Francis Creek Annual Suspended Sediment Yield

Turbidity Threshold Sampling Summary Report

Hydrologic Year 2016

Site FRC – 1099 Van Ness Avenue Ferndale, California

A collaborative project between

Humboldt County Resource Conservation District

Humboldt County

State Coastal Conservancy
Ducks Unlimited
State Department of Conservation
National Marine Fisheries Service
North Coast Regional Water Quality Control Board
State Department of Fish and Wildlife
Caltrans

For the

Salt River Ecosystem Restoration Project

By Clark Fenton
8-1-16 final

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1. Introduction

The Salt River Ecosystem Restoration Project is a joint effort by various agencies, including The County of Humboldt, The California State Water Control Board, Ducks Unlimited, The State of California Coastal Conservancy, The California Department of Fish and Wildlife, The California Department of Conservation and the California Department of Water Resources.

The goals are to improve riparian and fish habitat, reduce flooding, enhance sediment routing and lessen sewer plant impacts on Francis Creek and the Salt River. Suspended sediment yields from the Francis Creek watershed will continue to be quantified to provide planning data for future dredging downstream. The EIR and current progress may be viewed on the HCRCD's web site http://www.humboldtrcd.org, Salt River Restoration Project tab or at the Salt River Watershed Council website http://saltriverwatershed.org/.

Thanks to Valentina Cabrera-Stagno, Duane James, Lucrina Jones, Greg Nagle and Peter Husby of the United States Environmental Protection Agency – Region 9 Laboratory for running the Francis Creek suspended sediment concentration samples for Hydrologic Year 2016. Summer Daughterty of the Humboldt County Resource Conservation District persuaded the EPA to run our samples again this year.

The largest HY 16 storm event in Francis Creek on January 17th, 2016 transported **10,454 cubic yards** of suspended sediment and was a third of the 2016 annual total of **33,608 cubic yards**. Since starting operation in 2007 the Francis Creek TTS station has measured over **232,000 cubic yards** of suspended sediment passing the station. The Francis Creek annual suspended sediment load this year is the third highest since 2007. Despite a prolonged drought in California this 3.2 square mile watershed is still contributing large amounts of suspended sediment into the Salt River, The Eel River and ultimately Humboldt Bay.

The Humboldt County Materials Testing Lab and Clark Fenton continue to maintain a Turbidity Threshold Sampling (TTS) Station on Francis Creek in Ferndale California. Hydrologic Year 2016 was the ninth full year of TTS monitoring on Francis Creek. Sarah Wilson continues to analyze and report the annual suspended sediment yields.

Salt River Project on Hold:
In it's June 16, 2016 issue the Ferndale Enterprise reported that the Salt River Watershed Council "officially announced that the 2016 phase of the SRERP was put officially on hold because 2 property owners wouldn't sign final agreements allowing for the multi-million dollar, publically-funded endeavor to proceed."

It appears a difference of opinion has developed over whether a flood plain easement purchased in 2010 for $900,000 by the National Resource Conservation District on 100 acres by the Ferndale Sewage Treatment Plant includes the right to construct a 10-acre detention basin / sediment trap next to Francis Creek.

The legal department of the NCRS is the entity that will decide if the flood plain easement language and the funding enabling legislation language explicitly set forth that a detention basin / sediment trap is legally allowed for the 10 acres on Francis Creek.

With construction halted for the forseeable future, funding sources for the SRERP may be withdrawn and put to other shovel ready restoration projects in California. The project may be delayed indefinitely and have to secure funding all over again.

Photo #1.

2014 Aerial view of mouth of the Eel River and Salt River looking west.

The excavated channel is on the right side of photo.

The annual suspended sediment yield from the Francis Creek watershed above Site FRC for **Hydrologic Year 2016** from August 8th, 2015 to July 5th, 2016 was **77.1 million pounds or 12,052 tons per sq. mile per year**. At the 6.7 foot peak water stage of the storm on 3-5-16, almost **400,000 pounds / 173 cubic yards** of suspended sediment was flowing past the Francis Creek TTS Station **every 10 minutes**. A bulk specific gravity of 85 lbs. per cubic foot was used to calculate cubic yards of fresh flood deposit sediment. (USDA, 93) The purpose of this TTS monitoring station is to provide guidance on how much suspended sediment can be expected to enter the Salt River dredge or detention areas over time from the Francis Creek watershed.

The Ferndale Enterprise reported on 6-30-16 that rainfall for Ferndale for "The weather year to date from 7-1-15 to 6-26-16 was 125% of average at **50.53** inches. The Weather Year average from 1971, July 1st to 6-26-16 **is 40.29** inches rainfall. Rainfall **last year** from 7-1-14 to 6-26-15 was **38.77** inches." Rainfall from 7-1-13 to 6-29-14 was **19.50** inches.

The Salt River is a tributary of the Eel River that heads in the Wildcat Mountains above Ferndale, flows across the Eel River Delta, and enters the Eel River within one mile of the Pacific Ocean. The watershed is part of the Franciscan Complex and mainly underlain by Quaternary mudstones, siltstones and sandstones of the Wildcat formation (McLaughlin, R.J. and others. 2000). Habitats and land uses that characterize the Salt / Eel River delta include the fourth largest estuary in California, salt-, brackish-, and freshwater marshes, riverine wetlands, riparian wetlands, agricultural lands dominated by dairy farms and irrigated pastures, and small communities. (USDA, 1993)

