“Phosphorus Loading: Landscape Interactions and Management Implications in an Urban Watershed”

Synopsis

A Portland State University graduate student performed research on Oswego Lake Watershed towards a Masters in Environmental Management. Maddee Rubenson looked at landscape characteristics within the Watershed and how they influence phosphorus concentrations and loading in both streams and stormwater drain tributaries. Maddee also looked at sub-basins in which the stormwater is treated by wet retention ponds and their effectiveness as a stormwater best management practice (BMP). Here are her findings:

Why study phosphorus?

Within Oswego Lake, phosphorus is the limiting nutrient for phytoplankton (algae) growth. This means that when there is phosphorus within the system, it is readily taken up by phytoplankton and therefore, more phosphorus equates to more phytoplankton growth. Why does this matter? When there are large phytoplankton blooms, not only is lake access restricted, but it is also bad for the aquatic organisms that live within Oswego Lake. Therefore, understanding the factors that influence phosphorus loadings, will help us control future phytoplankton blooms.

There are two main types of phosphorus: dissolved and particulate. Particulate phosphorus is sticky and easily attaches to eroded sediments or organic material, while dissolved phosphorus is easily transported in a water column and readily available for plant uptake. Particulate phosphorus can be transformed through biogeochemical processing into the dissolved (and bioavailable) form.

What were the main findings of the study?

- Due to significantly larger flows, streams were able to transport more phosphorus than stormwater drains
- There was a strong correlation between total suspended solids (a good proxy for eroded sediments) and total phosphorus concentrations in stream tributaries. This suggests that phosphorus entering through stream tributaries is of the particulate (or bio-unavailable) form.
- There was a positive, but weaker relationship between total suspended solids and total phosphorus in stormwater drains. However, similar concentrations of total phosphorus suggest that the phosphorus entering through stormwater drains is in the dissolved (or bioavailable) form.
- Water treated using wet retention ponds generally had higher phosphorus concentrations and phosphorus loads, compared to sub-basins where the water was treated by a different forms of stormwater BMP such as bioswales or raingardens.

What’s next?

The second chapter of Maddee’s thesis highlights the importance of continuing to monitor stormwater in the Oswego Lake Watershed. A preliminary plan suggests partnering with the Oswego Lake Watershed Council to perform volunteer monitoring at three locations where restoration activities are taking place. Continued monitoring will provide the Oswego Lake

Watershed Council, the Lake Oswego Corporation, and the City of Lake Oswego with long-term stormwater data, pre-and post-restoration baseline data, and gain community involvement within the watershed.

Want more information?

- See below for the thesis abstract and second chapter
- Feel free to email Maddee Rubenson at rubenson.m@gmail.com for more information on her project, including the full thesis pdf

Phosphorus Loading: Landscape Interactions and Management Implications in an Urban Watershed

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Abstract

Approximately 70% of the U.S. population is centered in urban environments. Urbanization leads to an altered landscape, modified drainages, and excess pollutants providing multiple stressors on the surrounding ecosystem. Excess nutrient inputs create eutrophication events which deplete dissolved oxygen and lead to rapid die-off of aquatic life. In Oswego Lake, eutrophication events also lead to lake closure and economic loss. It is important, therefore to identify the primary sources of phosphorus (the limiting nutrient) to Oswego Lake in order to provide future mitigation efforts. Located nine miles south of Portland, Oregon, Oswego Lake has an 18.6 km^2 shoreline predominately occupied by residential lots. The Oswego Lake Watershed is 18.1 km^2, consisting primarily of urban and residential areas. Oswego Lake has a long history of algal blooms, due to excess phosphorus both internally and externally loaded. Two creeks flow into Oswego Lake, contributing an estimated 190 ug/l of phosphorus during storm conditions. Also surrounding the lake are 70 storm drains, which have yet to be assessed in terms of phosphorus loading. Oswego Lake Watershed was delineated into 22 sub-basins defined by their storm drain and stream network. Further delineating these sub-basins based upon physical land characteristics (percent imperviousness, percent developed open-space, gradient, and percent vegetated) yielded six sub-basins that were used to characterize the Oswego Lake Watershed. Sampling took place during the fall of 2015, with samples consisting of both storm and baseflow conditions. Samples included total phosphorus, total suspended solids, turbidity, and discharge. Linear mixed effect models showed the importance of imperviousness, total suspended solids, and presence of a stream in predicting phosphorus loading. Significant differences existed in phosphorus loading when comparing sub-basins drained by streams to sub-basins drained by stormwater pipes, though phosphorus concentrations were similar. Wet retention ponds in the watershed were assessed on how well they address TSS and TP loadings within the six sub-basins. Sub-basins with high coverage of wet retention ponds had larger phosphorus loads and concentrations than sub-basins with another structural BMP in place.

