technical memo

Project Name |	2016 Water Quality Monitoring	**Date** |	1/13/2016
To / Contact info |	Kayla Hasper: Squaw Creek WMA		
From / Contact info |	Pat Conrad, Meghan Funke, Joe Pallardy		
Regarding |	2016 Water Quality Monitoring Summary Report		

In an effort to establish a baseline measurement of water quality, the Squaw Creek WMA has installed automated monitoring stations within Squaw Creek immediately downstream of the Lincoln Way crossing in Ames and within East Indian Creek at the 650th St. crossing, southeast of Nevada (Figure 1). The monitoring stations consist of a level logger and an automated sampler which facilitates collection of grab samples as well as flow-based storm samples. The monitoring stations were installed in the fall of 2015 for a brief trial period and were re-deployed in the early spring of 2016. The monitoring stations recorded water level information within the streams at 15 minute intervals and were programmed to take storm-event samples when the water level within the stream reached a certain level. In addition to storm-events, grab samples were taken via automated samplers every two weeks throughout the year. The following memorandum summarizes the 2016 monitoring results.

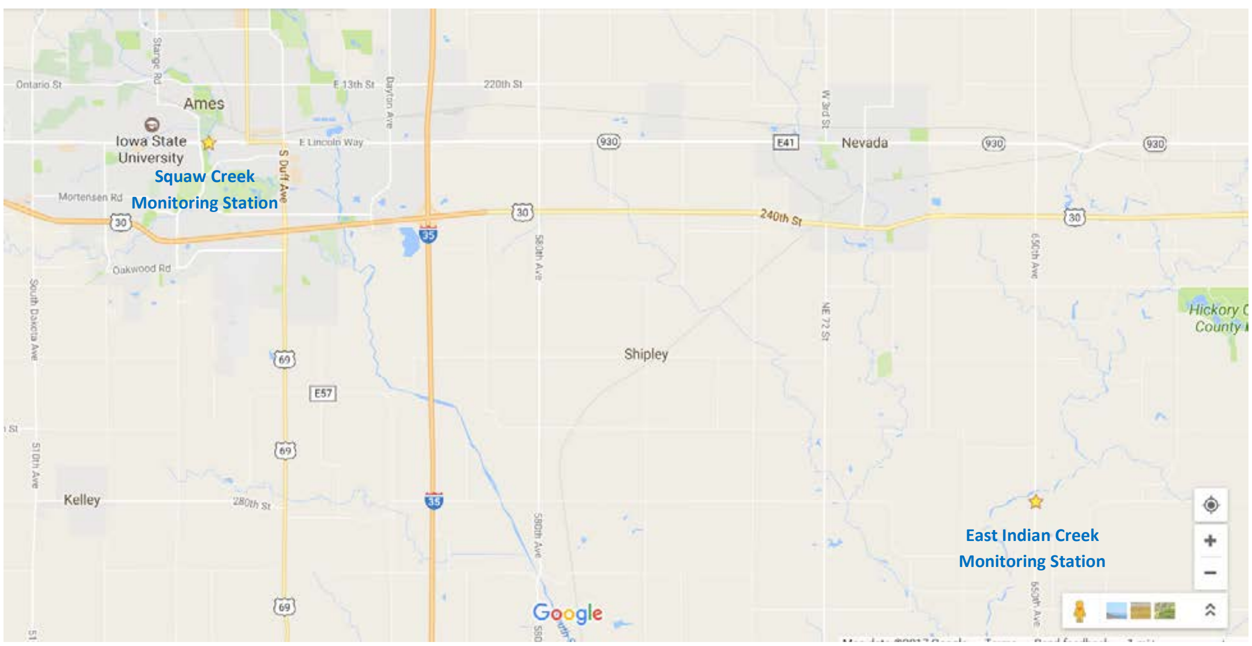

Figure 1. Monitoring Station Locations

1. WATER QUALITY CRITERIA

Based on its 1998 Nutrient Strategy, EPA (1998) developed a plan to adopt numeric nutrient criteria to protect surface waters against the negative effects of nutrient enrichment. In 2000, EPA issued nutrient criteria recommendations derived from statistical distributions of nutrient data from the nation's lakes and rivers (EPA 2000). These recommendations were developed with the available water quality data for each of the 14 "nutrient ecoregions" nationwide. Ecoregions are defined as areas of relative homogeneity in ecological systems and their components. Both East Indian Creek and Squaw Creek fall within Ecoregion VI: Corn Belt and Northern Great Plains and more specifically within Level III aquatic ecoregion Western Corn Belt Plains. **No state specific criteria have been established in Iowa, therefore, the EPA recommended criteria were used for this analysis.** Table 1 outlines applicable EPA Ecoregion 25th percentile for the Western Corn Belt Plain Ecoregion as well as the EPA Recommended Criteria Range for Iowa Streams.

2016 water quality monitoring data for East Indian Creek and Squaw Creek were evaluated in comparison with these criteria.

Table 1. Applicable Water Quality Criteria

Parameter	EPA Ecoregion 25th percentile	EPA Recommended Criteria Range for Iowa Streams
Total Phosphorous	0.118 mg/L	0.07 to 0.118 mg/L
Total Nitrogen	3.3 mg/L	0.712 to 3.26 mg/L
Parameter	**Long Term Geometric Mean**	**Maximum Sample MPN/100ml**
E. coli	126 MPN/100ml	235 MPN/100ml

2. EAST INDIAN CREEK 2016

A total of sixteen samples were collected from East Indian Creek from April through October in 2016 (Table 2).

Observed nitrogen concentrations (measured as Nitrate using EPA Method 4500 NO3D) were consistently higher than the EPA Recommended Criteria Range for Total Nitrogen (TN) with the exception of two samples collected on 8/10/2016 and 9/16/2016 (Figure 2). TN concentrations were highest during baseflow events suggesting near stream sources of nitrate as opposed to watershed runoff during storm events. The total annual TN load for East Indian Creek was estimated at 1,230,930 pounds per year.

Note: In this monitoring effort, samples were analyzed for the Nitrate form of nitrogen. The common convention when discussing nitrogen levels in streams is to report on Total Nitrogen, which includes ammonia, organic nitrogen and nitrate-nitrite. However, nitrate typically represents the largest portion of total nitrogen in surface water samples and therefore was used as a surrogate for total nitrogen concentrations. But as a result, total nitrogen levels reported are likely underestimated.

