MEMORANDUM

December 7, 2016

TO: Dustin Bilhimer

FROM: A. J. Whiley

RE: Relative N and P loading among major WWTPs discharging to Puget Sound.

Dustin –

This is an update from the prior memo regarding the relative level of nutrient loading among the various wastewater treatment plants that discharge directly to Puget Sound. (This latest round incorporates a few plants into the analysis that were initially overlooked. It's also not just based on 2006 data (which comprises the model dataset) and so takes into account the relatively new Brightwater plant, a major discharger.)

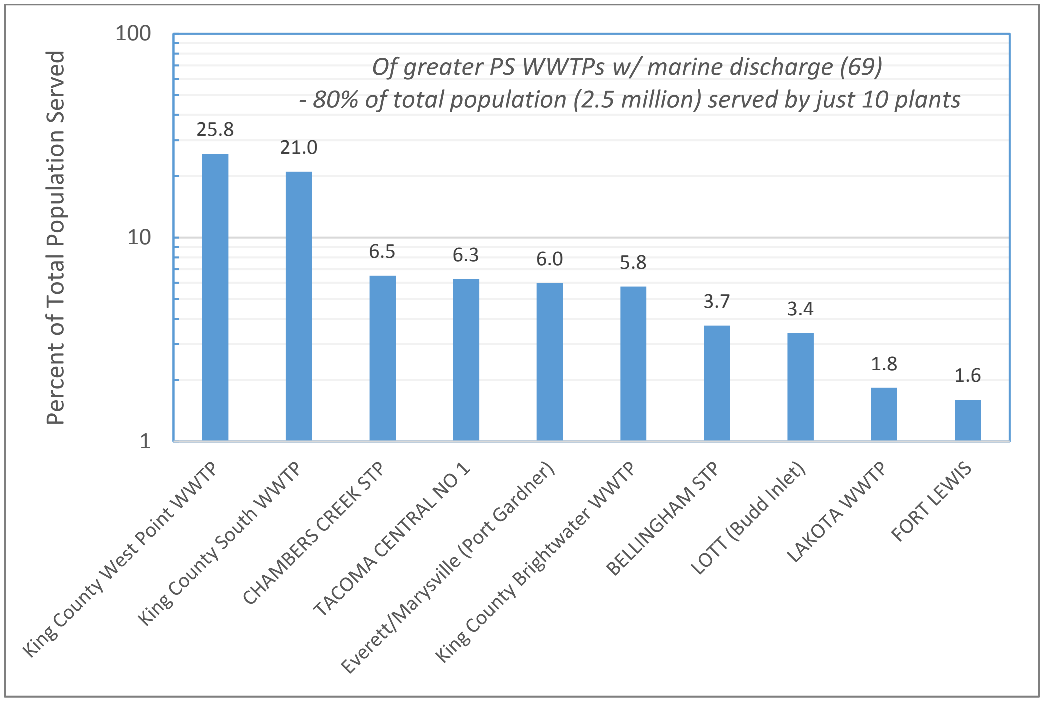
Among the 69 plants considered with marine discharge throughout the greater Puget Sound just 10 serve around 80% of the total population connected to a central sewer collection system. The vast majority of this population is connected to King County's West Point (26% of population total) and South Plant (21%). For this reason, these two facilities are the dominant point source discharge points for nutrients in Puget Sound.

