ANNUAL MONITORING REPORT
2015

Prepared for:

Lower Minnesota River Watershed District

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Lower Minnesota River Watershed District

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Introduction

This report focuses on the summary and comparison of water resources data collected by Scott Soil and Water Conservation District (SWCD) from 2015 and previous monitoring seasons. The monitoring work plan for 2015 included three temperature logging locations in Eagle Creek, one continuous water monitoring station in Eagle Creek (operated in conjunction with Metropolitan Council Environmental Services (MCES) Watershed Outlet Monitoring Program (WOMP)), 18 observation wells located in the Savage Fen and surrounding area, and one water monitoring station on the inlet to Dean Lake (DLI).

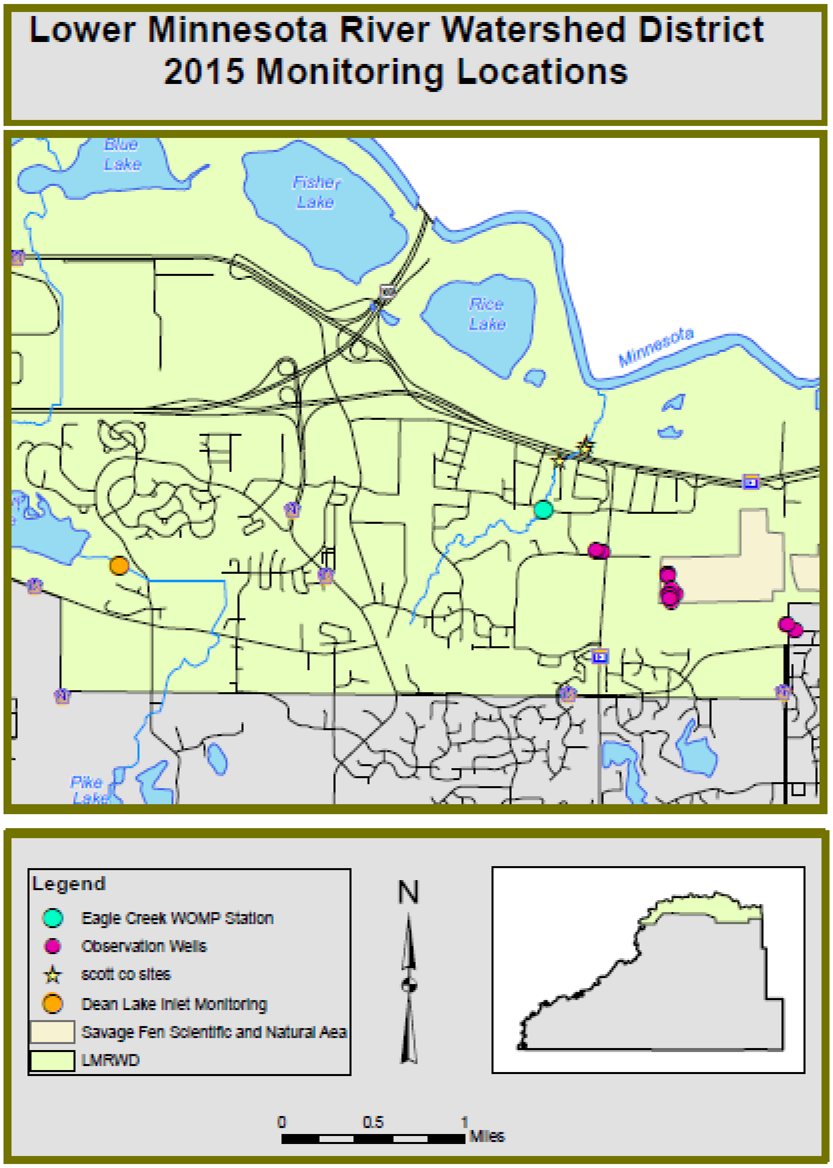

Figure 1. Monitoring Location Map.

I. Thermal Monitoring

This study was initiated by the Lower Minnesota River Watershed District (LMRWD) to evaluate the impact stormwater runoff from Highway 101 has on temperatures of Eagle Creek, a DNR designated trout stream. Brown Trout are very sensitive to temperature as it impacts growth rate, habitat, and food resources. The optimal temperature range for adult brown trout is approximately 12.4 – 17.6^{o} Celsius (Bell, 2006).

Methods

Temperature loggers were placed upstream and downstream of Highway 101 by Bonestroo in June of 2006 (Figure 2), and have been recording stream temperature since that time. In October 2012, a midstream logger was placed just upstream of a pond tributary to monitor its impact on stream temperatures. The loggers record continuous temperature data in 15-minute intervals. Scott SWCD contracted with the LMRWD to collect and report the temperature data. Rainfall data used for this report is taken from the Shakopee Mdewakanton Sioux Community (SMSC) rain gauge located in Shakopee.

Results

Under most conditions, stream temperatures trend with atmospheric temperatures. During winter months, the downstream water is cooler because it is exposed to cold air longer than upstream water. During summer months, the downstream water is warmer because it is exposed to warm air longer.

Figure 2. Location of temperature loggers and WOMP station.

During warm summer days, water temperatures occasionally exceeded the optimal range for trout but for only a few hours at a time (Figure 3). Noticeable warming of water temperatures downstream of highway 101 occured following some rain events. The upstream logger did not respond as drastically (Figure 4). This downstream warming is likely caused by warm stormwater from the pond located between Highway 101 and the railroad tracks discharging into the stream after a storm event. This pondwater is likely warmed by a combination of solar energy and warm surface runoff from impervious surfaces. Large amounts of warm water may be released during rain events as the pond fills and overflows. The downstream temperature logger is located approximately 30 feet downstream of this input.

An investigation was conducted on August 19, 2009 during a 2-inch rain event at numerous temperature monitoring locations on Eagle Creek. Termperatures were recoreded upstream and downstream of the pond tributary and in the tributary itself. The temperature of Eagle Creek rose almost 2°C directly after the tributary discharged into Eagle Creek. The tributary was almost 5°C higher than Eagle Creek. According to this study, temperature spikes in Eagle Creek appear to be from large volumes of solar heated pondwater and warm surface runoff dishcarhging from the pond. The temperature of the pond may not actually increase during storm events, but rather the volume of water discharging into Eagle Creek is perhaps the stronger influence on temperature rise. This greatly exceeds the small increase in temperature that typically occurs during dry periods that could be attributed to atmospheric warming of the stream. Even though the temperature exceeds the optimal range for trout by only a few degrees and for only a short period, these rapid temperature increases could be stressful to fish. The state water quality standard for Class 2A waters maintain there shall be “no material increase” in temperature.

All three temperature loggers remained functional throughout the year with the exception of a brief interuption at the upstream location. The upstream logger was found placed out of the water on 10/21. Someone must have inspected the logger out of curiosity not put it back in the water. The temperature data indicates the logger was removed from the stream on 9/26. Data from this logger was ommitted for the period 9/26 to 10/21.

Conclusions and Recommendations

A streambank improvement project was implemented in the spring of 2013 by the Minnesota Department of Natural Resources. Approximately 2705 linear feet of streambank was narrowed to improve Trout habitat upstream of the temperature loggers, along the West Branch of Eagle Creek. This stretch of stream was previously wide, shallow and sunny which created potential temperature increases that are harmful to Brown Trout. The continued thermal monitoring provides the opportunity to track the influence of the upstream habitat improvements as well as the effects of the stormwater holding pond downstream of Highway 101.