Chapter 2: Future Water Quality Sampling Plan

Study Design

A study of six drainage sub-basins to Oswego Lake focused on landscape characteristics at sub-basin scale and presence or absence of a surface stream, found that stream tributaries are a significant source of phosphorus to Oswego Lake[1]. Total

[1] Rubenson, M. (2016). Phosphorus Loading: Landscape Interactions and Management Implications in an Urban Watershed . Portland, Oregon: Unpublished.

phosphorus (TP) and Total Suspended Solid (TSS) concentrations were similar in stream and piped drainages, suggesting that phosphorus loading differences were primarily driven by higher flows in sub-basins containing streams. A Linear Mixed Effect (LME) model found that sub-basin imperviousness was the primary landscape characteristic influencing phosphorus loading within the sub-basins. Understanding the importance of different watershed characteristics will allow the Lake Oswego Corporation to enact future monitoring, which will hope to increase the knowledge of phosphorus sources within Oswego Lake Watershed. With an increased knowledge of phosphorus sources in Oswego Lake Watershed, management and mitigation efforts can be put in place to reduce tributary loading to Oswego Lake. Future monitoring will include present and new sub-basins and incorporate the watershed councils and citizen scientists in the monitoring process.

The Oswego Lake Watershed Council (OLWC) will be incorporated into future monitoring and restoration efforts. The OLWC was formed with the mission to conserve, restore, enhance, and maintain watershed functions to achieve and sustain a healthy watershed. They work closely with the City of Lake Oswego to identify sites that have running water, are adjacent to cities natural areas, and/or impaired by the effects of urbanization or invasive species. The OLWC began restoration activities during the spring and summer of 2015 with three demonstration sites and have future projects planned around the Oswego Lake Watershed (Figure 0-1).

Goals/Objectives

The goal of this chapter is to propose a study design based on the results from Chapter 1 to further describe phosphorous loads from Oswego Lake tributaries, both streams and storm pipes. In addition, information will be included on how to incorporate Oswego Lake Watershed Council and citizen science to reach this goal. The objectives are to obtain an increased understanding of tributary phosphorus sources in Oswego Lake, which can be applied to alum injection and phosphorus management by the Lake Oswego Corporation.