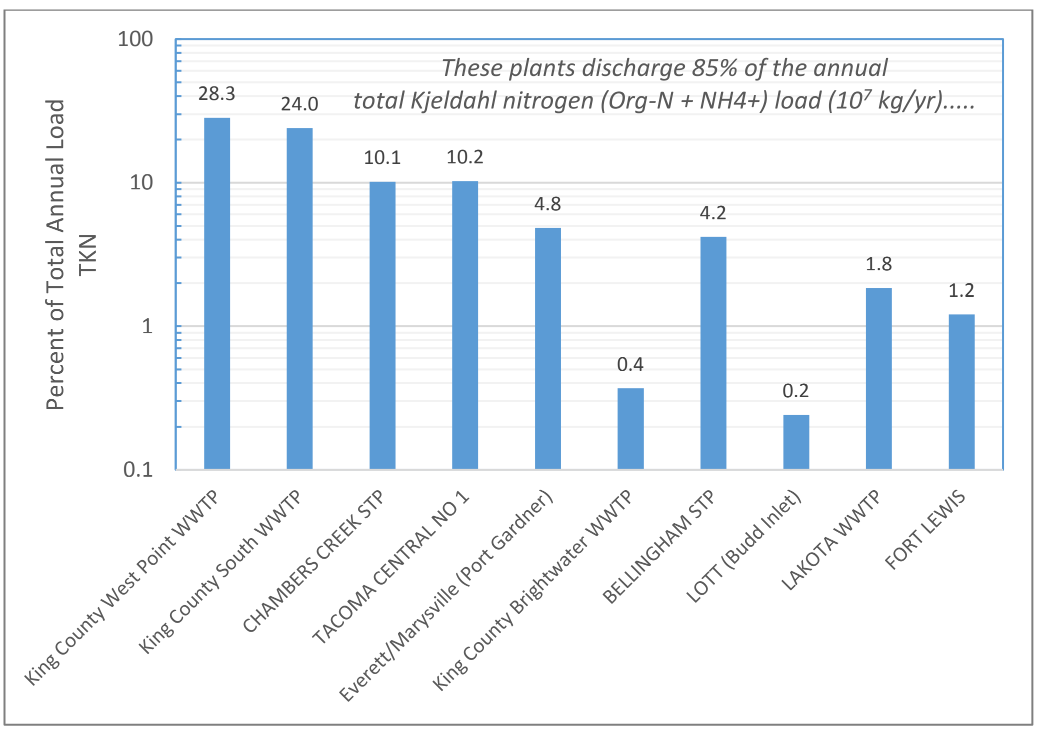
The West Point plant effluent alone comprises 28% of the total annual Kjeldahl nitrogen (organic N + ammonia) loading among all the marine dischargers to greater Puget Sound (10^7 kg/yr). Over 70% of the annual load associated with WWTP discharge is attributed to just 4 plants (West Point, South, Chambers, and Tacoma #1).

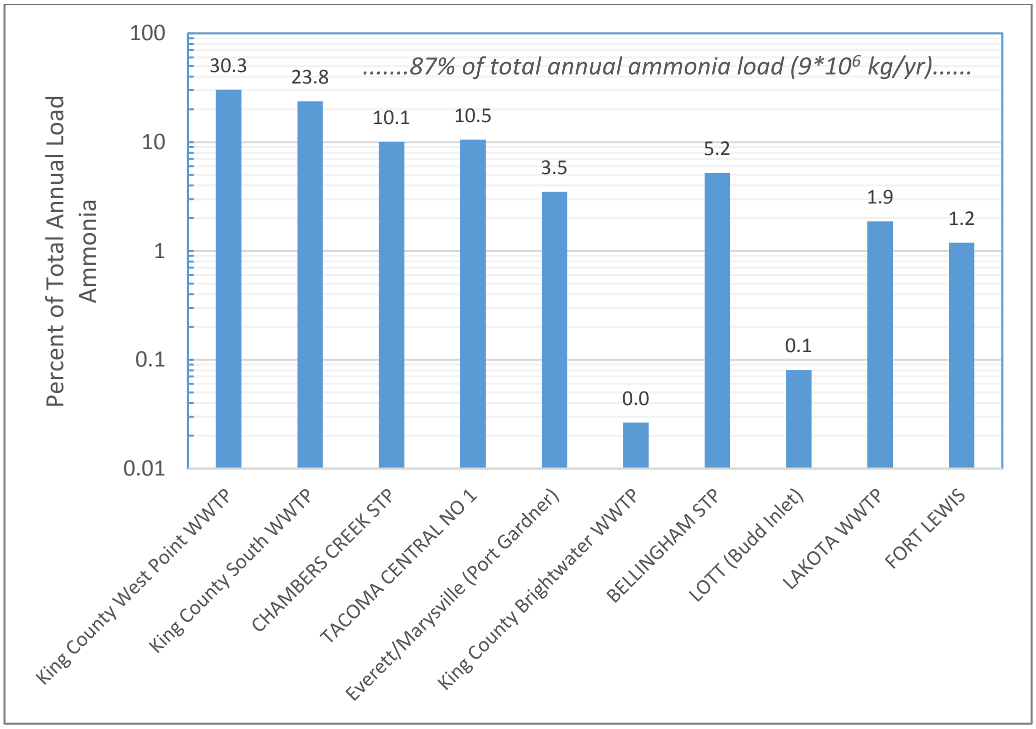
The relative contribution among the 10 major wastewater treatment plants for ammonia loading shows a similar relationship ($9*10^6$ kg/yr). Worth noting is that the dominant form of nitrogen, as nitrate or ammonia, differs among these plants. For instance, comparing the bar graphs of nitrate and ammonia loading, focusing on the Brightwater plant, effluent loading to Puget Sound as ammonia is negligible while the dominant form is nitrate. This has to do with the level of oxygen transfer during the treatment process; more oxygen transfer results in a higher representation of nitrate. More commonly, and particularly evident for facilities such as Chambers and Tacoma No. 1, the dominant form of effluent N is as ammonia.

