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September 22, 2011

Via email and U.S. Mail

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and

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RE: Proposed Richfield Dairy, Tn. of Richfield, Adams Co., WI – Comments Regarding High Capacity Well Permit/Approval and Associated WDNR Impact Analysis

Dear Mr. Kafka and Kozol:

I provided comments to you on behalf of the Friends of the Central Sands and Bob Clarke regarding hydrologic impacts associated with the proposed Richfield Dairy (RD) Site on July 25, 1011. I have reviewed information obtained in response to the August 1, 2011 Open Records Request to the Wisconsin Department of Natural Resources (WDNR) made by Christa Westerberg of Westerberg, McGillivary, Westerberg & Bender. I have also reviewed the July 25, 2011 comments regarding the draft WPDES permit and environmental assessment from Michael Best & Friedrich provided on behalf of Milk Source Holdings, LLC. I am providing the following additional comments regarding the potential impacts associated with the high capacity wells proposed for the facility. My comments address the WDNR analysis supporting its preliminary decision that the proposed Richfield Dairy high capacity wells would not have an adverse environmental impact to the waters of the State. This analysis was presented in the draft Environmental Assessment (EA) and elaborated in an August 11, 2011 WDNR email response by Eric Ebersberger, Water Use Section Chief to a August 4, 2011 email from Frances Rowe and an additional August 15, 2011 response from Eric Ebersberger to an email sent by Frances Rowe on July 11, 2011. I also contacted Rachel Greve, WDNR Water Supply Hydrogeologist, by phone on August 31, 2011 and discussed her methodology in analyzing the pumping impacts as was described in the Eric Ebersberger August 11, 2011 email. Rachel Greve followed up with more detailed documentation of her analysis by email that same day. Copies of the cited emails are attached.

Respectfully, my review concludes that the WDNR analysis is flawed and not sufficient to allow for the determination that the proposed pumping will have no significant impact to the State's water resources. I conclude instead, per my July 25, 2011 comments to you and the following discussion of the WDNR analysis, the pumping that would be allowed by the proposed high capacity well permits will result in significant adverse impacts to the waters of the State and therefore the proposed permits should not be approved.

My review of the July 25, 2011 Milk Source submittal concludes that the hydrogeological facts and analysis upon which their conclusions of no significant impact were based are incorrect and flawed and do not allow for a determination of no significant impact.

WDNR Pumping Impact Analysis

The WDNR draft EA indicates the WDNR Water Supply Section staff will assess the Richfield Dairy proposal to determine if the proposed high capacity wells would adversely affect water resources. The EA goes on to indicate that Pleasant Lake, located 2.75 miles east of the proposed site, has water level fluctuations that are mainly a result of natural influences with little impact from existing pumping and that the proposed wells should not have any noticeable effect.

The EA indicates Fordham Cr. is 4.7 miles southwest of the site and Little Roche a Cri Cr. is located 5.6 miles northwest of the proposed site. The EA indicates these are trout streams with flow characteristics similar to those of Pleasant Lake i.e. flow fluctuations in response to seasonal influences with no significant impact from current groundwater pumping with the conclusion that the proposed groundwater pumping is not a major threat to flow.

The July 15, 2011 email from Eric Ebersberger, WDNR Water Use Section Chief, in response to Frances Rowe's July 11, 2011 email addressed her concerns with the proposed well approval by indicating the circumstances under which the WDNR's authority and general duty to consider whether proposed pumping impacts may harm waters of the State. He specifically states: "…the general cumulative impact on surface water resources in the Central Sands region that the Kraft/Mechenich report attributes to the high capacity well pumping is not sufficient concrete, scientific evidence of potential harm to the waters of the state associated with the proposed wells in the specific case of the application from Milk Source, Inc./Richfield Dairy, LLC. To be sufficient, evidence in the form of professional technical analyses, e.g. groundwater modeling, must show potential harm to waters of the state directly attributable to the proposed wells. As the Supreme Court noted in Lake Beulah v. WDNR, the circumstances under which the DNR's duty is triggered are highly fact-specific. The DNR's review of the Milk Source, Inc./Richfield Dairy, LLC well application thus far has not indicated a potential for harm to the waters of the state directly associated with the proposed wells in this specific case."

