CHAPTER 3: ESTIMATING LOAD REDUCTIONS

Below is a list of long range goals for target pollutant loads, level, or value for 6 identified indicators or pollutants in the Deer Creek Watershed. The target loads are based upon the review of water quality data discussed in Chapter 2 (table 2-1). Due to the nature of urban streams, reaching targeted standards for dissolved oxygen, chloride, E. Coli and other pollutants must of necessity be long range, and may take 20 or more years to achieve. As additional water quality data becomes available the data will be assessed and targets values adjusted as necessary.

Indicator	Present pollutant load, baseline level, or benchmark value	Target Load, Level or Value
Dissolved Oxygen	avg. mean D.O 7.1 milligrams/liter Deer Creek @ Maplewood (23 samples, 2001-2004)	No more than 10% of all samples exceed criterion (5 mg/L for AQL) State of Missouri standard for the protection of aquatic life.
Chloride	Avg. mean chloride 407 milligrams/liter Deer Creek @ Maplewood	No more than one acute toxic event (230 milligrams/liter) in 3 years during periods of stable, low flow conditions. No more than one exceedence in three years of the 860 mg/L chloride acute criterion under any flow conditions.
E.Coli	avg. geometric mean E. coli 1860 colony forming units /100 milliliters Deer Creek @ Maplewood	During the recreational season not to exceed geometric mean of 206 cfu/dL- State of Missouri standard for whole body contact.
Volume as a surrogate for TSS	TSS increases with flow rates, and at first flush	Capture 1st 1.14 in rainfall onsite (90% of storms)-MSD standard
Phosphorus	Avg. mean of .63 milligrams/liter Deer Creek@ Maplewood	60% reduction of load in targeted sub-watersheds as per STEP-L model indications = .25 milligrams/liter

WATERSHED AND BMP MODELING

Information based upon actual water quality data collected provides trend information regarding the quality of water within the Deer Creek watershed. The data indicates sporadic excedences of the state's water quality criteria does occur. Further assessment of the frequency, timing and/or causes of excedences will be evaluated as additional water quality data becomes available. Estimated pollutant loads can be estimated using a variety of watershed models. Once a load has been estimated using models, then various types of BMP implementation simulations can be run through the model to determine the location and the number of BMP's needed to obtain pollutant load reductions. This chapter discusses a variety of models, their use, and pros and cons. In addition, a simplified model was used to estimate the loads for the Deer Creek Watershed near the mouth of Deer Creek, and to estimate expected loads from three biorentention demonstration sites.

A subcommittee was established as part of the Technical Advisory Group to review and recommend models for the Deer Creek watershed. The Deer Creek Watershed Technical Subcommittee on watershed modeling met on March 17, 2010. The purpose of the meeting was to review existing models and studies on Deer Creek, develop an overall approach with objectives for watershed modeling for water quality, and recommend specific modeling protocols/programs that could be used to accomplish these objectives. The participants on this subcommittee consisted of:

Len Madalon, Chairman	EDM
Elise Ibendahl	CH2MHill
Susan Maag	Barr Engineering
Eric Karch	River des Peres Watershed Coalition
Jeff Riepe	Metropolitan St. Louis Sewer District
Jay Haskins	Metropolitan St. Louis Sewer District
George Tyhurst	Metropolitan St. Louis Sewer District
Del Lobb	Missouri Department of Conservation
Karla Wilson	EcoWorks Unlimited
Bill Aho	EcoWorks Unlimited

Jeff Riepe presented a summary of historical modeling efforts for Deer, Two Mile, and Black Creeks. (The summary that was presented does not reflect the modeling that was done for the City of Frontenac by EDM). The modeling performed to date does not specifically address stormwater quality, but many parameters needed to perform stormwater quality flow modeling (e.g. stream sections and land use) are available. Elise Ibendahl commented that CH2M Hill generated many of the existing models and has additional information that may be of interest.

Susan Maag stated that public acceptance is important to implementation of controls and she offered to help with landscape architecture needed to address concerns.

The watershed improvement goals should drive the studies to be performed. Many members of the technical committee (Hoskins, Lobb, & Karch) expressed concern that modeling, without specific objectives for watershed improvement, would not provide value commensurate with the expense of the modeling exercise. There is general consensus that the modeling should evaluate the extent controls (e.g., post-construction best management practices (BMPs)) reduce pollutant loads and promote ecological stream flows. However, an important component of the modeling effort should be an evaluation of whether these controls result in a meaningful improvement in stream ecology.

One approach for restoring stream ecology would be to restore the stream hydrology to its pre-development flow regime. While the group agreed recreating the pre-development stream flow could be ideal, given the watershed is located in an existing highly urban area with multiple technical and political realities, this is unlikely to be practical in application. However, it may be possible to implement a sufficient number of controls such that a “nice urban stream” is established.

