Horse Creek Stewardship Program 2015 and 2016 Annual Reports Summary

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HCSP 2015 and 2016 Annual Reports

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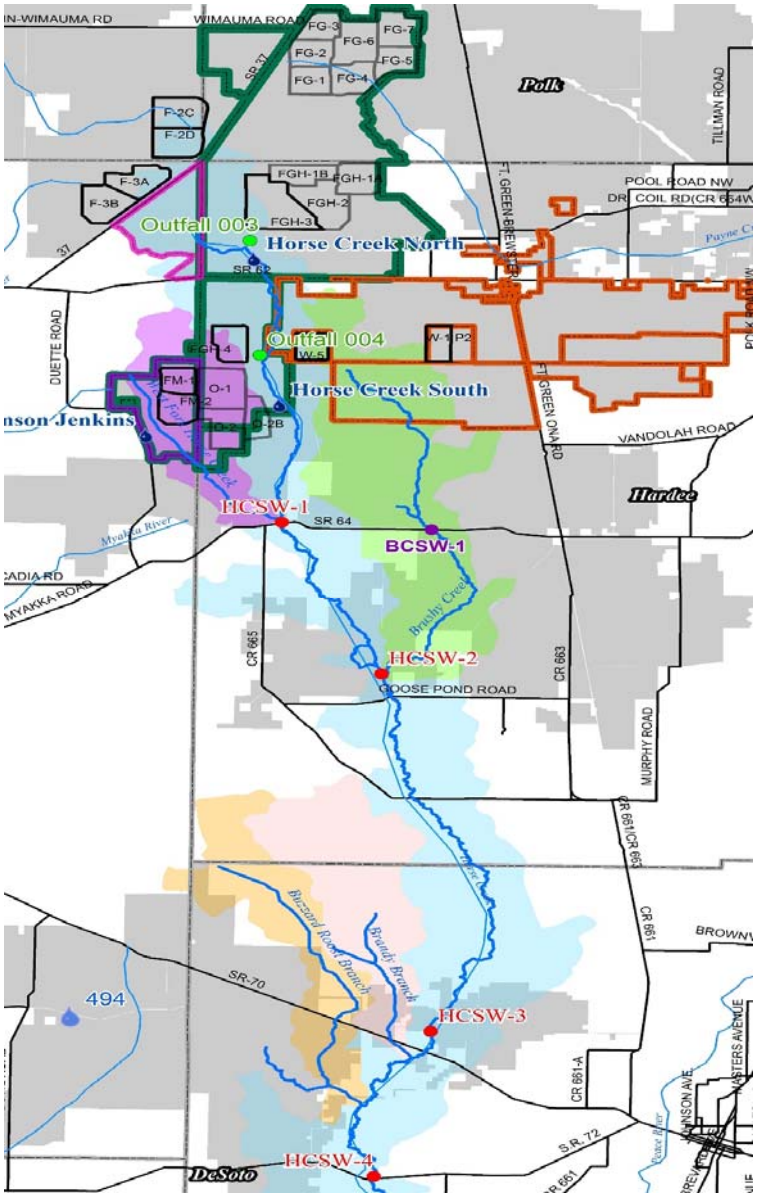
Project Methods

Horse Creek Stewardship Program Overview

- Created to ensure that Mosaic's mining activities do not adversely affect Horse Creek, Peace River, or Charlotte Harbor
- The 3 components of the plan are:
  - Monitoring and reporting on stream quality
  - Investigating adverse conditions or significant trends
  - Implementing corrective action for adverse changes to Horse Creek caused by Mosaic's mining activities


WIMAUMA ROAD
FG-3
FG-7
FG-6
FG-2
FG-5
FG-1
FG-4
Polk
TILLMAN ROAD
F-2C
F-2D
F-3A
F-3B
FGH-1B
FGH-1A
FGH-2
FGH-3
POOL ROAD NW
COIL RD(CR 654W
Outfall 003
Horse Creek North
SR 62
Outfall 004
W-5
W-1
P2
Horse Creek South
DUETTE ROAD
FGH-4
FM-1
O-1
FM-2
O-2
P-2B
FT. GREEN ONARD RD
VANDOLAH ROAD
Hardee
HCSW-1
SR 64
BCSW-1
Myakka River
MYAKKA ROAD
CR 665
HCSW-2
GOOSE POND ROAD
CR 663
MURPHY ROAD
CR 661
Brushy Creek
Buzzard Roost Branch
Brushy Branch
SR-70
494
HCSW-3
CR 661-A
JOHNSON AVE
HUSTERS AVENUE
S.R. 72
HCSW-4
DeSoto

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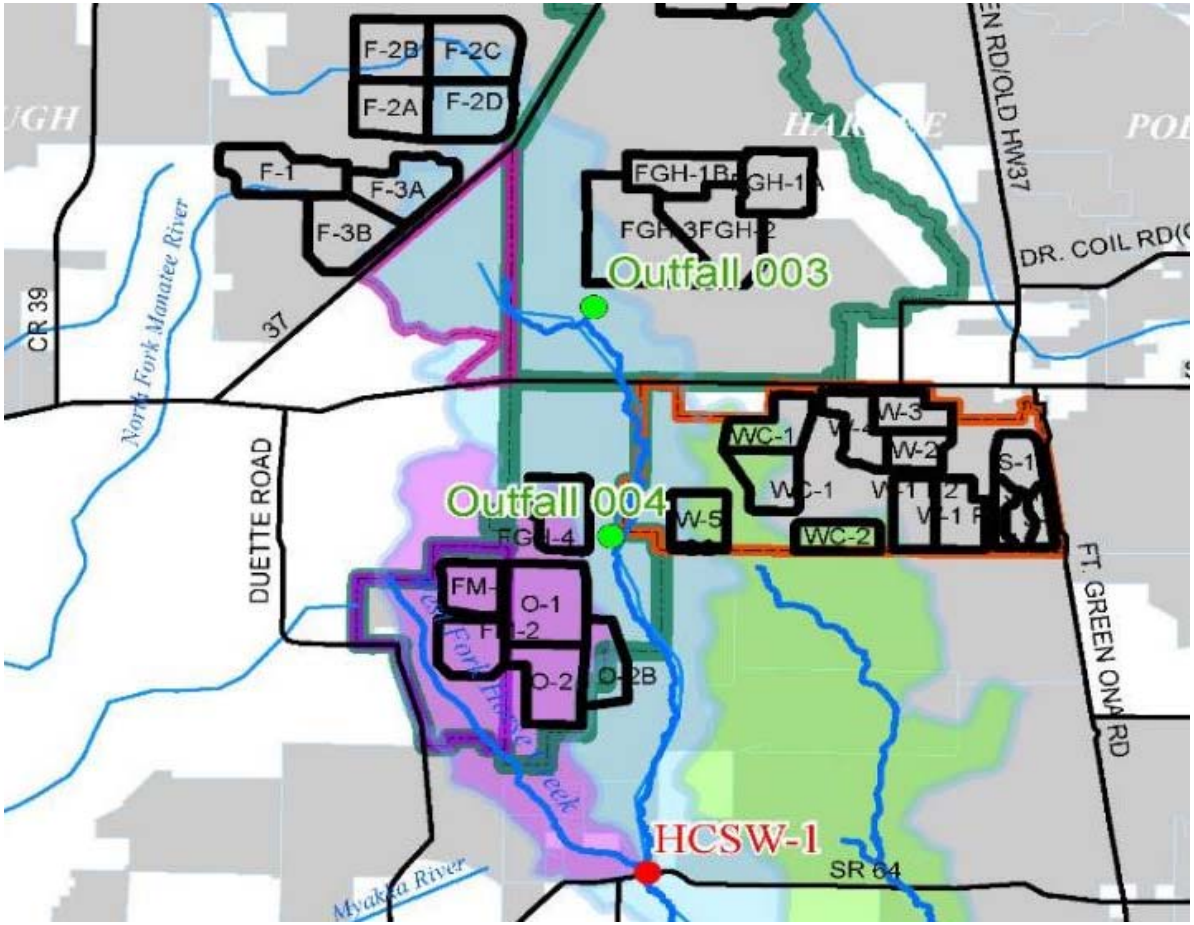
Horse Creek North of SR64



- Upper Horse Creek basin including Mosaic outfalls
- HCSW-1 is at SR64 bridge
- HCSW-2 is north of Goose Pond Road

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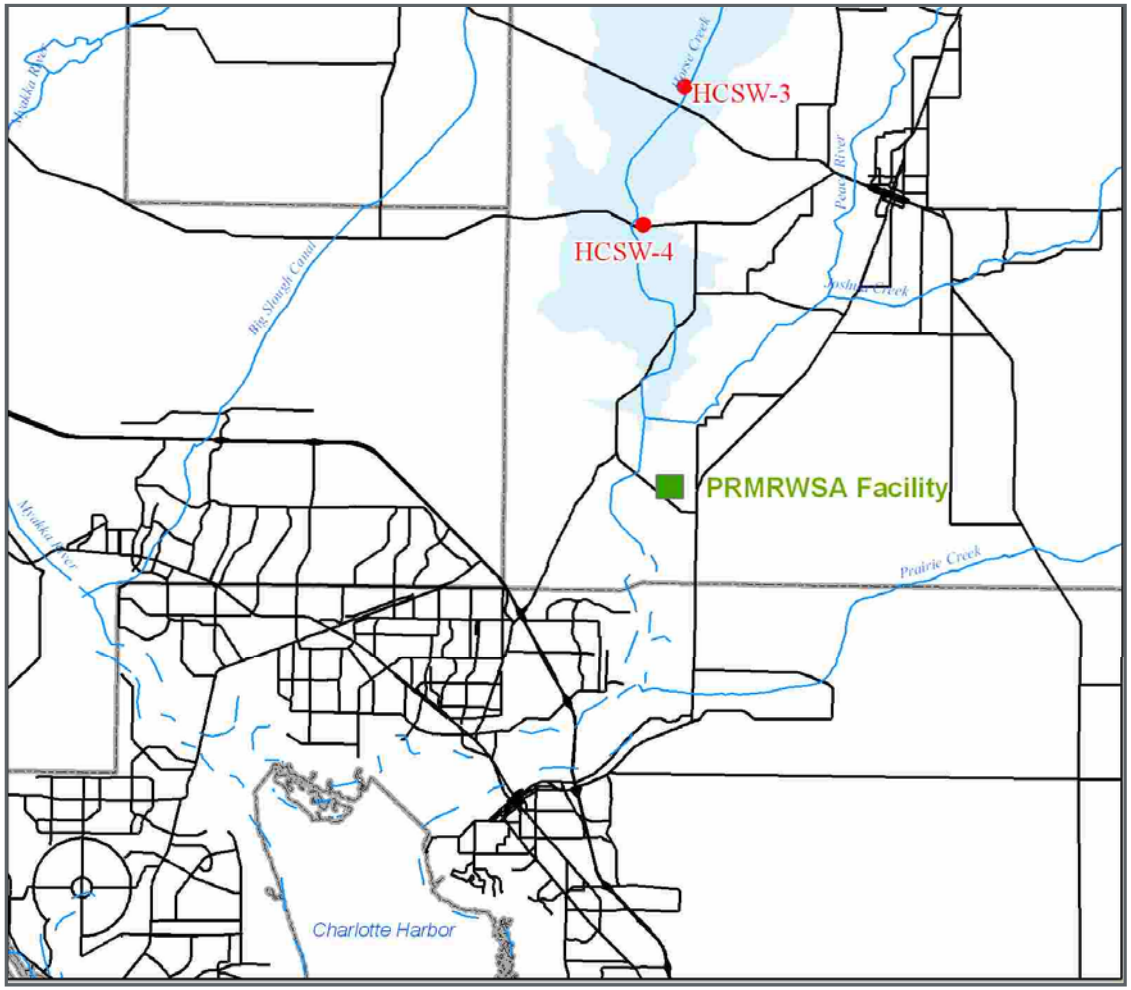
Horse Creek South of CR665



- Lower Horse Creek basin and the PRMRWSA Facility
- HCSW-3 is north of SR70
- HCSW-4 is at SR72 bridge

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Water Quantity

- Stream Level
  - Monthly staff gauge readings at four Horse Creek stations
- Discharge
  - USGS daily streamflow at HCSW-1 and HCSW-4
  - Continuous Mosaic NPDES discharge
- Rainfall
  - NOAA daily rainfall at Myakka River State Park and Arcadia
  - SWFWMD Flatford Swamp daily rainfall
  - Mosaic daily rainfall at three upper Horse Creek Basin gauges
    - Horse Creek North
    - Horse Creek South
    - Manson Jenkins

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Water Quality

- Monthly sampling by Mosaic at four stations
  - Stream Conditions
  - Field Measurements
    - Water temperature, pH, dissolved oxygen, specific conductivity, turbidity
  - Lab Analysis
    - 16 parameters including nutrients, minerals, and mining reagents
- Continuous sampling by Mosaic at HCSW-1
  - pH, dissolved oxygen, specific conductivity, temperature, turbidity
- Additional sampling coincident with biological sampling
  - Field parameters of temperature, pH, dissolved oxygen, specific conductivity, turbidity

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Biological Sampling

- Benthic Macroinvertebrates:
  - Stream Habitat Assessment
  - Florida Stream Condition Index (SCI)
    - 20 dip-net sweeps in 100m stream segment
    - FDEP methodology (SCI-1000)
  - Shannon-Weiner Diversity Index
- Fish:
  - Sampled with 4ft x 8ft seine and electrofishing
  - Shannon-Weiner Diversity Index
  - Morisita's Community Similarity Index
  - Species Accumulation Curve

HCSP Trigger Levels

Pollutant Category	Parameter	Trigger Level	Reporting Units
Physiochemical Indicators	pH	>8.5 or <6.0	SU
	Dissolved Oxygen	<38.0	%Saturation
	Turbidity	>29	NTU
	Color	<25	mg/L
Nutrients	Total Nitrogen	>3.0	mg/L
	Total Ammonia	>0.3	mg/L
	Orthophosphate	>2.5	mg/L
	Chlorophyll-a	>15	mg/m^3
Dissolved Minerals	Specific Conductivity	>1,275	µmhos/cm
	Total Alkalinity	>100	mg/L
	Dissolved Calcium	>100	mg/L
	Dissolved Iron	>1.0 or >0.3 (HCSW-4)	mg/L
	Chloride	>250	mg/L
	Fluoride	>4.0 or >1.5 (HCSW-4)	mg/L
	Sulfate	>250	mg/L
	TDS	>500	mg/L
Mining Reagents	Radium 226+228	>5.0	pCi/L

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Impact Assessments

- Monthly water quality data are submitted to the PRMRWSA for review
  - Measurements are compared to “trigger values” that are based on state water quality standards or historical ranges
  - If a parameter is above the trigger value, an impact assessment is completed by Mosaic
    - The impact assessment is accepted as sufficient evidence that the exceedance was not caused by mining
    - Or Mosaic provides additional data or completes other corrective actions
  - Impact Assessments have been requested for several parameters

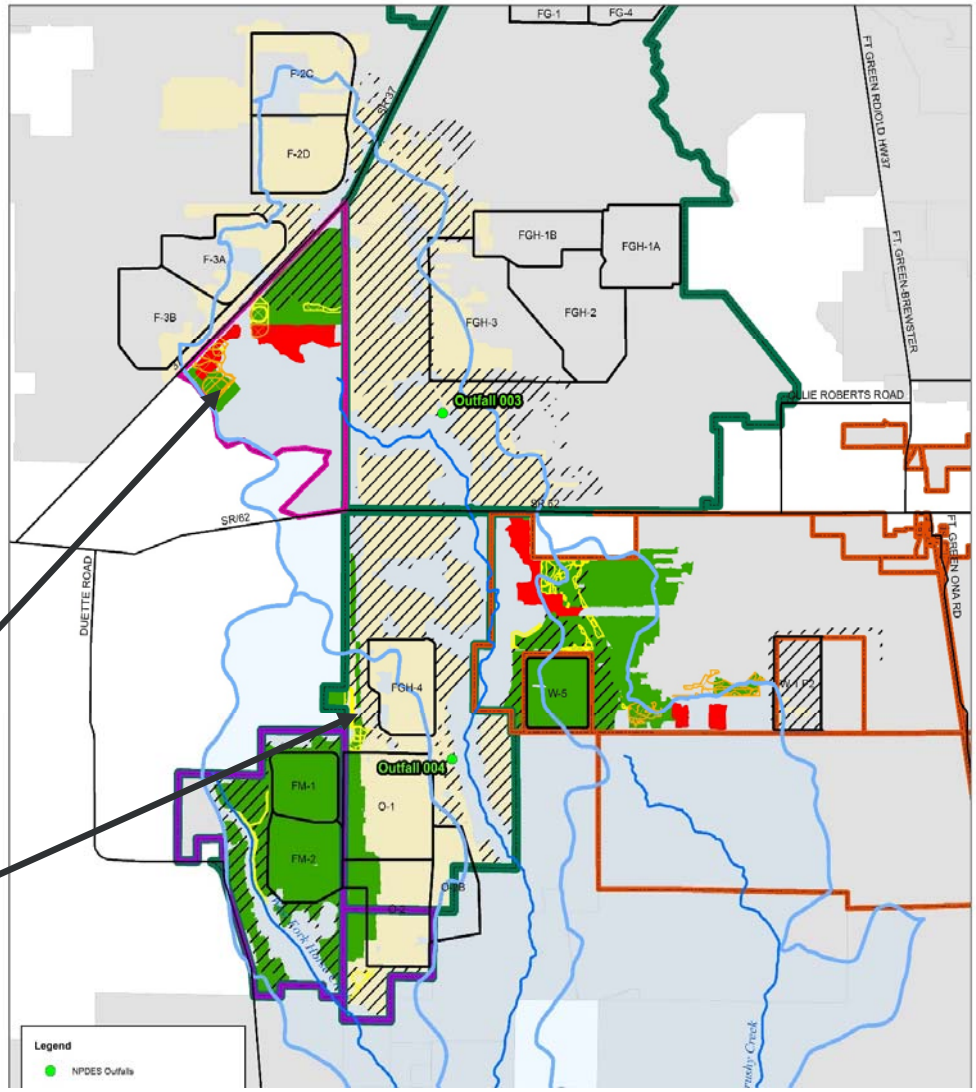
Annual Reports

- Annual reports are submitted to the PRMRWSA and the TAG for review
  - The TAG includes staff from several counties
  - Mosaic presents the results for water quantity, water quality, and biological data collected by the Program
  - The PRMRWSA and the TAG compile questions and comments that are incorporated into the final report draft
  - If any adverse long-term trends are identified in the report, Mosaic will conduct an impact assessment

Mining and Reclamation Methods

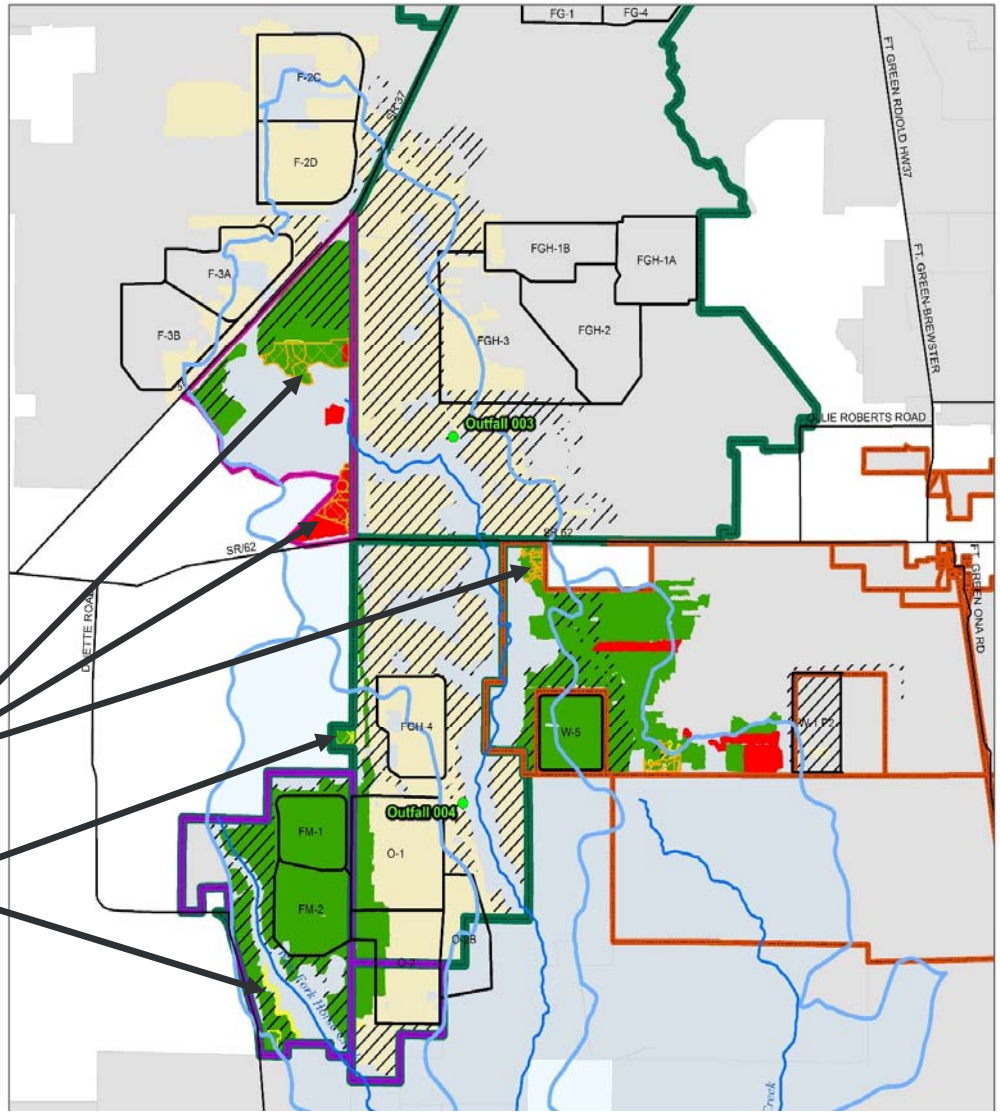
2015 Mining

- Mining
  - Acres mined in 2015 – Red
  - Acres mined in 2003-2014 – Green
  - Areas mined prior to 2003 – Tan
- Reclamation
  - Areas reclaimed prior to 2015 – Gray hatching
  - Areas reclaimed (contouring) in 2015 Orange hatching
  - Areas reclaimed (vegetation) in 2015 – Yellow hatching



2016 Mining

- Mining
  - Acres mined in 2016 – Red
  - Acres mined in 2003-2015 – Green
  - Areas mined prior to 2003 – Tan
- Reclamation
  - Areas reclaimed prior to 2016 – Gray hatching
  - Areas reclaimed (contouring) in 2016 Orange hatching
  - Areas reclaimed (vegetation) in 2016 – Yellow hatching



Mining and Reclamation History

Year	Acres Mined		Acres Reclaimed to Final Contour		Acres Reconnected	
	Horse Creek	Brushy Creek	Horse Creek	Brushy Creek	Horse Creek	Brushy Creek
2004	638	0	30	0	0	0
2005	590	169	205	0	38	0
2006	187	17	0	0	205	0
2007	0	146	106	42	0	0
2008	150	187	245	0	66	0
2009	137	16	711	95	315	0
2010	283	220	270	91	0	0
2011	100	164	114	12	0	0
2012	76	153	600	63	0	0
2013	198	96	71	85	0	0
2014	112	113	98	96	0	0
2015	378	126	318	81	793	183
2016	219	209	162	0	138	0

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Summary of Sampling Conditions

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April 2015 Conditions

October 2015 Conditions

December 2015 Conditions

March 2016 Conditions

November 2016 Conditions

Results and Conclusions: Biology

Biological Sampling Summary

- Benthic macroinvertebrates were sampled at all four locations during three events in 2015
  - Spring event on April 3, 2015, delayed Summer event on October 27, 2015, and Winter event on December 15, 2015
- Benthic macroinvertebrates were sampled at all four locations during two events in 2016
  - High water levels and flows prohibited a summer sampling event
  - Spring event on March 17, 2016 and Winter event on November 16, 2016.

- Fish sampling was conducted at all stations during three events in 2015
  - During the October 27, 2015 event the backpack electrofisher malfunctioned and samples were only collected via seine hauls
- Fish sampling was conducted at all stations during two events in 2016

Benthic Macroinvertebrate Conclusions - 2015

- Habitat Assessment
  - Optimal to sub-optimal
  - Main differences in scores for substrate diversity and availability
- Stream Condition Index
  - Healthy at all stations but HCSW-2 in October 2015 (Impaired)
    - Exceptional rating at HCSW-3 (April and October) and HCSW-4 (April and December)
- Biological Diversity
  - Diversity higher at HCSW-4 and HCSW-3
  - Diversity comparison only from 2007-2015 (updated 2-vial SCI method) and at stations HCSW-1, HCSW-3, and HCSW-4
  - Diversity not different among years
    - Spring and fall diversity at HCSW-3 increased

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Benthic Macroinvertebrate Conclusions - 2016

- Habitat Assessment
  - Optimal to sub-optimal
  - Main differences in scores for substrate diversity and availability
- Stream Condition Index
  - Healthy at all stations but HCSW-2 in November 2016 (Impaired)
    - Exceptional rating at HCSW-1 (April) and HCSW-4 (both events)
- Biological Diversity
  - No increase/decrease in diversity over time at all stations combined
  - Diversity not different among years from 2007 to 2016
  - HCSW-4 and HCSW-3 had a higher diversity

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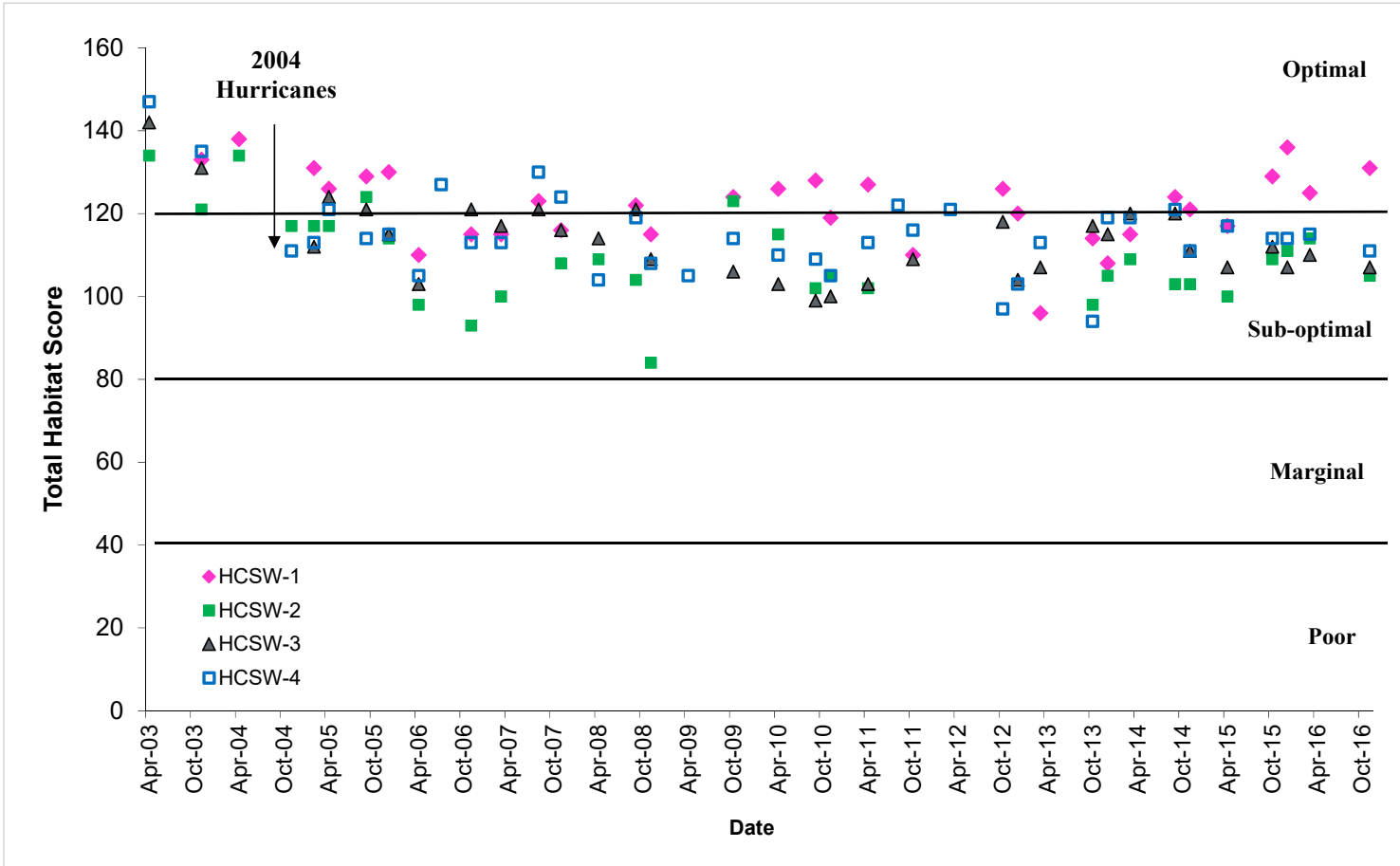
Habitat Assessment Scores



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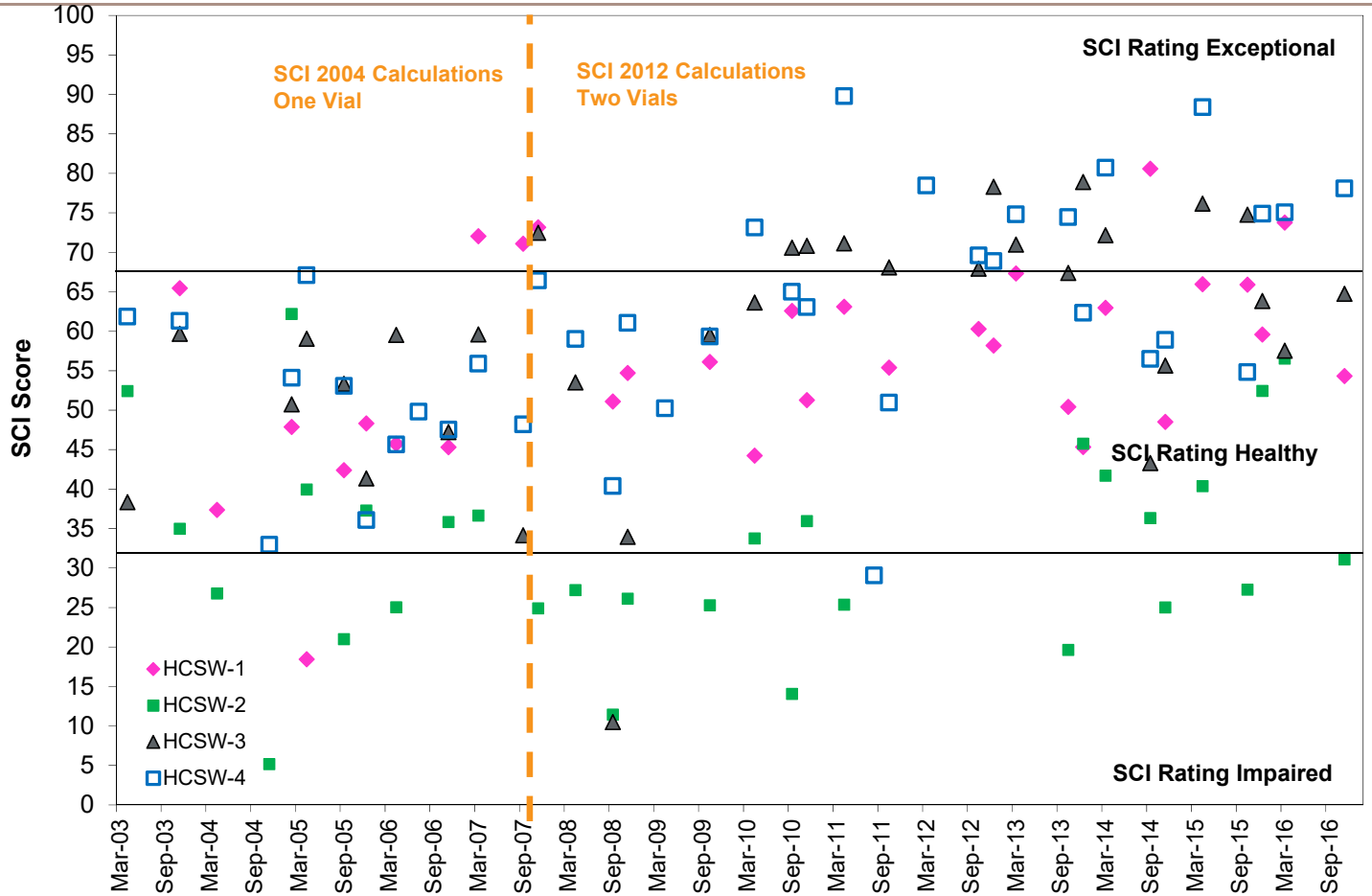
SCI Scores