Just focusing on the total nitrogen loading graph, it's evident that the percent representation among the various plants tends to follow the percent population (the dominant loading factor relating to influent/effluent quality and quantity) with the exception being the LOTT plant (due to advanced treatment that specifically targets N removal).

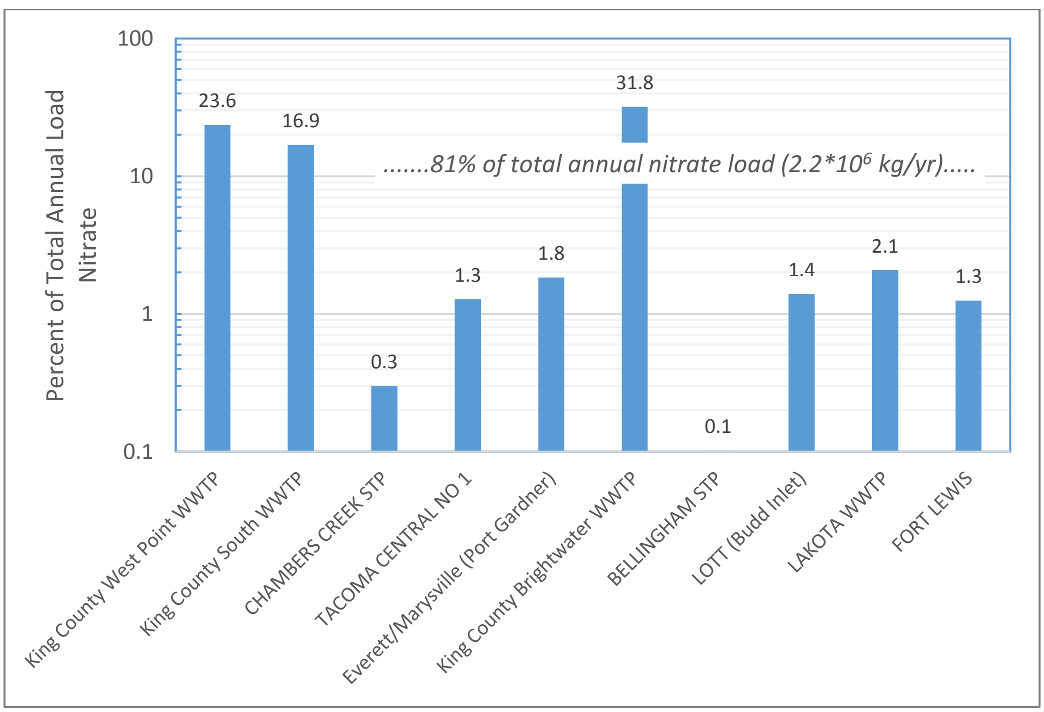
The relative effect these plants have on dissolved oxygen is not solely based on their individual loads, though that is important. Additional considerations include the depth and circulation patterns at the discharge point, among others. A great utility of the model is to examine how the wastewater effluent is circulated and its effect on primary production and, in turn, dissolved oxygen concentrations. It's likely that these larger plants have a more "regional" effect while the smaller plants have a more localized effect. For this reason, these 10 plants are good place to start when examining larger scale dissolved oxygen impacts.



