Central

Coast

Watershed

Studies

CCoWS

Hollister Hills SVRA Sediment Budget: Water Year 2012- 2013

FALL 2013

Douglas Smith, PhD
Andrea Goodmansen
John Silveus

Publication No. WI-2014-01

15 January 2014

The Watershed Institute

Division of Science and Environmental Policy

California State University Monterey Bay

http://watershed.csumb.edu

100 Campus Center, Seaside, CA, 93955

Acknowledgements

Thanks to:

- Wes Gray, Matthew Allen, Hollister Hills SVRA Park Staff
- Hydrology and Geomorphology students of Cal State Monterey Bay

Smith D., Goodmansen, A., Silveus, J. 2014. Hollister Hills SVRA Sediment Budget: Water year 2012-2013. The Watershed Institute, California State Monterey Bay, Publication No. WI-2014-01, 17 pp.

Executive Summary

California State Parks operates eight State Vehicular Recreation Areas (SVRA) where off-road driving is encouraged and managed. A core value of the Hollister Hills SVRA (HHSVRA) mission is conservation leading to sustainable off-road vehicle use. To further their proactive conservation program, resource managers from the Hollister Hills SVRA have initiated a partnership with Faculty and students from the Cal State Monterey Bay Division of Science and Environmental Policy to calculate and interpret the sediment yield from the park watersheds. The information will be used to inform future best management practices and restoration measures in the park.

The Radio Ridge rain gage in HHSVRA captured 248 mm (9.78 in) of rain in water year (WY) 2013 (October 1, 2012 to September 30, 2013), which is well below the 419 mm (16.50 in) average. This low rainfall total is in keeping with statewide conditions for the year. Sixty percent of the annual rainfall was concentrated in two periods in December 2012. During those two periods, cumulative rain over several days produced the only storm runoff events of the year.

A vented pressure gage located on Bird Creek near the park entrance recorded water pressure and stage. The gage was calibrated to discharge by measurements made over a wide range of flow conditions. The two precipitation events in December produced two minor runoff events, with the annual peak flow reaching approximately 0.15 m (0.5 ft) in depth while flowing at a rate of approximately 0.044 m^3/s (1.5 cfs). The rainfall produced approximately 2500 m^3 (2 acre-ft) of water at the Ranger Bridge gage. There was virtually no suspended or bedload sediment transport at the Nature Area, Ranger Bridge or Hudner Ranch gages. The Bird Creek channel remained mainly dry in WY 2013, except for a few short spring-fed reaches.

In past reports "water year" names were incorrect (Nicol et al., 2011; 2013). For example, in those reports the measurements made in the 2010-2011 water year were reported as having occurred in WY 2010, instead of the correct name, WY 2011. This error is corrected in this report, and the format will be adopted in future reports.

Hydrologic parameters of streamflow and sediment transport are highly variable through time. It is common to revise estimates of streamflow and sediment yield as more information becomes available. We present preliminary results in this report. These values may be revised in future reports.

Table of Contents

1 Introduction

1.1 Background

Hollister Hills State Vehicular Recreation Area (HHSVRA) contracted the Watershed Geology Lab at California State University Monterey Bay (CSUMB) to monitor sediment discharge in Bird Creek. CSUMB will conduct a five-year watershed assessment of HHSVRA that will help the resource managers of the park understand and manage the erosion impacts of off-highway vehicles (OHVs). This report presents the results of Water Year 2013, from October 1, 2012 to September 30, 2013 (WY 2013).

1.2 Study Area

The study area for this project is the Bird Creek watershed (Figure 1). Bird Creek drains an eastern slope of the Gabilan Mountain range down to the San Benito River. The Bird Creek watershed is located east of the Monterey-San Benito county line, approximately 20 km northeast of Salinas. Bird Creek watershed is 39.1 km^2, and 16.5 km^2 are within the boundary of HHSVRA. The ridge defining the upper watershed has an elevation of approximately 750 m and the watershed drains down to 115 m, where there is a confluence with the San Benito River. A portion of HHSVRA also drains into Cienega Creek, which is the neighboring drainage to the north of Bird Creek. Cienega Creek was not assessed in this study.

