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# MEMORANDUM

Date: **August 20, 1999**

To: **Paul Fendt**

From: **Jim Dexter**

Subject: **Sensitivity of Reasonable Potential Determination To Ambient Water Quality Contaminant Values**

cc: **Linda Logan**
**Ken Ludwa**
**Brian Pippen**

Project Number: **55-2912-61-01**

Project Name: **Port of Seattle Storm Water Quality Plan**

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**Background**

You raised a question related to the effectiveness using mixing zones to achieve compliance with stormwater discharge standards for the new runway (and existing ones). The question is how sensitive is the reasonable potential (to exceed State water quality standards)?

Recall from our discussion that the Permit Writer's Manual uses the following equation to characterize the reasonable potential:

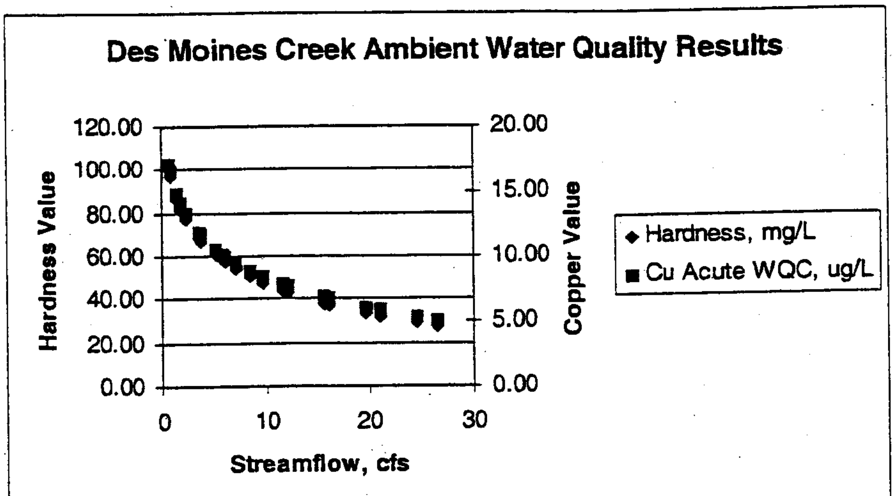
CP=(MEC+(MECB*DF-1))/DF

Where CP = pollutant concentration
MEC = effluent pollutant concentration
MECB = background (ambient) pollutant concentration
DF = Dilution Factor = ((Qa*vol_factor)+Qe)/Qe
Qa = ambient flow rate
Qe = effluent flow rate
vol_factor = allowable volumetric fraction of receiving body for mixing
this equals 0.025 (2.5%) for the acute zone in rivers and streams
and 0.10 (10%) for reservoirs and lakes

If numerical modeling shows the expected dilution factor is smaller than that based on the volumetric limitation shown above, the smaller DF is used in the calculation (per Ecology guidance).

I obtained Ken's gap analysis data (see attachment 1) to understand the basis of the evaluation to date. It used a DF of about 1.0. During our discussion we pondered whether there could be an increase in the dilution ratio such that it would more than offset increases in copper concentration with increased streamflow during the "design" condition.

**Findings**
Using the Des Moines Creek Station DM1 data as representative of the ambient condition, I evaluated the range in the water quality criteria (WQC) which is a function of water hardness. The following figure shows how the criterion varies.