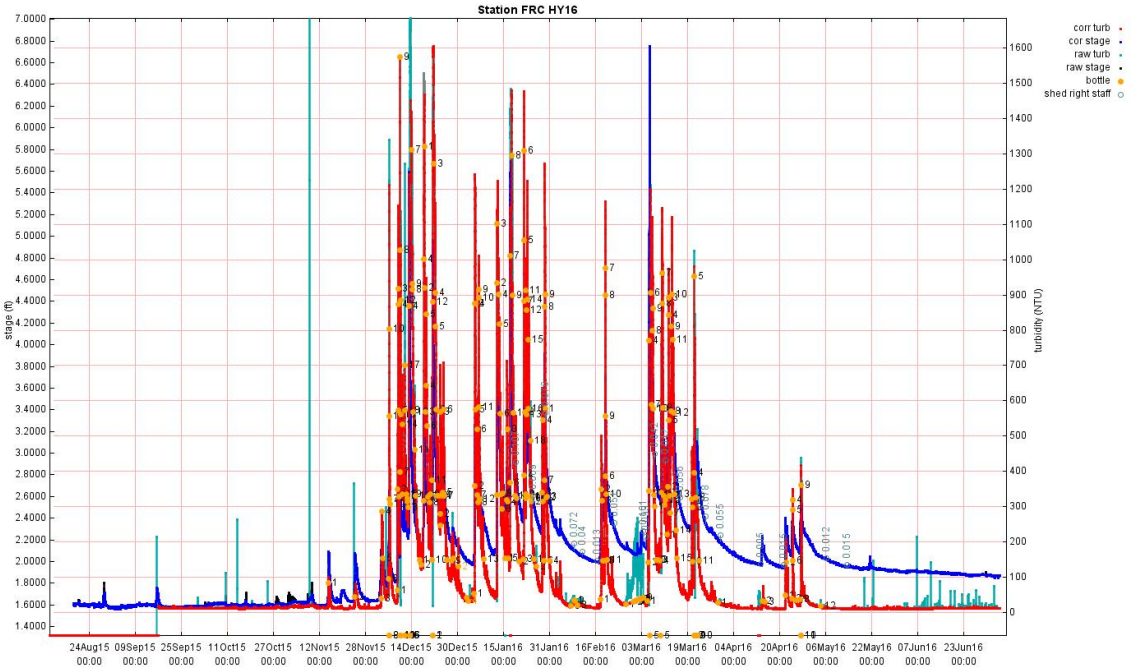
Sedimentation in the Salt River Channel has resulted in problems associated with flooding and drainage, including:

Decreased agricultural production and land values;
Degradation of the estuary and its habitats as excess nutrients are transported from flooded dairy lands downstream, Loss of a once navigable waterway; and
Increased health hazards posed by water quality degradation. (USDA, 1993)

The HY 2011, 2012, 2013, 2014, 2015 and 2016 totals include suspended sediment from the Francis Creek Ranch Slide in March 2011.

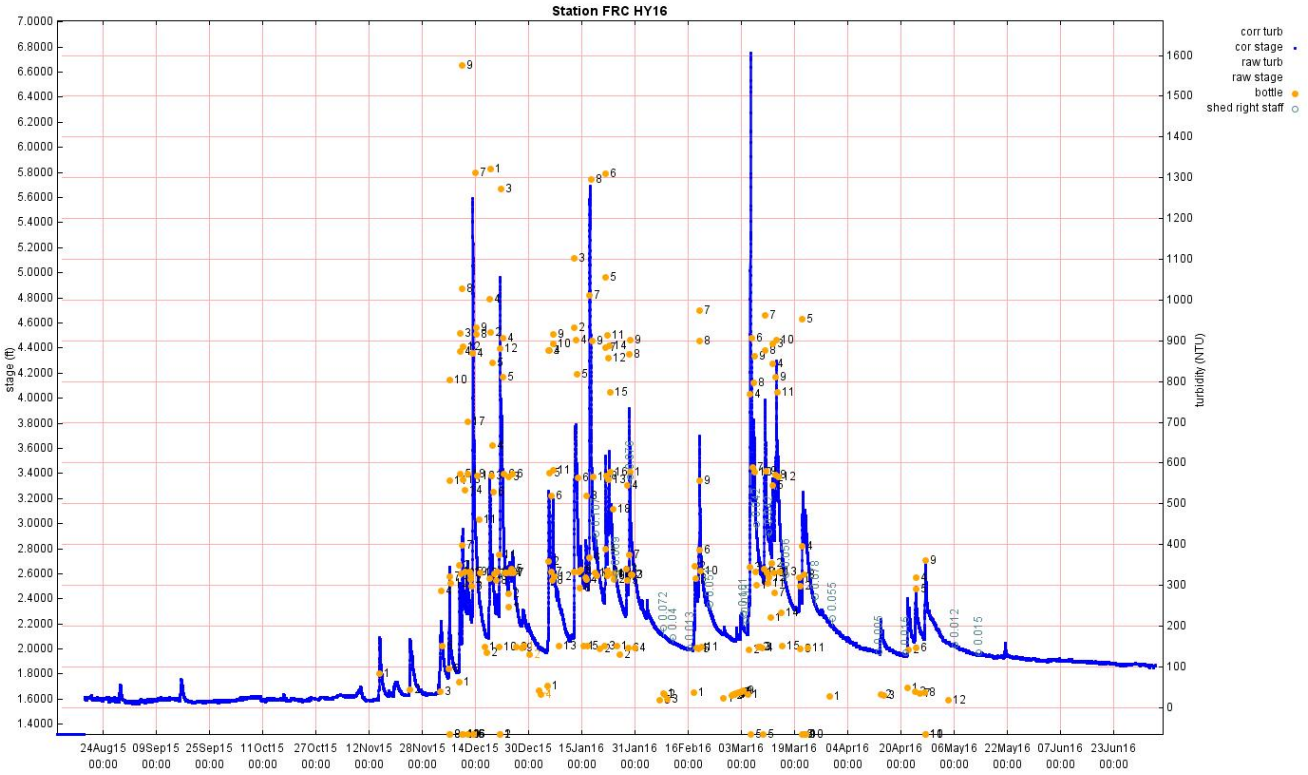
Hydrologic Year	Total Suspended Sediment Lbs.	Total Suspended Sediment Kg	Total Suspended Sediment Cubic Yards	Highest Single Storm Sediment Kg	Highest Single Storm Flow CFS	Annual Susp. Sed. Yield Tons/ Sq. Mile
2008	41,739,922	18,932,910	18,187	4,511,312	274	6,521
2009	12,578,664	5,705,593	5,480	1,351,049	135	1,965
2010	38,979,924	17,685,991	16,985	4,270,058	215	6,091
2011	70,342,760	31,915,953	30,650	17,045,608	268	10,991
2012	65,859,288	29,881,710	28,696	12,563,530	230	10,291
2013	139,352,629	63,209,938	60,720	28,228,313	462	21,774
2014	2,419,062	1,097,578	1,054	355,314	46	378
2015	84,450,445	38,316,899	36,798	20,380,963	488	13,195
2016	**77,129,899**	**34,995,417**	**33,608**	**10,855,762**	**335**	**12,052**
Totals	**455,722,694**	**206,746,572**	**232,178**			**Avg. = 9251**

