TABLE OF CONTENTS

Table of Contents

Introduction

Riparian forests, floodplains, and off-channel wetlands have also suffered degradation due to encroachment of residential and commercial development (Junior et al 2010). These ecosystems, which historically played pivotal roles in watershed hydrology, have been replaced largely by impervious surfaces (Roy et al 2003). This is because commercial and residential development results in vast increases in impervious surfaces, a key watershed health issue. An impervious surface is defined as "...any surface through which water cannot penetrate" such as, roads, parking lots, rooftops, etc. (Sleavin and Civco). Urbanization is inversely correlated with a decrease in the amount of open lands that can absorb and filter stormwater in unaltered ecosystems (e.g. forested lands, wetlands, prairies) (Brabec et al 2002). Declines in ecological integrity of stream ecosystems begin early on in development and increases with urbanization.

Urban development changes the fundamental hydrology of the region by altering the way water is received and stored. Small changes in inputs to streams can result in changes throughout the entire watershed. Numerous studies have implicated impervious surfaces as intensity indicators regarding urban development (Robson et al 2006, Boyd et al 1993, Junior et al 2010). Studies show there is a positive correlation with impervious surface presence and runoff (Boyd et al 1993, Junior et al 2010, Paul and Myer 2001). With an increase in impervious surfaces of 10%-20% the amount of surface runoff increases twofold. This impact increases threefold should the percent reach 35% (Paul and Myer 2001). This forces ecosystems to accommodate higher volumes of water at quicker rates.

These large quantities of water flood stream systems with more water than their hydrology can handle and exposes them to unfiltered contaminants. Common consequences of this include widening of streams, stream bank erosion, and heavy sedimentation loads (Paul and Myer 2001). Areas with heavy automobile use, such as roads and parking lots, can experience heavy metal, grease and hydrocarbon contamination into waterways (EPA 2012). These contaminates bind to sediment and then flow into receiving waters causing degradation downstream. As metals are washed into streams through surface runoff they can become trapped in the low-velocity heavy sediment areas of streams such as sand bars (Paul and Myer 2001). This can lead to long-term contamination degradation of physical habitat for stream biota (Roy et al.).

Due to the higher levels of contaminants, sensitive species may be unable to survive or adapt in within the changes in the ecosystem. Increased turbidity also increases stream temperature (EPA 2007). For species needing cold freshwater habitat, like salmonids, warmer temperatures have been shown to decrease egg survival, reduce fecundity, and reduce interspecies competition (Spence et al 1996). Sedimentation also directly degrades salmonid habitat by burying spawning gravels and limiting the production of aquatic insects for feed (Meyer 2002, Philips 1985). Studies show that salmonid behavior is directly affected by water clarity by reducing their feeding rates and fine sediments can smother eggs (EPA 2007, Lisle and Lewis 1992, Philips 1985, Stillwater Sciences 2010). Survival of salmonid embryos has been correlated with substrate and flow conditions (Lisle and Lewis 1992). It is expected that habitat degradation is the most significant contributor to declines in Salmon populations in the Pacific Northwest (Spence et al 1996).

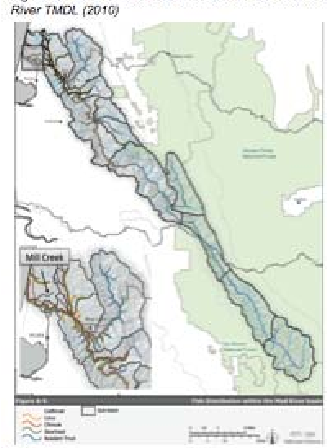
In California, Salmon are extinct in nearly 40 percent of the rivers they were known to historically inhabit (Northwest Power & Conservation Council 2008). Of those with remaining salmonid populations, many once abundant species have declined to such an extent that they are listed as either endangered or threatened under the Endangered Species Act (Stillwater Sciences 2010). Many of the rivers that once supported these massive salmonid populations have suffered the impacts of urbanization and degraded quality.

Formerly habitat to vast numbers of salmonid species, the Mad River in California, has experienced decline from historic numbers. Prior to the arrival of Euro-American settlers in the mid-1800s, the Wiyot occupied the lower Mad River (Figure 2). During this time of occupation "the population density in the North Coast Ranges during the ethnographic period equaled, or in some cases surpassed, the population density of the agricultural societies in other portions of aboriginal North America" (USDA Forest Service 1998). The Wiyot thrived off of the abundance They subsisted off salmon and steelhead from the Mad River, as well as deer and elk (Stillwater Sciences 2010). The Wiyot historically relied heavily on the ample fishery as a form of cultural identity as well as for subsistence (USFWS 2013)

In 1992, the Environmental Protection Agency added the Mad River to California's Clean Water Act Section 303(d) impaired water list due to turbidity and sedimentation. Local timber operations and road building are considered the manmade contributors to excessive sedimentation in waterways and the Mad River has been subject to both (Stillwater Sciences 2010). The North Coast Regional Water Quality Control Board (NCRWQCB) additionally added temperature as an impairment for the watershed in 2006.

The Mad River drains approximately 497 square miles of the Coast Range Geomorphic Providence and empties into the Pacific Ocean north of Humboldt Bay, in California (Stillwater Sciences 2010). Principal tributaries to the Mad River include South Fork Mad River, North Fork Mad River, Barry Creek, Pilot Creek, Deer Creek, Bug Creek, Graham Creek, Blue Slide Creek, Boulder Creek, Maple Creek, Canõn Creek, Lindsey Creek, and Mill Creek (Stillwater Sciences 2010). It is within one of these tributaries, Mill Creek, which we seek to investigate whether increased urban runoff may be degrading water quality (Figure 1).

Figure 1. Mill Creek and tributaries to the Mad River. *Mad River TMDL (2010)*



Site Location

Mill Creek flows through McKinleyville, an unincorporated community of approximately 15,000 residents. The boundaries of the region cover 12,000 acres (Mckinleyville Community Service District 2012). Within this area is parcel Chah-GAH-Cho is located in McKinleyville, along Mill Creek within the Mad River Watershed.