Observed total phosphorus (TP) concentrations were consistently reported below 0.1 mg/L which is the detection limit for Hach method 8190. Unfortunately, this is a relatively high detection limit which limits the capacity to compare these samples to the EPA Recommended Criteria Range of 0.07 to 0.118 mg/L (76-118 ug/L). Observed TP concentrations in grab samples collected during baseflow events were consistently below the EPA Recommended Criteria Range (Figure 3). Observed TP concentrations from grab samples collected following storm events in July and September were consistently above the EPA Recommended Criteria Range. The correlation between storm events and high observed TP concentrations suggests phosphorus loading increases as a function of increased overland flow during storm events. The total annual TP load for East Indian Creek was estimated at 47,147 pounds per year. Given that TP concentrations were highest during periods when stream flow (discharge) was also highest, the majority of the total annual TP load was derived from a small number of storm events that collectively represent a relatively small period of the entire monitoring season.

The observed *E. coli* geometric mean concentration was calculated by grouping samples into groups of two based on sampling date to help offset the impacts of extremely high or low observed values. A comparison of these values with the Iowa state standard of 126 organisms/100 ml revealed exceedances throughout the year with the highest values observed during storm events (Figure 4). The geometric mean for all samples collected from April through October was 1,283 organisms/100 ml. Increases in observed *E. coli* concentrations in samples collected following storm events indicates non-point sources are the predominant source of *E. coli* to this portion of East Indian Creek.

Observed Total Suspended Solids (TSS) concentrations in grab samples collected during baseflow events were significantly less than observed TSS concentrations from grab samples collected during storm events in July and September (Figure 5). The total annual TSS load for East Indian Creek was estimated at 68,789,330 pounds per year. Given that TSS concentrations were also highest during periods when stream flow (discharge) was also highest, the majority of the total annual TSS load was derived from a small number of storm events that represent a relatively small period of the entire monitoring season. The combination of high TSS loading with high TP loading during storm events provides evidence to suggest that the majority of the TP load is from sediment bound phosphorus.

Table 2: East Indian Creek Monitoring Results

Sample Date	Flow (m^3/s)	Nitrate (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	E.coli (MPN/100ml)
04/13/16	0.92	9.3	<0.1*	4.8	74
04/27/16	0.71	9.2	<0.1*	9.1	249
05/11/16	1.27	11	<0.1*	23	272
05/25/16	0.50	9.7	<0.1*	6.8	1,439
06/08/16	1.23	14	0.15	31	307
06/22/16	0.15	10	<0.1*	6.2	870
07/06/16	0.08	5.2	<0.1*	13	1,456
07/20/16	5.66	5.3	0.32	240	9,048
07/27/16	0.09	7.7	<0.1*	11	545
08/10/16	0.02	2.5	<0.1*	20	1,515
09/09/16	5.66	6.6	0.3	88	5,848
09/15/16	1.06	7.7	<0.1*	31	5,794
09/16/16	22.60	3	1.1	1,500	23,590
09/23/16	15.57	7	0.37	1,300	5,460
09/28/16	9.91	7.7	0.16	510	369
10/12/16	0.92	7.1	<0.1*	95	576

m^3/s – cubic meters per second, mg/l – milligrams per liter, MPN/100ml – most probable number(organisms) per 100 milliliters
<0.1* = Laboratory phosphorus detection limit

