First Triennial Review of Base Numeric Nutrient Standards and Variances

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EXECUTIVE SUMMARY

This report contains the technical materials reviewed as part of the Department of Environmental Quality's first triennial review of the base numeric nutrient standards and nutrient standards variances. The standards and variances were adopted by the Board of Environmental Review and the Department of Environmental Quality (DEQ) in August 2014. In August 2015, the U.S. Environmental Protection Agency (EPA) revised the federal rules pertaining to water quality standards variances. As a result, this triennial review encompassed analyses that were required under Montana law (75-5-313, MCA and Department Circular DEQ-12B) and analyses geared towards compliance with the new federal regulations. Since August 2014, no new numeric nutrient criteria were developed and therefore the triennial review focused solely on nutrient standards variances.

The key change in federal law necessitating significant technical analysis by DEQ was the requirement to identify a "highest attainable condition" (HAC) if base numeric standards cannot be met. This change affected the general variance treatment requirements in Circular DEQ-12B; going forward, the EPA expects that the circular's treatment levels reflect quantified cost thresholds determined for each of the discharger groups (i.e., ≥ 1 million gallons per day (≥1MGD), <1MGD, and lagoons). Towards that end, for the ≥1MGD and <1MGD groups, DEQ (1) identified those facilities likely to need a variance, (2) estimated the cost, with EPA assistance, via case-by-case facility cost projections for capital and O & M, and 10% extra for collection system replacement, to meet five duel-nutrient treatment levels (7 and 0.5; 7 and 0.1; 7 and 0.05; 3 and 0.5; 3 and 0.1; and 3 and 0.05, total nitrogen [TN] and total phosphorus [TP], respectively, in mg/L), (3) determined, using DEQ methods, the cost threshold (as a % of community median household income) each community should maximally pay towards nutrient standards compliance, and (4) determined the percentage of group members that could affordably achieve each of the nutrient treatment levels[1]. A similar but somewhat simplified version of this process was used to evaluate the lagoon discharger group. As a result, DEQ determined which treatment levels were unaffordable by the majority of POTW group members in each group. It should be noted that engineers associated with DEQ's Nutrient Work Group advisory group provided DEQ more accurate cost estimations for many communities in the ≥1MGD and <1MGD groups. The engineers' work made the estimation of cost thresholds much more accurate, especially for the ≥1MGD group. The cost analyses showed the following for group members likely to need a variance:

<u>≥1MGD</u>: The majority could afford to meet TN concentrations in the 4 to 7 mg/L range, in accompaniment with TP concentrations in the >0.1 to 0.4 mg/L range.

<u><1MGD</u>: Even the coarsest level of treatment examined (7 mg TN/L and 0.5 mg TP/L) was unaffordable for the majority of the members evaluated.

[1] It should be noted that, due to a lack of data and clear methodology, the private-sector facilities in the discharger groups were not reviewed; they comprise a significant proportion of the <1MGD and lagoon groups.

Lagoons: Only a minority (38%) of a random sample (n=8) of communities needing a variance and which use lagoons could meet the estimated cost for the lowest-cost option (land application of the wastewater). For the other four treatment levels examined—all which were variations of lagoon replacement with a mechanical plant—none (0%) of the sampled communities could afford the treatment level/technology.

Further considerations were necessary to identify the final HAC values for each of the mechanical facility groups. Consideration was given to the difficulty of reducing both TN and TP in effluent (i.e., dual nutrient control), and the fact that DEQ likely underestimated collection system replacement costs for the smaller sized communities. Final HAC values were identified as 6 mg TN/L and 0.3 mg TP/L for the ≥1MGD group, and 10 mg TN/L and 1.0 mg TP/L for the <1MGD group. Lagoon variances will be permitted in basically the same manner as they have been since 2014. These updated values will be placed in Table 12B-1 of Circular DEQ-12B.

The time required to achieve the updated treatment requirements is expected to vary. DEQ identified 9 steps, comprising a combining of optimization/advanced operational strategies with substantial infrastructure upgrade; these steps could take as long as approximately 17 years to complete. If a facility only needed a subset of the identified steps to achieve the treatment requirements, less time would be required to do so.

DEQ also evaluated the details of how two discharger categories (≥1MGD, <1MGD) are permitted. Based on this evaluation, a fixed coefficient of variation (CV; that is, the standard deviation/mean) of 0.6 is recommended for these two groups for deriving permittees' average monthly permit limits. Currently, DEQ uses a variable CV computed from samples collected over the recent past few years from a permittee's discharge. The evaluation revealed that the current approach may lead to permit limits in the future with an increasing likelihood of non-compliance, even though the permittee's discharge concentrations would in fact be lower (i.e., better). This is because the CV of effluent nutrient samples is likely to increase as lower nutrient concentrations are achieved. The proposed change should alleviate the issue because it institutes a CV that is realistic for the point in time in the future when permittees achieve low nutrient concentrations in their effluent. It may be necessary to further revise or adjust the recommended CV value in the future.

To conclude, the updated variance treatment requirements for Table 12B-1 of Circular DEQ-12B recommended here will ultimately result in significant reduction of nutrient loadings statewide. The updated concentrations for the ≥1MGD are 40% lower for TN and TP, and for the <1MGD group they are 50% lower for TN and TP than the current variance allows. The combination of facility optimization and (as needed) upgrades lays out a pathway for facilities to achieve the treatment requirements in a cost-effective manner, taking the time necessary to do so. Changes to the permitting process will assure that when low nutrient concentrations are achieved in effluent, the permits will better reflect the type of concentration variability DEQ expects to see. And it should be pointed out that if any of the updated treatment requirements are financially unattainable for a specific permittee under the general variance, the option to apply for an individual variance remains available. An individual variance will be tailored to the community's specific economic situation.

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ACRONYMS

Acronym	**Definition**
ACS	American Community Survey, an ongoing statistical survey by the U.S. Census Bureau
CV	Coefficient of Variation, the sample standard deviation divided by the mean
DEQ	Department of Environmental Quality (Montana)
DMR	Discharge Monitoring Report (component of the National Pollution Discharge Elimination System)
ECHO	Enforcement and Compliance History Online
EPA	United States Environmental Protection Agency
HAC	Highest Attainable Condition, *see* 40 CFR 131.14
ICIS	Integrated Compliance Information System (component of the National Pollution Discharge Elimination System)
MEPA	Montana Environmental Policy Act
MHI	Median Household Income
MGD	Million Gallons per Day
MPDES	Montana Pollution Discharge Elimination System
PER	Preliminary Engineering Report
POTW	Publically Owned Treatment Works
RP	Reasonable Potential, analysis to determine if water quality standards will be exceeded
TN	Total Nitrogen
TP	Total Phosphorus
WPCSRF	Water Pollution Control State Revolving Fund (part of DEQ)

1.0 Introduction, and Scope of this Triennial Review Report

This report documents the technical materials considered during DEQ's 2016/2017 triennial review of the state's base numeric nutrient standards and nutrient standards variances. This is the first triennial review to occur since the standards and variances were adopted in August 2014. At this triennial review, only the nutrient standards variances (found in Department Circular DEQ-12B) are addressed; this is because, since 2014, no new numeric nutrient standards have been developed. (Numeric nutrient standards are housed in Department Circular DEQ-12A.) However, computer modeling work (to derive numeric nutrient standards) is ongoing for segments of the Missouri and Yellowstone rivers. Development of numeric nutrient standards for the upper and middle Yellowstone River (Yellowstone National Park Boundary to Big Horn River confluence) is the most advanced, and is likely to be completed between the completion of this report and the next triennial review in 2020.

1.1 Changes in Federal Rules Since the 2014 Rule Adoptions

Montana's base numeric nutrient standards and nutrient standards variances were adopted in August 2014, and approvals by EPA were received in February 2015. In August 2015, EPA revised the federal rules which pertain to water quality standards variances. Modifications were made to 40 CFR 131, with the most important changes (in terms of affecting this triennial review) found in 40 CFR 131.14.The new federal rules provide much more detail and specificity as to what is required if a water quality standards variance is to be granted. Throughout DEQ's triennial review, careful consideration was given to the new federal rules and how they interact with the state's variance statute and rules.

2.0 Advances in Nutrient Wastewater Treatment Since 2014

As part of this triennial review, DEQ and EPA wastewater experts were consulted to determine if, in the few short years since nutrient standards and variances were adopted, any cost effective technological breakthroughs in wastewater nutrient removal had happened. The consensus was that nothing of specific note had occurred. Progress continues to be made, however. A key example is a 2015 study documenting the potential for deammonification (or ANOMMOX, anaerobic ammonium oxidation) to be used in the mainstream wastewater treatment process, rather than just as a side-stream process (O'Shaughnessy, 2015). The successful application of full-plant deammonification could save wastewater utilities operations costs for aeration and external carbon costs in the life cycle. The implications of deammonification for sustainable, cost effective and energy positive wastewater treatment were described as "extraordinary." DEQ will monitor advancements in this area in the coming years, however, it is DEQ's belief that reverse osmosis is still currently the method of treatment that is likely to achieve the lowest effluent TN and come as close as possible to meeting the TN water quality standards.

Another area showing tremendous potential to reduce wastewater nutrients in a cost effective manner is the implementation of optimization/advanced operational strategies using existing infrastructure. DEQ has sponsored work in this area for five years at a number of facilities around Montana. Facilities included are POTWs—both biological nutrient removal (BNR) and non-BNR plants—in both the ≥1 million gallons per day (≥1MGD) and <1MGD size categories. Results have been extremely promising, in some cases achieving around 90% reduction in TN or TP concentrations with almost no additional costs (*see report presentation at:* http://www.cleanwaterops.com/wp-content/uploads/2016/02/Montana-Report-Final-Proof.compressed.pdf). To achieve similar results through conventional improvements, the cost to each community would typically be several million dollars. As more cases are completed, DEQ anticipates that the lessons learned will be implemented at more facilities around the state.

3.0 STATEWIDE ECONOMIC IMPACT DEMONSTRATION

Two reports were released by DEQ in 2012 that demonstrated that meeting base numeric nutrient standards by discharge permittees across the state would cause substantial and widespread economic impact on a state-wide scale (Blend and Suplee, 2012; DEQ, 2012). The studies assumed that reverse osmosis was the technology that would achieve (or get as close as possible to achieving) base numeric nutrient standards. The 2012 reports (addressing 2011 data) formed the basis for the justification for the general variances. The essential 2012 rationale was reaffirmed in 2014 and in 2017.

For this triennial review, DEQ considered whether or not general variances are still justified, given Montana's current economic conditions. DEQ did this by obtaining the latest available data on median household income (MHI) for the same sample of towns included in the 2012 report. The latest data on number of households in each town were also included. These data were drawn from the American Community Survey (ACS) 2011-2015 (2015 data). Other data in the 2012 report, mainly the cost data for reaching numeric nutrient standards via reverse osmosis, were assumed to remain the same since nutrient treatment technology has not significantly advanced in the past five years and reverse osmosis is still considered the technology that comes closest to meeting the nutrient standards (see **Section 2.0**).