The Missouri Hydrologic Assessment Tool (MOHAT) is a tool developed by USGS that could help modelers evaluate and recommend a watershed retrofitting plan by evaluating the effect of controls by developing "ecological stream flows". Dell Lobb presented a brief summary on MOHAT. MOHAT can examine how different flow regimes affect several ecological indices (up to 171 indices). The tool will not tell one "how much" control is needed or where controls should be located. Rather, with >20 years of real or simulated mean daily flow data (from another hydrology model, such as the Stormwater Management Model (SWMM)), MOHAT can help modelers evaluate whether the hydrology produced by controls results in meaningful improvement in stream ecology. While MOHAT is a new and untested model, there are no models proven and tested in Missouri that provide the same information. Given this, there was general consensus that MOHAT should be considered to help evaluate the effect of controls on ecological parameters in Deer Creek.

Bill Aho presented to the group the Long-Term Hydrologic Impact Assessment (L-THIA) model, which was used to develop the Belews Creek Watershed Plan in Jefferson County. L-THIA is a screening-level tool that is helpful in showing the effect of land use changes on watershed pollutants, but not stream flow. However, the tool is straightforward and easy to use, and could provide some value in determining what areas of the watershed need the greatest attention for specific pollutants. (The STEPL (Spreadsheet Tool for Estimating Pollutant Load) is another inexpensive and simple model to apply.

The STEPL model is being used by Washington University to analyze three demonstration green infrastructure projects in Deer Creek. The results of this data can be used to inform future efforts in the watershed.)

After these presentations, the group discussed whether the overall watershed plan should address each of these concerns individually, or whether a surrogate should be used. The specific water quality and ecological parameters that the watershed plan will need to address are bacteria (e-coli), chloride, and habitat loss. Other problems that the plan could assist with are flash flooding and illicit discharges.[1] In the National Research Council (NRC) report *Urban Stormwater Management in the United States*, key findings were "a straightforward way to regulate stormwater contributions to waterbody impairment would be to use flow or a surrogate, like impervious cover, as a measure of stormwater loading…" and "Efforts to reduce stormwater flow will automatically achieve reductions in pollutant loading. Moreover, flow is itself responsible for additional erosion and sedimentation that adversely affects surface water quality." General consensus was that screening level tools, like L-THIA, could be beneficial in developing some estimate of the effect of imperviousness and land use on pollutant loading. Then, a more detailed modeling effort (SWMM and MOHAT combination) should focus on where controls would be applied and how these controls affect water quality by using flow as a surrogate for the water quality parameters. The new EPA model (System for Urban Stormwater Treatment and Analysis Integration, SUSTAIN), whose flow module is SWMM based but also generates pollutant removal data, may also be worth examining as part of the more detailed modeling effort (and for generating MOHAT input). For a detailed discussion of the capabilities and benefits of the L-THIA, SWMM, SUSTAIN and STEPL models, see Appendix 3A: Deer Creek Watershed Models.

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[1] It was noted that identifying and correcting illicit discharges are already addressed by MSD as part of the Phase II MS4 Permit.

STRATEGY TO APPLY MODELS

The project goal is to estimate existing annual pollutant loadings and to make planning level decisions on which BMP's most efficiently reduce loads of target pollutants. An efficient analysis includes the selection of stormwater pollutant models that blend accuracy, reliability, and timeliness, while minimizing the cost of obtaining the information. Though there are many computation methods for calculating annual pollutant loading, the methods generally fall into either *simple* or *complex* with respect to level of effort. Simple models are defined as those models that make assumptions about hydrology that allow the user to bypass the effort required to model the complex relationship between landuse, soil, topography, and detention facilities. STEPL and THIA are examples of simple models. Though the accuracy of pollutant load estimates are compromised by this simplification, the accuracy may be sufficient to provide valuable feedback where a high level of accuracy is not necessary. In contrast, typical "complex" computer models used to estimate loading include EPA's SWMM, SUSTAIN, and MoHAT. Data obtained from the simple models may also be used as a check on the complex model results.

National data for urban impairments will be used in the models to determine existing pollutant loadings by sub watershed. The national data will be checked against existing impairment data contained or described in this watershed plan and data that will be collected under this watershed plan. Existing pollutant loadings will be calculated in both simple and complex models.

The Center for Watershed Protection conducted a study of simple and complex models and it is this comparison that provides confidence in the accuracy of simple models (Article 13 *Watershed Protection Techniques. 2(2): 364-368).* The "Simple Method" was developed by Tom Schueler in 1987 to provide an easy yet reasonably accurate means of predicting the change in pollutant loadings in response to development. This method forms the basis of spreadsheet estimating tools like STEPL. The Center for Watershed Protection conducted a study to compare the Simple Method and computer model results by computing a "maximum ratio" for various parameters. (Article 13 *Watershed Protection Techniques. 2(2): 364-368).* The maximum ratio represents the largest ratio between the simple and complex model pollutant load and runoff volume estimates. Eighty seven percent of the maximum ratio values ranged from one to two, indicating that, in general, the computer model and Simple Method results were comparable. We are therefore confident that where simple modeling is appropriate, STEPL will allow screening level assessment of one BMP strategy relative to another necessary rank of a list of BMP strategies.