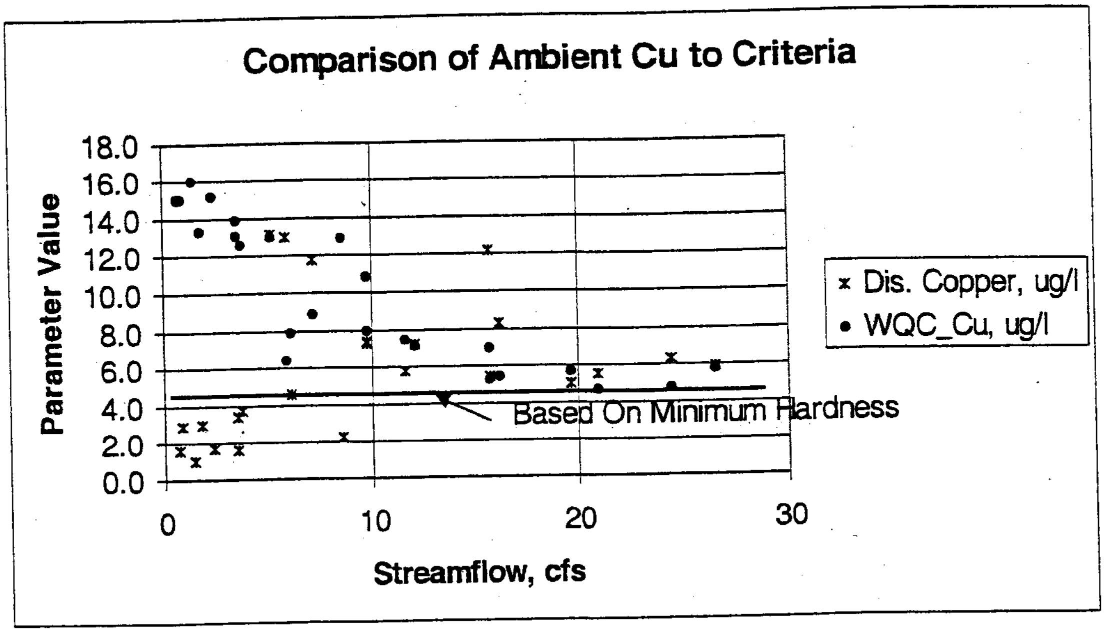



Ecology will probably select the lowest value to calculate the WQC; this results in a value of 4.8 ug/L as the acute total dissolved copper criterion.

The ambient values of total dissolved copper concentration exceed the water quality criteria (WQC) in about 37 percent of the samples, based on the associated water hardness value. The following figure (next page) shows the data. However, compared to the standard based on the minimum reported hardness value in the data set, about 65 percent of the ambient values exceed the standard.

In a separate evaluation (I provided to Linda Logan), the mean detention time for the NW ponds was determined to be well above the 15-day criterion for lake classification. The fact that the NW Ponds can be considered as a reservoir or lake means that they potentially have a different mixing zone size under the WAC 173-201A. For example, the volumetric limitation is 10 percent of the volume of flow for lake mixing zones.

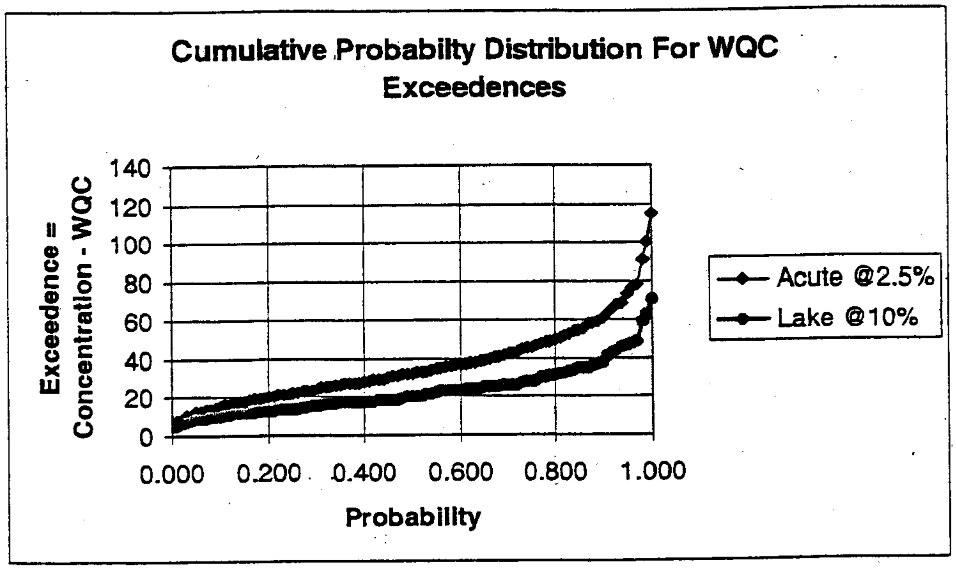
The HSPF model indicates the active volume in the NW Ponds is 233 ac-ft; if one considers, dead storage the total volume is about 250 ac-ft. If one divides this number by two (2), the result (125) is the flow in second-foot-days or cfs per day. Since the acute mixing zone analysis considers short-term, e.g. one-day duration exceedence of WQC's, presumably the dilution provided by the lake criterion could be based on a daily flow rate of about 12.5 cfs/day (10 percent of the volume).




