Jacque Klug

King County
Department of Natural Resources and Parks

August 27, 2025

Jeremy Reiman
Washington State Department of Ecology
Water Quality Program
P.O. Box 47600
Olympia, WA 98504-7600

King County Comments on Draft Puget Sound Nutrient Reduction Plan

Dear Mr. Reiman,

On behalf of the King County Department of Natural Resources and Parks (DNRP), thank you for the opportunity to provide comments on the draft Puget Sound Nutrient Reduction Plan (NRP). We appreciate the work conducted by the Department of Ecology staff to develop the draft NRP. King County is committed to the goal of protecting and restoring Puget Sound. Areas with low dissolved oxygen are influenced by a variety of factors, human-caused and natural, and an effective strategy will be guided by science and include multiple measures, an adaptive strategy, and strong partnerships. We support an approach using a general permit and an advanced restoration plan as workable mechanisms to address human impacts on Puget Sound dissolved oxygen.

Upgrading the dozens of wastewater treatment plants that discharge to Puget Sound for nutrient treatment will be one of the largest investments in water quality in state history, affecting communities and agencies large and small. Based on our preliminary planning, upgrading King County's wastewater treatment system may cost on the order of $10 to 20 billion or more in today's dollars, will require even higher rates imposed on communities, households, and businesses, and could take decades to implement.

There are also numerous areas where continued science is needed to resolve uncertainties and gaps, and where more consensus is needed, to ensure public dollars will result in tangible benefits. Regulators, utilities, Tribes, and interested parties have been in costly litigation for years, and this pattern could continue without establishing a regulatory framework that we can be confident will result in clear outcomes to cost-effectively address human impacts on dissolved oxygen in Puget Sound. We support a regulatory framework that will meaningfully address human impacts on dissolved oxygen in Puget Sound. With such high stakes, we must get this right.

Our comments on the draft Puget Sound Nutrient Reduction Plan (NRP) and Salish Sea Model Report, along with comments on the draft voluntary Puget Sound Nutrient General Permit (PSNGP, sent under separate cover and attached for reference), identify questions, concerns, and recommendations for improving the nutrient management framework. We respectfully ask that Ecology:

- Work collaboratively with regulated agencies and interested parties to find more consensus and reduce the chance for additional costly litigation.
- Reevaluate the marine dissolved oxygen standards to determine what standards are needed to protect aquatic life in the Sound and to what extent those standards are reasonably attainable.
- Acknowledge and consider scientific uncertainties in the nutrient reduction actions and adaptative management framework.
- Reconcile any differences between the proposed NRP treatment requirements and the PSNGP's Nutrient Reduction Evaluation planning targets through thorough discussion, analysis, and collaboration with the proposed Technical Advisory Committee.
- Take the time to ensure documents, materials, and regulations reflect areas of broad scientific consensus and support collaborative mechanisms to resolve areas where consensus is still needed.

Water quality standards review

The draft NRP outlines actions to meet the currently applicable water quality standards, including the numeric dissolved oxygen criteria. Those standards, however, are over a half century old with limited documentation on how the standards support specific dissolved oxygen needs of aquatic life native to Puget Sound.[1] Attaining these standards will require many years and tens of billions of dollars to address and could ultimately be unachievable in many portions of the Sound because of natural conditions and other conditions outside of the state's reasonable control.

As the state develops the NRP and PSNGP frameworks that will drive public investments for decades, it is essential to ensure that the underlying scientific foundation is valid and will result in the desired protections for Puget Sound aquatic species. A reevaluation should determine what standards are needed to protect aquatic life in the Sound and whether and to what extent the standards needed to protect aquatic life are reasonably attainable given natural conditions,

[1] Dunagan, C. (2025), *'Natural conditions' are at the center of disputes over dissolved oxygen standards*. Salish Sea Currents, University of Washington Puget Sound Institute. March 25, 2025. Available at: https://www.eopugetsound.org/magazine/natural-conditions-at-center-of-disputes-over-dissolved-oxygen-standards

other conditions outside the reasonable control of Washington or utilities, and the economic sustainability of our region.

Scientific gaps and uncertainties

Dissolved oxygen in Puget Sound is influenced by a variety of factors, many of which cannot be directly managed by humans (e.g., ocean conditions and temperature). Climate-related effects in Puget Sound, including warming waters, can negatively impact dissolved oxygen by decreasing the water's ability to hold dissolved oxygen. Recent research from the University of Washington suggests that climate change is responsible for 40-100% of the decreases in dissolved oxygen in Central Puget Sound.[2] The NRP must develop a science-based plan to contend with climate change and develop evaluation frameworks to determine the best human nitrogen reduction actions and how to measure their effectiveness.

If the human sources of nitrogen reduction proposed in the draft NRP are entirely successful, the dissolved oxygen change in Puget Sound from these actions will be difficult to detect with confidence. Most of the average predicted change will be virtually impossible to distinguish from natural variability and will be observable only in modeled values. This places great importance on the accuracy of the Salish Sea Model as the model will be used to determine water quality compliance. Recent analysis from the University of Washington Puget Sound Institute indicates that errors in embayments remain several times higher than the 0.2 mg/L human use allowance, challenging whether the model has the skill and granularity needed for the regulatory precision[3].

It is imperative to discuss within the NRP the strengths and weaknesses of the model and how those factors work with the regulatory framework. Additionally, the NRP should develop a plan for how modeling updates and enhancements will be used within the adaptive management framework. As has been done in other regions, such as Chesapeake Bay, the NRP should recognize that additional marine water quality models could enhance scientific understanding of marine dissolved oxygen in Puget Sound. Linked environmental models and ensemble

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[2] Mascarenas, D., Leeson, A., Horner-Devine, A., MacCready, P (2025). *Century-Scale Changes in Temperature, Salinity, and Dissolved Oxygen in Puget Sound*. Geophysical Research Letters, Submitted April 14, 2025, 43 p. Mascarenas_etal_01_submitted_20250403.docx Available at https://authorea.com/users/909699/articles/1283646-century-scale-changes-in-temperature-salinity-and-dissolved-oxygen-in-puget-sound

[3] Baker, J., Kanojia, M., Mazzilli, S. (2025) *Technical Memorandum Review of 2025 Salish Sea Model Updates and Application to Nutrient Management*. University of Washington Puget Sound Institute, pg. 3, 2025.08.22-Review-of-2025-Salish-Sea-Model-Updates-and-Application-to-Nutrient-Management.pdf

modeling has improved accuracy for climate change modeling. We believe a similar multiple model approach may be beneficial for modeling Puget Sound dissolved oxygen.

Economic, technical, and programmatic feasibility

The stated goal of the NRP is to develop a means of distributing nutrient reductions that meets water quality standards and is also equitable and reasonable between marine point sources and watershed sources. To achieve this goal, there needs to be greater consideration of the economic and technical feasibility of point and nonpoint source implementation prior to setting basin-wide load targets and finalizing the advanced restoration plan.

Marine point source load targets challenges

The methodology for calculating the marine point source load targets is unclear and requires more description. The PSNGP requires utilities to submit a NRE that identifies the All Known, Available, and Reasonable Treatment (AKART) alternative and the 3 mg/L Total Inorganic Nitrogen (TIN) seasonal treatment alternative. The NRE is intended to support treatment optimization, assess feasibility of additional treatment upgrades at each facility, and estimate impacts on rates and affordability to build the next phase of nutrient reduction.

We are concerned that the draft NRP seems to ‘move the goal post’ for wastewater treatment, proposing wastewater nitrogen loading targets beyond those required under the original PSNGP and that we are currently evaluating in the NRE. Most significantly, the marine point source nitrogen load targets are based on flows and loads from 2014 and therefore ignores the growth over the past eleven years and the impact on a utility’s ability to meet future growth. This means that as flows increase, the concentration limit continually ratchets down to achieve the load reduction. King County estimates that as soon as 2030, the concentration limit will go beyond Ecology’s definition of the limit of technology for our facilities.

Additionally, the NRP’s change of effluent load targets based on Total Nitrogen (inclusive of organic nitrogen) instead of TIN also could result in a treatment plant needing to achieve *negative* effluent TIN concentrations if an allowance for organic nitrogen is not afforded, especially as growth occurs. Early findings show that meeting the original NRE targets will be highly costly, technically difficult to implement, and likely will take at least 30-40 years to implement. With the NRP’s more aggressive treatment targets, it is unknown if these can be technically achieved at all.

Reconciling these inconsistencies will require significant discussion to understand how the proposed basin targets were developed and what analysis beyond the NRE planning is needed to determine treatment feasibility for individual facilities. As a starting point, King County recommends that NREs be submitted based on the original PSNGP treatment planning targets and that Ecology and the proposed Technical Advisory Committee determine if supplemental planning and additional Salish Sea modeling is needed to understand the technical and economic limits on attaining the proposed load reductions and the scientific impact on Puget Sound dissolved oxygen.

Watershed Load Targets

For the non-point and point sources in Puget Sound's freshwater watersheds, the proposed watershed targets are likely not reasonable or achievable. The NRP watershed targets are based on modeling that assumes, on average, a 53-67% reduction in anthropogenic loading in most watershed basins. Modeling and analysis in King County's Water Quality Benefits Evaluation Toolkit indicate stormwater best management practices only achieve a 50% reduction in nitrogen. Even with treatment of all urban stormwater, it's unlikely that the Puget Sound region would be able to achieve the target reductions.[4] Moreover, the proposed watershed reductions exceed what has been achieved even in the best cases in Denmark and the Chesapeake Bay, regions which have been working for decades to reduce human nitrogen loading.[5] The NRP requires additional analysis to develop reasonable targets and greater dialogue on how this influences the goal of equitable distribution of load targets.

The proposed targets in the NRP present enormous technical and economic challenges. The wastewater treatment upgrades necessary to achieve the proposed load targets will raise wastewater rates and exacerbate affordability concerns in the Puget Sound region. Additionally, nitrogen removal technologies have the potential to greatly increase greenhouse gas emissions and energy use from wastewater treatment facilities, increasing regional strain on the electrical grid and challenging goals to address climate change. The NRP must consider future planned growth, regional impacts to climate and energy goals, and provide opportunities to assess tradeoffs of nutrient control with regional economic and environmental values.

Getting this right requires collaboration

Meeting the proposed nutrient reduction framework in the NRP would represent one of the largest investments in water quality improvement ever in our state. The scale of this investment

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[4] Herrera Environmental Consultants (2024), *WQBE Phase 3 Water Quality Performance Parameter Data Compilation* (Appendix D to 439- TM1). Prepared for King County Water and Land Resources Division by Paradigm Environmental and Herrera Environmental Consultants. October.
[5] Baker et al., *Technical Memorandum Review of 2025 Salish Sea Model Updates and Application to Nutrient Management,* p.3

will require significant increases in regional and local utility rates on top of those already required to meet other regulatory obligations and ensure system reliability with population growth. As the state develops a framework for nutrient reduction, it is essential that both regulators and utilities fairly and transparently communicate the outcomes and costs.

King County is committed to working with Ecology and others to improve the advanced restoration plan and the draft nutrient general permit as a part of a sustainable regulatory framework for nutrient management. If you have questions or need more information, please contact Jacque Klug, the Wastewater Treatment Division's Nutrient Management Coordinator, at jacque.klug@kingcounty.org or 206-477-4474.

Sincerely,

Signed by:
John Taylor
397943501675477...
John Taylor, Director
King County Department of Natural Resources and Parks

Attachments
- Appendix A - King County Comments on the Draft Puget Sound Nutrient Reduction Plan
- Appendix B – King County Comments on the Volume 2: Model Updates and Optimization Scenarios, Phase 2

cc: Rachel McCrea, Water Quality Section Manager, Washington State Department of Ecology (Ecology)
Jon Kenning, Water Quality Program Manager, Ecology
William Weaver, Puget Sound Nutrient General Permit Writer, Ecology
Jeff Killelea, Permit and Technical Services Section Manager, Ecology
Chad Brown, Watershed Unit Supervisor, Ecology
Sean McKone, Municipal Wastewater Permits Unit Supervisor, Ecology
Sean Wilson, Senior Facility Management Engineer, Ecology

Appendix A: King County's Detailed Comments on the Draft Puget Sound Nutrient Reduction Plan

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11	If entirely successful, the largest predicted change in DO from the NRP will be an increase of approximately 1.0 mg/L, on average, from existing conditions. A change of this magnitude from nutrient reductions alone will be difficult to detect with confidence. Most of the change will be virtually impossible to distinguish from natural variability – only observable in modeled values. King County frequently observes daily variation in DO at some marine monitoring sites greater than 1.0 mg/L. Setting the expectation that field measurements can be used to evaluate the response and trigger adaptive management actions is misleading. Our ability to statistically distinguish an effect size of this magnitude resulting from implementation of the NRP from all other sources of variability (measurement error, natural variability, sampling error, etc.) is limited. The detectable effect size will be a function of our sampling design, measurement error, analysis interval, natural variability, etc.	Recommend a professional statistician perform a Sample Size Power Analysis on existing field observations to estimate the effect size that we can detect with a power level of 0.8 and an alpha value of 0.1 or 0.5.
11	Walker et al. (2022) predicts sea surface temp (SST) in Puget Sound will increase by 0.8-1.1 °C in the short term (2020-2050) and by 1.5-3.9°C in the long term (2070-2100), depending on the model and emissions scenario. Given the inverse relationship between temperature and solubility of oxygen in water, a 1.1°C increase in SST could reduce DO concentration by 2-3%; a 3.9°C increase in SST could reduce DO concentration by roughly 7-10%, regardless of the level of reduction in nutrient loading. Consequently, improvement in compliance and achievement of water quality standards	Explicitly state whether predicted outcomes assume stationarity in SST in 2050 or account for predicted increases of nearly 1.1°C by 2050 and 3.9°C by 2100. Consider and state implications for the degree of compliance with WQ standards that can be achieved by proposed load reductions in the face of predicted increases in SST by 2050 and 2100.

