is for the uninitiated…

- Major points include:
  - Dominance of snowmelt runoff and potential for rain-on-snow flood events
  - Significance of glacial history and geomorphology
  - Evidence for alteration of stream and riparian environments resulting from settlement by Euro-americans
  - Depredation of LCT and introduction of exotic species

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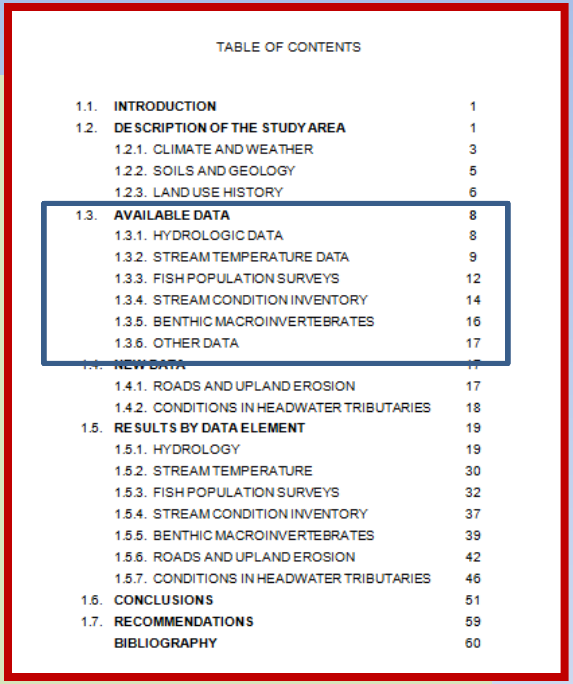
- 1.3.2 Stream temperature
- 1.3.3 Fish population surveys
- 1.3.4 Stream Condition Inventory
- 1.3.5 Benthic macroinvertebrates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Section 1.3.1 Available data>>**USGS hydrologic data**

Table 1: Summary of USGS stream gauge sites in the vicinity of Perazzo Meadows

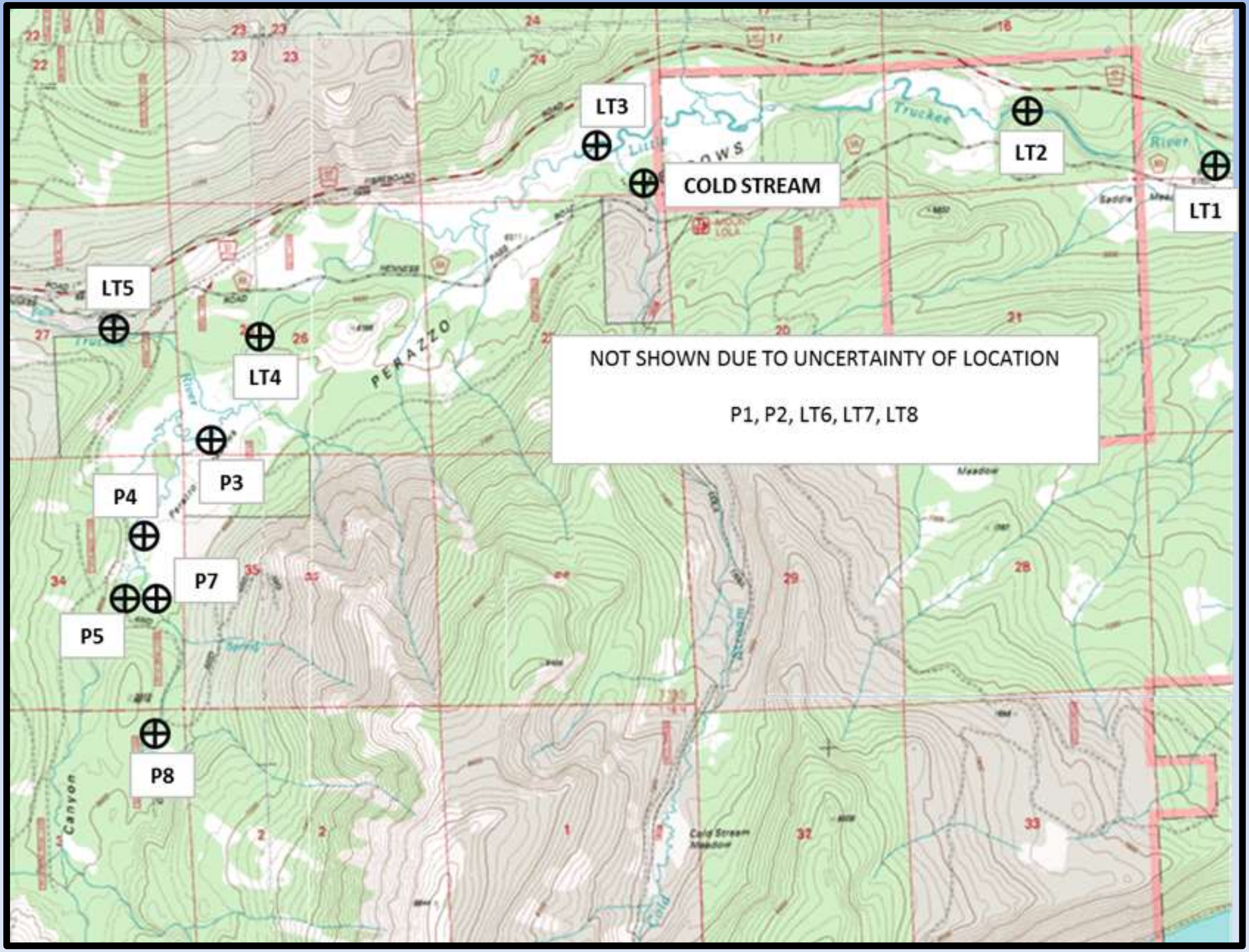
USGS #	SITE NAME	FROM	TO	# YEARS
10341950	LITTLE TRUCKEE R BL DIV DAM NR SIERRAVILLE CA	6/1993	9/1998	5
10342000	LITTLE TRUCKEE R NR HOBART MILLS CA	1/1947	10/1972	25
10343000	INDEPENDENCE C NR TRUCKEE CA	8/1968	PRESENT	43
10343200	LITTLE TRUCKEE R AT HWY 89 NR TRUCKEE	4/1993	7/1995	1
10343500	SAGEHEN C NR TRUCKEE CA	10/1953	PRESENT	48

Table 2: Summary of strengths and weaknesses of data from USGS gauges

USGS #	SITE NAME	COMMENT
10341950	LITTLE TRUCKEE R BL DIV DAM NR SIERRAVILLE CA	Short record. Some extreme values suggest rating curve affected by ice/debris
10342000	LITTLE TRUCKEE R NR HOBART MILLS CA	Good long-term record but ends in 1972. Good data for basin-to-basin correlation. Some records are probably ice-affected. Peak of record 7910 cfs.
10343000	INDEPENDENCE C NR TRUCKEE CA	Solid long-term record but flows are regulated and ice-affected. These factors limit utility of data.
10343200	LITTLE TRUCKEE R AT HWY 89 NR TRUCKEE	Only one complete water year of data.
10343500	SAGEHEN C NR TRUCKEE CA	Site not in watershed but representative of physiographic conditions. Excellent long term record. Site still active

Data from all sites listed here are available on an Excel spreadsheet as part of Appendix D of the report.

