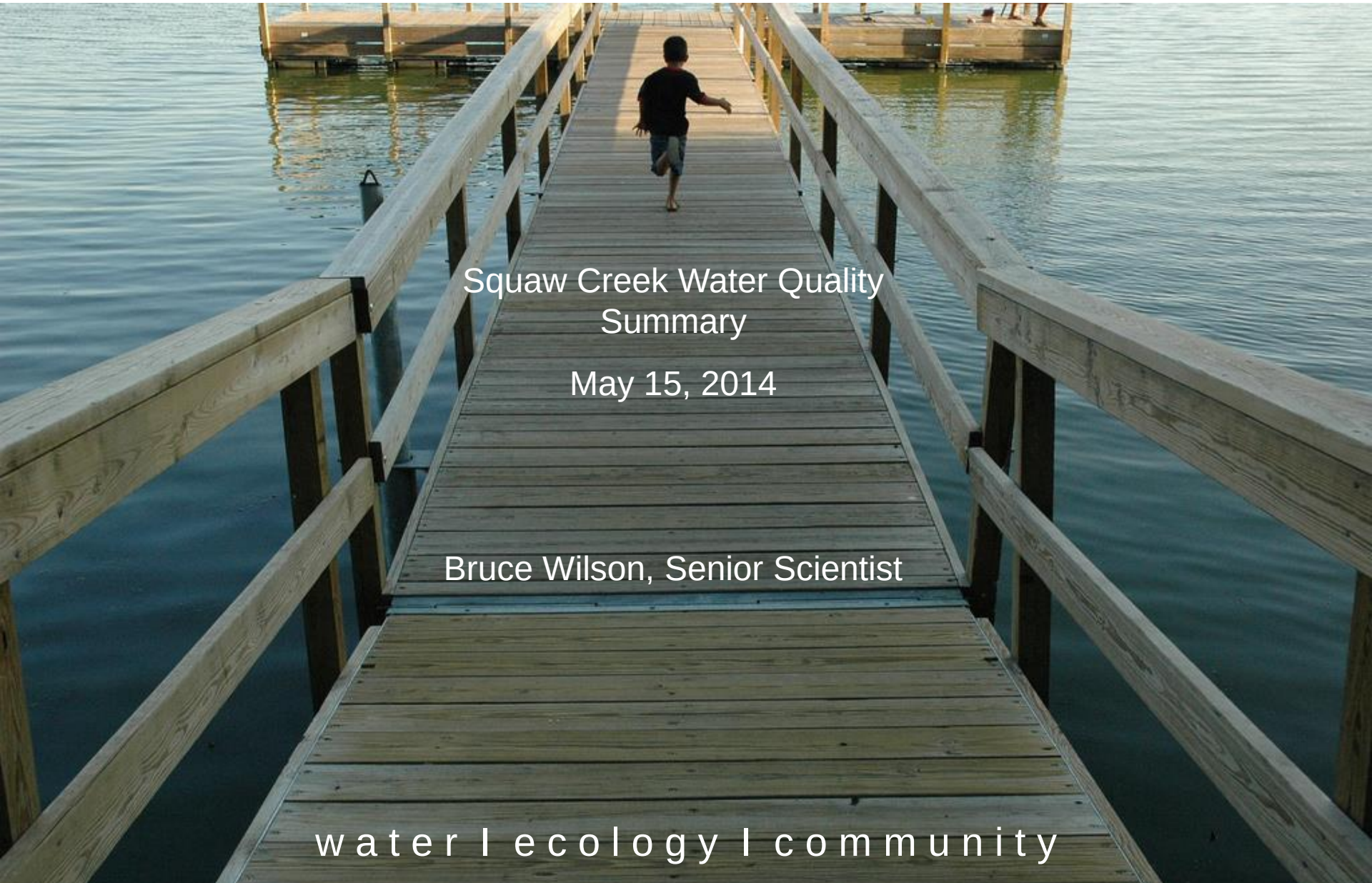
Emmons & Olivier Resources, Inc.