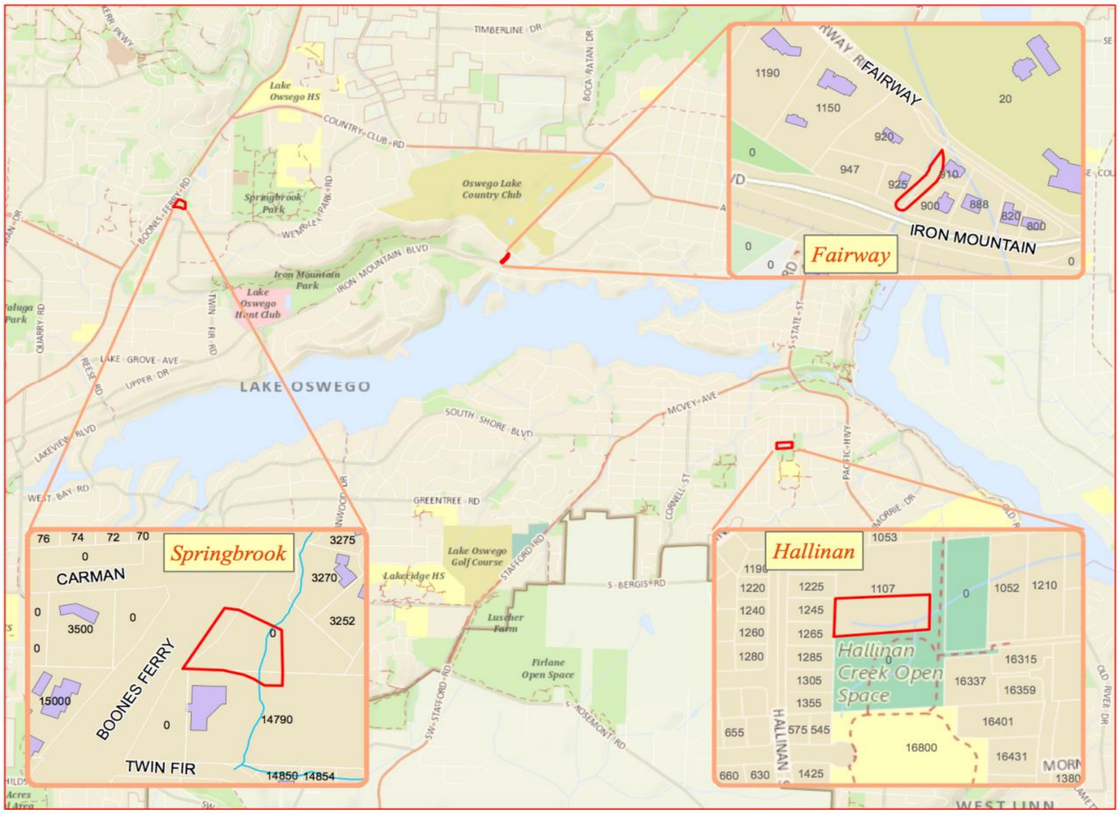

Figure 0-1 Current restoration projects completed by the Oswego Lake Watershed Council

Methods

All sub-basins were delineated by imperviousness and presence or absence of a stream to identify sub-basins that contained high impervious cover and surface streams. Sub-basins were only included if their sampling was possible, which was determined through field and geospatial analysis.

New sample locations were chosen based on their impervious cover, presence of a stream, and whether restoration was occurring or projected to occur in the sub-basin through the Oswego Lake Watershed Council. Three sub-basins contain restoration activity through the OLWC (**Table 0-1**), though only Cc and Sb are part of Oswego Lake Watershed as Mn flows into the Willamette River. OLWC plans to continue restoration activities in all three sites during 2016 and is working on plans to add the Park Academy site and continue work in Mountain Park.

Future monitoring efforts will sample for TP, TSS, and flow following the methods outlined in the Sampling Analysis Plan and Quality Assurance Project Plan.

Table 0-1 - Current and future restoration projects with the Oswego Lake Watershed Council

Site Name	Sub-Basin	Drainage Basin	Dates	Status
Fairway	Cc	Oswego Lake	Apr 2015-Present	On-going
Hallinan	Mn	Willamette River	Apr 2015-Present	On-going
Hope Church	Sb	Oswego Lake	Apr 2015-Present	On-going
Park Academy	Ld	Oswego Lake	N/A	Tentative
Mountain Park	Sb	Oswego Lake	Nov 2015-Present	On-going

Study Design

Future sampling locations were chosen based on the decision criteria (**Figure 0-2**). Three sub-basins were chosen for future analysis, Sb2, Cc, and Ld (**Figure 0-3**). Sb2 was chosen because it is adjacent to the Mountain Park restoration site and located on Springbrook Creek upstream from the previous sampling location (Sb3). This basin has a high amount of imperviousness (