Section 1.3.2 Available data>>**Stream temperature**



Section 1.3.2 Available data>>**Stream temperature** (con’t)

LABELED AS	NEW I.D.	SITE DESCRIPTION	2001	2002	2005	2006	2008	2009	2010	2011	2012
Perazzo Creek (2001) **Perazzo Lower (2006)**	P1	Exact location uncertain. Probably in Upper Meadow above confluence of LTR/Webber Lk. Br.	X			X					
Perazzo Creek (2001-2) **Perazzo Upper (2006)**	P2	Exact location uncertain. Probably near head of Upper Meadow	X	X		X					
DS_diversion	LT1	Below SVWC diversion						X			
Rest_site1_below(2009) **Per_Rest_EndRest (2010)**	LT2	Just upstream from SVWC diversion				X		X	X	X	X
SCI_R2	LT3	At SCI survey Reach 2 near Cold Stream confluence						X		X	X
Cold Stream (2009)	COLD	On Cold Stream alluvial fan 600' below Henness Pass Road						X			
LT RestEnd (2009)	LT4	500 m below LTR/Webber Lake Branch				X		X	X	X	X
Rest_US_bridge(2009) **PerRest_AboveBridgeLTK(2010)**	LT5	LTR/ Webber Lake Br. above bridge on 07-30 road					X	X	X	X	X
perazzo_main_lower (2005) **PerRest_LowerMn (2010)**	P3	Just above LTR/ Webber Lake Br. on LTR/Perazzo Br.			X			*1	X		X
perazzo_main_middle (2005) **PerRest_Middle (2008)** **PerRest_Mid (2010)**	P4	Near upper end of phase 1 restoration and below Mt. Lola tributary			X		X	*1	X	X	X
perazzo_main_top (2005) **PerRest_UpperMn (2008)** **PerRest_UpperMn (2010)**	P5	Main channel above 4WD crossing at head of Upper Meadow			X		X	*1	X	X	X
perazzo_middle_top (2005)	P6	Location uncertain			X						
perazzo_bottom_trib_t1 (2005) **PerRest_UpperT (2008)**	P7	Lower station on Mt Lola tributary			X		X				
perazzo_top_trib (2005) **PerRest_Trib (2010)**	P8	upper station on Mt Lola tributary			X				X	X	X

Note 1: Map shows 2009 data for this site but no data file was located.

Note 2: "LT" sites on Little Truckee below LTR/Webber Lk. Branch--"P" sites LTR/Perazzo Branch.

Section 1.3.3 Available data>>**Fish population surveys**

Surveys cover 2009-2013
2013 data not included in report

2009 survey

- All sampling in "Upper" reach
- Size class information available
- Sampling prior to restoration project implementation
- Sampling primarily by electrofishing (3-pass reduction)
- All sample sites within incised channel

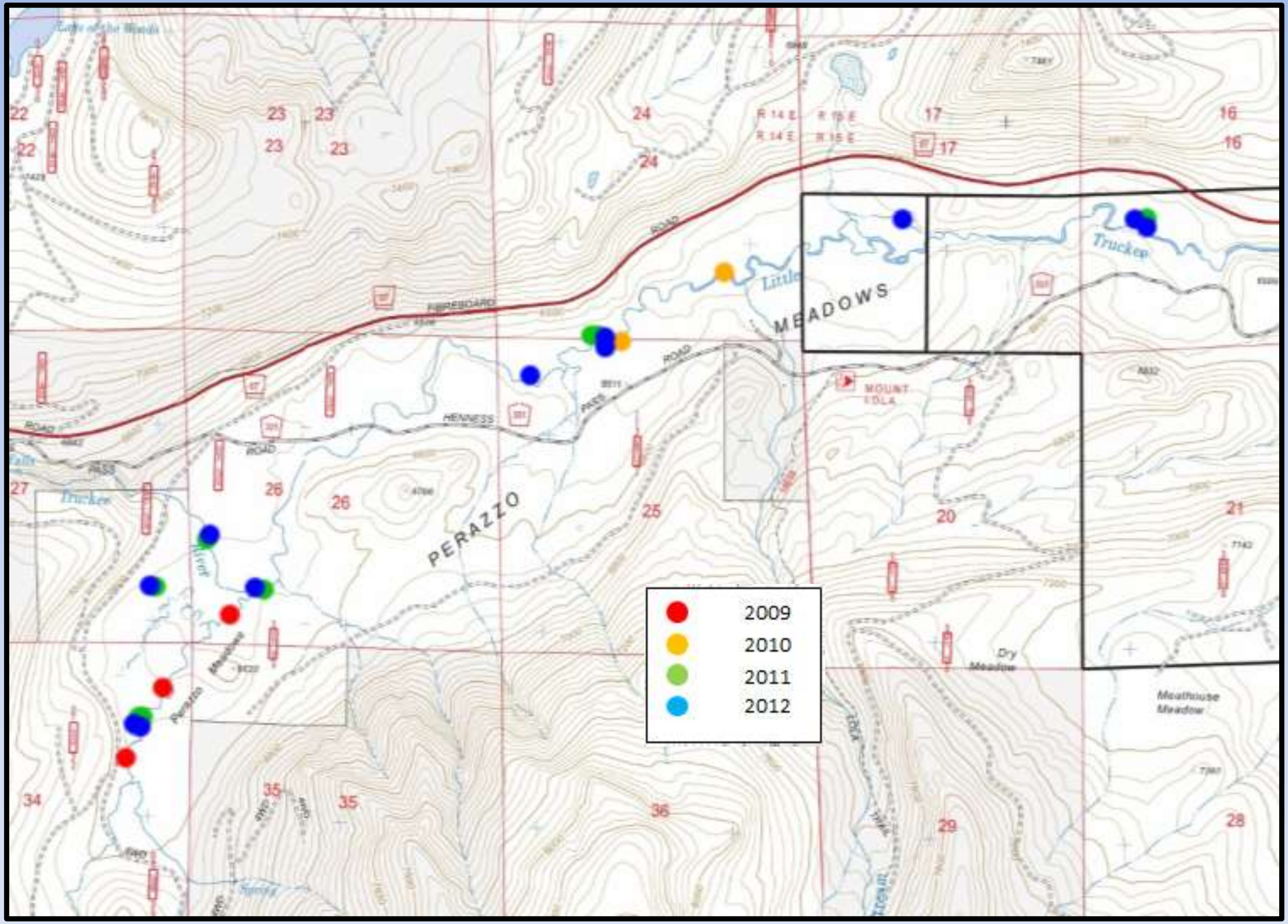
2010 survey

- All sampling in "Middle" reach
- Size class information available
- Sampling prior to restoration project implementation
- Sampling primarily by electrofishing (3-pass reduction)
- All sample sites within incised channel

2011 survey

- Sampling conducted post restoration implementation
- Sample sites stratified as "*inundated meadow*", "*riffle*", and "*pond*" due to greater diversity of habitats created by restoration project
- Variety of sampling methods used including seines, gill nets, hook and line. Different methods necessitated by different conformation of habitats.
- Limited size class data available
- Samples taken from Upper Meadow down to SVWC diversion
- 2011 was a high water year

Section 1.3.3 Available data>>**Fish population surveys**



Section 1.3.4 Available data>>**Stream Condition Inventory**

2004 Little Truckee below the LTR/Webber tributary and above bridge on Henness Pass Road. Labeled as “Perazzo Reach 1”. Survey data for this site does not appear in the R5 database. Located in MIDDLE reach.

