5.0 Priorities for Lake Restoration Projects

Priorities were developed for lake-specific water quality restoration projects as part of this WQMP. Factors considered in the ranking approach included water quality status (e.g. impairment status and chlorophyll trends), magnitude of required phosphorus concentration reduction, and relative lake location. Lake priority rankings are based on relative importance of a project to improving water quality in a lake. Project priorities are also assigned, but on a lake by lake basis. Cost was not included in the rankings, but relative magnitudes of restoration costs are listed with rankings as a means of comparison.

5.1. Lake Ranks

Lake priority rankings were developed using higher ranks for higher priorities and lower ranks for lower priorities. The ranking factors and scales used to assign priority to lakes are listed in Table 5-1. Individual ranks for water quality status, TP reduction required, and location were summed and averaged to provide an average rank for each lake (Table 5-2). Projects were examined and described in Section 4.0 and are listed by priority for each lake in Table 5-3.

Water Quality Status

Lakes were first ranked by water quality status using three criteria: impaired status, water quality in relation to NNC, and trends in chlorophyll *a*. For example, a lake designated as impaired that exhibited an increasing trend in chlorophyll *a* over time was ranked 5, while a lake designated as impaired but with a decreasing trend in chlorophyll *a* was ranked 4. Trends in chlorophyll *a* are presented for each lake in Section 4. A higher rank indicates higher restoration priority. For lakes that are unimpaired, water quality status was ranked based on trends in chlorophyll *a* and the likelihood of water quality reaching the NNC threshold (i.e. two standard errors (SE) below the NNC). The four unimpaired lakes that have TP and TN water column concentrations more than two standard errors below the NNC were assigned a rank of 1.

Required Phosphorus Reduction

The second factor for ranking lakes was required phosphorus reductions, based on the percent reduction required to meet targeted TP concentrations designated by the NNC (Figure 5-1). Higher ranked lakes have higher restoration priority. The highest priority lakes are those with the least (< 20 percent, e.g. Lake Haines) and greatest (> 50 percent, e.g. Lake Blue) phosphorus reduction required and were assigned a rank of 4. Water quality restoration projects completed on lakes with less than a 20 percent required TP reduction are likely to produce the most notable improvements in water quality. In contrast, lakes with greater than 50 percent TP reduction might require more time before substantial water quality improvements are observed, therefore, projects should be implemented sooner rather than later. Lakes with 20 to 40 percent TP concentration reduction, or with a standard error associated with the median TP concentration that is within two standard errors of the NNC, are ranked 3 for TP reduction. Lakes with 40 to 50 percent TP concentration reduction are ranked 2. Finally, lakes with no reduction in TP required were ranked 1.