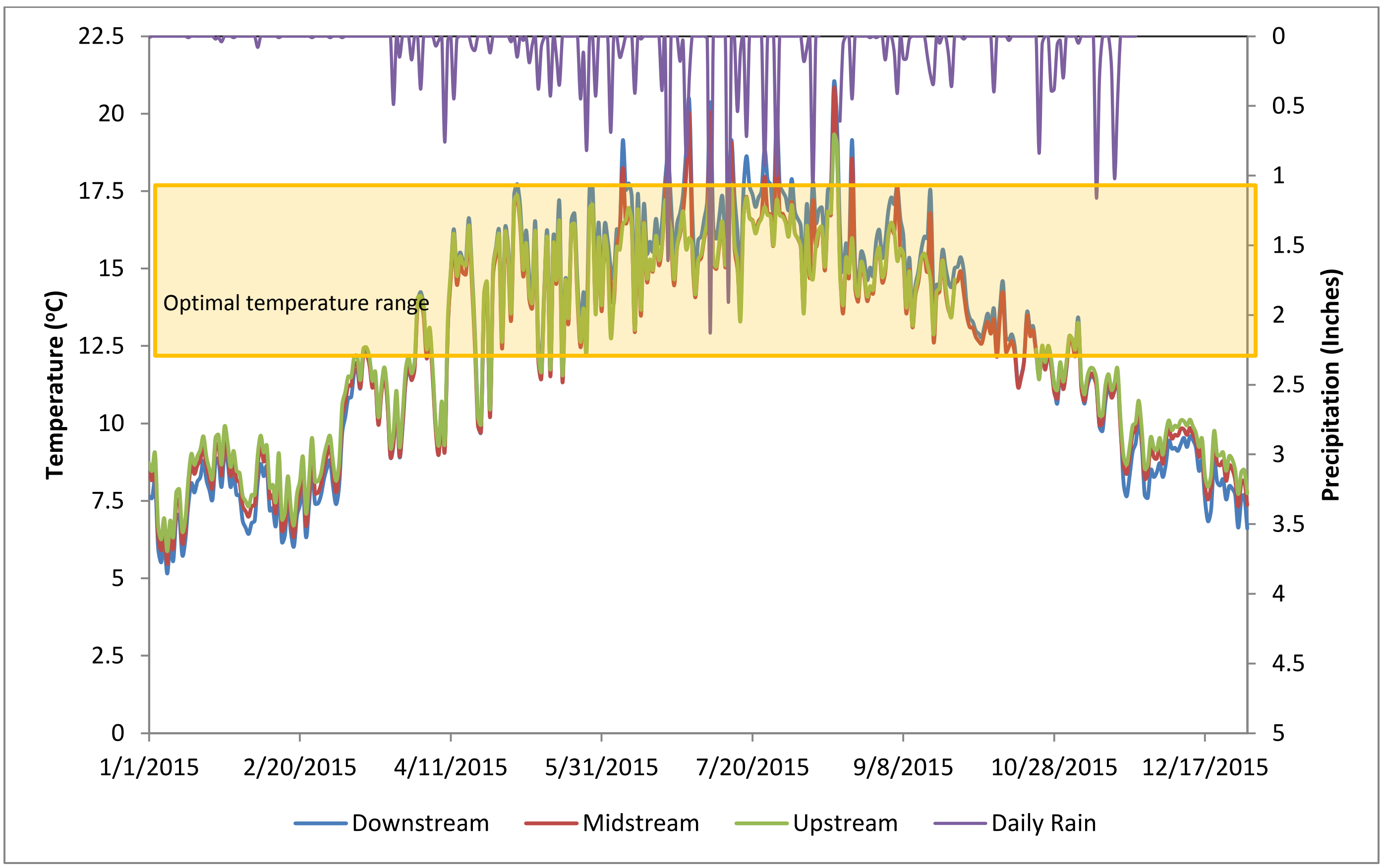

Figure 3. 2015 Maximum daily temperatures. The upstream logger was discovered out of the water on 10/21. Irregular data was removed between 9/26 and 10/21.

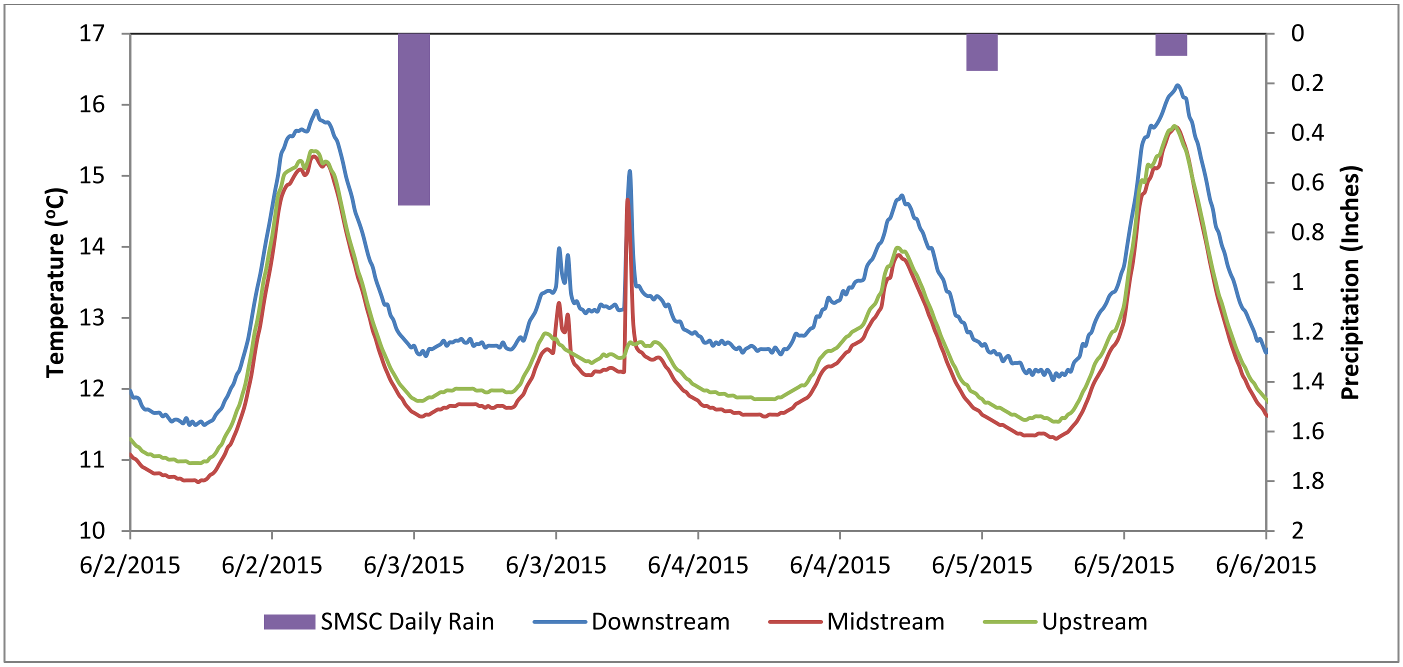

Figure 4. Eagle Creek rain event.

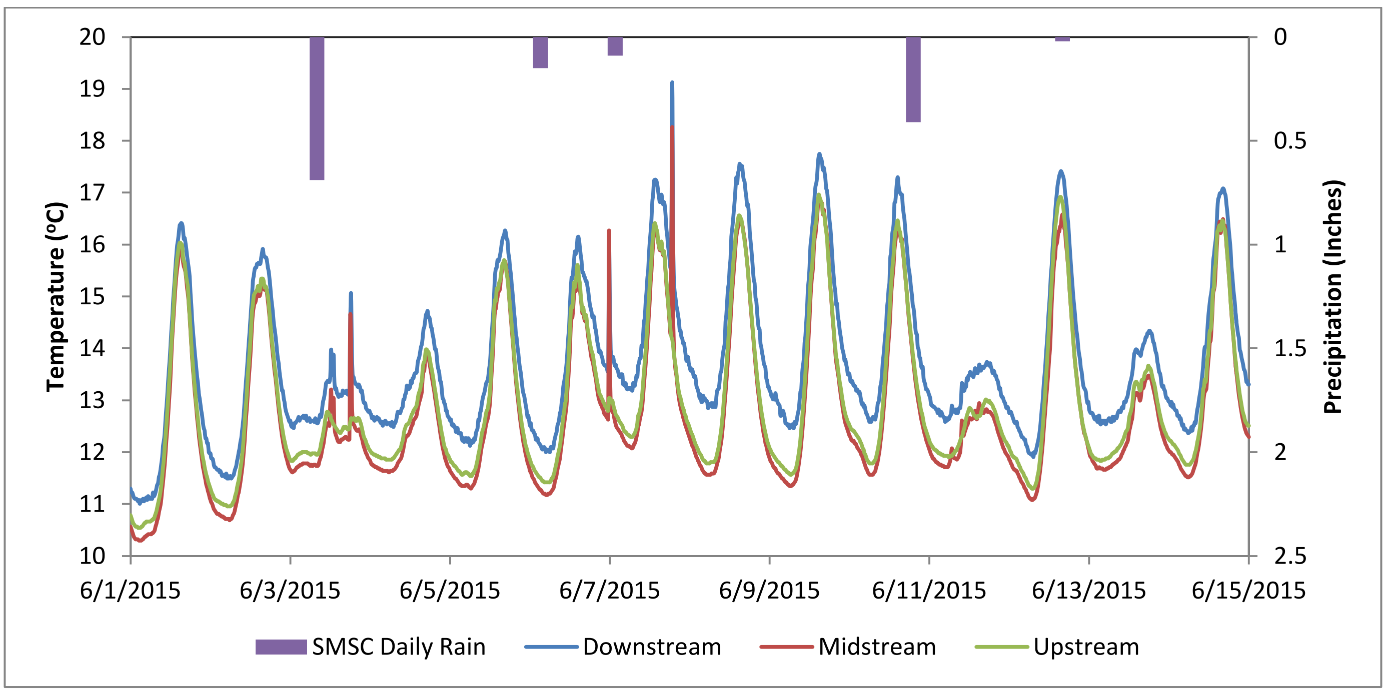

Figure 5. June storms temperature responses.

II. Watershed Outlet Monitoring Program

Eagle Creek is a Class 2A self-reproducing trout stream, a unique water resource in the metropolitan area. The Creek originates at the Boiling Springs (an area considered sacred by the Mdewakanton Sioux Community) and outlets into the Minnesota River. Significant measures have been taken over the past couple of decades to prevent degradation of Eagle Creek, including diverting stormwater from the stream, the establishment of a 200-foot natural vegetative buffer along each side of the bank, and most recently in 2013, a habitat improvement project along the west branch of Eagle Creek. These and other steps have helped to significantly minimize impacts from this rapidly growing suburban area.

The Eagle Creek monitoring station began in 1999 as part of the Metropolitan Council's Watershed Outlet Monitoring Program (WOMP). This program was designed and is currently managed by the Metropolitan Council, for the primary purpose of improving the ability to calculate pollutant loads to the Minnesota River. The Lower Minnesota River Watershed District (LMRWD) is the local funding partner for this station, and contracts with the Scott Soil and Water Conservation District (SWCD) to perform field-monitoring activities. The monitoring station is located in the City of Savage near Highway 13 and Highway 101, approximately 0.8 miles upstream of the confluence with the Minnesota River.

