August 21, 2013

M E M O R A N D U M

TO: Todd Crutcher, P.E.
Engineering Manager, Boise Regional Office

FROM: Adam Bussan, E.I.
Scientist, Technical Services

SUBJECT: Staff Analysis for Draft Reuse Permit M-088-04 (Municipal Recycled Water)
Idaho Department of Correction – Correctional Facility Complex (Ada County)

1 PURPOSE

The purpose of this memorandum is to satisfy the requirements of the *Recycled Water Rules*, IDAPA 58.01.17.400.05, for issuing reuse permits. This memorandum addresses draft reuse permit M-088-04, for the municipal wastewater treatment and recycled water reuse system owned and operated by the Idaho Department of Correction. The Idaho Department of Correction's treatment and reuse system is currently permitted under the terms of reuse permit LA-000088-03.

2 SUMMARY OF EVENTS

The Idaho Department of Correction (IDOC) operates several correctional institutions, including the Idaho State Correctional Institution (ISCI), the Idaho Maximum Security Institution (IMSI), the Southern Idaho Correctional Institution (SICI), and the South Boise Women's Correctional Center (SBWCC), that send wastewater to treatment systems described in this permit. The main address for this facility is 13400 Pleasant Valley Rd, Kuna, ID 83634. IDOC received its first wastewater reuse permit for this facility (LA-000088-01) on December 29, 1989 and its second permit (LA-000088-02) on May 22, 1998. Before starting wastewater land application, the facility possessed an EPA National Pollutant Discharge Elimination System (NPDES) permit to discharge effluent to Tenmile Creek, but since 1998 has not been permitted to discharge effluent. Currently IDOC is operating under the recycled water reuse permit LA-000088-03 which was issued on December 6, 2007. The purpose of draft permit M-088-04 is to renew reuse permit LA-000088-03, which expired on December 6, 2012.

A permit renewal application from IDOC was received on May 11, 2012, and largely serves as the basis for the terms and conditions contained in the draft permit. As required by the *Recycled Water Rules*, the draft permit will be presented for a public comment period. After the comment period has closed, DEQ will provide written responses to all relevant comments and prepare a final permit for IDOC's recycled water reuse facilities.

No notices of violation were issued to the permittee under LA-000088-03 and all of the permit's compliance activities were completed, with the partial exception of the lagoon seepage testing requirement, which will be discussed in Section 4.2 of this document.

3 PROCESS AND SITE DESCRIPTION

For additional discussion of the wastewater treatment system, refer to the staff analysis for the draft version of reuse permit LA-000088-03, dated July 23, 2007. A description of changes to the facility and an interpretation of the most recent five years of operation can be found in the sections below. Please see Figure 1 for a depiction of the physical features discussed in this section of the staff analysis.

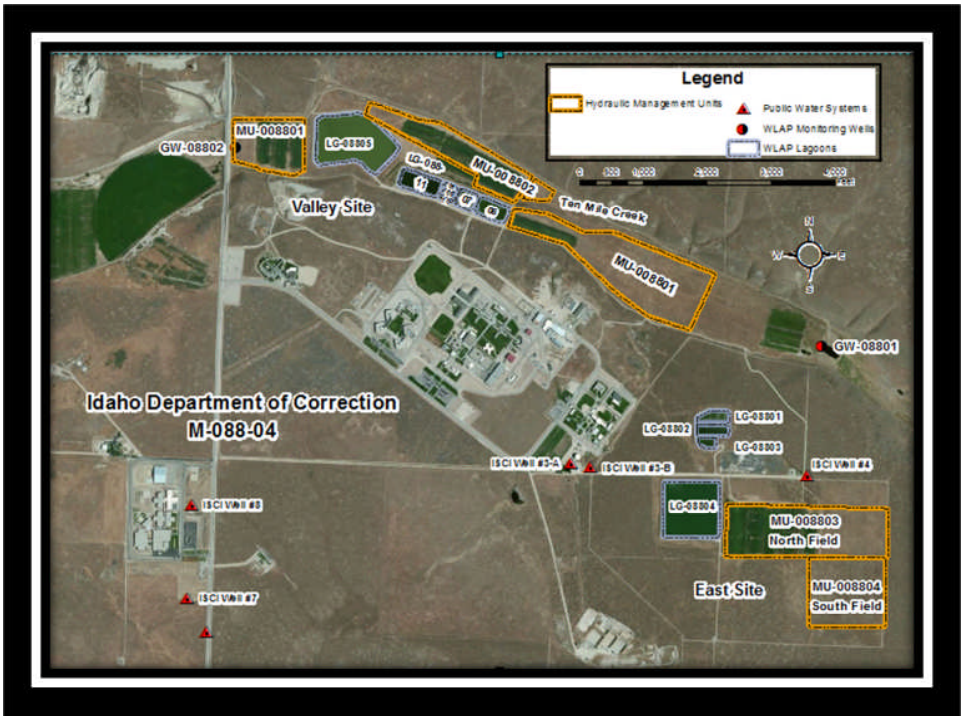

Figure 1: Site View of Idaho Department of Corrections M-088-04

3.1 Process

3.1.1 Current Process

Two separate systems treat the wastewater generated at the IDOC/ISCI complex, which are referred to as the Valley System and the East System. The East System is located to the southeast of the complex, and the Valley System to the north. Raw wastewater from IMSI, SBWCC, and the west part of ISCI is discharged to the Valley System, and the East System treats the remainder of ISCI's wastewater, including its cafeteria waste, and SICI's wastewater. Both are classified as municipal systems operating at a Class D level of disinfection.

The Valley system consists of six lagoons, with a combined storage volume of 13.23 MG. The first two lagoons are aerated, followed by three hydraulically connected small lagoons, and a final larger and aerated lagoon. After these treatment lagoons wastewater is sent to a 43.8 MG storage pond (Centra 2012b). Most effluent reaches the Valley system by gravity, though there is a booster station at the SBWCC facility. The Valley system currently treats the effluent generated by approximately 2,280 inmates and its maximum treatment

capacity is 365,000 gallons per day (Keller 2007).

Introduced in the facility's second permit, operation did not begin at the East Site until 1998. Influent arrives at the first of the three lagoons that make up the East system by force main. This first lagoon and the second are aerated and combined with the third lagoon have a volume of 7.8 MG. A 38.1 MG storage lagoon follows the treatment lagoons. The East system is currently treating the wastewater generated by 1,010 inmates, and its maximum treatment capacity is 285,000 gallons per day (Keller 2007).

After a time in the storage lagoons, effluent is disinfected by sodium hypochlorite at both treatment systems with a length of underground pipe providing contact time as effluent is pumped out for irrigation, through wheel lines. Though the total area permitted for reuse is 70 acres at the Valley Site and 75 acres at the East Site, not all of this acreage is in production. Irrigation can be supplemented by water drawn from nearby wells and delivered through overland hoses or temporary piping to the storage lagoons.

3.1.2 Future Expansion

A preliminary engineering report (PER) was submitted for construction of the new Idaho Secure Mental Health (ISMH) Facility, with the Valley system expected to receive the wastewater generated by its 300 to 600 additional inmates (Keller 2010). With the construction of the ISMH, it is expected that 80-150 gallons per day per inmate would be added to the Valley system. It is unknown at this time when or if the ISMH facility will be constructed, but the PER shows that wastewater would flow by gravity to an onsite lift station, where it would be pumped to a new wet well constructed next to the existing SBWCC booster station. Wastewater from ISMH and SBWCC would then be combined at this wet well before being pumped to the Valley sewer system. Before the combined effluent reaches the Valley system lagoons, solids will be removed by a new mechanical screen, a step that is expected help the lagoons to treat the increased influent flows (Centra 2012b). The PER and plans and specifications for the mechanical screen were received and approved by DEQ, and the screen will be in place by the end of 2012.

3.2 Site

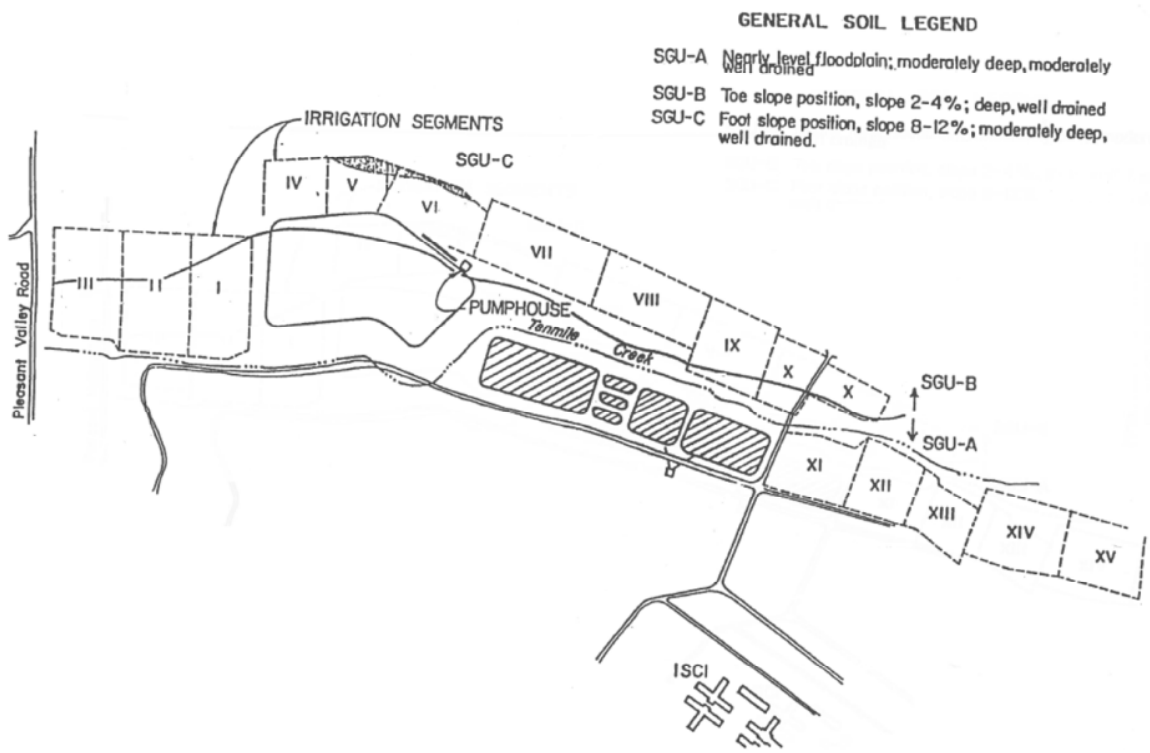

Figure 2. Valley Site Map as Currently Permitted (Keller 2007) See discussion of proposed changes in Section 3.2.1.

3.2.1 Site Realignment

When first establishing the Valley Site for wastewater application, the proposed area was divided into 15 roughly equally sized segments, which were then assigned to one of two hydraulic management units (HMUs) (see Figure 2). Segments I-II and XI-XV were assigned to MU-008801, with segments III-X assigned to MU-008802. As would be suspected by the non-consecutive numbering of the segments in MU-008801, this HMU is not a single unbroken field. It is separated by the lagoons and segregated from MU-008802 because of the differences between the two HMU's predominant soil types. MU-008801 is classified as nearly level, well drained Harpt loam, and MU-008802 is classified as Tenmile very gravelly loam at a slight –2 to 4 percent– slope and well drained (NRCS 2007). Segments I-III, however, are classified as roughly half one soil type and half the other. Since segment III was thought to have a soil classification closer to that of MU-008802, it was assigned to that HMU, despite it being contiguous with the segments from MU-008801. The placement of Segment III has complicated soil testing and created some confusion with the permittee, and has been asked to be reassigned to MU-008801 in the reuse permit renewal.

The permittee also requested other changes to the arrangement of the hydraulic management units, since seed has been purchased by the permittee to be planted in the fields southeast of the section of MU-008801 east of the lagoons. Of the additional acreage to be seeded, 12 acres are dormant portions of MU-008801, but 29 acres of the requested area are not in the current permit. The 29 acres to be added to MU-008801 is comprised of roughly

two thirds Harpt loam, with zero to two percent slopes, with the remainder made up of Tenmile very gravelly loam, with 0 to 4 percent slopes. Combining this new area to MU-008801 would make the most sense because the new area is adjacent to the existing portions of MU-008801and because it shares the two prevalent soil types as the rest of MU-008801 and are in roughly the same proportion as the rest of the hydraulic management unit. This segment is referred to as part of segment XV.

Additionally, Segments IV and V of MU-008801, just north of the storage lagoon LG-008805, were requested to be excluded from the permitted acreage because the permittee does not wish to extend wheel lines to reach those fields. These two segments are each 1.9 acres.

3.2.2 Site Management

Not all of the permitted acreage was used in the previous four years of operation, with only slightly more than half in production at the Valley Site, and slightly less than half at the East Site. At the Valley Site application has been limited to Segments I, II, XI, XII, and XIII of MU-008801 (40.4 acres) and to Segments VII, VIII, IX, and X of MU-008802 (29.6 acres). The two Valley Site management units are permitted for 70 acres, but beginning in 2002, many fewer acres were used to grow crops, with only 42 acres in production in 2011. The East System is comprised of two HMUs, the North, MU-008803 (45 acres), and the South, MU-008804 (30 acres), but irrigation was limited to only 26 acres at the North HMU.

In order for the fertility of the fields to be maintained, the Plan of Operations recommends that after four to five years of growing alfalfa, a grain crop be rotated in, and that there should be two to four cuttings of alfalfa made per year at the Valley Site to maximize nutrient uptake (CES 2010b). Wheel lines recently replaced hand lines as the method of applying wastewater.

3.2.3 Hydraulic Loading

Even though the effluent pipes at both sites are equipped with ultra-sonic flow meters, completely accurate measurement of hydraulic loading to the Valley Site is not currently possible. This is partly due to mechanical constraints, since to reduce the pressure in the irrigation system a fraction of the effluent pumped out of the storage lagoon is returned to the treatment lagoons without passing through the irrigation system and also without having the return flow monitored (Cook 2012b). Inaccurate measurement may also be introduced because hydraulic loading of the two Valley Site management units cannot be measured separately, and so the reported hydraulic loading to each HMU is estimated based on each HMU's fraction of the total acreage in production. An analysis of recent hydraulic loading is still worthwhile, assuming that flow has been measured consistently, even if not completely accurately.

Before 2007, the volume of effluent land applied was highly variable (see Kurtz 2007, Sections 4.5.1 and 4.5.2.3 for a description of hydraulic loading from 1998 to 2008) as was the acreage in production. After originally having hydraulic loading limits of set volumes, when LA-000088-03 was issued in 2007 the hydraulic loading limits were set to be substantially at the irrigation water requirement (IWR). At this same time the acreage in production became less variable, but total hydraulic loading did not. Hydraulic loading rates for this time period are shown in Tables 1 and 2 with the average of the loading rates for 1998 to 2006 available for comparison.

The cumulative yearly IWR limits for both application sites would be around 67 acre-inches, based on ETIdaho and the Kuna NWS NOAA station, for alfalfa with frequent cuttings, and calculated with an irrigation efficiency of 0.75. This yearly IWR was exceeded at the Valley Site for in 2008 and 2009 and at the East Site nearly so in 2009. The use of a large volume of supplemental irrigation water during these years was the main cause for the excessive volume of hydraulic loading.

Table 1: Valley Site Hydraulic Loading 1998 to 2011

Year	Recycled Water Irrigation Rate (MG)	Supplemental Water Irrigation Rates (MG est.)	Total Hydraulic Loading (MG)	Active Acreage	Total Irrigation Rate (in/ac)
1998-2006	—	—	43.9	49.6	28.4
2007	57.9	20.0	77.9	41.2	69.6
2008	66.4	14.7	81.1	41.1	72.6
2009	68.1	25.2	93.3	41.2	83.4
2010	50.9	0.0	50.9	41.2	45.5
2011	58.6	0.0	58.6	42.0	51.4
Avg (2007-2011)	*60.4*	*12.0*	*72.3*	*41.3*	*64.5*

Table 2: East Site Hydraulic Loading 1998 to 2011

Year	Recycled Water Irrigation Rate (MG)	Supplemental Water Irrigation Rates (MG est.)	Total Hydraulic Loading (MG)	Active Acreage	Total Irrigation Rate (in/ac)
1998-2006	—	—	30.0	39.1	24.1
2007	18.4	18.0	36.4	27.1	49.5
2008	24.6	10.0	34.6	27.1	47.0
2009	24.3	22.0	46.3	27.1	63.0
2010	19.9	0.0	19.9	27.1	27.0
2011	25.7	0.0	25.7	26.0	36.3
Avg (2007-2011)	*22.6*	*10.0*	*32.6*	*26.9*	*44.6*

In 2009 hydraulic overloading may have been the result of lagoon seepage testing, which, by interrupting early season irrigation because more effluent needed to be stored in the lagoons, required more supplemental irrigation water to be applied during that time (Centra 2012b). It is less clear why hydraulic loadings in 2007 and 2008 were also over the limit, without seepage tests being conducted during those years. Following the completion of seepage testing, hydraulic loading returned to below the IWR, sometimes a cumulative 10 to 20 acre-inches below the IWR (Centra 2012b). Also, marked as a concern on previous annual report reviews, the timing and management of wastewater application did not always match what would be most optimal, at least as determined by the calculated IWR (see Figure 3). Overall, while management of the land application sites has become more regular since LA-000088-03 was issued, there were still exceedances of hydraulic loading limits and reuse water did not have optimal agronomic timing. The permittee should continue addressing these issues

to further improve site performance. As discussed in section 4.3.2, the permittee will be required to update the Plan of Operation for this site which will include a Crop Management Plan and institute other changes in order to improve operations at this site.

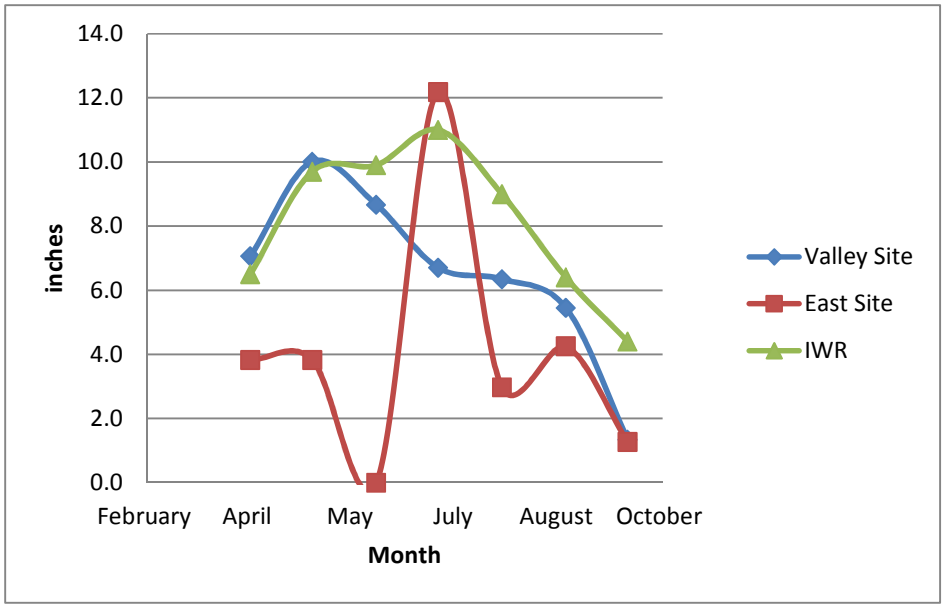

Figure 3: 2010 Wastewater Application and Irrigation Water Requirement (IWR) comparison (Source: SPF 2011)

3.2.4 Constituent Loading

Tables 3 and 4 show constituent concentrations and loading rates during the current permit term. The tables show that the average nitrogen loading from 2007 to 2011 increased slightly above what the average loading rate was between 1998 and 2006. At least part of this increase in nitrogen loading can be attributed to a decrease in the area of application. Even with increased and variable nitrogen loading, neither site exceeded its crop uptake based nitrogen loading limit in any of the years from between 2007 and 2011.

Table 3: Valley Site Annual Average Constituent Concentrations and Loading 1998 to 2011

Year	TKN (mg/L)	Nitrate (mg/L)	TDS (mg/L)	Nitrogen Loading (lbs/acre)	Nitrogen Uptake (lbs/acre)	TDS (lbs/acre)	Total Hydraulic Loading (in/acre)
1998-2006	—	—	534[a]	55.0	130.0	—	28.4
2007	9.98	0.38	1244	86.0	70.5	12,093.0	69.6
2008	5.23	0.47	602	99.0	178.7	9,432.0	72.6
2009	7.01	0.56	516	208.0	208.0	9,918.4	83.4
2010	10.9	0.26	716	73.5	100.0	7,201.7	45.5
2011	11.39	0.45	676	120.0	120.0	8,291.4	51.4
Avg (2007-2011)	*8.9*	*0.4*	*596.0*	*117.3*	*144.0*	*9,387.3*	*64.5*

a) Average concentration of both systems (Kurtz 2007)

Table 4: East Site Annual Average Constituent Concentrations and Loading 1998 to 2011

Year	TKN (mg/L)	Nitrate (mg/L)	TDS (mg/L)	Nitrogen Loading (lbs/acre)	Nitrogen Uptake (lbs/acre)	TDS (lbs/acre)	Total Hydraulic Loading (in/acre)
1998-2006	—	—	534[a]	64.0	126.0	—	24.1
2007	12.7	0.25	817	50.1	70.1	3,571.0	49.5
2008	12.8	0.47	602	97.0	148.7	5,029.4	47.0
2009	6.7	0.16	496	134.0	134.0	7,487.4	63.0
2010	14.6	0.14	721	73.5	66.0	4,815.0	27.0
2011	14.88	0.07	810	86.0	224.0	6,486.4	36.3
Avg. (2007-2011)	*12.3*	*0.2*	*689.2*	*88.1*	*128.6*	*5,477.8*	*44.6*

a) Average concentration of both systems (Kurtz 2007)

Total dissolved solids (TDS) concentrations from 2007 to 2011 were on average higher than in the previous ten years, as can be seen in Tables 3 and 4. Reported TDS and VDS concentrations also revealed that the average NVDS loading from 1998 to 2006 of 2,730 lb/acre more than doubled to 6,000 lbs/acre in 2011 (Kurtz 2007; Centra 2012a). However, TDS loading itself from between 2007 to 2011 did not display a noticeable increasing trend. Even so, if the permittee could decrease TDS loads towards their pre-2007 levels, some of the concerns for ground water TDS impacts to be described in Sections 3.5 and 3.6 would be lessened.

COD loading was well below the 50 lb/acre/day limit. Phosphorus loading rates in 2011 were 61 lbs/acre at the Valley Site and 42 lbs/acre at the East Site, much greater than the crop phosphorus uptake of 22 lbs/acre at the Valley Site and 23 lbs/acre at the East Site. Phosphorus is mainly a concern for surface water, but can also build up in the soil column; soil phosphorus concentrations are discussed in Section 3.4.3.

3.2.5 Crop Production

Between 1998 and 2006, alfalfa yields averaged 3.2 ton/acre at the Valley Site and 2.0 ton/acre at the East Site, which led to an average nitrogen uptake of 130 lb/acre at the Valley Site and 126 lb/acre at the East Site (Kurtz 2007). After the current permit was issued in 2007, crop yields increased moderately to average 4.1 tons/acre at the Valley Site and 3.9 tons/acre at the East Site. The highest yields were achieved in 2011 at both sites, at 4.3 tons/acre at the Valley Site and 5.4 tons an acre at the East Site. On average crop production was still nearly one ton/acre less than the 5 ton/acre Ada County averaged since 2008, but yields still increased significantly since LA-000088-03 was issued (2007-2011 Annual Reports; NASS 2012).

3.3 Surface Water

Part of the Valley Site is located in the 100 year floodplain of Tenmile Creek, which is the nearest surface water to the facility. Tenmile Creek is classified as a losing stream in the 2001 DEQ *Fivemile and Tenmile Creek Subbasin Assessment*. Measurements made by the permittee showed that irrigated portions of the hydraulic management units are within 90 feet from the creek at the closest point, which is less than the permitted buffer zone distance to permanent or intermittent surface water of 100 feet. Since water flows through the creek only

intermittently, mostly limited to wet springs, the risk to surface water is less than it would be if the creek was permanent. A requirement prohibiting land application within 100 feet of Tenmile Creek if water is flowing through Tenmile Creek has been included in Section 4.4 of the draft permit.

The East Site is above the Tenmile Creek Valley, and land application there does not pose a risk to surface water.

3.4 Soils

3.4.1 Soil Salinity

The 1998 permit renewal staff analysis discussed the high sodium concentrations in the soil at the time, and that Sodium Adsorption Ration (SAR) testing would need to be introduced. Noting that these SAR measurements that followed this testing requirement were very low, between 0.16 and 0.24, the 2007 Staff Analysis decreased SAR analysis to only samples taken during the first and last years of the permit cycle. Perhaps due to changes in analytic procedures, the SAR measurements from the most recent permit cycle were much higher than the original tests, measuring from 2.46 to 7.07 at the Valley Site and 8.23 to 12 at the East Site. The semiannual SAR samples, which were collected in March of 2008 and 2010 at one foot depths for the first three feet of soil, showed that SAR values at all soil depths slightly decreased at the East Site since 2007 and slightly increased at the Valley Site during the same time. Some of these measurements were nearly at or above 10; an SAR value that is often associated with soils of diminishing permeability (DEQ 2007, Glossary). The permit application reported, though, that there was not any evidence of worsening soil texture or inhibited infiltration (Centra 2012a). The draft permit includes a requirement to test soil SAR concentrations in the spring of the first and last years of the permit.

Electrical conductivity measurements were taken twice annually during the current permit term, and showed a slight increase in the previous four years, but soils can still be categorized as having low salinity, with average concentrations ranging between 380 and 494 umhos/cm for the different depths at Valley Site and between 668 and 792 umhos/cm at the East Site (DEQ 2007, Section 7.4.3). The previous four years of Valley Site electrical conductivity measurements were consistent with samples taken before the most recent permit was issued, though there may have been a slight increase in the concentrations at the East Site. The draft permit includes a requirement to test the soil for electrical conductivity annually in the spring.

3.4.2 Soil Nitrogen

Average soil nitrate concentrations for all soil monitoring depths ranged between 5 mg/kg and 8 mg/kg, and have generally been decreasing since 2007 (see Figure 4). Soil nitrate concentrations decreased to concentrations that can be classified as low or very low (DEQ 2007, Section 2.5.2). Soil ammonium concentrations similarly declined (see Figure 5). The 2007 Staff Analysis reported that average nitrate concentrations had remained relatively constant during the 1998-2006 time period, ranging between 10 mg/kg and 14 mg/kg at the Valley Site and 6 mg/kg at the East Site, suggesting that the recent decrease in soil nitrogen concentrations was the result of subsequent changes in the operation of the facility.