Table # 1 – Francis Creek Annual suspended sediment summaries



Plot # 1 Stage / turbidity plot of the HY 2016 water year at Site FRC on Francis Creek.

Maximum storm stage 3-5-16 in blue was 6.754 feet @ 1600 fbu @ 335 cfs.



Plot # 2 Stage and ssc bottles sampled plot of the HY 2016 water year at Site FRC on Francis Creek.

Humboldt County Public Works was awarded a grant from the Department of Fish & Wildlife's Fisheries Restoration Grant Program, supplemented with funds from the state Department of Water Resources, to replace the culverts on Francis Creek at Port Kenyon Road with a 42-foot-wide CON/SPAN modular bridge structure. The project will remove a fish migration barrier and open access to over three miles of spawning habitat in Francis Creek and remove a hydraulic constriction to allow more effective sediment transport and channel flushing. (Hank Seeman, personal communication 2013)

The Port Kenyon Culvert replacement project bids were opened on June 23rd, 2015 and it was installed in Fall 2015. Unfortunately the channel has not been excavated up to the culvert so Francis Creek floodwaters are still backing up and depositing sediment in the area and roadway.

Photo # 2 – Port Kenyon Culvert / Port Kenyon Road

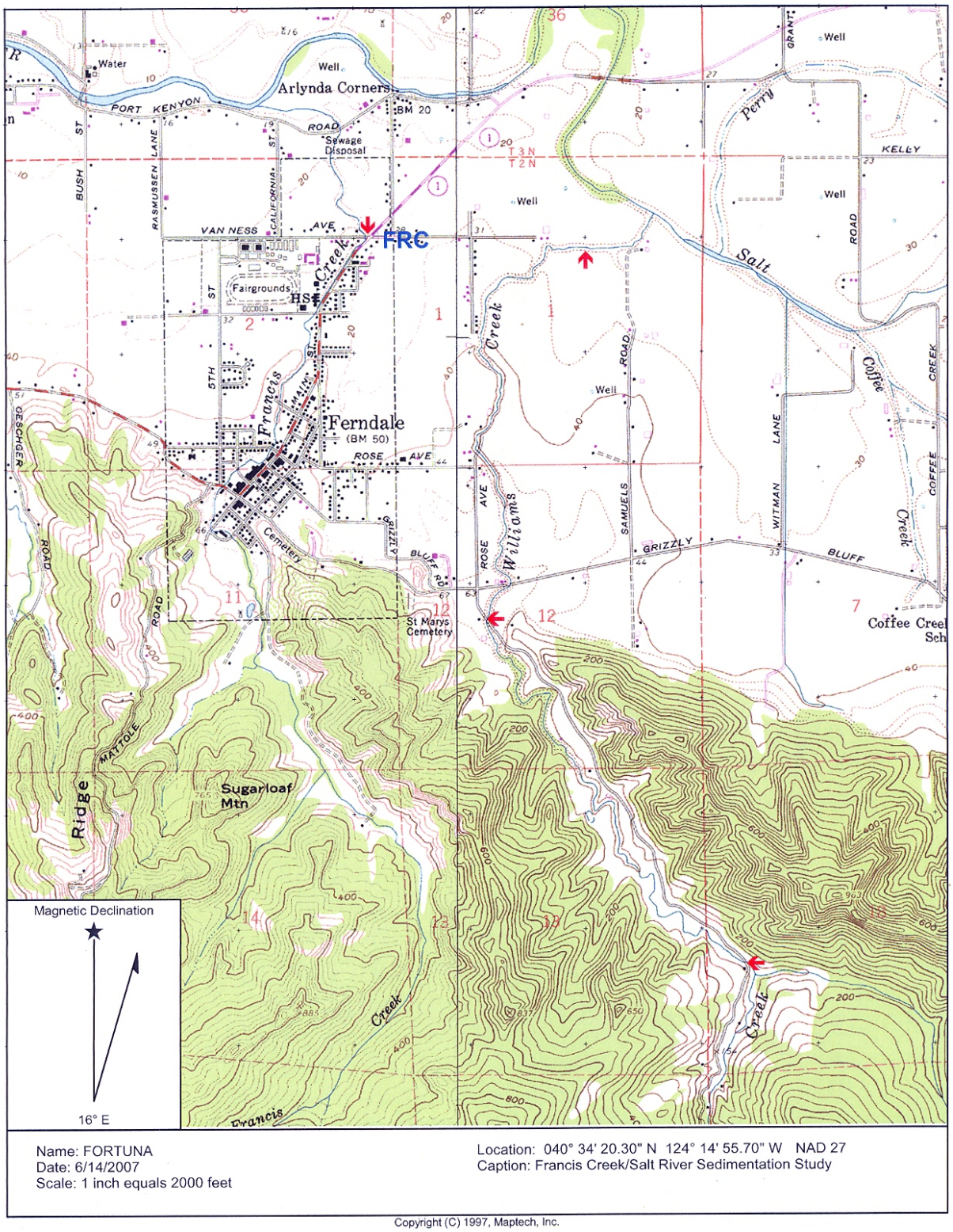


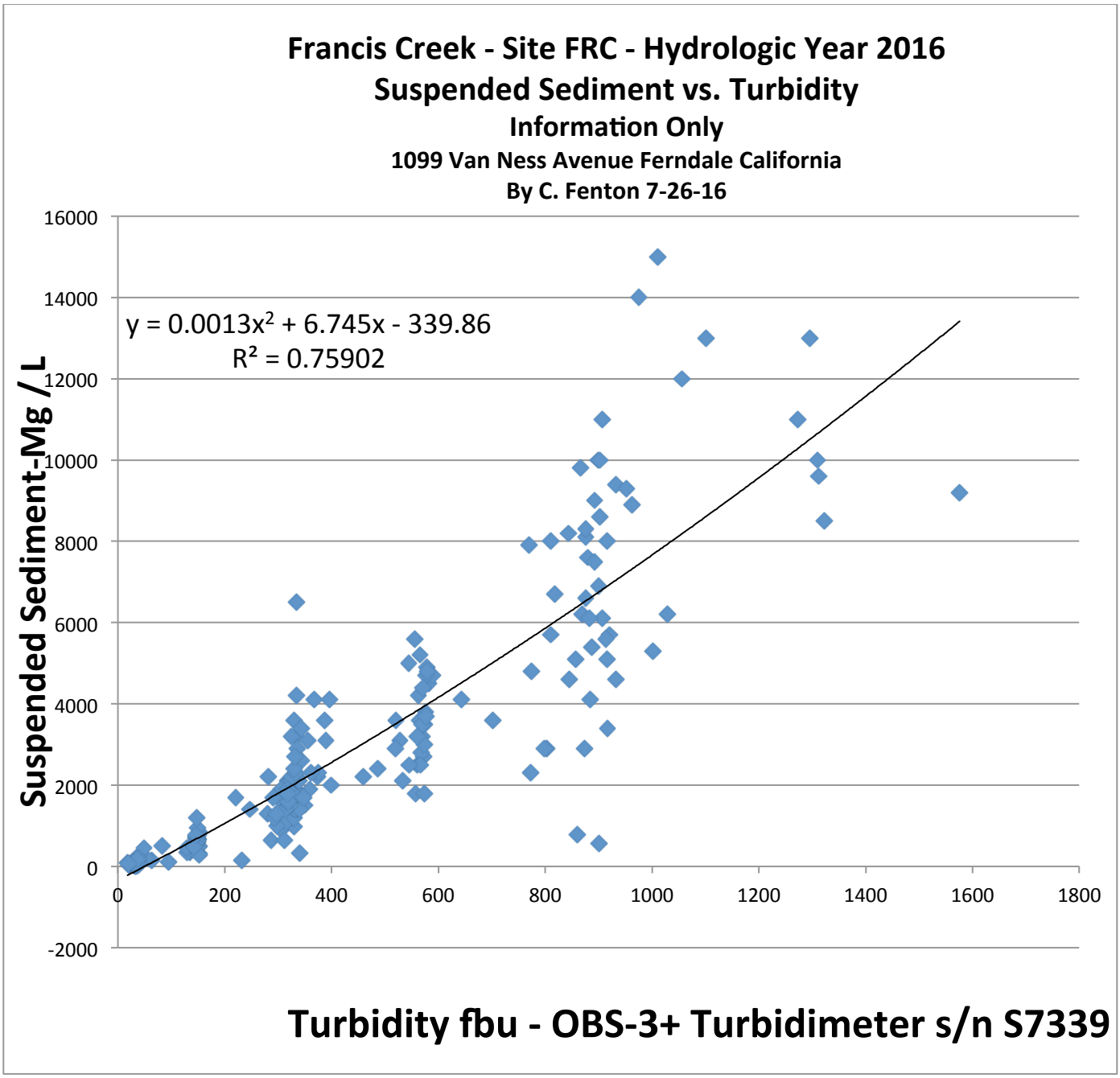
Figure # 1 Francis and Williams Creek monitoring locations

Turbidity Threshold Sampling (TTS)

Jack Lewis and Rand Eads at Redwood Sciences Lab developed turbidity Threshold Sampling over 10 years ago (Lewis, Eads, 2002). Redwood Sciences Lab is a research station for the USFS and deploys a network of these stations on Caspar Creek to monitor long-term sediment transport in the Jackson State Forest and other locations across Northern California. Redwood Sciences Lab provides all information and software for TTS sampling for free on their website. Implementation files, sampling software and TTS literature should be found at http://www.fs.fed.us/psw/topics/water/tts/.