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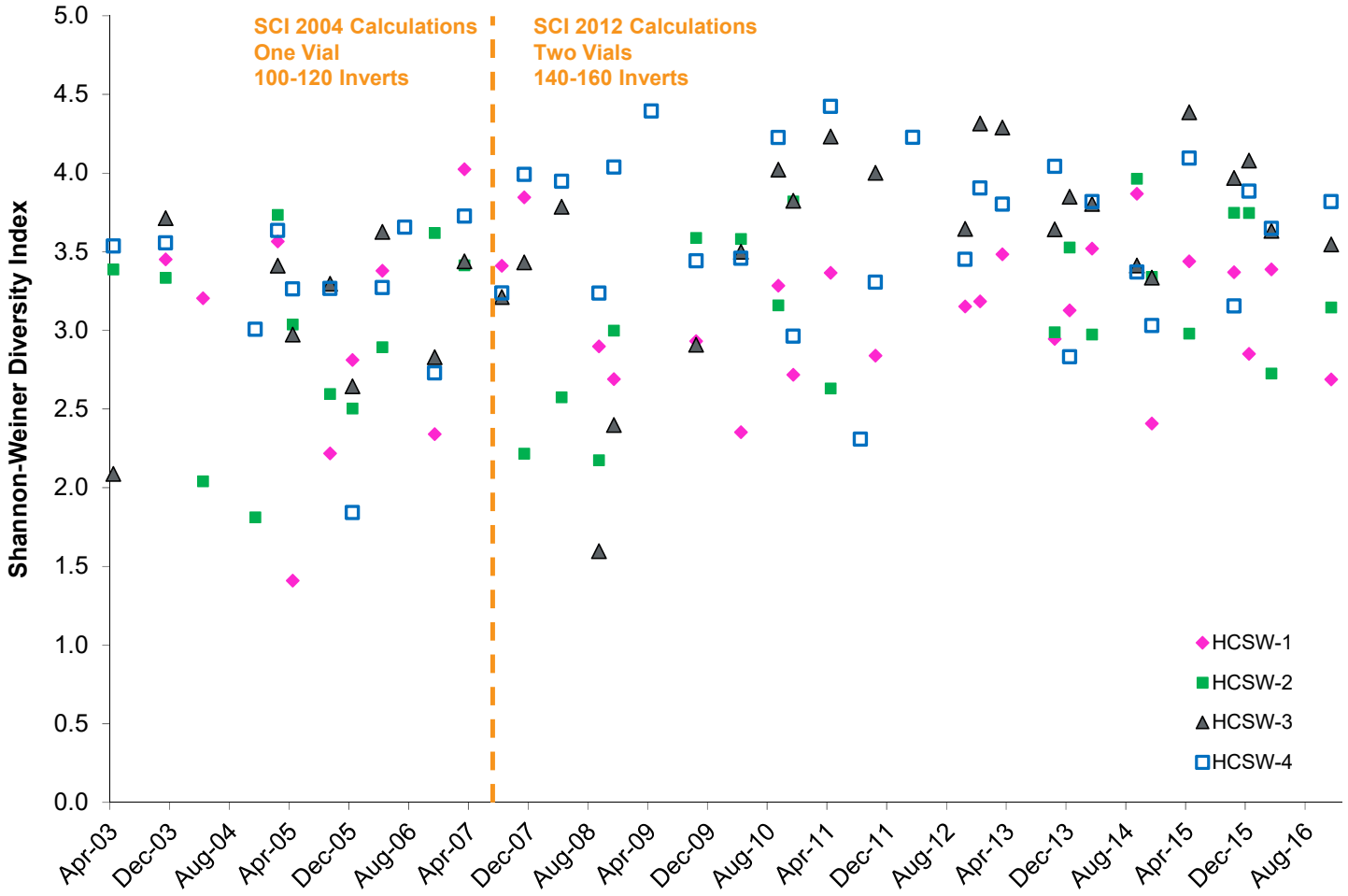
Benthic Macroinvertebrate Diversity



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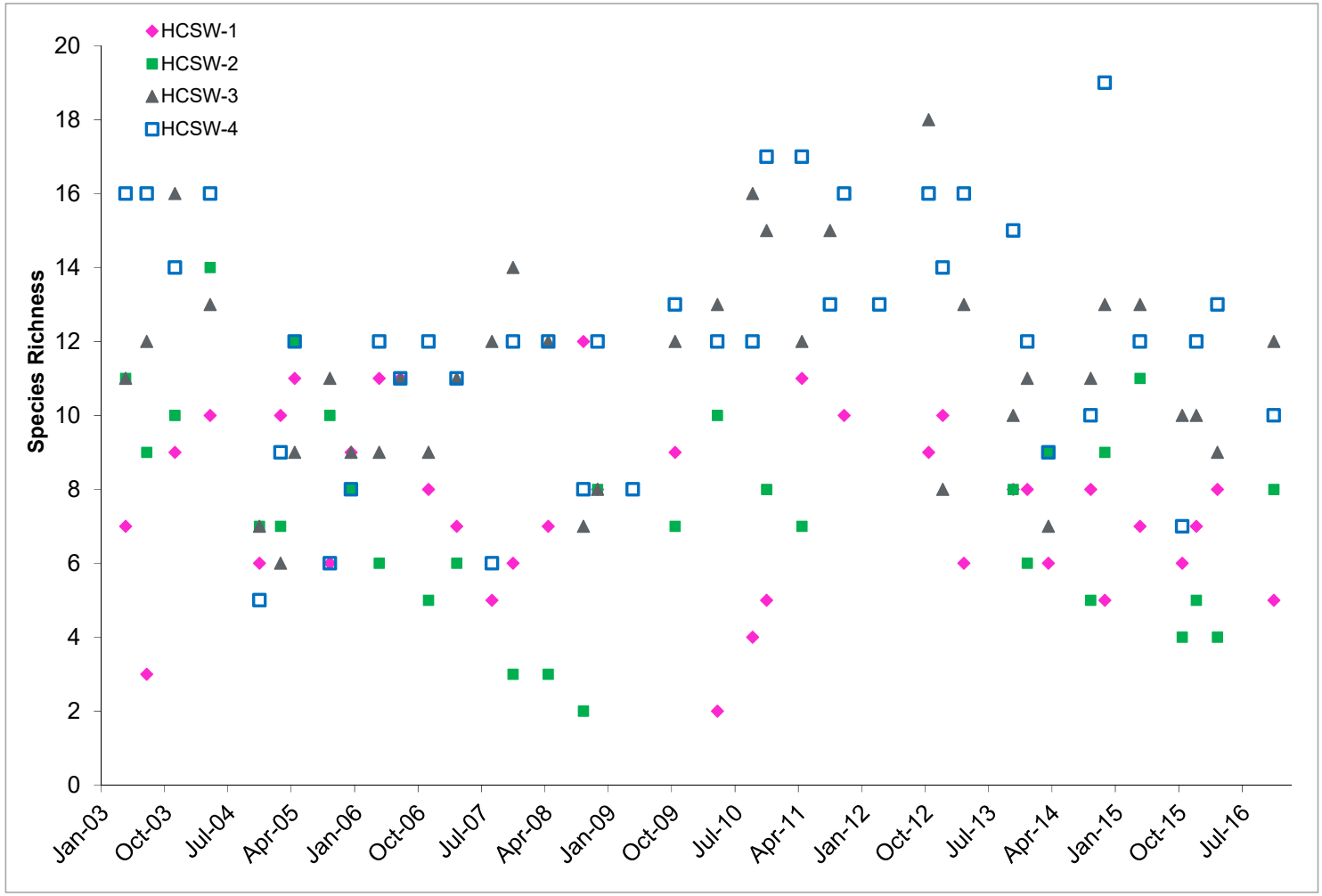
Fish Results – 2015

- 25 fish species collected, 43 total
  - New species to Horse Creek collected at HCSW-4 (Pugnose minnow – *Opsopoeodus emiliae*)
  - Most fish caught were Poeciliidae
- Shannon-Weiner Diversity Index
  - Fish diversity was significantly lower at HCSW-2 than the other stations
  - Fish diversity by year was higher in 2013 and lower in 2010
    - No increasing or decreasing trends in diversity by year
    - No increasing or decreasing trends for all stations in median or seasonal diversity (using only HCSW-1, HCSW-3 and HCSW-4)
- Morisita's Community Similarity Index
  - Communities similar between stations and years (ranging from 83 to 100% similar)

Fish Results – 2016

- 23 fish species collected, 44 total
  - New non-native species in Horse Creek collected at HCSW-1 (Asian swamp eel – *Monopterus javanensis)*
  - Two new species observed at HCSW-2 (Hogchoker – *Trinectes maculatus* and Blue Tilapia – *Oreochromis aureus*)
  - Most fish caught were Poeciliidae
- Shannon-Weiner Diversity Index
  - Fish diversity was significantly lower at HCSW-2 and higher at HCSW-4 than the other stations
  - Fish diversity by year was higher in 2013 and lower in 2010
    - No increasing or decreasing trends in diversity from 2003-2016
    - Small decreasing trend in fish diversity during spring sampling events (using HCSW-1, HCSW-3, and HCSW-4 data)
- Morisita's Community Similarity Index
  - Communities similar between stations and years (ranging from 83 to 100% similar)

Fish Species Richness



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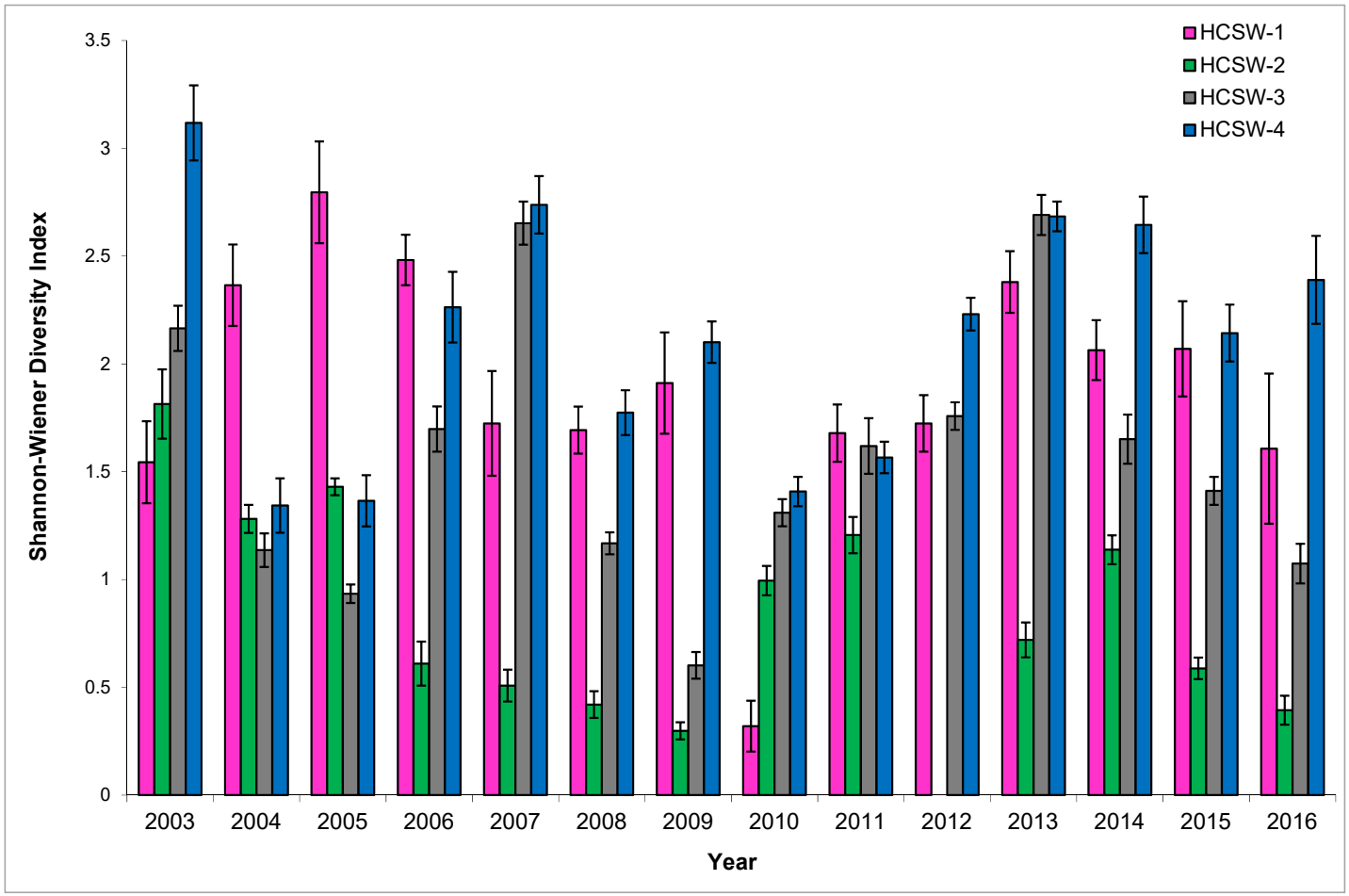
Fish Species Diversity – Stations by Year



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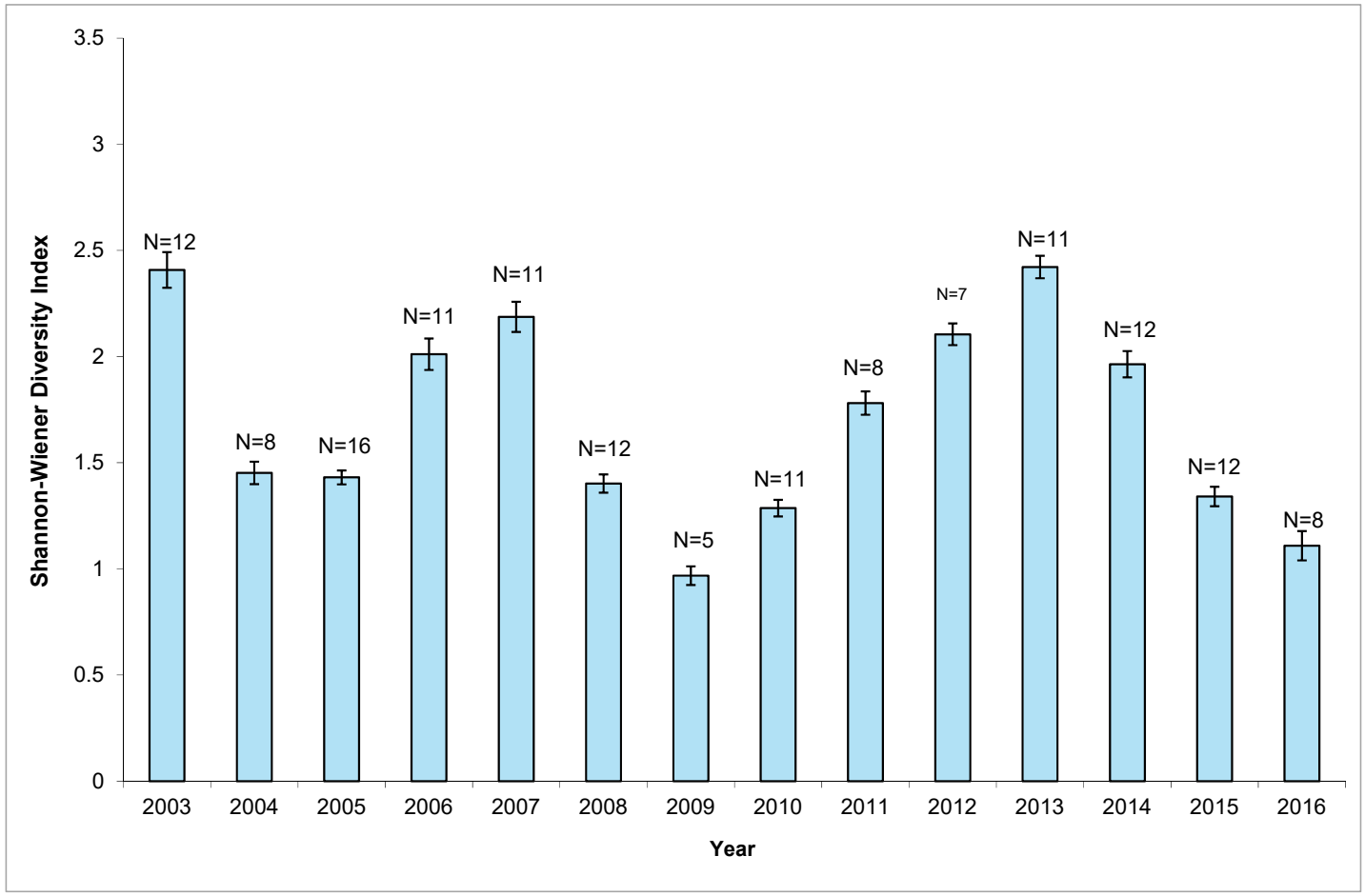
Fish Species Diversity - Years



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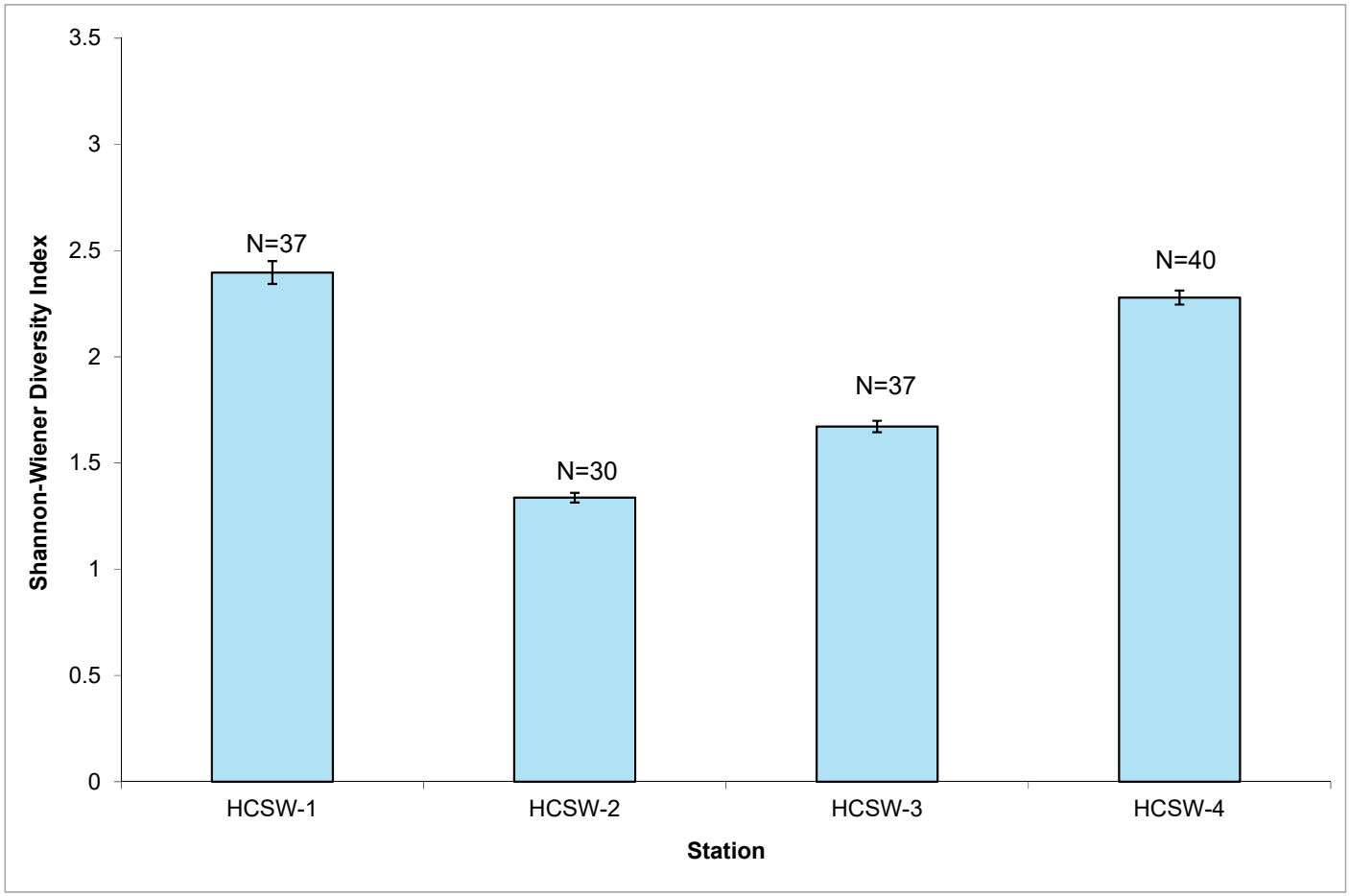
Fish Species Diversity - Stations



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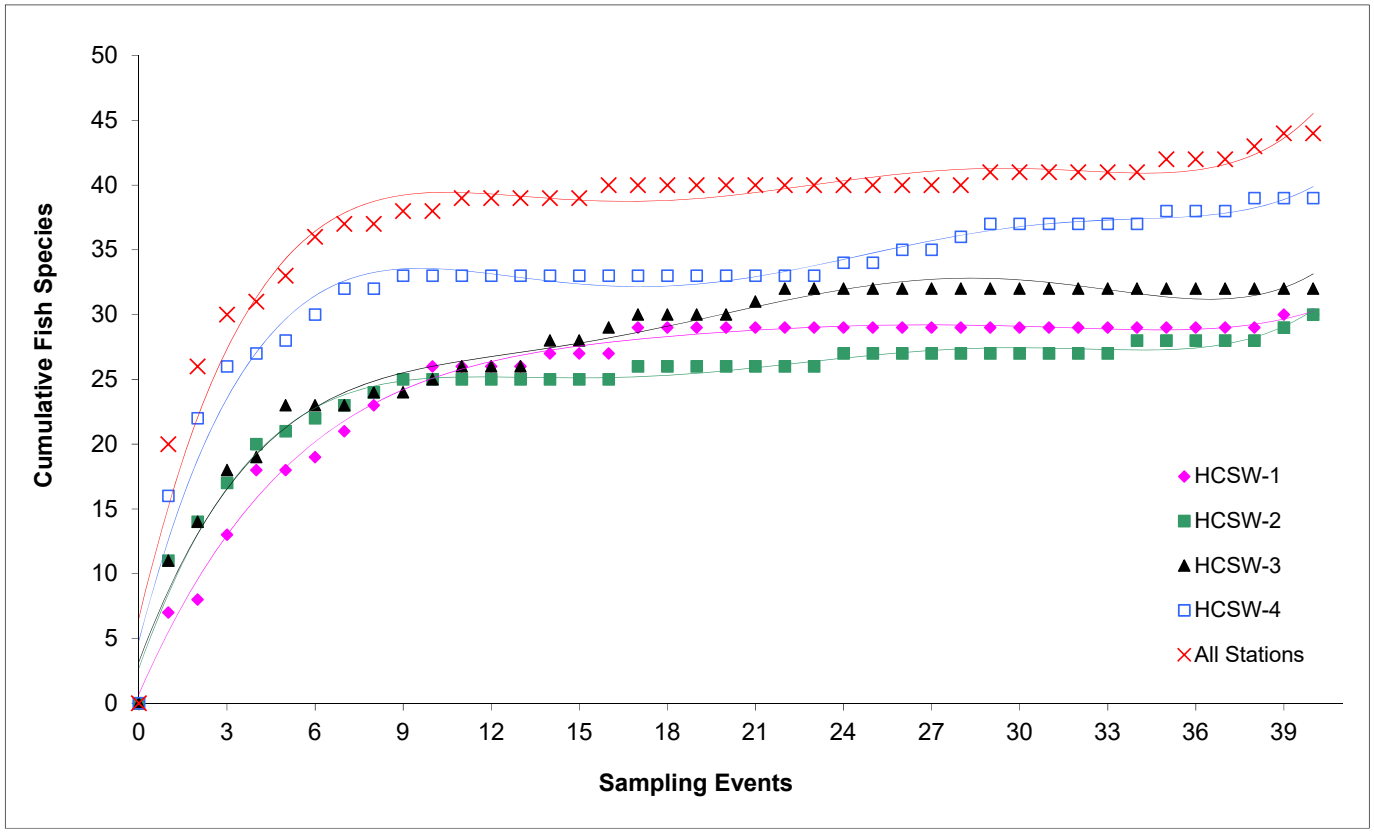
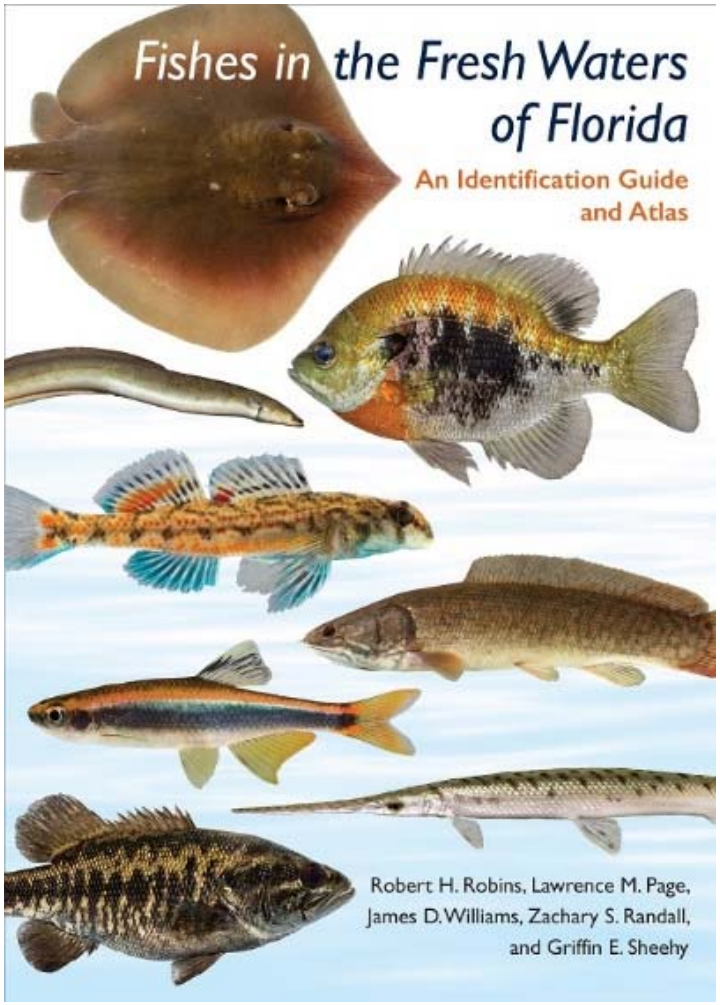
Species Accumulation Curve



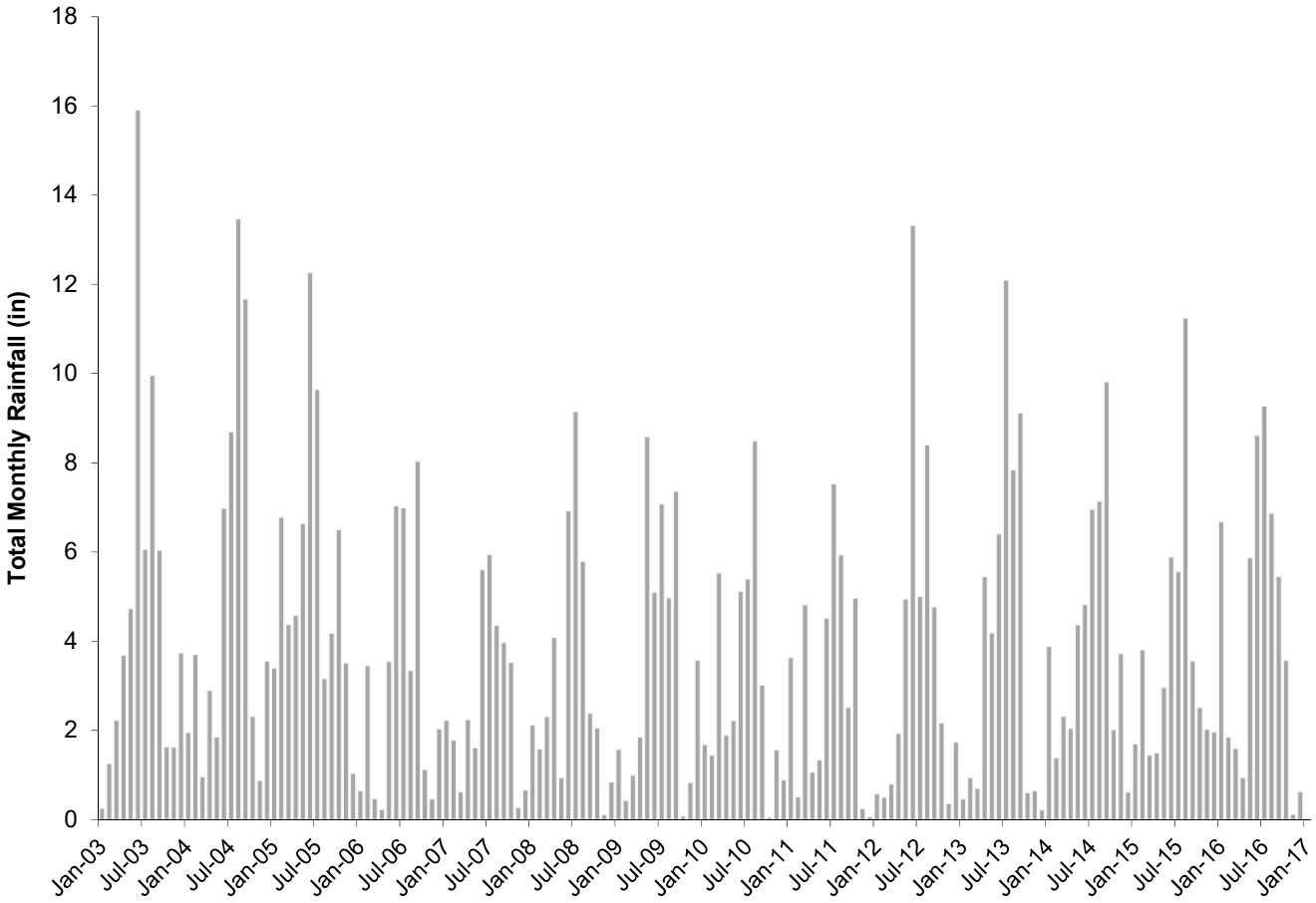
Horse Creek Fish

- Fish capture data through 2014 from the HCSP included in UF Publication
- All 4 HCSP locations on many individual fish species distribution maps
- Largest continuous collection of fish for any waterbody in Florida
- (Other Universities jealous of UF of the HCSP fish collection.)



