A Department of Ecology Report

Giffin Lake (Yakima County) Verification Monitoring

Abstract

Giffin Lake was once a popular recreation site, particularly for anglers, but an overabundance of macrophytes degraded the waterbody to the point that it was no longer an attractive location for fishing, hunting, or other recreational activities. The rampant macrophyte growth was attributed to an excess of nutrients resulting from a combination of internal lake processes and the input of nutrient-rich water from external sources.

Water samples collected from Giffin Lake in 1990 and 1991 showed elevated levels of phosphorus were present in the waterbody. The high concentration of phosphorus in the lake resulted in the lake being placed on the Clean Water Act 303(d) list of impaired waters.

This 2012 study verifies that the conditions found during the 1990-1991 sampling are still present in Giffin Lake. Data from the July 2012 sample events were disqualified from the study due to a procedural error in the planning process. However, samples collected in August and September of 2012 show that the lake is still in a eutrophic state, and phosphorus levels are still at levels higher than allowed for a lake in this region (WAC 173-201A).

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Background

This is a verification study on phosphorous concentrations at Giffin Lake in Yakima County, Washington. The purpose of the study is to determine whether the elevated phosphorous levels in the lake that led to its listing as an impaired waterbody are still present.

Location and Characteristics

Giffin Lake is located in the Sunnyside-Snake River Wildlife Area about three miles northwest of the town of Mabton and five miles south-southwest of Sunnyside, Washington (Figure 1). At 107 acres, it is the largest of six oxbow lakes formed by the Yakima River in the Sunnyside Headquarters unit of the wildlife area. The lake is relatively shallow, with a maximum depth of 7 to 9 feet and a mean depth of 4 feet, and does not become thermally stratified. Fragrant water lilies (*Nymphaea odorata*) have become so dominant in the lake that they have negatively impacted other species and recreational use.