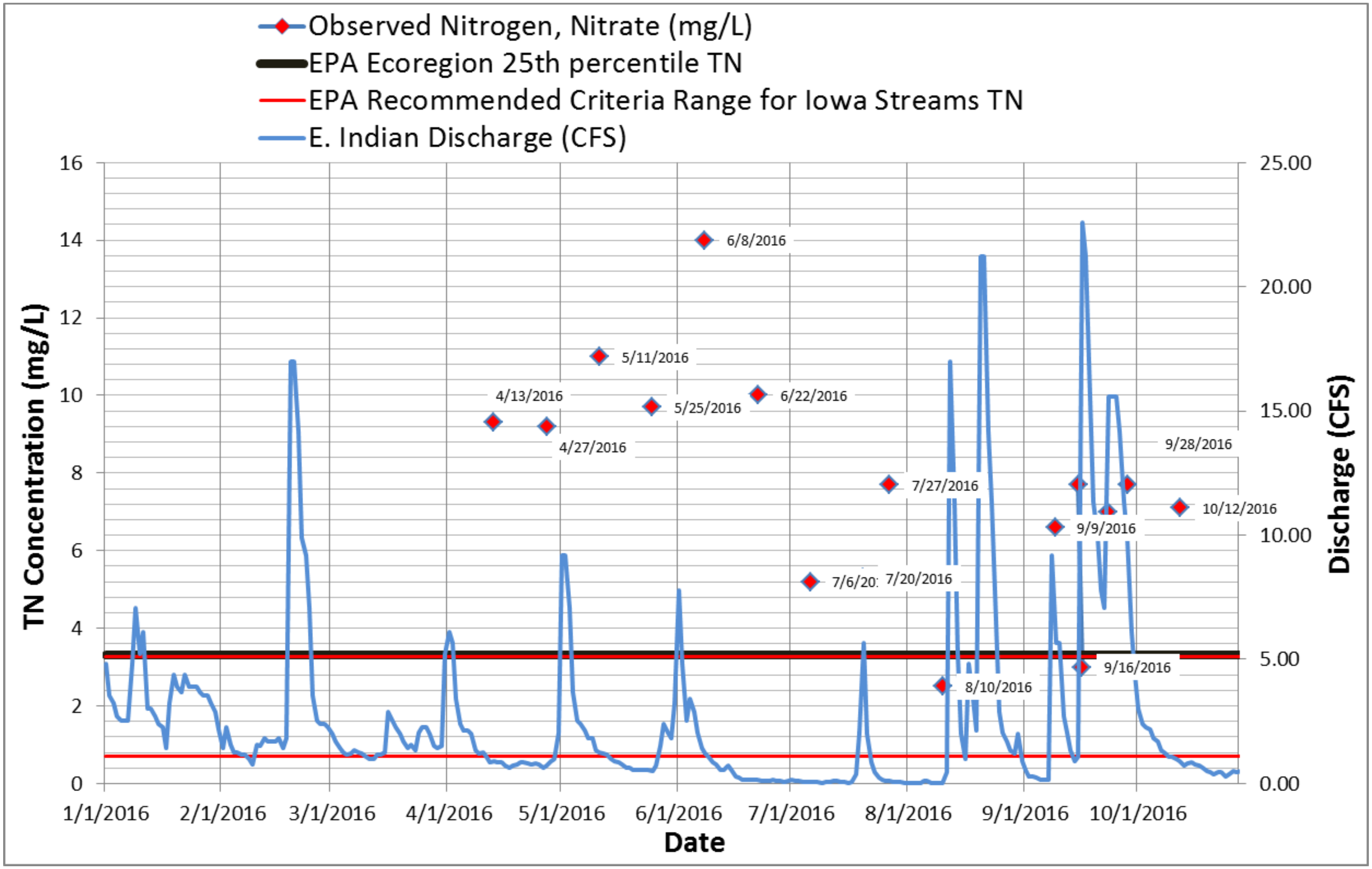

Figure 2. 2016 Observed Nitrogen (Nitrate) Concentrations for East Indian Creek in Relation to Flow (Discharge).

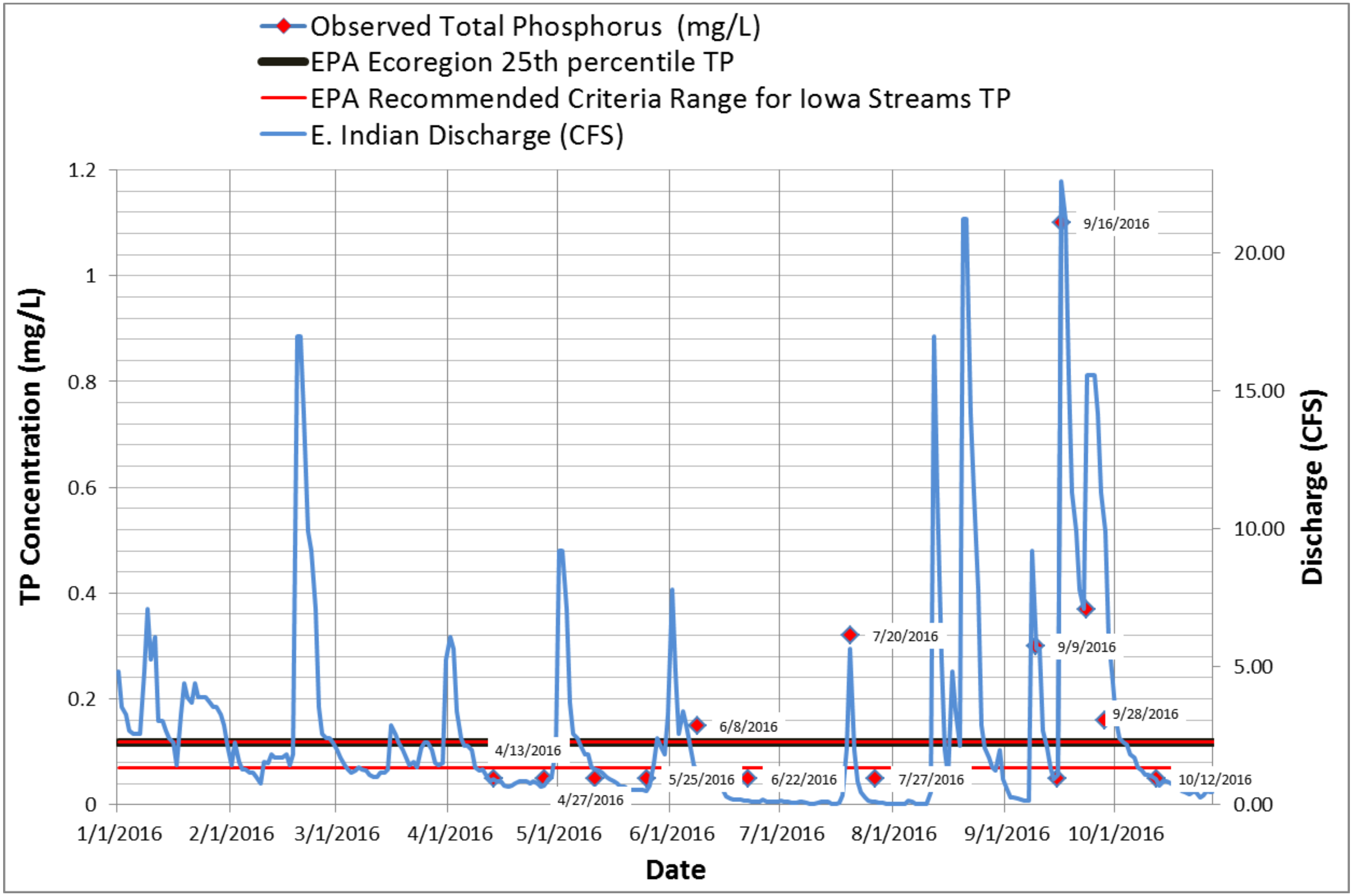

Figure 3. 2016 Observed Total Phosphorus Concentrations for East Indian Creek in Relation to Flow (Discharge).