I next considered the problem in relation to the change in ambient and effluent total dissolved copper concentrations as a function of stream flow rate and the potential volume of the receiving water. For this, I developed the probability distributions for contaminant concentrations using the ambient and effluent stormwater quality monitoring data, and probability distribution for the peak annual ambient and effluent streamflows. The probability distributions were integrated with the equations for the calculation of the dilution factor and the contaminant concentration shown on the first page of the memo. I have previously summarized my review of three different methodologies for determining DF's; Brian Pippen has used one of these to estimate conceptual DF's. The method I used herein is similar to the method (I described in an earlier memo) developed by Di Toro. It was an expeditious method to use to consider the streamflow variability without having to obtain more assistance needed using the continuous simulation method; but it provided a method to evaluate the sensitivity of the results to ambient water quality variability. I also made a single event calculation of the exceedence based on the joint occurrence of the 1-day, 3-year peak flows for comparison.

I computed the lognormal probability distributions for the contaminant concentrations using the 24 data values in the ambient set and the 25 data values in the SDS-3 effluent data set. The storm events are distributed throughout the year and therefore I developed an annual series. I used the HSPF output files for future conditions to generate Log Pearson Type III probability distributions (see Attachment 2) for both ambient and effluent flows. The effluent flow location is taken as the SDS-3 outfall and the ambient flow location is the outflow from the NW Ponds. The probability distributions for ambient and effluent streamflow shown in Attachment 2 indicate the ambient streamflow is on the order of 1.5 to 1.7 times the effluent streamflow magnitude. It's unlikely that the dilution factor will be significant greater than 1 if only streamflow is considered. However, considering the ponds volume increases the DF's to around 1.7.

The spreadsheet results are shown in Attachment 3. I used the @RISK add-in to EXCEL to calculate 100 random events using the probability distributions described above. The results of the simulation are shown in the following figure. The simulation showed that




The probability that the WQC annual exceedence for total dissolved copper was greater than 40 ug/L for an event with a probability of approximately 67 percent (once in three years). This is seen in the following figure. The results are somewhat sensitive to the lake criterion for allowable mixing volume. In comparison, the WQC exceedence for total dissolved copper was greater than 25 ug/L approximately 67 percent of the time.

The lake result varied the WQC as a function of ambient streamflow (and hardness).

**Conclusions**
The simulation results indicate that the WQC is exceeded regardless of the magnitude of the streamflow. This means that the near-zero joint probability distribution of the "critical" and "design" flow conditions are really a moot finding because the high ambient water quality concentration and low dilution factors are more significant in terms of determining the reasonable potential to exceed WQC. In fact, the high ambient conditions generally exceed the WQC and therefore Ecology could invoke the anti-degradation policy and not allow any further discharge that exceeded the discharge standard.

Another question that seems relevant is whether the NW Ponds are considered waters of the State and therefore under the protections of the WAC 172-201A. If these were constructed, as was the case for Lake Reba, which was determined by Ecology not to be waters of the State, why would the stormwater discharges to the NW Ponds be considered to be restricted by Ecology's mixing zone limitations? If the mixing zone criteria do not apply, can the ponds be considered as a treatment facility that could reduce the contaminant concentration in the discharge from the ponds?

Another consideration is whether additional stormwater discharge downstream of the NW Ponds can be shown to increase the dilution even further than evaluated above. In other words, can the water quality plan be configured to obtain more dilution water?

