Appendix E

ODEQ Point Source Technical Memorandums

State of Oregon

Department of Environmental Quality — Memorandum

Date: 1/24/96

To: File

From: Steve Schnurbusch

Subject: Ammonia Toxicity - Grande Ronde River

Ammonia toxicity criteria are exceeded in the Grande Ronde River during the summer months due to high pH and temperature values. There are two criteria for evaluating ammonia toxicity, chronic and acute. Chronic toxicity is based on a 4-day average occurring once in three years and acute toxicity is based on an hourly average occurring once in three years. Ammonia toxicity can be calculated from pH and temperature. The continuous monitoring data that has been collected in 1991 and 1992 is the best data available for computing acute and chronic ammonia toxicity levels. The continuous data provide temperature and pH measurements every 15 minutes. From this data, daily averages can be calculated to establish the chronic level of toxicity and hourly averages can be calculated to determine the acute level of toxicity. During the months of June, October, and November there is limited continuous data so grab sample data was used to best estimate ammonia toxicity levels in the Grande Ronde River. The toxicity values calculated will have some inherent error involved in the analysis due to limited data, which limits the analysis, and the possibility of incorrect data. Because of these errors, an arbitrary reasonable margin of safety has been applied to the results.

During the summer months of July - September the acute criteria is the controlling factor. Normally, one would anticipate that the chronic level would be controlling. During these months the pH in the Grande Ronde ranges from 7.0 - 10.0. The high pH values result in very low acute toxicity levels. From the continuous data, hourly acute toxic levels were calculated as low as 0.25 mg/l. Average daily chronic levels were calculated at 0.50 mg/l. Keeping in mind the safety margin, ammonia levels below 0.2 mg/l should be protective of the acute criteria during these months.

June and October are the transitional months and both display wide variations of calculated ammonia toxicity values between the beginning and the end of the month. For the entire month of June, using the grab sample data set, the lowest acute value was 0.33 mg/l and the average chronic value was 0.96 mg/l. The acute value occurred on June 30th. If the last two days of June (29th and 30th) are excluded from the data set, the lowest acute value jumps up to 1.26 mg/l and the average chronic value rises to 1.13 mg/l. In reference to the chronic values, the averages may not truly represent daily averages due to the time of day the samples were collected. From review of the continuous data sets, average values correspond to grab samples collected between 1100 am and 1200 noon. The average time of collection for the June data was near 1 pm, so the results should be reasonable possibly leaning towards the conservative side. Ammonia levels below 1.0 mg/l for the first half of June should protect the chronic toxicity levels. Ammonia levels for the latter part of June should not exceed 0.25 mg/l to protect the acute criteria.

A similar situation occurs in October except in reverse. If the first three days of October are included in the calculations the minimum acute level is 0.40 mg/l and the minimum chronic level is 0.79 mg/l. When the first three days are excluded the acute level jumps up to 1.94 mg/l and the chronic level becomes 1.30 mg/l. To meet acute toxicity levels in early October, ammonia should not exceed 0.30 mg/l. The average sample time for the data set excluding the first three days of the month is around 10 am. Since pH and temperature values are slightly below average at this time, the actual average chronic toxicity might be a little higher than the average that was calculated. In an effort to correct for the time of day affects, an ammonia level of 1.0 mg/l (slightly lower than the calculated average of 1.30 mg/l) should be protective of chronic toxicity during the latter part of October. (As a point of reference for permit issuance interest, the acute level for ammonia toxicity at a pH of 9.0 and a temperature of 15 °C is 0.70 mg/l.)

The chronic ammonia toxicity average for the months of December through April is 1.85 mg/l, but the chronic average for April was 1.77. Ammonia levels below 1.6 mg/l during these months should ensure that the chronic ammonia criteria is met.

May might need to be looked at closer after we get more data. There was one acute value in May that was measure at 1.25 mg/l.

Acute and chronic ammonia toxicity statistics tables are on the next page.