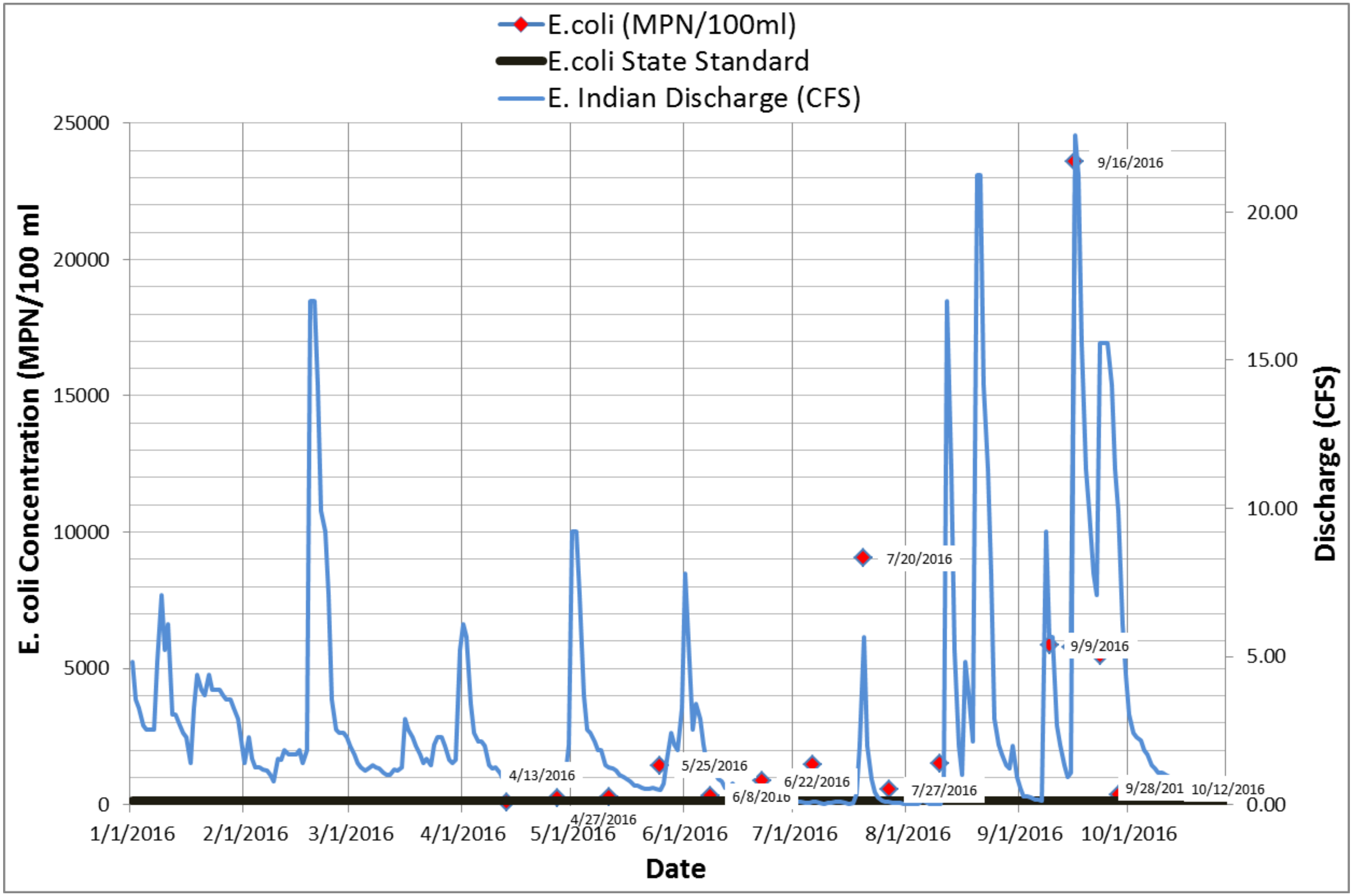

Figure 4. 2016 Observed E. coli Concentrations for East Indian Creek in Relation to Flow (Discharge).