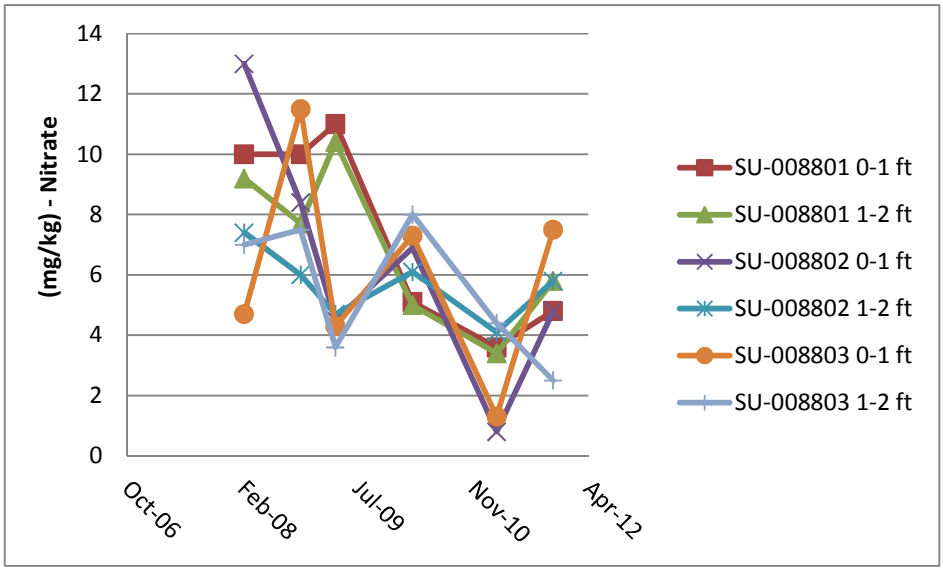

Figure 4: Soil Nitrate Concentrations by Hydraulic Management Unit (HMU) and Depth (ft)

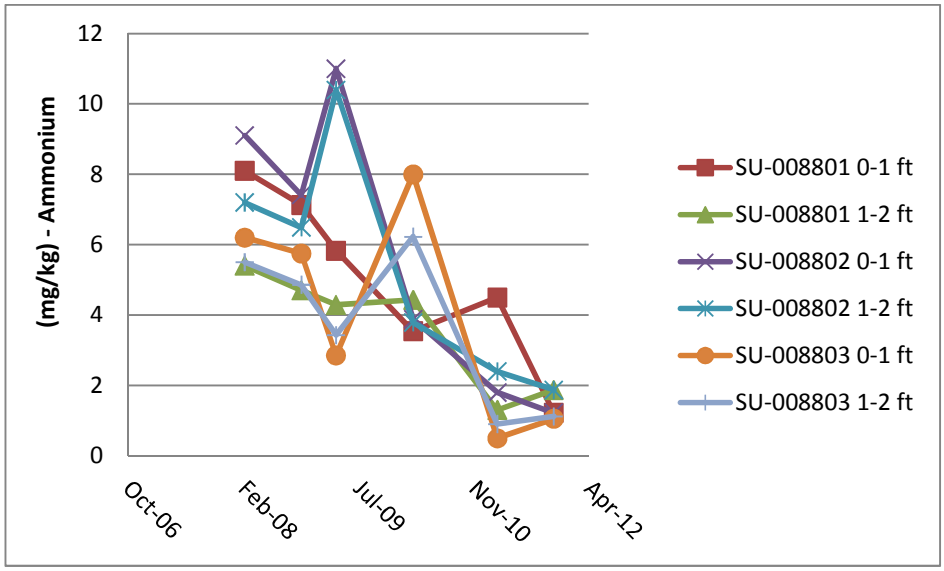

Figure 5: Soil Ammonium Concentrations by Hydraulic Management Unit (HMU) and Depth (ft)

The draft permit includes a requirement to test the soil for nitrate and ammonium-nitrogen annually in the spring. Given the data presented in Figures 4 and 5, addition of a nitrogen fertilizer may be necessary to improve overall crop performance.

3.4.3 Soil Phosphorus

Average phosphorus concentrations since 2007 ranged between 15 and 22.5 mg/kg at the different soil unit depths at the Valley Site and between 6 and 7 mg/kg at the East Site. No clear trends in soil phosphorus concentration can be seen since 2007 (see Figure 6), though the average concentration measured at the Valley

Site since 2007 was higher than the 8 and 10 mg/kg measured between1998 and 2006 (Kurtz 2007). The DEQ *Guidance for Reclamation and Reuse of Municipal and Industrial Wastewater* mentions that soil phosphorus concentrations of 20 ppm or greater can be of concern if the depth to ground water is less than five feet (DEQ 2007, Section 4.2.2.7.1). If ground water is at a depth greater than five feet then concentrations of 30 ppm or greater can be problematic.

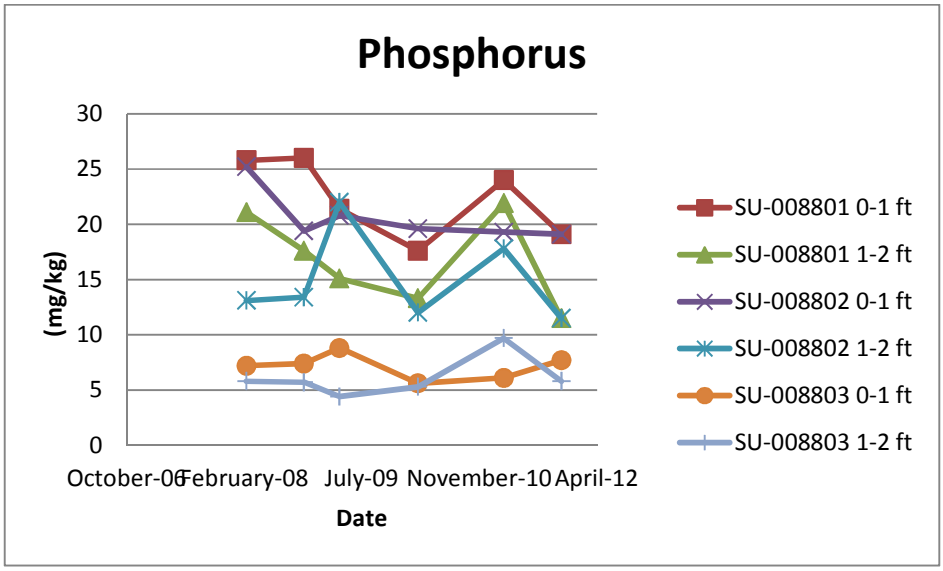

Figure 6: Soil Phosphorus Concentrations by Hydraulic Management Unit (HMU) and Depth (ft)

The draft permit contains a requirement to sample the soil for phosphorus annually each spring.
With the perched aquifer sometimes measured at less than five feet below the surface at the Valley Site, if an increasing trend in phosphorus concentration is observed in the soil, especially in the lower soil column, a change in loading or cropping practices may be necessary. With Tenmile Creek 90 feet away from some application sites, prevention of runoff from the Valley Site should be a priority for the permittee.

3.5 Valley Site Ground Water

The ground water characteristics differ greatly between the Valley Site and the East Site. A regional aquifer underlies both sites with depths to ground water between 368 to 496 feet below ground surface, and at the Valley Site, there is also a perched aquifer that was measured at less than 10 feet below the ground surface (CES 2010a). The regional aquifer is the source of the prison complex's drinking water. Early reports from the Idaho Department of Water Administration indicate that the Valley Site also has a shallower intermediate aquifer 160 feet below ground surface, which possibly also extends below the East Site (CES 1996). Ground water in the perched aquifer likely flows along the Tenmile Creek bed, traveling from the southeast to northwest. The regional aquifer's flow direction, however, is nearly perpendicular to the flow of the perched aquifer, flowing towards the Snake River, which is located to the south/southwest of the IDOC complex.

The Valley Site has two ground water monitoring wells, one upgradient and one downgradient, that were installed before wastewater land application was initiated at the facility, to monitor for the impacts of land application of sludge at the ISCI farm (CH2M Hill 1982). These shallow wells serve to monitor the perched

aquifer only.

In August of 2010, ISCI Well #3-A and #4 both yielded high concentrations of total coliform. Source water reports rated these wells as having moderate susceptibility to inorganic contaminants and coliform (DEQ 2002), and these wells have a zone of capture below the irrigation systems. It is not likely however that high hydraulic loadings in 2008 and 2009 at the Valley Site increased the likelihood of coliform being carried from the soil to the ground water, since the time of travel from the application sites to the drinking water wells is estimated at three to six years.

In addition to land application, seepage from the Valley Site's 10.4 acre six-cell treatment lagoon and 20 acre storage lagoon has the potential to greatly impact the perched aquifer. Assuming a seepage rate of 0.1 inches/day for the six treatment lagoons, which is based on the incomplete measurements of the most recent seepage testing, and 0.042 inches/day for the storage lagoon, an annual volume of 9.9 MG and 8.32 MG of wastewater seeps from the treatment and storage lagoons respectively, for a total of 18.22 MG. However, if the untested lagoons have a higher seepage rate (assuming at the 0.25 inch/day seepage rate limit) and employing 0.101 inch/day, the greatest seepage rate measured for the storage lagoon – Valley Pond 7 – then the total seepage volume for the Valley lagoons could be as high as 45.8 MG/yr, nearly as high a volume of wastewater that is land applied at the Valley Site.

3.5.1 Ground Water Nitrate

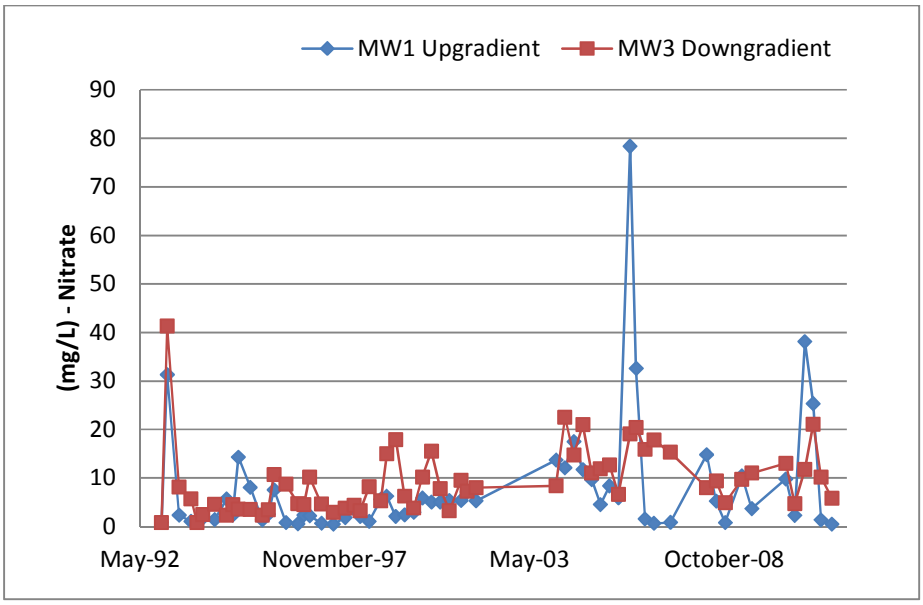

Figure 7: Ground Water Nitrate Concentrations

While the monitoring results presented in Figure 7 are not easily interpreted, when evaluated statistically, the average concentration of quarterly measurements of nitrate concentration in the downgradient monitoring well from 1993-2011 was, at 9.4 mg/L, higher than the 7.75 mg/L average concentration measured in the upgradient well, at a 95% confidence interval (Attachment 2, Cook 2012b). There is also in both wells a sporadic but

statistically significant increase in the measured nitrate concentration. Additionally, the highest concentrations of nitrate were measured in recent years: 38.1 mg/L and 25.3 mg/L measured in 2011 and 78.4 mg/L and 32.6 mg/L measured in 2006, all from the upgradient well. Despite the upgradient well registering the highest absolute concentrations of nitrate, in 77 percent of all monitoring well sampling events the highest concentrations came from the downgradient well.

More evidence that either the lagoons or land application at the Valley Site is contributing to an elevation of nitrate concentrations in the downgradient well is the difference in the seasonal variation between the two monitoring wells. As can be seen in Figure 8, the mean concentration of nitrate has been higher in spring than in any other season for both of the monitoring wells. However, mean nitrate concentrations are much more consistent between summer and winter in the upgradient well than they are in the downgradient well. In the downgradient well, MW3, spring and fall median groundwater nitrate concentrations are much higher than the winter median, but in the upgradient well, MW1, the median nitrate concentrations during fall, winter, and spring are nearly the same (See Figure 8). The source for the elevated spring and fall nitrate concentrations in MW3 is most probably attributable to the Valley Site water reuse operations. Common ion analysis of MW1, MW3, and the wastewater would help characterize the difference in the water sources of each well, and a plan for such an analysis is described in Section 4.3.1 of this document.

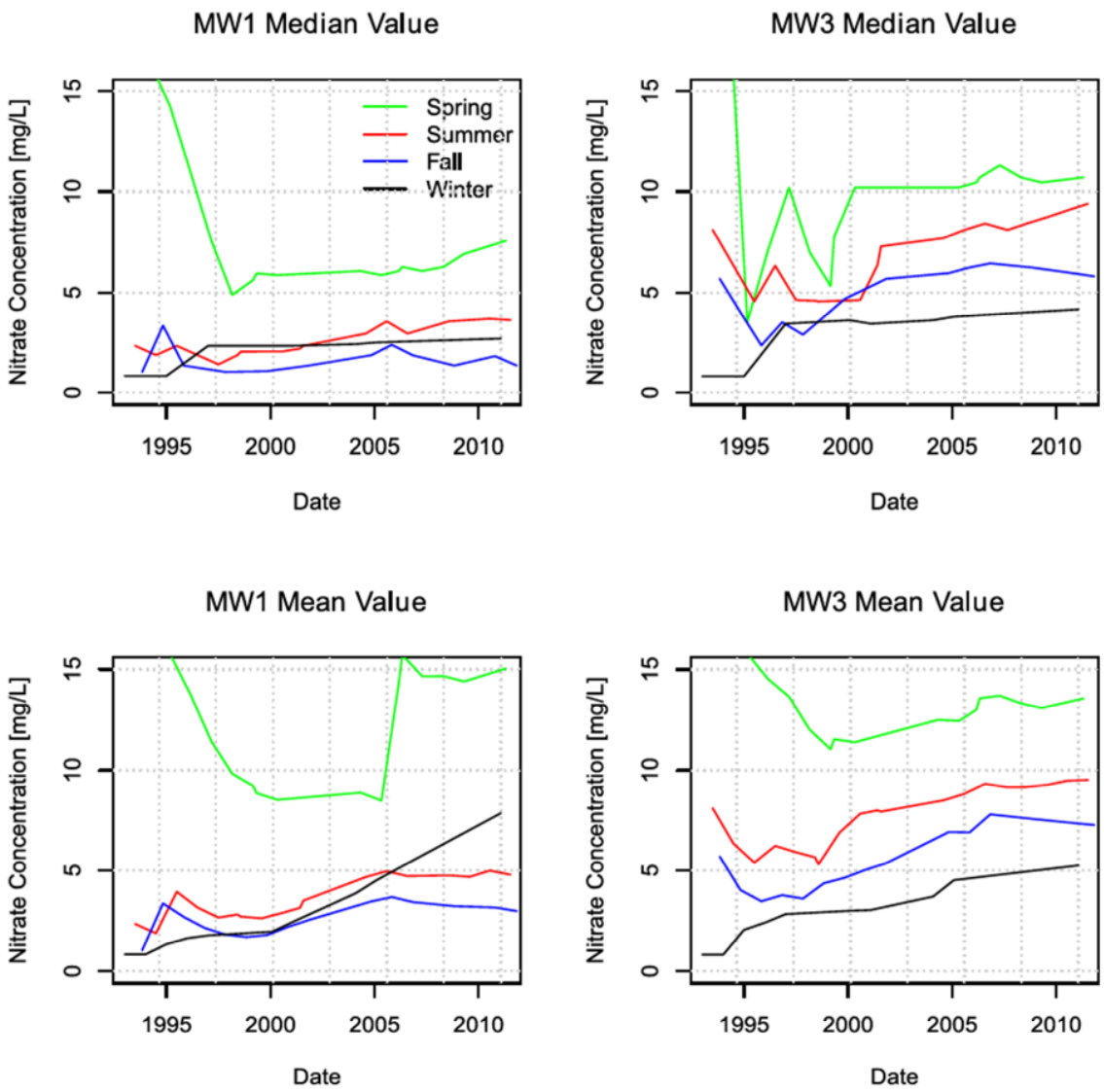

Figure 8: Median and Mean Time Series from MW1 (upgradient) and MW3 (downgradient)

The very high and irregular nitrate concentrations found in both wells may be the result of a significant source of nitrate higher up in the Tenmile Creek watershed from the Valley Site, considering that the relationship between upgradient and downgradient concentrations of TDS and nitrate are very different (compare Figure 7 to Figure 9). There are very few instances when upgradient TDS concentrations exceed those of the downgradient monitoring well. Seepage from the facility's wastewater treatment lagoons are likely also contributing to a statistically significant nitrate increase in the perched aquifer. This contribution is of growing concern since nitrate concentrations in both monitoring wells have been increasing and the most recent five years' average nitrate concentration was above the 10 mg/L primary ground water standard from the *Ground Water Rules*, IDAPA 58.01.11, in both monitoring wells.

3.5.2 Ground Water Total Dissolved Solids (TDS)

TDS concentrations in the downgradient well were consistently measured above the 500 mg/L secondary standard since operation began at the facility, and a visual inspection of Figure 9 reveals an increasing trend in the TDS concentration since 1992, but only in the downgradient well. TDS concentrations have been, on average, nearly 400 mg/L greater in the downgradient monitoring well than in the upgradient well, and downgradient concentrations were above the 500 mg/L standard in nearly all of the previous 10 years' samples. Downgradient concentrations of TDS were also higher than those measured in the wastewater effluent, a result, possibly, of evapotranspirative concentration during land application.

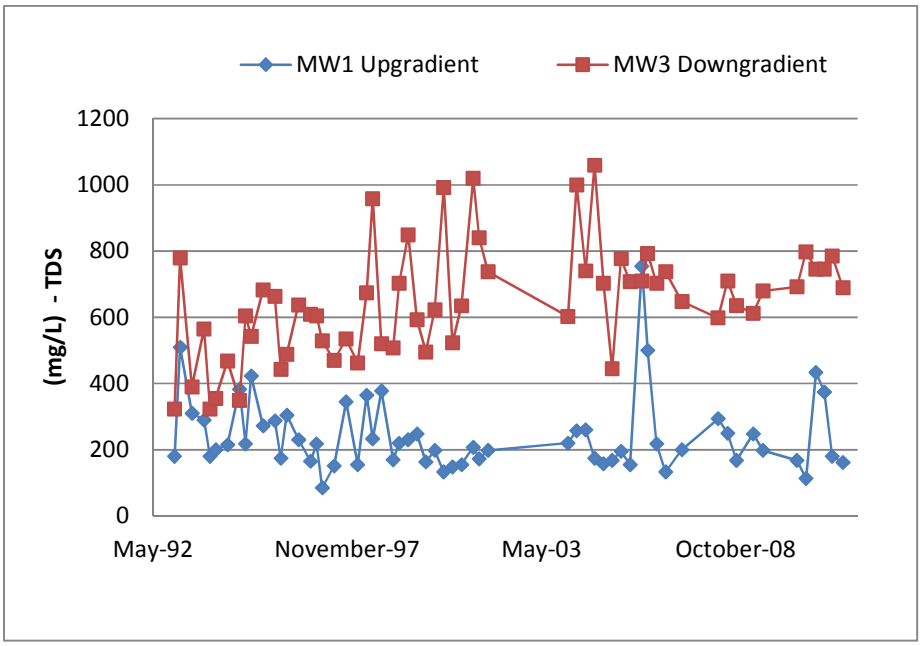

Figure 9: Ground Water Total Dissolved Solids (TDS) Concentrations

3.5.3 Iron and Manganese

Secondary standards for iron (0.3 mg/L) and manganese (0.05 mg/L) were exceeded during the previous five years, but only when analysis was limited to the metals' total concentrations. Dissolved concentrations were lower than the standard. Additionally, neither constituent has had downgradient concentrations consistently above upgradient concentrations (see Figure 10). It is possible that measurements of the high total concentrations are caused by a source other than wastewater treatment process, such as the dissolution of the well casings.

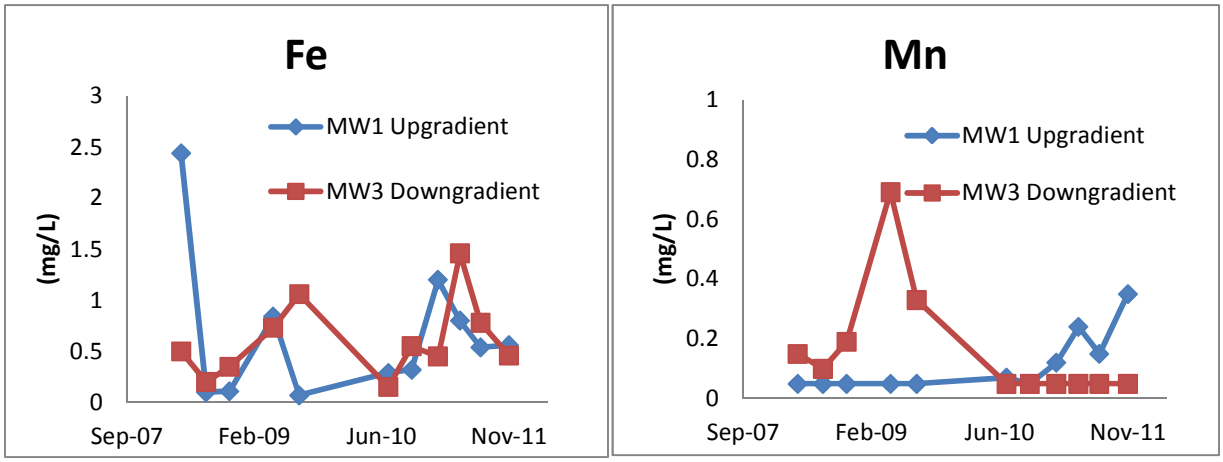

Figure 10: Ground Water Iron and Manganese Concentrations

3.6 East Site Ground Water

As mentioned in Section 3.5, the East Site is not reported to have a perched aquifer underlying it and because the depth to ground water is much deeper than at the Valley Site, between 368 to 496 feet below ground surface, a ground water monitoring network has not been required to be installed. Recent investigations of the East Site's ground water conditions were limited to modeling exercises (CES 2010; Cook 2012a). The results from these studies suggest that land application at the East Site is likely to raise concentrations of TDS at receptor wells downgradient of the site and that if the East Site is operated for wastewater reuse. Nitrate impacts are not of as great a concern, as long as there is sufficient crop nitrogen uptake. Nitrate may become more of a concern if management strategies implemented to reduce TDS loading have the side effect of decreasing crop yield and associated crop nitrogen uptake. A discussion of this can be found in DEQ's *Review of Cascade Earth Sciences, Ltd. August 4, 2010. Ground Water Impact Assessment of the East Site (Idaho State Correctional Institution)* (Cook 2012a), which is attached to this document.

Also, because of the greater depth to ground water at the East Site, the time of travel through the vadose zone is very long, perhaps as great as 67 years through the vadose zone, though preferential flow paths may exist that would reduce this time for at least some of the flow (Cook 2012a). Flow through the aquifer, from the downgradient boundary of the application site to the receptor wells, may take an additional 19 years. Because of the length of the time of travel through the vadose zone, a monitoring network might be too long in showing ground water impacts, and effort would be more beneficially spent on finding ways to reduce leaching to ground water.

There are a number of non-monitoring wells located around the facility, including public drinking water wells. One of these, ISCI Well #4, is closer than 1,000 feet to MU-008803, which is within the permitted buffer zone for a public drinking water well. A reduced buffer zone was allowed for this well based on a well location acceptability analysis, which concluded that the deep water table and local hydrogeology provided protection to local ground water users (Scanlan 2000). Only one new well, ISCI #3-B, was installed since LA-000088-03 was issued, and is located near to ISCI Well #3-A. See Figure 1 for the locations of the ISCI wells.

4 PERMITTING DISCUSSION

The following sections outline changes made to the terms of the draft renewal reuse permit, based on changes requested by the permittee, evaluations of past performance with previous permit requirements, and/or updates required by changes to the *Recycled Water Rules* or any other applicable regulatory standards. Terms and conditions that are unchanged from the previous permit and remain applicable to the facility are not addressed in this document. Changes made to update language and regulatory references are also not addressed in this document.

4.1 Section 2. Facility Information

Facility contact information has been updated to reflect personnel changes.

4.2 Section E. Compliance Schedule for Required Activities in LA-000088-03

Table 5: Status of Compliance Activities from LA-000088-03

Activity Number	Description	Due Date	Status
CA-088-01	Update Plan of Operation	June 2008	Received August 2010, Approved January 3, 2011
CA-088-02	Seepage Testing	December 2011	Incomplete testing in 2008 - 2009
CA-088-03	Disinfection Management Plan	June 2008	Approved April 9, 2009
CA-088-04	Ground Water Impact Assessment	June 2009	Approved November 18, 2010
CA-088-05	Renew Permit	June 2012	Submitted May 11, 2012

Seepage testing was performed for the Valley and East System lagoons in 2009, with one additional lagoon seepage test in 2010. This seepage testing was only partially complete though, because irregularly shaped piping did not allow Valley Ponds 1, 3, 4, and 5 to be sufficiently isolated for tests to be successfully performed on these lagoons. Completion of the testing is postponed until at least 2013, following solids removal occurring during the fall of 2012. All lagoons that were successfully tested according to DEQ guidance had seepage rates measured below the 0.25 in/day seepage rate limit in the *Wastewater Rules*, IDAPA 58.01.16.493.

Table 6: Seepage Testing Results

Valley System	inches/day	East System	inches/day
Pond 2	0.112	Pond 1	0.085
Pond 6	0.041	Pond 2	0.034
Pond 7 (1st test)	0.042	Pond 3	0.037
Pond 7 (2nd test)	0.101	Pond 4	0.026

Source: Pharmer, 2012

Exceedances of effluent coliform limits in the years preceding the previous permit renewal led to the requirement for the creation of a disinfection management plan. The final recommendations of this report included the repair of elements of the disinfection system and for the operator to make weekly inspections of the disinfection equipment. Subsequent monitoring revealed three exceedances of the Class D coliform standard shortly after the disinfection management had been approved, but generally the facility greatly improved their disinfection compliance. One exceedance of the single sample 2,300 cfu/100 mL limit and two exceedances of

the 3 day 230 cfu/mL median coliform limit occurred at the Valley System in 2009 (Idaho Department of Correction, 2010). The East Site also had two slight exceedances of the median coliform limit in 2010 (SPF Water Engineering, LLC, 2011).