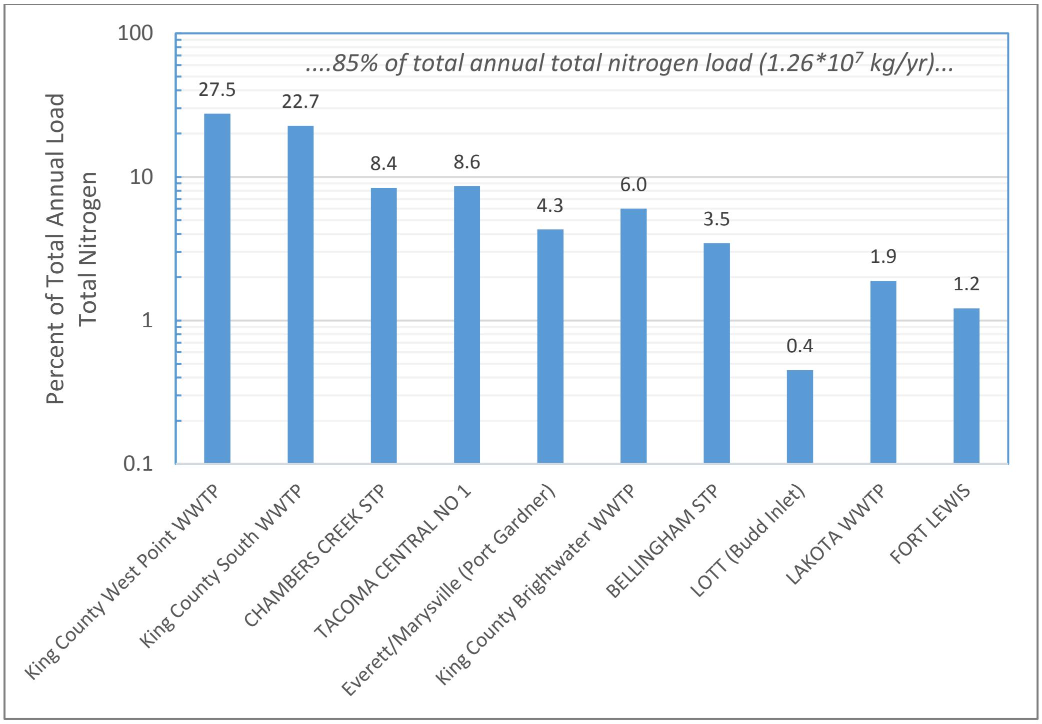




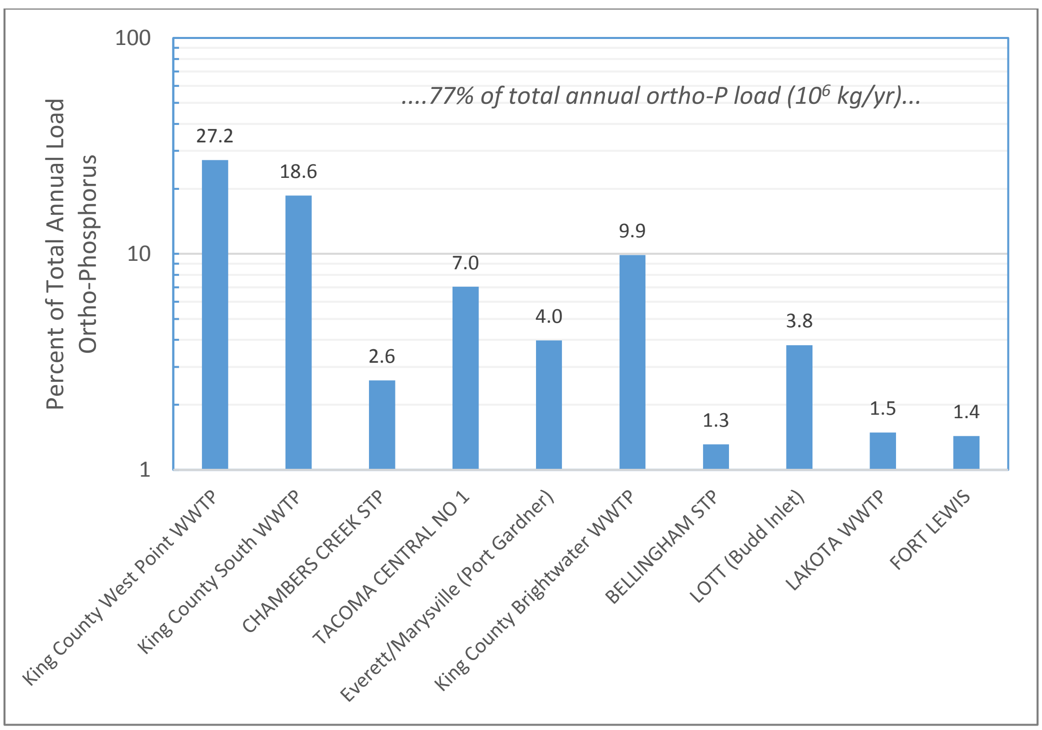
Percent of Total Annual Load Ammonia
100
10
1
0.1
0.01
.......87% of total annual ammonia load (9*10^6 kg/yr)......
30.3
23.8
10.1
10.5
3.5
0.0
5.2
0.1
1.9
1.2
King County West Point WWTP
King County South WWTP
CHAMBERS CREEK STP
TACOMA CENTRAL NO 1
Everett/Marysville (Port Gardner)
King County Brightwater WWTP
BELLINGHAM STP
LOTT (Budd Inlet)
LAKOTA WWTP
FORT LEWIS



