Salish Sea Model — Optimization Phase 2

Refined Scenarios and Dissolved Oxygen Noncompliance

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Authors: Teizeen Mohamedali, Cristiana Figueroa-Kaminsky, Anise Ahmed, John Gala and Hanis Zulmuthi

Contact Email: c.figueroa@ecy.wa.gov

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Summary

The Optimization Phase 2 (Opt2) report (Figueroa-Kaminsky, et al. 2025) encompasses Salish Sea model scenarios supporting the development of the Puget Sound Nutrient Reduction Plan (Ecology, 2025) which seeks to achieve compliance with the dissolved oxygen standard.

Ten refined Opt2 scenarios involved pairing different municipal wastewater treatment plants (WWTP) reduction frameworks with a single watershed reduction framework. A reference scenario refers to conditions as they would have occurred if local and regional human influences are removed, and an existing condition scenario refers to conditions as they occurred.

Using 2014 conditions and flows, for watersheds, all species of nitrogen (ammonium, nitrate-nitrite, and organic nitrogen) were reduced for ten refined scenarios (Opt2_1 – Opt2_10). For WWTPs, dissolved inorganic nitrogen (DIN) was reduced and reported as total nitrogen reductions for the refined scenarios. Total organic carbon reductions were also made for all sources.

This poster focuses on the nitrogen reductions for WWTPs.

- Table 1 shows the WWTP treatment frameworks associated with each refined scenario.
- Table 2 shows the breakdown of reference and anthropogenic loads for each basin and refined scenario.
- Table 3 shows loads and DO noncompliances for each of the refined scenarios
- Figure 1 shows anthropogenic WWTP and watershed loads and their proportions among eight basins for all refined scenarios.
- Figure 2 shows the anthropogenic total nitrogen watershed loads and percent reductions by basin under all refined scenarios.
- Figure 3 shows the number of days of noncompliance within the WA waters of the Salish Sea under existing and refined scenarios.

References:

Figueroa-Kaminsky, C., A. Ahmed, T. Mohamedali, J. Gala, and H. Zulmuthi. 2025. Puget Sound Nutrient Source Reduction Project. Volume 2: Model Updates and Optimization Scenarios, Phase 2. Publication 25-03-003. Washington State Department of Ecology, Olympia. https://apps.ecology.wa.gov/publications/SummaryPages/2503003.html

Ecology. 2025. Puget Sound Nutrient Source Reduction Plan: An advanced restoration approach to recovering water quality in Puget Sound, Washington State Department of Ecology, Olympia. Publication 25-10-038. https://apps.ecology.wa.gov/publications/SummaryPages/2510038.htm

Opt2 Refined WWTP Frameworks

Table 1. Refined Opt2 WWTP frameworks
(each of these is paired with a single watershed framework).

Scenario ID	Question that it addresses	WWTPs at existing 2014 loads	BNR levels[a] at WWTPs
Opt2_1	What is the effect of BNR 8/5/3 at all WWTPs on noncompliance?	None	All WWTPs at 8/5/3
Opt2_2	How does setting very small WWTPs at existing 2014 loads affect noncompliance?	Very small WWTPs[b]	All other WWTPs at 8/5/3
Opt2_3	How does increasing BNR treatment for those WWTPs discharging within or near Sinclair Inlet affect noncompliance?	None	Three WWTPs within or near Sinclair Inlet set at BNR 3/3/3. All other WWTPs at 8/5/3
Opt2_4	How does setting WWTPs discharging into the Straits of Juan de Fuca and Georgia, Admiralty Inlet, and Hood Canal, at existing 2014 loads, affect noncompliance?	WWTPs in Straits of Juan de Fuca and Georgia, Admiralty Inlet, and Hood Canal	All other WWTPs at BNR 8/5/3
Opt2_5	What is the combined effect on noncompliance of 1) setting very small WWTPs and 2) setting WWTPs discharging into the Straits of Juan de Fuca and Georgia, Admiralty Inlet, and Hood Canal at existing 2014 loads?	Very small WWTPs[b] and WWTPs in Straits of Juan de Fuca and Georgia, Admiralty Inlet and Hood Canal	All other WWTPs at BNR 8/5/3
Opt2_6	What is the combined effect on noncompliance of 1) setting WWTPs discharging into Straits of Juan de Fuca and Georgia, Admiralty Inlet, and Hood Canal at existing 2014 loads and 2) increasing BNR treatment for those WWTPs discharging within or near Sinclair Inlet?	WWTPs in Straits of Juan de Fuca and Georgia, Admiralty Inlet, and Hood Canal	Three WWTPs within or near Sinclair Inlet set at BNR 3/3/3. All other WWTPs at BNR 8/5/3
Opt2_7	What is the combined effect of 1) setting very small WWTPs at existing 2014 loads, 2) setting WWTPs discharging into Straits of Juan de Fuca and Georgia, Admiralty Inlet, and Hood Canal at existing 2014 loads, and 3) increasing BNR treatment for those WWTPs discharging within or near Sinclair Inlet?	Very small WWTPs[b] and WWTPs in the Straits of Juan de Fuca and Georgia, Admiralty Inlet, and Hood Canal	Three WWTPs within or near Sinclair Inlet set at BNR 3/3/3. All other WWTPs at BNR 8/5/3
Opt2_8	Can zero DO noncompliance be achieved everywhere with the largest (dominant) WWTPs in Main Basin at BNR 8/3/3 and those in the vicinity of Sinclair Inlet at BNR 3/3/3, but West Point (a dominant facility treating combined sewers) at 8/5/3?	Very small WWTPs[b] and WWTPs in the Straits of Juan de Fuca and Georgia, Admiralty Inlet, and Hood Canal	Three WWTPs within or near Sinclair Inlet set at BNR 3/3/3. All dominant Main Basin WWTPs[c] at BNR 8/3/3 (except West Point set at 8/5/3). All other WWTPs at 8/5/3.
Opt2_9	Can DO zero noncompliance be achieved everywhere with the largest (dominant) WWTPs in Main Basin at BNR 8/3/3 and those in the vicinity of Sinclair Inlet at BNR 3/3/3?	Very small WWTPs[b] and WWTPs in the Straits of Juan de Fuca and Georgia, Admiralty Inlet, and Hood Canal	Three WWTPs within or near Sinclair Inlet set at BNR 3/3/3. All dominant Main Basin WWTPs[c] at BNR 8/3/3. All other WWTPs at 8/5/3
Op2_10	Can DO zero noncompliance be achieved everywhere with the largest (dominant) WWTPs in Main Basin and those near the most difficult noncompliance location at BNR 3/3/3?	Very small WWTPs[b] and WWTPs in the Straits of Juan de Fuca and Georgia, Admiralty Inlet, and Hood Canal	Three WWTPs within or near Sinclair Inlet set at BNR 3/3/3. All dominant Main Basin WWTPs[c] at BNR 3/3/3. All other WWTPs at 8/5/3

