RESPONSE TO REQUEST FOR PUBLIC COMMENTS ON THE TMDL DRAFT DOCUMENT.

David H Milne
July 8, 2022.

General Impressions.

As a reader who has studied Budd Inlet and Capitol Lake exhaustively for many years, I had a running start on understanding the material in this document. Despite that, I found it a difficult and confusing text to try to wade through. Among other difficulties, I found many more pages than a reader could hope to comment on during the too-short 30-day comment period. It reads like it was written by technicians to be read by other technicians – not the public. One must look closely at Tables to be sure the numbers shown there are real, actual, observed values – "loads," for example – as distinct from calculated numbers – "allocations", for example. Where Tables and graphs show data, they seldom name the year in which the data were collected, and are often strung out Table after Table after Table on page after page after page, usually better presented as explaining one table in detail and relegating all others like it to a separate appendix. The manuscript is really in need of an editor.

One of the greatest shortcomings of this TMDL Draft is its omission of a pictorial representation of the sizes of the DIN loads delivered to Budd Inlet by the various contributing sources. That would show the public the gigantic contributions of "natural" and "anthropogenic" nitrogen entering through the open boundary, for visual comparison with the tiny contributions by watersheds and the LOTT plant that this TMDL Draft is focused upon.

I found it aggravating, but not unexpected, to see agency "mistakes" that I have exposed in my years of study and reporting repeated as "truths." For example, the identification of Capitol Lake as the "largest cause of pollution to Budd Inlet" via "excessive growth of freshwater algae" [*the vast majority of growth is by macrophytes and sessile algae that remain in the Lake all summer*] and "The lake also changes natural flow patterns resulting in an increased retention time in … part of Budd Inlet" [*a later desperate WDOE claim, not true, not demonstrated by the sources cited nor by any plausible resort to known flow mechanisms*]. (p. 9)

With that in mind, I have not had time to explore these pages exhaustively. I offer only a few in-depth thoughts about the some of the contents of the TMDL Draft in the following.

David H. Milne

RESPONSE TO REQUEST FOR PUBLIC COMMENTS ON THE TMDL DRAFT DOCUMENT.

David H Milne
July 6, 2022.

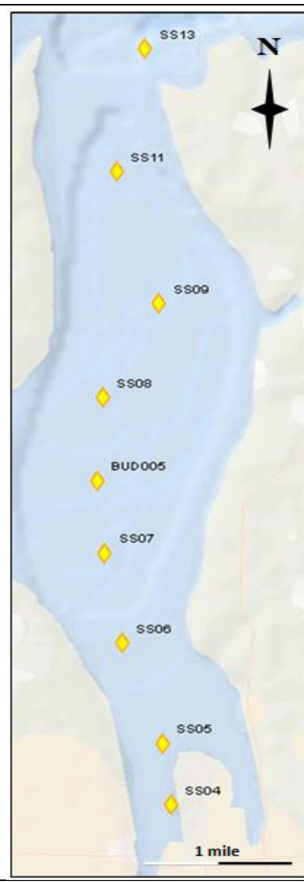
In the following, I refer to my own research on some of the computer simulation models cited in this TMDL Draft report. In the text that follows, I refer to this (the present) report as "TMDL Draft," WDOE's Supplemental Modeling Scenarios (Pub. No. 15-03-002) as "SMS Report," and my own critique of SMS Report as "SMS Review." [1]

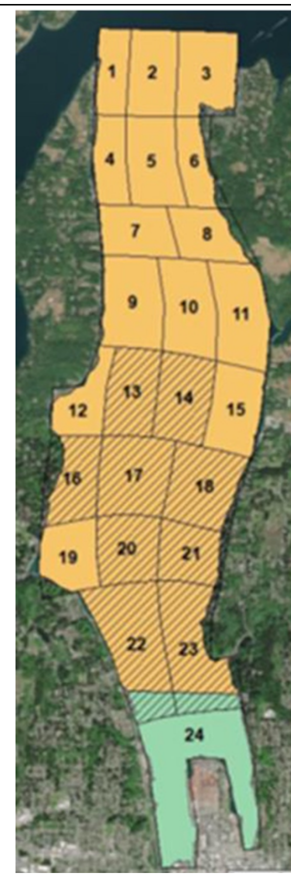
1) Limitations on use of the Salish Sea Model for simulations of Budd Inlet.

1a. Salish Sea and GEMSS Models. After I wrote the SMS Review, it appears that the modelers have elected to use the outputs of the Salish Sea Model (SSM) to calculate the outer boundary exchanges between Budd Inlet and the rest of Puget Sound. That is reasonable and acceptable. However, the Figures (for example A-5 p. A-15) give the impression that the SSM method of simulation has replaced the method of Budd Inlet simulation used in the older GEMSS model. That is very problematic.

The SSM, designed for a huge intricate waterway, must necessarily use a broad brush approach that can't resolve important hydrographic details of a small local waterway like Budd Inlet. For example the SSM simulation uses only 24 grid squares and evidently draws on data from only nine hydrographic stations, none of which are in critically important East Bay (Figures A-5 and A-1, respectively). By contrast, the GEMSS model uses some 160 grid squares and draws upon data taken for a full year at 26 stations (the "BISS data," see Fig. 2-2, SMS Review and below).