The following data is preliminary and is subject to change until the Metropolitan Council submits the final report for this period.

Table 1. Precipitation near Eagle Creek WOMP Station.

Month	2015 Precipitation* (inches)	30 Year Precipitation Average**
January	0.37	0.73
February	0.36	0.62
March	1.19	1.73
April	2.26	2.53
May	3.75	3.69
June	5.87	4.64
July	8.14	3.49
August	5.68	5.05
September	2.57	3.41
October	2.46	2.47
November	4.03	1.64
December	3.41	0.95
Total	40.09	30.95

*Precipitation data obtained from Shakopee Mdewakanton Sioux Community weather station.

** The 30 year average (normal) is from 1981-2010, National Climatic Data Center, Station: 214176 JORDAN 1 S, MN.
http://www1.ncdc.noaa.gov/pub/data/normals/1981-2010/products/station/USC00214176.normals.text

Methods

Sampling

Many parameters are recorded continuously at the Eagle Creek WOMP station including stage, velocity, conductivity, precipitation, and stream temperature. Samples are collected and analyzed for multiple parameters (Table 2) during base flow conditions and storm events. Base flow samples are taken monthly during periods of time unaffected by rainfall or snowmelt events. Samples are taken directly from the stream and then transported to the Metropolitan Council Environmental Services Laboratory (lab) for analysis. Composite samples are collected automatically during rainfall or snowmelt events using an automated sampler and datalogger. The sampler starts collecting water when the stream level (stage) rises above a predetermined activation stage set in the datalogger program. It continues to take a sample each time a fixed volume of water has passed the station. After 48 samples have been collected or the water level has dropped below the activation stage, the sampler automatically shuts off. This composite event sample is then brought to the lab for analysis. Three composite samples and thirteen base flow grab samples were collected in 2015. An *E. coli* grab sample was taken each time a composite sample was picked up.

Flow

There are two means of measuring stage and flow at the WOMP station: a WaterLOG bubbler system and Sontek Argonaut Shallow Water (SW) system. The bubbler system has been used since 1999 to measure stage. To determine the amount of flow related to stage, flow measurements are taken manually by MCES staff with a flow meter while the creek is at different stages and a rating curve is developed. With this data, a stage-flow relationship can be applied to the datalogger program, which then calculates continuous flow values as determined by the measured stage.

The Sontek Argonaut-SW was installed by the Metropolitan Council in 2008. This equipment calculates instantaneous flow based on the cross section area, stage, and velocity of the water. This equipment was determined necessary because of occasional backwater conditions caused by beaver dams or flooding of the Minnesota River. The bubbler system is not able to determine that the water is moving slower, so it automatically calculates higher flow as the stage rises. The Argonaut is able to adjust the flow as velocity changes, making the flow values more accurate during backwater conditions.

Results

The range of sampled water quality parameters are reported in table 2. The minimum, 25th percentile, median, mean, 75th percentile and maximum values are reported along with any state standard or comparable ecoregion range or mean for comparison purposes. Individual TSS, turbidity and *Escherichia coli (E. coli)* samples are plotted in figures 7, 8, and 9, respectively. The monthly geometric mean of all *E. coli* samples taken over the past 10 years is reported in figure 10.

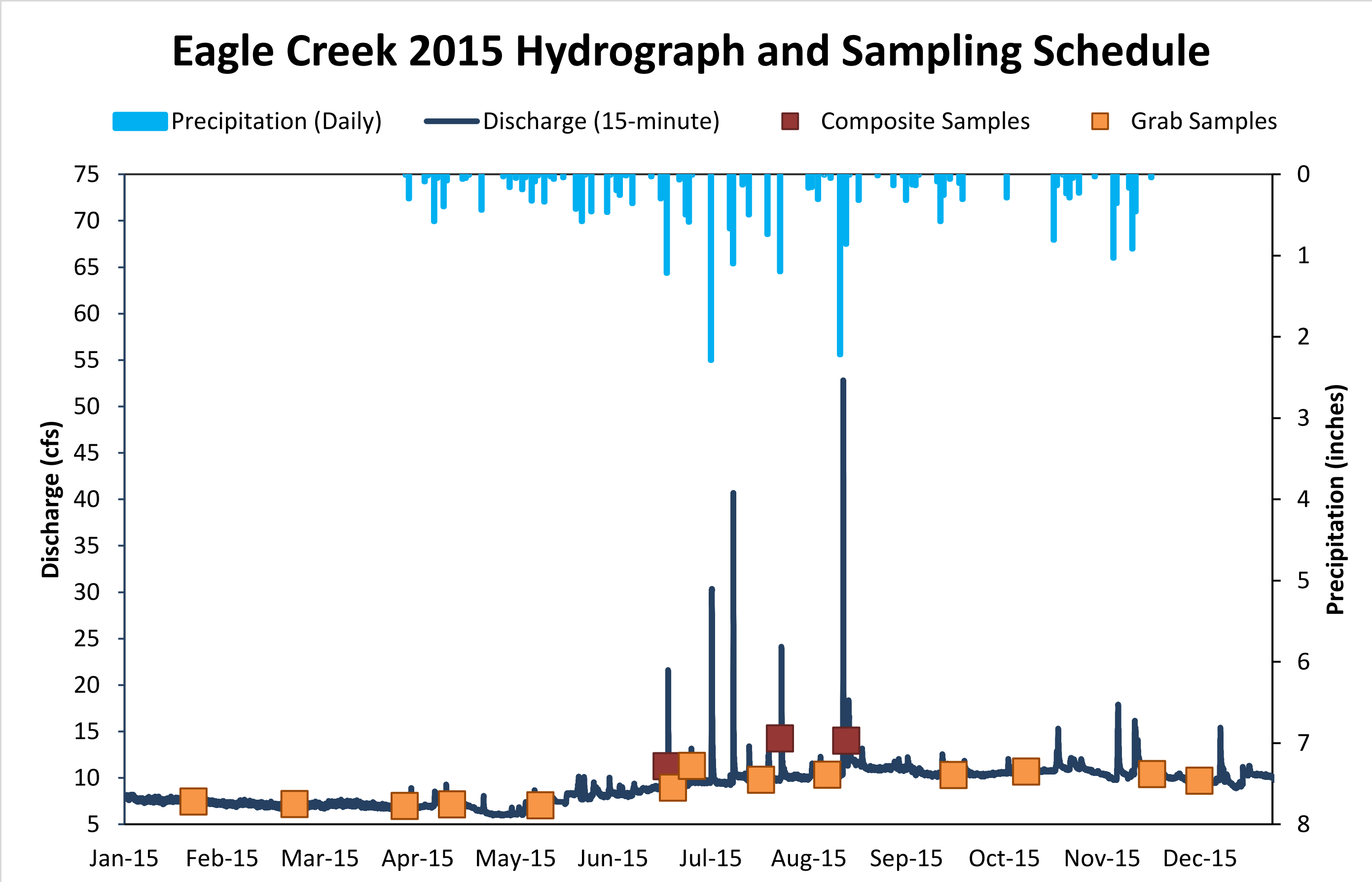

Figure 6: Flow, Precipitation, and Sample Schedule. Data is preliminary. Graph courtesy of MCES.

Table 2. Water quality preliminary lab results. Red, bolded text indicates exceedance of the state standard or NCHF ecoregion mean.

Parameter	Min	25th %	Median	Avg	75th %	Max	N	Notes
Alkalinity (mg/L)	249	263.3	269.5	267.6	272.8	282	16	No standard. 20-200 mg/L is typical.
Calcium (mg/L)	62.4	64	69.6	69.5	74.8	76.3	4	
Chloride (mg/L)	40.6	44.2	45.3	44.9	46.1	46.9	16	Standard = 230 mg/L
Chlorophyll-A (µg/L)	1	1	1.6	1.8	2.5	4.1	13	Standard = 18ug/L
CBOD (mg/L)	5	5	8	9.4	14.3	18	16	
E. coli (CFU/100ml)	6	23	115	118	186	328	15	Standard = 126 CFU/100ml as geometric mean
Hardness (mg/L)	150	285	308	295	318	336	16	
Ammonia (mg/L)	0.02	0.02	0.045	0.041	0.058	0.07	16	
TKN (mg/L)	0.23	0.26	0.28	0.37	0.47	0.78	16	
Nitrate (mg/L)	0.05	0.073	0.105	0.0981	0.12	0.17	16	Ecoregion mean = 0.4 - 0.26 mg/L
Nitrite (mg/L)	0.03	0.03	0.03	0.03	0.03	0.03	16	Ecoregion mean = 0.4 - 0.26 mg/L
Ortho-P (mg/L)	0.005	0.007	0.008	0.008	0.010	0.011	13	
TP (mg/L)	0.025	0.028	0.038	0.051	0.072	0.103	16	Standard = 0.1 mg/L
TSS (mg/L)	2	5	6.5	11.7	17	49	16	Standard = 10 mg/L
VSS (mg/L)	1	2	2	3.7	4.75	14	16	
Turbidity (NTRU)	3	5	6	7.5	9.5	17	13	Approximate standard = 10, replaced by TSS

Table 3. *In situ* water quality measurements taken by Hydrolab MS5 multi-probe mini sonde.