Results and Conclusions: Water Quantity

Rainfall – Mosaic Gauges Only



Gauge	Horse Creek North	Horse Creek South	Manson Jenkins	Average of Mosaic Gauges
2003	53.4	59.75	30.10*	57.10
2004	53.82	60.74	62.15	58.90
2005	54.52*	64.53	31.34*	66.04
2006	31.82*	34.17	41.26	37.35
2007	33.9	31.97	32.49	32.79
2008	40.49	36.8	37.48	38.26
2009	36.63	43.7	46.87	42.40
2010	32.53	37.47	41.84	37.28
2011	24.54*	31.73*	39.85	37.11
2012	19.99*	36.06*	37.96*	44.49
2013	38.54*	54.69	34.33*	48.63
2014	47.93	39.22*	40.37*	49.06
2015	37.20*	35.64*	45.38*	44.13
2016	46.76*	50.72	48.09	51.43

*Gauge inoperable during parts of the year

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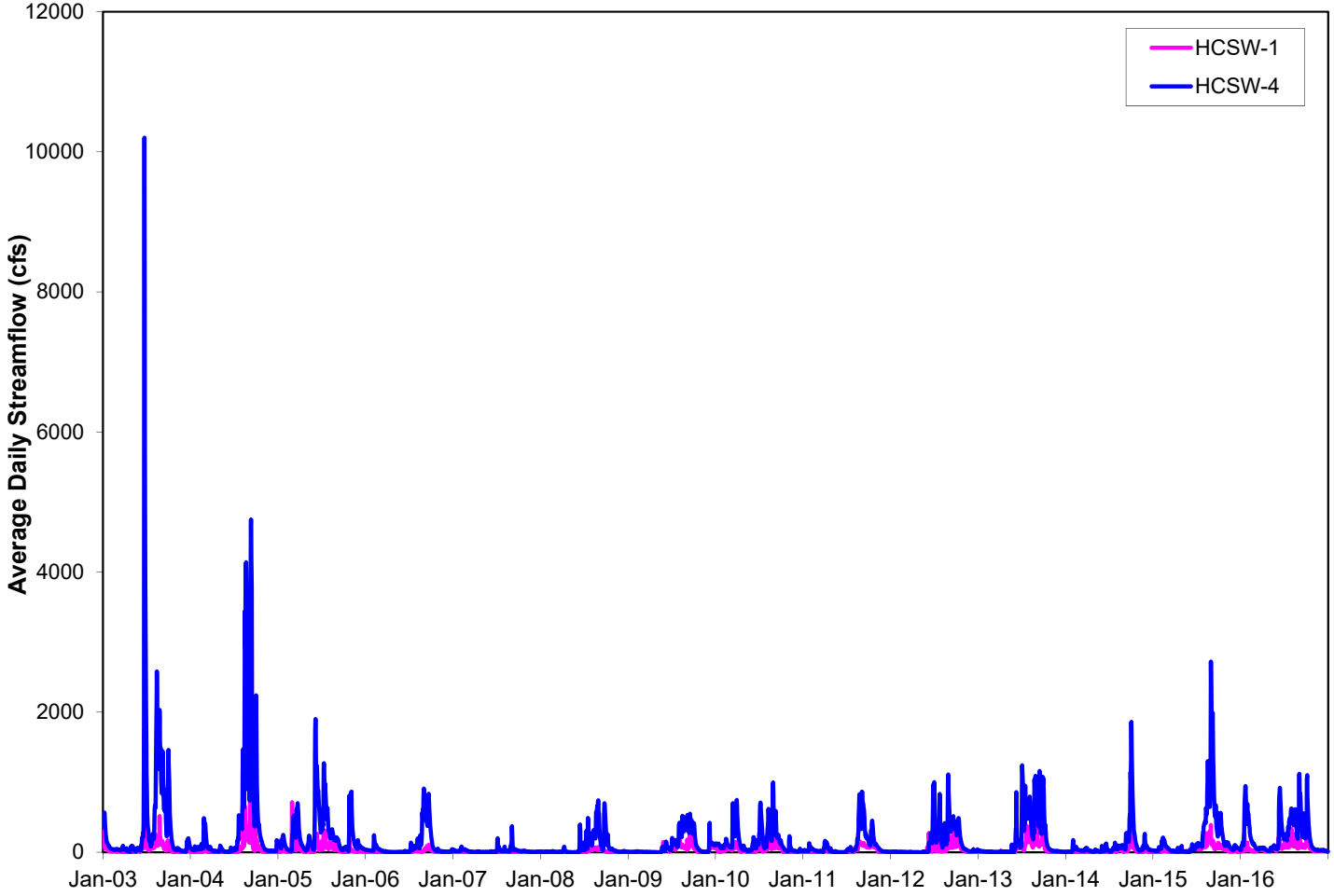
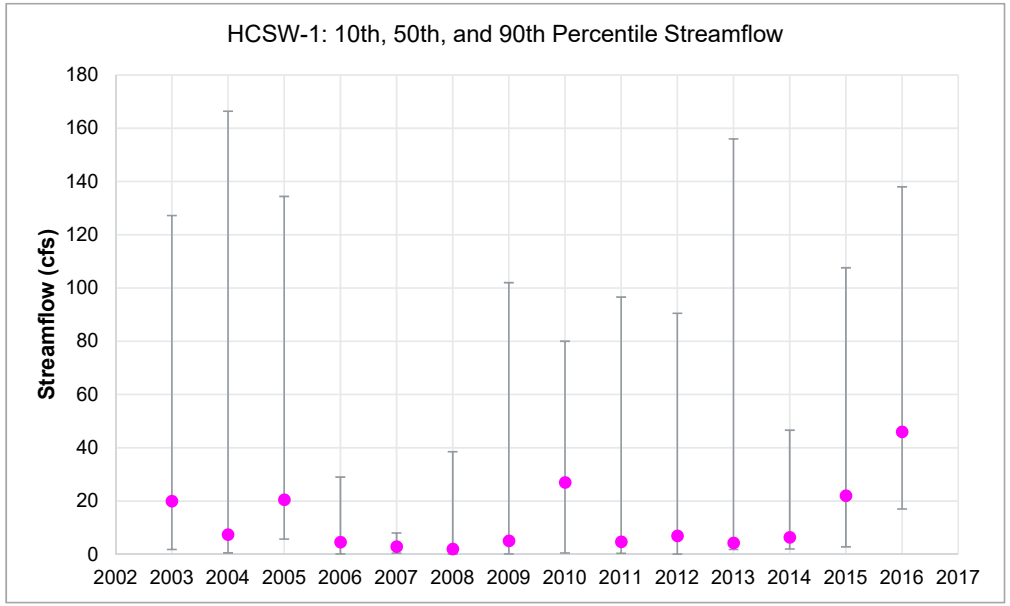
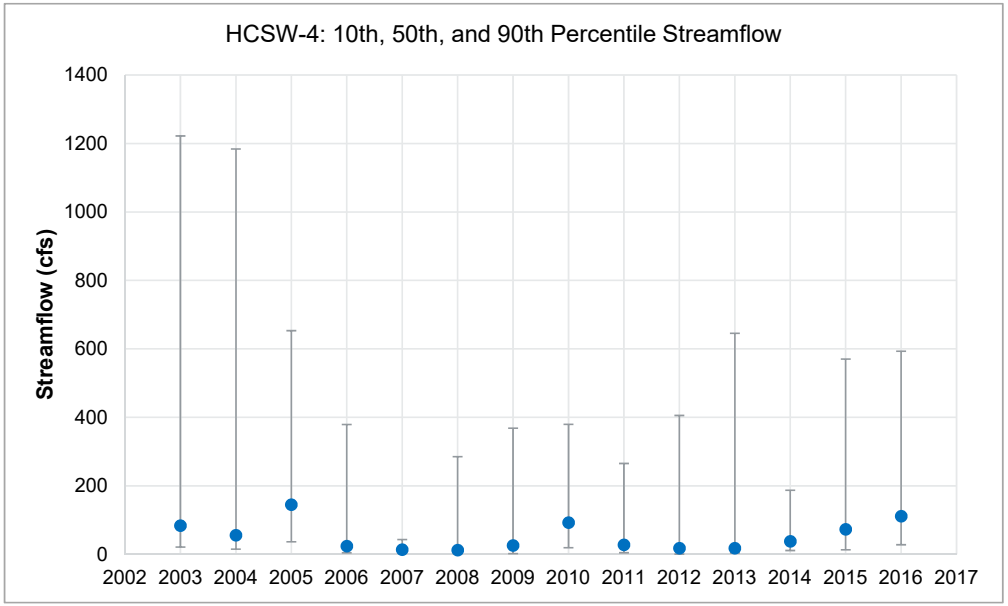
Horse Creek Streamflow 2003-2016

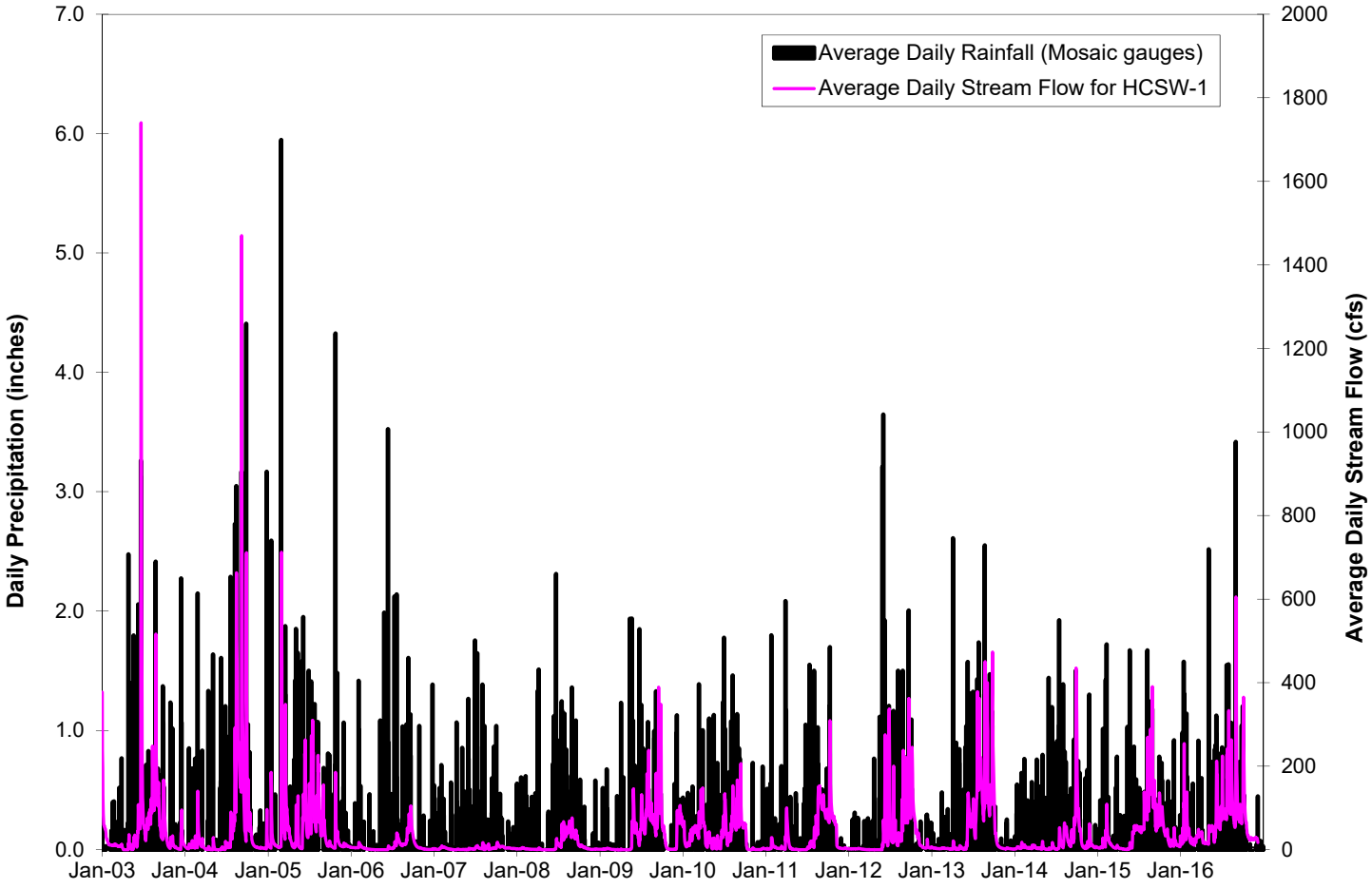


Percentile Streamflow 2003-2016





Mosaic Rainfall and USGS Streamflow 2003-2016



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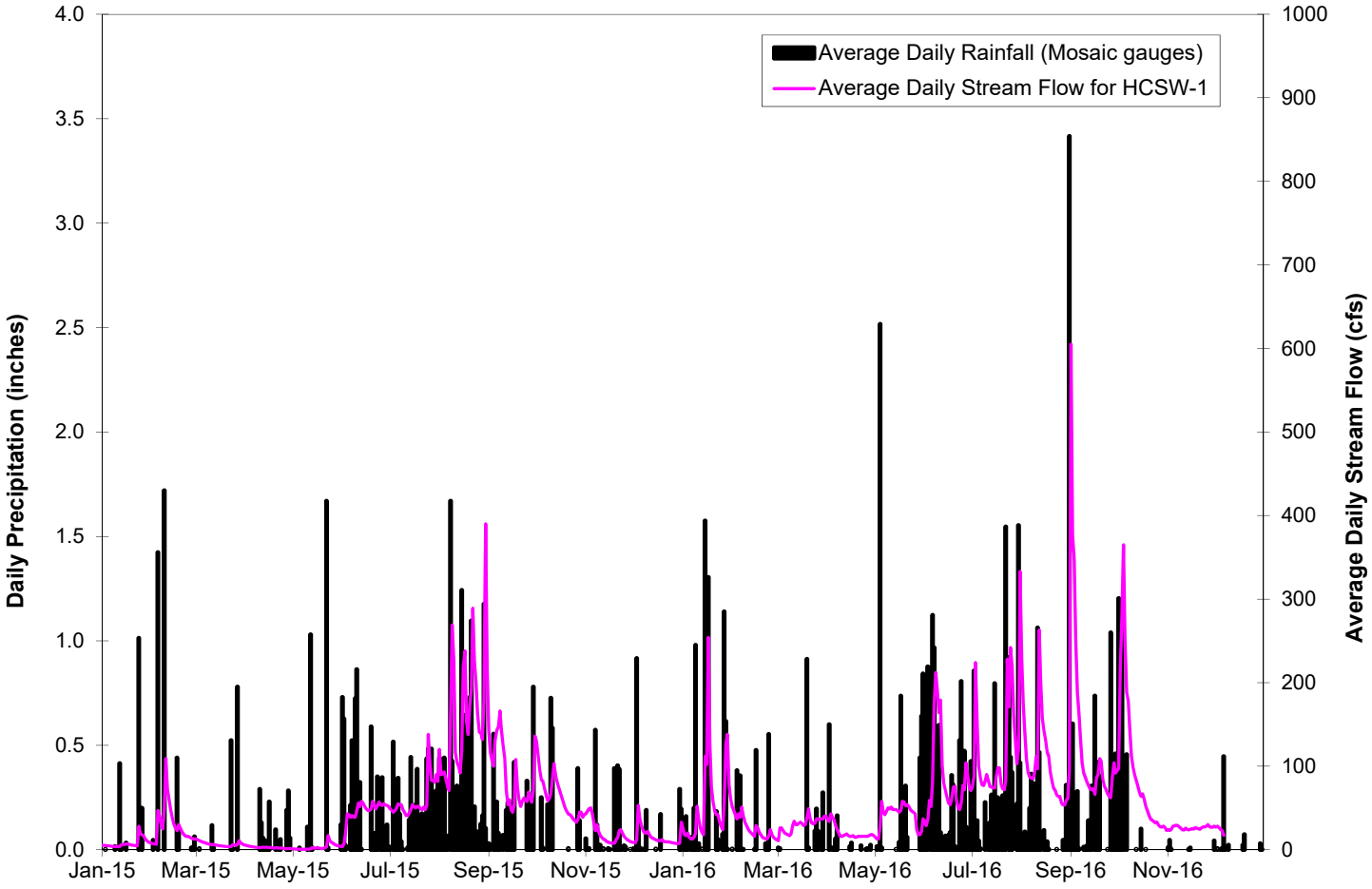
Mosaic Rainfall and USGS Streamflow 2015-2016



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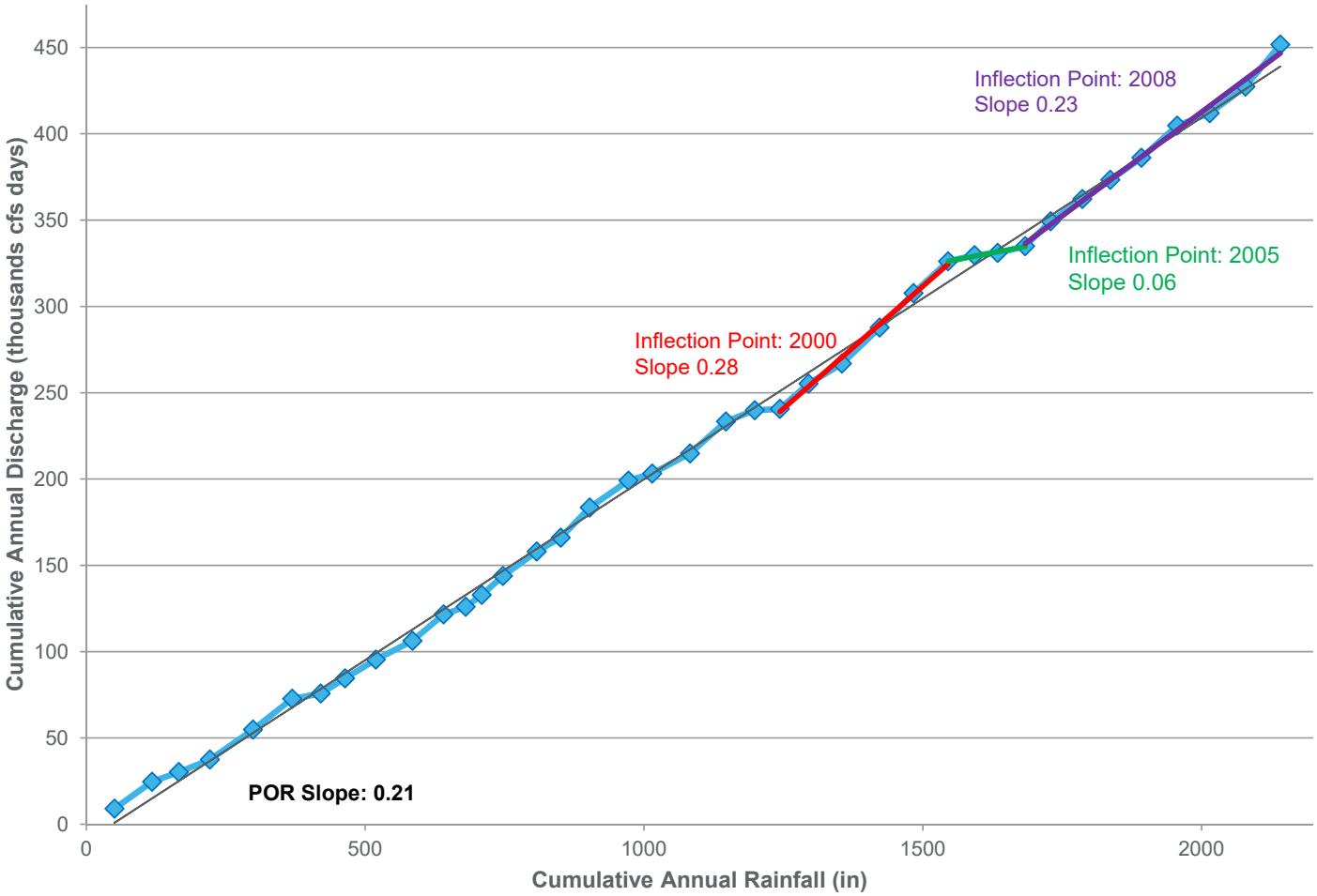
Rainfall and Streamflow – Double Mass Curve: 1978-2016



Double mass curve uses Horse Creek at SR64 Streamflow and average of two NOAA gauges (Myakka River State Park and Arcadia)

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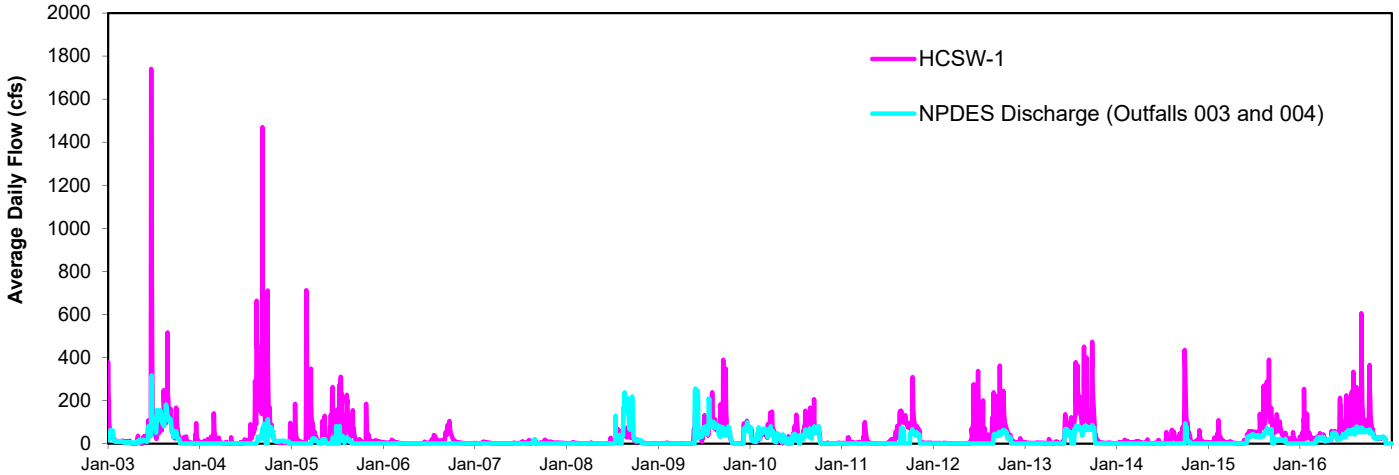
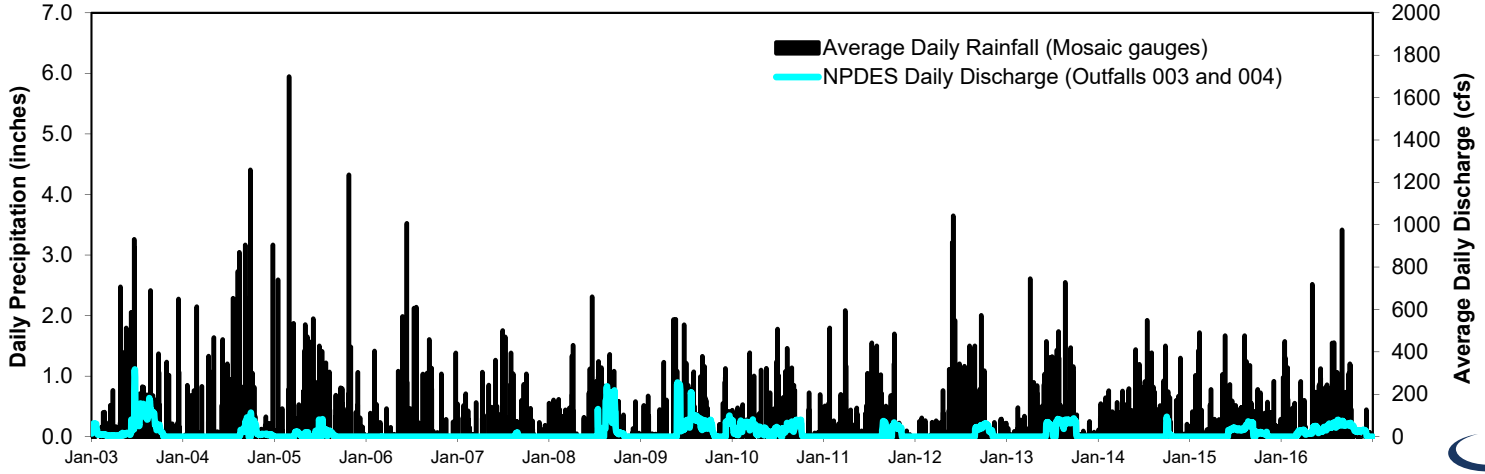
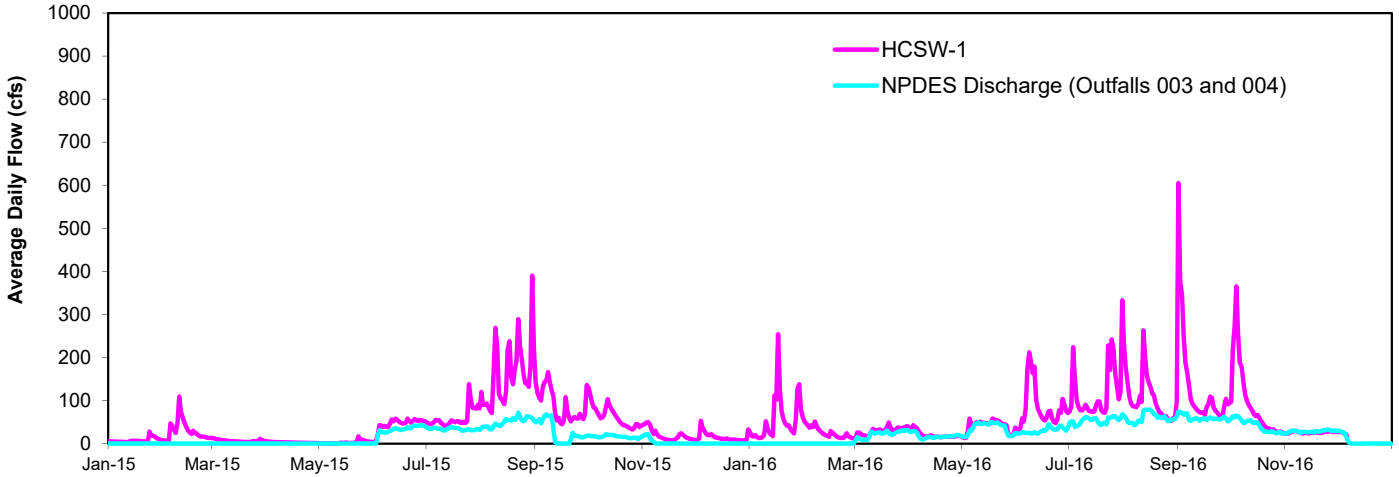
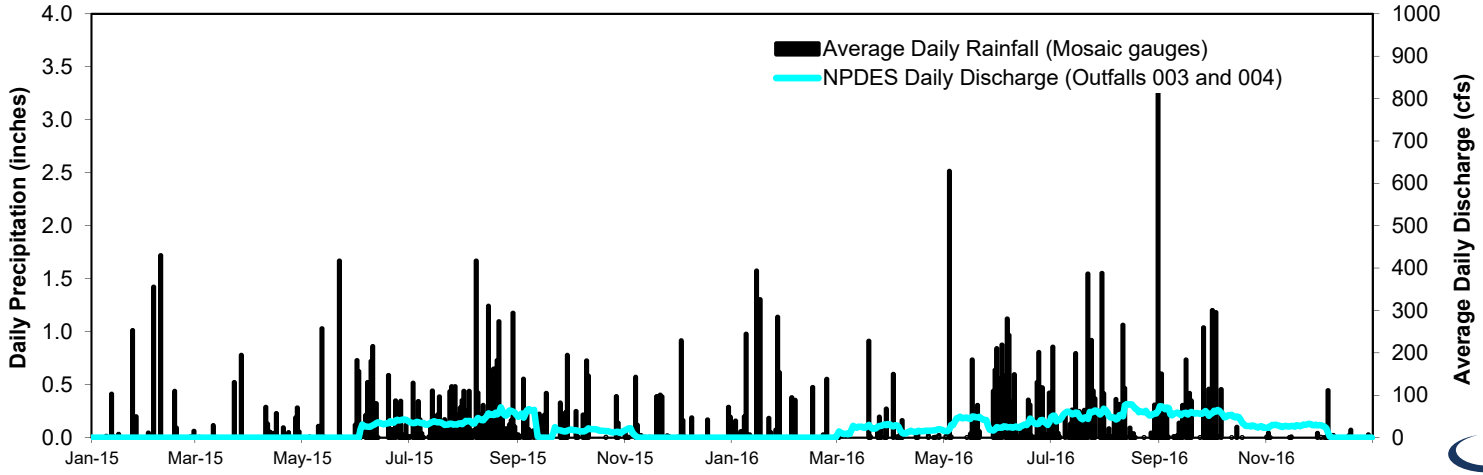
NPDES Discharge 2003-2016





NPDES Discharge 2015-2016





Water Quantity Conclusions-2015 and 2016

- Annual average daily streamflow at HCSW-1 and HCSW-4 was above the long term averages
- NOAA annual average rainfall above long term average (63-64 inches compared to 53 inches)
- Peak stream flow followed rainfall events
- Base streamflow at HCSW-1 reflected outfall discharge periods
- Outfall discharge quantity influenced by wetter conditions over two years
- Double mass curve analysis shows no evidence of a decrease in streamflow with respect to rainfall over time

Water Quantity Conclusions-2015

- Flows were generally low from January to early-June before increasing slightly
  - Period of slightly higher flows during the dry season (late-January to late-February)
  - Flows moderate in August before a sharp increase at the end of August through September
  - Stable moderate flows in October before decreasing through end of the year
- NPDES discharge from WIN-004 for 152 days accounted for 19% of streamflow on average
  - Discharge occurred from June through November 2015

Water Quantity Conclusions-2016

- Flows generally low from March to early-June before rapidly increasing and remaining high for the reminder of the wet season
  - Final large increase in streamflow occurred in early-October following rain events then decreased through the end of the year
- NPDES discharge from WIN-004 for 283 days accounted for 73% of streamflow on average
  - Discharge occurred from March through early December 2016

Results and Conclusions: Water Quality

2015 and 2016 Summary: Differences Between Stations

- Downstream versus upstream stations
  - Higher downstream: nutrients (nitrate-nitrite) and ions (SC, calcium, chloride, and sulfate)
- HCSW-2: Horse Creek Prairie
  - Lower pH, DO, orthophosphate, and fluoride
  - Higher chlorophyll-a, color, and TKN
- Higher at HCSW-1 and HCSW-4
  - Dissolved oxygen and alkalinity
- Brushy Creek
  - Slightly higher turbidity, color, nitrogen (TN and TKN,), ammonia, chlorophyll-a, iron, and chloride than HCSW-1 and HCSW-2 but generally within Horse Creek range
  - NO_x , SC, calcium, alkalinity, fluoride, sulfate, TDS, and radium slightly lower in Brushy Creek than Horse Creek (also orthophosphate in 2016 only)