2006 Perazzo Canyon just above the upper meadow on the alluvial fan. Labeled on data sheets as “Perazzo Reach 2”. Shown in R5 database as “Perazzo 06”. Classified as “Headwater” since it is not a classic response channel but a higher gradient transport reach.

2006 Labeled “Perazzo West 06”. This survey was located in the UPPER meadow reach along the intensely meandering historic channel that was abandoned when the main channel was re-routed decades ago.

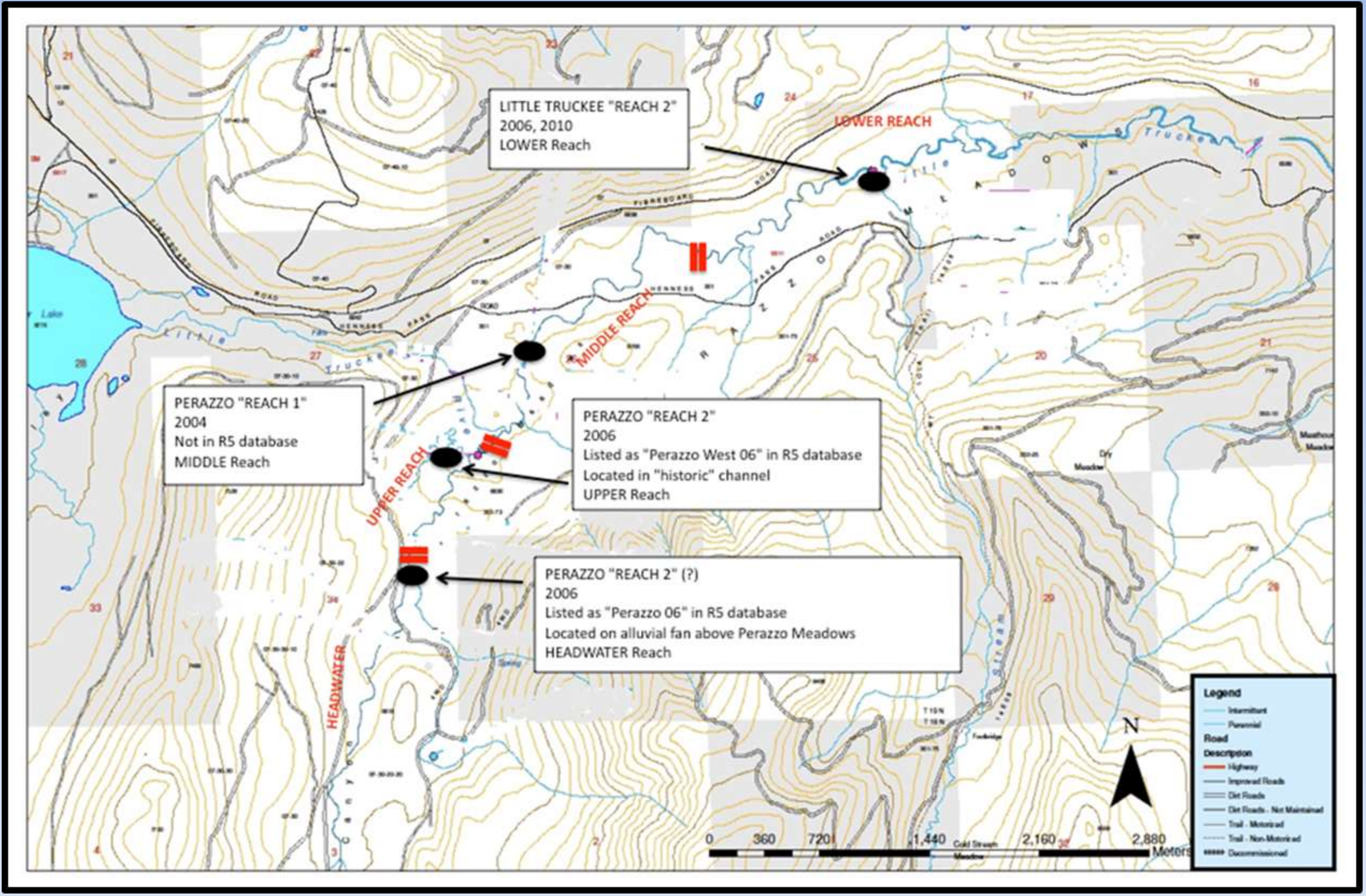
2006 Little Truckee in the lower meadow—in the vicinity of the confluence of Cold Stream. Labeled as “Reach 2”

2010 Little Truckee Reach 2—same as 2006 site

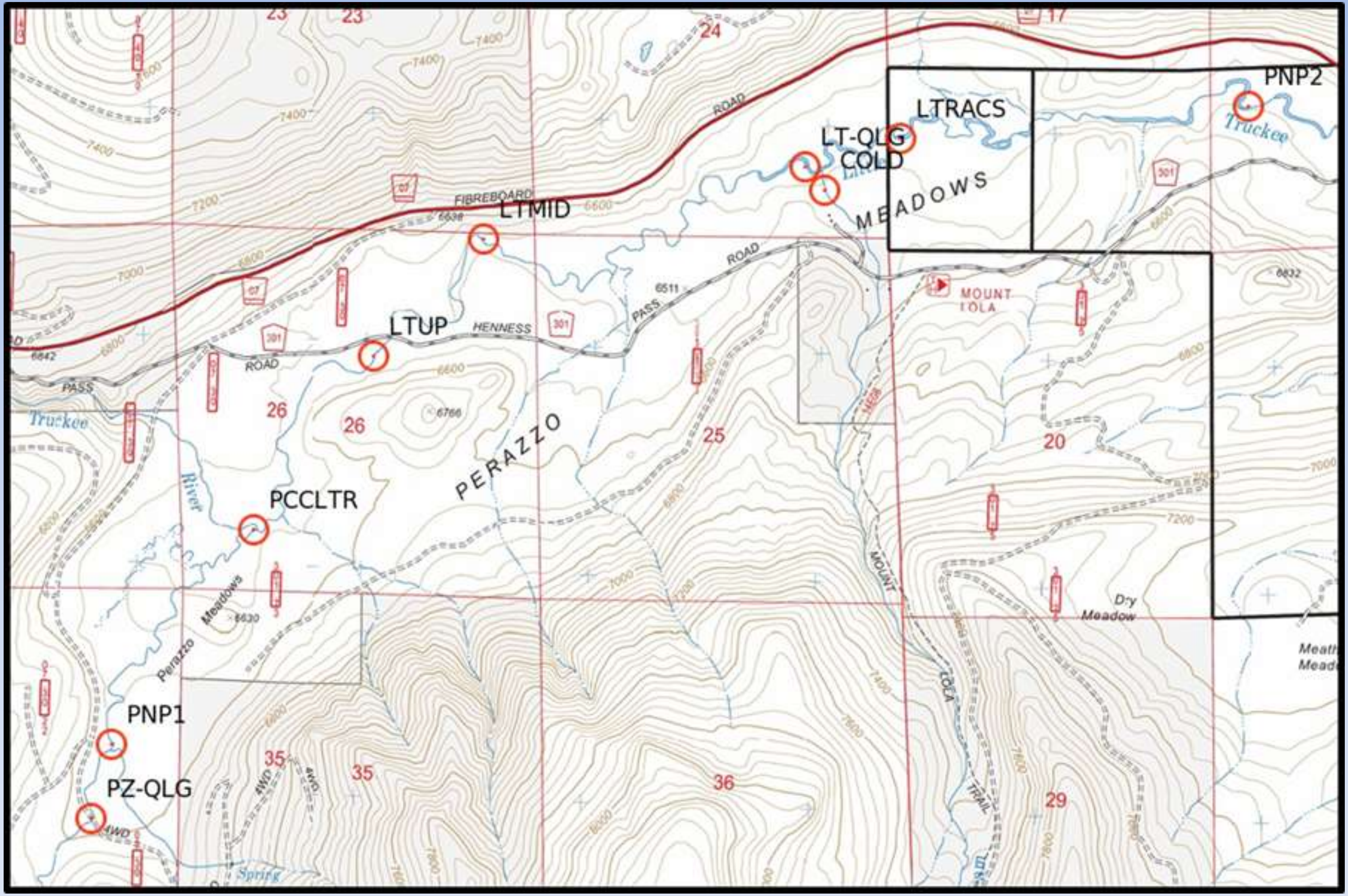
Data from this survey affected by erosion damage to Phase 1 PnP from rain-on-snow event

