<u>Project number:</u> EMC-2017-003

<u>Project name:</u> Monitoring Class III watercourse runoff in managed forests

Will Olsen[1], Drew Coe[1], Pete Cafferata[1], Joe Wagenbrenner[2]

<u>Introduction:</u>

Headwater streams area an important component of river networks in forested ecosystems, despite their ephemeral nature. Literature has indicated that these streams can account for a significant portion (up to 80%) of a drainage network (Gomi et al., 2002), yet exhibit transient connectivity spatially and temporally (Sidle et al., 2000). Headwater streams may store significant amounts of woody material, sediment, and organic matter for later delivery downstream, while rapidly supplying runoff to downstream river segments, relative to sub-surface flow (Ziemer and Rice, 1990; MacDonald and Coe, 2007).

Under the California Forest Practice Rules (FPR), ephemeral headwater streams are classified as Class III watercourses typically, indicating that aquatic life is not supported but that there is a potential to deliver sediment to a Class I or II watercourse [CA FPR 916.4(936.4, 956.4) (c)]. Table 1 summarizes watercourse monitoring in non-federal harvested areas within California from 1992-2013. Monitoring has indicated that Class III watercourses can have a high occurrence of sediment delivery, anthropogenic disturbance, and crossings. Past research in the north coast region of California found that extensive harvesting can increase runoff to channels (Lewis et al., 2001), and result in elevated gully occurrence and erosion rates (Reid et al., 2010). Buffleben (2009) found upward headwater channel migration following timber harvesting in watersheds with erodible terrain, increasing the stream density and sediment delivery to downstream fish-bearing watercourses.

Table 1: *Summary of results related to Class III watercourses and timber harvests in California*

Study	Result	Source
Hillslope Monitoring Program (1996-2001)	- 70% of rills and 49% of gullies associated with roads delivered to Class III watercourses - 83% of sediment delivering rills from skid trails went to Class III watercourses	Cafferata and Munn, 2002
Green Diamond Resource Company AHCP (1992-1998)	- Less than 25% of Class III watercourses surveyed across harvested areas had reaches with exposed active channel	Green Diamond Resource Company, 2006
Modified Completion Report Monitoring Program (2001-2004)	- 59% of watercourse crossings occurred on Class III watercourses	Brandow et al., 2006
PALCO Class III Study	- Geologic substrate and management were not significant predictors of sediment yield in Class III watercourses; only water year was a significant predictor; legacy effects may be important	O'Connor et al. 2007

[1] California Department of Forestry and Fire Protection
[2] US Forest Service Pacific Southwest Research Station

Battle Creek (2011)	- Harvested areas: 56% of sediment delivery occurred on Class III watercourses	Battle Creek Task Force, 2011
FORPRIEM (2008-2014)	- Timber harvest plans: 48% of watercourse crossings on Class III watercourses - Non-industrial timber management plans: 56% of watercourse crossings on Class III watercourses	Brandow and Cafferata, 2014

Very little is known about the frequency or spatial extent of surface runoff flow in Class III watercourses throughout the water year. Day (1978) found that ephemeral headwater streams typically exhibit longitudinal growth and contraction in both downstream and upstream directions within a channel segment during rainfall. Ziemer and Rice (1990) found in the North Fork of Caspar Creek that peak streamflow lagged in a downstream direction, while the streamflow from pipeflow and subsurface flow was shown to lag considerably more. In southwestern Washington, surface flow was found to be spatially intermittent for channel gradients below 30% slope, while channels with gradients 30% or greater displayed both increased intermittency in addition to upstream retreat of surface water towards channel heads (Hunter et al., 2005).

The rapid response of these watercourses to precipitation, snowmelt, and daylighted sub-surface flow requires field observations to occur during active flow, which may be difficult based on storm characteristics and watershed location. Traditional stream gaging methods such as weirs and flumes are not compatible in ephemeral channels, due in part to the small size of the channels and the lower discharge rates. Crest stages with ground cork may be used to record maximum stage height, but do not offer data on the timing and duration of flow. Past research on ephemeral channel flow was done with trade-offs in spatial, temporal, and measurement resolutions (Bhamjee and Lindsay, 2011). One approach, modified electric resistors, has been used successfully to accurately record flow state in ephemeral channels (Blasch et al., 2002, Goulsbra et al., 2009, Bhamjee and Lindsay, 2011).