2015 Summary: Trigger Level Exceedances

- pH (6.0 – 8.5)
  - HCSW-1 (December)
- Dissolved oxygen (<38%)
  - HCSW-2 (March, July-November)
  - HCSW-3 (August)
- Chlorophyll-a (>15 mg/m^3)
  - HCSW-2 (April, May)
- Dissolved Iron (>0.3 mg/L)
  - HCSW-4 (August-October)
- Alkalinity (>100 mg/L)
  - HCSW-1 (December)
- Sulfate (>250 mg/L)
  - HCSW-3 (June)
- TDS (>500 mg/L)
  - HCSW-4 (April-June)

2016 Summary: Trigger Level Exceedances

- Dissolved oxygen (<38%)
  - HCSW-2 (February-December)
- Total Nitrogen (3.0 mg/L)
  - HCSW-3 (February)
- Dissolved Iron (>0.3 mg/L)
  - HCSW-4 (July-September)
- Alkalinity (>100 mg/L)
  - HCSW-1 (December)

2015 Summary: Correlations with Water Quantity at HCSW-1

- Negative Correlation
  - Streamflow
    - Orthophosphate
  - Streamflow and NPDES Discharge
    - Radium
  - Streamflow and Rainfall
    - pH
  - Rainfall, Streamflow, and NPDES Discharge
    - DO (concentration and %sat) and chloride
- Positive Correlation
  - NPDES
    - Chlorophyll-a, SC, calcium, alkalinity, sulfate, TDS
  - Streamflow and NPDES
    - Fluoride
  - Rainfall, Streamflow and NPDES discharge
    - Turbidity, color, TN, TKN, nitrate-nitrite iron

2016 Summary: Correlations with Water Quantity at HCSW-1

- Negative Correlation
  - Rainfall
    - SC, calcium, alkalinity
  - Streamflow and NPDES Discharge
    - radium
  - Streamflow and Rainfall
    - pH
  - Rainfall, Streamflow, and NPDES Discharge
    - DO (concentration and %sat) and chloride
- Positive Correlation
  - NPDES Discharge
    - Chlorophyll-a, SC, calcium, alkalinity, sulfate, TDS
  - Rainfall, Streamflow, and NPDES Discharge
    - Turbidity, color, TN, TKN, iron

Seasonal Kendall Tau

- Non-parametric test for monotonic trends
- Identifies water quality trends after correcting for seasonality by only comparing median values between similar seasons over time
- Changes in detection limits in HCSP
  - Fluoride, nitrate-nitrite, ammonia
  - Used SWFWMD as an alternative to HCSP data
  - Went to annual trends only when SWFWMD data collection changed to bi-monthly
- Corrected for streamflow if relationship existed
- Produces a trend slope estimate

2015 Summary: Seasonal Trends over Time 2003-2015

Parameter	HCSW-1 Slope	HCSW-4 Slope	Discussion
pH	0.04 SU/yr		Slope very small in magnitude. Isolated step change. Not of concern. See further discussion in Appendix I.
DO (% Saturation)	1.29%/yr		Not an adverse trend
Color		6.32 PCU/yr	Not an adverse trend
Nitrogen, Ammonia	-0.001 mg/L/yr		Not an adverse trend
Specific Conductance	10.2 µmhos/cm/yr	7.47 µmhos/cm/yr	See further discussion in Appendix I
Calcium	0.86 mg/L/yr		Related to Conductance Trend Discussion (See Appendix I)
Iron	-0.01 mg/L/yr	-0.01 mg/L/yr	Not an adverse trend
Alkalinity	2.42 mg/L/yr	1.18 mg/L/yr	Related to Conductance Trend Discussion (See Appendix I)
Fluoride	0.01 mg/L/yr	0.01 mg/L/yr	Related to Conductance Trend Discussion (See Appendix I)
Sulfate	2.92 mg/L/yr		Related to Conductance Trend Discussion (See Appendix I)
TDS	8.31 mg/L/yr	9.26 mg/L/yr	Related to Conductance Trend Discussion (See Appendix I)

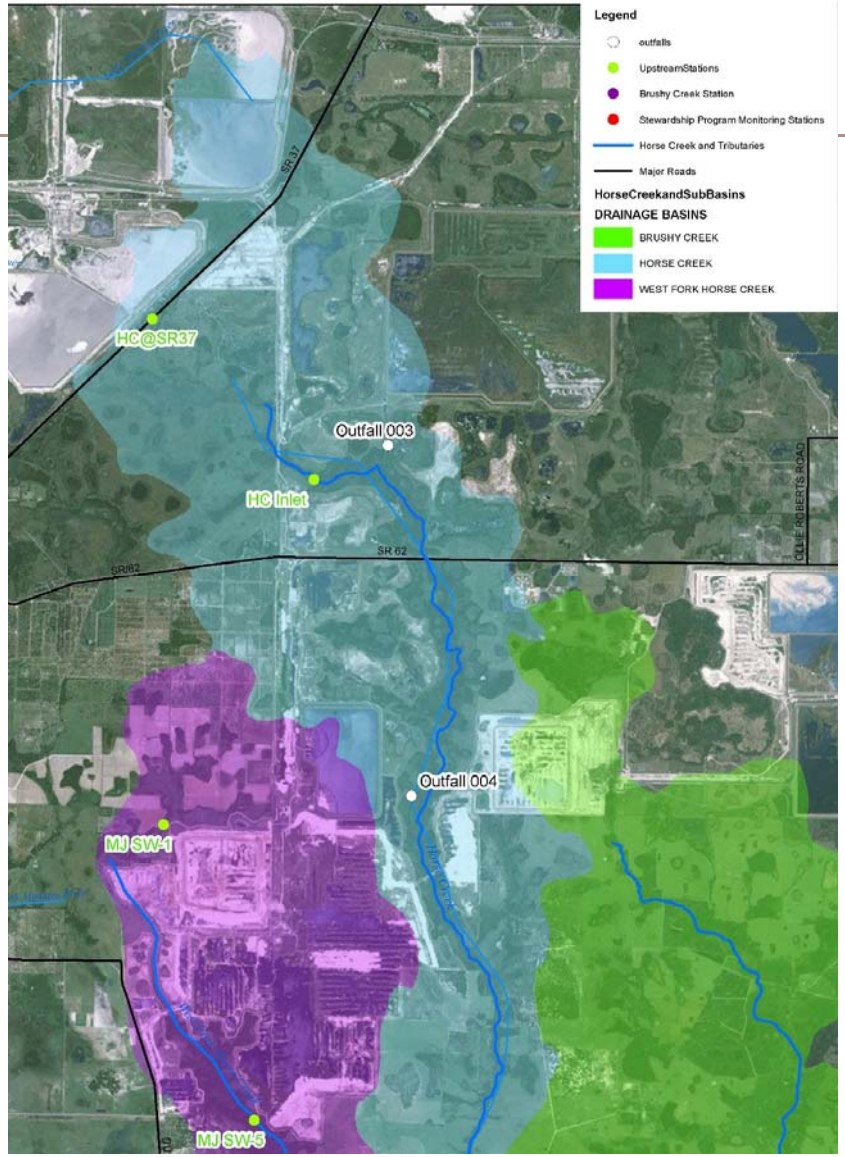
2016 Summary: Seasonal Trends over Time 2003-2016

Parameter	HCSW-1 Slope	HCSW-4 Slope	Discussion
pH	0.05 SU/yr		Slope very small in magnitude. Isolated step change. Not of concern. See further discussion in Appendix I.
DO (mg/L)	0.06 mg/yr		Not an adverse trend
DO (% Saturation)	0.74%/yr		Not an adverse trend
Color		4.31 PCU/yr	Not an adverse trend
Nitrogen, Ammonia	-0.001 mg/L/yr		Not an adverse trend
Specific Conductance	10.4 μmhos/cm/yr	7.94 μmhos/cm/yr	See further discussion in Appendix I
Calcium	1.05 mg/L/yr		Related to Conductance Trend Discussion (See Appendix I)
Iron	-0.01 mg/L/yr	-0.01 mg/L/yr	Not an adverse trend
Alkalinity	2.39 mg/L/yr	1.08 mg/L/yr	Related to Conductance Trend Discussion (See Appendix I)
Fluoride	0.01 mg/L/yr	0.01 mg/L/yr	Related to Conductance Trend Discussion (See Appendix I)
Sulfate	3.67 mg/L/yr		Related to Conductance Trend Discussion (See Appendix I)
TDS	8.56 mg/L/yr	6.02 mg/L/yr	Related to Conductance Trend Discussion (See Appendix I)

2015 and 2016 Impact Assessments

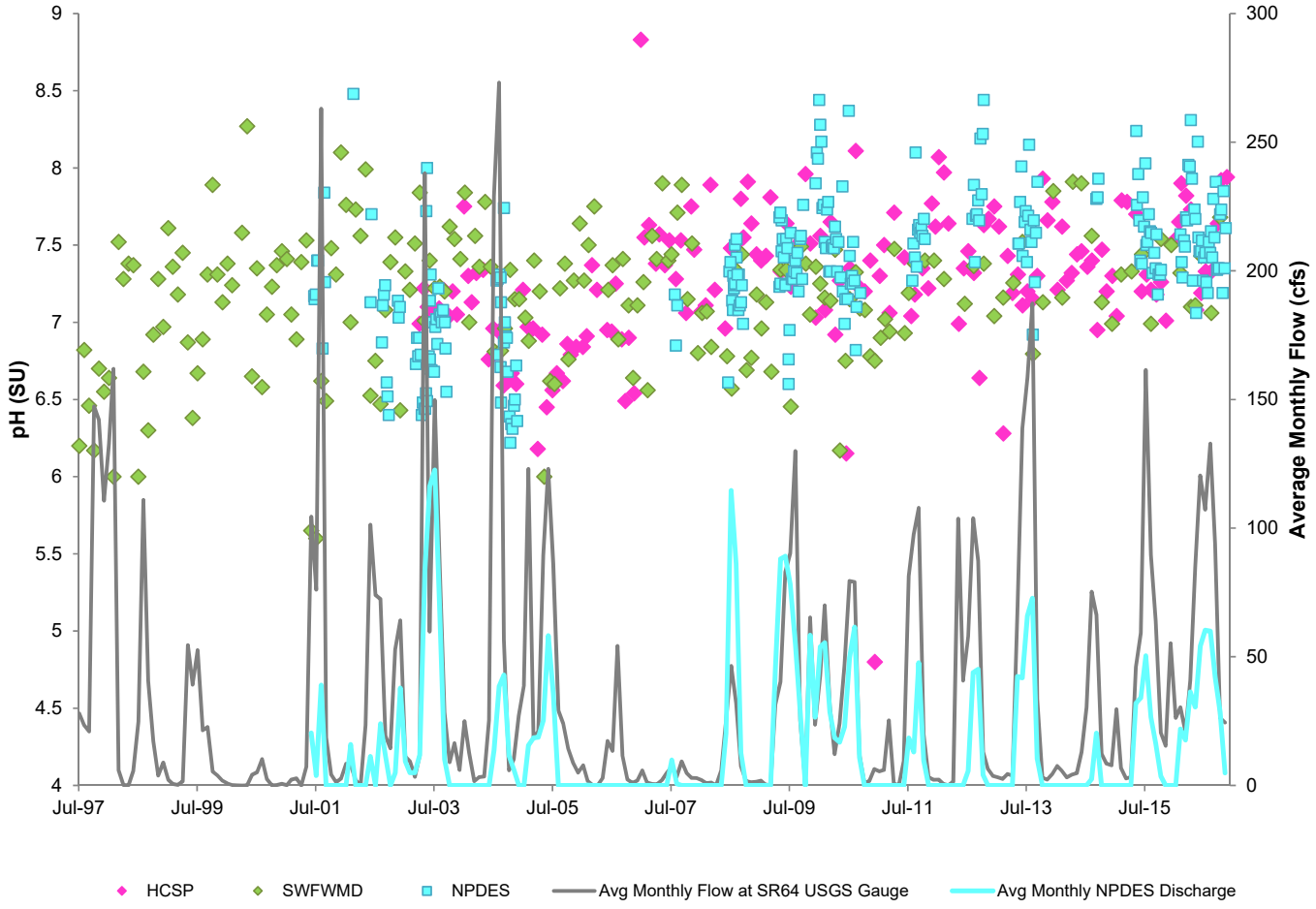
- Determined whether statistically significant trends were adverse
- Focused on pH and specific conductivity (mentioned other ions in 2016 report)
- Compared HCSP data to SWFWMD data over longer time period
- Compared to Charlie Creek
- Compared to upstream stations and mining activity history
- Evaluated stream biological health

Upstream Horse Creek Sampling Locations



Impact Assessment: pH

Monthly HCSP and SWFWMD pH



Monthly HCSP and SWFWMD pH

LOESS Smooth Parameter	Stat	SWFWMD – Horse Creek Near Myakka Head					HCSP – HCSW-1	
		Seasonal 1998-2015	Seasonal 2003-2015	Annual 1992-2015	Annual 1998-2015	Annual 2003-2015	Seasonal 2003-2015	Annual 2003-2015
None	p-value	0.41	0.67	**0.04**	0.25	0.54	**0.01**	0.25
	slope	N/A	N/A	**0.02**	N/A	N/A	**0.03**	N/A
Logged Flow	p-value	0.27	0.75	**0.04**	0.29	0.67	**0.001**	0.30
	slope	N/A	N/A	**0.01**	N/A	N/A	**0.04**	N/A

LOESS Smooth Parameter	Stat	SWFWMD – Horse Creek Near Myakka Head					HCSP – HCSW-1	
		Seasonal 1998-2016	Seasonal 2003-2016	Annual 1992-2016	Annual 1998-2016	Annual 2003-2016	Seasonal 2003-2016	Annual 2003-2016
None	p-value	0.50	0.85	**0.03**	0.25	0.58	**0.01**	0.08
	slope	N/A	N/A	**0.01**	N/A	N/A	**0.04**	0.03
Logged Flow	p-value	0.28	0.95	**0.03**	0.14	0.38	**0.001**	0.10
	slope	N/A	N/A	**0.01**	N/A	N/A	**0.05**	0.02

Change-point Analysis of HCSP pH Data (2003-2016)

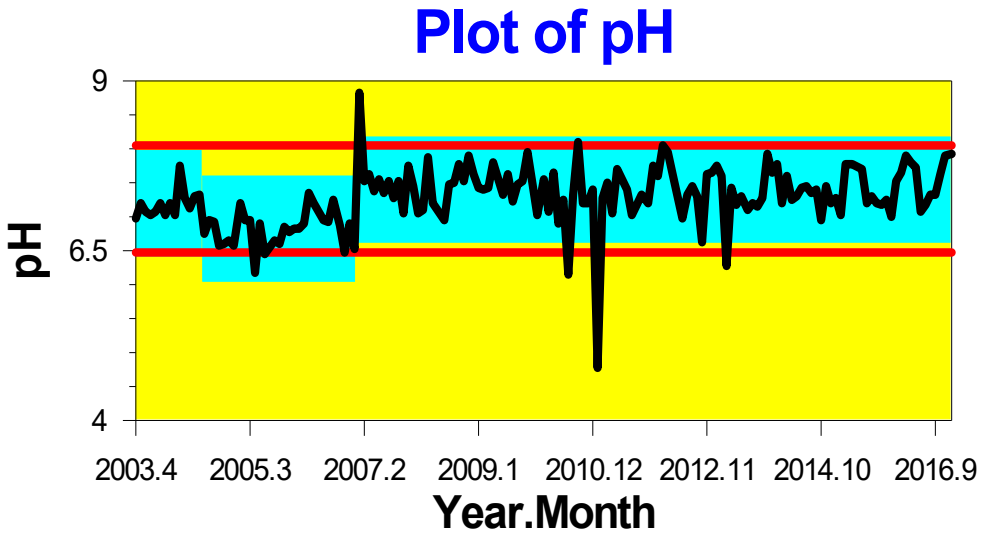


Table of Significant Changes for pH

Confidence Level for Candidate Changes = 95%, Confidence Level for Inclusion in Table = 95%, Confidence Interval = 95%, Bootstraps = 1000, Without Replacement, MSE Estimates

Year.Month	Confidence Interval	Conf. Level	From	To	Level
2004.6	(2004.5, 2004.12)	100%	7.1986	6.8153	2
2007.1	(2006.11, 2007.10)	100%	6.8153	7.4064	1

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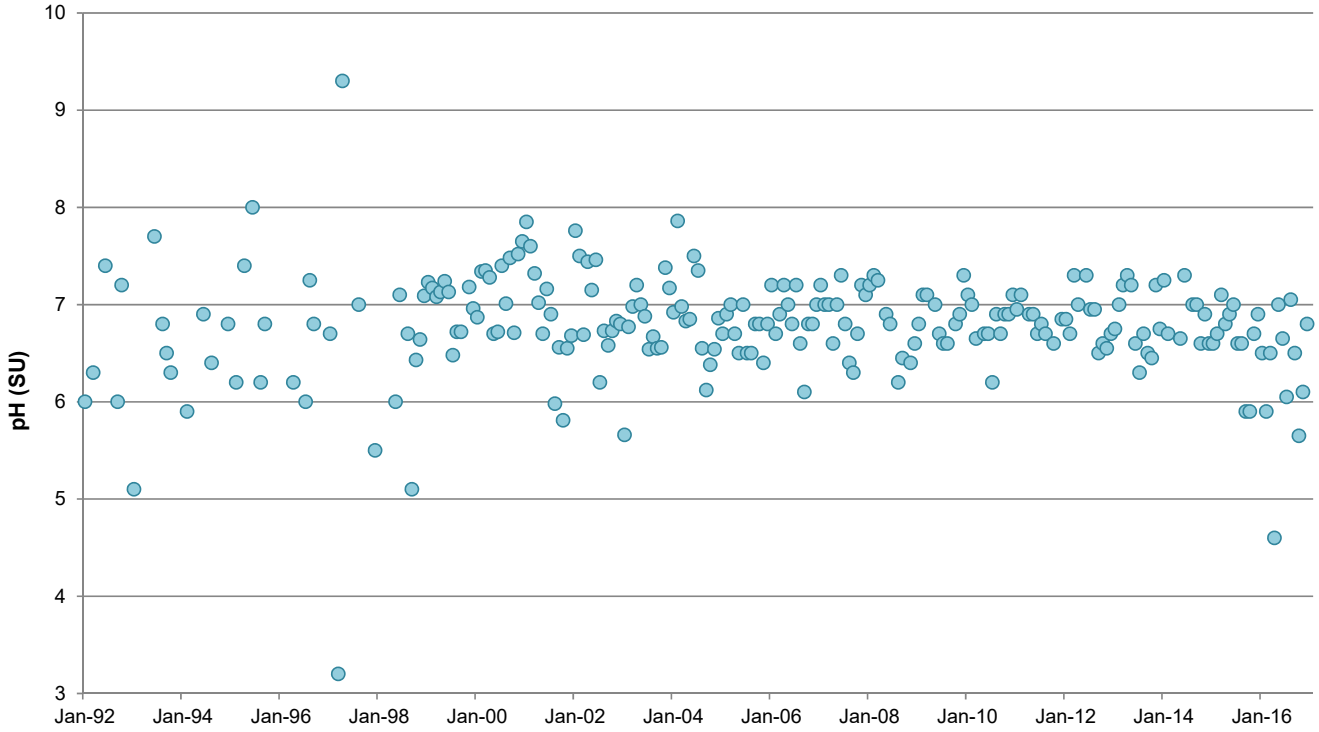
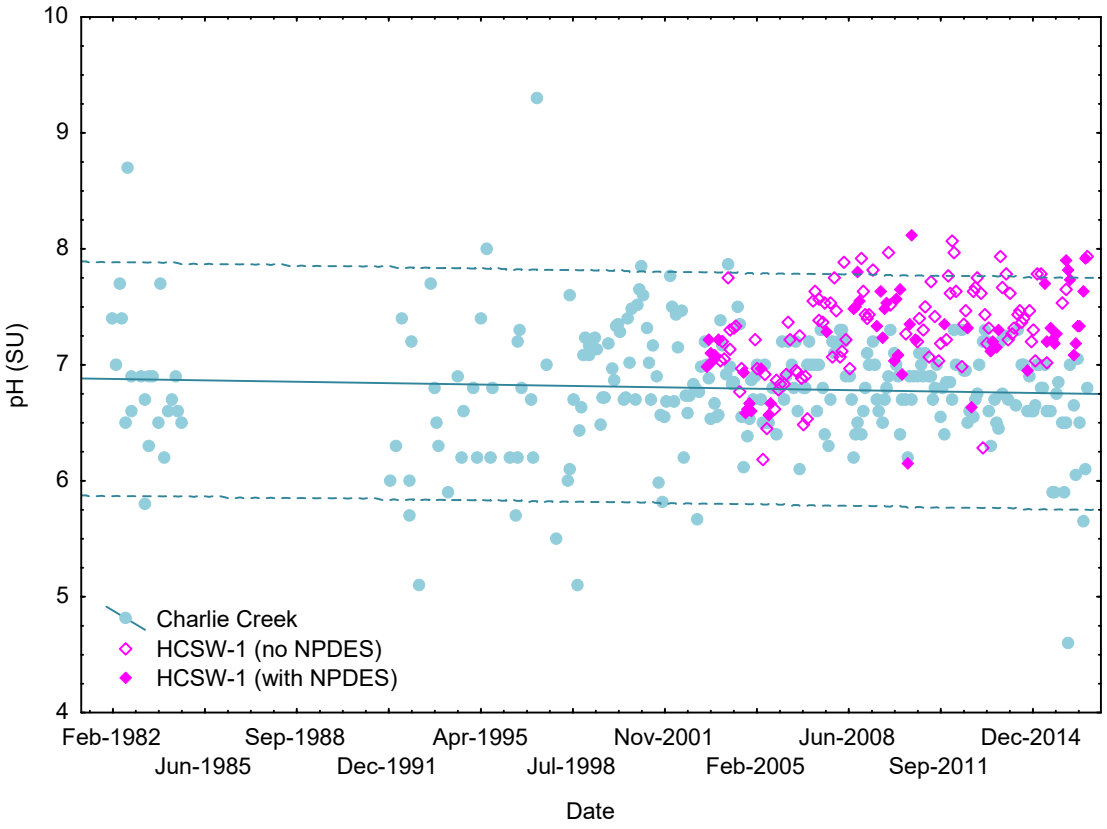
Charlie Creek pH

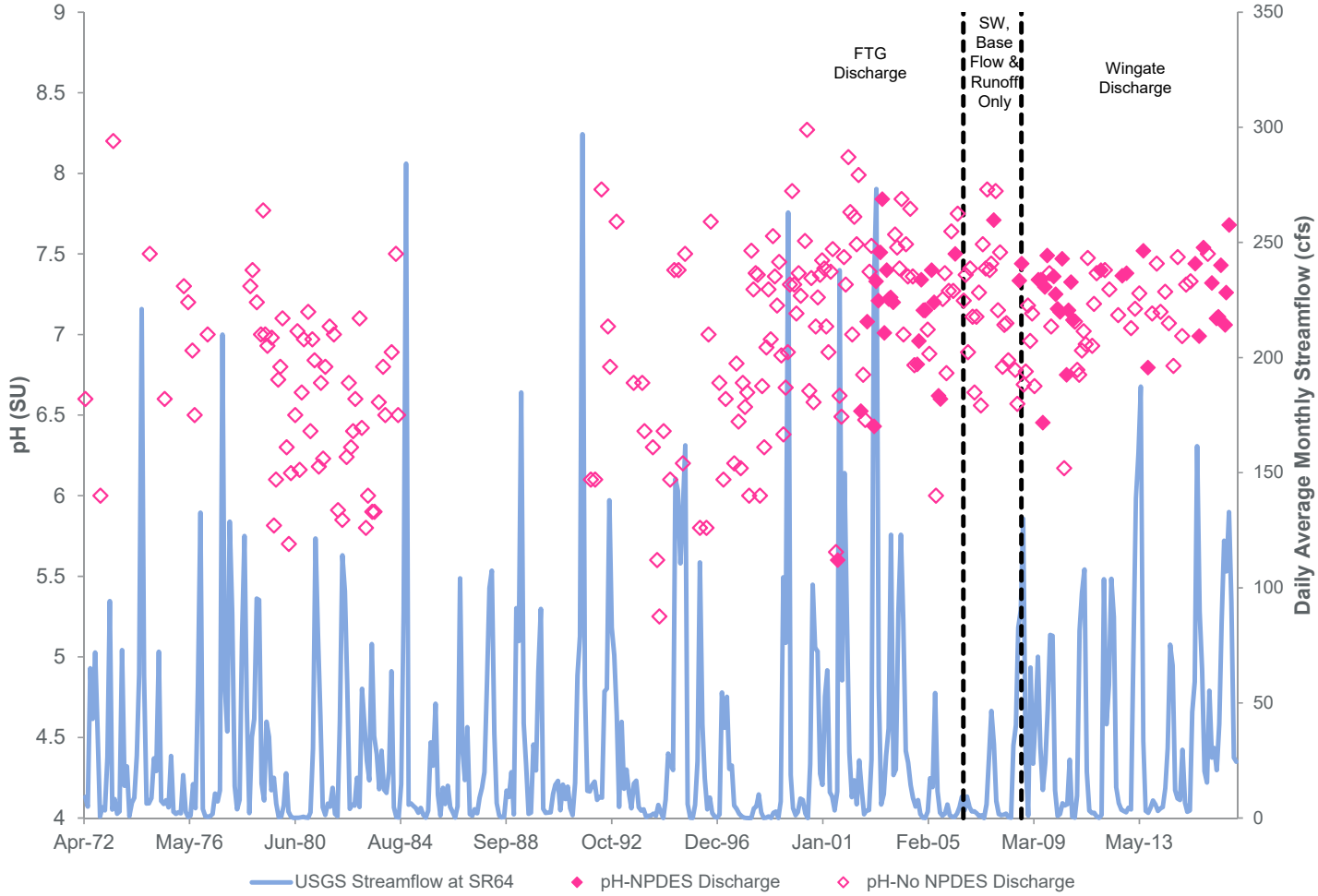


LOWESS Smooth Parameter	Statistics	SWFWMD and FDEP Data		USGS, SWFWMD, and FDEP Data		
		Seasonal 1999-2016	Seasonal 2003-2016	Annual 1992-2016	Annual 1998-2016	Annual 2003-2016
None	p-value	**0.002**	0.12	0.07	0.42	0.32
	slope	**-0.02**	N/A	N/A	N/A	N/A
USGS Log Flow	p-value	**0.002**	0.08	0.59	**0.03**	0.66
	slope	**-0.01**	N/A	N/A	**-0.01**	N/A

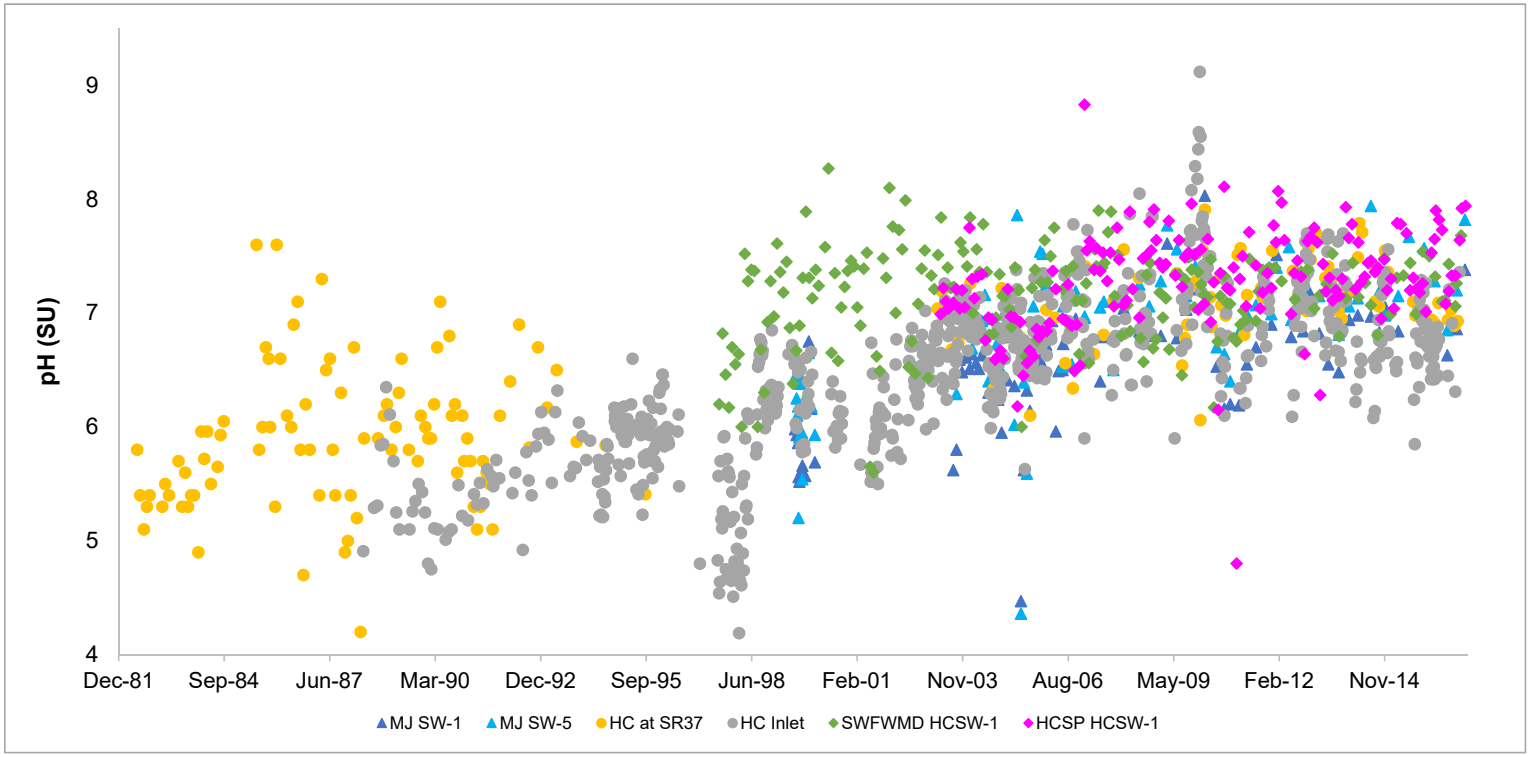
HCSP and Charlie Creek pH Data-Periods With and Without NPDES Discharge



Long-term pH and Discharge



Upstream Horse Creek pH



pH	HC at SR37	HC Inlet				MJ SW-1	MJ SW-5
	2003-2016	1988-2016	1992-2016	1998-2016	2003-2016	2003-2016	2003-2016
p-value	0.11	**<0.0001**	**<0.0001**	**0.01**	1.00	**0.05**	**0.02**
Slope	N/A	**0.07**	**0.07**	**0.05**	N/A	**0.03**	**0.04**