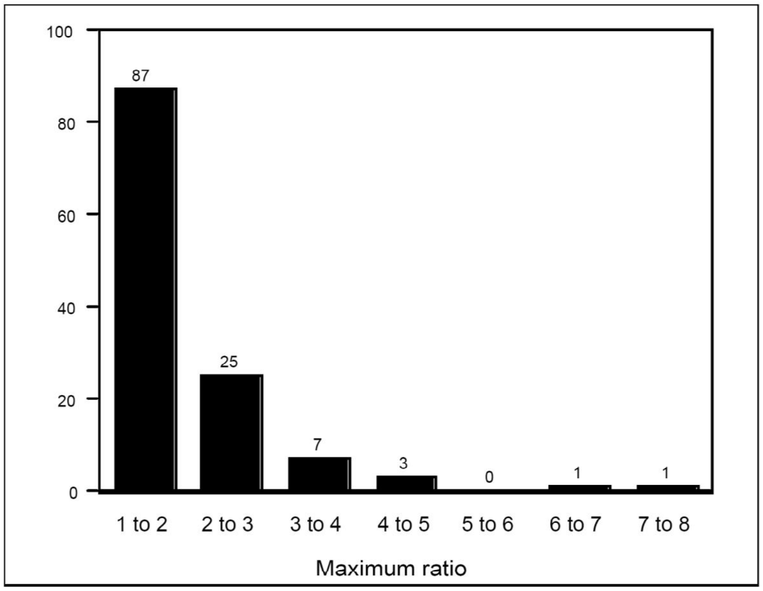


Figure 3A: Ratio of Load Difference Computed by Simple Method Compared to SWMM or HSPS (124 annual comparisons)

A list of appropriate BMPs to address water quality threats or impairments discussed in Chapter 2 will be outlined. This list will include structural stormwater BMPs (i.e. detention basins, bioretention systems), other site design changes, (i.e. disconnecting impervious areas, vegetated filter strips, soil amendments), and behavior management strategies (i.e.optimization of road salt application and improving pet waste practices). Simple stormwater pollutant loading models are appropriate to roughly rank the list in terms of pollutant load reduction potential. Even at this early stage of assessment, the nature of target pollutants like runoff volume, may require the use of complex models to evaluate the effectiveness of BMPs. After ranking BMPs, complex models may then be applied to "break a tie" where the simple method does not clearly select one BMP over another. The complex models will also be used to quantify the number/size of preferred BMPs needed to achieve the target load, level, or value of pollutant desired. This strategy minimizes application of complex models, thereby economizing time and effort.

STEPL (SPREADSHEET TOOL FOR ESTIMATING POLLUTANT LOAD)

The STEP-L model can be employed to estimate the impact of BMP implementation in each of four identified sub-watersheds in the Deer Creek Watershed. (See Appendix 3B and Appendix 3C). BMP's will be added to the BMP tab to determine type, drainage size, and number of BMP's needed per subwatershed to achieve the desired load reductions (goals as stated in this watershed plan).

The STEPL model was used to provide an estimated load for a subset of pollutants (T(N), T(P), BOD and TSS). The watershed estimates calculated using STEPL can be used as a starting point until additional funds become available to conduct more sophisticated watershed models or supplement additional water quality monitoring efforts. The information input into the STEPL models was based on the landuse data found in Appendix 3C. The Deer Creek was broken into four subwatersheds (Upper Deer Creek, Twomile Creek, Lower Deer Creek, and Black Creek). The pollutant loads estimated by STEPL in pounds per year for each subwatershed are as follows:

- Upper Deer Creek: T(N) 36,888; T(P) 5,928; BOD 159,739; and TSS 801
- Twomile Creek: T(N) 20,099; T(P) 3,417; BOD 87,963; and TSS 448
- Lower Deer Creek: T(N) 26,807; T(P) 4,308; BOD 113,827; TSS 595
- Black Creek: (T(N) 27,464; T(P) 4,408; BOD 117974; TSS 605
- Total Estimated Load for Deer Creek at Outlet: T(N) 111258 T(P) 18,061, BOD 479,502; TSS 2,450

The STEPL model was also used to predict impacts of three green Infrastructure demonstration projects on water quality in the Deer Creek Watershed and the information summarized in the following section. The load estimates per BMP type can then be used to estimate the effects of similar BMP practices at both the subwatershed level or for the entire watershed.

DEER CREEK DEMONSTRATION PROJECTS

Three MSD demonstration BMP projects are to be implemented to assess effectiveness of raingarden and bioretention BMP's in the Deer Creek Watershed. The design goals for the projects are as follows:

- Implement plant-based demonstration projects that reduce water pollution in the Deer Creek Watershed employing a green infrastructure approach.
- The performance goal of all green infrastructure techniques will be capturing, treating, and detaining stormwater runoff from 90% of the recorded daily rainfall events, which is based on a rainfall amount of 1.14 inches. Opportunities to design for larger events and incorporate enhanced infiltration techniques will be taken as downstream conditions warrant and with recognition that retrofitting in urban settings is challenging.
- Measure and document, over a five year period, the effectiveness of the demonstration projects.
- Monitor reduction in peak flow rates in relation to rainfall, overall volume reduction due to plant evapotranspiration and infiltration, and effectiveness of the system in filtering at least one organic pollutant.
- Leverage the demonstration projects as a marketing tool to increase social acceptance of stormwater bioretention methods in the Deer Creek Watershed.
- Support MSD in its process of developing appropriate processes and procedures that enhance its ability to implement green-infrastructure water pollution reduction projects moving forward.