The August 4, 2011 return email from Frances Rowe to Eric Ebersberger asks what would constitute "sufficient concrete, scientific evidence of potential harm to waters of the state". She also asked on what specifically did the WDNR base its assertion by stating: "The DNR's review of the Milk Source, Inc./Richfield Dairy, LLC well application thus far has not indicated a potential for harm to waters of the state directly associated with the proposed wells in this specific case. Do you have data, models, and peer reviewed journal articles to refute Kraft & Mechenich?" Eric Ebersberger responded in an August 11, 2011 email indicating the Kraft/Mechenich report and my July 25, 2011 analysis address cumulative impacts of groundwater withdrawals in the general area, but this is not sufficient to show that impacts from the proposed wells will contribute to preexisting conditions to trigger WDNR formal review of the high capacity well application. He goes on: "Rather, the concrete, scientific evidence must specify the harm directly attributable to the proposed wells: and the specific harm must be determined to pose a risk of significant adverse environmental impact before a formal environmental review will be conducted." In the same email he also indicated the WDNR reached its preliminary decision that the proposed wells would not have an adverse impact by using data from a municipal well in aquifer materials similar to those found at the proposed well site and running a simple groundwater model to predict a cone of depression that would result from pumping. The model assumed 300 days of continuous pumping at the maximum rate of 1000 gallons per minute. He reported the model results show that the proposed well will result in zero drawdown at distances greater than 4,100 feet and noted the water bodies of concern are roughly three times farther from the wells than the edge of the projected 4,100 foot cone of depression.

<u>WDNR Errors Regarding Streams West of the Proposed Site</u>

The EA indicates that Fordham Cr. is located 4.7 miles southwest of the proposed Richfield Dairy site and Little Roche a Cri Cr. is located 5.6 miles northwest of the site. The groundwater-dependent headwaters of these streams are actually located approximately 2.5 miles from the site (see Fig. 1). The headwaters to tributaries to Little Roche a Cri Cr. are located in Sections 15 and 22. The upper headwaters of Fordham Cr., located in Section 34, are hydraulically connected to the downstream segment by a wetland system.

<u>WDNR Proposed Well Permits Impact Analysis</u>

Rachel Greve, WDNR Water Supply Hydrogeologist, provided me documentation of the analysis she used to evaluate potential pumping impacts (see attached August 31, 2011 email). She also provided supplemental analysis of the impacts using the Theis method.

The analysis Rachel made that was referenced in the Eric Ebersberger August 11, 2011 email used a well drawdown analytical model based on the Jacob solution as calculated by a North Carolina DNR Water Resources Division program. Transmissivity values (averaging 3855 ft^2/d) and storage coefficient data (averaging 0.15) measured from two Coloma municipal wells sited in hydrogeological conditions similar to those found at the proposed Richfield Dairy well sites were used along with a well radius of 0.67 ft. Both proposed wells were assumed to be operating at full capacity for a total of 1000 gallons per minute for 300 days. I reproduced this analysis using the same model input data and program with the same results (see figure 2). After 300 days of pumping the model showed 70 feet of drawdown at the well, 30 feet of drawdown at 100 feet from the well, 11.0 feet of drawdown at 1000 feet from the well, and zero drawdown at 4,165 feet from the well. Rachel also made a similar analytical calculation using the same data, but using the Theis solution, which she indicated produced zero drawdown at 6600 feet from the well instead of at 4,165 feet. I have reproduced Rachel's Theis analysis using the same data and method of solution and came to the same result (see Fig. 3). Note that the aquifer transmissivity of 3855 ft^2/d was converted to 28,825 gal per day/ft to conform to the required model input requirements.

<u>Discussion of Model Results</u>

The analytical models used are based on the analytical solutions developed by Theis (1935) and further simplified by Jacob (1940) and Cooper and Jacob (1946). These models are all based on a simplification of the groundwater flow system using the following assumptions:

1. The pumped aquifer is infinite in areal extent.
2. The aquifer is homogeneous, isotropic, and of uniform thickness.
3. The water table is horizontal.
4. The well is fully penetrating with water withdrawal uniform across the entire thickness of the aquifer.
5. The drawdown associated with the pumping does not significantly decrease aquifer transmissivity.
6. All the water removed by pumping is taken from aquifer storage.
7. No water is added through recharge and no water is removed by streams, springs, wetlands, lakes or existing high capacity wells.

The Jacob solution further simplifies the Theis solution by assuming the aquifer is no longer experiencing significant change in hydraulic head over time i.e. that is the system is approaching steady state where the formula "*u*" value is very small, meaning the distance to the drawdown point of concern relative to the duration of pumping is very small. Kruseman & de Ridder, 1970, provide a maximum allowable "*u*" value of 0.01, while Heath, 1983 provides a maximum allowable "*u*" of 0.05.