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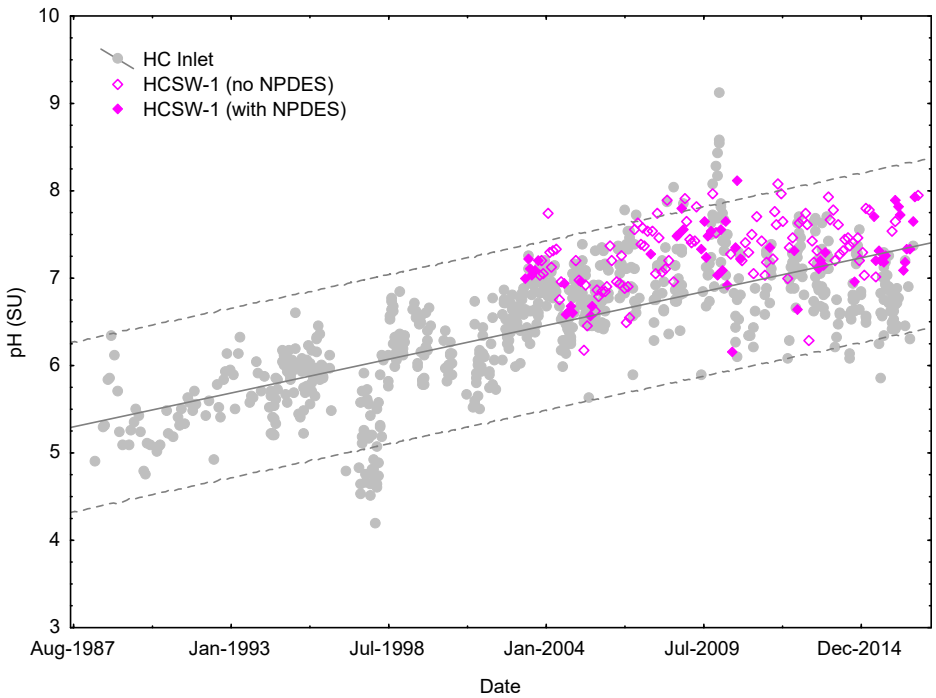
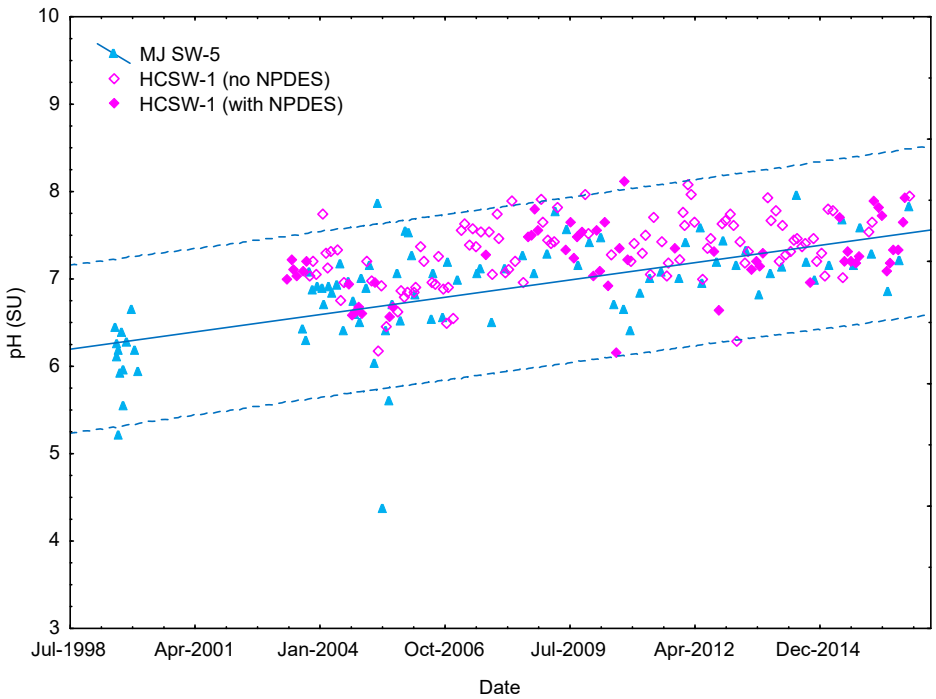
Upstream Horse Creek pH



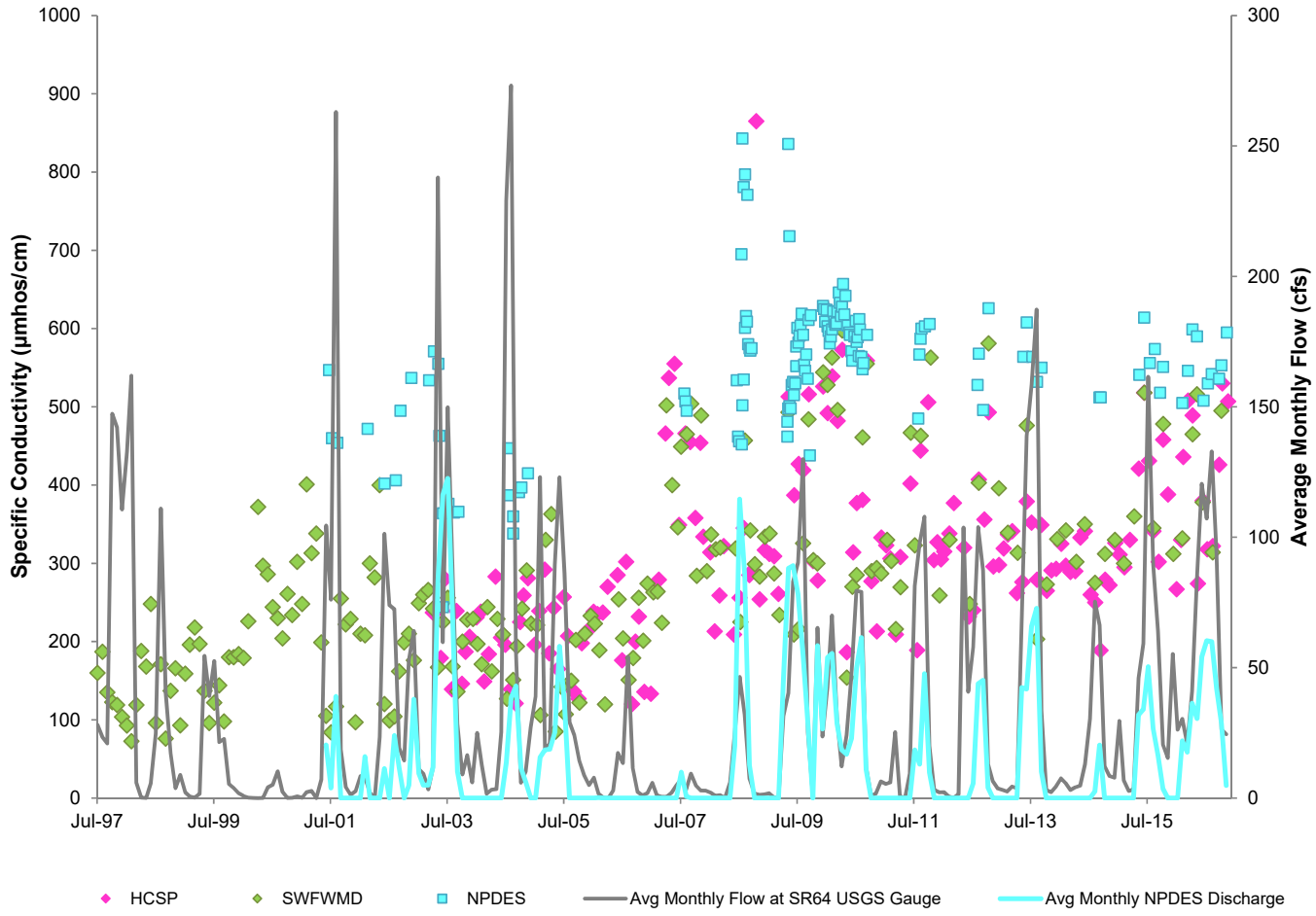


pH Summary

- Trend observed in seasonal analysis of 2003-2015 and 2003-2016 HCSP data but not annual analysis
- Increasing trend only in annual 1992-2015 and 1992-2016 SWFWMD data
- Change-point analysis of the HCSP data show a decline in 2004, increase in 2007, and stable from 2007-2016
  - Change-points correspond to a wet year with several hurricanes (2004) and a very dry time period (2006-2008)
- HCSW-1 pH values are almost all within the 95% prediction intervals of pH at Charlie Creek (unmined) and upstream stations, including during times of NPDES discharge
- No evidence of a consistent, continuing increase in pH at HCSW-1 over time

Impact Assessment: Specific Conductivity

Monthly HCSP and SWFWMD Conductivity



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Monthly HCSP and SWFWMD Conductivity

LOESS Smooth Parameter	Stat	SWFWMD – Horse Creek Near Myakka Head					HCSP – HCSW-1	
		Seasonal 1998-2015	Seasonal 2003-2015	Annual 1992-2015	Annual 1998-2015	Annual 2003-2015	Seasonal 2003-2015	Annual 2003-2015
None	p-value	<0.0001	<0.001	<0.0001	<0.001	0.10	<0.0001	0.04
	slope	12.4	12.4	9.6	11.5	11.3	10.0	10.1
Logged Flow	p-value	<0.0001	<0.001	<0.0001	0.001	0.06	<0.0001	0.20
	slope	11.2	11.2	9.8	10.2	4.4	10.2	N/A

LOESS Smooth Parameter	Stat	SWFWMD – Horse Creek Near Myakka Head					HCSP – HCSW-1	
		Seasonal 1998-2016	Seasonal 2003-2016	Annual 1992-2016	Annual 1998-2016	Annual 2003-2016	Seasonal 2003-2016	Annual 2003-2016
None	p-value	<0.0001	<0.0001	<0.0001	0.001	0.05	<0.0001	0.02
	slope	12.4	12.4	9.8	11.5	11.5	10.6	11.5
Logged Flow	p-value	<0.0001	<0.0001	<0.0001	0.0002	0.05	<0.0001	0.01
	slope	12.1	12.9	9.5	10.1	7.1	10.4	7.8

Change-point Analysis of HCSP SC Data (2003-2016)

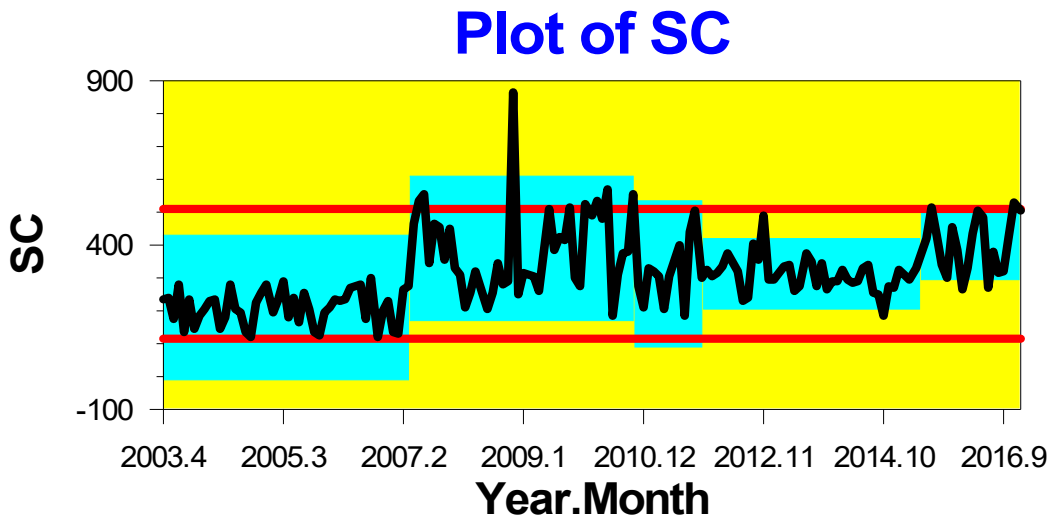

Table of Significant Changes for SC

Confidence Level for Candidate Changes = 95%, Confidence Level for Inclusion in Table = 95%, Confidence Interval = 95%, Bootstraps = 1000, Without Replacement, MSE Estimates

Year.Month	Confidence Interval	Conf. Level	From	To	Level
2007.4	(2007.4, 2007.9)	100%	211.34	391.64	1
2010.11	(2007.5, 2011.5)	99%	391.64	312.45	4
2015.6	(2014.10, 2016.2)	99%	312.45	402.42	3

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Change-point Analysis of SWFWMD SC Data (1998-2016)

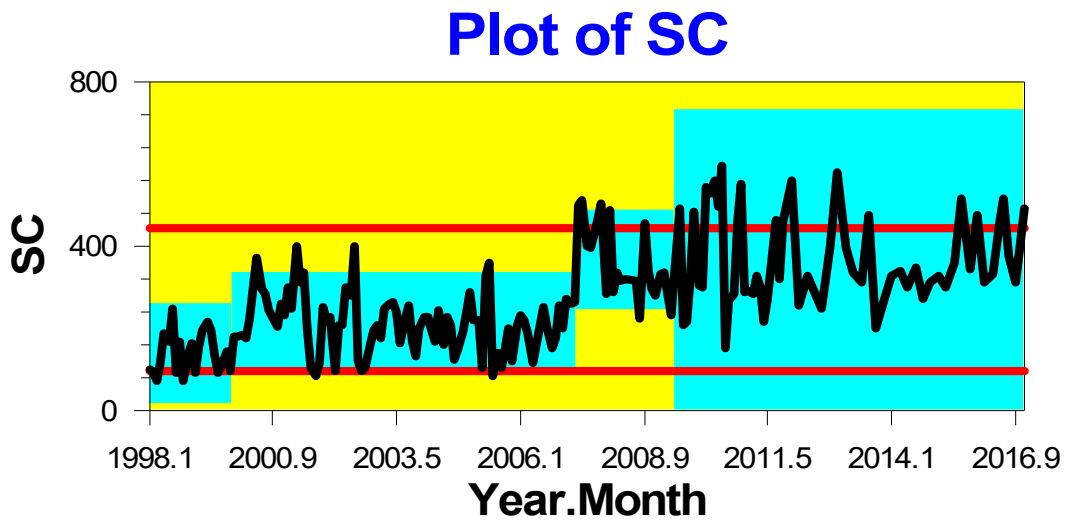

Table of Significant Changes for SC

Confidence Level for Candidate Changes = 95%, Confidence Level for Inclusion in Table = 95%, Confidence Interval = 95%, Bootstraps = 1000, Without Replacement, MSE Estimates

Year.Month	Confidence Interval	Conf. Level	From	To	Level
1999.11	(1999.7, 2001.2)	100%	140.82	213.64	2
2007.4	(2007.2, 2007.10)	100%	213.64	367.57	1

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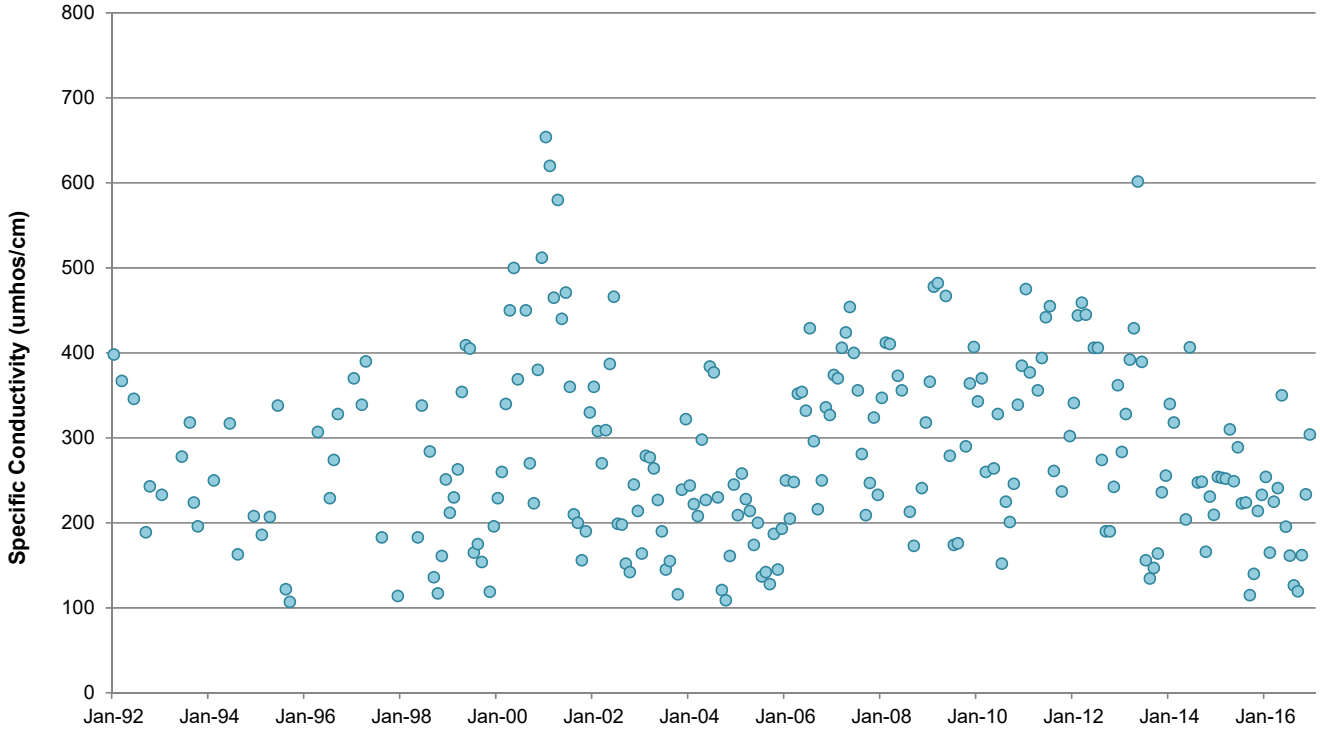
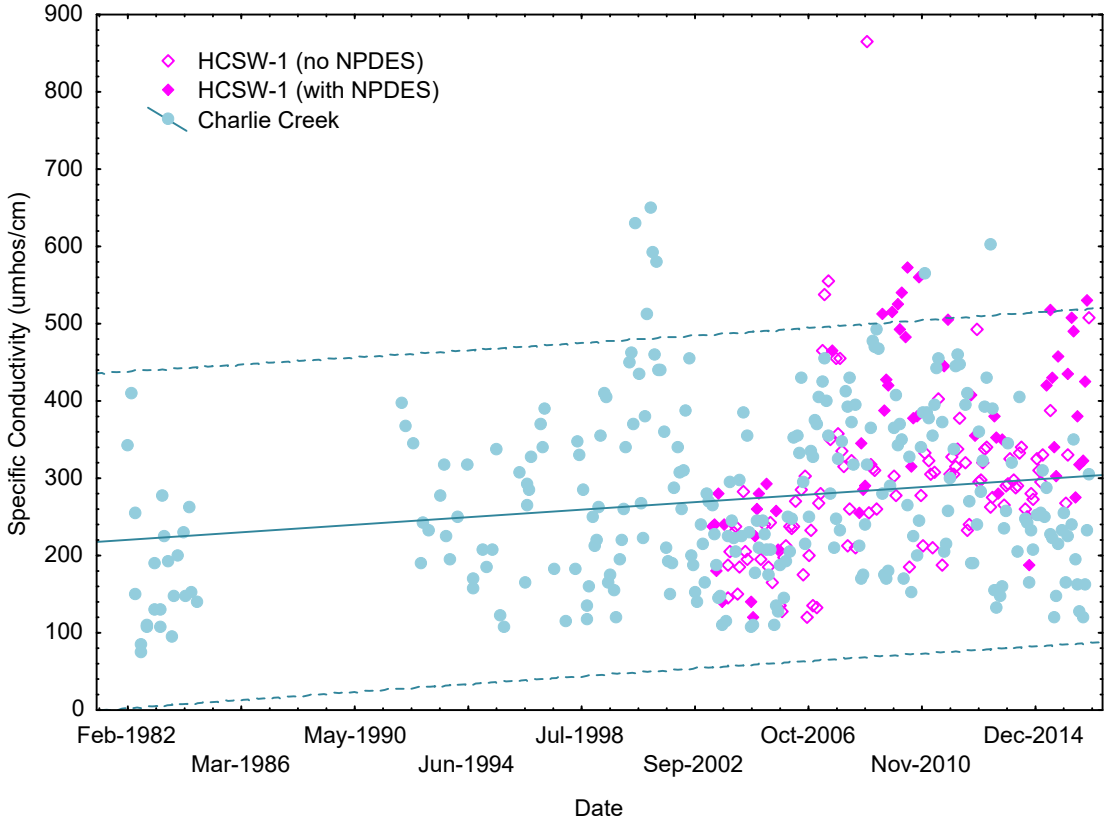
Charlie Creek Conductivity

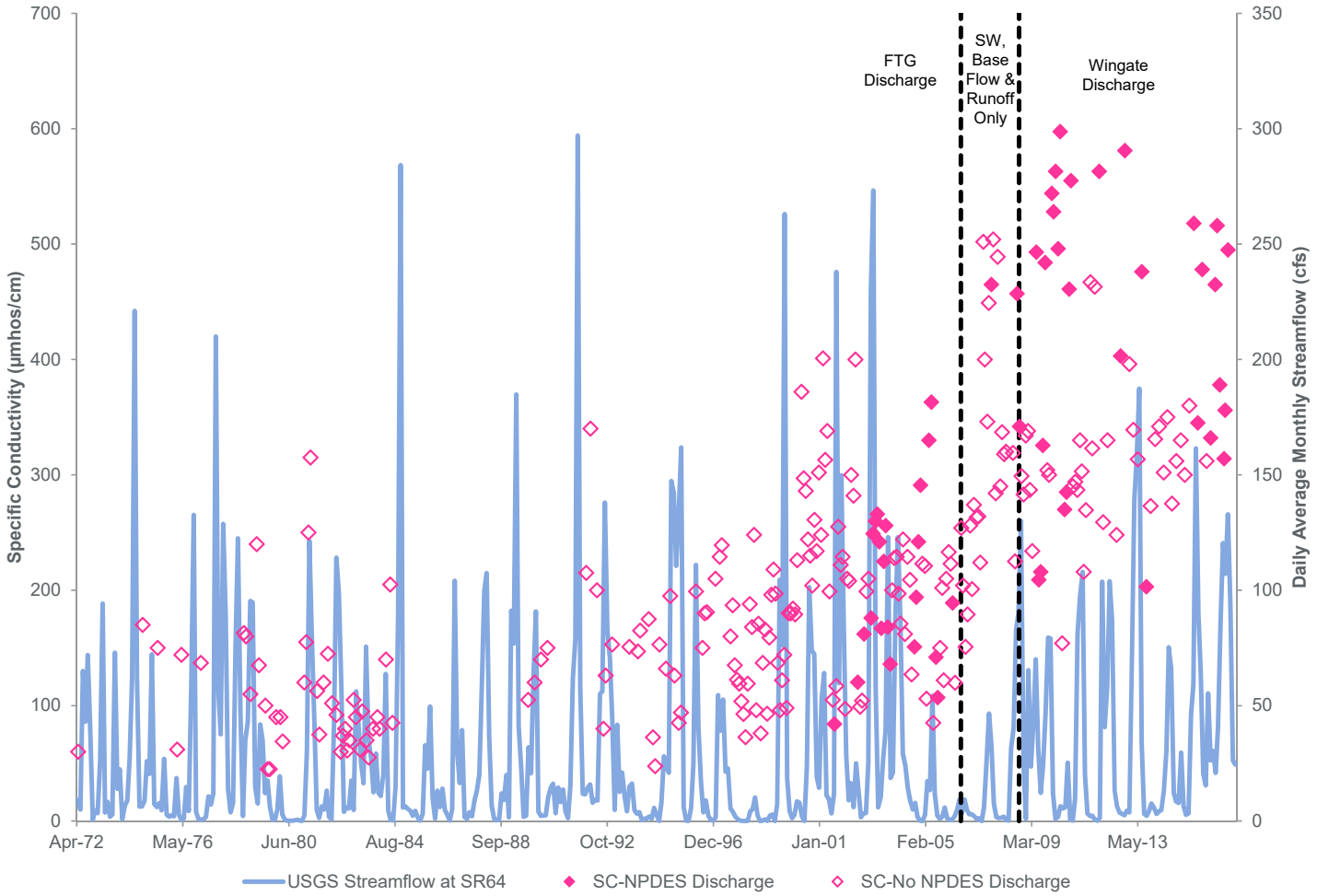


LOWESS Smooth Parameter	Statistics	SWFWMD and FDEP Data		USGS, SWFWMD, and FDEP Data		
		Seasonal 1999-2016	Seasonal 2003-2016	Annual 1992-2016	Annual 1998-2016	Annual 2003-2016
None	p-value	0.90	0.68	0.50	0.67	1.00
	slope	N/A	N/A	N/A	N/A	N/A
USGS Log Flow	p-value	0.46	0.90	0.27	0.67	0.58
	slope	N/A	N/A	N/A	N/A	N/A

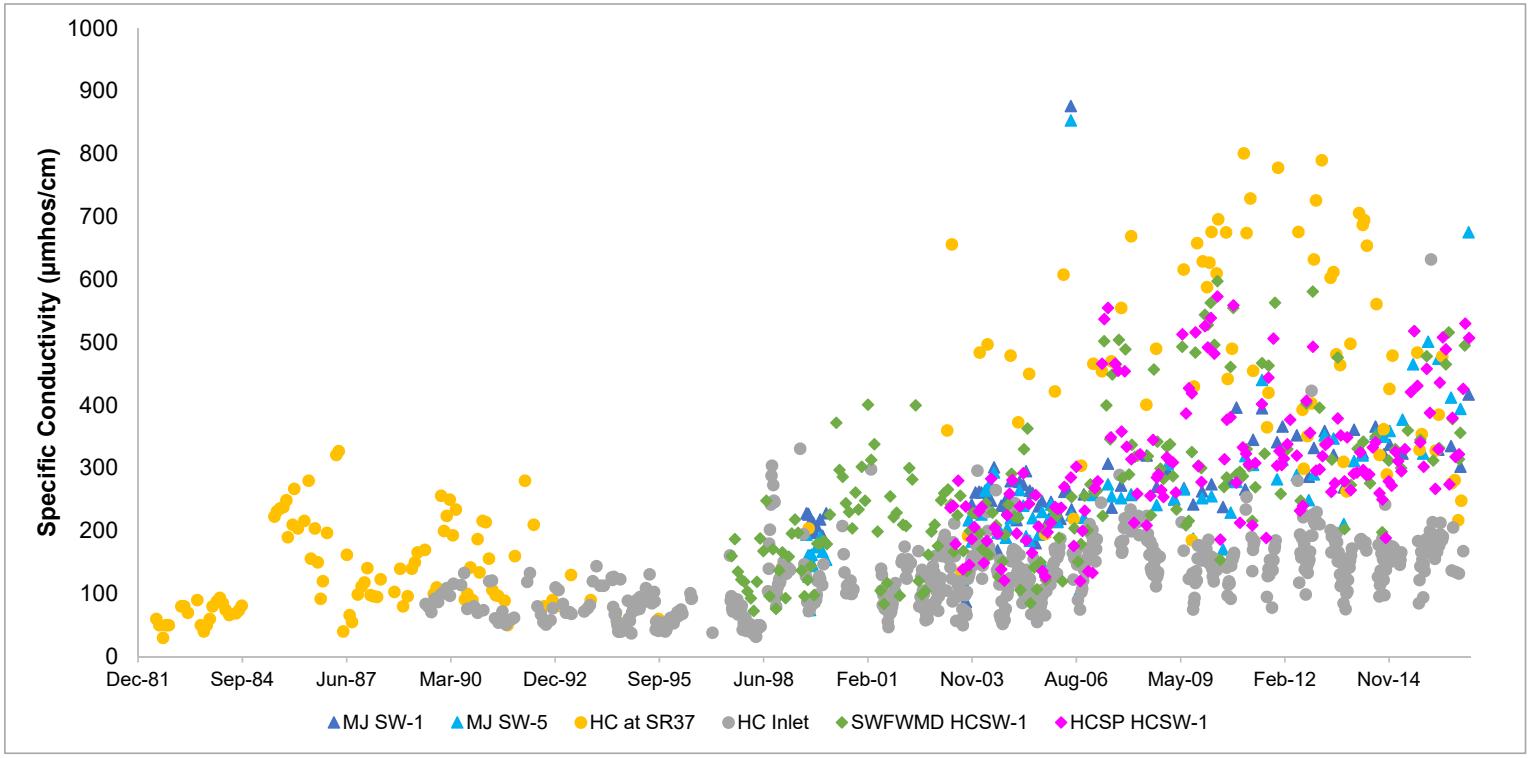
HCSP and Charlie Creek SC Data-Periods With and Without NPDES Discharge



Long-term Conductivity and Discharge



Upstream Horse Creek Conductivity



SC	HC at SR37	HC Inlet				MJ SW-1	MJ SW-5
	2003-2016	1989-2016	1992-2016	1998-2016	2003-2016	2003-2016	2003-2016
p-value	0.44	<0.0001	<0.0001	0.001	0.05	0.003	<0.0001
Slope	N/A	4.29	4.71	3.93	3.28	8.8	16.1

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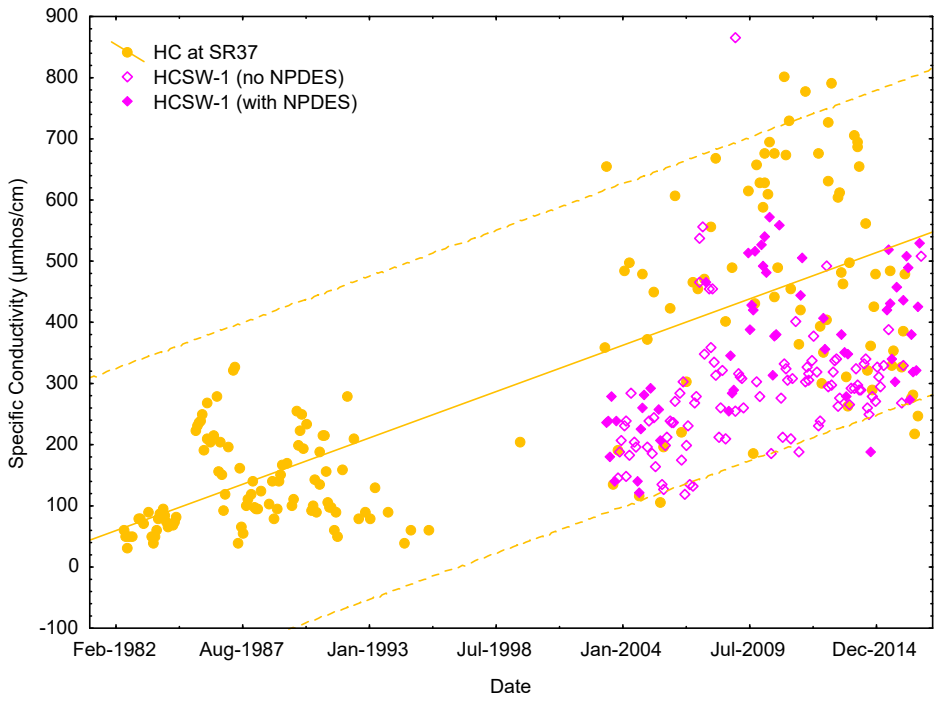
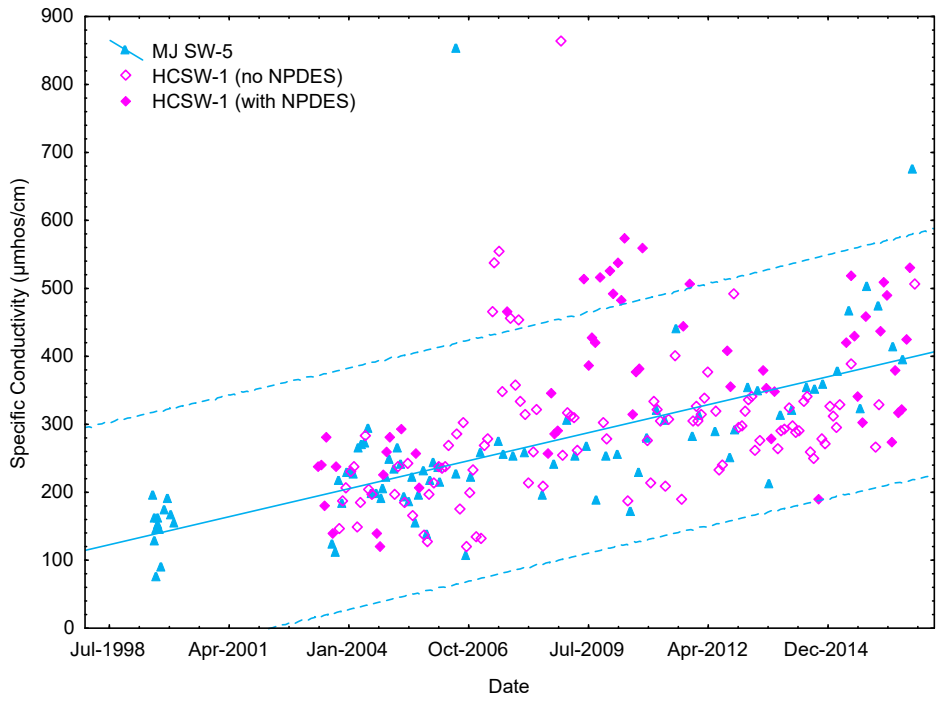
Upstream Horse Creek Conductivity