Acute Ammonia Statistics
Grande Ronde - All Stations (rm 151 - 168)

MONTH	N	LOW	MEDIAN	MEAN	S.D.	HIGH
JAN	6	7.53	17.98	16.72	6.96	27.21
FEB	12	5.23	12.25	13.77	4.82	21.47
MAR	4	9.68	10.83	11.91	3.05	16.3
APR	16	6.85	11.29	11.3	3.87	22.26
MAY	13	1.25	13.17	13.37	5.29	19.45
JUN	24	0.33	4.7	6.23	5.27	15.62
JUL	23	0.37	2.24	4.56	5.24	16.73
AUG	69	0.24	1.49	3.27	4.13	16.7
SEP	36	0.31	1.55	3.69	4.37	16.99
OCT	34	0.4	2.98	4.55	4.27	13.28
NOV	11	4.01	10.3	10.57	3.92	19.09
DEC	14	10.3	13.35	14.85	4.67	27.41

Chronic Ammonia Statistics
Grande Ronde - All Stations (rm 151 - 168)

MONTH	N	LOW	MEDIAN	MEAN	S.D.	HIGH
JAN	6	1.45	2.02	1.94	0.24	2.09
FEB	12	1.01	2	1.92	0.3	2.09
APR	16	1.32	1.87	1.77	0.22	2
MAY	13	0.24	1.86	1.69	0.49	1.95
JUN	24	0.05	0.9	0.96	0.72	1.88
JUL	23	0.05	0.31	0.56	0.57	1.95
AUG	69	0.03	0.2	0.42	0.47	1.49
SEP	36	0.04	0.26	0.6	0.65	1.86
OCT	34	0.06	0.57	0.79	0.7	1.98
NOV	11	0.77	1.89	1.76	0.38	2.09
DEC	14	1.98	2.06	2.05	0.04	2.09

State of Oregon

Department of Environmental Quality Memorandum

Date: 4/18/96

To: File

From: Stephen A. Schnurbusch

Subject: Grande Ronde River TMDL Analysis for the LaGrande WWTP

Summary:

Water quality data were analyzed to establish a set of ambient water quality criteria for the La Grande WWTP that could be used to define compliance periods for TMDLs that address pH standards violations. Water quality and flow data for the Grande Ronde River near La Grande are limited which made it difficult to determine with certainty what the no discharge criteria would be. Analysis of the available data demostrates a critical compliance period during the months of July, August, and September. No discharge from the LaGrande WWTP should be allowed during these months. June and October appear to be transitional months for the pH problems. Relationships between pH and other parameters were analyzed and criteria were established based on these relationships for these two months. During June, a relationship was found between flow and pH. pH began violating standards in June when flow fell below 150 - 200 cfs leading to a flow based discharge criteria. The data suggests that no discharge should be allowed if the average daily flow falls below 150 cfs. During October, temperature demonstrated a strong relationship to pH with pH falling below the standard when maximum stream temperatures dipped below 15 °C. Once afternoon stream temperatures get below 15 °C in October, the data shows the WWTP should be able to begin discharging without creating additional pH problems in the river.

Removing the La Grande WWTP discharge from the river during the above times will not ensure water quality standards will be met. Upstream non point source pollution is probably a bigger problem than the WWTP. This will guarantee that the WWTP will not be adding to the problems in the river and will help focus the Departments efforts on the non point source TMDL.

Analysis:

Historical ambient water quality data was limited to two DEQ sites near the La Grande STP:

1. Hilgard, rm 166.80 1968-1995
2. Peach Lane, rm 151.10 1986-1995

There is scattered ambient data at other sites between the above two sites.

Continuous data was collected at over a dozen sites between 1991 and 1992. Parameters included temperature, dissolved oxygen concentration and saturation, pH, and conductivity.

Flow sites were limited to two USGS sites near the La Grande STP:

1. Hilgard, rm 171.3 1968-1980
2. La Grande, rm 164.0 1928-1986

The pH violations that are occurring in the Grande Ronde River are a result of periphyton activity. Periphyton activity is dependent upon photosynthesis. Photosynthesis is the process by which algae (containing chlorophyll) use energy from the sun to convert carbon dioxide and water into new algal cells.

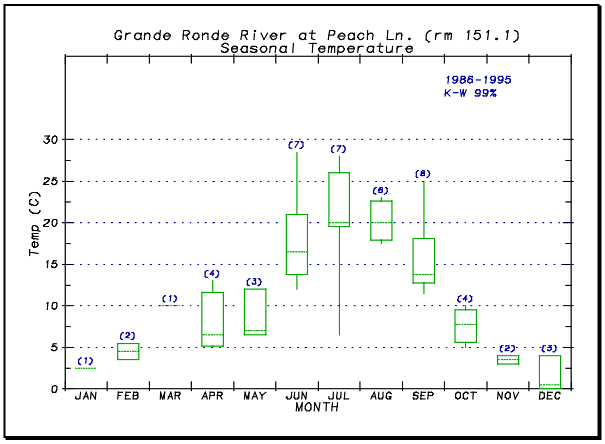

Figure 1: Seasonal Temperature at Peach Ln (rm 151.1)

