Sources and Fates of Nitrate, Phosphorus, E-Coli, Coliform and Chloride that Impair the Kewaunee, Ahnapee, and E. Twin River Watersheds in Northeast Wisconsin

by

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Citizen volunteers for Kewaunee CARES and WAV
(Citizens Advocating Responsible Environmental Stewardship, and Water Action Volunteers)

For presentation at the 2018 WAV Symposium
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Copies of this Power Point presentation may be obtained from the University of Wisconsin, Stevens Pt. website after the conference.

The complete Power Point of our 1 April 2016 Presentation is publically available at
https://www.uwsp.edu/cnr-ap/UWEXLakes/Documents/programs/convention/2016/FridayConcurrent/Session7/GeraldPellett_ThreeYearsOfWarmSeasonMonthlyData.pdf

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Information may also be obtained from the Kewaunee CARES Facebook Page

Outline of Presentation

Views of the Watersheds (see easel display; & Appendix for IDs of sites).

Introductory Bar Graphs: Mean Con's (3-yr data) & Recommended limits.

Total Phosphorus data for 8 Creeks, and Seasonal Patterns.

Refined Analyses of Nitrate, Total Phosphorus, E. coli and Total Coliform:

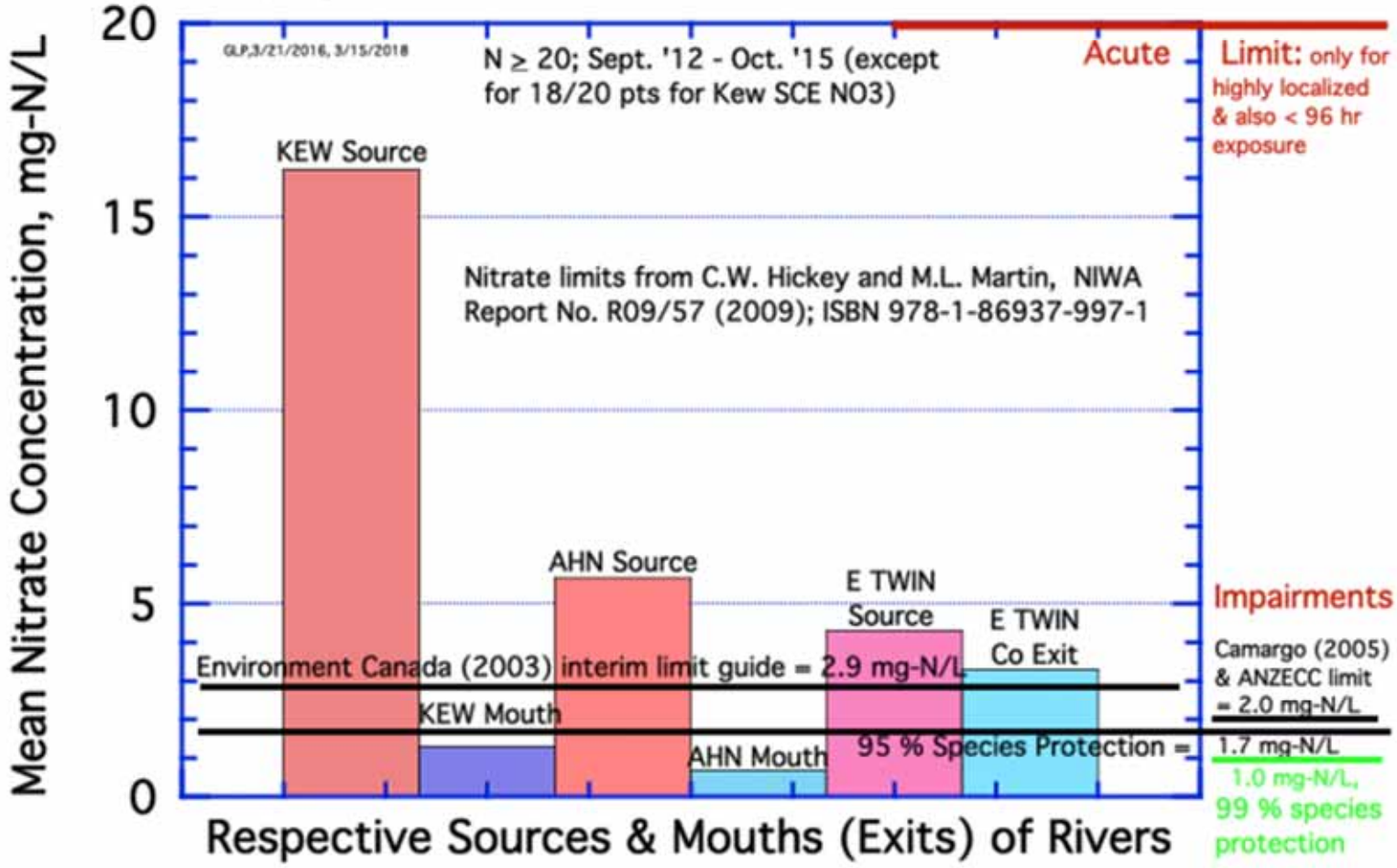
- **3-yr Temporal plots (Total Elapsed days)**
- **Seasonal plots (Day-of-the-Year)**
- **Washdown /Washout Effects (5-day prior rainfall)**

Bar Graph Summaries of Mean & Peak con's & Recommended limits.

Summary of Major Findings; Conclusions

Mean Nitrate in Kewaunee, Ahnapee & E. Twin Rivers; 3-yr simultaneous data.

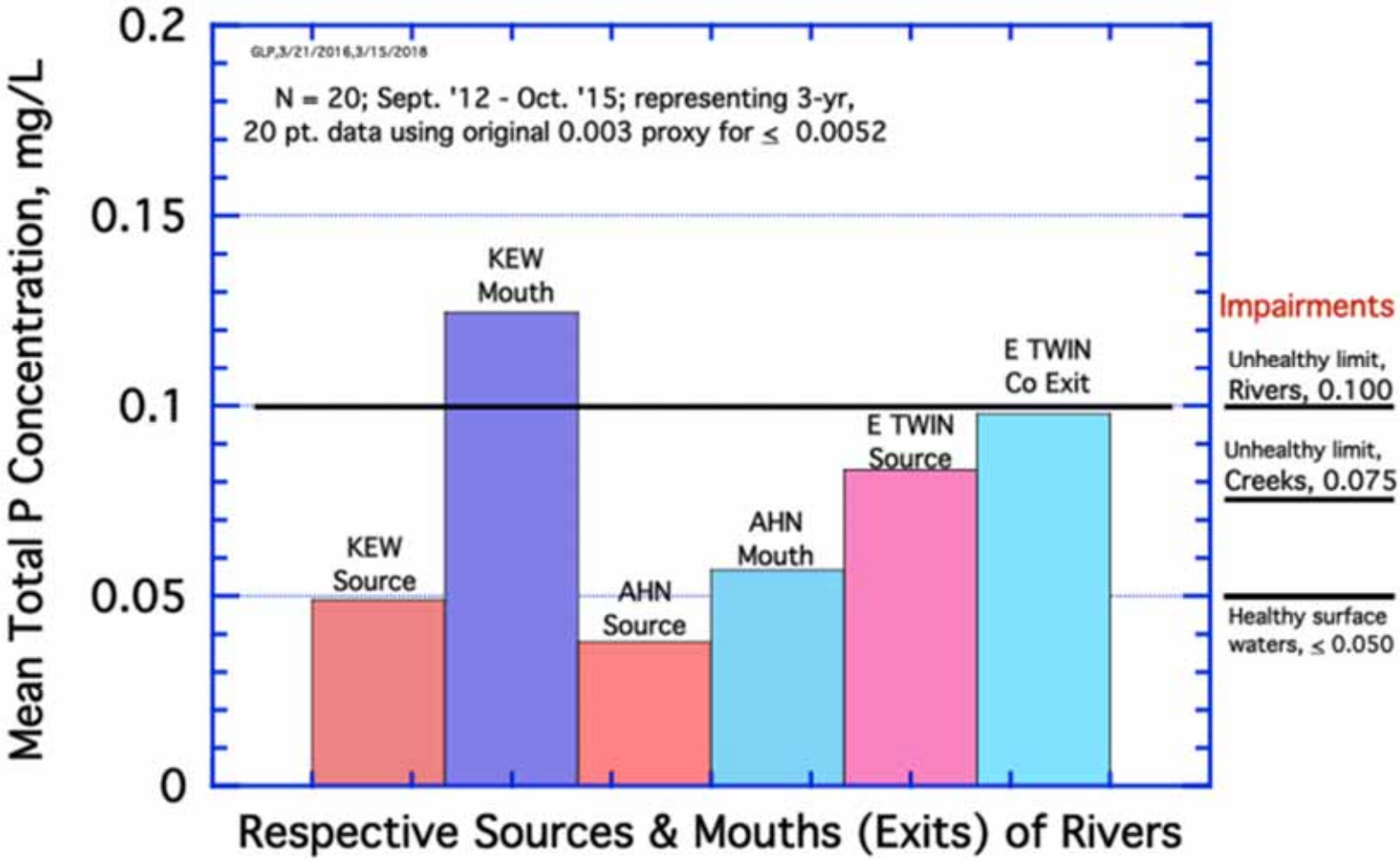
- NO3 in Kew. SCE >> Impair. limits; detailed Bovine manure sources uncertain.
- Mouth-NO3's reflect consumption by known aquatic vegetation, and also by abundant denitrifying bacteria in river sediment under marsh-like conditions.



3

Mean Total Phosphorus in Kew., Ahnapee & E. Twin Rivs; Orig. 3-yr simult's data.

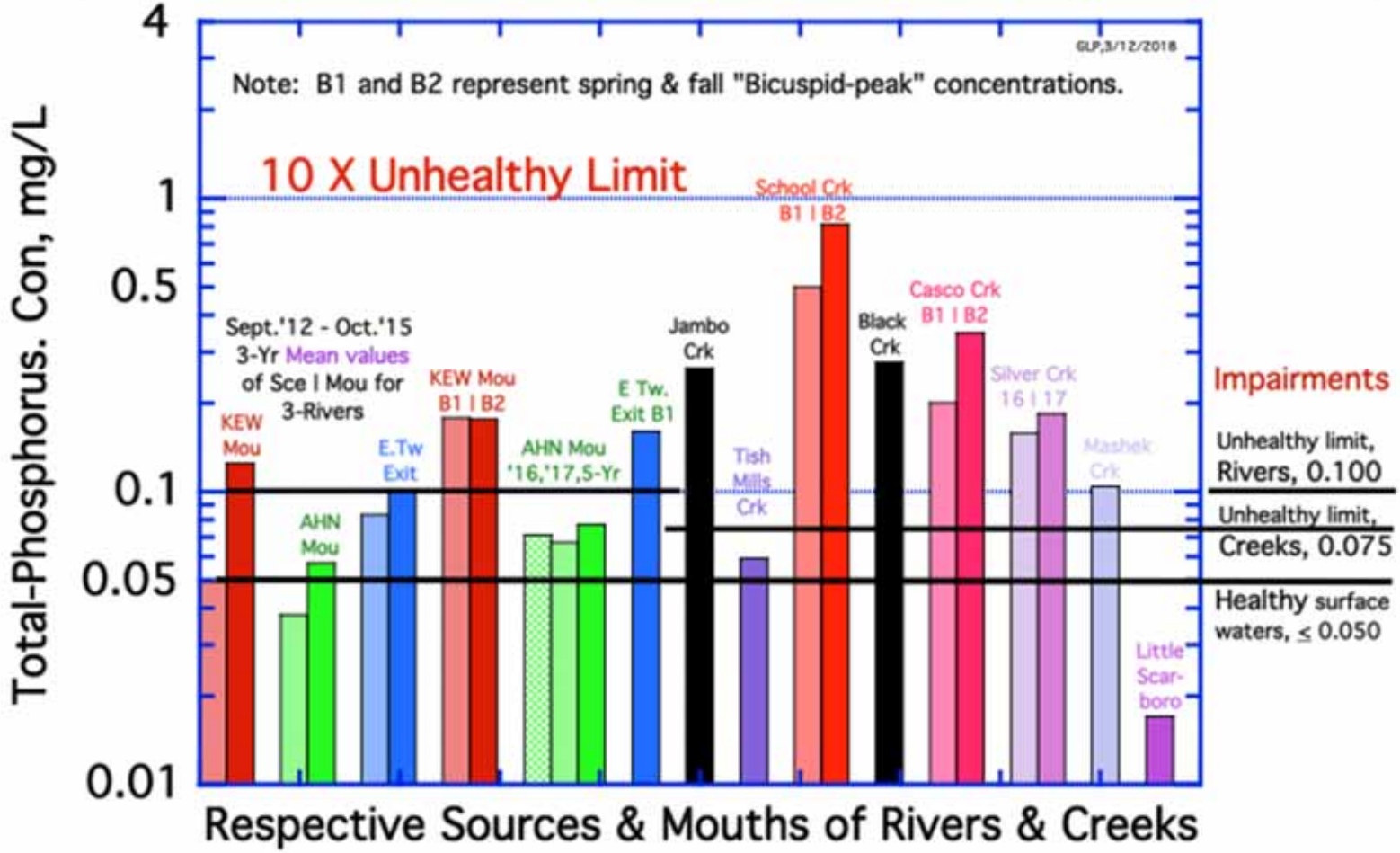
- Total P in Kew. MOU is "Unhealthy" and is 2 X that in Ahnapee MOU.
- Mean Total P's in Mouth areas always exceeded con's in Source areas.



4

Mean & Curve-Fitted-Max Total P in Kew., Ahn. & E. Twin Rivers, and 8 Creeks.

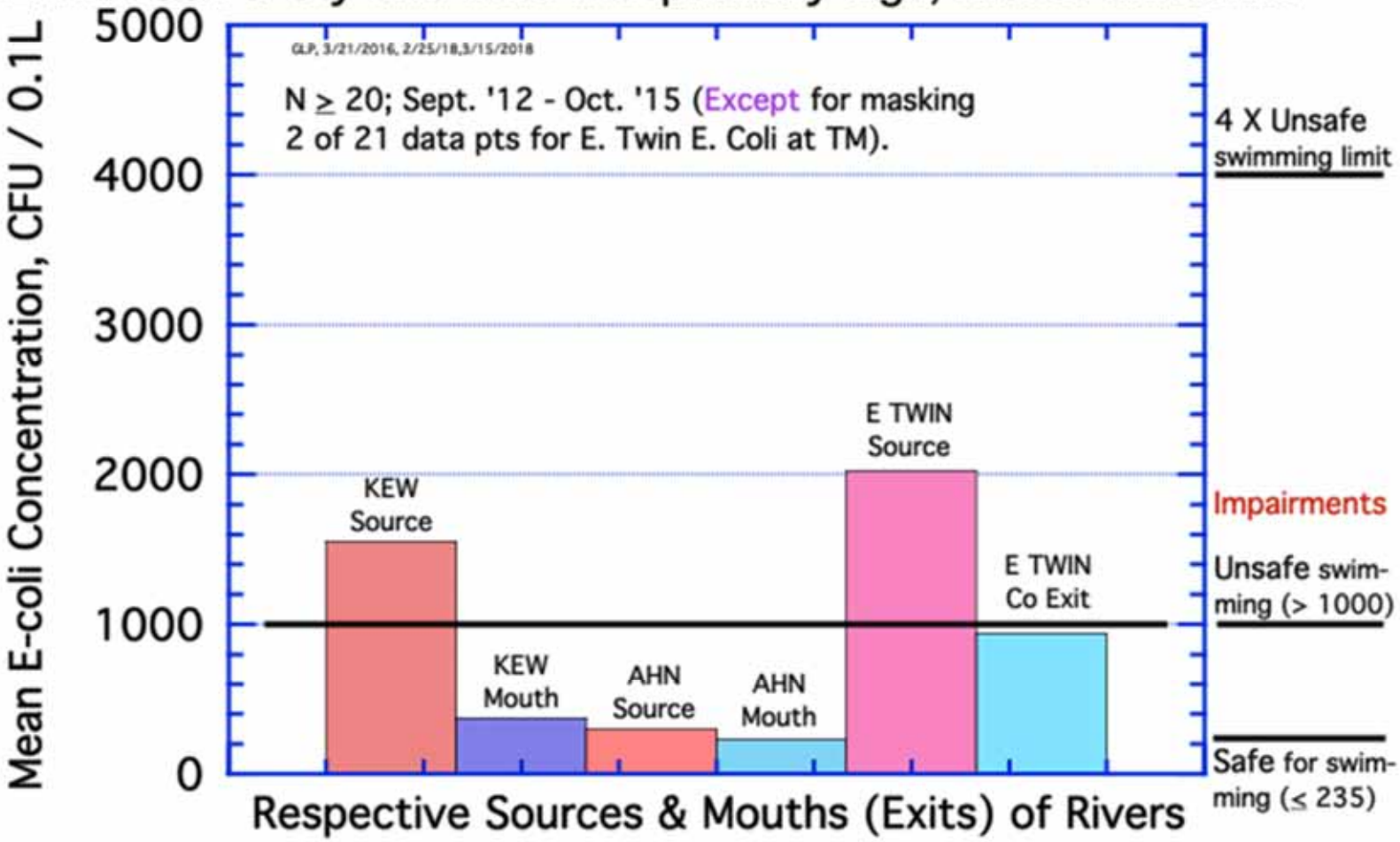
- "Poster Child" Little Scarboro Crk (1st class trout) is only fully "Healthy" str.
- School & Casco Crk MOUs very "Unhealthy;" same since DNR 2000 surveys.
- Ahnapee Riv MOU mid-Healthy/Unh'y; Kew, E.Twin (Tish M) gen'lly Unhealthy.



