## 5. CAPITOL LAKE PROTECTS BUDD INLET'S WATER QUALITY.

The SM Report presents a barrage of allegations that all implicate Capitol Lake … or are claimed to implicate Capitol Lake … as an adverse adjunct of Budd Inlet. The main claim is that dissolved oxygen levels in Budd Inlet would be higher if the dam and Lake didn't exist. In reality, hidden among the data presented by the modelers and apparently overlooked by them is exactly the opposite conclusion – namely that DO levels in Budd Inlet would be lower today – probably *much* lower – if the estuary had never been dammed.

In this Section I examine a few lesser errors in the SM Report before analyzing the data that show the Lake's beneficial effect on Puget Sound.

### 5-a. Miscellaneous Unimportant Mistaken Claims.

Page 34 of the SM Report presents three claims that provide a written description of how the modelers think the Lake exerts its negative effect. They are:

1) "The dam creates a pulsed flow that alters circulation in southern Budd Inlet."

2) "The dam and lake alter the concentrations and loads of carbon."

3) "The dam and lake alter the concentrations and loads of nitrogen. The assimilation of inorganic nitrogen by freshwater plants (e.g., *phytoplankton*)[1] with corresponding production of organic carbon alters discharges into Budd Inlet."

1) "Pulsed flow." The modelers don't define this for readers, nor do they say how "pulsed flow" alters circulation to the detriment of Budd Inlet. In this sub-section I explore this claim, with the observation that this is really not the reader's responsibility, the modelers themselves should have provided an explanation.

*All* estuaries experience "pulsed flow." Water exits seaward during ebb tides, usually at all depths, then reverses its movement and moves landward during flood tides, usually at all depths. Superimposed on this tidal movement is a persistent one-way incoming current along the bottom and a corresponding outgoing current at the surface. This is the crucial "estuarine circulation" that delivers dissolved oxygen to the bottom waters of Budd Inlet. That estuarine circulation is driven by the incoming flows of water from the Deschutes River and all of the creeks that enter Budd Inlet. "Pulsed flow" that "alters circulation" can only result from periodic modulation of (mainly) the Deschutes River discharge.

[1] Emphasis added …

Figure 5-1 shows the winter patterns of daily operation of two tide gates in the $5^{th}$ Avenue "dam" for a 60-hour interval beginning at 00:01 AM March 9 and ending about noon March 11, 1997. The actual flows through the gates were not monitored during this time, and evidently cannot be reconstructed from any other data (BISS, 1998).

The tide gates are opened and closed daily with the intent of maintaining the water level of Capitol Lake as near as possible to a "Set Point." In winter the Set Point is 5.8 feet above Mean Sea Level, during the summer the Set Point is 6.4 feet > MSL. (The latter is roughly at the +15 foot tide local tide level.)[2] The high Deschutes River flows during winter necessitate opening the gates three or four times every day at that time to maintain the lake level. Only about one opening per day is needed in summer to maintain the Set Point water level.[3]

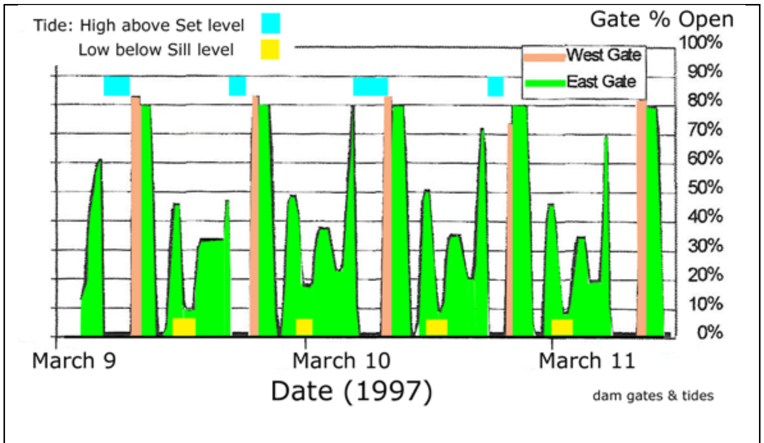


*Figure 5-1. Operations of the East and West tide gates in the $5^{th}$ Avenue dam during 60 hours from March 9 (00:01 AM) into March 11, 1997. Graphs show the durations of gate openings and the percent of maximum opening per incident. (The East and West gates are, respectively, 24 and 36 feet wide.) Blue bars are centered on the times when the high tides were above the Lake Set Level, yellow bars show times when the low tide was below the sill depth of the gates. The durations of the tide levels above and below those elevations are approximated by the widths of the bars. Source: BISS 1998.*

This description of the tide gates' operation is as described for year 1997 (the Budd Inlet Model simulation year) in the BISS study (1998).

The gates are never opened during the one or two daily intervals when the tide level is higher than the lake level. That is, under ordinary circumstances, saltwater is never deliberately admitted to the Lake through the tide gates. The gates are opened only when the Lake level is about six inches (or more) higher than the salt water level outside; the flow is mostly fresh water outward with slight mixing by salt water "leaking" inward during those times.