The southernmost of the grid squares of the SSM simulation includes both East and West Bays in a single cell. That cannot guide us in our understanding of the roles of those two bays. West Bay is dominated by a huge outbound low-





[1] Milne, D. H. 2018. The Department of Ecology's "Deschutes River, Capitol Lake, and Budd Inlet. Supplemental Modeling Scenarios. Publication No. 15-03-002. A Critical Review." Available on CLIPA website ___.

salinity surface flow and a corresponding powerful incoming high-salinity bottom	TMDL Draft Appendix A. Figures A-5 and A-1 pp A-10 and A-15.

flow, all driven by the Deschutes River and largely bypassing the mouth of East Bay. East Bay is influenced by the small flow of Moxlie Creek and a corresponding feeble incoming bottom flow (complicated by the large LOTT outfall flow), all of which give that Bay a longer turnover time than West Bay's and a different dynamic bearing on water quality.

1b. Simulation of Moxlie Creek Effect needed. The GEMSS model is capable of easily simulating the effects on East Bay of removal of Moxlie Creek's very high DIN load. I doubt that the SSM model is easily able to do that. For the GEMSS model, arbitrarily set the DIN loading of just one category of model inputs, "All Other Watershed Sources" (all minor creeks around Budd Inlet) at zero and run the model.

Zeroing the miniscule inputs of the other tiny creeks should make no difference. They are scattered around the perimeter of Budd Inlet and discharge into fast moving water along those shores. Moxlie Creek (with nearby Mission Creek) carries more DIN into Budd Inlet than does any other small watershed creek (see Table 30, 2nd data columns, TMDL Draft, p. 52). It discharges directly into near-stagnant East Bay.

I have long suspected that East Bay's unique low DO condition is caused by the heavy DIN load from Moxlie Creek in combination with the very sluggish estuarine circulation driven by its low flow – and by an interference effect from the LOTT outfall crossing the Bay entrance. I have asked the modelers to do that simulation, but to my knowledge they have not done so. My expectation is that this simulation would show that East Bay's seasonal low DO conditions are created by Moxlie Creek and its flow configuration – *not* by Capitol Lake.

Question. Why is Moxlie Creek largely unmentioned in the TMDL Draft?

2) A possible serious error in GEMSS simulation results for Budd Inlet.

2a. Critical missing data points in GEMSS calibration procedure. Figure D-14 below shows GEMSS simulations of DO levels in the bottom water (indicated by the fine-print "Kb" in each graph) throughout the whole simulation interval in 1997. Your reproduction of the graphs for stations BI-1, BI-2, and BI-6 implies that you have not noticed my identification of a major error that I believe could invalidate many (if not all) results of Ecology's earlier simulations (see SMS Review, Chapter 3).

The data points on the graphs show actual observations of DO levels in bottom waters made by the Budd Inlet Scientific Study (BISS) team in 1996-1997. The graphs show how closely the best version of the GEMSS model (ultimately used by Ecology) was able to track the real-world DO levels.

By inspection of the (enormous) BISS data set, I found that the modelers in this instance had neglected to include a few key BISS observations in their graphic portrayal of results at station BI-6 (lower left graph). One "overlooked" data point showed that the bottom water at BI-6 had the highest DO level of the entire simulated "year" on the same date that the GEMSS model calculated the lowest observed DO level of the entire "year." A graph reproduced from my report (SMS Review, Chapter 3) is reproduced on the next page showing the "missing" BISS data points.*[2]

