LOWER MINNESOTA RIVER
WATERSHED DISTRICT

Executive Summary for Action

Lower Minnesota River Watershed District Board of Managers Meeting
Wednesday March 20, 2019

Agenda Item
Item 5.A. - Presentation by Scott SWCD of 2018 monitoring results

Prepared By
Linda Loomis, Administrator

Summary
Troy Kuphal and Jon Utecht from the Scott County Soil and Water Conservation District will be at the meeting to present the results of the 2018 monitoring in Scott County. The annual report of the monitoring results is attached. Mr. Utecht and Mr. Kuphal will be able to answer any questions the Board may have.

Attachments
2018 Annual Monitoring Report

Recommended Action
No recommended action

Annual Monitoring Report 2018

Savage Fens summer of 2018

Prepared for:

Lower Minnesota River Watershed District

By: SCOTT SWCD
Jordan, MN

LOWER MINNESOTA RIVER WATERSHED DISTRICT

SCOTT SWCD

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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 2018 and previous monitoring seasons. Like previous years, the monitoring work plan for 2018 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). New to the 2018 monitoring activities included adding three additional temperature loggers and performing chloride sampling in the Eagle Creek watershed.

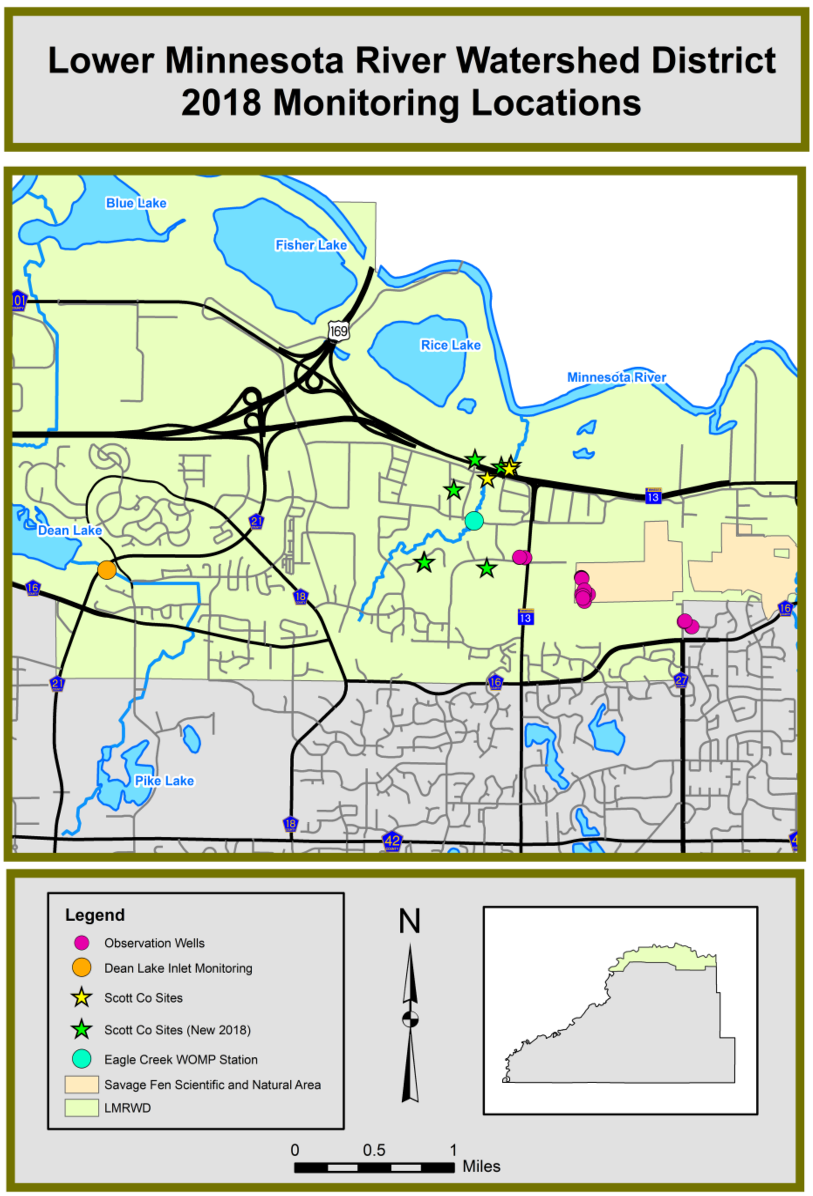

Figure 1. Monitoring Location Map.

I. Thermal Monitoring

This study was initiated by the Lower Minnesota River Watershed District (LMRWD) to evaluate the impact storm water runoff from Highway 101 has on temperatures in 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 in June of 2006 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. Three additional loggers have been placed on the outlets of the ponds adjacent to Eagle Creek in late July of 2018 (Figure 2). The goal of the additional pond loggers is monitor water temperatures leaving the ponds, and help zero in on potential warm thermal sources contributing to the creek. All 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. The new 2018 loggers are represented by the orange triangles.

During warm summer days, water temperatures occasionally exceeded the optimal range for trout but for only a few hours at a time (Figure 3). The maximum daily temperatures exceeded the optimal range 22, 14, and 16 times for the downstream, midstream, and upstream loggers respectively. Significant flooding from the Minnesota River backed up Eagle Creek a few times during 2018. This created deeper more stagnent turbid water in the creek, especially near the mouth. 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 recorded 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. The addition of the thermal loggers at the outlets of the ponds adjacent to the creek will provide a longer record of the actual influence of temperature increases from the ponds. 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.

To ensure all the loggers remained functioning and not gaps occurr due to dying batteries, like the downstream logger in 2017, both the upstream and midstream loggers were replaced with new loggers. These loggers had already exceeded their 6 year life expectancy. The pond loggers started recording data in late July and were generally uninterupted except for the logger at the end of Schroeders park pond. Construction near the loggers location resulted in a missing logger. The logger will be replaced following the completion of the construction before the summer of 2019.

Discussion

Multiple flooding events in the Minnesota River appeared to influence the data for all of the loggers early in the season. The late May into June flood levels kept field staff out of the water and the levels also seemed to impact the water temperatures as all three loggers remained above optimal trout temperatures. Following the flooding, all of the thermal monitoring loggers have shown a significant response to precipitation events (Figure 3). The downstream logger continues to show a greater and more sustained response to the events. This is likely due to the combination of the runoff from the crossing highway and overflow from the adjacent pond. All of the loggers showed spikes in maximum daily temperatures outside the opitimal range for the Brown Trout (Figure 4). The pond loggers tracked well with average air temperatures (Figure 5). The logger at Creek Way pond was never submerged so it’s readings are atmospheric temperatures at that location. This logger should track Spring thaw temperatures and significant rain events when the pond fills to capacity. The Hwy 101 pond logger tracked with both the downstream and midstream logger in Eagle Creek (Figure 6). With a limited dataset it is difficult to significantly dicern temperature influences from the Hwy 101 pond, but initial indications show some contribution. This is similar to the results found in the brief investigation in 2009. Continually monitoring of Eagle Creek and the adjacent ponds will allow the tracking of temperature shifts. It also allows for historical background for past and future restoration projects, similar to the MNDNR habitat improvement project in 2013.

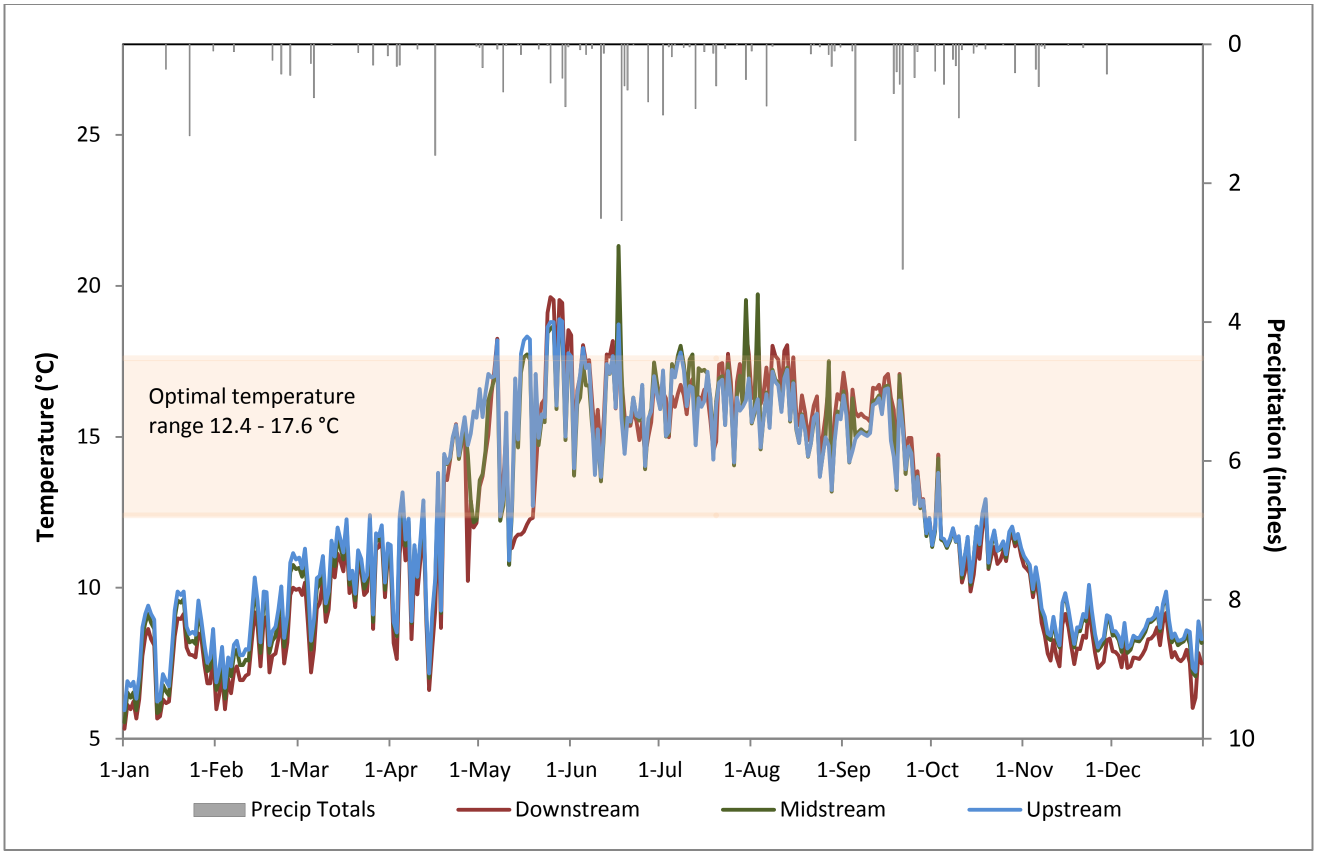

Figure 3. 2018 Maximum daily water temperatures in Eagle Creek.