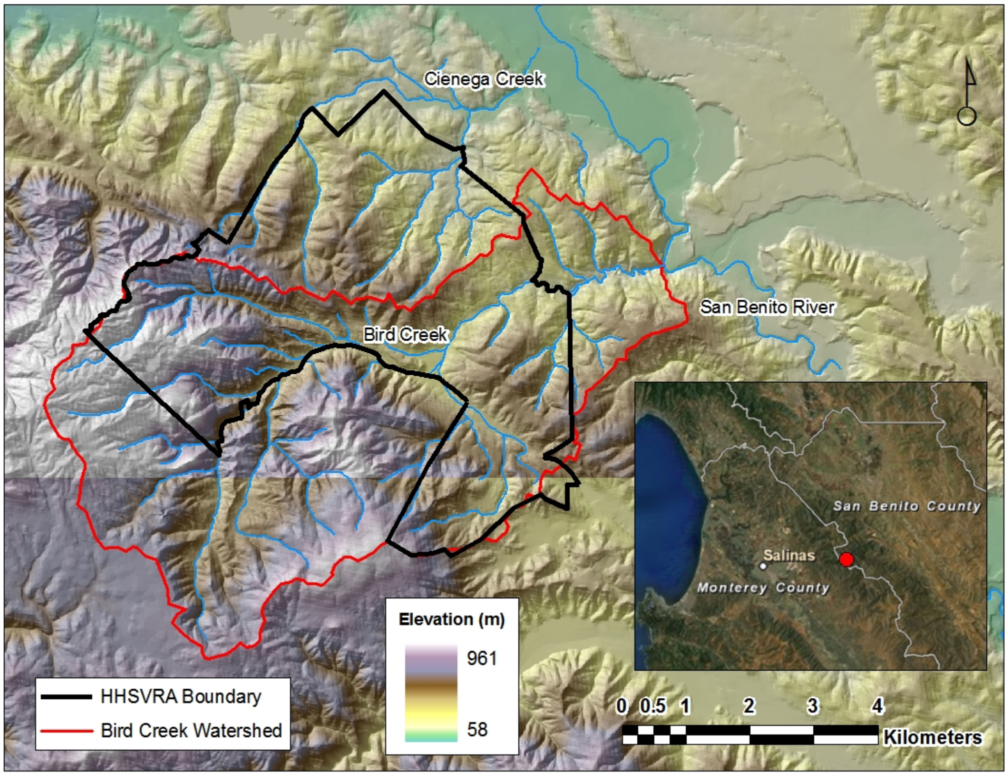

Figure 1. Location map for Hollister Hills State Vehicular Recreation Area and the Bird Creek watershed.

1.2.1 Geologic Setting

The geology of the study area may play a significant role in the sediment budget of Bird Creek. The San Andreas Fault, which forms the boundary between the Pacific and North American tectonic plates, runs through the center of the park (Figure 2). The Bird Creek channel and northern watershed divide are offset over 1000 m by the right-lateral motion of the San Andreas Fault. The presence of the fault creates two distinctly different geologic settings within the Bird Creek watershed and HHSVRA. There is great variability in the soil units on either side of the fault (Figure 2), as well as a widely used erodibility factor (*K*) (Figure 3). In practical terms, *K* is a parameter defined as the average annual erosion potential of a given soil through hydrological processes (i.e. rain drop splash, overland flow, etc.; Romkins et al. 1998). Soils high in clay or sand content usually have low *K* values (0.05-0.15), while soils with moderate silt content such as silt-loams and high silt content have moderate to high *K* values (0.2-0.4 and >0.4, respectively; IWR 2002).

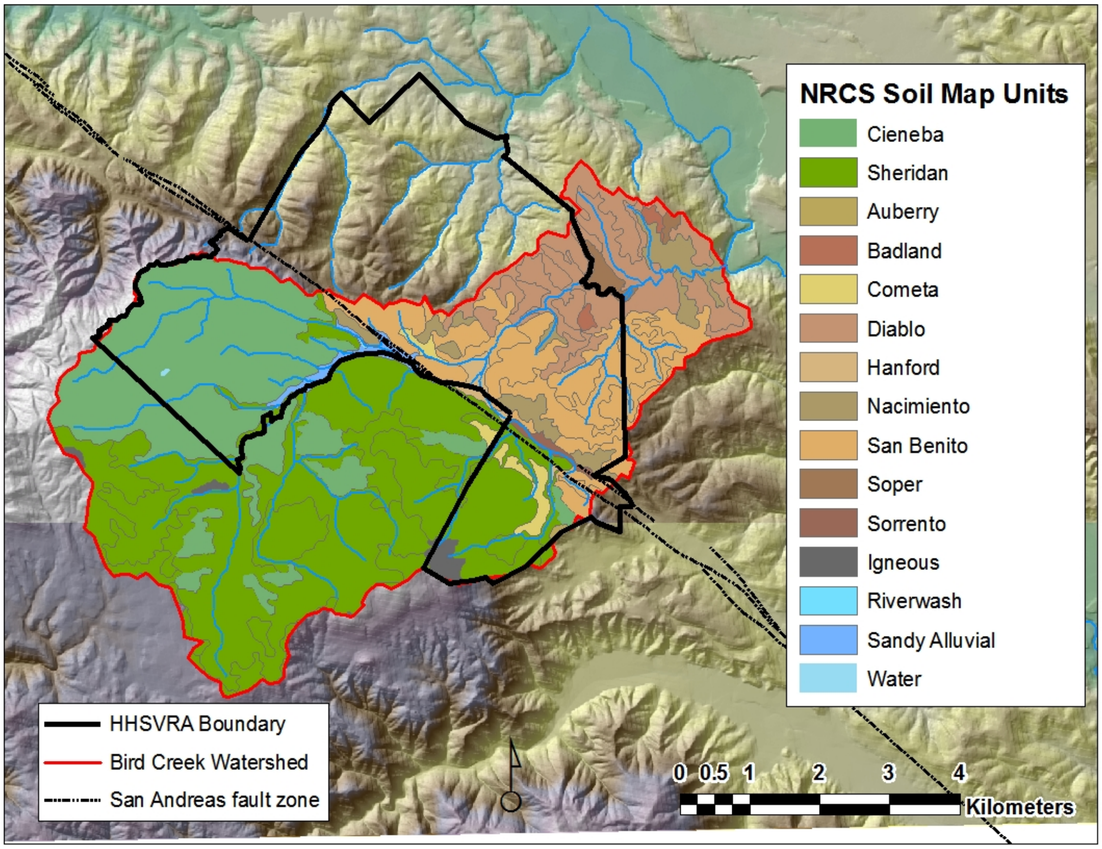

Figure 1. Soil map of the Bird Creek watershed. Note the change in soil type across the San Andreas Fault.