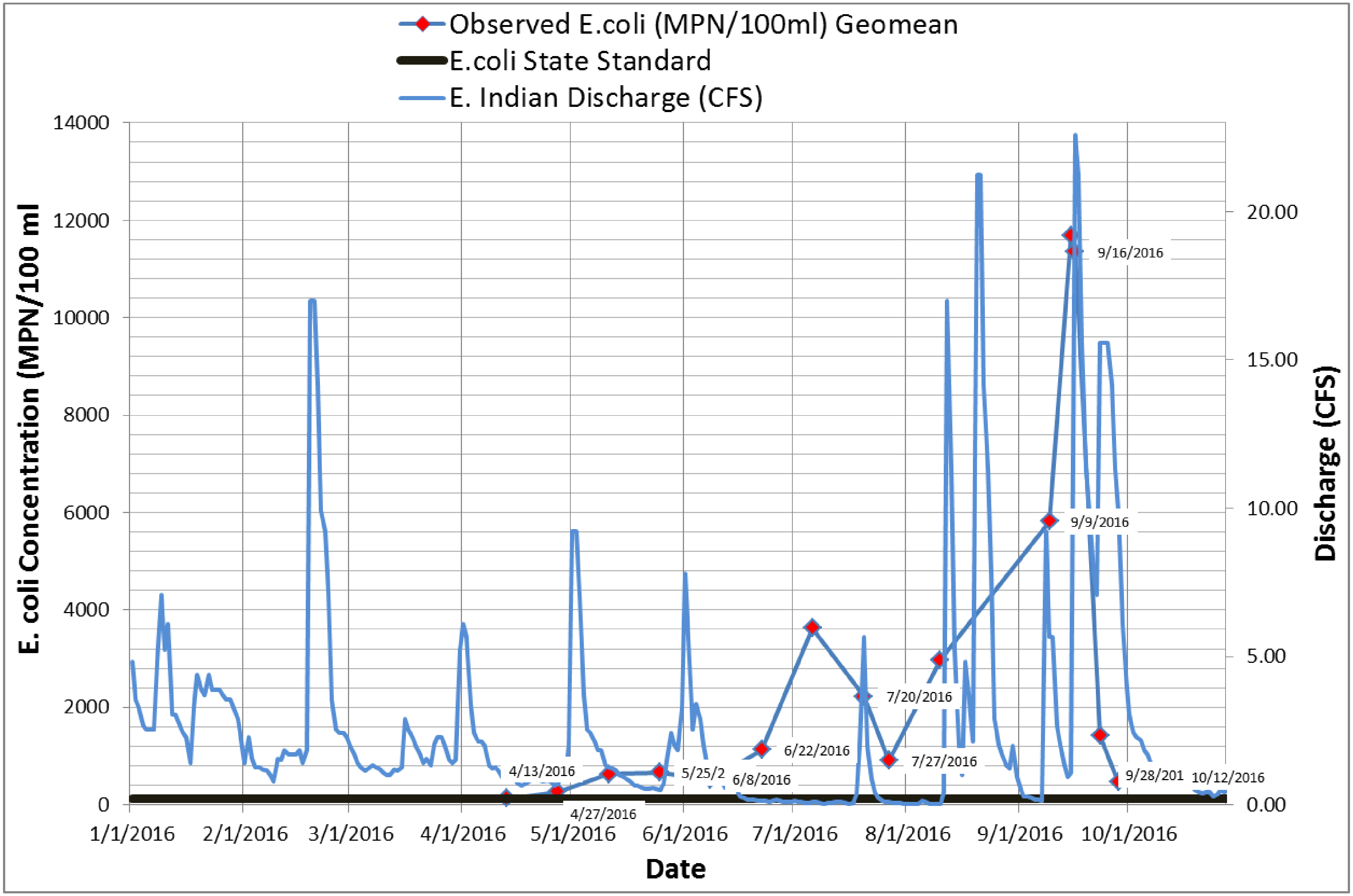

Figure 5. Observed Total Suspended Solids Concentrations for East Indian Creek in Relation to Flow (Discharge).

3. SQUAW CREEK 2016

A total of seventeen samples were collected from Squaw Creek from April through October in 2016, including one duplicate sample collected on September 23, 2016 (Table 3).

Observed nitrogen concentrations were consistently higher than the EPA Recommended Criteria Range for TN with the exception of samples collected on 7/27/2016, 9/9/2016, and 9/23/2016 (Figure 6). The total annual TN load for Squaw Creek was estimated at 4,535,454 pounds per year. TN concentrations were highest during baseflow events.

Note: In this monitoring effort, samples were analyzed for the Nitrate form of nitrogen. The common convention when discussing nitrogen levels in streams is to report on Total Nitrogen, which includes ammonia, organic nitrogen and nitrate-nitrite. However, nitrate typically represents the largest portion of total nitrogen in surface water samples and therefore was used as a surrogate for total nitrogen concentrations. But as a result, total nitrogen levels reported are likely underestimated.

Observed TP concentrations were reported below the 0.1 mg/L detection limit five times in 2016. Observed TP concentrations from grab samples collected following storm events in July and September were consistently above the EPA Recommended Criteria Range for TP (Figure 7). The correlation between storm events and high observed TP concentrations suggests phosphorus loading is likely correlated with increases in overland flow during storm events. The total annual TP load for Squaw Creek was estimated at 59,310 pounds per year. Given that TP concentrations were highest during periods when stream flow (discharge) was also highest, the majority of the total annual TP load was derived from a small number of storm events that collectively represent a relatively small period of the entire monitoring season.

The observed E. coli geo-mean concentration was calculated by grouping samples into groups of two based on sampling date to help offset the impacts of extremely high or low observed values. A comparison of these values with the Iowa state standard of 126 organisms/100 ml revealed exceedances throughout the year with the highest values observed during storm events (Figure 8); similar to the seasonal patterns observed in E. coli concentrations at East Indian Creek. The geometric mean for all samples collected from April through October was 1,464 organisms/100 ml. Increases in observed E. coli concentrations in samples collected following storm events indicates non-point sources are the predominant source of E.coli in Squaw Creek.

Observed Total Suspended Solids (TSS) concentrations in grab samples collected during baseflow events were significantly less than observed TSS concentrations from grab samples collected during storm events in July and September (Figure 9). The total annual TSS load for Squaw Creek was estimated at 106,944,500 pounds per year. Given that TSS concentrations were also highest during periods when stream flow (discharge) was also highest, the majority of the total annual TSS load was derived from a small number of storm events that represent a relatively small period of the entire monitoring season. The combination of high TSS loading with high TP loading during storm events provides evidence to suggest that the majority of the TP load is from sediment bound phosphorus.

Table 3. Squaw Creek Monitoring Results.

Sample Date	Flow (m^3/s)	Nitrate (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	E.coli (MPN/100ml)
04/13/16	3.7	10	<0.1*	26	110
04/27/16	3.9	8.4	0.14	32	>2,420
05/11/16	6.5	15	0.16	48	749
05/25/16	5.3	13	<0.1*	19	836
06/08/16	6.5	17	<0.1*	28	610
06/22/16	2.9	13	0.16	12	1,166
07/13/16	1.5	3.4	0.13	18	4,978
07/27/16	0.9	5.8	0.27	800	550
08/10/16	0.4	0.5	0.16	23	857
08/24/16	3.5	8.9	<0.1*	27	717
09/08/16	7.3	0.5	0.48	520	41,060
09/15/16	2.6	7.4	<0.1*	16	801
09/16/16	13.4	3.4	0.33	260	16,160
09/23/16	32.3	2.6	0.81	980	21,870
09/23/16	32.3	4.7	0.79	550	
09/28/16	13.48	8.8	0.36	300	613
10/12/16	5.58	9	0.16	27	496

m^3/s – cubic meters per second, mg/l – milligrams per liter, MPN/100ml – most probable number(organisms) per 100 milliliters
<0.1* = Laboratory phosphorus detection limit