1. ***Mount Calvary Church and Adjacent Neighborhood*** – The Calvary Church and its adjacent urban neighborhood is located in the Deer Creek watershed. The low-lying neighborhood homes that are in the storm water flow path have experienced repeated yard and structure flooding (UTM coordinates: 0729913, 4277911, elevation: 148 m). The BMP for this project is a commercial-sized bioretention system designed to capture runoff from the adjacent parking lot and church roof. Hardscape features include an underdrain and forbay.

2. *10920 Chalet Court* – The Chalet Court neighborhood is an urban neighborhood in the Deer Creek watershed where yard erosion is occurring at a pipe outlet. A Deer Creek tributary that flows behind the home is undergoing significant erosion and entrenchment (UTM coordinates: 0724457, 4282986, elevation: 188 m). This BMP includes four residential scaled raingardens and a revised cul-de-sac center circle design to capture runoff flowing down the street before it enters the storm drain.

3. *8360 Cornell Avenue* – Homes along Cornell Avenue and Gannon Avenue are also located within an urban neighborhood in the Deer Creek watershed. The storm water flow path is behind the homes. The home at the low point of the neighborhood has experienced repeated yard flooding and other yards have experienced erosion (UTM coordinates: 0730272, 4282615, elevation: 167 m). This BMP includes seven residential scaled raingarden cells working together to address a single problem. The treatment train will capture runoff flowing through backyards in a residential subdivision.

The projects will confirm, identify, and qualify the timing and magnitude of water levels, suspended sediment, an organic related pollutant, and rainfall in the Deer Creek watershed. This will be accomplished by collecting historical data on streams in the project area and broadly defining land use in the watershed. In addition to these efforts, monitoring data and models using EPA's Spreadsheet Tool for Estimating Pollutant Load program (STEPL) will assess the effectiveness of implemented green infrastructure demonstration projects on water quality in the Deer Creek watershed boundaries.

The STEPL model has been employed to estimate nutrient and sediment load reductions, variations in system behavior, and BMP effectiveness. Input data for the model has been obtained from the field and from the EPA's online data sources (http://it.tetratech-fx.com/stepl/; http://it.tetratech-ffx.com/stepl/STEPLmain_files/STEPL%20Field%20Data%20Entry%20Sheets.pdf) for the STEPL program.

In addition, raw data from pre- and post-BMP implementation will be evaluated using statistical comparisons such as the average, minimum, and maximum nutrient, sediment, and coliform loads for similar storms before and after implementation. This raw data will be compared against STEPL predictions to weigh the accuracy of the STEPL model under local conditions. Initial baseline monitoring data has been collected prior to BMP installation (See Appendix 3D)

Below are STEP-L modeling results for three demonstration projects to be implemented in the Deer Creek Watershed:

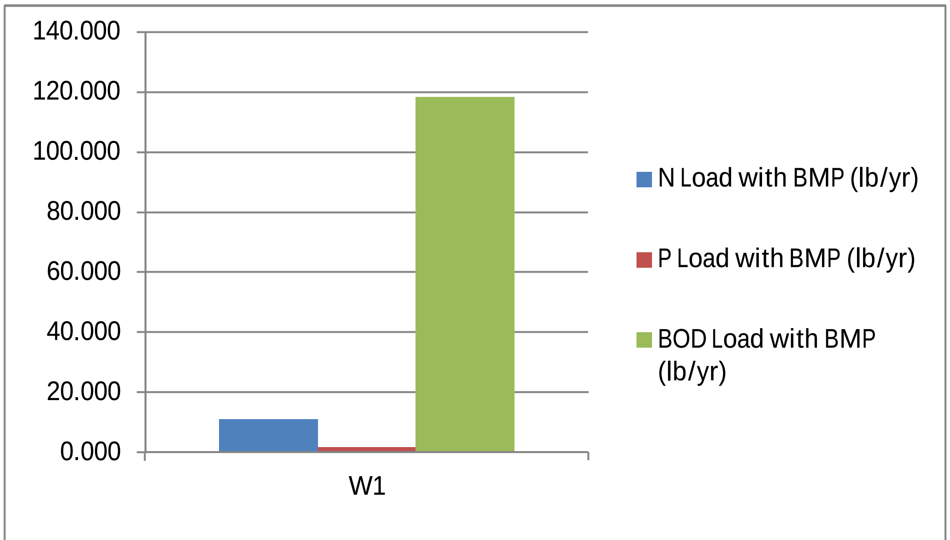
STEP-L MODELING RESULTS FOR THREE DEMONSTRATION PROJECTS