TTS is used to calculate annual suspended sediment loads using turbidity measurements every 10 minutes as a surrogate for suspended sediment measurements every 10 minutes. A Druck 1830 pressure transducer and an in-stream OBS-3+ turbidimeter are installed in conjunction with an ISCO pump sampler to take water samples at direction from TTS sampling software. An algorithm is used to trigger an ISCO pump sampler to take water samples at rising and falling turbidity thresholds. The final 10-minute data file is called a flo file and displays raw and corrected stage and turbidity data side by side for easy comparison. The flo files for Site FRC 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015 and 2016 are included in Appendix 5. **On-line real time plotting should be available on the HSU website** http://nrs-isa.humboldt.edu/rsl/tts_plot.html.

TTS water samples for HY 2016 were sent to the EPA Region 9 Laboratory by Summer Daughterty of the HCRCD for suspended sediment concentration determination by subtracting filtering (SSC / Sand Fraction - ASTM D3977 -02). A regression is developed for OBS-3+ turbidity versus suspended sediment concentration. The 10-minute turbidity data is converted to 10 minute calculated suspended sediment concentration. A discharge-rating curve is developed so flow is known for the every 10 min stage data. By multiplying flow / cfs and suspended sediment concentration, pounds of sediment passing by the station are calculated. TTS Adjuster software is used to do data correction and R Sed software is used to calculate suspended sediment loads. The best equation fit for the turbidity vs. suspended sediment concentration from **bottles sampled from each storm is used to calculate loads for each storm** and the loads are summed up for the year.



