


From Control Site to Treated Site: Quantifying Improvements at Walters Creek

Annie Gillespie, *Morro Bay National Estuary Program*
Andrew Schaffner, *California Polytechnic State University*
Anna Halligan, *Morro Bay National Estuary Program*

Morro Bay National Estuary Program

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Acknowledgements

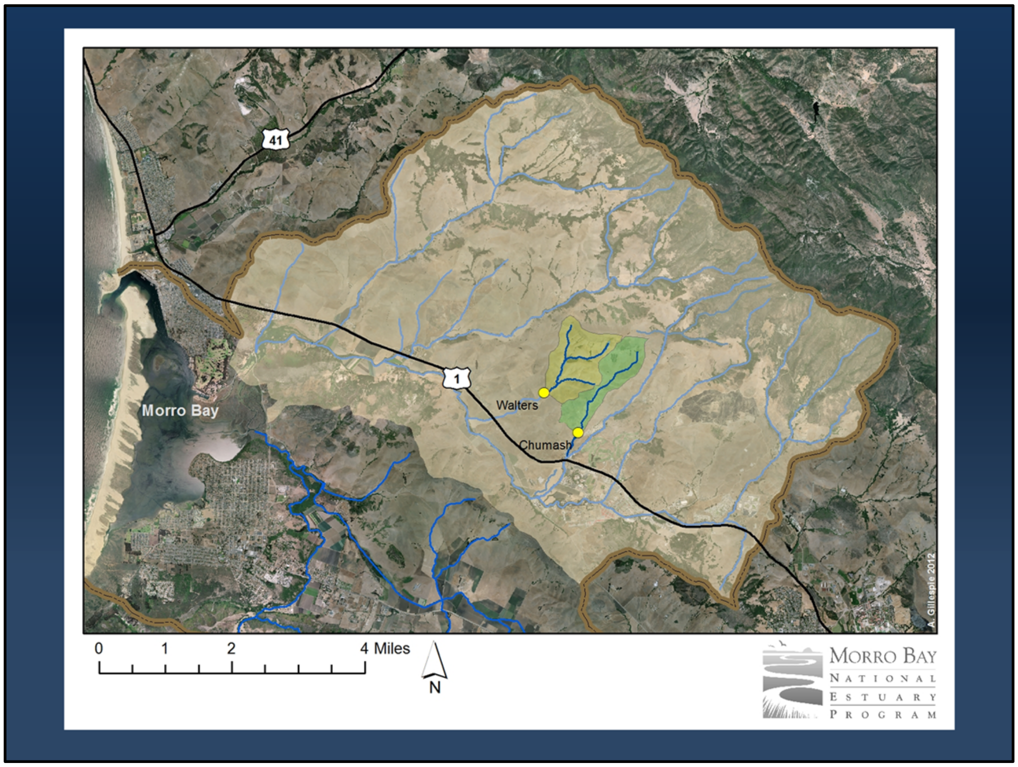
- Special thanks to YSI for travel assistance
- And to our many partners on this project

Foremost acknowledge YSI for providing travel assistance so that I could be here to present this project today.

The Morro Bay National Monitoring Program was funded through CWA Section 319 and took place from 1992-2001. One of the capstones was a paired watershed study used to evaluate the effectiveness of sediment-reducing BMP techniques in a rangeland setting. A very sizeable amount of land in San Luis Obispo county is used as rangeland for beef cattle operations, the work was very important in a regional context for water quality impairment and improvement.

BMP treatments included fencing the riparian corridors; creation of smaller pastures and adoption of rotational grazing techniques; installation of accessible water in each pasture; stabilization and revegetation of streambanks; and installation of rolling dips and re-sized culverts on farm roads.

For perspective, in 2011 crops report for SLO County cattle and calves were the third top valued crop at $66.8 million dollars. That figure does not include an additional $10.2 million in assessed value of grazed rangeland.