Percent of Total Annual Load Nitrate
100
10
1
0.1
.......81% of total annual nitrate load (2.2*10^6 kg/yr).....
23.6
16.9
0.3
1.3
1.8
31.8
0.1
1.4
2.1
1.3
King County West Point WWTP
King County South WWTP
CHAMBERS CREEK STP
TACOMA CENTRAL NO 1
Everett/Marysville (Port Gardner)
King County Brightwater WWTP
BELLINGHAM STP
LOTT (Budd Inlet)
LAKOTA WWTP
FORT LEWIS

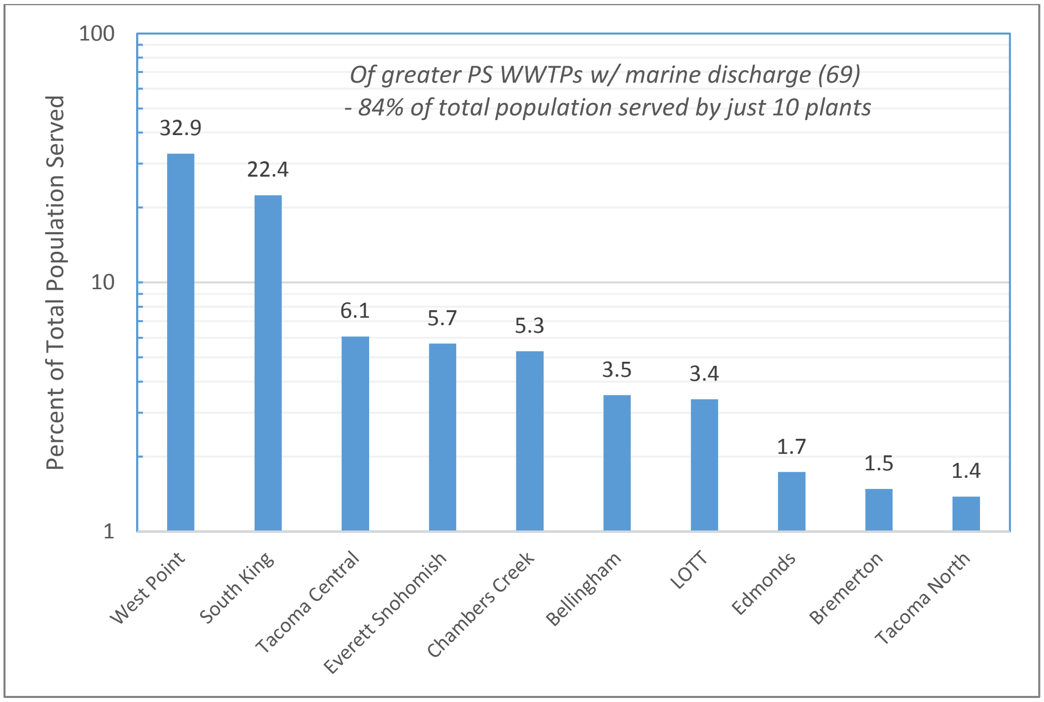