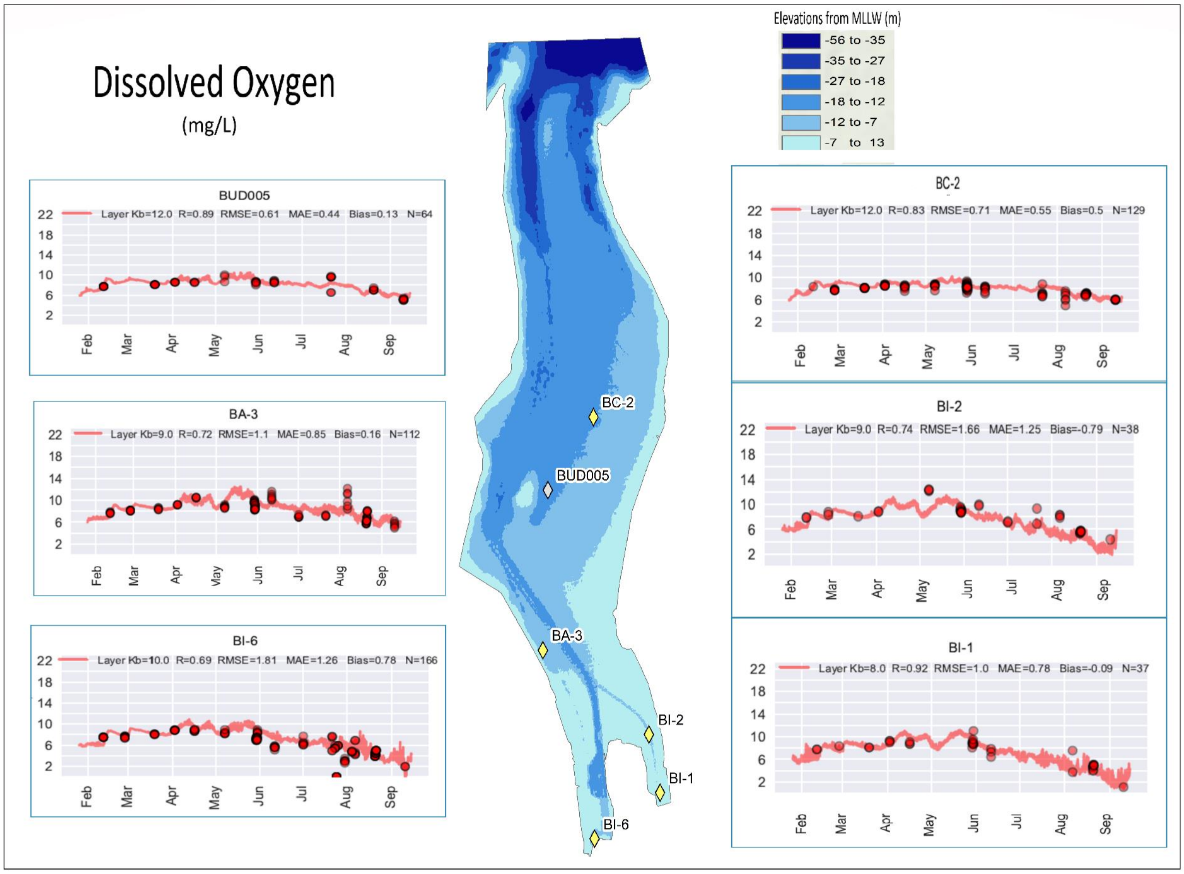


Figure D-14 (Appendix D, TMDL Draft). "Predicted and observed time series for DO concentrations (mg/L) at selected stations in Budd Inlet (*sic*)." Page D-29.

The same error – calculated lowest bottom DO of the year on the date when the observed level was actually at its highest value of the year – also occurred in the modelers' portrayal of East Bay stations BI-1 and BI-2.*[3]

The high bottom water DO levels on September 10, 1997 (not Sept. 11, as you report – p. A-20) were observed on a sunny summer day at a time when the tide was low. Sunlight was reaching the bottom and the mat of concentrated benthic algae there produced the excess oxygen that accumulated in the bottom water. Unlike oxygen produced near the surface, excess oxygen at the bottom is unable to escape into the atmosphere. In fact, the oxygen concentrations at the bottom at the two other sites (BI-1 and BI-2) were actually higher than the DO levels at the

[2] The graphs in Figure D-14 (this page) appear "closer to the bottom" of the panels than does the graph in my Figure 3-4 (next page) because the vertical scale origins on the two sets are different.

[3] My archived records are not accessible at this time. But (I remember) in the cases of BI-1 and BI-2, one of the two graphs was missing the high-DO data point, in the other the modelers actually showed it,

surface, and the DO saturation levels at the bottoms were greater than 150% (SMS Review Figures 5-9, 5-10 below.)

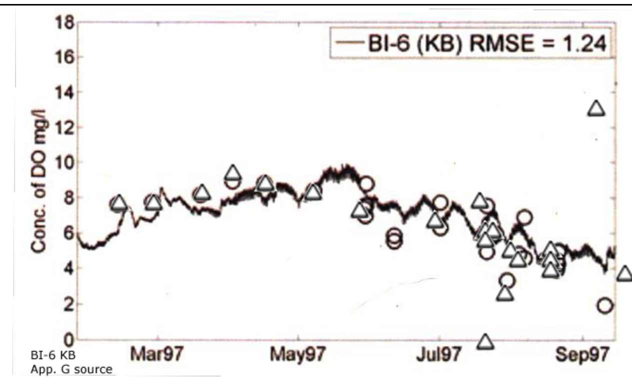


Figure 3-4. Computer simulation of dissolved oxygen levels in bottom water at station BI-6, Budd Inlet, January 25 through September 10, 1997. Graph shows calculated DO levels, circles show BISS data points used by modelers for calibration of the model. (Source: Deschutes TMDL Tech Report, 2012 Appendix.)
Triangles (added by me) are data from the BISS spreadsheet that the modelers did not show in this graph. The right-most triangle is September 24 a few days after the end of the computer simulation interval. Source of triangle points; BISS spreadsheet.

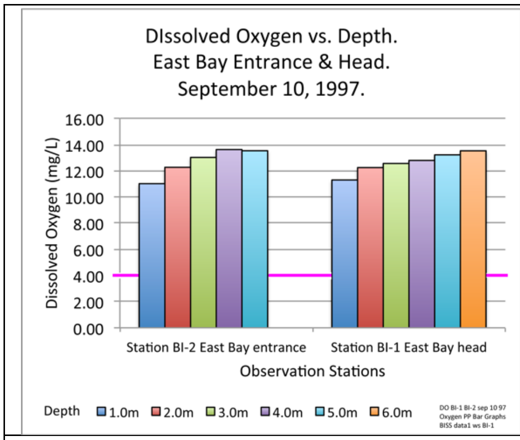


Figure 5-9. Dissolved oxygen concentrations vs. depth, BISS stations BI-2 and BI-1 (East Bay). September 10, 1997. Red line shows 4.0 mg/L ecological stress threshold. The water quality standard here is 5.0 mg/L. Data Source: BISS spreadsheet.