| Miller Background | Des Moines Background | Comments | Subbasin | 3RW North | SDS-3 | SDE-4 south of 170th |
|---|---|---|---|---|---|---|
| | | | Receiving Stream | Miller | DM | DM |
| 4.68 | 5.65 | used SDS-3 as representative of future airfield concentrations | Cu Concentration 95th %ile (µg/L) 3 | 86.0 | 86.0 | 119.0 |
| 5.01 | 5.64 | | | | | |
| 4.83 | 5.54 | amount of impervious area served by adequate BMPs | Current BMP coverage (%) | 45% | 45% | 45% |
| 14.6 | 10.2 | | Treatment BMP Cu removal efficiency 1 | 45% | 45% | 45% |
| 14.5 | 9.58 | extrapolation to copper conc, assuming 100% BMP cover | SDS Outfall Cu w/100% BMP Cover (µg/L) 1, 3 | 59.3 | 59.3 | 82.1 |
| 14.8 | 9.35 | | | | | |
| 13.2 | 1.3 | | Copper Removal in Lake Reba | N/A | N/A | 33% |
| 13.6 | 1.2 | | Cu Concentration at Point of Entry to Rec Waters | 59.3 | 59.3 | 55.0 |
| 14.5 | 1.3 | | | | | |
| 8.02 | 10.4 | from stream effects study, <20 data points, therefore 1.74 * geom | Background Copper 90th %ile (µg/L) 3, 4 | 16.4 | 7.5 | 7.5 |
| 8.02 | 10.5 | inverse of percentage of original concentration, after dilution in re | Mixing Zone Dilution Factor | 4.0 | 1.0 | 1.0 |
| 8.02 | 10.3 | | Cu @ Edge of Mixing Zone (µg/L) | 27.1 | 59.3 | 55.0 |
| | 2.14 | | | | | |
| | 2.14 | <20 data points; use lowest value in stream effects study | Rec. Stream Hardness (mg/L) 2 | 23.0 | 33.0 | 33.0 |
| 9.400871 | 2.14 | | Rec. Stream Copper Standard, DISS Cu (µg/L) | 4.3 | 6.0 | 6.0 |
| 16.35752 | | | | | | |
| | | | Receiving Stream WER (includes translator) | 4.0 | 4.0 | 4.0 |
| | 4.336429 | | Adjusted Rec. Stream Copper Std., TOT Cu (µg/L) | 17.0 | 23.9 | 23.9 |
| | 7.545387 | | | | | |
| | | | GAP (µg/L) | 10.1 | 35.4 | 31.0 |

**ADVANCED BMPs**

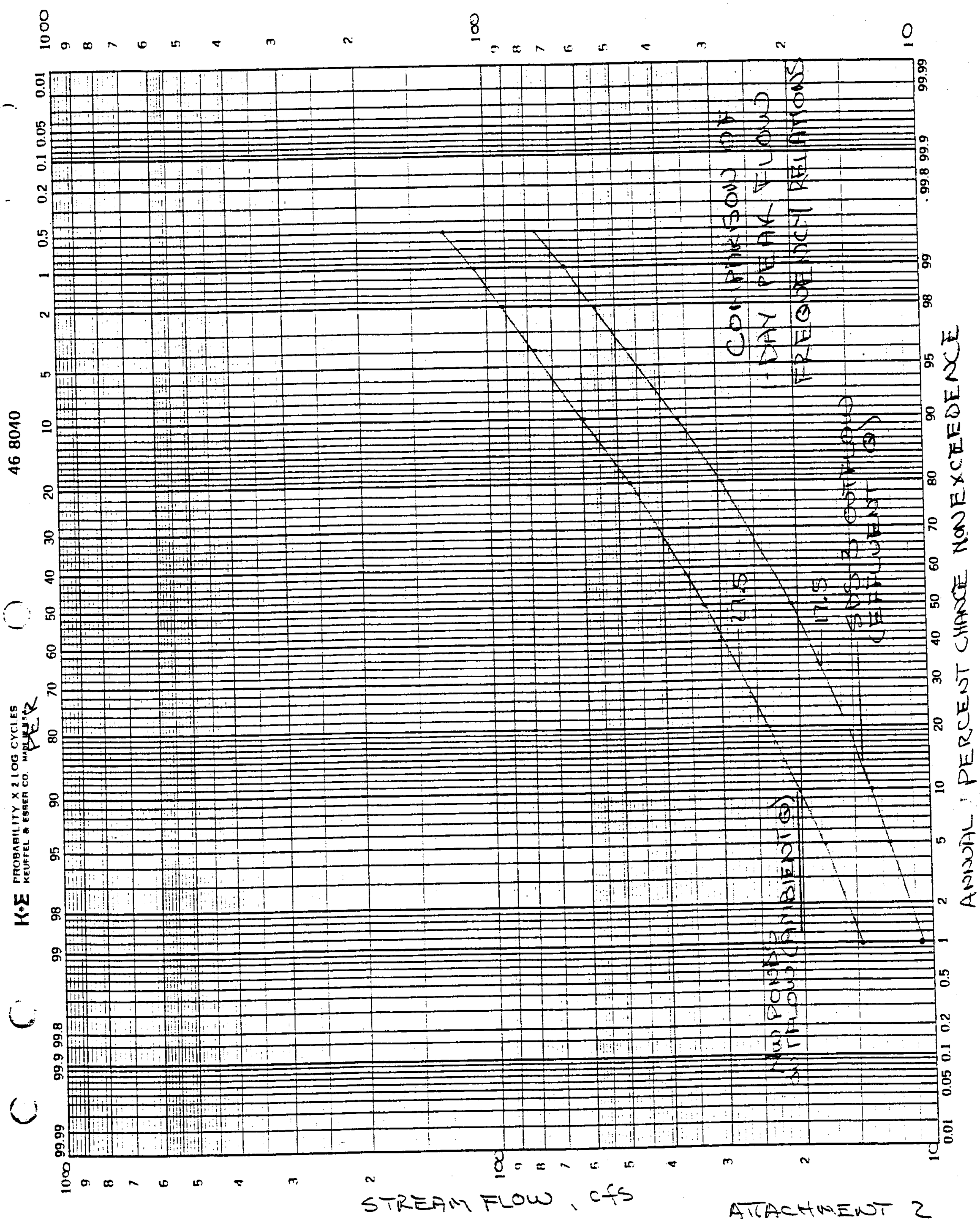
| | 3RW North | SDS-3 | SDE-4 |
|---|---|---|---|
| Additional Coverage (%)5 w/Limestone Swale | 100% | 100% | 100% |
| Cu Removal: Limestone Swale | 27% | 27% | 27% |
| New Resulting Cu at Point of Entry to Rec Waters | 43.1 | 43.1 | 40.0 |
| New Cu @ Edge of Mixing Zone (µg/L) | 23.0 | 43.1 | 40.0 |
| New GAP (µg/L) | 6.0 | 19.2 | 16.0 |
| Additional Coverage (%)5 w/Iron Oxide Sand Filter | 74% | 60% | 54% |
| Cu Removal: Iron Oxide Sand Filter | 75% | 75% | 75% |
| New Resulting Cu at Point of Entry to Rec Waters | 19.2 | 23.7 | 23.8 |
| New Cu @ Edge of Mixing Zone (µg/L) | 17.1 | 23.7 | 23.8 |
| New GAP (µg/L) | 0.0 | 0.0 | 0.0 |

