

Attachment I

Technical Response from Lion Oil to EPA



June 24, 2011

Mr. Steve Drown, Chief
Water Division
Arkansas Department of Environmental Quality
5301 Northshore Drive
North Little Rock, AR 72118

Re: Response to USEPA Comments Dated April 29, 2011
Dissolved Mineral Rulemaking for Loutre Creek and Bayou de Loutre
NPDES AR0000647, AFIN 70-00016
GBMc No. 2160-10-075

Dear Mr. Drown:

The following response has been developed and is being submitted on behalf of Lion Oil Company (Lion Oil). The following addresses issues raised in the USEPA comment letter addressed to Ms. Sarah Clem and dated March 10, 2011. USEPA comments are in response to the requested review of the supplemental information developed in accordance with the approved Plan dated June 15, 2009. The supplemental data (report dated January 5, 2011) was submitted to ADEQ and USEPA on or about January 7, 2011. The supplemental report provided the results of additional investigations related to the dissolved mineral criteria approved by the Arkansas Department of Pollution Control and Ecology (ADPCE) Commission in the Lion Oil 3rd party rulemaking for dissolved mineral of Loutre Creek and Bayou de Loutre. The supplemental information was developed at the request of ADEQ and Region 6 USEPA. The tasks completed as part of the Supplemental Report were identified during consultation with USEPA Region 6 and followed the study plan developed and submitted for ADEQ and USEPA review and comment.

The Region 6 USEPA cover letter references monitoring the criteria on the proposed sub-segments and requests a written agreement between Arkansas and the State of Louisiana. These issues are not addressed in this response due to the nature of the requests that are beyond the control of Lion Oil Company.

The response provided herein will address those comments directly related to the waterbodies included in the attachment to the USEPA cover letter entitled:

EPA Comments for Lion Oil Minerals Study (Dated 03/10/11)

Item 1 - Water Hardness

The water hardness used in the default calculations were identified on Page 10 of the Supplemental Report. The 100 mg/L water hardness is a routine default water hardness and was used by EPA in developing the draft water quality criteria documents for chloride and TDS (which were never finalized). Although the ecoregion default hardness value is 31 mg/L, this represents a "least disturbed" condition and does not reflect the effects of an urbanized receiving stream whose flow is dominated by a point source discharge. According to long term

monitoring associated with the WET testing history on Outfall 001 effluent, the average hardness value of the Lion Oil Outfall 001 discharge is 102 mg/L (WET testing data included in the Supplemental Report as Table 1 on Page 14 and on record at ADEQ with WET testing results).

In addition, the receiving stream hardness values of Loutre Creek and Bayou de Loutre was documented as part of the artificial matrix development at 88 mg/L and 84 mg/L, at LC-4 and BDL 3, respectively. (Information provided in Table 5 and Appendix E of the Supplemental Report). Therefore, the default hardness value of 100 mg/L was utilized as the basis for the projected Chloride and Sulfate criteria based on the approach proposed by the State of Iowa.

Item 2 - WET Testing Results

The results of the "spiked" toxicity tests completed as part of the supplemental data development were referenced in this section as well as in Item 4. These comments will be addressed in context with Item 4 below.

Item 2 also references the sporadic failures of the monthly WET testing and suggests that the sporadic failures "...point to a **POTENTIAL IMPACT** on sensitive species in the bodies of water immediately downstream of the Outfall." [Emphasis added], and points to Lion Oil's obligation to conduct additional testing to verify that the results of the WET testing failures are not a result of the dissolved minerals. Lion Oil has submitted extensive documentation in both the 3rd party rulemaking documentation and the Supplemental Report that demonstrates that the receiving stream maintains the designated uses with a fish community reflective of the Gulf Coastal fishery as described in Arkansas Water Quality Standards Regulation No.2. for watersheds of less than 10 square miles. In order to maintain the fish community, the receiving stream ecosystem must also support the foundation of the food chain, including the plankton (phytoplankton and zooplankton, including the Daphnid community) and invertebrate community. The 3rd party rulemaking documentation and the Supplemental Report has provided documentation that this occurs in the receiving streams. The focus on the WET failures of the laboratory crafted synthetic waters to meet a control criteria, to the exclusion of the preponderance of the supporting instream aquatic community assemblages fails to recognize the "real world" condition that exist as a result of the long term watershed land-use and water quality.

In addition, the 3rd party rulemaking documentation and the supplemental report provides a statistical summary of the relationship between the long term WET testing results and the effluent dissolved mineral concentrations demonstrating that there is no correlation between WET test results and the effluent dissolved mineral concentrations. (See Item 3 below for more information on the statistical analyses).

Lion Oil is currently implementing a voluntary effort to identify any significant and consistent WET test failures (Sub-lethal Response Plan - SLRP). This SLRP was initiated during the 4th QT 2010 and continues through January 2013. Through the initial nine months of the SLRP, there have been no consistent and significant WET tests failures that would require the implementation of the Toxicity Identification Evaluation (TIE) phase of the SLRP Plan. This Plan is being implemented at the effluent defined critical dilution of 96% effluent. The results of the SLRP are being submitted to ADEQ at six month intervals and the initial nine months of the increased monitoring demonstrates the lack of potential for instream adverse effects.

Item 3 - WET Results/Request of Additional Statistical Analyses

A statistical evaluation of the WET test results and the concentrations of the dissolved minerals was provided in Section 3.6.2 of the original documentation supporting the 3rd party rulemaking (October 2006 Report). In addition to the routine WET test results, the results of long term Microtox[®] monitoring completed on Outfall 001 effluent was also presented in Section 3.6.2 of the documentation. Both of these analysis demonstrated there was no correlation with the dissolved mineral concentrations in the Outfall 001 effluent and the performance in the WET testing.

Since the data set presented in the October 2006 report was limited due to comparing monthly dissolved mineral data with the WET test results that may or may not have been collected during the same collection periods, Lion Oil completed an extended period of monthly monitoring as Task 2 of the Supplemental Information Study Plan

The results of the Task 2 findings were summarized in Section 3.3 of the Supplemental Report. The primary focus of this effort was to characterize the dissolved mineral concentrations in the receiving stream to determine if the downstream concentrations would exceed the criteria approved by ADPCE Commission in the initial rulemaking and did not focus on a "formal" statistical assessment.

Although Section 3.3.1.3 of the Supplemental Report did address the WET testing results as influenced by the dissolved mineral concentrations and reported the absence of correlations between the dissolved mineral concentrations and the individual WET testing endpoints (i.e. lethality, reproduction and growth), a detailed statistical analyses was not presented.

In response to the USEPA Item 3, the following statistical assessment is provided. This assessment provides a more detailed statistical characterization of the WET testing results and the dissolved mineral concentrations of the effluent. A statistical analysis of minerals data associated with routine toxicity test endpoints was completed for data collected since 2000. The focus of the analysis was to determine if minerals levels (TDS, sulfate or Chloride) were related in some way to the periodic occurrence of whole effluent toxicity in Lion Oil's final effluent. A summary of the minerals data is presented in Table 1 below and all the data is summarized in Table 1 of the Supplemental Report.

Table 1. Summary of minerals data used in the statistical analysis.

Statistic	Calculated TDS(mg/L) ¹	Sulfate (mg/L) ²	Chloride (mg/L) ²	TDS (mg/L) ²
Average	2047	796	264	1875
Min	1276	389	153	1134
Max	2997	1086	500	2462
Stdev	426	184	91	306
Median	2041	822	255	1948
90%tile	2627	1027	354	2046

¹TDS values calculated from conductivity measurements for years 2000-2007. Values from 2008 forward actual measured values.