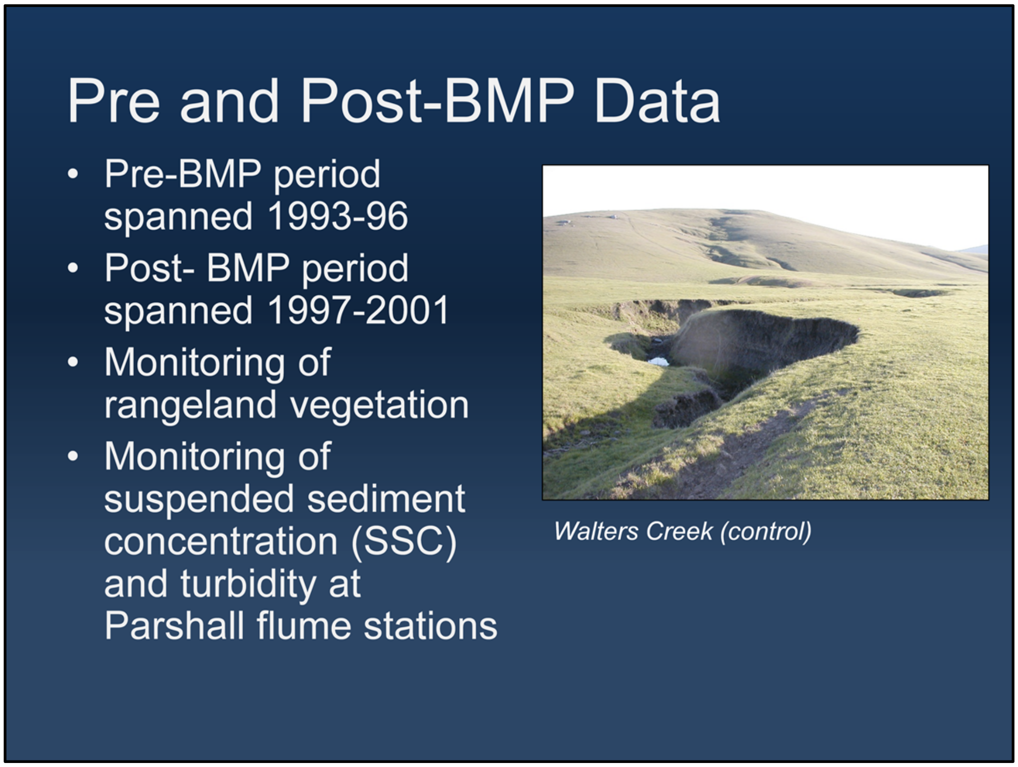


The paired study examined two tributary streams of Chorro Creek (Chumash: 400 acres and Walters: 480 acres) similar slopes, aspects, and land use characteristics.

Chumash Creek was chosen as the treatment watershed (partly due to winter accessibility issues). Walters remained a control site throughout the duration of the study.

Both watersheds are contained within the 2500 acre Cal Poly Escuela Ranch unit, where a herd of angus cow-calf pairs are managed by students in the College of Agriculture. Students studying animal science are actively involved in management of the Escuela Ranch herd.

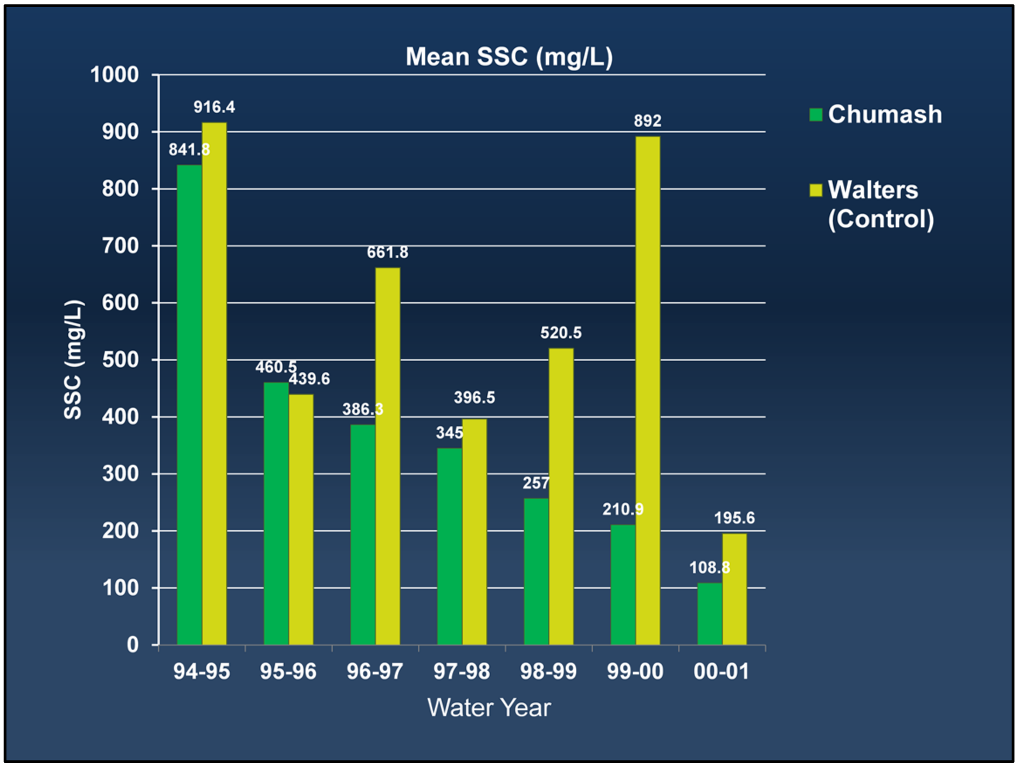
The central coast is prey to a Mediterranean climate regime: cold wet winters, long dry summers. Average annual rainfall is 17-24 inches, falling almost entirely between October and May. Snow is a rarity, but not impossibility in upper elevations of the watershed.



The National Monitoring Program began Pre-installation water quality monitoring in the paired watersheds in 1993. Installation and implementation of BMPs was underway in the Chumash watershed by 1996, with July 1, 1996 marking the official cutoff from “Pre” to “Post” BMP.