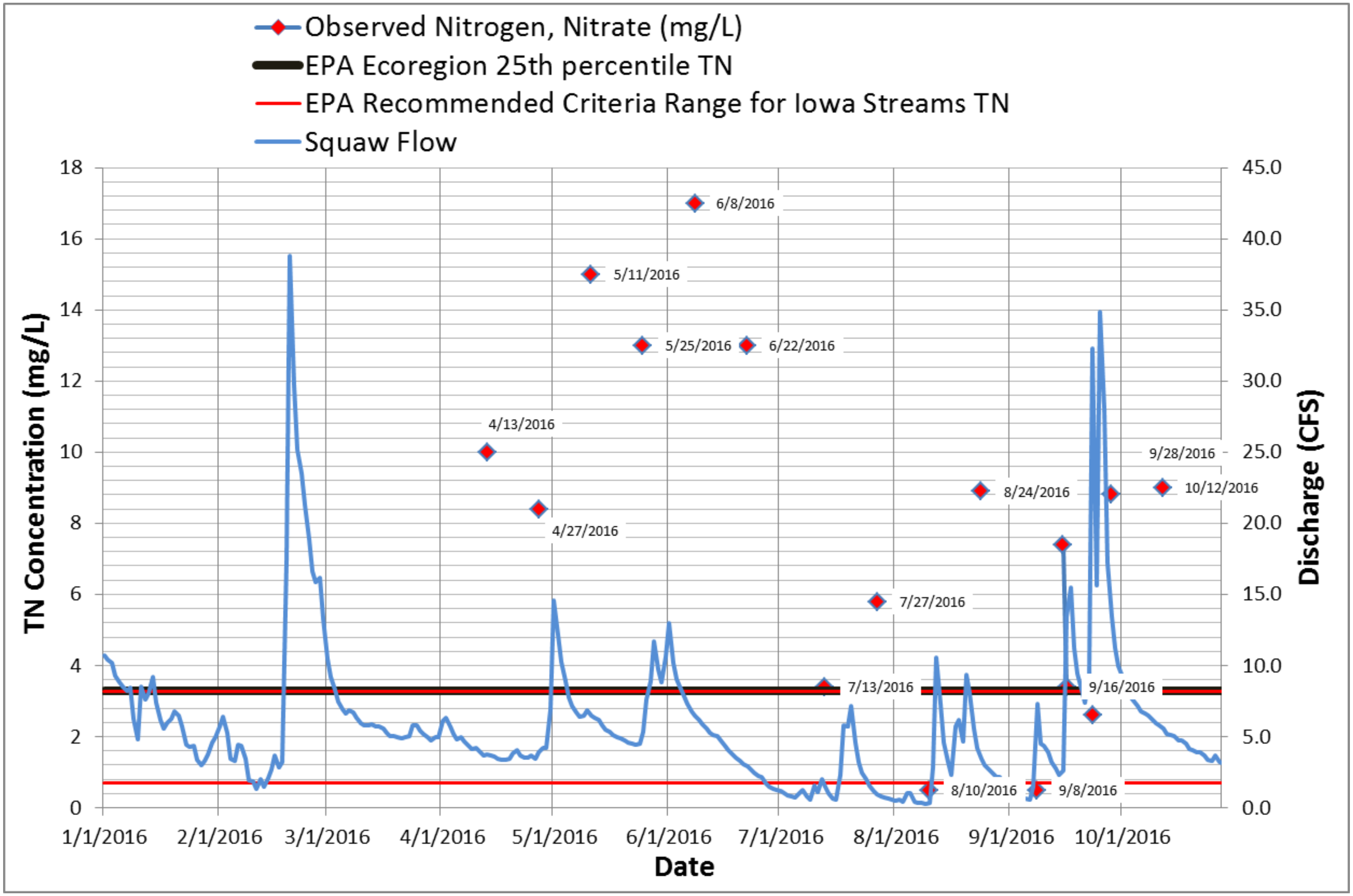

Figure 6. 2016 Observed Nitrogen (as Nitrate) Concentrations for Squaw Creek in Relation to Flow (Discharge).

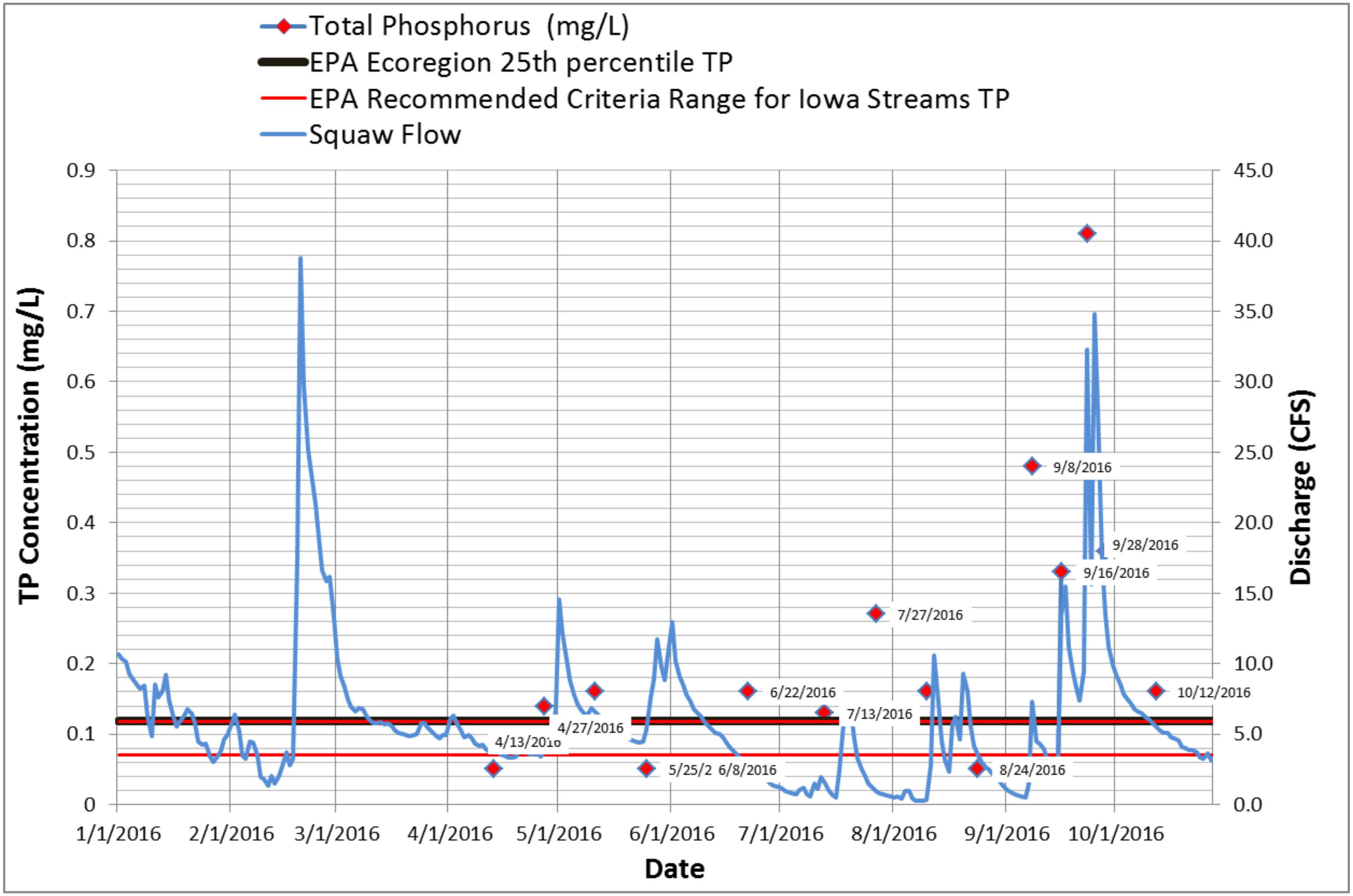

Figure 7. 2016 Observed Total Phosphorus Concentrations for Squaw Creek in Relation to Flow (Discharge).