²Sulfate, chloride and TDS values measured from effluent samples for years 2009-2011.

The statistical analysis was completed to determine if a statistically significant relationship existed at the $\alpha=0.05$ level, between the dissolved mineral concentrations and the *Ceriodaphnia dubia* (water flea) No Observed Effect Concentration (NOEC) sub-lethal endpoint. Water flea WET test failures was the focus of the statistical assessment as they exhibited more failures of the WET sub-lethal endpoint than did the fathead minnows.

Simple linear regression techniques were chosen for the analysis as it demonstrates if a relationship (a correlation) exists in the data, calculates a correlation coefficient to quantify the strength of the relationship and provides a quantitative measure if the relationship is significant statistically (has a significant line slope) or not. Linear regression analysis provides a visual representation of the relationship, depicted as a line best fit to the plotted data. The slope of the line demonstrates the type of relationship, either negative (downward slope) or positive (upward slope) that the variables have to one another. The term "relationship" refers to the reaction of one variables value to the fluctuation of another variables value. When a strong relationship exists, one variables value can be predictive of another variables value. In the case of this analysis, the key question is, are the dissolved minerals concentration(s) linked to WET test failures and can minerals (TDS, chloride or sulfate) levels be used to predict the potential WET test failures (e.g. reduced NOEC) of the Lion Oil effluent to water fleas.

Regression analysis variables were varied to ensure that every possible combination was examined. Dependant variables included: water flea NOEC and number of young produced at 96% effluent. Independent variable included: all TDS values (calculated during each test from the measured conductivity values, period of record 2000-2008), TDS concentrations measured from samples collected during the course of the test (2009- October 2010), chloride values measured from samples collected during the course of the test, and sulfate values measured from samples collected during the course of the test (2009 - October 2010). TDS, sulfate and chloride results from actual samples only exist for toxicity tests completed since 2009. Linear regression analysis was completed for the following pairs of data:

1. All NOEC results and all calculated TDS results (Figure 1).
2. Ceriodaphnid number of young produced at 96% effluent results and all calculated TDS results (Figure 2).
3. Recent NOEC results and recent TDS DMR results (Figure 3).
4. Recent NOEC results and recent chloride DMR results (Figure 4).
5. Recent NOEC results and recent sulfate DMR results (Figure 5).

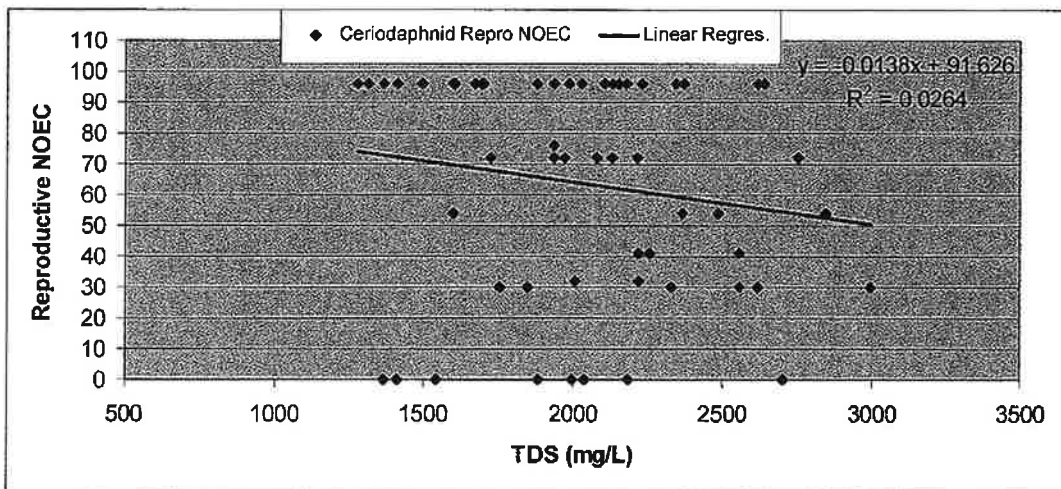


Figure 1. Chart displaying water flea reproductive NOEC versus TDS values.

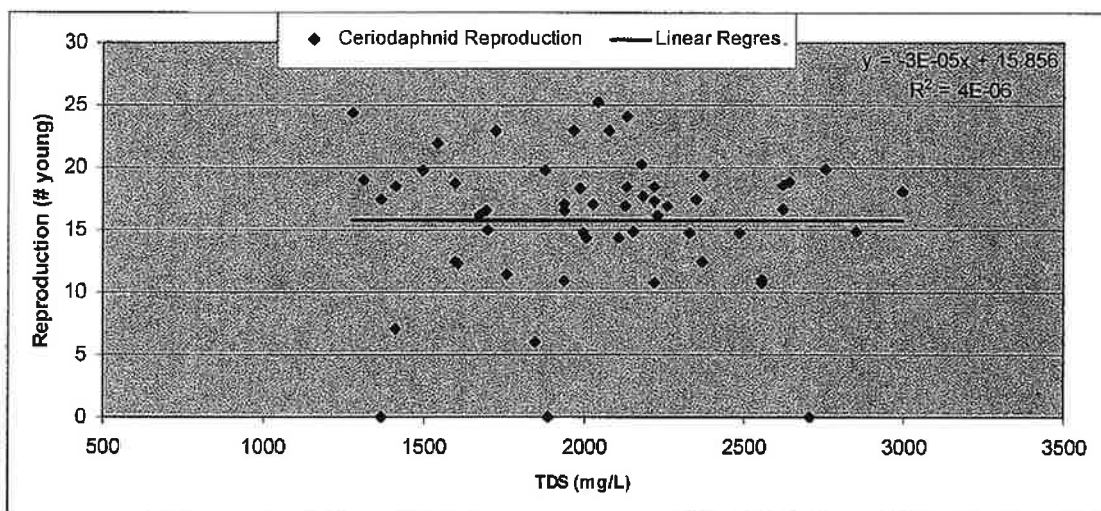


Figure 2. Chart displaying water flea total young produced at 96% effluent versus TDS values.

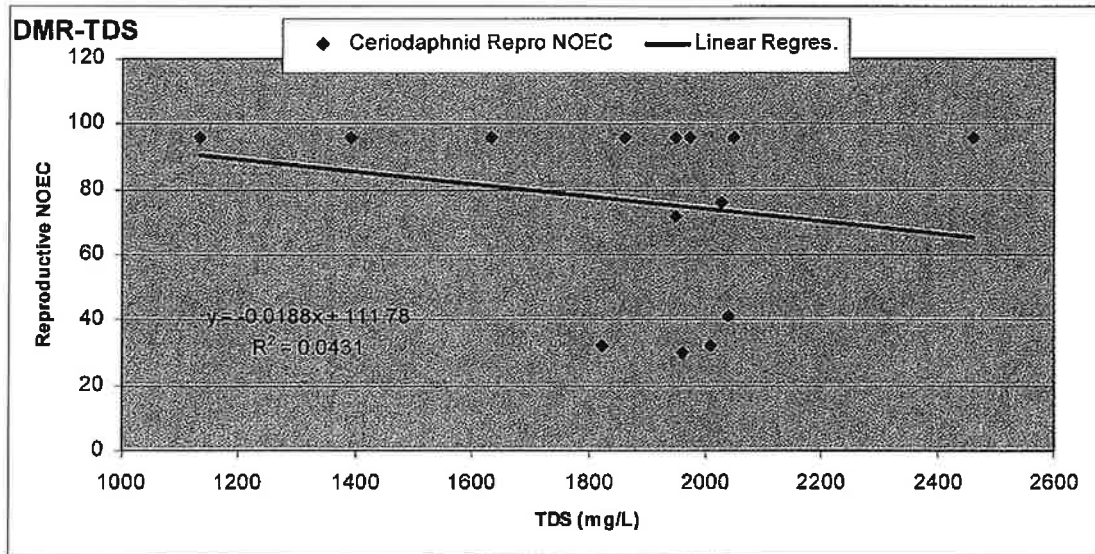


Figure 3. Chart displaying water flea reproductive NOEC versus TDS values since 2009.