In effect, these analytical models simply "mine the aquifer" over time by removing water from storage at increasing distances from the well. There is no allowance for the actual hydrogeological boundaries found in the proposed Richfield Dairy well site such as recharge or discharge boundaries, except for the pumping well itself. It is clear the analytical solutions used have significant limitations for use in evaluating the impacts of the proposed wells. The following discusses the most significant limitations of the use of the analytical models to evaluate pumping impacts at the proposed Richfield Dairy site.

The aquifer is not of infinite areal extent. Over long periods of pumping the system will be significantly affected by boundary conditions not represented in the model which will cause the simulation to be unrealistic. The simulations cannot produce a realistic steady state solution because the cone of depression continues to expand infinitely. Since the proposed pumping wells are expected to be in use for many years the impact of longer pumping can be evaluated with the same models using the same aquifer data. Increasing the pumping period from 300 days to 3000 days (8.2 years) produces a Jacob drawdown result showing drawdown increasing to approximately 78 feet at the well, 41 feet at 100 feet, 20 feet at 1000 feet, and 2.0 feet at 10,000 feet , and zero drawdown at 13,171 feet from the well (see Fig. 4). Figure 5 shows the results of a reverse-time drawdown analysis using the Cooper-Jacob formula with the same conditions as before (i.e. 3000 days pumping) with the drawdown over time calculated at 4165 feet from the well, which was the point of zero drawdown for the 300 day pumping simulation. The results show the drawdown at 4165 feet from the well first starting at 300 days, as would be expected, and increasing to approximately 9.1 feet of drawdown by 3000 days. Figure 6 shows the same calculation, but with the impacts calculated at 2.0 miles (10,560 feet) from the well. The drawdown begins at 1928 days (5.3 years) and results in approximately 1.75 feet of drawdown after 3000 days (8.2 years).

It should be noted that neither the 300 day nor 3000 day Jacob's calculations should be considered valid since the hydraulic heads do not meet the model requirements that the system is approaching steady state conditions. This is further evidenced by formula "*u*" values of much greater than the maximum recommended values. The time required for the hydraulic system to approach a steady state condition at a specific distance of interest from the pumping well can be calculated us within the limitations of the analytical formulas by setting "*u*" equal to 0.05 (Heath, 1983) where:

$u = (r^2S)/(4Tt) + 0.05$ and with substitutions;

$t_c = (7200)(r^2)(S)/T$

where t_c = time to "steady state" in minutes, r = distance from well,
S = storage coefficient, and T = transmissivity

At 4165 feet from the well ($T = 3855\ ft^2/d$ and S = 0.15) "steady state" is approached at 4.86×10^6 minutes (3375 days or 9.25 years) as calculated within the limitations of the analytical model. At the distance of 2.5 miles, where sensitive water resources are located, "steady state" is approached at 4.9×10^7 minutes (33,900 days or 93 years) as calculated within the limitations of the model.

A Theis calculation with 1000 gallons per minute pumping over 3000 days (8.2 years) was calculated by me as shown in Fig. 7. The results show drawdown ranges from approximately 94 feet at the well to 9.4

feet at 4165 feet. Fig. 8 shows that the same calculation produces 4.74 feet of drawdown at 8000 feet (1.52 miles) and Fig. 9 show the same calculation produces 1.94 feet of drawdown at 13,200 feet (2.5 miles).

Though the Theis analyses do not violate the steady state assumptions of the Jacob analyses, the results show that at distances greater than 4000 feet from the pumping wells the impact analyses for water resources must allow for approximately 9 years at 4000 feet to 90 years at 2.5 miles within the limitations of the this analysis so that the full impacts of pumping can be determined. Clearly, the WDNR analysis is flawed in that sufficient time for development of full impacts was not evaluated.

As seen by the analytical model analysis presented, the pumping impacts at the distances where water resources of significance are located can only be evaluated with these techniques by extending the time of calculation to allow the cone of depression to be propagated to the impact areas of concern. However, the limitations of these analytical models, including most importantly the lack of realistic boundary conditions as discussed previously, makes these models completely unsuitable for this purpose. In addition to the lack of appropriate recharge and discharge boundaries, the single pumping well analytical simulations presented completely neglect the impact of the other wells pumping in the area. Fig. 10 indicates approximately 50 high capacity wells are located within three miles of the proposed Richfield Dairy site. Without considering the pumping of other high capacity wells in the vicinity, the analysis of the significance of the impacts of the additional proposed wells cannot be made. Analytical modeling of multiple pumping wells by superposition of solutions using the summation of all the separate analytical results of all wells in the vicinity is theoretically possible, but not practical, and in any case suffers from the same boundary condition and steady state time constraints that make the single well analyses unacceptable.