Squaw Creek Water Quality Summary

May 15, 2014

Bruce Wilson, Senior Scientist

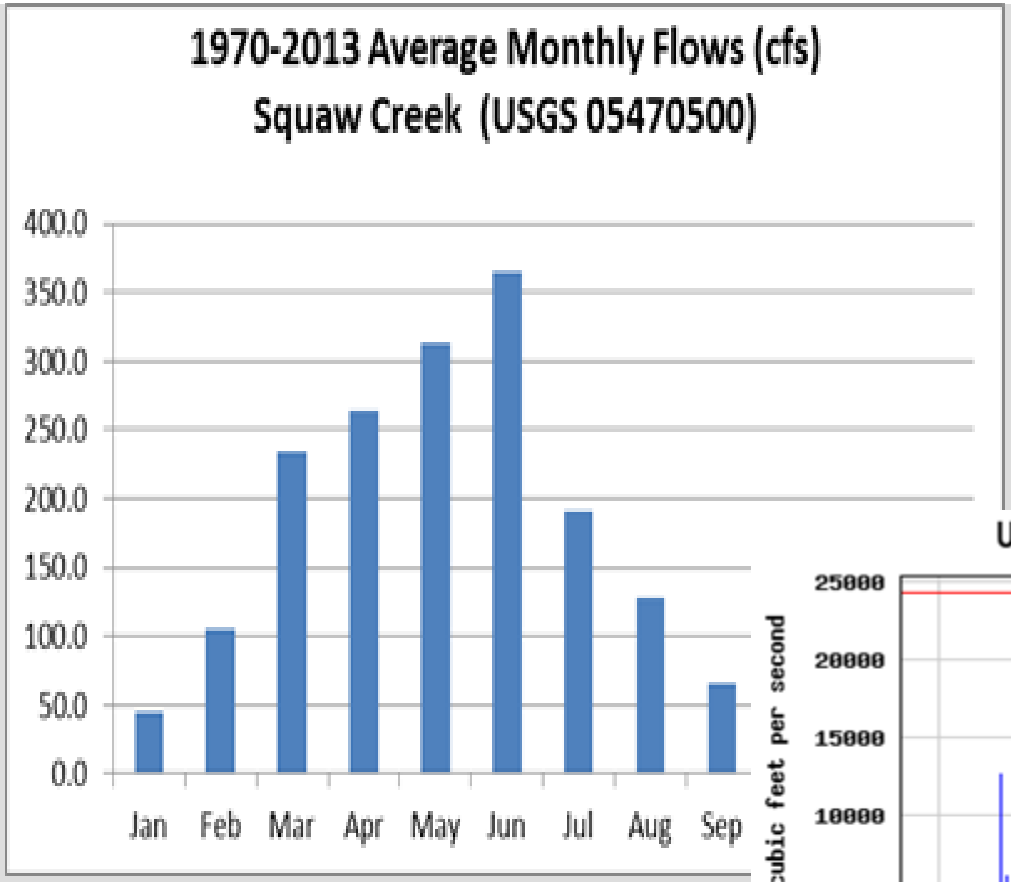
w a t e r I e c o l o g y I c o m m u n i t y

