ATTACHMENT B
TO THE 11/12 SEPTEMBER 2008 STAFF REPORT
CEASE AND DESIST ORDER FOR THE CITY OF DIXON

GROUNDWATER DISCUSSION

Background

In order to determine whether or not the City of Dixon has degraded or polluted groundwater due to the discharge of waste at its facility, one must first review the Groundwater Limitations contained in the current Waste Discharge Requirements (WDRs). Order No 94-187 states that the discharge of waste shall not cause underlying groundwater to statistically exceed certain receiving water limits where specified in the WDRs, or background groundwater quality where not specified. In this case, "receiving water" refers to groundwater. As discussed in the Staff Report, the WDRs list several receiving water limits, some of which are narrative and others of which are numerical. The receiving water limits specified in WDRs that most relate to salinity state that groundwater shall not contain chemicals in concentrations that adversely affect beneficial uses or exceed maximum contaminant levels (MCLs).

The 2005 Cease and Desist Order (CDO) No. R5-2005-0078 clarified the City of Dixon's groundwater limitations as follows:

> *Effective 30 October 2009, the Discharger shall comply with the following Groundwater Limitation:*
>
> > *The discharge of waste from any treatment pond, storage pond, disposal pond, land disposal area, or land application area shall not cause the underlying groundwater to contain constituents in excess of background groundwater quality, or in excess of the applicable water quality objective, whichever is higher. Compliance with this limitation shall be measured by a groundwater monitoring well network approved by Regional Board staff.*

At the time the 2005 CDO was adopted, the City of Dixon had not yet completed a statistical analysis to determine background groundwater concentrations of waste constituents. Therefore, the CDO required the submittal of a Background Groundwater Quality report that was to include proposed numerical groundwater limitations to implement the narrative limitation quoted above. Staff anticipated that background concentrations would then be compared to concentrations downgradient of the facility to determine whether or not the City complied with the Groundwater Limitations in the WDRs.

Groundwater Quality Technical Studies

The Discharger submitted the *Background Groundwater Quality Report* on 3 April 2006. On 6 June 2006, staff informed the Discharger that the report was incomplete because it did not include a summary of all monitoring groundwater monitoring data as required by the CDO. The data were necessary to allow staff to independently review the statistical analysis. The Discharger submitted the required data on 22 June 2006, and staff completed review of the report. Staff's 13 September 2006 comments on the *Background Groundwater Quality Report* informed the Discharger that the report was not adequate because the Discharger inappropriately excluded one of the background wells (TW-1) from the analysis, included a well that is considered not representative of background as a background well (SW-MWR), and used inappropriate statistical methods to determine background groundwater quality and the level of degradation in the compliance wells.

The technical issues were subsequently resolved to staff's satisfaction, and the City submitted *Addendum No. 2 to the Background Groundwater Quality Report*. The report included background groundwater concentration limits calculated by the Discharger using methods and background wells approved by staff. Staff approved the addendum and the revised background concentration values on 12 January 2007. The statistical method used to derive the groundwater limits was the 99% Upper Prediction Limit (UPL) for parametrically distributed data, using a pass 1-of-3 re-testing strategy. This methodology was agreed to following discussions between the Discharger's consultant, Regional Water Board staff, and Title 27 Program staff at the State Water Board. The selected methodology accomplished several goals, such as limiting the false positive rate and maintaining the statistical power of the tests, consistent with the data analysis methods of Title 27.

The background wells selected for use in the method were TW-1 and NW-2[1].Regional Water Board staff selected these wells because they best represented groundwater upgradient of the facility. The computed statistics for each background well were compared to one-another, for a given parameter, and the largest value chosen as representative of the upper range of background groundwater quality at the site. Certain wells, in particular SW-MWR and MW-6, were excluded by staff from use in the statistical method because they contained significantly higher concentrations of salinity constituents and were geochemically dissimilar to the selected background wells.