The Ground Water Impact Assessment was carried out to predict the impact that reuse operations at the East Site will have on regional ground water. The assessment concluded that some TDS impact was inevitable if land application was to proceed at the East Site. See Attachment 1 (Cook, 2012a) for a detailed evaluation of this assessment.

4.3 Section 3. Compliance Activities in M-088-04

Three new compliance activities have been included in the draft renewal reuse permit M-088-04, which are described in the following sections.

4.3.1 Ground Water Study CA-088-01

As discussed in Section 3.5 of this document, TDS and nitrate concentrations in ground water, measured in quarterly samples taken between 1993 and 2011, show that either the lagoon system or reuse application at the Valley Site is having an impact on the ground water quality in the perched aquifer under the Valley Site. Downgradient concentrations of both parameters were above ground water quality standards and also, on average, above those in the upgradient monitoring well.

These impacts to the perched aquifer give cause to acquire more evidence that could determine whether any ground water of regulatory concern is being impacted by reuse operations. This evidence could be acquired by sampling other wells near the facility to determine if the reuse operations are causing ground water quality standards to be exceeded or whether any beneficial uses of ground water have been impaired.

Section 3 of the draft permit, therefore, includes a compliance activity requiring the creation and implementation of a plan to assess impacts to domestic and municipal water supplies by the wastewater operations at the Valley Site. The plan is expected to identify and sample wells in either the shallow ground water or in the regional system. This compliance activity would update and expand previous work done at the site. There has been only one report completed in the last 10 years that analyzed regional aquifer impacts arising from ground water reuse, which was limited to only one well, and did not fully account for the flow of the perched aquifer (Scanlan 2000). Summer and winter samples from the selected wells, both monitoring wells, and wastewater effluent should be analyzed for common ions[1], nitrate-N, TDS, total and dissolved Fe, and total and dissolved Mn. These ions can then be plotted on trilinear diagrams to aid in differentiating upgradient from downgradient water chemistry and elucidate whether the facility is having any impacts on beneficial uses of local ground water.

While the IDOC prison complex's surroundings are not heavily developed, there are numerous domestic wells located in the area that are downgradient from the facility that could be impacted. Additionally, the IDOC drinking water wells serving the Idaho Correctional Center are in the regional aquifer downgradient of the

[1] Common ion analysis would measure the concentrations of Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, HCO_3^-, CO_3^{2-}, SO_4^{2-}, and Cl^- in meq/L.

Valley Site, and there is a 6 to 10 year time of travel from the ground water below the Tenmile Creek channel to three different public water sources (DEQ 2013).

It is recommended that the same receptor wells be resampled at the end of each permitting cycle if results from this compliance activity do not reveal an impact to ground water quality by the reuse operations at this time. However, if ground water impacts are shown to extend beyond the perched aquifer, then the facility should institute a management plan that would reduce the impact that the reuse operation and the lagoons are having on ground water.

This new management plan might include upgrading the lagoons to higher standards and modifying the irrigation system so that a more precise balancing of hydraulic, nitrogen, and TDS loading is possible.

4.3.2 Updated Plan of Operations CA-088-02

Updated Plans of Operations incorporating the requirements of this permit should be completed for each site. The Plan of Operation for the Valley Site should describe in detail the operation of the Valley Site irrigation system, both mechanically and agronomically. Since a portion of the total flow being pumped to the irrigation system is returned to the Valley System's lagoons unmeasured, it is not immediately apparent how the operator can match hydraulic and nutrient loading to agronomic rates. The plan will also be required to include a Crop Management Plan for each site, which would discuss crop type and crop rotation plans, plant and harvest dates, anticipated crop yield and nutrient uptake, anticipated fertilizer requirements, and the irrigation water requirement and the balance of effluent and supplemental irrigation water. The updated plan should also include a discussion of ground water protection relevant to site operations.

4.3.3 Quality Assurance Project Plan CA-088-03

The permittee shall prepare and implement a QAPP that incorporates all monitoring and reporting required by this permit, and shall be designed to assist in planning for the collection, analysis, and reporting of all monitoring in support of this permit and in explaining data anomalies when they occur.

4.3.4 Non-Volatile Dissolved Solids Source Analysis CA-088-05

Along with the actions taken in CA-088-01 to address the TDS impacts explained in Sections 3.5 and 3.6 of this document, the permittee will be required to investigate NVDS sources with the goal of reducing the loading sent to both of the lagoon systems. IDOCs TDS loading is high compared to other facilities in the state, and source reduction is likely to be an effective way for the facility to reduce ground water impacts from TDS.

To complete this compliance activity the permittee shall sample all influent streams to the lagoon systems – including individual buildings and any unique streams within these buildings– for the following constituents: Total Dissolved Solids (TDS), Volatile Dissolved Solids (VDS), and Sodium. A plan reviewing the technical and economic feasibility for the isolation or removal of the NVDS in these streams shall then be submitted to DEQ for review and approval.

4.3.5 Valley Site Addition CA-088-05

If the Idaho Mental Health Facility's (IMHF) is built, and the wastewater to be treated by the Valley System, the

Valley Site management plan should be updated to include a description of how additional acreage would be put into production at the site. This would be relevant if hydraulic or nutrient loading is above the IWR or nutrient uptake limits of the currently active acreage, a likely occurrence if the IMHF reaches capacity. Facility plans and preliminary engineering reports for this expansion project did not include a description of the expansion of land application acreage.

4.3.6 Midterm Review CA-088-06

With the length of the permit term at 10 years, a section of the 2018 Annual Report will be required to contain a review of all permitted activities conducted during the first five years of the permit term, as allowed in accordance with IDAPA 58.01.17.500.04. This section should include a compilation and review of all monitoring results and compliance activities completed so far during the permit term. The review should also include a summary of all non-compliance events that have occurred since the permit's issuance. DEQ will then determine whether the permit expiration date will remain in effect.

4.3.7 Pre-Application Workshop CA-088-07

If the permittee intends to continue operating the reuse facility beyond the expiration date of M-088-04, the permittee shall contact DEQ and schedule a pre-application workshop one year before the expiration of the permit to discuss the compliance status of the facility and the content required for the reuse permit application package.

4.3.8 Permit Renewal Application CA-088-08

One hundred and eighty days before M-088-04 expires, a complete permit renewal application package shall be submitted to DEQ, which fulfills the requirements specified at the pre-application workshop.

4.4 Section 4. Permit Limits and Conditions

4.4.1 Section 4.1 Hydraulic Management Unit Descriptions

The distribution of sections to hydraulic management units has been modified so that segment III is now assigned to MU-008801 instead of MU-008802. This action increased the area of MU-008801 by 6.6 acres and MU-008802 decreased by the same amount.

As discussed in Section 3.2.1 of this document, Segment III was assigned to MU-008802 because it was thought that the soil types in that field were more aligned with those in MU-008802 than in MU-008801. However, this assignment meant that Segment III was separated from the rest of MU-008802. The differences in soil type are not different enough to justify the confusion the split has caused and the increased possibility for mistaken soil testing. Soil sampling of the two Valley HMUs did not reveal significant differences between the results from the two different HMUs, so reassigning Segment III from one HMU to the other is not likely to invalidate comparisons between soil monitoring done before and after the HMU rearrangement. Segment III has not been active in recent years so reports of hydraulic loading submitted in the near term will not be affected.

Additionally, most analyses of the permittee's long term management looked at the Valley Site as a whole, and not the individual management units. This change in soil unit assignment will make the soil monitoring units more contiguous and is intended to simplify soil testing.

The permittee requested that unused farm acreage adjacent to the Valley Site be included in the permit. Forty acres have been added to MU-008801, bringing its total area to 80.6 acres. Disuse of two segments of MU-008802 due to their relative unsuitability for farming led the permittee to request that their combined 3.8 acres to be removed from the total area of this hydraulic management unit, resulting in a total area of 25.8 acres.

4.4.2 Section 4.4 Hydraulic Management Unit Buffer Zones, Fencing, and Posting

The distance between the active portions of MU-008802 and Tenmile Creek was shown to 90 feet in a measurement made by the permittee, less than the buffer zone distance established in previous permits. Because Tenmile creek only flows intermittently, allowing some leniency in the buffer zone distance between the fields and creek is acceptable. Therefore, the buffer zone distance between application sites and Tenmile Creek has been reduced from 100 feet to 90 feet except when water is flowing in Tenmile Creek.

4.5 Section 5. Monitoring Requirements

4.5.1 Microbial and Constituent Monitoring

Ammonia nitrogen has been eliminated from the monitoring requirements since TKN measurement incorporates ammonia.

4.5.2 Ground Water Monitoring

The permittee requested a reduction in ground water sampling frequency, but maintaining a quarterly ground water sampling frequency makes it possible to keep track of the seasonal trends that were observed in the monitoring wells and are discussed in Section 3.5. However, if the regional aquifer sampling plan compliance activity shows that there has not been an impact on local beneficial uses from reuse activities at the Valley Site, then a reduction in frequency of monitoring may be allowed.

4.5.3 Soil Testing

Soil testing is only required once a year in M-088-04, in the spring instead of semi-annually as was the case in LA-000088-03. Nitrogen loading has not been a concern, since the concentration of nitrogen species in the soil have been decreasing in concentration over the previous four years. Soil salinity has not been measured at a level that would cause concern. For a municipal wastewater reuse facility land application operation without nutrient overloading, and with soils generally in good health, no more than one annual soil analysis should be necessary. SAR will be required in the spring of the first and last years of the permit only.

4.5.4 Crop Sampling

Crop sampling will continue to be required in the place of relying only on published values of crop nutrient uptake.. The analysis should be made on a representative sample taken from the Valley Site and the East Site,

but separate samples would not need to be taken from each hydraulic management unit. Typical values published for the nitrogen content of alfalfa hay are around 50.4 lbs-N/ton. If, in the past, the facility had been basing their crop nitrogen uptake calculations on 50.4 lbs-N/ton, instead of calculating uptake based on the results of crop samples, then the corresponding nutrient loading limits would have been set much higher, sometimes by 100 lbs-N/acre. Because the historic nitrogen content of the alfalfa grown at the facility is so different from published values, crop sampling is recommended to be continued so that nitrogen loading limits reflect the actual crop uptake. Phosphorus analysis of the crop samples will no longer be required because phosphorus is not a limiting constituent for land application.

4.5.5 Reporting

Section 6 of M-088-04 contains reporting requirements, which have not been changed from the current permit.

4.6 Section 11. Site Maps

New site maps have been made for this permit to account for new numbering conventions. These maps can be found in Section 11 of the draft permit.

5 RECOMMENDATIONS

Based on review of applicable state rules, staff recommends that DEQ issue draft reuse permit M-088-04 for a public review and comment period. The draft permit contains effluent quality requirements for the recycled water treatment system, as well as terms and conditions required for operation of the reuse system in Section 4. Monitoring and reporting requirements to evaluate system performance and to determine permit compliance have been specified in Sections 5 and 6, and compliance activities have been incorporated into Section 3 of the permit.

6 REFERENCES

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TRIM Record 2012AGH1348

Attachment 1: Review of Cascade Earth Sciences, Ltd. August 4, 2010. Ground Water Impact Assessment of the East Site (Idaho State Correctional Institution).

October 10, 2012

MEMORANDUM

To: Adam Bussan, Scientist III

From: Michael Cook, Soil Scientist

Subject: Review of Cascade Earth Sciences, Ltd. August 4, 2010. Ground Water Impact Assessment of the East Site (Idaho State Correctional Institution).

1.0 Introduction

The following are brief comments related to the modeling project referenced above, hereafter CES 2010. The modeling seeks to predict influences on regional ground water at the wastewater land treatment area known as the East site, as a result of land application of facility municipal wastewater. See Appendix B for site map. Site soils, hydrogeology and wastewater management for three different years are described in CES 2010. Model output is shown in Attachment 6 of CES 2010. The model used is briefly described in section 2. Four confirmation scenarios were run. These are described in detail in section 3. Output graphics are explained in section 4. Confirmatory modeling inputs and outputs of selected scenarios conducted by DEQ, are shown in Appendix A.

Scenario 1 utilizes irrigation water only at irrigation water requirement (IWR). Scenario 2 reproduces the 'Overwatered' scenario proposed in CES 2010, Table 4d and page 8. Scenario 3 is the irrigation water requirement scenario with wastewater loadings at 2011 annual report rates. Scenario 4 reflects actual operations during the 2011 annual reporting year (Centra 2012).

2.0 About the Wastewater Reuse System Model

Detailed instructions for use, general description of model functions, and description/definitions of input parameters are found in *DEQ 2009. Wastewater Land Treatment System Modeling.* In brief, there are two module of this tool, the Nutrient/Hydraulic Balance module and the Contaminant Transport module.

2.1 The Nutrient/Hydraulic Balance (NHB) Module

The Nutrient/Hydraulic Balance module uses meteorological, site, and crop inputs to calculate both hydraulic balances and nutrient balances. The hydraulic balance yields a percolate volume on an annualized basis. The nutrient balance yields a mass of nutrient (here, nitrogen as well as the constituent TDS) lost below the root zone, also on an annualized basis. This N is regarded as nitrate as a conservative assumption. Coupling the percolate volume and mass loss yields a percolate concentration. Both the percolate concentration and volume are primary inputs into the contaminant transport module. For TDS it is assumed that there is no attenuation in the root zone or vadose zone due to precipitation and/or sorption mechanisms.

Generally, longer-term average meteorological data are used in the model. This is because it is thought that over the longer-term use of a wastewater reuse site, varying conditions and resulting environmental impacts will tend to be buffered. But if desired, other data such as 1 in ten year or other return rates may be used depending upon the purpose (usually to incorporate more conservatism in the model). Meteorological data include precipitation (PPT), evapotranspiration (actual) (ET_{act}), and net irrigation requirement (P_{def}).

Constituents modeled are generally N and TDS, but others may be as well. Phosphorus is probably better modeled using the newly developed Phosphorus Onsite Setback Model, which is an application of the WWRU System Model specifically for phosphorus that includes a soil sorption component for soil.

2.2 The Contaminant Transport (CT) Module

The Contaminant Transport module is basically that used in the DEQ Subsurface Sewage Disposal (SSD) program to conduct Nutrient-Pathogen studies, which studies determine suitability of proposed SSD installations. The CT module uses aquifer parameters, ground water quality information, site geometry, and percolate concentration and volume to calculate both an initial source concentration at the down gradient boundary of the field being modeled, as well as concentrations in ground water down gradient of the source.

A planar source representing a cross-sectional discharge area oriented perpendicular to ground water flow and vertically at the source boundary is defined through modeling inputs. The mixed percolate and ground water discharges through this planar source into down gradient ground water, as shown in Figure 1. Domenico equations are utilized to determine concentrations of down gradient ground water mixing with this source through advection and dispersion.

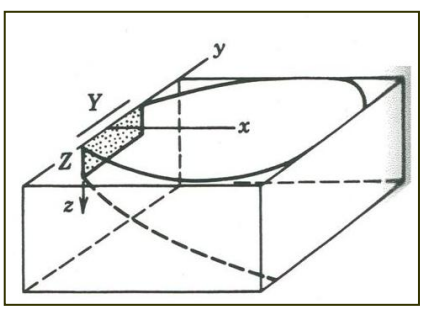


Figure 1. Vertical Planar Source and Coordinate System for a Contaminant Plume.

The source concentration, the mixed concentration of percolate and ground water being discharged from the source (C_{mix}) is corrected for background prior to the Domenico calculations. This correction involves subtracting background ground water concentration (C_{gw}) from C_{mix}, thus obtaining the mixed concentration change due to percolate only. Domenico calculations from the down gradient boundary then reflect the source mixing with ground water of zero background concentration, and the results down gradient reflect the change in ground water concentration due to mixing with the source. Background ground water concentration (C_{gw}) can then be added back to obtain an estimate of ground water quality down gradient. Or, if C_{gw} is not added back, the model output yields simply the change in ground water concentration

due to the source impacting ground water. Looking at the change in groundwater quality can be more helpful in comparing various scenarios, as it normalizes results.

2.3 Aquifer and Vadose Time of Travel Considerations

It is important to mention the importance of contaminant time of travel in relation to monitoring and evaluating data. The contaminant flow path includes both an unsaturated zone (the vadose zone) and a saturated zone (the regional aquifer in this case). An estimate of vadose time of travel can be done utilizing a simplified approach, the 'lump sum time of travel' methodology described in Guyman 1994 as well as in DEQ 2007, page 7-105 (section 7.7.5.2.3). The following simplifying assumptions are made: 1) the vadose zone is sand and gravel (there are significant intervals of basalt also); 2) coarse fragment content is 50%; 3) regional aquifer depth is 480 feet; and 4) percolate flow annually is 5 inches. Appendix C shows the output of many sand and gravel vadose scenarios. The value for conditions given above is 67 years. This value is an estimate utilizing a simple method with many simplifying assumptions and much uncertainty. The value should be interpreted carefully. It may be that, due to preferential flow, this estimate could be as low as 5 to 10 years (Winter 2012). Nevertheless, the time frame is significant enough to consider timing of land use activities in relation to predicted environmental impacts and the potential efficacy of a chosen monitoring strategy.

The next component is time of saturated flow once percolate reaches the aquifer. This is determined first by calculating a ground water velocity ($v = K_h*i/n_e$) where v is velocity, K_h is saturated hydraulic conductivity, i is the gradient (0.0026ft/ft), and n_e is the effective porosity (25%). The distance of travel is then divided by the velocity to yield time. For aquifer conditions considered in this evaluation a mean K_h of 67 ft/d is used. The time calculated for percolate (once it has reached the aquifer) to travel from the upgradient to downgradient boundaries of the site (~1108 ft) would be 4.4 years. The time calculated for ground water to travel from the downgradient boundary of the site to the PWS receptor (~4743 ft) would be 18.6 years.

3.0 Scenario Descriptions

As mentioned in section 1, four confirmation scenarios were run by DEQ. These are described in in section 3.1 through section 3.4, and results are summarized in Table 1. All results of scenarios are based upon the mean of the K_h range used for sensitivity analysis in these modeling runs. The K_h ranges from 21-112 ft/day, and the mean K_h is 67 ft/day. It is also assumed that there is no attenuation of TDS applied through mechanisms such as precipitation, sorption etc. See Appendix A for selected model inputs and outputs.

3.1 Scenario 1 - Irrigation Water Only at the Irrigation Water Requirement

The 'irrigation water only' scenario is typically run as a 'control' of sorts. In this scenario can be seen the predicted impacts to ground water of an agronomic scenario under good management. Results of this unregulated scenario are compared to scenarios involving wastewater reuse and differences can be compared to obtain important perspective on the degree of potential impacts between the two. Table 1 shows that this scenario yields a C_p-N less than C_{gw} so that C_{mix} is less than C_{gw} as well. This situation means that, in the case of N, the percolate will actually improve ground water quality.

Impacts to ground water from TDS are estimated to be 510 mg/L at the downgradient boundary (near the MCL of 500 mg/L). TDS concentration at the nearest receptor is estimated to be 314 mg/L. Results for Scenario 1 are compared to those of other scenarios in discussions that follow.

3.2 Scenario 2 – Early Season Lagoon Pumping and Overirrigation

As CES 2010 (page 8) states, it maynot be possible to avoid TDS impacts to groundwater. TDS is an aesthetic (secondary) constituent and the area is fairly remote. Some degree of impact would have to be accepted for ISCI to operate a land treatment operation on the East site. Attachment 4 (Table 4d) of CES 2010 is a proposed scenario for hydraulic and constituent loading – including a percolate concentration that would be achieved (871 mg/L; CES 2010, Table 5d) - that presumably would result downgradient TDS concentrations less than 496 mg/L. But this involves significant overirrigation of the crop early in the growing season to use greater volumes of wastewater that has not experienced evaporative concentration of TDS. This results in more percolate but of less concentration - not necessarily a reduction of the TDS mass load. This scenario also shows later in the season a depletion of soil water content below management allowable depletion (MAD) such that yield decrement of the crop would be expected. The scenario is not an agronomic one. But, as stated previously, this scenario presumably yields a range of impacts from 376 to 496 mg/L.

DEQ attempted to duplicate calculations that would arrive at the same or similar mass loading and percolate volume values (CES 2010, Table 5d). DEQ did arrive at a similar percolate volume value. Utilizing CES 2010 Table 1 (flows), Table 2 (NVDS concentrations), and Table 5d (loading rate), DEQ was unable to reproduce the scenario value of 814 lb NVDS (Table 5d) for April (an example month). Back-calculating a wastewater NVDS concentration from flows and acreage from the related Table 4d, a value of 312 mg/L was obtained as the scenario value. This value for wastewater is not representative of, and is significantly below, values for most all months of monitoring during 2007-2009, and for more recent 2011 data (Centra 2012).

Since scenario NVDS loading rates could not be verified, nor derived wastewater NVDS concentration appearing reasonable, the following was done: DEQ derived monthly average NVDS concentrations from 2007-2009 data, applied proposed flows for each month (CES 2010, Table 4d) to these concentrations, derived a mass of NVDS applied, and divided this by the proposed wastewater flow to the site to arrive at a scenario wastewater NVDS concentration of 497 mg/L. By employing these calculations, the facility can get ‘credit’ for land applying greater volume of lower strength NVDS wastewater early in the season. The nitrogen concentration, however, remained fixed in the scenario, and it may be that it would be greater since detention times are shorter and treatment would be presumably less.

Results of this scenario confirmation (Table 1) show that there are TDS increases significantly above MCL (994 mg/L; Scenario 2d), but significant attenuation is predicted at the nearest PWS receptor downgradient (572 mg/L). The ‘confirmation’ modeling does not agree with CES 2010 predicted outputs ranging from 376-496 mg/L TDS at the downgradient boundary.

Nitrate-N impacts for this scenario were assumed to be nil by CES 2010. Table 1 shows that, depending on the crop yield assumed, there are different predicted impacts. Two yields (Scenarios 2a and 2c) were assumed. The higher the yield (Scenario 2a), the more N is taken up

and the lower the ground water impacts that are predicted. Table 1 shows significant impacts at the lower assumed yield (Scenario 2c), and underscores the importance of managing the site for good yields. A 5.42 ton/ac yield (Scenario 2a) predicts a concentration of 3.57 mg/L at the downgradient boundary while a 4.5 ton/ac yield (Scenario 2c) predicts a concentration over twice that (8.09 mg/L). It must be remembered that excessive wastewater loading early in the season may provide opportunity for applying wastewater with lower concentrations, but it also means higher N loadings to the site, and perhaps higher N wastewater concentrations due to less detention time and less treatment.

3.3 Scenario 3 – Wastewater Reuse at the Irrigation Water Requirement

The purpose of this scenario developed by DEQ is to take operational data from the recent (2011) annual reporting year (Centra 2012) and model impacts. Since operation data shows no supplemental irrigation water applied, and an obvious irrigation deficit, DEQ took the 2011 operating data but added (via modeling) supplemental irrigation water until both crop needs and leaching requirement were met. Again, two different yields were modeled to see the sensitivity of the scenario to this parameter. As Table 1 shows, nitrate impacts for both yield scenarios (3a and 3c) were lower than the Scenario 2a 'higher yield' sub-scenario. It should be noted that N leaching had to be forced in the model since otherwise no N leaching would take place in these scenarios. This is an encouraging result since Scenario 3 is an agronomic scenario necessitating normal management of the site, while Scenario 2 involves specialized management, that must be consistently and conscientiously implemented each year.

Impacts to ground water from TDS are higher in Scenario 3 than in Scenario 2 (e.g. 572 mg/L for Scenario 2d; versus 623 mg/L for Scenario 3b at the downgradient receptor), but differences in this secondary constituent are minor compared to the differences in nitrate-N impacts between Scenario 3a and 3c and Scenario 2a and 2c previously discussed.

3.4 Scenario 4 – Wastewater Application Rates Based on 2011 Operational Data

Scenario 4, similar to Scenario 3, utilizes operational data from a recent annual reporting year (2011) and models impacts. As discussed in section 3.3, the operational data shows no supplemental irrigation water applied, and an obvious irrigation deficit. This results in zero percolate generation. Since there is no percolate to mix with ground water discharging from the downgradient boundary, the model calculates no impacts to ground water.

This might seem like a favorable scenario at first consideration. In situations such as this, the excess constituents applied are assumed to remain in the soil profile. Since no leaching takes place, the leaching requirement for the agronomic scenario is not met and salinity in the root zone increases. Over time such a scenario will result in soil salinity levels that will cause significant crop yield decrement and eventual crop death. A no-leaching scenario is not a sustainable one. More probable is the scenario where there is no leaching in certain years. Then management and/or weather changes in other years such that there is leaching of some of the stored constituents.

The utility of running Scenario 4 is to show that actual operations (for the 2011 operating year at least) are not agronomic, and that future permit conditions should require irrigation at irrigation water requirements so that land treatment at this site is sustainable.

4.0 Model Graphic Outputs

Plots of model output are found in Appendix A. The form of these plots is explained here. The plots are constructed as follows: The plume centerline plot (Figure 6 for example) has the change in NO_3-N concentration on the y-axis and distance from the down gradient edge of the source on the x-axis. The C_{mix} values typically decrease from the source at length along the flow path due to advective/dispersive processes. The long-dashed vertical line marks the distance to the receptor. The short-dashed horizontal line shows the upgradient ground water constituent concentration.

The vertical profile plot (Figure 7 for example) has the NO_3-N concentration on the x-axis and depth below the water table on the y axis. The point at which the vertical profile plot is observed is along the plume centerline and at a distance (here, 4743 feet to the receptor) from the down gradient boundary of the source on the x-axis to the receptor. The C_{mix} values typically decrease from the top of the water table to depth and eventually approach background ground water levels. The dashed horizontal line marks the aquifer depth. The dashed vertical line shows the upgradient ground water constituent concentration.

5.0 Conclusions

The following conclusions of this review are provided.

1) If the facility wants to pursue Scenario 2, further explanation of the model input parameter wastewater TDS concentration calculation will be needed, as well as making an estimation of wastewater nitrogen concentration to use in this scenario.

2) TDS impacts to ground water are inevitable for any scenario chosen, including Scenario 1 (irrigation water only). Remembering that the WWRU system model is conservative in the sense that it does not account for potentially important TDS attenuation mechanisms (such as precipitation), it is likely that TDS impacts will be less than those predicted.

3) Scenarios 3a and 3c (reuse at irrigation water requirements) seems to be promising with respect to N impacts to ground water. The model was made to force N leaching, otherwise there would not have been any calculated. The model was sensitive to crop yield so it is important that the site is well managed in order to achieve good yields.