Plot # 3 - Turbidity vs. Suspended Sediment Concentration

of Site FRC HY 2016 ISCO pump samples.

2. Francis Creek Ranch Slide – March 2011

During a set of 5 rainfall events starting 3-23-11 and ending 4-1-11 a large debris torrent occurred approximately 3.4 river miles upstream of the station. The forester of the upstream property, Chris Carroll, estimates the slide to be roughly 100,000 cubic yards in size.

The California Geological Survey visited the site on April 7, 2011. Details from their report by Don R. Braun dated April 18, 2011 include that a bridge was removed from its abutments by the debris. At the slide site bedrock materials "consisted predominantly of soft to moderately dark gray siltstone with minor amounts of fine sub rounded gravel. Significant precipitation in the area during the month of March may have been the main contributor to the recent failure. The debris is estimated to consist of about 50% wood or logs and about 50% dark gray silt. Information supplied by Mr. Mark Distefano of TRC suggests that the destroyed former bridge over Francis Creek was approximately 15 to 20 feet above the channel and that the current debris in the channel is about 4 to 5 feet above the height of the old bridge suggesting that the debris thickness at this location may be about 19 to 25 feet. Francis Creek will likely remain turbid with suspended sediment during future rainy seasons until a stable channel and side slopes develop." (CGS, 2011)

Photo # 3 Francis Creek Ranch Slide April 2011

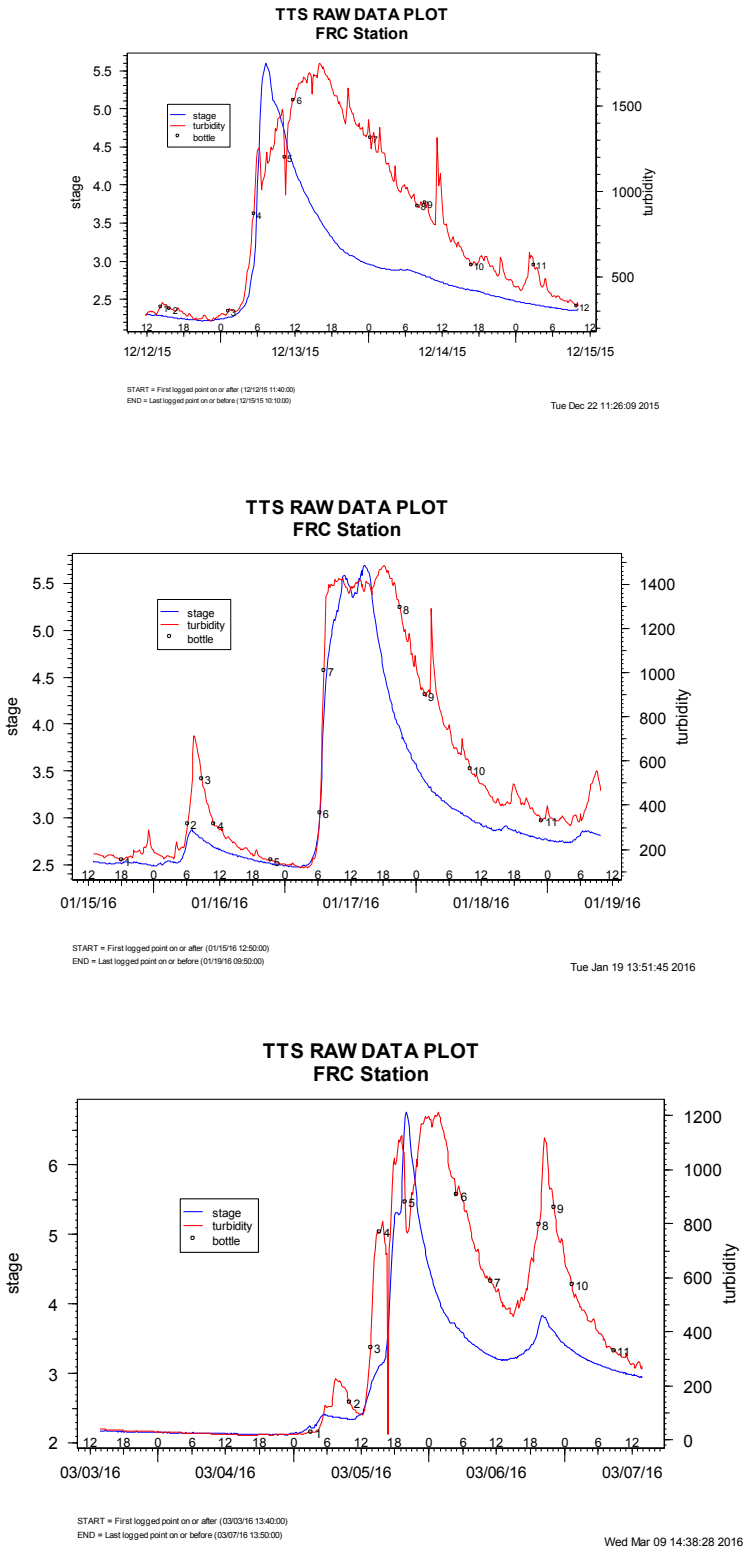
Using turbidity threshold sampling analysis Sarah Wilson estimated that approximately **11 million kilograms / 24 million pounds** / **10,600** cubic yards of suspended sediment presumably came from the Francis Creek Ranch Slide during this period. The suspended sediment is mainly fine sand and silt and totals do not include bed load gravel. During this slide event, the TTS station sucked over 40 water samples from Francis Creek, including 14 water samples over 35,000 milligrams/liter. Eight of those 14 bottles had over 65,000 mg/l, one bottle had 100,000 mg/l and one bottle had 180,000 mg/l.