Conductivity Trend Summary

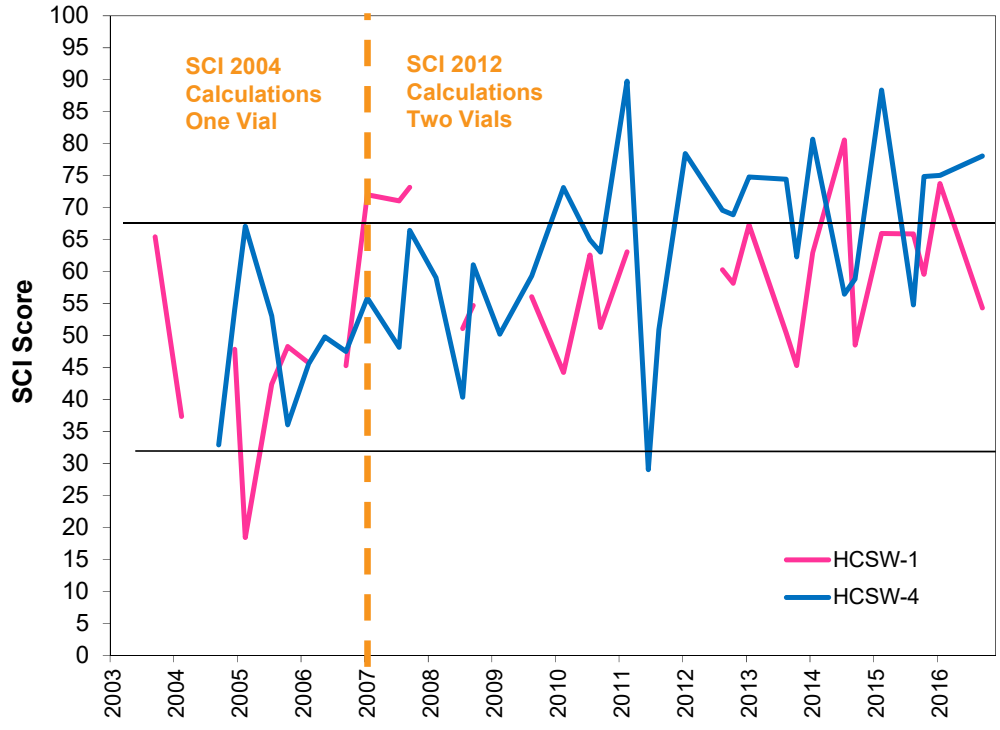
- Statistically significant increasing trend detected even when period of record was expanded
  - Analysis of other stations shows influence of climatic and upstream conditions
- HCSW-1 SC values are almost all within the 95% prediction intervals of SC at Charlie Creek (unmined) and upstream stations, including during times of NPDES discharge
- SC at upstream Horse Creek and West Fork Horse Creek (no NPDES outfalls present) had been increasing over the same time period
- While some isolated conductivity values at HCSW-1 may be related to increased groundwater influence from NPDES discharges, majority of increasing trend can be explained upstream conditions and regional factors unrelated to NPDES discharge

Biological Health With Respect to Conductivity

- HCSW-1 and HCSW-4 populations are healthy with no evidence of declines over time
- Fish species each have salinity/SC tolerance which vary by life stage of the species
- Other factors like temperature and suitable habitat may affect taxa richness and abundance in Horse Creek
- The average SCI score at both HCSW-1 and HCSW-4 is well above 40 and the two most recent scores are above 35
- HCSW-1 also passes other biological metrics (RPS and LVS), indicating no biological impairment

Fish Diversity

SCI Scores



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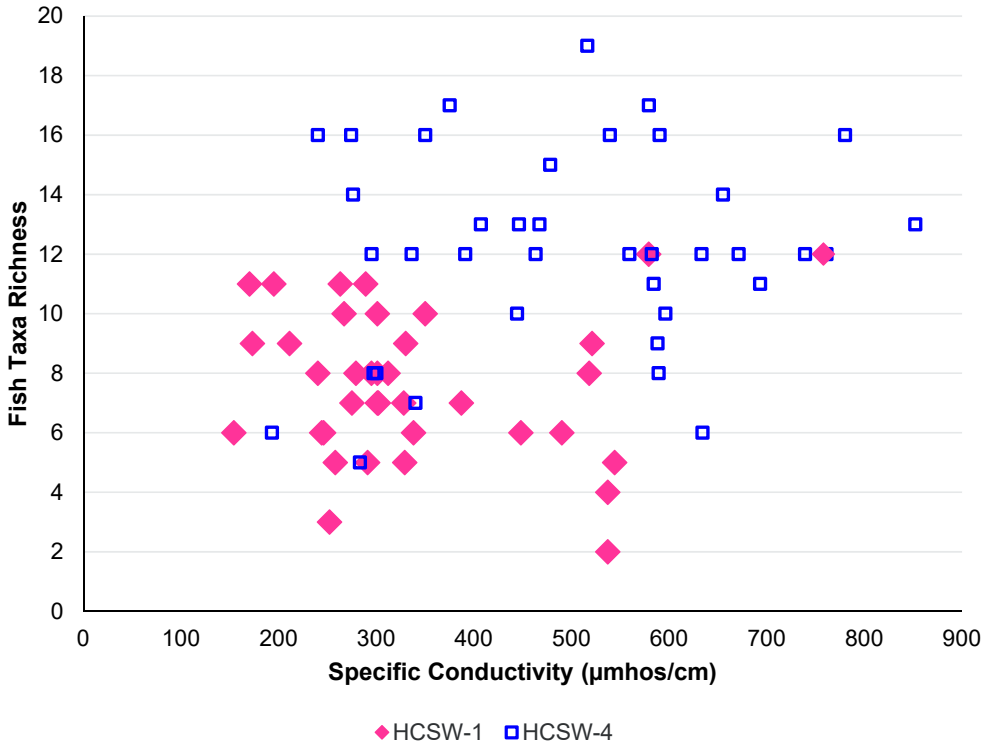
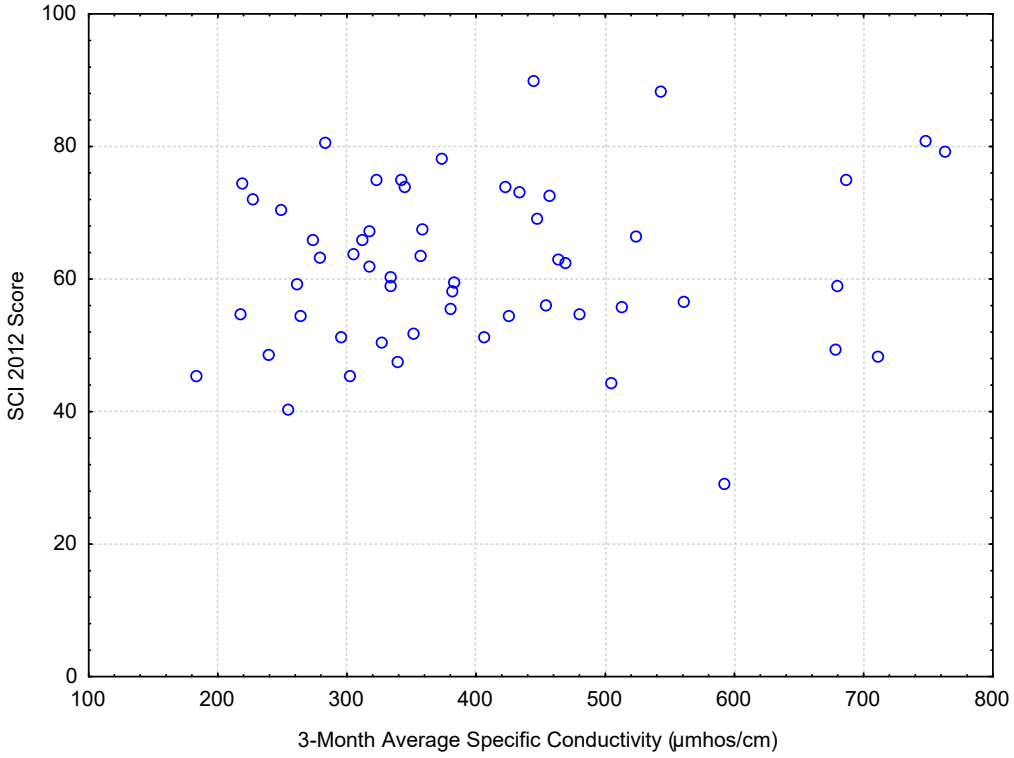
Biological Health and Conductivity





Water Quality Graphs 2003-2016

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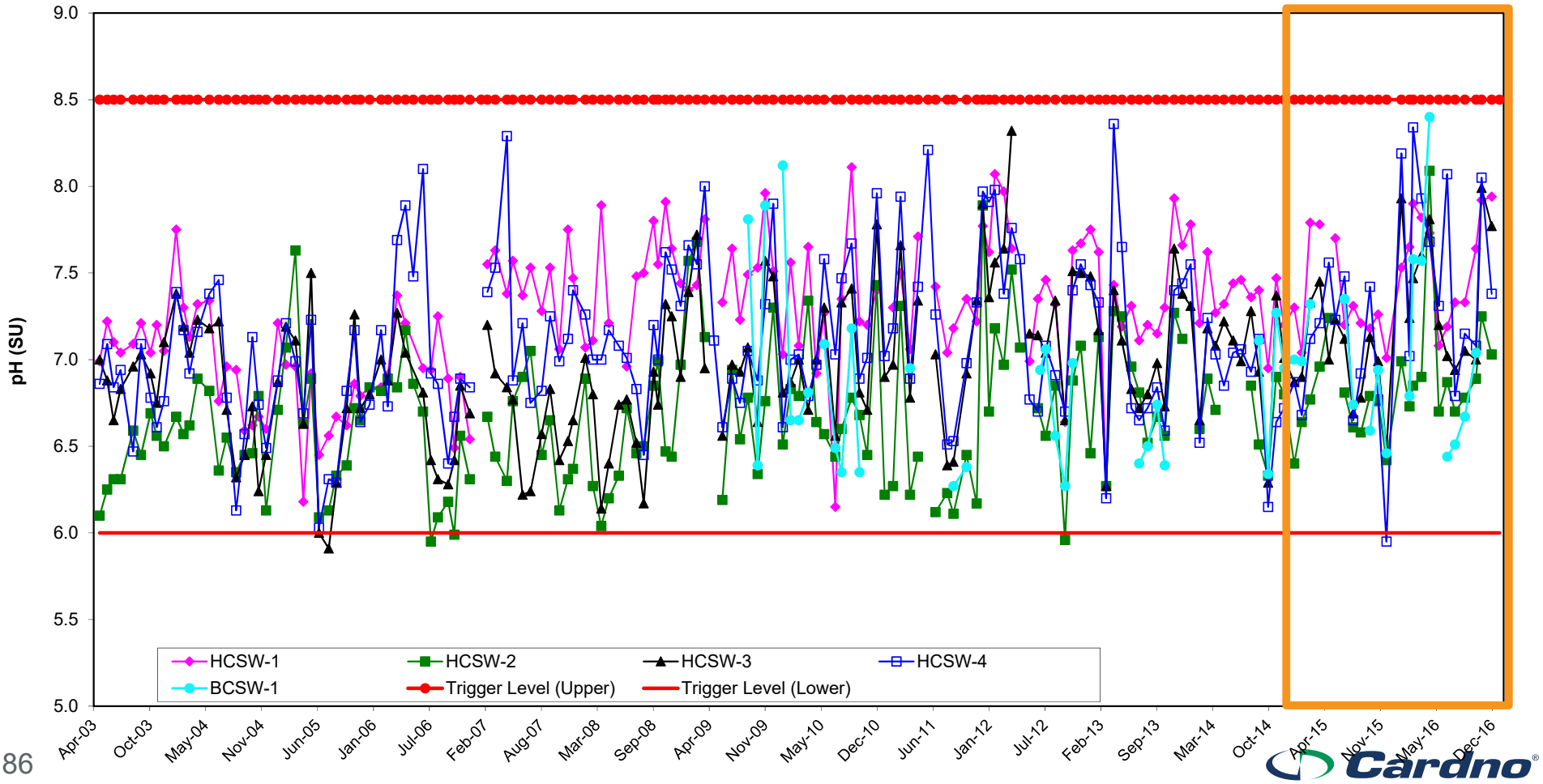
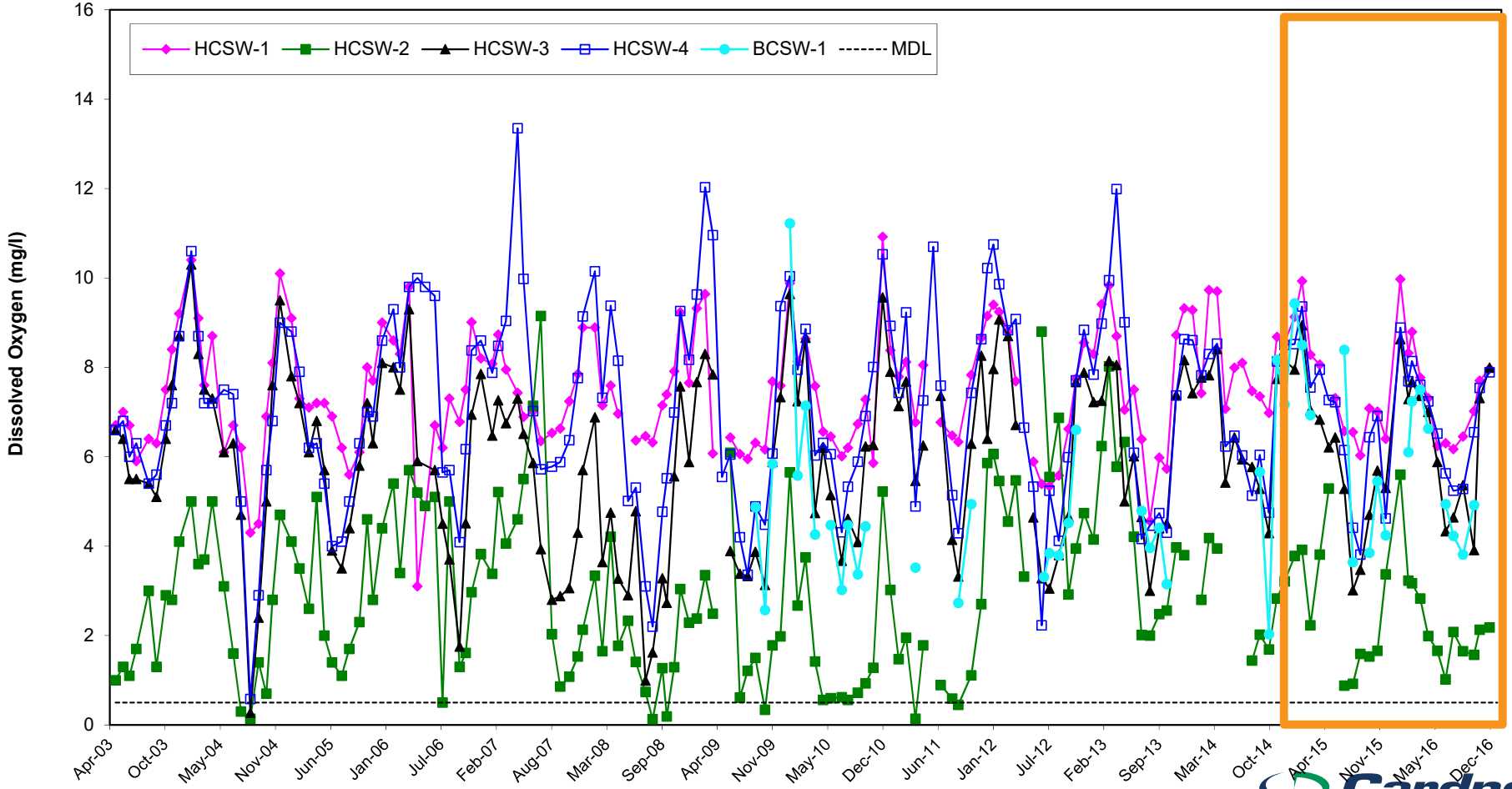
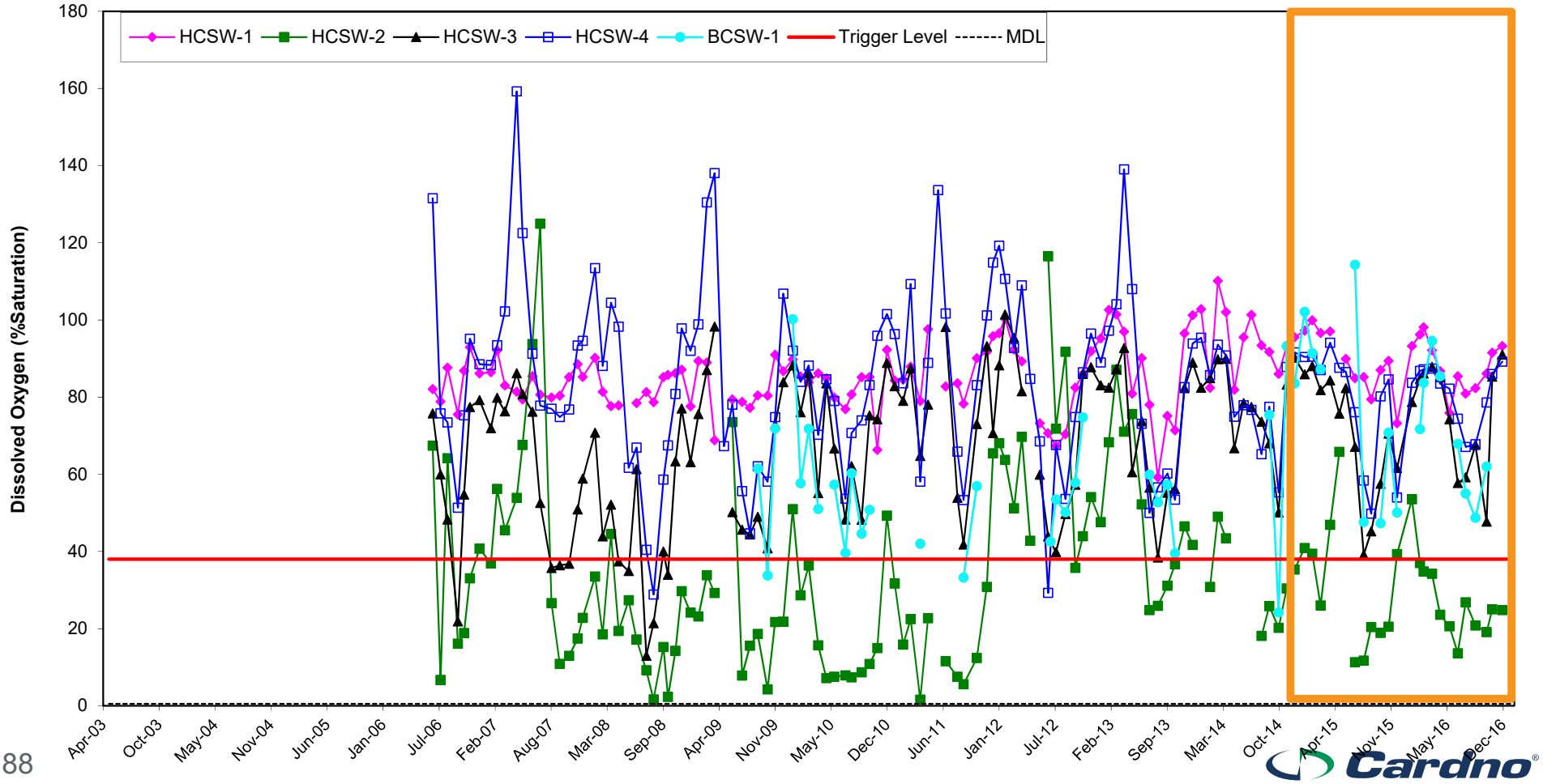
pH


pH (SU)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
Apr-03
Oct-03
May-04
Nov-04
Jun-05
Jan-06
Jul-06
Feb-07
Aug-07
Mar-08
Sep-08
Apr-09
Nov-09
May-10
Dec-10
Jun-11
Jan-12
Jul-12
Feb-13
Sep-13
Mar-14
Oct-14
Apr-15
Nov-15
May-16
Dec-16
HCSW-1
HCSW-2
HCSW-3
HCSW-4
BCSW-1
Trigger Level (Upper)
Trigger Level (Lower)

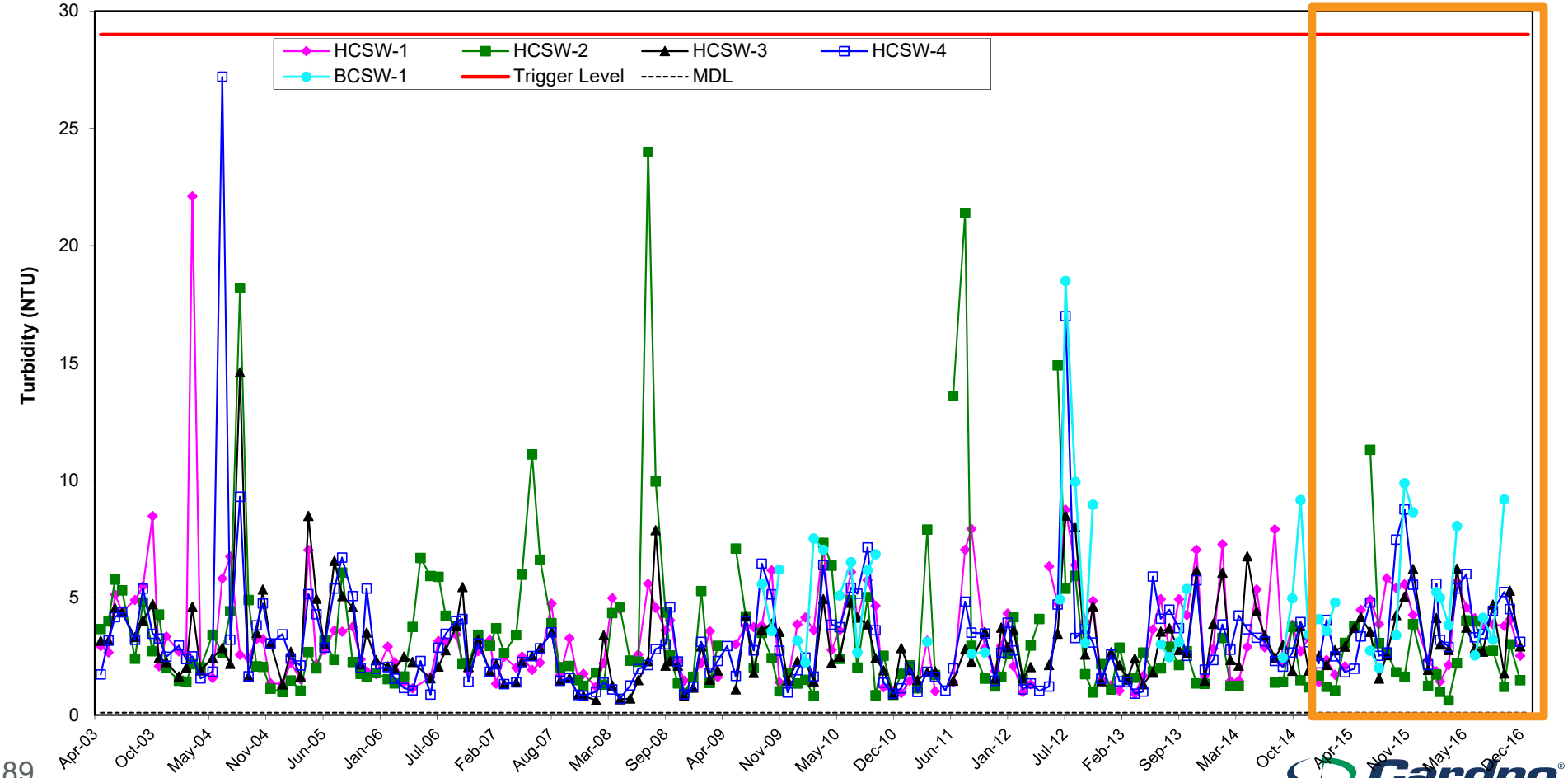
Dissolved Oxygen - Concentration



Dissolved Oxygen – Percent Saturation



Turbidity


HCSW-1
HCSW-2
HCSW-3
HCSW-4
BCSW-1
Trigger Level
MDL
Turbidity (NTU)
30
25
20
15
10
5
0
Apr-03
Oct-03
May-04
Nov-04
Jun-05
Jan-06
Jul-06
Feb-07
Aug-07
Mar-08
Sep-08
Apr-09
Nov-09
May-10
Dec-10
Jun-11
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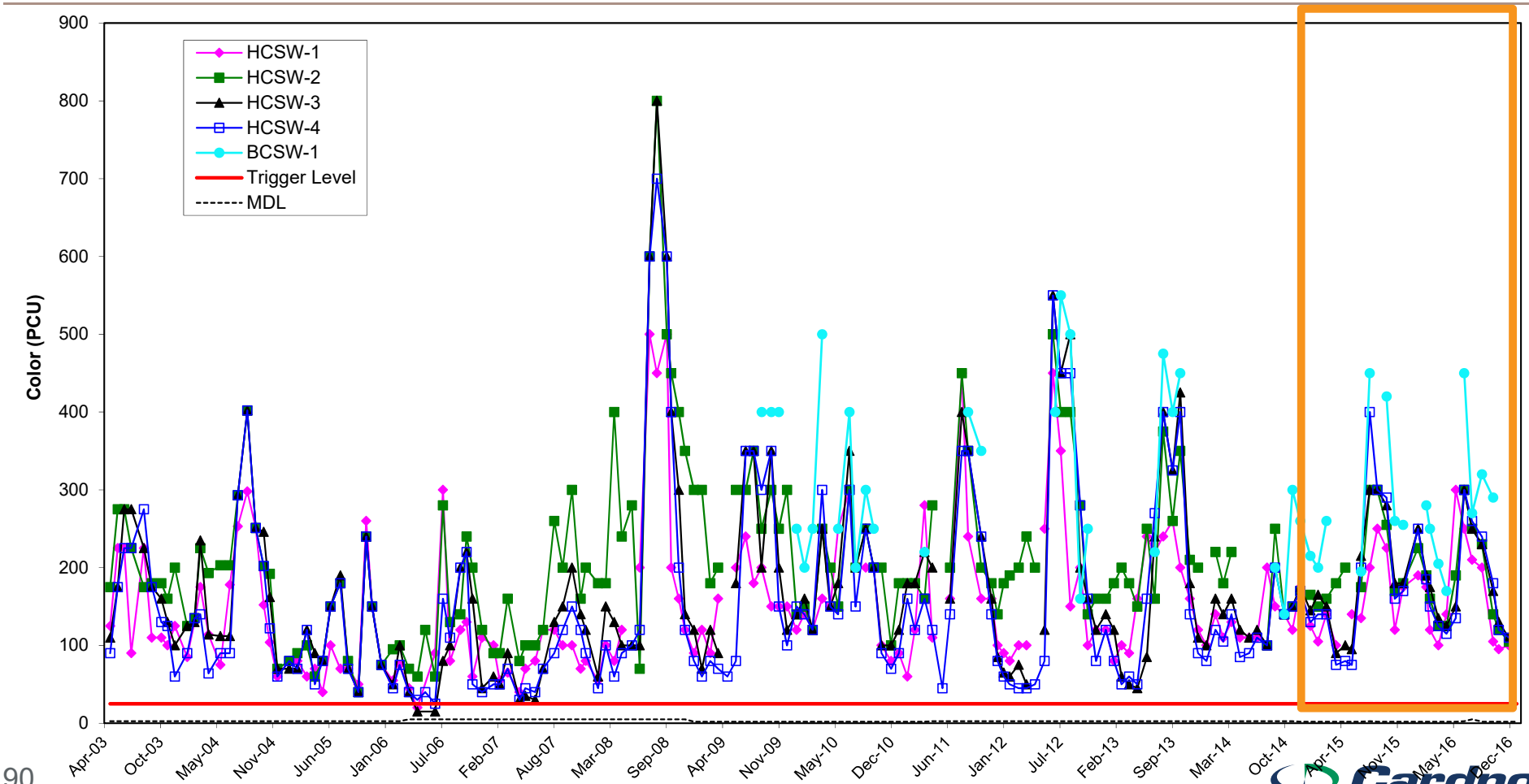
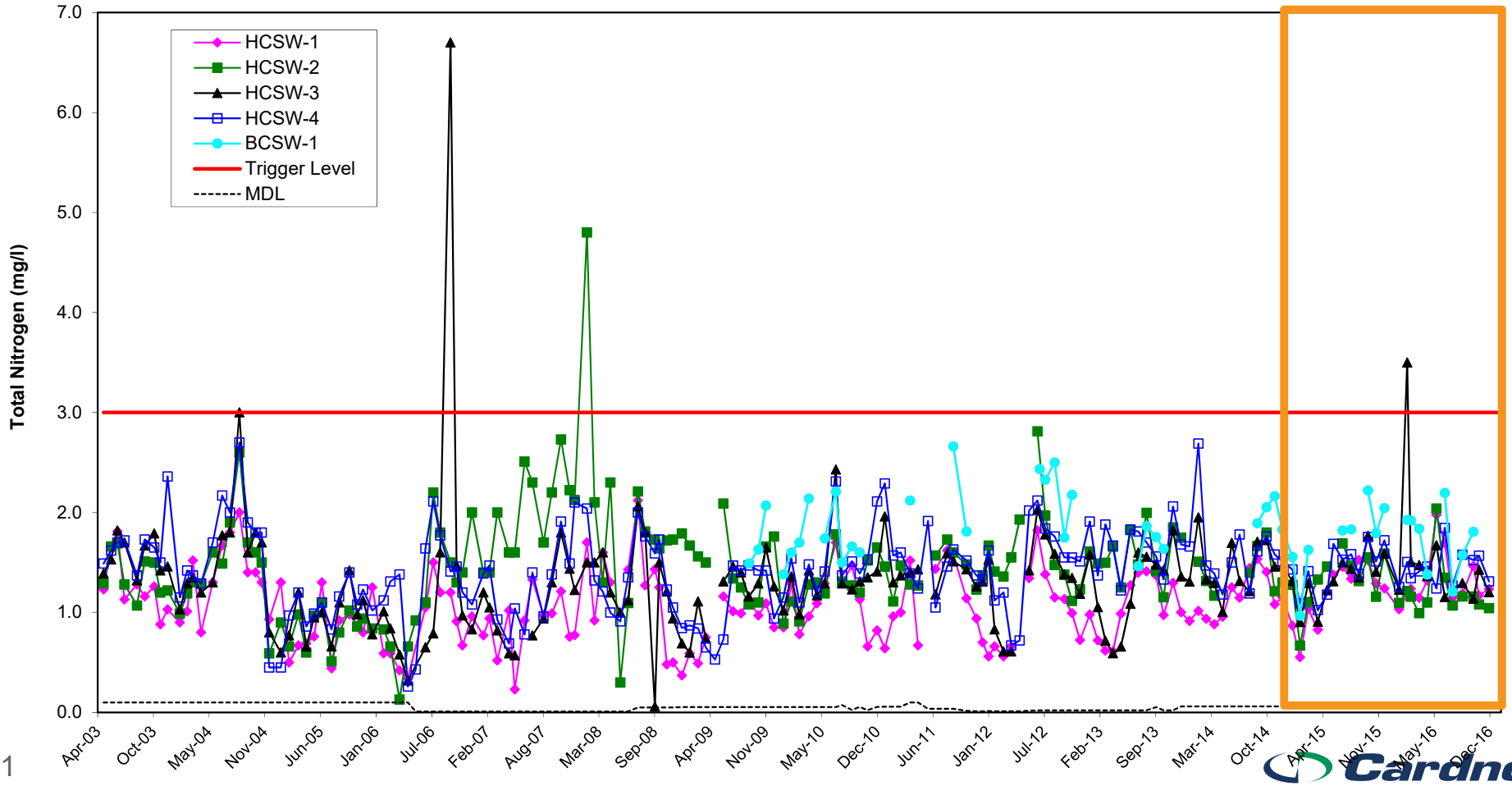
Jul-12
Feb-13
Sep-13
Mar-14
Oct-14
Apr-15
Nov-15
May-16
Dec-16