Salt water does enter the Lake daily, however, via another route during late summer and fall. A "fish ladder" (width 9.5 feet) for migrating salmon is positioned alongside the tide gates at the east end of the dam. It is closed during the winter but is left open from Aug-

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[2] I am not certain of the local position of mean sea level. A tide calculating routine available at http://tbone.biol.sc.edu/tide shows a line corresponding to MSL on a 1997 Budd Inlet tide graph that is at about +9 feet above MLLW.

[3] The gates are below the observation deck where their operation can't be seen. A torrent of outgoing water on the Budd Inlet side is the main visible evidence that they are open.

ust through December to enable entry of salmon to the Lake. Most of the flow through this opening is fresh water going outward. However when the tide rises higher than the lake level, salt water enters the lake. When that happens, a torrent of brackish water pouring through the "ladder" opening into the Lake can be seen by onlookers (Figure 5-2). Thus, from August through December there is never a time when ordinary tidal and river flow are completely blocked by gate closure.

To summarize, the tide gates briefly stop the river flow twice daily during the seven months January through July and restrict (but don't block) it during the five months August through December.[4] Since the river flow drives the estuarine circulation, what is the effect, if any, on that circulation?

*Figure 5-2. Saltwater with jellyfish pouring over the fish ladder, entering Capitol Lake. (Flow into the Lake is toward the top of the figure.) November 21, 2015.*

By analogy, it is as though you lift your foot from the gas pedal for a few moments while driving your car. The car starts to slow down. Then you depress the gas pedal below where you usually hold it, then ease it to let it return back to its usual position. The car momentarily speeds up faster than usual, then settles back to its average speed and stays there until your next adjustment.

By comparison with estuarine circulation, a moving car is a small fast-responding object that is tightly linked to the pedal position, its "driving" force. The estuarine circulation is the motion of a vast slow-moving body of water with enormous momentum, loosely linked to the very small driving force of the river.[5] If there is any "pulsing" of this moving saltwater by periodic slight modulation of the flow that is driving it, I expect that it would be so small as to be undetectable so long as the "pulsed flow" continued. Would there be any negative (or positive) effect on dissolved oxygen in Budd Inlet? I expect not, but in any case it is up to the modelers to describe "pulsed flow" and show readers of the SM Report why they allege that it is detrimental.

The designers of the original Budd Inlet Model considered the pattern of flow from the tide gates to be so irregular (and unimportant enough) that they didn't try to simulate it exactly in the Model (BISS, 1998). Instead, they devised an averaging subroutine. Presumably that subroutine is still in the Model. If so, could that artifact of the model be the

[4] The maximum amount of lake water that can depart via the salmon ladder (~ 51 cubic feet per second) is about half the amount carried into the Lake by the Deschutes River (~108 cfs in September during the river's low flow period. Hence the need to open the tide gates about once every day at that time.

[5] The estuarine surface current driven by watershed runoff is typically 10 to 50 times as large that freshwater runoff (in Budd Inlet, almost all of it from the Deschutes River). TMDL Appendix G, p. 49.

reason for whatever “pulsed flow” the modelers are seeing? Exactly what “pulsed flow” looks like in the real world, how it creates water quality problems (or improves water quality), or whether it is a spurious feature of the model output caused by the averaging subroutine all need to be clarified by the modelers. And if it really causes problems, those could be fixed without removing the dam, simply by changing its operation to keep the output discharge the same as the river’s input discharge at all times.

Figure 5-3 shows the modelers’ claim that the “residence time” of water in East Bay (that is, the average amount of time that water resides there before it moves out) is longer with the dam in place than if the dam were absent. The calculation is flawed, so is their explanation, and in any case, even if it were true … why is that important?

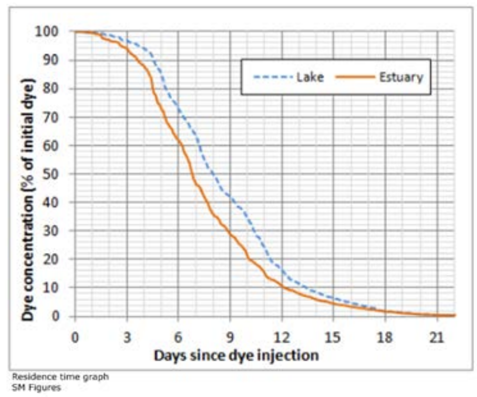



*Figure 5-3. Simulated decline of a tracer dye released in bottom water, East Bay, with time. Source: SM Report’s Figure 10 and Poster (2014). (The “e-folding time is mentioned in the Poster.)*

The graph in Figure 5-3 shows the decreasing concentration of dye “added” (by the model, that is) to the bottom water in a grid cell in East Bay as time goes by. No mention is made of how it relates to the “pulsed flow” claim. The graph shows the amount of dye that is still there at various times after its release. For example, a week after the “addition” of the simulated dye (7th day, x axis) some 60% of it would still be there if the Lake is in place, but only 46% of it would still be there if an Estuary were there in place of the Lake (y axis). (The modelers don’t tell us the time of year when the release is made, an important oversight.)

The modelers used a calculation technique that is not appropriate in East Bay – namely, the “e-folding time.” This statistic is used for basins in which the water is “well mixed” – blended from top to bottom by wind stirring, surface cooling or (less often) some other factor. (This situation is commonly seen in lakes during winter and spring.) East Bay is not a “well mixed” system – it is a “two-layer flow-through” system with a net outgoing surface current driven by Moxlie Creek and an incoming bottom flow, ultimately from the Pacific Ocean, coupled by an ongoing rise of bottom water to the surface (that is, the “estuarine circulation”).