5

Mean E. Coli in Kewaunee, Ahnapee and E.Twin Rivers; 3-yr simultaneous data.

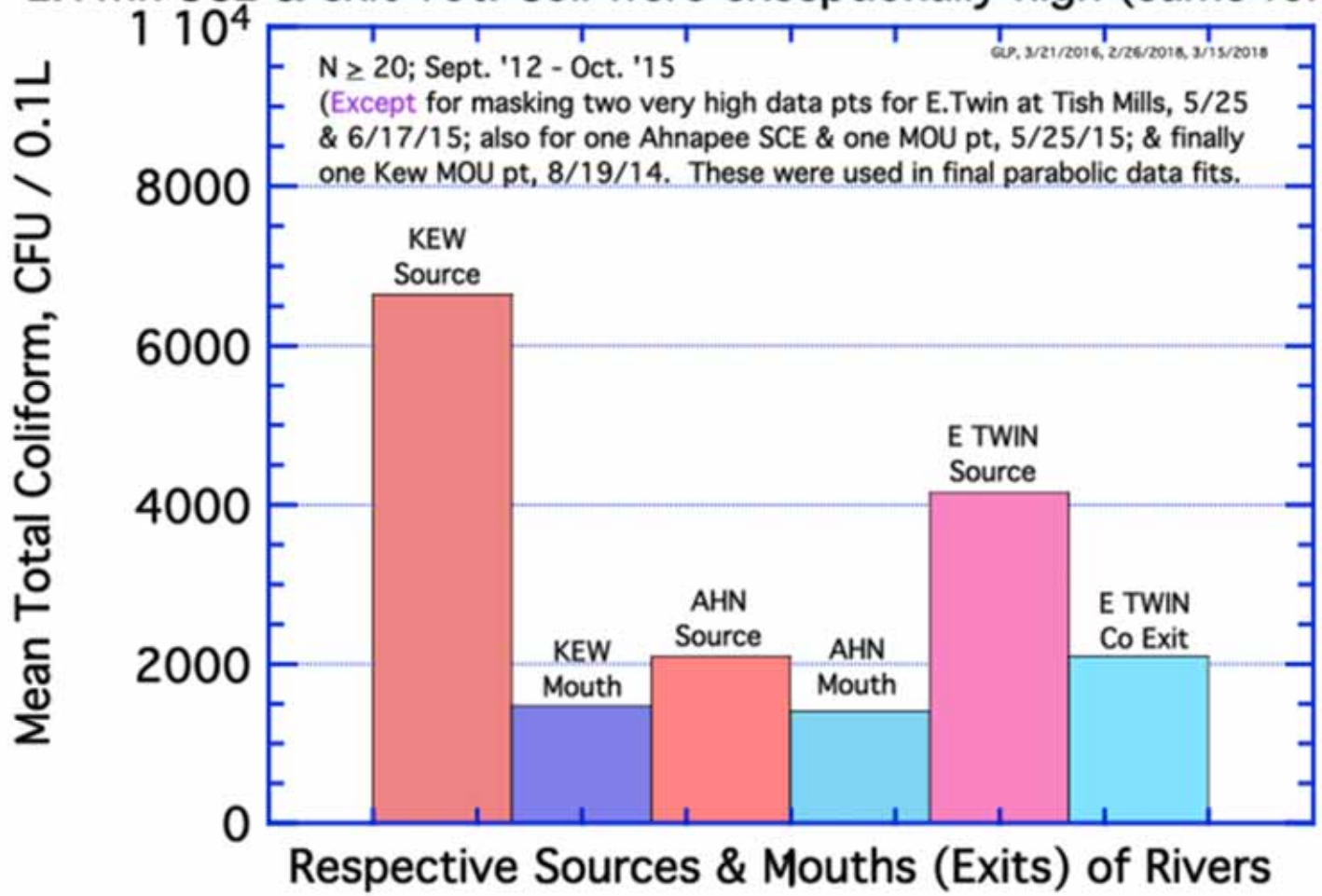
- Ahnapee SCE was much cleaner than Kewaunee and E.Twin Sources.
- E. Coli in SCEs were reduced at downstream sites for all 3 rivers.
- E.Twin SCE & Cty exit were exceptionally high; causes unknown.



6

Mean Total Coliform in Kew, Ahnapee and E.Twin Rivers; 3-yr simultaneous data.

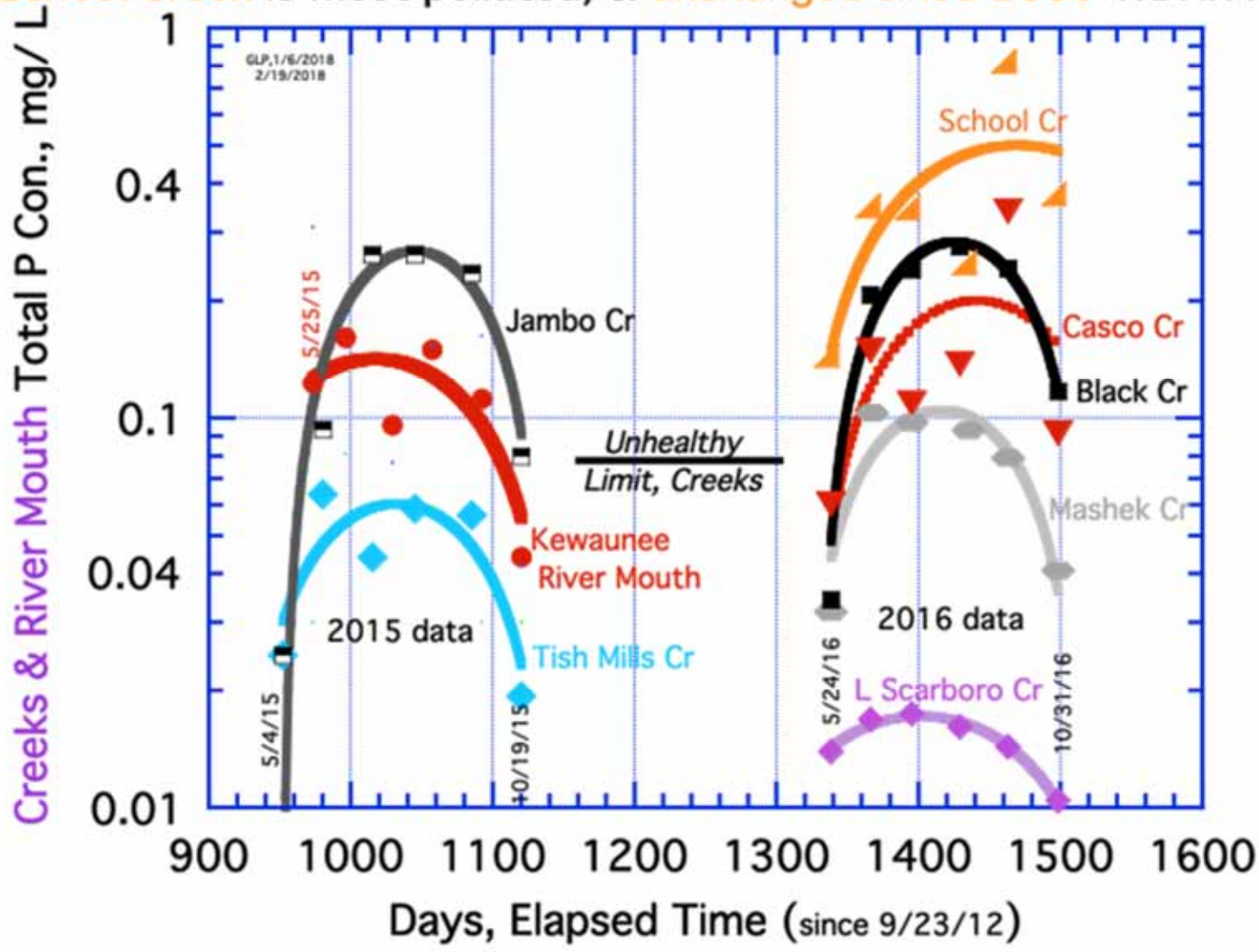
- Mean Tot. Coli. generally 2 -- 4 X larger than respective E. Coli con's.
- Reduction of Tot. Coli from SCE to MOU is significant for all 3 rivers.
- E.Twin SCE & exit Tot. Coli were exceptionally high (same for E.Coli).



7

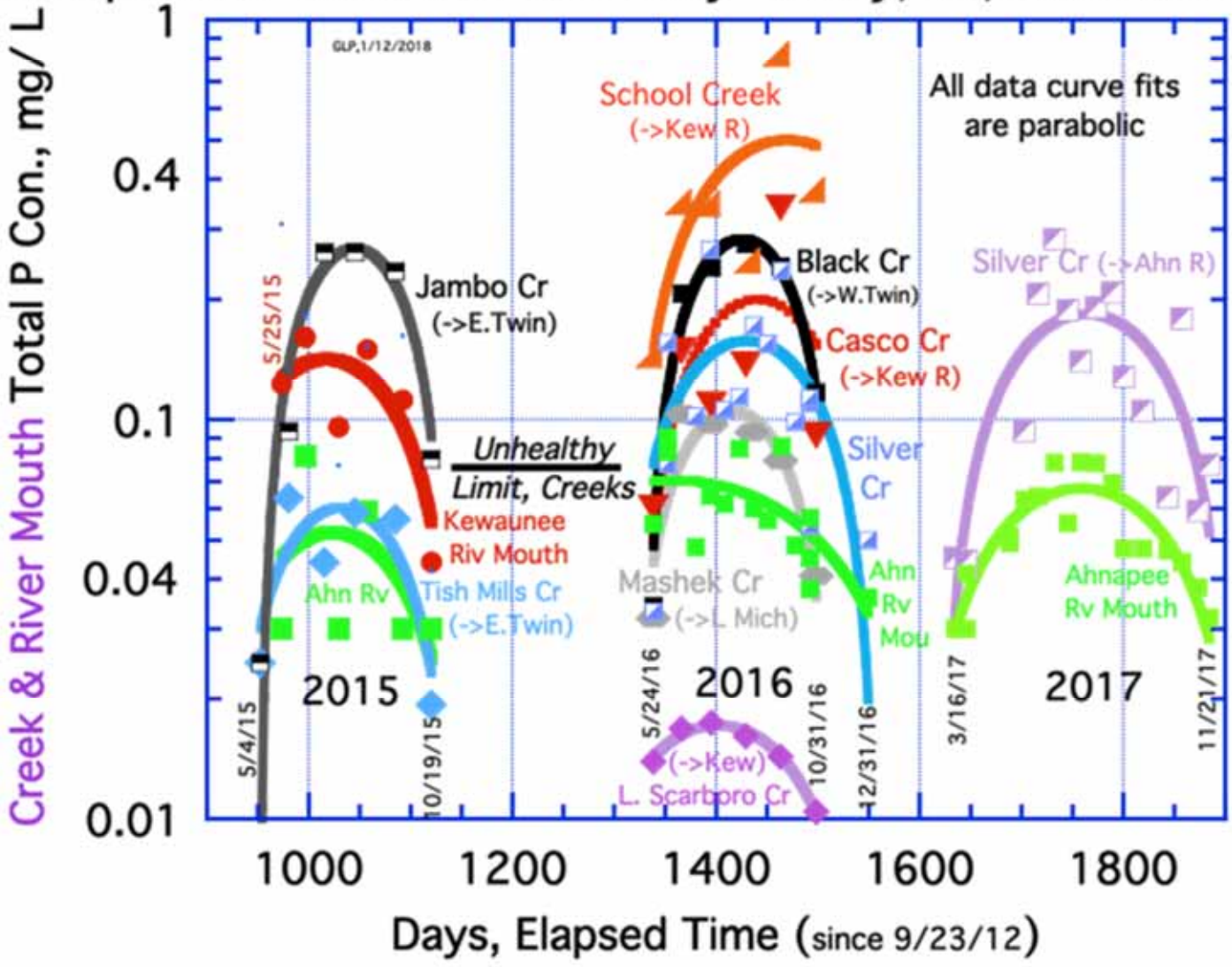
First look at Total Phosphorus data for some Creeks in Kew. County.

- Data show strong "Parabolic-like" seasonal effects on MOU Total P con.
- Little Scarboro Creek appears to be "Poster Child" of the County.
- School Creek is most polluted; & unchanged since 2000 WDNR meas.



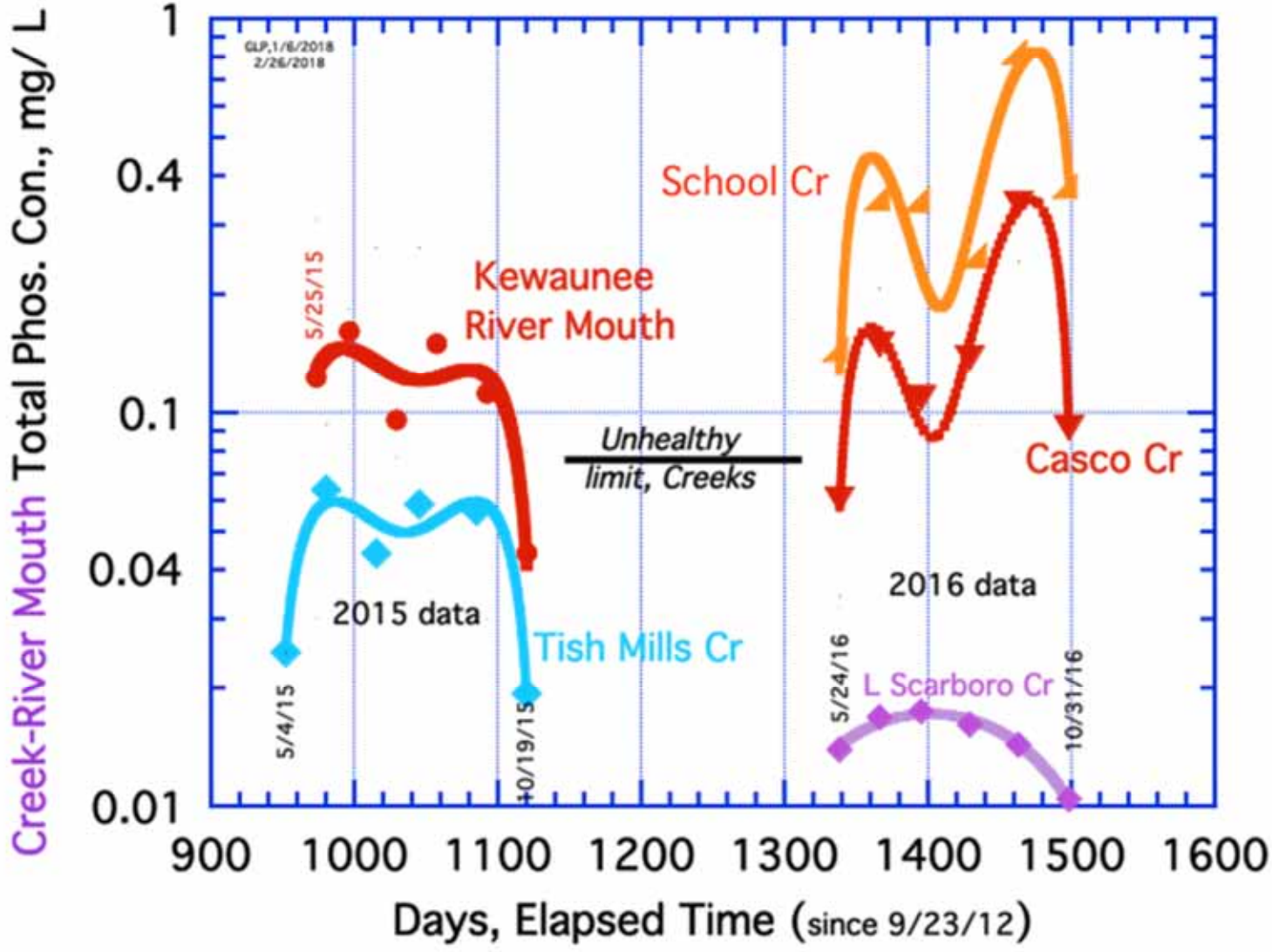
This 3-yr composite of Total Phosphorus in 8 Creeks & 2 Rivers Shows:

- Strong "Parabolic" Seasonal Effects in Creeks & Rivers, March--Nov.
- 6 of 8 Creeks significantly exceed *Unhealthy Limit* for Creeks, 0.075.
- Ahnapee River Mouth is occasionally *Healthy*; i.e., sometimes <0.05.