Need and objectives:

The potential for Class III watercourses to have timber-harvest related sediment delivery, coupled with limited knowledge of the thresholds to initiate and sustain flow in Class III watercourses, represents a knowledge gap for both understanding and managing hydrologic systems in working forests. The ability to determine the effectiveness of Forest Practice Rules in preventing detrimental hydrogeomorphic changes Class III watercourses relies heavily on a basic understanding of how these features function hydrologically in different areas. This project proposal has four objectives:

- Determine the Class III flow regimes in harvested and unharvested watersheds in the northern part of the California Coast Ranges, Inland Coast Ranges, and southern Cascade Range.
- Determine rainfall duration, depth, and intensity thresholds that control flow initiation.
- Assess the flow duration to determine temporal connectivity to the stream network.
- Determine the spatial connectivity of flow within Class III watercourses, and to the downstream hydrologic network.

Monitoring the flow within Class III watercourses throughout the year, over a range of locations and management histories, will help to clarify the degree to which Class III watercourses contribute to the hydrologic network in forests. Further, this project will offer critical insight to the flow regime of Class III watercourses, and the influence of timber harvesting. The study will also provide additional data for model calibration of the Distributed Hydrologic Soil Vegetation Model in the South Fork Caspar Creek.

Effectiveness Monitoring Committee Theme and Linkage to the California Forest Practice Rules:

This proposed Class III watercourse flow study ties to the EMC Theme 2 (Watercourse channel sediment), sub-theme 2.3, and Theme 3 (Road and WLPZ sediment), sub-theme 3.5. The critical questions this study would contribute to answering are:

(a) Are the CA FPRs effective at minimizing management-related sediment delivery for individual plans at the project level to evaluate channel response to forest management prescriptions and additional mitigation measures?
(b) Are the CA FPRs effective for minimizing management-related generation of sediment and delivery to watercourse channels?

This proposal corresponds broadly to 14 § 916, 936, and 956, which ensures that timber operations do not potentially cause significant adverse site-specific and cumulative impacts to the beneficial uses of water, native aquatic and riparian-associated species, and the beneficial functions of riparian zones. Specifically, 14 CCR § 916.4 [936.4, 956.4] (c) states:

The protection and WLPZ widths for Class III and Class IV waters shall prevent the degradation of the downstream beneficial uses of water and shall be determined on a site-specific basis.

The potential for downstream beneficial use impact from upland management activities depends upon the degree of connectivity between lower order watercourses (i.e., Class III) and downstream reaches (MacDonald and Coe, 2007). As such, the need to characterize Class III watercourses in terms of flow frequency and duration is a crucial step to determine whether upland timber operations can significantly impact downstream beneficial uses.

Study area and methods

The project area will instrument Class III watercourses in LaTour Demonstration State Forest (LDSF), Boggs Mountain Demonstration State Forest (BMDSF), and Caspar Creek at Jackson Demonstration State Forest (JDSF). Each study location represents an opportunity to collect data in areas with recent timber management, and in the case of BMDSF, also an environment recovering from extensive severe wildfire. Ten watercourses will be chosen, with varying slopes, channel gradients, and landscape treatments between locations (Table 2).

The South Fork of Caspar Creek at JDSF will involve a winter and spring pre-treatment period of data collection, before harvesting occurs around the Class III watercourses. For the unharvested treatments in JDSF, instruments will be installed within the Class III watercourses upstream of the current Class II temperature monitoring (EMC-2015-001).

Monitoring at BMDSF will be in Class III watercourses that were recently salvage logged following the 2015 Valley Fire. The results from BMDSF will compliment current monitoring of runoff from unharvested ephemeral channels burned at low, moderate, and high severity.

Monitoring in LDSF will occur in a recently harvested (within five years) area, while the two watercourses in unharvested areas will be monitored upstream of current Class II temperature monitoring (EMC-2015-001).