Monitoring efforts tracked a wide variety of potential indicators: grazing days each year, plant composition and biomass, channel stability evaluations and cross sectional profiles.

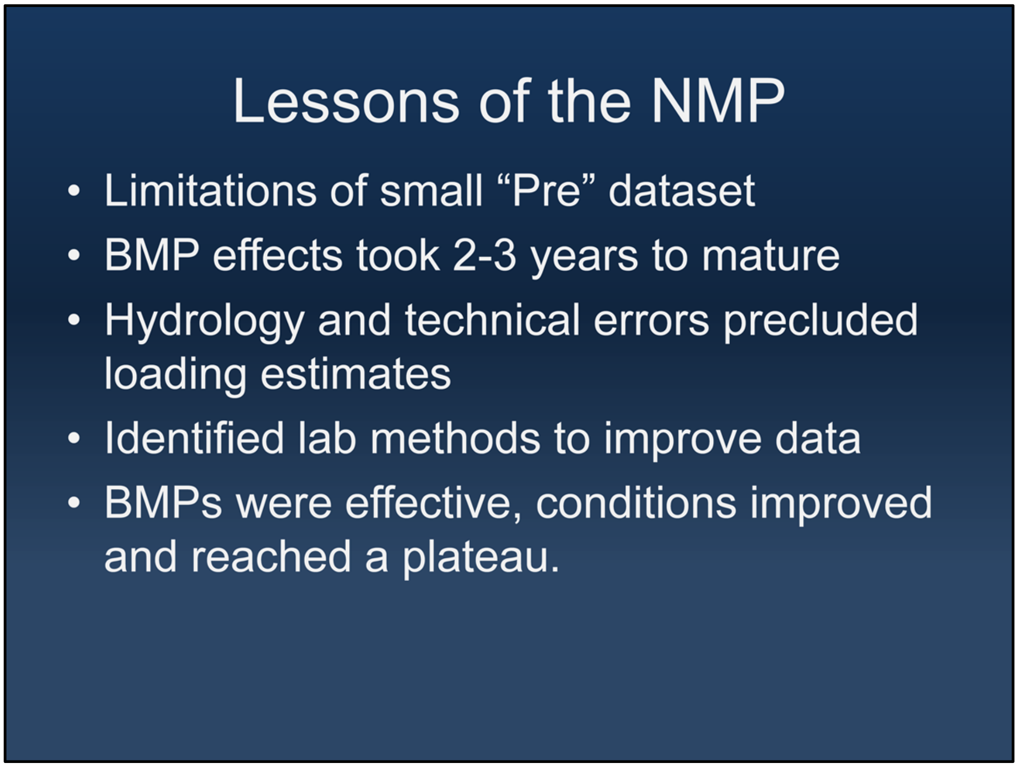
The bulk of water quality data collection focused on sample analysis for suspended sediment concentration and nephelometric turbidity at two flume sites that were installed in each watershed. The aim was to detect a significant reduction in annual suspended sediment load, with a target load reduction of 50%.



Although the aim was to detect whether sediment loading could be reduced by 50% hydrology and technical difficulties precluded loading calculations from the NMP Dataset. However, there was a steady decline in mean SSC values (as well as mean turbidity) at Chumash Creek following BMP Installation.

Relative to Walters Creek, both turbidity and suspended sediment decreased in small but significant increments at Chumash Creek following BMP installation.

The BMPs were determined to be effective in reducing the suspended sediment load from Chumash Creek.



One of the substantial limitations in the paired watershed study was the relatively small “Pre Project” dataset. Two years of pre-project data did not provide sufficient statistical power to characterize the Pre condition.

Another important finding was that BMP effects took 2-3 years to “mature.” This is an important point, particularly given the typical three-year timeframe provided for project installation and the demonstration of effectiveness.

Finally, the mediterranean climate and technical problems precluded the calculation of the most sought after numbers: annual sediment loads. The parshall flumes that were installed proved to be too small for “large events” but also too large for accurate capture of baseflow conditions. There were water years where the flumes (designed for a 10-year event) were overtopped, and also two water years where Walters Creek failed to rise to levels of measureable flow at any time.

Lab methodology for sample processing was also cited as a potential error source, as samples were processed according to TSS protocols, not SSC protocols. Aliquoting high concentration samples was noted as a problematic issue during the study.

Ultimately, the NMP concluded that the BMPs were largely effective in improving water quality. Reductions in SSC, Turbidity and a reduction in stream temperature in Chumash Creek were some of the measureable beneficial effects.

The results of the NMP provided an important framework for local range management and monitoring efforts. Concluding lessons of the study have been referenced repeatedly and considered in the subsequent build out of BMPs and design of effectiveness monitoring programs.

In 1998 the Central Coast Regional Water Quality Control Board determined that the entire Chorro Creek watershed was impaired for sediment and added to the regional 303d list. Following the conclusion of the NMP -in 2003 the Water Board and EPA approved a Sediment TMDL For Chorro Creek, Los Osos Creek and Morro Bay. The TMDL effectively covers the entire watershed for Morro Bay, but focuses largely on sediment loading from the Chorro Creek drainage network.