During the same period, the City voluntarily completed a supplemental groundwater quality study using several potential tracer constituents that are not usually included in a groundwater monitoring program. Samples from influent, effluent and facility monitoring wells were tested for:

- Stable isotopes of boron, nitrogen and oxygen in nitrate and ammonium, and oxygen and hydrogen in water;
- Rare earth elements, such as lanthanum, cerium and gadolinium;
- Several common drugs and chemicals found in personal care products;
- Common pesticides and herbicides; and
- Fluorescing compounds, such as rhodamine.

The results of this study were submitted in a January 2007 report titled *Differentiation of Effluent Impacts to Groundwater Using Multiple Tracers* (the Multiple Tracers report). The results of this study are discussed below.

The City also obtained additional information on regional groundwater chemistry as part of its efforts to identify a suitable expansion site for its WWTF. The City intended to submit these

[1] Well NW-2 was a replacement well for NW-MW, which was destroyed in 2004. The historic data set from NW-MW, however, was used in some calculations.

results in the *Hydrogeologic Investigation and Disposal Site Evaluation Report* due on 30 April 2007 pursuant to the 2005 CDO. However, the City did not submit the report because work on the project stopped following repeal of the sewer rate increase by voters in November 2006. The City used the analytical results in its 13 March 2008 comments to the Regional Water Board on the 2008 tentative CDO and other submittals.

The City's 13 March 2008 comments on the tentative CDO pertained to groundwater and responded to the Regional Board's earlier review of the Multiple Tracers report. The comments reiterated the City's position that other sources of salinity in addition to the wastewater ponds need to be considered in evaluating compliance with groundwater limits based on groundwater monitoring at the WWTF. At the request of staff, the City also submitted technical documents on 5 June and 31 July 2008. The 31 July report provided additional data collected since the Multiple Tracers report was written and provided a site conceptual model for hydrogeologic conditions at the WWTF.

Geology

The geology of the Dixon area generally consists of Holocene to Late Pleistocene stream or alluvial sediments consisting of poorly sorted stream and basin deposits, ranging in size from clay to boulders. In the vicinity of the WWTF, these sediments are mostly silt and clay with interbedded lenses or channels of sand and minor gravel deposited at the distal margin of large alluvial fan complexes originating from the Coast Ranges.

The City used borehole logs to assess the surface soils and sediments underlying the WWTF. These logs indicate that clays and silty clays extend from land surface down to about 15 to 30 feet below ground surface (bgs). Coarser-grained sediments consisting of silts to sands of varying thickness are generally found at depths below 15 to 30 feet bgs. These zones are the water producing sediment generally screened for the facility's ground water monitoring wells. The total thickness of the sandy zone was not determined, but extends to a depth of at least 40 feet below ground surface. While most borehole logs had sand at depth, certain logs showed only clay, indicating a limited or channelized distribution of sand in the subsurface. Channelized sands are expected in sediments deposited through alluvial processes.

Groundwater Hydrology

The depth to groundwater in the vicinity of the facility is generally between 15 and 40 feet. Groundwater elevations can vary significantly through the year. Groundwater elevations typically begin to drop in April, reaching their lowest point in October. These seasonal fluctuations ranged from 12 to 17 feet between 2005 and 2007.

The regional groundwater flow direction is generally east to southeast, toward Cache Slough and the Delta with a horizontal gradient of around 0.001 and an estimated horizontal velocity of 20 feet per year. However, groundwater monitoring at the facility shows the local gradient direction can vary seasonally from southeast to north and is likely influenced by a number of factors, such as wastewater disposal, irrigation, and agricultural pumping. Agricultural pumping likely induces vertical gradients in the aquifer as well.

According to Thomasson and others (1960)[2], groundwater of regional economic importance is contained in deeper sediments of the Pliocene Tehama Formation, but many wells in the Dixon area tap only the alluvium. The more permeable lenses of sand and gravel, which are in a matrix of flood plain silt, fine sand, and clay, are often hydraulically interconnected (Thomasson and others 1960). This observation is evidence that groundwater in shallow alluvium layers has existing beneficial uses in the Dixon area.