[a] Biological nitrogen removal (BNR) levels are specified in terms of cool (Nov – Mar), warm (Apr – Jun, and Oct), hot (Jul – Sep) months.

[b] Very small WWTPs are those discharging less than 10 kg TN/day or less than 6 kg DIN/day on a maximum monthly basis for model year 2014.

[c] Dominant Main Basin WWTPs include Brightwater, South King, Tacoma Central and West Point.

Scenario Loads

Figure 1. Annual anthropogenic total nitrogen (TN) watershed and marine point source loads entering different basins for each refined Opt2 scenario.

Watershed loads are the same across all scenarios and therefore represented by a single bar.

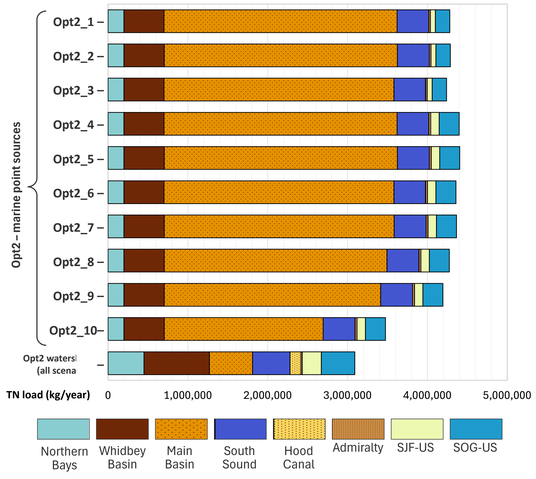
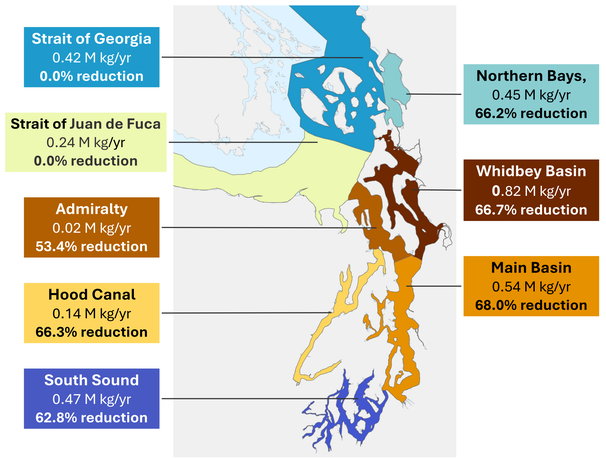


Table 2. Annual loads[a] and percent load reductions in total nitrogen (TN) to WA Salish Sea waters associated with each scenario for the year 2014.

[a] These are the sum of basin loads, rounded to four significant digits.