The BMPs implemented and tested at the Chumash site have been utilized throughout the watershed. Riparian fencing and off-creek water systems have been widely applied across numerous ranches in the watershed through partnership efforts. The suite of BMPs applied to any particular area has been driven by site specific factors.

Intensive effort was focused on the restoration of Walters Creek, which served as the control site during the NMP.

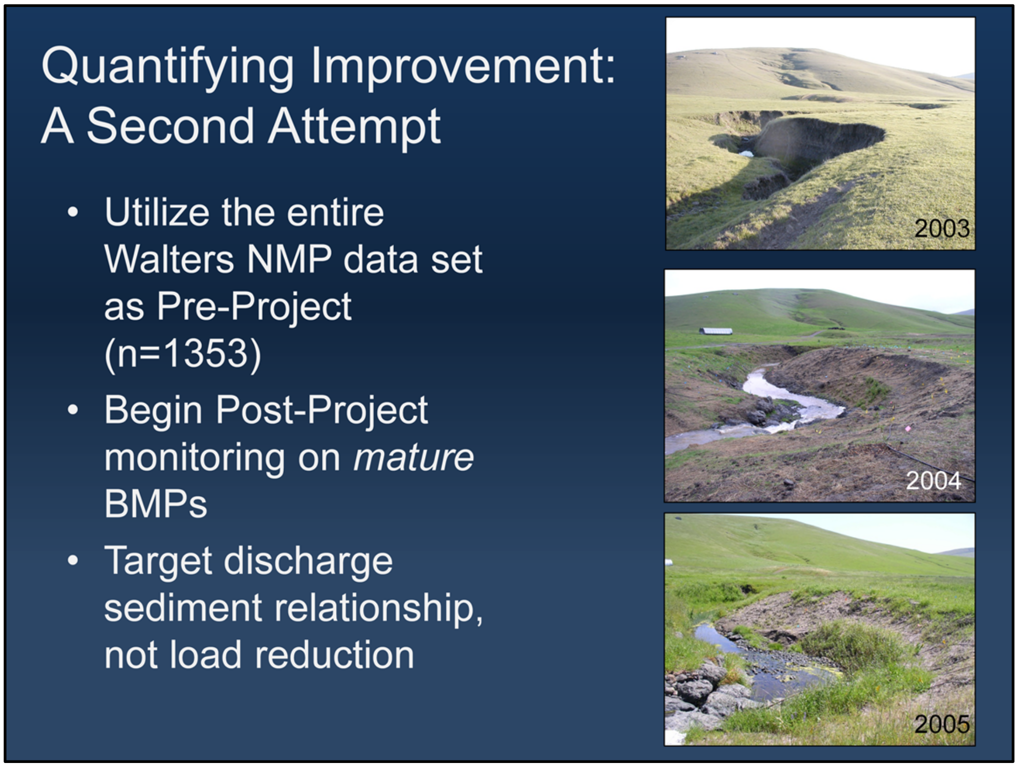
Phase I focused on installation of rangeland BMPs in the control watershed. Intensive restoration efforts included riparian fencing, off creek water sources for cattle, bank stabilization, and road drainage improvements.

Phase II focused on the remediation of the channel downstream of the flume in an area that is used as a shooting range. Although not grazed by cattle, the creek channel was severely incised and multiple culverts and crossings were failing and exacerbating erosion from the area.

First step of Walters Creek restoration was riparian fencing installed in 2003. Fencing was designed to create a larger riparian buffer and a riparian pasture that is flash grazed seasonally. Includes off-creek water system, network of troughs throughout small pastures.

In Fall 2004, construction started for installation of instream structures, bank grading, and road improvements. In the winter of 04-05 large flows damaged some of the newly installed features, additional work was implemented to repair these bank and gully failures.

Grazing of the riparian pasture was reinstated in 2008, (3yrs after restoration) and during that time vaca cages were installed to protect younger trees. These were very intensive restoration efforts, completed at a greater scale than those applied to Chumash during the NMP.

