Watershed Evaluation:
Water and Nutrient Budget
Lake Owen, Bayfield County Wisconsin
2019-2020

Supported by Wisconsin Dept. of Natural Resources and Lake Owen Association

Data collected and analyzed by Ecological Integrity Service-LLC, Black Brook Environmental-LLC, and Harmony Environmental, Inc.

Analysis Summary

The watershed of Lake Owen was evaluated by updating the watershed boundary regarding direct drainage and internally drained areas using the most recent LiDAR data available. The watershed was delineated into smaller sub-watersheds to better evaluate the watershed. The land cover was updated within the watershed. These watershed updates were used to determine the input of water and nutrients into Lake Owen.

Through monitoring of on-site precipitation and outlet flow (the input of water directly on to the lake, runoff off from the direct drainage watershed, and discharge from groundwater into Lake Owen) a water budget was established. Two years of data (growing season phosphorus, chlorophyll-a, Secchi depth) were used to determine the influx of phosphorus into Lake Owen during 2019 and 2020. The empirical model Bathtub was then used to predict the results of changes in phosphorus loading on chlorophyll-a and Secchi depth in response in an average year.

The watershed delineation update resulted in changes in the watershed boundary and determining the direct drainage area. The direct drainage portion of the watershed is much smaller than the entire watershed, with much of the watershed being internally drained (water does not runoff directly into Lake Owen). The direct drainage watershed was defined as 2298 acres (not including the area of Lake Owen surface), which is less than a 2:1 ration of watershed to lake area. The land cover showed that forested areas cover most of the watershed at 84%. Development is limited around Lake Owen making up only 6% of the total watershed. Evaluation of potential future development around Lake Owen considering public and private land ownership, allows for predicted water quality with increased development. There is approximately 717 acres available for future development within the direct drainage watershed.

The water budget shows that groundwater accounts for 77% of the water entering Lake Owen, followed by direct precipitation. Runoff covers a small fraction of the total water entering the lake due to the small watershed and the significant amount of forested land cover within the watershed. The nutrient budget estimates a total load of 493 kg of phosphorus per year. The main sources are groundwater (44%). The runoff from the watershed accounts for 32% of the phosphorus load, followed by atmospheric deposition (19%) and septic systems (5%).

The empirical model predicts that increases and decreases in phosphorus load can cause increases in phosphorus and chlorophyll-a concentrations resulting in a decrease in Secchi depth. The model also predicts increases in phosphorus and chlorophyll-a concentrations with increased development. These predictions demonstrate the importance of management practices within the Lake Owen watershed in the future to maintain the excellent water quality.

Introduction

Lake Owen, Bayfield County Wisconsin, is classified by the Wisconsin Department of Natural Resources as an oligotrophic lake. This classification is based upon data consistently showing low phosphorus concentrations, low chlorophyll-a concentrations, and high Secchi disk depths (high water clarity). A main objective for the Lake Owen Association is to manage the lake so that this exceptional water quality is maintained in future years.

To address the evaluation of water quality in Lake Owen, a large data set was established of total phosphorus, soluble reactive phosphorus, chlorophyll-a, and Secchi depth readings. Also, numerous temperatures, dissolved oxygen, and specific conductance profiles were collected to aid in determining the dynamics of Lake Owen during the growing season months (May through September). In 2019, an analysis was conducted to establish the reason Lake Owen is so clear. This analysis determined that not only is there limited nutrients available but that the lake becomes so stratified (and therefore stable) that little to no phosphorus mobilizes into the epilimnion, even though the hypolimnion (bottom layer) contains significant phosphorus. As a result, most of the algae (contributing to chlorophyll concentrations) occur in the metalimnion, just above the hypolimnion. Since this depth has typically been deeper than the Secchi disk depth, the result is exceptionally clear water in the epilimnion.

The results of the water clarity analysis suggest main changes that would contribute to the degradation of water clarity include increased mixing in the lake, resulting in high phosphorus concentrations from the hypolimnion; mobilizing into the epilimnion, making nutrients available for increased algae growth and increased flux of phosphorus into the lake via external sources, namely from the watershed. No perennial tributary flows into Lake Owen, so the main sources of phosphorus are atmospheric deposition, groundwater influx, septic leeching and overland runoff. Since atmospheric deposition and groundwater influx cannot be managed, overland runoff will be the focus.

This analysis is broken into sections that allow for the evaluation of the watershed and its impact on Lake Owen. The sections include:

1. Watershed delineation: The watershed delineation used for the Comprehensive Lake Management Plan was large with a concern that a sizable amount of this watershed is internally drained, meaning that the water running off these areas does not make it to the lake. The desire was to determine the actual watershed portion that directly runs off into Lake Owen to allow for better scrutiny of the watershed impact on the lake.
2. Update the land cover: The type of land cover can greatly affect the impact on overland runoff, both in terms of volume of water and nutrient concentration. For example, residential land cover with large amounts of impervious surfaces, manicured lawns, and potential fertilizer use can contribute much more water and nutrients during a storm event than a forest area. The land cover was updated to reflect the most recent land cover available. This was augmented by an evaluation of recent aerial photos of Lake Owen to better determine the type of residential land cover that is presently impacting the lake.
3. Evaluate the potential for build-out and the resulting changes in land cover: A large portion of the land surrounding Lake Owen is public land. The assumption is that potential land-use changes will likely occur on private land. The amount of private land that is undeveloped was analyzed and used to determine potential changes in development around Lake Owen in the

future. As stated, a change from undeveloped forested land to developed would potentially increase runoff and result in higher nutrient concentrations in Lake Owen[1].

4. Use water quality, on-site precipitation, and outflow data to determine the water and nutrient budgets for 2019-2020: This data collected, along with the water clarity analysis from 2019, was used to determine the water budget and nutrient budget for 2019 and 2020 (emphasis on growing season months for nutrients and chlorophyll-a). The septic data was used from the Lake Owen Comprehensive Lake Management Plan (adjusted in the model).
5. Use 2019-2020 data as inputs into the empirical model Bathtub: This data is used to calibrate the model Bathtub to more accurately predict the total phosphorus, chlorophyll-a, and Secchi depths for an average year. This allows for predictions about water quality changes that can be associated with changes in development around Lake Owen.

Upon the completion of these sections of the analysis, the Lake Owen Association should have adequate data to form sound management decisions regarding the immediate watershed of Lake Owen. Implementing best management practices (BMP's) allows for mitigating runoff and nutrient loading. This can result in offsetting development that may occur in the future allowing the potential for a zero-net increase of nutrient flux into Lake Owen from the watershed.

Watershed and Land cover Analysis

The watershed for Lake Owen was updated in 2019/2020 using LiDAR data. LiDAR is elevation data that allows for precise evaluation as to where water will flow when precipitation runs off the land. The watershed was broken down into two main areas of internally drained watersheds, which are areas where the water likely does NOT runoff directly into Lake Owen but ends up in wetlands or other smaller bodies of water. The second is the direct (drained) watershed, in which the water running off, does enter Lake Owen directly. The internally drained watershed was divided into sub-watersheds based upon topography. The direct watershed was divided into regions corresponding to different basins associated with Lake Owen (north basin (NB), outlet, mid basin (MB), and south basin (SB). Breaking up the watershed into sub-watersheds allowed for further evaluation of water and nutrient inputs by area.

The National Land Cover Database-USGS (NLCD 2016) land cover map does not include small, medium-high intensity rural development. Although most residential areas around Lake Owen have robust buffers between the developed property and the lake, some properties have clear, higher impact residential areas. To account for this, these areas were delineated using recent aerial photos. Any areas with little to no tree canopy cover where rooftops, lawns, and impervious areas were visible on the photos were delineated as higher impact residential areas. This land cover will contribute to higher runoff amounts, as well as a higher concentration of nutrients.

[1] Private land should be evaluated more in-depth for potential developable land. This was not done therefore all of the potential land for development may not actually be available.