Another very important limitation to the analytical modeling is that changes in flow to streams, wetlands, springs, or lakes of concern cannot be calculated.

The only way to realistically evaluate the impacts of the current and proposed pumping on the water resources of concern is through use of a calibrated numerical flow model such as was documented in Kraft & Mechenich (2010) and Kraft et al. (201X). My discussion of this numerical modeling in the Central Sands, including the area of the proposed Richfield Dairy, was presented in detail in my July 25, 2011 report to you. This model provides for realistic hydrogeological boundary conditions and was calibrated to actual recorded stream flows, measured well heads, and lake levels, resulting in a very high degree of scientific certainty regarding the validity of the model results. The model-calculated discharges at area streams such as Little Roche a Cri Cr. allow for evaluation of the specific impacts for discrete water resources that are impacted by the current and proposed pumping in the proposed Richfield Dairy site area.

My July 25, 2011 discussion noted the Kraft & Mechenich modeling showed a steady state reduction of 20 to 30% of stream base flow at the headwaters of a tributary to Little Roche a Cri Cr. located approximately 2.5 miles northwest of the proposed Richfield Dairy wells. This is because the headwaters of Little Roche a Cri Cr. are one of the groundwater discharge points closest to the recharge area in which the proposed Richfield site is centrally located, and that since recharge provides the groundwater discharge at the headwaters that supports the stream's base flow, it can be stated with a high degree of scientific certainty that the reduction in recharge in the area of the proposed Richfield Dairy site caused by high capacity well pumping results in a proportional decrease in stream base flow. Since the stream headwater areas closest to the pumping wells are the location of the initial expression of groundwater discharge, the effects of pumping are most pronounced in these areas. The headwater areas are also very sensitive to fluctuations in base flow because of their relatively low base flows. The flow reductions are much greater during conditions of low base flow such as during periods of lower precipitation. The result is reduced length of stream reach during normal base flow conditions and reduction of the trout habitat available during seasonal base flow reductions such as occur during drought or water warming periods associated with high air temperatures. Due to the dependence of the Roche a Cri Cr. trout fishery on cold base flow it is clear that water resources of the State have been significantly adversely impacted.

Streams east of the site area have also been documented to have experienced similar significant impacts, with a base flow reduction at Tagatz Cr. of 5% to 10%. Note that the Tagatz Cr. headwaters are approximately one mile further from the highly developed irrigated area than the headwater area of Chafee Cr., and therefore larger base flow reductions would be expected at Chafee Cr.

The regression analysis of Kraft& Mechenich (2010) showed that steady state declines of at least 1.5 feet at Pleasant Lake were attributable to the current irrigation pumping west of the lake. The report indicates that the Pleasant Lake impacts are likely to be understated by 0.4 to 0.76 feet because the regression calibration reference points assumed not to be impacted by pumping had actually experienced lake level declines due to pumping of 0.4 to 0.76 feet. While the Pleasant lake levels do fluctuate due to natural seasonal impacts related to variations in precipitation, evapotranspiration, and seepage to groundwater, the pumping impacts causing an additional 2.0 foot lake level decline represent significant adverse impacts to Pleasant Lake's water resource values, being expressed by shore line recession, access problems with docks, and fish habitat impacts related to a decreased water depth and volume, increased water temperature, and loss of lake bed structure. The recreational values of the lake have been significantly and adversely impacted. Since Pleasant Lake is a seepage lake, reduction in groundwater levels adjacent to the lake increases the hydraulic gradients out of the lake resulting in increased seepage losses.

The WDNR implication that the current and proposed pumping impacts are acceptable because of the presence of natural stream flow and lake level fluctuations is not valid. It is clear that the current pumping is causing significant adverse impacts to the water resources dependent on the groundwater base flow supported by recharge at the Proposed Richfield Dairy site area and that additional pumping at the proposed wells will exacerbate these impacts resulting in significant adverse impacts. WDNR could readily simulate these additional impacts, if needed, using the Kraft & Mechenich, 2010 calibrated numerical model, which is available as a public document.