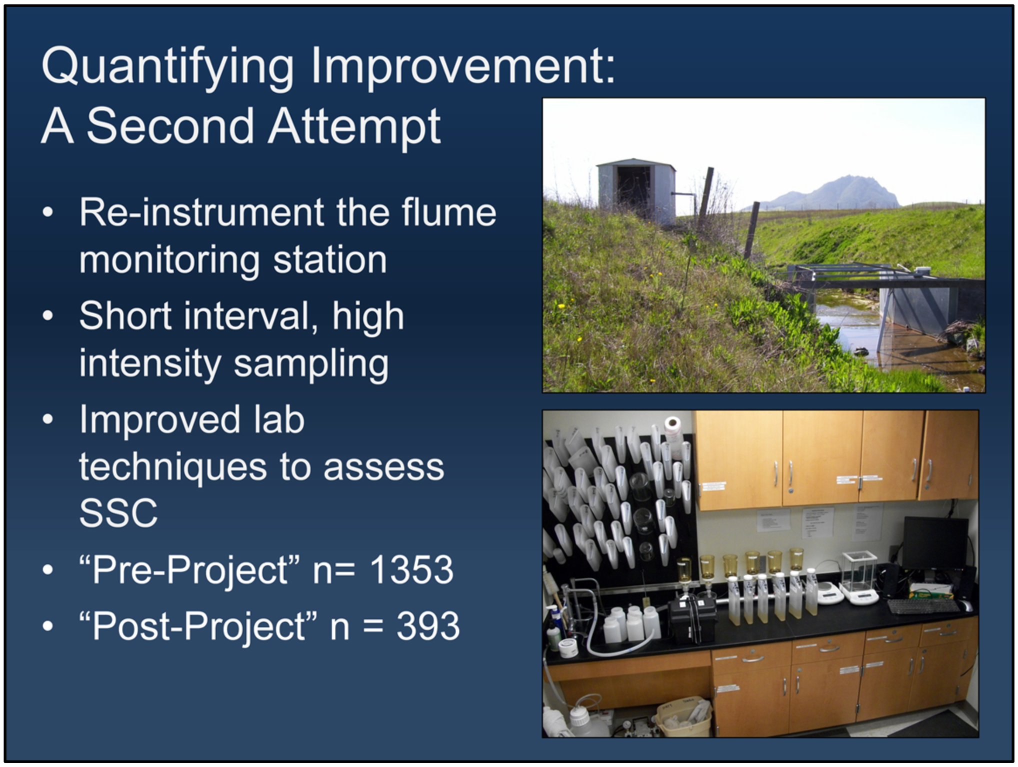


Building on the lessons of the NMP, MBNEP wanted to demonstrate the effectiveness of the Walters Creek Restoration. Now working towards achieving load reductions for an approved TMDL, demonstrate progress towards meeting TMDL goals.

Utilizing the entire NMP “Walters Control” dataset for analysis gave a substantially larger pre-project dataset, spanning a large range of hydrologic conditions.

Advantage of beginning monitoring on BMPs that had already matured. Most all construction was wrapped up in 2006, with limited maintenance and adaptive management activities through 2009. Allowed for time period for BMP measures to “mature and stabilize” and for effects to essentially plateau as seen in the NMP.

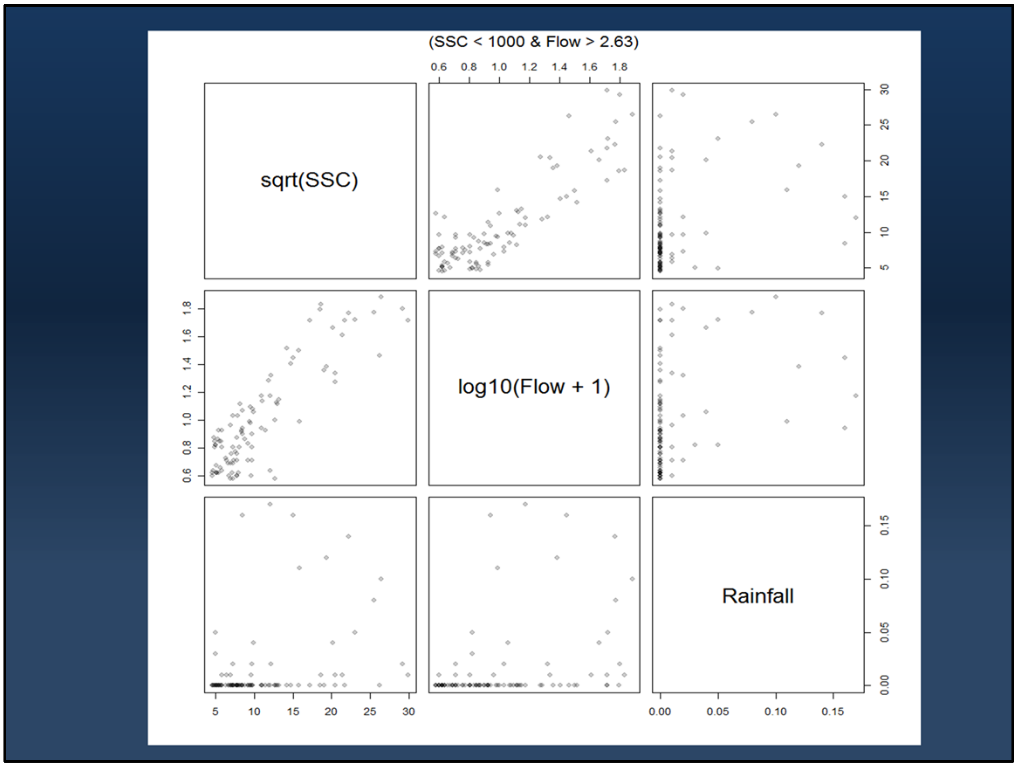
Rather than target loading, and a specific load reduction, the “Post” monitoring effort examined whether the relationship between SSC and flow volume had changed. Across the hydrograph, are suspended sediment concentrations significantly lower post project than pre project?