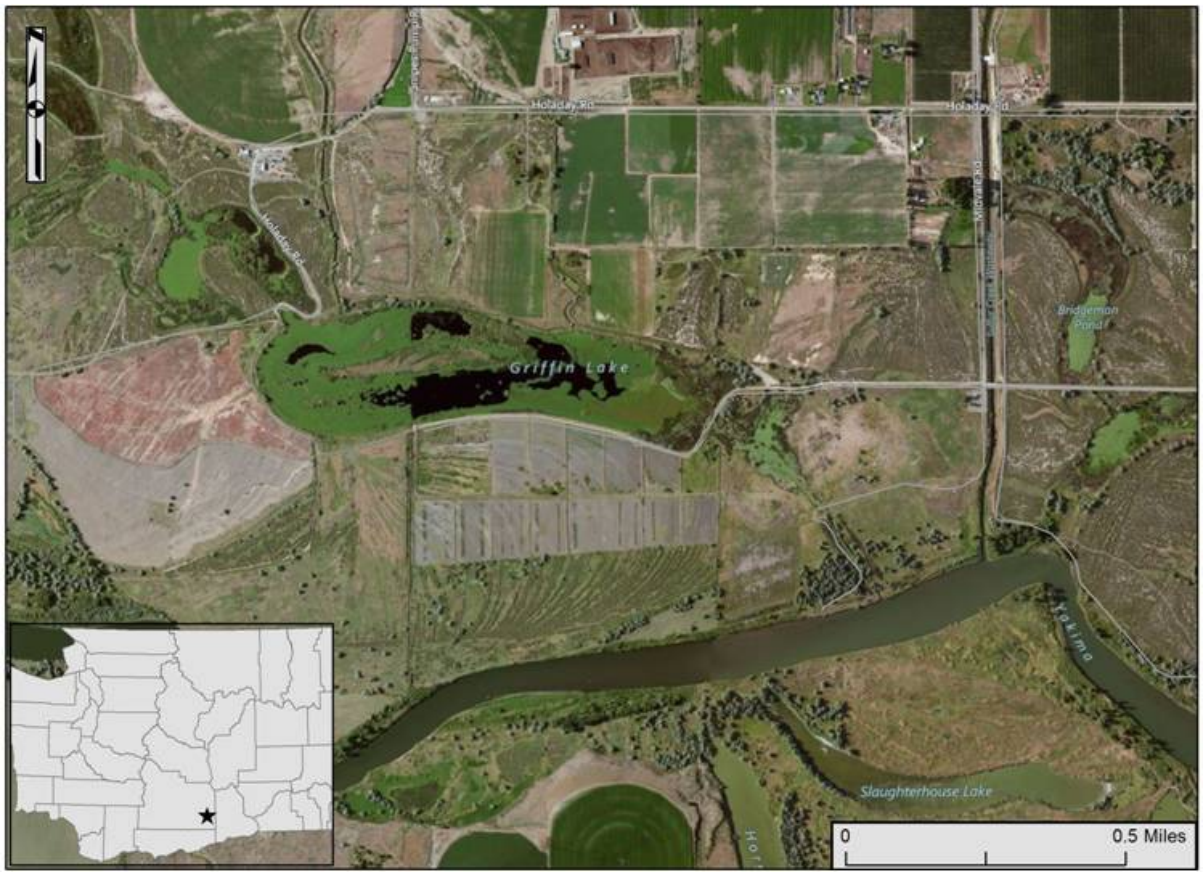

Figure 1. Aerial view of Giffin Lake. (Lake name is misspelled on the map.)

Input to Giffin Lake is primarily from irrigation return flows (Moore et al., 1992). Most of the water in these returns originates from the Yakima River. There is also evidence that at least one spring feeds Giffin Lake in addition to diffuse groundwater input. The direct drainage area feeding the lake is 7,985 acres, though the lake effectively drains a much larger area during the irrigation season. Giffin Lake is below the floodplain for the Yakima River, and it is occasionally inundated by the river at higher stages.

Land use in the Giffin Lake watershed is primarily agricultural (Moore et al., 1992). Major crops in the area include hops, alfalfa, grains, and grapes. The Sunnyside Headquarters Unit also supports commercial agriculture. Approximately 468 acres of the 2,786-acre wildlife area are under agricultural lease, with about 344 acres irrigated and the rest in dryland crops (WDFW, 2012a). However, not all of that acreage directly impacts Giffin Lake.

Historically, Giffin Lake has been used for both irrigation and recreation, but irrigation use has diminished greatly since the creation of the Sunnyside Valley Irrigation District. Lake water is used by the Washington Department of Fish and Wildlife (WDFW) to flood artificial wetlands used in waterfowl-banding efforts on an "as needed" basis. Angling is the predominant historical recreational use. WDFW lists Giffin Lake as having stocks of largemouth bass, pumpkinseed, and carp (WDFW, 2012b). Rainbow trout were once stocked in the lake, but WDFW discontinued that effort due to poor habitat conditions and decreased interest by the public, both largely due to the explosion of macrophyte growth in the lake. Giffin Lake is still used by waterfowl hunters, though even their ability to establish blinds and deploy decoys has been hampered by the lilies.

Historical Studies

In 1992, the Washington Water Research Center, in cooperation with the WDFW, the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology), published a Phase I Federal Clean Lakes Restoration Project report on Giffin Lake (Moore et al., 1992). The purpose of the study was to find the cause(s) of rampant macrophyte growth in the lake and recommend approaches to restoring it to an improved condition.

The authors of the Phase I study determined that Giffin Lake had been impacted by nutrients from anthropogenic sources over a long period of time. Excessive nutrient loading from both internal and external sources led to water quality problems, including excessive growth of aquatic macrophytes. The trophic state of the lake was eutrophic to hypereutrophic. The study also found that plant growth in Giffin Lake was nitrogen limited rather than phosphorus limited.

The preferred restoration plan for Giffin Lake included dredging, alum treatment of the main inflow, and nonpoint source pollution control in the basin.

Ecology records show that Phase II of an EPA Clean Lakes Program Restoration Project was completed in 1996, but no documentation of what that entailed could be located. Phase II is the implementation of recommendations from a diagnostic/feasibility study. However, there is no evidence that any of the recommendations from the Phase I study were implemented.

Water Quality Impairments

Giffin Lake was placed on the 303(d) list for phosphorus based on samples collected during the 1990-1991 study by Moore et al. The 303(d) list is a list of impaired waters maintained by the states under the requirements of the federal Clean Water Act (CWA). The State of Washington uses ecoregion-specific criteria to determine a total phosphorus numeric action value at which a lake is considered impaired. Lakes that do not meet (exceed) the action value for phosphorus can still be considered unimpaired if a lake-specific study (1) establishes a background concentration higher than the action value and (2) shows the lake is meeting its beneficial uses.