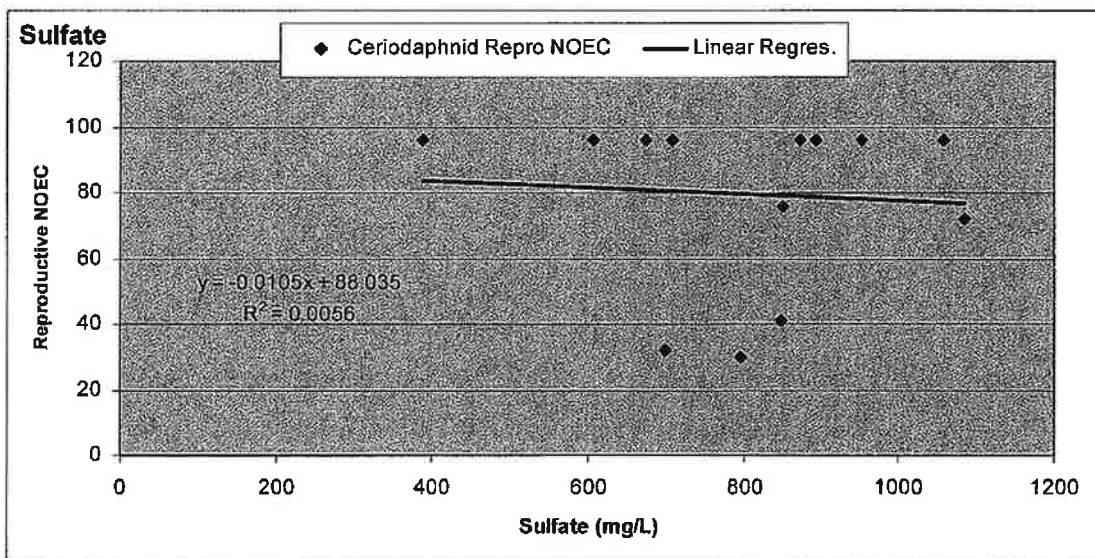


Figure 4. Chart displaying water flea reproductive NOEC versus sulfate values since 2009.

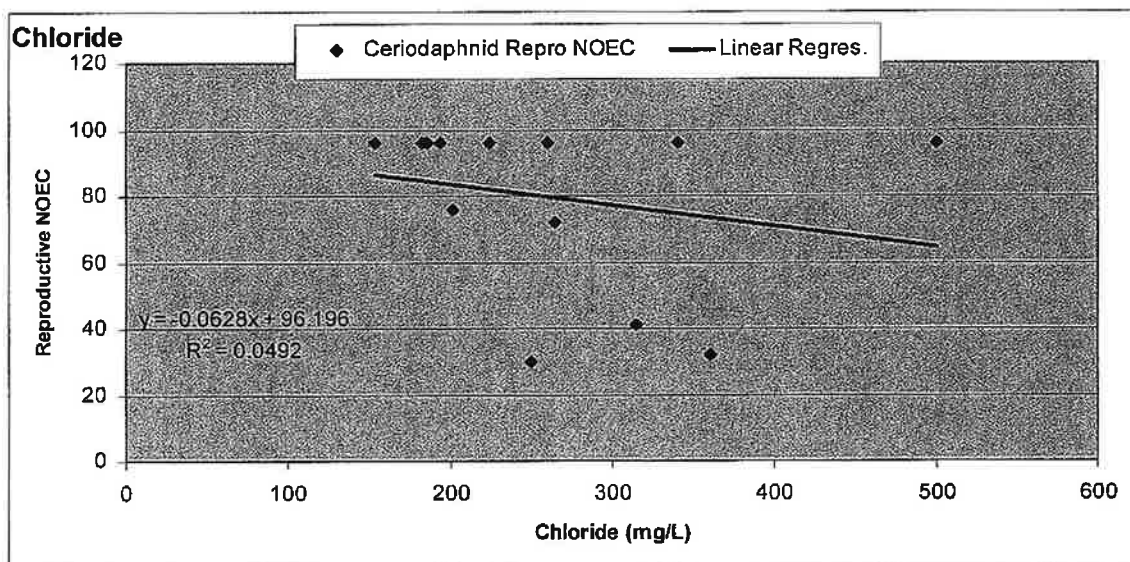


Figure 5. Chart displaying water flea reproductive NOEC versus chloride values since 2009.

Table 2 presents the results of the regression analyses. The R^2 value relates the predictive ability of the independent variable, indicating what percent of the time the dependant variable can be accurately predicted by the independent variable. The R^2 value is very low, less than 5%, for all paired variables, indicating that its predictive accuracy is less than 5%. None of the paired variables displayed a statistically significant slope (relationship) at the $\alpha=0.05$ level. Slopes were all close to flat indicating that **no relationship exists** for any pair of variables evaluated. Therefore, the lack of a significant relationship indicates that the dissolved mineral concentrations observed in the Lion Oil effluent are **not** having an effect on the periodic WET test failures observed.

Table 2. Summary of linear regression analysis results.

Variables Compared	Correlation Coefficient	R^2 Value	Slope	P-value ¹
NOEC:TDS	0.162	0.026	-0.014	0.232
# Young:TDS	0.002	0.0000038	-2.562	0.989
NOEC:TDS DMR	0.208	0.043	-0.019	0.458
NOEC:Sulfate DMR	0.075	0.006	-0.011	0.799
NOEC:Chloride DMR	0.222	0.049	-0.063	0.446

¹P-value (probability that the line slope is significant) must be below 0.05 for a slope to be considered statistically significant.

In addition to the detailed water flea regression analyses, a synoptic review of the fathead minnow data was also completed. Linear regression analysis was performed on the fathead minnow growth NOEC versus TDS, calculated (Figure 6) and on the fathead minnow fish growth in 96% effluent versus the TDS actual concentration (Figure 7).

In both cases the line slope observed was positive, indicating that WET test performance increased with increasing mineral levels. Therefore, the mineral levels observed in the Lion Oil effluent are **not** having an effect on the WET tests to fathead minnows.

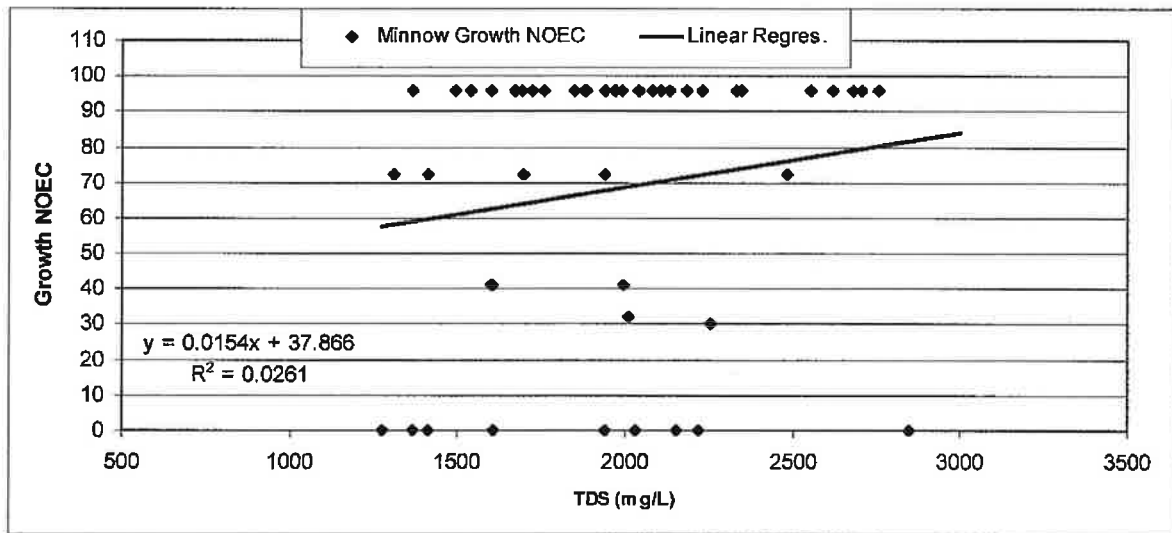


Figure 6. Chart displaying fathead minnow growth NOEC versus TDS values (calculated).