Results are shown in **Figure 3-1** and **Table 3-1**. The figures and tables compare MHI for meeting numeric nutrient standards in 2011 vs. the most current (2015) data. Using the ACS MHI data and the updated number of households in the towns, the results indicate that reaching nutrient standards would still be too expensive for almost all MT towns as of this triennial review. DEQ believes the conclusion reached in its 2012 report regarding substantial and widespread economic impacts on a statewide-scale also holds for this triennial review.

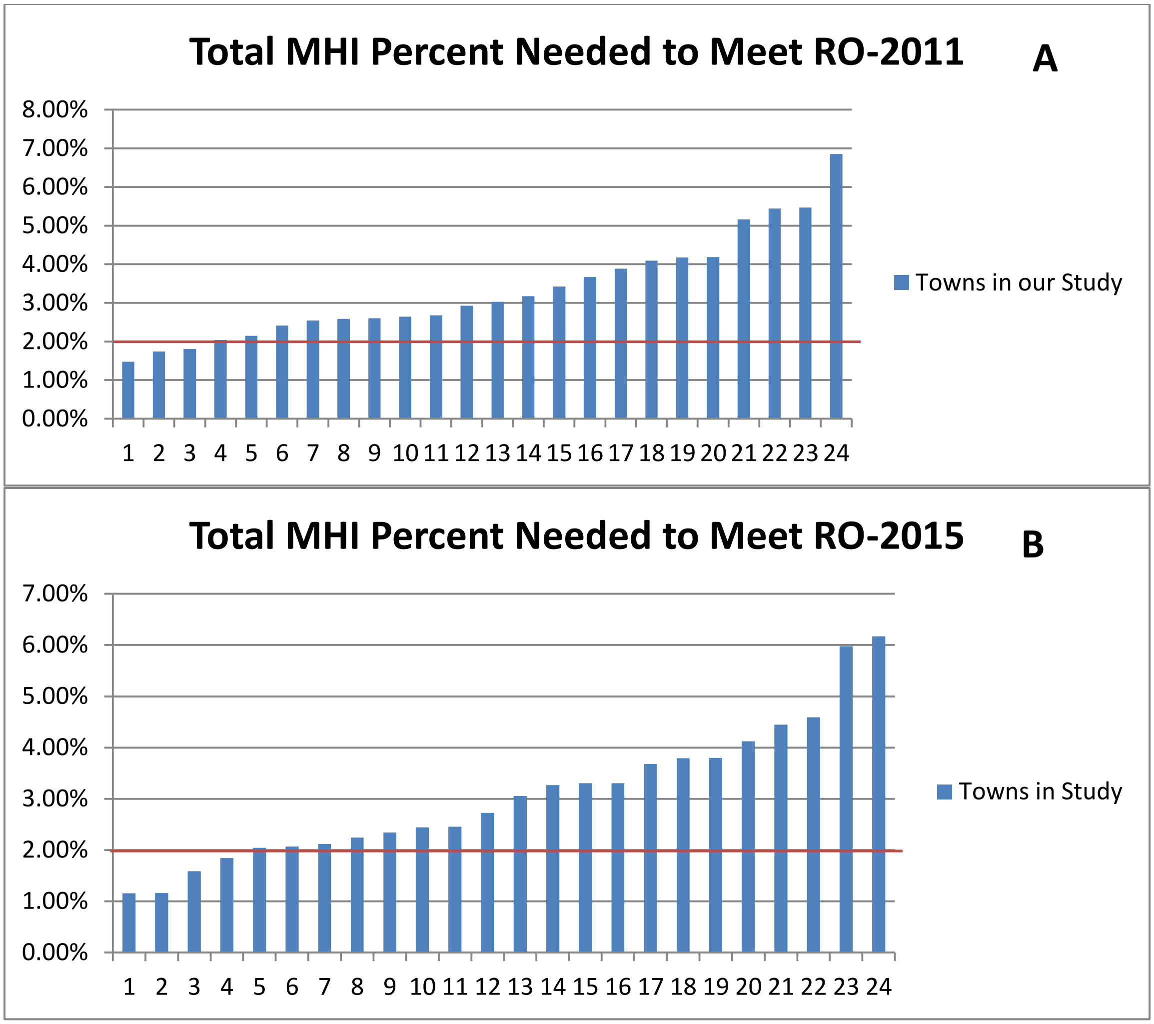

Figure 3-1. Using the same sample of towns, comparison of the cost (as a function of community MHI) to meet numeric nutrient standards via reverse osmosis in 2011 (original study) *vs.* this triennial review. A. Cost, by community, in 2011. B. Cost, by community, in 2015.

Table 3-1. Comparison of Cost (As % of Community Median Household Income) to Install Reverse Osmosis in 2011 *vs.* 2015. Communities are sorted by the 2015 results.

Community	Median Household Income (MHI) in 2010	MHI 2015	Estimated Number of Households (population /2.5) Based on 2000 Census	Estimated Number of Households, American Community Survey 2011-2015	Current Average Annual Household Waste Water Bill	Design Flow (MGD)	Actual Flow (MGD)	Current Cost of Waste Water (% MHI)	2011 % MHI needed to get to RO/Base Numeric Nutrient Standards (including current fees)	2011 Increase over Current Waste Water Bill to Reach RO	2015 % MHI needed to get to RO/Base Numeric Nutrient Standards (including current fees)	2015 Increase over Current Waste Water Bill to Reach RO	Change in Cost (as % MHI), 2011 vs. 2015
Missoula	$34,319	$41,421	27,553	29,860	$152	12	9	0.44%	1.47%	232%	1.15%	214%	-0.32%
Lolo	$46,442	$60,276	1,060	1,487	$363	0.34	0.38	0.78%	1.81%	131%	1.17%	94%	-0.64%
Helena	$47,152	$49,852	12,337	13,095	$265	5.4	3.00	0.56%	1.74%	196%	1.59%	185%	-0.16%
Havre	$43,577	$45,146	3,709	4,048	$240	1.8	1	0.55%	2.04%	270%	1.85%	247%	-0.19%
Billings	$45,004	$51,012	41,841	44,092	$218	26	26	0.49%	2.41%	398%	2.04%	377%	-0.37%
Butte	$37,335	$37,686	14,041	14,798	$360	8.5	4.00	0.96%	2.15%	123%	2.07%	117%	-0.08%
Big Fork	$44,398	$53,495	1,708	1837	$580	0.5		1.31%	2.65%	103%	2.12%	95%	-0.53%
Columbia	$38,750	$47,352	1,621	1,949	$532	0.766	0.37	1.37%	3.02%	120%	2.25%	100%	-0.78%
Kalispell	$39,953	$41,097	7,705	8,608	$216	5.4	3.10	0.54%	2.58%	186%	2.34%	166%	-0.24%
Bozeman	$41,661	$45,729	14,614	16,573	$372	13.8	5.80	0.89%	2.92%	228%	2.45%	201%	-0.48%
Manhattan	$50,729	$52,135	523	547	$362	0.6	0.4	0.71%	2.60%	264%	2.45%	253%	-0.15%
Highwood	$62,614	$45,250	53	83	$600	0.026	0.015	0.96%	2.54%	165%	2.73%	106%	0.18%
Lewistown	$31,729	$35,990	2,727	2,681	$388	2.5	1.5	1.22%	3.43%	180%	3.05%	184%	-0.37%
Stevensville	$33,776	$32,337	795	818	$535	0.3	0.29	1.58%	3.17%	100%	3.27%	97%	0.09%
Miles City	$37,554	$46,935	3,518	3,479	$236	3.7	2	0.63%	4.09%	551%	3.30%	557%	-0.79%
Glendive	$42,821	$41,250	1,883	2224	$214	1.3	N/A	0.50%	3.67%	635%	3.31%	537%	-0.36%
Circle	$29,000	$36,250	234	289	$260	0.16	0.065	0.90%	5.47%	511%	3.68%	414%	-1.79%
Philipsburg	$31,375	$41,103	399	327	$200	0.2	0.2	0.64%	4.19%	557%	3.79%	680%	-0.39%
Great Falls	$40,718	$42,896	23,998	25,194	$187	26	26	0.46%	4.18%	808%	3.80%	770%	-0.38%
Cut Bank	$44,833	$34,833	1,290	1,056	$138	0.643	0.643	0.31%	2.68%	767%	4.12%	937%	1.44%
Hamilton	$25,161	$27,907	2,092	2,371	$276	1.98	0.68	1.10%	5.44%	396%	4.45%	349%	-1.00%
Deer Lodge	$40,320	$37,934	1,522	1,323	$410	3.3		1.02%	3.89%	283%	4.59%	325%	0.70%
Livingston	$35,689	$40,619	3,188	3,215	$600	5	2	1.68%	6.85%	307%	5.98%	305%	-0.87%
Redlodge	$50,123	$42,500	1,055	1038	$305	1.2	0.65	0.61%	5.16%	747%	6.17%	759%	1.01%

4.0 Variances Issued by DEQ, Thus Far

Table 4-1 shows the general nutrient standards variances that DEQ's Water Protection Bureau has issued to MPDES permit holders through late 2016. As of this writing, there have been no requests to DEQ for an individual nutrient standards variance.

Table 4-1. General Nutrient Standards Variances Issued as of Late 2016.

Permit Number	Name	Expiration Date	TN (lb/day)	TP (lb/day)	Basis
MT0027821	Imersys Talc America Inc. Beaverhead	1/31/2020	5.7	-	current performance
MT0028797	Town of Twin Bridges WWTF	2/29/2020	9	3	current performance
MT0020249	Town of Joliet	6/30/2020	53.04	15.35	current performance
MT0020184	City of Whitefish WWTF	7/31/2020	176	10.4	>1.0 MGD
MT0021938	City of Kalispell	7/31/2020	286	9.9	current performance
MT0000205	Bonner Property Development	8/31/2020	4.5	-	<1.0 MGD
MT0021270	City of Harlem WWTF	8/31/2020	34.03	4.42	current performance
MT0031500	Town of Phillipsburg	9/30/2020	15.6	3.88	TMDL/current performance
MT0026808	Stillwater Mining Company - East Boulder	10/31/2020	30	-	current performance
MT0023639	Peace Valley Hot Springs	11/30/2020	1.45	0.12	current performance
MT0024716	Stillwater Mining Company	11/30/2020	60	-	current performance
MT0031879	Laurel Travel Center	6/30/2021	15	2	<1.0 MGD

5.0 Near-term Estimation of Variance Need

Under the general variance, there are three categories of dischargers (≥1MGD, <1MGD, lagoons)[2]. For the two mechanical-plant categories (≥1MGD, <1MGD), DEQ estimated (1) how many facilities in the group may need a variance in the near term[3], (2) how many should be able to meet numeric nutrient standards at the end of their mixing zone, and (3) how many do not currently need to address numeric nutrient standards. Regarding the last scenario, this included MPDES permit holders who discharge to waterbodies where numeric nutrient standards were not adopted (e.g., ephemeral streams), and where numeric nutrient standards may eventually be adopted but have not been yet (e.g., along the Missouri River). As noted in **Section 1.0**, standards for the Yellowstone River (YNP Boundary to Big Horn River

[2] In statute and rule. See Department Circular DEQ-12B.
[3] Over the next 3-4 years, as permits come up for renewal.

confluence) are likely to be completed prior to the next triennial review. Therefore, for these projections, estimated Yellowstone River standards[4] were used to place MPDES permit holders along that river into either scenario 1, 2, or 3 above. DEQ believes the inclusion of this part of the Yellowstone River in the analyses at this triennial review provides a more accurate picture of the state's status in the near-term (next few years) regarding compliance with nutrient standards and the need for variances.