Flume was still intact, sampling gear needed to be repaired and replaced. Opted to not replace the flume as majority of data expected to be within flume sizing capabilities, not targeting load estimates. Flume station was reactivated for sampling in the 2008-09 water year. As indicated by NMP, accessibility proves to be a continuing challenge. Only road to site is off-limits during rain events due to soil type.

Increased the frequency of data collection to capture very dynamic stage conditions: stage height records every 5-minutes, storm event SSC sampling to 30-minute intervals. Currently run sampling equipment off of batteries and solar power.

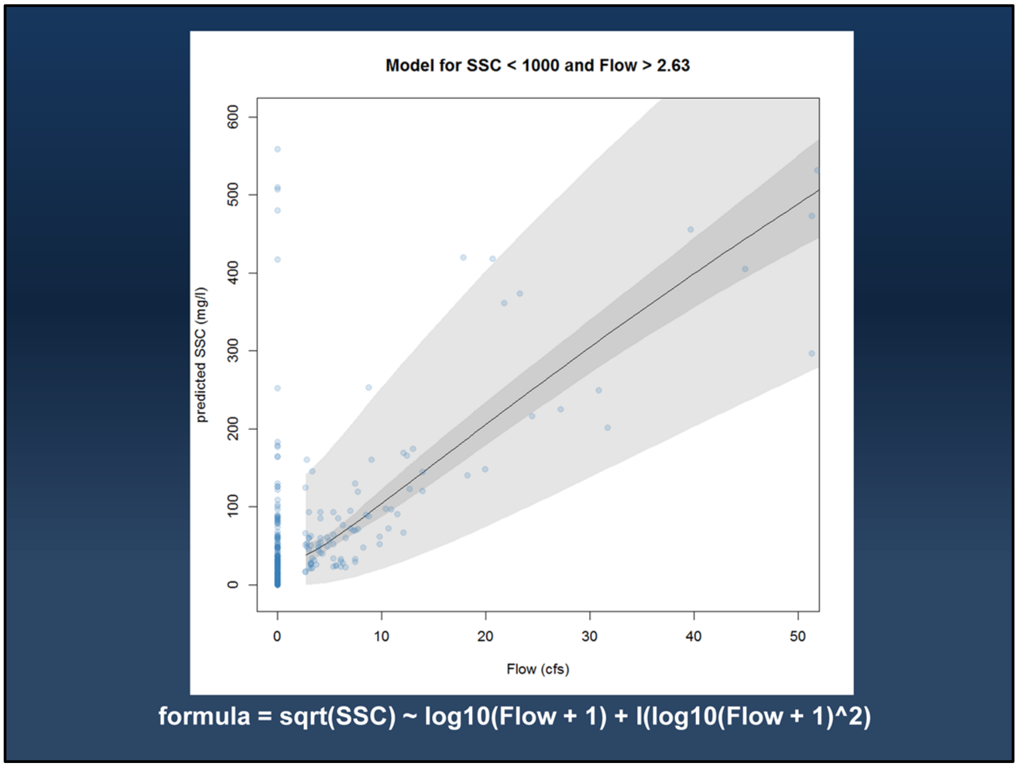
Modified the lab processing technique, use the ASTMD 3977-97 method with ability to conduct sand-fine split on samples. We participate in the USGS SLQA program.



Developed a model for the Post BMP dataset first. Model incorporated three variables into the Post BMP data modeling process: Flow Volume and rainfall as predictor variables, and SSC as a response. This graphic examines the relationships between transformed variables. SSC was transformed for normality, flow transformation improved linearity and predictive validity.

We had to instill a cutoff value for SSC due to problems associated with identified and presumed bed load contamination of samples. Experienced one major event where a restoration structure failed and wrapped a sandbag around our sampler intake. Based on SSC values from two operating simultaneously in nearby larger sub-watersheds, SSC values in excess of 1,000 mg/L were deemed unreliable. This criteria reduced our available pre project dataset by 11%, and post project dataset by 5%.

The model variables pointed to a problem in that there were non-zero SSC values in conditions where there were zero values for flow volume. ***(See these on the next slide.)***