	Total TN load (reference + anthropogenic)			Anthropogenic TN loads			Percent Reduction in TN loads		
Opt2 Model Scenario	Total TN load (thousands of kg/year)	Watershed TN load (thousands of kg/year)	Marine point source TN load (thousands of kg/year)	Total anthro. TN load (thousands of kg/year)	Watershed anthro. TN load (thousands of kg/year)	Marine point source anthro. TN load (thousands of kg/year)	Overall % reduction in anthro. TN loads	% reduction in watershed anthro. TN loads	% reduction in point source anthro. TN loads
Reference	8,630	8,537	92.9	0	0	0	100%	100%	100%
Existing	**29,930**	**16,380**	**13,550**	**21,300**	**7,843**	**13,460**	**0%**	**0%**	**0%**
Opt2_1	16,000	11,630	4,374	7,370	3,093	4,281	65.4%	60.6%	68.2%
Opt2_2	16,010	11,630	4,381	7,380	3,093	4,288	65.4%	60.6%	68.1%
Opt2_3	15,960	11,630	4,334	7,330	3,093	4,241	65.6%	60.6%	68.5%
Opt2_4	16,120	11,630	4,492	7,490	3,093	4,399	64.8%	60.6%	67.3%
Opt2_5	16,130	11,630	4,499	7,500	3,093	4,406	64.8%	60.6%	67.3%
Opt2_6	16,080	11,630	4,452	7,450	3,093	4,359	65.0%	60.6%	67.6%
Opt2_7	16,090	11,630	4,459	7,460	3,093	4,366	65.0%	60.6%	67.6%
Opt2_8	16,000	11,630	4,369	7,370	3,093	4,276	65.4%	60.6%	68.2%
Opt2_9	15,920	11,630	4,289	7,290	3,093	4,196	65.8%	60.6%	68.8%
Opt2_10	15,200	11,630	3,569	6,570	3,093	3,476	69.2%	60.6%	74.2%

Figure 2. Annual anthropogenic watershed total nitrogen loads and percent reductions under each of the refined Opt2 Scenarios in millions of kg per year



DO Noncompliance

Figure 3. Cumulative days of DO noncompliance in 2014 Sinclair and Henderson Inlets under different scenarios.

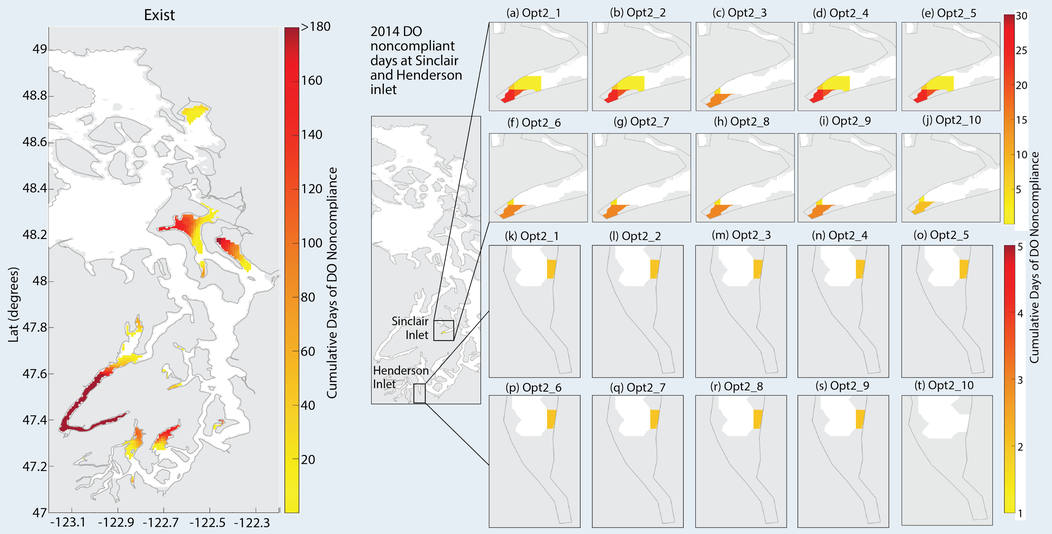


Table 3. Dissolved Oxygen (DO) noncompliances[a] and anthropogenic total nitrogen (TN) scenario loads in 2014.

[a]Noncompliance excludes masked areas (e.g., Budd Inlet).

Opt2 scenario	Anthropogenic TN load (thousands of kg/year)	Percent reduction in anthropogenic TN load relative to existing	Total days of noncompliance	Total area of noncompliance (km²)	Maximum magnitude of DO noncompliance (mg/L)	Percent of area with zero noncompliance (relative to 2014 existing noncompliant area)
Existing	**21,300**	**0%**	**80,279**	**467**	**-1.1**	**0.00%**
Opt2_1	7,370	65.4%	57	2.50	-0.1	99.5%
Opt2_2	7,380	65.4%	58	2.50	-0.1	99.5%
Opt2_3	7,330	65.6%	36	0.93	-0.1	99.8%
Opt2_4	7,490	64.8%	58	2.50	-0.1	99.5%
Opt2_5	7,500	64.8%	58	2.50	-0.1	99.5%
Opt2_6	7,450	65.0%	36	0.93	-0.1	99.8%
Opt2_7	7,460	65.0%	36	0.93	-0.1	99.8%
Opt2_8	7,370	65.4%	36	0.93	-0.1	99.8%
Opt2_9	7,290	65.8%	35	0.93	-0.1	99.8%
Opt2_10	6,570	69.2%	18	0.83	-0.1	99.8%