Parameter	Min	25th %	Median	Avg	75th %	Max	Samples	Notes
Conductivity (µS/cm)	642	649	655	655	660	670	15	
DO (mg/L)	7.7	7.97	8.36	8.41	8.88	9.3	14	
pH	7.14	7.48	7.81	7.69	7.86	8.12	13	
Temperature (°C)	8.08	9.06	10.09	10.51	12.03	12.96	15	
Transparency (cm)	49	100	100	94	100	100	11	
Turbidity (NTU)	1.7	3.4	5.9	6.8	9.7	17.7	14	

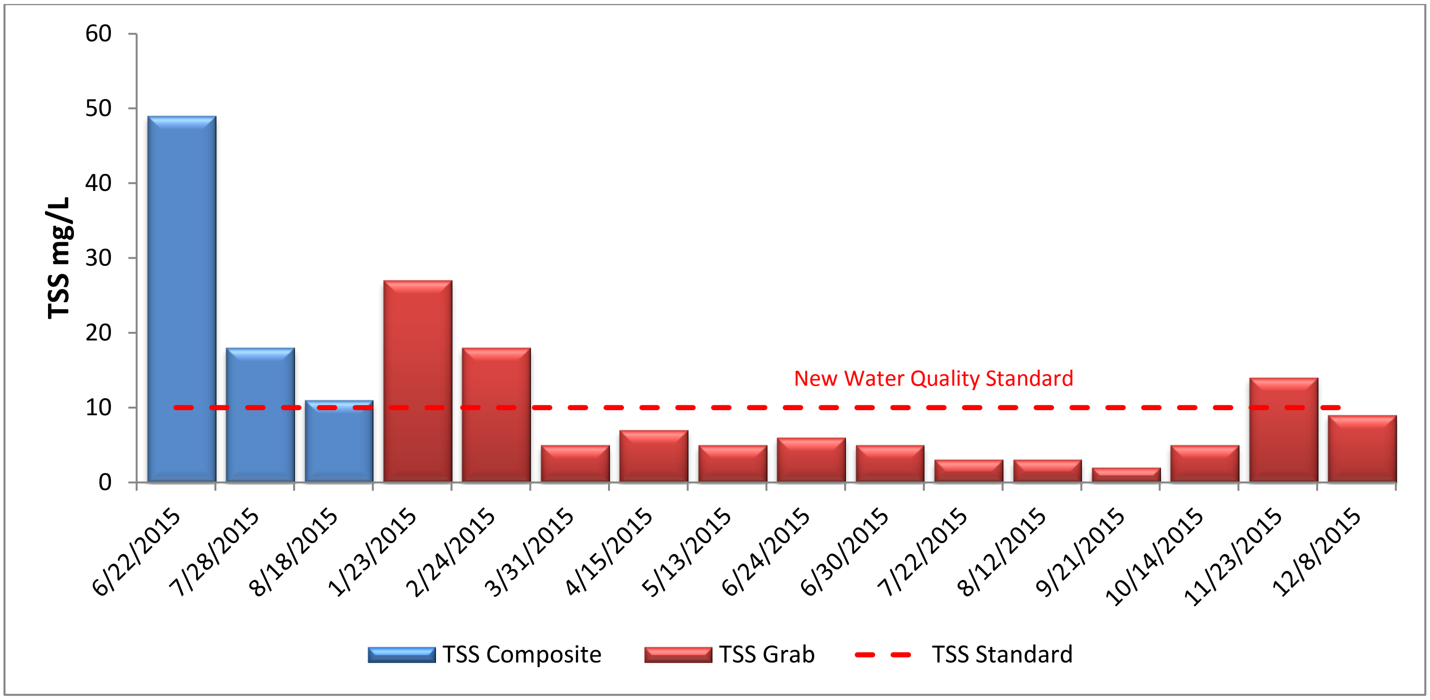

Figure 7. Total Suspended Solids. New TSS State Standard for Class 2A Waters = 10 mg/L with no more than 10% exceedance between April and September.

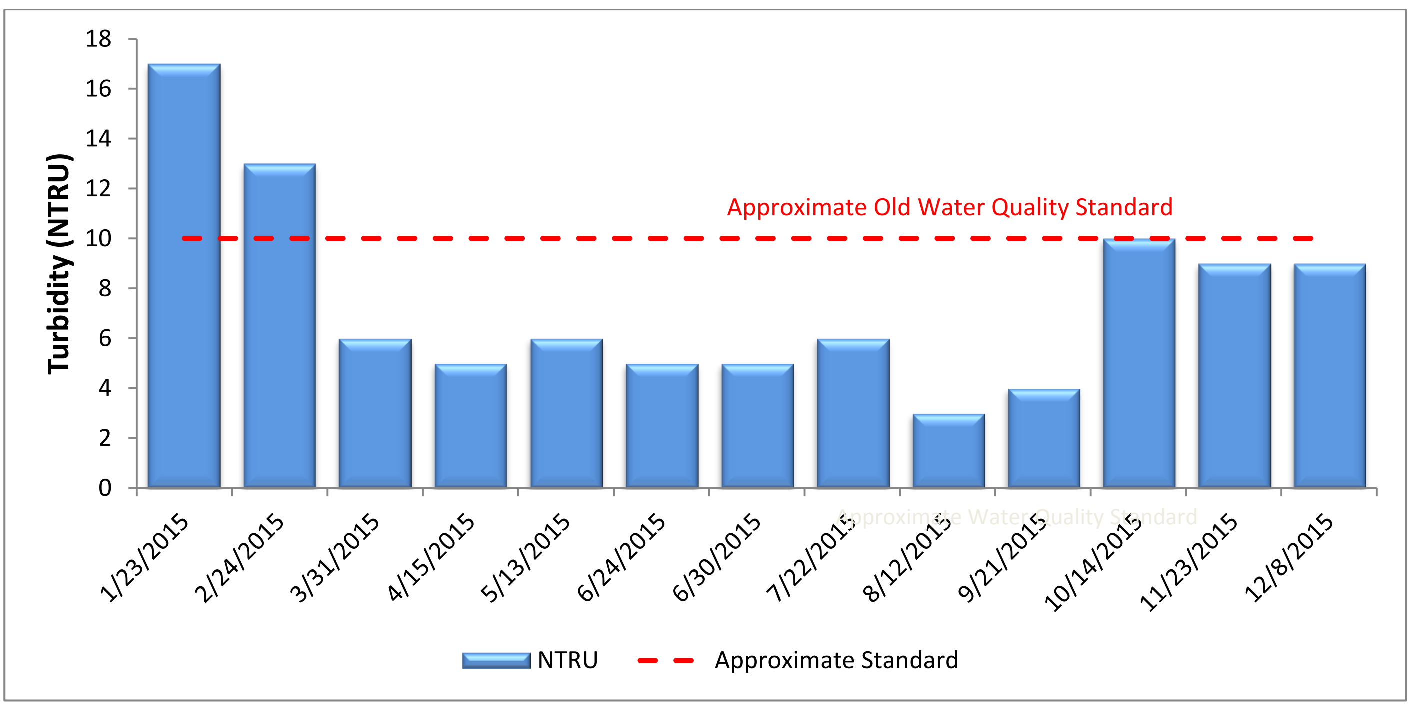

Figure 8. Lab Turbidity**.** The orange line indicates an approximate of the previous turbidity standard. Because turbidity was measured in Nephelometric Turbidity Ratio Units (NTRU), rather than Nephelometric Turbidity Units (NTU), the standard of 10 NTU's could not directly apply. Turbidity standards have been replaced by TSS starting in 2015.