There are 21 MPDES permits in the ≥1MGD category (i.e., group), and 37 in the <1MGD group. Data sources DEQ used were: permit Fact Sheets or Statements of Basis held by DEQ; ICIS/DMR data from late 2015-2016; DEQ's WPCSRF Public Wastewater Systems list; and DMR data (2013-2016) from EPA's Enforcement and Compliance History Online (ECHO) website. Some facilities were known by DEQ to have recently undergone an upgrade or substantial optimization; in such cases, only effluent nutrient data representing the facility's current effluent quality were used.

The analysis process for the mechanical facility groups was multi-step. It required compiling and statistically-summarizing effluent nutrient data for each facility, completion of a projected Reasonable Potential (RP) analysis for many facilities, calculation of the ratio of actual flow to design flow for each facility, and tallying the results for each outcome (scenario). The process is shown in **Figure 5-1**. When carrying out each RP analysis, we used the highest effluent nutrient concentration recorded in the DMR datasets we had, and the seasonal 14Q5 of the receiving stream (EPA, 1991; Dept. Circular DEQ-12B, 2014). For permittees found to have RP—and thus probably needing a variance—we also determined how many facilities (per discharge group) could meet the currently-adopted variance limits (i.e., 1 mg TP/L, 10 mg TN/L and 15 mg TN/L, 2 mg TP/L), as a monthly load limit, *given* their current actual-flow/design-flow ratio (this ratio is defined as a facility's current average daily flow divided by that facility's design average daily flow). Median facility effluent nutrient concentrations were used in this last analysis, as they best represent the central tendency of discharge nutrient concentrations of a facility over time (i.e., median conc. = rough surrogate for the long term average).

General variances for the lagoon discharge group are implemented differently from mechanical facilities (lagoons must maintain current performance, mechanical facilities are permitted to the Table 12B-1 concentrations in Circular DEQ-12B). A cursory RP analysis indicated that about half the POTW lagoons have RP.

[4] Numeric nutrient standards are already adopted on the lower Yellowstone River. Ecoregion-scale standards are adopted for the headwater region of the Yellowstone River. We assumed the Yellowstone River (YNP Boundary to Big Horn River confluence) will have standards concentrations falling somewhere between the two.

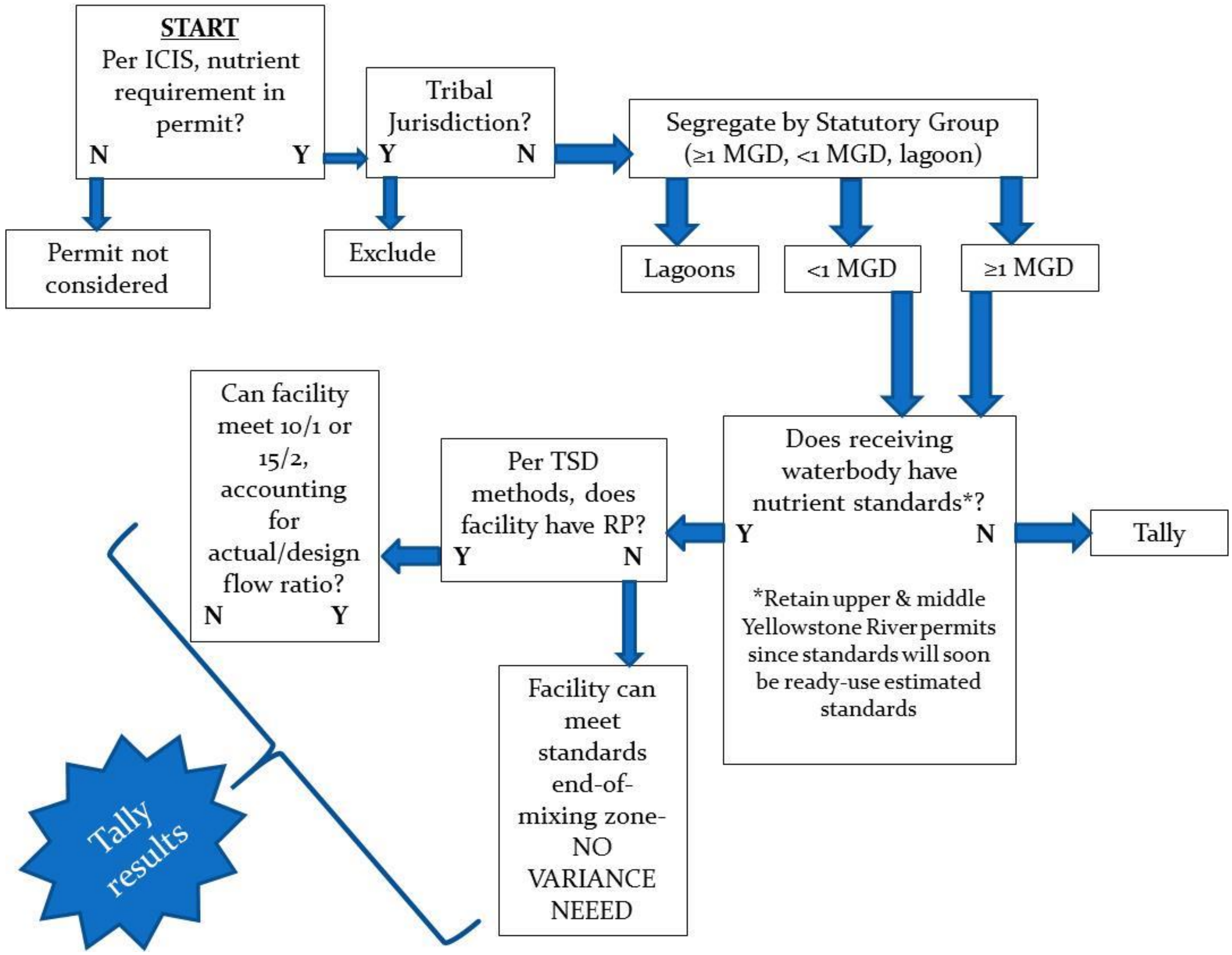

Figure 5-1. Process by which DEQ determined (for the ≥1MGD and <1MGD discharge groups) how many facilities meet numeric nutrient standard, how many do not have to address numeric nutrient standards, and how many will probably need a nutrient standards variance.
Present-day compliance with existing general variance treatment requirements was calculated based on each facility's actual-flow/design flow ratio.

Results for the ≥1MGD group are in **Figure 5-2**. As of this triennial review, about 48% of the facilities will probably need a variance in the near term (see **Appendix A** for a list of the facilities). Approximately 28% already meet their waste load allocation or do not have RP, and 24% do not have to address numeric nutrient standards in their receiving stream. Thus, ten facilities in this group will probably need a variance (red slice of pie, **Figure 5-2**) and will be the subject of further analyses in this report. Nine of these ten facilities are POTWs.

Figure 5-3 considers the ≥1MGD group again, but only addresses those ten facilities that will likely need a variance (i.e., the red slice in **Figure 5-2**). At the present time, nearly all these facilities would be able

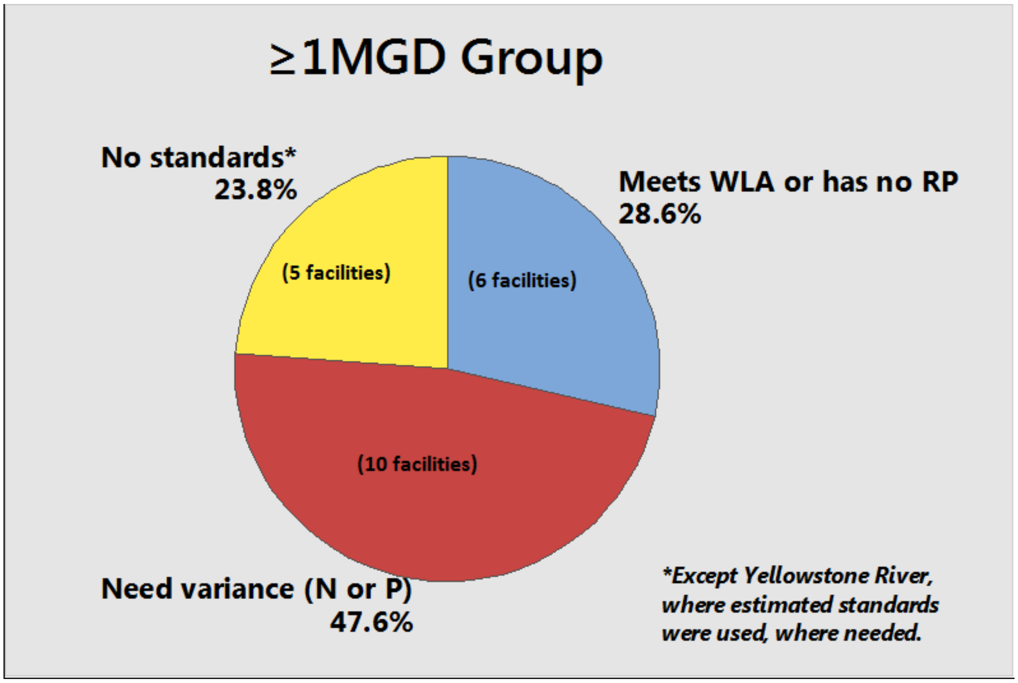

Figure 5-2. The entire ≥1MGD discharge group. Numbers of facilities in different scenarios, as of this triennial review.