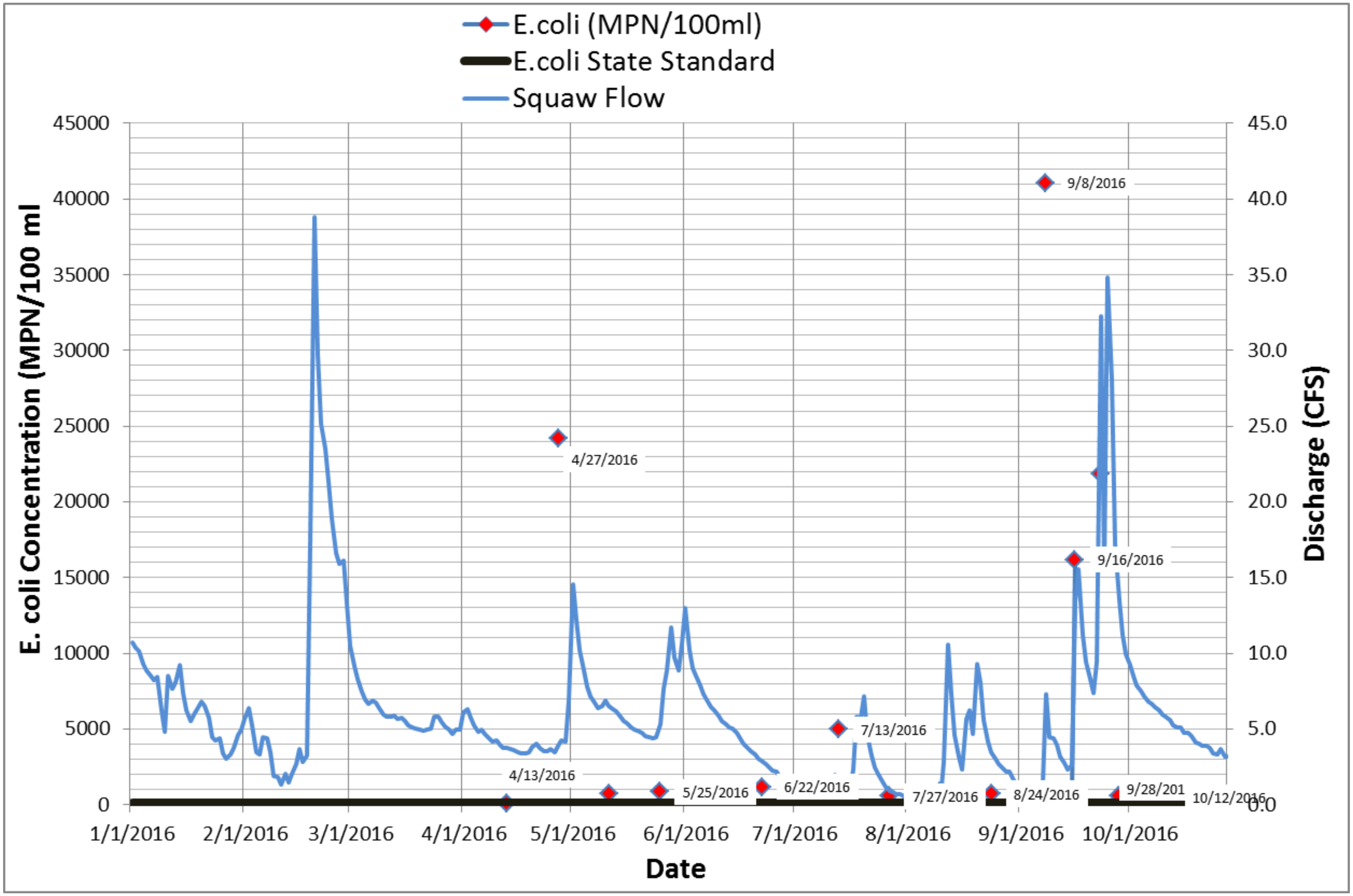

Figure 8. 2016 Observed E. coli Concentrations for Squaw Creek in Relation to Flow (Discharge).