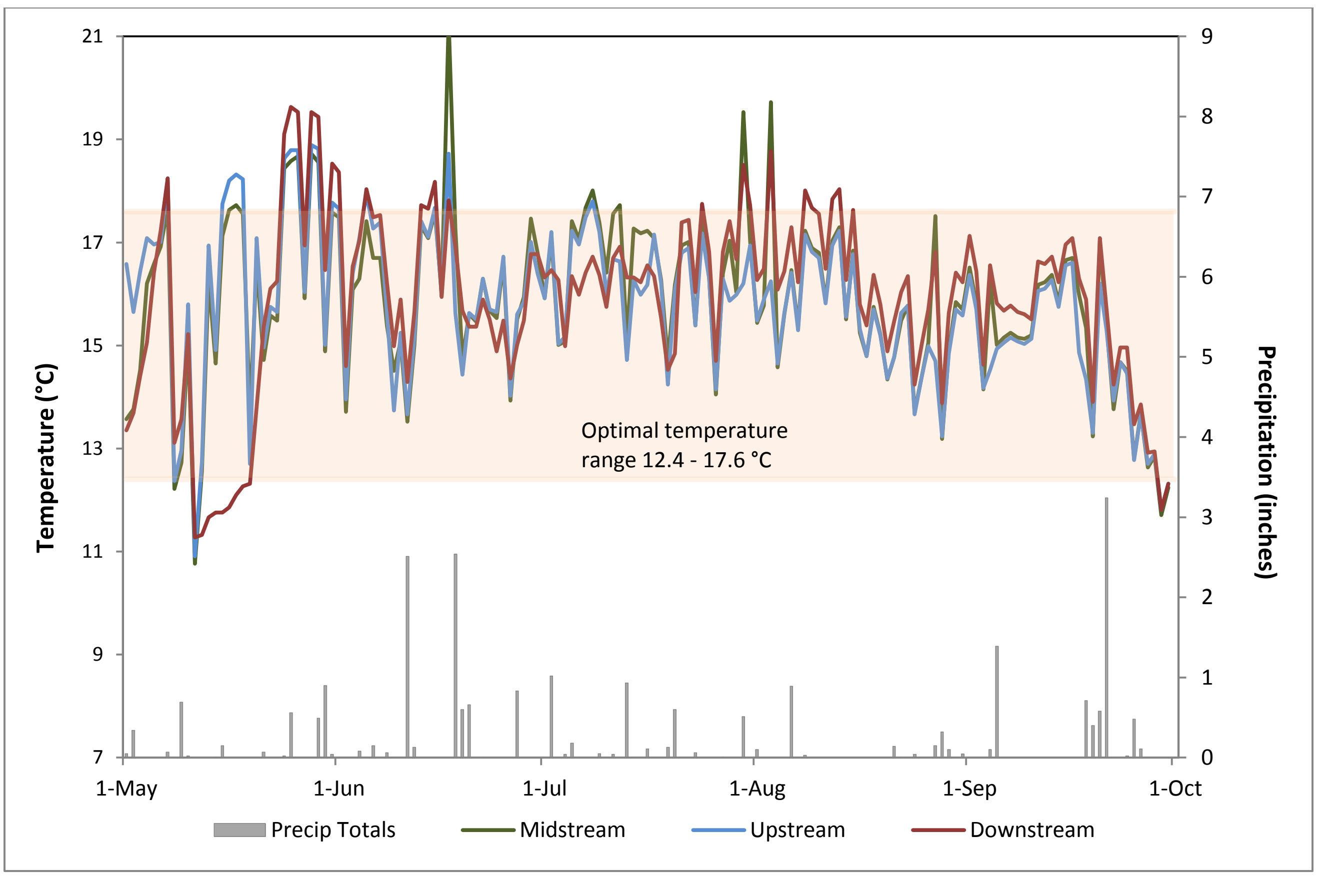

Figure 4. Maximum daily temperatures for the 2018 summer. An increase in temperature separation between the upstream and downstream loggers is noticed especially after precipitation events.

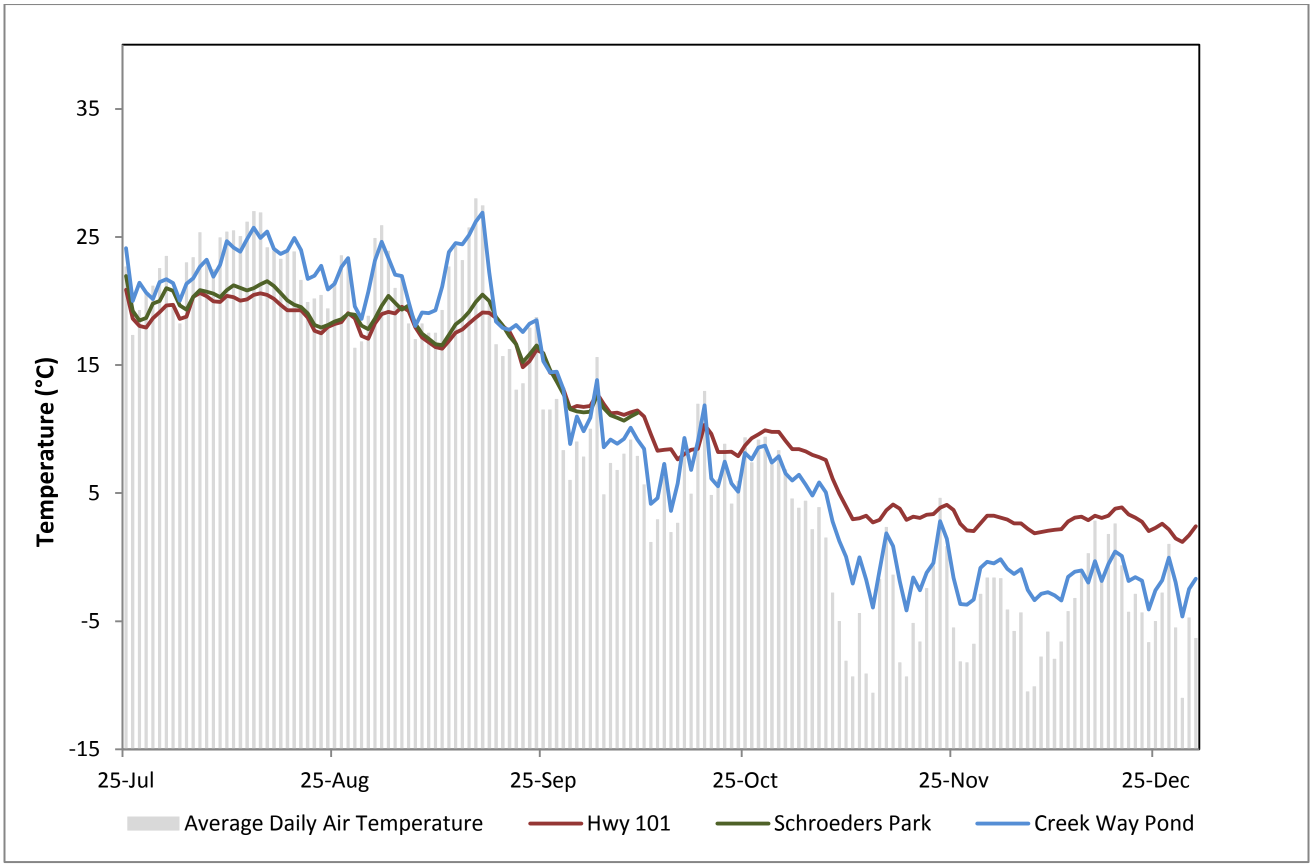

Figure 5. Pond outlet loggers 2018 average daily water temperatures. The Creek Way pond logger failed to be submerged by water during the monitoring period, tracked well with air temperatures. The Schroeder's Park logger was lost after the October download.

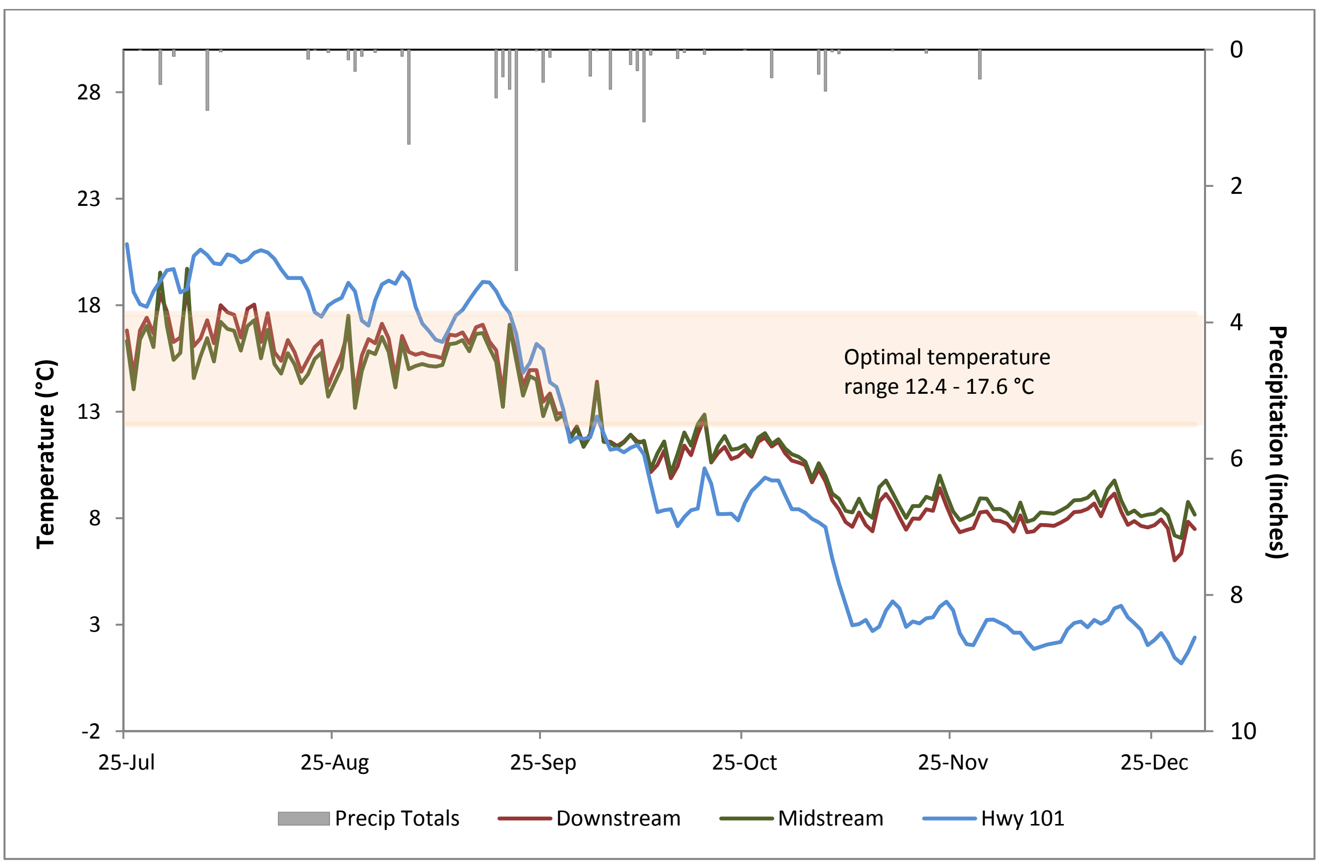

Figure 6. Comparison of 2018 water temperatures at the Hwy 101 pond and Eagle Creek just upstream and downstream of pond confluence.

II. Eagle Creek Monitoring

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 storm water 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.

Chloride Monitoring

Located in a highly developed area, Eagle Creek is a unique metropolitan Brown Trout (*Salmo trutta*) stream that may be susceptible to increased levels of chloride. With over 67% of the watershed "developed" and a road density greater than 18%, the runoff potential from impervious surfaces that can transport deicing products into the creek is significant (MPCA, 2018). High levels of chlorides have been found to impact trout development and reduce their growth (Hintz & Relyea, 2017). Smaller streams in highly urbanized areas, like Eagle Creek, are more susceptible to higher chloride concentrations (SEWRPC, 2013).