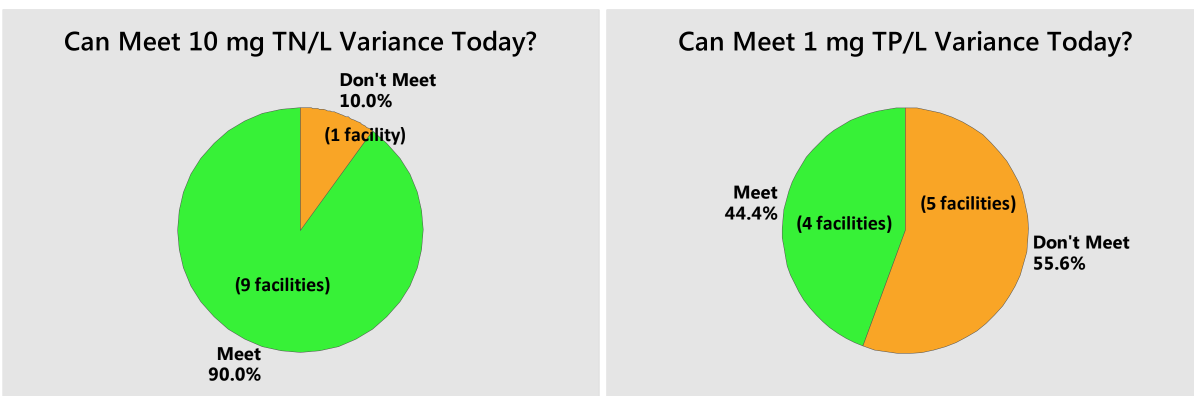

Figure 5-3. Facilities in the ≥1MGD discharge group that will probably need a variance (i.e., the red slice from Figure 5-2).
The number of facilities between the right and left panels differ because some facilities may only need a variance for TN or TP, but not both. The scenario shown will change going forward in time, as each facility moves closer to design flow.

to meet the 10 mg TN/L general variance (**Figure 5-3**, left panel). However, less than half would meet the TP general variance limit today. These compliance scenarios will likely change as each facility moves towards design flow (generally, one would expect increasing difficulty in complying with the limits, as lower and lower effluent nutrient concentrations would be required to achieve the same load).

Figures 5-4 and **5-5** show the same analyses, but this time for the <1MGD discharger group.

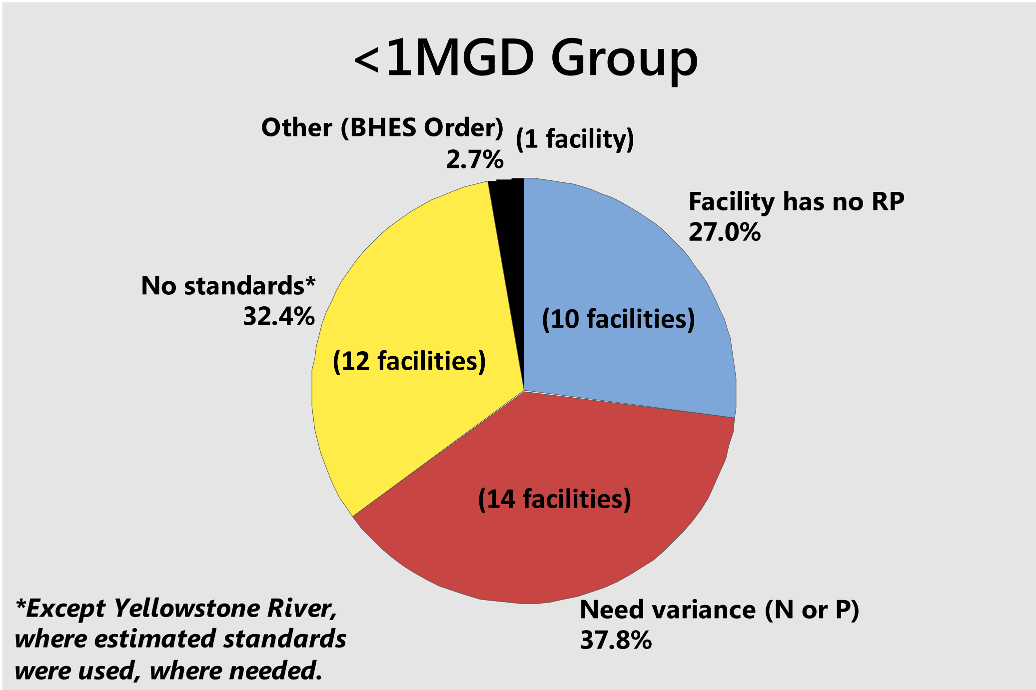

Figure 5-4. The entire <1MGD discharge group. Numbers of facilities in different scenarios, as of this triennial review.

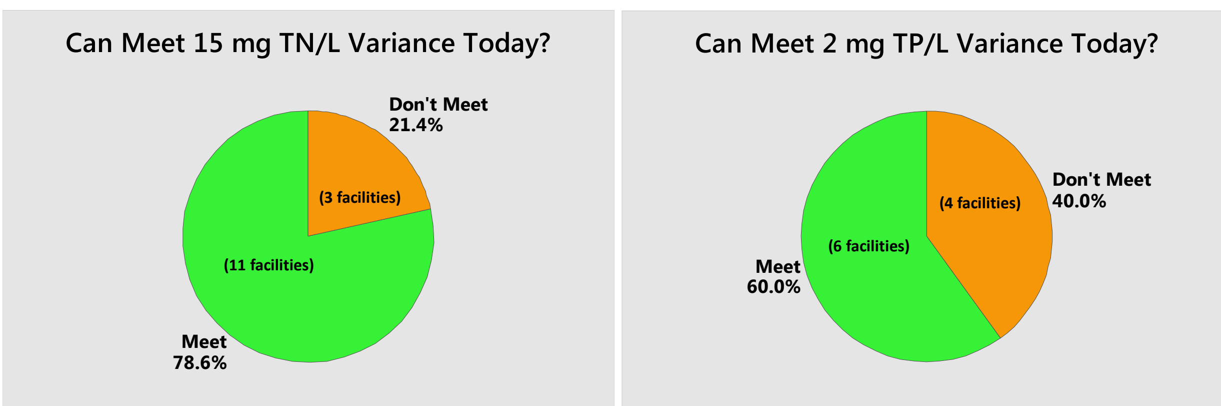

Figure 5-5. Facilities in the <1MGD discharge group that will probably need a variance (i.e., the red slice from Figure 5-4).
The number of facilities between the right and left panels differ because some facilities may only need a variance for TN or TP, but not both. The scenario shown will change going forward in time, as each facility moves closer to design flow.

Similar to the ≥1MGD group, less than half of all <1MGD group members (14 facilities, or 38%) are likely to need a variance in the near future (**Figure 5-4**). See **Appendix A** for the list of facilities. For this group of 14 facilities that will probably need a variance (red slice, **Figure 5-4**), estimated ability to comply with the current variance limits (i.e., 15 mg TN/L, 2 mg TP/L) is mixed, with about 79% of facilities able to meet the TN variance limit, and 60% able to meet the TP limit. And again, in the absence of facility upgrades, compliance with the variance limits will likely decline as POTWs move closer over time towards design flow. An important difference for the <1MGD group (in contrast to the ≥1MGD group) is that only 6 of the 14 (43%) facilities likely to need a variance are POTWs; the rest (8) are private-sector permittees.

What overall conclusions can be drawn from these analyses? At the present time, at the current state of design flow at each facility, for those facilities likely to need a variance in the near term:

≥1MGD Discharger Group: Compliance today with the TN general variance would be 90%, with only one facility not able to meet the limit today. Compliance with the TP general variance today would be 44%. In this discharge group there is a big difference between likely compliance with the TN limit, which is nearly universal, vs. compliance with the TP limit, which is less than half. Almost all are POTWs.

<1MGD Discharger Group: Compliance today with the TN general variance would be about 79%, and compliance with the TP general variance would be 60%, today. Stated simply, the majority of group members would meet the TN and TP variance limits on the books today, but there would still be a substantial proportion of permittees (21-40%) in the group that would not. Most facilities are private.

Another observation is that many more non-lagoon dischargers will be able to comply with the base numeric nutrient standards at the end of their mixing zone than was generally believed to be the case in the years and months leading up to the adoption of the nutrient standards in 2014.

6.0 Identifying the General Variance Treatment Requirements for Table 12B-1 of Circular DEQ-12B; Highest Attainable Condition

General variance treatment requirements for wastewater facilities are found in Table 12B-1 of Circular DEQ-12B. As noted in **Section 1.0**, EPA updated its variance rules in 2015, a year after nutrient standards and variances were adopted in Montana. The key piece of EPA's 2015 variance rule having a bearing on Montana's general and individual variances is EPA's discharger(s)-specific WQS variances, found at 40 CFR 131.14. Discharger(s) specific variances must define a Highest Attainable Condition (HAC), which is a quantifiable expression of the interim effluent condition reflecting the greatest pollutant reduction achievable. Relative to Montana's rules and guidance, this basically translates to effluent treated to the affordability threshold for a discharge group (e.g. <1MGD), or an individual community (for individual variances). To mesh with federal rules, DEQ needed to determine HAC for the discharger groups.

The ≥1MGD and <1MGD groups were evaluated the same way. Case-by-case estimates were made for the cost to achieve six dual-nutrient effluent levels for total nitrogen and total phosphorus, respectively, as follows: 7 and 0.5; 7 and 0.1; 7 and 0.05; 3 and 0.5; 3 and 0.1; and 3 and 0.05 (all in mg/L). Some of these estimates were from Tetra Tech (2016), others (almost all in the ≥1MGD group) were prepared by engineers associated with the Nutrient Work Group. Class 5 Engineering Estimated costs were used, per the Association for the Advancement of Cost Engineering (AACE) recommended practice No. 18R-97 (*see* http://www.aacei.org/toc/toc_18R-97.pdf). Class 5 is a concept screening level class, with cost accuracy ranges of -50% to +100%. For specific Montana communities—mostly in the ≥1MGD category—cost estimates provided by the engineers associated with the Nutrient Work Group had better accuracy, in the range of -50% to +50%. An additional 10% (commensurate with the 110% coverage requirement for Montana SRF loans secured with a revenue bond) was added to each cost estimate to provide some accounting for future collection system infrastructure replacement costs. This entire process was only applied to POTWs; DEQ does not have a straight forward way of estimating cost threshold *in advance* for private facilities. For ≥1MGD group members needing a variance, almost all are POTWs (**Section 5.0**). This is not the case for the <1MGD group, where only 43% of group members likely to need a variance are POTWs.

Once the cost estimates for each treatment level were completed, they were converted to a percent of community MHI and summed with existing user rates (as %MHI) each community is paying. The resulting %MHI each community would pay for a treatment level was then compared to the %MHI wastewater cost cap derived for that community using DEQ's sliding scale (**Figure 6-1**). DEQ uses a sliding scale by which affordability is calculated for each community that needs and is eligible for a variance, on a case-by-case basis, via a "secondary score" (**Figure 6-1)** which is a measure of the community's economic health[5]; see details in Section 3.3.1 of DEQ (2014).