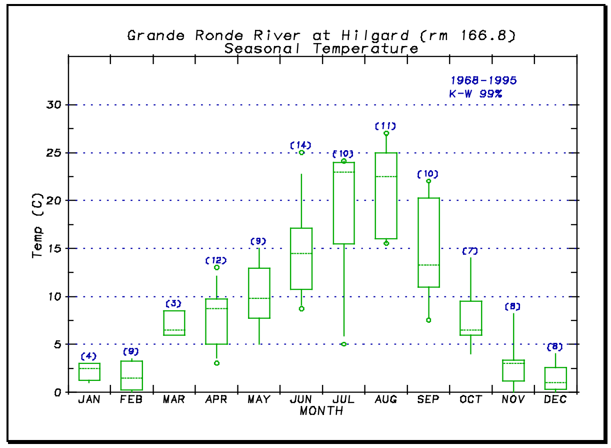

Figure 2: Seasonal Temperature at Hilgard (rm 166.8)

During the day, when sunlight is present, photosynthesis occurs. Photsynthesis uses available CO_2 in the water which can lead to increases in pH. At night respiration occurs and the algae produce CO_2 reducing the pH levels. In the case of the Grande Ronde River, excessive photosynthetic activity is pushing the pH values up during the day leading to pH standards violations in the afternoon.

Photosynthesis rates are dependent on ambient temperatures. Photosynthesis is very limited or does not not occur below 5 - 15 °C or above 30 - 40 °C, depending on the algal species. Since river temperatures never approach the upper limits the only concern here is the lower temperature limit. Temperatures increase dramatically in June to averages above 15 °C (see Figures 1-2). At these temperatures photosynthetic acitivity can take place and periphyton can begin to grow.

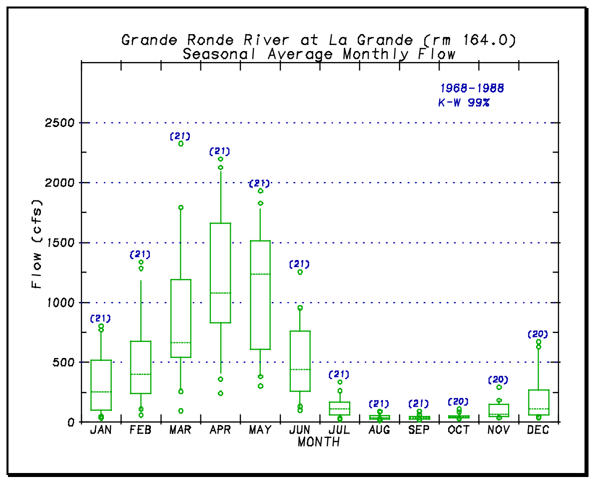

Figure 3: Seasonal Flows at La Grande

Photosynthesis is also dependent upon the availability of nutrients. Periphyton rely on nutrients as their source of energy for cell growth and maintenance. Nutrients in the Grande Ronde River are available from upstream non point sources and from the La Grande WWTP. The nutrient data set is limited but some seasonal trends are apparent in the data. Nutrient levels are high during the fall, winter, and spring months and at there lowest levels during the summer months. The low nutrient concentrations in the summer would indicate that periphyton are growing during the summer months and taking up the available nutrients.

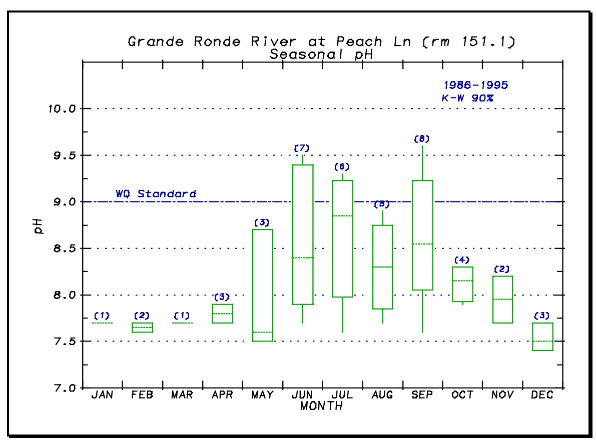

Figure 4: Seasonal pH at Peach Ln

Flow is another parameter that influences periphyton growth. High flows, creating high shear velocities, may shear algal from the substrate limiting algal biomass accumulation. High flows also tend to have higher reaeration rates, which increase the amount of atmospheric CO_2 that is dissolved into the water column, and higher flows carry more volume of CO2. With a larger concentration and a greater volume of CO2, there is more CO2 in reserve after periphyton take it up. This in turn has less affect on the pH levels.