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	by 2050 could be overstated. See also King County comment on page 39.	
13	Reference Text: "Regulatory Framework – An ARP contains many of the same elements as a TMDL but provides more flexibility in how clean-up efforts are approached, with the goal of cleaning up water faster than a traditional TMDL. We discuss ARPs in more detail in the "Advance restoration plan approach" section."	King County agrees with Ecology that a flexible and pragmatic approach to addressing DO impairment in the Puget Sound is needed. We recommend that Ecology revise the NRP to explicitly describe how it will result in faster water quality improvements over a traditional TMDL. Ecology should also explain how the flexibility envisioned in the NRP is necessary for implementation and consistent with the Clean Water Act.
15	Reference Text: "Nitrogen in the Sound - Nonpoint sources include runoff from crop and animal agriculture operations, nutrients in stormwater from residential and commercial land, excess fertilizers used for residential purposes, residential onsite sewage systems, golf-courses, and municipal parks."	Golf courses and municipal parks are not necessarily nitrogen pollution sources, depending upon their management practices. In fact, a few golf courses and parks in Puget Sound uptake nitrogen from reclaimed water use. Recommend changing to state "excess fertilizers used for turf or garden uses."
16	Figure 2 - The boundaries shown in Figure 2 appear not to consider jurisdictional and WRIA boundaries.	Please clarify if jurisdictional or WRIA boundaries cause any issues with regulation and implementation? We recommend Ecology to include jurisdictional boundaries for clarity in future drafts.
17	Reference Text: "Nitrogen in the Sound - We also acknowledge that many of the practices used to reduce nitrogen loading to aquatic systems can have other positive environmental outcomes, such as limiting harmful algae bloom occurrences and reducing discharges of toxic pollutants."	Ecology should also acknowledge the environmental tradeoffs associated with nitrogen removal, as these removal technologies have the potential to significantly increase greenhouse gas emissions and energy consumption.
18	Reference Text: "Efforts to address dissolved oxygen problems - A primary goal of these studies was to identify a nutrient reduction distribution that meets water quality standards and is also equitable and reasonable between the WWTPs and watershed sources."	Ecology should describe the criteria that was used to develop "equitable" and "reasonable" in relation to Ecology's goal of dividing up nutrient reductions across different human sources. Also, explain how Ecology will measure if the reductions are meeting those distribution goals and if redistributing reductions between human

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		sources will be potential action in the adaptive management process.
18	Reference Text: "Efforts to address dissolved oxygen problems - A primary goal of these studies was to identify a nutrient reduction distribution that meets water quality standards and is also equitable and reasonable between the WWTPs and watershed sources."	King County believes there needs to be greater consideration of the economic and technical feasibility of point and nonpoint source implementation prior to setting basin-wide caps and finalizing the advanced restoration plan. Given the challenges of naturally low DO, climate change driven impacts to DO and challenges of implementing watershed reductions, additional discussion is necessary to develop equitable and reasonable actions.
19	Reference Text: "Salish Sea Model - Ecology was confident the model performance was adequate for evaluating the cumulative impacts of human caused nutrient loads on DO and for determining what nutrient reduction scenarios can achieve DO standards."	Ecology should incorporate a robust discussion, including the chronology of the Salish Sea Model and its enhancements over time to support this statement. Ecology should also articulate whether the model can accurately predict to the 0.2 mg/L human use allowance. Recent analysis from the University of Washington Puget Sound Institute indicates that the Salish Sea Model may struggle with the skill to measure the 0.2 mg/L human use allowance: "Although overall model performance improved modestly, errors in embayments remain several times higher than the 0.2 mg/L human use allowance. Additionally, the subtraction of two scenarios does not cancel uncertainty—especially since the reference condition cannot be validated. As a result, when compliance is determined by comparing existing and reference scenarios, the true level of uncertainty in the outcome is larger than the model statistics alone suggest and must be explicitly considered in regulatory applications. It seems unlikely that any model could

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		reduce uncertainty to the point that it is lower than the current human use allowance of 0.2 mg/L."[1] As the Salish Sea Model continues to be improved, the NRP should discuss how model improvements will be incorporated by Ecology and used to refine the Advanced Restoration Plan. For instance, there is an updated version of the model with finer spatial resolution (114,590 nodes and 208,452 triangular elements vs. 16,012 nodes and 25,019 triangular elements in the version used), as well as ongoing work towards eliminating bathymetric smoothing within the model. This could improve its performance in the hard to model marine nearshore and increase our ability to understand DO in cells that have been masked in previous model runs. A detailed description of the strengths and limitations of the SSM should be incorporated in the NRP, including a description of why it supports the ARP as an appropriate advanced restoration approach.
20	Reference Text: "Footnote 4 – Dominant loaders cumulatively constitute greater than 80% of the TIN load to Puget Sound, while moderate loaders and small loaders represent approximately 19% and less than 1%, respectively." This statement incorrectly suggests that WWTPs account for all TIN load to Puget Sound.	Please revise the statement to reflect that these are percentages of the total domestic marine point source TIN load to Puget Sound. "Dominant loaders cumulatively constitute greater than 80% of the <u>domestic</u> marine point source TIN load to Puget Sound, while moderate loaders and small loaders represent approximately 19% and less than 1%, respectively."
20	Reference Text: "Puget Sound Nutrient General Permit - The permit categorized WWTPs in three different size	Loading is one of many factors that influence the impact of a wastewater plant. For instance, the proposed loading

[1] Baker, J., Kanojia, M., Mazzilli, S. (2025) *Technical Memorandum Review of 2025 Salish Sea Model Updates and Application to Nutrient Management*. University of Washington Puget Sound Institute, pg. 3, PDF Attachment

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	categories (dominant, moderate, small), with permit requirements varying based on size category." Given Ecology's stated goals of distributing nutrient reduction responsibilities equitably and reasonably, what evidence does Ecology provide that categorizing and allocating responsibility to WWTPs by nitrogen loading alone is the best course of action to address DO impairment?	targets in Appendix E identify that some smaller plants near shallow embayments may have more of an impact to local DO and modeled more treatment requirements to impact DO in those areas.
21	Reference Text: "Puget Sound Nutrient General Permit - Permittees that maintain an annual TIN average of < 10 mg/L and do document an increase in load through their discharge monitoring reports (DMRs) do not have to submit this analysis." This statement is incorrect since it is missing the word "not."	Please correct the sentence to: Permittees that maintain an annual TIN average of < 10 mg/L and do **not** document an increase in load through their discharge monitoring reports (DMRs) do not have to submit this analysis.
22	Reference Text: "Puget Sound Nutrient General Permit - At the time of this plan, Ecology has begun the process to reissue the General Permit to offer voluntary coverage for facilities that want to continue under the General Permit to address nitrogen reduction requirements. We currently plan to propose minimal edits to the permit through a public process with opportunities to review and provide comments."	The minimal edits to the draft PSNGP and the draft Fact Sheet made the documents difficult to read and assess as there were several out-of-date references, inconsistencies between versions and typographical errors. King County provided detailed comments on the draft PSNGP and encourages Ecology to consider those comments along with our comments on the NRP for recommendations on how to improve the nutrient management framework. Additionally, we want to emphasize that there are some critical inconsistencies between the PSGNP and the NRP with regard to future nitrogen treatment requirements for utilities. The draft Puget Sound Nutrient Reduction Plan proposes wastewater nitrogen loading targets that are based on several treatment assumptions that differ from the NRE requirements. These changes include assuming winter treatment of 8 mg/L Dissolved Inorganic Nitrogen

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		(DIN), 8 mg/L CBOD, introducing a third, intermediary nitrogen removal season, and changing the regulated nitrogen species to Total Nitrogen (TN) versus TIN. In addition, the Nutrient Reduction Plan calculates the load reductions based on 2014 flows, making a 3 mg/L equivalent load reduction calculated on ten-year-old flows translate into even lower effluent concentration limits for future flows. The potential shift in treatment targets and upcoming WQBELs could easily result in NREs that do not answer the question of whether or not a utility can afford the necessary upgrades to meet the DO water quality requirements.
23	Reference Text: "Advance restoration plan approach - We have utilized the technical rigor of the Salish Sea Model to develop nitrogen targets and will rely on the same permitting and nonpoint implementation tools that are foundational in TMDLs."	As most of the average predicted change in DO will be virtually impossible to distinguish from natural variability and will be observable only in modeled values, it places great importance on the accuracy of the Salish Sea Model as the model will be used to determine water quality compliance. Recent analysis from the University of Washington Puget Sound Institute indicates the model may lack the skill and granularity needed for the regulatory precision[2]. It is imperative to discuss within the NRP the strengths and weaknesses of the model and how those factors work with the regulatory framework.
23	Reference Text: "Advance restoration plan approach - Identifies financial support necessary to reduce nutrient loading to Puget Sound"	The NRP doesn't identify the financial support necessary to support nutrient reduction in terms of funding needs, rather it documents existing funding. This statement indicates there is an aggregate cost estimate and greater certainty than what is currently in the plan.
26	Reference Text: "Designated uses of waterbodies - Before finalizing the targets in this plan, we confirmed and have documented the nitrogen targets meet the	Please reconcile this statement with Appendix H: "While the Salish Sea Model scenarios were aligned with the conceptual framework of the TMDL, the specific nitrogen

[2] Baker, J. et. al, (2025) *Technical Memorandum Review of 2025 Salish Sea Model Updates and Application to Nutrient Management*. pg. 3

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	requirements of the bubble allocation in the Budd Inlet TMDL (Figueroa-Kaminsky et al. 2025, Appendix O)."	load targets produced through the Salish Sea Model effort did not match the final WLAs established in the Budd Inlet TMDL. Ecology acknowledges that these inconsistencies between the TMDL and the draft Puget Sound Nutrient Reduction Plan NRP create uncertainty for permittees in Budd Inlet."
28	Reference Text: "Water quality criteria – Washinton's water quality standards contain numeric DO criteria for marine waters in Chapter 173-201A-210(1)(d) WAC for the protection of aquatic life uses. These criteria protect all indigenous fish and non-fish species, such as shellfish and marine mammals, from lethal and sublethal effects of low dissolved oxygen levels and are often referred to as the "biologically-based numeric criteria"."	The draft NRP outlines actions to meet the currently applicable water quality standards, including the numeric dissolved oxygen criteria. Those standards, however, are over half a century old and may have been developed without documented evidence regarding any specific dissolved oxygen needs of aquatic life native to Puget Sound. Attaining these standards will require many years and tens of billions of dollars to address and will ultimately be unachievable in many portions of the Sound because of natural conditions and other conditions outside of Washington's reasonable control. Washington's DO standards should be reviewed to ensure the criteria are biologically-based and have appropriate seasonal and temporal resolution to protect diverse aquatic communities specific to those habitats. Ecology should also correct their spelling of "Washinton's" to "Washington's".
28	Reference Text: "Table 3 – The table defines the DO criteria for each aquatic life uses category. All DO concentrations are measured as a 1-day minimum. Concentrations of DO should not fall below these criteria more than once every ten years on average [WAC 173-201A-210-1(d)(ii)]."	The DO criteria, expressed as 1-day minimums, were not developed using robust knowledge of natural DO variability in the Salish Sea and do not account for the fact that DO concentrations do not meet these criteria at many locations, depths, and times under natural conditions. Washington's DO standards should be reviewed to ensure the criteria have appropriate seasonal and temporal resolution to protect Puget Sound's native aquatic communities specific to those habitats.

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30	Reference Text: "Water quality criteria - In addition to the numeric biologically based criteria, Washinton's water quality standards have historically included natural conditions provisions. Natural conditions criteria have been a part of Washington's surface water quality standards since the first regulations were adopted in 1967.[6]"	Ecology should explain more clearly what effect EPA's disapproval of the Natural Conditions Criteria has on Ecology's ability to achieve the applicable WQS through nutrient load reductions on point and nonpoint sources. Ecology should also explain if any of the comments received on the proposed marine DO performance-based approach guidance document might change or impact any of the approach to determining natural conditions used for the NRP.
31	Reference Text: "Nitrogen loading targets - This plan sets total nitrogen (TN) loading targets for Puget Sound's marine point sources and watersheds at a level that attains DO standards across the Sound… Total nitrogen was selected as the parameter of interest for targets as it is inclusive of all nitrogen species. Basin-wide TN targets provide flexibility in the implementation tools available to achieve reductions."	Salish Sea Modeling has used DIN/TIN, and the PSNGP regulates TIN. If TN will be used for future regulations for wastewater treatment facilities, an organic nitrogen allowance is needed to account for organic nitrogen that cannot be removed or does not have biological impacts. The allowance may vary depending on facility-specific treatment technologies and would require additional wastewater sampling.
31	Reference Text: "Nitrogen loading targets - While we have not assigned targets for carbon, this section describes the assumptions in organic carbon reductions associated with meeting TN targets. Organic carbon assumptions are based on previous evaluations of nutrient removal technologies at WWTPs (Tetra Tech, 2011)."	Additional analysis is needed to determine the importance of organic carbon both in relation to Puget Sound DO, and in the SSM, as well as appropriate organic carbon assumptions for different treatment technologies. We question if a single study, completed 14 years ago, meets the standards for rigor to be used for SSM modeling assumptions or as is later, implied, to create future permit limits.
31	Reference Text: "Nitrogen loading targets - While we have not assigned targets for carbon, this section describes the assumptions in organic carbon reductions associated with meeting TN targets. Organic carbon assumptions are based on previous evaluations of nutrient removal technologies at WWTPs (Tetra Tech, 2011)."	Please clarify if this TOC assumption is being applied to watersheds as well? If so, please clarify if this been studied in watersheds?

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31	Reference Text: "The nitrogen targets are derived from the loading scenario specified in Salish Sea Model scenario "Opt2_8" detailed in the Optimization Scenarios Phase 2 report." The Opt2_8 scenario assumes that treatment plants will be able to reasonably or feasibly meet the nitrogen effluent targets of the modeled scenario, in most cases, down to 3 mg/L TIN seasonally. Some of the treatment plants may find that meeting the effluent targets of the modeled scenario are not reasonable or feasible through an AKART analysis. If that is the case, a model scenario or scenarios could be conducted by Ecology to investigate the impact of the AKART treatment for one or more of these treatment plants. This could determine whether water quality is measurably impacted by the AKART treatment level(s).	Ecology should consider alternative modeling scenarios that measure the impact of higher nitrogen effluent targets for some treatment plants, given that the current proposed targets may not be achievable or are beyond what is considered AKART.
31	Reference Text: "Nitrogen loading targets - As with all the refined Phase 2 scenarios, nutrient load reductions were applied by reducing nitrogen and carbon concentrations relative to their 2014 concentrations. Flows were kept constant at 2014 levels." Because Ecology chose to use 2014 flows and loads in its SSM, the amount of load reduction required to meet the targets doesn't take into consideration the 10+ years of growth that have occurred since 2014 nor into the future. This could mean that the allowable/permitted effluent discharge concentration will continuously decrease to lower and lower levels that will be harder and harder (and more costly) to achieve as the flows increase but the load allocation remains the same.	Balancing nitrogen reductions while considering the past 11 years of growth, as well as future growth, is a key issue in the future work to translate Ecology's targets into WQBELs. Different assumptions and approaches could significantly impact treatment requirements, ratepayers, and the economies of communities around Puget Sound. This issue needs much more additional analysis and dialogue.