4) Time of travel analysis, as uncertain as it may be, implies longer time frames that might make ground water monitoring of limited utility. As nitrate-N contamination seems unlikely from model predictions (Scenarios 3a and 3c), consideration turns to TDS impacts. If monitoring well installation is opted for, it should be well defined by the agency what TDS levels would be acceptable, and what would be the regulatory consequences if those levels are not met.

5) Given the potential time lag between land use and observing environmental impacts, an alternate approach may be to strictly regulate operations rather than environmental impacts. Here a conservative scenario such as Scenario 3 would be strictly defined, and the loading parameters that are allowed. Regulatory oversight would need to be diligently exercised to see whether the facility is meeting limits, and to take prescribed action if it is not.

6.0 References

Cascade Earth Sciences, Ltd. August 4, 2010. Ground Water Impact Assessment of the East Site (Idaho State Correctional Institution).

Centra Consulting Inc. January 11, 2012. Idaho Department of Correction (IDOC) Recycled Water Permit LA-000088-03 – 2011 Annual Report for the Idaho State Correctional Institution.

Department of Environmental Quality (DEQ). July 2009. Wastewater Reuse / Land Treatment System Modeling – 2009 Course Curriculum (rev 7/16) and Model Documentation.

Department of Environmental Quality (DEQ). September 2007. Guidance for the Reclamation and Reuse of Municipal and Industrial Wastewater.

Guymon, G.L., 1994. Unsaturated Zone Hydrology. PTR Prentice Hall. 209 pages. (See Lumped Time of Travel Model. pp. 51, 71, 81-83, 103-104).

Winter, G. V. September 7, 2012. Personal communication.

Table 1. Confirmatory Scenario Descriptions

ISCI Reuse System Modeling: Confirmatory/Comparative Modeling							Nitrogen	Constit-	Force		Does		Legume	Cmix (i)		
					Irrigation Regimes (b)		Loading:	uent	N to		Qp meet		N Fixation	At the	At DG	
Scenario Number	Scenario Name	Crop Yield (ton/ac)	Constit-uent	Water Status(a)	Waste-water	Irrigation Water	% of Crop Uptake (c)	Loading (lb/ac)	Leach(d)? (y/n; pct)	Qp(e) (inches)	LR? (f) (y/n)	Cp(g) (mg/L)	Rate (h) (proportion)	Source (mg/L)	Receptor(j) (mg/L)	Comments
1a	Irrigation Water Only	4.5	Nitrate-N	IWR(k)	DEQ	DEQ	120%	21.9	yes; 2.5%	2.04	yes	1.0	0.90	1.99	2.07	Cp<Cgw, so gw quality improves slightly
1b	Irrigation Water Only	4.5	TDS	IWR	DEQ	DEQ	--	2330	--	2.04	yes	3202	--	510	314	
2a	Overirrigation - Early Season	5.42	Nitrate-N	Irrig Ex(l)	CES	CES	128%	212	no	11.16	yes	5.7	0.25	3.57	2.77	
2b	Overirrigation - Early Season	5.42	TDS	Irrig Ex	CES	CES	--	6186	--	11.16	yes	2044	--	965	559	
2c	Overirrigation - Early Season	4.5	Nitrate-N	Irrig Ex	CES	CES	154%	212	no	11.16	yes	16.8	0.25	8.09	4.82	compare 3a w/3c; Cmix sensitive to yield
2d	Overirrigation - Early Season	4.5	TDS	Irrig Ex	CES	CES	--	6186	--	11.16	yes	2114	--	994	572	
3a	Reuse @ IWR	4.5	Nitrate-N	IWR	2011 AR(m)	DEQ	111%	153	yes; 2.5%	5.48	yes	2.6	0.25	2.23	2.15	
3b	Reuse @ IWR	4.5	TDS	IWR	2011 AR	DEQ	--	6490	--	5.48	yes	4544	--	1303	623	
3c	Reuse @ IWR	5.42	Nitrate-N	IWR	2011 AR	DEQ	92%	153	yes; 2.5%	5.48	yes	2.6	0.25	2.23	2.15	
3d	Reuse @ IWR	5.42	TDS	IWR	2011 AR	DEQ	--	6490	--	5.48	yes	4403	--	1268	610	compare 3b w/3d; Cmix similar
4a	Actual 2011 Operations	5.42	Nitrate-N	Irrig Def(n)	2011 AR	2011 AR	88%	146	no	0.00	no	0.0	0.25	2.11	2.11	Qp = 0, so no changes in gw quality (z)
4b	Actual 2011 Operations	5.42	TDS	Irrig Def	2011 AR	2011 AR	--	5705	--	0.00	no	0	--	224	224	Qp = 0, so no changes in gw quality

Notes:

a. Water Status: Scenarios are modeled either at irrigation water requirement IWR) or at irrigation deficit - here denoted as 'stress'.
b. Irrigation regimes, for both wastewater and irrigation water, are either those presented in CES (2010) or those developed by DEQ.
c. CU = crop uptake of N as a percentage of that applied. N loading limits are often specified as a certain percentage of the crop N uptake.
d. Force leaching: Where calculations show total N uptake by the crop, Cp-N will be zero and there will be no N loss. In this case, the model can force any amount of N leaching to reflect perhaps a more realistic situation than zero N loss from leaching.
e. Qp = flow of percolate in inches (per acre)
f. LR = the leaching requirement on an annual basis to maintain a threshold soil salinity level.
g. Cp = maximum percolate concentration of TDS or N (assume all N is NO3-N).
h. N fixation: the proportion of crop content of N that is captured from the atmosphere. This factor only applies to leguminous crops such as alfalfa.
i. Cmix = concentration of ground water after mixing with percolate at the down gradient boundary.
j. The receptor is a public water system (PWS) located about 4743 feet downgradient from the site modeled.
k. IWR = irrigation water requirement.
l. Irrig Ex = excess irrigation applied, consisting of wastewater plus irrigation water.
m. 2011 AR = the annual report for operating year 2011. Operational data from this report is used in the scenario.
n. Irrig def = irrigation deficit: indicates those scenarios modeled under irrigation deficit conditions.

Appendix A – Example Scenario Inputs and Outputs- Scenarios 3a and 3b

Figure 1. Scenario 3a and 3b Nutrient/Hydraulic Balance Inputs

Wastewater Reuse Site System Model <Rev Aug 22, 2011> (sensitivity analyses)

INPUTS			
Run Date --->	9/4/12 4:58 PM		
Project Title	ISCI East Site; WWRU Permit # LA-000088		
Scenario Description	East Site; 2011 data; Irrigate at IWR (mjc)		
Wastewater Chemistry	Force N leaching? y/n		
	% appl N Avail to crop?		
Parameter	Value	Units	Data Source/Comments
COD (Yearly Average)	257.0	mg/L	2011 AR
COD (During the NGS	257.0	mg/L	2011 AR
COD (During the GS)	257.0	mg/L	2011 AR
N (total)	17.6	mg/L	2011 AR
P (Total)	3.6	mg/L	2011 AR
NVDS	689.0	mg/L	2011 AR
VDS	121.0	mg/L	2011 AR
TDS	810.0	mg/L	2011 AR
K	0.1	mg/L	no data
Mg	0.1	mg/L	no data
Ca	0.1	mg/L	no data
Na	0.1	mg/L	no data
Cl	0.1	mg/L	no data
SO4	0.1	mg/L	no data
pH	0.1	SU	no data
SAR (reported)		--	no data
Fat, Oil and Grease	0.0	mg/L	no data
Other (1)	0.0	mg/L	no data
Irrigation Water Chemistry			
TDS	224	mg/L	CES Aug 4, 2010 p. 8
N Total	2.11	mg/L	CES Aug 4, 2010 Attchmnt 5 2006 sample event
Irrigation System Information			
Irrigation System Type	Stationary lateral (wheel or handline		
Suggested Irrigation Efficiency (range)	60 - 75 %	Calculated cell - don't overwrite	
Irrigation Efficiency (enter one value)	0.70	(a proportion)	DEQ Sept 2007 Guidance Tbl 4-12
Suggested Evaporation Loss Fraction	0.1	Calculated cell - don't overwrite	
Evaporation Loss Fraction;	0.10	(a proportion)	
Soil Properties			
Applied N Denitrification rate in soil	0.15	proportion	Conservative value
Soil AWC to 60 in or limiting layer	4.46	inches	From CES 2010
General Soil Moisture Status in Spring	Very Dry (near Permanent Wilting Point)		DEQ Sept 2007 Guidance Tbl 7-25
Fraction: Soil AWC in Spring - Suggested	~0.25	a proportion: Calcuated cell - don't overwrite	
Fraction of Soil AWC Full in Spring	0.1	(a proportion)	
Crop Effective Root Depth - Suggested	48	inches: Calculated cell - don't overwrite - ENTER CROP DATA FIRST	
Crop Effective Root Depth (enter a value)	30	inches	
Soil AWC of Effective Root Depth only	4.46	inches	CES Aug 4, 2010, Table 4a
Acceptible Soil Salinity (ECe)	2	dS/m (mmhos/cm)	
Climatic Information			
Precipitation Info (Choose Type)	Custom Entry		
Climate Station - Ignore for Custom Entry	KUNA		
Non-Growing Season	D. Nov - Mar	months	
Choose whether to Force N leaching (y/n)	y		
Enter % of Forced N Leaching	2.5%		
Swath Dimensions			
- Length Parallel To GW Flow	1108.0	ft	26 acre site longest SW flow path; make width equal to 26 ac
- Width Perpendicular to GW Flow	1022.0	ft	

Hydraulic Inputs

					Re-irrigate @ Soil Θ =	2.01	
				Leaching Reqmnt ->	NOTE->There is likely sufficient leaching		
			Custom Entry -	GS Leaching -->	NOTE->Greater Than 1" Difference btwn Modeled and Expected		
		Irrigation	Gross		Soil Water		
	Wastewater	Water	Precipitation		Storage from		
	Applied	Applied	(select units)		Outputs Hyd Bal		
Month	(inches)	(inches)	mm/day		Sheet (inches)		Data Source & Comments
April	3.690	3.00	1.06		2.04		ww at 2011 rates
May	6.640	2.00	1.24		4.01		ppt; ETIdaho 2009 for BOI Airport
June	2.210	6.00	0.64		4.25		
July	8.850	2.00	0.26		4.46		adjust irrig water for IWR
August	10.740	0.00	0.22		4.46		
September	4.430	0.00	0.57		3.83		
October	0.000	2.50	0.66		3.53		
November	0.000	0.00	1.26		3.86		
December	0.000	0.00	1.33		4.46		
January	0.000	0.00	1.06		4.46		
February	0.000	0.00	0.92		4.45		
March	0.000	0.00	1.24		3.80		
Total (inches)	36.56	15.50					
Total (MG)	25.81	10.94					

Crop ET Related Data: PPT Deficit (Pdef) and Actual ET (ETact)

	P Def: Crop 1	ET act Crop 1	P Def: Crop 2	ET act Crop 2	P Def: Crop 3	ET act Crop 3	
Month	mm/d (1)	mm/d (1)	mm/d (1)	mm/d (1)	mm/d (1)	mm/d (1)	Data Source & Comments
April	3.49	4.53	3.15	3.94	0.03	0.81	Pdef & ETact; BOI Airport
May	4.43	5.63	5.56	6.36	0.34	1.11	crop 1: alfalfa, frequent cuttings
June	5.72	6.35	6.84	7.39	2.85	3.32	
July	6.1	6.36	2.19	2.50	7.15	7.43	
August	5.27	5.49	0.58	0.36	6.49	6.65	
September	3.74	4.29	0.30	0.33	2.60	3.06	
October	2.01	2.65	0.11	0.56	0.27	0.86	
November	-0.23	0.98	-0.49	0.64	-0.52	0.57	
December	-0.56	0.45	-0.62	0.44	-0.33	0.44	
January	-0.27	0.51	-0.38	0.51	-0.09	0.51	
February	0.15	0.93	0.29	0.93	0.12	0.76	
March	0.61	1.77	0.74	1.73	-0.02	0.93	

(1) Use Crop & Region-Specific ET act and Pdef data from Allen & Robison, 2007;

Vegetation Type:	Crops						
Crop Information:	NRCS Climate Region -->	Climatic Region 2	site is in Elmore Co. Climatic Region II				
	Crop 1	Units	Crop 2	Units	Crop 3	Units	Data Source & Comments
							Validation: Swath Percentages Equal 100%
Region & Crop	2 - Alfalfa Grass		2 - Grain		1 - Corn, Field (Silage)		
Percent Acreage on Swath	100.0%	percent acreage	0.0%	percent acreage	0.0%	percent acreage	2011 ISCI ann rept Alfalfa yield
Crop Yield	4.5	ton/ac	101	bu/ac grain	27.5	ton/ac	
Weight per Harvest Unit	lb/ton	2000	lb/bu wheat	60	lb/ton	2000	
Weight N per Harvest Unit	40.8	lb N /ton	1.67	lb N /bu wheat	16.07	lb N /ton	2011 AR; 2.042% TKN in plant tissue
Nitrogen Uptake in straw	0	lb N/ac	0	lb N/ac	0	lb N/ac	
Crop N Fixation	0.25	proportion	0	proportion	0	proportion	N fixation a parameter for sensitivity analysis
Legume N Release	0	lb/ac-yr	0	lb/ac-yr	0	lb/ac-yr	
Fertilizer N Applied	0	lb/ac-yr	0	lb/ac-yr	238	lb/ac-yr	
Ash content Harvested Crop	0.095	proportion	0.018	proportion	0.057	proportion	2011 AR: 9.5% ash

Figure 2. Scenario 3a and 3b Nutrient/Hydraulic Balance Outputs

Wastewater Reuse Site System Model <Rev Aug 22, 2011> (sensitivity analyses)	
OUTPUTS	
Run Date --->	9/4/12 4:58 PM
Project Title	ISCI East Site; WWRU Permit # LA-000088
Scenario Description	East Site; 2011 data; Irrigate at IWR (mjc)

Loading Rates		
Parameter	Rates*	Units
COD (Yearly Average)	5.8	lb/ac/d
COD (During the NGS	0.0	lb/ac/d
COD (During the GS)	9.9	lb/ac/d
N (total)	145.7	lb/ac/y
P (Total)	29.4	lb/ac/y
NVDS	5704.7	lb/ac/y
VDS	1001.8	lb/ac/y
TDS	6706.5	lb/ac/y
K	0.8	lb/ac/y
Mg	0.8	lb/ac/y
Ca	0.8	lb/ac/y
Na	0.8	lb/ac/y
Cl	0.8	lb/ac/y
SO4	0.8	lb/ac/y
SAR (Calculated)	0.1	--
Fat, Oil and Grease	0.0	lb/ac/y
Other (1)	0.0	lb/ac/y

Parameter	Value	Units
Swath Acreage	26.0	acres
WW Applied to Swath	25.8	MGA
Non-Growing Season Length	151	days
Growing Season Length	214	days
NGS Hyd Soil Storage Limit	3.04	in/acre
Modeled NGS Application	0.00	in/acre
NOTE->NGS Loading within Soil Stg Limit		

Month	WW NGS Loading in/acre	WW GS Loading in/acre	NGS Leaching in/acre	GS Leaching in/acre
April	0	3.69	0.00	0.00
May	0	6.64	0.00	0.00
June	0	2.21	0.00	0.00
July	0	8.85	0.00	1.61
August	0	10.74	0.00	2.73
September	0	4.43	0.00	0.00
October	0	0	0.00	0.00
November	0	0	0.00	0.00
December	0	0	0.47	0.00
January	0	0	0.67	0.00
February	0	0	0.00	0.00
March	0	0	0.00	0.00
Totals (in/ac)	0	36.56	1.14	4.34
Totals (MG)	0.0	25.8	0.8	3.1

Constituent Balance & Percolate Concentration			
	TDS (Inorganic)*	Nitrogen	
Applied in WW	5704.7	145.7	lbs/ac
Applied in Irrig Water	785.1	7.4	lbs/ac
N Release - Legume Plowdown		0.0	lbs/ac
Fertilizer N Applied		0.0	lbs/ac
Subtotal	6489.7	153.1	lbs/ac
N Available to Crop		130.1	lbs/ac
Ac Weighted Crop Uptake	855.0	137.7	lbs/ac
150% Crop Uptake		206.6	lbs/ac
Total Subject to Loss	5634.7	3.3	lbs/ac
Percolate Conc ----->	4544.0	2.6	mg/L

* Note: Inorganic TDS is variously reckoned, typically as follows: WW as FS or NVDS; IW as TDS; Crop tissue as ash.

N Applied as percent (%) of Crop Uptake----------> 111%

	Crop 1		Crop 2		Crop 3	
Growing Season	Julian Day	Date	Julian Day	Date	Julian Day	Date
Begin	98	7-Apr	91	31-Mar	125	4-May
End	298	24-Oct	220	7-Aug	259	15-Sep
Crop N Uptake	137.7	lb/acre	168.7	lb/acre	441.9	lb/acre
Crop Ash Uptake	855	lb/acre	109	lb/acre	3135	lb/acre

Percent Area of Swath	
Crop 1	100.0%
Crop 2	0.0%
Crop 3	0.0%

Month	PPT Deficit Crop 1 in/mo	ET act Crop 1 in/mo	PPT Deficit Crop 2 in/mo	ET act Crop 2 in/mo	PPT Deficit Crop 3 in/mo	ET act Crop 3 in/mo	P def Composite (Acre Weighted) in/mo	ET act Composite (Acre Weighted) in/mo
April	4.12	5.35	3.72	4.65	0.04	0.96	4.12	5.35
May	5.41	6.87	6.79	7.76	0.41	1.35	5.41	6.87
June	6.76	7.50	8.08	8.73	3.48	4.05	6.76	7.50
July	7.44	7.76	2.67	3.05	8.73	9.07	7.44	7.76
August	6.43	6.70	0.71	0.44	7.92	8.12	6.43	6.70
September	4.42	5.07	0.35	0.39	3.17	3.73	4.42	5.07
October	2.45	3.23	0.13	0.68	0.33	1.05	2.45	3.23
November	-0.27	1.16	-0.58	0.76	-0.63	0.70	-0.27	1.16
December	-0.68	0.55	-0.76	0.54	-0.40	0.54	-0.68	0.55
January	-0.33	0.62	-0.46	0.62	-0.11	0.62	-0.33	0.62
February	0.17	1.03	0.32	1.03	0.13	0.93	0.17	1.03
March	0.74	2.16	0.90	2.11	-0.02	1.14	0.74	2.16
Total (in/ac)	37.03	42.49	22.45	25.71	24.08	28.33	37.03	42.49

Figure 3. Scenario 3a and 3b Hydraulic Balance

Wastewater Reuse Site System Model <Rev Aug 22, 2011> (sensitivity analyses)								Appl WW + IW + PPT		64.58	in/ac	
				Soil Water in Spring =		0.45	inches	EC of Appl WW + IW + PPT		0.70	mmhos/cm	
OUTPUT - Hydraulic Balance				Re-irrigate @ Soil Θ =		2.01	inches	Leaching Reqmnt ->		0.08	proportion	
Run Date --->	9/4/12 4:58 PM			'Expected' GS Leaching =		6.35	inches	Approx minimal leaching		4.86	in/ac	
Project Title	ISCI East Site; WWRU Permit # LA-000088			Modeled GS Leaching =		4.34	inches	Total Leaching from Hyd Bal		5.48	in/ac	
Scenario Description	East Site; 2011 data; Irrigate at IWR (mjc)			NOTE->Greater Than 1" Difference btwn Modeled and Expected				NOTE->There is likely sufficient leaching				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Month	ET act Actual Evapotranspiriation (inches)	Gross PPT (inches)	Net Irrigation Requirement (PPT Deficit) (inches)	Irrigation Water Requirement (inches)	Wastewater Applied (inches)	Irrigation Water Applied (inches)	Irrigation Evaporation Losses (inches)	Number of Irrigations per Month (Count)	Wet Canopy Losses (inches)	Net Water Applied (inches)	Soil Water Storage (inches)	Leaching Loss (inches)
April	5.35	1.25	4.12	5.89	3.69	3	0.67	3	0.30	1.60	2.04	0.00
May	6.87	1.51	5.41	7.72	6.64	2	0.86	4	0.40	1.97	4.01	0.00
June	7.50	0.76	6.76	9.65	2.21	6	0.82	4	0.40	0.23	4.25	0.00
July	7.76	0.32	7.44	10.64	8.85	2	1.09	5	0.50	1.82	4.46	1.61
August	6.70	0.27	6.43	9.19	10.74	0	1.07	5	0.50	2.73	4.46	2.73
September	5.07	0.67	4.42	6.31	4.43	0	0.44	2	0.20	-0.63	3.83	0.00
October	3.23	0.81	2.45	3.50	0	2.5	0.25	1	0.10	-0.30	3.53	0.00
November	1.16	1.49	-0.27	-0.39	0	0	0.00	0	0.00	0.33	3.86	0.00
December	0.55	1.62	-0.68	-0.98	0	0	0.00	0	0.00	1.07	4.46	0.47
January	0.62	1.29	-0.33	-0.47	0	0	0.00	0	0.00	0.67	4.46	0.67
February	1.03	1.01	0.17	0.24	0	0	0.00	0	0.00	-0.01	4.45	0.00
March	2.16	1.51	0.74	1.06	0	0	0.00	0	0.00	-0.65	3.80	0.00
TOTAL (inches)	48.00	12.52	37.03	52.90	36.56	15.5	5.21		2.40			5.48
TOTAL (MG)	33.88	8.84	26.14	37.34	25.8	10.9	3.67		1.69			3.87
TOTAL (GS in)	42.49	5.59			36.56							
TOTAL (NGS in)	5.51	6.93			0.00							

Figure 4. Scenario 3a Contaminate Transport Inputs

INPUTS: GW Contaminant Transport Model: ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION <Rev 5/17/2012>

Note: All Inputs are in Rows 4 - 46 and are in Cells with Red Font.

Project Description:	ISCI; Permit no. LA-000088; IWR (mjc) for 2011 ann rept
Date:	9/4/2012
Prepared by:	M. Cook
Scenario Description:	Nitrate-N Impacts; Alfalfa Yield - 4.5 ton/ac

What is new with GW Contaminant Transport Module 5/17/2012:

1) There was a minor error in calculating Qgw in previous versions. Previously, the calculated mixing zone depth (dm) was assumed for convenience to be the dgw, but is depth of gw plus that of mixed percolate (dm=dgw+dp). Associated calcs have been corrected. See further note in GW Mixing Model spreadsheet.

2) A means to minimize the error from 'adding back' the GW background concentration to Domenico calculations has been included.

Mixing Zone Depth Calculation Inputs	Symbol	Units	Input	Data Sources and Comments
Land Treatment Swath Length Parallel to GW Flow	L	feet	1108	Assume longest SW flow path across site; then calculate a width to equal 26 ac
Land Treatment Swath Width Perpendicular to GW Flow	W	feet	1022	East Site
Percolate Volume	Qp	inches/ac	5.48	From Hydraulic SS; base Case
Percolate Constituent Concentration:	Cp	mg/L	2.6	From Outputs SS; Base Case
Upgradient GW Concentration:	Cgw	mg/L	2.11	CES Aug 4, 2010; attachment 6
Aquifer Hydraulic Conductivity: High Range	K	feet/day	112	CES Aug 4, 2010; attachment 6
Aquifer Hydraulic Conductivity: Low Range	K	feet/day	21	CES Aug 4, 2010; attachment 6
Aquifer Hydraulic Gradient	i	unitless	0.0026	CES Aug 4, 2010; attachment 6
Aquifer Material	Driscoll, 1987 - Sand and Gravel mixes			
Aquifer Porosity (Suggested literature values, range given in percent)	ne	unitless	10 – 35%	Suggested value. Don't overwrite
Aquifer Effective Porosity (enter suggested or other value as a percent)	ne	unitless	25%	CES Aug 4, 2010; attachment 6
Aquifer Thickness	da	feet	300	508 ft (CES Aug 4, 2010; attachment 6) set at 300 for visibility

Ground Water Transport Calculation Inputs	Symbol	Units	Input	Data Sources and Comments
Suggested LAMBDA (biodegradation constant) for non-decaying species)	λ	day-1	0	Suggested Value - Don't overwrite.
LAMBDA (biodegradation constant)	λ	day-1	0	
Soil Texture	--	--	Loam	Information not needed for this analysis
Suggested Soil Bulk Density Value (from RU Guidance)--->	Db	g/cm3	1.59	Suggested Value. Calculated Cell. Don't overwrite.
Soil Bulk Density (enter Suggested Value or Other Value)	Db	g/cm3	1.59	Information not needed for this analysis
Suggested Koc value (for conservative non-sorbing species)	Koc	cm3/g	0	Suggested Value - Don't overwrite.
Koc (organic carbon partition coefficient)	Koc	cm3/g	0	Information not needed for this analysis
Fraction of Organic Carbon	--	--	5.00E-03	Information not needed for this analysis
Spatial Coordinates of Concern (Origin is plume centerline at DG discharge boundary				
X (longitudinal)	x	feet	4743	Distance DG to nearest PWS Receptor
Y (latitudinal/transverse)	y	feet	0	
Z (depth)	z	feet	0	
Depth of Vertical Profile to Calculate and Observe	z	feet	300	for plotting purposes
Time that the Source is Discharging	t	days	10000000	High value to model steady-state conditions
AREAL Model Calculation Domain				
(dinensions of area modeled)				
Length (ft)	L	feet	5000	Golder 11-28-08 p.7
Width (ft)	W	feet	3500	a width greater than the pivot width
Validation: Vertical Dispersion Within Actual Aquifer Depth				

Figure 5. Scenario 3a Contaminate Transport Outputs

Data for Centerline and Vertical Profile Plots

	Plume Centerline:																	
	Kh	X	0	500	1000	1500	2000	2500	3000	3500	4000	4500	5000					
Kh = 112	112	Y	2.191	2.189	2.175	2.164	2.156	2.151	2.147	2.143	2.141	2.138	2.136					
Kh = 89	89	Y	2.208	2.205	2.190	2.177	2.168	2.161	2.156	2.152	2.148	2.145	2.143					
Kh = 67	67	Y	2.232	2.230	2.214	2.198	2.186	2.177	2.170	2.165	2.161	2.157	2.154					
Kh = 44	44	Y	2.275	2.274	2.258	2.238	2.222	2.210	2.200	2.193	2.186	2.181	2.176					
Kh = 21	21	Y	2.367	2.367	2.360	2.341	2.320	2.302	2.287	2.273	2.262	2.252	2.243	2.11				
Receptor ->			4743	4743	4743	4743	4743	4743	4743	4743	4743	4743	4743					
	Vertical Profile:																	Aquifer Depth
	Kh	Y	0.0	21.4	42.9	64.3	85.7	107.1	128.6	150.0	171.4	192.9	214.3	235.7	257.1	278.6	300.0	Error Flag
Kh = 112	112	X	2.137	2.136	2.132	2.127	2.122	2.118	2.114	2.112	2.111	2.110	2.110	2.110	2.110	2.110	2.110	0
Kh = 89	89	X	2.144	2.143	2.138	2.132	2.125	2.120	2.116	2.113	2.111	2.111	2.110	2.110	2.110	2.110	2.110	0
Kh = 67	67	X	2.155	2.153	2.147	2.139	2.130	2.123	2.118	2.114	2.112	2.111	2.110	2.110	2.110	2.110	2.110	0
Kh = 44	44	X	2.178	2.175	2.166	2.154	2.141	2.130	2.122	2.116	2.113	2.111	2.110	2.110	2.110	2.110	2.110	0
Kh = 21	21	X	2.247	2.241	2.225	2.202	2.177	2.154	2.137	2.125	2.117	2.113	2.111	2.111	2.110	2.110	2.110	0
																	Sum ->	0