After the large storm events in 2012, Tom Stephens, a local geologist, visited the slide and gave analysis and recommendations to the Ferndale City Council. His main recommendations were to continue close monitoring of the slide during storm events and encourage HSU students and faculty to survey cross sections annually to document changes.

His 2012 report said that the toe of the slide is migrating upstream as it erodes but most of the slide is still a slowly settling mass of trees and sediment. Some tree planting slide stabilization efforts by the CCC have been washed away but other revegetation efforts are holding. The stream is cutting down and widening and the previous waterfall at the base of the slide has disappeared. There is still a lot of sediment and debris in the stream channel above Ferndale and large storm events will continue to mobilize that sediment.

Sarah Wilson did not do a breakdown of the proportion of slide suspended sediment versus the total annual suspended sediment yield this year. As each year passes the slide's contribution gets more difficult to discern as the slide changes and annual rainfall totals change. The slide suspended sediment regime is now **baseline**.

3. FRC 16 – 3 Largest Storm Events



Plot # 4 Three Largest Storm Events Francis Creek HY 2016

4. Hydrologic Year 2016 Suspended Sediment Yield

The Francis Creek TTS Station (Site FRC) is located at 1099 Van Ness Avenue in Ferndale, California. Francis Creek is the second largest tributary to the Salt River watershed at 3.2 square miles (Buffleben, 2007). The Williams Creek watershed is the largest at 5.7 square miles. TTS Monitoring commenced at Site FRC on Francis Creek on 1-23-07.

Sarah Wilson continues to do suspended sediment analysis with Redwood Sciences Lab TTS Adjuster and R Sed analysis software. Sarah Wilson received her Bachelors of Science in Biology from San Jose State University and a Master's of Science in Watershed Management from Humboldt State University. Her husband is an active duty member of the US Coast Guard.

Since the start of the Salt River dredging project in 2013 a total of 250,000 cubic yards of sediment has been removed and another 90,000 cubic yards was estimated to be removed in 2015. The TTS station at the Van Ness Culvert on Francis Creek has measured a total of **160,000 cubic yards of suspended sediment in the last 5 years and over 230,000 cubic yards since 2007.**

The annual suspended sediment yield from the Francis Creek watershed above Site FRC for Hydrologic Year **2016** from 7-2-15 to 7-5-16 was **77,129,899 pounds** / **34,995,417 kg** / **33,608 cubic yards** or **12,052 tons per square mile per year** of suspended sediment. The largest suspended sediment estimation period of HY 2016 was storm period 7, the 1-17-16 storm event, yielding 23.9 million pounds or 31% of the HY 16 suspended sediment annual yield. See the summary Table #1 in section 1 for a comparison of the Hydrologic Years suspended sediment amounts.

The annual suspended sediment yield from the Francis Creek watershed above Site FRC for Hydrologic Year **2015** from 7-2-14 to 6-30-15 was **84,450,445 pounds** / **38,316,899 kg** / **36,798 cubic yards** or **13,195 tons per square mile per year** of suspended sediment. The largest suspended sediment estimation period of HY 2015 was storm period 7, the 2-6-15 storm event, yielding 44.7 million pounds or 53% of HY 15 suspended sediment annual yield.

The annual suspended sediment yield from the Francis Creek watershed above Site FRC for **Hydrologic Year 2014** from May 6th, 2013 to July 1st, 2014 was **378 tons / square mile per year.** The annual suspended sediment yield from the Francis Creek watershed above Site FRC for **Hydrologic Year 2013** from October 2nd, 2012 to May 6th 2013 was **21,774 tons / square mile per year.**

The **Eel River at Scotia** carries an almost incredible **4,330 tons of suspended sediment every year from every square mile** of its drainage basin. On average, 4 to 8 inches of soil is washing is washing off the slopes every hundred years. That is the highest regional rate of erosion ever measured in the United States, more than 13 times the national average. Most of that phenomenal load goes down the river in about 6 days of the largest discharges during the winter floods. (Roadside Geology of Northern and Central California – D. Alt / D. Hyndman – 2000)

The average annual suspended load for the **Mad River** is about 1,751,500 tons, or about **3,600 tons /sq. mi/yr.** for Qss. (Klein, R. 2007, Personal Communication.)

Summary of sediment load estimates for Station FRC, Water Year 2016

By Sarah Wilson

The table below is from the Sarah Wilson suspended sediment report for FRC **HY 2016**. Her complete report is in Appendix 1. The hydrologic year was broken up into storm-by-storm time periods and the suspended sediment load was calculated for each period. Ms. Wilson has done this same analysis for Redwood Sciences Lab

Summary of sediment load estimates for station FRC, water year 2016
Each estimate is given one of five grades: excellent, very good, good, fair and poor.
Grading is based on the quality within the following categories:

Number of sample bottles within the period and the coverage of bottles across the entire period.
The strength of the relationship between the surrogate variable (stage or turbidity) and sample ssc, as measured by CV and r2.
The complexity and number of models and object used to calculate the estimate for each period.
The quality of the surrogate variable data (usually turbidity).
An estimate cannot receive a high grade if the quality of the underlying data is questionable.

Discharge rating equation: Discharge = (9.6703*stage^2 - 15.792*stage + 0.32)
Updated equation for HY 2016

Period	Dates and Times	Dump: Bottles	Sediment Load (kg)	% of Total Load
01	150818,1300,151202,1200	none	9,554	0.03%
02	151202,1210,151217,2000	6:3-12,7:1-19, 8:1-11, 9:1-2	5,871,538	16.78%
03	151217,2010,151221,0300	9:3-4, 10:1-9	674,424	1.93%
04	151221,0310,160104,0000	10:10-12, 11:1-8, 12:1-9, 13:1-4	3,853,393	11.01%
05	160104,0010,160112,1200	14:1-13	716,699	2.05%
06	160112,1210,160117,0500	15:1-9, 16:1-5	1,637,122	4.68%
07	160117,0510,160121,2000	16:6-11	10,885,762	31.11%
08	160121,2010,160128,0600	17:3-20, 18:1-2	1,501,511	4.29%
09	160128,0610,160217,1200	18:4-9, 19:1-5, 20:1-3	728,174	2.08%
10	160217,1210,160226,1200	21:1-11	637,080	1.82%
11	160226,1210,160309,2300	22:1-9, 23:1-11, 24:1-5	4,592,139	13.12%
12	160309,2310,160312,0500	24:6-12, 25:1	955,441	2.73%
13	160312,0510,160318,0000	25:2-15	1,755,856	5.02%
14	160318,0010,160408,0000	26:1-11, 27:1	1,030,207	2.94%
15	160408,0010,160705,1020	27:2-3, 28:1-12	146,517	0.42%
		Total Load (kg)	**34,995,417**	

Table # 2 – HY 2016 Storm Period Suspended Sediment loads.