Southwest of the San Andreas Fault, the bedrock comprises dolomitic marble and Mesozoic granitic rocks (Harden et al. 2001). The marble from this area has been quarried for use in road construction, with at least one marble quarry still in operation. This area, the upper half of Bird Creek watershed, is dominated by two soil units: the Cieneba and Sheridan units (NRCS 2011; Figure 2). When examining soil stability in terms of *K*, the area southwest of the San Andres Fault (the upper watershed) has a midrange value of 0.17 (NRCS 2011). The relatively hard bedrock in this area weathers into coarse and highly permeable soiland is susceptible to gullying, but is less prone to large landslide events (Harden et al. 2001).

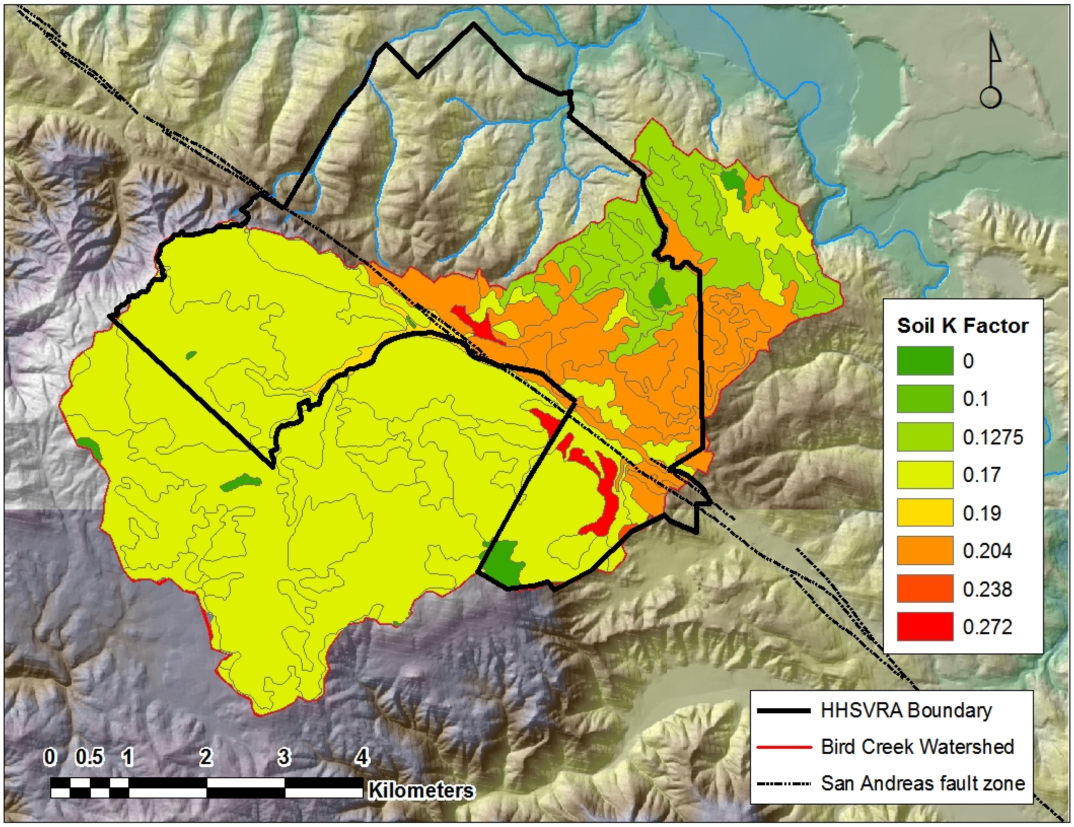

Figure 2. Soil erodibility factor (*K*) map. Nearly all of upper Bird Creek has a *K* factor of 0.17, while the soils in lower Bird Creek generally range from 0.1275 to 0.204.

Northeast of the San Andreas Fault the landscape (lower watershed) is chiefly underlain by Pliocene sandstone and mudstone (Harden et al. 2001). Marine invertebrate fossils are locally present in some of the sandstone outcrops in this area. The lower watershed has more soil variability than the upper watershed, and is composed of eight different types of soil (NRCS 2011). In terms of *K*, the lower watershed comprises moderately to highly erodible soils. Soils in this area typically have much finer grain size, and are often impermeable. These soils are less susceptible to gully formation, but soils in this area are more susceptible to slumps and earthflows (Harden et al. 2001).

1.2.2 Hydrologic Setting

The hydrologic setting for Bird Creek is a Mediterranean climate in which most of the precipitation falls between October and April. The average annual precipitation for Bird Creek is 419 mm (16.5 in), ranging from 397 mm (15.6 in) in the lower watershed to 491 mm (19.3 in) at the ridge tops (Prism 2004). The rainfall in Central California is characterized by rare, high-magnitude rain events (such as El Niño winters), which can have dramatic and lasting impacts on landscapes and infrastructure.