Figure 6. Scenario 3a Contaminate Transport Outputs

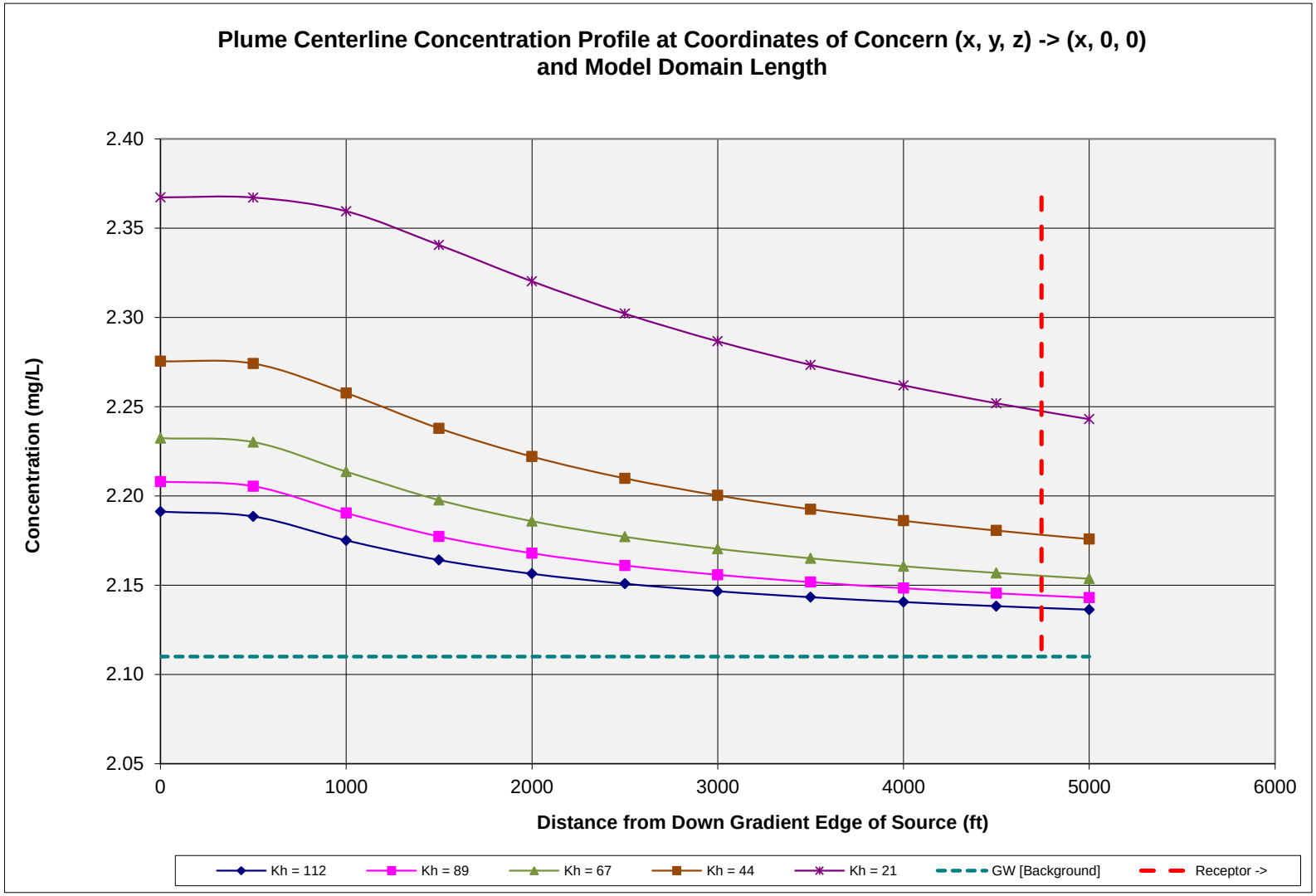


Figure 7. Scenario 3a Contaminate Transport Outputs

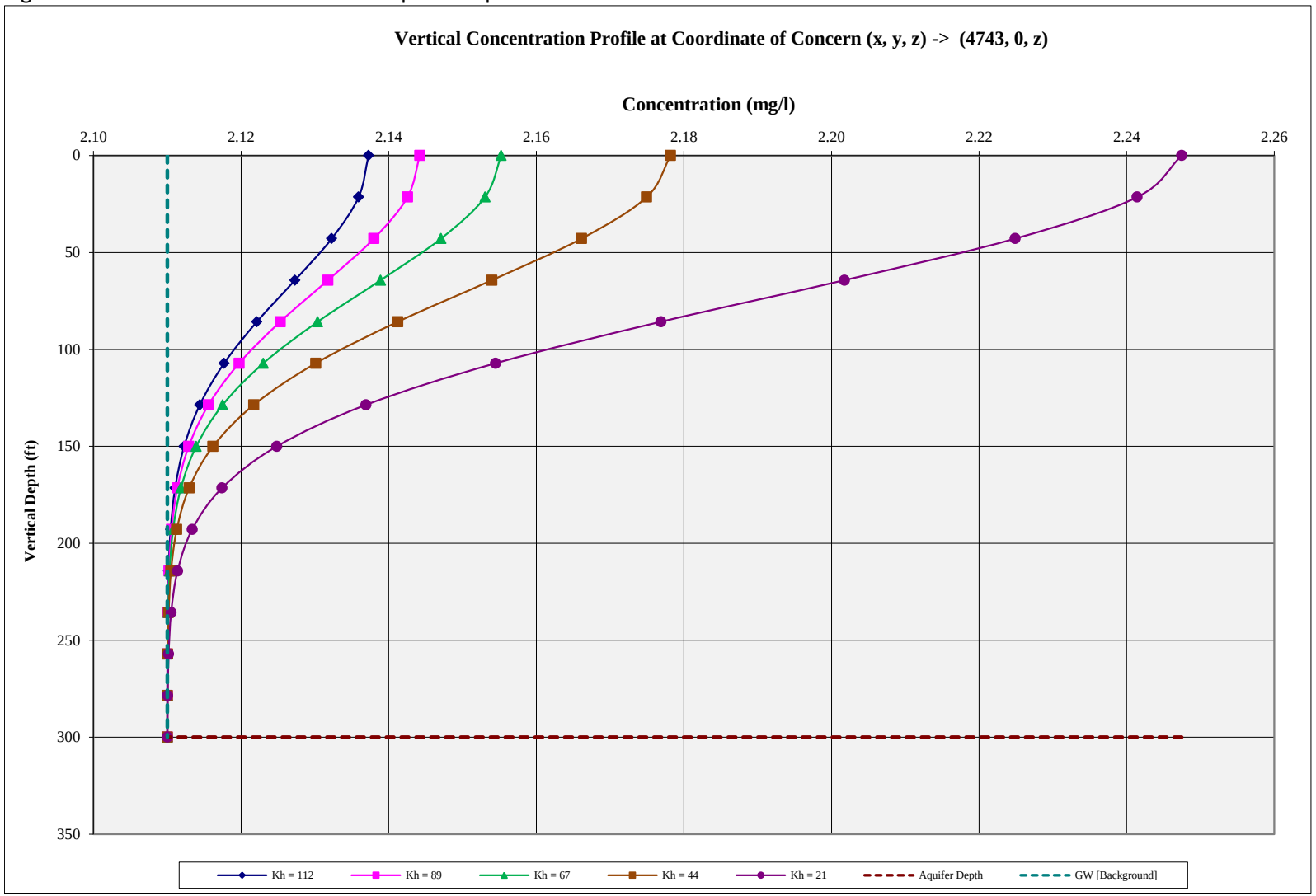


Figure 8. Scenario 3b Contaminate Transport Inputs

INPUTS: GW Contaminant Transport Model: **ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION <Rev 5/17/2012>**

Note: All Inputs are in Rows 4 - 46 and are in Cells with Red Font.

Project Description:	ISCI; Permit no. LA-000088; IWR (mjc) for 2011 ann rept
Date:	9/4/2012
Prepared by:	M. Cook
Scenario Description:	TDS Impacts; Alfalfa Yield - 4.5 ton/ac

What is new with GW Contaminant Transport Module 5/17/2012:

1) There was a minor error in calculating Qgw in previous versions. Previously, the calculated mixing zone depth (dm) was assumed for convenience to be the dgw, but is depth of gw plus that of mixed percolate (dm=dgw+dp). Associated calcs have been corrected. See further note in GW Mixing Model spreadsheet.

2) A means to minimize the error from 'adding back' the GW background concentration to Domenico calculations has been included.

Mixing Zone Depth Calculation Inputs	Symbol	Units	Input	Data Sources and Comments
Land Treatment Swath Length Parallel to GW Flow	L	feet	1108	Assume longest SW flow path across site; then calculate a width to equal 26 ac
Land Treatment Swath Width Perpendicular to GW Flow	W	feet	1022	East Site
Percolate Volume	Qp	inches/ac	5.48	From Hydraulic SS; base Case
Percolate Constituent Concentration:	Cp	mg/L	4544	From Outputs SS; Base Case
Upgradient GW Concentration:	Cgw	mg/L	224	CES Aug 4, 2010; attachment 6
Aquifer Hydraulic Conductivity: High Range	K	feet/day	112	CES Aug 4, 2010; attachment 6
Aquifer Hydraulic Conductivity: Low Range	K	feet/day	21	CES Aug 4, 2010; attachment 6
Aquifer Hydraulic Gradient	i	unitless	0.0026	CES Aug 4, 2010; attachment 6
Aquifer Material	Driscoll, 1987 - Sand and Gravel mixes			
Aquifer Porosity (Suggested literature values, range given in percent)	ne	unitless	10 – 35%	Suggested value. Don't overwrite
Aquifer Effective Porosity (enter suggested or other value as a percent)	ne	unitless	25%	CES Aug 4, 2010; attachment 6
Aquifer Thickness	da	feet	300	508 ft (CES Aug 4, 2010; attachment 6) set at 300 for visibility

Ground Water Transport Calculation Inputs	Symbol	Units	Input	Data Sources and Comments
Suggested LAMBDA (biodegradation constant) for non-decaying species)	λ	day-1	0	Suggested Value - Don't overwrite.
LAMBDA (biodegradation constant)	λ	day-1	0	
Soil Texture	--	--	Loam	Information not needed for this analysis
Suggested Soil Bulk Density Value (from RU Guidance)--->	Db	g/cm3	1.59	Suggested Value. Calculated Cell. Don't overwrite.
Soil Bulk Density (enter Suggested Value or Other Value)	Db	g/cm3	1.59	Information not needed for this analysis
Suggested Koc value (for conservative non-sorbing species)	Koc	cm3/g	0	Suggested Value - Don't overwrite.
Koc (organic carbon partition coefficient)	Koc	cm3/g	0	Information not needed for this analysis
Fraction of Organic Carbon	--	--	5.00E-03	Information not needed for this analysis
Spatial Coordinates of Concern (Origin is plume centerline at DG discharge boundary				
X (longitudinal)	x	feet	4743	Distance DG to nearest PWS Receptor
Y (latitudinal/transverse)	y	feet	0	
Z (depth)	z	feet	0	
Depth of Vertical Profile to Calculate and Observe	z	feet	300	for plotting purposes
Time that the Source is Discharging	t	days	10000000	High value to model steady-state conditions
AREAL Model Calculation Domain (dimensions of area modeled)				
Length (ft)	L	feet	5000	Golder 11-28-08 p.7
Width (ft)	W	feet	3500	a width greater than the pivot width
Validation: Vertical Dispersion Within Actual Aquifer Depth				

Figure 9. Scenario 3b Contaminate Transport Outputs

Data for Centerline and Vertical Profile Plots

	Plume Centerline:																	
	Kh	X	0	500	1000	1500	2000	2500	3000	3500	4000	4500	5000					
Kh = 112	112	Y	939.824	916.210	798.118	700.952	632.971	583.874	546.737	517.416	493.407	473.171	455.737					
Kh = 89	89	Y	1088.453	1065.727	933.068	817.214	734.451	674.083	628.159	591.765	561.888	536.658	514.890					
Kh = 67	67	Y	1303.033	1283.554	1137.517	996.895	892.888	815.752	756.509	709.268	670.317	637.320	608.780					
Kh = 44	44	Y	1682.864	1671.569	1525.520	1351.281	1211.806	1104.360	1020.009	951.784	894.968	846.480	804.308					
Kh = 21	21	Y	2492.440	2491.685	2423.789	2257.073	2077.643	1917.831	1781.354	1664.749	1563.830	1475.227	1396.489	224				
Receptor ->			4743	4743	4743	4743	4743	4743	4743	4743	4743	4743	4743					
	Vertical Profile:																	Aquifer Depth
	Kh	Y	0.0	21.4	42.9	64.3	85.7	107.1	128.6	150.0	171.4	192.9	214.3	235.7	257.1	278.6	300.0	Error Flag
Kh = 112	112	X	464.394	452.546	420.386	376.511	331.026	291.858	262.863	244.100	233.385	227.955	225.504	224.516	224.160	224.044	224.011	0
Kh = 89	89	X	525.701	510.913	470.749	415.889	358.919	309.749	273.252	249.557	235.978	229.068	225.936	224.667	224.207	224.058	224.015	0
Kh = 67	67	X	622.963	603.586	550.908	478.816	403.735	338.691	290.189	258.534	240.284	230.936	226.668	224.926	224.290	224.082	224.021	0
Kh = 44	44	X	825.291	796.699	718.792	611.699	499.432	401.342	327.438	278.626	250.105	235.282	228.407	225.555	224.496	224.143	224.037	0
Kh = 21	21	X	1435.850	1382.779	1236.921	1032.982	813.827	616.161	461.480	354.812	289.457	253.718	236.227	228.554	225.534	224.468	224.128	0
																	Sum ->	0

Figure 10. Scenario 3b Contaminate Transport Outputs

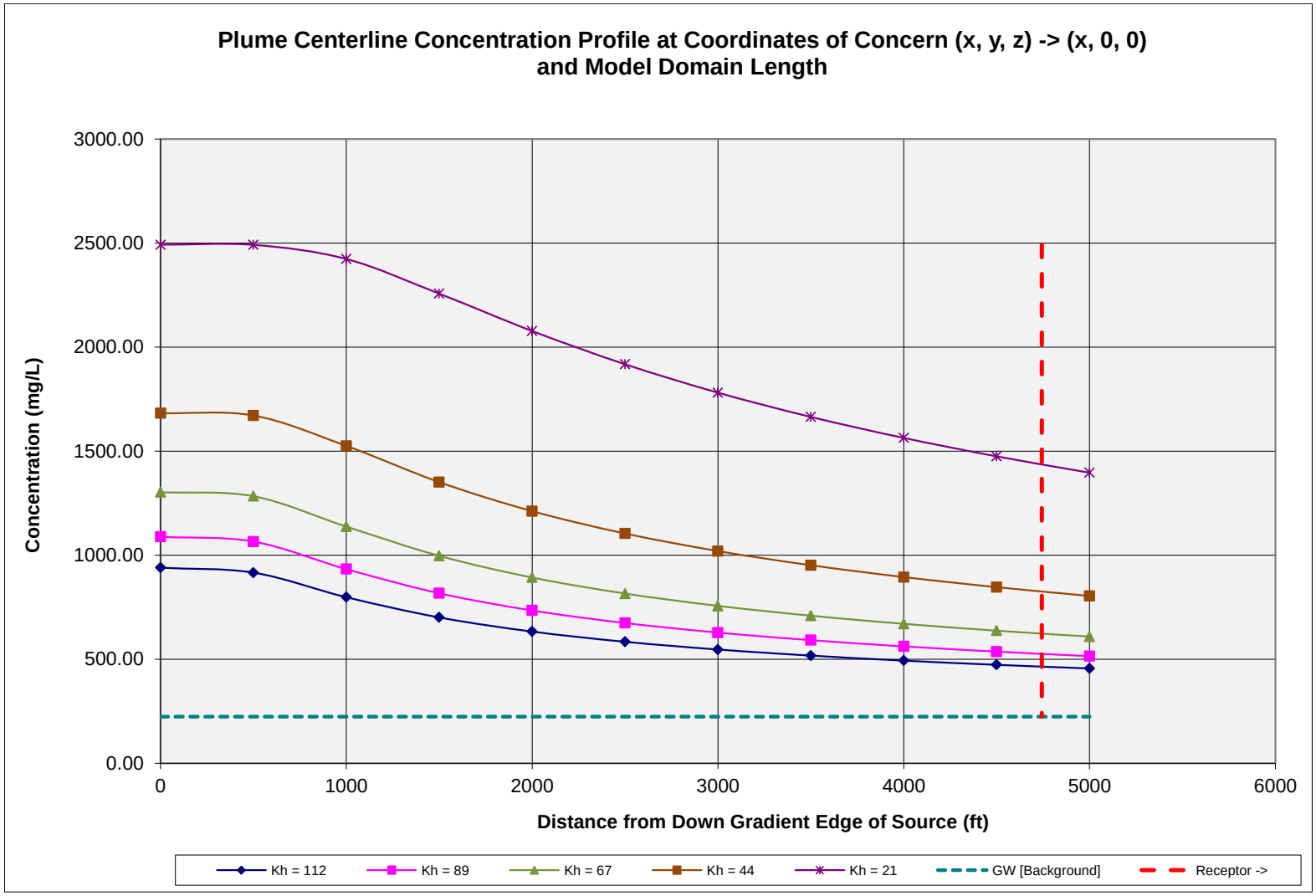
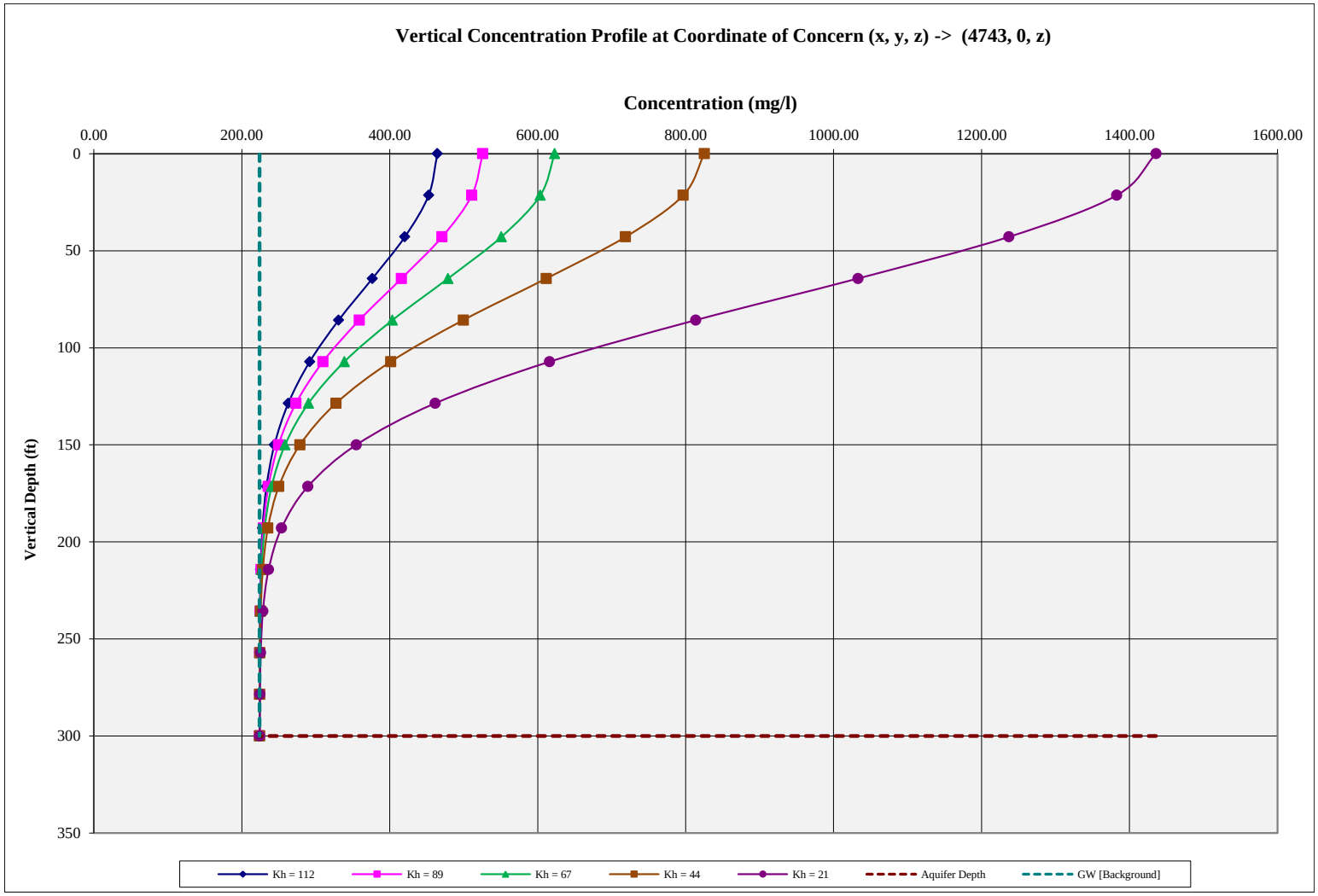
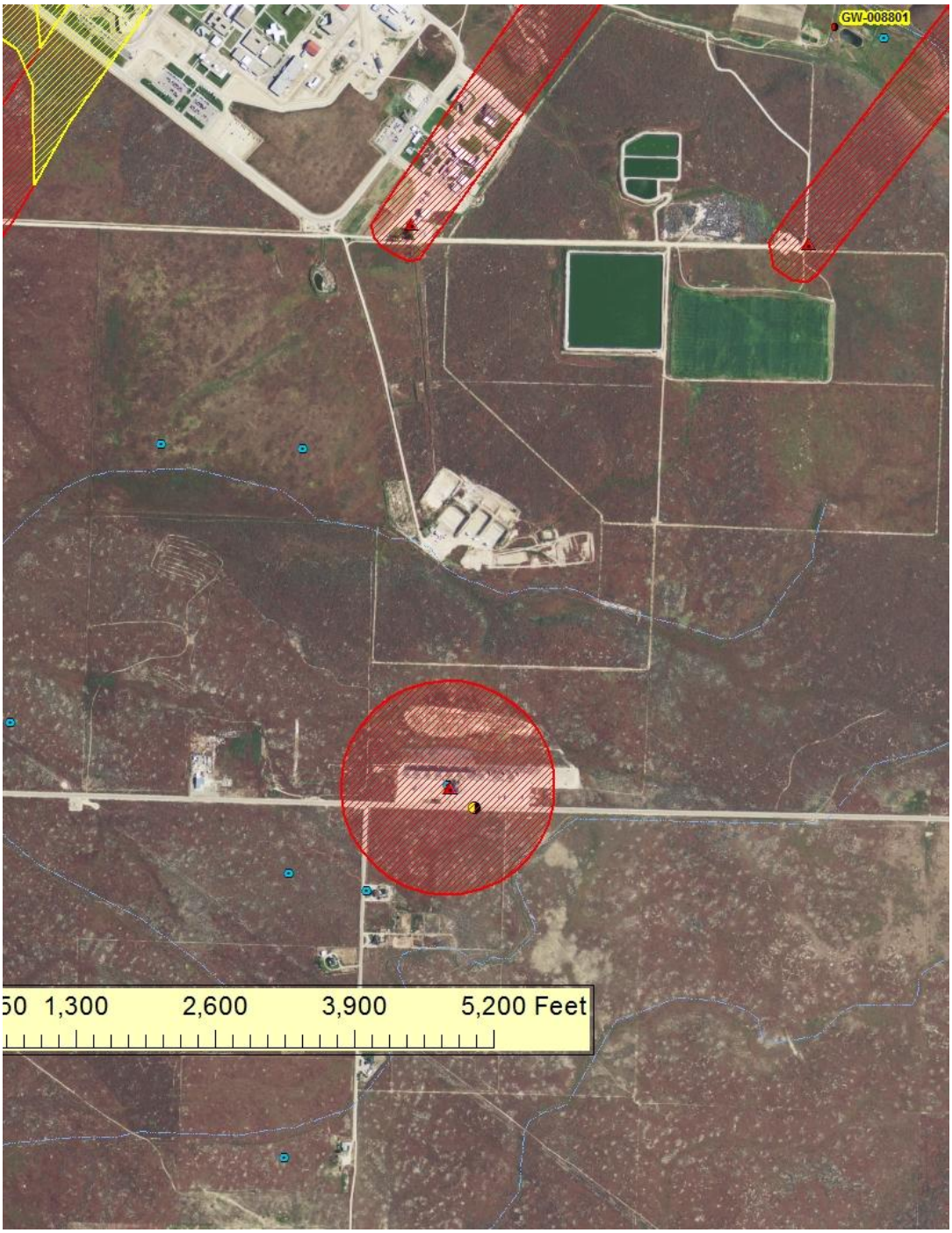


Figure 11. Scenario 3b Contaminate Transport Outputs

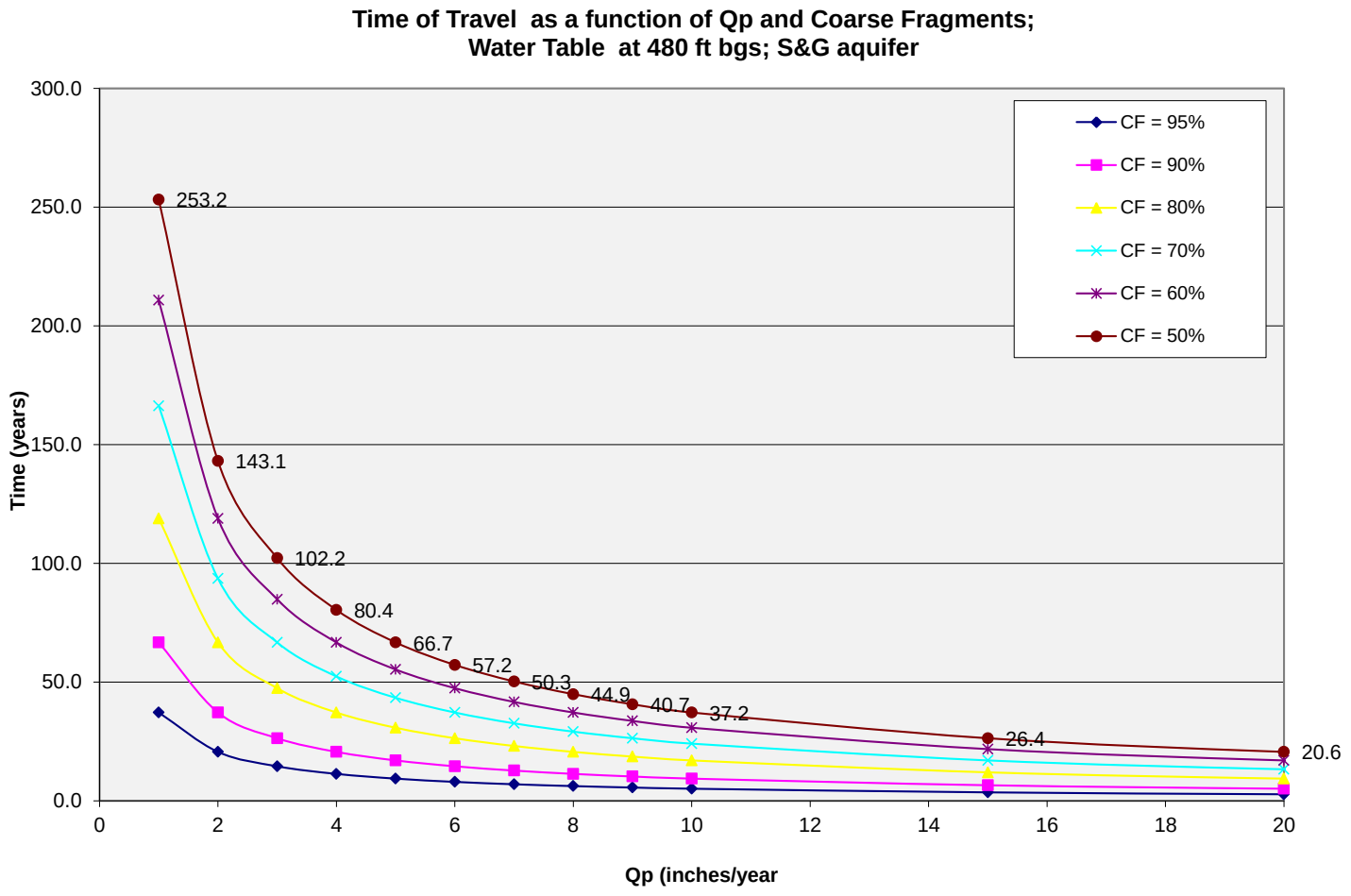


Appendix B – Site Map

East Site and Downgradient PWS Well and Well Capture Zone



Appendix C – Guyman Lump Sum Percolate Time of Travel for the East Site Vadose Zone



Attachment 2: Review of Ground Water Quality Data for the Valley Site, Idaho State Correctional Institution – Land Application Permit no. LA-000088-02

October 10, 2012

Memorandum

To: Adam Bussan, Scientist III

From: Michael Cook, Soil Scientist

Subject: Review of Ground Water Quality Data for the Valley Site, Idaho State Correctional Institution – Land Application Permit no. LA-000088-03

1.0 Purpose

The purpose of this memorandum is to review historical ground water chemistry data from shallow monitoring wells MW1 and MW3. These wells comprise the monitoring well network at the 'Valley' site. The Valley site is that area where hydraulic management units MU-000088-01 and MU-000088-02 are located, adjacent to the 6-cell treatment system and storage lagoon.