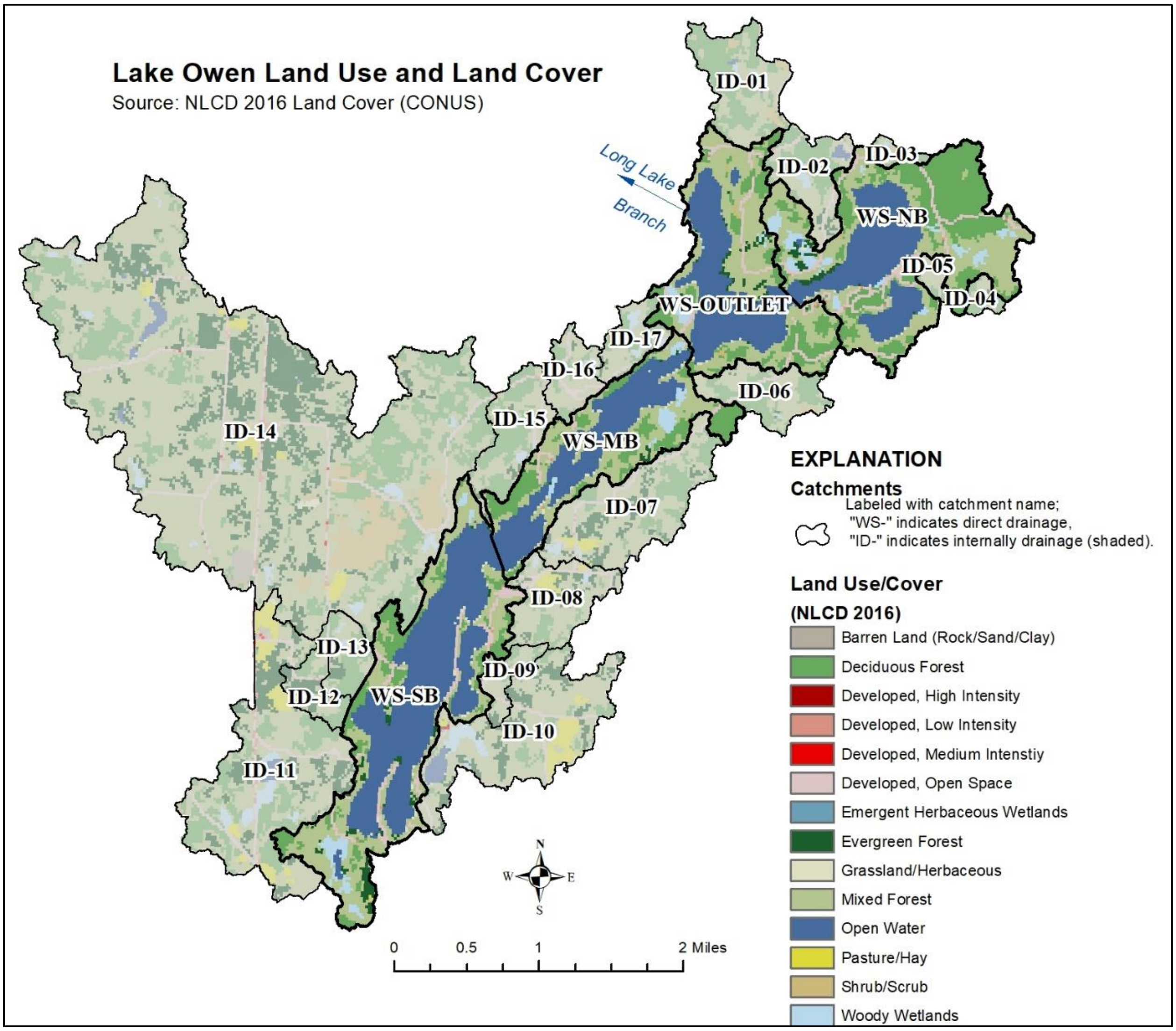

Figure 1: Map designating the sub-watersheds with land cover types. The direct drainage watershed is used to model Lake Owen for water and nutrient budgets.

The land cover was delineated within the internally drained and direct watersheds and obtained from 2016 NLCD land cover map.

Tables 1 and 2 summarize the sub-watershed that were delineated around Lake Owen in the direct watershed. The internally drained areas can contribute to groundwater recharge, but these areas are not used in the runoff values from overland flow.

Catchment	Total (acres)
WS_OUTLET	**772.15**
WS-MB	**626.49**
WS-NB	**1,023.90**
WS-SB	**1,125.54**
Total (acres)	**3,548.08**
Total (acres w/out Lake Owen area)	**2298.08**

Table 1: Sub-watersheds of direct drainage watershed.

Catchment	Open Water (included Lake Owen)	Developed, Open Space	Developed, Low Intensity	Developed, Medium-High Intensity	Barren Land (Rock/Sand/Clay)	Deciduous Forest	Evergreen Forest	Mixed Forest	Shrub/Scrub	Grassland/Herbaceous	Pasture/Hay	Woody Wetland	Emergent Herbaceous Wetlands
WS_OUTLET	273.99	45.37	1.11	5.21	0.00	134.33	16.01	284.22	3.78	3.34	0.00	10.01	0.00
WS-MB	266.65	13.12	0.89	7.79	0.22	128.10	6.89	178.36	0.00	9.56	0.00	22.46	0.22
WS-NB	263.54	62.94	1.78	2.73	0.00	317.80	16.01	308.02	0.67	5.34	0.00	47.59	0.22
WS-SB	543.98	58.93	2.00	37.82	0.00	139.44	33.80	306.24	0.44	10.90	0.44	29.36	0.00
Total (acres)	**1,348.16**	**77.78**	**5.78**	**54.53**	**0.22**	**719.67**	**72.72**	**1,076.83**	**4.89**	**29.13**	**0.44**	**109.42**	**0.44**

Table 2: Area of various land cover within the direct drainage watershed. Some of the various forms of land cover were combined for implementation into the model (for example, all types of forested areas were combined into one total forest cover area).

Regarding water and nutrient budgets, the type of land cover is important. Forested areas have much less runoff volume with lower nutrient concentrations than other areas. Agriculture land cover and developments typically result in higher runoff volumes and nutrient concentrations. In terms of runoff, the type and density of development can vary in terms of runoff. Denser development typically results in more impervious surfaces coupled with less native vegetation and more manicured lawns. This type of land cover will result in a higher volume of water and a higher concentration of nutrients in the runoff.

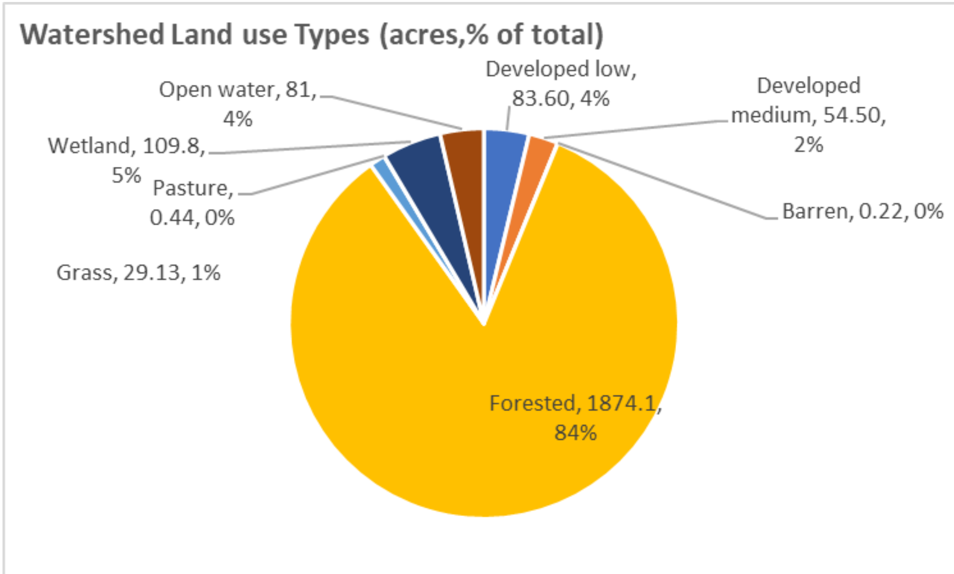

Figure 2: Graph showing the various land cover types with the direct drainage for Lake Owen.

An important factor to consider for future changes in water quality in Lake Owen is changes in the watershed land cover. Most of the watershed land cover is forested. Since the direct watershed is small compared to the lake area (less than 2:1 by area), land cover change can significantly affect the impact the direct watershed has on Lake Owen. In considering potential changes in land cover, most of the change will likely be from forested land cover to developed. Little or no change will occur on public land, which is a large area around Lake Owen. For these reasons, the direct watershed was evaluated by the area of undeveloped public land and the area of undeveloped private land. These values can be used to predict water quality changes as land cover changes.

Name	Total Area	Public Land*	Currently Developed (all classes)	Non-developable*** Lands	Potentially Developable (Build-out) ****
WS-OUTLET	772.15	387.20	46.48	284.00	54.48
WS-MB	626.49	66.70	14.01	289.34	256.44
WS-NB	1,023.90	698.00	64.72	311.35	0.00
WS-SB	1,125.54	85.50	60.94	573.33	405.77

**Public Land – determined from county parcel data (2020)*

***Currently Developed – Developed: Open Space, Low-High Intensity*

****Non-developable – open water + wetlands*

***** does not account for high slopes, shoreland zoning regulations, or other zoning regulations*

Table 3: Potential land area available for development by sub-watershed within the direct drainage watershed.

Water Nutrient Budget

To evaluate the impact of the direct drainage watershed on Lake Owen, the amount of flow overland into the lake needs to be determined. This is done by completing a steady-state, volume balance evaluation of the water budget. In basic terms, the inflow of water volume will equal the outflow of water volume. The inflow is from the following sources: groundwater + precipitation on lake + runoff from the watershed. The outflow of water includes the following: outlet tributary + evaporation from lake surface + groundwater outflow. Therefore, the following is the basis for the mass balance of water:

Groundwater inflow + precipitation + runoff = outflow of outlet + evaporation + groundwater outflow[2].

Some of these parameters were measured on-site, while evaporation values utilize averages from literature. The runoff from the watershed was estimated through the change in lake level and outflow in response to precipitation events and adjusted based upon the volume balancing of the water inputs. All water budget inputs and outputs were determined during measurement periods in 2019 (6 months) and 2020 (10 months). These results were used to calibrate the empirical model Bathtub to reflect an average year for precipitation and evaporation. When inputting the on-site measurements coupled with the literature evaporation value, the water balance was a good model fit, which reflects valid overland runoff amounts.