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31 & 32	Reference Text: "Nitrogen loading targets - …were set at average DIN concentrations of 8 mg/L in the cool season, 5 mg/L in the warm season, and 3 mg/L in the summer season. … …were set at assumed average DIN concentrations of 3 mg/L during the warm season (rather than just in the summer season)."	Ecology should explicitly state that these DIN concentrations are **effluent** concentrations. Additionally, we will note that these treatment assumptions are different than the treatment targets that were specified in the NRE, most significantly, assuming winter treatment of 8 mg/L DIN in the NRP where the PSNGP NRE had no winter treatment requirements. Ecology needs to clarify if utilities should alter their TIN treatment planning assumptions in the NRE to align with the NRP. The potential shift in treatment targets and upcoming WQBELs could easily result in NREs that do not answer the question of whether or not the necessary upgrades to meet the dissolved oxygen water quality requirements are financially reasonable or technically feasible. King County recommends that NREs be submitted based on the original PSNGP treatment planning targets currently listed in S4.E. and that Ecology issue any supplementary planning requirements after receiving and reviewing NRE results with the Nutrient Reduction Plan's proposed Technical Advisory Committee.
32	'Anthropogenic' TN and TOC imply that we can differentiate human inputs from 'natural' by the measured reduction of TN and TOC. Would it be more appropriate to just say TN and TOC reduction and omit the anthropogenic statement, or provide a definition of what 'all forms of anthropogenic' means for this NRP? It is understood that the intent of this NRP is to remedy human TN/TOC inputs, but many 'natural' sources of TN and TOC may be biased higher as an indirect result of historic riparian alteration (e.g., coniferous riparian conversion to deciduous riparian post-logging activities and due to past urbanization) that are not discussed in this NRP. Studies have shown an increase in nutrient	Studies have shown an increase in nutrient inputs to streams from riparian areas that have been altered from coniferous to deciduous by urbanization (Roberts et. al, 2008, Gao, et. al., 2022 as examples). Is the intent to consider this TN/TOC input as anthropogenic as well? Does SSM account for this?

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	inputs to streams from riparian areas that have been altered from coniferous to deciduous by urbanization (Roberts and Bilby, 2007[3], Gao, et. al., 2022[4] as examples). Is the intent to consider this TN/TOC input as anthropogenic as well? Does SSM account for this? These sources may (or may not) have an attenuating effect on the results of NPDES and non-point reduction efforts within each watershed and could skew the watershed reduction targets if they were not considered in the SSM.	
32	Reference Text: "Nitrogen loading targets - Domestic WWTPs not treating combined sewage and discharging greater than 2,000 lbs. TN/day[8]... [8] Definition of "Dominant Loaders" in the 2022 General Permit." The 2022 General Permit defines Dominant Loaders as WWTPs discharge more than 2,000 lbs/day of TIN, not TN.	Ecology should update the NRP to remove footnote 8 or change the sentence to "Domestic WWTPs not treating combined sewage and discharging greater than 2,000 lbs. TIN/day[8]..." if the 2,000 lbs. TIN/day was what was assumed for the model scenario.
32	Reference Text: "Nitrogen loading targets - Our modeling approach assumed that all facilities reducing DIN loads would also achieve an annual average carbonaceous biochemical oxygen (CBOD) concentration of 8 mg/L year-round (Tetra Tech, 2011), which is translated to a facility specific reduction in dissolved organic carbon (DOC) load in the model (McCarthy et al., 2018)."	The 8 mg/L CBOD assumption needs further analysis, especially if this were to be a treatment limit. The implication could range from significant to minor, depending on the facility and the averaging period for the CBOD permit limit, whether the limit is concentration- or load-based, and the selected technology for expansion.

[3] Roberts, L. Mindy., Bilby E. Robert., Booth, B. Derek., (2008). Hydraulic Dispersion and reach-averaged velocity as indicators of enhanced organic matter transport in small Puget Lowland streams across an urban gradient. PDF Attachment

[4] Gao, Jie., Huang, Yuyue., Zhi, Yue., Yao, Jingmei., Wang, Fang., Yang, Wei., Han, Le., Lin, Dummei., He, Qiang., Wei, Bing., Grieger, Khara., (2022). Assessing the impacts of urbanization on stream ecosystem functioning through investigating litter decomposition and nutrient uptake in a forest and a hyper-eutrophic urban stream. PDF Attachment.

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32	Reference Text: Table 4 How were these percent reductions determined/calculated by Ecology?	Ecology should add a description to the NRP that describes how the watershed percent reductions were set or calculated.
32	Our modeling for King County watersheds estimates that the largest proportion of stormwater TN loads is coming from residential land use, followed by commercial land use (see Table 2 below). As part of our modeling project, we looked at performance data for common BMPs for treating residential and commercial stormwater. Some of the best performers average about 50% TN reduction (like HPBSM bioretention and high-rate underground filter systems), but most others average less than 10% TN reduction, and some even export TN on average (like bioswales)[5] . This also doesn't account for water that may bypass these BMPs during very large storm events. Even if we treated 100% of the stormwater from these areas, we could not expect to achieve a 60% reduction.	Recommend considering feasibility and AKART as part of establishing the required watershed TN reductions.
32	Reference Text: Table 4 – *Defined as average daily anthropogenic TN load greater than 1,000 kg/day. Is this a TN load into or out of the watershed basins?	Ecology should explicitly state if the basin TN load of greater than 1,000 kg/day is an influent or effluent TN load.
33	Reference Text: "Marine point source targets - The results met the bubble allocation and resulted in the same level of noncompliance as the Opt2_8 scenario (See Salish Sea Model Optimization Phase 2 Report Appendix O)."	Please define what is meant by "level of noncompliance".
33	Reference Text: "Marine point source targets - In the Opt2_8 scenario, aggregating the bottom-two-layers (comprising approximately 33% of the water column	Ecology should provide some explicit criteria or examples that would allow an assessment of whether or not the appropriate aggregations were made.

[5] Wright, Olivia., Lenth, John. (2024). Technical Memorandum WQBE Phase 3 Water Quality Performance Parameter Data Compilation. PDF Attachment

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	depth) of these shallow waterbodies based on an assumption of similarity in habitat and biochemical conditions, results in zero noncompliance throughout the Sound."	
33	Reference Text: "Marine point source targets - The marine point source targets represent basin-wide annual loading targets for NPDES permitted domestic WWTPs and industrial facilities located in Washington and discharging to Puget Sound (Figure 6). We have divided the basin-wide target loads by state issued NPDES permits for domestic WWTPs (State WWTP), state issued NPDES permits for industrial facilities (State Industrial), and EPA issued NPDES permits for domestic WWTPs and industrial facilities (Federal) (Table 5), as the tools and programs responsible for implementing these targets in permits vary. However, the targets apply at the basin wide level to allow flexibility to adjust the distribution of loads between facilities and across permit types within each basin."	Ecology should more clearly explain what factors it is considering in allocating the available nutrient load among marine point sources. Ecology should explain any economic, technical, or environmental justice considerations that it may rely on in developing specific loading allocations for individual marine point sources. Ecology should also explain how its envisioned allocation of the nutrient load to individual WWTPs is equitable when considering the above factors.
36	Reference Text: Table 5 – Main Basin The reported Total Annual Target for the Main basin (6,300,000 lbs TN/year) is less than the sum of the three permitted sources (6,803,146 lbs TN/year). Based on Appendix E.1, the State WWTP (lbs. TN/year) for the Main basin should be 6,119,298 lbs./year.	Ecology should ensure the values reported in Table 5 and Appendix E are correct, especially since these could be the basis for WQBELs.
36 & 37	Reference Text: "Marine point source targets - The TN loads in Table 5 are the basis for calculating WQBELs in future reissuances NPDES permits for domestic WWTPs. ... As these permits are up for renewal in the future, the targets in this plan will serve as the foundation for calculating TN WQBELs.	In this section, Ecology notes that the load targets will be used for calculating WQBELs. However, on page 34, the load targets "may use when calculating WQBELs." Please clarify the intent of the load targets.

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	...These loads serve as the basis for calculating TN WQBELs in future NPDES re-issuances. ...pg 41, The marine point source nitrogen targets (Table 5) will be translated into WQBELs in the future... ...pg 57 The next reissuance of the marine point source permits will be crucial, as Ecology and EPA will establish WQBELs consistent with the TN targets in this plan for WWTPs and industrial facilities discharging to Puget Sound that will achieve water quality standards."	
36	Reference Text: "Marine point source targets - As of 2025, nine state-permitted facilities were actively discharging to Puget Sound."	Ecology should correct this sentence to clarify that these nine facilities are **industrial** facilities.
37	Watershed Targets paragraph.	Please add some description of this stated "flexibility." Is it based on data? underserved or financially disparate communities? Or add a statement that this will be addressed in the upcoming individual watershed studies to clarify for the reader.
39	Reference Text: "Non-local and regional sources -These external sources include Canadian wastewater treatment plants and rivers, atmospheric deposition, the open ocean boundary, and changes in nutrient loading and dynamics resulting from climate change. While their nutrient contributions and simulated effects on DO are components of the Salish Sea model (See McCarthy et al., 2018), we have not allocated a portion of the 0.2 mg/L DO human use allowance to these sources, and they were not assigned nutrient targets." This statement implies that atmospheric deposition and climate change dynamics are part of the SSM, but based on the statement on page 19 that states, "Sources of nitrogen to the Salish Sea within the model include rivers that drain watersheds, marine point sources, benthic	Ecology should clarify what inputs/dynamics are a part of the SSM, how potential impacts from climate change such as greater coastal upwelling will be measured and how those measurements will be incorporated into the SSM. Additionally, Ecology should clarify if the nutrient reduction targets were set at levels to remove enough nitrogen to meet DO standards without considering targets for "external sources" and whether considerations are being made for potential changes to the external sources from climate change.

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	sediment fluxes, and oceanic nitrogen." Atmospheric deposition and climate change are not in the model. Plus, Ecology's SSM website says that future work will look at the effects of climate change. Also, if these nutrient contributions are not allocated N, does that mean the targets for the marine point sources and watersheds are making up the difference if Opt2_8 is meeting DO standards, or will targets be lowered (more stringent) if the other sources are allocated part of the total target load? One potential impact of climate change is more coastal upwelling leading to more nitrogen input to the Puget Sound from the open ocean boundary. Since nutrients from the ocean boundary account for close to 90% of nitrogen loading to the Puget Sound, even a small change in loading from the ocean may have a large impact on nitrogen in the Puget Sound. It is unclear whether or how Ecology intends to measure and account for this potential change in the largest nitrogen input source to the Puget Sound in the SSM model.	
39	Climate-related effects in Puget Sound (warming, higher salinity, less stratification,) have a negative impact on DO by decreasing the oxygen saturation potential (e.g., a parcel of water's ability to hold DO). Changes in these parameters have accounted for approximately 25% of DO decreases seen in 2024, which can be well above the 0.2 mg/L threshold. It is unclear if the SSM run is accounting for the effects of temperature and salinity on DO, but running for a single model year does not account for future changes in temperature (see King County comment on page 11). Failing to account for the effect of warming conditions	Include a DO percent saturation provision to account for changes in DO concentration resulting from temperature and salinity. For example, if DO decreased by 0.2 mg/L or more, identify if that decrease corresponds with a X% decrease in percent saturation. If the change in percent saturation is not below the threshold, then the decrease in DO concentration was likely due to increases in T and S and not from nutrient inputs.

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	on DO puts an unrealistic emphasis on nutrients as the sole influencer of DO.	
41	Reference Text: "Marine point sources - No new WWTP or industrial discharge into Puget Sound will be permitted unless it can be demonstrated targets in Table 5 will be met." In practice, not allowing new WWTPs to discharge to the Puget Sound may limit how a utility might plan for nutrient removal upgrades or address non-point nutrient loading. Some WWTPs may have constraints (e.g., limited footprint) that limit the ability to install nutrient removal upgrades while maintaining the capacity of the WWTP. In that case, one option a utility may plan for is to split some of the influent flow from the existing constrained WWTP to a new WWTP so the requisite nutrient removal upgrades can be made while maintaining the capacity of the existing constrained WWTP. If building a new WWTP to take some of the influent wastewater is not an option, it limits the options for a utility to upgrade infrastructure to comply with the PSNRP. Another scenario would be the construction of a centralized wastewater or industrial treatment plant to address non-point nitrogen sources failing septic systems or as animal waste.	Ecology should add flexibility as to not preclude new nutrient treatment facilities if those represent the best option for reducing nitrogen loading and to build flexibility to move allocation from the watershed target to the marine point sources, where appropriate.
41	Reference Text: "Marine point sources - Due to the potential large difference between the current nitrogen effluent levels discharged from marine point sources and the effluent levels required to meet the nitrogen targets in this plan, we acknowledge that permittees may need to make large investments in treatment plant infrastructure to add nutrient reduction technologies necessary to meet their WQBEL. Construction of such	King County agrees that it will take time for point sources discharging to the Puget Sound to make necessary upgrades to meet nitrogen loading targets described by the NRP, and based on our preliminary planning and project delivery experience, implementation is likely going to take 30-40 years. This plan proposes a 19-year implementation timeline to meet final WQBELs for all 58 point source dischargers covered by the PSNRP. Setting

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	infrastructure can take many years, and in some cases, decades to complete."	aside the enormous challenges of financing these upgrades, the size and number of projects needed to upgrade all regulated treatment plants exceeds this timeline, given the typical timeline for design and construction and potential limitations in engineering, design, and contractor availability. Further, King County, like other Puget Sound utilities, has extensive capital investments that need to happen before nutrient-related upgrades can occur to meet regulatory obligations and capacity needs and to replace aging infrastructure.
41	Reference Text: "Marine point sources - For those WWTPs covered under the 2022 General Permit, nutrient reduction evaluations and AKART analyses we will receive will include essential information Ecology can use in establishing any compliance schedules and interim loading limits in the next and future phases of the General Permit."	In general, King County supports the concept of phased implementation and using the NRE AKART analyses to inform the process. However, there is considerable complexity in translating the NRE AKART analyses into interim loading limits. AKART should be established on a facility-by-facility basis, considering the unique technological and economic circumstances of each facility. AKART and any interim limits should not be implemented at a facility until appropriate water quality-based limits have been determined for the facility. Facilities should not be in the position of implementing costly AKART controls that may prove to be insufficient or incompatible with future water quality-based limits.
42	Nutrient Credit Trading	King County supports water quality trading and offset approaches as tools that could accelerate nutrient reduction. We support the concept of bubbling loading across our regional plants and trading amongst other dischargers. For these tools to be viable, further technical analysis is needed to explore concepts that would support a robust trading market such as inter-basin transfers and nutrient reductions between non-point and point source

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		dischargers. This would include additional scientific and modeling assessments as well as legal and economic analysis.
44	Reference Text: "Marine point sources - In evaluating the appropriateness of reclaimed water as a nutrient reduction strategy, communities must carefully consider future growth and whether viable uses of the water are available, along with the degree of treatment needed to produce reclaimed water suitable for the use."	King County produces reclaimed water at two of our three regional Puget Sound wastewater plants. We agree that reclaimed water is complementary to nutrient management and can support multiple water management objectives. However, there are many factors that challenge its use a tool for nutrient regulatory compliance, such as market development, short irrigation season, funding for distribution infrastructure, and treatment regulatory uncertainties. We advocate for additional discussion within the region on the role of reclaimed water in nutrient reduction.
45	Reference Text: "Marine point sources - The six tribal facilities and one state-owned facility can rear young salmon in pens from four to six months, while National Ocean and Atmospheric Administration's (NOAA) facility can be operational year-round. The EPA general permit for tribal and federal net pen facilities require all facilities to monitor for DO and conduct benthic sediment surveys. These facilities operate at a small scale and not in a continuous, annual manner."	The statement saying "these facilities operate at a small scale and not in a continuous, annual manner" conflicts with the text stating that the NOAA facility can be operational year-round. Ecology should correct the inconsistency.
46	Has Ecology considered a trading program in watersheds as described for marine point WWTPs?	We believe trading may be useful for achieving larger total reductions and allow some flexibility for smaller jurisdictions to participate.
47	Reference Text: "Watersheds - For watersheds with NPDES permitted point sources, such as municipal WWTPs or industrial facilities, TMDLs may be needed to set wasteload allocations consistent with the TN targets, that will allow the TN targets to be met at the mouth of each watershed."	More information is needed on how Ecology plans to differentiate which jurisdictions are meeting (or are not meeting) reduction criteria when the point of compliance for each contributor appears to be the mouth of the watershed? Even with WLAs for each jurisdiction, many monitoring locations could be needed to demonstrate that jurisdictions are meeting WLA targets.