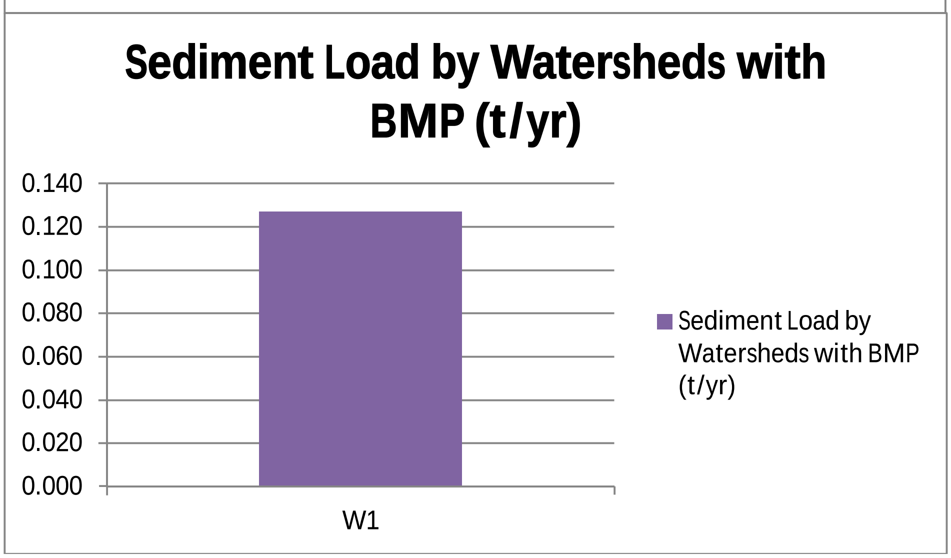
Prepared by: Elizabeth Hasenmueller and Dr. Robert Criss

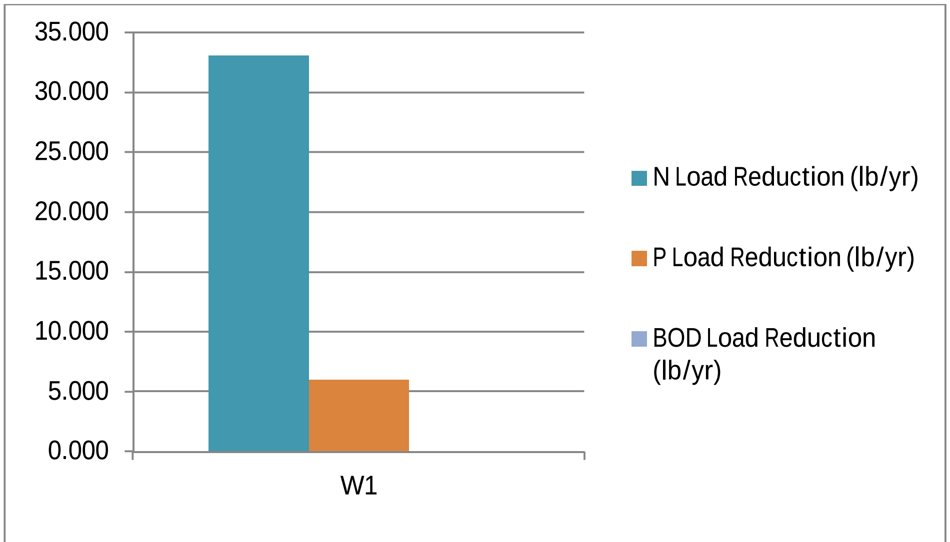
MT. CALVARY

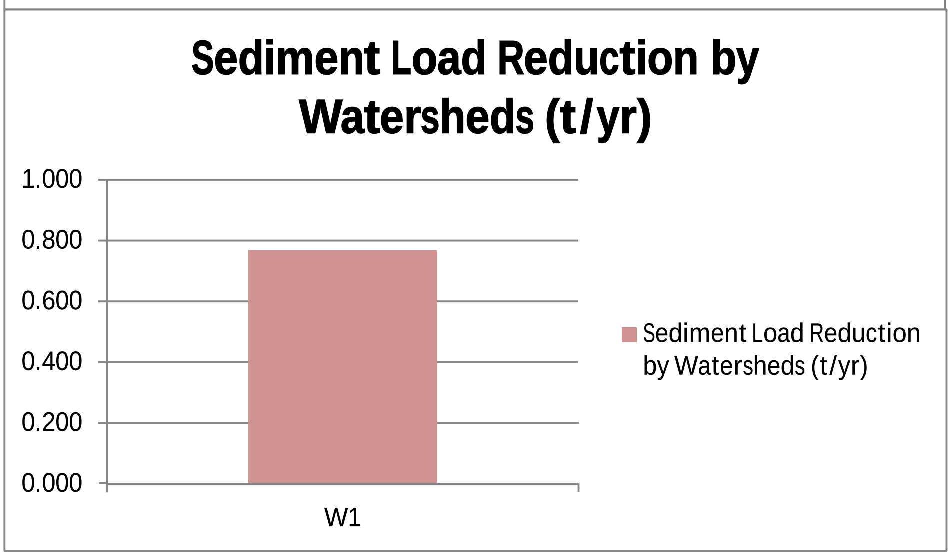
N Load (no BMP)	**P Load (no BMP)**	**BOD Load (no BMP)**	**Sediment Load (no BMP)**
lb/year	lb/year	lb/year	t/year
27.3	4.5	118.2	0.5
27.3	4.5	118.2	0.5
N Reduction	**P Reduction**	**BOD Reduction**	**Sediment Reduction**
lb/year	lb/year	lb/year	t/year
16.4	3.0	0.0	0.4
16.4	3.0	0.0	0.4
N Load (with BMP)	**P Load (with BMP)**	**BOD (with BMP)**	**Sediment Load (with BMP)**

lb/year	lb/year	lb/year	t/year
10.9	1.6	118.2	0.1
10.9	1.6	118.2	0.1
%N Reduction	**%P Reduction**	**%BOD Reduction**	**%Sed Reduction**
%	%	%	%
60.0	65.0	0.0	75.0
60.0	65.0	0.0	75.0