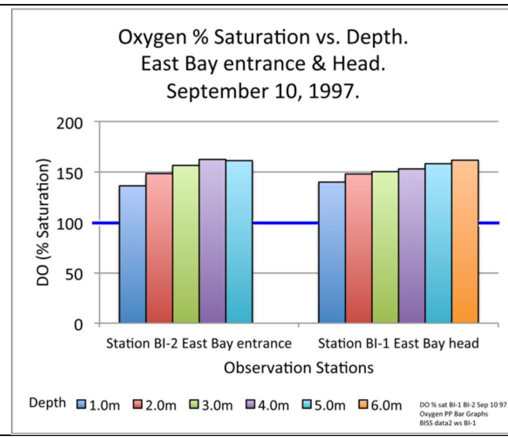


Figure 5-10. Dissolved oxygen saturation levels vs. depth, BISS stations BI-2 and BI-1 (East Bay). September10, 1997. Blue line shows 100% saturation. Percent saturations calculated via USGS DO TABLES tool from observed water salinity and temperature data from BISS spreadsheet.

2b. An inactive benthic algae subroutine in the GEMSS model? The GEMSS model calculated the lowest bottom water DO's of the entire season at those stations on a day when the real world values were almost certainly at their highest levels of the entire season. How did that enormously inaccurate prediction happen?

The model should have gotten it right. My inspection of a list of its subroutines and other mechanisms (source – one of the Appendices of Ecology Technical Report Deschutes TMDL) showed that it has a benthic algae subroutine. It is clear that that subroutine had not been activated.

Question. There are extensive shallow and intertidal shores around most of Budd Inlet. If the benthic algae subroutine was "off" throughout all of Ecology's modelling exercises might the overall results be as misleading as the results for East and West Bay in September 1997?

Question. Might the critical low DO levels in East Bay that dominate discussion of DO in all of Budd Inlet have resulted, first from WDOE's failure to simulate zero DIN in Moxlie Creek, and second from the absence of a functioning benthic algae subroutine in the GEMSS model?

3) Mistaken important assertion.

P A-20. Last paragraph. "The largest source of oxygen depletion in Budd Inlet is Capitol Lake." *I have researched this question and strenuously disagree with this statement*. My analysis …

To recap the argument, the claim is made that Capitol Lake's "algae" capture incoming DIN from the Deschutes River and that the TOC/POC created by their photosynthesis enter Budd Inlet where oxidation of this material depletes oxygen levels in the Inlet (see p. D-47, TMDL Draft). Page D-47 reports that C to N ratios in the Inlet's benthic sediments are characteristic of "algae." The implication is that the Lake is the source of the "algae."

This overlooks the fact that a mat of benthic marine algae exists in the shallow marine waters near the dam. These are surely the source of some of the OC found there. Far more importantly, the explanation never mentions the attached plants growing in Capitol Lake. Their biomass far outweighs that of the planktonic algae living there. The stems and leaves of those plants are fixed substrates to which most of Lake algae remain firmly attached, all summer. These fixed, non-motile formations store a vast amount of organic carbon and hold it there in the Lake until the end of the growing season. At that time, they stop growing, begin to decay, get detached and drift over the dam into the inlet – far too late to contribute to late-summer low DO levels in the marine water. This can be observed from the Lake shore – the Lake plants are still there in early October, and begin to disappear in November, when they detach and start to drift to the dam and exit to the Inlet. And the shallow bottom of the Lake is visible in the clear water around the shores all summer; it would be cloudy and opaque if the calculated biomass were all present as phytoplankton and/or suspended "algae."

The Figure on the next page illustrates the Lake's continued uptake of DIN until early November. The bars show year-long 1977 data derived from the CH2M-Hill Report of 1978. They represent measured concentrations of DIN in the Deschutes River where it enters Capitol Lake (blue) and in the Lake water at the dam (red). A huge difference between incoming and outgoing DIN develops in April and persists through October (beyond the end of Ecology's model simulation interval). That span of time is the period in which active uptake of DIN by the Lake's plants persists. The organic carbon that they have captured during the growing season begins to senesce in late October and at that time begins to drift toward the dam and Budd Inlet.

Superimposed (by me) on the bars is part of a Figure that is central to WDOE's claim that organic carbon from the Lake increases oxygen depletion in Budd Inlet. In this one, the pink data points show measured levels of DIN in the Deschutes River over the time span shown, the green graph shows values of DIN in Capitol Lake calculated by a model adapted to the Lake. That graph shows that DIN in the Lake decreases (to zero at times) and persists at zero as the growing season goes by (as do the red bars), until the end of the simulation interval.

The modelers' error in this case is their assumption that all of the DIN entering Capitol Lake ends up in organic carbon in phytoplankton. Phytoplankton is almost as easy to model as inorganic water features like salinity. The amount of biomass the modelers calculate is accurate; however most of it is in immobile plants and stays in the Lake all summer. (See Chapter 8, SMS Review.)