2004+ Sagehen Creek was surveyed in 2004 and 2007-2011. Sagehen Creek serves as the reference site against which the Little Truckee data is compared. The survey reach is approximately 0.45 miles downstream of the UC research facility. The channel at this site is transitional between a transport and response reach.

Section 1.3.4 Available data>>**Stream Condition Inventory** (con't)



Section 1.3.5 Available data>>**Benthic macroinvetebrates** (con't)



Section 1.3.5 Available data>>**Benthic macroinvetebrates**

SITE ID	DATE	YEAR	REACH	COLLECTOR
LTRACS	8/15/2009	2009	LOWER	TRWC
PCCLTR	7/18/2009	2009	UPPER	TRWC
PNP1	9/26/2011	2011	UPPER	FRTU
LTUP	9/27/2011	2011	MIDDLE	FRTU
LTMID	10/3/2011	2011	MIDDLE	FRTU
PNP2	10/12/2011	2011	LOWER	FRTU
COLD	10/12/2011	2011	HEADWATER	FRTU
LT-QLG	7/22/2010	2010	LOWER	USFS
LT-QLG	7/24/2006	2006	LOWER	USFS
SAGE-QLG	7/13/2010	2010	REFERENCE	USFS
SAGE-QLG	6/25/2009	2009	REFERENCE	USFS
SAGE-QLG	8/6/2008	2008	REFERENCE	USFS
SAGE-QLG	7/19/2007	2007	REFERENCE	USFS
SAGE-QLG	8/15/2001	2001	REFERENCE	USFS
SAGE-QLG	7/25/2000	2000	REFERENCE	USFS
PZ-QLG	7/19/2006	2006	HEADWATER	USFS

Section 1.4 New Data

- 1.4.1 Roads and upland erosion
  - ➢ Systematic survey of all road segments
  - ➢ and drainage structures
    - 30.2 miles of road surveyed
    - 219 road cross drains inventoried
    - 73 stream crossing inventoried

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- 1.4.2 Conditions in headwater tributaries
  - ➢ Reconnaissance survey of perennial and intermittent stream channels with emphasis on fish presence, habitat types and abundance, fish barriers, and channel condition.
  - ➢ Field reconnaissance of major erosion sites inventoried from aerial imagery
  - ➢ Random checking past timber harvest sites for skid trail condition and general soil cover

Section 1.5 Results by Data Element

- 1.5.1 Hydrologic data
- 1.5.2 Stream temperature
- 1.5.3 Fish population surveys
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- 1.5.5 Benthic macroinvertebrates
- 1.5.6 Roads and upland erosion
- 1.5.7 Conditions in headwater tributaries

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Water Balance Basics

Precipitation*	50-65 in/yr
ET	20-25 in/yr
Runoff	30-35 in/yr

*This is significantly higher than estimate provided by Sagehen rain gauge (32.6 in/yr)

- Peak Flow Regime

  - Short, unreliable record at diversion site (1993-98)

  - Used other approaches to estimate peak flow regime.
    - Hobart data adjusted for basin size
    - Extend Hobart data by correlation with Sagehen
    - Adjust Sagehen data for basin size (same as Swanson H+G, 2008)
    - Regional regression equations based on basin physiography (Magnitude and Frequency of Floods, Waananen, 1977)

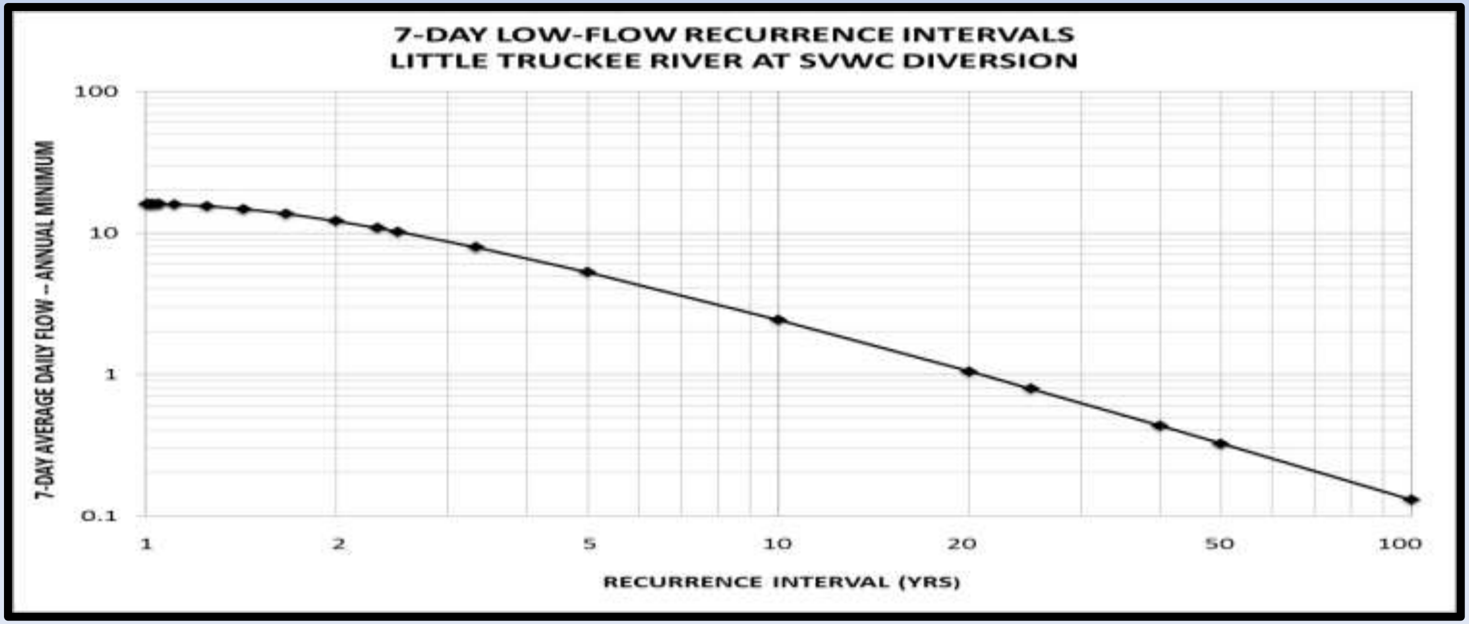
  - Results highly variable

SOURCE OF ESTIMATES	FLOOD RECURRENCE INTERVAL (YRS)						
	1.5	2	5	10	25	50	100
Hobart 1947-1972	710	1100	2400	3500	7000	*[7400]*	*[9200]*
Hobart extended record 1953-2011	450	750	2180	3900	7150	9190	*[10400]*
Sagehen adjusted for basin size ratio after Swanson (2008)	230	300	950	1750	3200	4180	*[5050]*
Regression estimates after Waananen (1977)	*[120]*	200	550	990	1800	2620	3620

- Low Flow Regime

  - Based on 7-day low flow moving averages (July-September) using diversion site daily mean flows extended by correlation with Sagehen.