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	and page 48: "We recognize the challenge of developing nutrient clean-up plans for Puget Sound's watersheds given our existing resource constraints."	King County agrees that the development of water clean-up plans is an immense undertaking. We question whether the proposed implementation schedule is realistic for this work.
48-49	Reference Text: "Watersheds - Note, all future nutrient permit limits will be consistent with the TN targets in this plan and permitted point source work can begin prior to the finalization of watershed water clean-up plans."	Language elsewhere indicates targets could change based on new monitoring and updated watershed modeling. Please clarify if the targets may be updated based on new science and modeling.
49	Municipal Stormwater Permits	Is Ecology planning to expand the SAM status and Trends program to accommodate the statements made in this section? Currently, the SAM efforts focus on small Puget Lowland streams and collect samples once each summer to monitor changes over time within these streams. It would seem that a single annual sample in the summer for TN at SAM sites may not be robust enough data to quantify nutrient reduction trends. Please elaborate on how this data will benefit in a meaningful way or explain how Ecology plans to expand the SAM status and trends program, which is currently bound to its existing QAPP, which only specifies one data point per year per stream.
49	Reference Text: "Watershed - In the meantime, continued implementation of these permits and their required Stormwater Management Programs, will include planning, monitoring, best management practice (BMP) implementation, and mitigating discharges of anthropogenic sources of nutrient pollution."	There is no specific language or requirements related to nutrients in our current Municipal Stormwater NPDES permit. Please clarify if this proposed future changes or reword to reflect the current permit language.
53	Reference Text: Ecology's Puget Sound Nutrient Reduction Grants Program	King County appreciates grant funding to assist with the implementation of nutrient reduction. Additional dedicated funding for nutrient implementation would benefit Puget Sound communities by lowering the financial burden on our ratepayers and accelerating

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		nutrient reduction. Having dedicated funding has been critical to the success in other region's efforts to reduce nutrients, like Long Island Sound and Chesapeake Bay. There needs to be a significant and on-going increase in the amount of state grant funding to be truly impactful for utilities. While we appreciate the $10 million in grant funding, we note that the cost to implement nutrient upgrades will be tens of billions of dollars across Puget Sound communities.
55	Reference Text: Nonpoint and other activities: • United States Department of Agriculture's (USDA) Water and Waste Disposal Guaranteed Land Program • ...	Ecology should move this list of links to the various funding programs to page 54 (i.e., combine this list with the list on page 54) because these links don't have to do with "EPA's WIFIA Funding in Action" and should not be part of the list of projects funded by WIFIA.
56	Reference Text: Nonpoint and other activities: • FSA's CLEAR 30 Program[36] The link and cited web address do not work for this resource.	Ecology should update the link and web address or remove this reference.
57	Figure 10 does not have a year identified for the middle text on the right side of the graphic.	As there is no scale on the year timeline, please update with target for the marine and watershed point source permit reissuance, watershed clean-up plans, and watershed prioritization strategies.
58	Reference Text: "Schedule and Milestones - Assuming all permits are renewed before their five-year expiration date, our goal is for all marine point source permits to be updated with WQBELs by 2031."	This seems unrealistic given the challenging work to determine how to translate the proposed load target to WQBELs and issue permitting by 2031.
58	Reference Text: "Schedule and Milestones - In a future reissuance of the General Permit, we intend to provide a framework for a nutrient credit trading program to incentivize early adoption of nutrient control technologies, while offering a temporary pathway to	King County supports water quality trading and offset approaches as tools that could accelerate nutrient reduction. We support the concept of bubbling loading across our regional plants and trading amongst other dischargers. For these tools to be viable, further technical

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	permit compliance for those facilities that are unable to meet their permit limits in the short-term. Any trading program established may not be permanent but rather a temporary measure to incentivize early adoption and allow time for dischargers to upgrade."	analysis is needed to explore concepts that would support a robust trading market such as inter-basin transfers and nutrient reductions between non-point and point source dischargers. This would include additional scientific and modeling assessments as well as legal and economic analysis. However, we would like to note that the WQBELs may be so low to limit the viability of trading.
58	Reference Text: "Schedule and Milestones - With each reissuance of the marine point source permits, we will be evaluating progress towards achieving TN targets identified in this plan and adjusting permit requirements as needed to achieve both compliance with the permitted WQBELs and targets in this plan by 2050."	King County agrees that it will take time for point sources discharging to the Puget Sound to make necessary upgrades to meet nitrogen loading targets described by the NRP. Unfortunately, we believe the proposed 19-year implementation timeline to meet final WQBELs for all 58 point source dischargers covered by the PSNRP is unlikely to be achievable. We recommend establishing an implementation horizon after the NREs are submitted and Ecology has a better picture of what is viable for utilities across Puget Sound.
58	Reference Text: "Schedule and Milestones - We intend to finish all necessary water clean-up plans in Puget Sound's watersheds by 2048 and have all necessary implementation measures in place to achieve our watershed targets by 2050."	It seems infeasible to complete multiple watershed clean-up plans by 2048 and implement them within 2 years.
58	Reference Text: "Schedule and Milestones - Tackling the more complex water clean-up plans sooner will allow more time for their development and implementation."	Ecology should describe how they plan to tackle the more complex clean-up plan sooner (i.e., how will they identify plans that are more complex, especially if all of the plans aren't scheduled to be complete until 2048).
58	Reference Text: "Schedule and Milestones - Our nonpoint program is already active in many of Puget Sound's watersheds and is supporting implementation of Clean Water Guidance BMPs that are shown to achieve water quality standards."	Ecology should describe how they are currently tracking implementation of nonpoint BMPs and how they are accounting for their reduction in nitrogen compared to the overall watershed targets.
60	Not compatible with commitment from page 11: "We will utilize existing systems to track where	Revise Exec Summary to reflect that only modeling (not field collected nutrient and DO data) will be used to

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	implementation is occurring, then evaluate field collected nutrient and DO data from existing monitoring programs to evaluate the response."	evaluate the effectiveness of nutrient reductions on DO in 2040 and 2053. Also, leave the door open to a newer, better, or suite of models to come along over the next 15-25 years.
60	Reference Text: Table 9 -Measurable milestones along with the relevant TN targets and due date for each milestone. King County anticipates that Ecology will continue to solicit funding for the Puget Sound Nutrient Reduction Grants Program, though this isn't mentioned in Table 9 expect for soliciting funds in 2025 for FY2027.	Ecology should add to Table 9 the additional years for which they will solicit funding requests for the Puget Sound Nutrient Reduction Grants Program.
60	Reference Text: Table 9- Measurable milestones along with the relevant TN targets and due date for each milestone. If watershed clean-up plans to address 60% of the target anthropogenic TN load reductions aren't beginning development until 2040, how does Ecology expect clean-up plans to address the remaining 40% of the target anthropogenic TN load reductions to be developed and implemented within 10 years? This also doesn't account for the need to implement clean-up plans to address the 60% within this 10-year period.	Ecology should revise the timeframes for the measurable milestones to be more realistic with what can actually be implemented, given limited resources.
61	Reference Text: "Schedule and Milestones -[41]Assumes we receive funding in FY25 legislative cycle." Based on page 54, the legislature approved funding for FY 2025-2027.	Ecology should remove this footnote as it is no longer applicable.
62	Reference Text: Table 10 -Ecology nonpoint staff conduct watershed evaluations in four Puget Sound watersheds and report progress in annual reports	Ecology should address how they plan to evaluate and meet N reduction targets for the other 44% of watersheds before 2050 or adjust the proposed timeline to be more realistic.

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	If conducting four watershed evaluations annually, starting in 2026 and ending in 2048, that will include a total of 92 watershed evaluations. However, based on Appendix F, there are ~163 watersheds with nutrient reduction targets. Therefore, Ecology will have only evaluated ~56% of watersheds by the end of this plan.	
63	Reference Text: "Effectiveness Monitoring - Monitoring alongside implementation ensures limited resources are used efficiently and enables timely adjustments to achieve meaningful improvements in water quality."	Given natural variability of DO and the impact of temperature on DO, field monitoring will be difficult to use to measure the impact of human actions on DO. See King County's comments on page 11 and 39 for some recommended actions relating to monitoring and management action assessment.
63	Please clarify in the Effectiveness Monitoring section who will be conducting this work. Ecology? Jurisdiction? A combination of the two?	Clarification requested
63	Reference Text: "Effectiveness Monitoring - Implementation tracking - including both point source implementation via permit reporting requirements and nonpoint source BMP implementation and restoration efforts."	Is this reporting requirement associated with the implementation timeline on page 57? The current Municipal Stormwater permit does not include this language, specifically relating to nutrient reduction. If it is intended for the next permit cycle, please specify the intent in the text.
66	Watershed Nitrogen Loads – freshwater monitoring programs	Please clarify if you are proposing to use surrogate flow data from other stations within the watershed to infer nitrogen loads based on the data collected at existing monitoring sites. This could be problematic if land use is different, as these stations are not all located near-mouth within the watersheds.
66	Watershed Nitrogen Load – freshwater monitoring	Please provide more explanation on how data from these stations correlate for the entire watershed and are representative of the entire area. Do these continuous stations only collect nitrate data? How is Ecology using nitrate as a surrogate for TN and TOC? Please provide explanation of method or provide a citation for the reader.

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66	Watershed Nitrogen Load – freshwater monitoring	Is Ecology comparing the continuous data to nearby stream data or the ambient sampling efforts? Text for both continuous and ambient is used interchangeably and is somewhat confusing to the reader. The same occurs below Table 11. Can you separate these two topics in the discussion for clarity?
66	Fig. 11 illustrates that King and Pierce Counties operate robust water quality monitoring programs, but other counties have not yet made similar investments.	Highlight King and Pierce County programs so they continue to be prioritized for funding and encourage other counties to make similar investments.
68	Reference Text: Table 11- Ecology continuous nitrogen monitoring stations and the proportion of the basin-wide TN watershed inflow targets the stations represent. ... For direct evaluation of the watershed inflow loads in this plan, we recommend the following: Are the watershed TN targets influent targets, as it seems like these targets are watershed outflow targets?	Ecology should clarify whether the watershed TN targets refer to inflow or outflow. If outflow, correct the language used on page 68 and elsewhere in the NRP.
68	Regarding the discussion below Table 11.	Is the goal to extrapolate TN from this variable surrogate data? If so, please clarify. Can future monitoring efforts focus on (or include) TN or nitrate at the ambient stations, as is being monitored at the continuous stations, to harmonize the efforts and make the data relatable?
68	King County uses an advanced suite of models known as the Water Quality Benefits Evaluation (WQBE) toolkit that effectively and (more) accurately estimates nitrogen loads to streams.	Add WQBE as an example of a locally-produced and operated tool that could be used/duplicated by other agencies for this purpose, in addition to or instead of SPARROW.
70	Figure 11 - This statement implies that improvements in DO, resulting from nutrient reductions, will be detectable from measurements at the subset of stations in Figure 11. But this is not likely to be the case, even if the PSNRP is fully successful, because the effect size is small relative to natural and sampling variability.	Acknowledge that the combined impact of nutrient reductions on DO in Puget Sound will not be detectable from environmental monitoring data (direct observations). It will only be 'detectable' in the SSM runs.

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70	Reference Text: "Puget Sound dissolved oxygen - However, some of the smaller bays in the Main and South Sound basins demonstrating noncompliance with the dissolved oxygen standard within the Salish Sea Model are not currently being monitoring (noted by black circles in Figure 12). Collecting long-term ambient dissolved oxygen data in these areas would allow us to track whether dissolved oxygen is improving in these critical areas."	Ecology should outline its plan for collecting DO data in these areas. Additionally, Ecology should conduct an analysis of existing DO data to assess how many years of monitoring post completion of the nitrogen reduction implementation efforts (based on current monitoring programs) would be required to see a statistically significant change in DO levels at every location/depth.
71	Reference Text: "Adaptive Management - Natural systems are complex and dynamic. There is always a degree in uncertainty of predicting how an ecosystem will respond to changes. Therefore, adaptive management, or strategic "trial and error", is a crucial tool for ensuring success of any environmental restoration efforts. … It can also require multiple iterations of adjustments to achieve desired outcomes." While the idea of "trial and error" is great in theory, the practice of "trial" will be a huge investment in resources. Therefore, the room for "error" should be minimal to none, and there should be strong science to support what is outlined in the NRP. If WTTPs are constantly applying adaptive management, the risk for stranded assets or needing to replace assets before they have reached their useful life is high.	Ecology should define and describe the amount of uncertainty associated with the SSM. Ecology should also mention in the Adaptive Management section the added cost that is associated with "multiple iterations of adjustments," which adds more strain to the already expensive approaches needed to meet the nitrogen loading targets.
71	Reference Text: "Adaptive Management - We will use adaptive management when water quality monitoring shows that TN targets are not being met or implementation activities are not achieving the anticipated result. If water quality standards are	Ecology should discuss how equity factors into adaptative management and actions.

