Interoffice Memorandum June 24, 2002

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To: Coquille team
Re: Update Coquille TMDL Review
From: Bob

This memo will provide a quick update on the current efforts to update the WASP-DYNHYD model used to develop waste load allocations for Myrtle Point and Coquille wastewater treatment plant dischargers in the Coquille Estuary. Please review the memo and provide feedback on:

The level of documentation needed
Alternative effluent limit and WLA strategies
What further do we want to do?

The memo will provide an indication of the issues and explanations for the updated analysis.

Background:

The lower Coquille River was listed on the States 303(d) list for dissolved oxygen in 1992 requiring the development of a Total Maximum Daily Load. To support the development of the TMDL the Department applied the USEPA supported WASP4-Dynhyd5 numerical model. The model was calibrated using two independent synoptic data sets collected in 1990 and 1991. The synoptic data showed dissolved oxygen concentrations falling below the standard of 90% of saturation to minimum concentrations near 7 mg/l near Coquille. Analysis of the data indicated that elevated levels of sediment oxygen demand (SOD) in the upper reaches of the estuary near Myrtle Point. Subsequent sediment oxygen demand measures verified elevated SOD near the head of tidal influence.

The major findings of the analysis were that:

The wastewater treatment plants on minimum dissolved oxygen estimated were estimated as <0.50 mg/l,

that Waste Load Allocations of 10 mg/l BOD5 and 4 mg/l ammonia would result in no measurable impact on dissolved oxygen during critical low flow conditions, and

That discharge from Bandon, in the lower estuary, and Powers upstream of the estuary did not influence the oxygen depressions observed near Coquille.

Updated Conditions:

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Since the development of the TMDLs the dissolved oxygen standards has changed from a minimum percent saturation to a 30-day average of 8 mg/l, a 7-day mean minim of 6.5, and an absolute mean of 4.0 mg/l. In addition the dissolved oxygen allows for a 0.10 mg/l depression to be assigned to any single source and 0.20 mg/l for all sources when natural background conditions preclude attainment of the criteria. Prior to implementing the WLAs the Department agreed to re-assess the TMDL and allocations.

To support this re-assessment the Department collected further data on SOD near where the elevated levels of SOD were observed in 1991, additional source load data, and ambient temperature and dissolved oxygen levels between Myrtle Point and Coquille. The ambient data showed dissolved oxygen near a minimum of 8.0 mg/l near Coquille. Since ambient data did not provide direct measures of stream flow, ammonia, nitrate, of ultimate carbonaceous oxygen demand the data does not support model verification. However, if the previous evaluation may help explain why higher dissolved oxygen levels were observed in 1999 compared to 1991.

Approach:

To support the re-assessment the Department updated the antiquated wasp and dynhyd files to be compatible with the newer window versions WINWASP2 and WINDYNDHYD. The updated input files were then modified to represent conditions observed in the 1999 field data surveys. Modified inputs including, stream flows, tides, effluent loads, temperature, and sediment oxygen demand.

	At Powers			To Bay	N. Fk
	Day	7-day	30-day in Sept.	Inst	Inst
9/15/1990	25	26.7	24.7	35	28
9/27/1991	14	15.14	18.5	27	12
9/8/1999	22	23	21.9		
9/12/2000	25	27.1	NA		
30Q10	15.5e			30e-21.7e	13.5e
7Q10	13e			24.7e-18e	11.3e

E = estimated

Estimated method for N. Fk compared to Powers

25/28 = 0.89, 12/14 = 0.86, $Q_{NFk} = Q_{powers}*0.875$

Estimated method for S.Fk. to head of tide

35/25 = 1.4, 27/14 = 1.9. $Q_{\text{head of tide}} = Q_{\text{powers}}*1.9$ highest estimate, $Q_{\text{head of tide}} = Q_{\text{powers}}*1.4$ lowest estimate,

Stream flow was not directly measured for the 1999 data set. Stream flow can have a significant influence on the influence of the wastewater discharges on dissolved oxygen. Stream flow was estimated using data collected in 1991 and extrapolation from the gauge on the South Fork near Powers. In 1990 and 1991 stream flow was measured directly. Stream flows measured in 1999 were greater than those observed in 1991 and used to establish the original allocations. The method for estimating stream flows is crude and the lack of precession is indicated by the different ratios observed for the data collected in 1990 and 1991. The flow statistics at Powers were developed using data collected between 1916 and 2000.