Additional Discussion

As indicated, the WDNR analysis of pumping impacts did not directly address reductions in groundwater flow to streams or the lake level declines associated with increased lake seepage. Instead, the WDNR used inappropriate analytical methods applied over an insufficient duration of pumping time to conclude there would be no impacts associated with the proposed pumping. In addition to the technical analysis provided in this report, the inadequacy of the WDNR methodology can be readily understood if the same analysis were to be used for a similar high capacity well proposed 6600 feet from the Little Plover River or Long Lake where irrigation pumping in the Central Sands has been documented to have completely dried up reaches of the Little Plover River and have produced periods when Long Lake has been completely dewatered. The simulation would indicate there would be zero drawdown at 6600 feet and therefore there would not be any significant impact to the Little Plover River or Long Lake. Of course the impact analysis would be invalid because the analysis would not have accounted for the long term annual reduction of 440 million gallons of groundwater withdrawn by the well nor the cumulative impacts of the other high capacity wells already approved in the vicinity that would otherwise support base flow to the river or maintain the head levels needed reduce lake seepage to rates that maintain the normal lake levels.

The WDNR's unwillingness to acknowledge the concrete scientific documentation of impacts to water resources in the proposed Richfield Dairy vicinity due to the cumulative impacts of pumping as provided by the numerical groundwater analysis conducted by Kraft & Mechenich (2010) is not defensible. This type of scientific analysis is very seldom available to address specific impacts such as those caused by the current and proposed pumping. The availability of this work allows for an unusual degree of scientific certainty as to the degree, specific location, and significance of the current and proposed pumping impacts in the proposed Richfield site area along with the specific adverse impacts that result at the specific water resources located in the proposed Richfield Dairy vicinity.

Conclusions

1. The WDNR Environmental Assessment errors in indicating that surface waters of concern west of the proposed Richfield Dairy site are located 4.7 to 5.6 miles from the site. Instead, the headwaters of Little Roche a Cri and Fordham Creeks are approximately 2.5 miles from the site.

2. The WDNR used simple analytical groundwater models to evaluate the impact of high capacity well pumping on water resources in the site area. These models are not adequate for the determination of pumping impacts in the site area because:

    a. The assumed model boundary conditions deviate significantly from those actually found in the site area.

    b. The assumption of near steady state conditions required for the Jacob's analysis was not met.

c. The pumping period duration simulated was not of sufficient length to allow impacts to be evaluated at the areas of water resource concern.

d. The model boundary conditions are unrealistic for the long near steady state simulations that are required to evaluate impacts at distances greater than 4000 feet from the proposed wells.

e. The model conditions do not incorporate the recharge and discharge boundaries required to evaluate impacts at the water resources of concern located at 2.5 to 3.0 miles from the proposed well locations.

f. The model simulation does not include the very significant cumulative impact of approximately 50 high capacity wells currently located within 3.0 miles of the site.

g. The model simulation used does not provide any analysis of the changes in the quantity of water flow between the specific water resources of concern (including streams, lakes, springs, and wetlands) that is a result of the impacts of existing and proposed pumping as superimposed over the natural flow system.

3. The regression analysis and calibrated numerical groundwater model analysis of the existing flow conditions in the vicinity of the proposed Richfield Dairy wells, as documented in Kraft & Mechenich (2010), provides the best available method to evaluate the pumping impacts from the proposed wells. The model results show with a very high level of scientific certainty that the existing high capacity well pumping in the site vicinity has resulted in significant adverse impacts to specific water resources in the site vicinity and that the pumping associated with the proposed wells will cause additional significant adverse impact to these water resources.

Milk Source Holding's, LLC Comments dated July 25, 2011

Michael Best & Friedrich, on behalf of Milk Source, indicates the wells proposed should not be considered "new withdrawals" because they are replacing an existing on-site high capacity well with significant historic pumping and concludes that no new impacts or additional impacts are expected.

The accompanying analysis prepared by Conestoga Rovers & Associates (CRA) concludes the proposed wells "will not cause any detrimental impacts to surface water, nor will they change current groundwater withdrawal conditions enough to cause any new impacts to the aquifer" and "will not cause further depreciation of the groundwater system". Their conclusions are based on the following points with my comments following each:

1. Pumping rates at the current on-site well #146 pumped an average of 12.4 Mg/month during the summers of 2007 – 2009 and the expected RD well pumping is expected to be 4.5 Mg/month so would result in less impact than the existing well.