2.0 Discussion

The following discussion includes information on the hydrogeology of the Valley site, monitoring well network, chemical signature interpretation of ground water and wastewater, and historical ground water data.

2.1 Hydrogeology and the Valley Monitoring Well Network

The geology and hydrogeology of the area is discussed in CES (1989, Sections 2.2 and 2.3). There are three aquifers in the area. Shallow ground water occurs from 5-10 ft bgs and is shown in Figure 1 of CES (1989). Two other aquifers exist; a regional system at a depth of approximately 480 ft bgs, and an aquifer of intermediate depth (c. 160 ft bgs) which is of intermittent occurance in the area. Surficial geology and soils of the Valley site are discussed in Northern (1988). This study shows silty materials underlain by gravelly substratum. The monitoring well network for the valley shallow ground water consists of one upgradient and one downgradient well, designated MW1 and MW3 respectively. It is assumed that the water table slope generally follows the topography of the Ten Mile Creek drainageway, and so the assumption of up and downgradient positions for these two wells. There are not adequate monitoring wells in the drainageway to triangulate a ground water direction.

Historic data, in particular for nitrate-N and TDS, spans the time period 1992 to present. Chloride monitoring ceased after November 2006 and iron and manganese commenced in March 1998 to present.

Before discussing historical data of the monitoring well network, ground water and wastewater chemical signature information is presented which will provide some context for data discussion.

2.2 Ground Water and Wastewater Chemical Signatures

Trilinear plots can be very useful in geochemical analysis and interpretation. Construction and interpretation of these plots are discussed in Fetter (1988, pp. 354-355). Figure 1 below is a trilinear (Piper) diagram which plots the chemical signature of waters utilizing the relative milliequivalent (meq/L) percentages of common ions (Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}, HCO_3^{-}, CO_3^{-2}, SO_4^{-2}, and Cl^{-}). Chemical signatures plotted in this way can help differentiate different types of waters and wastewaters, and, in our application, whether wastewater has influenced (impacted) the quality of ground water.

In Figure 1, three wastewater signatures (from CES 1996 and Bell-Walker 1989) are plotted along with one ground water signature (Micron well) from a downgradient or crossgradient well in the regional system (Scanlan 2000), and another ground water signature from a well (Black's Creek well) likely downgradient from the East site lagoons and land application area (CES 2010, Attachment 1). Data sets are limited in this project to those in Table 1 as well as a few more largely duplicative wastewater data sets found in Bell-Walker (1989). Unfortunately there are no common ion data for recent wastewater samples nor for shallow ground water of the Valley site. Information regarding the plotted data points is shown in Table 1.

Table 1.

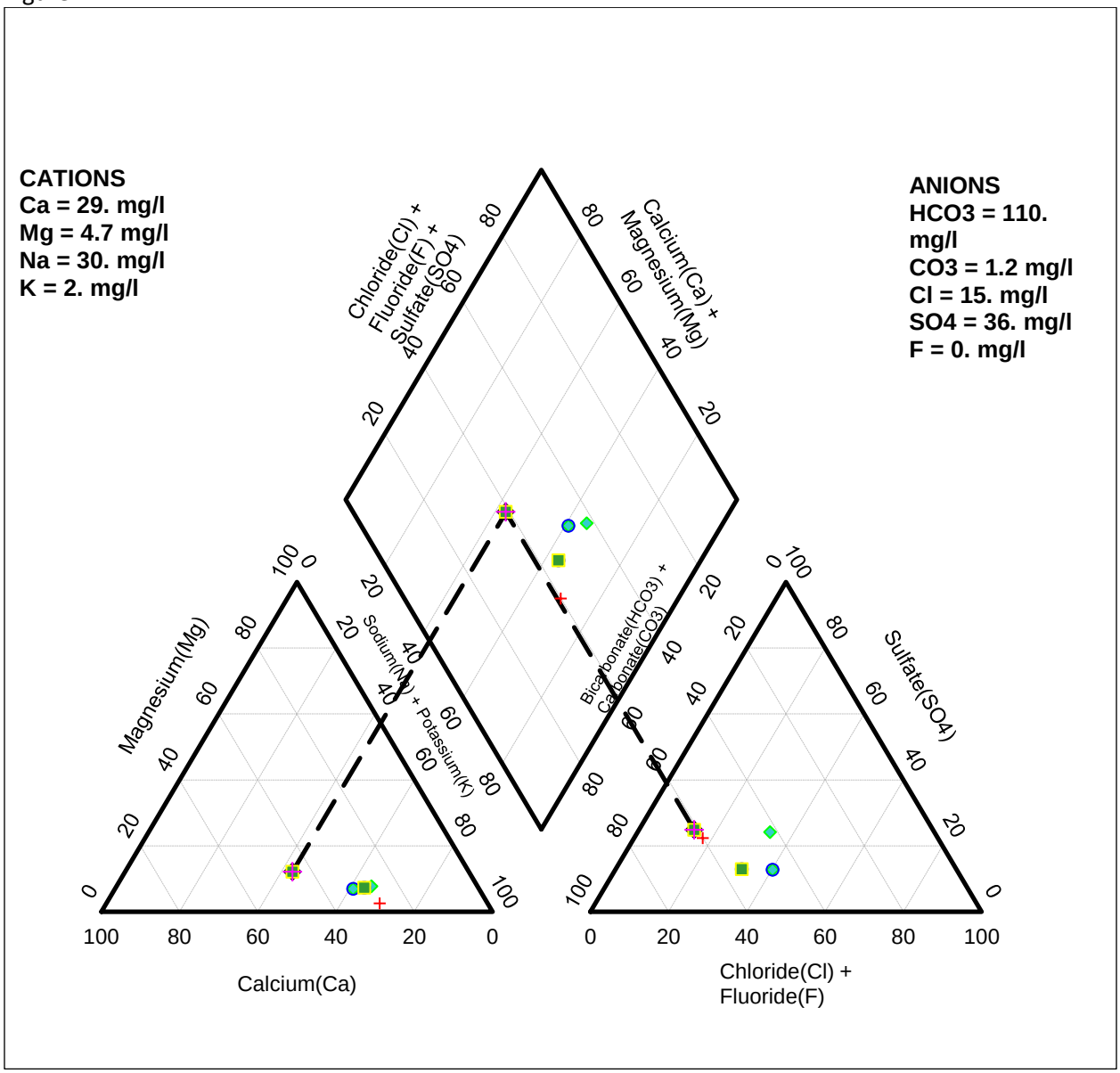
Water Source	Symbol	Reference
Micron Ten Mile Creek Ranch Domestic Well; downgradient in regional system.	Red Cross over Green Square	Scanlan, T. February 2, 2000
ISCI Wastewater Constituent Estimates (projected). Table 9.	Blue-Green Diamond	CES, March 7. 1996.
ISCI Wastewater Constituent Analysis. Table 3; Sample date - Friday 12/2.	Blue Circle	Bell-Walker Eng. February 1989.
ISCI Wastewater Constituent Analysis. Table 3; Sample date - Wed 12/7.	Green Square	Bell-Walker Eng. February 1989
Black's Creek Public Shooting Range Well. Attachment 5; Sample date – 6/9/2006.	Red Cross	CES, August 4, 2010,

The cation and anion concentrations appearing in Figure 1 are those of the 'Micron' well and appear by plotting convention of the software used because this is the first datapoint. From the trilinear diagram in Figure 1, it can be seen that, for the most part, the wastewater chemical signature of the three data sets plotted are similar. The lower left triangle shows wastewater cations tightly clustered. While there is slight decrease in manganese in wastewaters, the major difference is that sodium is elevated in wastewaters while more calcium is seen in Micron well ground water. Black's Creek well clusters along with wastewater. Since the latter well is downgradient of East site ponds and land treatment area, this may suggest some wastewater influence, or may merely reflect ambient variation in regional ground water. The right triangle (anions) shows wastewaters less clustered, yet showing elevated chloride compared to regional ground water. The ground water, both Micron and Black's Creek wells, has more bicarbonate than the wastewaters generally.

Overall, the plot shows an elevation in wastewater of both sodium and chloride above that of Micron well ground water from the regional system which reflects more the characteristics of a calcium bicarbonate water. This elevation of sodium and chloride of municipal wastewaters is to be expected

considering that these ionic species are excreted in substantial amounts by human beings. The Black's Creek well ground water compared to the Micron well is more of a sodium bicarbonate.

Figure 1



As mentioned above, it is unfortunate that there are no common ion data for the shallow monitoring wells MW1 and MW3. If there were, a trilinear plot might be able to differentiate differences between up and downgradient ground water, as well as compare downgradient ground water with the wastewater chemical signature.

2.2.1 Lagoon Seepage as a Ground Water Contamination Factor

There are about 30.4 acres of lagoons that are in close proximity to MW3. Note that MW1 and MW3 are labeled as GW-008801 and GW-08802 respectively in Appendix A1 aerial photo. These lagoons include

the six-cell treatment lagoon [10.4 ac] and storage lagoon [20 ac] (DEQ 1998, p.3). For example purposes, if these structures have seepage rates that meet the DEQ standard of 0.25 inches/day (IDAPA 58.01.16.493.03(b)), this would amount to annual seepage volumes of about 26 million gallons and 50 million gallons for the treatment and storage lagoons respectively for a total of 75 million gallons annually. Actual seepage testing results for the storage pond are 0.1 inches/day (Bussan 2012), so that would change the 50 MGA value to 19.8 MGA for a total of 45.8 MGA, still an appreciable volume per year.

Even before construction of the storage pond, CES (1989, Section 2.3) makes note that mounding and the perched system at the Valley site is thought to be due to lagoon seepage. So, if common data for MW1 and MW3 were to become available, it would likely show that MW3 has a signature similar to wastewater (indicating significant influence of lagoon seepage), and MW1 would likely have a signature reflecting 'native' ground water unaffected by lagoon seepage. Of course this cannot be known without obtaining and analyzing the data.

2.2.2 Land Application of Wastewater as a Factor in Ground Water Contamination

A second factor to consider when analyzing impacts to the shallow ground water is that of land application of wastewater and the generation of percolate mixing with ground water. As mentioned above, the hydraulic management units in the Valley site are in close proximity to both the lagoons and MW3. Important information to have regarding land application is the wastewater loading rate to the land. In a DEQ inspection report dated 8/20/2007 (DEQ 2007), it is noted on page 8 in some detail that flow measurement is inaccurate, fraught with problems, and in need of correction.

The author of this document visited the ISCI Valley site 8/14/20012 and spoke with the wastewater operator on this problem. The above assessment is likely true. If the author understood correctly, appropriate loading rates are first calculated based upon 30+ year average evapotranspiration data from ETIdaho, a website sponsored by University of Idaho. The crops are irrigated such that they are adequately watered (as determined by the operator) and it is assumed they are being watered at irrigation water requirement. Since the operating pressure of the pump pressurizing the land treatment system cannot be adjusted, its pressure is so great that it will blow various seals on the irrigation system. This is resolved by splitting about 30 percent of the pumped wastewater stream so that it bypasses the irrigation system and returns to one of the wastewater lagoons. Suffice it to say that wastewater loading to the hydraulic management units is probably not known to the degree that is necessary in order to evaluate the possibility of impacts to the shallow ground water from this source. Wastewater Reuse system modeling of hydraulic balances and both percolate volumes and concentrations would be helpful in interpretation of impacts once the flow and loading questions have been resolved.

2.3 Historic Data for the Valley Monitoring Well Network

The following sections discuss historic data for the shallow monitoring well network, and include the constituents nitrate, total dissolved solids (TDS), chloride, iron, and manganese. These discussions include statistical analyses for establishing trends and hypothesis testing to determine statistically significant differences between up and downgradient consitituent levels.

2.3.1 Nitrate

Nitrate summary data are shown in Table 2. Nitrate data fluctuates both in MW1 and MW3 (Figure 2). For the range 1992 to present, 77% of the upgradient / downgradient sample pairs show that MW3 (downgradient concentrations) are greater than MW1. The average difference in concentration between upgradient and downgradient pairs is about 5.3 mg/L. It is clear that downgradient nitrate-N concentrations are elevated with respect to upgradient concentrations.

Basic statistical analyses of nitrate-N data are found in Appendix C (Johnson 2012a). The Mann-Kendall test shows significant increasing trends in both MW1 and MW3 nitrate-N levels (Appendix C, Figure 3). The Kendall Correlation analysis shows dependence between MW1 and MW3 (Appendix C, Figure 4). This may be due to the fact that upgradient ground water nitrate-N is a (not the only) source for nitrate-N in downgradient MW3. Seasonal statistical analyses of nitrate-N data are found in Appendix D (Johnson 2012b). Data are partitioned into defined three-month seasons to differentiate statistical features of each of these seasons. Figure 4 of Appendix D shows an upward trend in MW1 during the winter (December-February) and a strong lack of trend in the fall (September-November). Variability in MW1 in each of the seasonal periods is far less than variability in the seasonal periods for MW3 (Figure 5 of Appendix D). This may be due to less influences to upgradient ground water than may be experienced by downgradient ground water. Downgradient ground water is, as mentioned previously, likely influenced by lagoon seepage and perhaps by wastewater land treatment as well. Both of these potential influences do not exist upgradient. As with MW1, MW3 shows a statistically significant upward trend in nitrate levels during the winter (December-February). The reason(s) for winter trends is not apparent.

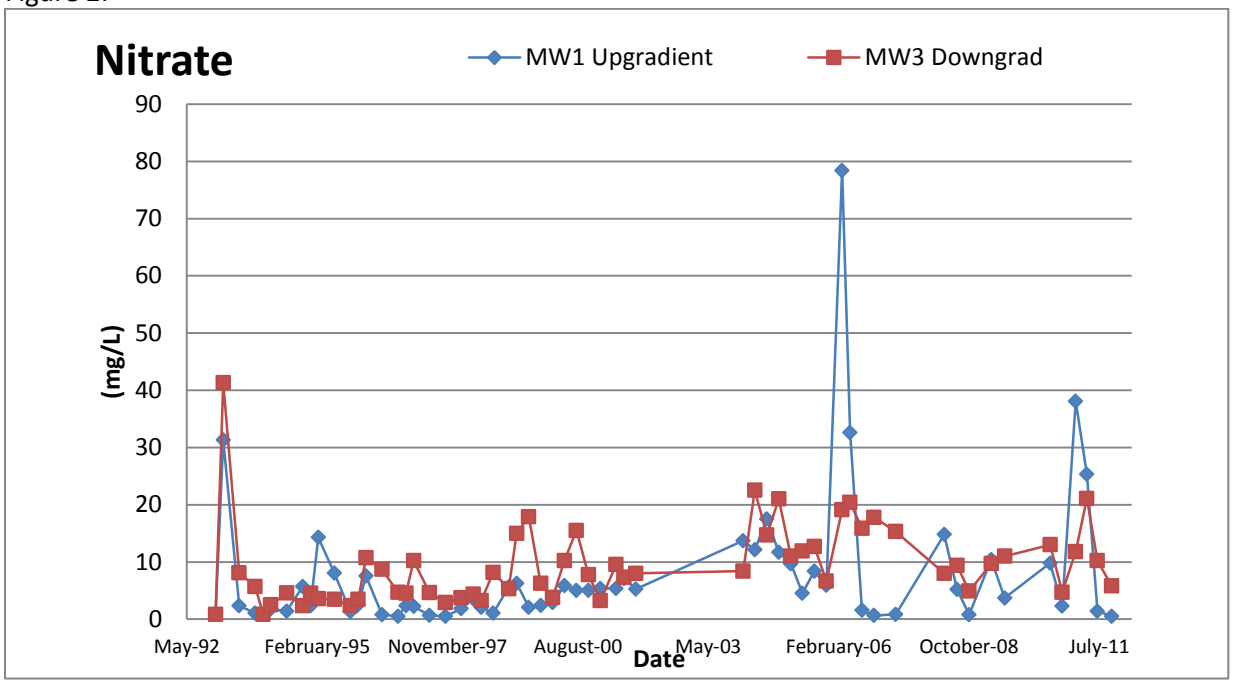
Effluent values for TKN, for example during the 2008 permit reporting year (5 samples) (IDOC 2008, tab no. 3), show a range of 2 to 10 mg/L. Both ammonia and nitrate-N on the other hand are generally <1 mg/L. Given a median nitrate-N value during the monitoring period of 4.12 mg/L in MW1 possibly contributing to downgradient ground water levels, TKN inputs from wastewater oxidizing to nitrate, and N losses from land treatment activities, these factors may help to explain the median value of 8.0 mg/L over the monitoring period in downgradient well MW3.

Table 2.

Parameter (mg/L)	MW 1	MW 3
Average	7.75	9.39
Median	4.12	8.00
Maximum	78.4	41.3
Minimum	0.49	0.81

Explanation of the elevated upgradient nitrate-N concentrations would require some analyses of upgradient activities along the Ten Mile Creek drainageway. Such activities may include pasturing of cattle or irrigated agriculture upstream. There is a gun range upgradient (Appendix A2 aerial photo of upgradient areas). There is the possibility that nitrate residues from gunpowder may be washing from the range and into shallow ground water. It is doubtful whether mounding of groundwater from lagoon seepage would be a cause, but common ion sampling would help answer that question.

Figure 2.



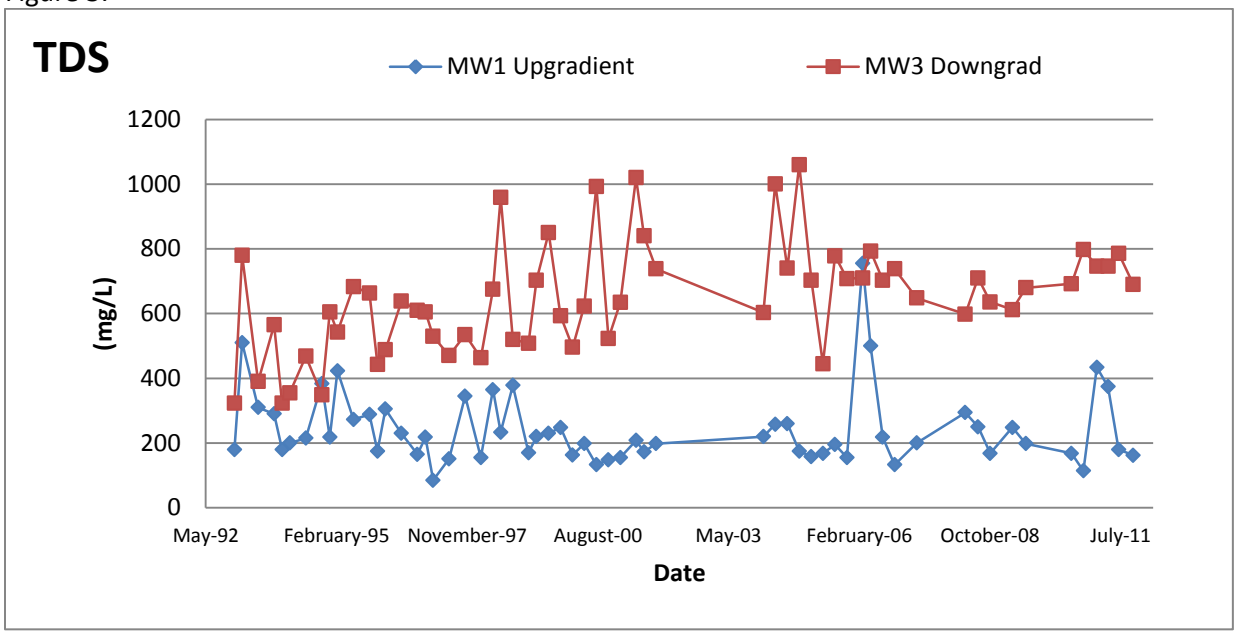
2.3.2 Total Dissolved Solids (TDS)

TDS summary data are shown in Table 3. TDS levels follow the pattern of nitrate-N, with higher concentrations in MW3 as shown in Figure 3. From visual examination of Figure 3 it appears that there has been a downgradient increase from approximately 500 mg/L to about 700 mg/L during the monitoring period. Upgradient TDS concentrations appear somewhat stable around 250 mg/L or so. Common ion data would provide valuable information as to whether the downgradient TDS was derived from wastewater and possibly establish evidence for downgradient ground water contamination from lagoon seepage. Effluent values for TDS, for example during the 2008 permit reporting year (5 samples) (IDOC 2008, tab no. 3) show a range of 420 to 836 mg/L while volatile dissolved solids (VDS) values ranged from 42 to 202 mg/L. Percolate from land application activities would have higher TDS concentrations than effluent. This is because of the evapotranspirative concentration of applied wastewater. Such percolate inputs from land application could result in higher TDS values in ground water than the effluent, as the data in Figure 3 occasionally shows.

Table 3.

Parameter (mg/L)	MW 1	MW 3
Average	241.7	648.0
Median	211.5	648.0
Maximum	755.0	1060.0
Minimum	85.0	323.0

Figure 3.



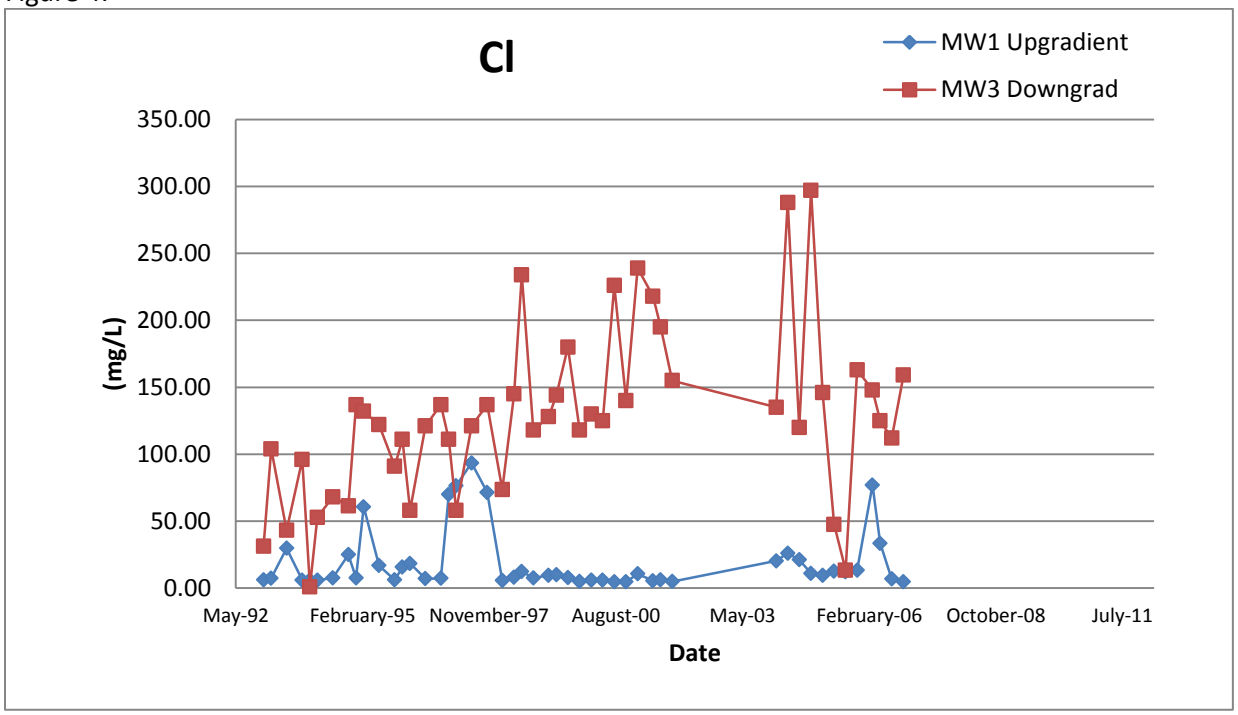
2.3.3 Chloride

Chloride summary data are shown in Table 4. Chloride levels seem to follow a similar pattern to TDS, with higher concentrations in MW3 as shown in Figure 4. From visual examination of Figure 4 it appears that there has been a downgradient increase from 75 mg/L to about 150 mg/L during the monitoring period. Upgradient TDS concentrations appear somewhat stable during certain periods, usually less than 20 mg/L or so, but showing significant variability earlier in the sampling period. As previously discussed with respect to trilinear plots of regional ground water and wastewater, it is expected to see elevated levels of chloride in municipal wastewaters compared to other waters. Percolate from land application activities would have higher chloride concentrations than effluent (which is about 80 mg/L based on data used for trilinear plots). This is because of the evapotranspirative concentration of applied wastewater. Such percolate inputs from land application could result in higher chloride values in ground water than the effluent, as the data in Figure 4 occasionally shows.