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Tides were taken from the NOAA/NOS web page for the dates sampled and modified using the constants for Bandon, Oregon.

Effluent loads were taken from monitoring data reported for the month. Reported monthly average discharge and BOD5 were used. Data collected on the day ambient samples were collected were used for ammonia and nitrate. Organic nitrogen was estimated as by definition as the difference between Total Kjeldahl and Ammonia nitrogen. The BOD5 values were converted to UCBOD by applying the calibrated instream decay rate: $\frac{BOD_5}{1-e^{-0.055*5}}$.

	Q mgd	TKN	NH3	TSS	BOD
Myrtle Point	0.209	10.3	7.6	8.0	31
Coquille	0.37	1.6	0.74	3.2	2.0

In the 1991 surveys the observed effluent quality for mid September (9/20/1991) for Myrtle Point discharging near 0.2 mgd of 14 mg/l ammonia and 55 mg/l BOD. Coquille was discharging at near 0.76 mgd of 14.5 mg/l and 9 mg/l BOD5.

Temperature was similar in 1991 and 1999. Temperature was entered as a state variable and was not simulated. For those reaches where temperature was not measured in 1999 the temperatures observed in 1991 were assumed.

Sediment oxygen demand was measured at three sites generally corresponding with the area of observed high SOD during 1991. The individual sites were evaluated for the best stabilized measure of SOD. A grand mean of 8.0 g/o2-m2-day was calculated. The initial SOD was used in the model application for the area where SOD appears to cause oxygen depletion. SOD was modified by trial and error to a value of 7.0 g02-m^2dday to allow the simulated oxygen to represent the observed oxygen depletion. In 1991 a SOD of 4.0 was used in the upper reaches. The SOD for the remainder of the model reaches was the 0.5 g/02-m2-day used in the original calibration.

Site, 1999	SOD
1	11.5
2	8.71
3	3.9
Mean	8.04

Verification to 1999 data				
Location	Time	Obs. DO	Simulated SOD / DO	
			8.0	7.0
Low DO	12:48	7.8	7.65	7.8
Increased Peak DO	13:21	8.5	8.40	8.5
Near Coquille	15:15	8.0	8.20	8.25
Lowest Observed	15:50	7.9	7.9	7.95

All other rates, constants, and kinetics were held constant. Once adjusted for SOD the model appeared to explain reasonably well the observed instream dissolved oxygen concentrations observed in 1999.

Potential Allocations / Sensitivity

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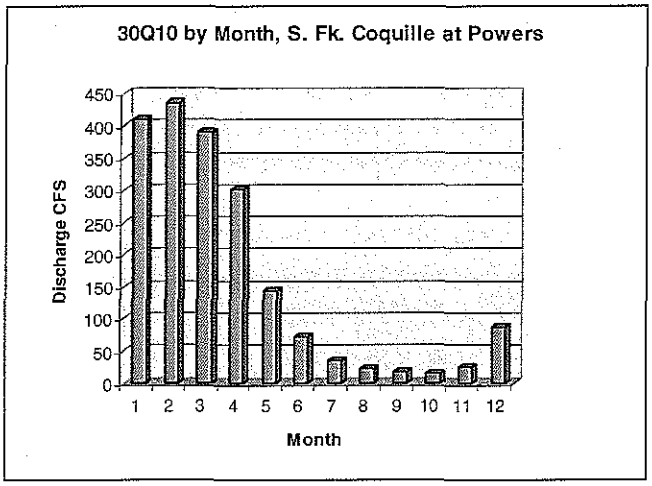
Two sets of potential WLA strategies were evaluated. The allocations were developed by identifying a set of design conditions used to simulate the affect of alternative effluent limits on instream dissolved oxygen depression. The design conditions established stream flow, tides, stream temperature, boundary conditions, and effluent discharge volumes.