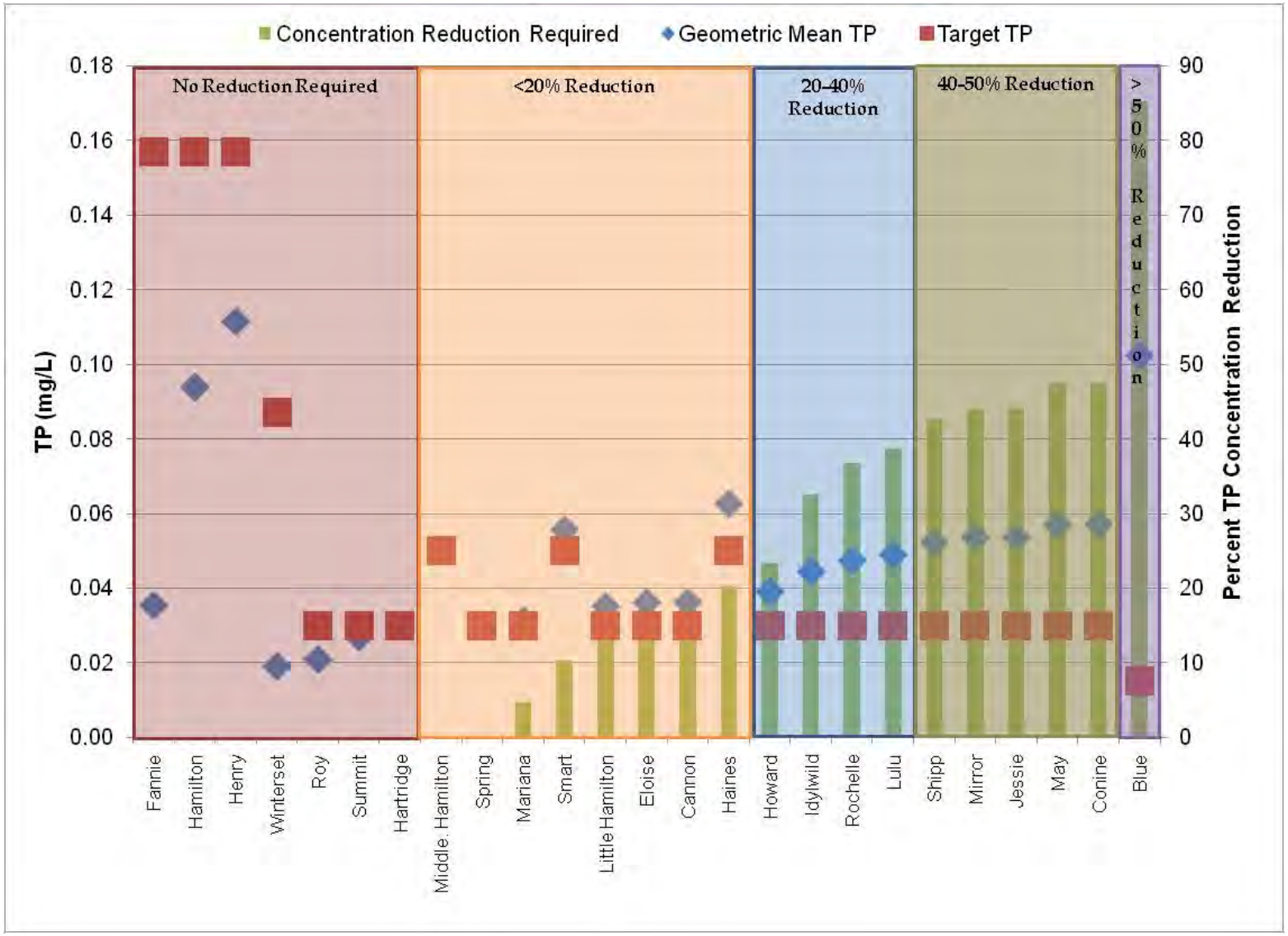
Table 5-1. Ranking scale used to assign priority to lakes for the WHCL.

Factor Used in Ranking	Rank
Water Quality Status	
Impaired, increasing or no trend in chlorophyll *a*	5
Impaired, decreasing trend in chlorophyll *a*	4
Unimpaired (<2SE), increasing or no trend in chlorophyll *a*	3
Unimpaired (<2SE), decreasing trend in chlorophyll *a*	2
Unimpaired (>2SE)	1
TP Reduction Required	
<20 percent or >50 percent	4
20-40 percent or within NNC 2SE	3
40-50 percent	2
No reduction	1
Location Relative to other Lakes	
Headwater lakes or proximate to headwater lake	4
Intermediate location	3
Discharge lake or adjacent	2
Hydrologic isolation due to gated structures	1
Estimated Restoration Cost	
<$500,000	$
$500,000-$1,000,000	$$
>$1,000,000	$$$

2SE= twice the standard error of the ten year median chlorophyll *a* data

The average percent reduction in phosphorus required for lakes with an adopted TMDL was 52 percent and an average 56 acres of SIAs is required to treat the external load associated with the TMDL (refer section 3.4 for detail). Percent phosphorus reductions required to meet NNC targets (Figure 5-1) for lakes with TMDLs averaged 66 percent with a corresponding average of 71 acres of SIAs to treat external phosphorus loads. In contrast, the average percent reduction required for lakes without an adopted TMDL to meet their NNC was an estimated 33 percent, with a corresponding average of 30 acres of SIA required to meet that reduction, approximately half that of lakes with TMDLs. As described previously, internal phosphorus loads are not a component of these estimates.

Figure 5-1. Required TP reductions, geometric mean TP concentrations, and targeted TP concentrations for the WHCL.



Lake Location

Lake location relative to the entire WHCL was also included in the rankings because of the potential influence of upstream projects on downstream lakes. For example, a project implemented in the headwaters of the WHCL would likely have a positive influence on the lakes downstream from the headwaters and are assigned a rank of 4, while a project at the "terminus" of the Southern Chain would not be expected to influence any of the other lakes and was assigned a rank of 1.

Rankings

As described earlier, rankings were assigned based on the importance and/or potential success of a project. Therefore, cost estimates are included in the summary tables and provide an estimate of the magnitude of the cost associated with projects but was not a component in ranking projects.