Table 0-2), which gives a new perspective on the effects of urbanization on Springbrook Creek. Citizen scientists are measuring discharge and collecting water quality data at Mountain Park, which when combined with new data and past data from Sb3 will give a longitudinal representation on p-loading in Springbrook Creek. Sub-basin Cc was chosen to have continued measurements, because of the restoration that has and will continue on Boutwell Creek (**Table 0-1**). Sampling began at Boutwell Creek after restoration began, yet continued observations on water quality and discharge levels will give the Lake Oswego Corporation the ability to monitor TP-loading over time after restoration has occurred. The last sub-basin chosen is Ld and the upper reaches of Lost Dog Creek. This site will drain the Park Academy proposed restoration site, which ideally will give a before and after restoration result of TP-loading. Data from this site can be compared to the data that was collected by Ben Johnson in 2009 for his master's thesis on the longitudinal effects of phosphorus in Lost Dog Creek.

Sampling for all three sites will follow the standard procedures outlined in the QAPP and SAP. Monitoring at sites will begin during the summer of 2016 to gain baseflow measurements and continue throughout the calendar year. Communication with the OLWC project coordinator (**Table 0-3**) is imperative to ensure sampling is occurring at sites that restoration is in progress. Measurements will include TP, TSS, and discharge at all locations. TP-loading will be calculated following the equation outlined in the SAP and chapter 1. At least three baseflow measurements will be taken during the summer of 2016, wet season measurements will occur between October and April with monthly sampling events.

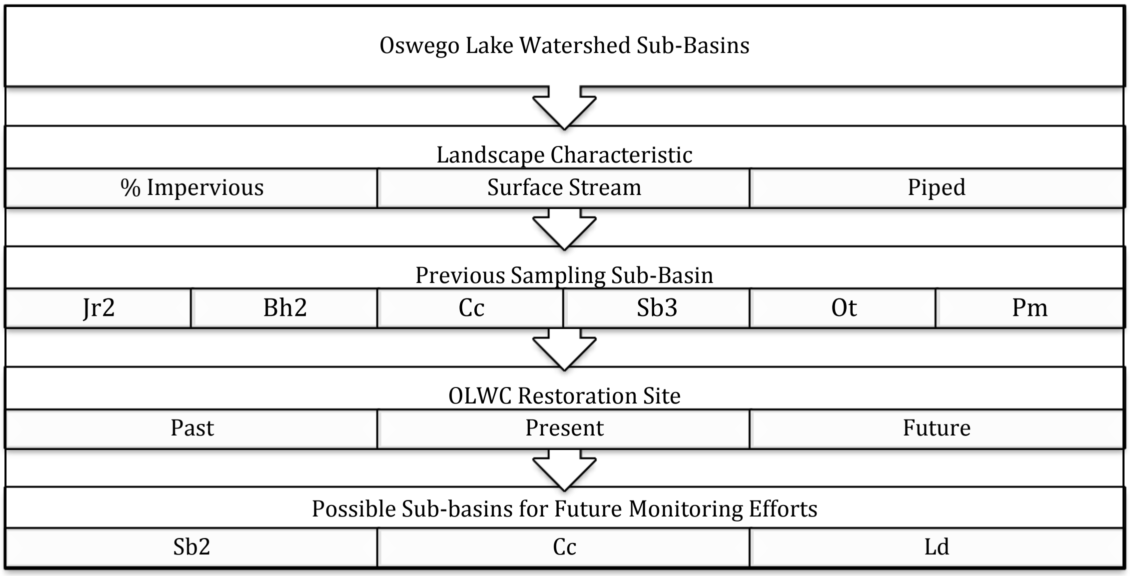

Figure 0-2- Decision criteria for selection of sub-basins in future monitoring efforts