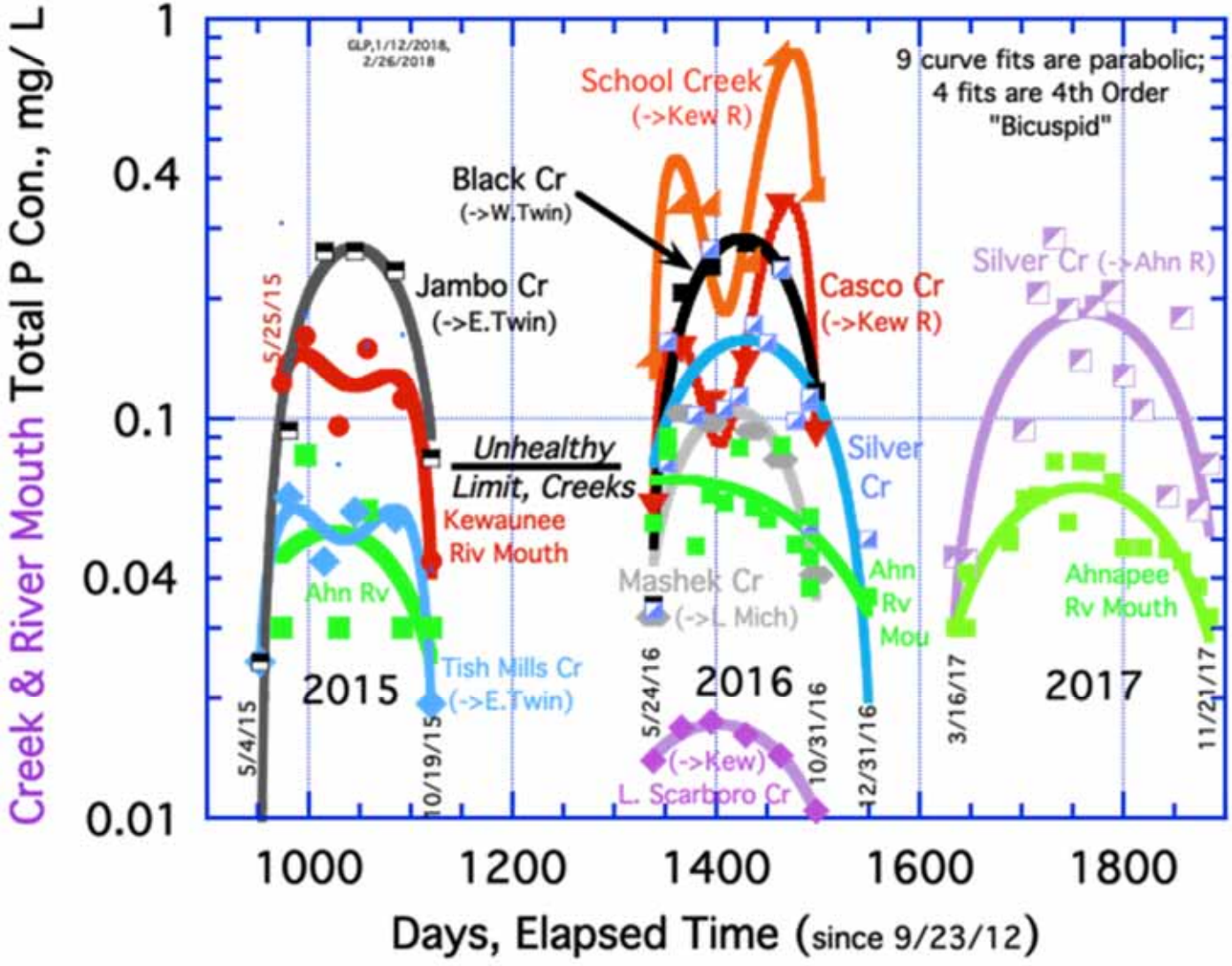
Refined Total P plot for 3 Agriculture-perturbed Creeks & Kew Riv Mouth shows distinct 4th-Order "Bicuspid" seasonal effects in spring & fall.

- The L. Scarboro Cr. is isolated, well protected, & basically unperturbed.
- Casco Cr. & especially School Cr. remain highly Phosphorus-polluted.



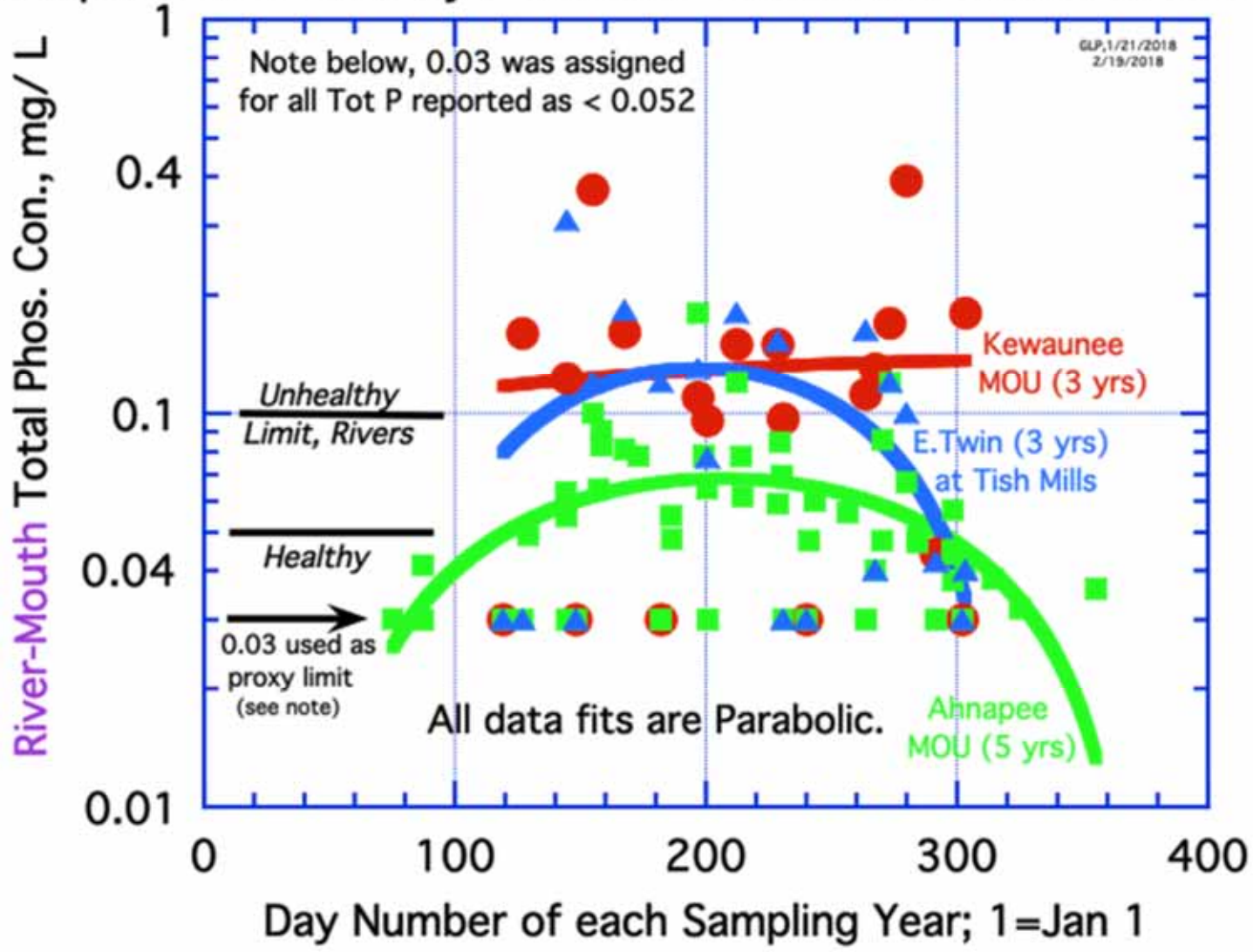
Final composite of Total Phosphorus Con's in 8 Creeks & 2 Rivers Shows:

- Strong "Parabolic +" Seasonal Effects in Creeks & Rivers, March--Nov., sometimes including "Spring Thaw, Manure Spreading, Bicuspid Bumps".
- Ahnapee River is More Healthy than Kewaunee, & is sometimes <0.05.



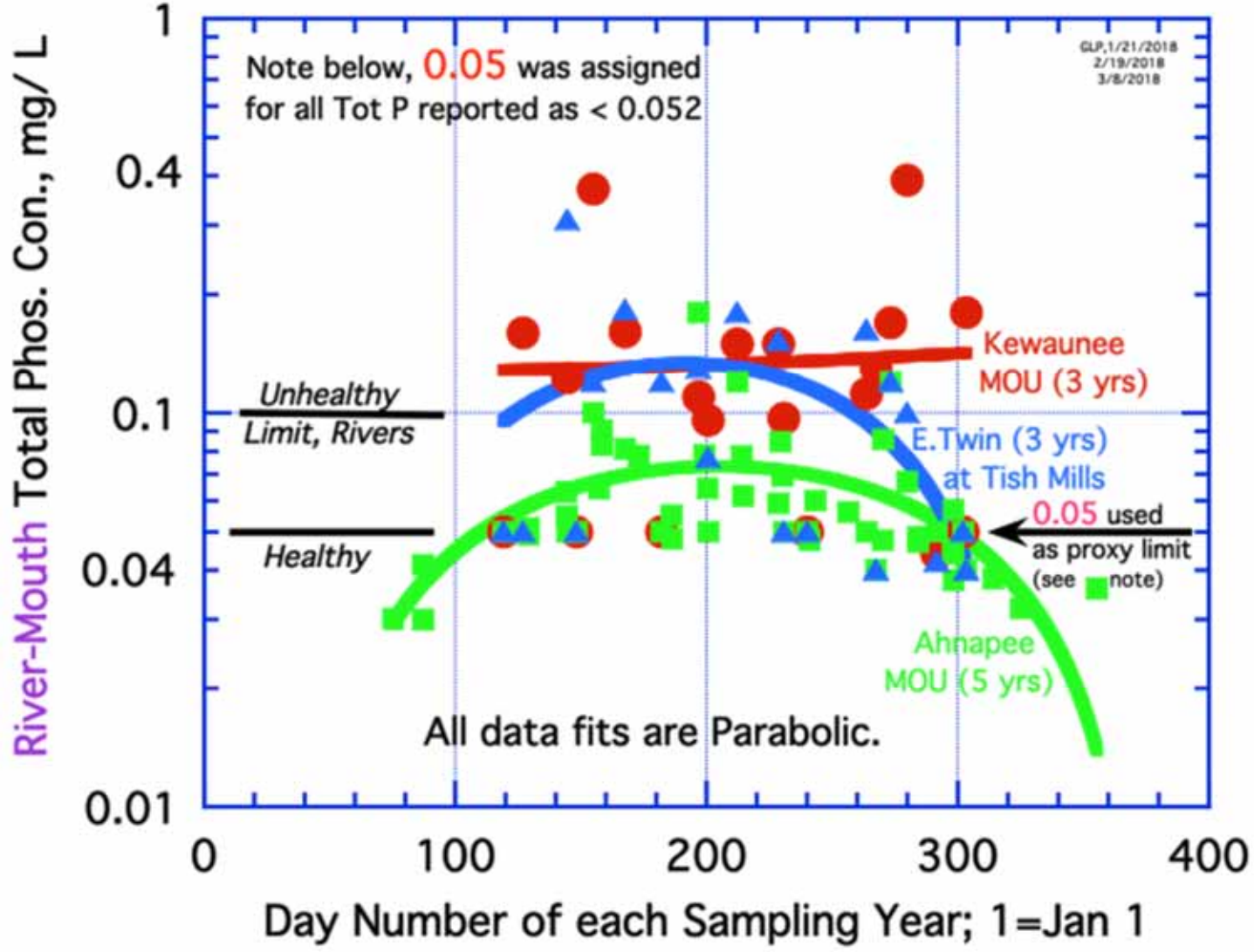
Initial Plot of River-Mouth Total Phosphorus cons. vs Day-of-Year; 3 Rivers.

- Large scatter reflects erosive runoff of multiple independent sources.
- 5-yrs of Ahnapee data follow parabolic-like annual cycle quite well.
- Ahnapee River is notably P-healthier than Kewaunee and E. Twin.



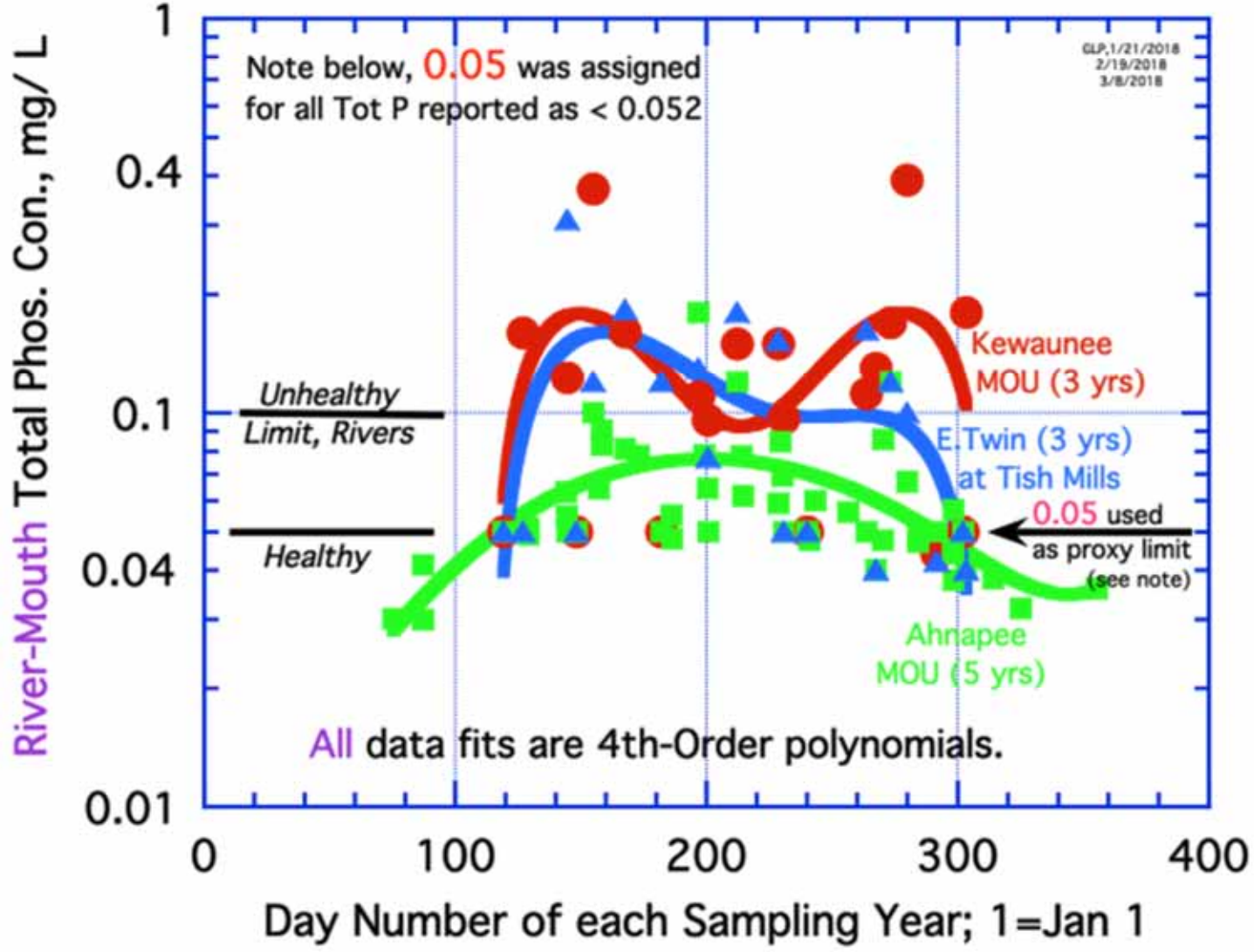
Replot of River-Mouth Total Phosphorus cons. vs Day-of-Year for 3 Rivers.

- Resetting proxy limit to 0.05 improved fidelity of Ahnapee data plot.
- Large scatter in Kew, E.Twin still reflects variable runoff, multi sources.
- 5-yr Ahnapee data follow "Parabolic-like" annual cycle slightly better.