Individual lakes in the WHCL, associated TMDL status, and recommended projects are listed in Table 5-2. Lakes are grouped into tiers, based on relative importance (rank) of needed restoration. Recommended restoration projects should be implemented first in the first (red) tier lakes, followed by implementation in the second, third, and fourth tiers of lakes.

Priority rankings for restoration lakes ranged from 4.3 (highest importance) to 0.7 (least importance) and were grouped into five tiers based on average ranking values. All lakes in the first three tiers are designated impaired and therefore ranked either 4 or 5 for water quality status.

Total phosphorus values relative to NNC were also used to rank lakes for water quality status. TP values less than two standard errors below the TP NNC for a particular lake suggests that a relatively small decline in water quality could lead to impairment. For example, only Lakes Summit, Roy, and Hartridge ranked 3 under water quality status, indicating no impairment but TP values within two standard errors of the TP NNC. Therefore, projects were proposed for these lakes even though they are not designated as impaired. No lakes ranked 2 under water quality status, i.e. unimpaired, more than two standard errors below the TP threshold, and a decreasing trend in chlorophyll *a*.

Required reductions in TP were also used to rank lakes from 1 (no reduction required) to 4 (<20 percent or > 50 percent required). The first two tiers of lakes consistently ranked 3 or 4, while tiers three and four ranked 2 or 3 (with the single exception of Lake Blue). No phosphorus reductions are required for the unimpaired tier five lakes.

Relative location in the chain of lakes ranked lakes from 4 (headwaters) to 1 (isolated). The first tier of lakes were ranked 3 (intermediate location) and 4, compared with the second tier in which lakes ranked 2 (a discharge lake or adjacent to a discharge lake) and 3. There was no consistent pattern in the remaining tiers and lakes generally ranged from 1 to 4 in each tier.

Little Lake Hamilton is in the first tier (highest priority) of lakes. The lake is impaired, exhibits no trend in chlorophyll *a,* and is connected to Lake Hamilton. The median total phosphorus (TP) concentration in the lake exceeds the NNC established by EPA, but by less than 20 percent,

suggesting that implementing a water quality improvement project may have enough influence to reduce TP to below the NNC target, allowing the lake to be de-listed (no longer impaired).

Table 5-2 . Priority rankings for lakes in the WHCL (higher numbers indicate greater priority and same color shading indicates equal priority).

Lake	WBID Number	WQ Status	TP Reduction Required	Location	Average Rank	Estimated Restoration Cost
Mariana	1521L	5	4	4	4.3	$
Spring	1521G1	5	4	4	4.3	$
Idylwild	1521J	5	3	4	4.0	$
Little Hamilton	15001	5	4	3	4.0	$
Haines	1488C	4	4	4	4.0	$$$
Rochelle	1488B	5	3	4	4.0	$$
Cannon	1521H	4	4	3	3.7	$
Smart	1488A	4	4	3	3.7	$$
Middle Hamilton	15002	5	4	2	3.7	$$
Howard	1521F	5	3	3	3.7	$$$
Eloise	1521B	5	4	2	3.7	$$$
Mirror	1521G	5	2	3	3.3	$
Blue	1521Q	5	4	1	3.3	$
Jessie	1521K	4	2	4	3.3	$$$
May	1521E	5	2	3	3.3	$$$
Lulu	1521	5	3	2	3.3	$$$
Summit	1521M	3	3	3	3.0	$
Conine	1488U	4	2	3	3.0	$$$
Shipp	1521D	5	2	2	3.0	$$$
Roy	1521O	3	3	2	2.7	$$
Hartridge	1521I	3	3	4	2.3	$$
Winterset	1521A	1	1	4	2.0	NA
Henry	1504A	1	1	4	1.7	NA
Hamilton	15041	1	1	2	1.0	NA
Fannie	14882	1	1	1	0.7	NA

In contrast, Lake Blue is impaired, shows no trend in chlorophyll *a*, and requires a large TP reduction (85 percent). It is not connected to (i.e. has no influence on) to another lake and ranked in the third tier of lakes. Lake Conine ranks in the fourth tier of lakes. It is impaired but has a declining trend in chlorophyll *a*, therefore water quality may be improving in response to whole lake alum treatment (sediment inactivation) in the mid-1990s. The lake needs a 40 to 50 percent reduction in phosphorus, compared, for instance, to 85 percent needed in Lake Blue and less than 20 percent in Little Lake Hamilton. Lake Conine ranks in the fourth tier (lower priority).