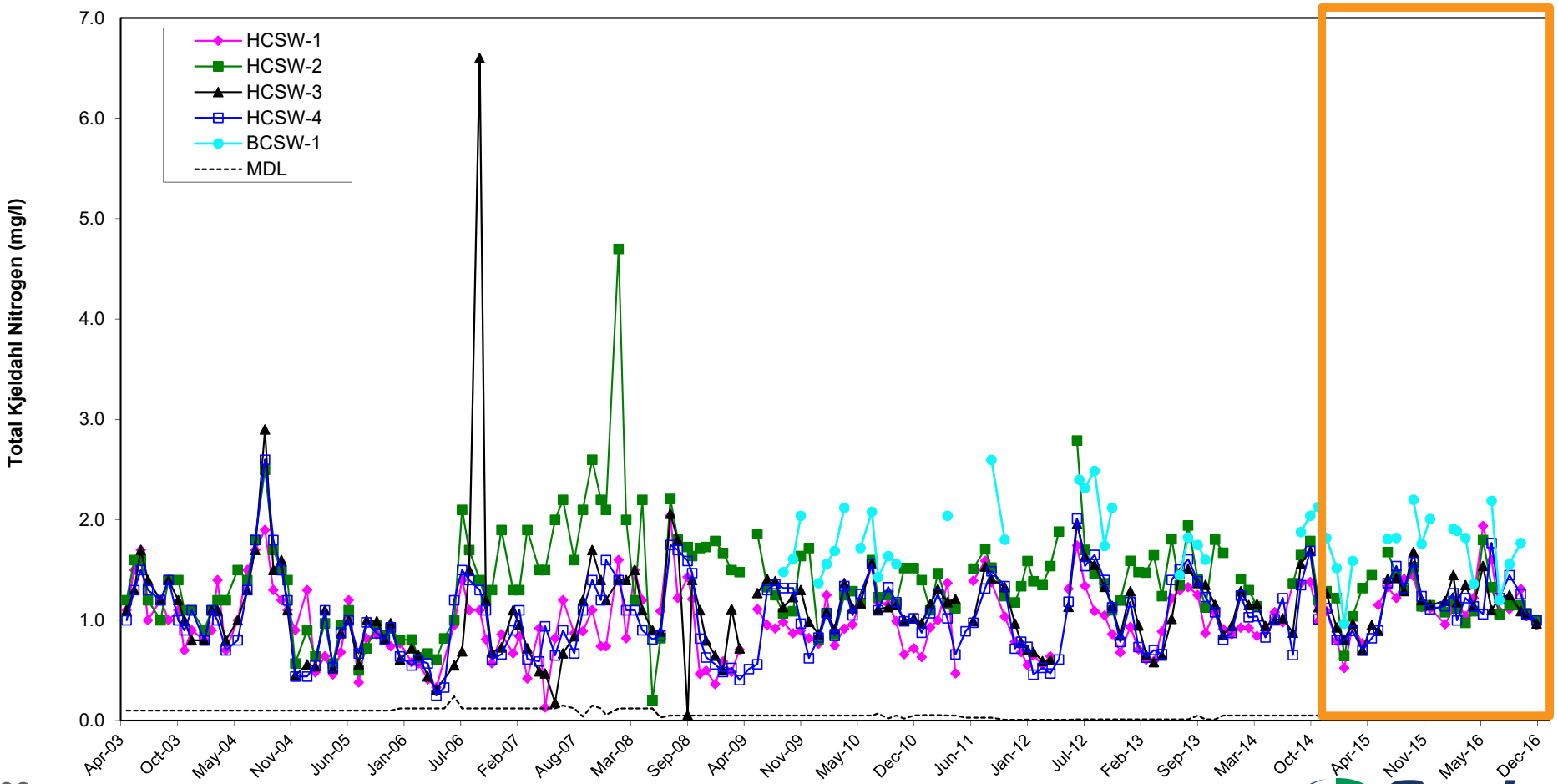
Color


HCSW-1
HCSW-2
HCSW-3
HCSW-4
BCSW-1
Trigger Level
MDL
Color (PCU)
900
800
700
600
500
400
300
200
100
0
Apr-03
Oct-03
May-04
Nov-04
Jun-05
Jan-06
Jul-06
Feb-07
Aug-07
Mar-08
Sep-08
Apr-09
Nov-09
May-10
Dec-10
Jun-11
Jan-12
Jul-12
Feb-13
Sep-13
Mar-14
Oct-14
Apr-15
Nov-15
May-16
Dec-16

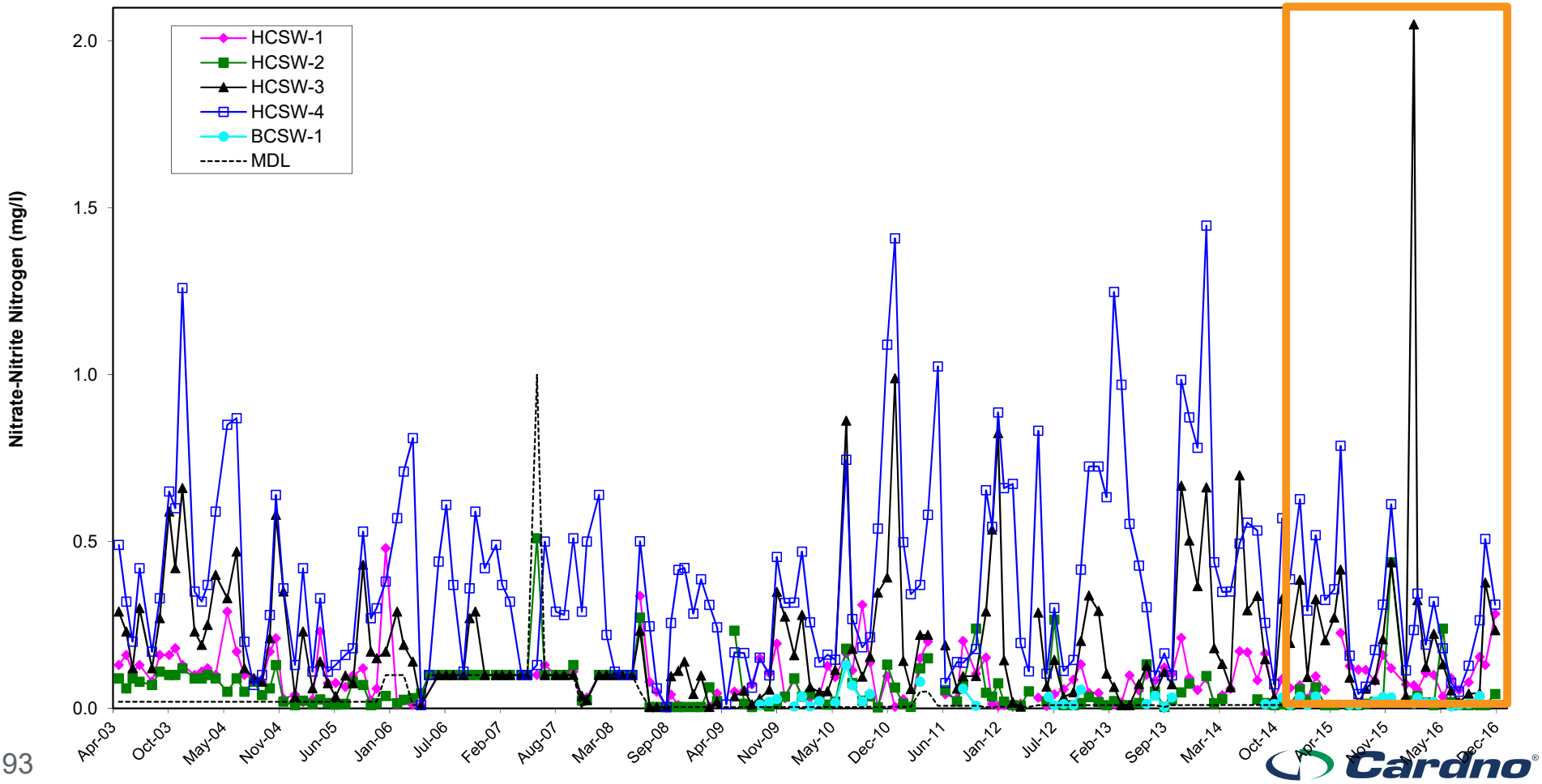
Total Nitrogen



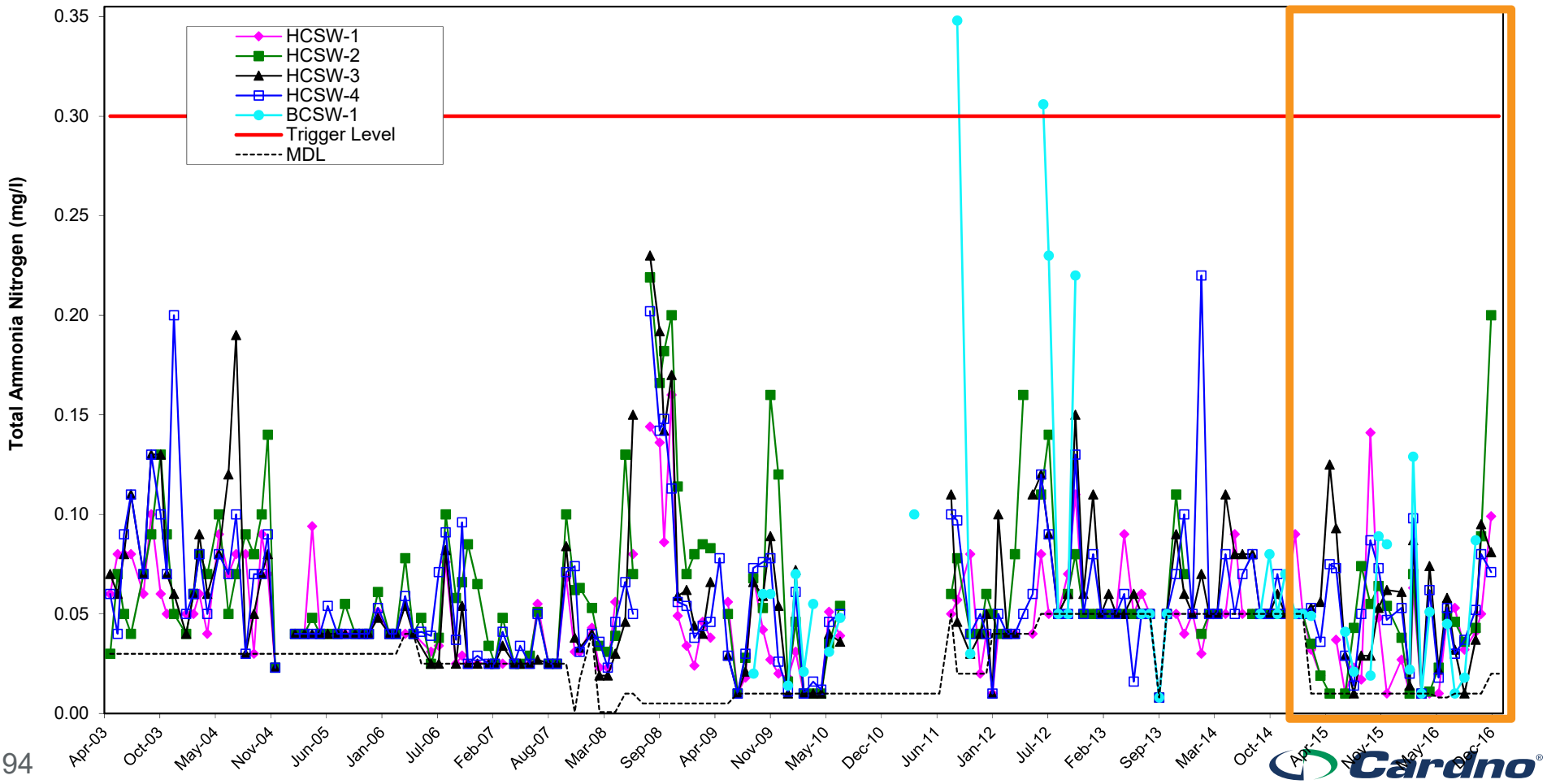
TKN


HCSW-1
HCSW-2
HCSW-3
HCSW-4
BCSW-1
MDL
Total Kjeldahl Nitrogen (mg/l)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Apr-03
Oct-03
May-04
Nov-04
Jun-05
Jan-06
Jul-06
Feb-07
Aug-07
Mar-08
Sep-08
Apr-09
Nov-09
May-10
Dec-10
Jun-11
Jan-12
Jul-12
Feb-13
Sep-13
Mar-14
Oct-14
Apr-15
Nov-15
May-16
Dec-16

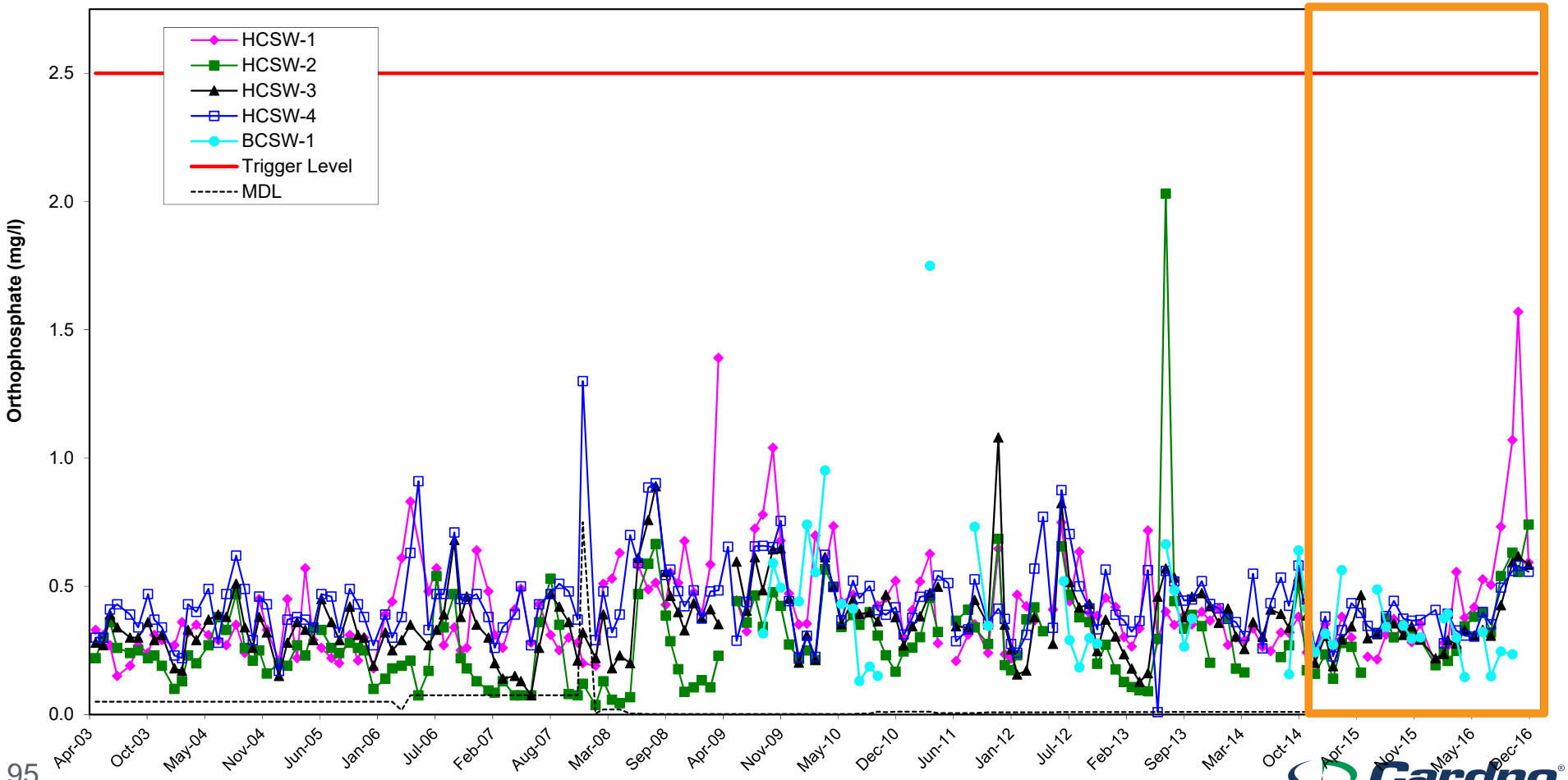
Nitrate-Nitrite



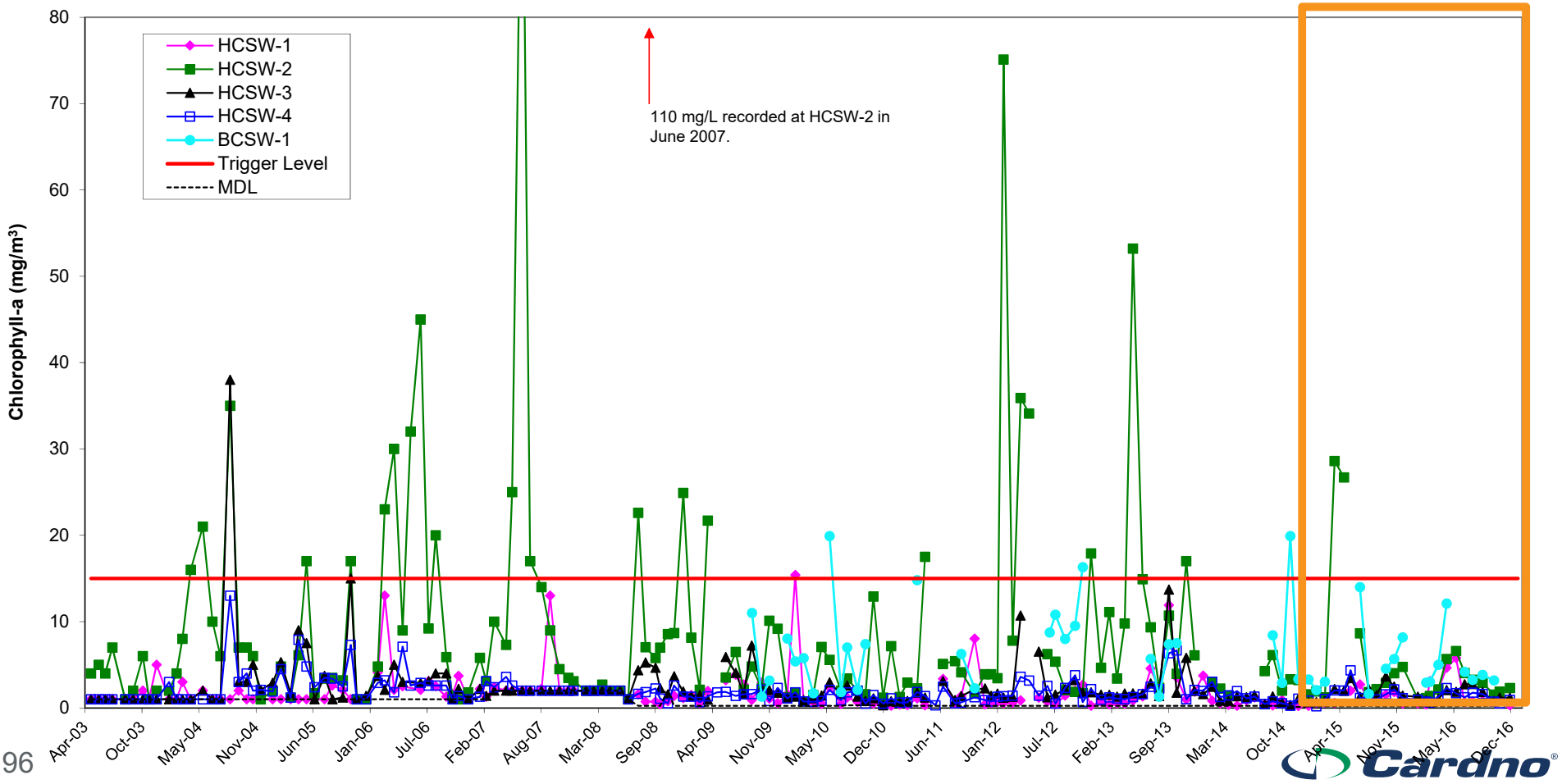
Ammonia


HCSW-1
HCSW-2
HCSW-3
HCSW-4
BCSW-1
Trigger Level
MDL
Total Ammonia Nitrogen (mg/l)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Apr-03
Oct-03
May-04
Nov-04
Jun-05
Jan-06
Jul-06
Feb-07
Aug-07
Mar-08
Sep-08
Apr-09
Nov-09
May-10
Dec-10
Jun-11
Jan-12
Jul-12
Feb-13
Sep-13
Mar-14
Oct-14
Apr-15
Nov-15
May-16
Dec-16