Table 5-1 shows the “flow through” effect at station BI-1 (at the head of East Bay near the mouth of Moxlie Creek). Highlighted cells show the depths where DO levels were below the standard (4.8 mg/L) on August 20 and August 21, 1997. As can be seen, the rising tide of early morning August 21 brought in a bottom layer that slid under the layer of DO-deficient “violation” water present on August 20 and raised it toward the surface – the kind of flow-through action to which the “e-folding time” doesn’t apply. For such systems, the residence time is calculated from the volume of the basin and the rates of inflow and outflow (see BISS Report Table 2-1 p. 2-3, 1998) – not the e-folding time.

As part of this discussion, the modelers state that increased residence time … "creates more stagnant conditions and allows for greater consumption of DO by heterotrophic bacteria as they decompose organic matter in the water column and the sediments." That is only half of the story. They forgot to mention that it also creates more time for phytoplankton, algae, and the algal mat on the mud bottom – especially in a well-lit, shallow intertidal embayment like East Bay – to create more oxygen via photosynthesis – a compensating factor.

| Station BI-1 | Time & Date, 1997 | |
|---|---|---|
| DO's (mg/L) | 23:36 | 5:29 |
| Depth | Aug 20 | Aug 21 |
| (m) | | |
| -0.5 | 4.79 | 4.14 |
| -1.0 | 4.45 | 3.96 |
| -1.5 | 4.64 | 3.96 |
| -2.0 | 4.60 | 4.10 |
| -2.5 | 4.96 | 4.22 |
| -3.0 | 5.10 | 4.20 |
| -3.5 | 5.04 | 4.34 |
| -4.0 | 4.86 | 4.61 |
| -4.5 | 4.74 | 4.86 |
| -5.0 | 4.79 | 4.91 |
| -5.5 | | 4.90 |
| -6.0 | | 4.90 |
| -6.5 | | 4.90 |
| -7.0 | | 4.90 |
| -7.5 | | 5.02 |
| -8.0 | | |

*Table 5-1. Dissolved oxygen levels at depths from the surface to the bottom. Station BI-1 (head of East Bay) August 20 and 21, 1997. Highlighted DO levels below 4.8 mg/L (WQ standard violation threshold) at the bottom Aug 20 are replaced by higher DO bottom water Aug 21. Source: BISS data.*

How large an error is made by using the e-folding time to calculate the residence time of water in a flow-through system? In another report that models all of South Puget Sound, the same modelers (with two other authors) calculate the e-folding time for Budd Inlet at 18 days (SPSDOS Draft, Figure 55 p. 104). The residence time for Budd Inlet as calculated for a flow through system by the BISS team is 8 - 12 days (BISS Report).

In summary, the "pulsed flow" and "increased residence time" claims are founded on very incomplete flawed and inadequate explanations.

2) "The dam and lake alter the concentrations and loads of carbon." Of course they do. The ways in which those alterations benefit Puget Sound are analyzed in Sections 3 and 6. Those alterations seem to benefit water quality in Budd Inlet.

3) "The dam and lake alter the concentrations and loads of nitrogen." Of course they do. The ways in which those nitrogen alterations benefit Puget Sound are also analyzed in other Sections.

## **5-b. Miscellaneous Puzzling Figures**.

Beginning on page 31, the SM Report presents a barrage of Figures aimed at showing that "the dam" causes widespread DO depletion throughout Budd Inlet. As usually seems to be the case, the modelers' Figures raise more questions than they answer.

Regarding nitrogen, the modelers present three Figures using data from other sources. These are reproduced here. Two of them show nothing that supports their claims. The third is from a source (Evans-Hamilton, not cited in the SM Report's References) that I have not seen.

Figure 5-4 shows nitrogen concentrations in the Deschutes River and at an unidentified site in Capitol Lake ("CL-6") said to be near the dam. It shows, as expected, that the Lake doesn't remove nitrogen from the water during the winter. Nitrogen concentrations near the dam appear to begin to drop by early June, as expected – but there the data abruptly end.

Figure 5-5 shows additional data included in the SM Report, equally devoid of anything that supports the modelers' claims.

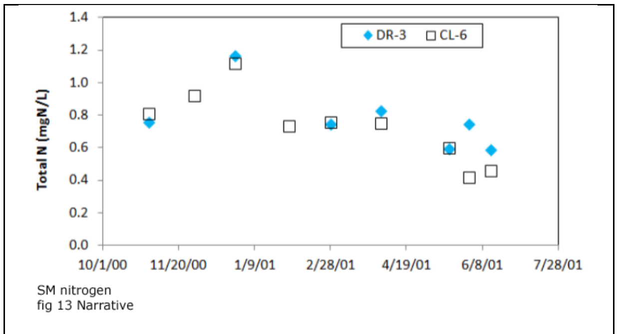
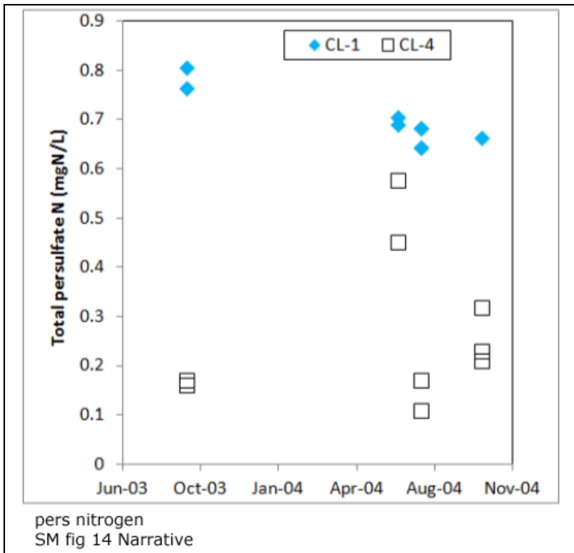