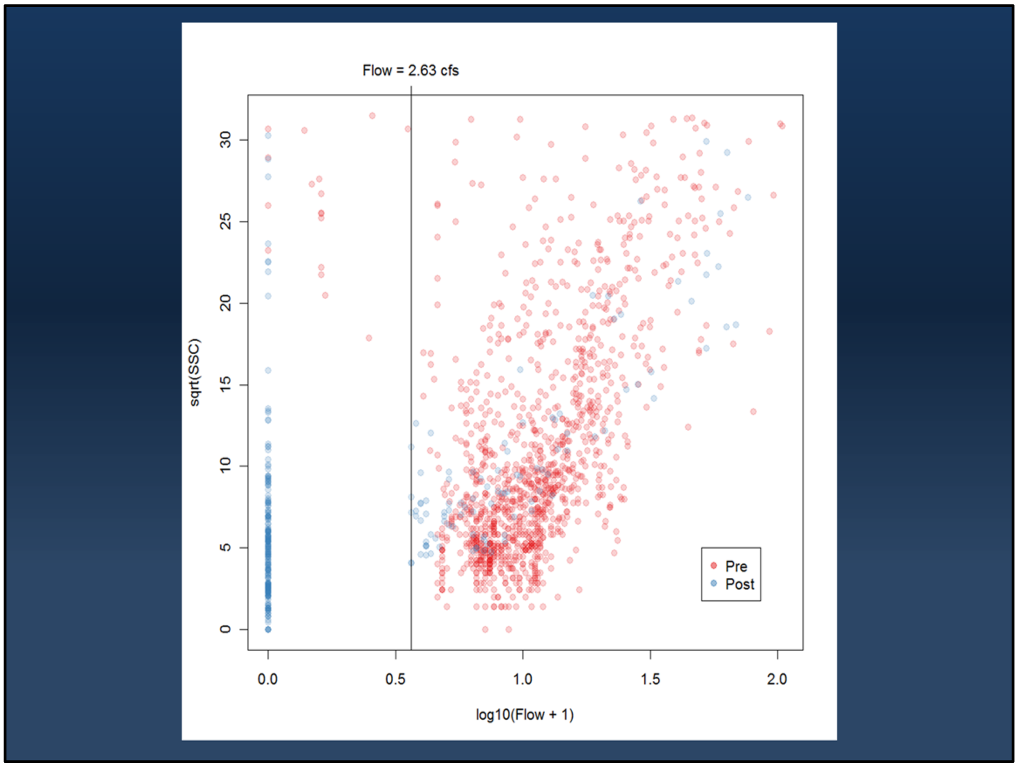


The lower limit for measureable flow volumes for the flume is 2.63 cfs, at approximately 0.20ft of gauge height. Configuration of the sampler intake allows for sample collection at and slightly below 0.20ft. Due to uncertainty in determining the actual flow volume at this height and inexplicable variability in SSC values, SSC values for flows less than 2.63 cfs were ultimately excluded from the model.

Initial model run using the POST project trimmed dataset with transformed variables demonstrated a high adjusted R-squared of 76%. But there was clear curvature in the residuals versus fitted values that suggested the need for a higher order term. Flow was given a higher order term to improve predictive ability and reduce bias across the range. Ultimately, rainfall did not prove to be a significant predictive variable, and was dropped from the model

The final model residual diagnostics appeared to satisfy modeling requirements. This final model achieved a very high R-sq (adj) = 79% indicating that a substantial fraction of the variability in SSC could be explained by Flow alone. These model results showed promise in evaluating the success of the project using similar methods. The dark grey bands indicate the 95% confidence interval, the light grey the prediction interval.

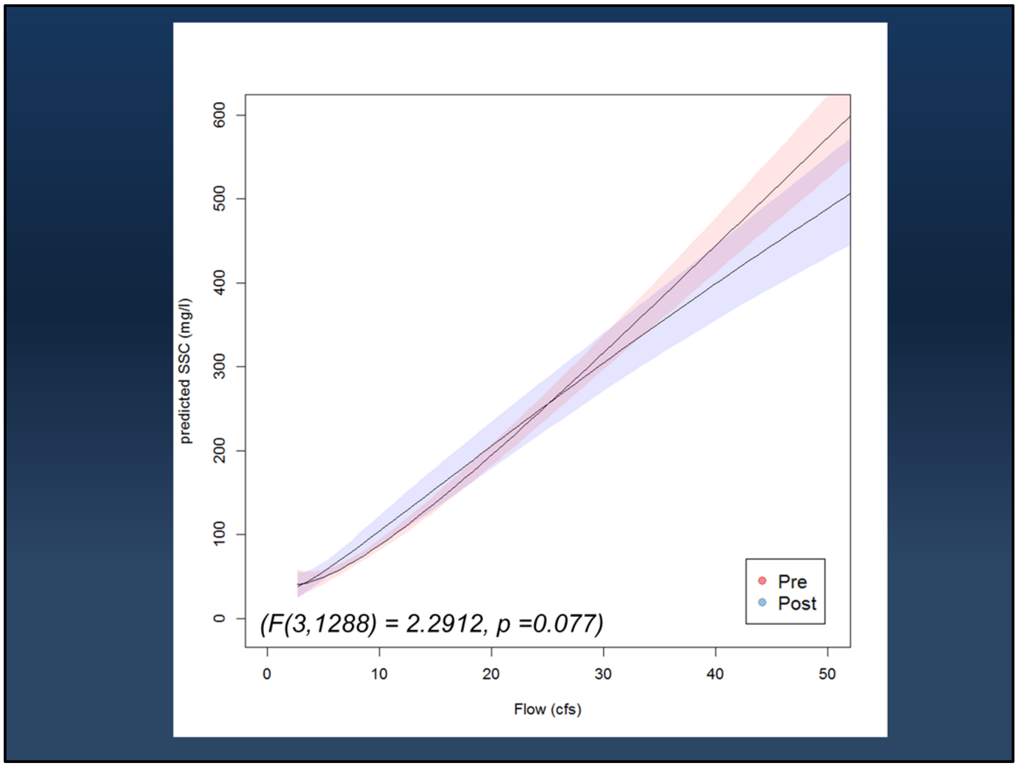
In this image, all the data is shown, although it isn’t all included in the model. Data at the zero mark on the X axis represents the SSC results generated below the spec of the flume, and was not included in the model.