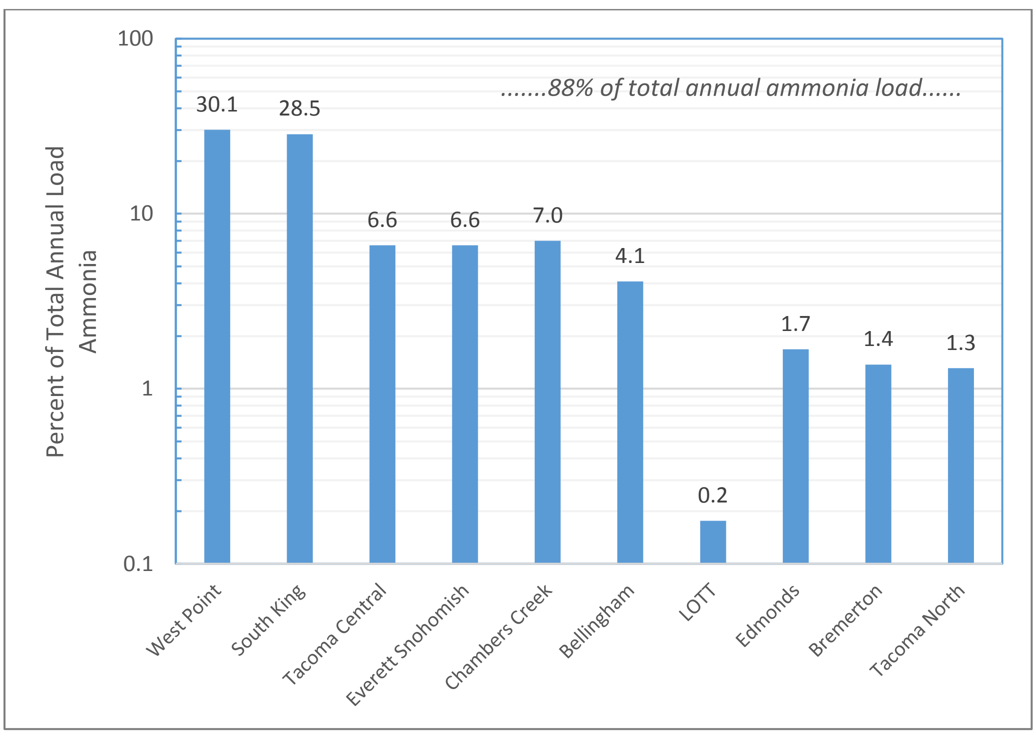
Percent of Total Annual Load
Total Nitrogen
....85% of total annual total nitrogen load (1.26*10^7 kg/yr)...
100
10
1
0.1
27.5
22.7
8.4
8.6
4.3
6.0
3.5
0.4
1.9
1.2
King County West Point WWTP
King County South WWTP
CHAMBERS CREEK STP
TACOMA CENTRAL NO 1
Everett/Marysville (Port Gardner)
King County Brightwater WWTP
BELLINGHAM STP
LOTT (Budd Inlet)
LAKOTA WWTP
FORT LEWIS