Stream flow for one scenario was set at an estimated annual thirty day average with a recurrence interval of 10 years (30Q10). The 30Q10 was developed for the USGS gauge at Powers. The monthly 30Q10 flows are lowest in September – October corresponding with historical period of lowest dissolved oxygen as reported in the TMDL. The 30Q10 for Powers was converted to discharge from the North Fork and S. Fk. At the head of tide as described in table 1 above.

A representative September tide was developed as the average depth relative to mean sea level for each of the four (higher high, lower lows, lower high, higher low) tides that occurred in September for the past 10 years. Data was developed from the NOAA-CO-OPS tide predictor.

Stream temperature for September was derived from the observed data in 1991 and 1999 as described above.

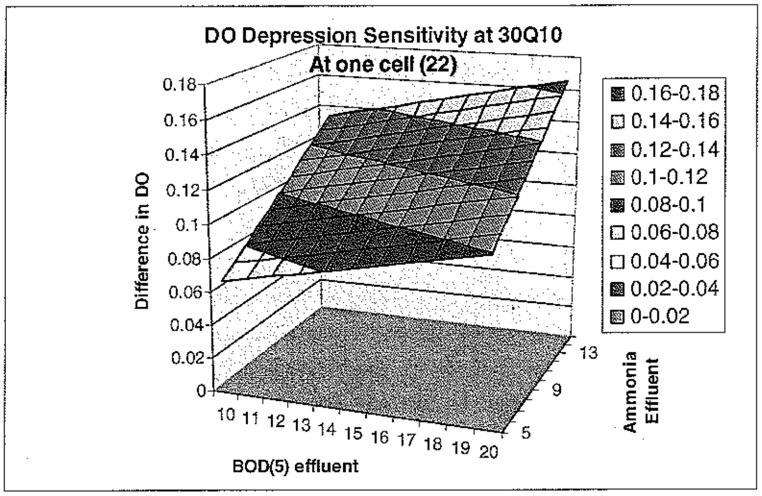
Boundary conditions were held consistent with calibration except for ocean water oxygen. The dissolved oxygen for the ocean water was calculated at saturation using APHA standard methods.

The STP flows were derived using data from September for current discharge monitoring reports. Effluent discharge for Myrtle Point was 0.209 mgd, Coquille 0.37 mgd, and Bandon of 0.3 mgd. Sensitivity was evaluated using 4 scenarios by adjusting mass loads for BOD, TSS, Organic Nitrogen, and Ammonia. The organic nitrogen was estimated as the stoichimetric equivalent of organic nitrogen contained in a typical cell (0.124). The TSS discharged was assumed to be primarily wasted bacterial cells. Organic nitrogen was then 0.124*TSS. The ultimate BOD was estimated from the BOD5 as using the instream decay rate as described above. The effluent dissolved oxygen was assumed to be 6.5 mg/l. The mass loads were developed

Represented Effluent Quality			
	NH	BOD	TSS
1	15	20	20
2	5	10	10
3	5	20	20
4	15	10	10

to represent specific effluent quality. Ammonia was assumed to be either 15 or 5 mg/l and BOD5 was either 20 or 10 mg/l. The minimum basin treatment requirements are 20 mg/l BOD (5) and 20 mg/l TSS. The effluent dissolved oxygen was assumed to be 6.5 mg/l.

The sensitivity analysis indicated that the dissolved oxygen responds to both the ammonia and BOD discharged. Because the observed instream dissolved oxygen falls to at or below the criteria of 8.0 mg/l in September the allocations would be based on the allowance of 0.10 – 0.20 mg/l depression. The 0.20 covers all sources including point and no point sources. Because all sources are not known and both Coquille and Myrtle point independently may exceed a 0.10 mg/l depression in dissolved oxygen it appears that the 0.10 for individual sources is the applicable criteria. One model cell, near river mile 22, was selected to represent the relationship between oxygen depression and BOD and Ammonia. Allocations to achieve a maximum oxygen depression of 0.10 mg/l may control either ammonia or BOD.