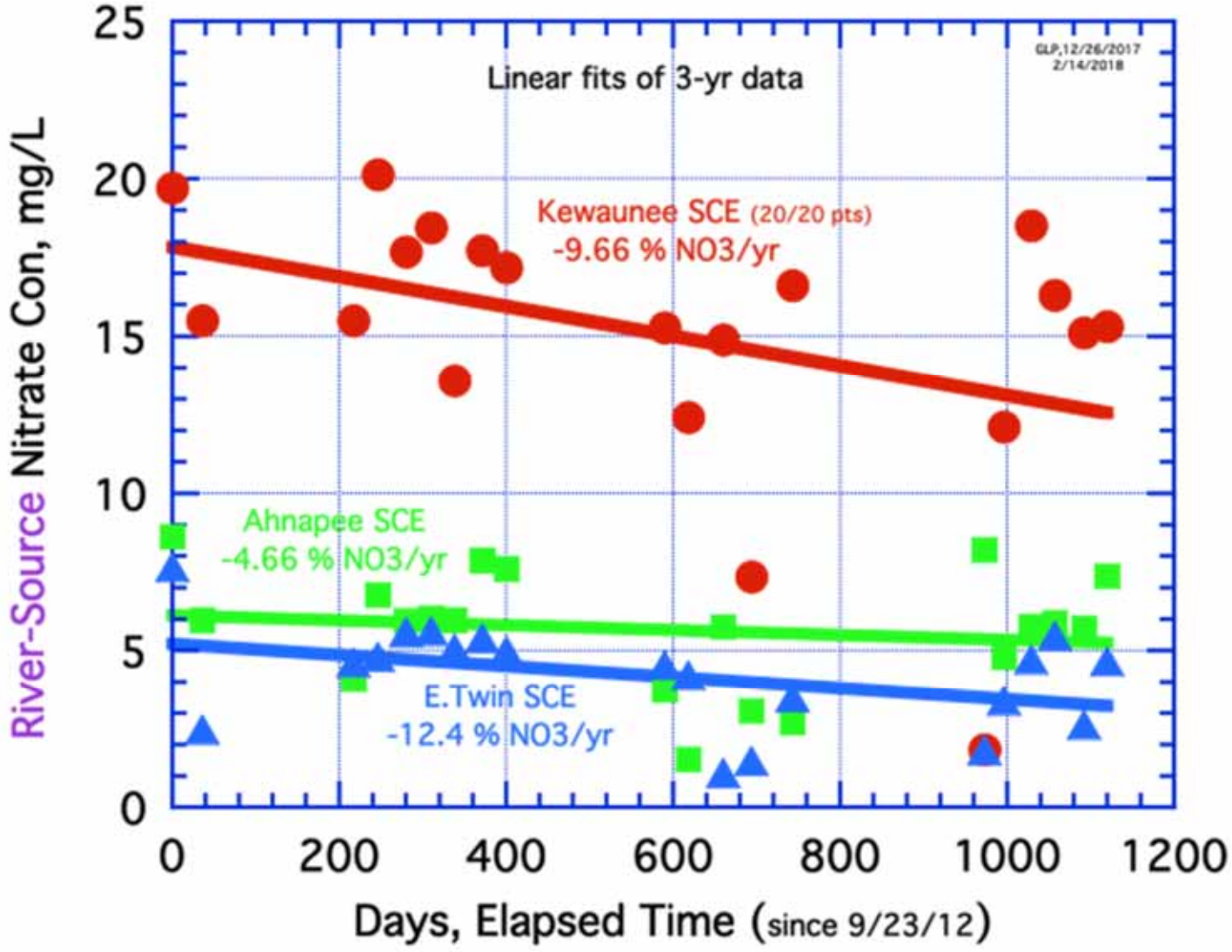
Final Replot of River-Mouth Total Phos. data vs Day-of-Year for 3 Rivers.

- 4th-Order fits of Kew, E.Twin data show "Bicuspid" spring-fall effects.
- Large variations in Kew, E.Twin reflect variable runoff of multi sources.
- 4th-Order, 5-yr Ahnapee data still follow "Parabolic-like" seasonal cycle.



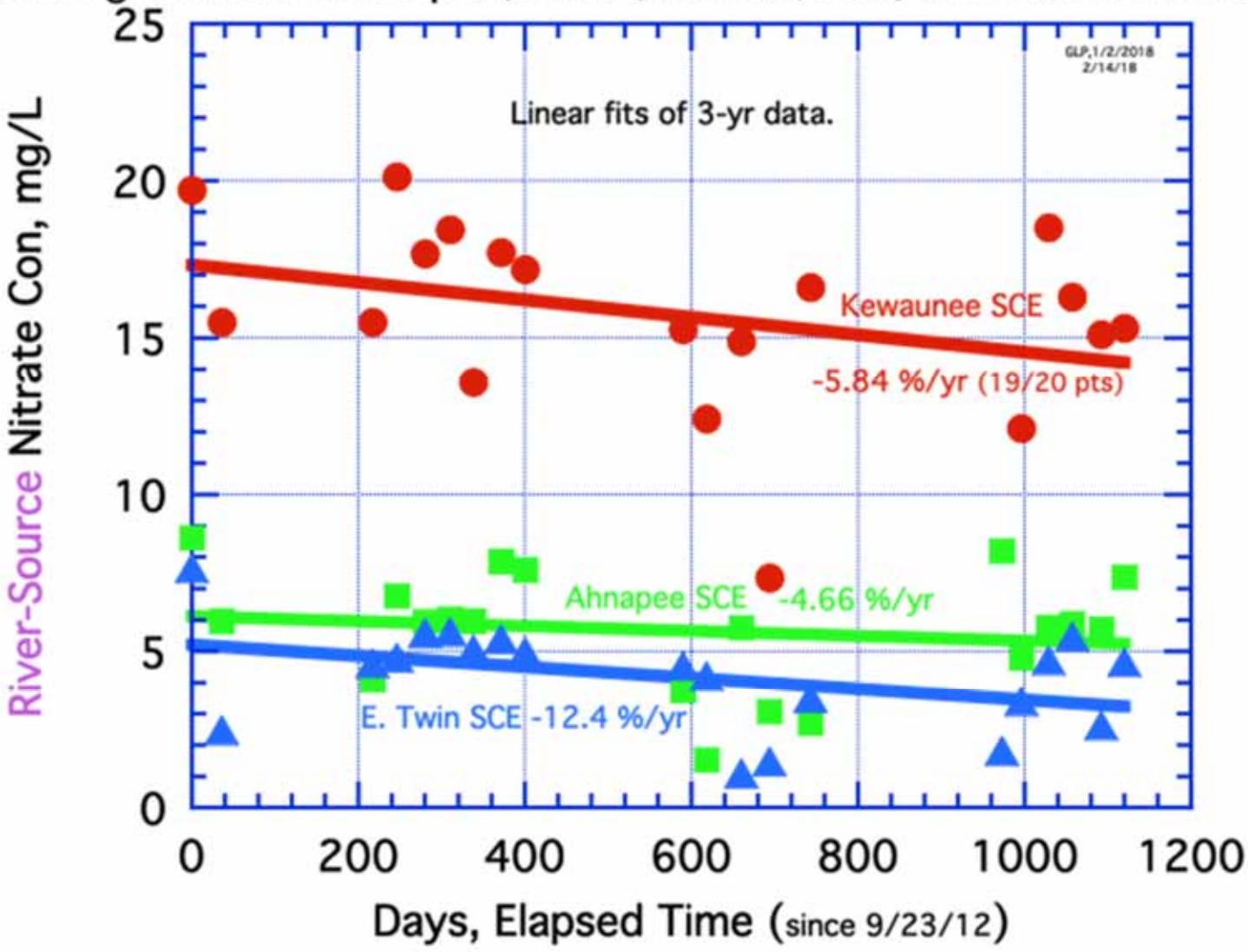
Initial Linear fits of River-Source Nitrate Data vs Elapsed Time; 3-yr data.

- Kew. Source has both high and notably-variable Nitrate contamination.
- Effects of 2 low pts (of 20) are examined next to assess annual change.



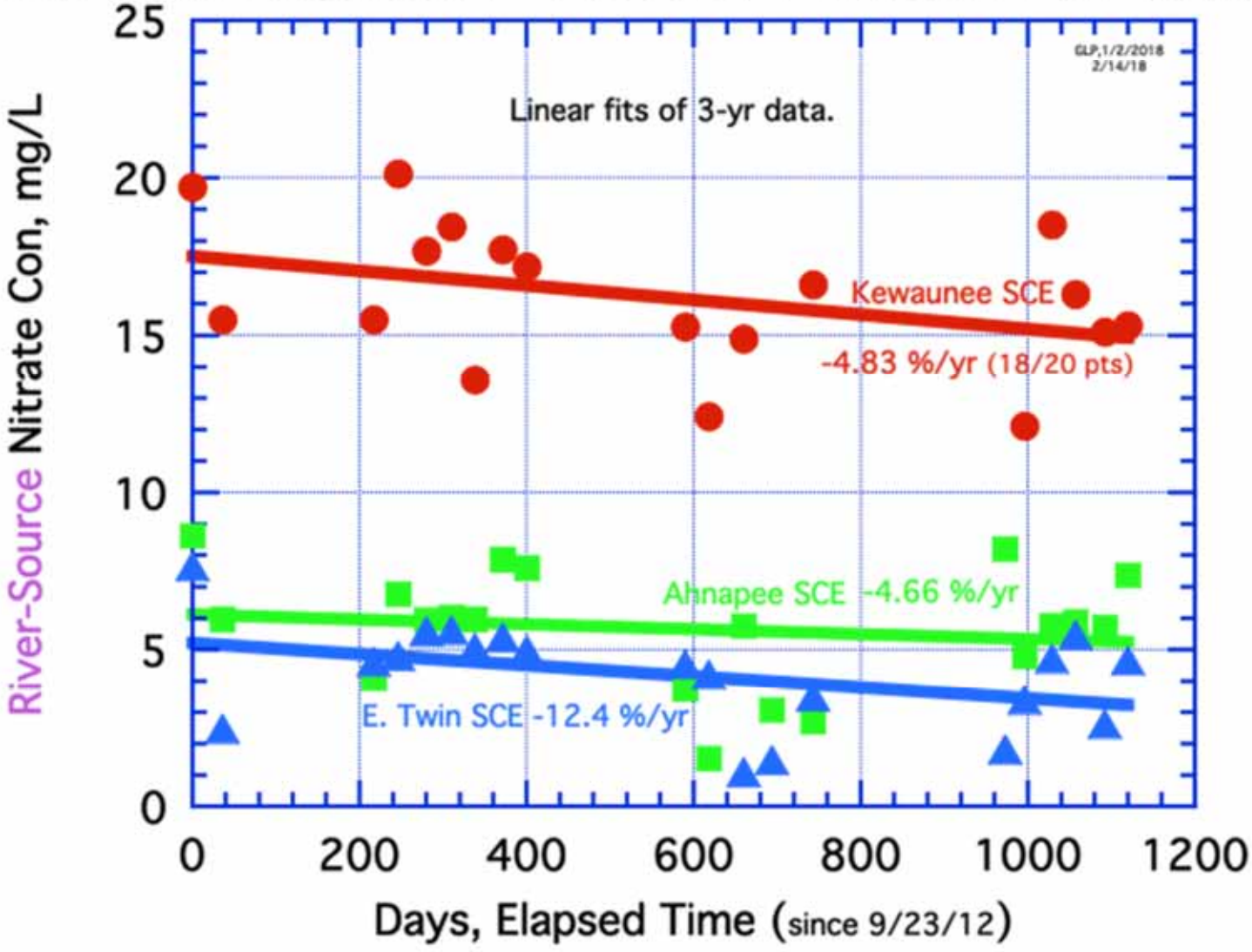
Retest Linear fits of River-Source Nitrate Data vs Elapsed Time; 3-yr data.

- Masking of lowest pt. for Kew. Riv. (5/25/15, 1.5 in rain) changed the apparent annual decrease in NO3 from -9.66 to -5.84 %/yr.
- Masking of 2nd lowest pt. (8/19/14, 1.4 in rain, below) is evaluated next.



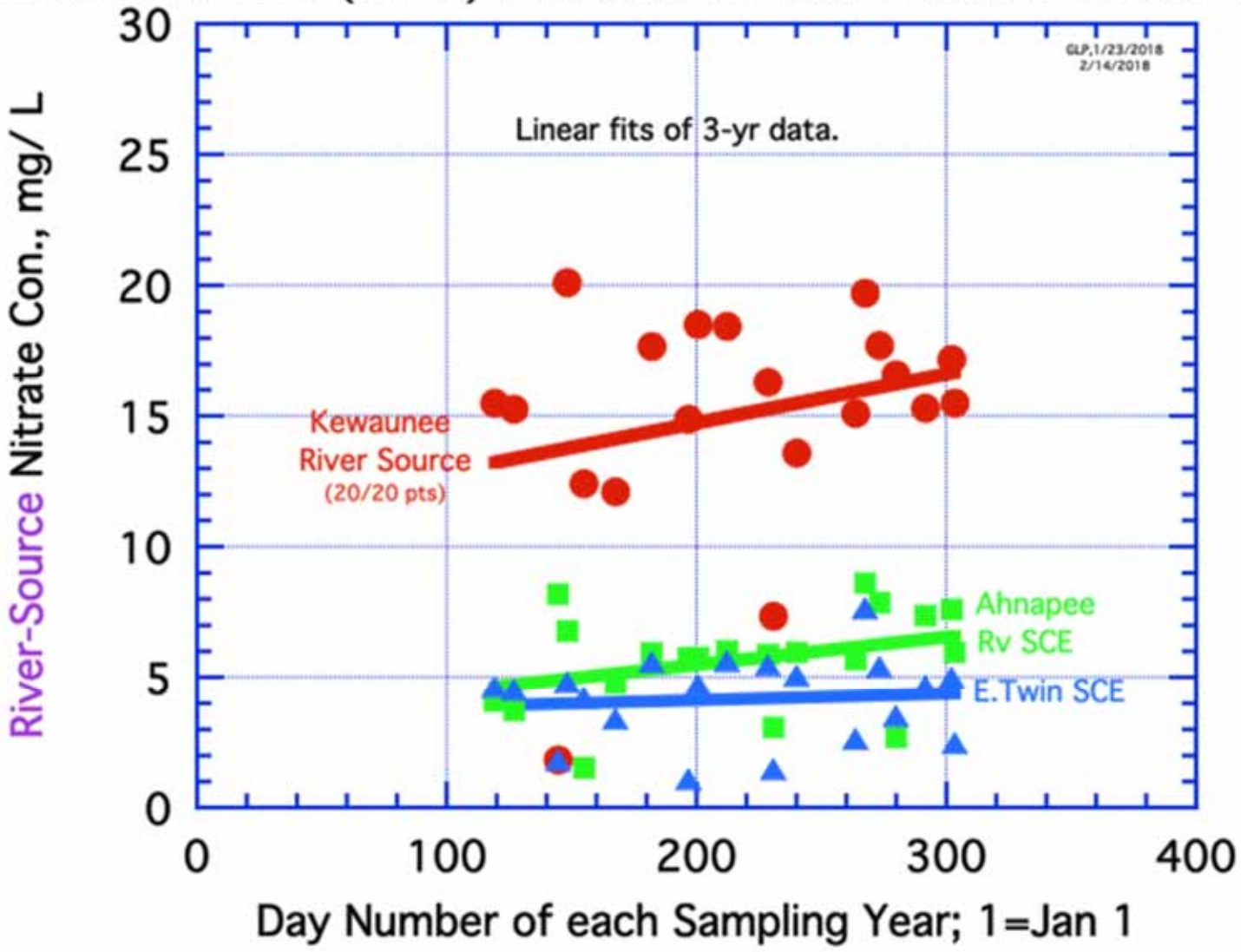
Final Linear fits of River-Source Nitrate Data vs Elapsed Time; 3-yr data.

- Masking of 2nd low Kew. pt. (to 18/20) further changed annual decrease in Nitrate from -9.66 (20/20) to -5.84 to -4.83 %/yr.
- Resultant NO3 decreases in 3 Riv's may reflect beneficial Agr. practice.