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	achieved across all of Puget Sound but the targets are not fully met, the goal of this plan will be considered satisfied."	
71	Reference Text: "Adaptive Management - Step 3b. If the goals and objectives are not achieved, then BMPs and the implementation activities will be modified or new actions identified. The new or modified activities are then applied as in Step 1."	Ecology should also add "publicizing" to Step 3b, so that other entities can learn what isn't working and avoid implementing those actions.
72	Adaptive Management framework – step 3b	In step 3 of the adaptive management section, please include recalibration of the SSM when new data has been collected to check for model drift and to verify the targets created from the previous iteration compare with the actual field data collected.
72	It would be helpful to identify the specific comparisons that will be made to determine whether the plan is on target or off target, and include a timeline for those comparisons. A robust adaptive management plan would include a structured decision-making process and quantifiable, time-bound outcome-based targets for triggering adaptive management decisions.	Outline the highest-priority comparative analyses that would be performed post-2050 using "all readily available" data. Doing so will help ensure collaborators continue to invest in the environmental monitoring required to support those comparisons.
General Comment	This PSNRP does not account for growth or changes since 2014.	Ecology should describe in the PSNRP how it plans to accommodate for population growth and other changes since 2014, which will in turn lead to more nutrients flowing into WWTPs.
Appendix A – page 30	The draft outline for the Nutrient Reduction Plan stated that the following would be included in the NRP, but little detail, if any, is contained in the draft NRP: 5.1.1. Model assumptions used to develop marine and watershed source allocations 5.2. Methods used to determine when dissolved oxygen water quality criteria objectives are met	King County requests that Ecology add discussions for these topics to the NRP.

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	5.3. Baseline assumptions (Reference Condition) used for determining nutrient load capacity and allocations 5.4. Comparison with other coastal nutrient management approaches for modeling 6.5. Margin of safety and allocation for growth 8.1.3. The role of groundwater and local nitrate vulnerability 13. Environmental Justice Requirements and Considerations	
Appendix C.1 and C.2		It would be helpful if Ecology added another column to these tables to show which one of the eight basins the specific waterbody impairment is in.
Appendix E	Appendix E identifies marine point source model inputs under four reduction frameworks in lbs. of total nitrogen (TN) per month. While the reduction frameworks for 8/5/3, 8/3 and 3 are identified as representing effluent concentrations in mg DIN/L, the appendix does not identify the concentration of mg TN/L for each point source and what, if any, organic nitrogen allowances are made for each marine point source input. An additional series of tables with the effective concentrations of mg TN/L for each marine point source load as input into the model would make clear the organic nitrogen allowance. Additionally, given the importance of these load targets into the future, a step-wise description of what data was used for organic nitrogen allowances and how those allowances were calculated for all the facilities is necessary to understand the process used by the modelers. An additional organic nitrogen load allocation or concentration limit could result in the need for treatment above and beyond those required to meet the limits outlined in the NRE and result in treatment	Ecology should include an additional series of tables with effective concentrations in mg TN/L for each marine point source load in Appendix E that describe what, if any, organic nitrogen loads are assumed in the SSM. Ecology should include a description of all the data used to calculate the organic nitrogen loads for each marine point source used in the model and a stepwise description of the calculation methodology used to arrive at these load values. Ecology should indicate whether these loads are a place holder, or whether the intention is to use these load values or concentrations limits in the WLAs.

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	requirements that are unreasonable for a given treatment plant.	
Appendix F	Reference Text: "The following tables represent the Salish Sea Model watershed load inputs used in the selected scenario, Opt2_8. that collectively represent the watershed inflow targets in this plan. All loads are presented in lbs."	Ecology should clarify whether the watershed TN targets refer to inflow or outflow. If outflow, correct the language used in Appendix F. Delete the sentence that says "all loads are presented in lbs" as this isn't specific, and there is a sentence following that states that all loads are in lbs. of TN.
Appendix F	Reference Text: "Table 4 below describes the watershed specific nutrient reduction framework and their respective loads that represent the basis for the watershed targets in this plan."	Ecology should edit this text as there is no Table 4 in Appendix F.
Appendix G.2	Reference Text: "All monitoring stations plotted in Figure 13 of the Puget Sound Nutrient Reduction Plan."	Ecology should correct the figure reference in this sentence to Figure 12.
Appendix G.2	Reference Text: "University of Washington ORCA buoy network (UW-ORCA)[7] Northwest Indian College (NWIC)[8]"	Ecology should ensure that the correct links and web addresses are listed for these two sources since the same web address is listed for both sources.
Appendix H (page 1 and 9)	Reference Text: Pg. 1: "Ecology plans to convene the Committee in 2026 and will provide more information about its development outside of this document." Pg. 9: "Assuming comments received are supportive of continued discussion, Ecology plans to proceed with the formation of a Technical Advisory Committee by determining a topical framework and schedule for the Committee's work."	King County supports the proposed use of Technical Advisory Committee (TAC) and will be actively participating. As stated in our comment letter, we believe there is need for collaboration and regional discussion on a variety of issues to refine the NRP. Topic areas for the TAC, or other committees, include considering WQBELs in context of the Salish Sea Model (SSM), limits of technology, reasonableness of implementation schedules, financial burden on the region and individual communities, and expanded review of ecological outcomes to drive WQBELs.
Appendix H (page 5)	Reference Text: "Ecology is interested in feedback as to preferred options or alternative approaches to translating modeling results into WQBELs."	The most significant challenge with translating the proposed load target based on 2014 flows to effluent limits is how population growth factors into the effluent limits. These approaches and strategies require analysis

Page	Comment	Recommended Action
		and discussions as many of the options and strategies considered in Appendix H drive concentrations to below Ecology's definition of Limit of Technology for TIN or present equity concerns for facilities that grew at different rates or implemented nutrient controls more quickly. This will require robust analysis and discussion among all entities.
Appendix H (page 4)	Reference Text: Option 1	One potential impact of assigning the load allocation in this manner is it does not account for differences in the loading from year-to-year or from growth in the system (since 2014 or into the future). King County estimates that without a factor for growth, the summer limits would be below Ecology's 3 mg/L limit of technology as early as 2030.
Appendix H (page 4)	Reference Text: Option 1	Option 1 generally appears to be the most fair relative to all parties unless Option 2 were to use current **influent** nitrogen loads (this would account for growth at a treatment plant without penalizing those treatment plants that made early nitrogen removal upgrades).
Appendix H (page 4)	Reference Text: Option 2– it is unclear how "current" is defined or whether reallocations would occur.	Ecology should clarify how "current" is defined, e.g., is it some point between 2014 and when load limits are set? Will reallocations occur?
Appendix H (page 4)	Reference Text Option 2	One potential impact of this option is that will advantage or disadvantage dischargers that grew faster or slower than others. It would also penalize facilities that have proactively implemented some nitrogen removal or increased reclaimed water (although basing allocations on **influent** flows or loads could alleviate that concern).
Appendix H (page 5)	Reference Text: Option 3	This option advantages and disadvantages dischargers based on how close they were to their rated capacities in 2014. Therefore, it could benefit facilities that are at a comparatively lower percent of rated flow capacity. It is unclear how WLA would be assigned on a seasonal basis.

Page	Comment	Recommended Action
		The impacts are likely the greatest on small- and medium-size facilities. This approach is silent on future reallocation of loads based on expansion that could re-rate treatment facilities. The advantage or disadvantage to a particular discharger would be hard to predict in nature since it depends where that treatment plant is in their capacity expansion cycle.
Appendix H (page 5)	Reference Text: "Ecology would like input from interested parties on the development of WQBELs for CBOD5."	The 8 mg/L CBOD treatment limit could range from significant to minor, depending on the facility and the averaging period for the CBOD permit limit, with an average annual limit being easier to comply with than a monthly limit. It would also be more impactful if it was load based versus concentration based and more impactful depending upon the selected technology. There needs to be further analysis on the actual impact of CBOD on dissolved oxygen. Ecology has not independently shown the impact of CBOD in the SSM.
Appendix H (page 5)	Reference Text: "Looking forward, Ecology believes TN is the best parameter to use for Puget Sound Nutrient Reduction Plan-related permit limits and monitoring."	Given that the SSM measures in DIN/TIN, the draft NRP would need key revisions to explain the process and assumptions used to translate the model results to TN. If TN will be used for future regulations for wastewater treatment facilities, an organic nitrogen allowance is needed to account for organic nitrogen that cannot be removed or does not have biological impacts. The allowance may vary depending on facility-specific treatment technologies and would require additional wastewater sampling or using conservative values from the literature to ensure that limits are not set below the limit of technology.
Appendix H (page 6)	Reference Text: "Ecology believes the best approach is to use mass-based loading limits unless a permittee specifically requests concentration-based limits.	Since concentration was used to determine loading in SSM to minimize days of impairments, we advocate that limits should be concentration based. True concentration-based limits are typically technology-based and do not change

Page	Comment	Recommended Action
	Ecology seeks feedback on the appropriate flow statistic to use as a limit if a permittee requests a concentration-based effluent limit in lieu of a loading."	with changing flows. A concentration-only limit provides more flexibility in achieving limits as it does not change with increasing flows or loads to a facility. However, Ecology's suggested methods for determining concentration-based limits appear not to be true concentration-based limits but load-based limits. These limits will likely decrease between 2014 and the year the limit is set as flows have grown due to population growth, resulting in lower effluent concentration requirements. The two approaches of using a mass-based loading limit and TN instead of TIN (if no organic nitrogen allowance is afforded) would have compounding impacts on treatment requirements for a discharger. This could potentially result in a treatment plant being required to produce an effluent with a negative TIN concentration, which is not feasible.
Appendix H (page 6)	Reference Text: "Ecology would like feedback on the preferred averaging period selected for final WQBELs."	A seasonal averaging period would be preferred only if it would allow for a higher or no-load limit during the winter period for a discharger such that a lower level of treatment and less required tank volume would be required for the winter period.
Appendix H (page 7)	Reference Text: Compliance Schedules	Compliance schedules should consider financial burden and availability of design and contractor resources.
Appendix H (page 7)	Reference Text: Phased implementation Limits	In general, we support the concept of phased implementation and using the NRE AKART analyses to inform the process. Phased implementation should be on a facility-by-facility basis to take into account specific site constraints, unique implementation timelines of upgrading existing treatment configurations to different nitrogen removal technologies, and relative impact to desired biological outcomes.

Page	Comment	Recommended Action
		Phases should build on, not change, targets between phases. There are limited funds for the phased implementation timeline, which compounds affordability considerations. In addition, utilities have other financial commitments that must be met from a regulatory and capacity standpoint.
Appendix H page 8	Reference Text: Interim Limits	Ecology should clarify on how NREs would be used to inform interim limits and use of an interim technology-based treatment standard. How would an AKART approach be used to set interim limits with varying AKART options for each different discharger? Ecology should not implement AKART and any interim limits at a facility until appropriate water quality-based limits have been determined for the facility. Facilities should not be required to implement costly AKART controls that may prove to be insufficient or incompatible with future water quality-based limits.

Minor Formatting/Grammatical Errors		
9	Reference Text: Glossary, Acronyms, and Abbreviations - Target(s), TN Target(s), Nitrogen Target(s): The maximum amount of total nitrogen loading (lbs. TN/yr) to Puget Sound needed to meet dissolved oxygen water quality standards Puget Sound.	Missing the word "in" or "of" between "standards" and "Puget Sound."
10	Reference Text: Glossary, Acronyms, and Abbreviations - WWTP: Wastewater treatment plan	"Plan" should be corrected to "plant."
11	Reference Text: Executive Summary - Establishing total nitrogen effluent limits as WQBELs for wastewater	"Wastewater treatment plans" should be corrected to "wastewater treatment plants."

	treatment plans and industrial facilities discharging to Puget Sound by 2031	
41	Reference Text: "Marine Point Sources - No new WWTP or industrial discharge into Puget Sound will be permitted unless it can be demonstrated targets in Table 5 will be met. "	Please correct the grammatical error in this sentence to: "No new WWTP or industrial discharge into Puget Sound will be permitted unless it can be demonstrated that targets in Table 5 will be met."
43	Reference Text: "Marine Point Sources - determining baselines (nitrogen WQBEL and therefore threshold which a facility can sell credits)"	Please correct the grammar in this bullet to something like: "determining baselines (nitrogen WQBEL and therefore can sell credits).
45	Reference Text: "Marine Point Sources - In total, eight non-commercial s net pen facilities are currently operating."	Please correct the sentence to: In total, eight non-commercial net pen facilities are currently operating.
45	Reference Text: "Marine Point Sources - The nutrients from these non-commercial, small-scale and seasonal operations are de minimus and the permits will provide continued assurance."	Correct spelling of "de minimus" to "de minimis."
46	Reference Text: "Watersheds - The following section describes these three primary elements that will be the foundation for developing our prioritization strategies and achieving the watershed targets."	It isn't clear what "these three primary elements" are.
47	Reference Text: "Watersheds - Work to address nutrients may have already started in some of these watershed and Ecology encourages… "	Correct "watershed" to "watersheds."
50	Reference Text: "Watersheds - This statute also makes it unlawful for any person to contribute pollution to waters of the state and authorizes Ecology to issue enforcement orders to address sites that not only pollute state waters, as well as any site that has substantial potential to pollute state waters. "	Correct the grammar in this sentence to something like: This statute also makes it unlawful for any person to contribute pollution to waters of the state and authorizes Ecology to issue enforcement orders to address sites that pollute state waters, as well as any site that has substantial potential to pollute state waters.
52	Reference Text: "Watersheds - The recently released USGS SPARROW mapping tool may be useful tool for nonpoint prioritization efforts. "	Correct the grammar in this sentence to something like: The recently released USGS SPARROW mapping tool may be **a** useful tool for nonpoint prioritization efforts.
55	Reference Text: "Nonpoint and other activities - Multiple improvement projects at their three regional wastewater treatment plants"	It is unclear who "their" is. Please correct to: Multiple improvement projects at King County's three regional wastewater treatment plants.

61	Reference Text: "Schedule and Milestones - [42] Assume we have discharger interest and broader partner support in a water quality trading program."	Correct "assume" to "assumes."
65	Reference Text: "Implementation tracking - We should prioritize monitoring implementation of projects that are consistent with our Clean Water Guidance and that will have direct impacts on nitrogen loads and as a result, and downstream dissolved oxygen levels in Puget Sound."	Correct grammar to: We should prioritize monitoring implementation of projects that are consistent with our Clean Water Guidance and that will have direct impacts on nitrogen loads, and as a result, on downstream dissolved oxygen levels in Puget Sound.
Appendix A	Pages 39 and 40 are duplicative.	Remove page 40 of Appendix A.