  - These data suggest that
    - 4 years out of 5 have low flows that exceed 5 cfs.
    - One year out of 20 will see low flows below 1 cfs.
    - Most commonly, low flows will be in the 5-10 cfs range.



- Snow data

Month	Avg. Snow Water Content (in.)	# Observations
Jan	9.2	7
Feb	19.9	25
Mar	27.5	26
Apr	31.6	86
May	28.4	24
Jun	17.1	8

- Groundwater data 2010 (courtesy of D. Shaw, Balance Hydrologics)

Table 7: Groundwater data for WY 2010 (average of 7 sites)

Max drawdown (ft)	3.37
Min drawdown (ft)	1.11
Avg drawdow (ft)	2.39
Date of Max WSE	Apr-May
Date of Min WSE	Aug-Sept

**WSE = Water Surface Elevation*

Section 1.5.2 Results by Data Element>>**Stream Temperature**

1. Late July into early August is the period that typically exhibits maximum stream temperatures
2. Stream temperatures increase significantly below the Phase 1 project reach ("UPPER" reach).
3. Above the confluence of LTR/Webber Lake Branch, temperatures rarely exceed the threshold. ("*Threshold*" defined as 21.8^{o}C, D. Urich)
4. Headwater tributaries in Cold Stream and upper Perazzo Canyon rarely exceed 59^{o}F (15^{o}C)
5. For the period of record, stream temperatures in the Middle and Lower Reaches have exceeded the threshold temperature in years when precipitation is less than about 70% of average. Table 8 shows the percent of days in the July-September period with daily maxima exceeding the threshold.

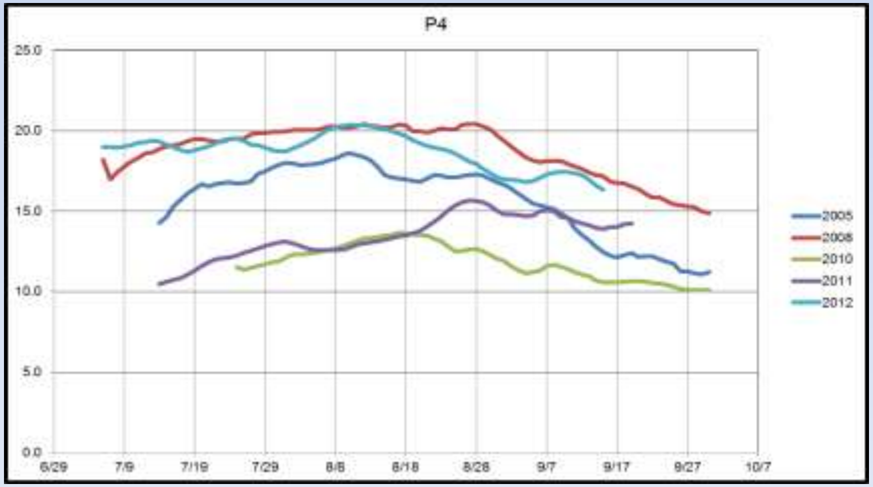
Section 1.5.2 Results by Data Element>>**Stream Temperature** (con't)

Year	Precip--Percent of Average	Perazzo Tributary	Above Bridge/Webber Lk. Tributary	Upper Perazzo	Middle Perazzo	Lower Perazzo	Below SVWC diversion
2005	90%	0.0%		0.0%	0.0%	23.1%	
2006	150%			0.0%	0.0%	0.0%	6.5%
2008	***47%***	0.0%	0.0%	0.0%	***24.4%***	**33.3%**	**41.1%**
2009	***71%***	0.0%	0.0%	0.0%	***18.9%***		***22.8%***
2010	82%	0.0%	0.0%	0.0%	0.0%	2.2%	2.2%
2011	134%	0.0%	0.0%	0.0%	0.0%		0.0%
2012	***62%***	0.0%	0.0%	0.0%	***24.2%***	0.0%	***75.8%***

Section 1.5.2 Results by Data Element>>**Stream Temperature** (con't)

6. Ponds do not appear to cause significant heating. Deeper ponds tend to stratify in late summer. Shallower ponds do not stratify. Groundwater influx appears to help keep temperatures below threshold in ponds.

7. Dissolved oxygen levels reach an annual low in September as flows decline, temperatures increase, and biological consumption of oxygen increases. The lowest level observed in 2011 was 6.4 mg/l in still-water habitats (ponds and meadows). Though less than optimal for LCT, these levels are not regarded as intolerable for support of an LCT population.



All stream temp data plots available in Appendix B

- Eight species of fish were encountered during conduct of the surveys.

- Five are native non-salmonids.

  - speckled dace (Rhinichthys osculus)
  - Paiute sculpin (Cottus beldingi)
  - Lahontan redsides (Richardsonius egregious)
  - Tahoe sucker (Catostomus tahoensis)
  - Mountain sucker (Catostomus platyrhynchus)

- Three salmonids not endemic to the study area were sampled.

  - brook trout (Salvelinus fontinalis)
  - rainbow trout (Oncorhynchus mykiss)
  - brown trout (Salmo trutta)

Section 1.5.3 Results by Data Element>>**Fish Population Surveys** (con't)

- 2009 -10 Surveys (pre-restoration)
  - Salmonids less than 5% of individuals sampled
  - 2009: rainbow trout were dominant salmonid
  - 2010: brook trout were only salmonid sampled
  - Size class data suggests all non-salmonids and brook trout were successfully reproducing. No sexually mature rainbow trout were sampled.
  - Population densities (all species) were highest in the middle reach

- 2011 -12 Surveys (post-restoration)
  - Sampling methods changed due to changes in habitat types created by plug-n-pond restoration design
    - Inundated meadow (not present in unrestored reaches)
    - Riffle
    - ponds
  - Inundated meadow habitats:
    - 2011: dace and redsides dominant
    - 2012: Much of this habitat type was dry or stagnant
  - Riffle habitats:
    - Dace numbers increase in upper reach
    - Brook trout increase in middle reach
  - Pond habitats: (Based on 2012 gill netting)
    - Brook trout and suckers are the predominant large fish utilizing pond habitat.
    - High variability in fish numbers between the nine ponds sampled with gill netting.
    - No rainbow trout found utilizing ponds

Section 1.5.3 Results by Data Element>>**Fish Population Surveys** (con't)