Methods

New monitoring to trace potential chloride inputs began in early November of 2018 and is scheduled to conclude at the beginning of May 2019. Samples are collected in three targeted areas around the watershed to capture baseline and runoff chloride concentrations to see if there are areas that are susceptible to higher levels of chloride pollution during the winters (Figure 7). The selected locations will divide the watershed into sections that can help identify areas with the highest inputs. Chloride and *Escherichia coli* (E. coli) samples are collected bi-weekly along with up to eight additional event samples. The event samples are dictated by two consecutive days of above freezing ambient temperatures (32°F). This will capture the greatest potential for chloride runoff into the creek. During each sample run in a sonde reading will be collected at each sample location along with additional sonde sample sites. The goal is to relate chloride concentrations to conductivity levels and translate the correlated chloride values to the sonde only measurements. In addition to chloride, E. coli samples are also collected to help isolate the source of historically high levels observed during the winter months.

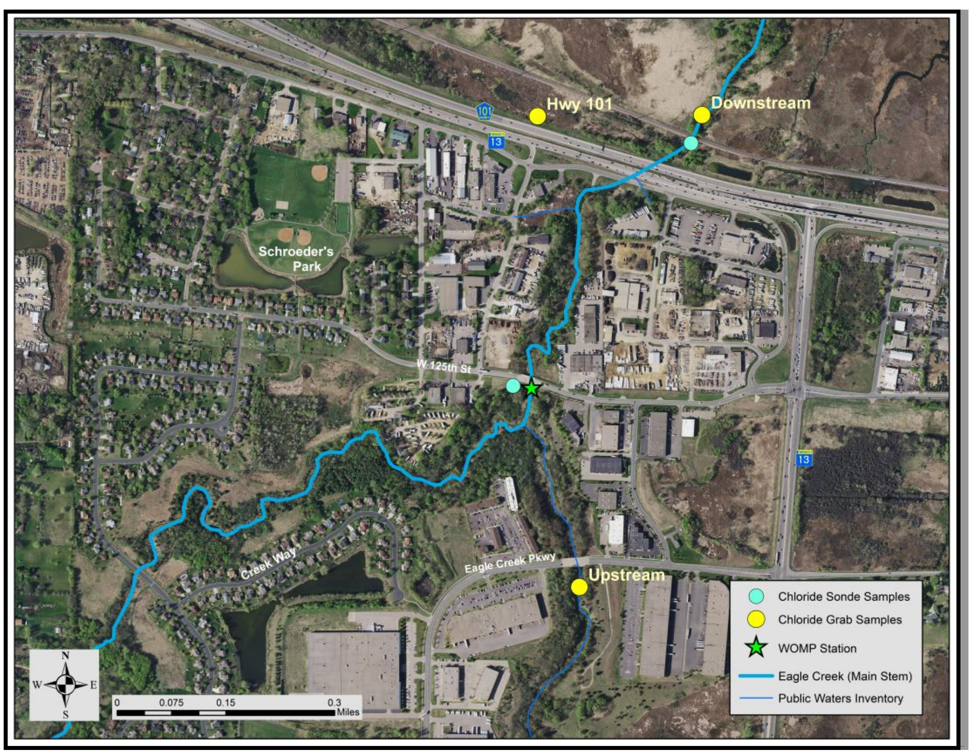

Figure 7. Map depicting the locations of the grab samples and sonde readings for the 2018-2019 chloride analysis.

Results

Chloride and E. coli concentrations around the Eagle Creek watershed from early November 2108 to mid-February of 2019 are reported in Table 1. This project is only set to conclude in May of 2019, so this data is only reporting the first half of the project. This dataset still provides an insight into chloride concentration distribution throughout the watershed. Three event samples were collected between December and January. The first event sample on 12/17/18 followed a warm weekend but did not have much snow to melt prior to the event. During the second event (12/27/18) was collected while it was raining and followed a snow event. The final event shown (1/7/19) followed a week of unseasonably high temperatures >32°F, but had small amounts of snow to melt.

Table 1. Results of samples collected for the Eagle Creek chloride project. Data represents samples from 11/7/18 to 2/13/19. Red values are in exceedance of state standards for chlorides and numbers of concern for E. coli.

Site	Parameter	Min	25th %	Median	Avg	75th %	Max	N
Downstream	Chloride (mg/L)	58.9	59.3	63.5	65.4	69.0	84.9	11
	E.Coli (CFU/100ml)	8	11	17	124	242	649	12
Hwy 101	Chloride (mg/L)	102.9	124.8	131.2	142.5	162.1	237.6	11
	E.Coli (CFU/100ml)	16	18	29	46	35	201	12
WOMP	Chloride (mg/L)	4.3	47.8	48.4	43.7	50.4	53.0	8
	E.Coli (CFU/100ml)	9	15	25	175	423	548	9
Upstream	Chloride (mg/L)	48.7	50.0	51.4	51.8	53.9	56.3	11
	E.Coli (CFU/100ml)	8	10	16	33	28	211	12

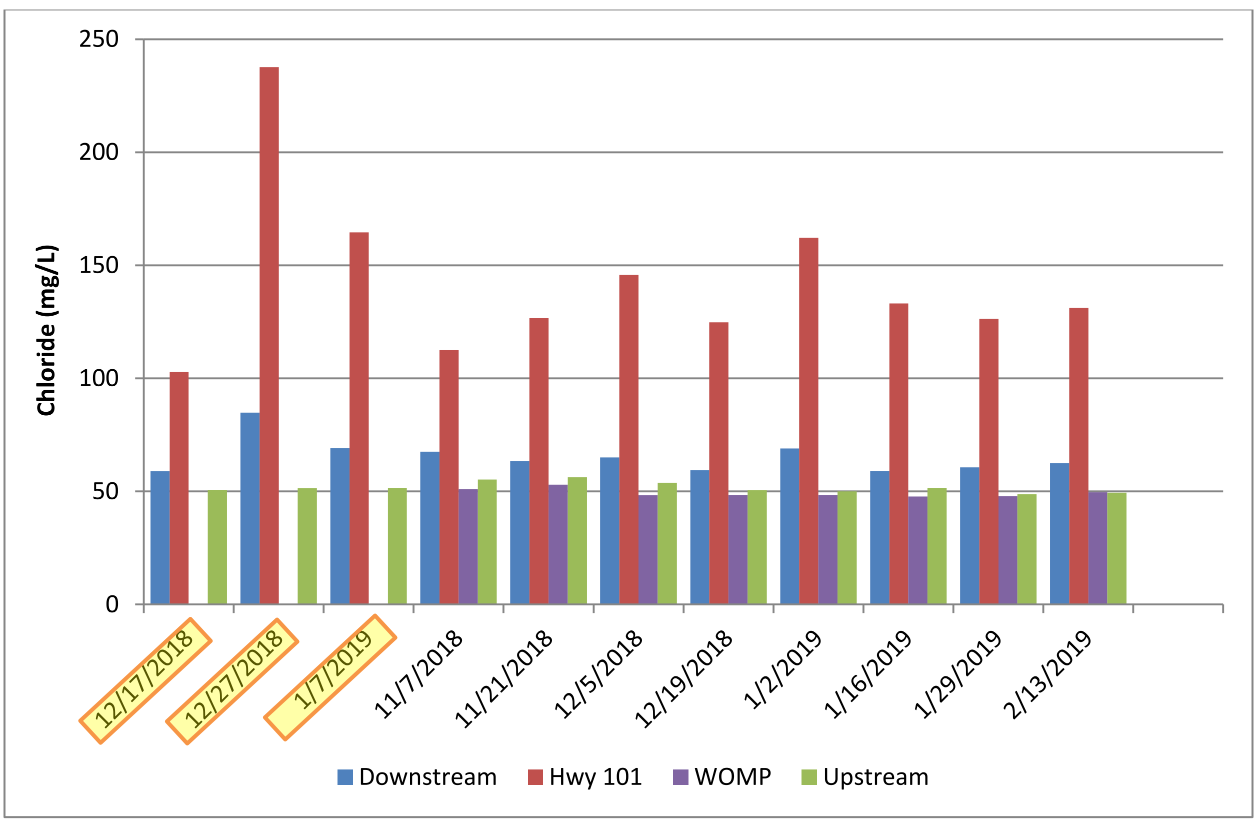

Figure 8. Distribution of chloride concentration for each grab sample. Highlighted dates are event samples and do not include WOMP values.

Watershed Outlet Monitoring Program

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 water quality and flow 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	2018 Precipitation* (inches)	30 Year Precipitation Average**
January	1.78	0.73
February	1.22	0.62
March	1.66	1.73
April	2.32	2.53
May	3.41	3.69
June	7.57	4.64
July	3.69	3.49
August	1.82	5.05
September	7.03	3.41
October	3.32	2.47
November	1.56	1.64
December	0.00	0.95
Total	**35.38**	**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. The station is set with a composite sampler to collect a number of samples during peak flow events, but due to equipment issues this piece of equipment was not operational during the 2018 sampling season. Instead of composite samples, event samples were collected in conjunction with significant rain events. The goal is to capture the water quality at or near the peak of the hydrograph. The event samples are treated similar to base flow samples and the grab samples are brought to the lab for analysis. Three event samples and twenty six base flow grab samples were collected in 2018. An E. coli grab sample was taken during each base and event sample.

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 and E. coli samples are plotted in figures 7 and 9 respectively. The 5 year trend of monthly TSS values and monthly geometric mean of all E. coli samples taken over the past 10 years are reported in figure 8 and 10 respectively.

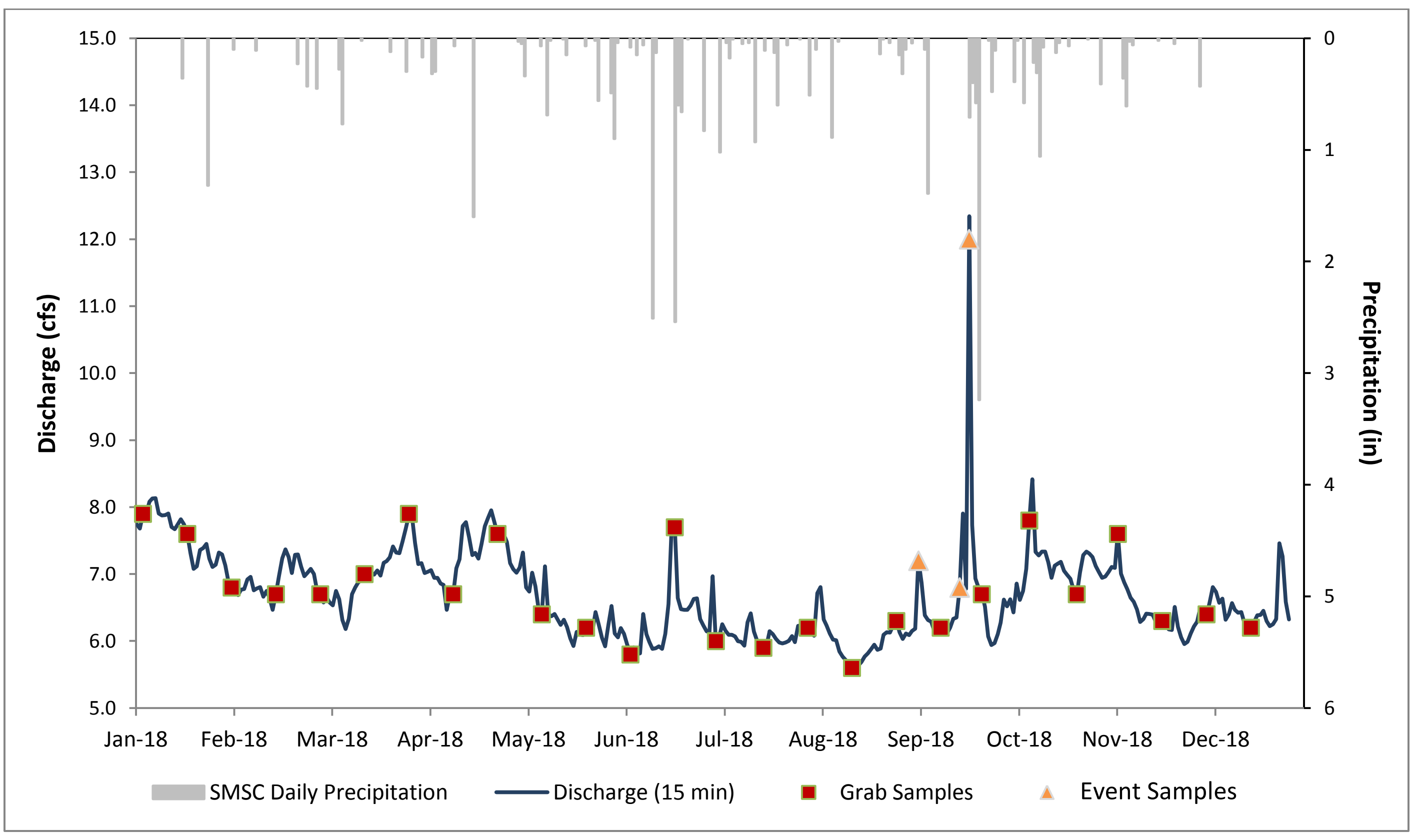

Figure 6: Eagle Creek WOMP Flow, Precipitation, and Sample Schedule (2018). Discharge data is provided by METC and is preliminary.