The Chah-GAH-Cho property is bound by Central Avenue to the east and Mill Creek Shopping Center and parcels set aside for future development to the north (Figure 3). Prior to construction of the shopping center, over eighty-five percent of the acreage was used for pasture. Red alder (*Alnus rubra*), California blackberry (*Rubus ursinus*), and seedling Douglas fir (*Pseudotsuga menziesii*) are rapidly encroaching on the open grassland. Himalaya blackberry (*Rubus discolor*), an aggressive invasive, is also established and spreading in disturbed areas, notably in the southeast quarter of the site (Chah-GAH-Cho Plan). In the southeast corner of the Chah-GAH-Cho property (Figure 2) there is a small spring-fed wetland. South of the wetland, a gully drains water into a drainage ditch ,which runs parallel to Turner Road and ultimately empties into Mill Creek.

Figure 2. Chah-GAH-Cho Property boundary.

Mckinleyville Land Trust

Urban development sparked the creation of The McKinleyville Land Trust (MLT). Development for the now existing Mill Creek Shopping Center operations resulted in massive sediment inflows during a winter rain event (Dunk pers. comm). The construction company, Browman Development Company, was accused of inadequately winterizing their operations and sued by “Concerned Citizens of McKinleyville.” The lawsuit was eventually settled resulting in nine acres behind the shopping center for a land conservation agency. This parcel, named and Chah-GAH-Cho, means “a sacred place” in reference to nearby Turner Falls, McKinleyville’s only waterfall (Correll pers. Comm.). The language is taken from the Wiyot tribe to honor their historical presence in the region. The MLT “promotes voluntary conservation of land for nature, timber, agriculture, education, recreation, history, and scenery” (McKinleyville Land Trust Mission Statement).

Problem Statement and Background

In the 1990’s after runoff from construction operations polluted Mill Creek, a group of concerned citizens took legal action against Browman Development Company. During litigation a settlement was agreed upon by both parties. There is a need to verify whether Browman Development Company did comply with this agreement.

Constraints

Our project is limited by a lack of documentation and information. The original settlement was in 1992. Since then, it seems, the project has not been a priority and therefore has been neglected from being followed up on sooner.

During the time of this study, no monitoring plans have been found by the Department of Fish and Wildlife. These plans were to be submitted as per the conditions of the settlement between the “Concerned Citizens of Mckinleyville” and the Browman Development Company. It is unclear to whether these plans were not submitted or lost over the years.

Perhaps the biggest limitation of our study is that the drainage pipe from the shopping center is not exclusively used by the shopping center. Upstream facilities also use the drainage pipes that go into Mill Creek. To the best of our ability, our study can only estimate the effects of the shopping center by investigating and postulating the likely runoff from these other facilities. Due to the later construction date of the facilities compared with other business along Central Avenue and the absents of observable sediment and grease traps we assume that the Mill Creek shopping center would be a substantial contributor to contaminants found in Mill Creek

Due to the short duration of this study, continued monitoring by the McKinleyville Land Trust or another party would enable more precision in determining sources of contamination. We will never be able to unambiguously determine a cause-and-effect relationship because true replication cannot occur (Smith et al 2011). It is based on this that premise, that our project seeks to investigate and identify potential impacts to Mill Creek that can occur to better narrow down these pollutants.

Objectives

1. The objective of this project is to determine whether the construction of the Mill Creek Shopping Center complied with the settlement agreement and included the addition of sediment and grease traps on the property.
2. Within this objective we hope to locate the missing maintenance schedule for these traps, should it exist, and share it with the Department of Fish and Wildlife that was supposed to receive a copy once construction was completed.
3. Additionally, once potential runoff locations are found, water quality tests will be conducted to determine the types of contaminants that could flow into Mill Creek.
4. Based on the results, we will include recommendations for the Mill Creek shopping center to better mitigate for these contaminants into the creek in the future.

Methods

Sampling was conducted within three locations along Mill Creek (Figure 1). The upstream site was located a few miles upstream on Azalea Road (40.931902,-124.081738). This region had with limited development compared with the downstream location. The transect began at the culvert on the west side of Azalea Road. The stream depth at the deepest point was about 12 inches with a low gradient and flow.

Our second site, called our "midpoint" (40.930208,-124.10146) is located west of Central Avenue upstream of the discharge pipe outlet on Turner Road. This site was sampled due to assess potential impacts from Central Avenue that may affect the stream. The water sampled is still upstream from where the discharge pipe discharges into Mill Creek. The downstream site (40.929759,-124.102055) is 400 feet further west from the midpoint location, downstream of discharge pipe . Both site's water depths were between 8 to 24" inches, with a low gradient and flow. Samples from all three sites were taken about 10 feet apart in oxygenated, rocky areas.

Figure 3. Map of McKinleyville, California. Solid circles indicate sampling locations.

A 16 x 9" rectangular kick net was used to collect specimens. The net was held against the streambed while one person agitated the streambed upstream allowing specimens to flow into the net. Three kicks lasting 60 seconds each were conducted at all three sites, starting downstream and working upward. Specimens were placed in 16 oz. jars filled with 75% ethanol. Samples were then taken to the lab, and evaluated under a dissecting microscope to key to order and family. The macroinvertebrate key used for identification was "An Introduction to the Aquatic Insects of North American Guide." We then used Hilsenholf's "List of Californian Macroinvertebrate Taxa and Standard Taxonomic Effort," to create a

Hilsenhoff Biological Index. Tolerance values of each taxa were assigned and multiplied by number of species found. Each specimen's individual value rating was then divided by all specimens found at the site to determine a water quality rating.

Water quality sampling was conducted at the same three sites as benthic macro invertebrate testing and included one additional site. The additional site is located adjacent to Mill Creek in the V-ditch across Turner Road. The V-ditch was chosen as an additional site due to the fact that it is the discharge location for storm water runoff of the Mill Creek Shopping Center and other businesses along Central Avenue. Testing of the V-ditch site was conducted in a pool of standing water about one meter from the discharge pipe and during a first flush rain event. All four sites were tested for pH, dissolved oxygen, heavy metals, and turbidity. After testing of a site was concluded using the pH meter and the dissolved oxygen meter both probes were rinsed with distilled water to prevent any residue from altering the results of another test site. All meters were collaborated before testing to ensure accurate results.