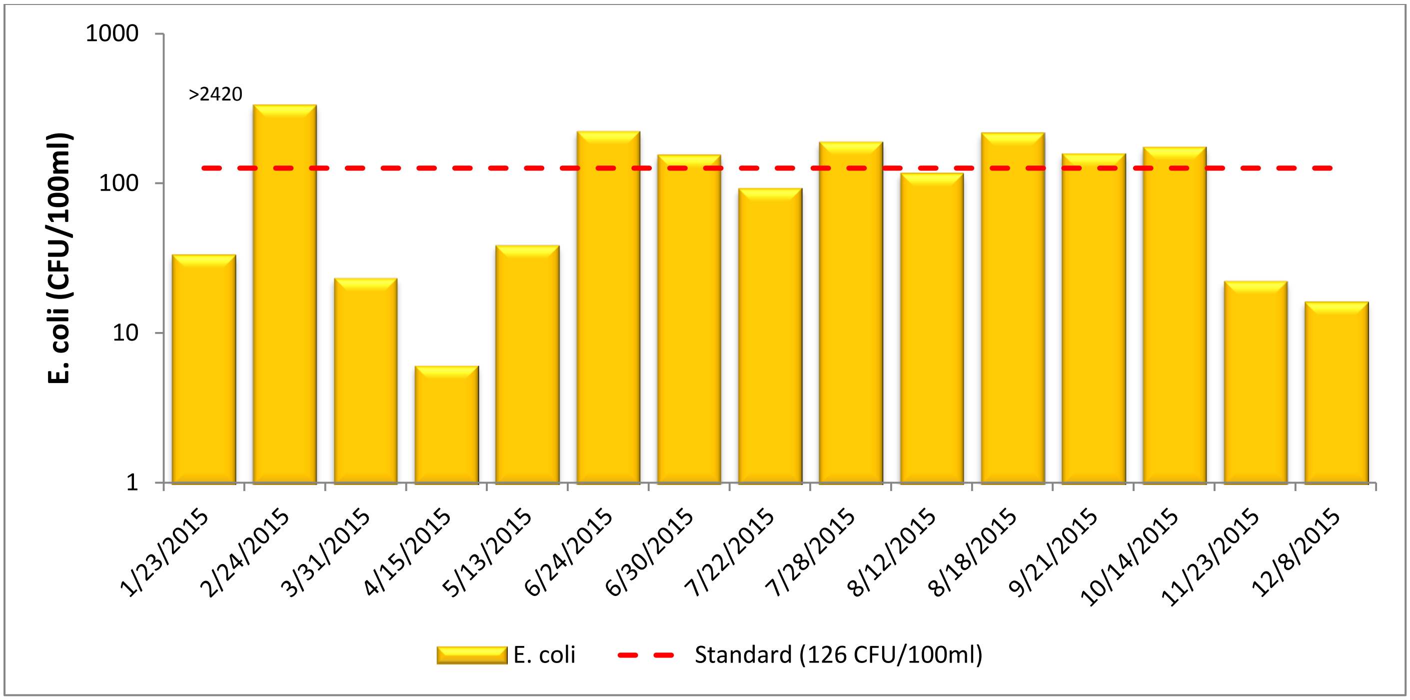

Figure 9. *E. coli* 2015 samples. *E. coli* state standard for class 2A waters is not to exceed 126 organisms/100 ml as a geometric mean of not less than 5 samples representative of conditions within any calendar month. Nor shall more than 10% of all samples taken during any calendar month individually exceed 1,260 organisms per 100 ml. The standard applies only between April 1 and October 31.

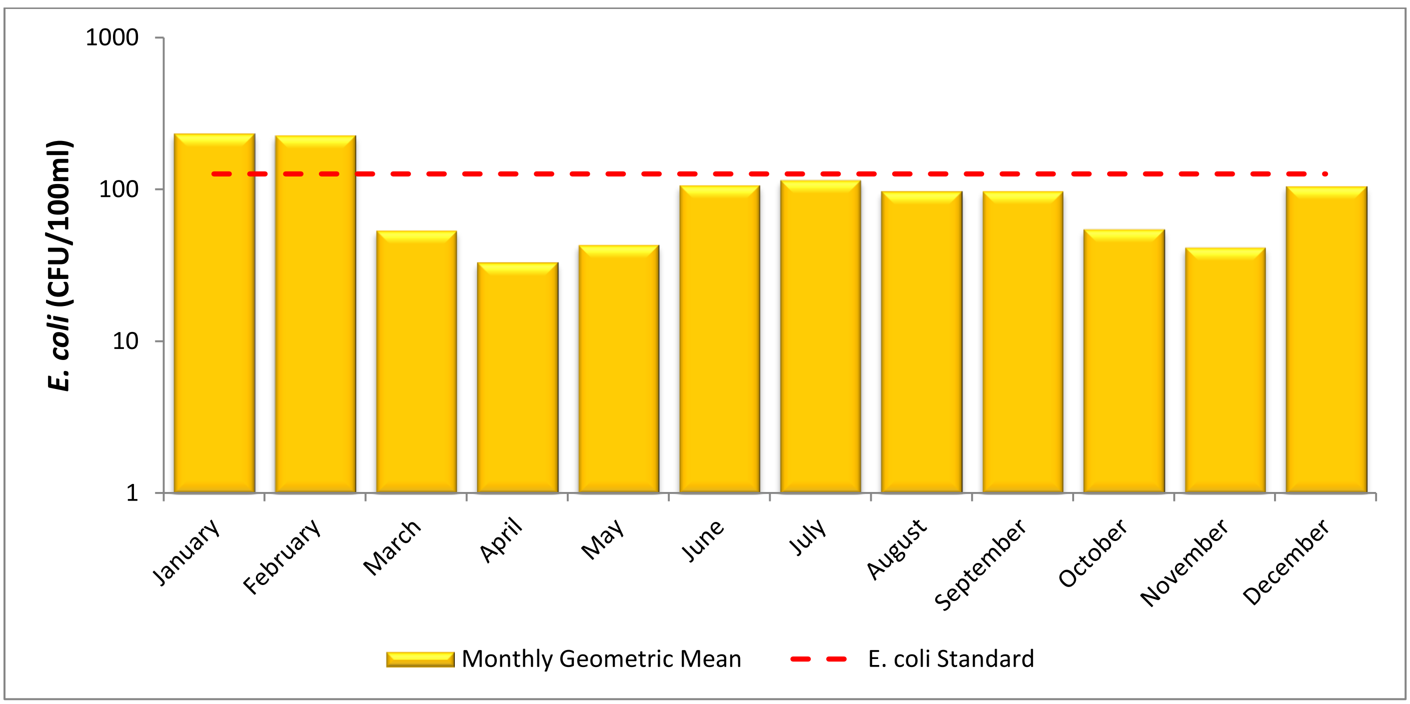

Figure 10. Geometric mean of *E. coli* at Eagle Creek. The geometric mean was calculated using all samples over the past 10 years for any given month. *E. coli* state standard for class 2A waters is not to exceed 126 organisms/100 ml as a geometric mean of not less than 5 samples representative of conditions within any calendar month. Nor shall more than 10% of all samples taken during any calendar month individually exceed 1,260 organisms per 100 ml. While no individual measurement exceeds 1,260, June and September exceed the chronic 126 standard.

Discussion

Monitoring data suggests that Eagle Creek consistently meets state water quality standards and ecoregion means[1], with the exception of bacteria, turbidity, and suspended solids (Tables 2 and 3). The elevated levels of these parameters in winter is characteristic of this stream due to the fact that Eagle Creek is spring fed and does not freeze over in the winter. The open water attracts a large number of waterfowl, which results in higher bacteria, sediment, and turbidity levels than observed in summer months (Figures 7, 8, and 9).

The *E. coli* standard is applicable from April 1 – October 31 and is exceeded when greater than 10% of the samples exceed 1260 Colony Forming Units (CFU) per 100 ml *or* the geometric mean of no fewer than five samples in a calendar month exceed 126 CFUs. None of the samples exceeded 1260 CFU's from April through October (Figure). Six samples between April and October 2015 exceed 126 CFU/100mL. However, the geometric mean of the previous ten years of *E. coli* samples does not exceeded 126 CFU's for any month between April and September (Figure 10).

The previous state turbidity standard was replaced with a Total Suspended Solids (TSS) standard. The new TSS standard for Class 2A waters state that no more than 10% of samples shall exceed 10 mg/L between April 1 and September 30. This year, Eagle Creek exceeded 10 mg/L in 3 of 10 (30%) lab samples during the applicable season (Figure 7). All of the TSS exceedances were sampled during storm events.

It is important to note that conclusions based on monitoring data for Eagle Creek are influenced (i.e. biased) by the relative percentage of samples collected during and immediately after storm events. For instance, 3 of the 16 (19%) samples were collected during events. Each of these event samples exceeded TSS standards. This bias is a result of the monitoring protocols specifically used at the Eagle Creek station. As stated, these protocols were designed to enable the Metropolitan Council to calculate pollutant loads to the Minnesota River. In order to assign load values, it is best to collect many storm event samples. Different protocols are typically used for assessing whether or not a particular water body meets state water quality standards. Therefore, caution must be used when attempting to characterize the condition of Eagle Creek based on data collected through this project.

III. Dean Lake Inlet Monitoring

Dean Lake is identified as a priority management area by the LMRWD. It was placed on the Minnesota Pollution Control Agency's (MPCA) 303 (d) list of impaired waters in 2006. It is impaired for Aquatic Recreation due to excess nutrients causing eutrophication. In an effort to gather more data, the LMRWD has contracted with Scott SWCD to provide monitoring data on the inlet to Dean Lake to document nutrient loading. The monitoring site is located where CR21 passes over the Prior Lake Outlet Channel to the southeast of Dean Lake. The SWCD monitors water chemistry and continuous stage and flow. The SWCD also monitors water quality downstream of Dean Lake through a surface water assessment grant from MPCA and funding from Prior Lake Spring Lake Watershed District (PLSLWD). This downstream site is part of the watershed restoration and protection strategy (WRAPS) process of assessing major watersheds in Minnesota. PLSLWD also contracted Scott SWCD to expand its 2015 monitoring of Dean Lake Inlet to include soluble reactive phosphorus (SRP) and five *E. coli* samples.

[1] There are seven ecoregions in Minnesota. Ecoregions are classified by geographic areas with similar plant communities, land use, soil, and geology. Eagle Creek is located in the North Central Hardwood Forest (NCHF) ecoregion. Each ecoregion has unique water quality goals as determined by historical monitoring of representative and minimally impacted reference streams within that ecoregion.

Methods
In-stream field measurements of dissolved oxygen, temperature, turbidity, pH and conductivity were taken using a Hach MS5 Multiprobe Sonde. Field transparency was measured with a 1 meter secchi tube. In 2015, 14 base and 4 event grab samples were collected totaling 18 samples. Samples were collected on a biweekly schedule, with additional event grab samples taken after rain events. In order to develop a rating curve used to calculate discharge, flow and stream stage measurements were taken at the monitoring site

Results
The 2014 monitoring data suggest that the inlet to Dean Lake meets water quality standards in most cases, with the exception of Nitrate and TSS (see 2014 report). The 2015 monitoring results similarly show elevated nitrate levels above ecoregion mean (Table 3). However, total suspended solids met state standard (30 mg/L) for each sample in 2015. This decrease, compared with 2014, is likely due to a decreased number of large storm events and lower flows.