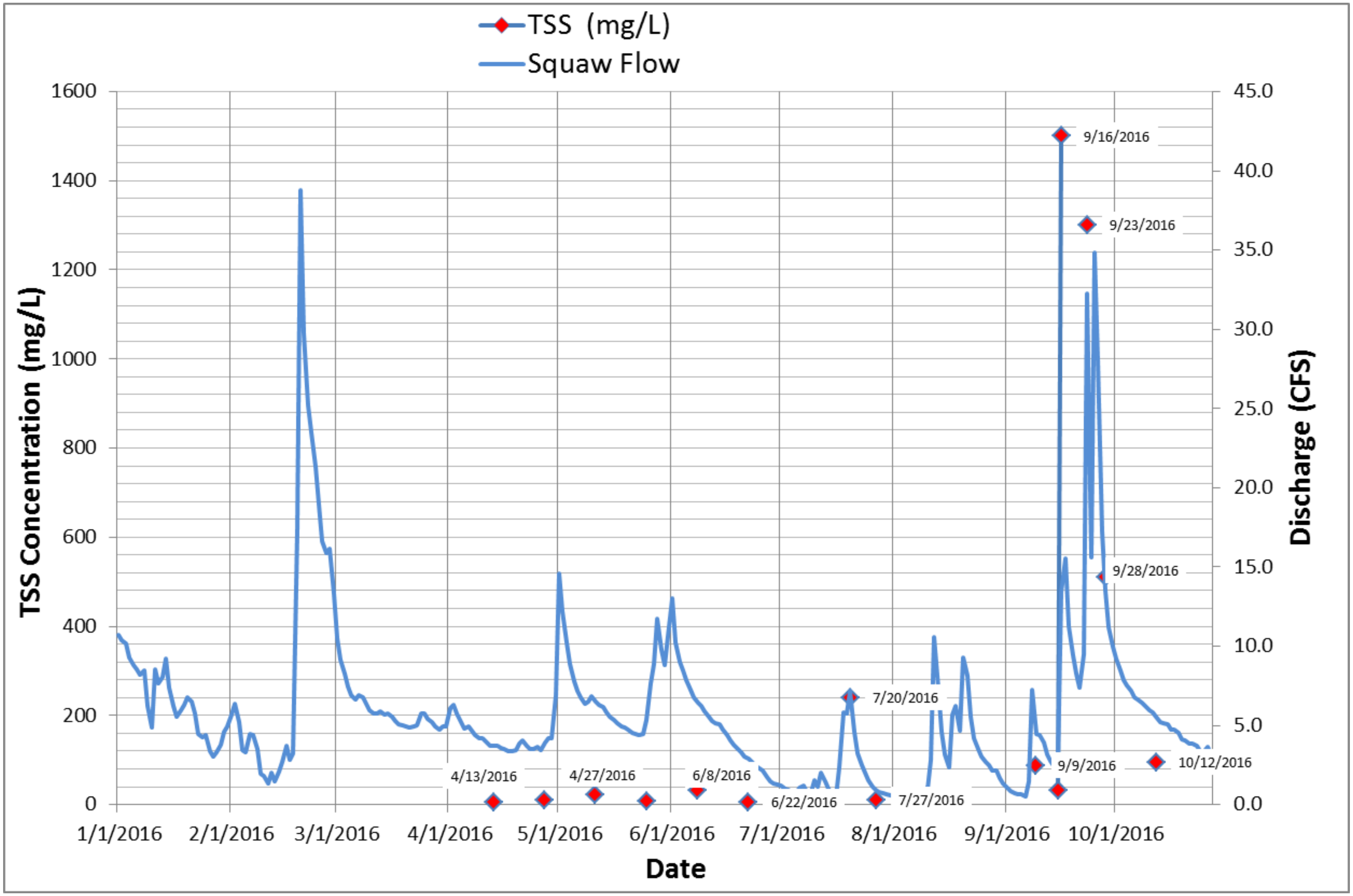

Figure 9. Observed Total Suspended Solids (TSS) Concentrations for Squaw Creek in Relation to Flow (Discharge).

4. FLOW AND POLLUTANT LOADING CALCULATION METHODS

Continuous stage data (collected at 15 minute intervals) for East Indian Creek and Squaw Creek were downloaded from the Iowa Flood Information System (IFIS) for the entire 2016 monitoring season (1/1/2016-12/14/2016). The 15 minute interval data were aggregated to a daily time series which is the preferred timestep for FLUX32. FLUX 32 is the standard program used to calculate annual pollutant loads based on observed streamflow data and pollutant concentrations based on water quality grab samples in river systems. FLUX 32 was created by the U.S. Army Corps of Engineers and has been applied to streams and rivers across the country. Inputs to the FLUX 32 program include grab sample water quality data which is organized in an excel spreadsheet such that each water quality grab sample collected corresponds with a specific flow measurement and date.

While continuous stage data was available, daily flow data was not collected at East Indian Creek nor Squaw Creek. In the absence of observed flow data, a rating curve can be used to approximate daily flow values. A rating curve is a graph of stream volume(s) (discharge) versus stage (elevation) for a chosen point in a stream or river. A collection of measurements of discharge at various stages can be used to estimate flow during times when flow collection is not possible. In Squaw Creek a downstream USGS stream gauge was used to develop a rating curve. This rating curve was then applied to the observed stage measurements to estimate discharge at the Squaw Creek monitoring site.

In East Indian Creek, the USGS gauge was too far downstream to develop a meaningful rating curve. Instead, the USGS has developed a method for computing daily mean streamflow at ungaged locations in Iowa using the Flow Anywhere Statistical Methods (Linhart et., al, 2012) available online through the USGS Stream Stats Program. This program can be used to 1) delineate an upstream drainage area, 2) identify key watershed characteristics (e.g., dominant soil types), and 3) compare the upstream drainage area and watershed characteristics to 123 continuous-record stream gages in Iowa to develop a regression equation which approximates flow duration statistics such as those shown for East Indian Creek in Table 4. Next, the 2016 stage data were grouped into percentiles to evaluate the relative standing of each stage data as a percentage of the entire data set. Each stage data was then assigned a representative discharge based on the values shown in Table 4.

Next steps included arranging the daily flow data and water quality data into the format required for FLUX 32. Once the data was input to the FLUX 32 program, the following basic calibration steps were completed to estimate annual pollutant (nitrogen, phosphorus) loadings in accordance with standard operating procedures developed by the Environmental Services Division of Minnesota's Metropolitan Council https://eims.metc.state.mn.us/Documents/GetDocument/854.

- Adjusting flow or seasonal stratification breaks to reduce the coefficient of variance (C.V.) to 0.2 or lower
- Adjusting flow or seasonal stratification breaks to reduce the slope and regression coefficient in residual plots to approximately 0.

Table 4. Flow-Duration Statistics for East Indian Creek.

Statistic	Discharge (Cubic Feet per Second)	Prediction Error (Percent)
1 Percent	798	3.5
5 Percent	377	3.6
10 Percent	215	24.2
15 Percent	137	24.6
20 Percent	107	22.1
30 Percent	75.8	17.1
40 Percent	53.6	14.9
50 Percent	40.4	16.4
60 Percent	29.3	22.1
70 Percent	18.8	32.4
80 Percent	7.98	40.1
85 Percent	5.72	42.5
90 Percent	4.21	51
95 Percent	2.2	74.9
99 Percent	0.656	97.7

5. REFERENCES

Linhart, S.M., Nania, J.F., Sanders, C.L., Jr., and Archfield, S.A., 2012, Computing daily mean streamflow at ungaged locations in Iowa by using the Flow Anywhere and Flow Duration Curve Transfer statistical methods: U.S. Geological Survey Scientific Investigations Report 2012–5232.