Appendix B:

King County's Detailed Comments on Puget Sound Nutrient Source Reduction Project Volume 2:

Model Updates and Optimization Scenarios, Phase 2

Page	Reference Text	Comment	Recommended Action
9	p 9 abstract - The total estimated noncompliance area in 2014 is 467 km2, excluding certain areas.	It is incomplete to express noncompliance in terms of area when there are also vertical considerations and time considerations.	Recommend instead describing the percent of non-compliance modeled calculated as the sum of the number of cells not in compliance per time step divided by the total sum of the number of cell/timestep combinations.
10	"Multiple physical, chemical, and biological factors affect DO levels in Puget Sound. These include…"	The list implies a rank-ordering of their importance.	Re-order the list of factors from increasing to decreasing importance
11	"The model demonstrates the level of performance needed to determine the impact of hypothetical reductions in human loads from watersheds and wastewater treatment plants."	Framed as statement of fact rather than the judgement. Also, not clear that there was any way for the model to fail.	Re-frame as a judgement or a determination by Ecology.
14	Table ES-1 & ES-2	Analyses of the 10 Opt2 WWTP frameworks are framed as a sort of alternatives analysis. However, the anthropogenic load reductions are nearly identical among scenarios (differing by <1,000,000 kg/yr); no scenarios evaluate percent reduction, noncompliant area or days, or max magnitude of DO noncompliance for anthropogenic loads	Evaluate 3-5 additional and distinct scenarios that reflect actions to reduce anthropogenic loads to intermediate levels between 21,300,000 kg and 7,500,000 kg/yr. If the present analysis includes only 'status quo' and 10 'best-case' scenarios, this means adding scenarios that reflect approaches that characterize worst-case,

Page	Reference Text	Comment	Recommended Action
		between existing (21,300,000 kg/yr and 7,500,000 kg/yr). Accordingly, the alternatives are not substantively different, reducing the decision to a) no action or b) reducing loads to 6,570,000—7,500,000 kg/yr.	constrained, most likely, and innovative (or similar) approaches.
19	Table ES-2	Report states 80,279 days of noncompliance for existing conditions in 2014	Table caption implies that the denominator for this statistic is a single year, which must be incorrect. Clarify how one year of existing conditions could produce over 80k days of noncompliance.
23	"…this report and its appendices also contain details about recently updated model input files, reference condition scenario, updates to a newer model version at the same intermediate scale/spatial resolution as before, as well as a comprehensive model evaluation and other related and relevant results."	These model runs did not use the high spatial resolution version of the SSM (114,590 nodes and 208,452 triangular elements), which has stated improved performance for modeling biogeochemical processes. As this analysis used a volume-weighted average of all grid cells that fit into a 303(d) assessment unit, the higher resolution model would work here, with likely better results.	Add a statement regarding why they didn't use or at least assess the high-spatial resolution model. Computation time is an insufficient answer if they did not evaluate performance of the high res model.
31	Reference conditions for each of these years represent nutrient inputs from watershed and marine point sources estimated in the absence of local and regional anthropogenic influence.	It is unclear how reference conditions were calculated, and whether these values reflect naturally elevated nitrogen concentrations in Puget Lowland soils and groundwater, which can be elevated even in the absence of anthropogenic influence. Applying a uniform "natural background" across the region may result in underestimating the	Recommend clarifying whether regional variation in natural nitrogen conditions—particularly in the Puget Lowlands—was accounted for when defining reference watershed concentrations and specifying how reference conditions were determined.

Page	Reference Text	Comment	Recommended Action
		natural baseline in lowland basins and overstating the anthropogenic load. For example, Green River reference conditions were shown at <0.05 mg/L (Appendix D, pg 360). These levels are lower than the 25th percentile of reference site data used in the SAM status and trends study (0.459 mg/L; DeGasperi et al, 2018) and NAWQA reference site values (Embrey and Inkpen, 1998).	
32	"…interannual differences in watershed loads are primarily driven by flow magnitudes."	Unclear whether this is a scientific fact or simply a function of how the watershed loads are modeled	Add a statement clarifying whether this finding is an artifact of how the model works or is a scientific statement of fact.
65	The data are provided with a disclaimer that states that the data have been automatically processed and not validated, so the data are preliminary. Our SSM applications QAPP (McCarthy et al. 2018) precludes us from using unvalidated or preliminary data in a quantitative sense, but we can use it for qualitative comparisons.	Data used from King County CTD profiles listed in Appendix D are very likely the non-QC'd version, as they list of green2 site as their source instead of contacting KC directly. Technically this would preclude this data from use in a quantitative review by their own QAPP. Page 68 implies use of KC data for quantitative review.	Contact MarineWQ@kingcounty.gov for QC'd data, and change the reference to the green2 website to that email address.
66	"Predicted temperature was about one degree Celsius higher than observed at Twanoh during that period, which can result from the model overshooting vertical	At constant salinity, this degree of temperature error could account for over a 0.1 – 0.15 mg/L decrease in dissolved oxygen saturation and may result in noncompliance resulting from T error.	Check how the SSM incorporates T and S for calculating dissolved oxygen saturation, and asses what the impacts T and S error could have on DO compliance.

Page	Reference Text	Comment	Recommended Action
	mixing in mid-September and allowing warmer water and higher DO concentrations from an upper layer to mix with bottom waters sooner than when DO levels started increasing towards the end of October."		
96	At most locations and times, DeltaDO_Algal (shown in green) is negative, signifying that respiration overtakes algal DO production in the two bottom layers.	Measured chlorophyll is typically low (but not zero) at the bottom depths in CTD profiles at West Point, though algal respiration constitutes a significant fraction of overall DO consumption in the modeled results.	Add note on chl concentration at the bottom two layers for comparison to observed values. While we don't have observed algal respiration data, we can estimate accuracy based on the chl concentration at the bottom layers.
83-84 (Appendix B)	"As in other sections of the report and Appendices, "anthropogenic" refers to local and regional human loads or influence."	How are anthropogenic loads estimated from the total nitrogen (TN) watershed loads? Is any groundwater/baseflow included in the anthropogenic loads?	Recommend providing more detail on what is included in the anthropogenic loads. Knowing how these loads are defined will be important for planning interventions to reduce the load.
84 (Appendix B)	Figure B2-1	Modeling done as part of our Water Quality Benefits Evaluation Toolkit for King County watersheds estimates TN loads to be about half what is estimated by Salish Sea model.	Recommend an ensemble approach to modeling watershed estimates to better understand variability of different projections with a goal to reduce uncertainties and discrepancies in the data

TECHNICAL MEMORANDUM

Date: October 4, 2024

To: Carly Greyell, King County Water and Land Resources Division
Jim Simmonds, King County Wastewater Treatment Division

From: Olivia Wright, Herrera Environmental Consultants, Inc
John Lenth, Herrera Environmental Consultants, Inc.

Subject: WQBE Phase 3 Water Quality Performance Parameter Data Compilation (Appendix D to 439-TM1)

Contents

Attachment

Tables

Introduction

The King County Wastewater Treatment Division (WTD) is developing the Water Quality Benefits Evaluation (WQBE) toolkit to inform King County (County) decision-making processes for selecting cost-effective water quality investments, reducing pollutant load and improving ecological and human health outcomes. The WQBE Toolkit will include a set of computational models:

- Integrated pollutant loading models, which estimate pollutant loads for major King County waterbodies taking into account major pollutant pathways and sources. Included in the suite of integrated pollutant loading models is a watershed model for estimating runoff volumes and pollutant loads that are delivered via stormwater and baseflow.
- System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) models, which identify cost-effective combinations of potential water quality improvement investments for reduction of pollutant loads or stormwater volumes.
- Qualitative causal models, which define relationships between potential water quality projects and programs and five ecological/human health endpoints (southern resident orca population trends, Chinook salmon population trends, toxics in fish, toxics and pathogens in shellfish, and algal toxins and pathogens at swimming beaches).

The WQBE Toolkit provides information that will be used in planning and prioritization of water quality investments. However, it is not the only information that informs these decisions. These efforts will also consider information not provided by the WQBE Toolkit, including how well different actions would advance equity and social justice, meet regulatory requirements, impact the cost of wastewater rates, and reflect other regional priorities (e.g., sustainability, community well-being, and more).

Part of this effort has involved the development of model inputs for “Actions” composed of structural or nonstructural stormwater controls that improve water quality and/or provide flow control. These Actions provide the unit building blocks (or “unit Actions”) that are aggregated and combined to develop "Programs,” or groups of Actions that can be implemented to achieve a stormwater management target over a broad geographic area. SUSTAIN models are then developed for each Program to evaluate cost effectiveness combinations of Actions, or “Packages,” for improving water quality or providing flow control.

The WQBE Toolkit is being developed in three phases over a period extending from 2020 through 2024.

- Phase 1 (2020): Assumptions for a preliminary set of nineteen Actions and three Programs focused on improving water quality were developed to be modeled with the WQBE Toolkit.
- Phase 2 (2021-2022): Preliminary Actions and Programs from Phase 1 were refined to improve their representation in SUSTAIN (Herrera 2022a). The three water quality Programs from Phase 1 were subsequently modeled with SUSTAIN (Paradigm and Herrera 2022).

- **Phase 3 (2023-2024)**: An additional five Actions and four Programs focused on providing flow control were developed and the Phase 2 Action costs were refined using a simplified approach that allows for more direct comparison to similar planning level cost estimates in the region.

This memorandum documents the technical basis for pollutant removal performance parameter (performance parameter) data for the Actions developed in Phase 2 and Phase 3. It begins with a description of the methods that were used to compile and review these data. It then documents the approach used to fill gaps where existing data were not available for specific combinations of Actions and pollutants. Finally, the performance parameter data that are recommended as input for SUSTAIN models and included in the Action Fact Sheets are summarized.

Methodology

The Actions in the WQBE toolkit were developed in two Phases. The following Actions were developed in Phase 2.

- Bioretention
- Raingarden
- Bioretention planter
- Bioswale
- Media Filter Drain
- Drywell
- Deep underground injection control (UIC) well
- Permeable pavement
- Depaving
- Detention vault
- Detention pond
- Infiltration vault
- Infiltration pond
- Cistern
- Stormwater treatment wetland
- Wetpond
- Wetvault
- High rate underground filter system (underground filter system)

- Regional vegetated media filtration stormwater facility [Stormwater park (water quality treatment)]
- The following Actions were developed in Phase 3:
- Sports field and park detention
- Compost amendment
- Blue roof
- Reforest High Density Development
- Reforest Pervious Area

See Appendix B and Appendix C of Herrera (2024) for the design details of the Actions developed in Phase 2 and Phase 3, respectively.

The SUSTAIN model simulates Action performance through the following three treatment pathways:

- Untreated bypass. Any water that overflows an Action or exceeds the capacity of an Action results in bypass. This water receives no treatment and retains the influent concentration.
- Retention, detention and filtration. Water that receives treatment through retention, detention and filtration that also discharges through a pipe to receiving waters is assigned a percent removal down to a minimum effluent concentration, or irreducible concentration. This reduction is applied to the water discharging through an orifice or an underdrain.
- Infiltration to groundwater. Runoff that infiltrates to groundwater is lost from SUSTAIN, the surface water model. SUSTAIN model results can be put back into the watershed model where the increased volume from infiltration to subsurface flow and groundwater can be assigned a pollutant concentration.

This section presents the methods used to compile and review the performance parameter data for each Action needed to model their performance using the SUSTAIN model. Also discussed are methods used to fill gaps when no data could be found for an Action and pollutant combination.

Data Compilation

The Actions were screened and categorized into one of four groups to determine if performance parameter data would be needed to support SUSTAIN model development:

1. Actions that are expected to provide negligible water quality benefit. Actions in this category include:
    - Cistern
    - Blue roof

2. Actions that will not require compilation of performance parameter data for representation in SUSTAIN models. Actions in this category include:
   - Depaving
   - Reforest high density development
   - Reforest pervious area
3. Actions that provide pollutant removal through infiltration. All water that infiltrates is lost from the SUSTAIN model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Actions in this category include:
   - Raingarden
   - Drywell
   - Deep UIC well
   - Permeable pavement
   - Infiltration vault
   - Infiltration pond
   - Compost amendment
4. Actions that provide treatment via a combination of unit processes (e.g., filtration, sedimentation, sorption, etc.) and have the potential for a direct discharge to a receiving water via an outlet or underdrain pipe; hence, the associated influent and effluent pollutants will be included in the surface water model. Actions in this category include:
   - Bioretention
   - Bioretention planter
   - Bioswale
   - Media filter drain
   - Stormwater treatment wetland
   - Detention vault
   - Detention pond
   - Wetpond
   - Wetvault
   - Underground filter system
   - Stormwater park (water quality treatment)
   - Sports field and park detention

Attachment A presents a matrix that documents the results from this screening process with explanations for why Actions were categorized in specific groups.

No performance parameter data are required for Actions categorized in the first, second, and third groups based on their representation in the SUSTAIN models. Performance parameter data are required for Actions categorized in the fourth group to allow their representation in these models in one of two ways depending on their physical configuration:

- For Actions with an underdrain, the influent flow concentration is assigned a percent removal and an irreducible concentration for each pollutant.
- Water that flows through a pond or vault outlet is assigned a percent removal to the influent flow concentration and an irreducible concentration for each pollutant.

For Actions falling in category 4, Herrera (2022b) performed a literature review for the following suite of pollutants for the WQBE Toolkit:

- Total copper
- Dissolved copper
- Total zinc
- Dissolved zinc
- Total phosphorus
- Total nitrogen
- Total suspended solids (TSS)
- Total polychlorinated biphenyls (total PCB)
- Total polybrominated diphenyl ethers (total PBDE)
- Total polycyclic aromatic hydrocarbons (total PAH)
- Bis(2-ethylhexyl) phthalate (BEHP)
- Fecal Coliform

This literature review specifically focused on obtaining measured percent removal and effluent concentration (used as a surrogate for irreducible concentration) data for each Action using the following stepwise process:

- The International Stormwater Best Management Practices Database (ISBMPD) was queried on May 13, 2020 (ISBMPD 2019) to obtain all available influent and effluent data for each Action and pollutant combination. Because the ISBMPD is considered a highly consistent and complete source for these data, results from this query were prioritized in the compilation of performance parameter data for each Action. If no data were identified for a specific Action and pollutant combination through this query, the following additional step was performed.

- Additional sources for performance parameter data were identified using online literature search engines (Web of Science, UW library, internet searches) and knowledge of local/regional studies. These sources included peer reviewed papers, consultant reports, white papers, and agency reports. The additional data sources identified through this process are documented in Attachment A for specific Action and pollutant combinations where relevant.