Table 2. 2018 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_CaCO3)	273	273	280	282	294	294	3	No standard, 20-200 mg/L typical
Chloride (mg/L)	43.9	45.5	48.9	61.5	50.4	**436.8**	29	Standard = 230 mg/L
Hardness (mg/L_CaCO3)	293	293	298	303.33	319	319	3	
Ammonia (mg/L)	0.02	0.05	0.06	0.07	0.08	0.11	29	
Sulfate (mg/L)	17.6	17.6	18.1	18.3	19.1	19.1	3	
Nitrate (mg/L)	0.07	0.15	0.17	0.18	0.22	**0.48**	29	Ecoregion mean = 0.04-0.26 mg/L
Nitrite (mg/L)	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	29	Ecoregion mean = 0.04-0.26 mg/L
Total Kjeldahl Nitrogen (mg/L)	0.18	0.26	0.31	0.33	0.40	0.64	29	
Total Phosphorus filtered (mg/L)	0.020	0.020	0.020	0.023	0.020	0.097	29	Ecoregion mean = 0.06-0.15 mg/L EPA recommends < 0.1 mg/L
Total Phosphorus unfiltered (mg/L)	0.020	0.024	0.038	0.047	0.063	**0.131**	29	Ecoregion mean = 0.06-0.15 mg/L EPA recommends < 0.1 mg/L
Ortho Phosphate (mg/L)	0.005	0.006	0.008	0.008	0.010	0.014	29	
Total Organic Carbon (mg/L)	2.0	2.0	2.2	2.3	2.8	2.8	3	
Suspended Solids (mg/L)	2	4	6	9	12	**27**	29	Ecoregion mean = 4.8-16 mg/L Standard = 10 mg/L
Volatile Suspended Solids (mg/L)	1	2	2	3	4	7	29	
E. Coli (CFU/100ml)	4	20	110	**153**	**200**	**727**	29	Standard = 126 CFU/100ml as geometric mean

Table 3. 2018 *In situ* water quality measurements taken by Hydrolab MS5 multi-probe mini sonde during 2018 sampling.

Parameter	Min	25th %	Median	Avg	75th%	Max	N	Notes
Temp (deg C)	6.51	8.20	10.75	10.51	12.65	13.32	29	
DO (mg/L)	7.47	8.20	8.51	8.58	9.04	9.81	28	Standard = > 7 mg/L
pH (Units)	7.53	7.69	7.71	7.71	7.74	7.83	29	Standard = 6.5-8.5
Conductivity (umho/cm)	364.8	626.7	638.8	639.4	673.0	676.6	29	

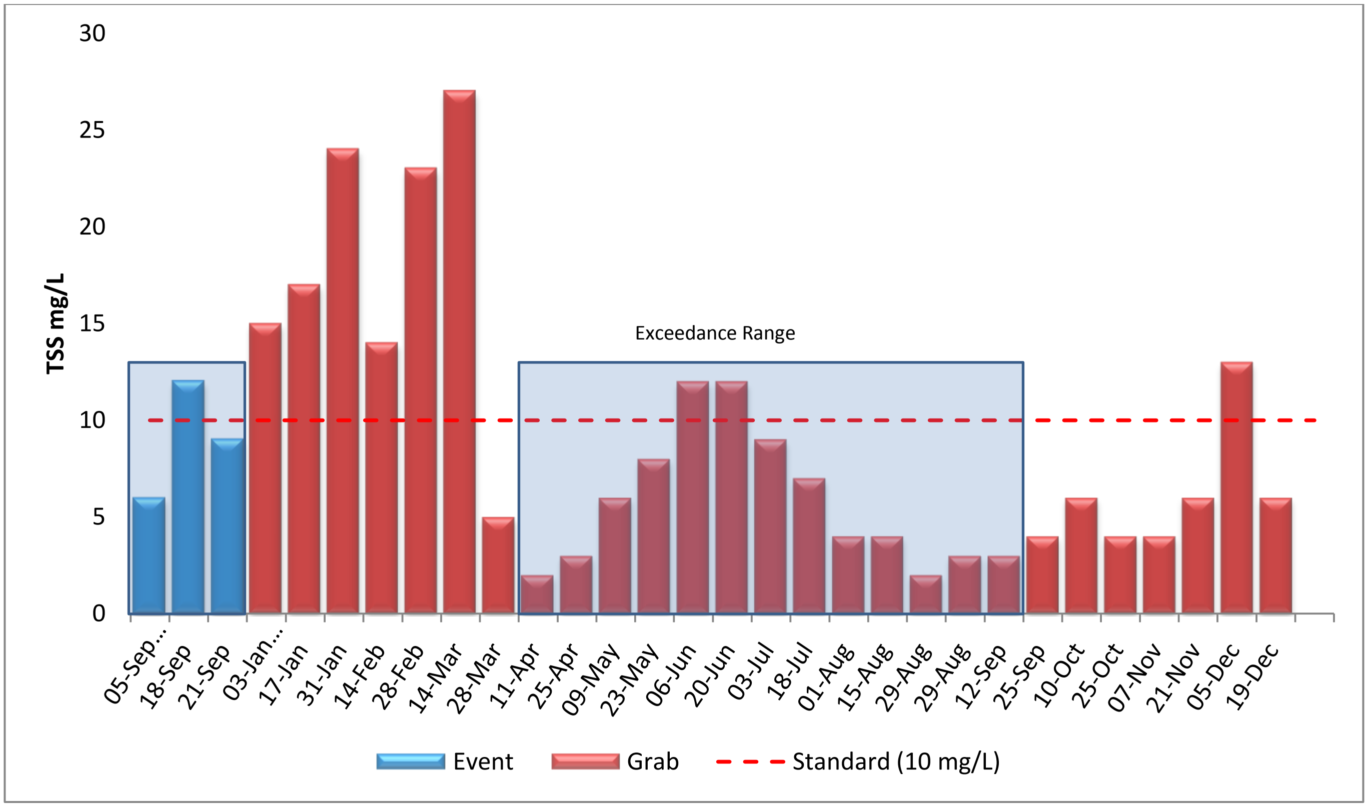

Figure 7. Total Suspended Solids (2018). State Standard for Class 2A Waters = 10 mg/L with no more than 10% exceedance between 1 April and 30 September (indicated by the red dashed line and the blue outlined box).

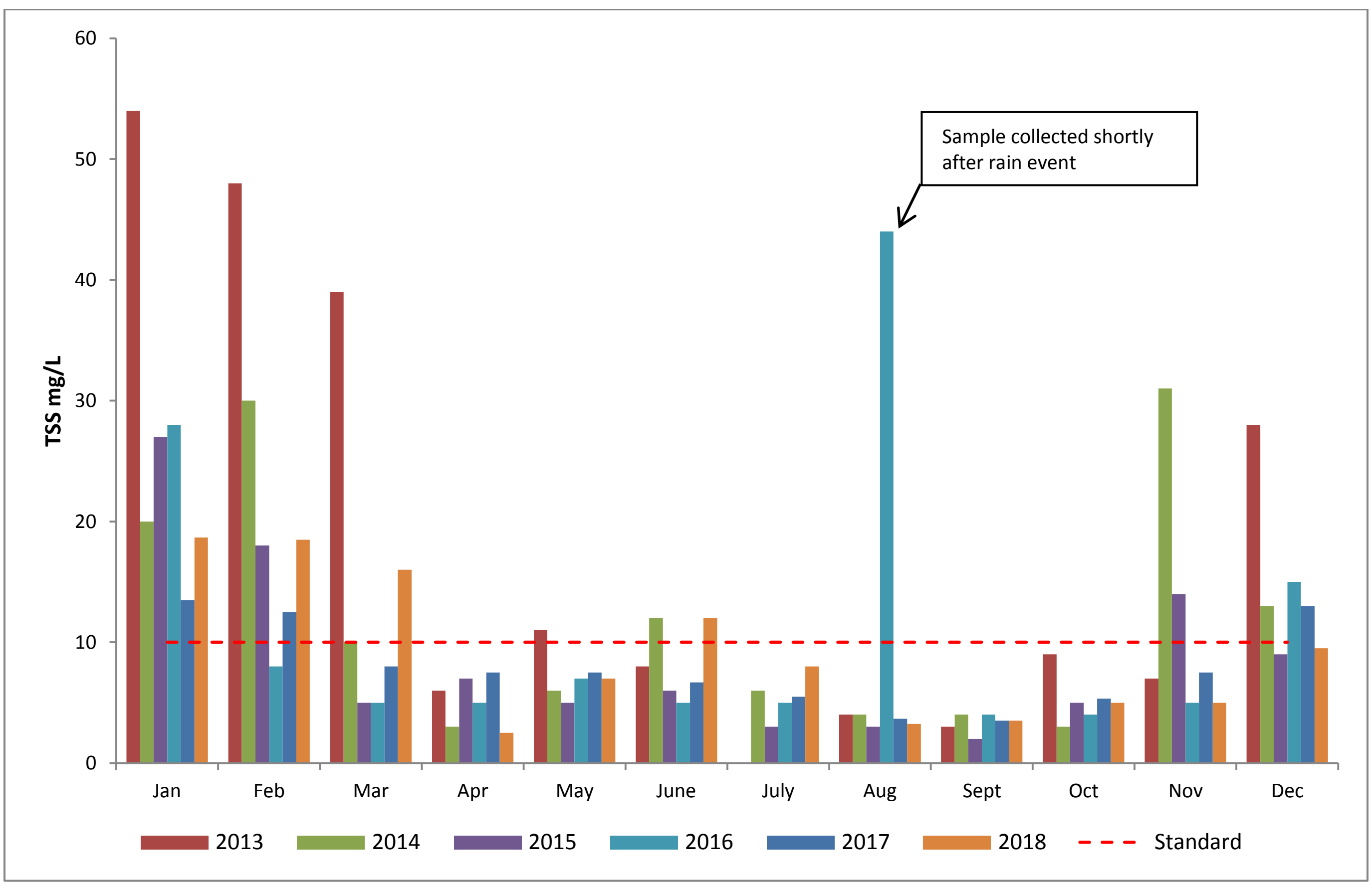

Figure 8. Total suspended solid monthly average over the last 5 years for non-event samples. The state standard is 10mg/L indicated by the dashed red line. No more than 10% exceedance shall occur between 1 April and 30 September.