The pH tests were conducted using an OAKTON PH 110 series handheld electronic PH meter. Each site was tested before a rain event and after a rain event. The probe was submerged until the PH readings stabilized producing a result. Each site was tested three times to compensate for any possible anomalies during testing.

Dissolved oxygen testing was conducted using an YSI Pro-ODO handheld digital dissolved oxygen meter. Three samples were taken from each to offset for any possible anomalies during testing. As with the PH meter, the probe was submerged until readings stabilized and a result was given.

Heavy metal samples were collected using sterilized 50 ml vials. Four samples were taken across the width of each site. Sterile gloves were used during collection at each site to prevent any cross contamination between sites. Samples were taken to the biology lab for testing of the presence of heavy metals. The metals tested for were Nickel (Ni), Copper (Cu), Cadmium (Cd), and Lead (Pb). Water samples were analyzed using a PerkinElmer Atomic Absorption Spectrometer AAnalyst 400 machine.

The Turbidity test was conducted using HACH 2100Q handheld digital meter. Testing was conducted before a rain event and after a rain event. A vial from the meter's kit was utilized to collect a water sample from each site. Each sample was tested three times using three different settings. The first test setting used was the 'default' setting, which takes three readings and averages the results. The second setting was the 'signal average' setting. This setting compensates for reading fluctuations caused by drifting sample particles through the light path and takes 12 readings which are then averaged to produce a final result. The last setting used was the 'rapidly settling turbidity' mode, which calculates and continuously updates the turbidity reading of the sample to a confidence level of 95% based on the accumulated trend of the real time measured values. This setting yields results based on five readings. These three settings where used to provide an overall average of results due to possible inaccuracies of the default setting.

Results

Heavy Metals

Nickel (Ni)

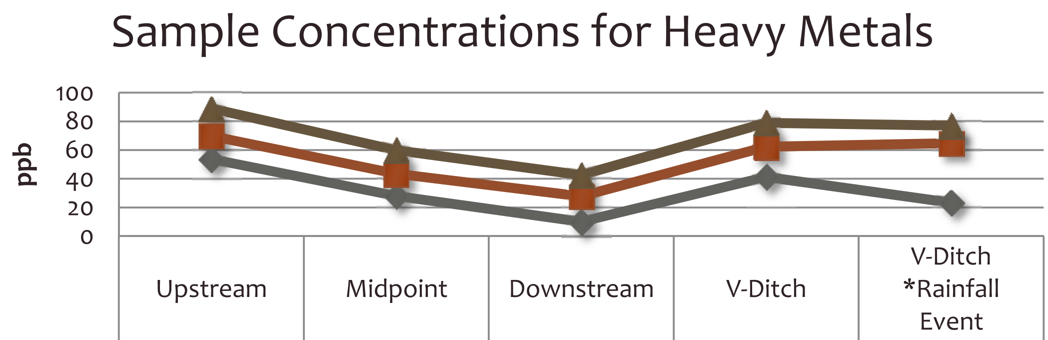
Results from the Ni testing yielded the highest concentrations within the control site and the V-ditch at 53.8 parts per billion (ppb) and 41.3 ppb. Due to the unusually high amounts of NI within the control site we have determined that an error occurred during testing. The control site was tested last and we hypothesize that the results drifted causing an error in the results. Otherwise as we expected the V-ditch contained the highest amounts of Ni at 41.3 ppb. With sites 2 and 3 yielding results of .028 ppm and .01 ppm.

Results from the copper testing yielded traces of copper (Cu) throughout all sites. Concentrations within Sites 1-3 were within the range of 15-17 ppb, with higher concentrations within the V-ditch at 21 ppb and .42 ppb.

Lead (Pb)

Results from the Pb testing yielded the highest concentration at the upstream site (191.8 ppb) and decreased progressively in both downstream sites 147.8 ppb. The V-ditch site yielded lower Pb results during both sampling periods (16.65 ppb and 12.28 ppb).

Figure 4. Concentrations of Nickel (Ni), Copper (Cu), and Lead (Pb) taken at Mill Creek, measured in ppb



	Upstream	Midpoint	Downstream	V-Ditch	V-Ditch *Rainfall Event
Pb	19.18	16.4	14.78	16.65	12.28
Cu	16	15.5	17.8	21	41.5
Ni	53.8	28	10	41.3	23.3

Dissolved Oxygen

The average dissolved oxygen levels found at sites 1-3 varied from 11.63-11.88 mg/L at an average temperature of 10.8° C. The V-ditch was found to have a dissolved oxygen level of 9.7 mg/L at a temperature of 12.7° C.

Dissolved Oxygen	Test #1	Test #2	Test # 3	**Average**
Upstream	10.7° C	10.8° C	10.5° C	10.7° C
	11.88	11.87	11.89	11.88
Mid-Point	10.8° C	10.8° C	10.8° C	10.8° C
	11.64	11.63	11.63	11.63
Downstream	10.7° C	10.7° C	10.7° C	10.7° C
	11.65	11.65	11.64	11.65
V-Ditch	12.6° C	12.8° C	12.7° C	12.7° C
	9.62	10.03	9.45	9.7

Table 1. Dissolved Oxygen Measurements at three Site Locations measured in mg/L

Turbidity

Turbidity measurements slightly increased downstream from our control (Site 1). The control site measured at 5.31 NTU. The Mid-Point (Site 2) measured at 5.52 NTU and Downstream (Site 3) at 5.81 NTU. The V-Ditch had the lowest turbidity readings at 2.14 NTU. Rainfall turbidity measurements increased in all locations. The V-Ditch measurement increased the most from 2.14 NTU to 26.21 NTU.