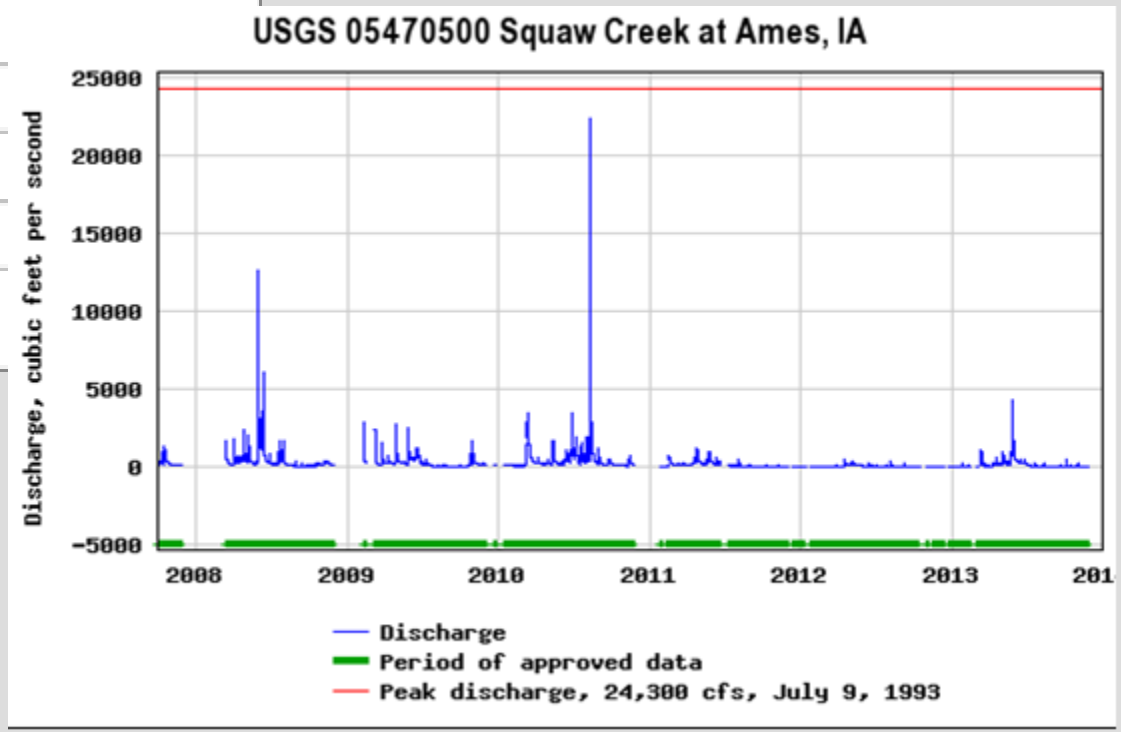
Squaw Creek Overview

- **Squaw Creek is shallow (mostly third order stream (wadeable)**
  - **Algae grows on rocks/substrates**
- **Drains approximately 230 square miles.**
- **Squaw Creek Class A 1stream: Glacial Creek to Mouth Primary Contact Recreational Use designation.**