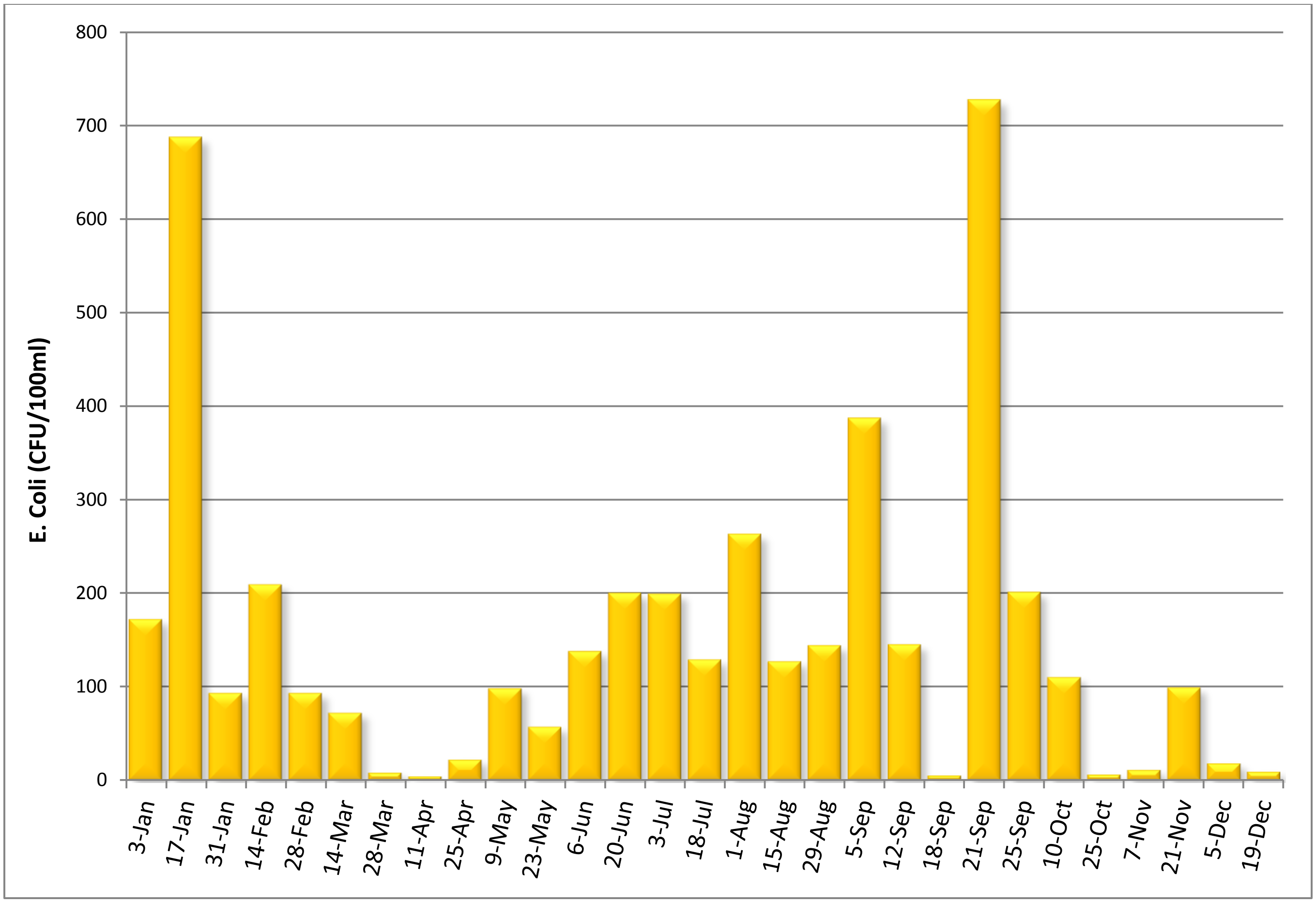

Figure 9. *E. coli* samples (2018). *E. coli* state standard for class 2A waters is not to exceed 126 organisms/100 ml as a geometric mean of not less than 5 samples representative of conditions within any calendar month. Nor shall more than 10% of all samples taken during any calendar month individually exceed 1,260 organisms per 100 ml. The standard applies only between April 1 and October 31.

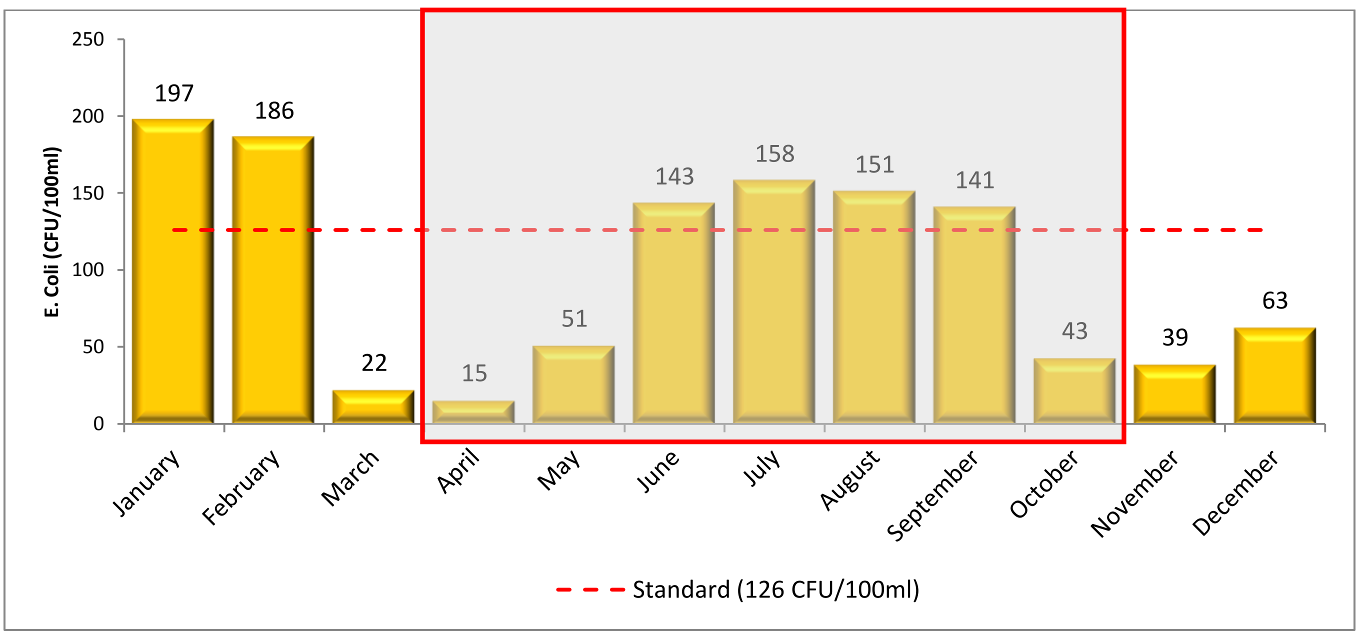

Figure 10. Geometric mean of *E. coli* at Eagle Creek. The geometric mean was calculated using all samples over the past 10 years (2008-2018) for any given month. *E. coli* state standard for class 2A waters is not to exceed 126 organisms/100 ml as a geometric mean of not less than 5 samples representative 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 thru September exceed the chronic 126 standard.

Discussion

New to the Eagle Creek monitoring activities in 2018 the chloride data is already showing signs of potential areas contributing to higher chloride levels. Although all recorded chloride levels within Eagle Creek are below state standards of 230 mg/L the pond adjacent to the creek has elevated levels (Figure 8). The samples downstream of the pond confluence have also shown to have an uptick in chloride levels, likely due to the ponds influence. As the elevated snow levels around the watershed begin to melt it is likely that chloride contributing areas will become more predominant in the collected samples.

In general, the monitoring data suggests that Eagle Creek consistently meets state water quality standards and ecoregion means[1], with the exceptions being bacteria and suspended solids (Figure 10 and Table 2). 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 historically higher bacteria, sediment, and turbidity levels than observed in summer months (Figures 8 and 10). Elevated levels during the summer are a result of continual waterfowl use and runoff from significant rain events (Figure 7 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 9). However, the geometric mean of the previous ten years of *E. coli* samples resulted in the exceedance of 126 CFU's for June thru September (Figure 10). January and February also exceeded the 126 CFU threshold leaving six month below the standard.

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 2 of 13 (15%) lab samples during the applicable season (Figure 7). In addition one of the three event samples and all samples from January to mid-March that were collected exceeded the 10 mg/L level.

III. Dean Lake Inlet Monitoring

Dean Lake Inlet was once on the Minnesota Pollution Control Agency (MPCA) 303 (d) list of impaired waters from 2006-2016. It was impaired for Aquatic Recreation due to excess nutrients causing eutrophication. In 2016 the body of water was re-assessed and reclassified as a wetland in the MPCA's Lower Minnesota River Watershed Monitoring and Assessment Report of June 2017. Although the reclassification removes the body of water from the 303 (d) list the nutrient loading still remains. Scott SWCD continues 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 at this location. This site has been monitored from 2014 to present.

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[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 is measured with a 1 meter secchi tube. Bi-weekly scheduled samples and additional event grab samples taken after rain events are taken while the stream channel is open (April-November). In 2018, 17 base grab samples and 4 event grab samples were collected totaling 21 samples. In addition to water quality samples, a total of six periodic flow measurements taken in 2018 and in conjunction with flow measurements taken over the previous years a discharge rating curve is developed. This rating curve is applied to the continuous 15 minute stage measurements collected by Campbell Scientific SR50 Ultrasonic Distance Sensor and CR1000 data logger to calculate continuous discharge data at the site (Figure 11).

Results

The 2018 monitoring data suggest that the inlet to Dean Lake meets MN water quality standards for all measurable categories, but it fell out of ecoregion mean and EPA recommendations for Phosphorus and Nitrate (Table 3). Historically, the inlet has seen spikes in Nitrate and Phosphorus. In the past three years grab samples have shown Phosphorus levels exceeded EPA recommendations an average of 33% of the time, but only exceeded the ecoregion mean 17% of the time. Similarly, Nitrates exceeded ecoregion means 60% throughout the last three years. Suspended solids have also shown signs of values exceeding the state and ecoregion standards 33% and 25% of the time respectively over the last three years.

Table 3. 2018 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	25th %	Median	Avg	75th%	Max	N	Notes
Chloride (mg/L)	47.4	50.4	53.6	54.1	58.0	61.2	20	
Nitrate (mg/L)	0.05	0.11	0.19	0.29	0.46	0.90	21	Ecoregion mean = 0.04-0.26 mg/L
Nitrite (mg/L)	0.30	0.03	0.03	0.03	0.03	0.05	21	Ecoregion mean = 0.04-0.26 mg/L
Total Kjeldahl Nitrogen (mg/L)	0.43	0.64	0.77	0.80	0.90	1.30	21	
Total Phosphorus filtered (mg/L)	0.020	0.020	0.025	0.037	0.043	0.129	21	Ecoregion mean = 0.06-0.15 mg/L EPA recommends < 0.1 mg/L
Total Phosphorus unfiltered (mg/L)	0.022	0.042	0.060	0.067	0.076	0.174	21	Ecoregion mean = 0.06-0.15 mg/L EPA recommends < 0.1 mg/L
Lab Turbidity (NTRU)	2	4	5	7	8	30	21	
Suspended Solids (mg/L)	3	4	7	13	12	44	21	Ecoregion mean = 4.8-16 mg/L
Volatile Suspended Solids (mg/L)	1	2	2	4	5	10	21	

Table 4. 2018 *In situ* water quality measurements taken by a YSI EXO1 multi-probe mini sonde for Dean Lake Inlet.