- Surveys in Headwater Tributaries
  - Brook trout are the dominant species in all tributaries
  - Native species present are mostly sculpin and dace. These species decline in abundance in the upstream direction, leaving the upper most reaches to brook trout solely.
  - Brown trout and rainbow trout were present in the largest tributaries (Cold Stream and Perazzo Canyon) but in very low numbers
  - Geomorphically, Cold Stream and Perazzo Canyon have a similar arrangement of stream types along the channel profile.
    - High density populations of brook trout in high elevation, low gradient alluvial reaches
    - Population density decreases dramatically in high-gradient step-pool reaches downstream

Section 1.5.3 Results by Data Element>>**Fish Population Surveys** (con't)

Overall conclusions concerning fish populations
(…more on this topic from Deborah)

- Native non-salmonids dominate the meadow reaches, usually comprising nearly 90%-95% of the overall population.
- Salmonids, all non-native, usually comprise less than 5% of the overall population.
- Preliminary evidence suggests that ponds may provide formerly unavailable habitat for mature brook trout and suckers. More data is needed to confirm this hypothesis. May indicate increased use of meadow reaches by brook trout.
- Annual variation in runoff, fish migration, and varying capture efficiency associated with different sampling methods limits our ability to assess the effects of the restoration project on fish communities. Except for the apparent increase in brook trout use of ponds, no clear trends are apparent.
- There is no conclusive data on seasonal migration patterns of fish during the low flow period.
- No sexually mature rainbow trout were sampled.
- Inundated meadow provides seasonally ephemeral habitat for speckled dace only (provisional finding)
- Paiute sculpin encountered only in riffle segments or lower reaches of tributaries. Riffles were consistently the most diverse habitat type.
- Brook trout density is highest in tributaries, particularly Cold Stream and Perazzo Canyon.
- Sculpin dominate the Lower Reach (un-restored)

Section 1.5.4 Results by Data Element>>**Stream Condition Inventory (SCI)**

- SCI data grouped by reach
- Sagehen used as reference site. Some issues with comparability.
- Subset of SCI parameters judged most relevant to LCT habitat suitability were included

REACH	Number of LWD Key pieces / 100 m	Particle Count % < 2mm	Median Bed Particle Diam.(mm) D50	Gradient%	Entrench	W:D Ratio	Residual Pool Depth (m)	% Pool Tail Surf Fines	% Stable Banks	% Shade
REFERENCE[1]	30.8	3.8	50.5	2.7%	4.61	15.8	0.40	8.0%	83.8%	65.5
HEADWATER	37.0	2.2	69.4	2.9%	UNC[2]	21.8	0.62	2.8%	51.0%	39.8
UPPER	0.0	100.0	2.0	0.2%	UNC[2]	17.4	0.64	100.0%	65.0%	18.8
MIDDLE	6.1	18.0	22.6	0.3%	UNC[2]	30.6	0.93	6.9%	53.0%	3.1
LOWER	0.2	3.2	30.1	0.5%	1.92	65.0	0.92	18.7%	32.0%	3.5

Note 1: Sagehen Creek HFQLG site used as reference site

Note 2: UNC = unconfined

A complete SCI dataset in spreadsheet format is available in Appendix D of the report

Overall conclusions regarding SCI data

These data suggest that there are some critical issues for salmonids in the middle and lower meadow reaches. Many of these parameters influence non-morphological habitat factors like stream temperature and dissolved oxygen (related to shade, cover, and W/D ratio).

- high temperatures (less than 5% shade in Middle and Lower Reaches)
- lack of cover/refugia (very low values for LWD and low shade)
- limited high-quality spawning habitat (high percent pool tail fines)
- continued input of fine sediment from channel widening and bank erosion (% stable banks-W/D ratio).

The extent to which these conditions represent limiting factors for salmonids is not known to a certainty but it is a reasonably strong possibility. Channel condition in headwaters is much better by comparison but the amount of habitat per stream mile is much less because flows and channel dimensions are small.

Section 1.5.5 Results by Data Element>>**Benthic macroinvertebrates**

- Small subset of BMI metrics used in the analysis

  - **Taxa richness**—number of taxonomic groups represented in the sample. Larger values indicate greater species diversity.

  - **Shannon diversity**—numerical index that integrates both taxa richness and evenness of distribution between taxa. (Scores ranging in 2-3 range generally indicate high diversity)

  - **Number EPT taxa**—"EPT" is shorthand for insect orders Ephemeroptera (Mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). The index is the sum of EPT taxa represented in a sample. Larger values indicate more favorable conditions of temperature and oxygenation for salmonids.

  - **RIVPACS O/E** scores and ratings—In simplest terms, this is a predictive model using statistical methods to make an inference about "how different" the BMI community is compared to reference sites. A value of 1.0 indicates a perfect match between the observed BMI composition at the study site and the expected composition (reference sites). Values less than 1.0 suggest fewer taxa than expected.

Section 1.5.5 Results by Data Element>>**Benthic macroinvertebrates** (con't)

	UPPER	MIDDLE	LOWER	HEADWATERS	REFERENCE
Taxonomic richness	29.0	17.0	31.0	23.0	28.7
Shannon's diversity	2.36	1.87	2.09	2.38	2.27
# EPT taxa	17.8	7.5	15.5	14.0	16.8
O/E score	0.86	0.58	0.59	1.09	0.89
RIVPACS Rating	Good (n=1)	Poor (n=1)	Poor-Good (n=3)	Good (n=1)	Fair-Good (n=6)

- Results are descriptive, not enough replication to make statistical inferences
- Middle reach scores lowest on all metrics
- Variable conditions in lower reach. Repeat sampling in reaches where n=1 might inject similar variability into results (time of year, low flow conditions etc.)

Section 1.5.6 Results by Data Element>>**Roads and Upland Erosion**

Overall road-related erosion rate from field survey estimated at

9.76

Mg/ha/yr

Entire road survey database available in spreadsheet format in Appendix D

Study location	Portion of road prism	Sediment production rate ($Mg\ ha^{-1}\ yr^{-1}$)	Reference
North Carolina, USA	Travelway	1143	Lieberman & Hoover, 1948
North Carolina, USA	Travelway	7110	Hoover, 1952
Idaho Batholith, USA	Travelway	73	Megahan & Kidd, 1972
Idaho Batholith, USA	Travelway	20	Megahan, 1975
Washington, USA	Travelway	4.8 – 66	Wald, 1975
Southeast, USA	Travelway	8 -120	Dissmeyer, 1976
North Carolina, USA	Travelway	37	Simons et al., 1978
Northeast Oregon, USA	Travelway	0 – 7	Buckhouse & Gaither, 1982
Northwest Washington, USA	Travelway	1 – 1010	Reid & Dunne, 1984
North Carolina, USA	Travelway	0.3 - 52.4	Swift, 1984
Western Washington, USA	Travelway	52	Bilby, 1985
Idaho Batholith, USA	Travelway	23 - 76	Vincent, 1985
New Zealand	Travelway	0 – 113	Fransen et al., 2001
Poland	Travelway	98	Froehlich, 1991
Australia	Travelway	50 – 90	Grayson et al., 1993
Oregon Coast Range, USA	Travelway	1.8 – 37	Luce and Black, 1999
U.S. Virgin Islands	Travelway	0.46 – 74	MacDonald et al., 2001
U.S. Virgin Islands	Travelway	74	Ramos-Scharrón & MacDonald, 2005
Sierra Nevada CA, USA	Travelway	0.002 - 40	Coe, 2006

MacDonald, L. H., & Coe, D. B. (2008). Road sediment production and delivery: processes and management. In Proceedings of the First World Landslide Forum, International Programme on Landslides and International Strategy for Disaster Reduction.