Table 4.

Parameter (mg/L)	MW 1	MW 3
Average	18.91	127.42
Median	8.78	125.0
Maximum	93.5	297.0
Minimum	4.67	1.0

Figure 4.



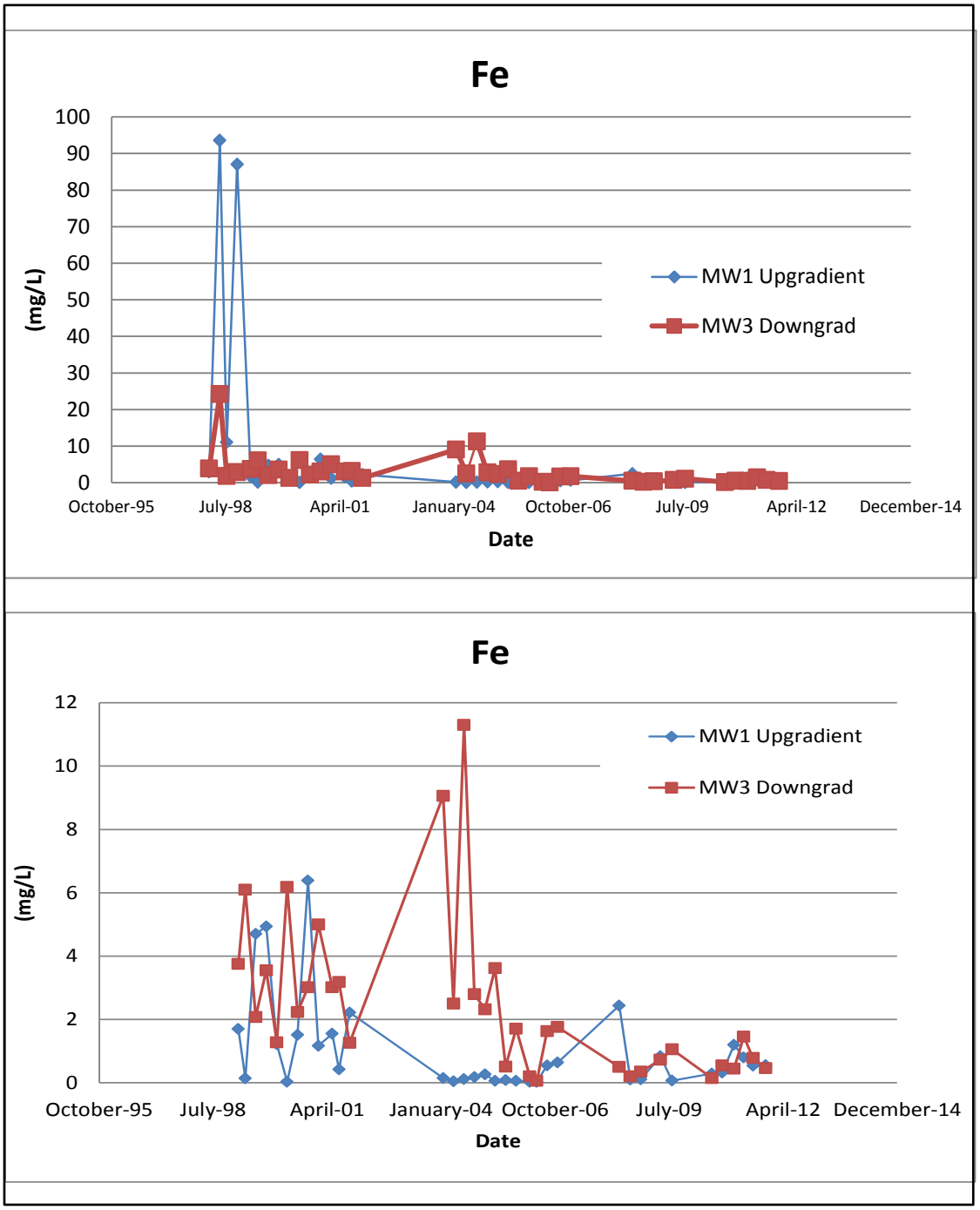
2.3.4 Iron

Iron summary data are shown in Table 5. Median iron levels are higher in MW3 than in MW1, as shown in Table 5. This is not the case for the average values, however, as these are influenced by extreme (possible outlier) values. For the range 1992 to present, 70% of the upgradient / downgradient sample pairs show that MW3 (downgradient) are greater than MW1. The average difference in concentration between upgradient and downgradient pairs is about 2.3 mg/L. Downgradient Fe concentrations are elevated with respect to upgradient concentrations, yet upgradient values are unusually high as well (Table 5). Figure 5 (top) shows all Fe data. The scale of the plot is too great to see up and downgradient differences. Figure 5 (bottom) eliminates the first four data points in the data set that show extreme and fluctuating values. This latter plot shows more clearly up and downgradient differences between wells. Explanation of the elevated upgradient iron concentrations would require some analyses of upgradient activities along the Ten Mile Creek drainageway and perhaps possible occurance and cause of low redox conditions in ground water to cause dissolution of iron.

Table 5.

Parameter (mg/L)	MW 1	MW 3
Average	5.90	3.01
Median	0.55	1.79
Maximum	93.6	24.2
Minimum	0.03	0.06

Figure 5.



2.3.5 Manganese

Manganese summary data are shown in Table 6. Manganese levels seem to follow a similar pattern to Fe, with higher concentrations in MW3 as shown in Figure 6. For the range 1992 to present, 85% of the upgradient / downgradient sample pairs show that MW3 (downgradient) are greater than MW1. The average difference in concentration between upgradient and downgradient pairs is about 0.32 mg/L.

Downgradient Mn concentrations are elevated with respect to upgradient concentrations, yet upgradient values, like the case of Fe, are unusually high as well.

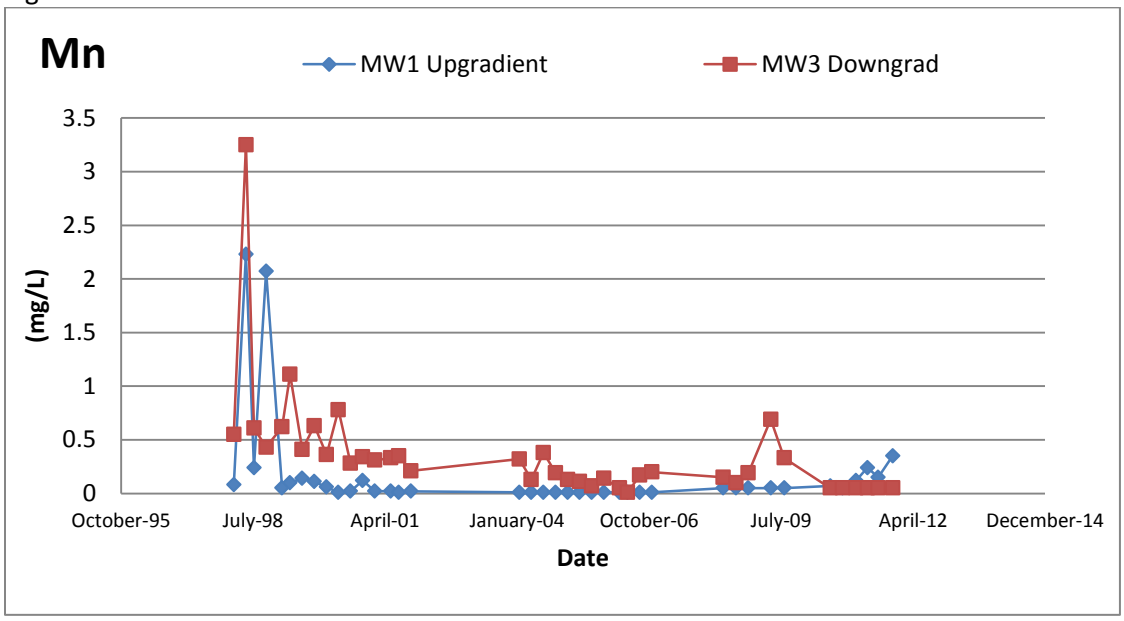
Table 6.

Parameter (mg/L)	MW 1	MW 3
Average	0.17	0.36
Median	0.05	0.21
Maximum	2.23	3.25
Minimum	0.01	0.01

Manganese data from April 2008 to July 2009 and July 2010 to October 2011 appear suspicious. The first block of data show MW1 values at 0.05 mg/L (presumably the particular laboratory's detection limit) while MW3 data for the same period shows higher values (what we would expect). The second block of data shows the reverse – that is, MW3 values at 0.05 mg/L while MW1 data for the same period showing higher values (what we would not expect). It may be possible that these data have been inadvertently inverted during data entry. If this is the case, Figure 6 would not be showing a recent reversal (difficult to see in the plot) in Mn contamination between up and downgradient wells.

Also, previous Mn data for MW1 during the period February 2004 to November 2006 shows a 'less than detect' level of 0.01 (perhaps a different laboratory with a different detection or reporting level). The data set of MW1 from February 2004 to October 2011 would be more in line with prior data points being 'less than detect' while data from MW3 having elevated levels as we would expect.

Figure 6.



3.0 Conclusions

As noted above, the causes of contamination present in upgradient well MW1 is not clear and would require some analyses of upgradient activities (such as the possible influence of the gun range). Contamination in downgradient well MW3 of nitrate, TDS, chloride, Fe and Mn can be seen from the

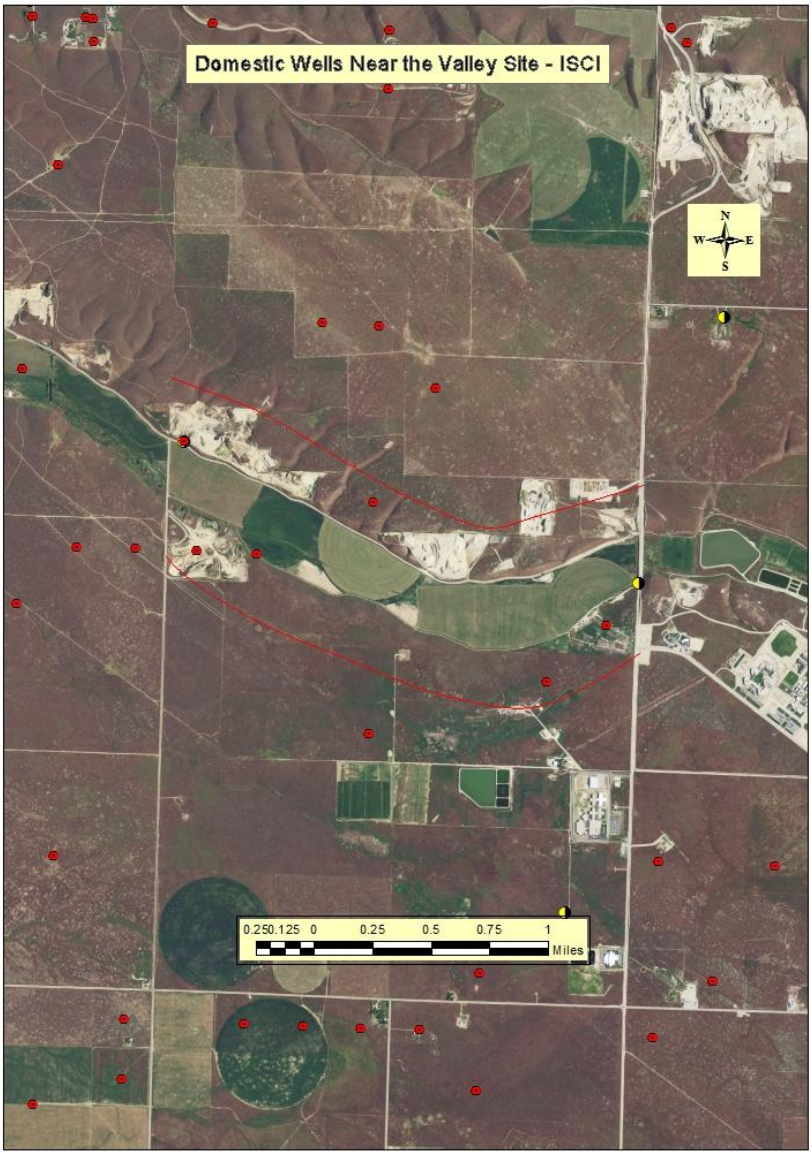
data sets. How much is due to upgradient ground water is not clear, with the possible exception of TDS (TDS is assumed to be conservative – that is, it is non-reactive along the flow path, and TDS constituent load could be assumed to be 'additive' to those TDS inputs occurring further downgradient). As mentioned previously, common ion data for shallow groundwater at MW1 and MW3, in addition to that for more recent effluent data, would be of interpretive value; it would help to corroborate the hypothesis that contamination is due largely to lagoon seepage. The contribution of land application activities to downgradient contamination is not clear.

The impact of contaminated ground water discharging from the downgradient boundary of the Valley site does not seem to be presented in available submittals. It is likely that the Ten Mile drainage could serve to 'canalize' shallow ground water such that it continues to flow as shallow groundwater downgradient in a west-northwesterly direction following the drainage. To what extent and at what rate shallow ground water might discharge to the regional system, and to what extent the shallow system downgradient of ISCI might be recharged by other tributaries to Ten Mile Creek is not known. These factors may contribute to attenuation of ground water constituent concentrations measured at MW3.

As mentioned previously, a well location acceptability analysis has been done according to conventions stipulated in the Guidance (section 6.6.4, Figure 6-2) – evaluation of domestic water supplies within ¼ mile of the Valley site (Scanlan 2000). The only well of concern identified in this area was a Micron domestic water supply 1000 feet southwest of the land treatment site (Scanlan 2000, p. 2 and Figure 1). At the time of sampling, results yielded no constituents that were at levels of concern. Since this well is the closest (and downgradient) of all domestic wells in the area, such results are a good indication that pond seepage is not impacting the regional system. But in consideration of the volume of seepage annually, this percolate may be exiting the shallow system elsewhere. What might not have been appreciated during agency review of Scanlan 2000 is, as previously discussed, the possibility of 'canalizing' of the ground water flow along the drainage and possibly impacting domestic wells along the drainage some distance away.

Given this possibility, an assessment of downgradient receptors along the Ten Mile Creek drainage would provide an indication of the degree of regulatory concern DEQ should have. According to Figure 7, this would amount to evaluating about three wells along a one-mile stretch of Ten Mile Creek that are approximately ¼ mile from the drainage, and about six wells along a two-mile stretch.

Figure 7.



4.0 Recommendations

The following are recommended actions to be considered.

1. Re-assess potential receptors (i.e. potable water supply wells). These would include those that are adjacent to the Valley site, as assessed by Scanlan (2000), as well as those potential receptors that are adjacent to Ten Mile Creek drainageway downstream from MW3. Potential receptors would be those in either in the shallow ground water or in the regional system, for a distance of 1 mile downstream along Ten Mile Creek from MW3. See Figure 7 and the wells located in the area bounded by the red lines. Consider having these wells sampled and analyzed for common ions, nitrate-N, TDS, total and dissolved Fe, and total and dissolved Mn.

2. In the event that no significant impacts to ground water are found in domestic wells, it would be assumed that localized contaminated shallow ground water discharging from the Valley site would not be a regulatory concern. Periodic re-sampling of these potential receptors should be done, say every permit cycle of five years.

3. For one regularly scheduled sampling event of MW1 and MW3, analyze for common ions in addition to the suite of constituents required in the permit. Also, during a regularly scheduled wastewater sampling event, analyze for common ions in addition to the suite of constituents required in the permit.

5.0 References

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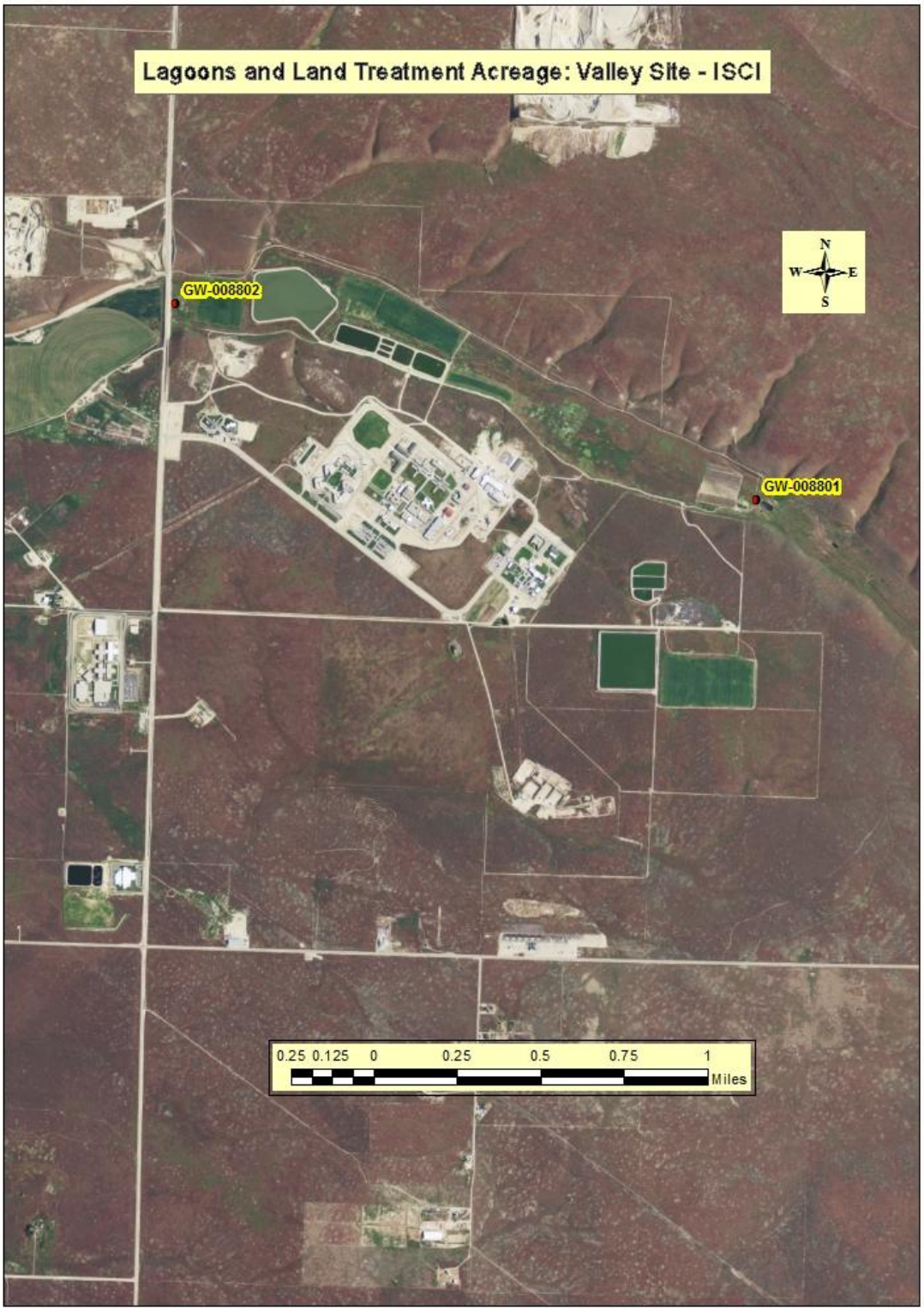
Johnson, Brady. September 7, 2012b. Seasonal Statistical Analyses of Monitoring Wells 1 and 3, Idaho Correctional Institution.

Scanlan Engineering. February 17, 2000. Well Location Acceptability Analysis – Wastewater Land Application Permit Compliance Activity Number CA-088-05.

Appendix A – Aerial Photos of the Valley Site

A1. Lagoons and Land Treatment Area: Valley Site - ISCI



A2. Upstream of Valley Site Along Ten Mile Creek - ISCI

Appendix C – Basic Statistical Analyses of Nitrate-N data for MW1 and MW3

Basic Statistics

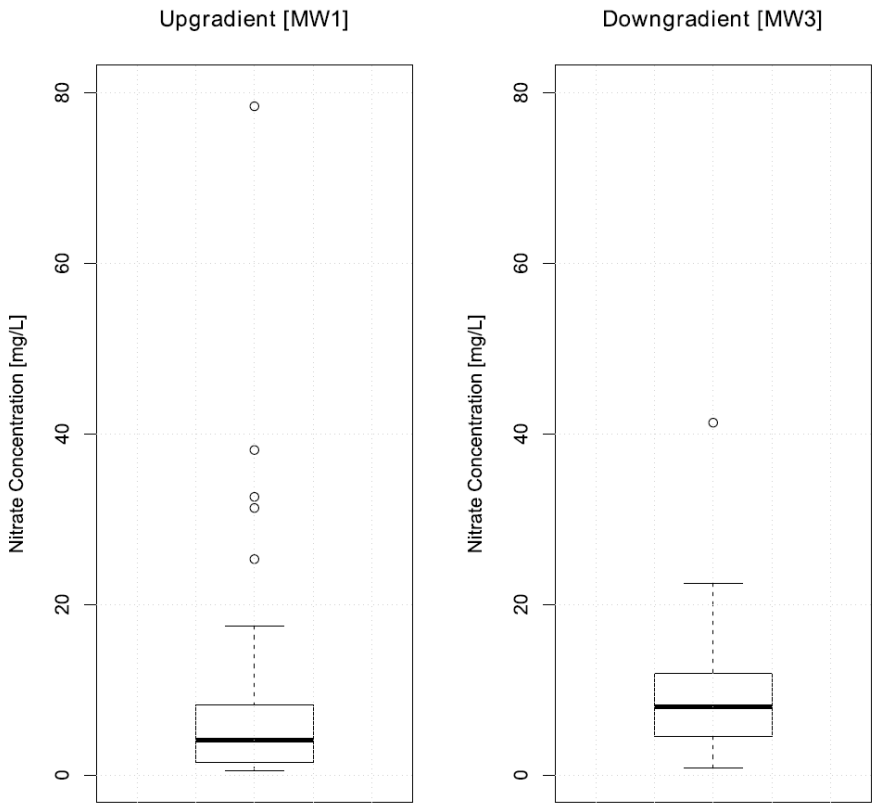


Figure 1: Basic statistics for the upgradient and downgradient wells.

Table 1: Basic statistics for nitrate concentrations in upgradient [MW1] and downgradient [MW3] wells.

	Min	Q1	Median	Mean	Q3	Max	NaN
MW1	0.49	1.53	4.115	7.750	8.13	78.40	1
MW3	0.81	4.53	8.00	9.391	11.90	41.30	0

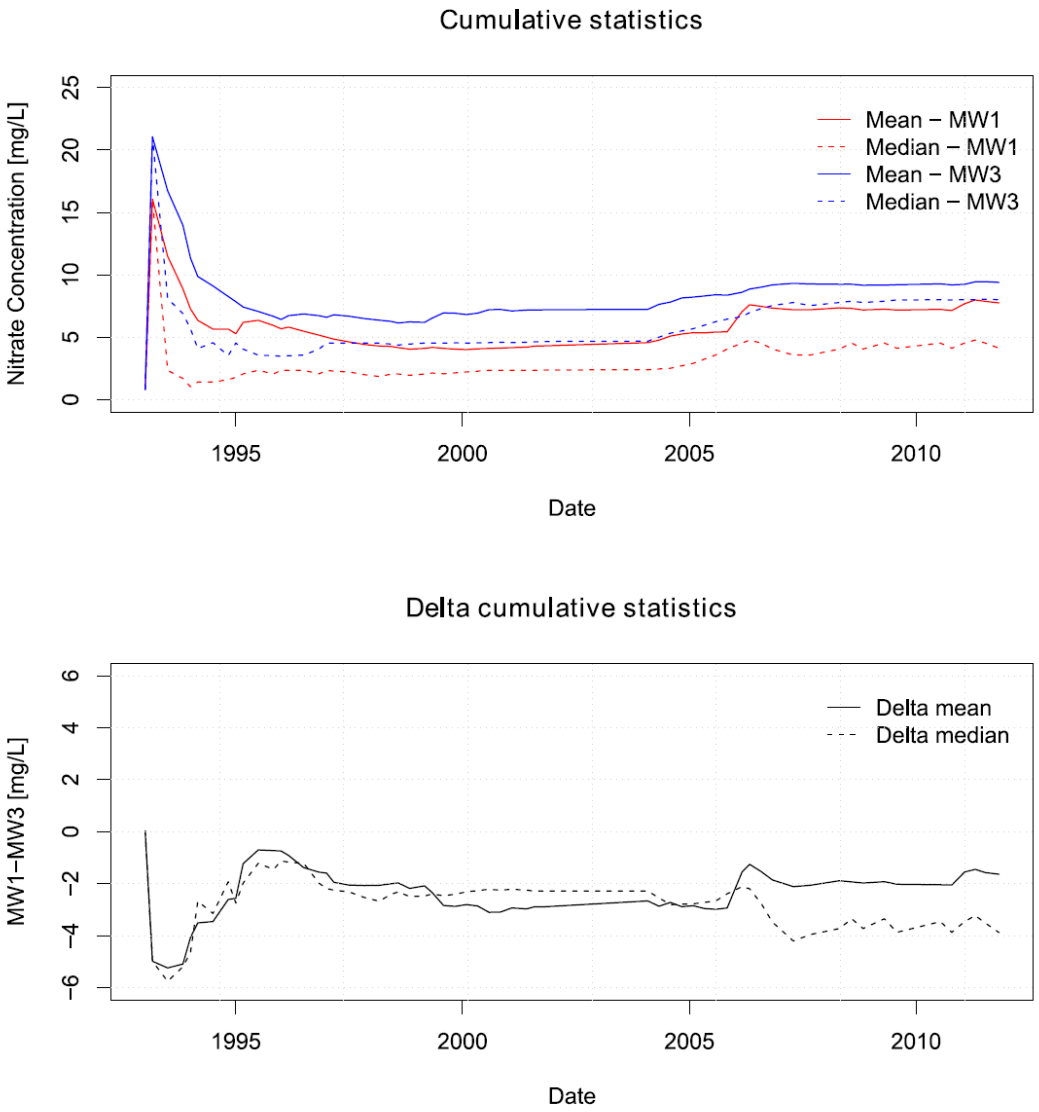


Figure 2: Mean and median nitrate concentrations for MW1 and MW3 are plotted against time. All measurements are increasing with time. The difference between the two means and medians are also plotted with time to show changes in basic statistics between the two wells.