Parameter	Min	25th %	Median	Avg	75th%	Max	N	Notes
Temp (deg C)	2.61	12.34	17.57	16.62	21.68	25.20	21	
DO (mg/L)	4.50	6.75	7.65	8.15	9.24	13.26	21	
pH (Units)	7.44	7.55	7.81	7.77	7.97	8.13	21	
Conductivity (umho/cm)	397.8	423.5	449.4	495.6	576.1	695.1	21	

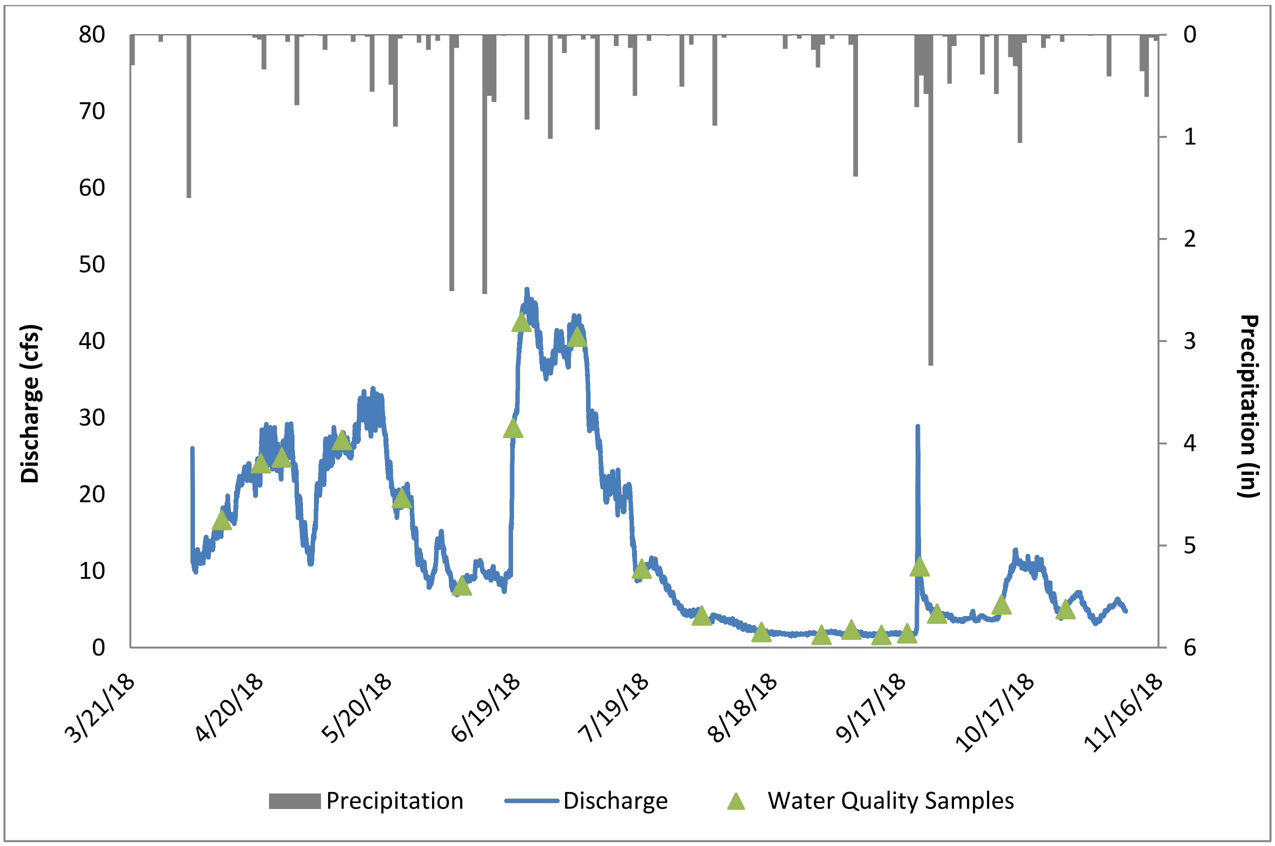

Figure 11. Dean Lake Inlet Flow, Precipitation, and Sample Schedule (2018).

Discussion:
Most of the water quality parameters at the Dean Lake Inlet are within the recommended standards and ecoregion averages. The levels of Phosphorus are generally within the recommended ranges; with concentrations only exceed the standards 17% of the time, on the other hand Nitrates are exceeding 60% of the time in the last three years. In both cases, most exceedance is occurring after precipitation events, droughts, or seasonally influence. Monitoring these levels should continue to track any potential increases or decreases in these levels. Although Dean Lake Inlet is no longer on the 303 (d) list because of its reclassification, it is important to track the amount of nutrients at the site to maintain historical data and track nutrient loading downstream.

IV. Well Monitoring

In 2005 the LMRWD contracted with Scott Soil and Water Conservation District to collect groundwater measurements from 13 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 13 wells in the Savage Fen monthly between April and November (Figure 12). 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 14).

The SWCD monitors two additional wells in the Savage Bluff area. In 2010 the Savage Post Office and Fire Department was constructed near the bluff wellheads and as a result, the wellheads were reconstructed and placed below the street, accessible beneath a manhole cover. The SWCD did not read these two wells in 2011 or 2012 as a result of the construction. In 2013, the SWCD resumed monitoring these wells with the City of Savage staff providing access.

In total, the SWCD recorded 129 water level measurements in 2018 from 19 wells for LMRWD.

Results

The Savage Fen water levels started and ended at relatively the same levels even with a spike in June and a drop in late August (Figure 12). Overall, the average Savage Fen water levels for 2018 increased 0.198 feet throughout the year, even with a significant drop in levels during August (Figure 14, 15 &16). Historically, the Fens have shown signs of fluctuation, and besides a dip in 2012 the water levels have shown a general sign of increase. This year the wells continue to rise with an average 0.31 foot gain in water levels over the last 11 years (Figure 13). The 2018 Eagle Creek well levels generally showed an increase throughout the year with all the wells averaging a 0.43ft rise throughout the year (Figure 17). Only EC3 showed a drop in the average yearly water levels dropping 0.29ft throughout 2018, while EC5 had the largest average gain of 1.83ft. Over the past 11 years average water level shows a 0.39ft rise in water elevations with EC3, EC4 and EC6 gaining 0.23, 0.45, 1.13 respectively (Figure 18). The only historical average decrease in elevation was EC5 with a drop of 0.043ft.

The bluff wells both showed signs of dropping water levels throughout the year (Figure 19). The water level in the deep bluff dropped 0.90ft throughout 2018, and the shallow well also dropped 0.91ft. The historic monitoring at the bluff well sites is discontinuous due to construction. However, since the construction water levels have generally increased and are the highest levels recorded since the initial observation in 1994 (Figure 20). This year is the first year that the wells have shown signs of decreasing water levels since post construction observations, but are still higher than the initial post construction observations. All figures in this section are reported in depth to water (DTW) which is a product of the wells measuring point elevation minus the elevation of the recorded observed elevation.

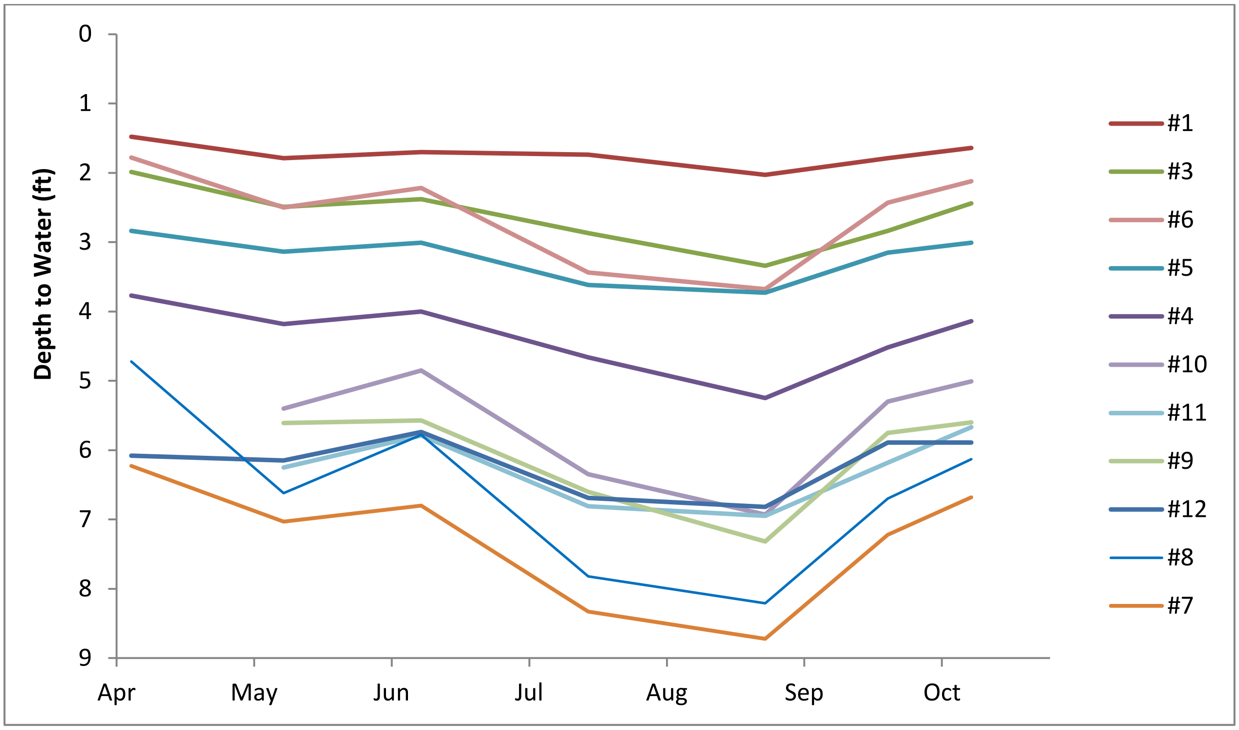

Figure 12. Savage Fen Wells (2018).

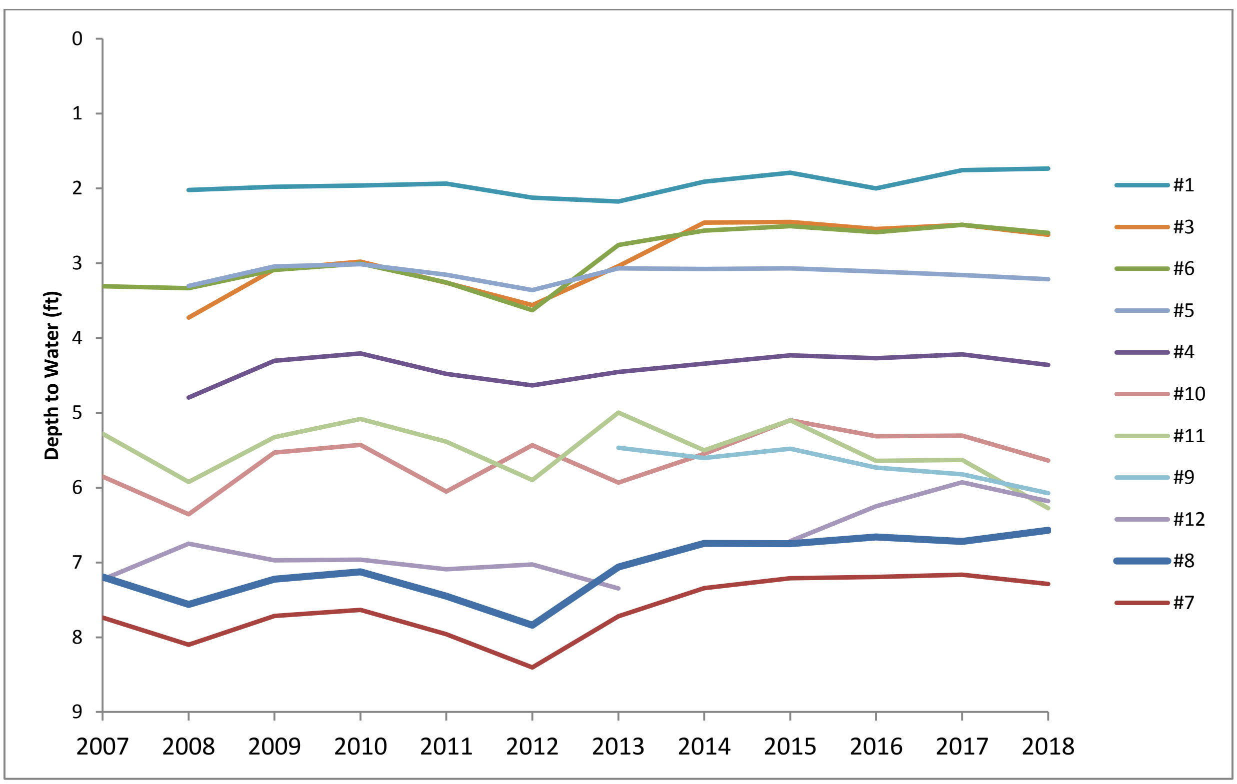

Figure 13. Average annual water level in Savage Fen wells (2007-2018). Averages include all observations in a calendar year.