It may also be more difficult for sunlight to penetrate to deeper depths when flows are high which can limit photosynthetic activity. Figure 3 shows how quickly flows decrease from May to June and again from June to July. When the flow decreases during these months, the shear velocities are not great enough to remove algae from attaching itself to the substrate, allowing algal biomass to accumulate. CO_2 concentrations and volumes decrease and the uptake of the limited CO_2 by periphyton starts to have a dramatic affect on pH levels. Shallow waters allow sunlight to penetrate the river bottom increasing photosynthesis and thereby affecting pH.

The combination of higher temperatures and lower flows starting in June and the abundance of nutrients provide a good environment for periphyton acitivity. It is apparent from looking at the seasonal pH trends of our grab sample data (see Figure 4-5), that periphyton is causing an increase in pH values during the summer months of June to October. Since our grab sample data is always taken during the daytime and often in the afternoon, when photosynthesis is occurring, we see pH increases during the summer months of these two plots. Our continuous data shows large swings in the diurnal pH values with maximums occurring in the late afternoon and minimums occurring in the early morning when respiration is taking place (see Figure 6 for an example plot).

Grab sample data sets for Hilgard and Peach Lane showed pH violations in June, July, August, and September. The ambient data at these two sites for October showed no pH violations because the samples were all collected in the morning when pH values are low. There were some October pH violations at other sites between Hilgard and Peach Lane where grab samples were taken. These occurred in the afternoon. Continuous monitoring data collected from October 1-2 of 1991 at several sites near La Grande had pH violations during the late afternoon. Values were recorded as high as pH of 9.6. Violations occurred consistently during the months of July, August, and September resulting in the decision to identify these months as part of the critical period.

The more difficult part of the analysis was determining how to handle the transitional months of June and October. The analysis for these months focused around establishing relationships between pH and other parameters. These relationships would then be used in defining a set of criteria to protect water quality from standards violations. Attempts were made to develop a relationship