The outlet flow was monitored for a total of 16 months. A hydrograph was developed from the data and used to estimate the amount of runoff and groundwater inflow through estimation of baseflow. During lengthy non-precipitation periods, the baseflow was assumed to reflect the groundwater inflow into Lake Owen, which maintains the outflow volume. Evaporation values were implemented to account for more outflow, which was used to adjust the watershed runoff and the groundwater inflow to balance the water budget.

The following table and graph represent the modeled water budget based on an average climate year in terms of precipitation (30-year average for Drummond Wisconsin).

Source	**hm^3**
Outlet sub-watershed	0.3
Mid Basin sub-watershed	0.2
North Basin sub-watershed	0.5
South Basin sub-watershed	0.4
Groundwater	21
Precipitation	4.5

Table 4: Water budget source by volume into Lake Owen during an average precipitation year.

[2] Groundwater outflow is not known. It was assumed to be negligible but an in-depth analysis of groundwater model will determine if this is the case in the future.

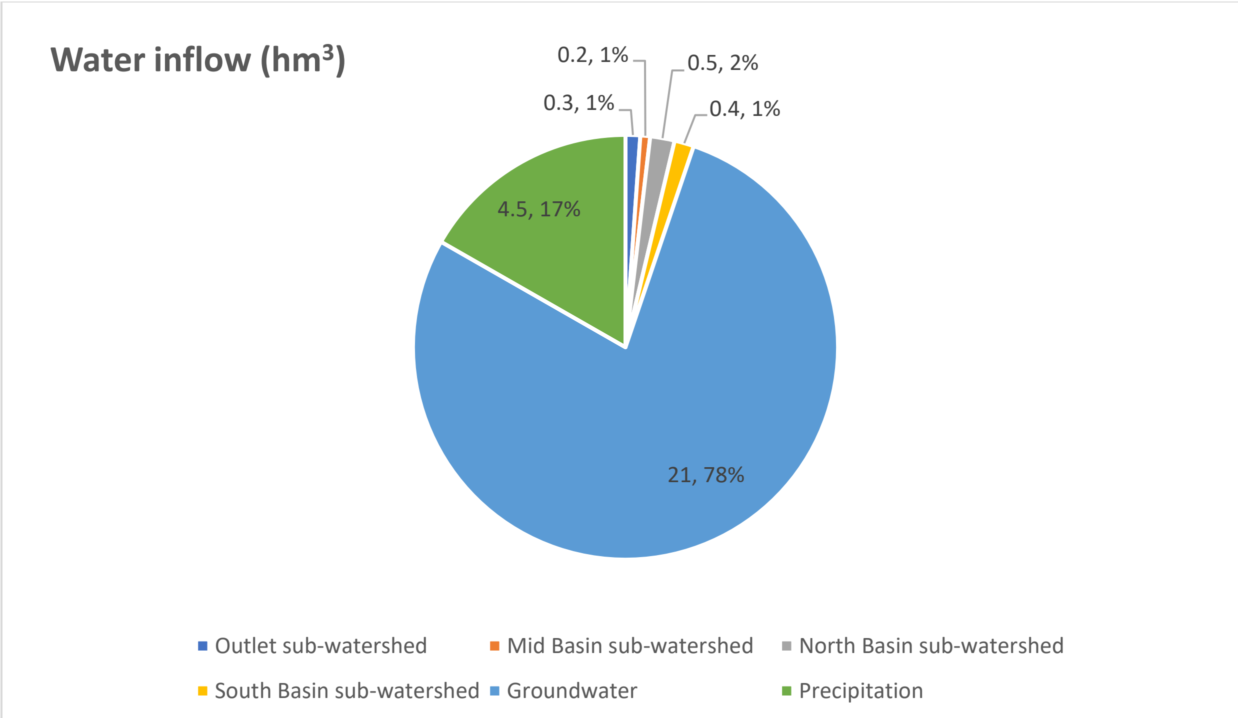

Figure 3: Graph of the water inflow sources by volume and percent of entire budget.

As this data shows, the largest inflow in the water budget is groundwater[3] supporting that Lake Owen is a groundwater lake. Groundwater lakes typically result in higher water clarity and limited nutrients available for algae growth. The mapped groundwater watershed is much larger than the direct drainage watershed for Lake Owen (see appendix to view map). This is supported by the significant water inflow from groundwater. Precipitation (directly onto the lake surface) accounts for the second-highest source of water into Lake Owen. The North Basin sub-watershed has the highest input of the sub-watersheds due to being the largest area of the sub-watersheds. All the sub-watershed has forest accounting for most of the land cover, which will have lower runoff volumes during storm events.

The water budget shows lower values for watershed runoff and higher for groundwater (by % of total) than the data used in the 2015 Comprehensive Lake Management Plan. The difference in the watershed runoff would be expected as that plan considered the entire watershed, which has been reduced in this analysis. The reason for the difference in the groundwater value is unknown as the data collection method and the data set was limited in the plan. The flow and precipitation data do show that although the direct drainage watershed is small, the runoff is enough to be reflected in outflow data following precipitation events. This increase in flow is due to precipitation falling directly onto the lake and the runoff from the land.

[3] A groundwater model is being developed in 2020-21 and has not been completed for this analysis. This data is based upon outflow data with the baseflow being estimated from the hydrograph. The groundwater model may lead to changes in the groundwater inflow values. 2020 data in the appendix shows the accumulation of phosphorus that occurs in the hypolimnion.

Nutrient (phosphorus) budget

The focus of the nutrient budget as it relates to water quality is phosphorus, which was listed as the limiting nutrient in the Comprehensive Lake Management Plan from 2015.

The phosphorus budget was estimated using a steady-state, mass balanced approach, which considers that the input mass of phosphorus will equal the output mass. The inputs and outputs were either measured directly or utilized published values and adjusted to fit the balance. The mass balance is based upon the observed in-lake phosphorus concentration observed from May through October in 2019 and 2020.

Inputs of phosphorus in Lake Owen include overland runoff + groundwater influx + atmospheric deposition + septic systems + sediment release (internal loading).

Outputs of phosphorus from Lake Owen include outflow tributary + sedimentation/uptake (which can be retained).

The mass balance approach would then indicate:

Overland runoff P + groundwater flux P + atmospheric deposition P + septic system release P + internal load P = outflow of P + sedimentation/retention P

Data were collected to determine groundwater flux, as well as internal loading. The septic release was used from the Lake Owen Comprehensive Lake Management Plan (the lower value published in the data set). The other inputs are estimated based upon published predicted values for land cover and atmospheric deposition and were adjusted to fit the mass balance. Outflow data were measured for 16 months at the outlet. The sedimentation rate is based upon the model equation used. When comparing predicted phosphorus concentrations and actual field-measured concentrations, the Canfield-Bachman equation was utilized, as it often fits northern Wisconsin Lakes.

The Canfield-Bachman equation is as follows:

$$P = \frac{L}{z\left(0.162(L/z)^{0.458} + p\right)}$$

Where *P* is the concentration of total phosphorus (mixed lake), *L* is the total phosphorus load into the lake, *z* is the mean depth of the lake, and *p* is the lake flushing rate per year, which uses the sedimentation rate. Since the lake is covered with ice in the winter months, the predicted phosphorous concentrations, which is the focus of Lake Owen, are for the growing season.

This equation fits nicely with the 2019 data resulting in a near-perfect match between the predicted and the actual phosphorus concentrations observed in Lake Owen. The 2019 observed data was somewhat difficult to evaluate as the reported results from the State Lab of Hygiene were below the LOQ[4], and in some cases, the LOD[5] for total phosphorus. Several samples with the dissolved reactive phosphorus

[4] LOQ stands for level of quantitation, which is the lowest level the analysis can reliably test for.

[5] LOD stands for level of detection., which is the lowest level the analysis can detect.

values were higher than the total phosphorus, which is not chemically possible and did not occur in 2020 with results from the Water Environmental Analysis Lab (WEAL) at the University of Wisconsin-Stevens Point.

Using similar export coefficients as 2019, the 2020 precipitation and outflow data in the model resulted in less of a good of fit for 2020. The model predicts a slightly higher total phosphorus concentration than was observed in the lake data in 2020. The only input data that isn't measured directly or indirectly is the runoff from overland and the concentration of phosphorus in that runoff. The overestimation may be that the runoff with the lower precipitation amounts in 2020 did not result in similar runoff intensity. Since the 2019 precipitation was closer to an average precipitation year and the fact that the predictions in 2020 from the model were still quite close to the observed, the 2019 coefficients were used to predict the average year in Lake Owen and should be a good representation of what happens in the lake in a typical year.

When evaluating the lake nutrient budget, one of the unknowns is the amount of export of phosphorus from the watershed. There are published export coefficients based upon data sets from other lakes. However, precipitation can vary immensely, thus changing the runoff that occurs. Furthermore, the timing and intensity of precipitation is a major factor. For example, if a high level of precipitation falls as snow, the runoff will mostly occur in spring melt, likely when the ground may be frozen resulting in a larger volume of runoff than in mid-summer. If rainfall occurs in few, intense rainfalls versus several smaller rainfalls, the amount of runoff will greatly vary. The steepness of slope of the watershed near the lake is also important. The higher degree of slope the more intense the runoff. Therefore, these exports are adjusted so the lake phosphorus concentrations match the model output. When this model was developed, the commonly published export coefficients suggested much higher phosphorus inputs than the model would accept. The coefficients were lowered to fit the observed phosphorus concentrations, but the magnitude differences between export coefficients are consistent with published values. Managers need to recognize these are estimates and not based on actual runoff measurements.