*Figure 5-4. Modelers' portrayal of "total nitrogen" in the Deschutes River and at location CL-6 ("near the dam") vs. date in 2000. (Site CL-6 is not shown on an accompanying map of Capitol Lake.) Attributed to CH2M-Hill 2001 Source by SM Report.*



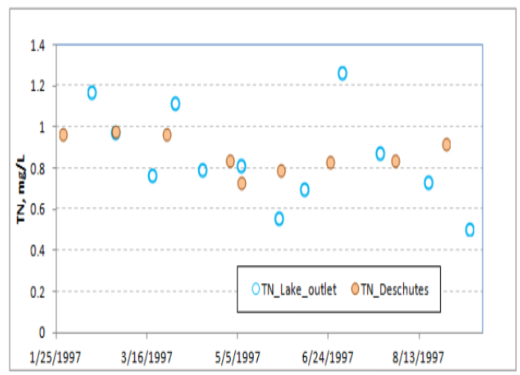




Figure 12. Total nitrogen concentration in the Deschutes River and at the location of the Capitol Lake outlet near dam during 1997.

*Source: Evans Hamilton Capitol Lake data used in the 1997 Budd Inlet Scientific Study and Ecology continuous monitoring data for Deschutes River at E Street.* Evans Hamilton data graph

*Figure 5-5. Removal of persulfate nitrogen from Lake water as the water moves toward the dam. Sites in Capitol Lake are CL-1 (near the entry of the Deschutes River to the Lake) and CL-4 (in the North Basin near the dam). Source: Roberts, Bos and Albertson, 2008, as cited in SM Report p. 37.*

*Figure 5-6. "Total Nitrogen" concentrations in Deschutes River (orange dots) and Capitol Lake near the dam (blue circles), January 1 to about late August, 1997. SM Report Figure 12, including caption. Modelers' sources "Evans-Hamilton" and "Budd Inlet Scientific Study" are not cited in their References.*

Figure 5-5 shows the concentrations of "persulfate nitrogen" (obtained via a technique that measures nitrogen in drifting bits of organic matter as well as the DIN in the water) at two sites in Capitol Lake, one at the extreme south end of the Middle Basin (CL-1) and the other near the dam (CL-4). This Figure shows dramatic drops in persulfate nitrogen in summers 2003 and 2004, and fall 2004. That is exactly consistent with what we already know about the Lake, namely that it removes nitrogen from the water as the water flows toward the dam.

Figure 5-6 from an Evans-Hamilton source (not seen by me) shows no significant change in the "Total Nitrogen" between the Lake Outlet and the Deschutes River during summer,

1997. Taken at face value, this contradicts the findings of other researchers but would support the modelers' claims if verified.

## 5-c. Where are the Estuary Data?

Figure 5-7a shows the modelers' portrayal of the theoretical water quality violations in Budd Inlet allegedly caused by "the dam" and also (Figure 5-7b) by all modern "anthro-pogenic" (that is, human-caused) agents of oxygen depletion. These Figures show that theoretical water quality violations occur throughout most of the modern Inlet. Figure 5-8 shows another example from the barrage of Figures shown on nearby pages of the SM Report. *All of the Figures presented in this format have colored DO scales in which dark blue is the smallest possible violation.* With that in mind, Figure 5-7a shows that the about half of the widespread theoretical violations "caused" by the dam are the smallest possible "violations."