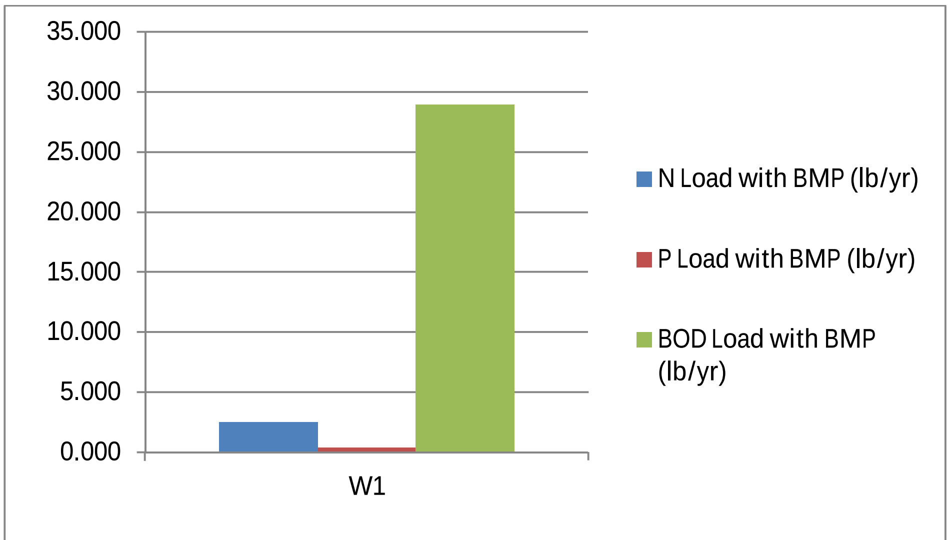


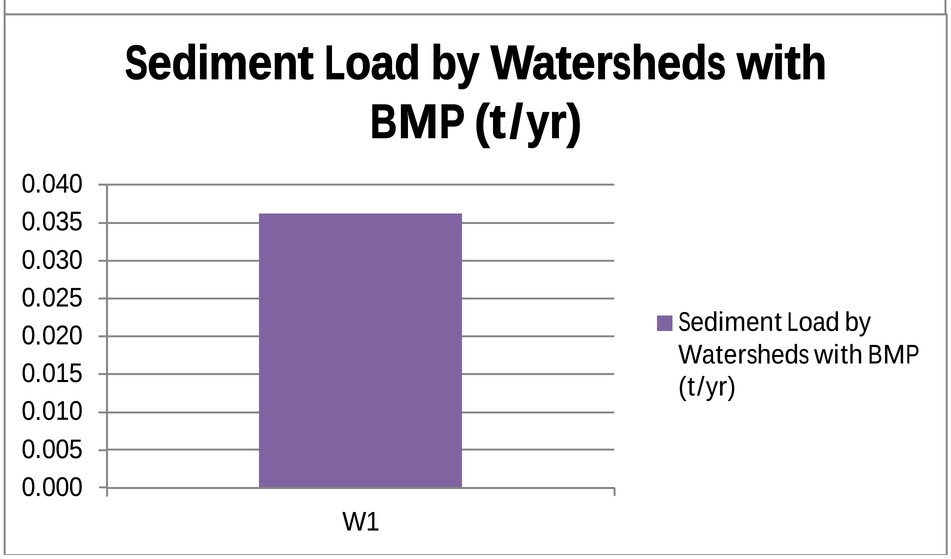


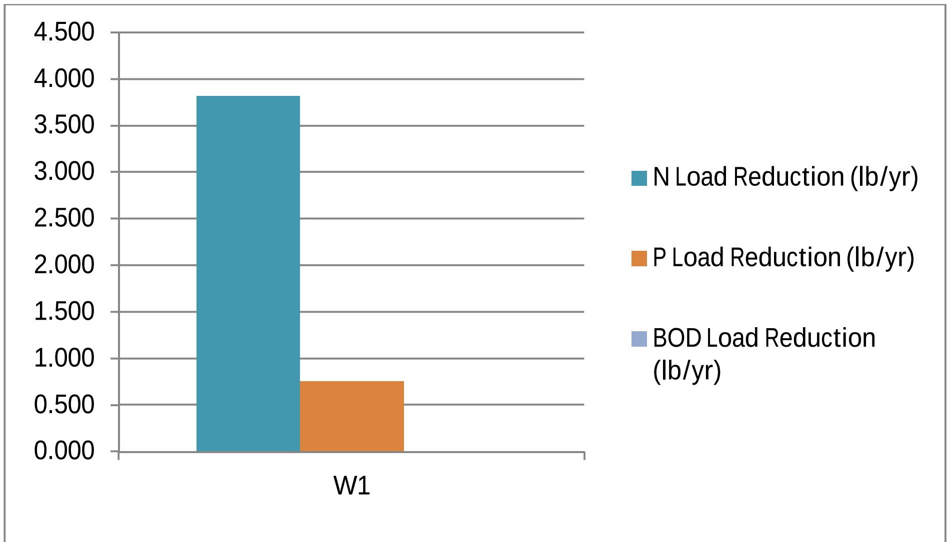
CHALET CT.