Section 1.5.6 Results by Data Element>>**Roads and Upland Erosion** (con't)

ROAD ID	SITE NUM	10 UTME	10 UTMN	DESCRIPTION
301	159	724765	4373798	Mass instability potential. This is the road section above the '97 slide. Scarp face of past movement evident on road cut bank. Wet with nemerous seeps. Stream cutting at toe of slope. Sediment delivery put at 1000 yd3 but is probably many times that value.
301	172	727298	4374182	This is the site identified in the Perazzo Allotment EA as the "Terrace" stream intercepted by the road ditch and discharged across the 301 Road into an artificially eroded channel
301	177	728826	4374350	Low bridge on 301 road across Cold Stream. Crosses alluvial fan of Cold Stream and constricts flow. Frequent overtopping and end-running of bridge is common
07-30C.2	240	722113	4368292	Road intercepts abundant runoff from logged slope above. Some gullying on hillsde above road is evident. Rolling dips are conveying flow across road prism but some outlet erosion is initiating.

Identification of road sites with high erosion/sedimentation potential

Section 1.5.6 Results by Data Element>>**Roads and Upland Erosion** (con't)

Identification of non-road sites with high erosion/sedimentation potential

Section 1.5.7 Results by Data Element>>**Conditions in Headwater Tributaries**

Sample format of this section. Uses narrative description of channel reaches, photos, videos, and UTM coordinates. Electronic collection of photos and videos is available in Appendix D.

Section 1.5.7 also contains a bullet list summary of the 2009 Cold Stream Assessment. The entire Cold Stream Assessment report is available in Appendix D in PDF format.

724536 4369687 A significant rock outcrop forms a potential fish barrier at this site. While perhaps not a total barrier to upstream migration, it is a deterrent and could be made into a barrier should that become desirable from the standpoint of LCT reintroduction. Photo taken at UTMe 724173, UTMn 4369493. Video segment of reach available with the accompanying photo and video collection in Appendix D.

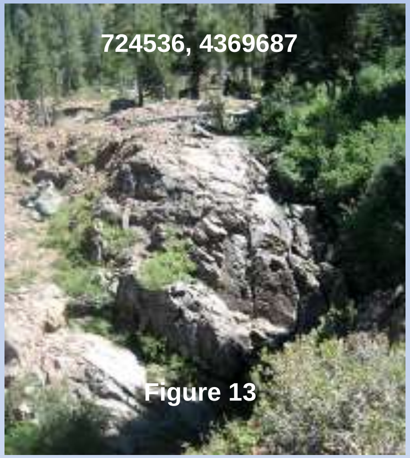


Figure 13

Figure 14

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724107 4369427 The rock outcrop that functions as a potential fish barrier also functions as a geologic control for stream reaches above. Gradient flattens to ~1% (or less). Small basins in underlying bedrock are filled with gravelly alluvium and the small channel meanders through these sediments. Riffles, gravel bars, log-formed pools common. Alders and willows completely occupy the gravelly floodplain. Maximum pool depths of 1.5' to 3.5' were measured. All life stages of brook trout (including YOY) were present but not excessively numerous (3-4 adults per pool). Reach length 0.67 miles.
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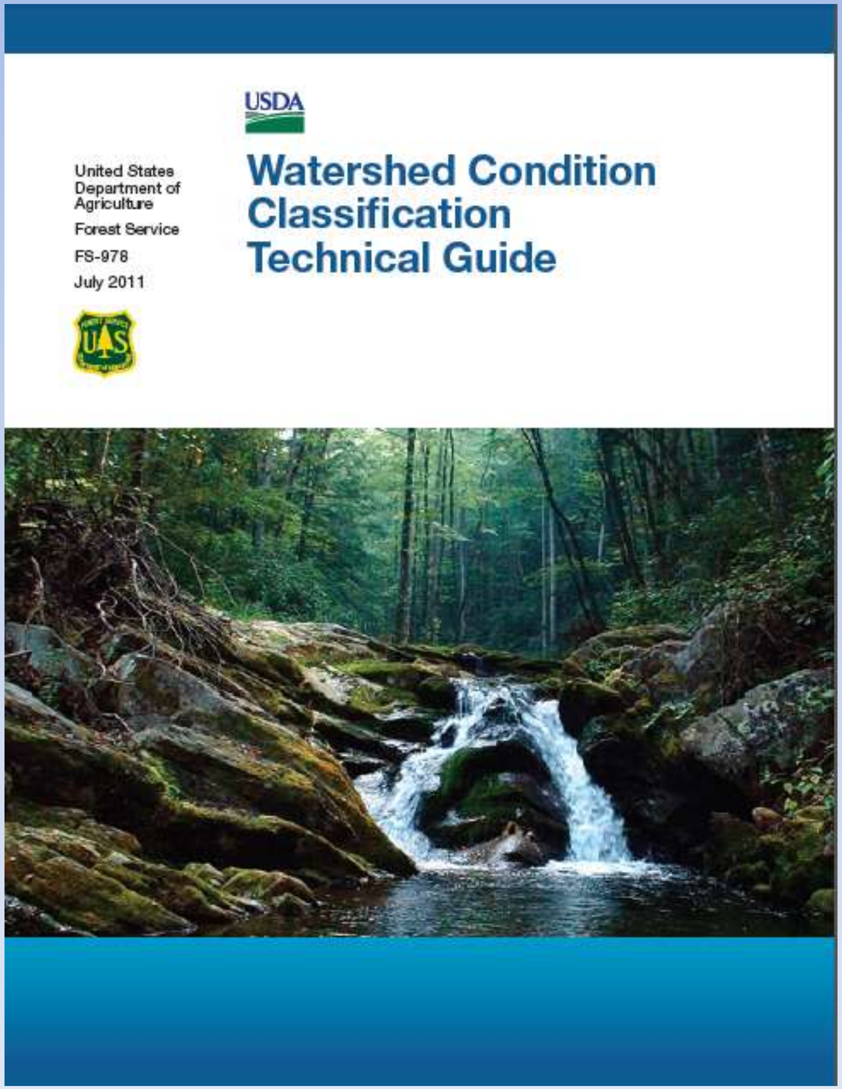
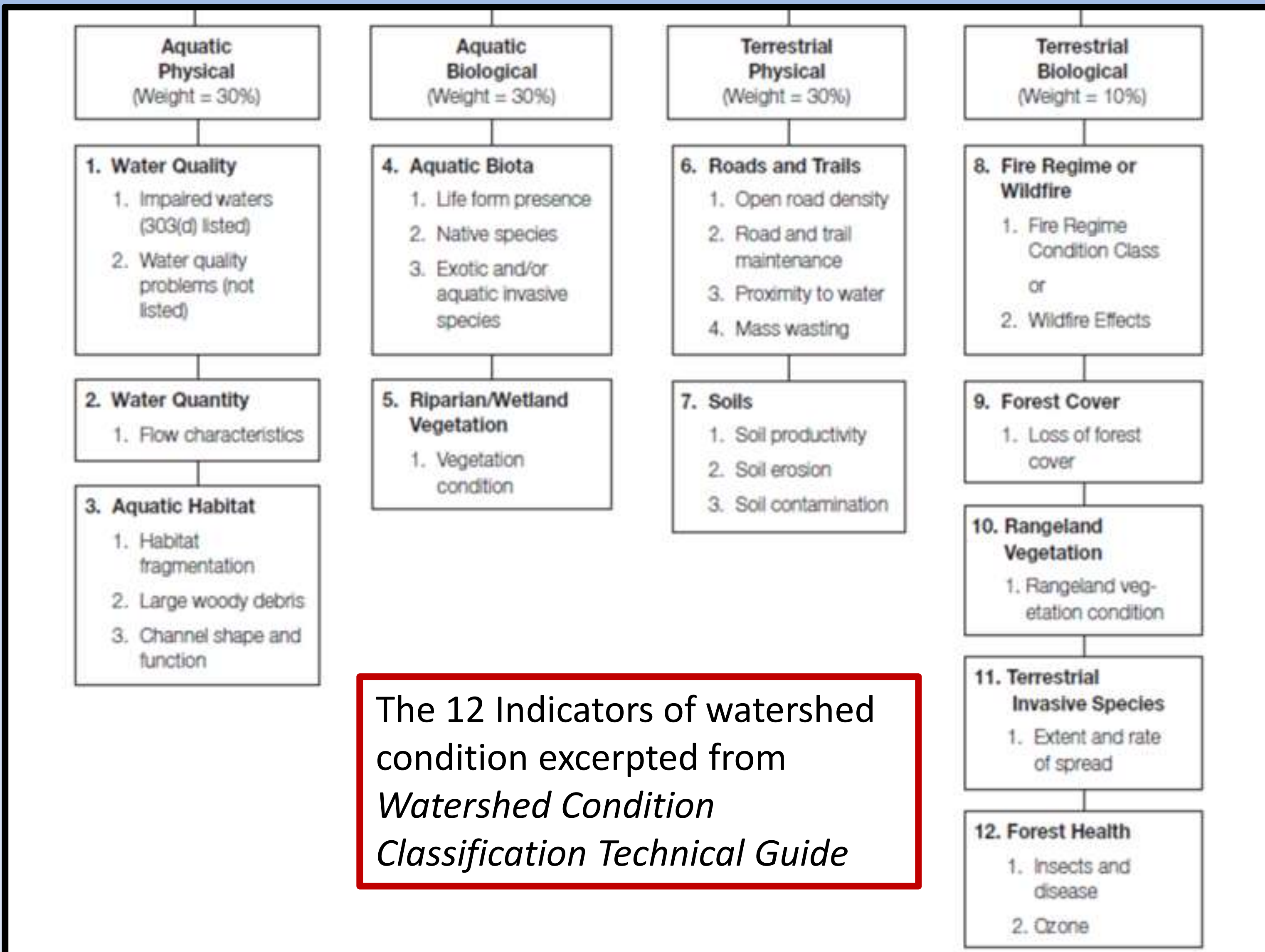
Section 1.6 Conclusions