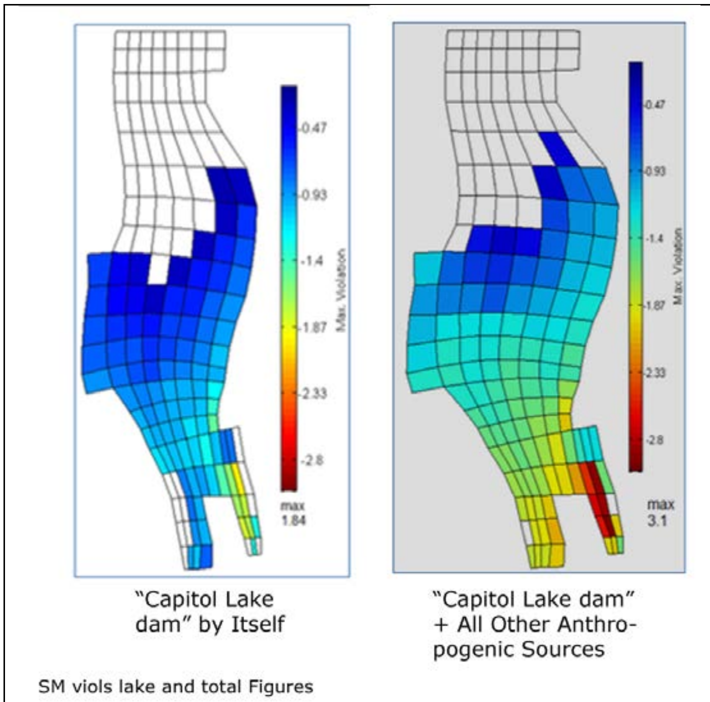



*Figure 5-7. Figures from the SM Report showing theoretical widespread DO depletion in Budd Inlet due to (left) "Capitol Lake dam" by itself, and (right) "Capitol Lake dam" plus all other anthropogenic (modern) sources. The scale colors show the maximum theoretical violation in each cell. Source: SM Figures 9 (dam) and 8 (total), p 34 and 33.*

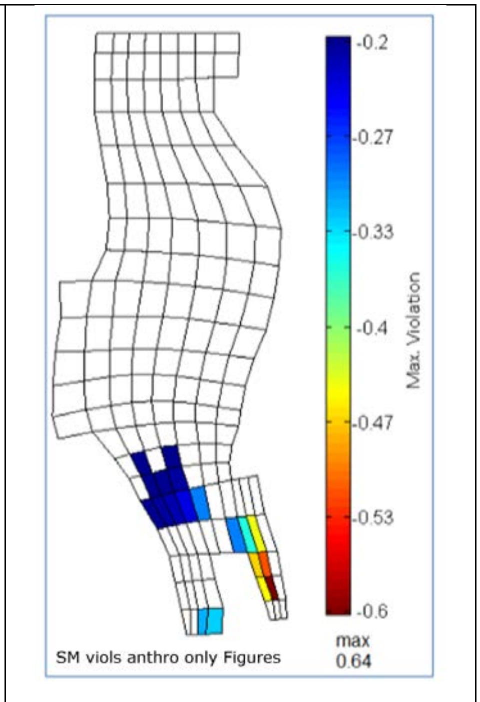



*Figure 5-8. Portrayal of theoretical oxygen depletion alleged by the modelers to be due to "all anthropogenic nutrient loads with no Capitol Lake dam." Source: Figure 17 of SM Report, p. 40.*

A puzzling feature of all of these graphs is that the captions assign the blame to "the dam" – not to "the lake." In Figure 5-8, this is especially puzzling. Does "with no dam" mean "estuary?" And if that Figure predicts the situation in a restored modern estuary, does it imply that the huge nutrient nitrogen load in the modern Deschutes River would have only the tiny localized effect shown? Or does the Figure show only the net effect of a creative interpretation of "anthropogenic?" Readers shouldn't have to wonder about interpreting the Figures. Nor should they have to resort to the following to get an unvarnished "big picture" of what the modelers are presenting.

**<u>1) Finding the 'Natural Estuary.'</u>** The most glaring of all omissions in the modelers' presentation is the apparent absence of an explicitly labeled Figure -- *in the format of Figures 5-7 and 5-8* -- that shows what theoretical water quality violations would be present if a modern-day estuary were to replace Capitol Lake and the dam. That would provide the quickest, easiest way for readers to see and compare the two options (a 'Modern Estuary' Figure with Figure 5-7b, say) and judge for themselves. Yet there is no such labeled formatted Estuary Figure in the entire Report.

There is, however, a way to reconstruct one, at least for the 'natural' pre-modern estuary. That reconstruction follows.

**<u>2) Methods and Results. Reformatting the 'Natural Estuary.'</u>** Figure 7 in the SM Report shows the minimum theoretical dissolved oxygen level for each grid square in the 'natural estuary' as calculated by the Budd Inlet model. That Figure is reproduced here as Figure 5-9[6] for readers' convenience in visualizing the method by which a re-formatted Figure (Figure 5-10) was constructed. Note that the colored scale of Figure 5-9 is visually similar to those of Figures 5-7 and 5-8 above (dark blue at the top, red at the bottom for those Figures), but Figure 5-9b's scale shows something entirely different – actual DO levels with the best water quality at the top.

The formatting procedure that I used is the same as the one by which the WDOE 'natural' estuary Figure was analyzed in another context in section 2, there to show the extent of Budd Inlet throughout which it is impossible to check up on the modelers' calculations. Here the procedure is described in detail.

I examined a full screen image of WDOE's 'natural' estuary portrayal (Figure 5-9b) using Photoshop software (Photoshop Elements 12 Expert Level). First I constructed a black-and-yellow scale bar with numbers and calibrated it by stretching it to fit the modelers' essentially unreadable color scale (see Figure 5-10a). I then used the "polygonal lasso" selection tool to carefully select the interior color of one grid square on the image in Figure 5-9b, taking care not to include any parts of the grid lines. I then clicked "Similar" under Photoshop's Selection Menu. This highlights ("selects") every grid square in the Figure that has a "similar" color, *and also that color on the modelers' scale.* The selected color on their scale always spanned a small range that could be measured with my calibrated scale. I hand-colored all selected grid squares on a printed copy of the grid, noted the DO range indicated on the scale, and repeated the process by deselecting the image and selecting another grid square.

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[6] This Figure was also used in Section 2 of this (my) Analysis, there as Figure 2-8.