Mann-Kendall

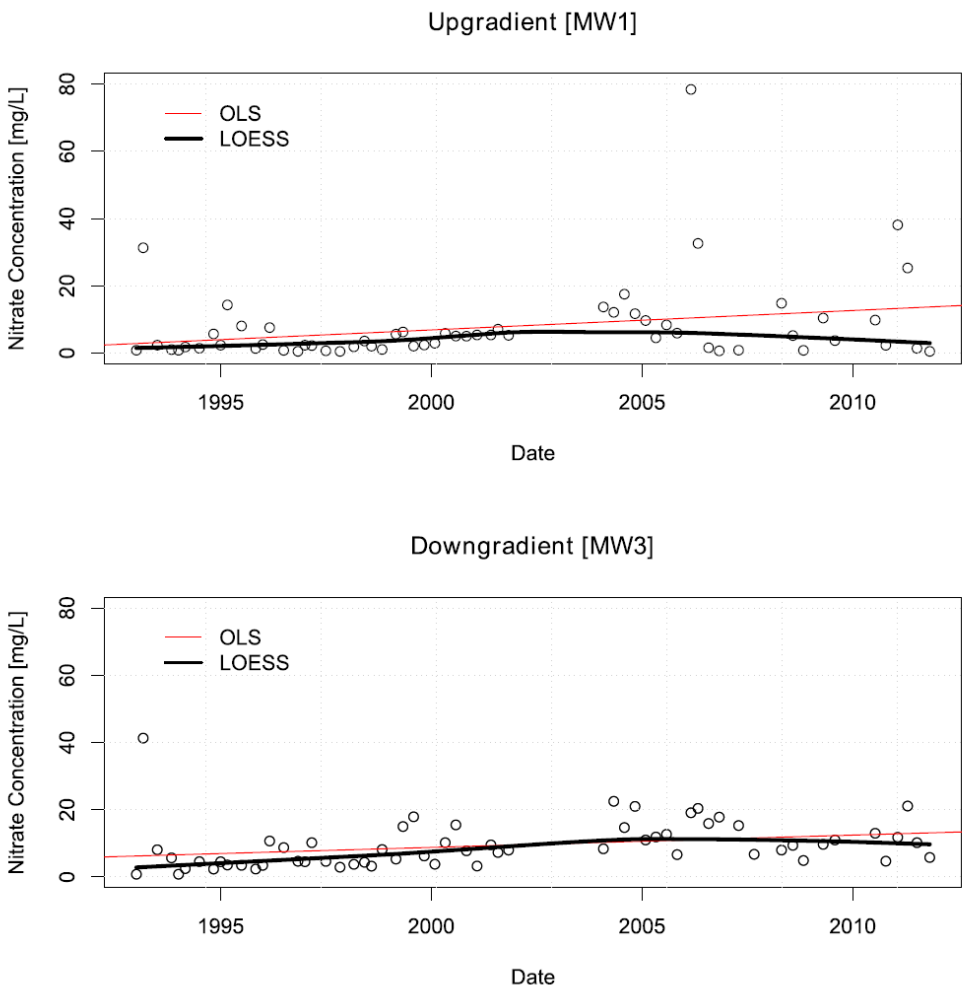


Figure 3: Nitrate concentrations observed in wells from 1993-2011. Ordinary least squares (OLS) and local polynomial regression (LOESS) lines are presented for each well.

Mann-Kendall is a statistical test for monotonic trend in a time series based on the Kendall rank correlation computed computed independently at each well [Null hypothesis (H_0): No trend in data]. No assumption of normality is required for the test. P-values are valid only for data sets where serial correlation is not present.

Table 2: Mann-Kendall statistics for MW1 and MW3. Results from each provide significant evidence (α = 0.05) for an increasing trend in Nitrate concentration with time.

	τ	2-sided p	Significant at α 0.05
MW1	0.221	0.013089	Yes
MW3	0.37	2.657e-05	Yes

Kendall Correlation

The Kendall tau (τ) coefficient is a statistic used to measure the association between two measured quantities. Here, it is used to measure the association between measured nitrate concentrations in two wells (MW1 and MW3). The null hypothesis (N_0) is MW3 is independent of MW1. Under this, the sampling distribution of τ has an expected value of zero. Concentrations measured at the wells are correlated at $\alpha = 0.05$.

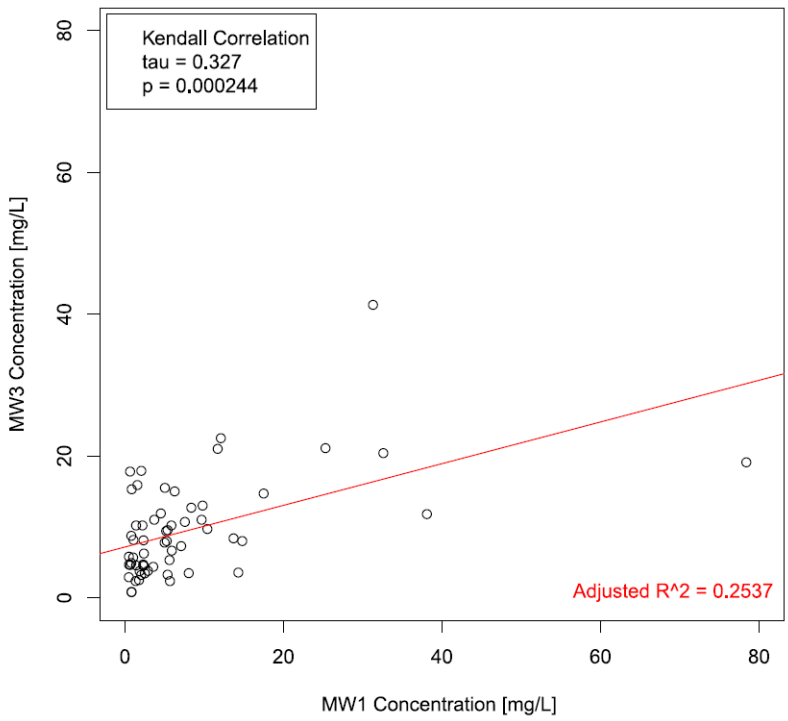


Figure 4: Nitrate concentration in MW1 versus MW3 over the entirety of the recording period (1993-2011). OLS line is plotted with the adjusted R^2 in addition to Kendall correlation statistics.

Wilcoxon Signed-Rank Test

The Wilcoxon Signed-Rank Test can determine whether data population distributions are identical without assuming them to follow a normal distribution. We can test at $\alpha = 0.05$ significance level if MW1 and MW3 have identical data distributions. The null hypothesis (N_0) is that MW1 and MW3 have identical populations.
Results: P-value = 0.0006106
This is less than our set α and the null hypothesis is rejected. From this, we can conclude that MW1 and MW3 are from nonidentical populations at the 0.05 significance level.

Appendix D – Seasonal Statistical Analyses of Nitrate-N data for MW1 and MW3

Seasonal Statistics

The data here are presented in grouped months to capture seasonal changes over the entirety of collection period. A moving window of 3 months was used to select the the presentation most likely show systematic trends in the data. Admittedly, outside variables not considered here could be forc changes and if these data become available they can be implemented in the analysis.

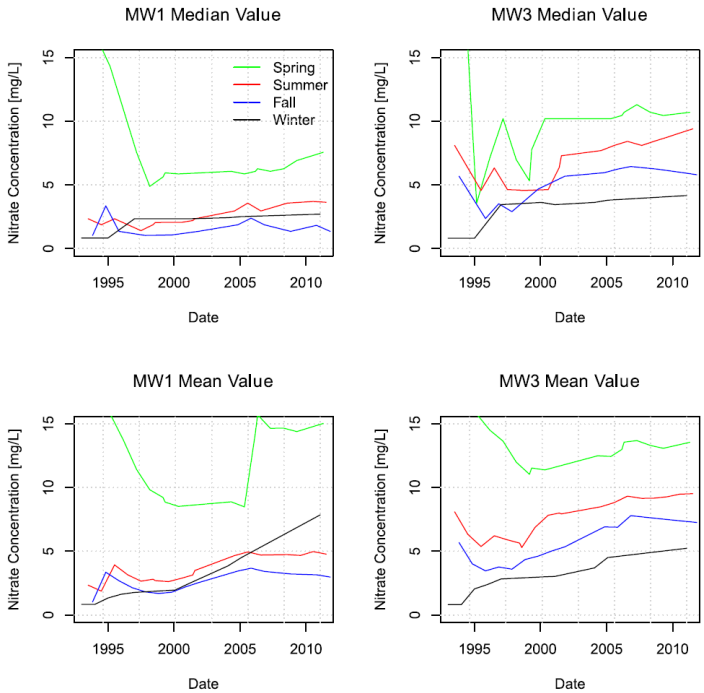


Figure 1: Median and mean time series from MW1 and MW3. Some early time data were cut out presentation but factored into calculations.

Table 1: Seasonal statistics for nitrate concentrations in upgradient [MW1] and downgradient [MV wells.

	Min	Q1	Median	Mean	Q3	Max	n
MW1							
Mar - May	0.85	4.53	7.56	15.04	14.80	78.40	17
June - Aug	0.67	1.69	3.64	4.78	6.66	17.50	18
Sept - Nov	0.490	0.73	1.35	2.98	5.14	11.70	15
Dec - Feb	0.83	2.34	2.71	7.86	8.60	38.10	10
MW3							
Mar - May	2.49	8.00	10.70	13.56	19.10	41.30	17
June - Aug	3.22	5.69	9.40	9.52	12.85	17.90	19
Sept - Nov	2.35	4.69	5.80	7.27	7.89	21.00	15
Dec - Feb	0.81	3.31	4.17	5.24	7.42	11.80	10

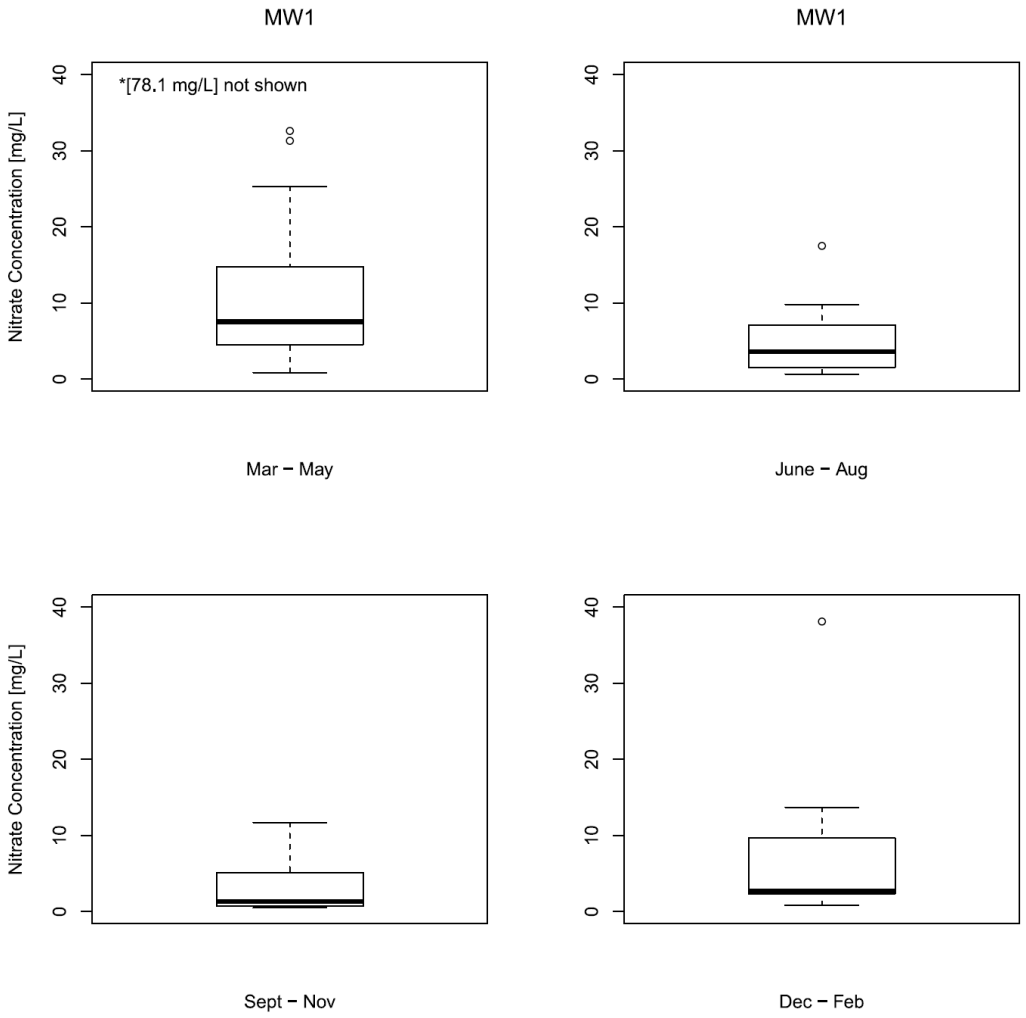


Figure 2: Box plots of seasonal nitrate concentrations in MW1. *Note: Sample collected in March 2006 [78.1 mg/L] not shown in the plot to preserve a consistent axis scale in all figures.

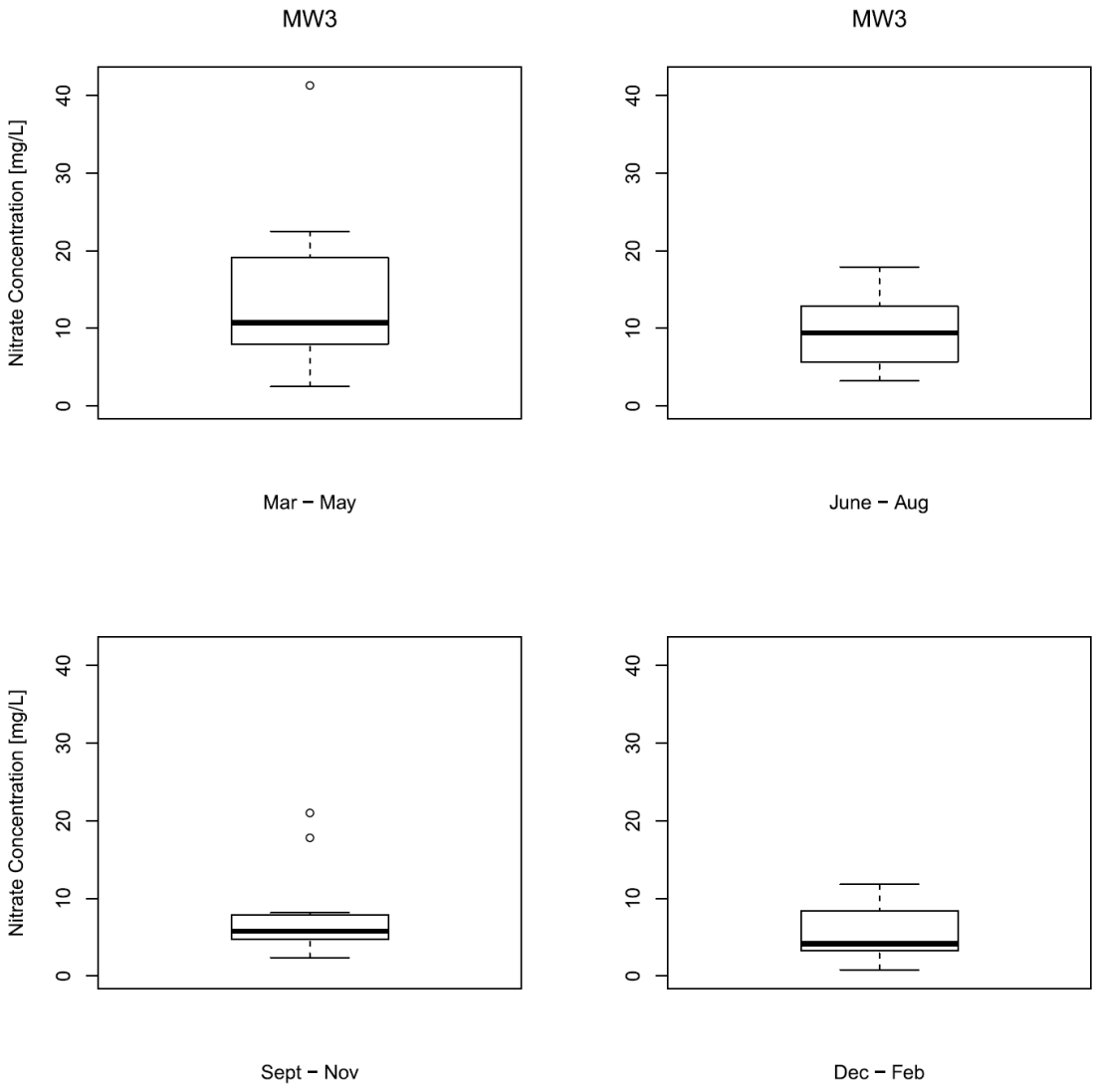


Figure 3: Box plots of seasonal nitrate concentrations in MW3 (downgradient of MW1).

Mann-Kendall

A Mann-Kendall trend test was performed (seasonally) on the observed nitrate concentrations at each well. Trends presented seasonally are, on average, less robust than the data as a whole. At well MW1, the December - February time period is the only period where a significant trend is observed at $\alpha = 0.05$. MW3 has a similar trend (significant at $\alpha = 0.05$) from December - February but stronger trends are observed in all seasons. June - August is significant at $\alpha = 0.10$ and all periods show a significant increasing trend at $\alpha = 0.15$. Excluding the March 1993 sampling event in MW3 increases the significance of the trend to $p = 0.01910$.

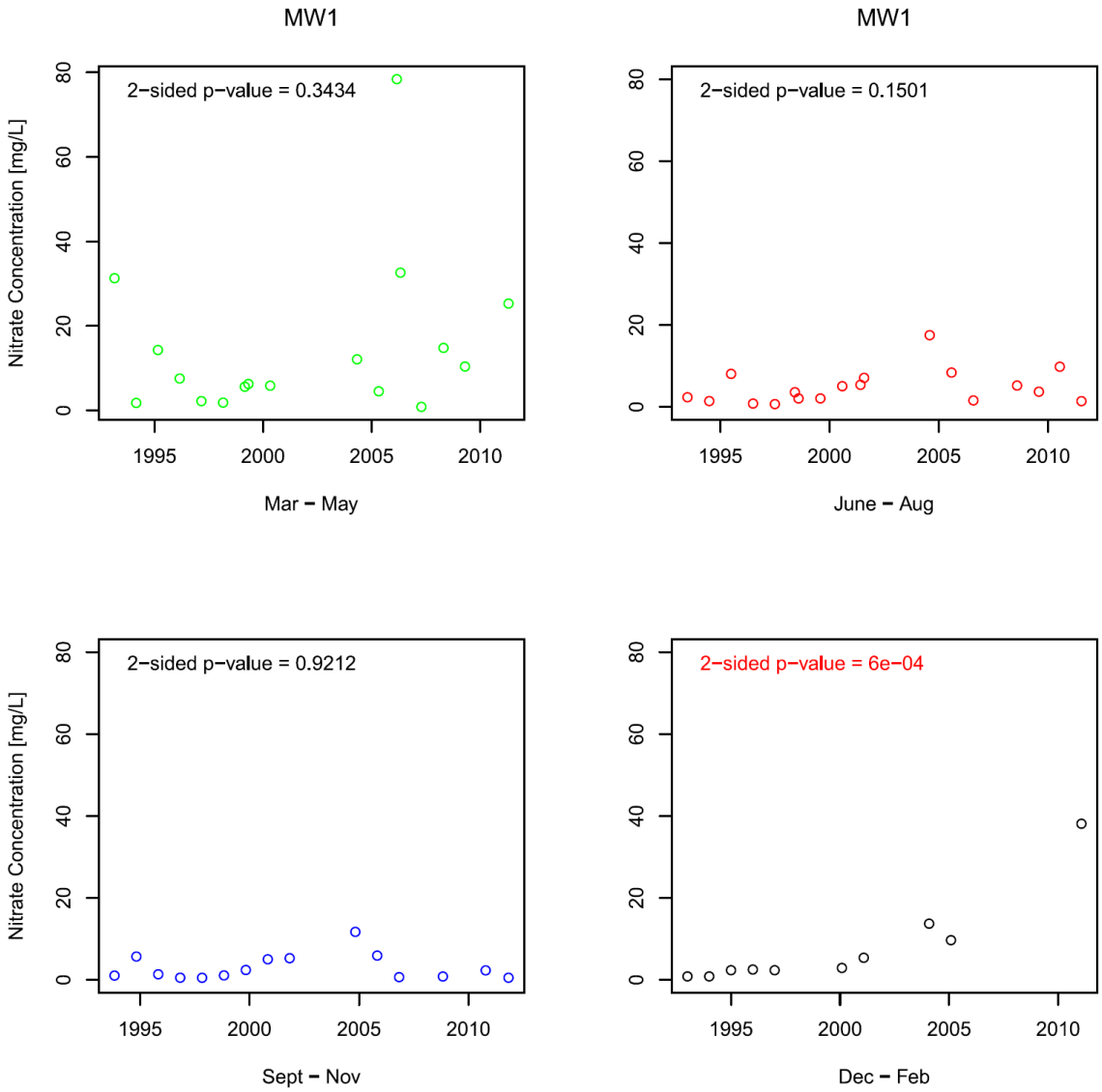


Figure 4: Nitrate concentrations observed in wells from 1993-2011. Two-sided p-value from Mann-Kendall test for each set of seasonal data is included for each plot. Values with $p < 0.05$ are in red.

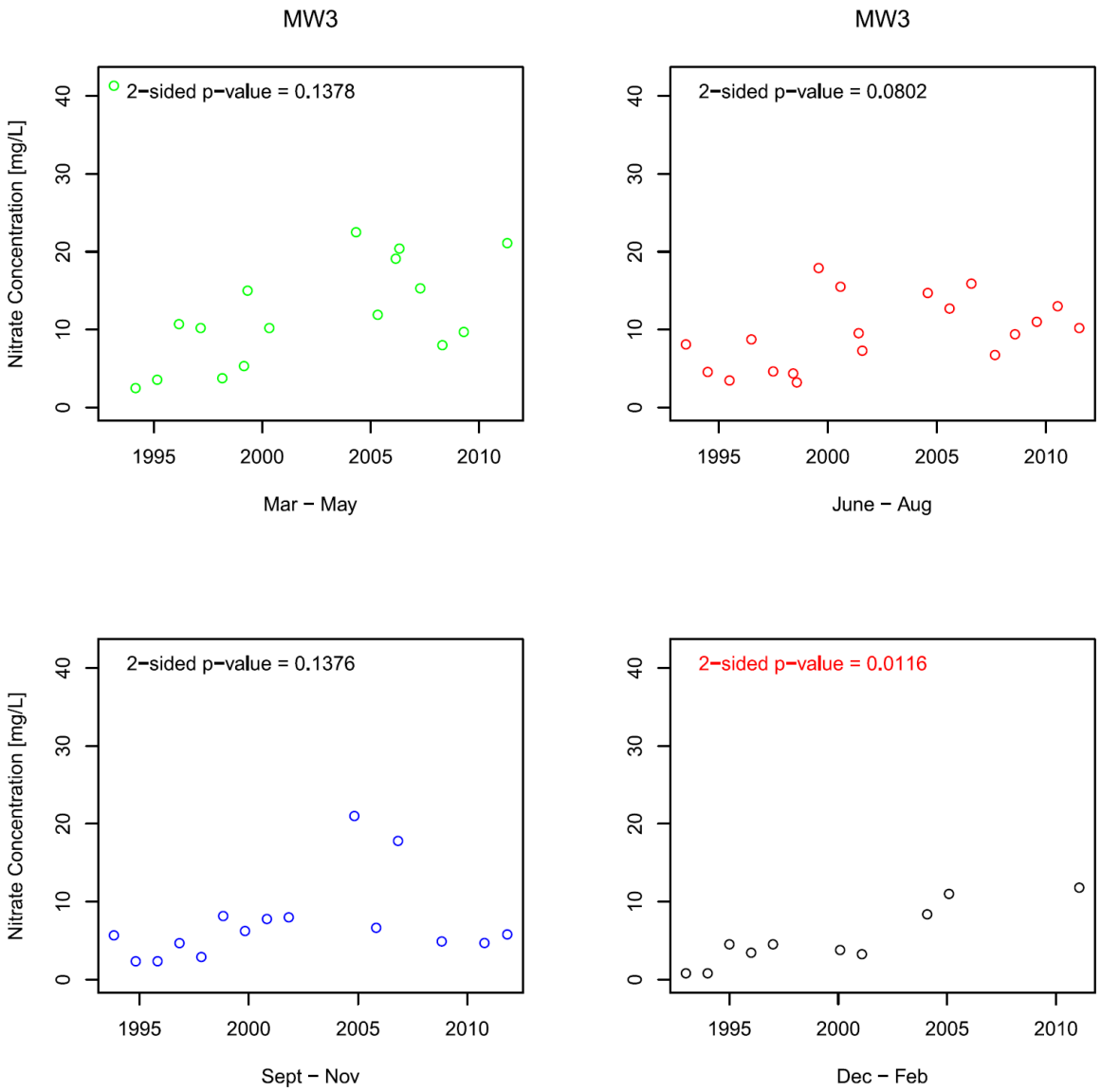


Figure 5: Nitrate concentrations observed in wells from 1993-2011. Two-sided p-value from Mann-Kendall test for each set of seasonal data is included for each plot. Values with $p < 0.05$ are in red. Note that removing the apparent outlier [March 1993 - 41.3 mg/L] in the March - May data results in a significant trend [$p = 0.01910$].