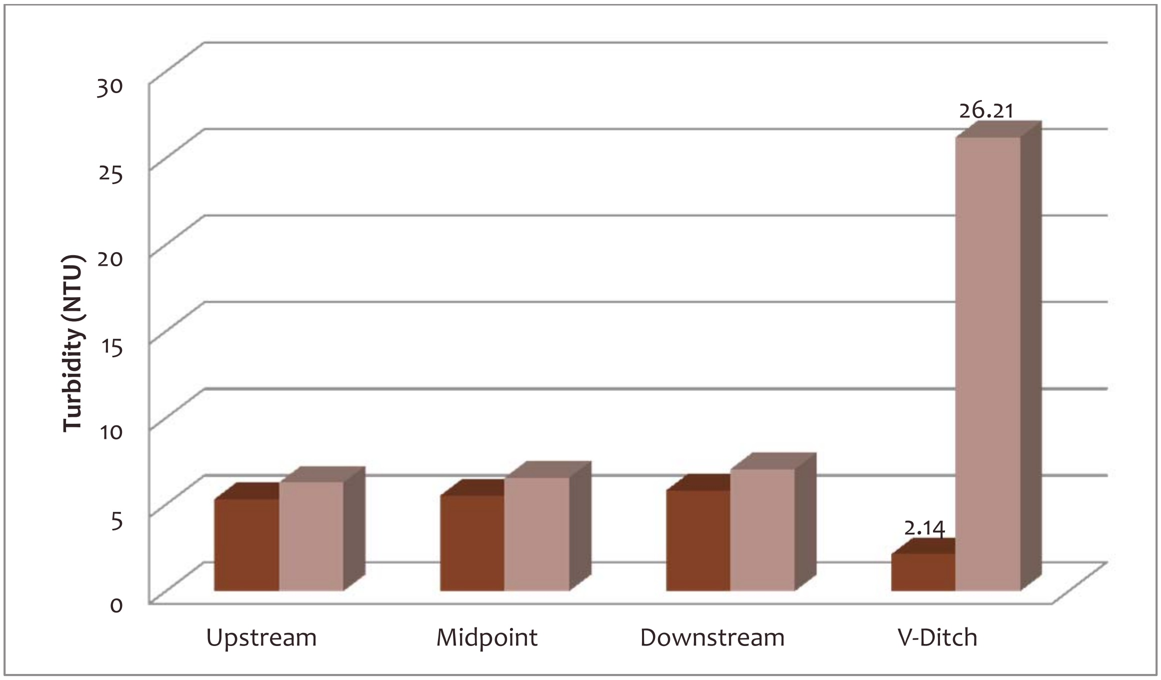


Figure 5. Turbidity comparisons between rainfall and dry event.

pH

Initial pH testing showed variability between site locations in pH. The control (Upstream) measured with a pH of 6.83. Our downstream site (Site 3) had a lower pH of 6.8. Midpoint site (site 2) and the V-ditch were more alkaline. Following a rainfall event, the results from pH testing show increases in all other sites when compared with control (Upstream).

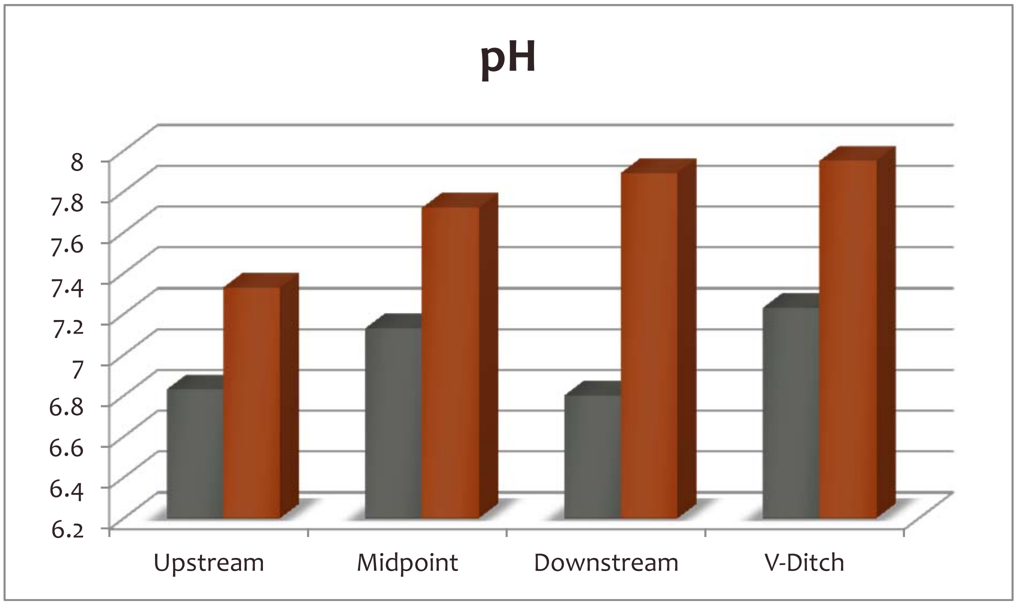


Figure 5. pH comparison between sites before and after a rainfall event.

Macroinvertebrates

Results for all three sites showed that water quality in Mill Creek is fell within the "excellent" category in the Hilsenhoff Biotic Index. Taxa richness was most reduced at the Mid-Point. Surprisingly, Taxa evenness was lowest at the Upstream location, but we believe this is likely due to the abundance of one single species, and biased the sample.

Taxa	Tolerance Level	Upstream	Midpoint	Downstream
Ephemoeroptera				
Baetidae	4	1	21	**16**
Heptagenidae	4	55	63	**9**
Plecoptera				
Leuctridae	0	2		
Nemouridae	2	13	19	**23**
Perlodidae	2	1	11	**5**
Trichoptera				
Brachycentridae	1		7	**7**
Hydrobiosidae	4	1		
Hydropsychidae	4	1		**1**

Odontoceridae	0	65		
Amphipoda				
Gammaridae	6	81	52	**29**
Coleoptera				
Elimidae	2	2	1	
Diptera				
Chironomidae	6	1		
Tipulidae	3			**4**
Gastropoda	6	2	6	**4**
Oligochaeta	5	11	2	**9**
Nematocera	n/a	1		**4**
Collembola				
Poduridae	n/a	1		
SUM		238	182	**107**
HBI		**3.48**	**4.19**	**3.94**
% EPT		**58.40**	**62.64**	**50.47**
Taxa Richness		**13**	**9**	**11**
Taxa Evenness		**2.52**	**34.62**	**27.10**