Small streams in Central California often have a "flashy" hydrograph, in which short term large flow events account for a large portion of annual stream discharge. Most stormflows can be expected to last less than 24 hours, although multiple rain events within a short period of time may lead to longer lasting (and relatively higher) flows. Similarly, rain events late in the season will generate larger runoff events, as a wet antecedent moisture condition will not allow soils to absorb as much of the rainfall. Hot and dry summers typically lead to ephemeral streamflow in the regional waterways, including Bird Creek. Ephemeral streams typically have a period of baseflow between late spring and the start of the next rainy season. Baseflow is the condition when all streamflow originates from gradually declining groundwater reserves, which were recharged during the rainy season. This behavior is present in Bird Creek except in two short reaches that have nearly perennial flow because of locally active springs.

Bird Creek has several tributaries on both HHSVRA land and neighboring private land (Figure 4). Bird Creek exists in a managed landscape which has led to alterations in the natural hydrology of the area. Many of the tributaries on HHSVRA property have sediment basins which store and moderate the release of stormwater, perhaps reducing the "flashiness" of the hydrograph (Figure 4).

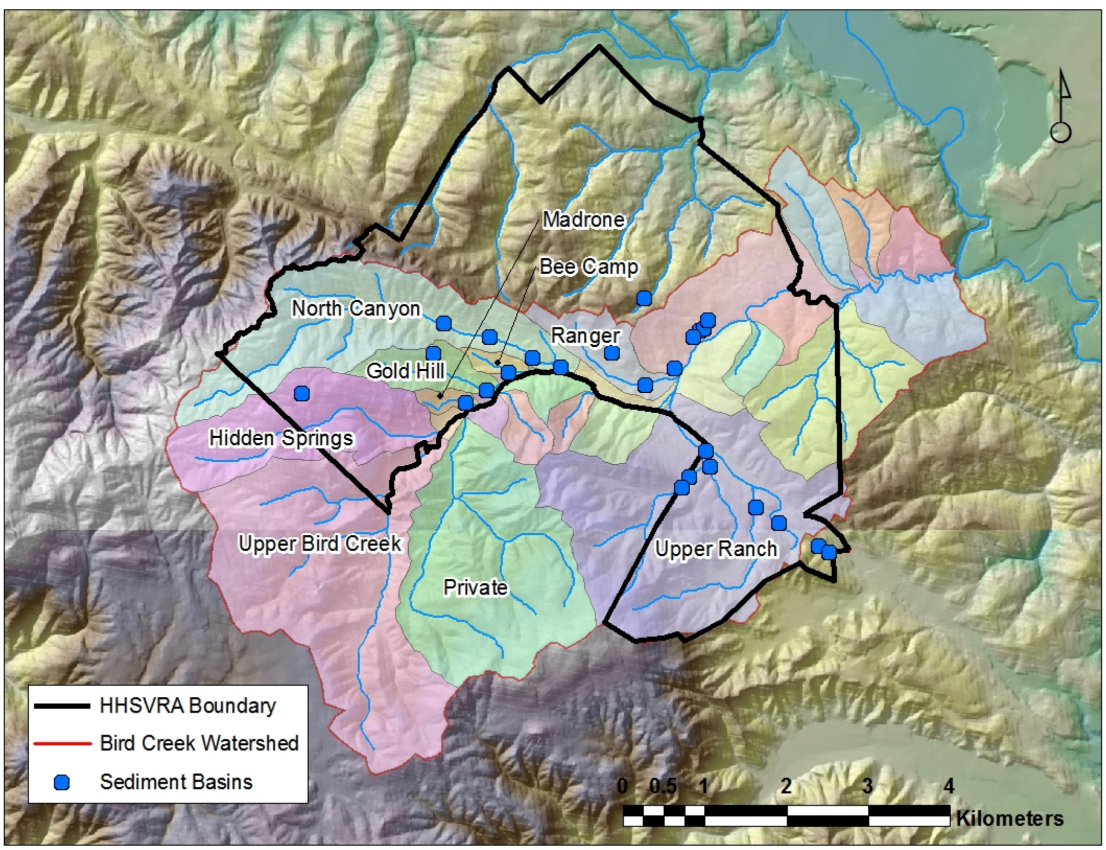

Figure 3. Area map showing sub-watersheds within the Bird Creek watershed and HHSVRA sediment basins.

1.3 Goals

The five year duration of this project allows us to split the project goals into an overall goal and annual goals for each of the current years of the project.

Overall Goal: Quantify the total volume of sediment entering Bird Creek from HHSVRA property, qualitatively document the sediment sources, and suggest strategies to reduce sediment input.

Goals for WY 2011:

1. Create long-term gage sites on Bird Creek.
2. Install and calibrate all monitoring equipment.
3. Quantify sediment discharge in Bird Creek above the Park and near where Bird Creek exits the Park.
4. Survey initial stream cross sections and longitudinal profiles, and set bank pins for bank erosion measurements.
5. Collect baseline terrestrial LiDAR at a few key erosion and landslide sites.