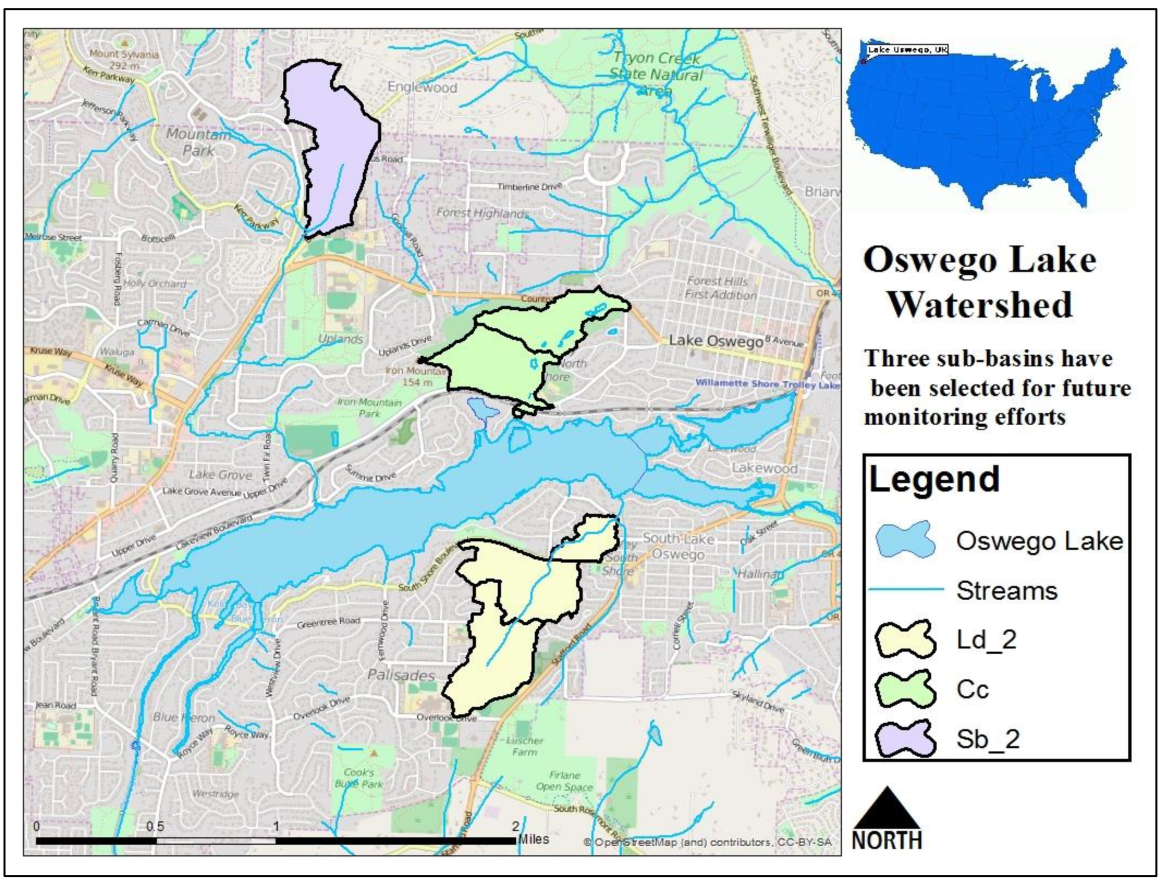

Figure 0-3- Sub-basins that have been selected for future monitoring efforts for the Lake Oswego Corporation and Oswego Lake Watershed Council

Table 0-2- The sub-basin characteristics used for identifying which tributaries would likely have high P-loads. The sub-basins are organized by increasing imperviousness. Underscores represent a sub-basin that was unable to sample and modified. Only basins that are able to be sampled are included in this chart; *denotes a sub-basin that has current or future restoration projects with the Oswego Lake Watershed Council; +denotes a sub-basin that is part of initial study.