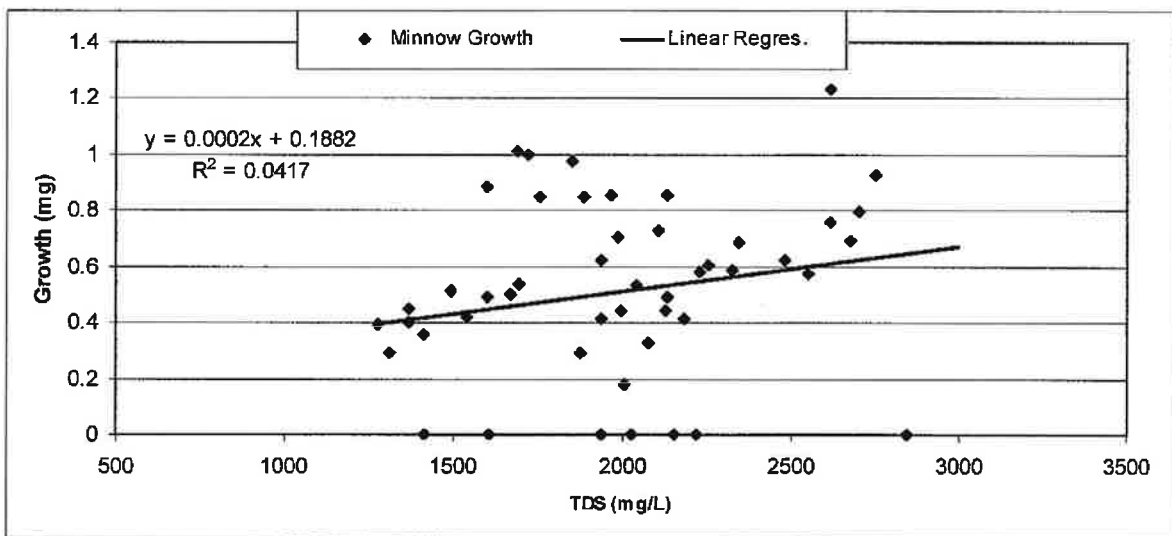


Figure 7. Chart displaying fathead minnow growth at 96% effluent versus TDS values (measured).

In summary, as previously stated in both the 2006 3rd party documentation and in the Supplemental Information submitted in October 2010, the statistical assessment of the most recently updated WET test and effluent dissolved mineral data once again demonstrated there is no correlation with the dissolved mineral concentrations and WET test performance (except that the fathead growth is positively impacted as the TDS concentration is increased).

Item 4 - Results of the Synthetic Waters WET testing

We agree that the results of BDL-La were likely impacted by the performance of the control but this does not automatically equate to a "laboratory error". A control failure (in this case the

failure of the control to reproduce the minimum number of young) means that the control organisms did not "perform" to minimum standards, it does not mean that the Laboratory erred during the execution of the WET test.

The WET test failures observed in the LC-4 were completed in an artificial environment, the laboratory, using organisms born and maintained in a contrived lab culture condition and exposed to a water solution that was developed in the laboratory to represent a theoretical condition based on extrapolated chemical concentrations that might be present during a worst case condition, and roughly based on the concentrations as measured during a single collection event. The laboratory synthetic water was designed to reflect a potential dissolved mineral complex that could reflect the new dissolved mineral criteria. As depicted in Table 6 (Page 37) of the Supplemental Information Report, although the target sulfate and chloride concentrations were not attained, the TDS target was exceeded by 150 mg/L, depicting the challenges with accurately developing theoretical synthetic waters.

Although the NOEC (a statistical measure of the differences in variability between the control, and the exposure concentration) implicated a failure, the water flea exposed to 100% of the synthetic matrix produced 12.2 young per female compared to the control (e.g. lab culture water) that produced 17.9 young per female. Although there was a significant difference, the 100% synthetic waters allowed reproduction at a rate of greater than 10 to 1.

Although the survival NOEC of BDL-2 was reported as 50%, there was actually 80% survival in the 100% exposure. In WET testing, the control is allowed 20% lethality and still be valid, implicating that one can allow for the 20% lethality (80% survival) as occurred in the BDL-2 synthetic matrix, and still be valid. Also, as the discussion in the Supplemental Report addressed, the reproductive performance of the control (e.g. narrow variability of the individual organisms) drove the significance when comparing the control and the dilutions. Lastly, the observation relating the role of the dissolved mineral in the synthetic matrix WET testing was made based on the results of the historical WET test results and the actual dissolved mineral concentrations as discussed in Item 3 above.

According to ADEQ, WET testing on samples collected from BDL-6 (ADEQ monitoring station OUA 5), have never been found to fail agency run WET testing, further supporting the conclusions that the ADPCE Commission approved criteria are;

- reflective of the long term historical dissolved mineral concentrations, and
- supportive of, and maintains, the aquatic life community and designated uses of the individual stream reaches.

Item 5 - Available Evidence

We respectively disagree on what the available evidence suggests regarding the ADPCE Commission approved dissolved mineral criteria. Based on the preponderance of the evidence presented in the 3rd party rulemaking documentation, the additional information developed as part of the Supplemental Documentation Package and continued supporting data as presented herein, especially the statistical analyses, the dissolved mineral criteria approved by ADEQ, and the ADPCE Commission for Loutre Creek and Bayou de Loutre, continue to be protective of the designated aquatic life use.

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Lion Oil looks forward to the resolution of the rulemaking issues and appreciates the efforts of ADEQ in their review and comments. If you have any questions, please do not hesitate to contact me or Vince Blubaugh at (501) 847-7077.

Respectfully Submitted,
GBM^c & ASSOCIATES



Roland McDaniel,
Principal/Senior Project Scientist

ecc: Chuck Hammock, Lion Oil Company
Miguel Flores, Region 6 USEPA
Chuck Nestrud, CN&J
Sarah Clem, Water Division ADEQ

Technical Memorandum

DATE: August 20, 2012

TO: Lion Oil UAA Technical File

FROM: Roland McDaniel
GBM^c & Associates

RE: Response to EPA August 2011 letter signed by Phil Crocker
GBM^c No. 2160-12-052

Dissolved Minerals Rulemaking for Loutre Creek and Bayou de Loutre NPDES AR0000647, AFIN 70-00016 GBMc No. 2160-10-075

In 2007, the Arkansas Pollution Control and Ecology Commission (Commission) adopted new site specific water quality criteria for dissolved minerals (sulfate, chloride and total dissolved solids (TDS)) for Loutre Creek and Bayou de Loutre. The U.S. Environmental Protection Agency (EPA) subsequently disapproved these criteria in a 2009 Record of Decision (ROD). After EPA issued its ROD, GBMc, on behalf of Lion Oil Company, prepared and submitted a January 5, 2011 Aquatic Life Supplemental Report Dissolved Minerals Rulemaking (Supplemental Report) to resolve EPA's concerns raised in the ROD. On March 10, 2011, EPA provided initial comments on the Supplemental Report and GBMc responded to those comments on June 24, 2011. On August 31, 2011, EPA provided further comments identifying four additional items that relate to the Supplemental Report. This paper addresses these four items in the order presented by EPA. For ease of reference, EPA's August 31, 2011 is attached.¹

Item 1 – Water Hardness.