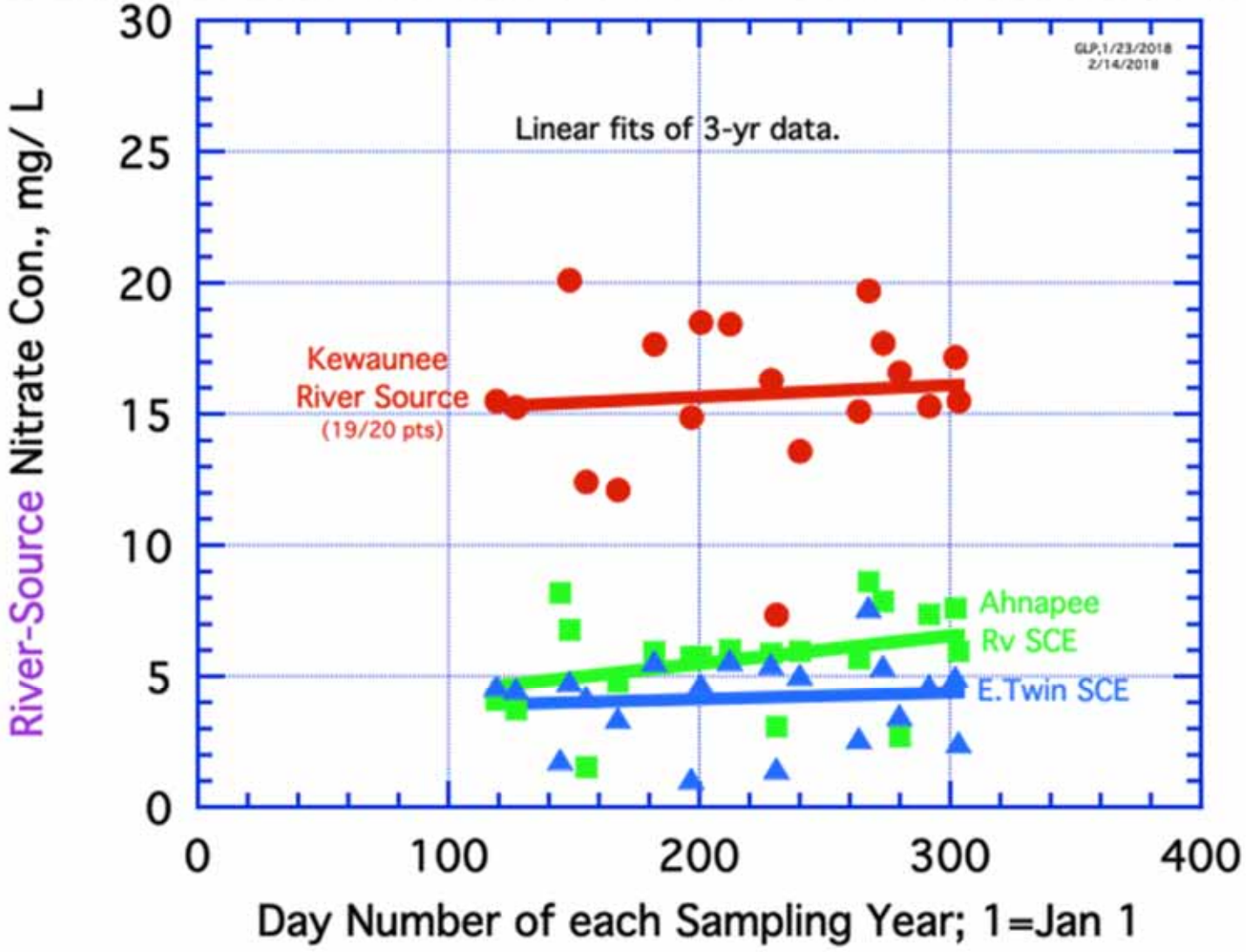
Initial Linear Fits of River-Source Nitrate vs Day-of-Year; for 3-yr Data.

- The Ahnapee & E. Twin rivers don't exhibit significant seasonal trends.
- Kew. SCE has very high NO3; *note* Kew. shows original 2 low outriders.
- Effects of these 2 (of 20) are examined next to assess uncertain trend.



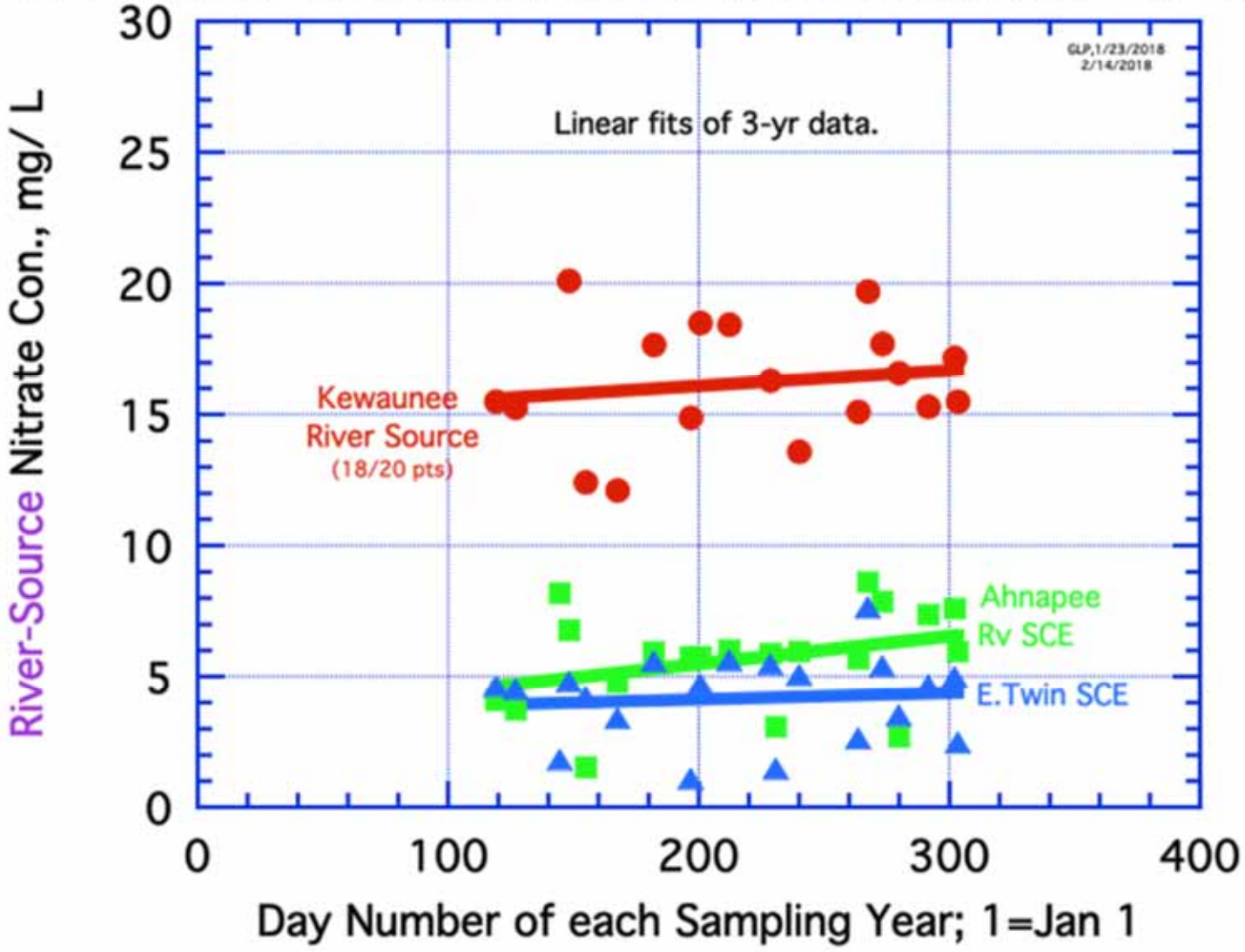
Retest Linear Fits of River-Source Nitrate vs Day-of-Year; for 3-yr Data.

- Ahnapee & E.Twin remain unchanged & don't exhibit seasonal trends.
- Masking of 1 low outrider for Kew. produces a negligible seasonal trend.
- Masking of 2nd low outrider for Kew. will check for additional effect.



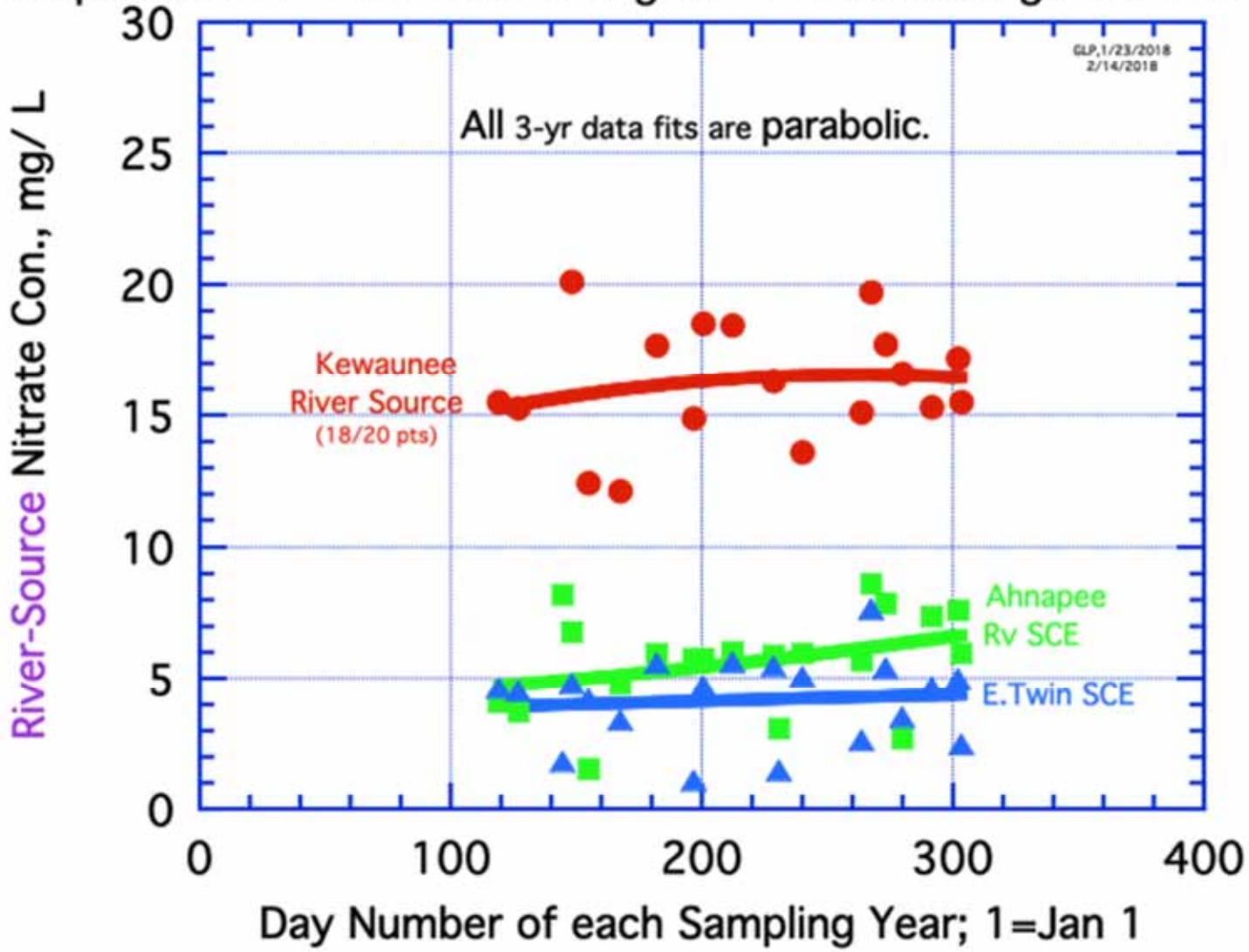
Final Linear Fits of River-Source Nitrate vs Day-of-Year; for 3-yr Data.

- Masking 2 low outriders for Kew. reinforces negligible seasonal trend.
- Ahnapee & E.Twin remain the same & don't exhibit sig. seasonal trends.
- Parabolic data fits are shown next to check for weak seasonal variation.



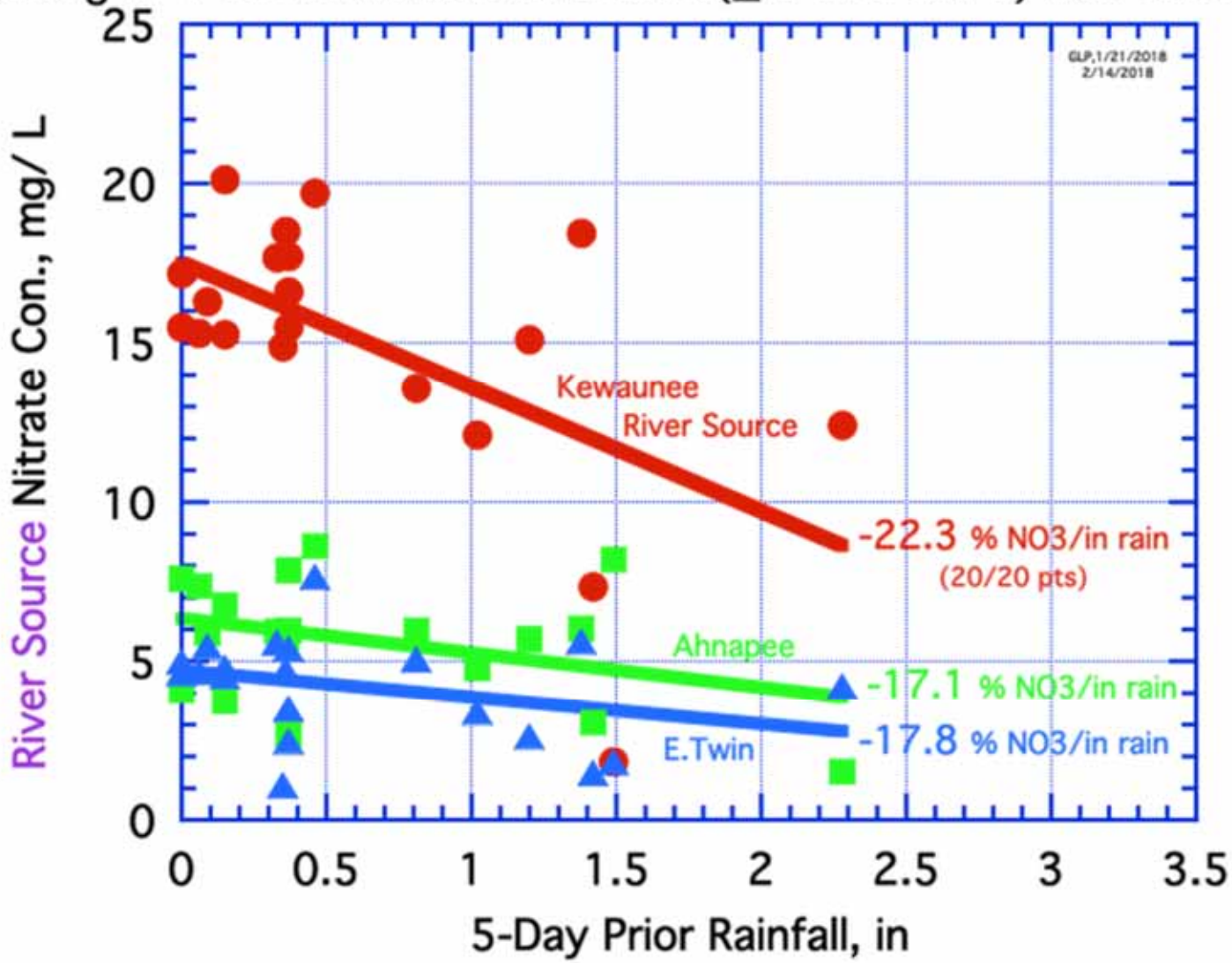
Parabolic Fits of River-Source Nitrate vs Day-of-Year; for 3-yr Data.

- This Parabolic fit of 18/20 pts. for Kew. differs only slightly from the previous linear fit -- & shows a negligible seasonal trend for SCE-NO3.
- Ahnapee & E.Twin remain unchanged -- & show no sig. seasonal trends.