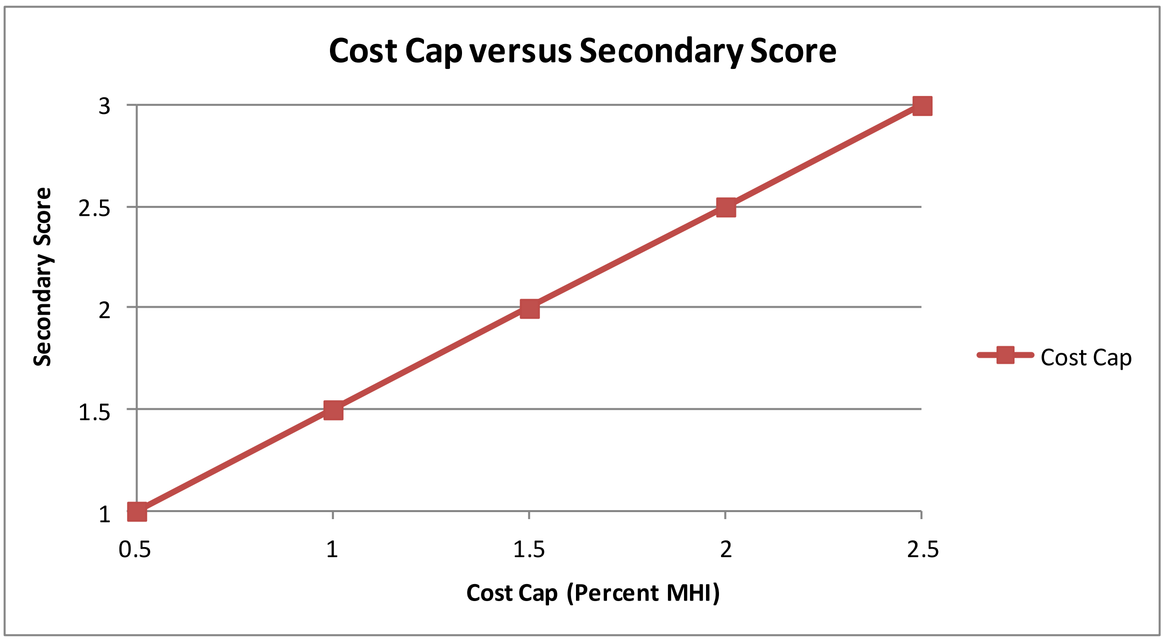

Figure 6-1. Determining cost cap based on a community's secondary score.
The x-axis is the percentage of a community's median household income (MHI) the community would be expected to expend towards a pollution control project as a function of the secondary score on the y-axis. The secondary score is derived from tests in DEQ guidance (DEQ, 2014).

The aggregate results for the ≥1MGD and <1MGD groups is shown in **Figure 6-2** (on page 16). The cost analysis and associated technical considerations showed:

≥1MGD Discharger Group: The majority can afford to meet 7 mg TN/L and 0.5 mg TP/L, but other treatment levels were only marginally affordable or were unaffordable for most (as few as 50% of members can afford 3 and 0.5, and 3 and 0.1). A treatment level of 3 mg TN/L is marginally affordable,

[5] DEQ previously showed that the communities statewide would have substantial economic impacts if they were to achieve the base numeric nutrient standards at (essentially) the end-of-pipe, and that virtually all Montana communities would also experience widespread economic impacts (Blend and Suplee, 2012; **Section 3.0**, this report) .

and becomes unaffordable as lower TP concentrations accompany it. Simultaneous biological treatment of both nitrogen and phosphorus poses design and operational challenges that affect system cost and reliability and can limit effluent quality of either or both nutrients. Generally speaking, it is both a design and operational challenge to balance the biochemistry for the various aerobic, anaerobic and anoxic environments necessary for dual nutrient removal to occur at low effluent concentrations. Further, due to the sensitivity of nitrifying bacteria in colder temperatures, treating down to 3 mg TN/L in Montana may not be as consistently achievable as in states where warmer wastewater temperatures exist year-round. While warmer temperatures do exist during Montana summers, the cold winters require significant seasonal operational adjustments that can sometimes adversely affect the stability of treatment. Therefore, DEQ and the Nutrient Work Group believe that 4 mg TN/L is a more appropriate lower limit than is 3 mg TN/L for Montana conditions. With regard to phosphorus treatment, Tetra Tech (2016) suggests that fermentation with single point alum addition can treat effluent down to 0.5 mg TP/L and the addition of a fermenter and tertiary filtration system with chemical precipitation can provide effluent quality as low as 0.1 mg TP/L. Falk et al. (2011) suggests that, in addition to fermentation and filtration, tertiary high rate clarification is necessary to produce effluent at the 0.1 mg TP/L level. As shown in **Figure 6-2**, this may not be affordable for the majority of the group. DEQ feels that optimized biological phosphorus removal (from BNR-designed plants) with fermentation, along with the option of polishing with metal salts, could be affordable and potentially achieve effluent values in the 0.2 to 0.4 mg TP/L range.

The preceding discussion suggests TN concentrations in the 4-7 mg/L range are affordable and achievable, in accompaniment with TP concentrations in the >0.1 to 0.4 mg/L range for this group.

<u><1MGD Discharger Group</u>: Even the coarsest level of treatment (7 mg TN/L and 0.5 mg TP/L) was not affordable for the majority of the members evaluated. However, DEQ experience with Montana operators in applying advanced operational strategies in order to lower nutrient concentrations in suspended growth secondary treatment systems, such as activated sludge systems, shows that these practices can play an important role in lowering nutrients affordably. It is predicted that most of these systems treating conventional municipal wastewater could produce effluent TN of approximately 10 mg/L by applying advanced operational strategies. Manipulating secondary treatment systems, operationally, to remove phosphorus to low levels appears to be more of a challenge, although great success has been shown in some cases. DEQ has determined that many secondary systems can produce effluent phosphorus of about 2 mg TP/L through advanced operational strategies. In many cases, operational changes combined with the addition of alum or iron salts could potentially achieve an effluent concentration of about 1 mg TP/L. Achieving TP concentrations below 1 mg/L are possible with the above strategy, but the increasing addition of metal salts and the significant increase in chemical sludge processing and disposal are likely to bring operational costs up to the point of being unaffordable as shown in **Figure 6-2** for the TP concentrations of 0.5 mg/L. It should be noted that different facilities will respond in varying degrees to advanced operational strategies.

The preceding discussion suggests that, based on affordability and the potential to optimize POTWs in this group[6], a range of >7 to 10 mg TN/L and a value of 1.0 mg TP/L are appropriate HAC targets.

[6] This information was provided by DEQ engineers in the State Revolving Fund program.

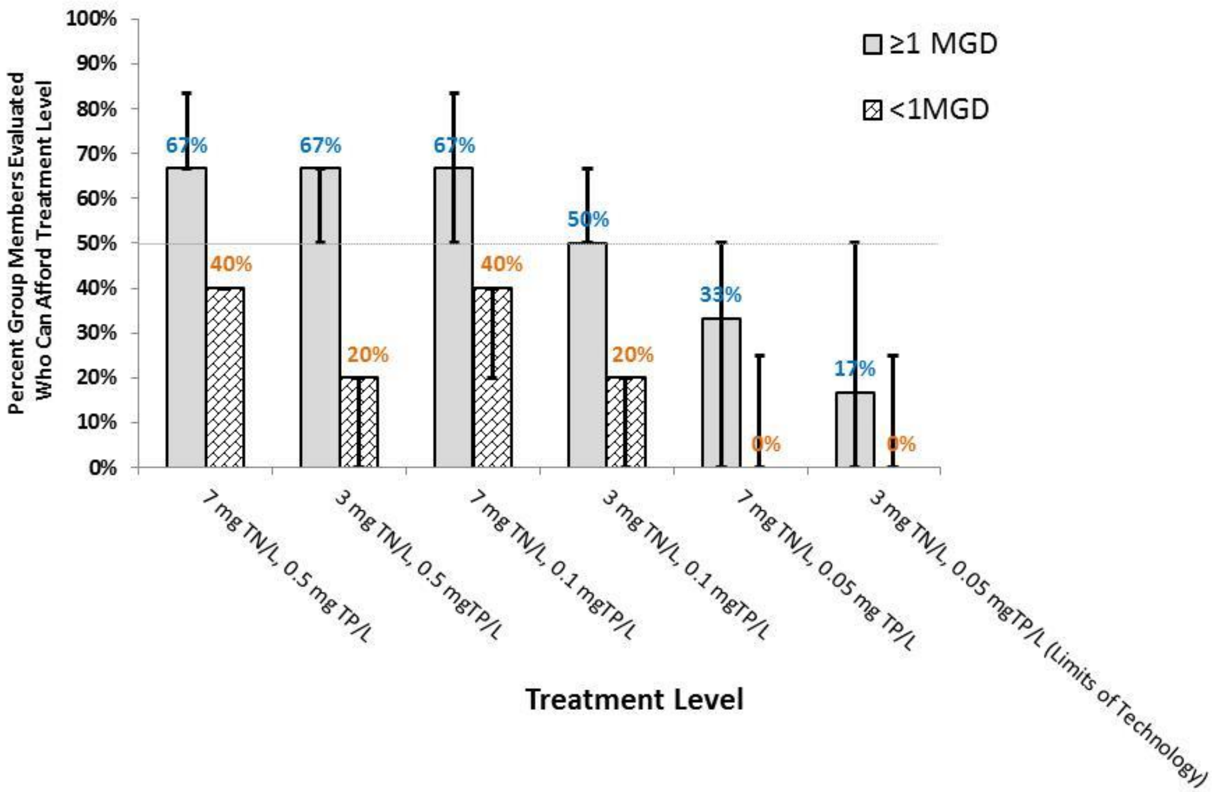

Figure 6-2. Percent of members in a discharger group (≥1MGD, <1MGD) who can affordably meet a specified wastewater treatment Level.
Only POTW group members were evaluated and, among them, only those likely to need a variance (i.e., those in the red slices of the pie in **Figure 5-2** and **Figure 5-4**). Error bars are based on the range of cost estimates for the facility upgrades per class 5 engineering planning estimates (see text).

Additional information was considered to assist DEQ and the Nutrient Work Group in identifying the final highest attainable conditions. As noted, dual nutrient control is more difficult than single nutrient control, so for the ≥1MGD category ten wastewater facilities that achieve low nutrient concentrations for TN and TP were reviewed (**Tables 6-1)**. Two facilities are from Montana, the rest were identified and reported on in EPA (2007). The 95th percentile of recent effluent quality is shown; 95th percentile concentrations would not, based on the proposed permitting process (**Section 8.0**), result in permit exceedences[7]. The data in **Table 6-1** do not lead DEQ to exact numbers, but show that real-world facilities with relatively strict nutrient limits in their permits are consistently achieving concentrations in the ranges suggested by the cost analysis (4-7 mg TN/L and >0.1 to 0.4 mg/L).