EPA raised a concern about the water hardness value used for the equations that support the 2007 dissolved minerals criteria for Loutre Creek and Bayou de Loutre. EPA suggested that a hardness value of 31 mg/l, which is a default for a least-disturbed stream in the Gulf Coast Ecoregion, should be used rather than 100mg/L referenced in the Supplemental Report.

The historical water quality data for Loutre Creek and Bayou de Loutre demonstrate that the mean hardness value for these two waterbodies is higher than the default value associated with a least-disturbed stream. It is appropriate to use hardness values that are characteristic of the waterbody (instead of a default value) where such data is available to demonstrate the hardness values that support the aquatic life in the receiving streams.

¹ EPA states in its August 31, 2011 letter that its comments are in relation to Lion Oil's final study plan prepared to support the establishment of site-specific criteria for chloride, sulfate, and TDS. This appears to be a drafting error because EPA's comments address the results of the study plan, not the earlier study plan.

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EPA also suggests that if a hardness value other than the least-disturbed stream default value is used, Lion Oil should consider undertaking a Use Attainability Analysis (UAA) to develop the dissolved minerals criteria. This comment seems to suggest that the process of evaluating the state of a fishery through a UAA would serve to document the hardness values that support the fishery.

A UAA has been completed for Loutre Creek and the analysis demonstrates there is a healthy fishery in Loutre Creek, but it is not a Typical Gulf Coastal Fishery. The UAA proposes that the designated use be changed to a new fishery subcategory, which it identifies as a Limited Gulf Coastal Fishery. Thus, based on EPA's comment, the hardness value used to develop the dissolved minerals criteria for Loutre Creek is appropriate because this value reflects the water quality conditions that support the fishery in Loutre Creek.

Item 2 – Artificial Matrix WET testing Results.

After the ROD was issued, laboratory analysis referred to as “Artificial Matrix WET tests” were performed to evaluate whether the dissolved minerals concentrations at the criteria levels adopted by the Commission in 2007 would have any toxic effects on a water flea (*Ceriodaphnia dubia*) and fathead minnow (*Pimephales promelas*). In its August 31, 2011 letter, EPA stated that the results of the tests indicate there are likely toxic impacts under the 2007 dissolved minerals criteria. We disagree as explained below, and in any event, these previous tests are not relevant to the criteria now being proposed.

The dissolved minerals criteria that are now proposed for adoption for Loutre Creek and Bayou de Loutre are lower (more stringent) than the previous criteria adopted by the Commission. For the Loutre Creek segment, the chloride levels have been reduced by 3 percent, sulfate levels reduced by approximately 35 percent, and the TDS levels reduced by approximately 30 percent. Thus, prior WET test results bear no relation to these revised criteria.

The previous Artificial Matrix WET test results performed with the higher (less stringent) dissolved minerals criteria were performed as one time “artificial” laboratory tests. The artificial laboratory test were completed using a water matrix developed in the lab that was designed to mimic the receiving stream chemical matrix in the event that the maximum dissolved minerals occurred. The tests failed some of the laboratory simulations, but these laboratory simulations represent a worse case condition that are not likely to occur in the natural environment and therefore have limited value to demonstrate the toxicological effects of the revised dissolved minerals criteria on the fishery. This is because these tests are designed as an artificial worst case scenario that, to our knowledge, have never been documented to occur in Loutre Creek or Bayou de Loutre and do not reflect the on-the-ground conditions of these waterbodies.

To perform the test, chloride, sulfate, and TDS were added to an artificial matrix of chemicals, dissolved in sterile water and then used at maximum exposures (100%) to evaluate the potential for toxic effects in a laboratory environment. Because it is difficult to prepare a matrix in the laboratory, the total dissolved minerals in the artificial matrix were actually higher than the 2007 adopted TDS criteria by more than 150 mg/L. (See Table 6 of the Supplemental Report). Thus, the WET tests reflect the results of dissolved minerals levels that are higher than the criteria adopted by the Commission in 2007. These laboratory conditions are not likely to be reflected in the stream.

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Over the past 12 years, the WET tests performed by Lion Oil continue to demonstrate that the discharge of dissolved minerals does not cause toxic effects on the water flea or fat head minnow. This issue is more fully discussed under items 3 and 4 below. The analysis shows there is no relationship between the level of dissolved minerals in the discharge and the historical WET test results.

Item 3 – WET Results/Request of Additional Statistical Analyses and

Item 4 – Results of the Synthetic Waters WET testing.

Items 3 and 4 of EPA's August 31, 2011 letter both concerned WET testing. The issues raised in these items are related and therefore discussed together.¹

On June 24, 2011, GBMc submitted to the Arkansas Department of Environmental Quality (ADEQ) more recent monthly WET test results that Lion Oil performed as required by its wastewater discharge permit. This submittal included results from January 2000 to March 2012. (includes up to date data that was not in previous submittals The more recent routine monthly WET tests indicated some failures, so GBMc performed a simple linear regression statistical analysis² to investigate whether the level of dissolved minerals in the discharge had any statistically significant relationship to these test results. GBMc's analysis of these results indicated that there was no statistically significant relationship.

In response, EPA stated that the simple linear regression that GBMc relied on for its analysis was used inappropriately and the trends were selectively interpreted as being conclusive when the "r-values" in the analysis (a measure of the statistical relationship between the level of dissolved minerals in the discharge and the WET tests) are extremely low and the slopes are not statistically significant. EPA pointed out that the regression analysis findings for the fathead minnows (that indicated the slope of the regression line was positive and indicated reduced toxicity with increased dissolved mineral levels), conflicted with the results of the water flea where the slope line had little to no predictive value. EPA also maintained that the results of WET tests indicate lethal and sub-lethal effects to the water flea at the dissolved minerals criteria adopted by the Commission.

These points are addressed as follows in two parts:

¹ EPA also stated in its August 31, 2011 letter that additional data related to WET testing was requested in 2008 but never submitted. On behalf of Lion Oil, GBMc prepared a response to the issues of concern stated in EPA's January 3, 2008 letter to DEQ. The GBMc letter was dated July 29, 2008. It is our understanding that the GBMc submittal was subsequently forwarded to EPA by ADEQ on August 14, 2008. Lion Oil is not aware of any additional information request that EPA may have made in 2008.

² A simple linear regression technique was used because it demonstrates if a relationship (a correlation) exists in the data, calculates a correlation coefficient to quantify the strength of the relationship and provides a quantitative measure if the relationship is significant statistically (has a significant slope line) or not. Simple linear regression analysis provides a visual representation of the relationship, depicted as a line best fit to the plotted data. The slope of the line demonstrates the type of relationship, either negative (downward slope) or positive (upward slope) that the variables have to one another. The term "relationship" refers to the reaction of one variable value to the fluctuation of another variable value. When a strong relationship exists, one variable value can be predictive of another variable value. In the case of this analysis, the key question is: are the dissolved minerals concentration(s) linked to WET test failures and can mineral (TDS, chloride or sulfate) levels be used to predict the potential for WET test failures (e.g. reduced "No Observed Effect Concentration" known as NOEC, reduced number of young, etc.) due to the discharge?