Goals for WY 2012:

1. Install all monitoring equipment once baseflow returns to Bird Creek.
2. Quantify suspended sediment discharge in Bird Creek above the Park and near where Bird Creek exits the Park.
3. Re-survey stream cross sections and longitudinal profiles, and reset bank pins
4. Collect the second year terrestrial LiDAR at the same locations as in 2010.
5. Begin strategic sampling of suspended sediment at specific sites to determine if specific tributaries are disproportionately adding sediment to Bird Creek.

Goals for WY 2013:

1. Install all monitoring equipment once baseflow returns to Bird Creek.
2. Quantify suspended sediment discharge in Bird Creek above the Park and near where Bird Creek exits the Park.
3. Re-survey stream cross sections and longitudinal profiles, and reset bank pins
4. Collect the terrestrial LiDAR at the same locations as in 2010, 2011 and 2012.
5. Continue strategic sampling of suspended sediment at specific sites to determine if specific tributaries are disproportionately adding sediment to Bird Creek.

2 Methods

Sediment monitoring in Bird Creek can be broken down into two categories: continuous gaging and event based sampling. Continuous gaging yields surrogate parameters (water depth, turbidity) which are later converted into useful sediment discharge parameters (water discharge, suspended sediment discharge, bedload discharge). The continuous parameters are converted using event-based spot samples and a rating curve, which is a mathematical relationship between the continuous data and the event based data. Suspended sediment was rated with water discharge, which assumes a positive correlation between water discharge and sediment discharge. Additionally, suspended sediment was rated with turbidity, which assumes suspended particles that refract light are positively correlated to suspended sediment (Minella et al. 2008; Wass et al. 1997). Bedload sediment transport was measured in addition to suspended sediment in the WY 2011. In that year bedload was found to be a insignificant fraction of the total sediment load (Nicol et al. 2011), so bedload monitoring has been discontinued until conditions indicate that bedload transport markedly increases. Visual inspection of the bed during the peak flows of the current water year confirmed the lack of significant bedload transport during WY 2013. Future work will continue to focus on suspended sediment transport and sources.

2.1 Continuous Gaging

In years with typical rainfall, telemetered YSI multi-parameter water quality sondes are deployed at the Nature Area (upstream of HHSVRA) and at the Hudner Ranch (at the downstream edge of HHSVRA) (Figure 5). These sondes record pressure, pH, temperature, dissolved oxygen, and turbidity at 15 minute intervals. In WY 2013, the reach of Bird Creek at the Nature Area only briefly achieved continuous winter base flow conditions, so a sonde was not deployed there. Two very low magnitude runoff events occurred in late December, but the rain did not create sustained baseflow, so the Hudner Ranch sonde was not deployed until later in the year. The Hudner Ranch sonde was deployed from February 21, 2013 to May 30, 2013, once continuous winter base flow was established at the site. The late 2012 flow events missed by the Hudner Ranch sonde were captured by the Ranger Bridge gage located upstream of a small bridge near the ranger housing at park headquarters (Figure 5). The Ranger Bridge gage is a vented Level Troll pressure transducer that records stage and temperature at 15 minute intervals. Except for short periods of maintenance, the Ranger Bridge gage has been in continuous operation since it was installed in 2010.