K.W.: A complete review of Well #146 pumping records from 1978 through 2010 shows the average annual pumping to be 15Mg/year or 1.25Mg/month. In addition, the impact of the proposed RD well pumping will have a much greater impact on reduction of the groundwater base flow that supports the water resources of concern in the area. This is because the pumped RD well water will be subjected to very high evapotranspiration losses due to incorporation into dairy products, evaporative cooling at the facility, animal transpiration, and surface and near-surface land spreading of liquid waste products with little percolation below the root zone of waste liquids anticipated. A reasonable estimate would be that less than 10% of the RD water pumping is likely to be returned to replenish groundwater base flow and 90% or more would be lost. In contrast the Kraft & Mechenich (2010) modeling conclusively shows that pumping for irrigation results in an average of a 1.9" reduction of recharge to the groundwater flow system. Using a reasonable average estimate of 8 inches of water applied to irrigated fields per year, the relative impact of irrigated pumping to groundwater base flow can be calculated to be 1.9"/8" = 24% loss of pumped water. Therefore the relative impact of RD pumping compared to irrigation pumping would be 90%/24% or 3.75 times greater for the RD pumping. Therefore the expected RD pumping of 52.5Mg/yr, as stated in the EA, would be equivalent in impact to 197Mg/year of irrigation pumping and the average expected pumping of 440Mg/year, as allowed in the proposed high capacity well permit, would be equivalent to 1650 Mg/year of irrigation pumping. Therefore, in order for the RD well pumping to be limited to the impacts historically produced by the on-site irrigation well, and not cause additional impacts, the RD pumping would need to be limited to the 15Mg/year irrigation pumping divided by the 3.75 relative impact factor resulting in a maximum pumping rate of 4.0 Mg/year.

2. A zone of capture (ZOC) analysis, based on analytical modeling and an assumed and fixed general gradient condition, was used to conclude well pumping impacts could not extend to the water resources of concern.

   K.W.: This analytical modeling suffers from the same flaws as that I discussed previously for the Theis and Jacob analysis conducted by the WDNR with the addition of further unsupported constraints of a fixed horizontal gradient. This model cannot provide for any realistic evaluation of impacts to the groundwater discharge areas of concern due to the lack of any connection of the model to those resources.

3. CRA discounted the results of the Kraft & Mechenich (2010) modeling saying the report:

   a. Showed no clear impacts to Pleasant Lake that were specifically identified.

   K.W.: Their analysis clearly showed, through statistically significant regression analysis of historic lake levels, that the lake has been impacted by irrigation pumping.

   b. Insufficient data was used to conclude impacts to Pleasant Lake had occurred.

   K.W.: See above.

c. Corroborating groundwater declines at Pleasant Lake were not provided.

K.W.: The model-calculated decline at Pleasant Lake was 1.0 foot.

d. Other pumping sources, such as lake home development were not considered.

K.W.: The pumping for domestic use is not significant in quantity compared to the irrigation/agricultural pumping and most of the domestic water pumped is returned to the groundwater system through on-site wastewater systems.

e. The modeling analysis was general in nature, not site specific, and therefore cannot be relied upon to determine impacts from RD's proposed wells.

K.W.: The model is calibrated to hundreds of historic water levels and stream flow measurements, and the model discretization and realistic boundary conditions allows for the impacts at any specific area of water resource concern to be evaluated, including determination of stream flows and lake levels. The modeling analysis is vastly superior to any of the analytical analyses used by WDNR or the RD consultants.

The analysis presented by New Fields (NF) shared some of the analysis as CSA, as discussed above, but added the following points that are followed by my comments:

1. NF indicates the impact on the shallow sand & gravel aquifer will be reduced because the well is completed in the sandstone and not the overlying sand & gravel.

K.W.: Since the sand & gravel is approximately 10 times more transmissive than the sandstone and since there is a direct hydraulic connection between them, the pumping will induce flow into the sandstone from the sand & gravel a very short distance from the well and therefore the sand & gravel and sandstone units should be considered a single aquifer with the understanding that approximately 90% of the flow will be occurring in the sand & gravel.

2. NF indicates the four high capacity wells closest to Pleasant Lake area more likely to have a direct impact on Pleasant Lake.

K.W.: Though the four wells are closer to Pleasant Lake than the proposed RD wells and the hundreds of irrigation wells two to five miles away, the cumulative impacts of the more numerous distant wells on the water levels and stream flows in the Pleasant Lake area are of much greater in magnitude than that caused by the four closer wells.

Prepared by Kenneth S. Wade, P.E., P.G. – September 22, 2011

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