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- (a) a review of trend lines in the statistical analysis submitted to ADEQ on June 24, 2011; and
- (b) a review of the historical data (2000-2012) to supplement the statistical analysis;

(a) Review of trend lines in June 24, 2011 statistical analysis

The statistical analysis submitted to ADEQ on June 24, 2011 shows there is no statistically significant relationship between the level of dissolved minerals in the discharge and the WET test results for the fat head minnow and the water flea. Sometimes dissolved mineral levels in the discharge were above average and the WET test passed, and other times the dissolved minerals levels in the discharge were below average and the WET test failed. In other words, because there is no significant relationship (little to no predictability) between the dissolved minerals in the discharge and the WET test results, there is no measurable connection between the two.

(b) Review of historical data (2000-2012) to supplement statistical analysis

GBMc performed an updated statistical analysis to determine if there is a relationship (at the $\alpha=0.05$ level) between the level of dissolved minerals in the discharge and the WET tests results over an approximately 12 year period (2000 and 2012). This updated analysis involved two steps: a statistical analysis of impacts of TDS in the discharge on the water flea, and a synoptic analysis of impacts of TDS on the fat heat minnow. A summary of the dissolved minerals data used in the analysis is presented in Table 1.

Table 1. Summary of minerals data used in the statistical analysis (based on 2000 to 2012 data).

Statistic	Calculated TDS(mg/L) ¹	Sulfate (mg/L) ²	Chloride (mg/L) ²	TDS-DMR (mg/L) ²
Average	2118	746	264	1882
Min	1276	389	153	1134
Max	3110	1086	500	2462
Stdev	447	180	91	298
Median	2130	745	255	1911
90%tile	2707	975	354	2162

¹TDS values are calculated from conductivity measurements for years 2000-2007. Values from 2008 forward are typically from actual measured values.

²Values are measured from effluent samples for years 2009-2012 for TDS and sulfate and 2009-2011 for chloride.

Analysis of TDS on water flea. The analysis of the impact of TDS on the water flea focused on a variable in the WET tests known as “No Observed Effect Concentration” or NOEC (a measure that tracks the number of young produced in the highest effluent dilution (96%)). The analysis focused primarily on the effects of TDS on the water flea because there have been more historical WET test failures involving these two variables when compared to the tests involving other dissolved minerals and the fat head minnow.

To begin the analysis, the distribution of TDS in the historical discharge and the WET test data was evaluated and determined to generally fit a normal curve. Regression analysis was then completed. Regression variables were varied to ensure that every possible combination was examined. Dependant variables included: water flea NOEC and number of young produced at 96% effluent. Independent variables included: all TDS values (calculated during each test from the measured conductivity values, period of record 2000-2008), TDS concentrations measured from samples collected during the course of the test (2009-2012), chloride values measured from samples collected during the course of the test (2009-2011), and sulfate values measured from samples

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collected during the course of the test (2009-2012). TDS, sulfate and chloride results from actual samples¹ only exist for toxicity tests completed since 2009. Linear regression analysis was completed for the following pairs of data:

1. All NOEC results and all calculated TDS results (Figure 1).
2. Water flea (*Ceriodaphnia*) number of young produced at 96% effluent results and all calculated TDS results (Figure 2).
3. Recent NOEC results and recent TDS DMR results (Figure 3).
4. Recent NOEC results and recent sulfate DMR results (Figure 4).
5. Recent NOEC results and recent chloride DMR results (Figure 5).

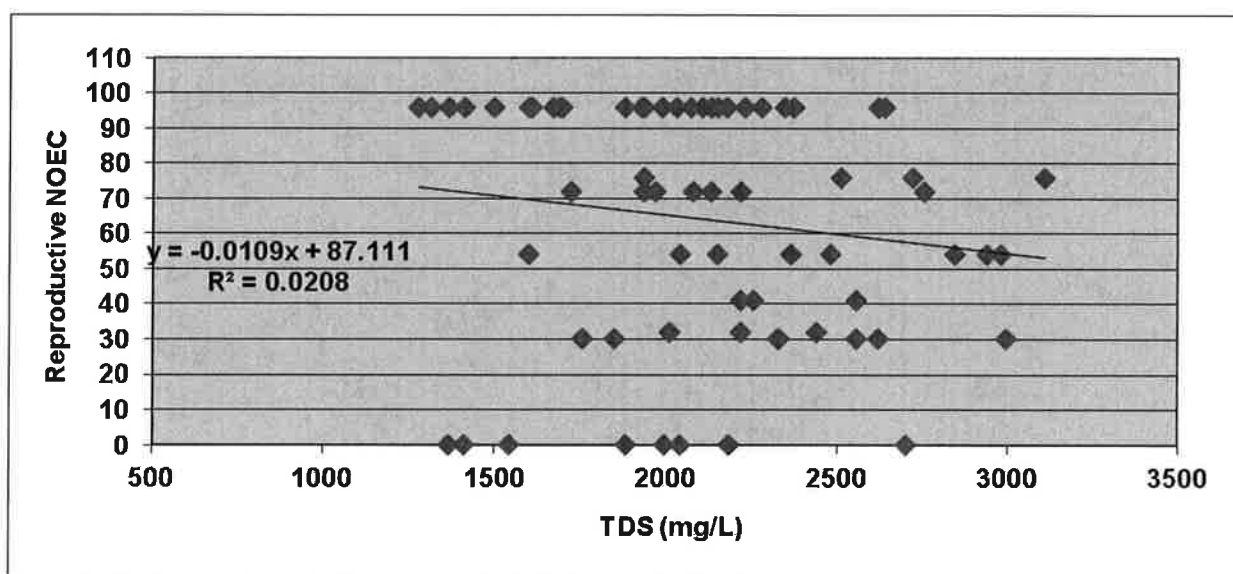


Figure 1. Chart displaying water flea reproductive NOEC versus TDS values.

¹ TDS values prior to 2009 were calculated from conductivity using the formula: $0.65 * \text{conductivity}$.

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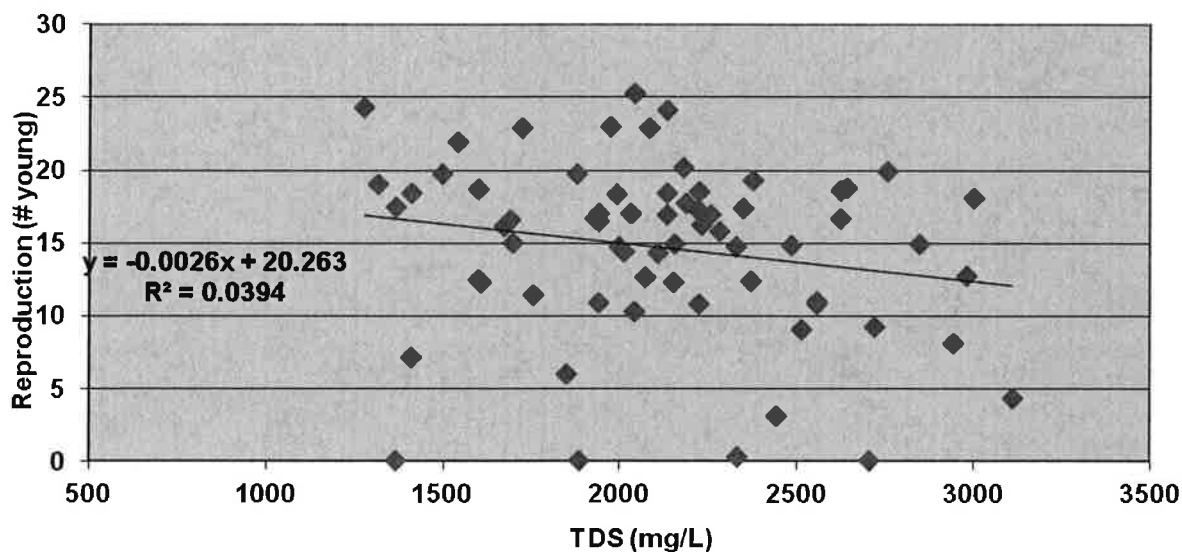


Figure 2. Chart displaying water flea total young produced at 96% effluent versus TDS values.