Hydrogeologic Model

The City provided a conceptual site model for the hydrogeology at the WWTF in its 31 July 2008 technical report to the Regional Water Board. In the report, the City summarized that the surface deposits consist of mostly silts and clays down to a depth of 15 to 30 feet below ground surface. Below this horizon, lenses of water bearing sands of varying thickness are generally found. The report provided preliminary cross sections of the geology under the WWTF. Based on available data however, the City was unable to determine whether the sand layers make up interconnected units or if they are more characteristic of isolated, channelized deposits.

The City concluded groundwater movement in this sandy horizon is likely influenced by wastewater disposal, irrigation return flows, and irrigation water conveyances. The movement of solutes (salts and other constituents) under and surrounding the WWTF is also complex and involves multiple sources, including wastewater and non-wastewater components (agricultural and geologic) with similar or even greater concentrations than the City's effluent.
The site conceptual model presented by the City incorporates the major findings and interpretations of its work to date. Staff concludes, however, that the model is not sufficiently robust to fully explain the distribution, extent, or interconnection of sand zones in the subsurface. These sand zones are important because they provide the pathways for groundwater movement at the site, while the surrounding clay impedes groundwater movement. The model is not yet a useful tool to help optimize groundwater monitoring, or help explain certain water quality differences observed at the site.

Groundwater Quality

Thomasson and others (1960) described groundwater in the Dixon area as characterized by either magnesium bicarbonate or calcium magnesium bicarbonate chemistry. At the time of the study in the late 1950's, sodium constituted 10 to 40 percent of the total cations, and bicarbonate constituted 70 to 95 percent of the total anions. Hardness is a measure of calcium and magnesium content in water. Hardness was reported to range from 150 and 450 mg/L, resulting in water considered to be hard to very hard. Boron concentrations in the extreme southern part of the sub-basin and east of Dixon were reportedly as high as 1 to 2 mg/L. Thomasson and others also stated that the shallowest wells tended to have higher concentrations of dissolved solids than nearby deeper wells in the eastern part of the sub-basin, but that there was no evidence at that time to show whether the salinity difference was a natural condition or caused by percolation of irrigation water.

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[2] Thomasson, H.G., Jr.; Olmsted, F.H., LeRoux, E.F., Geology, water resources and usable ground-water storage capacity of part of Solano County, California, Water Supply Paper No. 1464, U.S.G.S., 1960.

The City has sampled shallow groundwater quality over a large area surrounding the WWTF. The City concluded that high quality surface water from Lake Berryessa used for irrigation since the 1960's has improved upgradient or background conditions at the site. It concludes that areas of higher salinity exist at the WWTF and further downgradient. According to the City, this regional salinity gradient increases from northwest to south and southeast toward the Delta and results from irrigation with high quality surface water north and west of the WWTF.

However, staff notes that the elevated salinity levels in groundwater near WWTF are surrounded by better quality groundwater, as shown in Figure 1 and 2 (attached). Therefore, migration of the WWTP effluent in the subsurface has the potential to degrade intervening groundwater between the WWTP and the higher salinity areas farther downgradient.

The groundwater studies submitted by the City also provide site-specific groundwater quality information. Based on the approved Background Groundwater Quality Study and the Multiple Tracers report, the discharge to the treatment ponds and disposal areas has caused groundwater impacts for several constituents, as summarized in the following table. The upper prediction limit (UPL) background values shown in the table were derived using the statistical methods described above and were calculated with data from the upgradient or background wells shown in parentheses. Compliance wells in the table are those monitoring wells that are downgradient of the WWTF.