[7] Average effluent concentrations from the **Table 6-1** facilities are lower than 95th percentile concentrations. But average concentrations, permitted as loads using DEQ's methods, might lead to 1-3 exceedences per permit cycle. Therefore, DEQ did not consider these facilities' average concentrations to be as helpful for identifying HAC within the cost-based ranges.

Table 6-1. 95th Percentile Performance of Example Facilities with Advanced Nutrient Removal.

	Facility	Design Flow (MGD)	TN (mg/L)	TP (mg/L)
Dual Nutrient Control Facilities	Butte (MT)	5.5	3.2	*too soon*
	Bozeman (MT)	8.5	8.1	0.58
	Palmetto (FLA)	2.4	3.6	0.56
	Annapolis (MD)	6.0	6.8	0.25
	Bowie (MD)	3.3	4.6	*no data*
	Largo (FLA)	15.0	3.5	0.60
	Frederick (MD)	8.0	9.1	1.07
	Westminster (MD)	5.0	5.7	0.40
	Cambridge (MD)	8.1	3.9	*no data*
	Cumberland (MD)	15.0	3.8	0.30
		Average:	**5.2**	**0.54**

Discussions within the Nutrient Work Group found that certain treatment plant configurations or technologies treat to specific treatment levels. The Tetra Tech 2016 report supports this argument. For example, Tetra Tech (2016) asserts that in order to go from a level of nitrogen treatment of 7 mg/L down to 3 mg/L, the addition of denitrification filters is probably needed. This argument could be taken a step further by saying that in order to treat to below 7 mg TN/L, a plant must be designed at the next level, which is, perhaps, a plant designed for 3 mg TN/L effluent. As shown (**Figure 6-2**), it is not affordable for the ≥1MGD group to treat to 3 mg TN/L while also treating to low phosphorus concentrations. Therefore, DEQ is proposing an HAC value of 6 mg TN/L based on the rationale that the group can afford to build infrastructure to treat to 7 mg TN/L, and that additional gains in treatment (down to about 6 mg TN/L can be made with advanced operational strategies. DEQ has determined that building a facility to treat to 7 mg TN/L and optimizing down to 5 mg TN/L may be too optimistic or too unpredictable, especially as facility loading approaches design capacity.

With regard to the phosphorus HAC, a similar approach can be taken. The cost to build infrastructure to treat to a 0.5 mg TP/L is shown to be affordable by the majority of the group. Advanced operational strategies may be able to add additional treatment, but probably not below 0.3 mg/L (40% improvement over 0.5 mg TP/L). DEQ has determined that consistently treating significantly below 0.3 mg TP/L would require tertiary filtration, shown to be unaffordable or marginally affordable for the group. **Based on the above discussion, DEQ is proposing an HAC of 6 mg TN/L and 0.3 mg TP/L.**

For the <1MGD group, consideration was given to the projected high price of future collection system replacement for group members (**Table 6-2**). Communities shaded in gray are of a size where they are likely to have a mechanical facility (communities smaller than about 3,000 usually have lagoons, which are addressed in the following paragraph). Cost for collection system infrastructure replacement increases substantially as towns become smaller, and the 10% additional cost DEQ included in the original estimates was probably too low of an estimate. The high future cost of collection system infrastructure replacement suggests that HAC should be established towards the higher end of the <1MGD group's treatment range. **This consideration, along with the potential for advanced operational strategies, as discussed previously, to reduce nutrient concentrations in effluent of this group's facilities led to the final HAC concentrations of 10 mg TN/L and 1.0 mg TP/L.**

Table 6-2. Estimated Costs, by Population, for Water and Sewer-collection System Replacements.[8]

Category	Population Range	Average LF Sewer (note 1)	Average Sewer Collection System Cost (note 1&6)	Average Annual Cost per User @ 75 year (note 1&2)	% of MHI @ 75 yr (note 1,2 &4)	Average Annual Cost Per User @ 100 year (note 1&3)	% of MHI @ 100 yr (note 1, 3 &4)
1	0-300	10,000	$1,600,000	$337	1.56	$254	1.17
2	300-500	20,000	$3,200,000	$251	0.79	$189	0.60
3	500-1000	23,000	$3,400,000	$178	0.56	$134	0.42
4	1000-2000	40,000	$6,300,000	$166	0.48	$125	0.36
5	2000-3000 (note 5)						
6	3000-4000	75,000	$12,000,000	$125	0.31	$94	0.23
7	4000-5000	92,000	$16,000,000	$118	0.29	$89	0.23
8	5000-6000 (note 7)	92,000	$16,000,000	$59	0.12	$44	0.10
9	6000-7000 (note 7)	158,000	$27,000,000	$144	0.35	$108	0.26
10	7000-8000 (note 5)						
11	9000-10000 (note 7)	314,000	$55,000,000	$217	0.50	$164	0.37

1. Average of communities included in evaluation
2. Based on 75 year service life
3. Based on 100 year service life
4. MHI = Median Household Income
5. No data yet, but working on it.
6. Includes construction costs only not O&M
7. Only one community - need more

For the lagoon category, DEQ did not carry out the same analysis that was described above for mechanical facilities. Instead, DEQ took a representative random sample of POTW lagoons and estimated the cost and economic impact for them to achieve different nutrient treatment levels. Among the 49 POTW lagoons with individual permits, half were likely (based on un-official RP analyses) to have RP to exceed nutrient standards. DEQ randomly sampled 8 facilities from the 25 POTW lagoons that were likely to have RP and, with assistance from EPA, estimated the cost to achieve varying nutrient concentrations in their effluent. Cost estimates for five treatment levels were developed for TN and TP concentrations, respectively, as follows: 3 and 0.05, as land application; 7 and 0.1, add-on/retrofit; 8 and 0.1, replacement with a mechanical plant; 3 and 0.1, replacement with a package mechanical plant; and 3 and 0.1, replacement with a mechanical plant (all concentrations in mg/L). Details of the methodology used by EPA to estimate costs are in **Appendix B**.

DEQ then applied the same economic health (average secondary score) and sliding scale process (**Figure 6-1**) used for mechanical facilities to each sampled lagoon community in order to determine the cost cap for nutrient wastewater treatment. The collective results are shown in **Figure 6-3.** Only a minority (38%) of the sampled communities could afford the lowest-cost option, land application. Beyond that, all technologies examined were too expensive for any of the sampled communities. Presuming that the random sample is representative of lagoon-based communities in Montana, the analysis shows that conversion to mechanical facilities is too expensive for communities using lagoons; this makes sense, since many of these communities have very small populations. Land application is affordable for a sizeable (but still minority) fraction, consistent with our experience over the past 25+ years where we have found that some lagoon-based communities have switched to summertime land application. However, even though land application may be affordable for some communities, land may not be

[8] Data provided by Great West Engineering, 2501 Belt View Drive, P.O. Box 4817, Helena, MT 59604.

available or, if land is available, the soils may not be suitable for land application due to shallow groundwater, tight soil conditions, or salt accumulation in the soils.

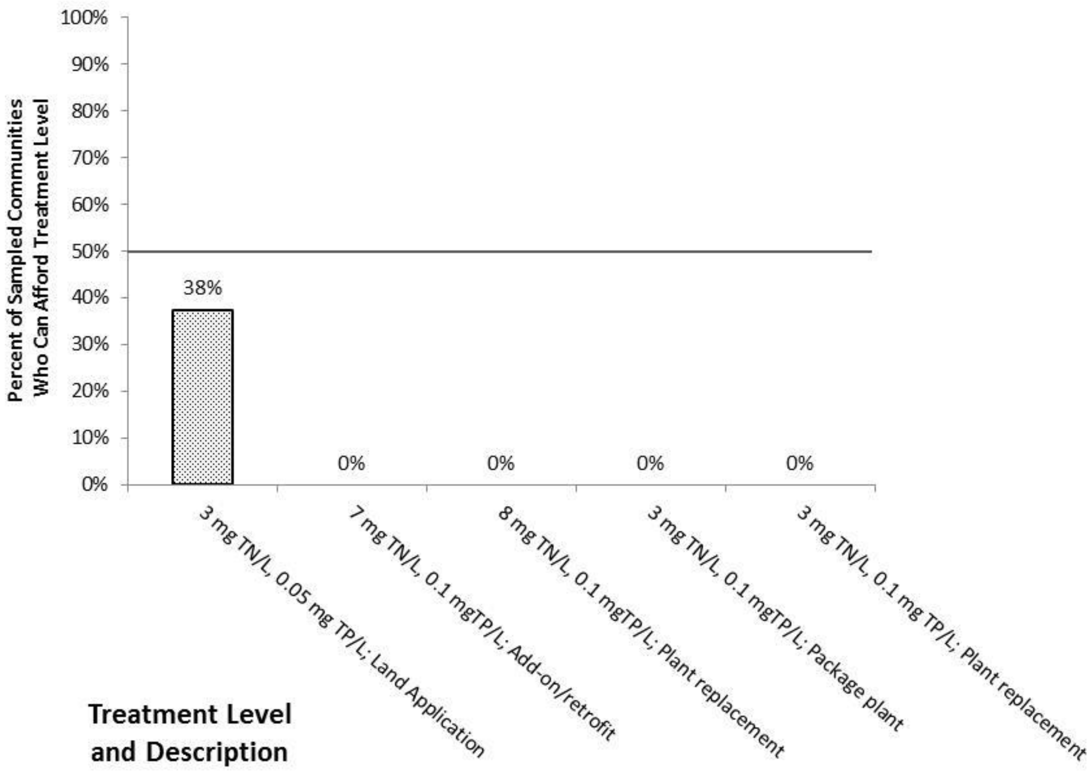

Figure 6-3. Affordability of different nutrient treatment technologies for a random sample of 8 communities likely to need a variance and who use lagoons for wastewater treatment.
Only land-application was affordable, and only for a minority of the sampled communities.

7.0 TIME TO ACHIEVE UPDATED CONCENTRATIONS IN TABLE 12B-1

After updated general variance treatment requirements are included in Table 12B-1 of Circular DEQ-12B, and adopted and approved by EPA, permittees will be required to meet those limits if they are to qualify for a general variance. However, it is not the case that the limits always have to be achieved immediately. DEQ recognizes that many factors influence how quickly a facility can move from its current level of wastewater nutrient removal to those in updated Table 12B-1. Factors may include: when the facility was last upgraded; whether or not optimization has potential to substantially reduce effluent, funding requests which require a PER, etc. These factors will be tailored to each community and facility.

DEQ believes that optimization/advanced operational strategies for facilities, both before and after substantial upgrades, will be an important factor in many cases to achieve low nutrient effluent concentrations (see **Section 2.0**). This is presented conceptually in **Figure 7-1.** Reducing nutrient effluent concentrations and moving towards the Table 12B-1 treatment requirements in a staged manner over time affords more opportunity for the community to find lower-cost options to achieve the limits. The steps in **Figure 7-1** are described narratively in **Table 7-1**. Generally, if fewer than all the steps in **Table 7-1** are required, less time is necessary to achieve the general variance treatment requirements. For example, if a community has already constructed some version of a BNR facility, but is still above the HAC, perhaps only two years are needed to see what improvements in effluent quality can be made with advanced operations. If that proves unsuccessful in meeting the HAC, another 3 to 5 years might be necessary for planning, funding, design and construction of a polishing facility to meet the HAC.