The data collected in 2019 and 2020 indicate a release of phosphorus from the bottom sediment, where the lake is anoxic (DO < 1.0 mg/L). Nutrient profiles in the north basin and hypolimnion samples from the south basin show an accumulation of phosphorus in the hypolimnion. Total iron was also measured in the hypolimnion of the south basin through the growing season in 2020. The iron demonstrates binding of phosphorus, and when the lake is anoxic, the iron becomes reduced and releases phosphorus. However, the analysis of water clarity in 2019 and the 2020 profile data indicate that this phosphorus is not mobilized into the upper layer until late October when the growing season has ended. Therefore, internal loading during the growing season is considered 0 kg[6].

The concentration of phosphorus is directly related to the amount of algae and plants that can grow in the lake. The number of algae growing in the lake will affect the water clarity (Secchi depth). The algae are measured as chlorophyll-a concentrations. The chlorophyll-a and Secchi depths were entered into models and calibrated to fit the observed values in 2019 and 2020.

[6] An analysis of internal loading with calculated amounts are part of a separate analysis yet to be completed. Although evidence suggests little to no phosphorus fluxes into the euphotic zone, knowing the amount of phosphorus released is important for future reference.

Once the model was calibrated, the parameters for an average year in Lake Owen were entered into the empirical lake model Bathtub. When a good fit is established, the model can be used to make predictions about increased and decreased phosphorus loading, as well as chlorophyll-a and Secchi depths based on loading changes (by %).

The chart and graph summarize what the Bathtub model estimates for a phosphorus load in an average year in Lake Owen.

Phosphorus Source	kg of P	% of Total
Outlet sub-watershed	33.0	7%
Mid Basin sub-watershed	22.4	4%
North Basin sub-watershed	47.5	10%
South Basin sub-watershed	55.7	11%
Groundwater	216.3	44%
Atmospheric deposition	92.3	19%
Septic systems	25.7	5%
Total annual load	**492.9**	**100%**

Table 5: List of phosphorus loading by source of percent of the total budget.

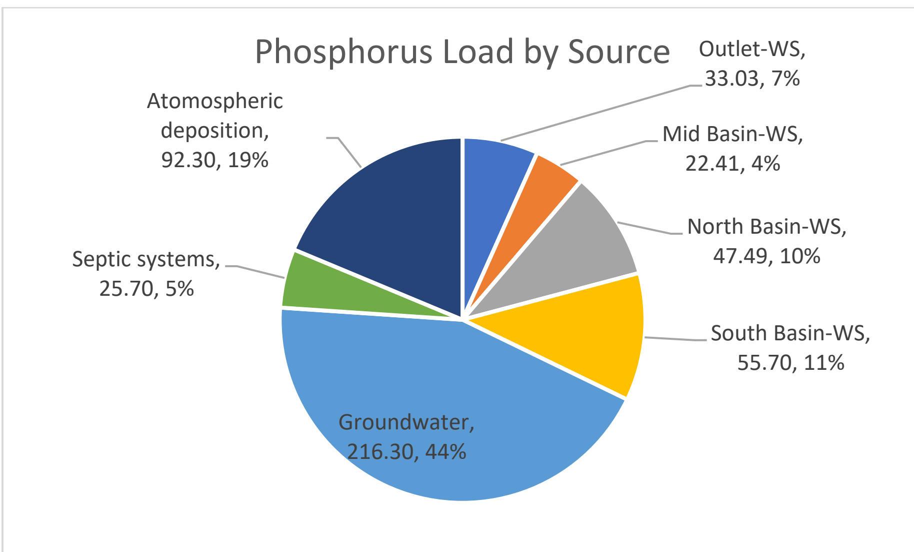

Figure 4: Graph showing the amount of phosphorus loading by source and the percent of the total phosphorus budgets.

As the chart/graph shows, the groundwater influx is the highest contributor at 44% of the total budget. This is largely due to the volume of water the groundwater is contributing. Eight shallow wells near the lake were tested for phosphorus, all of which were within the mapped recharge zone for groundwater into Lake Owen. The mean concentration of phosphorus (total) was 10.35 ug/l.

The second highest contributor is the direct drainage watershed runoff at 32% of the total budget. This is followed by atmospheric deposition at 19.0%. Early June phosphorus data in 2019 showed that pine pollen is likely a significant contributor of phosphorus (approximately 58 kg). Older data from 2016 in early June show a similar spike.

Septic influx amount into Lake Owen was estimated and is uncertain. The Lake Owen Comprehensive Lake Management Plan estimated that 35.5 kg of phosphorus is coming from septic systems, based upon the number of residents using septic systems for an estimated number of days and it is assumed soil type was considered. If 35.5 kg is used in the model, the predicted concentration of phosphorus is a little high. A range of estimated phosphorus was given in the plan and the lower end of that range (25.7 kg) was used in the model and resulted in a better fit to the observed lake nutrient values. If the 35.5 kg or higher is a better estimate of what is occurring in Lake Owen, then the watershed contributions would need to decrease for the model to fit observed lake concentration values. Both septic system and runoff from land are sources that can be mitigated.

The sub-watershed that is the highest contributor of phosphorus in total is the South Basin. This is likely because there is more development land cover in this basin. These exports do not consider the degree of slope, any soil type differences, or specific distance between the lake and the objects that would contribute to more runoff (roads, sidewalks, roofs, and paths). However, assuming that if all development that is identified as medium to high is treated the same on average, those basins with higher areal coverage will have more significant contributions. The North Basin is second in total mass of phosphorus exported into Lake Owen, but it also is the largest sub-watershed by area, so the kg/km^2/yr. is smaller than the Outlet sub-watershed. Data suggests that runoff and nutrient loading is greatest during the spring melt. The chart below shows the sub-watershed export of phosphorus per year by area.

Sub-watershed	**Sub-watershed Basin Phosphorus export rate (kg/km^2/yr.)**
South Basin sub-watershed	23.7
Outlet sub-watershed	16.4
North Basin sub-watershed	15.4
Mid Basin sub-watershed	15.4

Table 5: Export rate of each sub-watershed in the direct drainage watershed.

Although the direct drainage watershed into Lake Owen is small and has limited impact on the lake nutrients, the data shows that the lake does respond to runoff from this watershed. In 2020, the precipitation was lower than 2019, and the nutrient concentrations reflected this. Historical data going back to 2013 shows variations from year to year in phosphorus (and chlorophyll-a) concentrations, which is likely due to the most variable component in the nutrient cycle, precipitation and therefore runoff.

Predictions in phosphorus and chlorophyll-a concentrations/Secchi Depth

An important aspect of modeling a lake is to allow for the prediction of changes due to runoff and nutrients into the lake from land-use changes or implementation of best management practices (BMPs).

In Bathtub, changes in nutrient loading can be implemented with the model predicting the resulting concentration of phosphorus, chlorophyll-a, and the Secchi depth. The charts that follow outline those predicted changes.

Change in P load (all sources)	Predicted mean GSM total P concentration (ug/L)	Predicted mean GSM chlorophyll-a (ug/L)	Predicted Secchi Depth (m)
Base from model (avg. year)	11.0	2.0	6.8
20% increase	12.4	2.4	6.1
40% increase	13.7	2.7	5.5
-20% decrease	9.6	1.7	7.8
-40% decrease	8.1	1.3	9.2

Table 6: Predicted total phosphorus and chlorophyll-a concentrations as well as Secchi depth with varying degrees of phosphorus load increases and decreases.

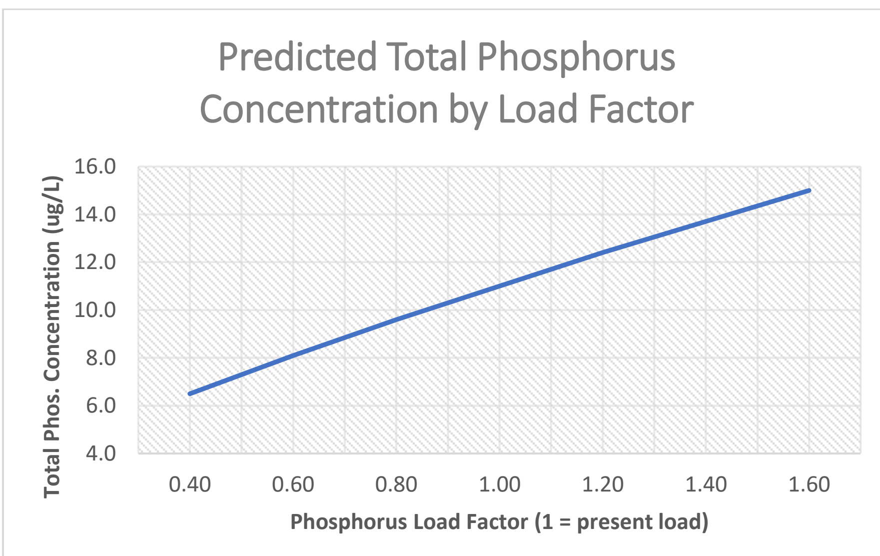

Figure 5: Predicted total phosphorus concentration in Lake Owen with varying phosphorus load increases and decreases. The present load that is modeled is a loading factor of 1.00.