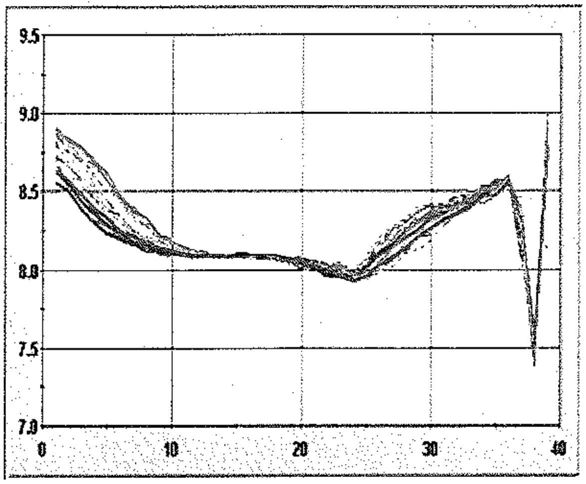
	Basin Standard	Advanced Treatment
BOD	20	10
Ammonia	5.0	9.0

Under current discharge rates, typical September tide, and upgraded to a minimum of basin standards, removal of ammonia would be required to assure that the sources would not create a measurable decrease in dissolved oxygen under current conditions. Less effort at ammonia removal would be needed if effluent BOD and TSS is treated to 10 mg/l. For the one cell presented the inclined plan describing the oxygen depression related to point source discharge loads can be approximated as: $\Delta DO = 0.00252 + 0.0066(NH_{3+4}) + 0.0032(BOD_5)$. The intercept (0.00252) could be decreased by increasing effluent dissolved oxygen.

The TMDL allocations need to be based on design conditions to assure for future growth and development of permitted sources. Potential WLAs were calculated for a scenario representing design conditions. The river design conditions included lower estimates of the 30Q10, oxygen saturation at the head of tide and ocean, temperatures as observed in 1999, the representative September tides, and calibrated SOD. The WWTP plant design flows were used to derive mass loads for ammonia at 5.0 and 15.0 mg/l and for BOD_5 at 5 and 10 mg/l.

Design flows	
Source	Flow (MGD)
Bandon	0.50
Coquille	0.66
Myrtle Point	0.37

A representative background condition was developed by applying the calibrated model without discharge volumes of discharge loads. Similar to the analysis in 1991 the simulations suggest that the ambient dissolved oxygen can be expected to fall to near of below the criteria of 8.0 mg/l of oxygen near Coquille and upstream near the Head of tide. The dissolved oxygen levels falling to a seasonal low near the criteria appear consistent with the historical interquartile range for DO concentrations observed for July-September in the Coquille between 6.5-8.0 mg/l (TMDL report 1996). The 1991 simulation anticipated minimum dissolved oxygen near 7.5 mg/l. The lower dissolved oxygen simulated for background in 1991 background would be influenced by a more critical conditions with different tides, lower freshwater flows, and slightly higher temperatures.



The assimilated capacity may then be defined as one of two conditions, the difference between the anticipated oxygen and the criteria of 8.0 mg/l, or when the anticipated oxygen is at or below the criteria the allowance for a 0.10 mg/l DO reduction for each source and a maximum reduction of 0.20 mg/l for all anthropogenic sources.

The allowance for all sources includes non point sources. The influence of human activities on the SOD and subsequent observed oxygen reduction near the head of tide is not well known. The contribution of NPS to the overall oxygen reduction is not well quantified, but during summer low flow appears minimal (TMDL report). There are two separate locations were oxygen falls below the criteria, near Coquille and near the head of tide. Coquille and Myrtle Point discharges influence these areas differently. For these reasons the point source reduction of 0.10 mg/l provides the appropriate criteria for assigning WLAs.