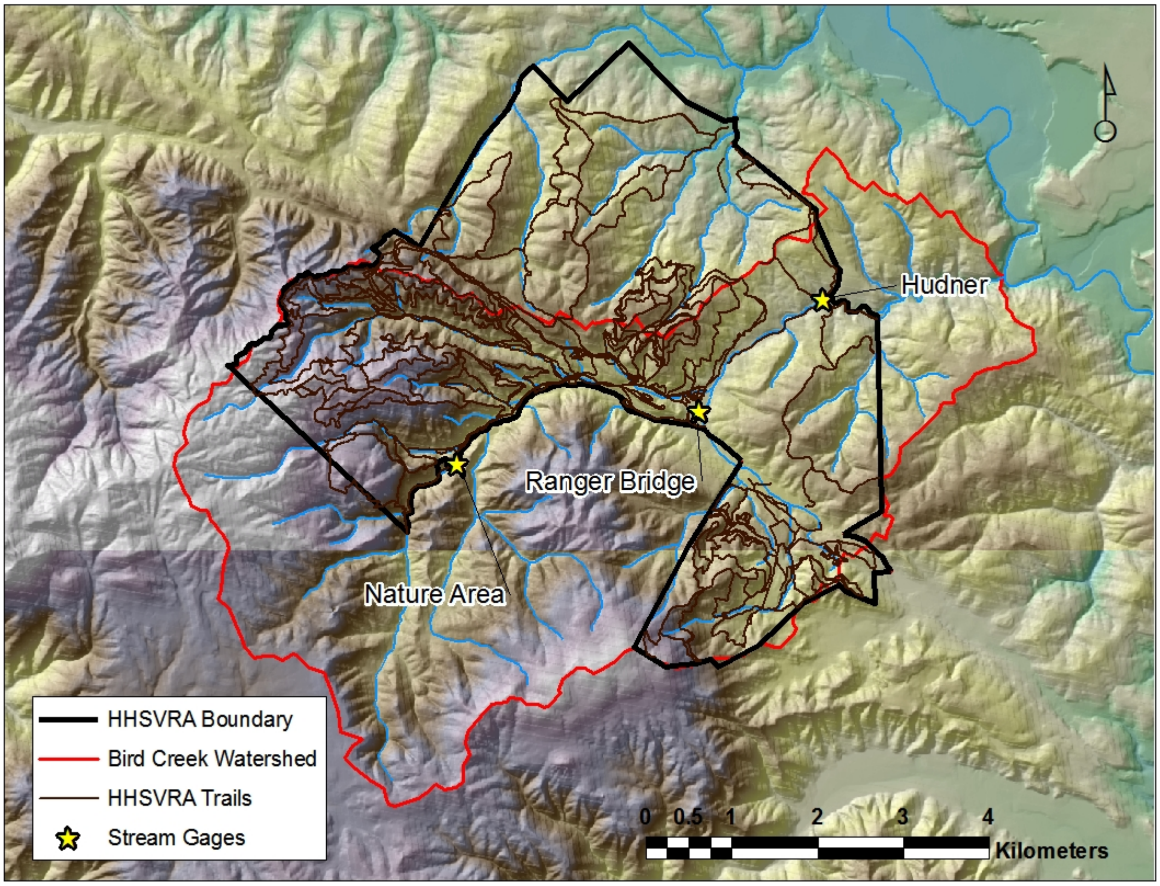

Figure 4. Map of the locations of the Nature Area, Ranger Bridge and Hudner gages. Note the Nature Area gage is upstream of nearly all OHV impact, and Hudner is downstream of nearly all OHV impact.

An above-and-below impact sampling design is used to quantify the amount of sediment that entering Bird Creek from HHSVRA. In WY 2013, the "above impact" sediment input was ungaged, but negligible, because Bird Creek channel at the upstream site (Nature Area) never achieved continuous winter base flow. The "below impact" sampling site is located near the eastern park boundary at the Hudner Ranch special use area. This site was selected due to accessibility, and because it is located below all frequently used OHV trails. The Ranger Bridge pressure transducer was installed at the ranger housing where the geology changes from granitic rocks to sedimentary rocks. The site is a hydraulically stable because there is a concrete box culvert located just downstream.

2.2 Event-based Sampling

Sediment discharge in a fluvial system often only happens during storm events, so the sampling design for this project is focused on flood events. Water discharge and suspended sediment are measured over a wide range of flows to create robust rating curves. Curves are produced or modified during each year of operation, when storm runoff occurs.

Water discharge was measured using a Flowtracker Acoustic Doppler meter when water was deep enough, and a three-inch Parshall flume was used at low flow conditions. Discharge was measured near the stream gage at all sites in order to minimize the variance between the water discharge recorded at the gage and the discharge at the location of the discharge measurements. Discharge at each site was calculated using a modified version of the U.S. Geological Survey (USGS) guidelines as described by (Nolan and Shields 2000), The only significant modification to the USGS guidelines was when we sampled discharge measurements at fewer verticals across the stream due to the small cross-sectional width of Bird Creek.

Suspended sediment samples were collected using a DH-48 depth integrated suspended load sampler. Suspended sediment samples were collected at even spacing across the stream channel in order to integrate spatial variation of sediment discharge within the cross section. Suspended sediment samples were processed in the CSUMB lab to yield a suspended sediment concentration (SSC) (mass/volume). Suspended sediment concentrations were multiplied by instantaneous water discharge (volume/time) to calculate suspended sediment discharge (mass/time). The turbidity of each sample was measured with a Lamotte 2020 turbidity meter.

The sediment and turbidity values were used to rate the gages so that annual yield of suspended sediment mass could be calculated from the continuous gage records of stage and turbidity.

2.3 Sediment Source Analysis

It was our intent to continue monitoring suspended sediment samples at a variety of locations along Bird Creek to determine if specific tributaries, campgrounds, or parking lots were adding a disproportionate amount of suspended sediment to the creek. Given the lack of runoff events, we were only able to sample at very low discharge that occurred during unsustained baseflow conditions.

2.4 Stream Surveys

Several benchmarked stream cross sections established in 2010 were resurveyed in the current year, and several more were added. The new cross sections are focused on capturing landslide impacts to and un-named creek located along the downstream boundary of the park. We call the creek "Hudner Creek" in our field notes. Bank pins installed in 2010 were measured and reset. New bank pin monitoring sites were established in several reaches of Bird Creek west of the San Andreas Fault. Lastly, a few locations were resurveyed with mobile terrestrial LiDAR. The results of these surveys will be presented in a future report.

3 Results

The watershed data are presented in three sections: hydrology, suspended sediment yield, and source analysis.

3.1 Hydrologic Data

Hydrologic data for this report consists of rainfall and streamflow records for the year. Rainfall data were downloaded from the telemetered HHSVRA weather station (Radio Ridge; WesternWeather 2013). WY 2013 produced 248 mm (9.78 in) of rain, which is well below the 419 mm (16.50 in) average (Table 1). That value is similar to the previous year with 271 mm (10.67 in). Precipitation fell from many small storms rather than larger events that would have produced significant runoff (Figure 6). Two weak frontal systems that impacted the region in late 2012 account for over 60% of the year's precipitation (Figure 6). The first event was near November 30, 2012 when 104 mm (4.1 in) fell over several days, and the second was during several days near December 25, 2012, when 53 mm (2.07 in) were recorded. The low rainfall values are in keeping with generally dry conditions in California. The 2013 calendar year was the driest year since State records began in the mid 1800's.