Table 2: Project study areas, proposed instrumentation approach, and watercourse treatments

Study area	Instrumented watercourse area treatment
LaTour Demonstration State Forest	- Two watercourses in recently unharvested (over 10 years) areas - One watercourse in a recently harvested (within five years) area
Boggs Mountain Demonstration State Forest	- Two watercourses within high soil burn severity areas that have been recently harvested (since recent wildfire in fall 2015)
Jackson Demonstration State Forest/Caspar Creek	- Two watercourses in a recently unharvested (over 10 years) area in South Fork Caspar Creek - Two watercourses in a recently harvested (within one year) area in South Fork Caspar Creek - One watercourse in recently unharvested (over 10 years) area in North Fork Caspar Creek

The Class III watercourses will be instrumented at four to ten locations within each channel, depending on channel length. After channels have been identified at each study area, a final determination will be made for instrument spacing. Instruments will be placed in such a way that watercourses will have instruments set at roughly the same distance apart (see example shown in Figure 1).

Instrumentation will be a modification of the approach used by Blasch et al. (2002) and Goulsbra et al. (2009). Temperature loggers will have thermistors removed, converting each sensor to an electrical resistance (ER) sensor. The theory behind this approach is the ER sensor circuit is completed by the presence of water, which in turn would indicate flow, giving data on a flow/no flow state. Each ER sensor will be placed in plastic PVC tube with holes drilled to allow for water passage, and connected by steel cable to a two-foot rebar piece to keep the ER sensor in place. A similar design is currently being used for temperature monitoring of Class II streams in California (EMC-2015-001) (see Figure 2).

At the downstream tributary junction or mapped Class III to Class II transition of each Class III watercourse, an 18” eTape liquid level sensor (Milone Technologies) will be installed to record stage height at 5 minute intervals. Each channel will also have a tipping bucket rain gage coupled with a HOBO Pendant event and temperature data logger in order to determine rainfall characteristics, including when snowfall may be occurring. This instrumentation approach will allow for detailed spatial and temporal data on when and where surface flow occurs throughout each Class III watercourse, while the stage height data will allow comparison of responses among Class III’s.

For each Class III watercourse, the stream will be walked with a sub-meter GPS unit to determine the channel length. Additionally, digital elevation models (DEMs) will be used to calculate topographic characteristics for each channel, including gradient, catchment topographic index, planform and profile curvature, and mean slope.

Canopy cover measurements will be taken at each instrument using hemispherical photography (Roxburgh and Kelly, 1995), and repeated for the fall, winter, spring, and summer seasons. Additionally, at each instrument, photo points will be taken concurrently with the hemispherical photos, both to record general conditions, and also to create digital surfaces of the channel using structure-from-motion techniques, in order to show any channel morphology changes over time. This additional data will illuminate possible controls from canopy cover, and capture any downcutting or sediment deposition in the channel.