Sub-Basin	Surface Stream	Area (sqft)	Imp (%)	%slope>=25	AverageK	Developed, Open Space (%)	Vegetated (%)
Cc+*	Yes	5,538,241	7.3	12.4	0.34	71.4	19.1
Sb_3+*	Yes	4,025,260	14	0.1	0.37	4.7	57.3
Ot+	No	1,008,670	20.2	50.0	0.37	10.6	58.2
Bh_2+	Yes	1,267,360	21.9	4.4	0.35	14.7	48.0
Ld*	No	19,032,526	22.6	2.3	0.34	7.9	34.6
Pv	No	835,256	23.2	5.0	0.28	22.4	22.6
Ml	Yes	1,360,784	24.4	0.6	0.28	13.5	28.0
Bf	No	16,708,887	25.4	0.1	0.37	8.7	20.5
Bc_2	No	6,244,580	28.0	17.2	0.37	14.2	36.9
Pm+	No	568,926	29.2	8.7	0.33	12.9	22.8
Lf	Yes	2,402,649	29.9	1.4	0.28	10.5	10.9
Fr	No	3,886,390	30.5	13.5	0.37	10.3	30.4
Sb_2	Yes	4,943,070	33.8	4.6	0.35	12.1	5.7
Pr	No	1,120,800	36.4	0.8	0.34	0.2	20.6
Ph	No	3,935,124	37.9	6.0	0.37	4.8	21.5
Rs	No	5,128,580	40.6	3.2	0.34	9.9	22.6
Jr_2+	No	6,922,054	43.4	0.0	0.35	5.6	5.5

Analysis

Water quality measurements will be analyzed following the Sampling Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP) that were created for the preliminary analysis.

Watershed Council and Community Support

Future monitoring will be communicated with the OLWC in order to achieve before and after water quality results from the sub-basins in which restoration activities are occurring. At least one sampling sub-basin will include an OLWC restoration site, to ensure the ability to gain knowledge on the effects of restoration activities. The main contact for the OLWC will be Adra Lobdell, the current project coordinator (**Table 0-3**).

Active communication and the development of a monitoring schedule with the OLWC is currently in the works. The OLWC has strong interest in developing a volunteer monitoring effort at all sites where restoration is occurring, yet currently do not have the funds to back it. A volunteer monitoring program will be based off of the current program in place at Tryon Creek Watershed Council (TCWC). Volunteers would help collect monthly flow, TSS, and TP measurements at sample locations. Currently, TCWC uses ~4 volunteers who work for ~5 hours to collect water samples. Staff time is needed to recruit, prepare sampling supplies, and communicate with volunteers which takes 5-15 hours/month at $22/hr. Based on TCWC's monitoring program, the OLWC can expect to spend approximately $110-$330/month on a watershed water quality monitoring program (**Table 0-4**). The intern at Lake Oswego Corporation will be responsible for analysis of TSS, which will take approximately 6-8 hours and ideally align with long sample analysis (**Table 0-4**).

Table 0-3- Contact information for project coordinator with Oswego Lake Watershed Council

	Title	Name	Email
Primary	Project Coordinator	Adra Lobdell	Adra@oswegowatershed.org
Secondary	Secretary	Mike Buck	Mike@oswegowatershed.org

Table 0-4 - Preliminary budget for OLWC and LOC to enact a volunteer monitoring program

OLWC Staff Resources		Hours/month	# People	Monthly Cost ($)	Yearly Cost ($)
	Volunteers	5	4	--	--
	Staff	5-15	1	110-330	1,320 -3,960
LOC Resources		Hours/month	# People	Monthly Cost ($)	Yearly Cost ($)
	LOC Intern	6-8	1	90-120	1,080-1,440
Necessary Supplies		Item	Cost	Uses	Description
		Wading Wand	$1,106	Flow measurements	Hach Standard Wading Wand Kit