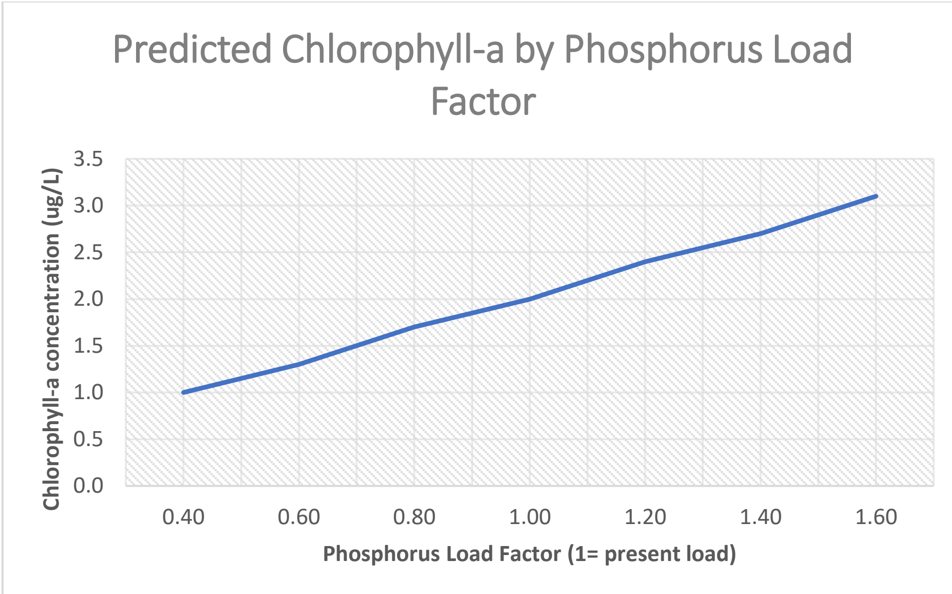

Figure 6: Predicted chlorophyll-a concentration in Lake Owen with varying phosphorus load increases and decreases. The present load that is modeled is a loading factor of 1.00.

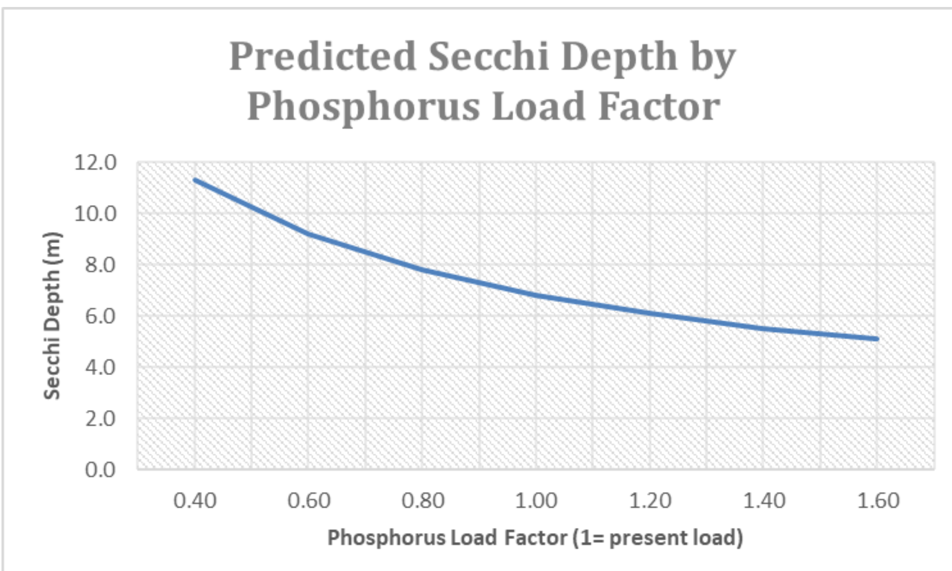

Figure 7: Predicted Secchi depth in Lake Owen with varying phosphorus load increases and decreases. The present load that is modeled is a loading factor of 1.00.

Since the South Basin sub-watershed is the largest phosphorus source per square km of the sub-watershed basins, this would likely be the focus of phosphorus/nutrient mitigation. Changes in phosphorus exports only from this sub-watershed were predicted in Bathtub. The chart below shows the results of changing phosphorus loading on Lake Owen from the South Basin only.

Change in P load (South Basin (SB) Only)	Predicted mean GSM total P concentration (ug/L)	Predicted mean GSM chlorophyll-a (ug/L)	Predicted Secchi Depth (m)
Base from model (55.7 kg)	11.0	2.0	6.8
20% increase in SB	11.2	2.1	6.7
40% increase in SB	11.4	2.1	6.6
-20% decrease in SB	10.8	2.0	6.9
-40% decrease in SB	10.6	1.9	7.1

Table 7: Predicted total phosphorus and chlorophyll-a concentrations as well as Secchi depth with changes in phosphorus loading factor in the South Basin only. These values predict for mean in the entire lake.

In the watershed delineation evaluation, the amount of potential build-out possibilities was summarized for each sub-watershed. The predicted changes in phosphorus, chlorophyll-a, and Secchi depth were predicted through input into land-use changes in Bathtub. To reflect those changes within each sub-watershed, forested land cover was decreased by 10%, 25%, and 50% of the potentially developable land, and the medium/high development land cover was increased by these same percentages of the potentially developable land. Predictions were made from the model for each of these increases of the potential development areas. The chart summarizes the response to these changes within the model.

Change in land cover through development (by %)	Predicted total phosphorus concentration (ug/L)	Predicted chlorophyll-a concentration (ug/L)	Predicted Secchi depth (m)
Baseline (present-0%)	11.0	2,0	6.8
10% of developable land developed-all basins	11.8	2.5	6.2
25% of developable land developed-all basins	13.3	3.1	5.4
50% of developable land developed (all basins)	14.8	4.2	4.5

Table 8: Predicted total phosphorus and chlorophyll-a concentrations as well as Secchi depth with changes in development within the direct drainage watershed. These values predict for mean in the entire lake.

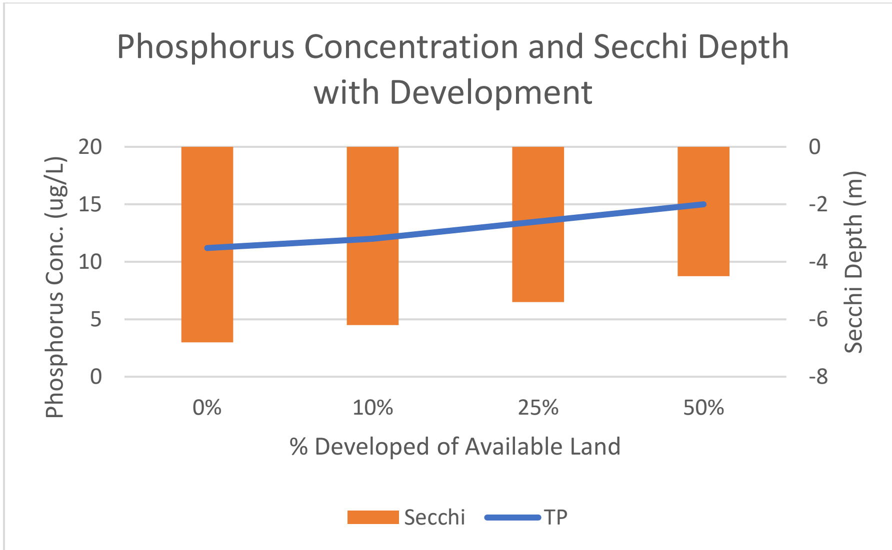

Figure 8: Graph reflecting changes in phosphorus concentration and Secchi depth with various levels of development (by percent of total available)

These estimates are based upon assumptions that the developed land will have similar runoff coefficients and phosphorus concentrations to what was utilized in the model. This may not be the case since different development based upon the slope, the number of impervious surfaces, and management practices could result in different runoff amounts. This allows for evaluating development potential and management of Lake Owen but is an estimate.

Otter Bay

Otter Bay has higher trophic state readings for total phosphorus, chlorophyll-a and Secchi depth than Lake Owen as a whole. This bay is quite isolated from the main lake basin and has a small volume of water. For these reasons, the mean values for Otter Bay were not used in the observed values for the model which would skew the mean for each value. With some development present and the lower volume of water (coupled with the isolation), this portion of Lake Owen is more susceptible to impacts from human activity. In reviewing the 2020 data, the phosphorus and chlorophyll-a concentrations increase in response to the higher precipitation periods. This suggests Otter Bay phosphorus concentration is affected by runoff events.

2020 Otter Bay Data Comparison	Mean GSM Total Phosphorus	Mean GSM Chlorophyll-a
Otter Bay	13.9	4.0
North Basin	10.0	2.0
South Basin	8.6	1.4

Table 9: Otter Bay total phosphorus and chlorophyll-a concentrations compared to other basins in Lake Owen, 2020.

The reduction in runoff and phosphorus into Otter Bay will likely have a more dramatic response. Therefore, mitigation of phosphorus into Otter Bay will improve water quality, and if management practices are not implemented during development, any future development could have a significant negative impact on the water quality in Otter Bay.

Discussion

The data used to model the water and nutrient budget for Lake Owen resulted a model with a good fit (based on predicted vs observed values). Since some inputs were derived from published/adjusted estimates, there is the potential for error. However, with a good fit, this model should be a suitable predictor of phosphorus, chlorophyll-a, and Secchi depth values with changes in the inputs into Lake Owen.