The Photoshop “similar selection” process clearly identifies the squares with similar colors in, say, 90% of cases while leaving some doubt about others. (In the doubtful squares, the selection lines may follow only three of the four grid square sides, or wander across some grid squares, or appear as shimmering “islands” in the centers of some otherwise unselected squares, etc.) I resolved doubt in most cases by selecting the doubtful squares themselves and clicking “Similar” on the Selection Menu. Where doubt was not completely resolved, if any part of a square was selected I considered the whole square to be selected.

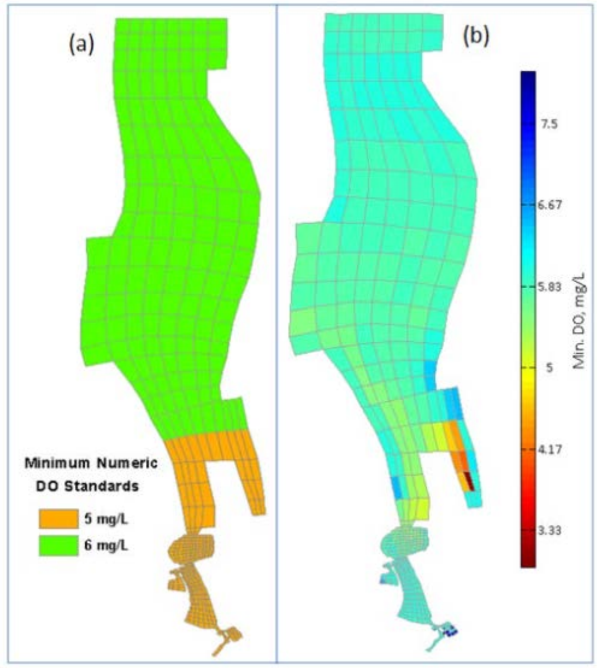


*Figure 5-9 (a). Modern water quality standards that apply to Budd Inlet. (b) Minimum dissolved oxygen levels in Budd Inlet as calculated by the modelers for ‘natural’ waters before they were altered by human activity. (In Fig. 5-9b, the “Capitol Lake” area is an estuarine extension of West Bay.) Source: Both images constitute Figure 7 (p. 32) in the SM Report. Note the impossibility of judging the extent of standards violations in Fig. 5-9b by visual comparison with Fig. 5-9a.*

There was little “overlap” of the grid squares selected in this way. Perhaps five of all of the grid squares ultimately selected by all of the similarity searches were highlighted more than once throughout this process. In those cases, I assigned the lower of Photoshop’s two “DO readings” to such squares. Groups of squares that were never matched with DO scale values of 4.8– or 5.8 mg/L or lower (orange or green ‘violation’ thresholds in Figure 5-9a), or whose mean DO’s exceeded these limits (as explained below) were judged to be in compliance with water quality standards and were left uncolored in Figure 5-10b. Figure 5-10b is the end result of that process.

This procedure identifies the theoretical DO concentrations in the ‘natural estuary’ grid squares, not the sizes of the water quality standards violations. To convert the DO levels to “violations” I used the procedure shown in Table 5-2 (page 5-11). In the Table, Columns A and B show the upper and lower DO values of all selected grid squares grouped in “similar” batches as shown by my scale in Figure 5-10a. Column C shows the means of the numbers in A and B. Batches of selected squares with means greater than 5.8- (Central Inlet) or 4.8- (Lower Inlet) mg/L were considered to meet or exceed the standards; that is, “no violations” were assigned in those squares. Column D is the maximum size of the “violation” obtained by subtracting the lower DO value of each batch (in Column B) from the 6.0- or 5.0- mg/L standard for the Central or Lower Inlet areas. Column E shows the key colors assigned to the various violations. The vertical bar in Figure 5-10b uses those colors; the same colors with the corresponding DO limits of each batch are also shown at the bottom of the Figure.