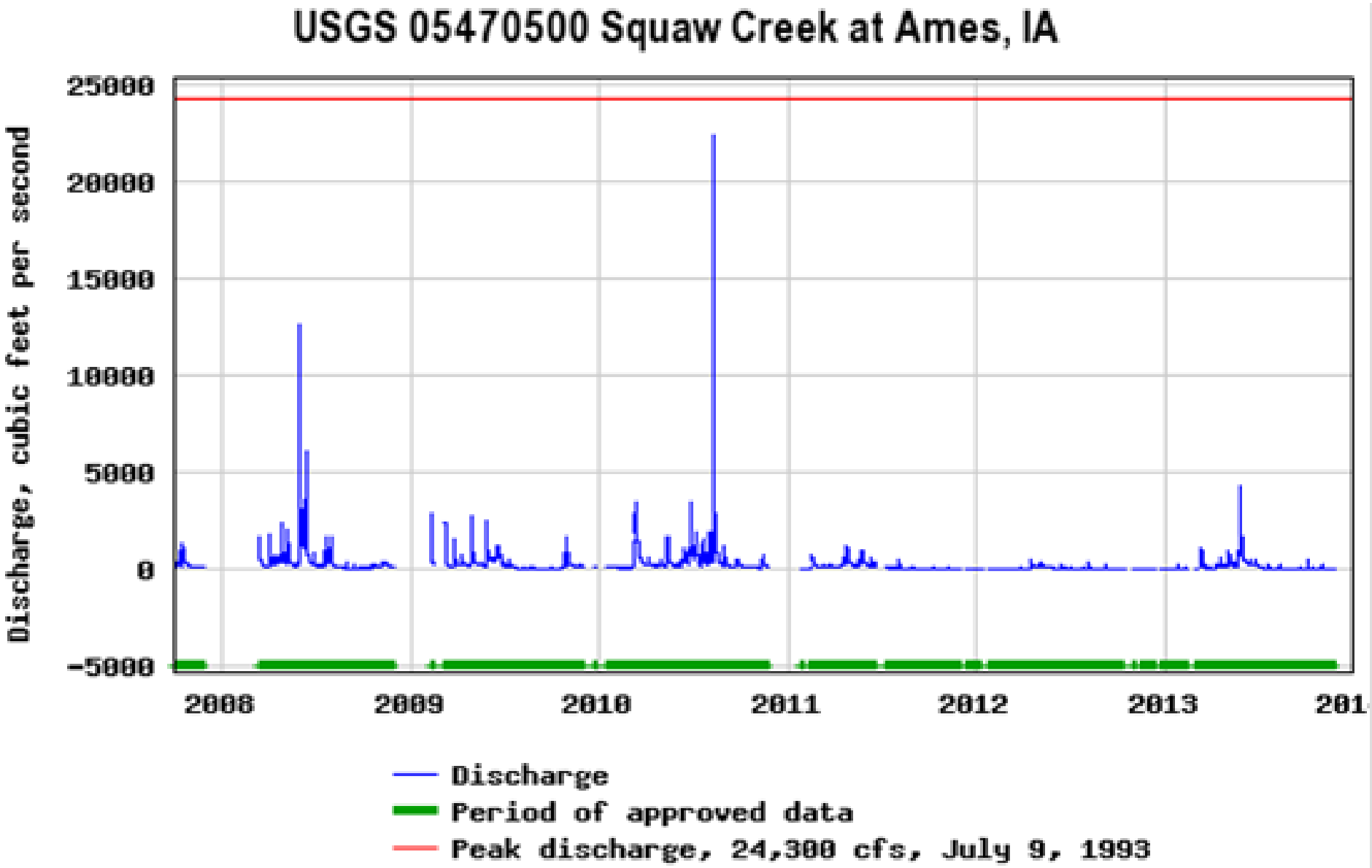
- **Squaw Creek's hydrology altered.**
- **Altered hydrology inseparable from degraded water quality.**
  - **Nutrient enrichment: P & N**
  - **Causes shifts in organic matter, dissolved oxygen, food resources and habitat**
    - Fish, macroinvertebrates
    - Recreation