Five *E. coli* samples were collected in 2015 at Dean Lake inlet for PLSLWD. These samples were paired with samples taken at Dean Lake outlet at Hwy 101. Of the five samples at DLI, only one was below the standard of 126 CFU/100mL (Table 3). DLO *E. coli* values were much lower and suggest Dean Lake may act as a filter for *E. coli*. DLO 2015 *E. coli* and other parameters are reported in table 4.

Table 3. 2015 water quality data from Dean Lake Inlet. Red, bolded text indicates exceedance of the state standard or North Central Hardwood Forest ecoregion mean.

Parameter	MIN	25^{Th} %	AVG	75^{Th} %	MAX	MEDIAN	N	Notes
Chloride (mg/L)	37.4	49.7	52.5	54.2	82.6	52.9	18	Standard = 230
Nitrate (mg/L)	0.07	0.15	0.36	0.56	0.69	0.34	18	Ecoregion mean = 0.04-0.26
Nitrite (mg/L)	0.03	0.03	0.04	0.04	0.04	0.04	18	Ecoregion mean = 0.04-0.26
Dissolved P(mg/L)	0.02	0.02	0.03	0.04	0.09	0.03	18	
TSS (mg/L)	1	3	5.9	8	23	4	18	Standard = 30, not to be exceeded more than 10% of the time.
TKN (mg/L)	0.4	0.55	0.78	0.87	1.5	0.73	18	
Total P (mg/L)	0.04	0.05	0.08	0.09	0.22	0.6	18	Standard = 0.1
Lab Turbidity (NTRU)	2	4	8	8.8	29	6	18	
VSS (mg/L)	1	1	2.6	3	9	2	18	
SRP (mg/L)	0.005	0.01	0.036	0.032	0.259	0.015	17	
E. coli (mpn/100 ml)	119	Geo-mean = 309			>2420		5	Standard = 126

Table 4. 2015 water quality data from Dean Lake Outlet.

Parameter	MIN	25^{Th} %	AVG	75^{Th} %	MAX	MEDIAN	N	Notes
Chloride (mg/L)	20.8	49.9	60.5	78.7	102.2	54.9	19	Standard = 230
Nitrate (mg/L)	0.05	0.10	0.44	0.86	1.57	0.11	19	Ecoregion mean = 0.04-0.26
Nitrite (mg/L)	0.03	0.03	0.03	0.03	0.03	0.03	19	All 19 samples below reporting limit (<0.03 mg/L)
Dissolved P (mg/L)	0.02	0.02	0.03	0.036	0.085	0.024	19	
TSS (mg/L)	1	2	6.4	7.5	50	3	19	Standard = 30, not to be exceeded more than 10% of the time.
TKN (mg/L)	0.24	0.47	0.68	0.91	1.3	0.62	19	
TP (mg/L)	0.028	0.040	0.060	0.080	0.154	0.52	19	Standard is 0.1
Lab Turbidity (NTRU)	1	2	4	5	12	3	19	
VSS (mg/L)	1	1	2.6	3	9	2	19	
SRP (mg/L)	0.005	0.010	0.036	0.0320	0.259	0.015	17	
E. coli (mpn/100 ml)	33	Geometric mean = 125			1,300		5	Standard = 126

III. Well Monitoring

In 2005 the LMRWD contracted with Scott Soil and Water Conservation District to collect groundwater measurements from 12 wells in the Savage Fen, 4 wells in the Eagle Creek area and 2 Bluff wells. The data from these recordings is used to assess groundwater resources, determine long-term trends and interpret the impacts of pumping and climate. The wells in the Savage Fen were installed by the DNR to monitor development effects and water usage from the City of Savage on the water level in the Fen. All well data is entered into the DNR's groundwater level database and can be accessed at http://www.dnr.state.mn.us/waters/cgm/index.html.

Savage Fen Area Wells

The Savage Fen is a rare wetland complex at the base of the north-facing bluffs in the Minnesota River Valley, the largest calcareous fen of its kind in Minnesota. A plant community of wet, seepage sites with an internal flow of groundwater rich in calcium, magnesium bicarbonates and sulfates result in a thick peat base that is able to support a unique diversity of plants. More than 200 various plant species have been found in the Savage Fen, some of which are rare.

Methods

Scott SWCD monitors 12 wells in the Savage Fen and four Eagle Creek wells just outside of the Fen monthly between April and November (Figure 11). The water level fluctuates throughout the year and many of the artesian wells record water levels above ground level. In addition, four wells are monitored in the Eagle Creek portion of Savage Fen on the other side of highway 13 (Figure 13).

In 2010 the Savage Post Office and Fire Department were constructed near the bluff wellheads and as a result, the wellheads were reconstructed and placed below the street, accessible by a manhole cover. The bluff wells were not read in 2011 or 2012 as a result of the construction. With assistance from City of Savage staff opening manhole covers, SWCD resumed monitoring of these wells in 2013.

Results

The average Savage Fen water level remained high through midsummer and then began a decrease into the fall (Figure 11). The average Savage Fen well level measurement in 2015 was slightly higher (0.14 feet) than 2014 but the trend since 2010 seems flat (Figure 12). The 2015 Eagle Creek well levels remained flat through spring, increased slightly in July, then declined throughout the remainder of the year (Figure 13). Eagle Creek average well water depth increased 0.10 feet from 2014 to 2015. Average well depth remains near the highest it has been over the past six years (Figure 14).

The bluff wells both show an increase in water level through spring followed by a late summer/fall decline and slight bump in October (Figure 15). The historic monitoring at the bluff well sites is discontinuous due to construction. However, recent water levels over the past three years are increasing and are the highest levels recorded since the initial observation in 1994 (Figure 16).

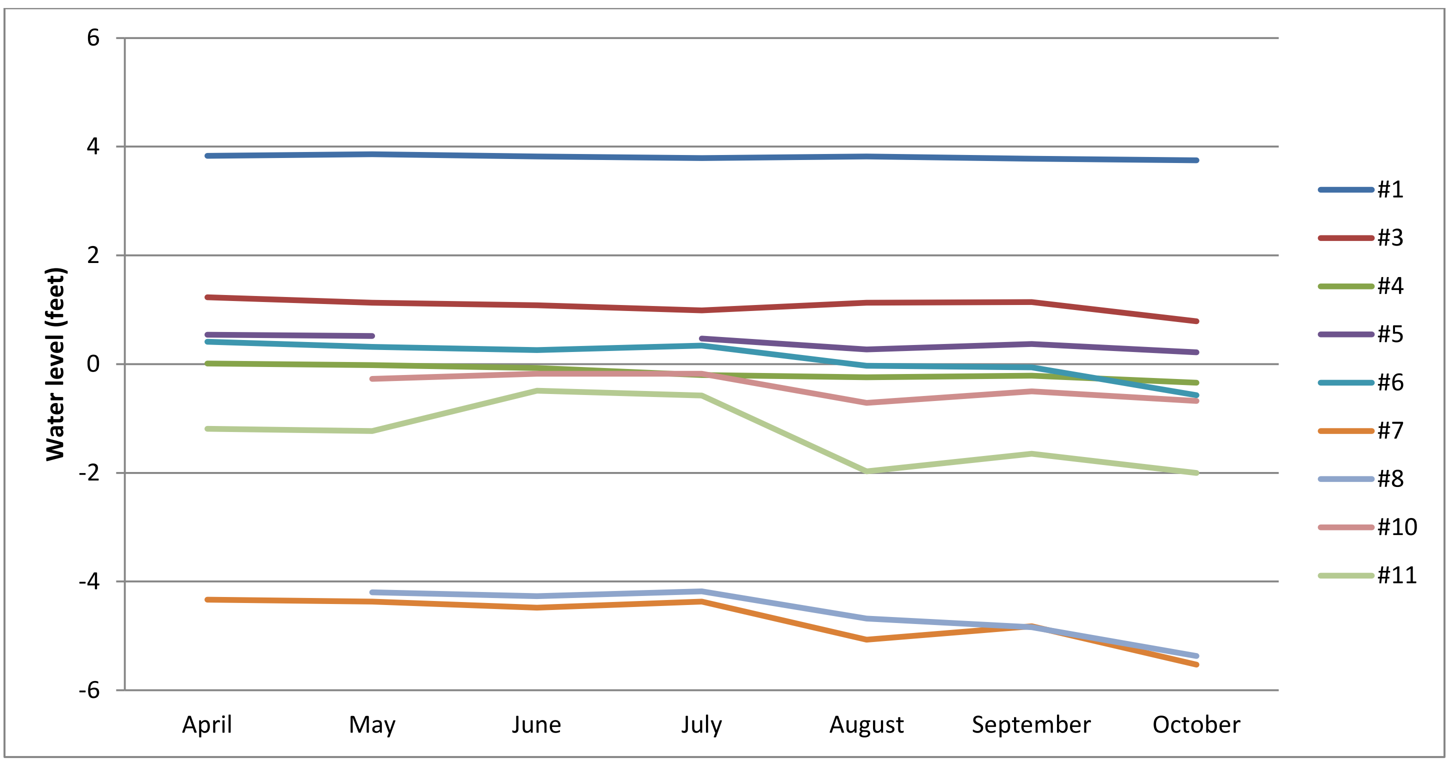

Figure 11. Savage Fen wells (2015). One measurement was taken during each month for each well. The water level is reported in relation to ground level.