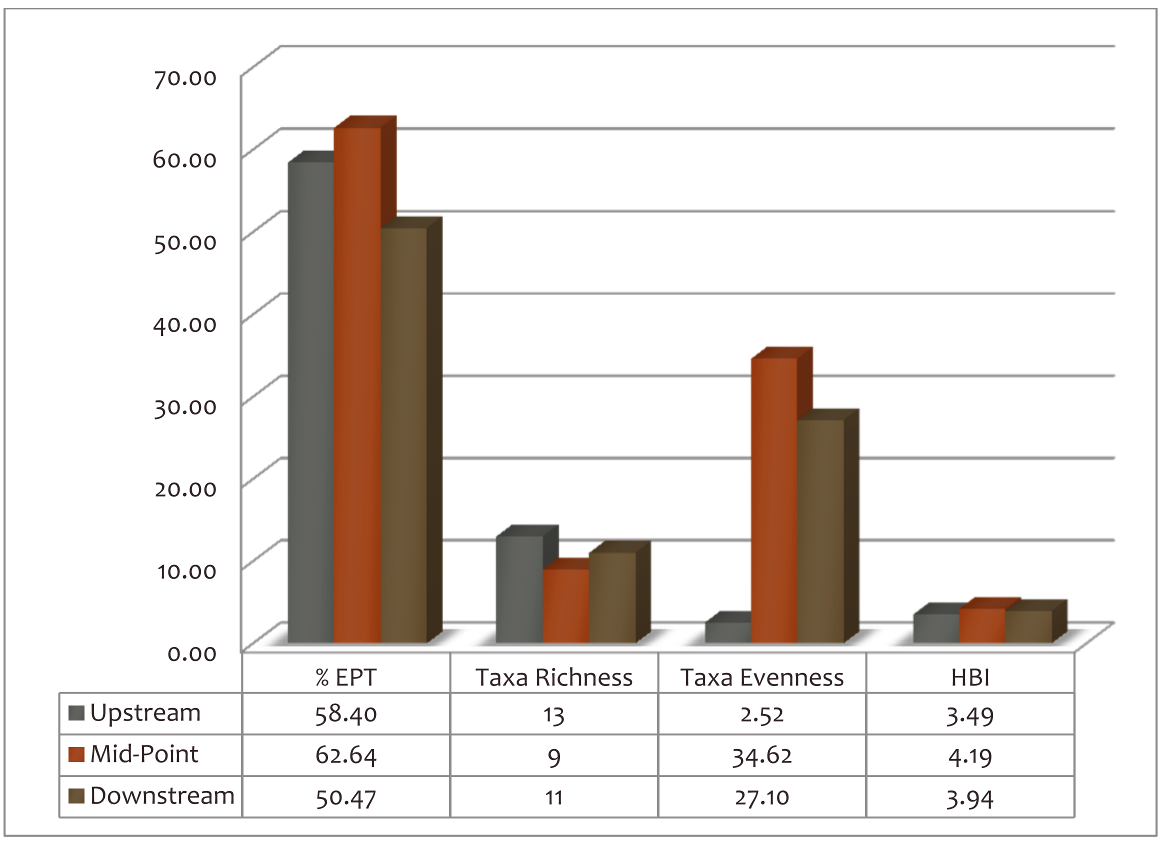


Figure 6. Biodiversity comparison between site locations.

Discussion

It is the conclusion of this report that we did not find sediment or grease traps on the Mill Creek Shopping Center Property. Blueprints held at Eureka Public Works did not show traps included in either the construction plans or in the “as-built” plans. After contacting the California Department of Fish and Wildlife we were unable to find any sort of maintenance schedule for these traps, although they did state that they may have been misplaced. After contacting the Browman Development Company Darrel Browman stated that they do have an oil water separator and that it is being maintained by a contracted company. Darrel Browman provided us with the contact person within the Browman Company who is responsible for the oil water separator upkeep, but after multiple attempts to contact that employee to get specific information about the device we received no response.

Water quality data provides critical information regarding the health of a catchment. Water quality data were not collected prior to the shopping center’s construction, making it difficult to ascertain historic conditions. This, along with increased urbanization since construction, makes it difficult for us to make any substantive conclusions regarding the Mill Creek Shopping Center's specific impacts on Mill Creek. Future water quality monitoring could provide more conclusive data and give a better understanding of the possible contamination sources flowing into Mill Creek. This information would also be useful for the implementation of management strategies and an increasing understanding of the ecological condition of Mill Creek (Lessels and Bishop 2013). Perhaps most importantly, more water quality data can assess whether pollutants violate state or federal standards and whether regulatory agencies, such as the California Department of Fish and Wildlife, should intervene.

While the proportion of pollution due to presence of the Mill Creek Shopping Center cannot be determined from the data, water quality and macroinvertebrate assessment indicate that Mill Creek is suffering from anthropogenic activities. It is highly likely that increased urbanization is responsible as both the source and the mechanism for transport of chemical and biotic contaminant. Due to the short time frame of this study, it is not yet possible to yield a specific determination that the Mill Creek Shopping Center is exclusively responsible for effluence entering Mill Creek.

Dissolved Oxygen (DO)

The stream temperature of the sites tested at Mill Creek are within limits of survivability for all salmon species within the northern California area, considering the temperature upper limits of survivability for salmon species are between 13 and 16 degrees Celsius (Azuma et al 2007). Dissolved oxygen levels found within site 1-3 were found to be within healthy ranges. Salmon can effected by dissolved oxygen levels below 9 mg/L, but given these levels were all higher than 11 mg/L effects are not likely (CA Water Resource Control Board 2004). Levels within the V-ditch are near the harmful level of 9 mg/L and the upper limits of temperature for salmon survivability. As a whole temperature and dissolved oxygen levels are likely to not affect aquatic organisms such, as salmon.

According to the United States Environmental Protection Agency, dissolved oxygen (DO) when influenced by anthropogenic inputs can result in an increased Biological Oxygen Demands (BOD) (USEPA 2012). An increase in BODs can reduce the amount of oxygen available in the stream and negatively affect the biotic community. Since DO readings fluctuate seasonally and over a 24-hour period, more can be ascertained through longer sampling periods that include multiple seasons. For the purpose of this study, we would recommend increased DO measurements at Mill Creek in order to understand annual DO variations.

pH

Our pH readings at our sampling locations did not show any substantive adverse impacts from contaminants. While a pH of 7 is considered to be neutral, most natural waters have pH values that fall between 6.5 and 8.5 (Dave 2005). None of our samples fell outside of this range. pH was tested twice in the study, secondly after a rainfall event. Results indicate that pH increased after a rainfall event.