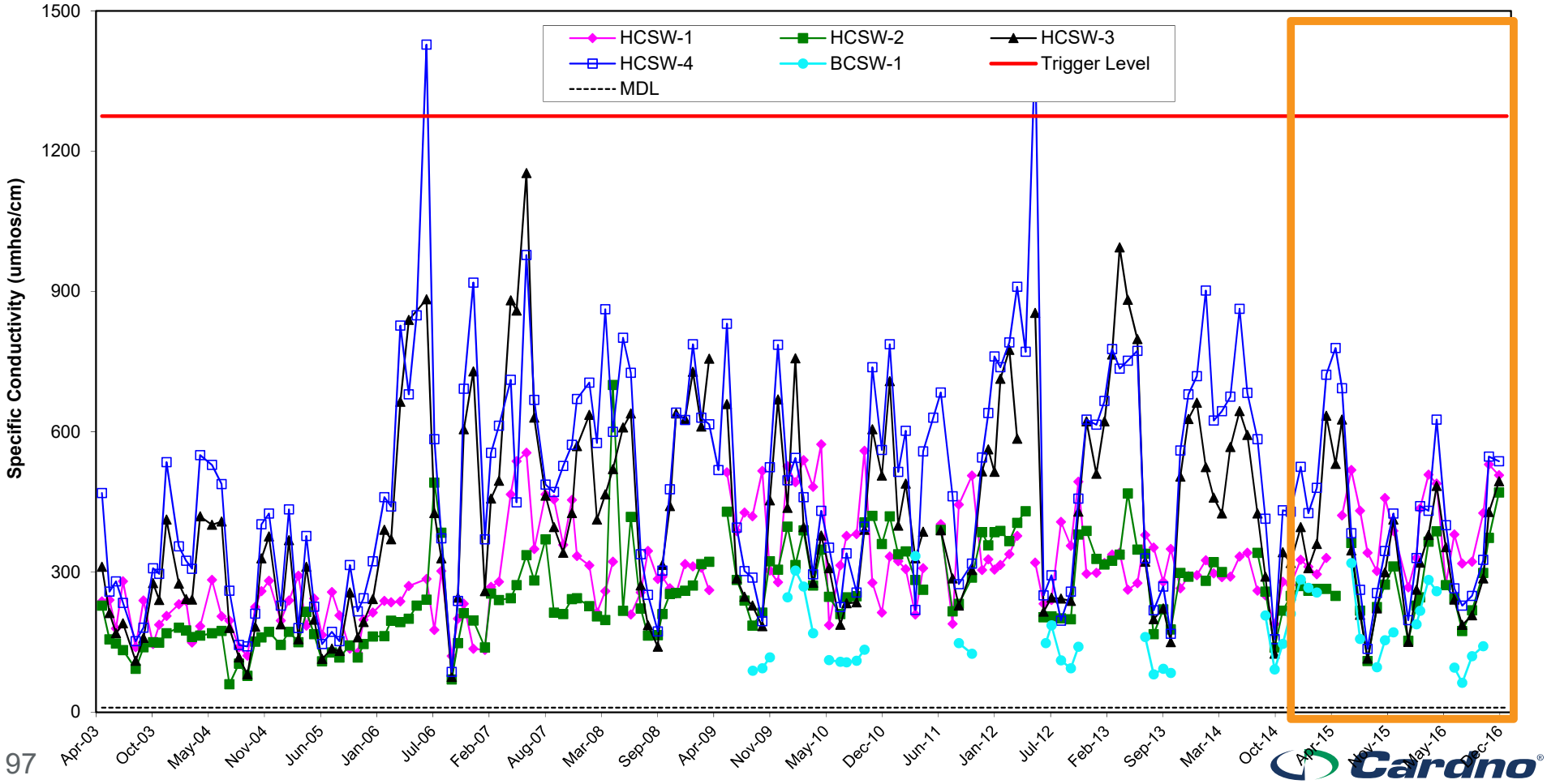
Orthophosphate



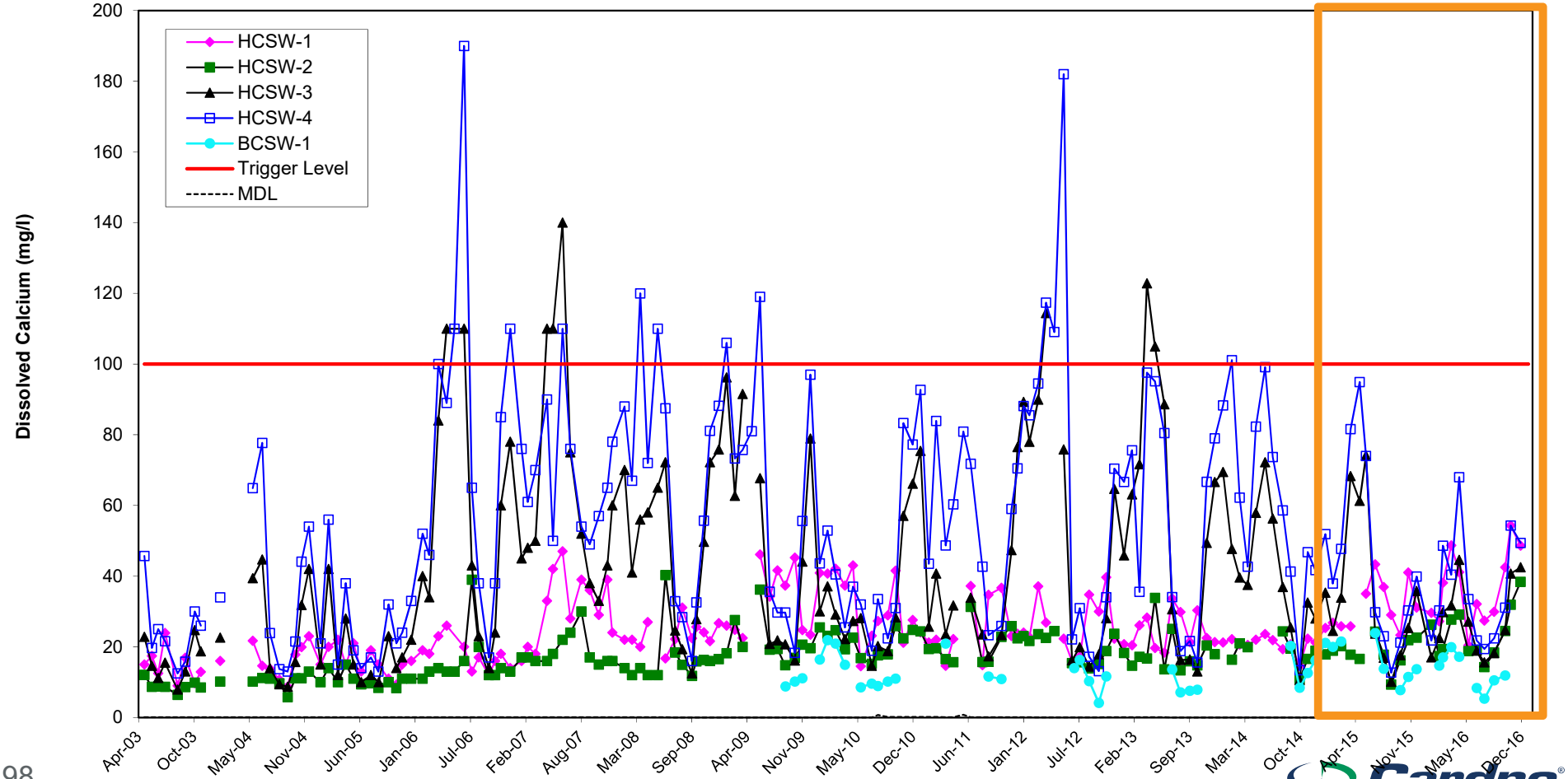
Chlorophyll-a



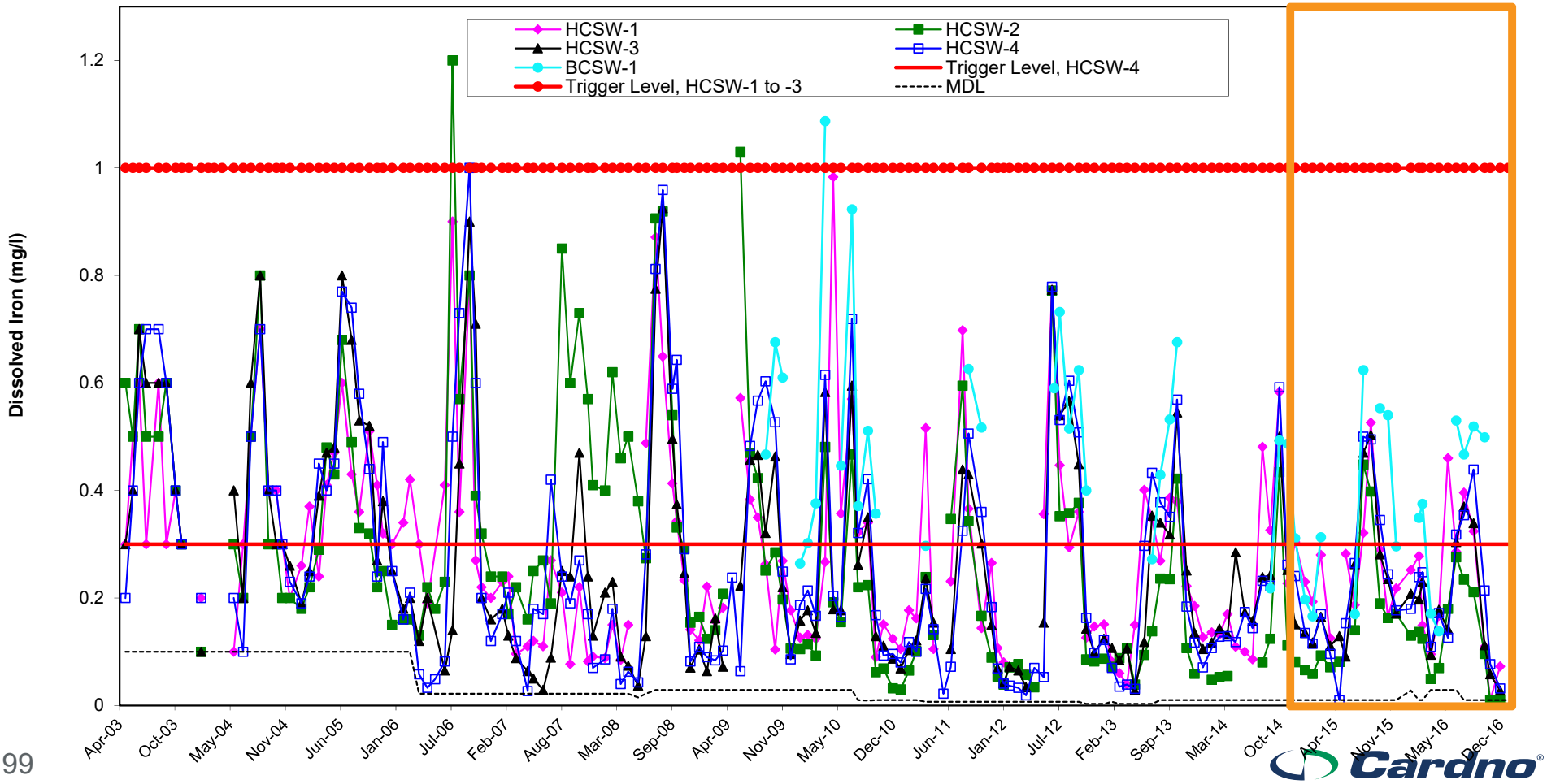
Specific Conductivity



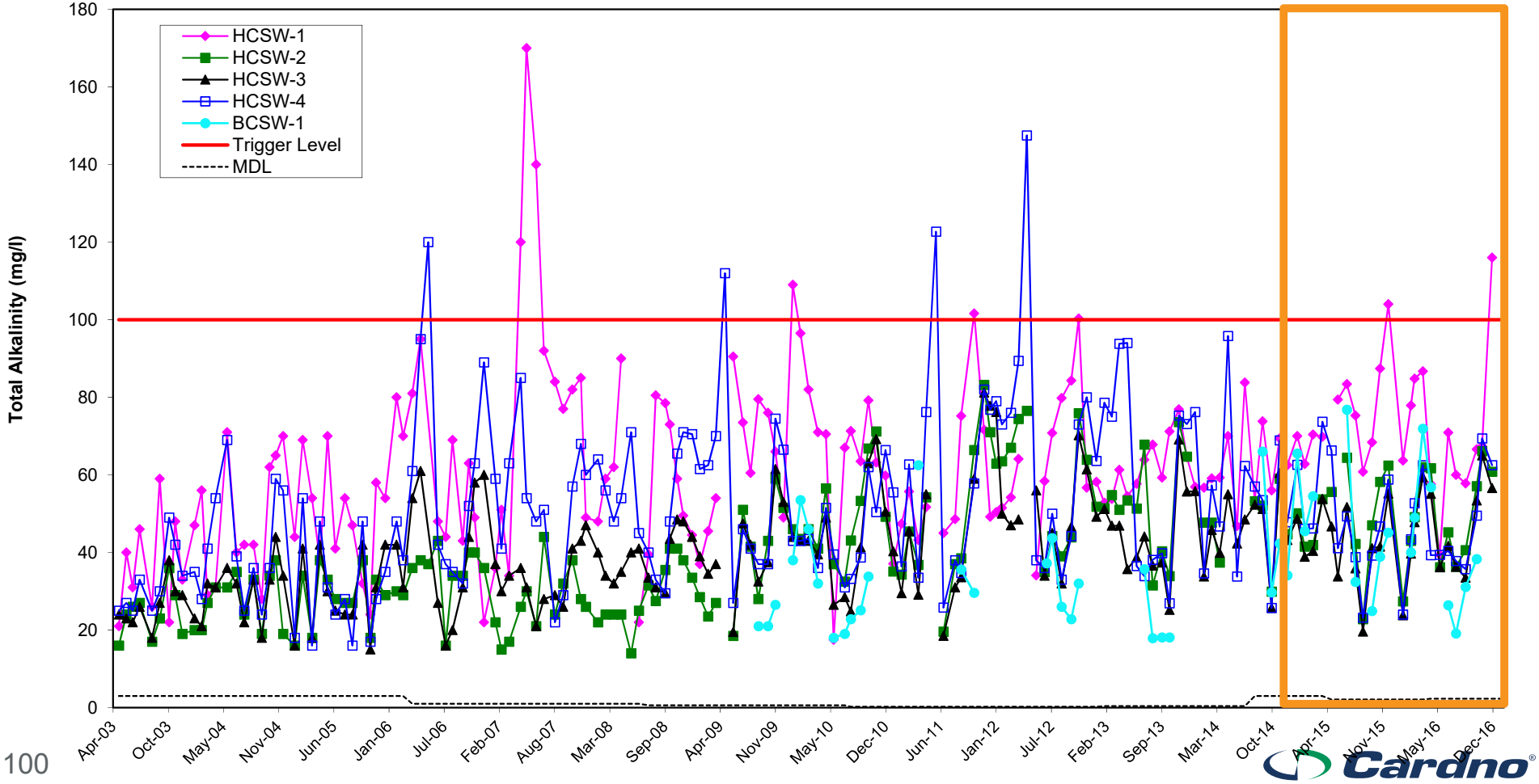
Calcium


HCSW-1
HCSW-2
HCSW-3
HCSW-4
BCSW-1
Trigger Level
MDL
Dissolved Calcium (mg/l)
0
20
40
60
80
100
120
140
160
180
200
Apr-03
Oct-03
May-04
Nov-04
Jun-05
Jan-06
Jul-06
Feb-07
Aug-07
Mar-08
Sep-08
Apr-09
Nov-09
May-10
Dec-10
Jun-11
Jan-12
Jul-12
Feb-13
Sep-13
Mar-14
Oct-14
Apr-15
Nov-15
May-16
Dec-16

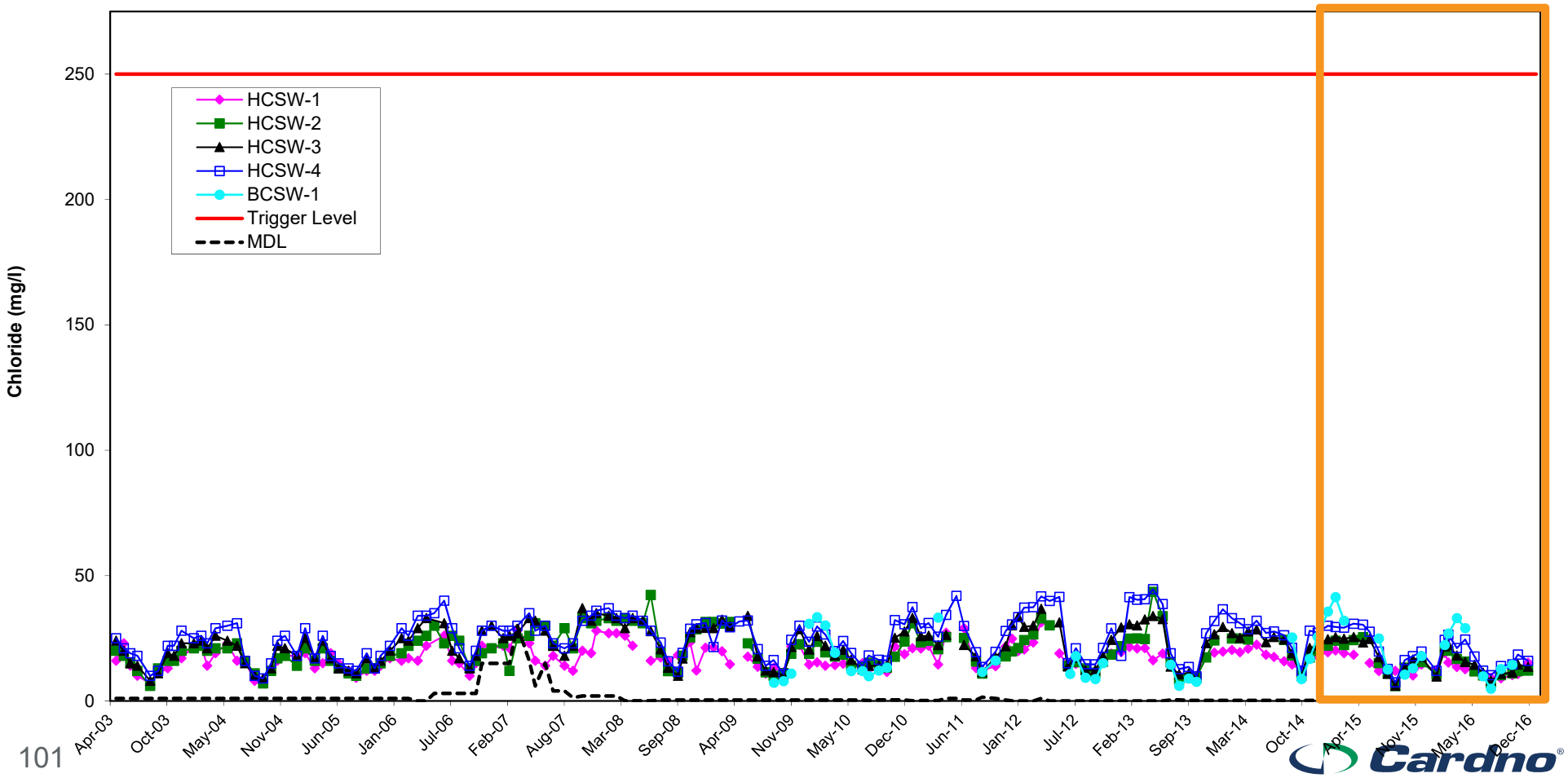
Iron


HCSW-1
HCSW-2
HCSW-3
HCSW-4
BCSW-1
Trigger Level, HCSW-4
Trigger Level, HCSW-1 to -3
MDL
Dissolved Iron (mg/l)
1.2
1
0.8
0.6
0.4
0.2
0
Apr-03
Oct-03
May-04
Nov-04
Jun-05
Jan-06
Jul-06
Feb-07
Aug-07
Mar-08
Sep-08
Apr-09
Nov-09
May-10
Dec-10
Jun-11
Jan-12
Jul-12
Feb-13
Sep-13
Mar-14
Oct-14
Apr-15
Nov-15
May-16
Dec-16

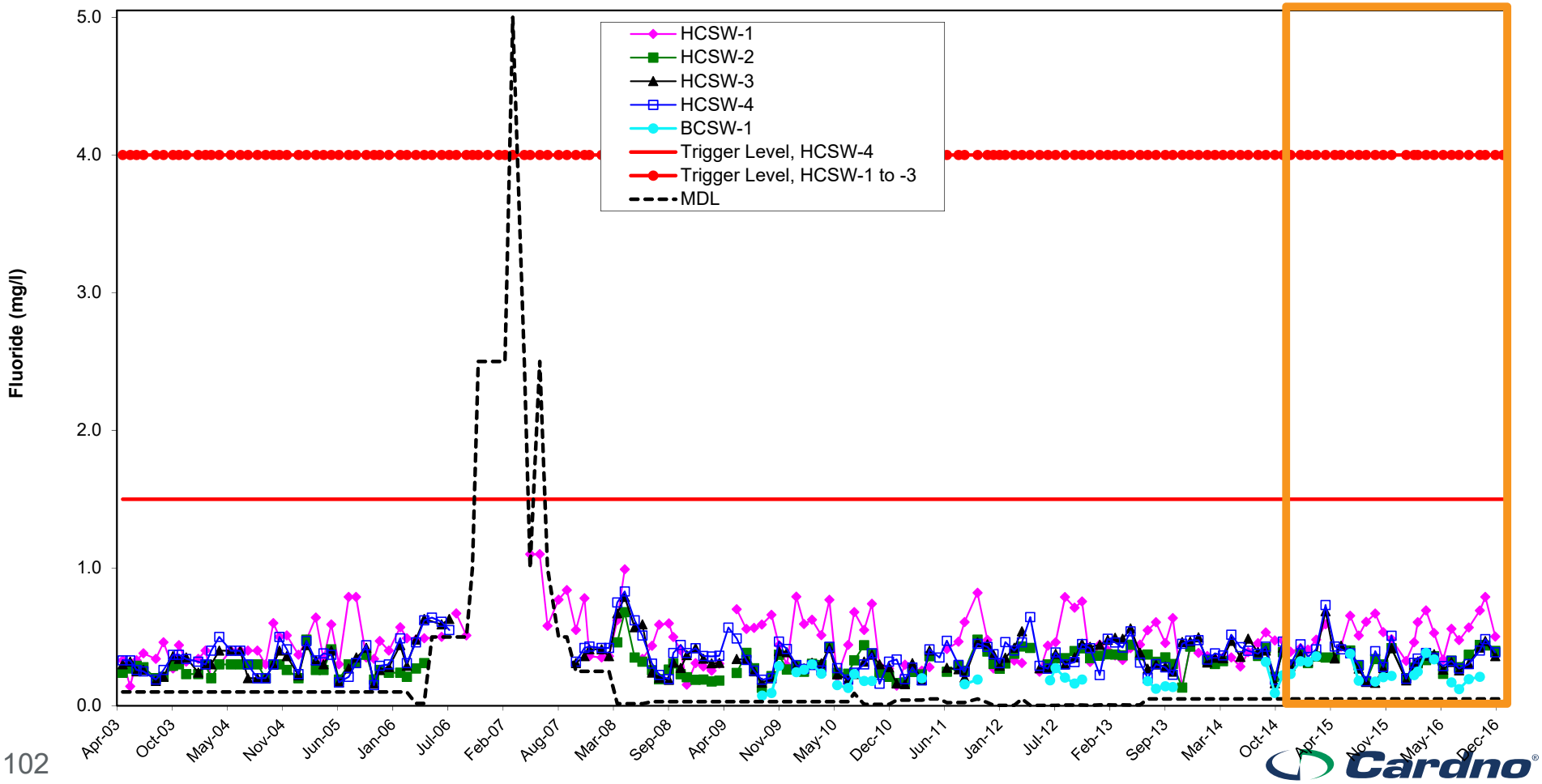
Alkalinity


HCSW-1
HCSW-2
HCSW-3
HCSW-4
BCSW-1
Trigger Level
MDL
Total Alkalinity (mg/l)
0
20
40
60
80
100
120
140
160
180
Apr-03
Oct-03
May-04
Nov-04
Jun-05
Jan-06
Jul-06
Feb-07
Aug-07
Mar-08
Sep-08
Apr-09
Nov-09
May-10
Dec-10
Jun-11
Jan-12
Jul-12
Feb-13
Sep-13
Mar-14
Oct-14
Apr-15
Nov-15
May-16
Dec-16

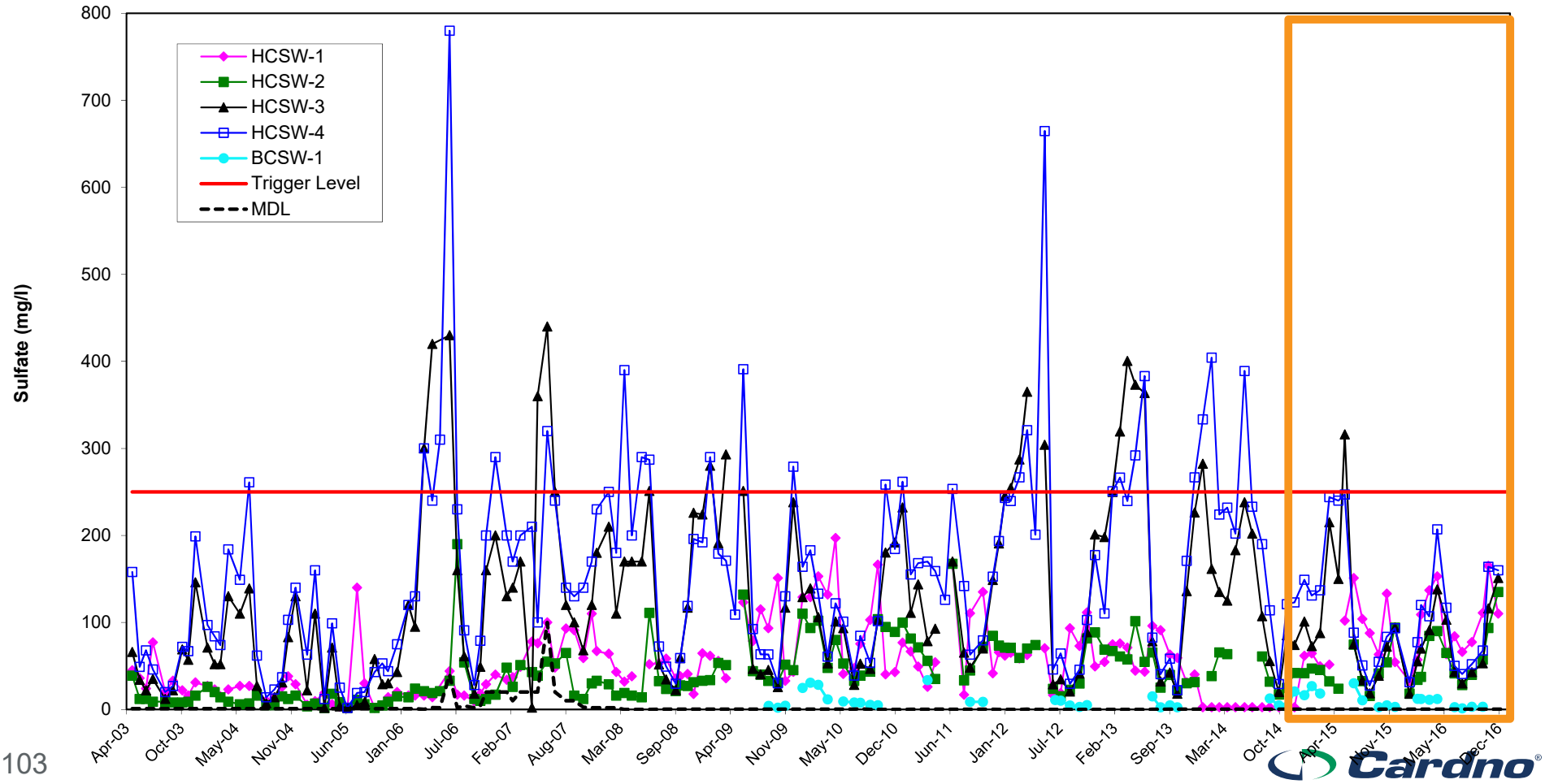
Chloride


Chloride (mg/l)
250
200
150
100
50
0
HCSW-1
HCSW-2
HCSW-3
HCSW-4
BCSW-1
Trigger Level
MDL
Apr-03
Oct-03
May-04
Nov-04
Jun-05
Jan-06
Jul-06
Feb-07
Aug-07
Mar-08
Sep-08
Apr-09
Nov-09
May-10
Dec-10
Jun-11
Jan-12
Jul-12
Feb-13
Sep-13
Mar-14
Oct-14
Apr-15
Nov-15
May-16
Dec-16

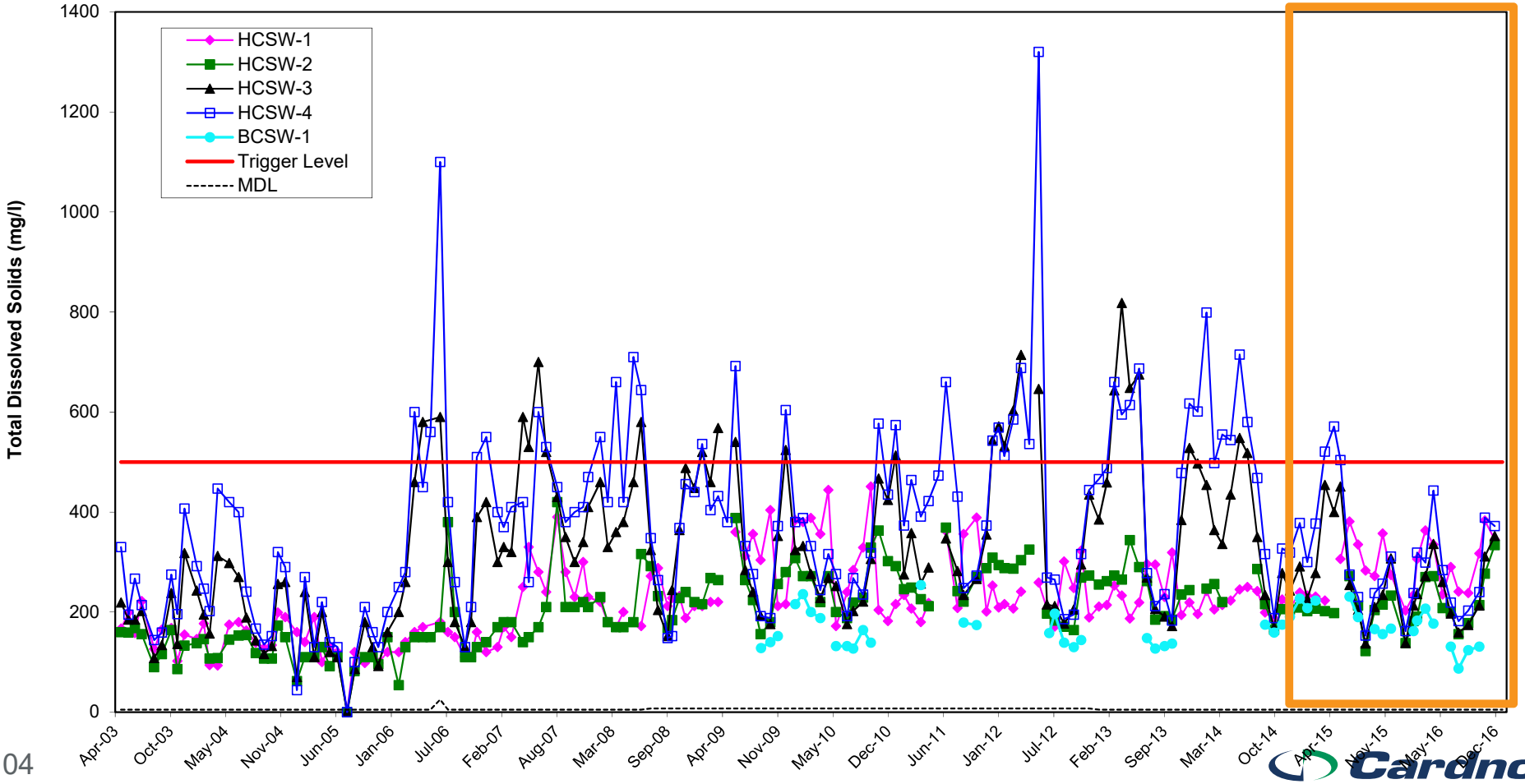
Fluoride


Fluoride (mg/l)
5.0
4.0
3.0
2.0
1.0
0.0
HCSW-1
HCSW-2
HCSW-3
HCSW-4
BCSW-1
Trigger Level, HCSW-4
Trigger Level, HCSW-1 to -3
MDL
Apr-03
Oct-03
May-04
Nov-04
Jun-05
Jan-06
Jul-06
Feb-07
Aug-07
Mar-08
Sep-08
Apr-09
Nov-09
May-10
Dec-10
Jun-11
Jan-12
Jul-12
Feb-13
Sep-13
Mar-14
Oct-14
Apr-15
Nov-15
May-16
Dec-16

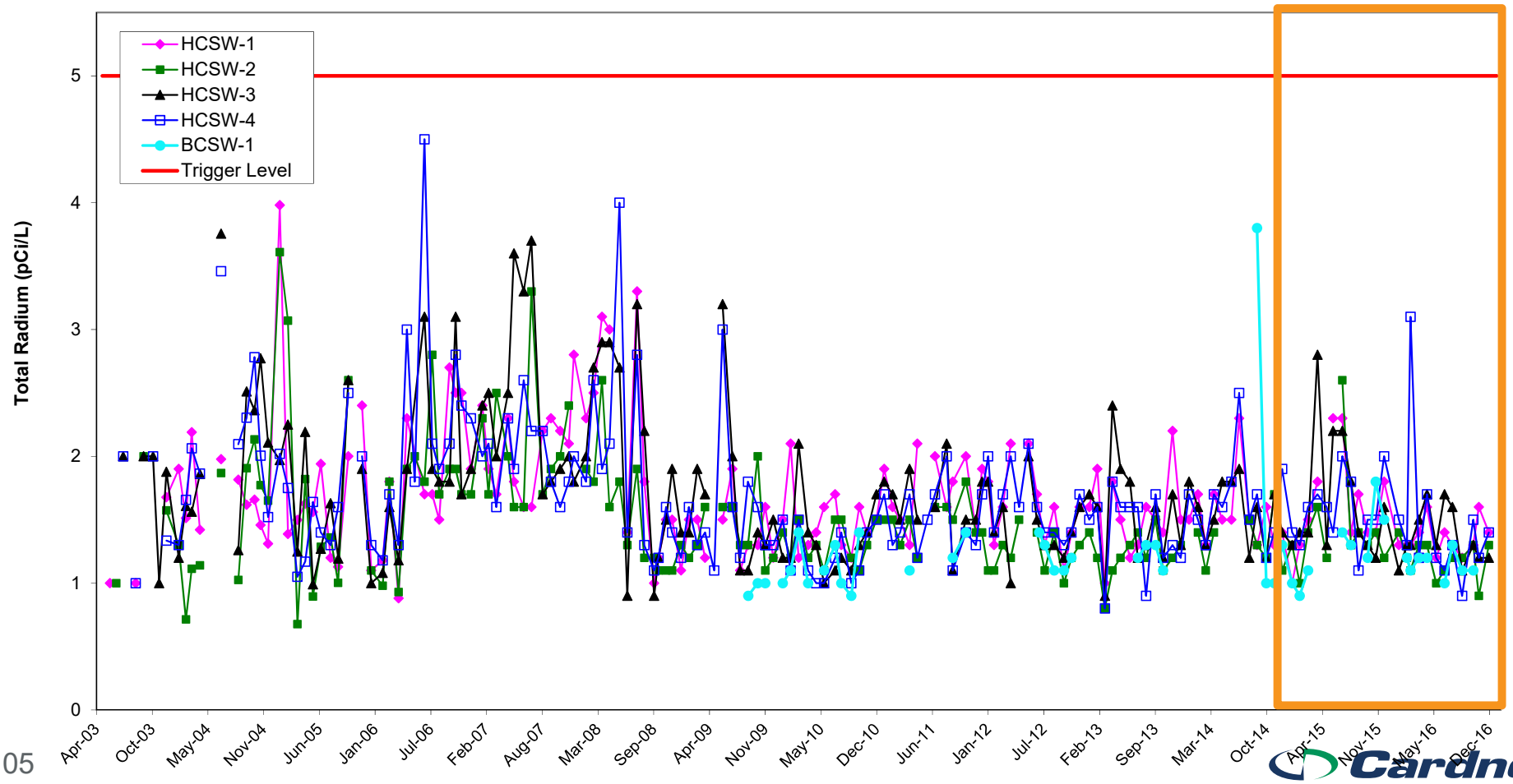
Sulfate


Sulfate (mg/l)
800
700
600
500
400
300
200
100
0
HCSW-1
HCSW-2
HCSW-3
HCSW-4
BCSW-1
Trigger Level
MDL
Apr-03
Oct-03
May-04
Nov-04
Jun-05
Jan-06
Jul-06
Feb-07
Aug-07
Mar-08
Sep-08
Apr-09
Nov-09
May-10
Dec-10
Jun-11
Jan-12
Jul-12
Feb-13
Sep-13
Mar-14
Oct-14
Apr-15
Nov-15
May-16
Dec-16

Total Dissolved Solids



Radium


HCSW-1
HCSW-2
HCSW-3
HCSW-4
BCSW-1
Trigger Level
Total Radium (pCi/L)
0
1
2
3
4
5
Apr-03
Oct-03
May-04
Nov-04
Jun-05
Jan-06
Jul-06
Feb-07
Aug-07
Mar-08
Sep-08
Apr-09
Nov-09
May-10
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Feb-13
Sep-13
Mar-14
Oct-14
Apr-15
Nov-15
May-16
Dec-16

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Thank you

For more information

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Events Timeline

- April 2003 – HCSP Began
- August-September 2004 – Three Hurricanes (Charley, Frances, Jeanne) move up HC Basin
- August 2005 – Invert sorting method change (100-120 inverts in vial)
- June 2006 – Last clays from Ft. Green plant sent to CSAs FGH3 and FGH4
- November 2006 – FDEP invert sorting method change (2 vials, 140-160 inverts)
- 2006-2008 – Time of lower than average streamflow and rainfall in HC Basin
- October 2008 – Clays mined via dredge from Wingate Mine begin discharging through FTG-004
- March 2009 – Added CSA FM-1 to monitoring program
- September 2009 – discontinue monitoring FL-PRO, fatty acids, and total amines at all HC Locations. Added location in Brushy Creek w/out trigger levels and Impact Assessments
- Winter 2009/2010 – Experienced one of coldest winters on record.
- December 2010 – Coldest December for Tampa Bay area in recorded history
- October 2011 – SWFWMD reduced sampling frequency at HCSW-1 and HCSW-4 to every other month
- November 2011 – SWFWMD rain gauge discontinued
- January 2013 – supplemented SWFWMD Flatford Swamp rain gauge in addition to NOAA and Mosaic gauges in annual report tables and graphics
- July 2014 – new FDEP SOP for the SCI (SCI 1000) calculations along with bioregions went into effect with the approval of the new QA rule.

Lab Changes Timeline

- April 2003 – November 2004: Various labs
- Parameters except Radiologicals:
  - December 2004 – May 2008: STL/Test America
  - June 2008 - Mosaic's Laboratory
  - July 2008 – July 2010: Benchmark Analytical (still analyzing color and chlorophyll-a)
  - August 2010 – July 2011: Phoslab
  - August 2011 – Present: Mosaic's Laboratory
- Radiologicals:
  - April 2006 – July 2008: KNL Labs (Radiologicals only)
  - August 2008 – Present: Florida Radiochemistry (Radiologicals only)

Major MDL Changes

- January 2006 – July 2008: nitrate-nitrite highly variable
- April 2003- December 2011: ammonia (around 0.3 mg/L through Oct 2007, variable through July 2008, stable through July 2011, then variable)
- December 2007: orthophosphate abnormally high value (0.75 mg/L)
- April 2003 - December 2011: dissolved iron started at 0.1 mg/L, reduced to 0.022 mg/L in March 2006, then stable at 0.01 mg/L from August 2010
- March 2006 – February 2008: chloride numerous changes from 0.022-30 mg/L; stable since March 2008
- March 2006 – February 2008: fluoride numerous changes ranging from 0.017-5 mg/L; relatively stable since March 2008
- March 2006 – February 2008: sulfate numerous changes; stable since March 2008