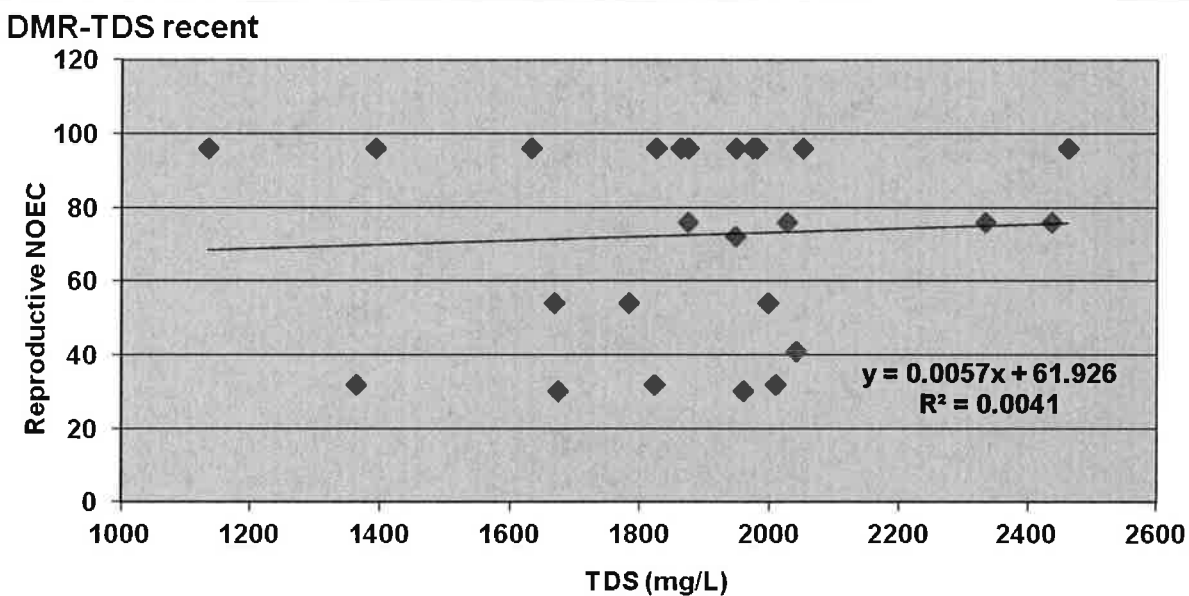


Figure 3. Chart displaying water flea reproductive NOEC versus TDS values 2009-2012.

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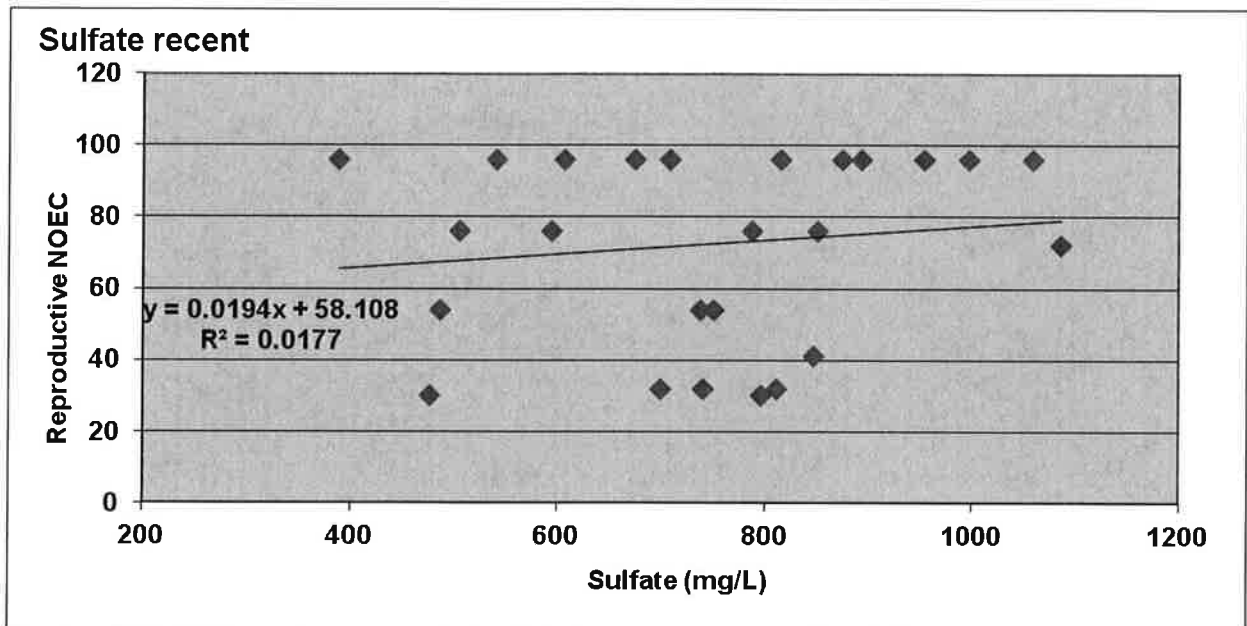


Figure 4. Chart displaying water flea reproductive NOEC versus sulfate values 2009-2012.

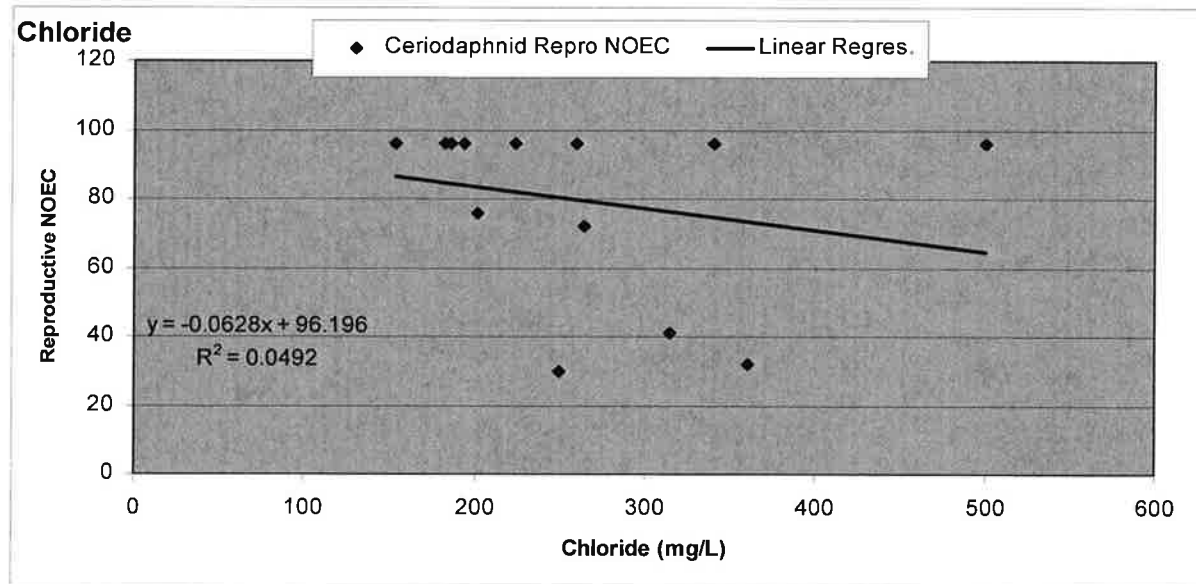


Figure 5. Chart displaying water flea reproductive NOEC versus chloride values 2009-2011.