The Columbia Basin Ecoregion covers most of eastern Washington, including Giffin Lake. The action value for total phosphorus in that ecoregion is 35 micrograms per liter (ug/L). The lowest value recorded for Giffin Lake in the 1991-92 study was 70 ug/L, and the highest was 792 ug/L. Typical values were in the 100-200 ug/L range, though concentrations of 300 ug/L or higher were not uncommon.

The total nitrogen (TN) to total phosphorus (TP) ratio is also a concern at Giffin Lake. While no standard exists for TN:TP ratio, it is a factor in setting phosphorous limits in lake-specific studies (Ecology, 2004). A 10:1 ratio is considered necessary to prevent blue-green algae dominance in a waterbody. During the 1990-91 sampling period for the Phase I study, TN:TP ratios were 6:1 at the highest and 1:1 at the lowest. The mean TN:TP ratio was 3:1.

This 2012 study was conducted to verify that the conditions that led to the inclusion of Giffin Lake on the 303(d) list are still present.

Data Collection

Data were collected on July 1, July 16, August 15, and September 12, 2012. However, because supervisor approval for sample collection was not obtained prior to the sampling events in July, data from those dates was ruled unusable. Additionally, due to the thick vegetation on the lake (primarily lilies), only one sample site was accessible by boat. Contingency plans were developed to conduct additional sampling in June and July 2013, but this was deemed unnecessary after review of the data collected (see *Conclusions and Recommendations*, below).

Samples were collected using the field methods described in the Quality Assurance (QA) Project Plan for this study (Anderson, 2012a).

Samples were collected just below the surface (0.5 meters) using a Kemmerer sampler. Hydrolab measurements were taken at 0.5-meter depth intervals.

Field staff experienced problems collecting dissolved oxygen (DO) grab samples using the Kemmerer sampler. Despite the crew's best efforts, they were unable to prevent exposure of the sample to the air while transferring the sample from the Kemmerer sampler to the sample bottle. For the September samples, the DO grab samples were collected using a hand-sampler.

Results

Sampling Results

Samples and measurements were collected for a total of 12 parameters. The results are shown in Tables 1 and 2.

Table 1. Results for field parameters measured at Giffin Lake.

Parameter→ Date:	Depth	Temperature (°C)	pH	Specific Conductivity (uS/L)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)	Secchi Depth (m)
8/15/2012	0.5	23.26	7.23	322.5	3.92	47.8	0.4
8/15/2012	1.0	22.82	7.05	338.1	1.10	10.1	n/a
8/15/2012	1.5	20.76	6.83	393.7	0.25	2.9	n/a
9/12/2012	0.5	17.19	7.55	119.8	7.04	74.9	1.5
9/12/2012	1.0	17.16	7.57	119.4	7.17	76.2	n/a
9/12/2012	1.5	16.56	7.25	117.7	0.36	3.8	n/a

Table 2. Results for lab analyses conducted on samples collected at Giffin Lake.

Date	Parameter	Result	Unit		Date	Parameter	Result	Unit
8/15/2012	Ammonia	0.01	mg/L		8/15/2012	Ortho-Phosphate	0.104	mg/L
9/12/2012	Ammonia	0.01	mg/L		9/12/2012	Ortho-Phosphate	0.0753	mg/L
9/12/2012*	Ammonia	0.01	mg/L		9/12/2012*	Ortho-Phosphate	0.0759	mg/L
8/15/2012	Chlorophyll	64.9	ug/L		8/15/2012	Nitrate-Nitrite as N	0.01	mg/L
9/12/2012	Chlorophyll	28.6	ug/L		9/12/2012	Nitrate-Nitrite as N	0.01	mg/L
9/12/2012*	Chlorophyll	26.2	ug/L		9/12/2012*	Nitrate-Nitrite as N	0.01	mg/L
8/15/2012	Total Persulfate Nitrogen	0.339	mg/L		8/15/2012	Total Phosphorus	0.255	mg/L
9/12/2012	Total Persulfate Nitrogen	0.265	mg/L		9/12/2012	Total Phosphorus	0.121	mg/L
9/12/2012*	Total Persulfate Nitrogen	0.276	mg/L		9/12/2012*	Total Phosphorus	0.124	mg/L

* Sample collected as a replicate.