Lakes Mariana, Idlylwild, Little Hamilton, Spring, Haines, and Rochelle were the highest ranked lakes for water quality restoration projects (ranked from 4.0 to 4.3). The five lakes are designated as impaired. Lake Haines exhibited a decreasing trend in chlorophyll *a*, while the remaining five lakes exhibited increasing (or no) trends in chlorophyll *a*.

The second tier of lakes includes Lakes Cannon, Smart, Middle Hamilton, Howard, and Eloise, each with a 3.7 rank and all designated as impaired. Chlorophyll *a* trended downward in Lakes Cannon and Smart for the period examined, but increased or had no trend for the other three lakes. The third tier of lakes (ranked 3.3) are also all designated as impaired and only one of the lakes (Jessie) exhibited a decreasing trend in chlorophyll *a*, while Lakes Mirror, Blue, May, and Lulu all exhibited a decreasing chlorophyll *a* trend.

The fourth tier of lakes includes Lakes Summit, Conine, Shipp, Roy, and Hartridge (ranked from 2.3 to 3.0). Only Lakes Conine and Shipp are designated impaired. Chlorophyll trends indicated an increase or no change in chlorophyll *a* in Lake Shipp and a decrease in chlorophyll *a* in Lake Conine. The fifth tier of lakes includes Lakes Henry, Winterset, Hamilton, and Fannie (ranked 1 to 1.7), none of which are designated impaired and none of which exhibit trends in chlorophyll *a*.

5.2. Project Ranks

Projects were listed (and ranked) for each lake in Section 4.0 and ranks are presented here as part of the overall restoration ranking matrix Table 5-3. Sediment removal or sediment inactivation projects, SIAs, and SAV and EAV planting projects are proposed for all lakes with impairment designations and for all lakes with a required and/or adopted TMDL. Sediment removal/inactivation is recommended for Lakes May, Lulu, and Shipp without a feasibility study because available data indicated it will be more than 20 years before sediment phosphorus in the three lakes is biologically unavailable in the three lakes. Sediment removal, rather than inactivation, is recommended for Lake May because of the shallow lake depth. Forested wetland rehydration is proposed for four lakes (Haines, Rochelle, Middle Hamilton, Smart, and Lulu) and artificial circulation is proposed for four other lakes (Blue, May, Spring, Summit, and Roy). Project priorities are outlined below.

- If external loads have not yet been addressed, stormwater projects to reduce nutrient loading are a priority project for a lake to reduce external nutrient loads to the lakes.

- If stormwater reduction projects have already been implemented for external nutrient loading and the lake has a history of point source loads, a sediment inactivation or removal feasibility study is recommended to evaluate the internal phosphorus loads to the lake. If internal nutrient loads are such that the time to phosphorus steady state without a project is more than 20 years, the sediment inactivation/removal project becomes a priority. If/once internal and external pollutant loads are addressed, aquatic vegetation projects (e.g. SAV, EAV, FTWs) may provide the only sustainable removal mechanism for phosphorus in these lake systems by facilitating the microbial activities responsible for permanent phosphorus burial.

- If/once internal and external pollutant loads are addressed, forested wetland rehydration is proposed for valley lakes in which high water color ameliorates the impacts of phosphorus on chlorophyll by reducing the light available to algae.

- Artificial circulation is another means to address in-lake phosphorus loads but is recommended only for small lakes.

Table 5-3. Restoration project ranking matrix for lakes in the WHCL.

Lake	TMDL Status	Sediment Removal or Inactivation	Stormwater Infiltration Areas	Forested Wetland Rehydration	SAV Planting or Floating Treatment Wetland	EAV Planting	Artificial Circulation
Mariana	R	2	1		3	4	
Spring		2	1		3	4	5
Idylwild	A	2	1		3	4	
Little Hamilton	R	2	1		3	4	
Haines	R	2	1	3	4	5	
Rochelle	R	2	1	3	4	5	
Cannon	A	2	1		3	4	
Smart	R	2	1	3	4	5	
Middle Hamilton		2	1	3	4	5	
Howard	A	1	2		3	4	
Eloise	R	2	1		3	4	
Mirror	A	2	1		3	4	
Blue	R	2	1		3	4	5
Jessie	A	2	1		3	4	
May	A	1	2		3	4	5
Lulu	A	1	2	3	4	5	
Summit		2	1		3	4	5
Conine	R	2	1		3	4	
Shipp	A	2	1		3	4	
Roy		2	1		3	4	5
Hartridge		1	2		3	4	
Hamilton							
Fannie							
Henry							
Winterset							

project not selected or TMDL not required

A = TMDL adopted; R = TMDL required;