This section borrows from the ***USFS Watershed Condition Classification Technical Guide (USDA Forest Service, 2011)*** as a tool to help integrate the preceding information into an overall assessment of watershed integrity.



Section 1.6 Conclusions >>**Summary of watershed condition indicators**



The 12 Indicators of watershed condition excerpted from *Watershed Condition Classification Technical Guide*

Section 1.6 Conclusions >>**Summary of watershed condition indicators**

1. Of the factors contributing to the extirpation of LCT listed in the Recovery Plan (USFWS, 1995), three appear to be most relevant in the study area. Those are:

   --historic over-harvesting of the resource
   --alteration of channel morphology (habitat degradation)
   --introduction of non-native fish

   The first factor is moot at present. The latter two factors are still relevant.

   Channel morphological response to historic disturbance is best summarized as downcutting and entrenchment in the Upper meadow and channel widening and bank erosion in the Middle and Lower Meadows (Swanson H+G, 2008). Clearly, salmonid use of the lower meadow reaches is limited. Wide and shallow channels lacking complexity and large wood recruitment offer less than optimal salmonid habitat. These morphological factors have opened the channel to solar heating that produces sub-optimal thermal conditions, mostly in years with below average precipitation.

Section 1.6 Conclusions >>**Summary of watershed condition indicators**

2. If successful in the long-term, the PnP restoration treatments could positively affect these conditions by eradicating the wide and shallow morphology and increasing vegetative shade. Qualitative observations suggest that channel networks between ponds are evolving (bed scour) and are expected to provide increased riffle habitat in coming years. Fish survey data suggests that ponds created by the project are supporting the growth of larger size classes of brook trout. It is reasonable to speculate that they might perform a similar function for LCT should other obstacles to reintroduction be overcome.

3. Channel morphology in headwater reaches is unmodified and fish habitat is limited primarily by the quantity of late season flows. They appear capable of supporting large numbers of salmonids but lack habitat elements necessary to produce large size classes of fish.

Section 1.6 >>**Conditions in Headwater Tributaries**

4. The abundance of brook trout remains as the single greatest challenge to the reintroduction of LCT. A fair amount of uncertainty remains about the ecological mechanisms by which brook trout-LCT interactions limit the success of LCT introductions (Dunham et al., 2002). Eradication of brook trout in the study watershed would be a challenging task with short-term adverse effects to native fish, amphibians, and invertebrates. Several miles of headwater tributaries would need treatment as would the newly diverse restored sections of the meadow reaches.

5. In the short-term, assuming successful control of brook trout, LCT might be expected to be most successful in the larger headwater tributaries. Over the longer-term, restoration and proper management of the lower meadow reaches could increase salmonid use of these reaches. More time and experience is needed to evaluate these admittedly speculative observations.

Section 1.7 Recommendations

- Continue monitoring stream temperature and fish populations through meadow reaches to assess trends post-restoration. Consider adding air temperature monitoring to assess any fundamental change in relationship between air temperature and stream temperature.

- Continue to monitor hydrologic impacts of PnP with special emphasis on impacts to low flow regime and quality and quantity of late summer fish habitat. Do PnP treatments increase the frequency of critical low flows? Do these flows increase temperatures or cause habitat fragmentation?

- Correct known road problems such as the Henness Pass road crossing of Cold Stream.

- Consider managing selected meadow reaches for recovery of the tree layer to riparian vegetation complex. Persistent saturated soil conditions resulting from PnP treatments may limit opportunities to establish riparian tree species that do not do well in persistently saturated soils.

- Consider modification of naturally occurring partial fish barriers in Cold Stream and Perazzo Canyon to prevent upstream migration of non-native salmonids

- Target Perazzo Canyon for monitoring of BMP implementation and effectiveness relative to timber harvest and road maintenance operations.

- Promote and participate in inter-agency collaboration on means and methods for control of brook trout populations specific to the study area.

LIST OF APPENICES

SAMPLE CONTENT OF PHOTO LIBRARY IN APPENDIX D

Example of photo series of Phase 1 PnP sites

Example of photo documentation of headwater channels

WP 269

NEAR END OF "ENTRENCHED ROAD" (SECOND LEFT OFF OF 07-30). WP IS NEAR, NOT ACTUALLY ON THE CHANNEL

2 CFS BOULDER STEP POOL. SAW ~12 ADULTS IN 100M OF CHANNEL. YOY VERY SPARSE.

BOULDER COBBLE SUBSTRATE–VERY LITTLE SPAWNING HABITAT IN THIS REACH. WATER COLD AND CLEAR.

VIDEO CLIPS 7 AND 8 DEPICT THESE CONDITIONS

END