Data Quality

All of the data collected met measurement quality objectives (MQOs) except for the DO measurement collected on August 15 and the DO replicate collected on September 12. In both cases, there is reason to suspect that the QA sample measured using Winkler titration may be inaccurate. The August sample was collected from the Kemmerer, a technique that was abandoned because of issues with exposure to air while transferring water from the sampler to the sample bottle. In September, the bi-iodate normality check indicated that there was either human error or issues with the concentration of chemicals used in titration. Regardless of the cause, the DO measurements collected should be viewed as estimates.

Additionally, the conductivity probe on the Hydrolab malfunctioned prior to the September 12 sampling, and data recorded from that probe were thrown out.

Table 3. Comparison of samples to quality assurance samples.

Comparison of Samples to Sample Replicates									
Parameter	Sample	Replicate	Difference	Std. Dev.	Mean	CV[1]	RSD[2]	RPD[3]	Flag
Total Phosphorus	0.121	0.124	-0.003	0.002	0.124	0.017	1.7%	2.4%	N
Total Persulfate Nitrogen	0.265	0.276	-0.011	0.008	0.276	0.028	2.8%	4.0%	N
Ortho-Phosphate	0.0753	0.0759	-0.0006	0.0004	0.0759	0.0056	0.6%	0.8%	N
Nitrate-Nitrite as N	0.01	0.01	0.00	0.00	0.01	0.00	0.0%	0.0%	N
Chlorophyll	28.6	26.2	2.4	1.7	26.2	0.1	6.5%	9.2%	N
Ammonia	0.01	0.01	0.00	0.00	0.01	0.00	0.0%	0.0%	N
Dissolved Oxygen	6.8	6.8	0.0	0.0	6.8	0.0	0.5%	0.7%	N

Comparison of Hydrolab Dissolved Oxygen Measurements to Winkler Titration Samples									
Date	Hydrolab DO	Winkler DO	Difference	Std. Dev.	Mean	CV[1]	RSD[2]	RPD[3]	Flag
8/15/2012	3.92	4.3	-0.4	0.3	4.1	0.1	6.5%	9.2%	Y
9/12/2012	7.04	6.8	0.2	0.2	6.9	0.0	2.5%	3.5%	N
9/12/2012	7.04	6.8	0.3	0.2	6.9	0.0	3.0%	4.2%	Y

Comparison of Hydrolab Measurements to Replicates									
	Hydrolab Mmt	Hydrolab Replicate	Diff	StD	Mean	CV[1]	RSD[2]	RPD[3]	Flag
Temp	23.62	23.54	0.08	0.06	23.58	2.40E-03	0.2%	0.3%	N
pH	8.75	8.74	0.01	0.01	8.75	8.09E-04	0.1%	0.1%	N
SpC	297.5	299.4	-1.9	1.3	298.5	4.50E-03	0.5%	0.6%	N
DO (mg/L)	12.11	12.25	-0.14	0.10	12.18	8.13E-03	0.8%	1.1%	N

[1] Coefficient of Variance [2] Relative Standard Deviation [3] Relative Percent Difference

Replicate Hydrolab data for determining whether MQOs were being met were part of the rejected sample data from July 2012. Replicate data from nearby Myron Lake, collected using the same probe with the same calibration on August 15, 2012, were used as a surrogate (Anderson, 2012b).

Conclusions and Recommendations

Based on the 2012 samples, there is little doubt that Giffin Lake remains an impaired waterbody. In both August and September, phosphorus concentrations were an order of magnitude higher than allowed by Washington State standards. In addition, low DO concentrations, explosive macrophyte growth, and low TN:TP ratios continue to be water quality concerns at Giffin Lake. Given that these conditions are similar to those described in 1990-1991, there is little indication that water quality at Giffin Lake will improve without intervention.

Phosphorus

Phosphorus concentration was the primary issue being investigated in this 2012 study. Levels of phosphorous in Giffin Lake were similar to levels found at comparable times of year in the early 1990s; this suggests that there has been little or no improvement of conditions over the past two decades. All of the 2012 samples had total phosphorous values an order of magnitude higher than the recommended action value, ranging from 346% to 729% of that value.

In order to make a Category 5 determination for phosphorus concentration in a lake, Washington policy states:

> A lake or lake grid segment will be placed in Category 5 when the calculated mean phosphorus concentration of a single season or "critical condition" period exceeds the criterion or action value for that lake or lake grid segment. A Category 5 determination may also result from narrative standards as described in section 6 of this policy (Ecology, 2012).