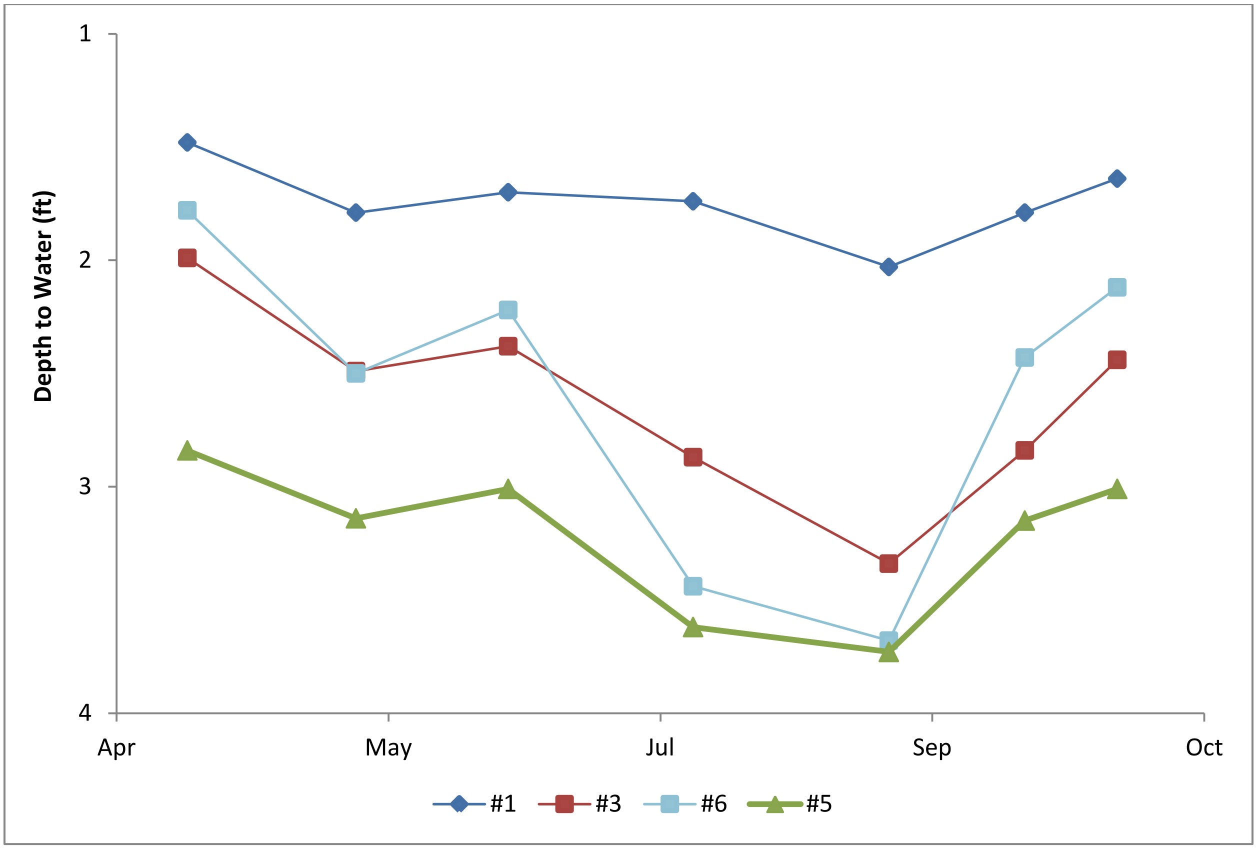

Figure 14. The four Savage Fen wells with the lowest DTW values (2018).

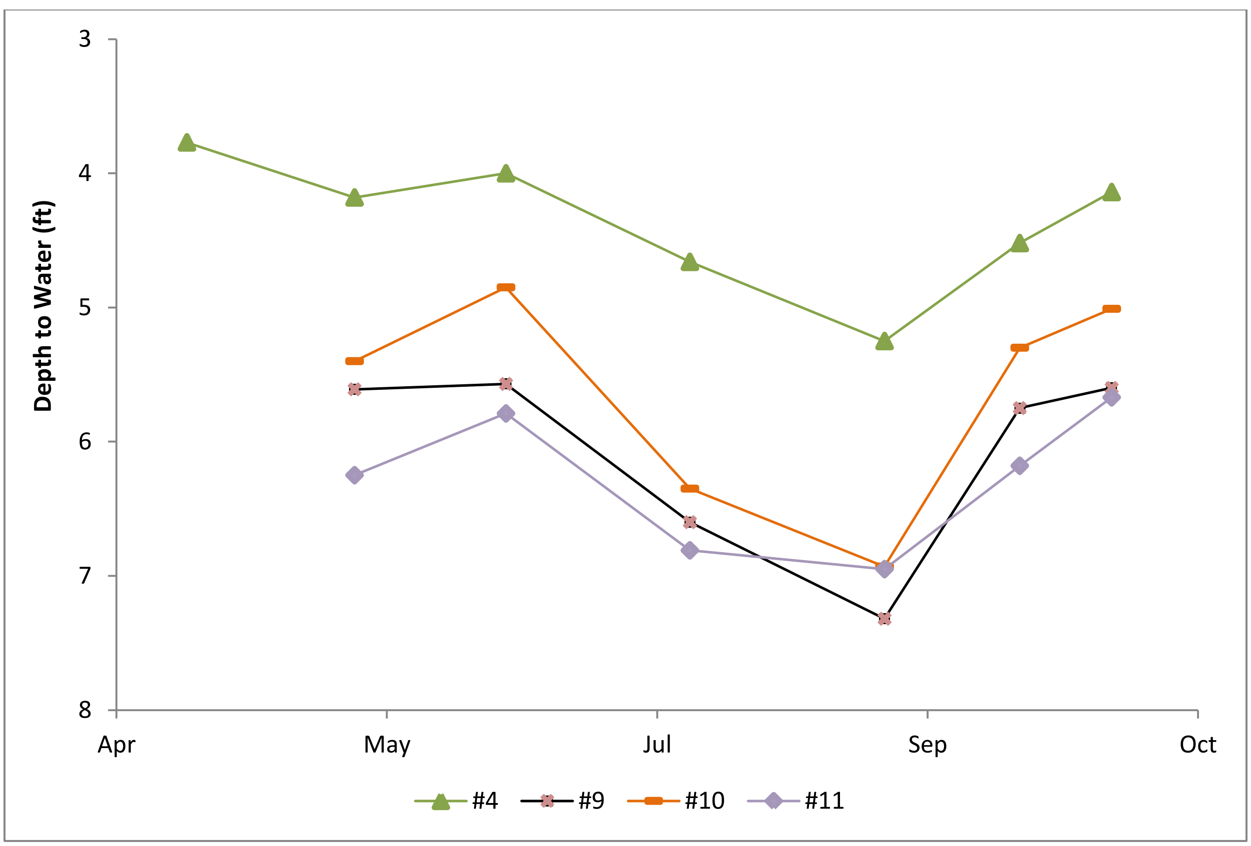

Figure 15. The four Savage Fen wells with the mid-level DTW values (2018).

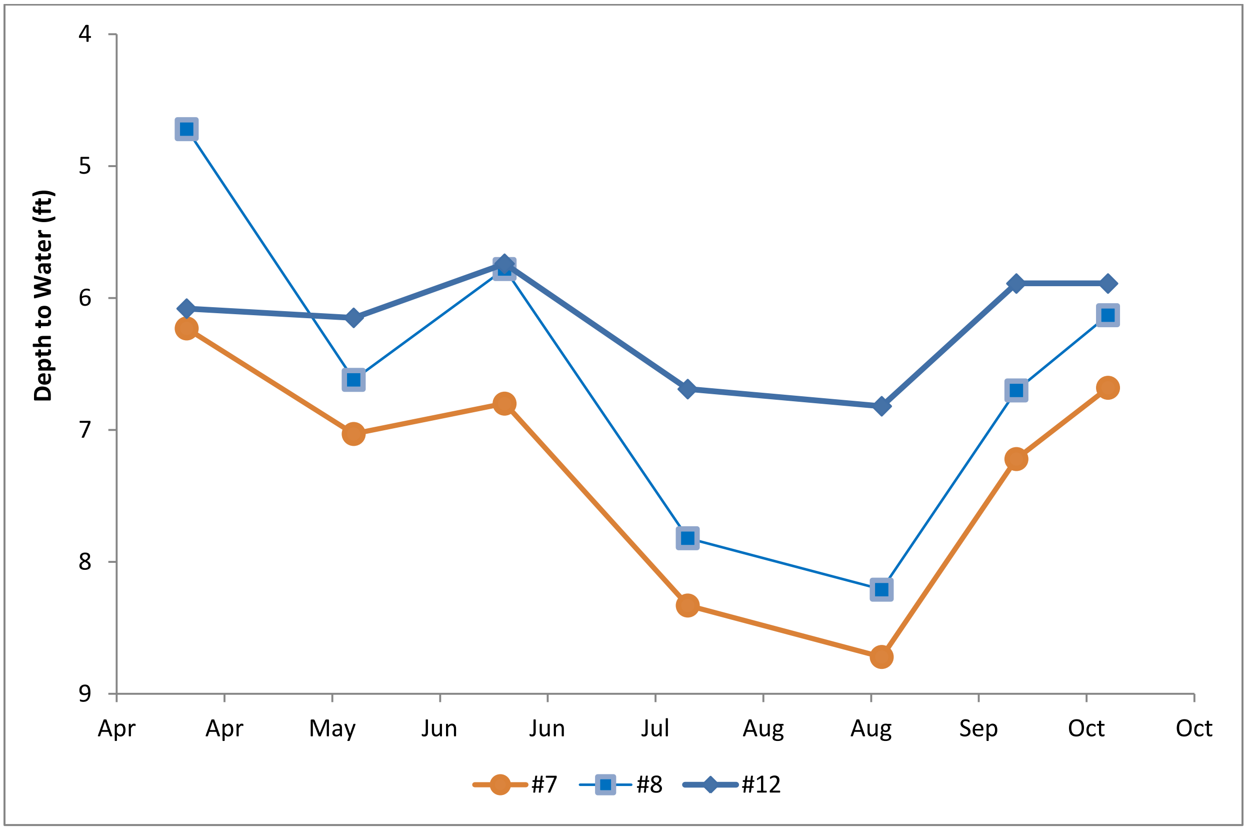

Figure 16. The three Savage Fen wells with the highest DTW values (2018).