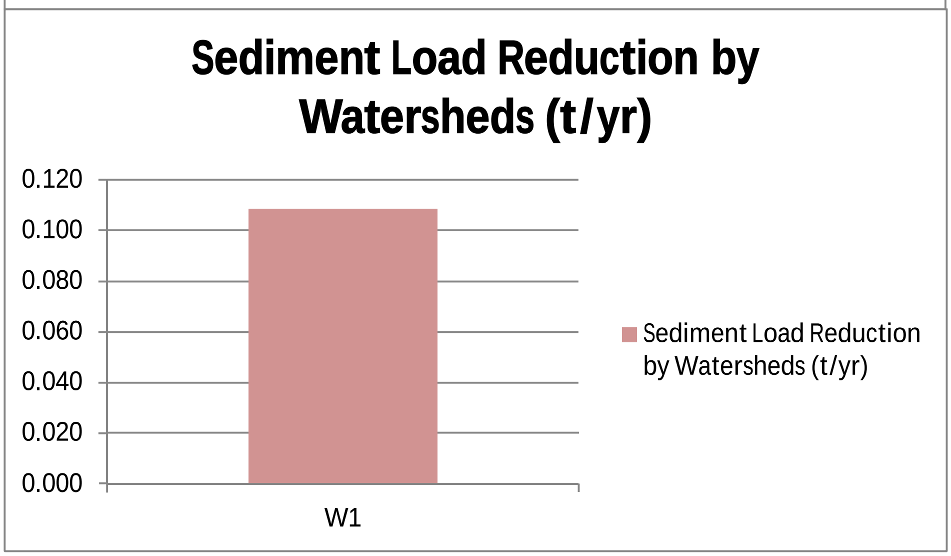
N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)
lb/year	lb/year	lb/year	t/year
6.4	1.2	28.9	0.1
6.4	1.2	28.9	0.1
N Reduction	**P Reduction**	**BOD Reduction**	**Sediment Reduction**
lb/year	lb/year	lb/year	t/year
3.8	0.8	0.0	0.1
3.8	0.8	0.0	0.1

N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
lb/year	lb/year	lb/year	t/year
2.5	0.4	28.9	0.0
2.5	0.4	28.9	0.0
%N Reduction	**%P Reduction**	**%BOD Reduction**	**%Sed Reduction**
%	%	%	%
60.0	65.0	0.0	75.0
60.0	65.0	0.0	75.0