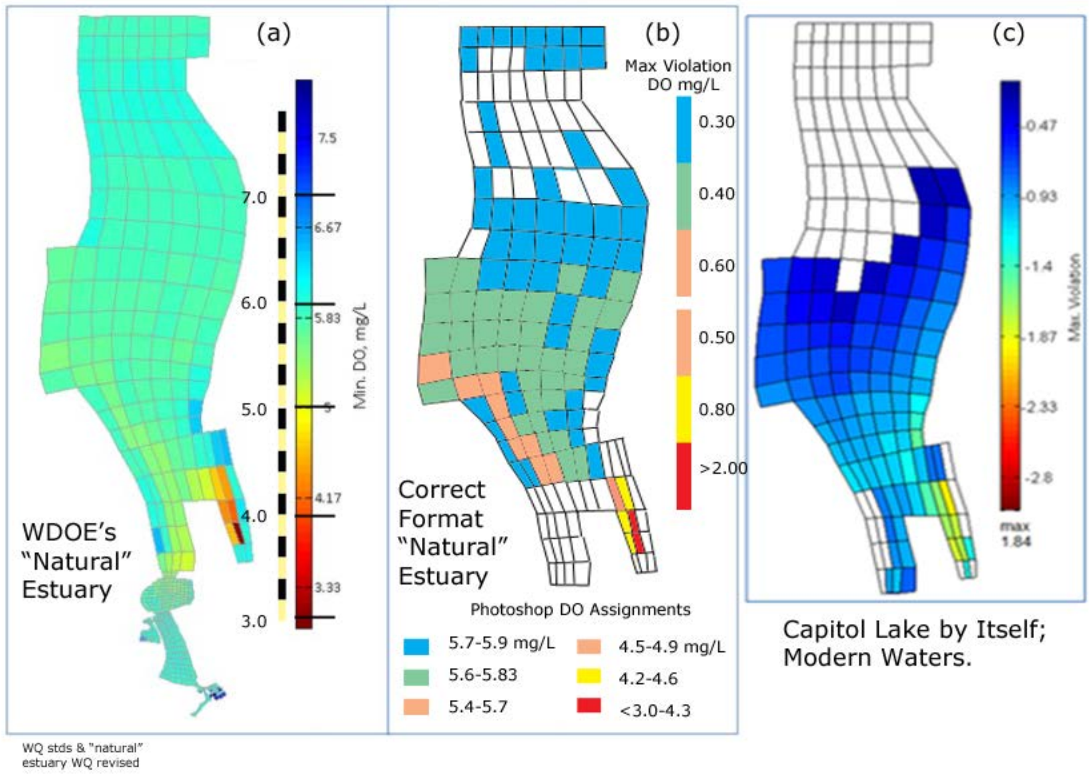


*Figure 5-10. Budd Inlet 'natural estuary' theoretical water quality violations reformatted for comparison with alleged modern violations attributed to the "Capitol Lake dam." (a) Natural estuary theoretical DO minimum levels as presented by the modelers. (Black and yellow scale bar added by me.) (b) 'Natural estuary' theoretical violations formatted for visual comparison with the alleged Capitol Lake effect (Figure 5-10c). The key color DO ranges shown at the bottom of the central figure are from Columns A and B of Table 5-2; their corresponding "violations" are in Column E. Source: Figures 5-10a and 5-10c are from SM Report's Figures 7 and 9, pp. 32 and 34.*

No attempt was made to include the Capitol Lake part of the "natural estuary." The grid squares are so tiny as to be indistinguishable and only vague washes of color are discernible there (Figure 5-10a) hinting at a null zone at the dam site but not interpretable.

The key colors used are not precisely the same as those of the modelers' scale (Figure 5-10c). As with the modelers, blue on the scale shows the smallest (near-zero) violations and red (not actually used by the modelers' in their Capitol Lake figure) shows the largest theoretical violations. The intermediate colors used by me were chosen to make the "violation" zones visually distinct in the 'natural estuary.' The exceptionally laborious nature of this Photoshop procedure required that I divide the inlet into the two zones with different water quality standards and key colors (Central and Lower Inlet, 6 and 5 mg/L respectively). Thus orange in Figure 5-10b shows the largest violations in the Central Inlet but also shows the smallest violations in the Lower Inlet.

**<u>3a) Discussion 1. Interpreting the Simulation of the 'Natural Estuary.'</u>** The modelers' discussion of their "natural estuary" findings is abbreviated. In fact, their entire discussion of Figure 5-9b (here same as Figure 5-10a) consists of just one sentence; "*The minimum DO under natural conditions is predicted to fall below the water quality standards in portions of Budd Inlet, with lowest DO predicted in East Bay*." (P. 32, SM Report).

More accurately, that sentence should have read "The minimum DO under natural conditions is predicted to fall below the water quality standards in *most* of Budd Inlet, with lowest DO predicted in East Bay." The reformatted natural estuary simulation and comparison with modern Budd Inlet (Figure 5-10) tells us much more than that, as noted below.

| Sizes of Water Quality Violations in Natural Estuary. | | | | |
|---|---|---|---|---|
| A | B | C | D | E |
| upper DO (mg/L) | lower DO (mg/L) | Mean (mg/L) | Max. Violation (mg/L) | Key Color |
| (Central Inlet) | | | | Central Inlet std = 6 mg/L |
| 5.90 | 5.70 | 5.80 | 0.30 | blue |
| 5.83 | 5.60 | 5.72 | 0.40 | green |
| 5.70 | 5.40 | 5.55 | 0.60 | orange |
| (Lower Inlet) | | | | Lower Inlet std = 5 mg/L |
| 4.90 | 4.50 | 4.70 | 0.50 | orange |
| 4.60 | 4.20 | 4.40 | 0.80 | yellow |
| 4.30 | < 3.00 | 3.65 | >2.00 | red |
| | | | | |

*Table 5-2. Conversion of the scale of Figure 5-10a (amount of oxygen in the water, mg /L) to the scale of Figure 5-10c (size of WQ 'violation,' mg/L). Size of the 'violation' (Column D) is the difference between the lowest DO value of each selected batch of similar grid squares (Column B) and the size of the standard; 6.0 for the central inlet, 5.0 for the lower inlet.*

Recall that all three of the images in Figure 5-10 are based on uncertain values. The computer often gets wrong answers in its calculations of DO's in grid squares (see Section 2) and there is no way to tell whether the computer got it right in any particular square or missed the mark. That is, the exact values shown in such Figures are not terribly trustworthy. But the value of a simulation is that it is broadly suggestive, not precisely predictive. That is, the overall visual impression – not the exact values of the numbers assigned to the squares – provides the "take home" message. *In this case, the main visual impression is that the 'natural' estuary has about as many and as widespread theoretical water quality violations as does modern Budd inlet with the dam.*

Another noticeable visual impression is that the 'natural estuary' doesn't have a low-DO null zone in West Bay, as would most real estuaries, modified or unmodified by human activity. The "Capitol Lake" part of WDOE's 'natural estuary' (Figures 5-9b and 10a) shows mostly blue high-DO water with only a visual threshold hint of an orange wash, essentially not interpretable. There probably was such a zone in the pre-modern estuary; if it was where Capitol Lake is now located, restoring the estuary would change that basin for the worse.