However, pH measurements can serve as simple and quick indicators of possible contamination. Contaminants that can contribute to alkaline pH include nitrogen compounds, boron, phosphorus, and potassium (Schwarzenbach et al. 2003). Studies have shown that mercury concentrations have increased with decreases in pH (Moore et al 2009). pH variations can serve as an indicator whether more extensive testing should be conducted.

Turbidity

Turbidity readings indicate that Mill Creek may have increased turbidity and Total suspended solids (TSS). Reducing potential inputs that affect turbidity will: increase water clarity and provide better fish visibility, increase aquatic plant presence with greater light penetration, increase oxygen concentrations, and reduce sedimentation and stress on benthic stream biota. It has been shown that higher turbidity can indicate fecal bacteria presence. California forested lands has requirements that vary from a 1 NTU increase from background data to a 20% NTU above background data. Unfortunately, there has not been consistent testing at this location to determine background data for this assessment.

Heavy Metals

The results from water testing of heavy metals yielded concentrations of Nickel (Ni), Copper (Cu), and Lead (Pb) within each site (Table 3). Cadmium (Cd) was found to be absent from each site and therefore excluded as a probable pollutant.

Nickel (Ni)

Based on our results contamination levels have been found to be very low. Nickel has an LC50 (Lethal Concentrations to 50% of population) for most fish species at contamination levels of 4-14 parts per million (ppm) with a duration of 96 hours within soft water and an LC50 of 24-44 ppm for a duration of 96 hours in hard water (Eisler 1998). Based on the lethal nickel levels stated, nickel concentrations currently in Mill Creek are within safe levels and will have no adverse effect on aquatic organism. The toxic effects of nickel are influenced by pH. Nickel has been determined at being most lethal at pH of 8.3 and having the lowest impact at a pH of 6.3 (Eisler 1998).

Copper (Cu)

Cu contamination can have multiple effects on salmonids. Contamination can affect salmonids sensory abilities leading to an interruption of spawning migrations, can affect growth, and can be lethal depending on the dose and duration of exposure. The LC50 of dissolved copper, above a background concentration of led set at 3 ppb for the study we used, for adult Coho salmon are 46 ppb and 57 ppb for adult Steelhead, both at a 96 hour exposure (Hecht et al 2007). The dissolved copper LC50 for Chinook salmon fry is 19 ppb, for Coho salmon fry is 28-38 ppb, and Steelhead and Rainbow trout fry is 9-17 ppb, all at an exposures of 96 hours (Hecht et al 2007). Given these levels of lethality copper levels within Mill Creek are likely not be lethal to adult Coho salmon and Steelhead, but could possibly be lethal to Steelhead and Rainbow trout fry. Due to the fact that the samples tested were not filtered before testing, the dissolved Cu could be lower than the yielded Cu concentrations. Cu levels at Mill Creek are not projected to be lethal to Steelhead and Rainbow trout fry. The V-ditch Cu levels are within lethal ranges for fry within the four species listed above, but are below lethal ranges for adult Coho salmon and Steelhead. These V-ditch levels can be potentially dangerous during a first flush depending on the level of contamination and the duration of exposure to fry.

Lead (Pb)

The Pb results yielded may not have an effect on certain aquatic organism, such as mayflies (Ephemoroptera). Studies have shown that mayfly molting rates can be affected when exposed to lead rates of 664 ppb for a duration of 96 hours (Mebane et al 2008). With rainbow trout, effects have been observed during constant exposure to lead within the early life stages at concentrations of 12-384 ppb (Mebane et al 2008). This effect was caused by constant exposure and water hardness of 20 ppm. Lead contamination can have increasing effects depending on pH, water temperature, and hardness of water (Eisler 1988). Given these factors effects may increase or decrease throughout the year as water temperature and pH fluctuate. This factor illustrates the importance of baseline data and testing throughout the year. Given that results were found to be relatively low when compared to concentration effects stated above it is not likely that aquatic organisms will be affected by the levels found during testing.

Benthic Macroinvertebrate Assessment

While the previous water quality information can be used as indicators of ecosystem structure, macroinvertebrate sampling can indicate both function and services. Measurements of physicochemical variables only reflect conditions at the time the sample is taken. Monitoring biotic communities can be a more useful tool in assessing ecosystem health both spatially and temporally (Carter et al 2006). Since macroinvertebrate communities are a central component of stream food webs they are pivotal in comprehensive impact analysis (Carter et al 2006). The abundance, richness, and evenness of assemblages can all be examined in water quality studies. Additionally, invertebrate monitoring is low cost and has had success with volunteer monitoring.

Recommendations

In light of the need for verification regarding whether or not the traps exist as per the settlement agreement, we have divided our recommendations for either scenario.

If Traps are Present

- The MLT should contact BDC to obtain a copy of the maintenance schedule. This may be conducted personally or perhaps at the request of the Department of Fish and Wildlife.
- Continue monitoring for water quality
- Assess whether the traps accommodate for Phase II permitting

If Traps are not Present

- It is our recommendation that the MLT should contact the North Coast Regional Water Quality Board Office of Enforcement regarding a potential violation of Phase II permitting. .
- If desired, the MLT would have standing to pursue litigation regarding violations to the settlement agreement.

Phase II permitting stipulates that commercial sites within Phase II municipalities must use best management practices (e.g. oil water separator) to treat the 85 percentile of rain during a storm event. If commercial sites are not treating this 85 percentile of rain then they are in violation of the Phase II permit.

Based on our study's findings additional monitoring is recommended for either scenario in order to provide establish background information and to assess whether state or federal standards are being violated.

Monitoring Recommendations

Based on our study's findings additional monitoring is recommended for either scenario in order to provide establish background information and to assess whether state or federal standards are being violated.

It is our recommendation that monitoring be conducted adjacent to Central Avenue (where the drainage occurs) to better indicate the impacts of urbanization on the creek's health. Without consistent, regular, and long-term gathering of data analysis management may be insufficient and ineffective. Samplers should operate using standard operating procedures based on state and national standards.