The Nature Area YSI sonde was not deployed because baseflow was present for a very short period. The Hudner Ranch YSI sonde was deployed when base flow was present between February and May. The Ranger Bridge gage, located upstream from Hudner Ranch was selected to represent the annual flow leaving the park because it had the most consistent record and captured all significant runoff events (Figure 6).

Table 1. Summary of hydrology data from Water Year 2012-2013.

	Gaged Period	**Total Precipitation**		**Total Q_w**	
	mm/dd/yy	mm	in	m^3	acre-ft
Radio	10/1/2012-9/30/2012	248	9.78	-	-
Ranger	10/1/2012-9/30/2013	-	-	2,500	2

The rainfall of WY 2013 generated very little surface runoff. The two significant rain events of late 2012 produced the only flow above base flow during the year (Figure 6). The highest runoff of the year was generated by the late December storm system. This peak "flood wave" was approximately 0.15 m (0.5 ft) deep with a flow rate of 0.044 m^3/s (1.5 cfs). Bird Creek quickly dried following each runoff event. Following the late 2012 storms, the soils dried enough to allow the subsequent rain events to infiltrate rather than produce runoff. The diminutive runoff events of WY 2013 are plotted with the events for the previous two years for comparison (Figure 7). Approximately 2500 m^3 (2 acre-ft) of water flowed past the Ranger gage (Table 1).

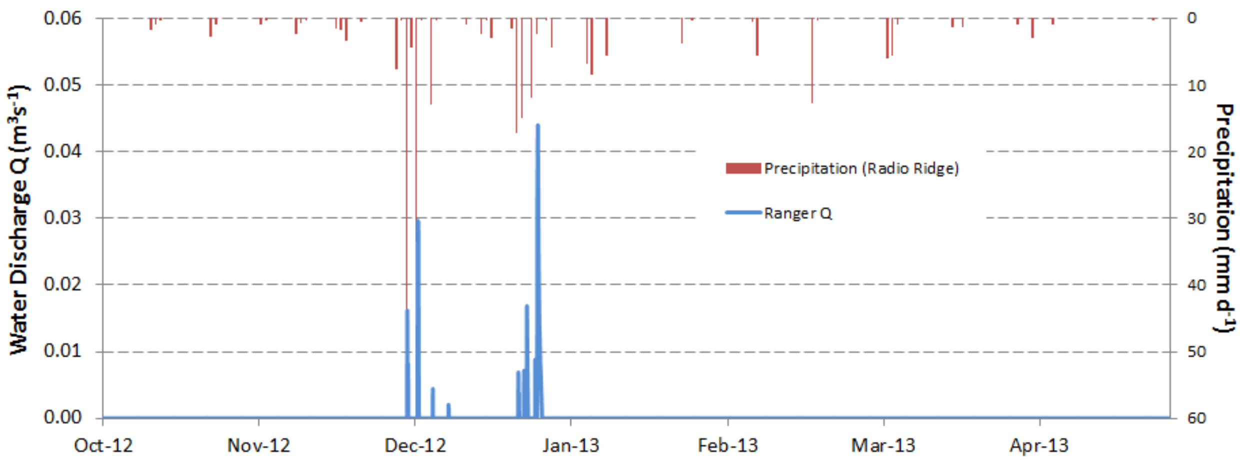

Figure 6. Precipitation and discharge for Water Year 2013. There were two minor runoff events during this winter.

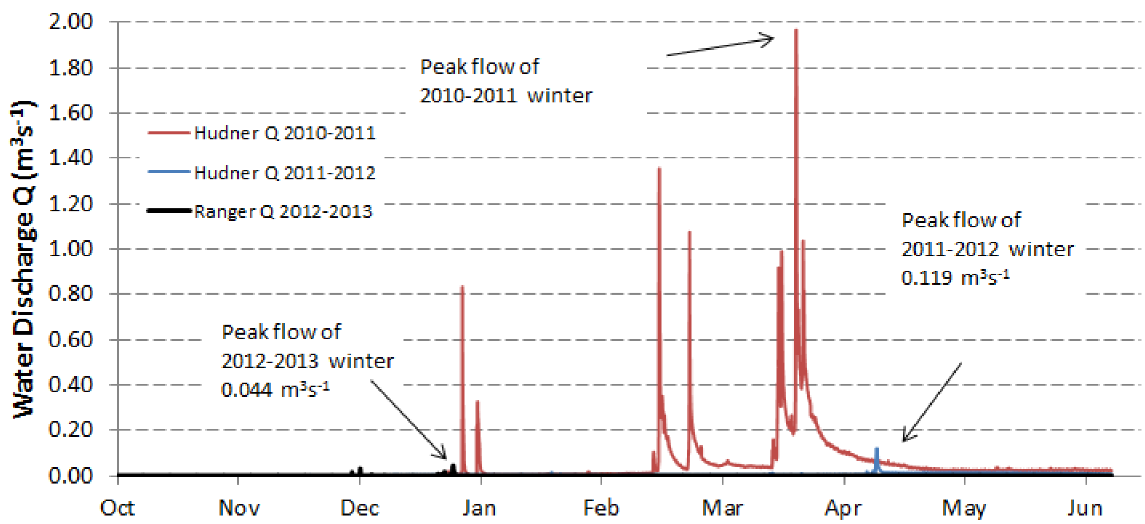

Figure 7. Comparison of the discharge of Bird Creek in Water Year 2011, 2012 and the current Water Year 2013.