1. Cu removal efficiency with bioswales and filter strips = 45%, wetvaults = 40%
2. <20 data points inexisting data set; used lowest value, per RPD guidance.
3. Total Cu.

4. <20 data points in data set; used 1.74 * geomean, per RPD guidance.
5. Assumes that concentrations are relatively homgenous throughout basin and BMPs applied only to this % of basin, or runoff has been collected and this % split off for treatment.

ATTACHMENT 1.

AR 024639




ATTACHMENT 2

AR 024640

## REASONABLE POTENTIAL EVALUATION FOR SDS-3

*Sensitivity of WQC Exceedence To Ambient WQ*

| | | Stochastic Simulation Values | | Single Event Values |
|---|---|---|---|---|
| Ambient Flow, Qa,cfs | | | | |
| | Mean Qa= | 33.73 | | |
| | Std Dev.= | 1.53 | | |
| Lognormal Distribution | | 35.1 | 1-day, 3-yr high flow | 27.5 |
| Ambient Hardness, mg/L | | 21.4 | | 26.4 |
| Hardness=(-20.315*LN(Qa))+93.704 | | | | |
| Ambient WQC for Cu, ug/L | | 4.0 | | 4.8 |
| Ambient Dissolved Cu, ug/L | | | | |
| | Mean= | 5.83 | | |
| | Std Dev.= | 3.69 | | |
| Lognormal Distribution, MECB | | 2.7 | 90% Cu, ug/L | 12.5 |
| Effluent Flow, Qe, cfs | | | | |
| | Mean Qe= | 21.88 | | |
| | Std Dev= | 1.48 | | |
| Lognormal Distribution | | 23.2 | 1-day, 3-yr high flow | 17.5 |
| Effluent Dissolved Cu, ug/L | | | | |
| | Mean= | 42.6 | | |
| | Std Dev.= | 20.8 | | |
| Lognormal Distribution, MEC | | 39.7 | 90% Cu, ug/L | 71.8 |
| Dilution Factor, DF | | | | |
| DF= ((Qa*vol_factor)+Qe)/Qe | | 1.04 | | 1.04 |
| | vol_factor | 0.025 | | |
| Acute Mixing Zone | | | | |
| Pollutant Concentration, ug/L | | 39.93396 | | 80.62371 |
| CP=(MEC+(MECB*DF-1))/DF | | | | |
| Potential WQC Exceedence | | 36.0 | | 75.8 |

ATTACHMENT 3

AR 024641