Another strong overall impression is that almost all of the theoretical violations in the 'natural estuary' and modern Budd Inlet are small – marginal – right on the edge of what we can measure. Individual calculations are not to be trusted, but when almost all of them are roughly the same, perhaps that is an indication that none of this is (from an ecological standpoint) worth worrying about. Neither is it worth worrying about from a regulatory standpoint; numbers from a computer are not real-world water quality violations.

**3b) Discussion 2. The enigmatic puzzle of Figure 5-8.** Why does Figure 5-8, showing the effects of "all anthropogenic nutrient loads with no Capitol Lake dam" show such tiny localized effects? The Deschutes River today almost certainly has much higher nutrient nitrogen levels than it did in the pre-modern past. If the dam were not present, that load of nitrogen would go full blast directly into Budd Inlet, creating as much plant growth (mainly in the form of phytoplankton) as it creates today in Capitol Lake, with consequent bottom water DO depletions. That would color most of Budd Inlet with "violations." Did the modelers subtract the "natural" NN load of the pre-modern Deschutes River from the modern real-life NN load and call the difference "anthropogenic" to get the tiny "anthropogenic effect" shown in that Figure?

Figure 5-7b supposedly shows the combined total effect of both the Capitol Lake dam and "all other anthropogenic sources" of oxygen depletion (in the Figures to the left and right of Figure 5-7b) on Budd Inlet. The "combined effects" Figure could not have been obtained by simply adding the data in the two Figures that flank it. "All anthropogenic effects" (Figure 5-8) shows no effect at all in West Bay, except for two corner grid squares. Capitol Lake by itself (Figure 5-7a) shows mostly tiny effects in West Bay, with grid squares along the west shore (same as in the "all effects" Figure) totally unaffected. Yet addition of the blank squares in both the "dam" and "all anthropogenic" Figures created theoretical violations throughout all of West Bay.[7] Elsewhere (say along the east shore of Central Budd Inlet) the total violation sizes are, according to their colors on the modelers' scale, greater than the sums of their parts. In addition the range of the area affected by both dam and "all other" sources has been extended northward from the limit "caused" by the dam by itself.

Figure 5-7b – "total effects" -- can't be obtained simply by adding the dam effects and the "all other anthropogenic sources" effects of the two Figures flanking it. Something else not explicitly mentioned has been added to produce Figure 5-7b. I speculate that the "something else" is the full sum total blast of nutrients from the Deschutes River, "natural" and "anthropogenic" (the amount used in creating Figure 5-8). But readers should not have to speculate about how the modelers arrived at their answers; the modelers should have made that clear.

[7] If certain squares had DO's barely above the standards – say, depleted by only 0.1999 mg/L, not technically "violations" – they would appear uncolored in the Figures. Addition of two such squares from Figures 5-8 and 5-7a could give a "violation" of up to 0.4 mg/L. The colors of the previously uncolored grid squares in Figure 5-7b usually show "violations" in excess of 0.4 mg/L, indicating that this mathematical accounting artifact is not the reason for "violations appearing out of nowhere."

What would a modern Estuary look like, formatted in the manner of the Capitol Lake Figures, with the full blast of modern-era “natural” + “anthropogenic” NN pouring into it? *The absence of a “modern estuary” Figure formatted like the other Figures is the most glaring omission from the entire SM Report.* The modelers didn’t show us that, *and need to do so*.

**5d. Conclusions.**

The modelers have not shown us that Budd Inlet would be better off if the dam were removed. On the contrary, the information contained in this part of the SM Report strongly suggests the opposite. That is;

*Budd Inlet in its “natural” pre-dam condition would have had as widespread water quality violations as it does in modern times with the dam and Capitol Lake in place.*

Another way of phrasing that is this;

*The dam and Capitol Lake have kept modern Budd Inlet at nearly the same overall level of water quality with regard to modern standards as would be present in the “natural” Budd Inlet of pre-modern times.*

Or, *Budd Inlet’s water quality is no worse today than it would be if the ‘natural estuary’ were here instead of the dam*.

However, there is no bringing back the ‘natural estuary.’ If the dam were removed today, we would have a ‘modern estuary’ loaded with Deschutes River N-nutrients. This would almost certainly cause serious low DO violations virtually everywhere. That is almost certainly the reason why the modelers didn’t show it.

*The dam and the Lake provide powerful protection of the Inlet’s water quality from the anthropogenic effects of modern activities.* Without the dam, it is to be expected that the condition of modern Budd Inlet would be much more degraded than it is today. That is to be expected, from the ecology of Capitol Lake behind the dam and its huge removal of nutrients from the Deschutes River.