Constituent	UPL Background Values (source)	Water Quality Limit *	Groundwater Limitation **	Compliance Wells Exceeding Groundwater Limitation
Electrical Conductivity, umhos/cm	1,302 (NW-2)	700	1,302	SE-MW, MW-7, MW-8, MW-9, MW-10
Sodium, mg/L	143 (TW-1)	69	143	SE-MW, MW-7,
Chloride, mg/L	50 (NW-2)	106	106	SE-MW, MW-7, MW-8, MW-9, MW-10

* Based on protection of beneficial use for agricultural supply (WDRs Groundwater Limitation D.6).
** Based on WDR and 2005 CDO limits. Selected value is either the water quality limit or the calculated upper prediction limit (UPL) based on background wells, whichever is greater.

The primary purpose of the City's Multiple Tracers study was to test groundwater samples for several constituents to assess whether wastewater or irrigation water is the primary source of groundwater recharge in the area. Examples of tracer constituents that are normally found in domestic wastewater but not in uncontaminated groundwater are caffeine, testosterone, DEET (insect repellent), and triclosan (disinfectant). Other examples of potentially useful tracer constituents are pesticides, stable isotopes of water, nitrate, ammonium, and boron.

Such data can be used to assess whether a given well has been influenced by wastewater, irrigation water, agricultural chemicals, and/or other sources. However, interpretation of some tracers may not be definitive because some of the tracer constituents are only present at very low levels in the effluent and can be diluted to non-detect levels when the effluent reaches the aquifer.

The Multiple Tracers report made the following significant findings that staff concurs with:

- TW-1 and NW-2, which are defined as the two background wells in the 2005 CDO, appear to be primarily influenced by agricultural activities, including irrigation with high quality surface water imported from Lake Berryessa. These wells have low chloride concentrations, in the range of 10 to 50 mg/L.
- MW-10, which is a downgradient well, also appears to be primarily influenced by agricultural activities. This well has a higher chloride concentration, averaging near 108 mg/L.
- Wells NE-MW, SE-MW, MW-7, MW-8, and MW-9 (which are downgradient compliance wells) appear to contain a significant fraction of wastewater. These wells have chloride concentrations ranging from about 60 to 280 mg/L.

The report also states that wells SW-MWR and MW-6 appear to be primarily influenced by agricultural activities but also show some influence from effluent. These wells also have concentrations of chloride and sulfate that, at times, have significantly exceeded wastewater concentrations. These wells have high chloride concentrations, near 350 mg/L. Staff has maintained that SW-MWR and MW-6 should be excluded from the groundwater degradation analysis because of the dissimilar chemistry compared to the other wells. The reasons for the chemical differences have not been fully determined.

Staff notes that the well logs for wells SW-MWR and MW-6 show they are screened in clay while the other monitoring wells are screened in sand zones. Those wells showing impacts from wastewater disposal are also screened in sand, indicating these coarser-grained sediments are the flow paths for the migration of wastewater in the subsurface. The City's 31 July 2008 report, however, suggests that the distribution of sands and clays under the WWTF is not known well enough to discern the their influence on groundwater chemistry, and attributes the high solute concentrations to irrigation practices. The City may conduct additional studies of this issue.

Outstanding Issues

The groundwater quality aspects of the proposed CDO are based on staff's conclusion that the City of Dixon's WWTF has caused degradation or pollution of groundwater underlying the site. This assertion was also made in the 2005 CDO.

The City of Dixon has invested significant time and money in acquiring the water quality data discussed above. In general, Regional Water Board staff believes that the data are of sufficient quality and quantity to determine that the discharge has impacted groundwater quality. Staff also believes that most of the data interpretations presented by the City are appropriate and sound. However, the City's comments on the tentative CDO raised technical issues regarding staff's determination that the discharge has caused significant groundwater degradation and how to assess compliance with the City's WDRs. Although the comments themselves are lengthy and technically complex, there are two key issues:

1. The City is concerned that monitoring groundwater to assess compliance with its WDRs is complicated by the chemical variability seen in groundwater at the site. Groundwater with elevated solute concentrations unrelated to effluent discharge may affect downgradient monitoring wells and cause exceedences of groundwater limits. This impact would result in perceived non-compliance with the groundwater limits regardless of the effects of wastewater discharge. The City contends that the two approved background wells, TW-1 and NW-2, do not adequately represent background groundwater quality because they do not include the high salinity groundwater found near the WWTF. The City notes that monitoring wells SW-MWR and MW-6 better represent these high salinity areas, but were excluded by Board staff from the groundwater limit calculations because of their dissimilar chemistry.