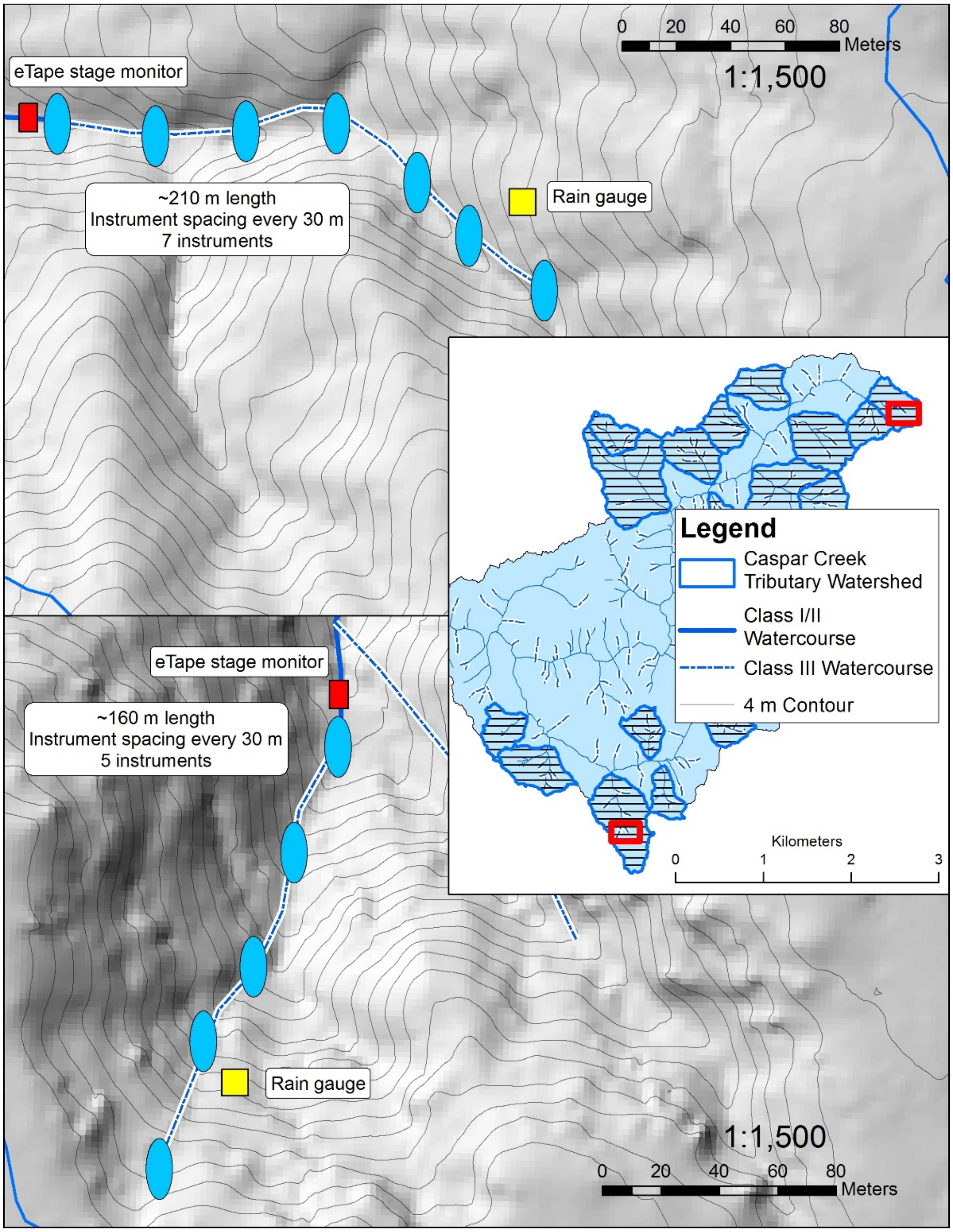

Figure 1: Example of proposed approach to instrumenting Class III watercourses, shown here in the Caspar Creek watershed, Jackson Demonstration State Forest.

Figure 2: Instrumentation placement example, to be adopted from current Class II temperature study in California

Timeline, deliverables, budget

Timeline

- Fall 2017: Identify in each study area Class III watercourses to instrument, install instruments
- Winter 2017 – Spring 2018: Data collection
- Summer 2018: Processing of data and report of initial findings
- Summer – Fall 2018: Install instruments within recently harvested Class III watercourses in the South Fork of Caspar Creek (timing dependent upon logging)
- Fall 2018 – Spring 2019: Year two of data collection
- Summer 2018: Processing of data and report of preliminary findings

- Fall 2019 – Spring 2020: Year three of data collection
- Summer 2020: Processing of data, final report of all findings

Deliverables:

Formal technical report (CA Forestry Note or Report) with rainfall thresholds and flow regimes for each study area and treatment, including empirical models to determine expected runoff responses from Class III's, for use by land managers and other researchers. Possible journal article/peer reviewed paper.

Budget:

$11,000 - 80 Onset TidbiT Water Temperature Data Loggers

$1,100 – 10 Onset HOBO Pendant Event Data Loggers

$80 – Onset HOBO Pro Software

$130 – Onset USB Base Station

$800 – 10 RainWise Tipping Bucket Rain Gauges

$550 – Rebar and caps for ER sensor installation

$120 – Steel cable and wire clips (connect ER sensor to rebar)

$700 – PVC pipe and end caps (for ER sensors, rain gauge mounts, eTape housing)

$3200 – 10 HOBO U12 data loggers, wiring, and housing

$750 – 10 18" eTape liquid level sensors

$500 – Miscellaneous expenses

$18,930 in funds requested in total

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