The phosphorus inputs from atmospheric deposition and groundwater (unless there are sources reaching groundwater that can be managed) cannot be mitigated. However, the inputs from overland runoff and septic influx can be mitigated. This potential mitigation indicates that as Lake Owen moves to the future, management practices that can reduce phosphorus sources would be helpful. The direct watershed of Lake Owen is small, therefore identifying locations that could have a potentially significant influx of nutrients should be easier to identify than if the watershed were more expansive.

Septic system influx is based on the number of people using these systems for the year. The estimates can immensely vary due to soil retention dynamics, the age of the system, and if the system is functioning correctly. One mitigation step is to evaluate the septic systems around Lake Owen for age and functionality. Some counties monitor their septic systems, so this could be discussed with Bayfield County. If there are several suspect systems, the next step would be to improve these systems. Just the range of 25.7 kg/yr. (used in this model) and the 35.5 kg/yr. (from the Lake Owen Comprehensive Lake Management Plan) is a measurable difference in the total phosphorus load. This suggests the potential for moderate mitigation of phosphorus.

Management practices within direct watershed basins could reduce phosphorus influx. The difference in exports of phosphorus between sub-watershed basins is largely due to more development or higher intensity development within the watershed. The change in load model outputs shows that reducing phosphorus runoff from these areas could reduce total phosphorus concentrations and therefore chlorophyll-a. The South Basin is estimated as the largest phosphorus load source of the four basins. The load analysis predicts that if that phosphorus is reduced by 40%, the overall lake phosphorus concentration will go from 11.0 ug/L to 10.6 ug/L. The chlorophyll-a concentration is predicted to decrease from 2,0 ug/L to 1.9 ug/L.

These decreases do not seem significant, but the build-out analysis shows that as development increases around Lake Owen, the phosphorus and chlorophyll-a concentrations will increase. Therefore, if phosphorus is mitigated around Lake Owen, it could offset the increase likely to occur with added development. Any future development should include best management practices to avoid increases in phosphorus loads.

High runoff amounts, especially from higher density development, can affect more than just water quality. Impervious surfaces (do not allow water to infiltrate) such as roof tops, driveways and sidewalks increase runoff. This runoff can increase the temperature of the water which could affect the thermodynamics of Lake Owen. The runoff can increase sedimentation changing benthic (bottom) habitat for fish and other organisms by filling in space between rocks with fine sediments. Sediment build-up can also provide more conducive habitat for invasive species such as Eurasian watermilfoil.

Presently, Lake Owen has excellent water quality. the watershed has limited impact on Lake Owen at this time. However, maintaining this high-water quality is important and will need to involve mitigation efforts, especially with future development. Lake Owen is fed largely by groundwater, which helps maintain the water quality. Even with added input of phosphorus, managing Lake Owen for little to no phosphorus increase is attainable.

The simplest focus for management practices is the South Basin. These properties are easy to identify even without modeling their impacts. Numerous practices could be effective which include rain gardens, shoreline restoration with native vegetation, and infiltration practices near impervious surfaces.

The water clarity analysis in 2019, determined that a tremendous amount of energy is needed to mix Lake Owen enough to result in bottom level phosphorus to reach the top layer. Climate change patterns that could increase this potential of mixing are difficult to predict. Larger rain events and more intense storms coupled with shorter and warmer winters could change the stratification dynamics of Lake Owen. If mixing occurs during the growing season, there is a significant concentration of phosphorus in the lower layers that could contribute to higher concentrations of phosphorus in the upper layer changing the algae concentration and water clarity.

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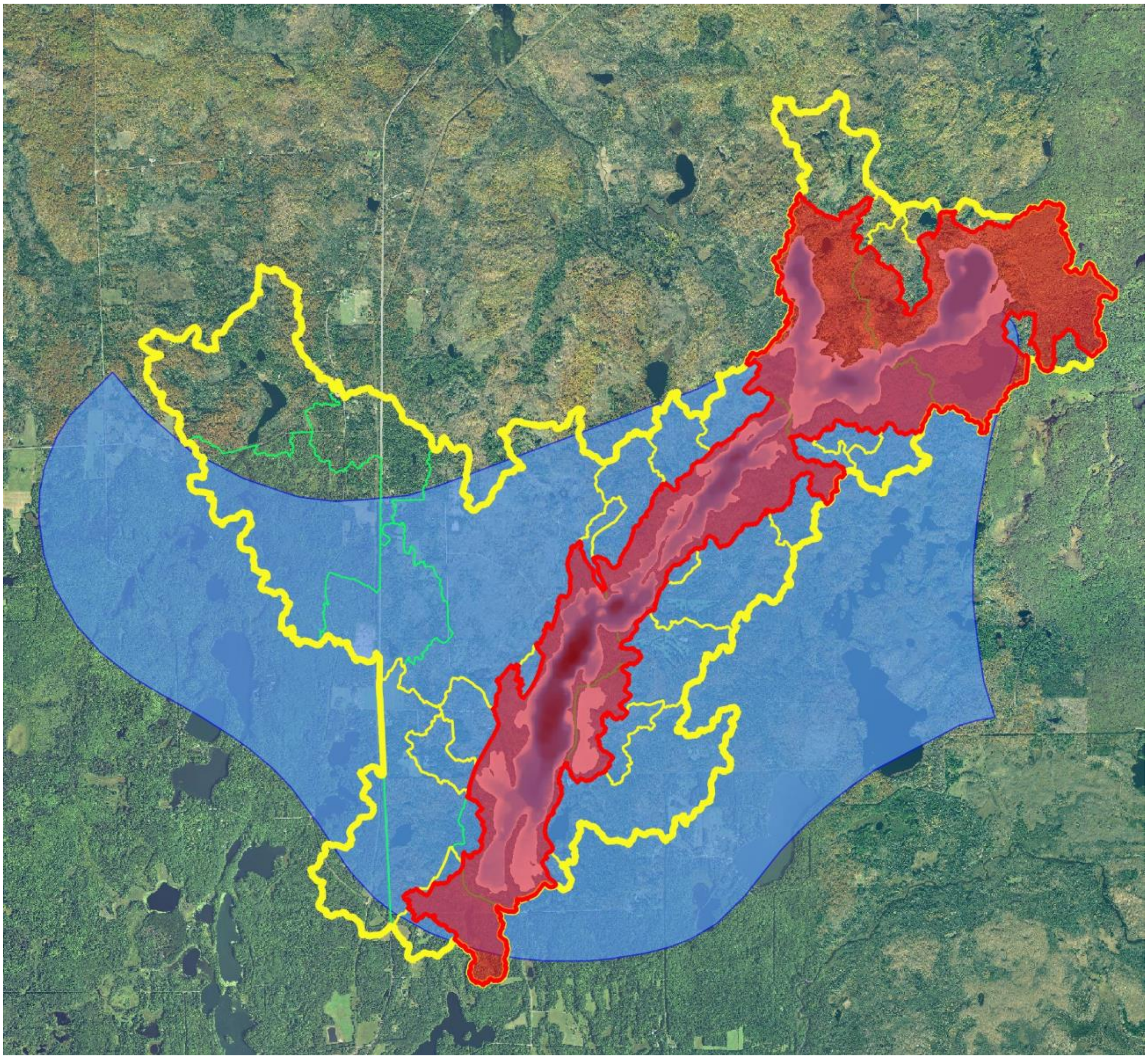
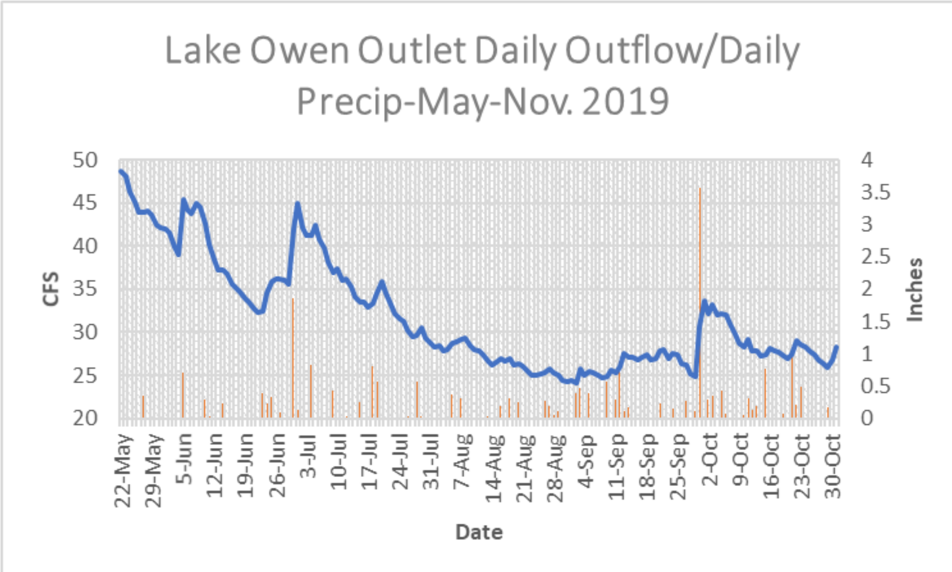
Appendix A-Data Set