2. The City also contends there is substantial evidence that, if additional background groundwater sampling locations are considered, the WWTF discharge has not significantly degraded groundwater quality in a manner substantially different than is occurring with the surrounding land use in the immediate vicinity of the WWTF.

The first point regarding compliance with groundwater limitations was addressed in the tentative CDO by imposing effluent limits on the City's wastewater discharge, rather than groundwater limits. The effluent limits are protective of water quality and beneficial uses. They were derived as discussed above and in the Staff Report. The use of effluent limits to protect groundwater is a departure from the approach used in the 2005 CDO, which required compliance be measured by a groundwater monitoring well network. The proposed CDO anticipates that groundwater monitoring will continue under the facility's revised monitoring and reporting program (MRP) to assess the facility's performance and effects on groundwater. Compliance, however, will be assessed through comparison of effluent quality in the wastewater ponds to the effluent limits in the proposed CDO. The City has full control over the quality of its effluent and therefore it is appropriate to assess compliance at this location.

The proposed CDO has effluent limits for sodium and chloride because these are the controllable wastewater constituents that have caused observed degradation in groundwater. The additional limits in the tentative CDO for total dissolved solids and electrical conductivity were deleted from the proposed CDO because staff have determined that compliance with the sodium and chloride limits will, in turn, lower the concentrations of total dissolved solids and electrical conductivity to concentrations which will be protective of groundwater.
The City's second point is that its discharge has not significantly degraded groundwater quality in a manner substantially different than occurs with the surrounding land use. The surrounding land use is primarily irrigated agriculture. The City found groundwater near the facility with salt concentrations significantly higher than its effluent, especially in wells SW-MWR and MW-6. The City also demonstrated through various geochemical studies that this groundwater has little influence from wastewater. The City suggested that agriculture is the principle contributor to the observed salinity, likely through the use of local groundwater for irrigation and possibly soil amendments.