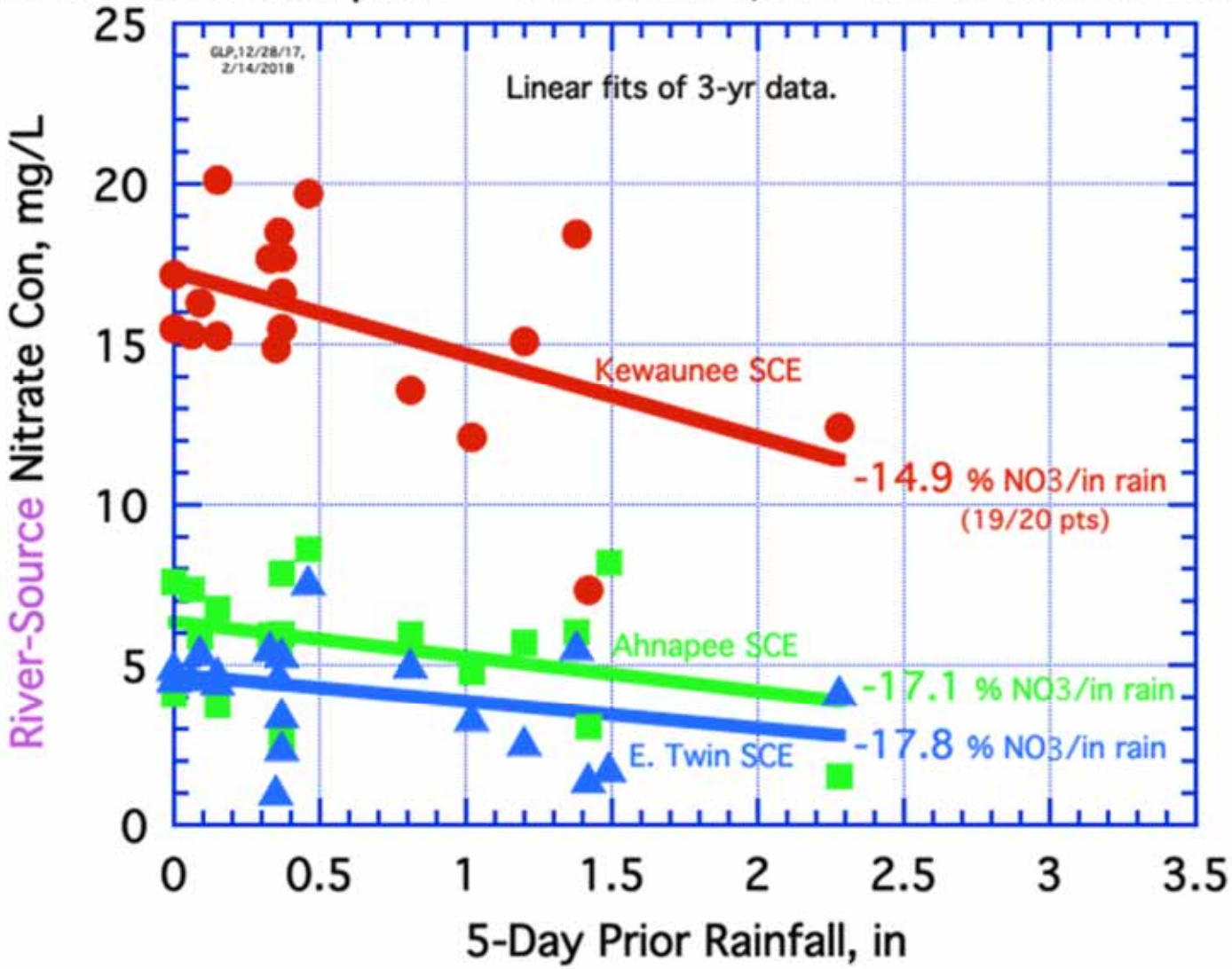
Initial Linear fits of River-Source Nitrate vs 5-Day Prior Rainfall; 3-yr data.

- Plots like this help assess "Rain Downwash" effects on pollutants.
- Kew. Riv. NO3 decreased with 5-day Prior Rain (-22.3 % NO3/in rain).
- Masking of 1 & 2 Kew. data outriders (≥ 3 st'd dev's) was tested next.



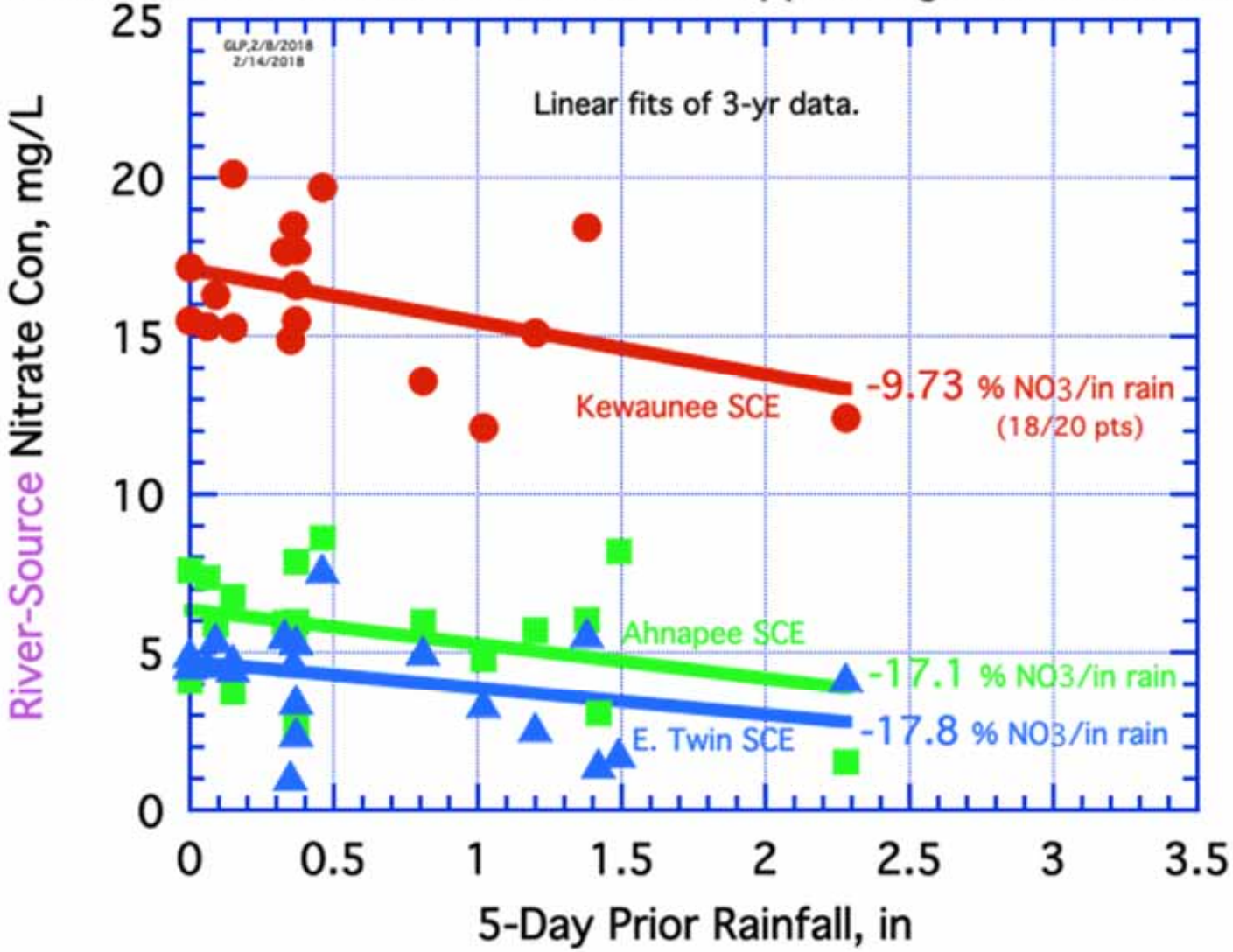
Retest Linear fits River-Source NO3 Data vs 5-Day Prior Rainfall; 3-yr data.

- Masking lowest Kew. data pt. was 1st step to assess "Rain Downwash".
- Kew. Riv. % NO3/in rain changed from -22.3 (20/20) to -14.9 (19/20).
- Second lowest data pt. is ~ 3 st'd dev's, and will be masked next.



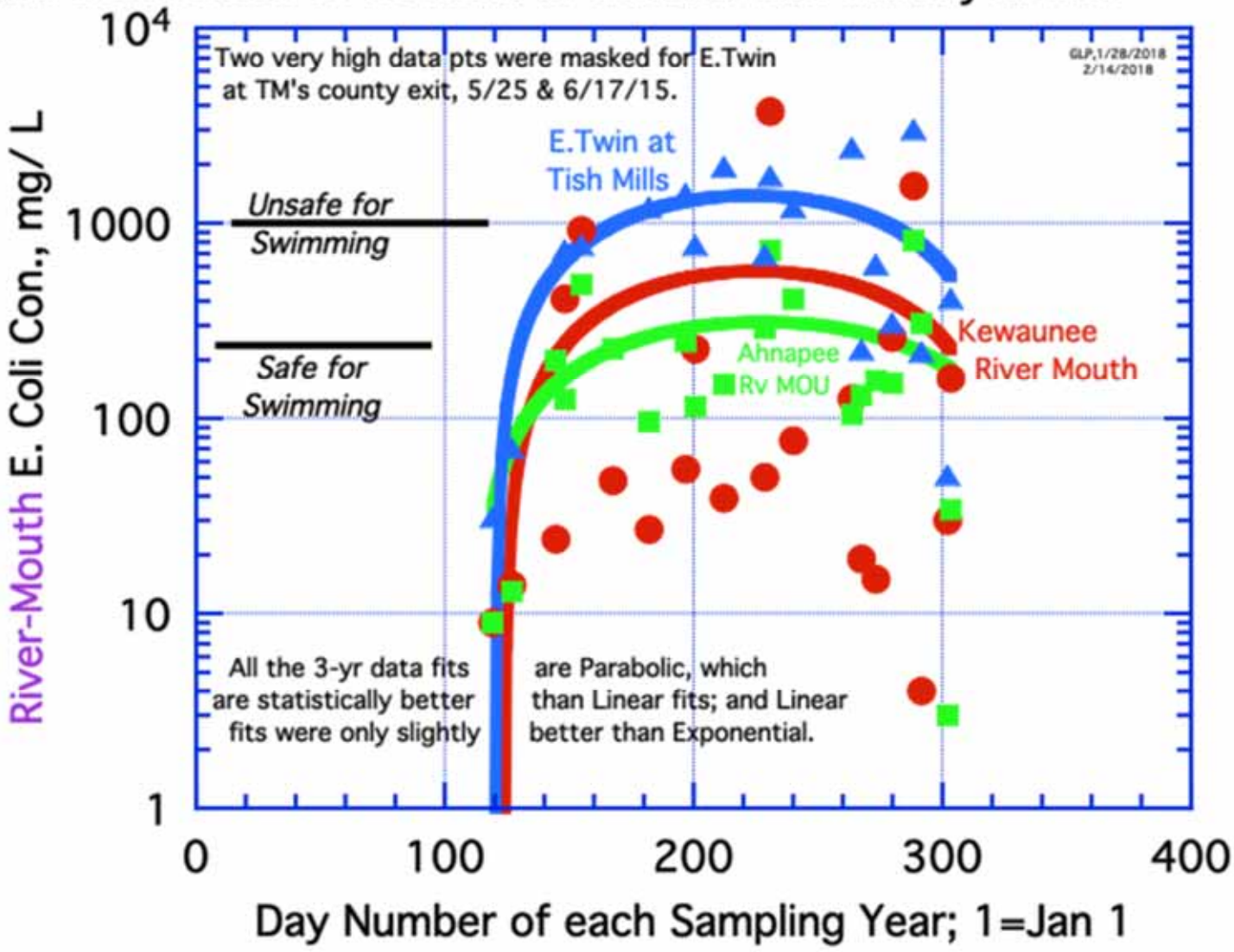
Final Linear fits, River-Source Nitrate Data vs 5-Day Prior Rainfall; 3-yr data.

- Successive masking of 2 low pts. was used to assess "Rain Downwash".
- Kew. Riv. % NO3/in rain spanned -22.3 (20/20) to -14.9 to -9.73 (18/20).
- Rain Washdown effects on Source-NO3 appear significant in each river.



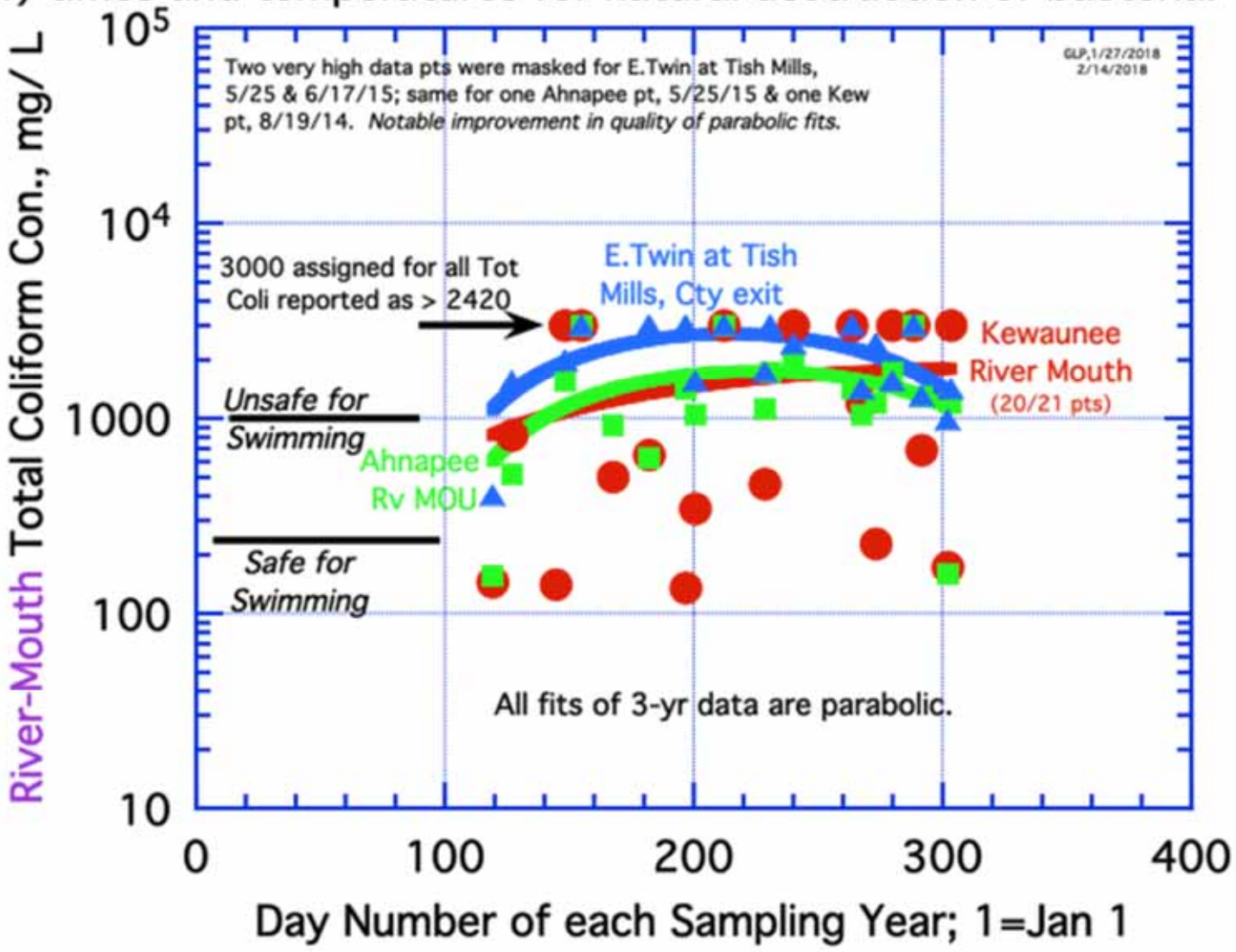
Best Seasonal Parabolic Fits of River-Mouth E. Coli con; for 3-yr Data.

❄ Large data scatter for Kew. Riv. (1000 x) surely reflects highly variable source strengths *and* also residence (flow) times and temperatures for natural destruction of bacteria in downstream marshy areas.



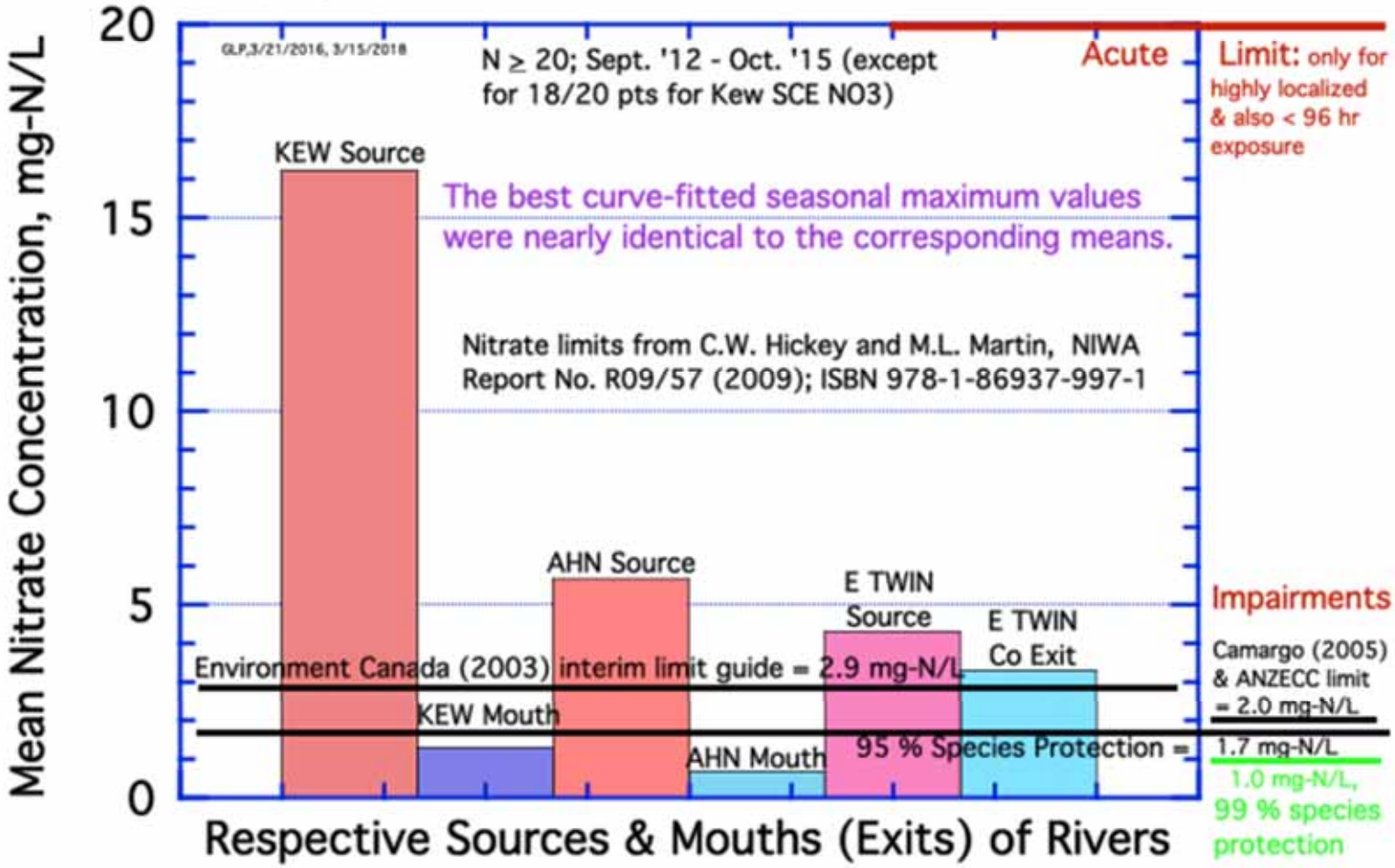
Best Seasonal (parabolic) Fits of River-Mouth Total Coliform; for 3-yr Data.