Instream dissolved oxygen concentrations are reduced as effluent ammonia of BOD mass loads increase. The load of TSS was assumed to be equivalent to the BOD5 loads. The organic nitrogen was assumed to be stoichimetrically proportional to TSS (Organic N = 0.124*TSS). Effluent DO was assumed to be 6.5 mg/l. The reduction in instream dissolved oxygen was calculated for each 1-mile cell as hourly averages and as the daily average reduction.

Effluent Quality		Day	Day
NH	BOD	Max	Avg
15	20	0.26	0.22
1 5	10	0.22	0.18
5	20	0.27	0.14
5	10	0.13	0.06

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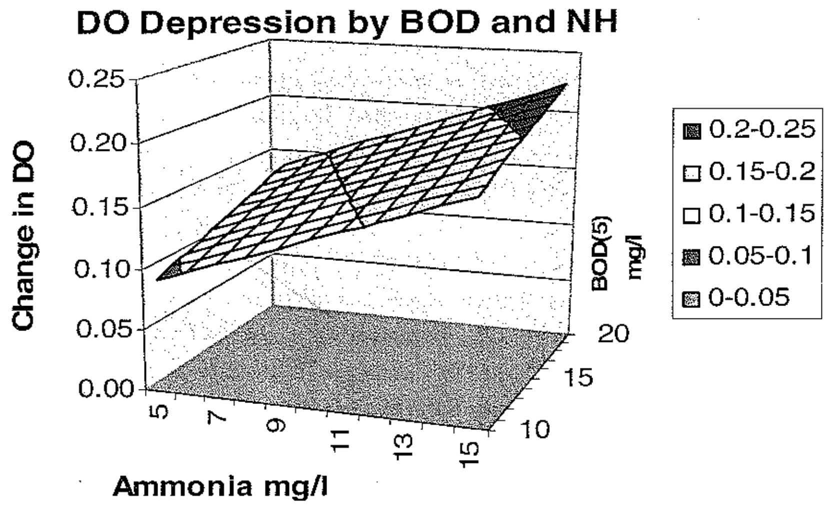
The oxygen depression for the daily average dissolved oxygen reduction can be viewed as an inclined plan proportional to the ammonia and BOD5 loads. The influence of alternative allocations can be estimated through interpolation as:



$$\Delta DO_{day} = 0.0066 + 0.0085 NH_{3+4} + 0.0043 BOD_5 .$$

The allowance for a decrease in dissolved oxygen applies to the 30-day mean minimum criteria of 8.0 mg/l. The 30-day mean minimum is a grand mean, the 30-day average of the daily averages. The allowance should therefore apply to a reduction of the 30-day mean dissolved oxygen concentrations. To be consistent between the simulation and criteria the 0.10 mg/l reduction should be applied to the simulated daily mean as opposed to daily maximum reduction.

Allocations strategies focus on a combination of BOD5 and ammonia reduction. Table __ illustrates the oxygen depression from incremental changed in BOD and Ammonia. The estimated oxygen depression is rounded down to the nearest 0.1 mg/l as the minimum measurable value.

Daily Average Dissolved Oxygen rounded off to significant figure

	Effluent Ammonia										
CBOD(5)	5	6	7	8	9	10	11	12	13	14	15
10	<0.1	<0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
11	<0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
12	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
13	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
14	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2
15	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2
16	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
17	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
18	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
19	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
20	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Allocation strategies are illustrated in the table by darkened lines. Allocations below an ammonia concentration of 6 mg/l and a BOD of 10 mg/l would certainly achieve the criteria of 0.10 mg/l. Allocations for BOD of 20 and ammonia of 6 rounds off to a reduction of 0.10 mg/l which is consistent with the criteria. This could reasonably be

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interpreted to not create a measurable increase in oxygen depression. A similar result would occur at a BOD of 10 and an ammonia limit of 11 mg/l.