Table 2 presents the results of the regression analyses. The R^2 value relates the predictive ability of the independent variable, indicating what percent of the time the dependant variable can be accurately predicted by the independent variable. The R^2 values are very low, 0.05 or lower, for all paired variables, indicating that its predictive accuracy is no greater than 5% of the time. None of the paired variables displayed a statistically significant slope (relationship) at the $\alpha=0.05$ level. Slopes were all close to flat indicating that **no significant relationship exists** for any pair of variables evaluated. Therefore, the lack of a significant relationship indicates that the dissolved minerals concentrations observed in the discharge are **not related** to the WET test results.

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Table 2. Summary of linear regression analysis results.

Variables Compared	Correlation Coefficient	R ² Value	Slope	P-value ¹
NOEC:TDS	0.01	0.02	-0.011	0.241
# Young: TDS	0.02	0.04	-0.003	0.105
NOEC:TDS DMR	0.04	<0.01	0.006	0.755
NOEC: Sulfate DMR	0.02	0.02	0.019	0.517
NOEC: Chloride DMR	0.22	0.05	-0.063	0.446

¹P-value (probability that the line slope is significant) must be below 0.05 for a slope to be considered statistically significant.

To further evaluate whether these results show any significant correlation between TDS and the water flea WET test results, Kendall's Tau correlations were calculated. Kendall's Tau is a non-biased (in that it is un-affected by data distribution) estimator of correlation between two variables. The results of the Kendall's Tau correlations are provided in Table 3. Kendall's Tau results verify that no significant correlation exists between TDS and either water flea NOEC or the number of young produced by the water flea in the WET tests.

Table 3. Kendall's Tau results for *Ceriodaphnia dubia*

Variables Compared	Correlation (Tau) Statistic	P-Value (2-tailed)
TDS:NOEC	-0.16	0.07
TDS :# Young	-0.13	0.11

Impacts of TDS on fathead minnow A synoptic review of the impacts of TDS on WET tests involving the fathead minnow data was completed for the period of 2000 through April 2012. Linear regression analysis was performed on the fathead minnow growth NOEC versus TDS (Figure 6) and the actual per larval growth versus TDS. (Figure 7).

In both cases the slope of the line observed is positive, indicating that there is no significant relationship between the dissolved minerals levels and the fathead minnow WET test results. This is the same finding with respect to the water flea WET test results.

In summary, the dissolved mineral levels in the Lion Oil discharge do **not** have a measurable effect on the WET test results.

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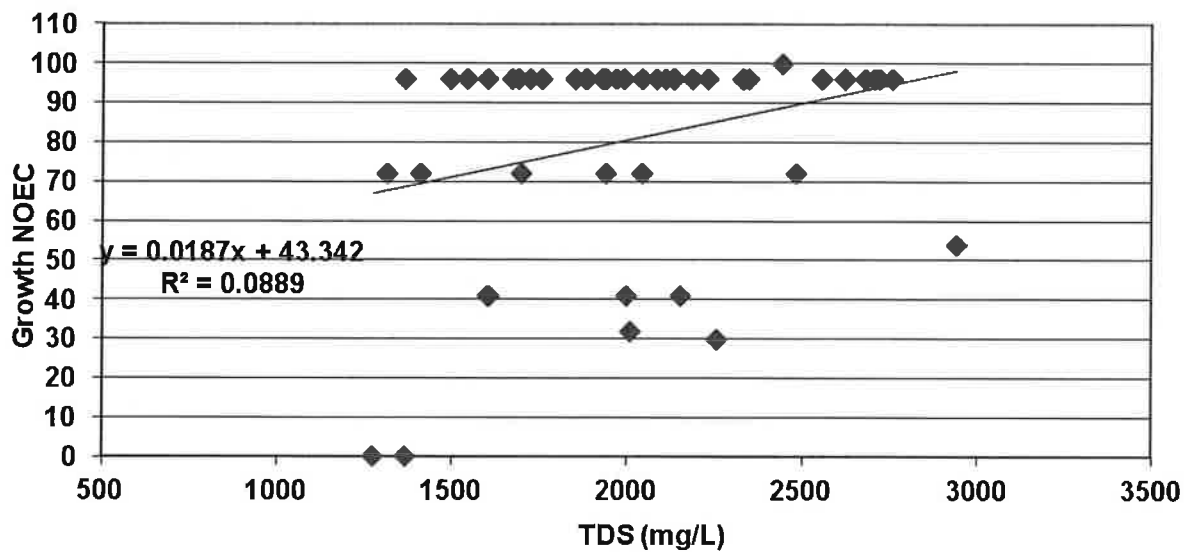


Figure 6. Chart displaying fathead minnow growth NOEC versus TDS values (calculated).

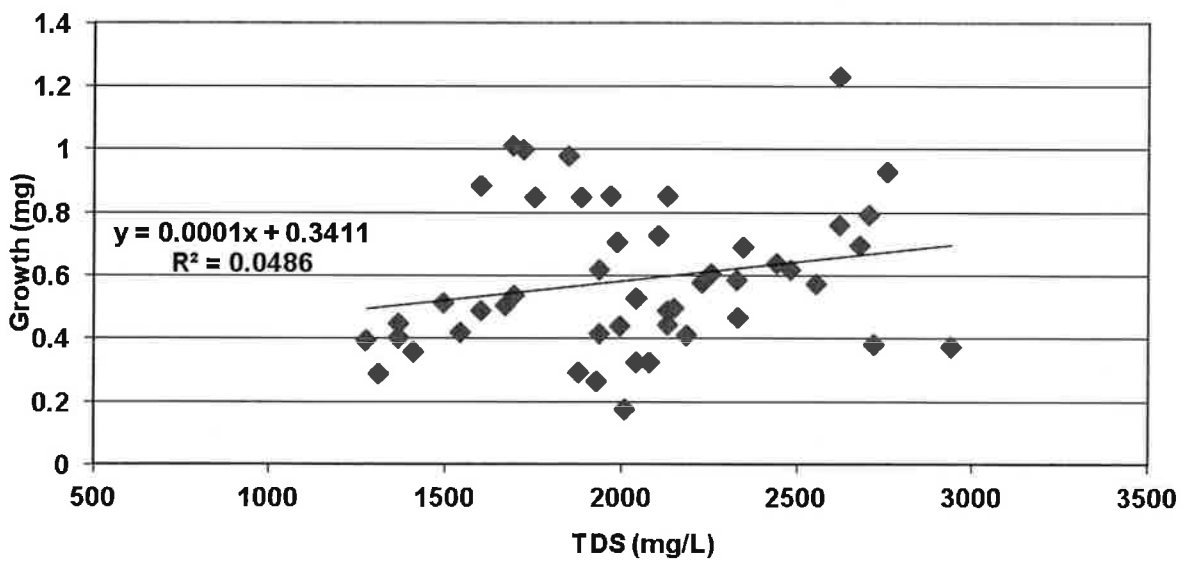


Figure 7. Chart displaying fathead minnow growth at 96% effluent versus TDS values (measured).