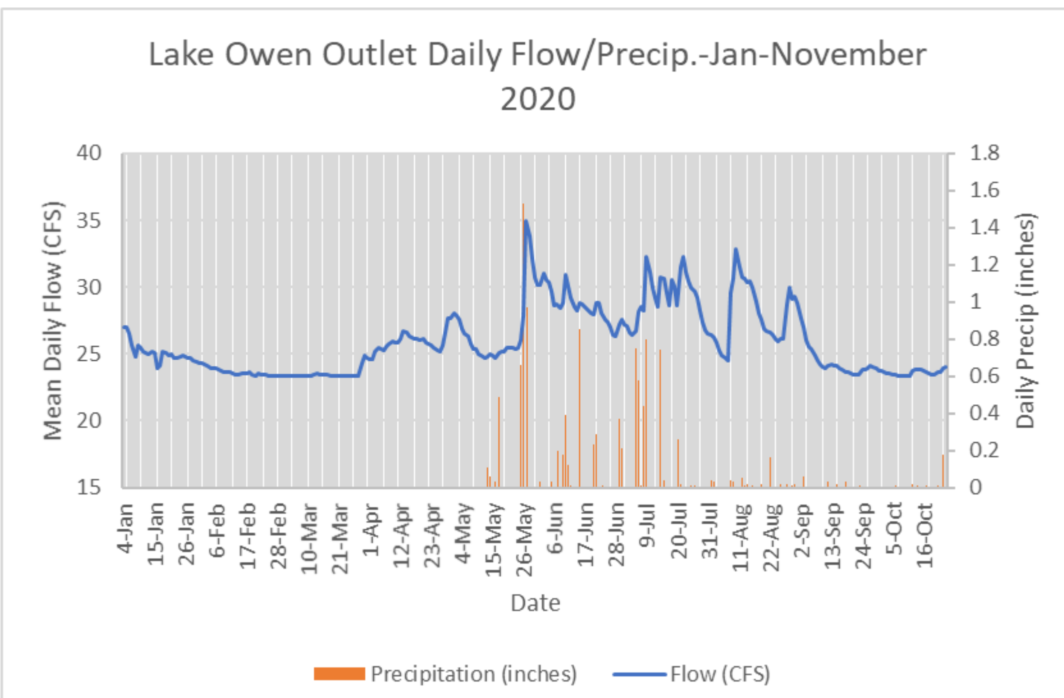
Lake Owen Watershed. Blue is groundwater watershed discharge. Yellow outline is the internally drained watershed area. Red is the direct drainage watershed.

2019 Outlet Hydrograph



2019 mean daily baseflow=25 cfs 2019 Mean daily runoff flow=6.33 cfs

2020 Outlet Hydrograph



2020 mean daily baseflow=20.3 cfs; 2020 mean daily runoff flow = 5.4 cfs

Onsite precipitation 2019 (these values were augmented for periods onsite logger on installed by Bayfield County/Drummond Station in 2019 and 2020):

Date	Inches
6/12/2019	0.01
6/14/2019	0.24
6/15/2019	0.01
6/23/2019	0.4
6/24/2019	0.24
6/25/2019	0.33
6/27/2019	0.09
6/28/2019	0.01
6/30/2019	1.86
7/1/2019	0.14
7/4/2019	0.82
7/5/2019	0.01
7/9/2019	0.43
7/12/2019	0.04
7/15/2019	0.25
7/16/2019	0.01
7/18/2019	0.8
7/19/2019	0.57
7/20/2019	0.01
7/26/2019	0.04
7/28/2019	0.57
7/29/2019	0.03
8/5/2019	0.37
8/7/2019	0.32
8/13/2019	0.04
8/16/2019	0.19
8/18/2019	0.31
8/20/2019	0.26
8/26/2019	0.28
8/27/2019	0.2
8/28/2019	0.06
8/29/2019	0.11
9/2/2019	0.4
9/3/2019	0.47
9/5/2019	0.39
9/6/2019	0.01
9/9/2019	0.57
9/10/2019	0.02
9/11/2019	0.3
9/12/2019	0.88
9/13/2019	0.12
9/14/2019	0.17
9/21/2019	0.23
9/24/2019	0.16
9/25/2019	0.01

9/26/2019	0.02
9/27/2019	0.28
9/29/2019	0.12
9/30/2019	3.56
10/2/2019	0.29
10/3/2019	0.35
10/5/2019	0.43
10/6/2019	0.08
10/10/2019	0.05
10/11/2019	0.32
10/12/2019	0.13
10/13/2019	0.19
10/14/2019	0.01
10/15/2019	0.76
10/16/2019	0.02
10/19/2019	0.07
10/21/2019	0.95
10/22/2019	0.22
10/23/2019	0.48
10/24/2019	0.01
10/25/2019	0.02
10/29/2019	0.17
11/3/2019	0.04
11/4/2019	0.01
11/7/2019	0.03

Onsite precipitation 2020:

Date	inches
5/13/2020	0.11
5/14/2020	0.06
5/16/2020	0.03
5/17/2020	0.49
5/25/2020	0.66
5/26/2020	1.53
5/27/2020	0.97
6/1/2020	0.03
6/5/2020	0.03
6/7/2020	0.2
6/9/2020	0.18
6/10/2020	0.39
6/11/2020	0.12
6/12/2020	0.01
6/15/2020	0.85
6/20/2020	0.23
6/21/2020	0.29
6/23/2020	0.01
6/29/2020	0.37

6/30/2020	0.21
7/5/2020	0.75
7/6/2020	0.58
7/7/2020	0.01
7/8/2020	0.44
7/9/2020	0.8
7/14/2020	0.74
7/15/2020	0.04
7/20/2020	0.26
7/21/2020	0.02
7/25/2020	0.01
7/26/2020	0.01
8/1/2020	0.04
8/2/2020	0.03
8/8/2020	0.04
8/9/2020	0.03
8/12/2020	0.05
8/13/2020	0.01
8/14/2020	0.02
8/16/2020	0.01
8/19/2020	0.02
8/22/2020	0.16
8/26/2020	0.02
8/28/2020	0.02
8/30/2020	0.01
8/31/2020	0.02
9/3/2020	0.06
9/12/2020	0.03
9/15/2020	0.02
9/18/2020	0.03
9/23/2020	0.01
10/6/2020	0.01
10/12/2020	0.02
10/14/2020	0.01
10/17/2020	0.01
10/21/2020	0.01
10/23/2020	0.18

2019 Water Chemistry Data Summary (means are from numerous samples):

North Basin	Mean Epilimnion TP (ug/L)	Mean Epilimnion Chl-a (ug/L)
May	11.1	5.59
June	13.8	2.13
July	10.0	1.04
August	12.4	1.3
September	8.5	1.24
Mean	11.2	2.27

South Basin	TP 0-2m	Chlor-a 0-2m
May	10.0	2.17
June	8.7	1.99
July	9.8	0.80
August	10.2	0.85
Sept	n/a	1.07
Mean	9.7	1.4

LOD for TP = 8 ug/L
LOD for Chl-a = 0.26 ug/L
LOQ for TP = 27 ug/L
LOQ for Chl-a =0.87 ug/L

2020 Water Chemistry Data Summary:

North Basin	Mean Epilimnion TP	Mean Epilimnion Chl-a
May	9	--
June	9.8	1.4
July	7.5	1.95
August	12.8	1.7
September	11.0	3.05
Mean	10.0	2.03

South Basin	Mean TP 0-2m	Mean Chlor-a 0-2m
May	14.0	--
June	12.0	1.4
July	7.0	1.2
August	7.0	1.35
Sept	5.5	1.75
Mean	9.1	1.43

LOD for TP = 6 ug/L
LOD for Chl-a = 0.6 ug/L
LOQ for TP = 18 ug/L
LOQ for Chl-a =1.8 ug/L

North Basin 2020 for internal load determination

Depth (m)	May (ice out) TP	SRP	June 1 TP	SRP	June 2 TP	SRP	July 1 TP	SRP	July 2 TP	SRP	Aug 1 TP	SRP	Aug 2 TP	SRP	Sept 1 TP	SRP	Sept 2 TP	SRP	Fall Turnover TP
0-2	9	ND	9	ND	8	3	9	ND	9	ND	13	ND	13	ND	10	ND	11	4	16
4			13	ND	9	2	7	ND	ND	ND	7	ND	18	3	11	2	12	ND	
6			11	ND	8	2	11	ND	7	ND	2	2	13	2	10	ND	10	ND	18
8			11	ND	12	3	10	ND	17	ND	7	ND	12	ND	7	ND	10	ND	
10			14	3	13	3	14	3	9	ND	11	ND	16	2	10	2	11	ND	
12			25	5	31	4	18	4	16	ND	29	ND	17	2	25	ND	29	2	
14	79	12	36	8	36	8	36	5	39	5	51	ND	21	ND	56	ND	86	10	20

South Basin 2020 for internal load determination

Depth (m)	May (ice out) TP	SRP	June 1 TP	SRP	June2 TP	SRP	July1 TP	SRP	July2 TP	SRP	Aug1 TP	SRP	Aug2 TP	SRP	Sept1 TP	SRP	Sept2 TP	SRP	Fall Turnover TP
0-2	14	3	15	ND	9	2	7	2	7	3	7	ND	7	nd	8	ND	3	ND	16
10																			18
18	18	5																	17
26 (hyp)			26	5	63				141	32			229	37	299	47			225

Appendix B-Model Inputs/Outputs

Global Variables	**Mean 2019**	**Mean 2020**
Precipitation (m)	0.7	0.47
Evaporation (m)	0.55	0.55
Storage Increase (m)	-0.09	-0.03