In light of possible limitations regarding monitoring resources and funding, we have prioritized parameters for monitoring based on necessities and likely impacts from the Mill Creek Shopping Center. Monitoring should be routine but also include event-based sampling in order to fully capture the inputs into Mill Creek. While monitoring date, time, and weather conditions should be recorded for measurements that exceed guidelines. If possible take photos of sampled sites. Include a description of the location, compass bearing, and any additional notes.

Based on our assessment we recommend monitoring for the following parameters: turbidity, heavy metals (such as nickel, copper, lead, and mercury), pH, and Dissolved Oxygen.

Monitoring Parameters (based on impact analysis)

Priority Parameter

- Turbidity

Additional Parameters

- Heavy Metals
- Dissolved Oxygen
- pH

Additionally, we believe that this is a great way to incorporate the community. Grassroots monitoring has been shown to increase public interest and involvement and several studies have found that given training volunteers can collect high quality data

(Fore et al 2001). Grassroots monitoring (aka “public participation” or “community monitoring”) has been deemed by the United Nations Environmental Programme as an essential component of sustainable development (Sharpe and Conrad 2006). This data can substitute for information that is typically collected by governmental agencies to establish background conditions and identify ecosystem changes. Increasing public awareness about natural resources can help ensure their protection in the future.

References

Andews et al. “A Methodology for Evaluating and Ranking Water Quality Indicators of Ecosystem-Based Management.” *Environmental Management*. 49:3 (2012) 703-719.

Azumaya, T. & Nagasawa, T. & Temnykh, O.S. et al. “Regional and Seasonal Differences in Temperature and Salinity Limitations of Pacific Salmon (*Oncorhynchus* spp.). *North Pacific Anadromous Fish Commission*. 4 (2007) 179-187. Web.

Cafaro, P. and E. Crist. 2012. Life on the Brink. University of Georgia Press. 331 pgs.

Carle et al. “Patterns of Watershed Urbanization and Impacts on Water Quality.” Journal of the American Water Resources Association. 41:3 (2005) 693-708.

“The Clean Water Team Guidance Compendium for Watershed Monitoring and Assessment: Dissolved Oxygen Fact Sheet”. *CA State Water Resource and Control Board*. 29 September 2004. Web.

Dave, Joseph. “What’s the real pH of that Stream?” Chemical Engineering. 112:3 (2005) 60-62.

Department of Parks & Recreation. “Parks and Recreation Master Plan”. *McKinleyville Community Services District*. May 2, 2012. Web

Eisler, Ronald. “Lead Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review”. *U.S. Fish and Wildlife Service*. Biological Science Report 85(1.14). 1988. Web.

Eisler, Ronald. “Nickel Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review”. *U.S. Geological Survey*. Biological Science Report No. 34. April 1998. Web.

Environmental Protection Agency. "Controlling Nonpoint Source Runoff Pollution from Roads, Highways and Bridges". 1995.

Fore et al. "Assessing the performance of volunteers in monitoring streams." *Freshwater Biology*. 46 (2001) 109-123.

Lisle, T. E., and J. Lewis. 1992. "Effects of sediment transport on survival of salmonid embryos in a natural stream: a simulation approach." *Aquatic Sciences.* 49: 2337-2344.

Mad River Alliance. Nd. The Mad River. http://madriveralliance.org/the-mad-river/

"List of Californian Macroinvertebrate Taxa and Standard Taxonomic Effort" 1987. Hilsenhoff Biological Index.
http://www.safit.org/Docs/CABW_std_taxonomic_effort.pdf

Mad River watershed assessment. 2010. Final report. Prepared by Stillwater Sciences, Arcata, California in association with Redwood Community Action Agency, and Natural Resources Management Corp. Eureka, California.

Mallin et al. "Comparative impacts of stormwater runoff on water quality of an urban, a suburban, and a rural stream." Environmental Monitoring and Assessment. 159:4 (2009) 475-91.

Maniquiz et al. "Long-Term Monitoring of Infiltration Trench for Nonpoint Source Pollution Control." *Water, Air, & Soil Pollution.* 212 (2010) 13-26.

McCabe, Decaln J. & Gotelli, Nicholas J. "Effects of Disturbance Frequency, Intensity, and Area on Assemblages of Stream Macroinvertebrates". *Oecologia* Vol. 124 (2000): 270–279.

McKinleyville Land Trust. "Chah-GAH-Cho Plan".

Mebane, Christopher A., Hennessy, Daniel P. & Frank S. Dillon. "Developing Acute-to-chronic Toxicity Ratios for Lead, Cadmium, and Zinc using Rainbow Trout, a Mayfly, and a Midge". *Water, Air, and Soil Pollution*. Vol.188 (2008):41-66. Web.

Merritt, R.W., Cummins, K.W. &M.B. *An Introduction to the Aquatic Insects of North America*. U.S.: Kendal/Hunt Publishing, 2008. Print.

Moore et al. "Relationship between pH and stream water total mercury concentrations in Shenandoah National Park." *Water, Air, and Soil Pollution.* 201:1 (2009) 233-238.

Northwest Power & Conservation Council. "Extinction." (Nov. 6, 2008) Accessed December 6, 2013: http://www.nwcouncil.org/history/Extinction.asp

Phillips, Glen. "Metals Concentrations and Stream Discharge in the Upper Clark Fork River." Clark Fork River Symposium. Montana Academy of Sciences, Montana College of Mineral Science and Technology. Butte, Montana.

Schwarzenbach et al. (2003). *Environmental Organic Chemistry, 2nd Ed.*

Sharpe, Andy and Cathy Conrad. "Community Based Ecological Monitoring in Nova Scotia: Challenges and Opportunities." *Environmental Monitoring and Assessment*. 113:3 (2006) 395-409.

Sleavin, William J. & Civco, Daniel L. "Measuring Impervious Surfaces for Non-Point Source Pollution Modeling". Department of Natural Resources Management and Engineering. The University of Connecticut.

Smith et al. "Long-Term Benthic Macroinvertebrate Community Monitoring to Assess Pollution Abatement Effectiveness." *Environmental Management.* 47:6 (2011) 1077-1095.

Spence et al. (1996) "An Ecosystem Approach to Salmonid Conservation." ManTech Environmental Research Services Corp., Corvallis, OR.