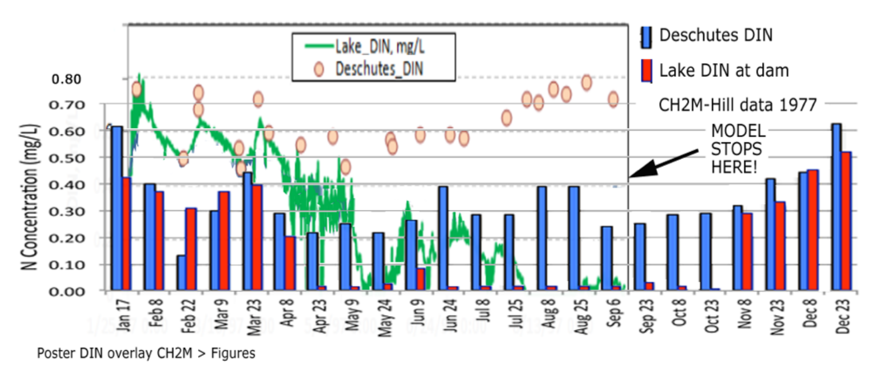


Figure 8-5. Budd Inlet Model prediction of Dissolved Inorganic Nitrogen (DIN) in Capitol Lake compared with observed data. The Model simulation ends while DIN uptake in the Lake is still continuing through mid-September and October. Superposition of Figures 7-1 (1977 data, CH2M-Hill) and 7-3b (1997 Poster- and SM Report - data and graph in Organic Carbon section, Chapter 7. The green graph is that in Fig. 8-1b above.) CH2M-Hill data (bars) are from 1977, SM graph and data points are from 1997.[This is the caption of this Figure in my SMS Critique, 2018. It refers to other pages and chapters in that Critique.]

This Figure is from Chapter 8 in my SMS Review (2018). That Chapter also describes observational evidence that the large plants (= majority of plant life in the Lake) remain attached until October, at which time they carry their stored TOC into Budd Inlet.

While responding to this same mistaken claim (that the Lake puts more TOC in Budd inlet than an estuary would) I prepared an alternative way of showing the following;

The amount of TOC transferred to Budd Inlet each year is exactly the same, whether its origin be the Lake or the Estuary. The key difference is, the Estuary would transfer a large dose every day of the growing season, whereas the Lake transfers almost all of the season's TOC production at once, in late October/early November after the growing season is over.

That detailed alternative analysis was submitted in response to an invitation to comment on the Draft Environmental Impact Statement (August, 2021) now in preparation. I've included it as an Appendix below. It is easier to follow than the first draft analysis presented earlier in my SMS Review Chapter 8 (2018). (The text that follows refers to "Table 1," where the calculations mentioned in my "Methods" section below are displayed. Table 1 itself is not included here, but can be found in my SMS Review, Chapter 8.)

4). Appendix. Analyzing WDOE's assertion that Capitol Lake puts more TOC into Budd Inlet than an Estuary would. [Text sent to writers of the Draft Environmental Impact Statement on envisioned environmental impacts of a lake, estuary, or combined feature. August, 2021.]

-------- text to DEIS writers starts here. ---------

The central flawed claim – that Capitol Lake impairs Budd Inlet's water quality – is based on the computer simulation whose output is shown below. The output is said to show that *Capitol Lake transfers more TOC [Total Organic Carbon) to Budd Inlet than would be transferred by a replacement estuary.*

Wrong.

Conclusion (in advance). The amount of TOC transferred to Budd Inlet each year is exactly the same, whether its origin be the Lake or the Estuary. The key difference is, the Estuary would transfer a large dose every day of the growing season, whereas the Lake transfers almost all of the season's TOC production at once, in late October/early November after the growing season is over.

(Introduction.) Ecology's claim that Capitol Lake puts more total organic carbon (TOC) into Budd Inlet during the growing season than a replacement estuary would do is based on the output of a computer simulation model. The Figure by WDOE showing that model's output is the oft-cited centerpiece of that flawed claim (Figure 1; shown in the DEIS as Figure 4-14, page 4-38, Water Quality Discipline Report).

The upper graph shows the concentrations of TOC in the water said by WDOE to be entering Budd Inlet from the Lake (ragged green line) or from a proposed estuary (ragged blue line) each day from January 25 to about September 15. Those amounts were *calculated* by a computer simulation of photosynthesis in those water bodies. The "pink dots" show concentrations of TOC that were *actually observed* in the Deschutes River near where it enters the south end of the Lake basin on 23 different dates.

The lower WDOE graph shows the concentrations of DIN *calculated* to be entering Budd Inlet from the Lake (green line) or an alternative estuary (blue line). The "pink dots" in that graph show concentrations of DIN *observed* in the Deschutes River where it enters the Lake basin, on the same 23 dates when the TOC entering the basin was measured.

Excess DIN is the great enemy of good water quality (that is, high bottom water oxygen levels). The lower graph shows little or no DIN escaping to Budd Inlet during late summer in the Lake alternative (green line) but a veritable firehose torrent of DIN escaping to Budd Inlet in the Estuary alternative (blue line) all summer long. Ecology's preference is to redirect attention to the upper graph, where interpretation appears to favor their claim – but in reality it does not.