In all cases, the following criteria were used to guide the compilation of performance parameter data during the literature review:

- Data must represent the performance of each Action individually (i.e., not in a treatment train).
- Data from both laboratory and field studies were included in the review.
- Data ideally consisted of influent and effluent concentrations from individual sampling events.

The data obtained from this literature review were subsequently compiled in a database for additional processing. Influent and effluent concentration data from individual sampling events were specifically processed as follows:

1. Influent and effluent concentration data from individual sampling events were excluded from subsequent analysis if the influent concentration was below the applicable reporting limit for the pollutant. These data were excluded because they cannot provide a meaningful assessment of treatment performance.
2. For each Action and pollutant combination, the influent and effluent concentration data from individual sampling events were analyzed to compute the median percent removal to represent the typical performance of an Action. The 25th percentile effluent concentration was calculated to represent the irreducible concentration for each Action and pollutant combination. In these computations, the reporting limit was used when the effluent concentration was below the applicable reporting limit for the pollutant. This resulted in a conservative estimate of performance in relation to using other substitution methods (e.g., 1/2 the reporting limit) in these computations.

The number of sampling events with influent and effluent concentration data for these computations is documented in Table 1 for each Action and pollutant combination; this table also identifies where significant data gaps exist for these combinations. The following section describes the process that was used to fill these data gaps where feasible.

Table 1. Number of Sampling Events with Influent and Effluent Concentration Data for each Action and Pollutant Combination.

Parameter	Bioretention/ Bioretention Planter[a]	Bioswale	Media Filter Drain[b]	Stormwater Treatment Wetland	Detention Pond	Detention Vault	Wetpond	Wetvault	Under Ground Filter Systems/Stormwater Park[c]	Sports Field and Park Detention
Copper, Dissolved	30	139	27	51	179	NF	287	NF	39	NF
Copper, Total	28	243	27	270	249	NF	712	NF	49	NF
BEHP	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Fecal Coliform	15	84	NF	82	145	NF	163	NF	3	NF
Nitrogen, Total	10	204	NF	539	153	NF	533	NF	38	NF
PBDE	NF	NF	NF	NF	NF	1	NF	NF	NF	NF
Total PAHs	15	NF	NF	18	NF	6	NF	NF	NF	NF
Total PCBs	NF	NF	NF	15	NF	NF	NF	NF	4	NF
Total Phosphorus	44	364	39	714	414	NF	911	NF	109	NF
Total Suspended Solids	14	377	39	632	432	NF	967	NF	107	NF
Zinc, Dissolved	29	132	39	81	128	NF	238	NF	39	NF
Zinc, Total	29	281	39	327	269	NF	778	NF	54	NF

[a] Bioretention and bioretention planters are assumed to have equivalent performance (see assumptions in Attachment A).

[b] Media filter drain data Includes samples with unpaired influent and effluent concentrations from WSDOT (2013). Median percent removal was calculated for paired data only. 13 paired influent and effluent concentration data were available for total copper and dissolved copper, and 25 paired influent and effluent concentration data were available for total phosphorus, total suspended solids, total zinc, and dissolved zinc.

[c] Underground filter systems and stormwater parks (water quality treatment) are assumed to have equivalent performance (see assumptions in Attachment A).

NF = No data found

Data Gaps

This section describes the processes used to fill data gaps when performance parameter data were not identified through the literature review described in the previous section for a given Action and pollutant combination. These processes involved filling data gaps based on data obtained from surrogate Actions or surrogate pollutants.

Surrogate Actions

Where feasible, data gaps for specific Action and pollutant combinations were filled based on data obtained from surrogate Actions that are expected to provide equivalent treatment based on their unit processes (i.e., pollutant removal mechanisms). The surrogate Actions that were used to fill data gaps were discussed with King County and are presented below.

Detention Pond, Detention Vault, and Sports Field and Park Detention: Sedimentation is the primary unit process for pollutant removal in a detention pond. The ISBMPD contains a substantial amount of data for this Action, but data were unavailable for detention vaults and sports field and park detention, which also use sedimentation as their primary unit process for pollutant removal and have as similar structural geometry to detention ponds. Therefore, detention pond performance parameter data obtained from the ISBMPD for the following pollutants were also used for detention vaults and stormwater field and park detention:

- Total copper
- Dissolved copper
- Total zinc
- Dissolved zinc
- Total phosphorus
- Total nitrogen
- TSS

It is likely that the performance of detention vaults and sports field and park detention may be overestimated based on this approach due to these Actions lacking all of the unit processes present in a detention pond.

Similarly, performance parameter data for total PBDEs and total PAHs were summarized in Sebastian et al. (2014) for detention vaults but not detention ponds or sport fields and parks detention. Hence, these data were also used for detention ponds and sports fields and parks detention.

Wetpond and Wetvault: The primary unit processes for pollutant removal in a wetpond are sedimentation and biological uptake. Biological uptake is only an important unit process for those wetponds with abundant vegetation in the littoral zone. Many ponds lack this biologically active area and rely primarily on sedimentation for treatment; this makes them similar to wetvaults. Wetpond performance parameter data obtained from the ISBMPD for the following pollutants were also used for wetvaults:

- Total copper
- Dissolved copper
- Total zinc
- Dissolved zinc
- Total phosphorus
- Total nitrogen
- TSS
- Fecal coliform bacteria

It is likely that the performance of wetvaults may be overestimated based on this approach due to wetvaults lacking all of the unit processes present in a wetpond.

Surrogate Parameters

As Table 1 demonstrates, performance parameter data were identified for most of the Actions through the literature review described above for TSS, most nutrients, and metals. However, data were not identified through this effort for most of the following organic pollutants:

- Total PCBs
- Total PAHs
- Total PBDE
- BEHP

In addition, performance parameter data were also not identified for some of the following additional pollutants:

- Total nitrogen
- Fecal coliform bacteria.

The sections below describe the methods used to fill these data gaps where possible.

Organic Chemicals

Because the organic pollutants identified above are all strongly associated with suspended solids in stormwater due to their hydrophobic properties (Schueler and Youngk 2015), TSS was considered as a suitable surrogate for estimating their removal via treatment with the various Actions. Table 2 summarizes results from research on the affinity of the organic pollutants identified above for sediments. As is apparent, the fraction of organic pollutants associated with suspended sediments ranges from 78 to 86 percent. This implies that the removal of a large percentage of suspended sediment from stormwater by an Action will also result in the effective removal of these organic chemicals.

Given this consideration, the results in Table 2 were used to develop equations for estimating effluent organic pollutant concentrations (total PCBs, total PAHs, total PBDEs and BEHP) based on the effluent TSS concentrations obtained from the literature review described above. Specifically, the 25th percentile effluent TSS concentration (in mg/L) for each Action was multiplied by the estimated concentration of the organic pollutant in the associated sediment from Table 2. This resulted in an estimate of the organic chemical associated with the TSS. However, not all the organic pollutant will be associated with the sediment, a smaller fraction will also be in solution. Using data from Table 2 that quantifies the partitioning of the organic pollutant between the solid and aqueous phase in stormwater, the following correction factor was therefore applied to derive a final estimate of the effluent organic pollutant concentration from the Action:

RatioTD = 1 + (1- % in Sed/100). The % in Sed values are derived from Table 2.

The resultant equations are as follows:

Action effluent total PCB concentration (pg/L) =

$$\mathrm{TSS}\left(\frac{\mathrm{mg}}{\mathrm{L}}\right) \times \mathrm{Sed_C} \times \mathrm{Ratio_{TD}}$$

Where:

$\mathrm{Sed_C} =$ 21.8 ug/kg. The estimated total PCB concentration in the suspended solids (Table 2)

$\mathrm{Ratio_{TD}} = 1.22$. The ratio of total PCB associated with the liquid versus the solid phase.

Action effluent total PAH concentration (µg/L) =

$$\mathrm{TSS}\left(\frac{\mathrm{mg}}{\mathrm{L}}\right) \times \mathrm{Sed_C} \times \mathrm{Ratio_{TD}}$$

Where:

$\mathrm{Sed_C} =$ 108 ug/kg. The estimated total PAH concentration in the suspended solids (Table 2)

$\mathrm{Ratio_{TD}} = 1.15 \times 10^{-6}$. The ratio of total PAH associated with the liquid versus the solid phase, with unit adjustment.

Action effluent PBDE concentration (ng/L) =

$$\text{TSS}\left(\frac{\text{mg}}{\text{L}}\right) \times \text{Sed}_{\text{C}} \times \text{Ratio}_{\text{TD}}$$

Where:

$\text{Sed}_{\text{C}} =$ 2.2 ug/kg. The estimated PBDE concentration in the suspended solids (Table 2)

$\text{Ratio}_{\text{TD}} = 1.14 \times 10^{-3}$. The ratio of PBDE associated with the liquid versus the solid phase, with unit adjustment.

Action effluent BEHP concentration (µg/L) =

$$\text{TSS}\left(\frac{\text{mg}}{\text{L}}\right) \times \text{Sed}_{\text{C}} \times \text{Ratio}_{\text{TD}}$$

Where:

$\text{Sed}_{\text{C}} =$ 2,743 ug/kg. The estimated BEHP concentration in the suspended solids (Table 2)

$\text{Ratio}_{\text{TD}} = 1.19 \times 10^{-6}$. The ratio of BEHP associated with the liquid versus the solid phase, with unit adjustment.

Table 2. Organic Chemical Associations with Suspended Solids.

Study	Source	Total PCBs (ug/kg)[a]	Total PCBs % in Sed[b]	Total PAHs (ug/kg)	Total PAHs % in Sed	PBDE (ug/kg)	PBDE % in Sed	BEHP (ug/kg)	BEHP % in Sed
Ecology (2009)	Lower Duwamish stormwater	14.5	–	143.5	–	–	–	–	–
CSN (2015)	Norway sediment traps (PCB), Wisconsin stormwater suspended sediment (PAH), France urban and river sediment (PBDE and BEHP)	29	–	72.85	–	2.2	–	1,230	–
Ko and Baker (2004)	Major tributaries to Chesapeake Bay	–	75	–	80	–	–	–	–
Bressy et al. (2012)	Paris storm drains	–	85		90	–	–	–	–
ZWW (2017)	Seattle catch basins	–	–	–	–	–	–	2,000	–
Zgheib et al. (2011)	Paris storm drains	–	–	–	–	–	–	5,000	81
King County (2013)	Storm and stream discharging to Lake Washington	–	73.7	–	–	–	85.5	–	–
Average		**21.8**	**78**	**108**	**85**	**2.2**	**86**	**2,743**	**81**

[a] ug/kg columns indicate the concentration of the organic chemical in collected sediment (typically from sediment traps or catch basin sumps).

[b] % in Sed = the portion of the organic chemical associated with suspended solids in collected water samples.

Percent removal of the organic pollutants via treatment with the Actions was estimated based on research by Schueler and Youngk (2015) that established simple, relative relationships between TSS removal using stormwater treatment best management practices and the removal of various pollutants. This research established these specific relationships for TSS and the organic pollutants:

- Total PCB removal = TSS removal
- Total PAH removal > TSS removal
- PBDE removal < TSS removal
- BEHP removal < TSS removal

Based on these relationships, total PCB and total PAH percent removal was assumed to be equivalent to the TSS percent removal identified for each Action through the literature review. Percent removal for PBDE and BEHP was reduced relative to the TSS percent removal based on the partitioning values from Table 3 as follows:

- PBDE removal = TSS removal * 0.86
- BEHP removal = TSS removal * 0.81

These equations assume that PBDE and BEHP in the aqueous phase act conservatively as the Action treats the stormwater. While this is an oversimplification, the resultant values from these equations are considered acceptable given the lack of data directly related to these pollutants.

Total Nitrogen and Fecal Coliform

TSS is not strongly related to total nitrogen and fecal coliform bacteria in stormwater; therefore, TSS was not considered a suitable surrogate for estimating effluent concentrations and percent removal of these pollutants via treatment with the Actions. Other pollutants were also not considered suitable for this purpose. Therefore, data gap still exists in the performance parameter data for the following combinations of Actions and pollutants:

- Total nitrogen treatment with the media filter drain.
- Fecal coliform bacteria treatment with the media filter drain, underground filter system, and stormwater park (water quality treatment).

Summary of Compiled Performance Parameter Data

Tables 3 through 12 in this section document the performance parameter data compiled for each Action and pollutant combination through the methods described above. These data will be used as SUSTAIN model input to estimate percent reductions and effluent concentrations for Actions that will be evaluated in specific Programs with the WQBE toolkit. During future phases, the performance parameter data for this set of Actions may be updated and refined and data for new Actions may be added.

Table 3. Bioretention/Bioretention Planter Performance Parameter Data.

Target Pollutants	Median Percent Removal[a,b]	25th Percentile Effluent Concentration[a,b]
Total Copper	62.3%	7.1 µg/L
Dissolved Copper	57.6%	4.6 µg/L
Total Zinc	91.0%	5.0 µg/L
Dissolved Zinc	86.2%	<4.0 µg/L[c]
Total Phosphorus	54.9%	0.024 mg/L
Total Nitrogen	51.3%	1.2 mg/L
Total Suspended Solids	78.0%	13.5 mg/L
Total PCBs	78.0%	358 pg/L
Total PBDEs	67.1%	0.034 ng/L
Total PAHs	95.1%	<0.01 µg/L[c]
BEHP	63.2%	0.044 µg/L
Fecal Coliform	61.5%	31.5 CFU/100 mL

[a] Bioretention and bioretention planters are assumed to have equivalent performance (see assumptions in Attachment A).

[b] Performance based on the low phosphorus alternative bioretention soil media with 70% sand/20% coconut coir/10% high carbon wood ash.

[c] Method detection limit.

Note: Grey shaded values were derived from TSS translator equations discussed in the Methods section.

Table 4. Bioswale Performance Parameter Data.

Target Pollutants	Median Percent Removal	25th Percentile Effluent Concentration
Total Copper	33.9%	4.8 µg/L
Dissolved Copper	8.99%	3.6 µg/L
Total Zinc	33.3%	20.0 µg/L
Dissolved Zinc	29.0%	15.0 µg/L
Total Phosphorus	-37.2%	0.100 mg/L
Total Nitrogen	-7.63%	0.562 mg/L
Total Suspended Solids	27.9%	10.0 mg/L
Total PCBs	27.9%	265 pg/L
Total PBDEs	24.0%	0.025 ng/L
Total PAHs	27.9%	0.0012 µg/L
BEHP	23.0%	0.033 µg/L
Fecal Coliform	6.25%	1,775 CFU/100 mL

Note: Grey shaded values were derived from TSS translator equations discussed in the Methods section.

Table 5. Media Filter Drain Performance Parameter Data.