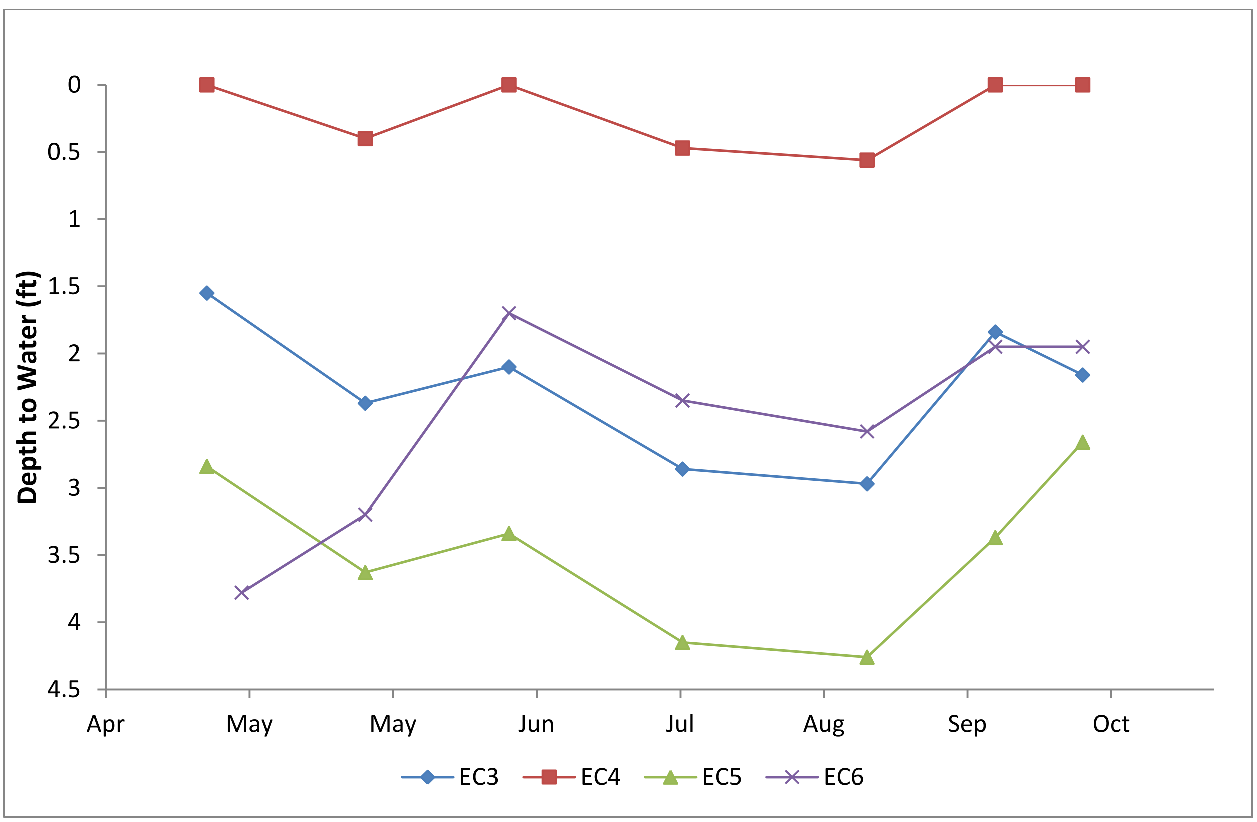

Figure 17. Eagle Creek wells (2018).

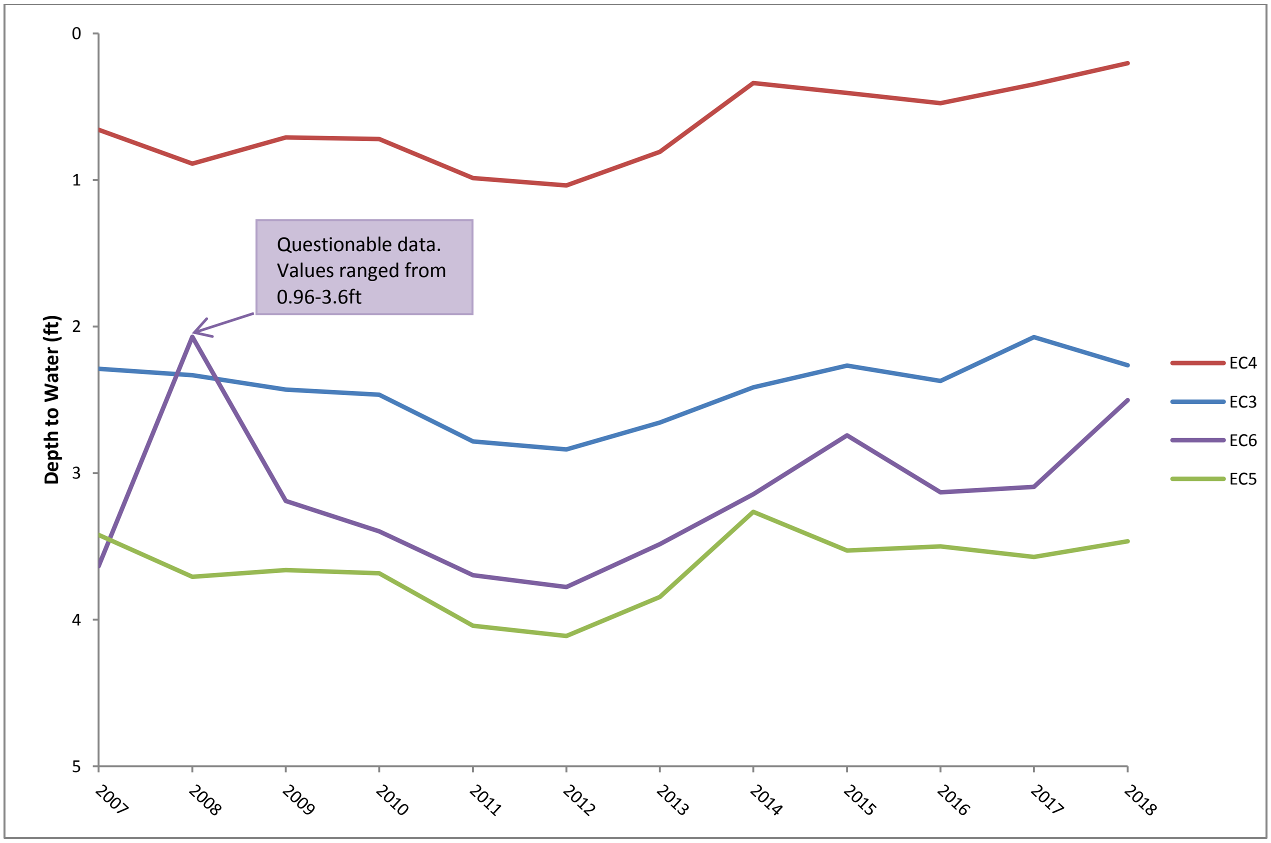

Figure 18. Eagle Creek historical 10 year trend. Values are yearly averages and include all values taken within the year.

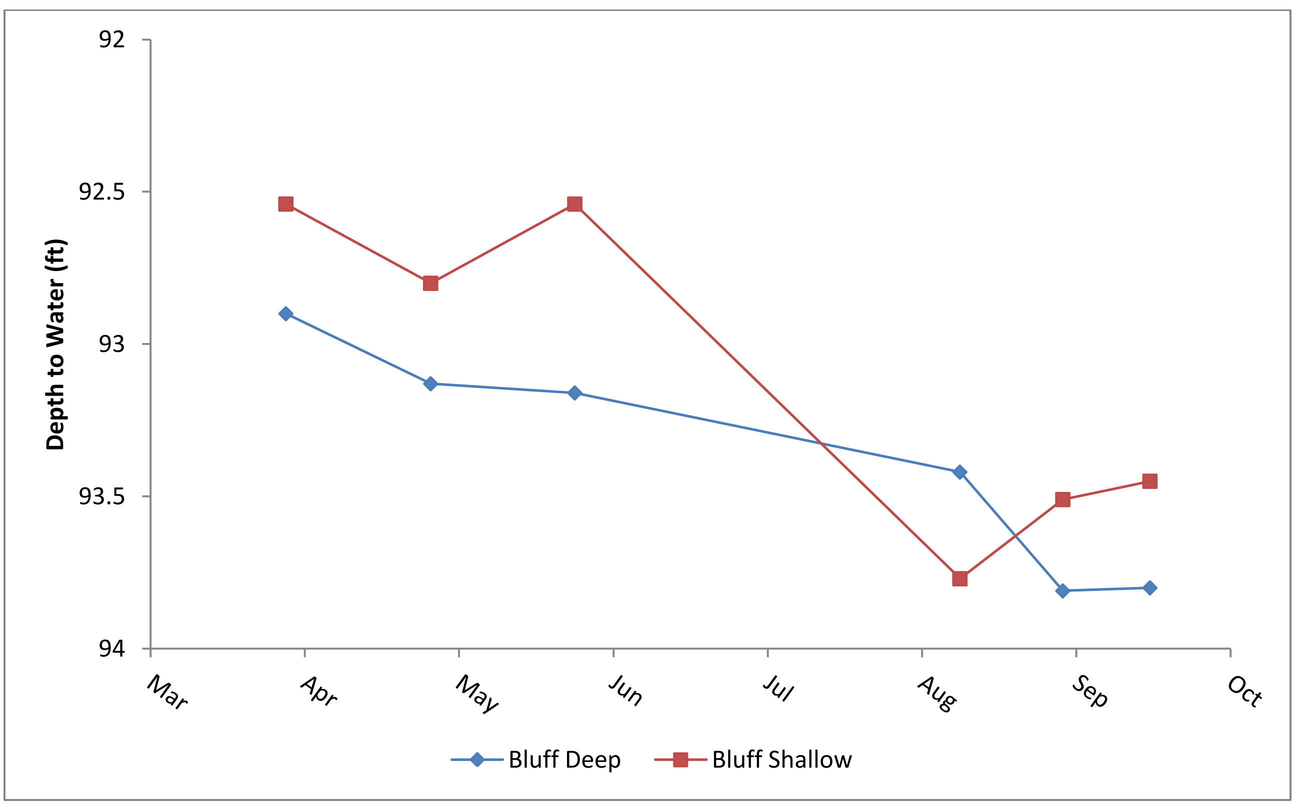

Figure 19: Shallow and deep bluff well data (2018).

Figure 20. 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.

Discussion:

All the wells in the LMRWD area (except the bluff wells) continue to show signs of increase since a draw down in 2012. For the past 3-5 years the Savage Fen wells have leveled off with only slight increases in their levels. It appears that they are reaching a normalized state. Seasonally, the Savage Fens had a significant draw down period during the summer. There was a moderate dry spell during the middle of the summer in 2018 followed by a very wet fall resulting in a yearly average nearly 5in above the 30yr average (Table 1). This amount of moisture likely allowed the wells to recharge causing an up-tick after the drawdown periods resulting in a yearly net gain in levels. This was the first year since the construction that the Bluff Wells showed a sign of decreasing water levels. The levels showed some signs of recovery during the end of the monitoring season, and are still historically higher than initial and post construction observations. Continual monitoring of all the wells in the LMRWD area will provide information on groundwater levels that can provide information on the impacts of water usage and recharge capabilities.

V. References

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