The green and blue lines on the upper graph show the amounts of TOC calculated for every day in the range of calendar dates shown. That is, for every day in that entire interval the lake (green) TOC line shows the calculated amount that is *said to be present at the dam* and therefore poised to go over it into Budd Inlet, while the estuary (blue) TOC is the calculated amount that is said to be present at the same place and therefore also poised to leave the lake basin to enter Budd Inlet, in that case with no dam present.

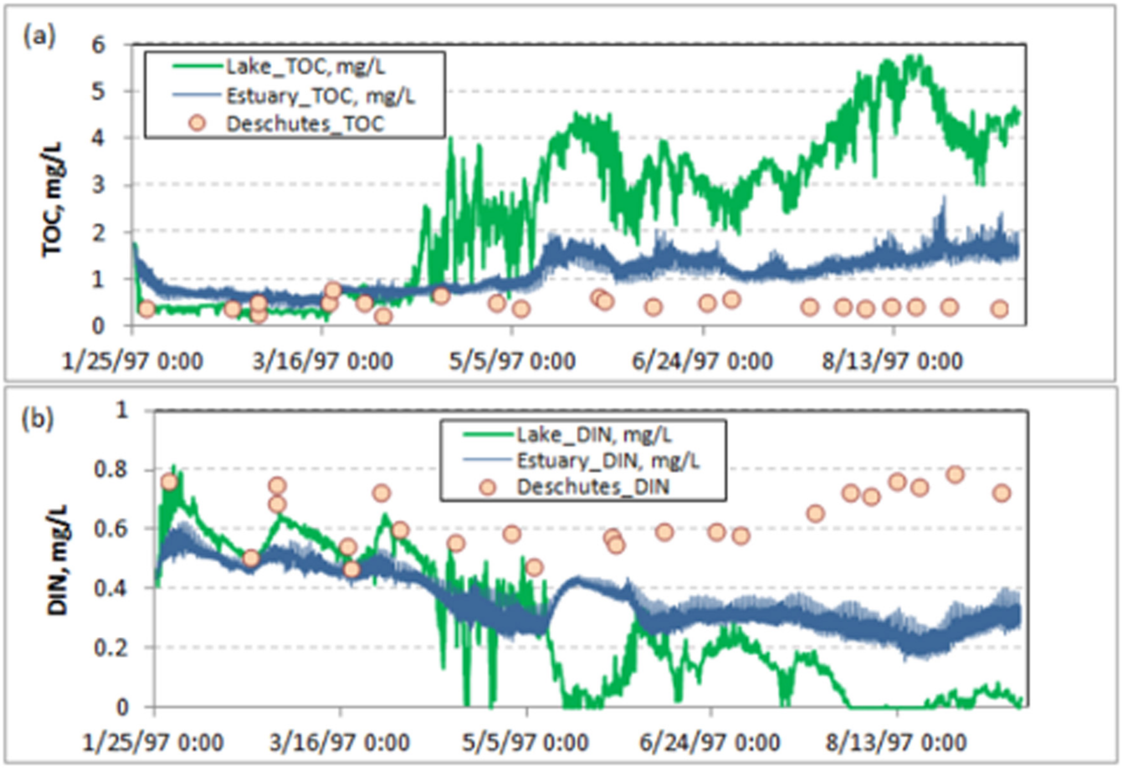


Figure 11. a) Total organic carbon (TOC) and b) dissolved organic nitrogen (DIN) concentrations <u>at the position of the Capitol Lake dam</u> under the Lake (with the dam) and Estuary (without the dam) scenarios compared with concentrations in the Deschutes River at E Street. [This Caption is Ecology's wording accompanying this graph in the document where it was presented as "Figure 11". Underlined text shows WDOE's error for the Lake case, highlighted by me.]

Figure 1. Computer simulation outputs predicting TOC formation and DIN uptake, used by Ecology to claim that the Lake puts more TOC into Budd Inlet than would a replacement estuary. DEIS Figure 4-14, page 4-38, Water Quality Discipline Report.

Ecology's upper graph shows the Lake TOC (green line) is always higher than the Estuary TOC (blue line) during the late spring and summer. *That is the reason why the claim is made that the Lake puts more TOC into Budd Inlet than would an Estuary*.

I used the observed data shown in the graphs (the "pink dots") and Ecology's method of calculation (see Column F, Table 1 below) to present the results of the computer's calculations in a different format. *That alternative format helps to show why Ecology's claim is mistaken and misleading.*

(Methods) I displayed enlarged images of the graphs on a computer screen using Photoshop. I measured the horizontal and vertical distances of the "pink dots" from the origin. From the graph scales, I determined the dates on which those observations were made and the amount of TOC or

DIN actually observed on each date. On those same dates, I also measured the heights of the green and blue graphs (x-axis to the top of the graph) and determined from those measurements the concentrations of TOC and DIN calculated by the computer for each of those dates. Using Ecology's formula converting DIN uptake to TOC created (TOC = 7 x DIN) I calculated the amount of new TOC that would result from uptake of the observed concentrations of DIN. The values I obtained are shown in Table 1 at the end of this section.