❄ Large data scatter for Kew. Riv. (> 30 x, bounded by upper meas. limit) surely reflects large variations in "source strength" *and* also residence (flow) times and temperatures for natural destruction of bacteria.



Mean Nitrate in Kewaunee, Ahnapee & E. Twin Rivers; 3-yr simultaneous data.

- NO3 in Kew. SCE >> Impair. limits; detailed Bovine manure sources uncertain.
- Mouth-NO3's reflect consumption by known aquatic vegetation, and also by abundant denitrifying bacteria in river sediment under marsh-like conditions.



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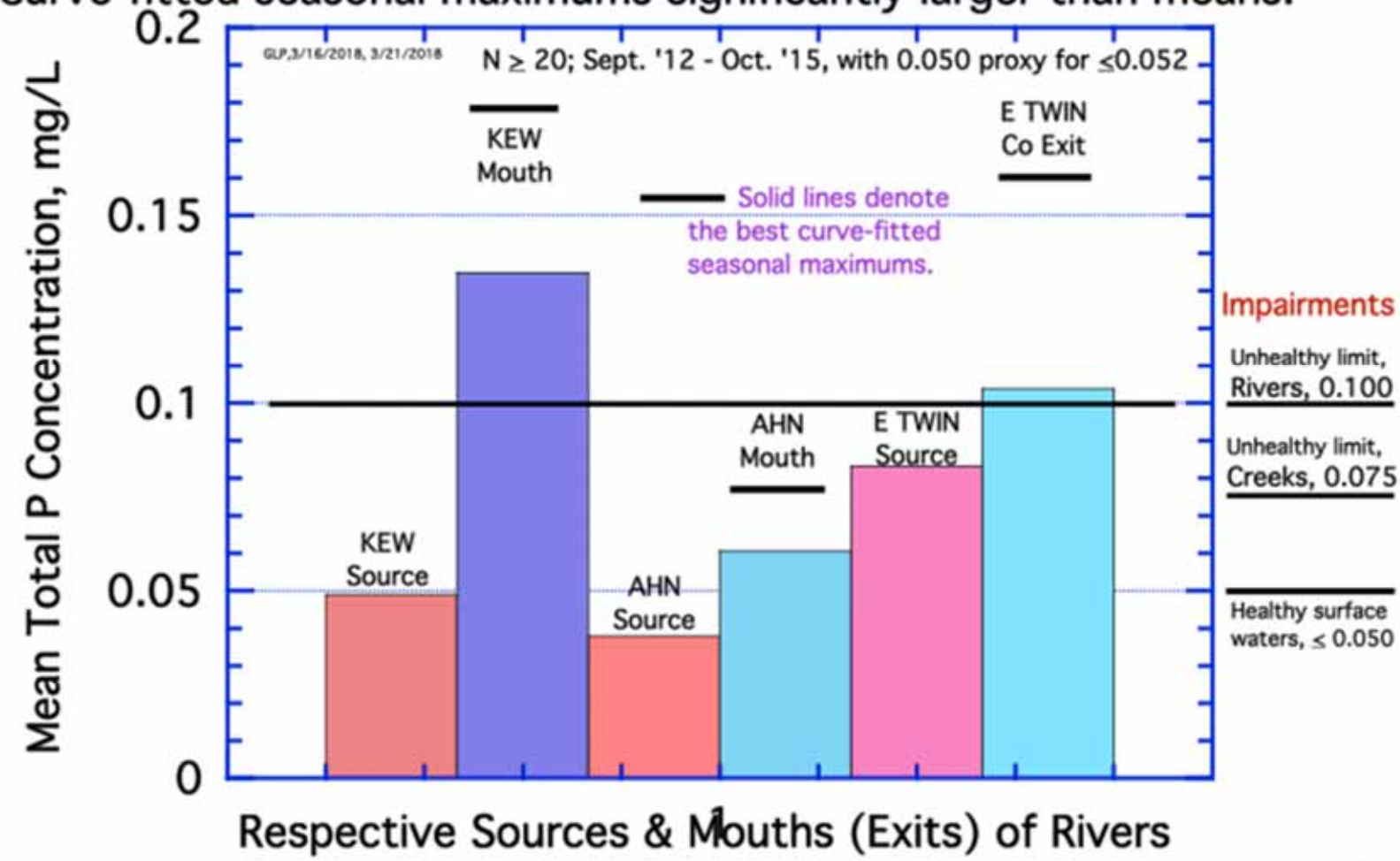
Mean & Max Total Phos. in Kew, Ahnapee and E.Twin Rivs; 3-, 5-yr simult's data.

- Total P in Kew. MOU is "Unhealthy" and is >2 X that in Ahnapee MOU.
- Mean Total P's in Mouth areas always exceeded con's in Source areas.
- Curve-fitted seasonal maximums significantly larger than means.



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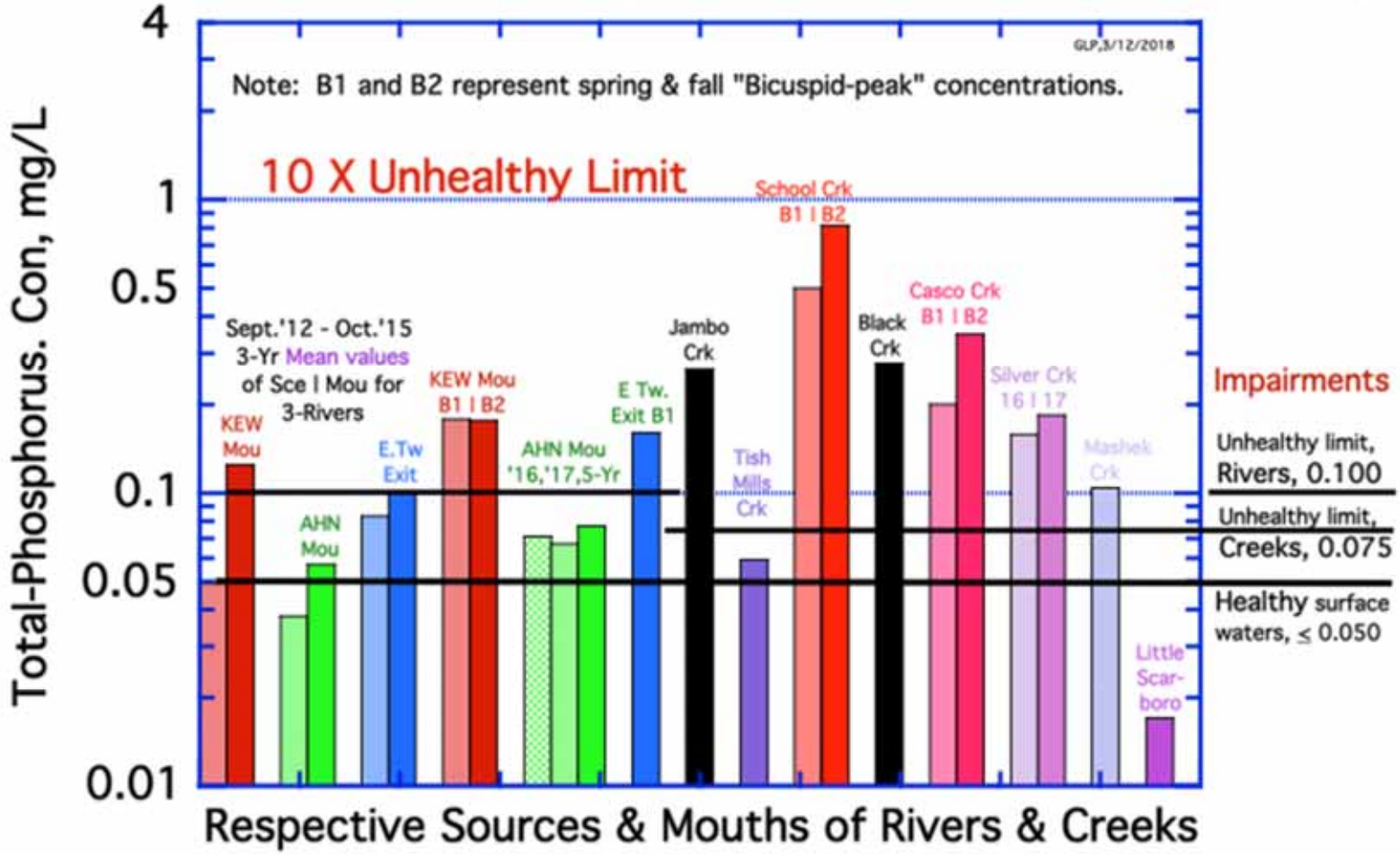
Mean & Curve-Fitted-Max Total P in Kew., Ahn. & E. Twin Rivers, and 8 Creeks.

- "Poster Child" Little Scarboro Crk (1st class trout) is only fully "Healthy" str.
- School & Casco Crk MOUs very "Unhealthy;" same since DNR 2000 surveys.
- Ahnapee Riv MOU mid-Healthy/Unh'y; Kew, E.Twin (Tish M) gen'lly Unhealthy.



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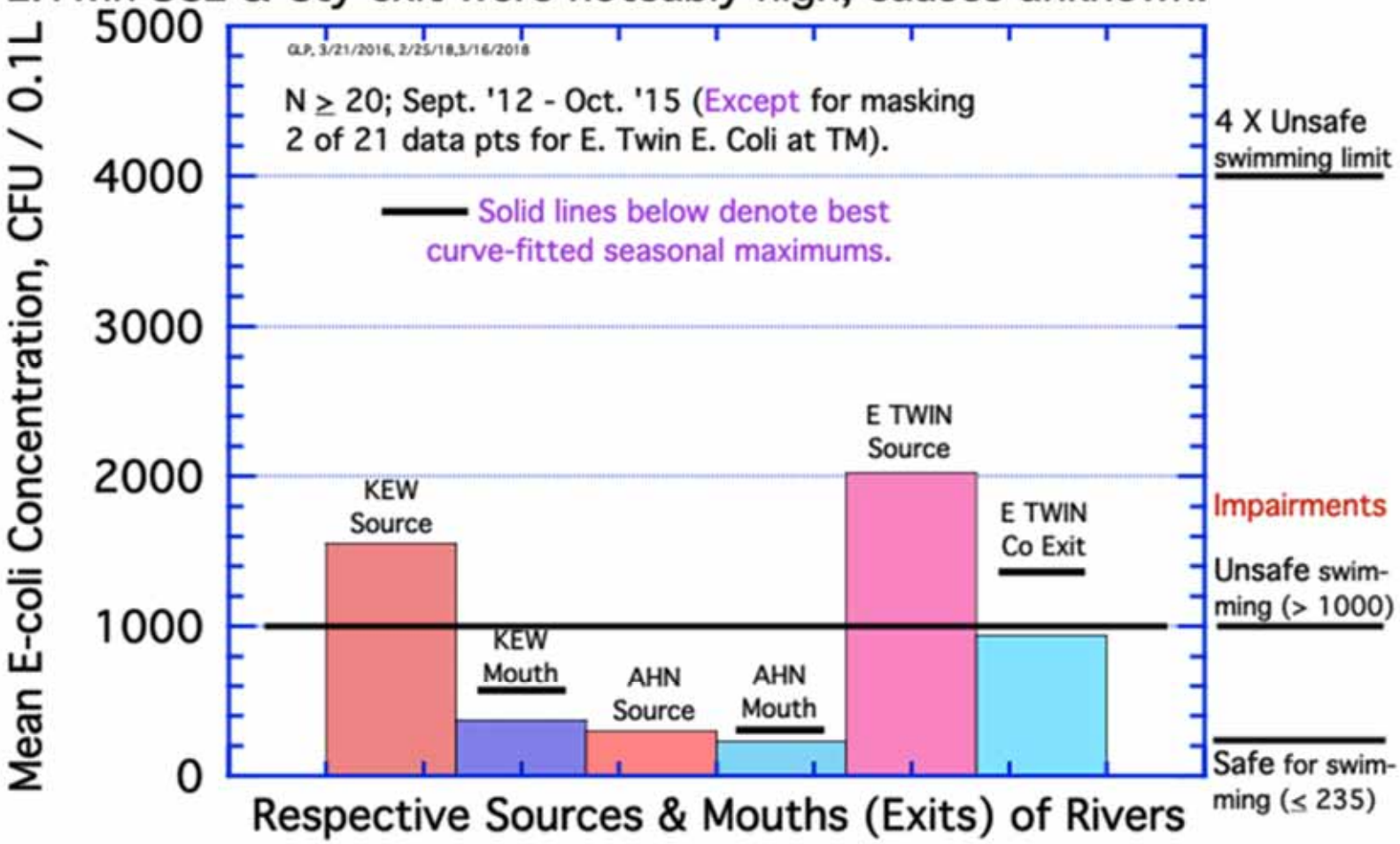
Mean & Max E. Coli in Kew, Ahnapee and E.Twin Rivs; 3-yr simultaneous data.

- Ahnapee SCE was much cleaner than Kewaunee and E.Twin Sources.
- Curve-fitted seasonal maxim's generally a little larger than means.
- E.Twin SCE & Cty exit were noteably high; causes unknown.



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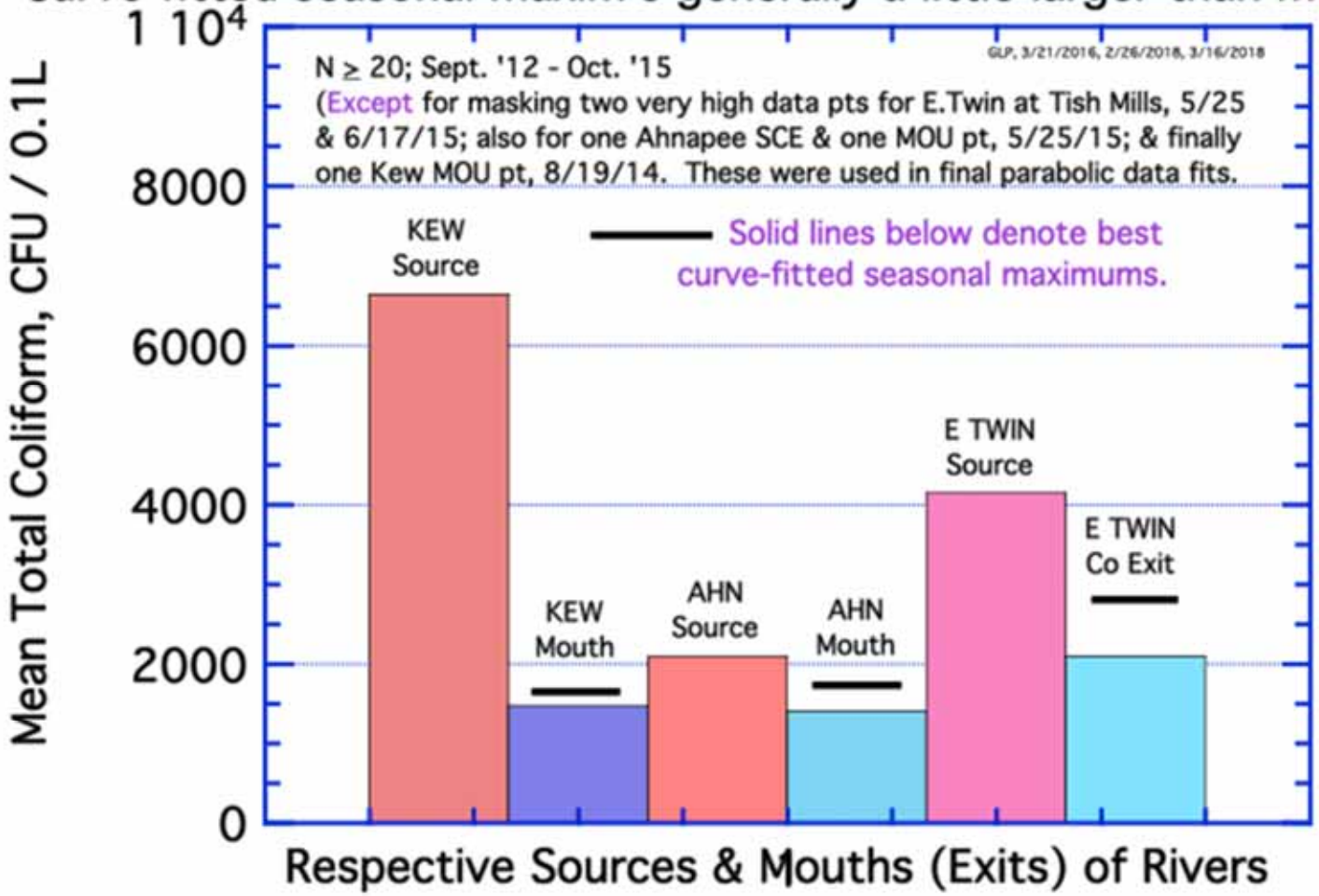
Mean & Max Total Coliform in Kew, Ahnapee and E.Twin Rivs; 3-yr simult's data.