Generally, making such a determination requires a minimum of four samples over the course of the critical period in order to determine both the calculated mean phosphorus concentration and the trophic state of the lake. In the case of Giffin Lake, however, phosphorus concentrations measured in August and September of 2012 were so high that even if two more samples were collected that had phosphorus concentrations of zero, the mean would still be more than two times greater than the phosphorus action value for an eutrophic lake. In light of this fact, it was determined that additional sampling would be superfluous.

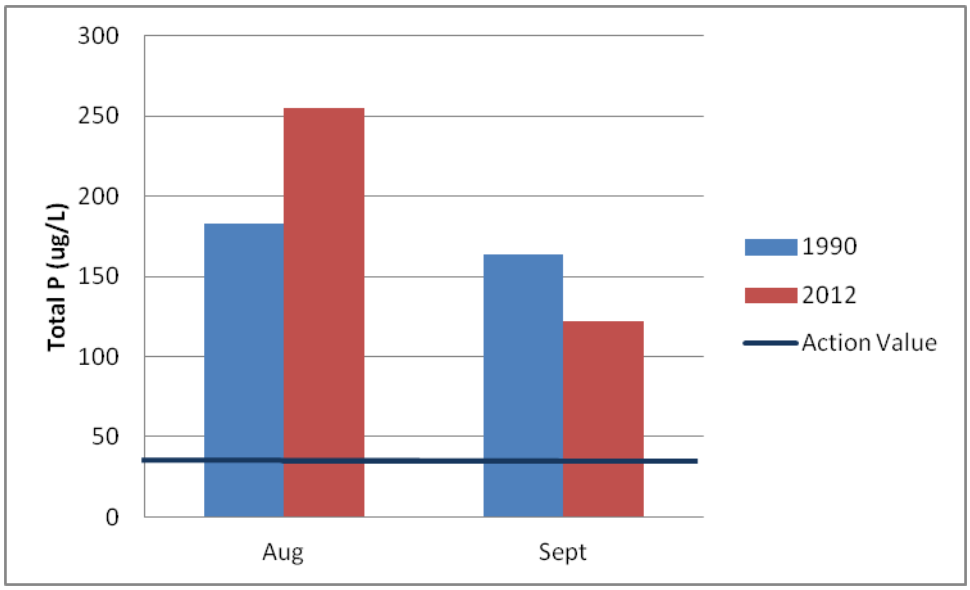

Figure 2. Comparison of total phosphorus results in 1990 and 2012 with phosphorus action value shown.

Nitrogen

Nitrogen levels in Giffin Lake were within the expected range for lakes in this ecoregion. TN:TP ratios continue to be of concern. The samples collected during this study had an average TN:TP ratio of 1.8:1, indicating that productivity in the lake remains nitrogen limited. The unusually low TN:TP ratio may be more of an indicator of the high amount of available phosphorus than of a low availability of nitrogen.

Dissolved Oxygen

Low levels of DO were measured throughout the water column. While these measurements did not all meet their MQOs, that variation is small relative to the degree to which the measured oxygen levels were below Washington standards. The overabundance of lilies is likely the major factor in low oxygen levels observed at the lake. A Category 2 determination for DO at Giffin Lake may be appropriate.

Trophic State

Giffin Lake's trophic state falls well into the eutrophic range based on phosphorus concentrations, chlorophyll concentrations, and Secchi Disk readings. As noted by Moore et al. in their 1992 publication on Giffin Lake, the use of phosphorous as an indicator of trophic state assumes a phosphorous limited environment, which is not the case in Giffin Lake. However, the chlorophyll and Secchi depth data confirm the classification of the trophic state of Giffin Lake as eutrophic.

Recommendations

As a result of this 2012 study, the following recommendations are made:

- Giffin Lake should retain its Category 5 classification for phosphorous on the 303(d) list.
- A Category 2 listing for dissolved oxygen should be considered for Giffin Lake.

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Appendix: Acronyms and Abbreviations

DO	Dissolved oxygen
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
et al.	And others
MQO	Measurement quality objective
QA	Quality assurance
RPD	Relative percent difference
RSD	Relative standard deviation
TN	Total nitrogen
TP	Total phosphorus
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resource Inventory Area

Units of Measurement

°C	degrees centigrade
ft	feet
g	gram, a unit of mass
km	kilometer, a unit of length equal to 1,000 meters
m	meter
mg	milligram
mg/L	milligrams per liter (parts per million)
mL	milliliters
mm	millimeter
s.u.	standard units
ug/L	micrograms per liter (parts per billion)