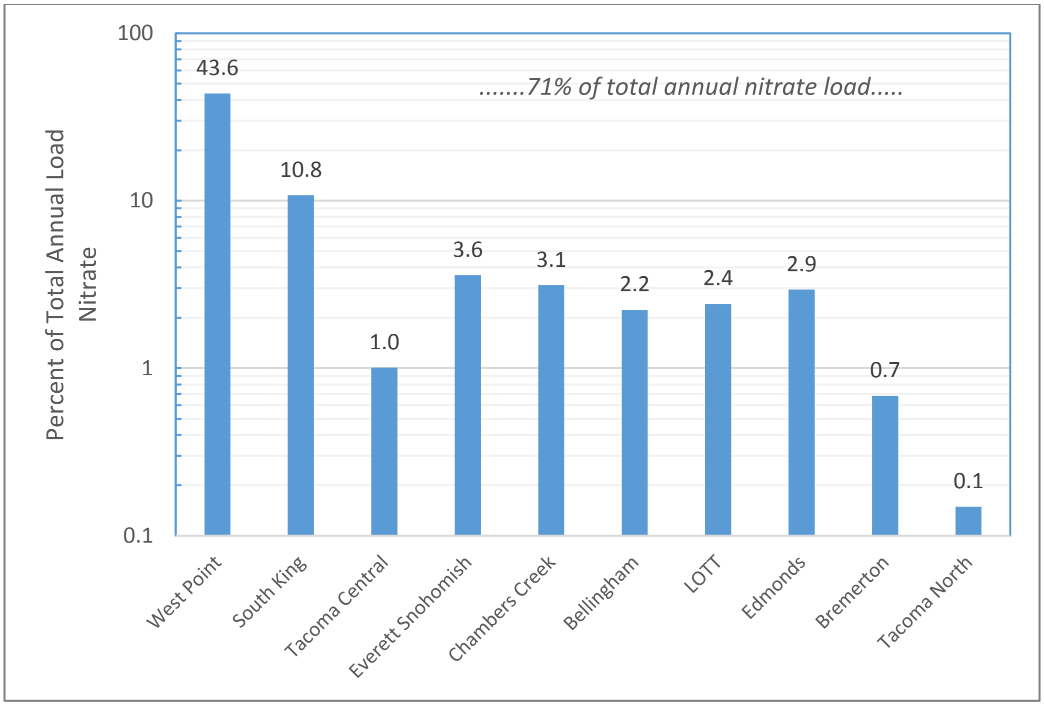


Percent of Total Annual Load
Ortho-Phosphorus
....77% of total annual ortho-P load (10^6 kg/yr)...
100
10
1
27.2
18.6
2.6
7.0
4.0
9.9
1.3
3.8
1.5
1.4
King County West Point WWTP
King County South WWTP
CHAMBERS CREEK STP
TACOMA CENTRAL NO 1
Everett/Marysville (Port Gardner)
King County Brightwater WWTP
BELLINGHAM STP
LOTT (Budd Inlet)
LAKOTA WWTP
FORT LEWIS

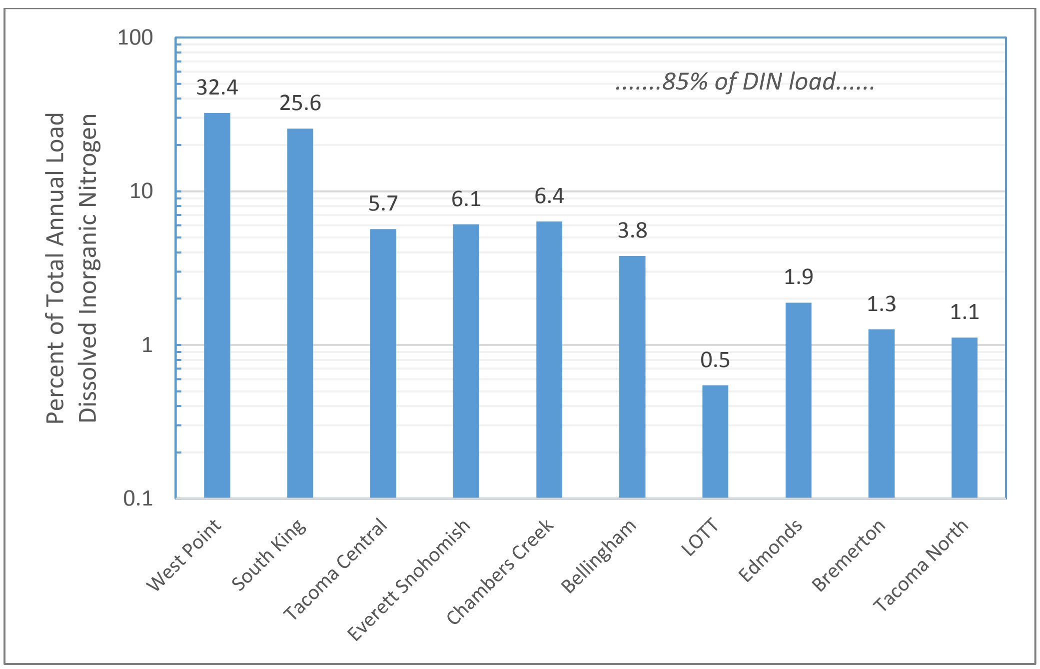
The next series of graphs present the major wastewater dischargers but solely based on 2006 data (from Teizeen). This data served as input to the model. For the most part there is a similar story between the two datasets. Differences arise primarily with the addition of the Brightwater discharge (takes flow away from West Point and South plants), the emergence of the upgraded Fort Lewis plant and the segregation of flows for Marysville and Everett (I combined the discharge of both plants since they both (at times) release flows to the same marine location).