(Results) My alternative portrayals of the Ecology TOC calculations are shown in the bar graphs below (Figures 2 and 3). In both graphs, the black bars (carbon creatable from total uptake of the observed DIN (Col. F Table 1) are the same. Each black bar shows the maximum *potential* TOC that *could be created* if the photosynthesizers succeeded at taking up *all* of that day's observed available DIN.

The colored bar next to each black bar shows the computer's calculation of how much TOC *was actually created* by plants on or near that day. The green and blue bars [from Cols. D and E, Table 1] show the same values as the tops of the green and blue lines on those dates in WDOE's TOC graph (Figure 1 above. Where the black bar is much longer than the colored bar (Lake and Estuary simulations, early spring) the plants did not succeed at converting very much DIN to carbon while the water was moving through the basin. Where the colored bar is about as long as the black bar or longer (Lake simulation, growing season) the plants used up *all* of the available DIN during those days and converted it to carbon before the water reached the dam.* * See end note, this section.

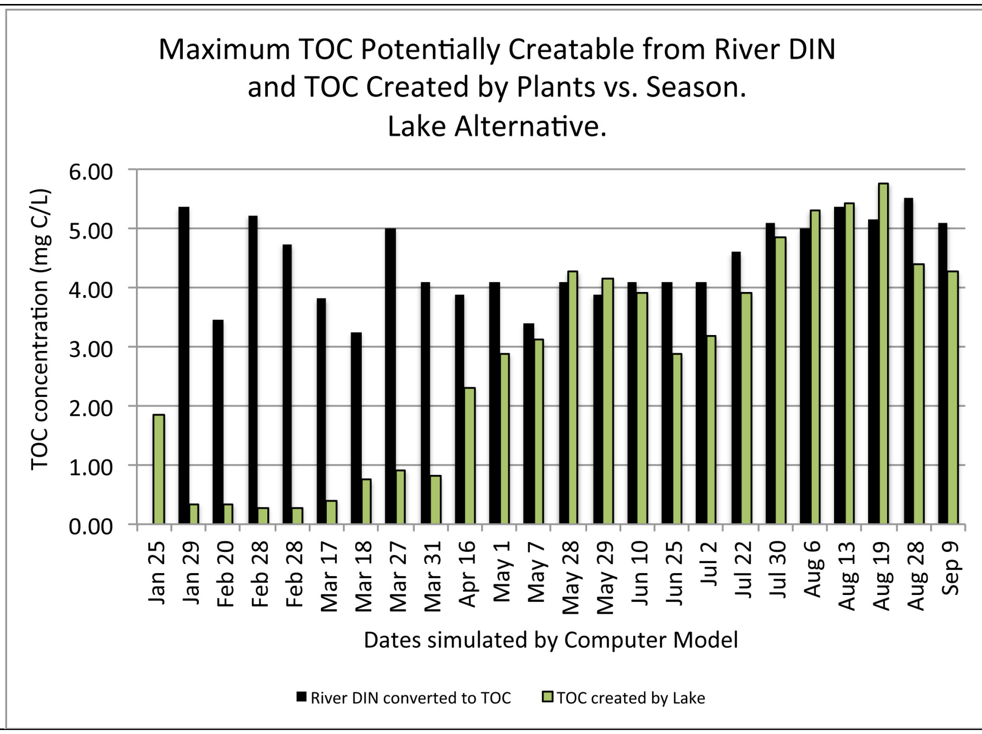


Figure 2. TOC created by Lake plants (green, from computer simulation) compared with the maximum TOC that could be created from observed DIN values (black, calculated from observed data) for 23 dates. (Cols. D and F, Table 1. See Methods, above.)