Atmos. Loads (kg/km²-yr)	**Mean**	**CV**
Total P	18	0.50
Total N	1000	0.50
Ortho P	5	0.50
Inorganic N	500	0.50

Model Options	**Code**	**Description**
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	5	P, JONES & BACHMAN
Secchi Depth	4	VS. TP, CARLSON TSI
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	0	USE OBSERVED CONCS
Output Destination	2	EXCEL WORKSHEET

Cat	**Land cover Name**	**Runoff coef (of total preci**	**P concentration (ug/L)**
1	Low density Resid	0..5	100
2	Med/High Density Resi	0.66	300
3	Barren	0.66	150
4	Grass	0.4	100
5	Pasture	0.4	350
6	Forested	0.13	75

7	Wetland	0.2	75

Water inflow (hm3)	2019 (0.5 yr)	2020 (0.75 yr)
Precipitation	3.6	2.4
Groundwater	12.0	18.0
Outlet WS	0.2	0.2
Mid-Basin WS	0.1	0.1
North Basin WS	0.3	0.3
South Basin WS	0,3	0.2

Phosphorus load (kg))	2019 (0.5 yr)	2020 (0.75 yr)
Precipitation	92.3	75.9
Groundwater	124.8	185.4
Outlet WS	18.3	14.9
Mid-Basin WS	11.9	10.7
North Basin WS	28	23.2
South Basin WS	33.1	25.8
Septic	25.7	25.7

2019 Lake Owen Variable	Predicted Mean	Observe Mean
TOTAL P MG/M3	10.4	10.4
CHL-A MG/M3	1.9	1.9
SECCHI M	7.1	7.0
CARLSON TSI-P	38.0	37.9
CARLSON TSI-CHLA	36.7	36.9
CARLSON TSI-SEC	31.7	32.0

2020 Variable		Predicted Mean	Observed Mean
TOTAL P	MG/M3	9.9	9.4
CHL-A	MG/M3	1.7	1.7
SECCHI	M	7.5	7.1
CARLSON TSI-P		37.2	36.5
CARLSON TSI-CHLA		36.0	35.8
CARLSON TSI-SEC		30.9	31.8

Calibration Factors used in Bathtub to make chlorophyll a and secchi closely match 2019 and 2020 in-lake observations:
Chlorophyll a: Callibration factor of 0.75
Secchi depth: Calibration factor of 1.55

Overall Water Balance-Average precipitation year Lake Owen								
				Area	**Flow**	**Runoff**		
Trb	**Type**	**Seg**	**Name**	**km²**	**hm³/yr**	**m/yr**		
1	2	1	Outlet-WS	2.0	0.3	0.16		
2	2	1	Mid Basin-WS	1.5	0.2	0.16		
3	2	1	North Basin-WS	3.1	0.5	0.16		
4	2	1	South Basin-WS	2.4	0.4	0.18		
6	1	1	Groundwater		21.0			
8	1	1	septic		0.0			
PRECIPITATION				5.1	4.5	0.87		
TRIBUTARY INFLOW				8.9	21.0	2.36		
NONPOINT INFLOW				8.9	1.5	0.17		
***TOTAL INFLOW				22.9	26.9	1.17		
ADVECTIVE OUTFLOW				22.9	24.1	1.05		
***TOTAL OUTFLOW				22.9	24.1	1.05		
***EVAPORATION					2.9			

Overall Mass Balance Based Upon				**Observed**		**Outflow & Reservoir Concentrations**		
Component:				**TOTAL P**				
				Load		**Conc**	**Export**	
Trb	**Type**	**Seg**	**Name**	**kg/yr**	**%Total**	**mg/m³**	**kg/km²/yr**	
1	2	1	Outlet-WS	33.0	6.7%	100.4	16.4	
2	2	1	Mid Basin-WS	22.4	4.5%	98.7	15.4	
3	2	1	North Basin-WS	47.5	9.6%	94.8	15.4	
4	2	1	South Basin-WS	55.7	11.3%	131.8	23.7	
6	1	1	Groundwater	216.3	43.9%	10.3		
8	1	1	septic	25.7	5.2%	257000.0		
PRECIPITATION				92.3	18.7%	0.50	20.7	18.0

TRIBUTARY INFLOW	242.0	49.1%	0.00	11.5	27.2
NONPOINT INFLOW	158.6	32.2%	0.00	107.2	17.8
***TOTAL INFLOW	493.0	100.0%	0.09	18.3	21.5
ADVECTIVE OUTFLOW	269.6	54.7%	0.00	11.2	11.8
***TOTAL OUTFLOW	269.6	54.7%	0.00	11.2	11.8
***RETENTION	223.4	45.3%	0.21		

Overflow Rate (m/yr)	4.7		Nutrient Resid. Time (yrs)	0.9417
Hydraulic Resid. Time (yrs)	1.7221		Turnover Ratio	1.1
Reservoir Conc (mg/m3)	11		Retention Coef.	0.453

Segment:	**1**
	Predicted Values--->
Variable	**Mean**
TOTAL P MG/M3	11.0
CHL-A MG/M3	2.0
SECCHI M	6.8
CARLSON TSI-P	38.7
CARLSON TSI-CHLA	37.5
CARLSON TSI-SEC	32.4

Global Variables	**Mean**	**CV**			**Model Options**		**Code**	**Description**
Averaging Period (yrs)	1	0.0			Conservative Substance		0	NOT COMPUTED
Precipitation (m)	0.87	0.0			Phosphorus Balance		8	CANF & BACH, LAKES
Evaporation (m)	0.56	0.0			Nitrogen Balance		0	NOT COMPUTED
Storage Increase (m)	0	0.0			Chlorophyll-a		5	P, JONES & BACHMAN
					Secchi Depth		4	VS. TP, CARLSON TSI
Atmos. Loads (kg/km^2-yr)	**Mean**	**CV**			Dispersion		1	FISCHER-NUMERIC
Conserv. Substance	0	0.00			Phosphorus Calibration		2	CONCENTRATIONS

	Total P	18	0.50				Nitrogen Calibration		2	CONCENTRATIONS
	Total N	1000	0.50				Error Analysis		1	MODEL & DATA
	Ortho P	5	0.50				Availability Factors		0	IGNORE
	Inorganic N	500	0.50				Mass-Balance Tables		0	USE OBSERVED CONCS
							Output Destination		2	EXCEL WORKSHEET
	Segment Morphometry									
			Outflow		**Area**	**Depth**	**Length**	**Mixed Depth (m)**		**Hypol Depth**
Seg	**Name**		**Segment**	**Group**	**km²**	**m**	**km**	**Mean**	**CV**	**Mean**
1	Lake Owen		0	1	5.13	8.08	10	7	0	28
Segment Observed Water Quality										
	Conserv		**Total P (ppb)**		**Total N (ppb)**		**Chl-a (ppb)**		**Secchi (m)**	
Seg	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**
1	0	0	11.2	0	0	0	1.9	0	6.75	0
	Segment Calibration Factors									
	Dispersion Rate		**Total P (ppb)**		**Total N (ppb)**		**Chl-a (ppb)**		**Secchi (m)**	
Seg	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**
1	1	0	1	0	1	0	0.75	0	1.55	0
	Tributary Data									
					Dr Area	**Flow (hm³/yr)**		**Conserv.**		**Total P (ppb)**
Trib	**Trib Name**		**Segment**	**Type**	**km²**	**Mean**	**CV**	**Mean**	**CV**	**Mean**
1	Outlet-WS		1	1	2.015	0.3	0	0	0	110
2	Mid Basin-WS		1	1	1.456	0.2	0	0	0	112
3	North Basin-WS		1	1	3.078	0.5	0	0	0	95
4	South Basin-WS		1	1	2.353	0.4	0	0	0	139.25
5	Outlet		1	4	0	0	0	0	0	10

6	Groundwater		1	1	0	21	0	0	0	10.3
7	Watershed		1	1	8.9	0	0	0	0	0
8	septic		1	1	0	1E-04	0	0	0	257000
Tributary Non-Point Source Drainage Areas (km^2)										
			Land cover Category--->							
Trib	**Trib Name**		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	Outlet-WS		0.167	0.021	0	0.013	0	1.774	0.04	0
2	Mid Basin-WS		0.025	0.032	0.001	0.039	0	1.268	0.092	0
3	North Basin-WS		0.251	0.011	0	0.022	0	2.6	0.193	0
4	South Basin-WS		0.089	0.157	0	0.044	0.002	1.942	0.119	0
5	Outlet		0	0	0	0	0	0	0	0
6	Groundwater		0	0	0	0	0	0	0	0
7	Watershed		0	0	0	0	0	0	0	0
8	septic		0	0	0	0	0	0	0	0
Non-Point Source Export Coefficients										
			Runoff (m/yr)		**Conserv. Subs.**		**Total P (ppb)**		**Total N (ppb)**	
Categ	**Land cover Name**		**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**
1	Low density Resid		0.44	0	0	0	150	0	0	0
2	Med/High Density Resi		0.58	0	0	0	300	0	0	0
3	Barren		0.57	0	0	0	150	0	0	0
4	Grass		0.35	0	0	0	100	0	0	0
5	Pasture		0.35	0	0	0	350	0	0	0
6	Forested		0.13	0	0	0	75	0	0	0
7	Wetland		0.2	0	0	0	75	0	0	0
8	open wate		0.87	0	0	0	15	0	0	0