3.2 Suspended Sediment

The low rainfall and runoff conditions of WY 2013 resulted in virtually no suspended sediment transport as indicated by visual inspection of the creeks and turbidity readings from the Hudner Ranch sonde.

3.2.1 *Sources of Suspended Sediment*

As part of the sampling methods in WY 2013, suspended sediment was spot sampled in Bird Creek on two occasions. On 2/10/13 the Nature reach had a discharge of 0.014 m^3/s (o.49 cfs) and suspended sediment concentration of 0.01 g/l, creating a sediment discharge of 0.14 g/s. All other sites had no flow or negligible flow at that time. On 2/20/13 all sites visited were either dry or had negligible flow. In all cases where suspended load was sampled, the concentrations were either at or below detection limits. The low flow year has left little new information about suspended sediment sources.

In late 2012, a small plume of fine gravel was seen in Bird Creek below the tributary called "Hidden Spring." Initial reconnaissance in the watershed could not pinpoint the source. Further work in WY 2014 will focus on evaluating that sediment source.

4 Discussion

Table 2 summarizes the water and sediment discharge record for this study. The table entries designated as "low" are unmeasured estimates that fall several orders of magnitude below values from typical years. These low values are driven by low rainfall values. Bird Creek was only briefly fully flowing in WY 2013, and commonly in only certain segments, rather than along the entire creek bed. These flow conditions are of very limited value for assessing potential sediment impacts or efficacy of BMPs.

Table 2. Summary of hydrology and sediment data from Water Years 2011, 2012, and 2013.

	Water Year		
Location	**2011**	**2012**	**2013**
Radio Ridge Precipitation (mm)	494	271	248
Nature Gage Flow (acre-ft)	268	-	low
Ranger Gage Flow (acre-ft)	670	-	2
Hudner Gage Flow (acre-ft)	787	74	2
Nature Gage Suspended Sediment (tonnes)	23.3	low	low
Hudner Gage Suspended Sediment (tonnes)	173.2	21.6	low

5 References

Harden DR, Stenner H, Blatz I. 2001. The Calaveras and San Andreas Faults In and Around Hollister. Field Trip 6. Available from: http://pubs.usgs.gov/bul/b2188/b2188ch6.pdf

[IWR] Institute of Water Research. 2002. Revised Universal Soil Loss Equation (RUSLE): An Online Tool. Michigan State Universtiy. [Online]. Available from: http://www.iwr.msu.edu/rusle/kfactor

Minella JPG, Merten GH, Reichert JM, Clarke RT. 2008. Estimating suspended sediment concentrations from turbidity measurements and the calibration problem. Hydrological Processes 22: 1819–1830

Nicol C, Smith D, Nitayangkul K, Williams C, Moreland S. 2011. Hollister Hills SVRA Sediment Budget: Water year 2010-2011. The Watershed Institute, California State Monterey Bay, Publication No. WI-2011-04b, 25 pp.

Nicol C, Smith D, Williams C. 2013. Hollister Hills SVRA Sediment Budget: Water year 2011-2012. The Watershed Institute, California State Monterey Bay, Publication No. WI-2013-01, 22 pp.

Nolan, K. M. and Shields, R. R., 2000, Measurement of stream discharge by wading, U. S. Geological Survey WRI 2003-4103, CD-ROM, various pages

[NRCS] Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Soil Survey Geographic (SSURGO) Database for [San Benito County, CA]. Available online at http://soildatamart.nrcs.usda.gov. Accessed [Feb 2011].

PRISIM Climate Group, Oregon State Univertiy, http://www.prisimclimate.org, created 4th Feb, 2004

Romkins MJM, Young RA, Poesen JWA, McCool DK, El-Swaify SA, Bradford JM. 1998. Soil Erodibility Factor (K). Chapeter in: Guidelines for the use of the Revised Universal Soil Loss Equation (RUSLE), version 1.06, on Mined Lands, Construction Sites, and Reclaimed Lands. 1998. The Office of Technology Transfer Western Regional Coordinating Center. Available from: http://www.techtransfer.osmre.gov/NTTMainSite/Library/hbmanual/rusle.shtm

Wass PD, Marks SD, Finch JW, Leeks GJL, Ingram JK. 1997. Monitoring and preliminary interpretation of in-river turbidity and remote sensed imagery for suspended sediment transport studies in the Humber catchment. The Science of the Total Environment 194: 263-283

WesternWeather. 2013. Web-accessed weather database for Hollister Hills SVRA: http://www.westernwx.com/HollisterHills/ (last accessed December 2013).