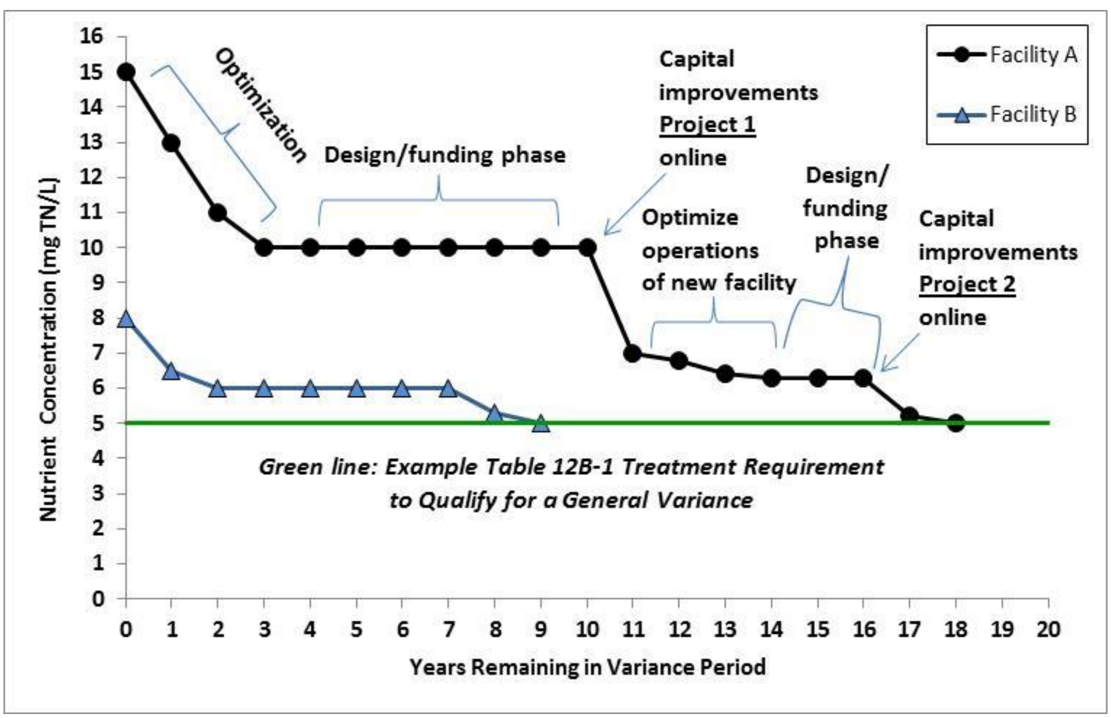

Figure 7-1. Conceptualized approach for integrating both facility optimization and capital improvement upgrades over the course of the variance period.

Facility A is furthest from the example Table 12B-1 treatment requirement and takes a series of steps to achieve it. Facility B was closer to the treatment requirement, and was able to achieve it more quickly using a single optimization step and a single capital improvements step.

Table 7-1. Steps and Approximate Times to Achieve the Treatment Requirements in Table 12B-1 of Department Circular DEQ-12B.

Description of Step	Approximate Time to Complete Step (years)
1. Implementation of advanced operational strategies to reduce nutrients using existing infrastructure. Evaluate effects of operational changes and fine tune as necessary. Operations staff identify potential minor capital improvements, if any, that could be made to further advance operational strategies. Prepare optimization study, as required in **Section 2.2** of this circular, including documentation of operational changes and results as well as a preliminary feasibility assessment of the viability of trading, reuse, etc.	**2**
2. **If Table 12B-1treatment requirements are not achieved**, hire an engineer to prepare a preliminary engineering report (PER) that evaluates options for minor and/or major facility improvements, trading or reuse that lead to further nutrient reductions that build upon developed operational strategies, if appropriate. Continue to fine-tune operational strategies. Begin discussion with funding agencies and submit PERs to those agencies, if necessary (for major upgrades).	**1**
3. Go through funding agency timelines and requirements for planning, if necessary. This may involve legislative approval. Implement minor facility improvements, if appropriate, and fine tune operations for further TN and TP reductions.	**2**
4. Design major capital improvements. Go through the department (DEQ) and other funding agency review and approval processes for the design/bidding phase, including MEPA analysis, adjustments of rates and charges, legal opinions, etc. Bid major capital project.	**2**
5. Construct major capital project, including trading and/or reuse, if appropriate. Begin operating new infrastructure and fine tuning operations. Continue with advanced operational training with new infrastructure. Evaluate nutrient reductions achieved with major capital project and operator optimization.	**4**
6. **If Table 12B-1 treatment requirement are still not achieved**, hire engineer to evaluate alternatives in a PER for next steps to meet **Table 12B-1** treatment requirements for TN and TP.	**1**
7. Submit PER to funding agencies for review, approval, MEPA, etc. Legislative approval required? Obtain funding.	**2**
8. Design and bid capital project to meet **Table 12B-1** treatment requirements for TN and TP.	**1**
9. Construct capital upgrades, including trading, reuse, etc., if appropriate. Continue with operational optimization to meet **Table 12B-1** treatment requirements.	**2**

8.0 Recommended Modification to How Variances are Permitted

During this triennial review it was found that the way variances (general and individual) for the mechanical facility discharge groups (≥1MGD, <1MGD) are currently permitted could be, going forward, a disincentive for wastewater system operators to operate the plants in ways that produce higher quality effluent or effluent with more consistent effluent values. We are recommending a minor change that will correct this issue. To understand this requires some background on the variance permitting process. Per statute (75-5-313, MCA) and rule (Dept. Circular DEQ-12B, and ARM 17.30.1345), variances are permitted as monthly averages, as a load only, as follows:

[Long Term Average] X [Table 5-2 Value$_{95th}$] X [Design Flow] X [conversions] = permit limit (lbs/day)   (1)

In equation 1, the Long Term Averages are the concentrations in the 2nd and 3rd columns of Table 12B-1 of Circular DEQ-12B. Table 5-2 values (EPA, 1991) are based on the coefficient of variation (CV) of the effluent data (TN and TP each considered separately) from a facility as recorded over the past few years of the permit.

When the highest attainable condition is established as the Long Term Average[9], the effect of the initial CV used to identify the Table 5-2 value and in turn derive the load limit (lbs/day) becomes significant, because the load established will not be allowed to increase due to anti-backsliding requirements. As such, a well-run facility currently discharging (for example) TN at a very consistent concentration today (e.g., it has a low CV for its TN of, say, 0.1) will be held to that level of consistency, even if other factors going forward may increase the CV. Unfortunately, this creates a disincentive to run a wastewater facility consistently or to target lower effluent limits in the months and years prior to the receipt of the 1st variance. This was not the intention when the process was adopted in 2014.

Members of DEQ's Nutrient Work Group responsible for POTWs have indicated that as a wastewater facility's actual flow approaches design flow (i.e., loading increases), treatment consistency may suffer (i.e., the CV may go up). In contrast, studies on this subject indicate there is no clear relationship between flow and loading and performance of biological nutrient removal facilities, unless the facility is actually overloaded (Bott and Parker, 2011). Either way, as HAC gets lower and approaches the limits of technology, the CV of the effluent will likely go up, regardless of the facility's loading status. This is because when designing for typical secondary treatment requirements, high effluent concentration days can be balanced against low effluent concentration days (especially for a permit based on a monthly average). When designing for low nutrient concentrations or those approaching zero (e.g., TP), it would require negative concentrations (which do not exist) to provide similar risk mitigation as had occurred in the past with conventional secondary treatment (Bott and Parker, 2011).

The last thing DEQ wants is for communities and other permittees to expend resources on treating nutrients to low concentrations, only for them to find that a CV from past performance (when actual treatment levels were less difficult to achieve) has made it difficult for them to consistently meet their permit limit. To remedy this, DEQ recommends that a standard, fixed CV of 0.6 be used going forward

[9] The time required for any facility to achieve the general variance treatment requirement (i.e., the Long Term Average) is a separate matter; see **Section 7.0**.

when establishing the load-based variance limit for the ≥1MGD and <1MGD discharge categories[10]. This fixed CV will be used when deriving the Table 5-2 Value_{95th} (EPA, 1991). A CV of 0.6 is recommended regardless of the actual CV of a mechanical facility's past performance. (Note: a CV of 0.6 has long been used in permitting when data are lacking or datasets are small, and small datasets are commonly the case here as well.) Additional justification for a CV of 0.6 is the fact that DEQ's proposed HAC values are based partially on nutrient reduction through advanced operational strategies (optimization). This is an evolving field with unknown outcomes for each facility, as well as unknown outcomes as loading approaches design capacity. The added flexibility of a higher CV, such as 0.6, may be necessary to allow an operator room to experiment with operational strategies to lower effluent nutrient concentrations.

DEQ should revisit this recommendation in the future. It may be necessary to further revise or adjust the recommended CV. It may be necessary to make case-by-case considerations when more is known about how facilities actually perform in Montana at lower nutrient effluent concentrations and higher percentages of design flow.

[10] This fixed CV of 0.6 should not be applied to the lagoon category, at least at this time. Effluent quality of lagoons is very hard to manipulate once the lagoon is up and running. Lagoon variances are based on current performance, and if current performance has an associated CV >0.6, the community would have a permit limit more strict than what their system actually performs at, without any immediate mechanism to reduce the CV. Studies underway by DEQ may show other options may be available to lagoons, but results from that work are some years away.

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Appendix A. Facilities Identified at this Triennial Review as Likely to Need a Nutrient Standards Variance (≥1MGD, <1MGD Discharger Groups).

Table B-1. Facilties in ≥1MGD Category Likely to Need a Variance.

MPDES ID	Size	Total Actual Average Flow (MGD)	Facility Type Indicator	FLOW (MGD) (Design average, or if private, average of most recent 2 years)	Facility Type (L-lagoon, M-mechanical O-other, with detail)	Permit Name	Receiving Waterbody
MT0020184	> 1 MGD	0.92	POTW	1.8	M	CITY OF WHITEFISH	Whitefish River
MT0022586	> 1 MGD	15	POTW	26	M	CITY OF BILLINGS	Yellowstone River
MT0021938	> 1 MGD	2.7	POTW	5.4	M	CITY OF KALISPELL	Ashley Creek
MT0022535	> 1 MGD	1.384	POTW	1.8	M	CITY OF HAVRE	Milk River
MT0022641	> 1 MGD	2.8	POTW	5.4	M	CITY OF HELENA	Prickley Pear Cr.
MT0022608	> 1 MGD	6.225	POTW	8.5	M	CITY OF BOZEMAN	East Gallatin River
MT0020028	> 1 MGD	0.677	POTW	1.984	M	CITY OF HAMILTON	Bitterroot River
MT0022012	> 1 MGD	3.64	POTW	5.5	M	BUTTE SILVER BOW CITY AND COUNTY	Silver Bow Creek
MT0000256	UNK	see column "FLOW (MGD)"	NON-POTW	1.573	M	PHILLIPS 66 BILLINGS REFINERY	Yegan Drain and Yellowstone River
MT0031755	UNK	see column "FLOW (MGD)"	NON-POTW	0	M	BUTTE HIGHLANDS JV LLC	Basin Cr., trib to Fish Cr., MF Moose Cr., and trib to MF Moose Cr.