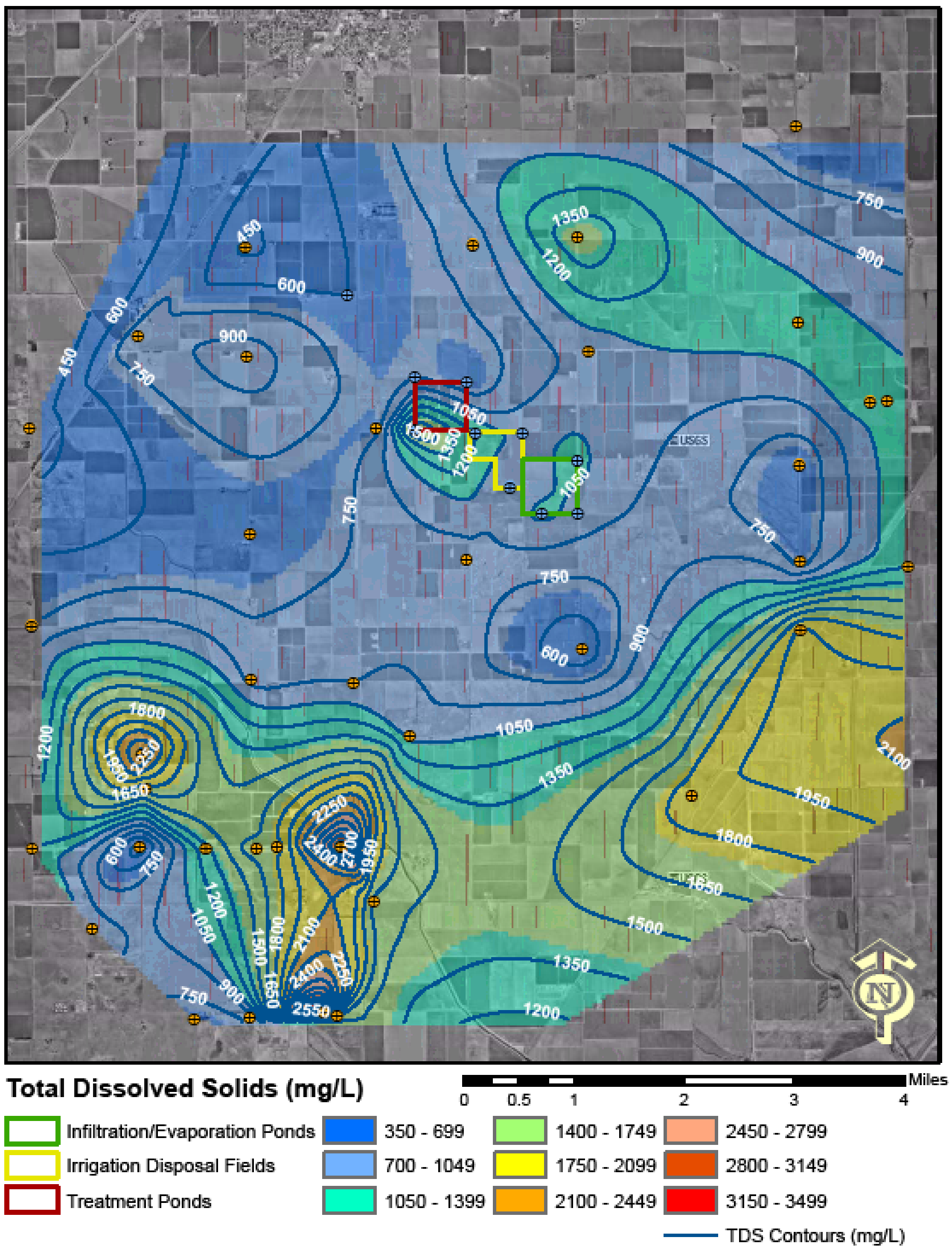
However, the City also identified good quality groundwater in its monitoring wells upgradient from the facility. Staff approved two of these wells (TW-1 and NW-2) to calculate background groundwater concentrations, as discussed above. The City also demonstrated that these wells are influenced by agricultural irrigation. In this case however, the surface water used for irrigation is of excellent quality and results in good quality groundwater upgradient from the facility. The proposed CDO imposes effluent limits to protect the beneficial use of this good quality groundwater because it is the mission of the Regional Water Board to protect and enhance waters of the state. This approach of protecting the higher quality water is consistent with the Basin Plan's anti-degradation policy to prevent or minimize water quality degradation.

Staff concludes that it has adequately addressed the City's concern about groundwater monitoring through the application of effluent limits to determine compliance. Staff further concludes that the City's position that its impacts to water quality are indistinguishable from those of adjacent land use is not consistent with the water quality protection strategy in the Basin Plan. Therefore, staff has included effluent limits to protect existing beneficial uses.

The proposed CDO notes that the City may submit additional data to support a report of waste discharge or revised effluent or groundwater limitations, provided the City submits a workplan to staff prior to conducting the work. This provision is intended to ensure coordination with Board staff and allow for discussion of data quality objectives of future submittals. Given the complex hydrogeology at the site, the City may undertake such work to better define the site conceptual model, local background conditions, and/or the water quality impacts of the facility and surrounding land use. This work, in turn, may lead to a proposal to recalculate background concentrations and/or final effluent limits through submittal of a report of waste discharge. While the proposed CDO does not require additional groundwater investigations, staff is committed to working with the City on these issues.