4. Field Operations HY 2016

The station on Francis Creek – Site FRC – was made possible by funding from the Humboldt County Resource Conservation District, 5 Counties Salmonid Conservation Program, City of Ferndale and the Road Fund of the Humboldt County Public Works Department**.** The City of Ferndale Public Works constructed the Site FRC Equipment Enclosure Shed, and the equipment was installed in January of 2007.

Photo # 4 - Site FRC at 1099 Van Ness Avenue

The TTS station uses an ISCO Model 6700 automatic pump sampler, a Campbell CR101X data logger, Druck 1830 pressure transducer, and an OBS-3+ turbidity probe. The data logger and pressure transducer were up and running on 1-18-07. The OBS-3+ in-stream turbidimeter hangs from a boom off the ceiling of the culvert and has been operational since 1-23-07. The equipment has been mostly trouble free and the turbidimeter is sent in for calibration each summer.

Field Operations still include upgrading TTS station equipment, taking discharge measurements, making TTS Station FRC data dumps / sample bottle swaps, repairing storm damage to equipment and removing sediment and debris covering the pressure transducer pipe tip and/or hanging on the turbidimeter boom. Streambed aggradation has forced raising the boom and turbidimeter housing and pressure transducer pipe every year as the streambed rises to touch the housing.

A data logger modem was also purchased so that real time stage (water level) and turbidity data could be posted on the Redwood Sciences Lab website, which could function as part of an early warning network for flooding. This real time on-line data plotting has been available since the beginning of HY 2008. Humboldt State University and Redwood Sciences Lab are upgrading plotting servers and software.

Turbidity:

Francis Creek continues to maintain a high turbidity response level with the Francis Creek Ranch landslide upstream.

Turbidity is a number derived from the amount of light suspended sediment blocks from passing through water. Turbidity is usually caused by rising water flow transporting increasing levels of suspended sediment. Chronic turbidity is the tendency for streams to remain at elevated levels of turbid water for long periods. Causes of chronic turbidity can include landslides into a stream bleeding sediment for long periods to several storms in a row hitting a watershed in close intervals and keeping flow and turbidity and suspended sediment concentrations elevated. Land use in a watershed can contribute to chronic turbidity. Elevated levels of turbidity can cause harm to aquatic species.

This watershed has a very energetic and long lasting elevated turbidity response compared to other North Coast watersheds. Sediment is mobilized fast and available longer after the peak of a storm event.

Anomalous turbidity spiking may be land management activities or discrete bank failures or activity at the Francis Creek Ranch slide or some sediment delivery mechanism that keeps turbidity levels elevated.

The OBS-3+ Turbidimeter was chosen for this application because of the expected very high turbidities. The OBS-3+ sensor consists of a high intensity infrared emitting diode, which shines out into the water flow and a detector to measure light bounced back from the suspended sediment. The more infrared light bounced back the higher the turbidity. FBU turbidity units are used per the USGS turbidimeter nomenclature table from May 2012. The OBS-3+ has a stated range of 4000 fbu but has a practical high range of about 2900 fbu for Francis Creek Sediments, which is the highest available for an in-stream turbidimeter. Flow based suspended sediment loads will be used for turbidities above the range of the OBS-3+ Turbidimeter or where debris has pushed the turbidimeter instrument boom out of the water.

Discharge Measurements HY 2016:

A single discharge rating curve was used for HY 16. Clark Fenton collected 7 discharge measurements for Hydrologic Year 2016. The deepest wading rod measurement was at 3.39 feet / 75.00 cubic feet per second and the baseline HY 16 wading rod measurement was 1.60 feet at 0.32 cfs.

A lack of high flow discharge measurement equipment, the challenge of catching high flow events and only Clark Fenton to take the measurements has hampered timely updating of the discharge rating curve.

The highest stage for Hydrologic Year 2014 was **3.15 feet @ 46 cfs on March 14th, 2014**.

The highest stage for Hydrologic Year 2015 was **8.04 feet @ 488 cfs on February 6th, 2015**.

The highest stage for Hydrologic Year 2016 was **6.754 feet @ 335 cfs on March 5th, 2016**.

USFS / USGS methods were used for obtaining flow measurements. (Harrelson 1994, USGS). Low flows were measured with a Wading Rod using either a Pygmy current meter or a Price AA current meter. For higher flows an A-55 Reel, 30 lb. Columbus Weight, Price AA current meter and a bridgeboard were used. An accurate estimate of stream discharge is vital to accurate suspended sediment load calculations.

See Appendix 3 for discharge sheets and rating curves.