Having established the model for Post Project data, the next step was to fit the Pre Project data to the model and test for differences.

There was substantially more variability in the Pre Project dataset, (more data, collected over a longer timeframe). Dataset was trimmed to exclude flow values below 2.63 cfs in both datasets, which were deemed highly unreliable. These are shown on the left side of the graphic.

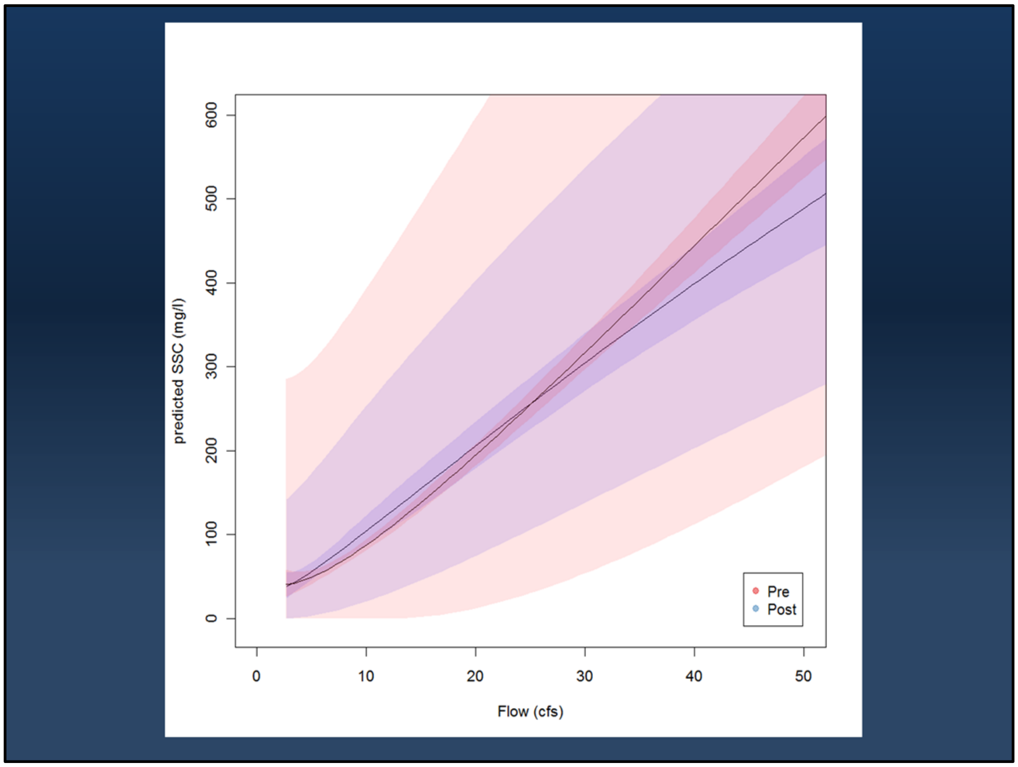
These data constraints allowed the incorporation of 88% of Pre project data, but only 42% of post project data.



This graphic displays the model outputs for both the pre project and post project data. The bands here represent the pre and post project confidence bands.

As you can see, the pre and post project confidence bands essentially overlap. Although there is some indication that SSC has been reduced at high flow volumes in the post project dataset. While not statistically significant this does provide some motivation for collecting further data.

A formal test to compare the models indicates that there is only weak evidence for a difference between the two (F(3,1288) = 2.2912, p =0.077) This indicates that the models based on the pre and post project data are statistically not distinguishable from each other with only three years of 'post project' monitoring.



This graphic illustrates both the confidence and prediction bands for pre and post project datasets.

The pre project data (red) has a very narrow confidence band (due to large sample size), but wide prediction band (due to highly variable SSC within the pre project dataset). Due to a lower sample size in post project data, and less variability in the results, there is a wider confidence interval, but narrower prediction interval.

Residual standard error in the Pre project data was 5.33 mg/L, whereas in Post Project data it was only 2.836 mg/L. Thus, the pre project data had a lower adjusted R-squared value of 41% in contrast to post project Adj R-squared of 79%.

High frequency data collection hasn't necessarily generated a greater volume of useable data. Normal to dry rainfall years don't allow for any data collection. This past winter left our county at "moderate drought" status, unlikely that any samples will meet model criteria.

Considering possibility of moving data into a SWAT model that has been developed for the Chorro Creek watershed, as a different means for modeling BMP effectiveness.

Clear that demonstrating success towards TMDL achievement in our area isn't straightforward. Need to consider other measures for evaluating positive effects of BMP implementation.