Figure 1

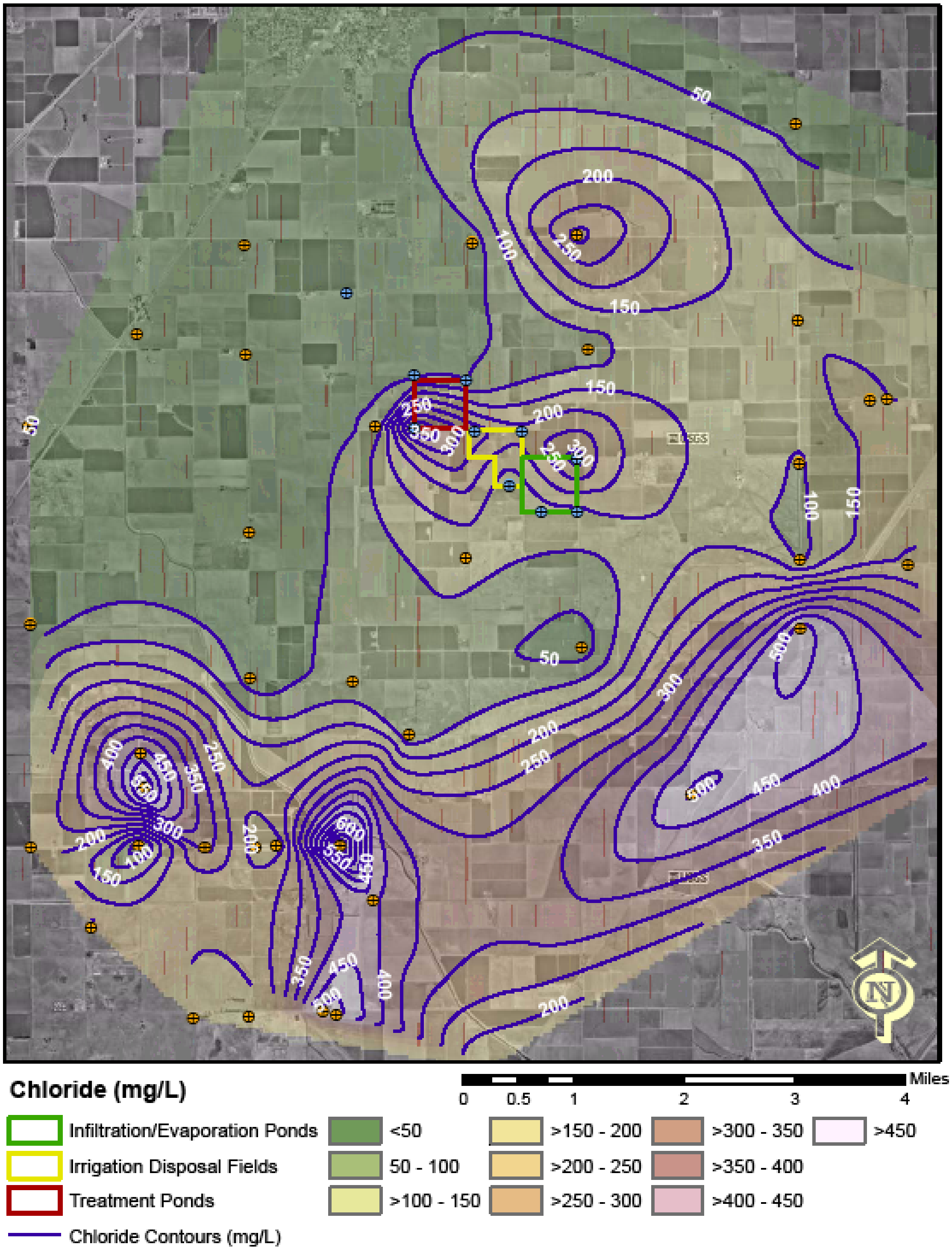
Distribution of TDS in Groundwater



from City of Dixon WWTF, Background Groundwater Quality Report prepared by ECO:LOGIC Engineering, 30 March 2006

Figure 2

Chloride Distribution in Groundwater



from City of Dixon WWTF, Background Groundwater Quality Report prepared by ECO:LOGIC Engineering, 30 March 2006