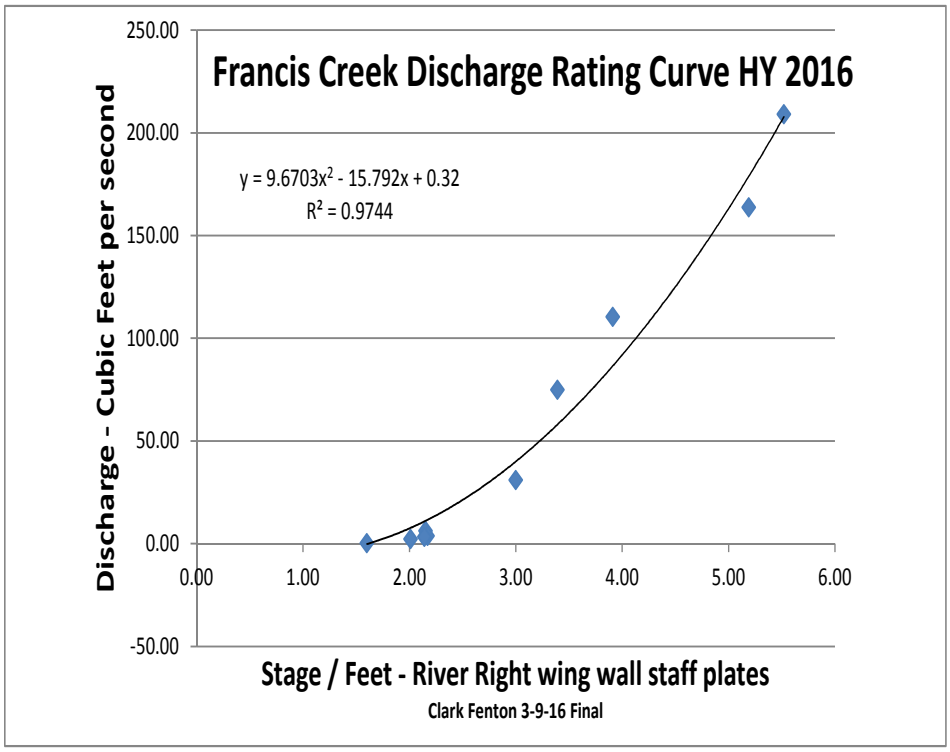
Aggradation or rising of the streambed around the staff plates from bed load mobilization is still being observed. The streambed is mobile gravels and annual discharges are needed in this location to ensure representative discharge measurements.

Low flow discharges were taken in HY 16 to try to record any low flow changes in the discharge rating curve.

Francis Creek HY 2016

Final Discharge Rating Curve

CF 3-9-16



CFS Comparison

Stage	HY 13	HY 16	HY 16
feet	curve	curve	actual
1.6	3.9	-0.2	0.32
2.15	13.3	11.1	6.31
3.39	56.4	57.9	75.00
5.52	201.4	207.8	

The only high flow data available is from HY 13

Need more low flow data from HY 16

Streambed aggradation affecting low flow relationship the most

No high flow equipment available

Did not use HY 14 or HY 15 data due to streambed aggradation

Chart Data		Stage	CFS
5-HY13	11/29/2012	5.19	163.76
6-HY13	12/2/2012	5.52	209.03
1-HY16	7/6/2015	1.60	0.32
2-HY16	1/11/2016	2.15	6.31
3-HY16	1/29/2016	3.39	75.00
9-HY13	12/21/2012	3.91	110.47
4-HY16	2/8/2016	2.17	3.72
5-HY16	2/9/2016	2.14	3.31
6-HY16	2/16/2016	2.01	2.26
7-HY16	3/7/2016	3.00	30.96

Plot # 5. FRC HY 2016 Discharge Rating Curve

5. Lab Operations 2016

The United States Environmental Protection Agency – Region 9 Laboratory ran the Francis Creek suspended sediment concentration (mg/l) samples for Hydrologic Year 2014. Suspended sediment concentration determination by subtracting filtering (SSC / Sand Fraction - ASTM D3977 -02) was used.

Thanks to Valentina Cabrera-Stagno, Duane James, Lucrina Jones, Greg Nagle and Peter Husby of the United States Environmental Protection Agency – Region 9 Laboratory for running the Francis Creek suspended sediment concentration samples for Hydrologic Year 2016.

The Francis Creek TTS sampling software triggered **234** ISCO Pump samples in HY 2016, **100** ISCO Pump samples in HY 2015, **34** ISCO Pump samples in HY 2014 and **193** ISCO pump samples for HY 2013. The suspended sediment concentration of each bottle is compared to the corresponding OBS-3+ Turbidity and a regression is developed for each storm period. See the FRC 2015 turbidity / suspended sediment concentration regression chart / Plot #2 in Section 1.

EPA Region 9 Laboratory reports are on file at the Humboldt County Materials Testing Lab.

Photo # 5 ISCO Pump Sampler Bottles

6. Closing Summary:

The Francis Creek annual suspended sediment load this year of 77 million pounds is the third highest since monitoring started in 2007. Despite a prolonged drought in California this 3.2 square mile watershed creek is still contributing large amounts of suspended sediment into the Salt River, the Eel River and then the Humboldt Bay Harbor entrance.

The largest HY 16 Francis Creek storm event on 1-17-16 transported **10,454 cubic yards** of suspended sediment and was a third of the HY 2016 annual total of **33,608 cubic yards**. Since starting operation in 2007 the Francis Creek TTS station has measured over **232,000 cubic yards** of suspended sediment passing the station.

The large difference between HY 2014's very low annual suspended sediment yield and this year's yield illustrates the large effect of drought and the timing and duration of rainfall on the quantities of suspended sediment being transported in Francis Creek each year.

The 2011 Francis Creek Slide continues to elevate the suspended sediment regime on Francis Creek.

The Port Kenyon / Francis Creek culvert replacement was supposed to alleviate backing up of Francis Creek and deposition of sediment at that location but channel dredging has not reached up to the new culvert yet.

The HCRCD funded two new 12-volt batteries to run the data logger and sensors at the station. Much of the equipment is 9 years old and still hanging in there. An upgrade of the datalogger and sampling software may be needed soon.

Streambed aggradation at the station site continues.

Thanks to Summer Daughterty of the HCRCD for convincing the EPA to run our ssc samples again this year.

7. References / Bibliography

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10-m DEM and calculated the upland area to be 82,955 cells which translates to:
8,295,500 square meters or 2,050 acres or 3.2029 square miles.

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