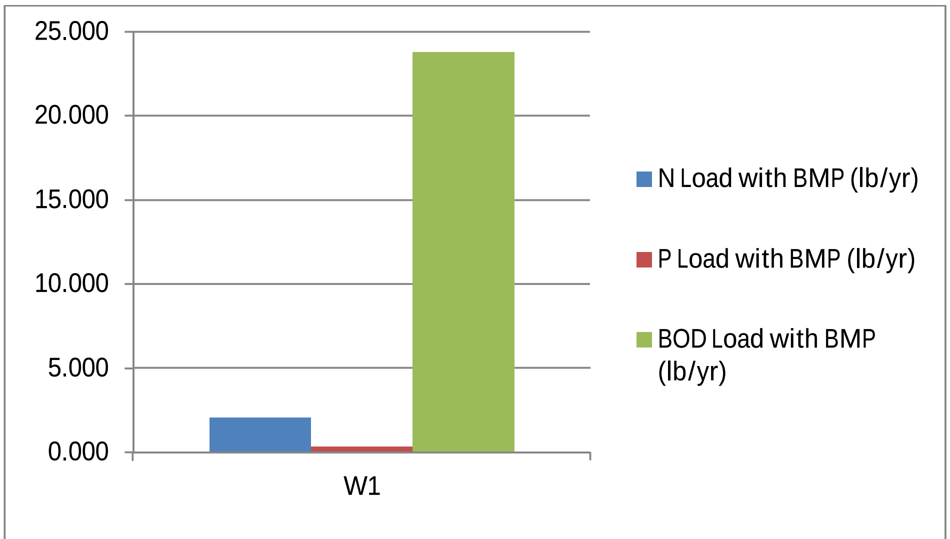


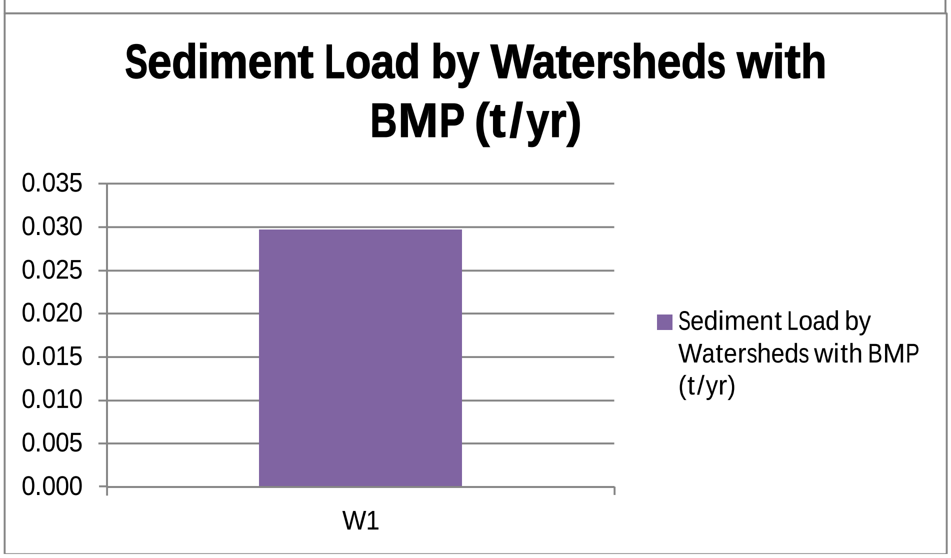


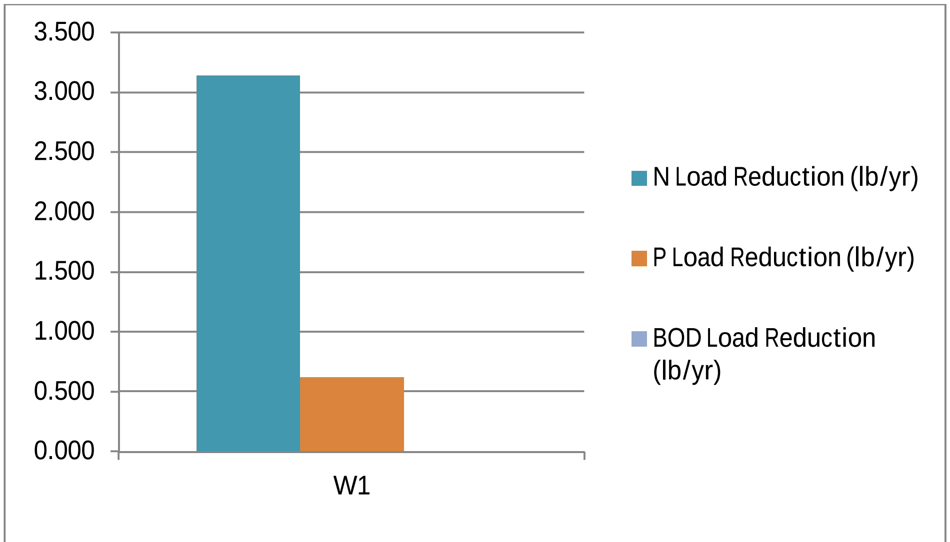
CORNELL AVE.

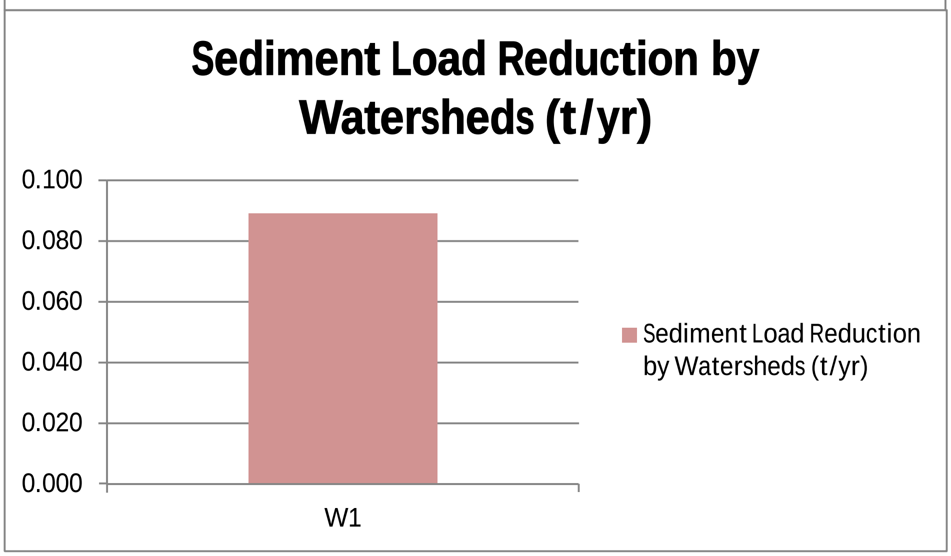
N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)
lb/year	lb/year	lb/year	t/year
5.2	1.0	23.8	0.1
5.2	1.0	23.8	0.1
N Reduction	**P Reduction**	**BOD Reduction**	**Sediment Reduction**
lb/year	lb/year	lb/year	t/year
3.1	0.6	0.0	0.1
3.1	0.6	0.0	0.1

N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
lb/year	lb/year	lb/year	t/year
2.1	0.3	23.8	0.0
2.1	0.3	23.8	0.0
%N Reduction	**%P Reduction**	**%BOD Reduction**	**%Sed Reduction**
%	%	%	%
60.0	65.0	0.0	75.0
60.0	65.0	0.0	75.0






3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
W1
N Load Reduction (lb/yr)
P Load Reduction (lb/yr)
BOD Load Reduction (lb/yr)


Sediment Load Reduction by Watersheds (t/yr)
0.100
0.080
0.060
0.040
0.020
0.000
W1
Sediment Load Reduction by Watersheds (t/yr)