- Mean Tot. Coli. generally 2 -- 4 X larger than respective E. Coli con's.
- Reduction of Tot. Coli from SCE to MOU is significant for all 3 rivers.
- Curve-fitted seasonal maxim's generally a little larger than means.



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Summary of Nitrate Results; Part 1

e Nitrate in Kew. SCE >> Impairment limits; detailed Bovine-manure "watershed sources" are uncertain, and "blurred" by extensive county-wide manure trucking and drainage tiling near streams.

e Much lower river Mouth NO3's reflect consumption by aquatic vegetation, and also by denitrifying bacteria in river sediment under marsh-like conditions (--> N2 and N2O, a potent Greenhouse gas and destroyer of Stratospheric ozone).

e Large data scatter for rivers reflects variable runoff / erosion of multiple semi-independent sources.

e "Rain Washdown" effects on Source-NO3 are significant for each river.

e Detailed fits of SCE NO3 data show negligible seasonal trend for each river.

e Annual NO3 decreases (5-12%) in 3 Rivers over 3-yrs *may* reflect beneficial Agricultural practices.

e Ahnapee SCE & MOU are generally much lower in all pollutants than Kew. & E. Twin river sites.

Summary of Phosphorus Results; Part 2

e Strong "Parabolic-like" Seasonal Total-P profiles are evident in Creeks & Rivers, March--Nov.

e Seasonal Total-P profiles in highly-polluted Creeks & Rivers show “Bicuspid Peaks” attributed to Spring Thaw runoff, and Spring & Fall Tilling & Manure Spreading.

e 6 of 8 Creeks significantly exceed P-Unhealthy Limit for Creeks, 0.075 mg P/L.

e School & Casco Creek MOUs very P-Unhealthy; same since DNR 2000 surveys.

e "Poster Child" Little Scarboro Creek (1st class trout) is only fully "Healthy" str.

 5-yr Ahnapee Total-P follows parabolic-like seasonal cycle; and Ahnapee is notably P-healthier than Kewaunee and E. Twin.

e Mean Total P's in Mouth areas always exceeded Source con’s.

e Curve-fitted seasonal maximums in Total-P are somewhat larger than means.

Summary of Coliform Results; Part 3

e Large data scatter for Kew. MOU E. Coli (1000 x) reflects highly variable source strengths, *and also* residence (flow) times, temperatures and oxygen levels for natural destruction of bacteria in downstream marshy areas.

e E. Twin SCE & County exit were notably high in E. Coli & Total Coliform; detailed *Bovine* sources unknown.

e Mean Total Coliform generally 2 -- 4 X larger than respective E. Coli con's.

e Reduction of E. Coli and Coliform from SCE to MOU is significant for all 3 rivers.

From 1 April 2016 Summary of Major Results

Over last 15 - 50 years, con's of Source-nitrate in Kewaunee R. tripled, and Mouth Total-P increased about 20 %.

Projected Kew. Total-P Discharge (20 days over 3-yr) = 34,100 lb P/yr

Projection is typically influenced by large episodic River discharges, including heavy early-spring runoff (often not sampled in Kew. R).

The projected P-discharge compares with 1984-WDNR-ave = 42,000 for CYs 1969-1978 (annual ave ranged 11,000 to 106,000); and also with USGS unfiltered-P results (n=6 days) of 13,500 lb P/yr for CY 2002.

Conclusion Regarding Nitrate

Advocacy is strongly needed to (1) adopt an interim Nitrate Standard; and (2) begin including, for the first time, unacceptably high nitrates, e.g., > 5 mg N/L, in required WDNR biennial listings of Impaired Surface Waters to EPA and Congress.

Nitrate is important because: (1) levels > 2 to 3 ppm become increasingly toxic to aquatic life; (2) both Phosphorus and Nitrate are needed to produce Hazardous Algae Blooms (HAB) of cyanobacteria -- very toxic to humans, animals that inhale toxic aerosol, and also contact/consume HAB-containing water; and (3) Nitrate in surface water reflects a major "driving source" for nitrate in ground water.

Notably, the past 3 or more WDNR Impaired Waters reports have NOT CONTAINED A SINGLE NITRATE impairment out of each 1400 to 1600 impairments reported.

Conclusion without data: "There is no known Nitrate pollution of surface waters".

Probable Conclusion with data: "There are significant Nitrate pollution problems in certain listed waters".

Questions and Comments?

Written suggestions and comments are welcome.
Please see available handouts after session for further information.

Copies of this Power Point presentation may be obtained from the University of Wisconsin, Stevens Pt. website after the conference.

The complete Power Point of our 1 April 2016 Presentation is publically available at
https://www.uwsp.edu/cnr-ap/UWEXLakes/Documents/programs/convention/2016/FridayConcurrent/Session7/GeraldPellett_ThreeYearsOfWarmSeasonMonthlyData.pdf

The Kewaunee CARES e-mail is kewauneecares4u@gmail.com

Information is also posted on **Kewaunee CARES Facebook Page**

Appendix A

Information Relevant to Kewaunee CARES / WAV Stream Sampling Program

Quality Assurance Plan, Notes on Sampling, and Contacts

Sampling and analysis of surface waters in Kewaunee County, WI, from the Kewaunee, Ahnapee and East Twin River systems was conducted monthly, for 7- 8 months during the "warm season," from 24 Sept. 2012 thru 19 Oct. 2015 (the 3-yr Program). Citizen volunteers from Kewaunee CARES (Citizens Advocating Responsible Environmental Stewardship) were allied with Water Action Volunteers and the Clean Water Action Council. Additionally, subsets of volunteers obtained samples for chloride analyses in upper portions of the E. Twin river, and also Total Phosphorus (with WDNR laboratory analyses) in eight creeks and the Ahnapee river during the "warm seasons" of 2016 and 2017.

Trained water sampling personnel were always used (often two, assisted by two helpers) in the sampling, handling and labeling of at least three river water samples at each site (for Nitrate, Total Phosphorus, and E. Coli / Total Coliform in the 3-yr program). Photo and written documentation of water sampling processes, sampling time, location, air temperature, and sample bottles with definitive labels was employed throughout the study. Sample bottles were immediately placed in an ice chest prior to delivery for analysis. Also, duplicate water sample bottles (split samples) were sometimes sent to the Wisconsin DNR for Total Phosphorus analyses, for the rivers; recent creek samples obtained by volunteers were analyzed entirely by the WDNR.

Analytichem LLC, registered in Wisconsin thru 12/31/2014 as WDATCP No. 115205-D3 (and also thru 2015) conducted the primary 3-yr analyses and provided reports to the Kewaunee CARES organization. Methodology included: Nitrate reported as N (mg NO3-N/L) using EPA Method 300; Total Phosphorus reported as P (mg P/L), analyzed by Pace Analytical; E. Coli, Standard Method 9223, MPN bacteria results in CFU / 0.1 L; Total Coliform, Standard Method 9223, MPN bacteria results in CFU / 0.1 L.

Data from Analytichem LLC data sheets were originally organized and analyzed through development of detailed Excel spreadsheets of increasing complexity. Interim 2-yr - 4-yr drafts were typically made available to Kewaunee CARES and WAV volunteers, and also concerned citizens. Those Excel data were subsequently translated to respective DNR-provided Excel spreadsheet formats for uploads of volunteer sampling data and sampling-site locations to the WDNR for consideration in Wisconsin's 2016 Impaired Waters report to Congress and the EPA. Similar translations and reporting of data were carried out for Wisconsin's 2018 Impaired Waters report.

Whenever Nitrate, Total-Phosphorus, E. Coli and Total Coliform concentrations were reported as "smaller than" or "greater than" specific analytical limits, because actual concentrations sometimes exceeded normal analytical ranges, a carefully checked and validated set of assumptions was used to plot as much "real" data as possible – in order to define appropriate representative data trends. For results below the lower detection limit, the following were applied: nitrate = 0.010 for < 0.014 mg NO3-N/L; Tot-P = 0.030 (and later 0.050) for < 0.052; and Tot P = 0.040 for < 0.088 mg P/L. For results above the upper detection limit: Total Coli = 3000 for > 2419.6; and Total Coli = 60,000 for > 48,392 CFU/0.1 L.

The 2-yr structured data reports to the WDNR (12/28/2014 and 1/10/2017), and detailed data analyses presented 4/1/2016 and here (4/20/2018) were generated by this writer, Gerald L. Pellett, who is a Research Associate at NASA Langley R.C. and also a warm-season resident of Kewaunee. The writer's entire efforts on this project have been as an unpaid citizen volunteer for Kewaunee CARES, a non-profit organization allied as a working committee of the Clean Water Action Council. The organization's website is kewauneecares.com and e-mail is kewauneecares4u@gmail.com . Information may also be obtained from the Kewaunee CARES Facebook Page. Further detailed information on the subject Kewaunee County stream sampling program can be obtained from Kewaunee CARES leaders and participants in the program, Mr. Lynn Utesch <lnutesch@yahoo.com> (920) 388-0868), and Dr. William Iwen <iwenwilliam22@gmail.com> (920) 487-7215.

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Some notes on Water Quality Limits (summary bar graphs show additional criteria)

The following Water Quality Limits are listed on the original Kewaunee CARES Analytichem certified water analysis data sheets (Analytichem Certification is noted in the QAP), and they apply to the present analyses.

Regarding E-Coli CFU/100 mL {Most Probable Number (MPN) of Colony Forming Units (CFU) per 100 milliliter river water}:

For E-Coli <1 CFU/100 mL, *water is safe for drinking*

For E-Coli 0 - 234, *No Public Beach advisory* (green sign, EPA / Great Lakes Research Initiative)

For E-Coli 235 - 999, *Public* B*each advisory is issued* (yellow sign, EPA / GLRI)

For E-Coli >1000, Public B*each is closed* (red sign, EPA / GLRI)

Regarding Phosphorus, mg P/Liter in stream water:

For 0.01 - 0.05 mg P/L, Healthy, Good Water Quality

For 0.05 – 0.075 mg P/L, Borderline Healthy in <u>Creeks</u>

For 0.05 - 0.10 mg P/L, Borderline Healthy in <u>Rivers</u>

For > 0.10 mg P/L, Unhealthy in stream water

For Nitrates in drinking water, maximum allowed by the EPA is 10 mg NO3-N/L

Sampling Locations on Kewaunee, Ahnapee, and East Twin Rivers, 2012-2017

(Original in 4/1/2016 paper was revised 1/26/2017; revised and expanded 3/25/2018)

Kewaunee River Watershed; **Kew-Srce1** [Kewaunee R. Source (**Casco Creek,** Maple Rd. & County S)]; 90700 (WBIC);

SWIMS 1xxxxxxx; TK03; GPS coordinates: 44.61792, -87.60243

Kewaunee River Watershed; **Kew-Mouth1** [Kewaunee R. Mouth (Harbor Landing, 100 ft upstream of Hwy 42 bridge)]; 90700 (WBIC);

SWiMS 10039266; TK03; GPS coordinates: 44.46366, -87.50408

Ahnapee River Watershed; **Ahn-Sce1** [Ahnapee River Source (Stevenson Pier Rd. & County H)]; 94800 (WBIC);

SWIMS 1xxxxxxx; TK04; GPS coordinates: 44.74767, -87.53740

Ahnapee River Watershed; **Ahn-Mouth1** [Ahnapee River near-Mouth (Olson Park, Algoma)]; 94800 (WBIC);

SWIMS 1xxxxxxx; TK04; GPS coordinates: 44.61749, -87.44461

E. Twin River Watershed; **E. Twin-Srce1** [East Twin R. Source (Ellisville, County F & AB)]; 84000 (WBIC);

SWIMS 10034445; TK02; GPS coordinates: 44.45698, -87.68444

East Twin River Watershed; **E.Twin-Mid1** [East Twin Midpoint (Townline Rd., just north of Hwy 29), WDNR survey point]]; 84000 (WBIC); TK02; GPS coordinates:

East Twin River Watershed; **E.Twin-Exit1** [East Twin River County Exit at Tish Mills (near County Rd. BB & Mill Lane)]; 84000 (WBIC); SWIMS 10016588; TK02; GPS coordinates: 44.32953, -87.61972

Sampling Locations on Upper E. Twin River for Chloride (based on Electrical Conductivity).

East Twin River Watershed; Sample sites Nos. 1 thru 4, beginning with Un-Named Tributary (UNT) from vicinity of Kewaunee County Rd. AB and Cherneyville Rd.

The UNT flows northeast ~ 1.5 mile before passing under Sleepy Hollow Rd.
Site 1; 84000 (WBIC); GPS coordinates: 44.44120, -87.66426, for UNT of E. Twin R. at Sleepy Hollow Rd.

Next, the UNT flows 0.5 mile east before passing under Rustic (Hrabik) Rd.
Site 2; 84000 (WBIC); GPS coordinates: 44.44227, -87.65422, for UNT of E. Twin R. at Rustic (Hrabik) Rd.

Next, the UNT flows 0.7 mile east before it joins the E. Twin R. ~ 20 yards south of Hwy 29 bridge over the E. Twin. The 3rd site is on the E. Twin R. just north of the Hwy 29 bridge, ~ 5 yds upstream.
Site 3; 84000 (WBIC); GPS coordinates: 44.44362, -87.64080, ~ 5 yards upstream of Hwy 29 bridge and ~ 40 yards (total) upstream of the UNT junction with the E. Twin R.

The 4th and last site is on the E. Twin R., ~ 0.8 mile downstream of the UNT + E. Twin R. merge point and after flowing under a small bridge at Townline Rd (Lane);
Site 4; 84000 (WBIC); GPS coordinates: 44.43028, -87.64406, for E. Twin R. ~ 0.8 mile S (downstream) of Hwy 29, at Townline Rd.

Sampling Locations for Selected Creeks in Kewaunee County

School Creek; 90700 (WBIC);
SWIMS 1xxxxxxx; TK03; GPS coordinates: 44.xxxxx, -87.xxxxx

Casco Creek; 90700 (WBIC);
SWIMS 1xxxxxxx; TK03; GPS coordinates: 44.xxxxx, -87.xxxxx

Little Scarboro Creek; 90700 (WBIC);
SWIMS 1xxxxxxx; TK03; GPS coordinates: 44.xxxxx, -87.xxxxx

Silver Creek; 94800 (WBIC);
SWIMS 1xxxxxxx; TK04; GPS coordinates: 44.xxxxx, -87.xxxxx

Tish Mills Creek; 84000 (WBIC);
SWIMS 1xxxxxxx; TK02; GPS coordinates: 44.xxxxx, -87.xxxxx

Jambo Creek; 84000 (WBIC);
SWIMS 1xxxxxxx; TK02; GPS coordinates: 44.xxxxx, -87.xxxxx

Black Creek; West Twin xxxxx (WBIC)**;**
SWIMS 1xxxxxxx; TK0x; GPS coordinates: 44.xxxxx, -87.xxxxx

Mashek Creek; Lake Michigan xxxxx (WBIC)**;**
SWIMS 1xxxxxxx; TK0x; GPS coordinates: 44.xxxxx, -87.xxxxx