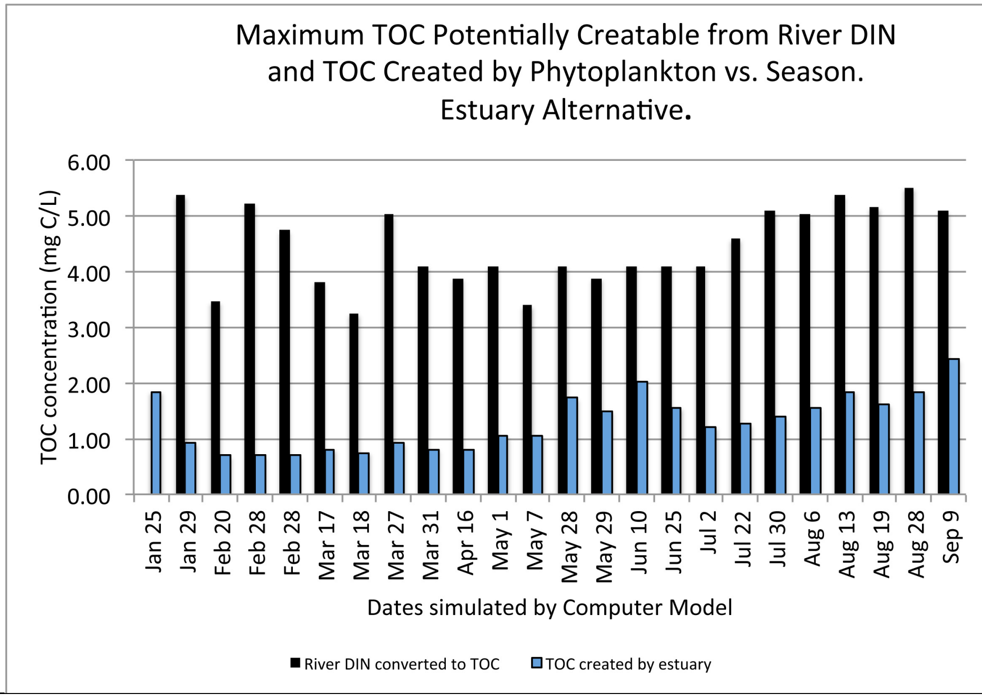


Figure 3. TOC created by Estuary phytoplankton (blue, from computer simulation) compared with the maximum TOC that could be created from the observed DIN values (black, calculated from observed data) for 23 dates. (Cols. E & F, Table 1.)

(Discussion.) Estuary Alternative. The phytoplankton in the estuary *never* succeed at converting all or even half of the DIN available into TOC before the water escapes to Budd Inlet. The escaping water carries enough DIN to more than double the amount of TOC created in the estuary itself past the dam site and out into Budd Inlet. Conversion to TOC of all of the DIN entering Budd Inlet will continue after that escaped DIN enters the Inlet, within the next day or two.

But that is outside the simulation region – "beyond the computer's view," so to speak. Tally up the TOC that forms in the inlet just beyond the simulation boundary and the result, a day or so after the estuary water escapes, is that just as much TOC is delivered to Budd Inlet as the Lake is claimed to create, each day.

Counting the TOC that forms in the Inlet as a contribution by the escaped estuary DIN, the WDOE claim that "the estuary would put less TOC into Budd Inlet than does the Lake" is false.

Lake Alternative. WDOE's computer simulation asserts that all of the newly minted TOC in the Lake moves to the dam. That could only happen if all of the new TOC was in the form of phytoplankton. Not so; almost all of the new TOC stays put in the plants that created it, all summer long. The "green line" doesn't show TOC at the dam site about to go over the dam; it shows the amount of new TOC created and parked somewhere, everywhere throughout the Lake each day, almost none of which moves downstream. In the real world, the TOC calculation is correct – *but what happens to the TOC is an uninformed assumption by the computer operators.*

Ecology's model is a superb simulation of the whole complex world of moving water, chemical processes including photosynthesis, complex shoreline configurations, tides, weather, seasonal temperature and river runoff changes, and every other major factor that affects the levels of dissolved oxygen (DO) from surface to bottom, over the whole extent of Budd Inlet. The marine model was easily extended to Capitol Lake – for phytoplankton. A crude lump-sum subroutine is said to have been attached to it to try to represent the activities of large plants, but that first approximation doesn't compare with the elegance and detail of the original model, can't possibly provide much help with understanding their roles, and is never mentioned by the modelers when interpreting the results.

So why would the model accurately calculate the amount of TOC formed daily in the Lake, if its focus is on phytoplankton? The answer is that phytoplankton, minute plants capable of doubling their biomass every 24 hours, would have enough time in the Lake to take up all of the available DIN. The transit time of water through the Lake varies from about 6-8 days to 15 days [p. 4-3, AE], longer in the low-river-flow days of summer. During that time, large plants and phytoplankters alike are able to convert all of the available DIN to TOC. The transit time of water through the proposed estuary, on the other hand, is only about one day. During that much shorter time, the sparse marine phytoplankton are unable to photosynthesize all of the available DIN and half or more of the DIN "escapes" to fuel TOC formation in Budd Inlet beyond the dam site. Beyond the "view" of the computer.

(Conclusions.) The estuary and lake alternatives would deliver exactly the same load of TOC to Budd Inlet during a year's time. The estuary would deliver about half of each new daily production of TOC directly to the Inlet in the form of new phytoplankton biomass and enough escaped DIN to enable Inlet phytoplankton to make up the full TOC load the next day, every day. The lake would store all of the daily load of TOC created by plants in the lake basin, then release the whole gigantic stored TOC reservoir into Budd Inlet during a few weeks in late October and early November – after the growing season and too late to lower the DO of the Inlet's bottom water during the critical month of September.

Conclusion. Ecology's claim is false. an estuary would deliver to (and create within) Budd Inlet more TOC every day during the growing season than would Capitol Lake.

* End note.

Complication. Each colored bar in Figures 2 and 3 actually shows the calculated amount of TOC created from DIN that became available at a time earlier than the date of the bar. For the estuary, with the river water passing through it in about one day, that would be the day before. For the lake, in which the river water takes about 15 days to pass through, the colored bar shows TOC created using DIN that entered the Lake some 15 days earlier – not the black bar standing beside it on the same date. Including this "time lag effect" in the bar graphs shown here would be so gigantically complicated as to distract from the message. I have actually shown that calculation in another publication (my SMS Review). The time lag results and the simplified same-day results shown in that exercise are so similar that the simplified bar graphs presented here show the situation we need to understand with very close fidelity.
[Note added for readers who might notice this and wonder about it.]

End of Appendix text.