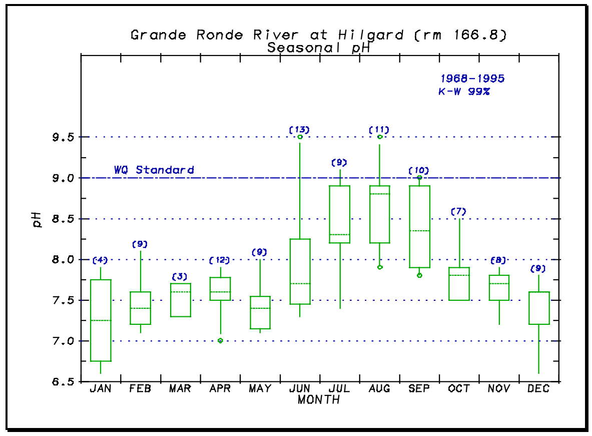

Figure 5: Seasonal pH at Hilgard

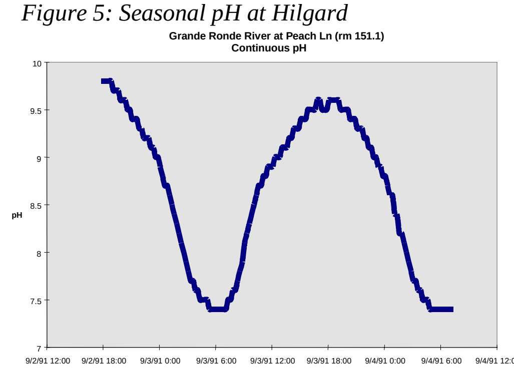

Figure 6: Continuous pH at Peach Ln

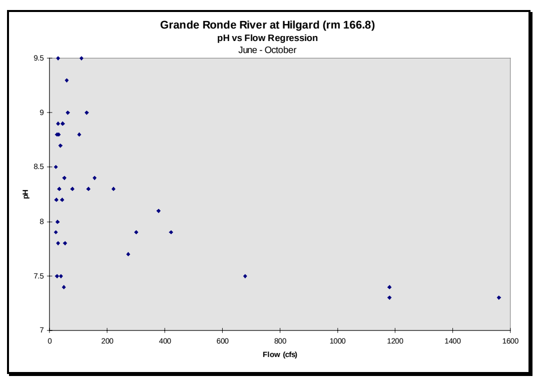

Figure 7 : Regression using all data

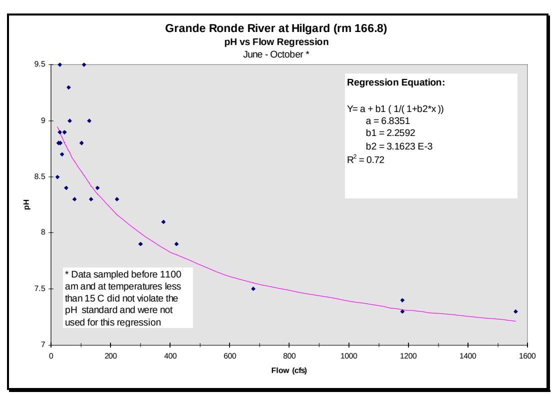

Figure 8: Regression using defined data set

between flow and pH. There were a couple problems in establishing this relationship. Firstly, the data set to be used for this analysis was fairly small. Matching DEQ's historical ambient water quality data and USGS's flow data resulted in a data set which only included the years 1968-1986 Some of these years had only two or three water quality samples. Secondly, pH was dependent on several other parameters other than flow. pH also varied with temperature, time of year, and time of day. Plotting pH vs flow for all data between the months of June and October resulted in a wide variation for lower flows. Looking at Figure 7, it is apparent that many pH values fall below 8.0 when flows are below 100 cfs. The reasons for these low pH values appear to be related to low temperatures and day of year, or time of day collected. After removing all early morning samples (before 1100 am) and all samples in June or October that were taken at temperatures below 15 °C another regression analysis was performed. This resulted in the regression relationship seen in Figure 8. The relationship between pH and flow can be seen more clearly when the variability, due to pH's dependence on other parameters, is removed. The regression gives us an idea of what flow values pH may start to exceed standards. pH violations start to occur when flows approach 150 - 200 cfs. This analysis leads to the establishment of a flow based criteria for the La Grande's WWTP discharge permit. In June, if flows get below 200 cfs, the La Grande WWTP should discontinue discharging to the Grande Ronde river.

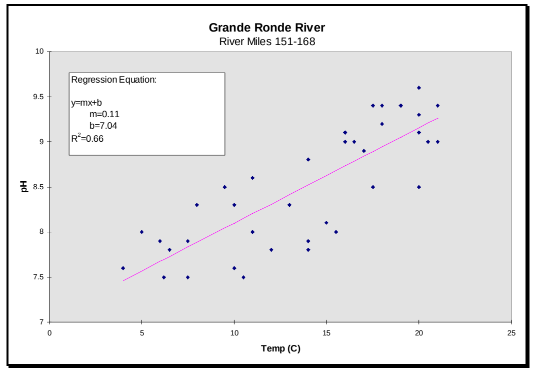

Figure 9: October pH/Temp Relationship

The final problem is determining what to do in October. As mentioned above, there are pH violations recorded from the continuous monitoring data on October 1-2, 1991 and there are also some pH violations in some of the grab sample data. The violations occur when the temperatures are still fairly high in the river. At these higher temperatures, periphyton is still able to grow and cause wide swings in daily pH values. Once the maximum temperatures drop below 15 °C the average stream temperatures are probably not warm enough to sustain periphyton growth. Thus, we start to see pH values fall below the standard of 9.0 when temperautres get below 15 °C (see Figure 9). A temperature criteria could be used to determine when the WWTP can resume discharging to the stream during the month of October. Temperature values would need to based on late afternoon samples when temperatures are at a maximum.

Depending on the ability and resources of the La Grande WWTP to measure ambient pH, it might be easier to set a pH criteria instead of temperature for the month of October. It should be noted that regardless of the criteria that is used, measurements of pH or temperature need to be taken in the late afternoon (around 4- 6pm) when maximums of both parameters occur.

This analysis was done with minimal data and results could likely be different if more data was available. The results of this analysis should be looked at with caution and future monitoring should be done to test the reslults of this analysis. Heavier monitoring should be done during the transitional months of June and October and should be focused during the afternoon hours when standards violations occur. Further data and analysis could lead to slightly different discharege permit requirements and criteria for the La Grande WWTP. No forseen changes will occur for the no discharge months of July, August, and September, but changes could occur during the months of October and June. Keep in mind that upstream non point sources are likely a greater problem than the WWTP, which are not addressed in this TMDL.

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This document can be accessed on the Internet

http://waterquality.deq.state.or.us/wq/