Target Pollutants	Median Percent Removal	25th Percentile Effluent Concentration
Total Copper	86.2%	9.45 µg/L
Dissolved Copper	40.8%	6.25 µg/L
Total Zinc	85.1%	22.0 µg/L
Dissolved Zinc	80.8%	16.0 µg/L
Total Phosphorus	85.7%	0.033 mg/L
Total Nitrogen	NF	NF
Total Suspended Solids	94.1%	2.8 mg/L
Total PCBs	94.1%	74.3 pg/L
Total PBDEs	80.9%	0.007 ng/L
Total PAHs	94.1%	0.00035 µg/L
BEHP	76.2%	0.0091 µg/L
Fecal Coliform	NF	NF

NF = No data found

Note: Grey shaded values were derived from TSS translator equations discussed in the Methods section.

Table 6. Stormwater Treatment Wetland Performance Parameter Data.

Target Pollutants	Median Percent Removal	25th Percentile Effluent Concentration
Total Copper	25.0%	3.0 µg/L
Dissolved Copper	0.0%	2.0 µg/L
Total Zinc	45.9%	12.0 µg/L
Dissolved Zinc	0.0%	10.0 µg/L
Total Phosphorus	24.2%	0.071 mg/L
Total Nitrogen	5.81%	0.932 mg/L
Total Suspended Solids	52.4%	6.81 mg/L
Total PCBs	78.1%	165 pg/L
Total PBDEs	45.1%	0.017 ng/L
Total PAHs	85.6%	0.024 µg/L
BEHP	42.4%	0.022 µg/L
Fecal Coliform	19.1%	425 CFU/100 mL

Note: Grey shaded values were derived from TSS translator equations discussed in the Methods section.

Table 7. Detention Pond Performance Parameter Data.

Target Pollutants	Median Percent Removal	25th Percentile Effluent Concentration
Total Copper	26.2%	4.17 µg/L
Dissolved Copper	3.23%	3.0 µg/L
Total Zinc	44.0%	18.0 µg/L
Dissolved Zinc	13.6%	16.1 µg/L
Total Phosphorus	17.7%	0.113 mg/L
Total Nitrogen	7.80%	0.674 mg/L
Total Suspended Solids	57.6%	12.9 mg/L
Total PCBs	57.6%	342 pg/L
Total PBDEs	*56.9%*	*93.5 ng/L*
Total PAHs	*52.1%*	*0.228 µg/L*
BEHP	46.7%	0.042 µg/L
Fecal Coliform	31.5%	500 CFU/100 mL

Note: Grey shaded values were derived from TSS translator equations discussed in the Methods section.
Italicized values derived from surrogate BMP (Detention vault).

Table 8. Detention Vault Performance Parameter Data.

Target Pollutants	Median Percent Removal	25th Percentile Effluent Concentration
Total Copper	*26.2%*	*4.17 µg/L*
Dissolved Copper	*3.23%*	*3.0 µg/L*
Total Zinc	*44.0%*	*18.0 µg/L*
Dissolved Zinc	*13.6%*	*16.1 µg/L*
Total Phosphorus	*17.7%*	*0.113 mg/L*
Total Nitrogen	*7.80%*	*0.674 mg/L*
Total Suspended Solids	*57.6%*	*12.9 mg/L*
Total PCBs	*57.6%*	*342 pg/L*
Total PBDEs	56.9%	93.5 ng/L
Total PAHs	52.1%	0.228 µg/L
BEHP	*46.7%*	*0.042 µg/L*
Fecal Coliform	*31.5%*	*500 CFU/100 mL*

Italicized values derived from surrogate BMP (Detention pond).

Table 9. Wetpond Performance Parameter Data.

Target Pollutants	Median Percent Removal	25th Percentile Effluent Concentration
Total Copper	45.0%	3.0 µg/L
Dissolved Copper	22.7%	3.0 µg/L
Total Zinc	62.5%	13.0 µg/L
Dissolved Zinc	36.8%	10.0 µg/L
Total Phosphorus	49.5%	0.071 mg/L
Total Nitrogen	27.6%	0.904 mg/L
Total Suspended Solids	76.2%	7.5 mg/L
Total PCBs	76.2%	199 pg/L
Total PBDEs	65.5%	0.019 ng/L
Total PAHs	76.2%	0.00093 µg/L
BEHP	61.7%	0.025 µg/L
Fecal Coliform	60.0%	85.5 CFU/100 mL

Note: Grey shaded values were derived from TSS translator equations discussed in the Methods section.

Table 10. Wetvault Performance Parameter Data.

Target Pollutants	Median Percent Removal	25th Percentile Effluent Concentration
Total Copper	*45.0%*	*3.0 µg/L*
Dissolved Copper	*22.7%*	*3.0 µg/L*
Total Zinc	*62.5%*	*13.0 µg/L*
Dissolved Zinc	*36.8%*	*10.0 µg/L*
Total Phosphorus	*49.5%*	*0.071 mg/L*
Total Nitrogen	*27.6%*	*0.904 mg/L*
Total Suspended Solids	*76.2%*	*7.5 mg/L*
Total PCBs	*76.2%*	*199 pg/L*
Total PBDEs	*65.5%*	*0.019 ng/L*
Total PAHs	*76.2%*	*0.00093 µg/L*
BEHP	*61.7%*	*0.025 µg/L*
Fecal Coliform	*60.0%*	*85.5 CFU/100 mL*

Italicized values derived from surrogate BMP (Wetpond).

Table 11. Underground Filter System Performance/Stormwater Park (Water Quality Treatment) Performance Parameter Data.

Target Pollutants	Median Percent Removal[a,b]	25th Percentile Effluent Concentration[a,b]
Total Copper	51.6%	3.1 µg/L
Dissolved Copper	34.2%	2.0 µg/L
Total Zinc	56.4%	20.1 µg/L
Dissolved Zinc	53.4%	26.0 µg/L
Total Phosphorus	42.4%	0.034 mg/L
Total Nitrogen	45.8%	0.422 mg/L
Total Suspended Solids	86.4%	2.45 mg/L
Total PCBs	84.1%	414.1 pg/L
Total PBDEs	74.3%	0.0061 ng/L
Total PAHs	86.4%	0.00031 µg/L
BEHP	70.0%	0.008 µg/L
Fecal Coliform	NF	NF

[a] Underground filter systems and stormwater park (water quality treatment) are assumed to have equivalent performance (see assumptions in Attachment A).

[b] Performance based on proprietary Filterra® engineered media.

NF = No data found; Assigned a value of 0 in SUSTAIN since no data was found.

Note: Grey shaded values were derived from TSS translator equations discussed in the Methods section.

Table 12. Sports Field and Parks Detention

Target Pollutants	Median Percent Removal	25th Percentile Effluent Concentration
Total Copper	*26.2%*	*4.17 µg/L*
Dissolved Copper	*3.23%*	*3.0 µg/L*
Total Zinc	*44.0%*	*18.0 µg/L*
Dissolved Zinc	*13.6%*	*16.1 µg/L*
Total Phosphorus	*17.7%*	*0.113 mg/L*
Total Nitrogen	*7.80%*	*0.674 mg/L*
Total Suspended Solids	*57.6%*	*12.9 mg/L*
Total PCBs	*57.6%*	*342 pg/L*
Total PBDEs	*56.9%*	*93.5 ng/L*
Total PAHs	*52.1%*	*0.228 µg/L*
BEHP	*46.7%*	*0.042 µg/L*
Fecal Coliform	*31.5%*	*500 CFU/100 mL*

Italicized values derived from surrogate BMP (Detention pond).

Limitations and Future Considerations

This document summarizes the pollutant removal performance data and approach used to represent the typical performance of the Actions included in the WQBE toolkit. The following text provides a summary of the limitations in the data available:

- When performance parameter data were not identified through the literature review, data gaps were filled based on data from surrogate Actions and pollutants as appropriate. Periodic reviews should be conducted to identify new data that could be used to quantify the pollutant removal performance of an Action.
- To simplify modeling assumptions, the 25th percentile effluent concentration was used as a surrogate for the irreducible concentration for each pollutant based on best professional judgement.
- The influent and effluent concentration data from individual sampling events were analyzed to compute the median percent removal for each Action and pollutant combination. These data were then used to represent the typical pollutant removal performance of each Action. However, these data do not capture complex dynamics that occur in association with specific unit processes for pollutant removal. For example, these data do not reflect variations in pollutant removal performance stemming from biological processes that may be influenced by seasonal factors (e.g., nutrient capture in plants during the growing season and subsequent release with plant senescence). Due to model limitations, it is generally not possible to capture the influence of these complex dynamics in the model output.
- Correction factors were derived using the data from Table 2 to quantify the partitioning of organic pollutants between the solid and aqueous phase in stormwater. These correction factors were then used to derive a final estimate of the effluent organic pollutant concentration for each Action. These estimates could be refined in future phases of the project using partition coefficient (Kow) that are derived from literature.

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Attachment A

Phase 2 and Phase 3 Action Screening Process, Data Sources, and Key Assumptions

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Table A-1. Phase 2 and Phase 3 Action Screening Process, Data Sources, and Key Assumptions.					
Action	**WQBE Phase**	**Primary Unit Processes**	**Screening Process Category**	**Data Source**	**Modeling and Performance Assumptions**
Bioretention	2	Sedimentation, sorption, filtration, biological uptake, Infiltration	4	Herrera (2015), Herrera (2020)	Concentration percent reductions from this review are assigned to underdrain outflow. All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. Performance results were gathered from lab studies, which used the Puget Sound region's new High Performance Bioretention Media (HPBSM) specification, a mixture of sand, coconut coir, and biochar (Herrera 2020).
Rain garden	2	Sedimentation, sorption, filtration, biological uptake, Infiltration	3		All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.
Bioretention Planter	2	Sedimentation, sorption, filtration, biological uptake, Infiltration	4	Herrera (2015), Herrera (2020)	Concentration percent reductions from this review are assigned to underdrain outflow. All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. These systems function equivalent to bioretention.
Bioswale	2	Sedimentation, filtration, biological uptake, infiltration	4	ISBMPD (2019)	Bioswales are modelled as a flow through system. Concentration percent reductions from this review are assigned to water that exits the bioswale. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.
Media filter drain	2	Sedimentation, sorption, filtration, infiltration	4	Herrera (2006), WSDOT (2013)	Concentration percent reductions from this review are assigned to underdrain outflow. All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.
Dry well	2	Infiltration	3		All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. Action will be paired with a pretreatment Action when included in a Program.

Table A-1 (continued). Phase 2 and Phase 3 Action Screening Process, Data Sources, and Key Assumptions.					
Action	**WQBE Phase**	**Primary Unit Processes**	**Screening Process Category**	**Data Source**	**Modeling Assumptions**
Deep underground injection control (UIC) well	2	Infiltration	3		All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. Action will be paired with a pretreatment Action when included in a Program.
Permeable pavement	2	Infiltration	3		All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.
Depaving	2	–	2		Action will be modeled in SUSTAIN by converting the depaved area from an impervious to pervious surface. Load reduction would be the result of the differences in pollution generating in surface runoff from the different land surfaces.
Detention vault	2	Sedimentation	4	Sebastian et al. (2014), ISBMPD (2019)	Water that flows through the orifice is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (while not designed for treatment, there will be some pollutant removal via sedimentation). Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. Performance assumed equivalent to a detention pond except for the specific data found for detention vaults for PBDEs and Total PAHs.
Detention pond	2	Sedimentation	4	Sebastian et al. (2014), ISBMPD (2019)	Water that flows through the orifice is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (while not designed for treatment, there will be some pollutant removal via sedimentation). Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. Performance for PBDEs and Total PAHs assumed equivalent to detention vaults.

Table A-1 (continued). Phase 2 and Phase 3 Action Screening Process, Data Sources, and Key Assumptions.					
Action	**WQBE Phase**	**Primary Unit Processes**	**Screening Process Category**	**Data Source**	**Modeling Assumptions**
Infiltration vault	2	Sedimentation, infiltration	3	Sebastian et al. (2014), ISBMPD (2019)	All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. Action will be paired with a pretreatment Action when included in a Program. Assumed same performance as detention pond/vault, but will be part of a treatment train.
Infiltration pond	2	Sedimentation, infiltration	3	Sebastian et al. (2014), ISBMPD (2019)	All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. Action will be paired with a pretreatment Action when included in a Program. Assumed same performance as detention pond/vault, but will be part of a treatment train.
Cistern	2	–	1		Model will assume no treatment provided unless Program includes manual operation of orifice valve by property owner. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.
Stormwater treatment wetland	2	Sedimentation, sorption, filtration, biological uptake	4	ISBMPD (2019), King County (2019)	Water that flows through the Action (to the max flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.
Wetponds	2	Sedimentation, biological uptake (depends on pond quality)	4	ISBMPD (2019)	Water that flows through the Action (to the max flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.
Wetvaults	2	Sedimentation	4	ISBMPD (2019)	Water that flows through the Action (to the max flow rate) is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. Performance assumed equivalent to Wetpond.

Table A-1 (continued). Phase 2 and Phase 3 Action Screening Process, Data Sources, and Key Assumptions.					
Action	**WQBE Phase**	**Primary Unit Processes**	**Screening Process Category**	**Data Source**	**Modeling Assumptions**
High Rate Underground Filtration System	2	Sedimentation, sorption, filtration	4	Gilbreath et al. (2018), ISBMPD (2019)	Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. Performance assumed equivalent to Filterra®.
Stormwater park (water quality treatment)	2	Sedimentation, sorption, filtration	4	Gilbreath et al. (2018), ISBMPD (2019)	Underdrain flow is assigned a percent removal and irreducible concentration for each pollutant based on media effectiveness. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment. Performance assumed equivalent to Filterra®.
Sports field and park detention	3	Sedimentation	4	Sebastian et al. (2014), ISBMPD (2019)	Water that flows through the orifice is assigned a percent removal and irreducible concentration for each pollutant based on the Action effectiveness (while not designed for treatment, there will be some pollutant removal via sedimentation). Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.
Compost Amendment	3	Sedimentation, sorption, filtration, infiltration	3		All water that infiltrates is lost from the model to groundwater, so the associated pollutants are 100 percent removed from the surface water model. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.
Blue roof	3	–	1		Model will assume no treatment. Water that exceeds the capacity of the Action is modeled as bypass and receives no treatment.
Reforest High Density Development	3	–	2		Action will be modeled in SUSTAIN by converting the reforested area from an impervious to forested surface. Load reduction would be the result of the differences in pollution generating in surface runoff from the different land surfaces.
Reforest Pervious Area	3	–	2		Action will be modeled in SUSTAIN by converting the reforested area from a pervious to forested surface. Load reduction would be the result of the differences in pollution generating in surface runoff from the different land surfaces.