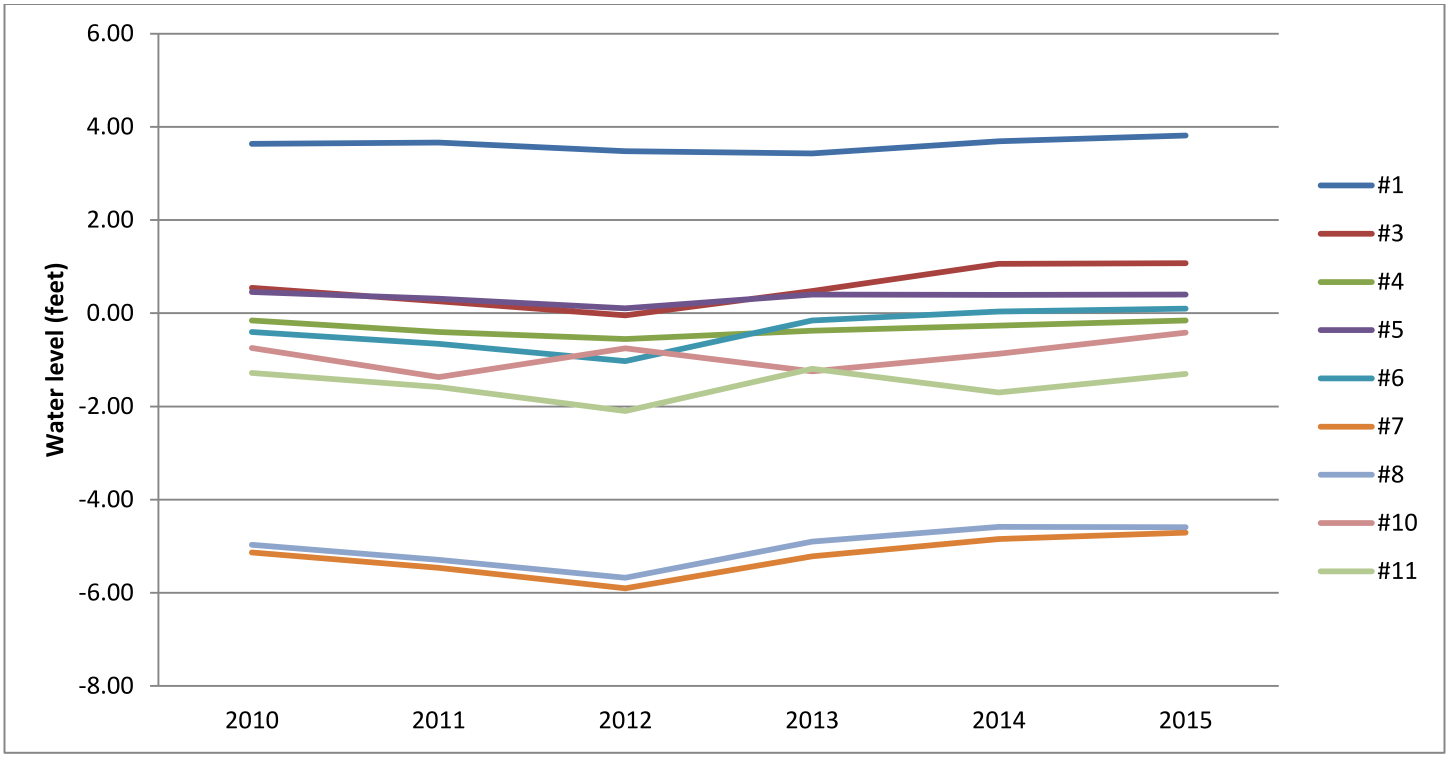

Figure 12. Average annual water level in Savage Fen wells (2005-2015). Averages include all observations in a calendar year. Water levels are reported in relation to ground level.

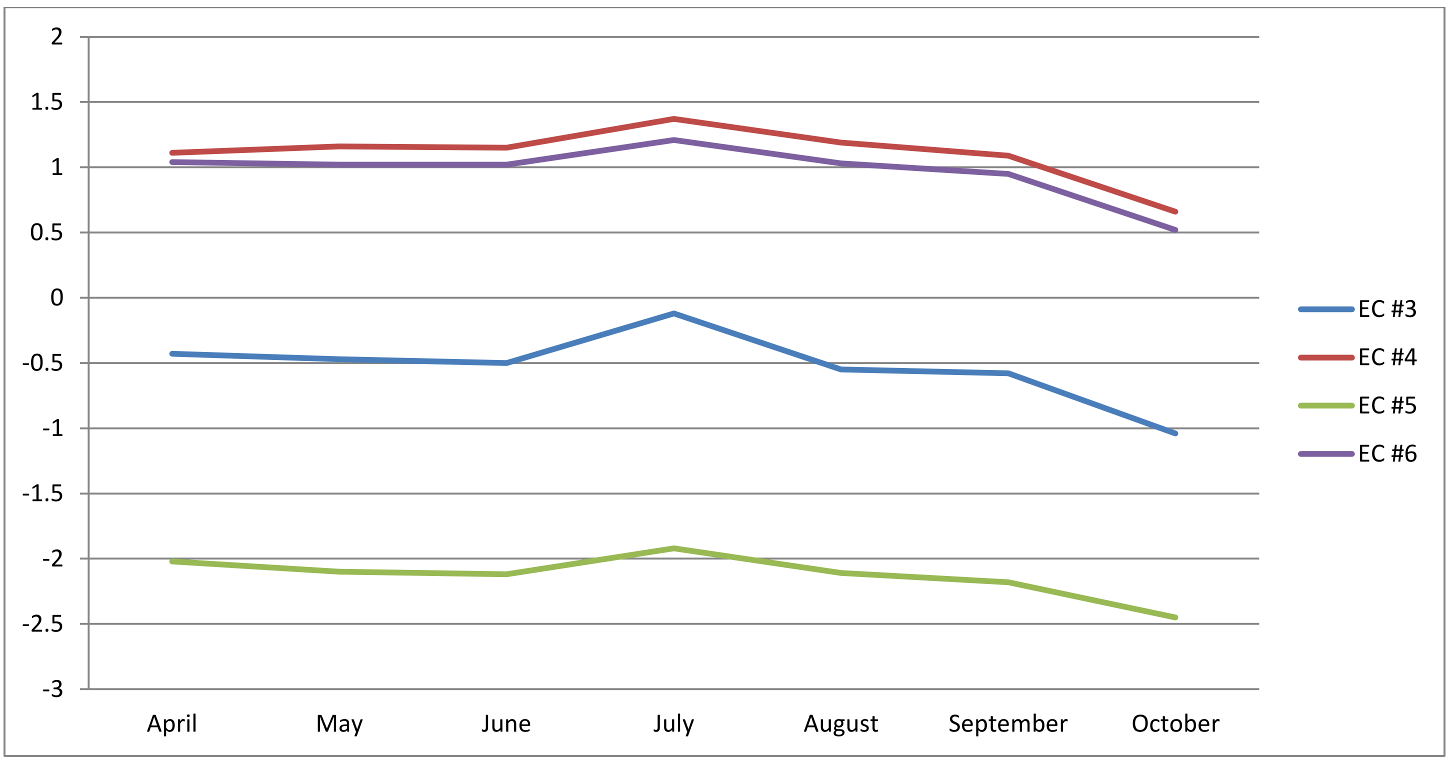

Figure 13. Eagle Creek 2015 well water levels. One measurement was taken in each month for each well. Water levels are reported in relation to ground level.