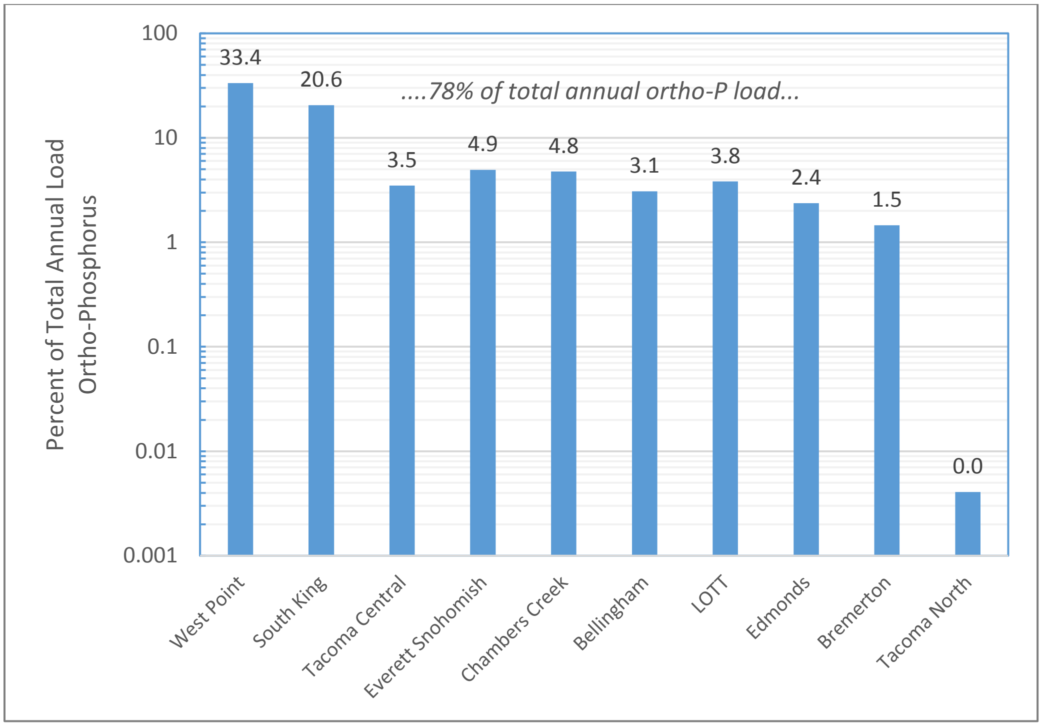




Percent of Total Annual Load
Nitrate
100
10
1
0.1
.......71% of total annual nitrate load.....
43.6
10.8
1.0
3.6
3.1
2.2
2.4
2.9
0.7
0.1
West Point
South King
Tacoma Central
Everett Snohomish
Chambers Creek
Bellingham
LOTT
Edmonds
Bremerton
Tacoma North



Percent of Total Annual Load
Dissolved Inorganic Nitrogen
100
10
1
0.1
.......85% of DIN load......
32.4
25.6
5.7
6.1
6.4
3.8
0.5
1.9
1.3
1.1
West Point
South King
Tacoma Central
Everett Snohomish
Chambers Creek
Bellingham
LOTT
Edmonds
Bremerton
Tacoma North



Percent of Total Annual Load
Ortho-Phosphorus
100
10
1
0.1
0.01
0.001
33.4
20.6
3.5
4.9
4.8
3.1
3.8
2.4
1.5
0.0
....78% of total annual ortho-P load...
West Point
South King
Tacoma Central
Everett Snohomish
Chambers Creek
Bellingham
LOTT
Edmonds
Bremerton
Tacoma North