U.S. Environmental Protection Agency (2007). "Mad River Total Maximum Daily Loads for Sediment and Turbidity." U.S. Environmental Protection Agency Region IX.

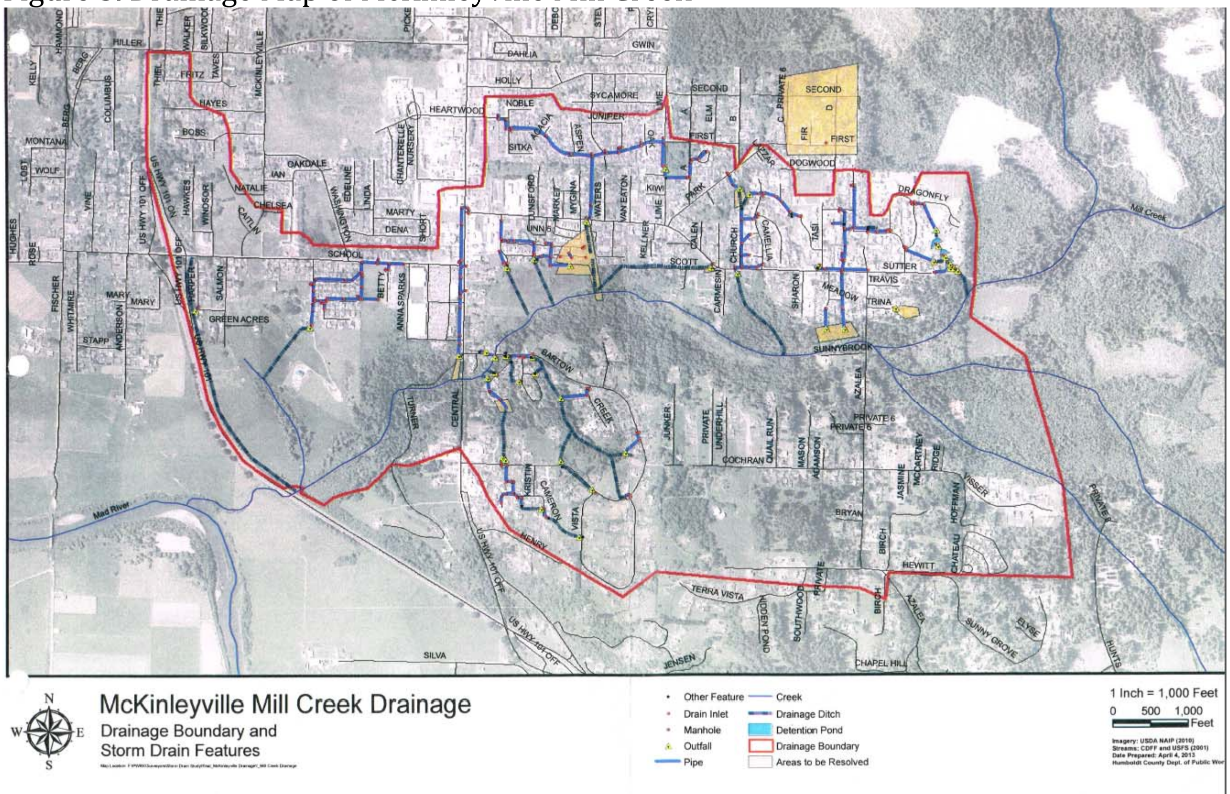
United States Environmental Protection Agency. (March 2012) "5.1 Dissolved Oxygen and Biochemical Oxygen Demand." Accessed November 21, 2013: http://water.epa.gov/type/rsl/monitoring/vms52.cfm

United States Fish and Wildlife Services (May 2013). "Wiyot Tribe." Accessed November 14, 2013: http://www.fws.gov/refuge/Humboldt_Bay/WiyotTribe.html

Zeyuan, Qiu. "Comparative Assessment of Stormwater and Nonpoint source pollution best management practices in suburban watershed management." *Water*. 5 (2013) 280-291

Tables & Figures

Figure 5. Drainage Map of McKinleyville Mill Creek



upstream site

)  midpoint

 downstream

 v-ditch

Appendix.

Water Quality Results.

Dissolved Oxygen	Test #1	Test #2	Test # 3	Average
	10.7° C	10.8° C	10.5° C	**10.7° C**
Site #1 (Control)	11.88 mg/L	11.87	11.89	**11.88**
	10.8° C	10.8° C	10.8° C	**10.8° C**
Site #2 (Mid-Point)	11.64	11.63	11.63	**11.63**
	10.7° C	10.7° C	10.7° C	**10.7° C**
Site #3 (Lower)	11.65	11.65	11.64	**11.65**
	12.6° C	12.8° C	12.7° C	**12.7° C**
V-Ditch	9.62	10.03	9.45	**9.7**
Turbidity	Default Setting	Signal Average	Rapid Settling Turbidity Mode	**Average**
	5.39	5.36	5.18	**5.31**
Site #1 (Control)	5.48	5.53	5.55	**5.52**
Site #2 (Mid-Point)	6.06	5.83	5.55	**5.81**
Site #3 (Lower)	2.21	1.90	2.3	**2.14**
V-Ditch				
pH	Test #1	Test #2	Test # 3	**Average**
	7.07	6.74	6.69	**6.83**
Site #1 (Control)	7.64	6.84	6.91	**7.13**
Site #2 (Mid-Point)	7	6.78	6.63	**6.8**
Site #3 (Lower)	7.34	7.2	7.15	**7.23**

V-Ditch

Sample Monitoring Table

Parameter	Turbidity, suspended sediment, sediment loads
Objective	Track trends in contaminants and suspended solids
Date and Weather Conditions	Note Date, Time, weather conditions, and temperature if possible.
Procedure and techniques	Instruments and methodologies should be noted for reporting
Locations	Locations should be noted to best precision allowable. Use of GIS and/or maps are useful
Frequency and duration	Continuous measurements at acceptable time intervals, include regular frequency and event-based
Measurable milestones	Decreasing trends? The Mad River TMDL recommends an 89% reduction in suspended sediment loads from urbanized contributions
Benchmark conditions where available	The Mad River TMDL recommends a target loading of less than 120% over the background suspended sediment load of 809 tons/mi^2/yr
Responsible Parties	State and Federal Agencies