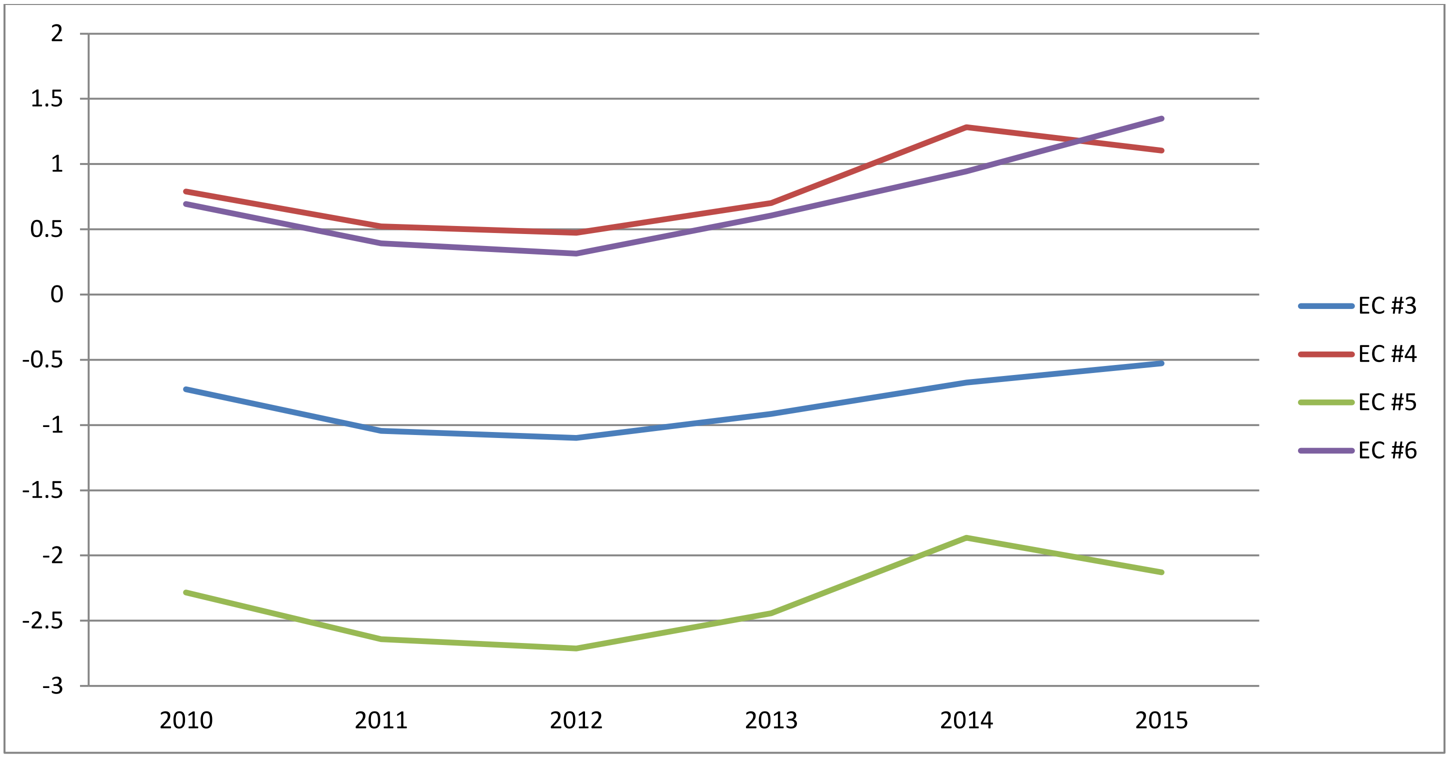

Figure 14. Average annual Eagle Creek well levels (2010-2015). Averages include all observations in a calendar year. Water levels are reported in relation to ground level.

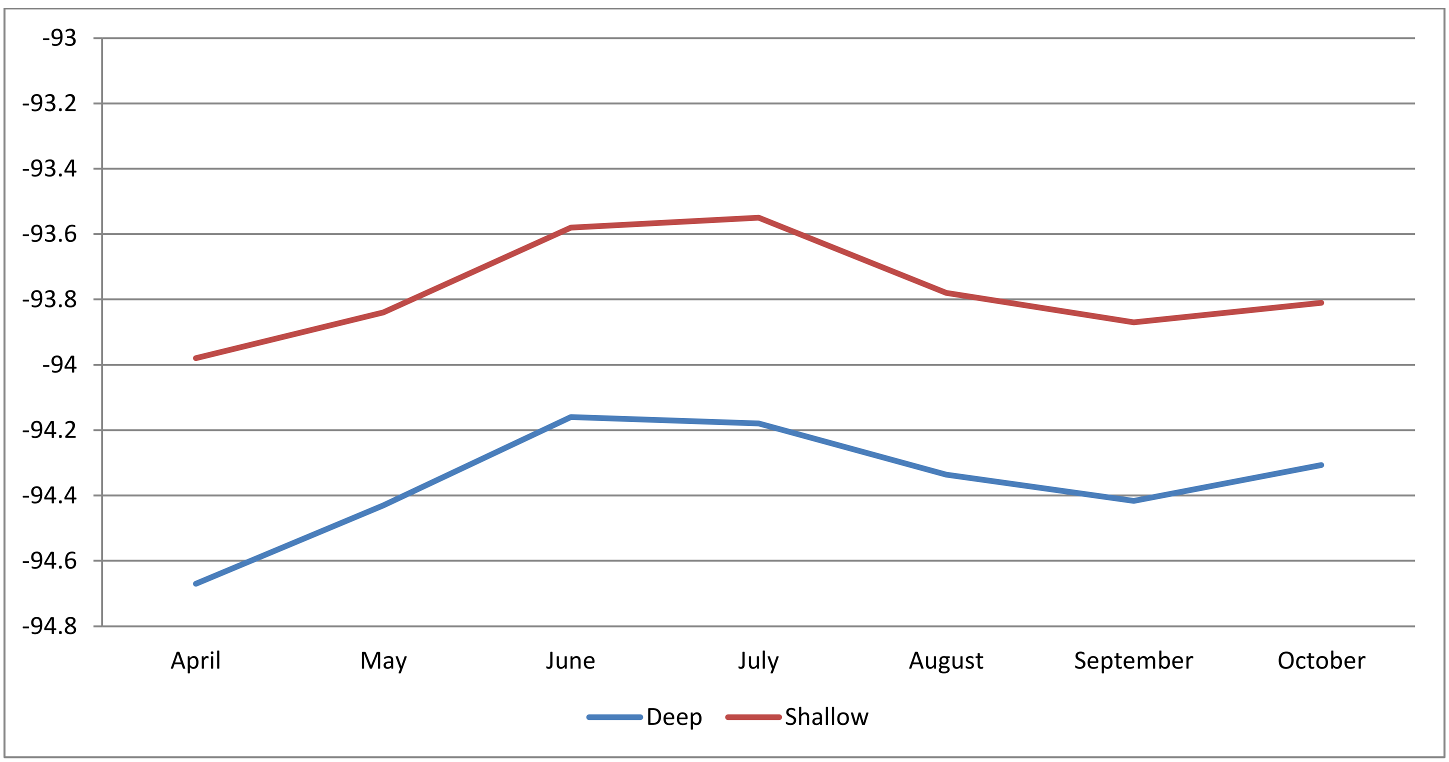

Figure 15. Savage Fire Station 2015 well levels. One measurement was taken during each month for each well. The water level is reported in relation to ground level.

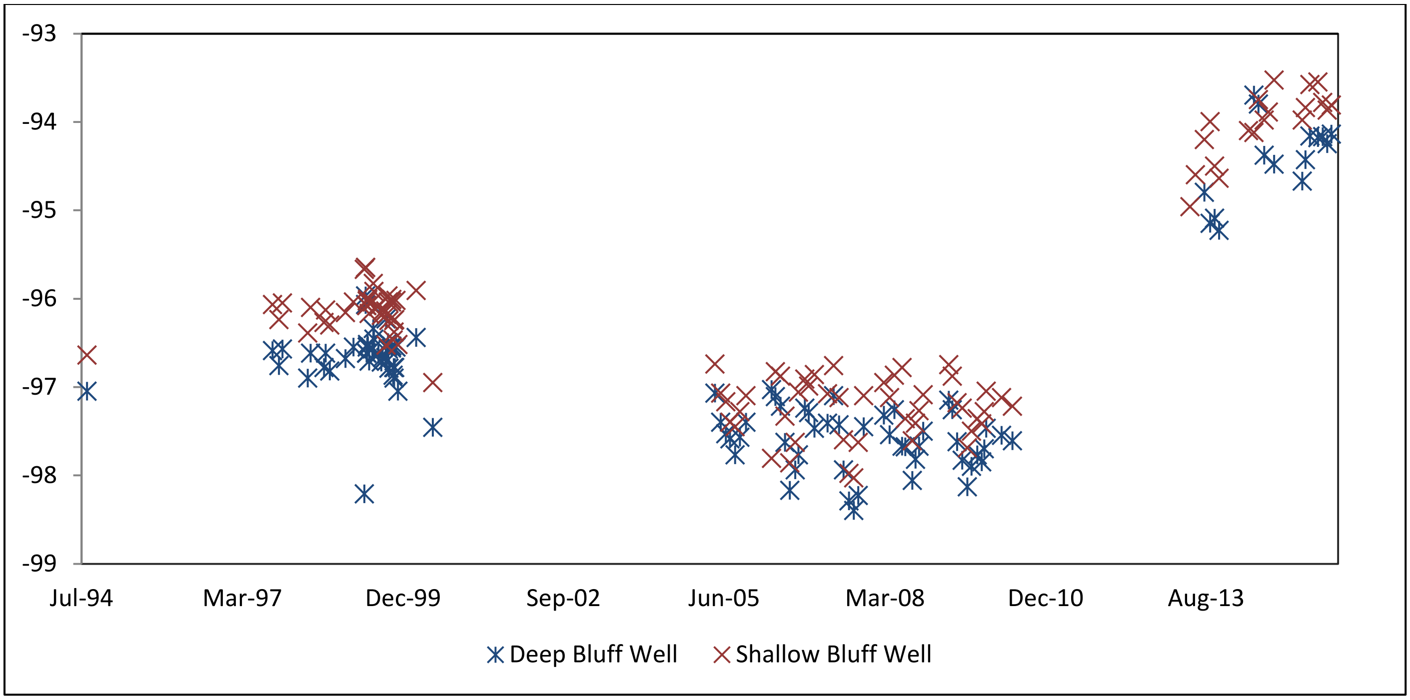

Figure 16. Shallow and deep bluff well historic water levels. Scott SWCD began monitoring in 2005. Monitoring was suspended between 2010 and 2013 due to construction in the area. All available data for these two wells are reported.