Table B-2. Facilties in <1MGD Category Likely to Need a Variance.

MPDES ID	Size	Total Actual Average Flow (MGD)	Facility Type Indicator	FLOW (MGD) (Design average, or if private, average of most recent 2 years)	Facility Type (L-lagoon, M-mechanical O-other)	Permit Name	Receiving Waterbody
MT0021431	< 1 MGD	see column "FLOW (MGD)"	NON-POTW	0.01	M	MONTANA BEHAVIORAL HEALTH	Unnamed field irrigation ditch, tributary to the Clark Fork River
MT0000205	UNK	see column "FLOW (MGD)"	NON-POTW	0	M	BONNER PROPERTY DEVELOPMENT	Blackfoot River
MT0027430	< 1 MGD	0.023	POTW	0.05	M	COUNTY SEWER AND WATER DIST OF ROCKER	Silver Bow Creek
MT0023566	< 1 MGD	see column "FLOW (MGD)"	NON-POTW	0.01	M	APPLE REHAB WEST LLC	Prickly Pear Cr.
MT0022713	< 1 MGD	0.344	POTW	0.344	M	TOWN OF STEVENSVILLE	Side channel of Bitterroot River
MT0024716	UNK	see column "FLOW (MGD)"	NON-POTW	0.51	M	STILLWATER MINING COMPANY	Stillwater River
MT0022560	< 1 MGD	0.307	POTW	0.434	M	CITY OF EAST HELENA	Prickly Pear Cr.
MT0021857	< 1 MGD	0.15	POTW	0.37	M	CITY OF MANHATTAN	Dita Ditch
MT0020079	< 1 MGD	0.32	POTW	0.54	M	CITY OF CONRAD	Unnamed tributary to Dry Fork of the Marias River
MT0026808	UNK	see column "FLOW (MGD)"	NON-POTW	0.28	M	STILLWATER MINING CO. (E.B.P.)	East Boulder River
MT0029891	UNK	see column "FLOW (MGD)"	NON-POTW	0.48	O	BARRETTS MINERALS INC	Left Fork Stone Creek
MT0020125	< 1 MGD	0.11	POTW	0.502	M	CITY OF CHINOOK	Milk River
MT0031721	< 1 MGD	see column "FLOW (MGD)"	NON-POTW	0.864	M	DRUMLUMMON GOLD CORP	Silver Creek
MT0030350	UNK	see column "FLOW (MGD)"	NON-POTW	0.44	M	REC ADVANCED SILICON MATERIALS LLC	Sheep Gulch and Silver Bow Creek

Appendix B. EPA Methodology for Estimating Different Treatment Cost Upgrades for Lagoon Systems

Target effluent concentrations (TEC) were identified as shown in **Table 1**. An effluent TN of 7-8 mg/l was assumed to be achievable by amending/retrofitting the existing system with denitrification filters after lagoon treatment, provided the lagoon was already achieving nearly complete nitrification (i.e., an aerated lagoon currently demonstrating relatively high concentrations of effluent nitrate and low concentrations of effluent ammonia). Cost estimates for retrofitting unaerated, facultative lagoons assume that an aeration system would be installed in the existing lagoon(s) prior to a new biological (denitrification) filtration system. For comparison, considering that retrofitting may not be feasible at some lagoons, we provided a second option for $TEC_{8.0TN}$ which uses cost data for new MLE-based mechanical WWTPs. We assumed that a TN of 3.0 mg/l could be met by replacing the lagoon with a new mechanical enhanced nutrient removal (ENR) plant or by removing the existing direct surface water discharge and using spray irrigation instead (while retaining the lagoon for treatment). The latter option assumes that the spray irrigation site/soils and design are sufficient to further treat lagoon effluent to 3.0 mg/l total nitrogen (not factoring in any dilution) prior to the effluent reaching surface waters via subsurface (vadose zone and groundwater) flow.

Table 1. Target Effluent Concentration (TEC) definitions for lagoons.

TEC	Options for Facultative Lagoons	Options for Aerated Lagoons
$TN_{7.0}$	Aeration + denitrification filters (*retrofit:* existing lagoon system retained/modified)	Denitrification filters (*retrofit:* existing lagoon system retained/modified)
$TN_{8.0}$	MLE Process (*replacement:* new mechanical treatment plant)	N/A
$TN_{3.0}$ + $TP_{0.1}$	ENR + chemical precipitation + tertiary filtration (*replacement:* new mechanical treatment plant)	ENR + chemical precipitation + tertiary filtration (*replacement:* new mechanical treatment plant)
$TN_{3.0}$ + $TP_{0.05}$	Spray irrigation system (*retrofit:* existing lagoon system retained/modified)	Spray irrigation system (*retrofit:* existing lagoon system retained/modified)
$TP_{0.1}$	Chemical precipitation + tertiary filtration (*retrofit:* existing lagoon system retained/modified)	Chemical precipitation + tertiary filtration (*retrofit:* existing lagoon system retained/modified)

MLE = Modified Ludzack-Ettinger process. ENR = enhanced nutrient removal, which includes some type of improved MLE-based biological nitrogen removal process and enhanced biological phosphorus removal (EBPR).

For phosphorus removal, we defined two TECs, since these increments of TP reduction typically require significant differences in technology and associated costs. $TEC_{0.1TP}$ generally assumed the addition of conventional chemical precipitation and tertiary filters (e.g., moving bed filters, media filters, cloth/screen filters). For BNR process options with $TEC_{0.1TP}$, we assumed that EBPR would be both viable and cost effective for TP removal, with polishing by chemical precipitation (and tertiary filtration). We further assumed that spray irrigation would be capable of meeting an effective (i.e., before dilution) TP concentration of 0.05 mg/l prior to reaching a surface water, based on phosphorus sequestration within the soil matrix.

We have not taken into account any collection system improvements that may be required, as mechanical WWTPs can be more sensitive to influent flows impacted by inflow and infiltration (I/I) than lagoons which typically have enough attenuation to mitigate wide ranges in flow. Our approach to costing lagoon retrofit/replacement options was to develop a relatively small set of "model" lagoons that represent the range of systems under consideration. This approach has been used by the authors of several reliable costing references (e.g., Utah Division of Water Quality, 2010; Washington State Department of Ecology, 2011). Since costs based on the references used are largely a function of plant size (i.e., reflecting economies of scale), we divided the 51 minor lagoons into four flow ranges based on representative percentiles of the design flows for the population of lagoons (**Table 2**). Median (i.e., 50th percentile) flow for the major lagoons was used to generate a single model lagoon to represent the three major Montana lagoons.

Table 2. Montana minor and major lagoon design and actual flows and ranges.

NPDES Permit Type	Percentile	Design Flow (Range), MGD	Actual Flow (Range), MGD
Minor	25th %	0.050 (0-0.163)	0.038 (0-0.099)
Minor	75th %	0.275 (0.164-0.388)	0.159 (0.100-0.230)
Minor	90th %	0.400 (0.339-0.999)	0.300 (0.231-0.628)
Major	50th %	1.450 (>1.000)	0.955 (>0.629)

Because the one nitrifying lagoon was a minor facility falling into the 90th percentile flow range, a fifth model lagoon (Model 4) was provided at this level, as illustrated in **Table 3.**

Table 3. Model lagoon characteristics.

Model	Design Flow MGD	Actual Flow MGD	TN[1] mg/l	TP[1] mg/l	Type
1	0.050	0.038	15.0	5.0	Non-nitrifying
2	0.275	0.159	15.0	5.0	Non-nitrifying
3	0.400	0.300	15.0	5.0	Non-nitrifying
4	0.400	0.300	15.0	5.0	Nitrifying
5	1.450	0.955	15.0	2.5	Non-nitrifying

[1] Average starting TN and TP concentrations - based on the facility characterization data - are provided mostly for informational purposes, as they have little bearing on the treatment options and costs reported.

Where multiple reliable references address similar TECs (and similar existing facility "starting points"), we generally averaged the capital and O&M costs from the multiple references or options to determine a likely cost for achieving a certain TEC for final reporting purposes.

One $TEC_{7.0TN+0.1TP}$ option, and one $TEC_{8.0TN+0.1TP}$ were developed for lagoons associated with Models 1, 2, 3 and 5[11]. Two $TEC_{3.0TN+0.1TP}$ options and one $TEC_{3.0TN+0.05TP}$ as land application (**Table 1**) were developed for lagoons associated with Model 1. The $TEC_{7.0TN+0.1TP}$ option was constructed by adding costs for adding aeration and adding denitrifying filters to existing lagoons—this could be considered a "retrofit" option—along with the cost for chemical precipitation add-on for TP removal. We added the costs associated with needed retrofits from two references: one addressing costs for adding aeration, and one addressing costs for adding denitrifying filters.

The $TEC_{8.0TN+0.1TP}$ option was developed based on cost data from Washington (2011) for lagoon replacement with an MLE-based treatment plant. Likewise, one Model 1 $TEC_{3.0TN+0.1TP}$ option is based on cost data from Foess (1998), while the other $TEC_{3.0TN+0.1TP}$ option is based on a non-linear extrapolation of the best fit line to the Washington (2011) dataset. The Foess-based costs could be considered more appropriate for modular or package treatment units. Because there is some uncertainty about the ability of these systems to consistently meet low TEC limits and because the Foess reference is somewhat dated, the Washington (2011) data were extrapolated in order to provide a "high-end" estimate for a field-constructed BNR system with EBPR.

To develop lagoon-specific cost estimates, we first estimated costs for each of the TECs for each of the five model lagoons, resulting in a total of the 25 possible scenarios. Then we normalized the costs for each of these scenarios by dividing the total costs by the average *design* flow and the average *actual* flow associated with each model lagoon. Appropriate unit costs were than multiplied by the flow for each lagoon associated with each model lagoon to generate plant-specific cost estimates. Design flow was used as the costing basis whenever it was available. Where design flow for a given lagoon was not known/reported, actual flow was used as the costing basis instead (costs for 12 lagoons were based on actual flow instead of design flow).

1.0 APPENDIX B REFERENCES

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[11] When DEQ carried out its random sampling, only model lagoons 1, 2 and 3 were selected.

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