Altered Hydrology

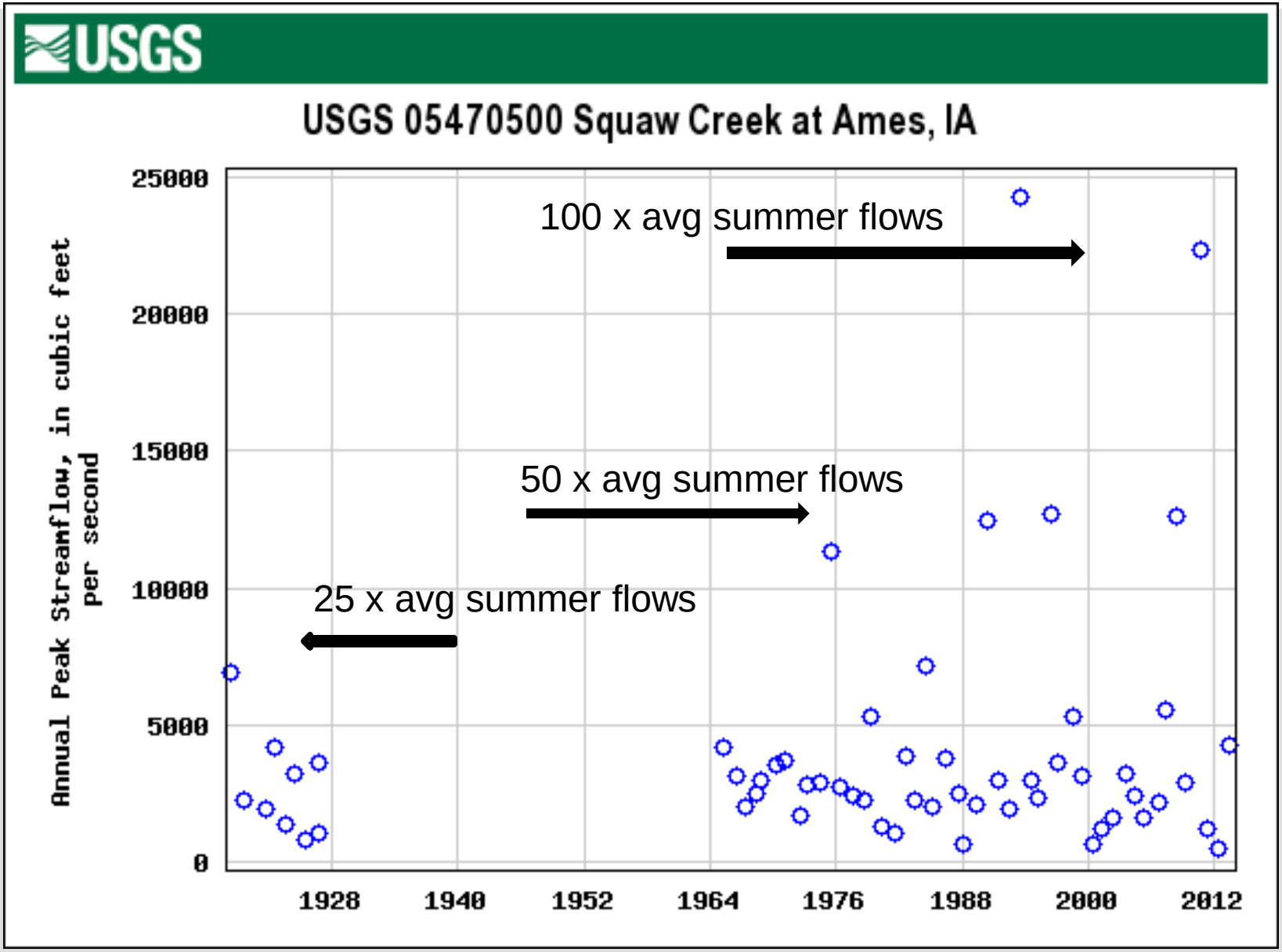




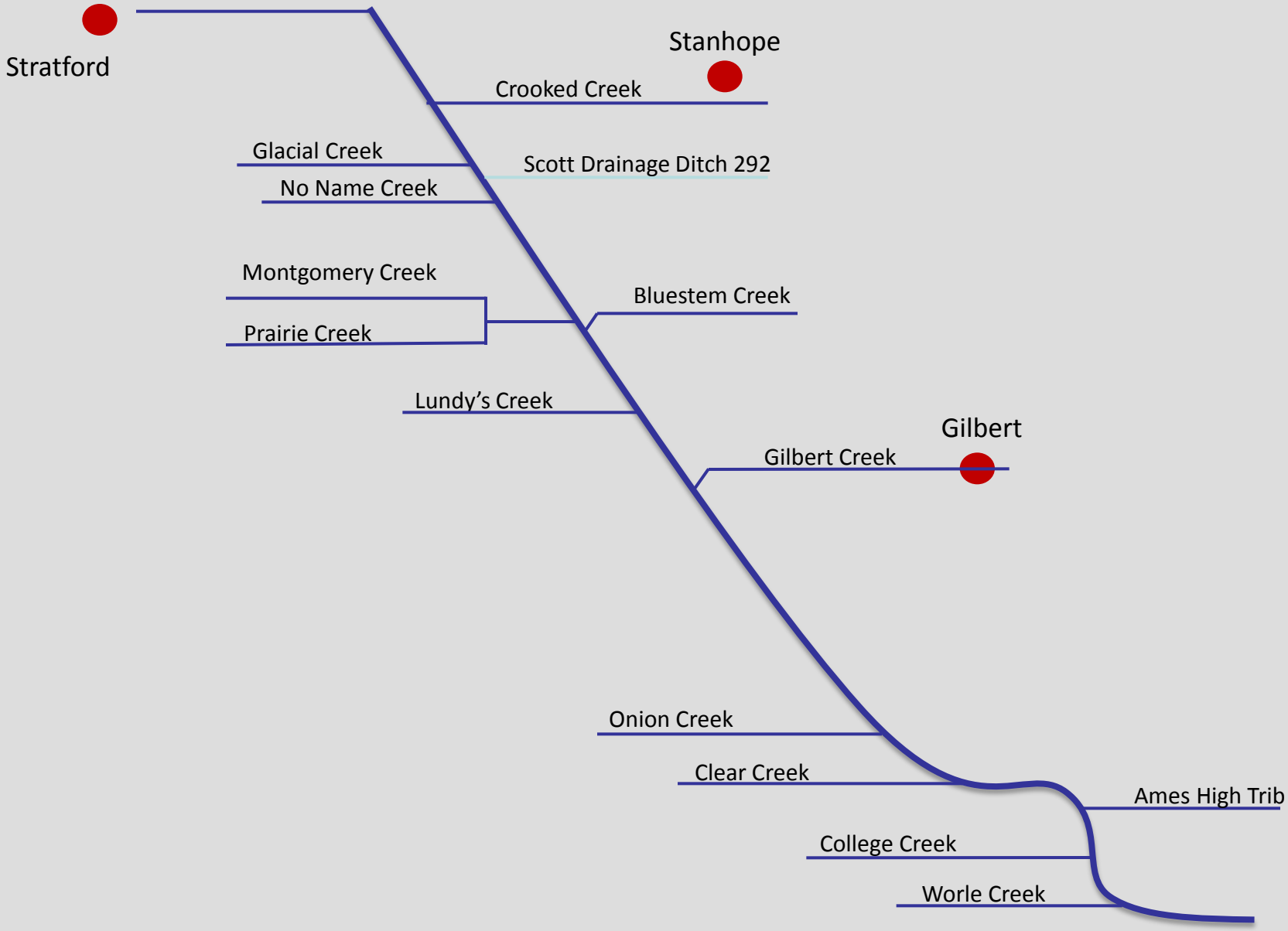
Squaw Creek 'Flashy' Runoff



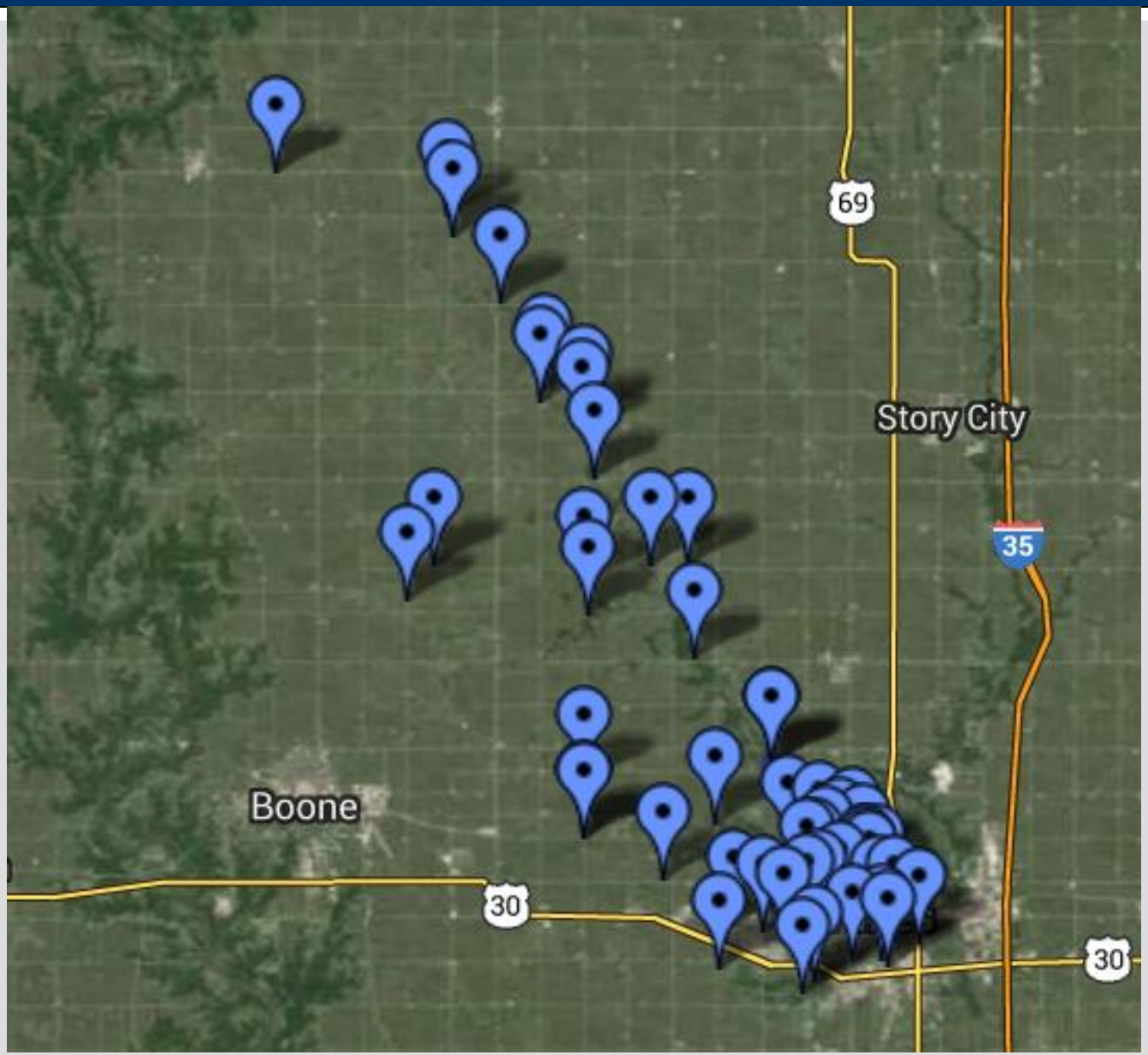
Altered Peak Flows



Watershed Stream Network



Volunteer Monitoring Location Distribution



Monitoring Sites: Upper Squaw

	SAMPLE EVENTS (2000-2013)	FLOW			WATER QUALITY			BIOTA		STREAM CHARACTERIZATION				USES	
	SITE NUMBER - SITE DESCRIPTION (approximately in order from upstream to downstream)	Flow	Stream Morphology	Stream Width	DO, pH, Nitrate-Nitrite, Phosphate, Chloride	Temperature	Transparency	Bacteria (*E. coli* and Coliform)	Macroinvertebrates	Stream Substrate	In-stream Habitat Characterization	Streambank Characterization	Riparian Zone Characterization	Adjacent Landuse	Human Use
UPPER SQUAW CREEK	940010 - Squaw Creek at Hwy 175 (Snapshot Site SC1)	1 2		2	12	11	12	2							
	940014 - Squaw Creek Snapshot (Crooked Creek, N Branch - SC45)	8			8	8	8								
	940015 - Squaw Creek (Crooked Creek, S. Branch - SC46)	8			8	7	8								
	940009 - Squaw Creek at 390th Street (Snapshot Site SC2)	1 6		2	16	15	16	2							
	908031 - Squaw Creek - 110th St & U Ave. (Snapshote Site SC3)	2 2	2	1 1	22	21	22		4		4	4			
	908028 - Glacial Creek (Squaw Creek Trib; U Ave S of 110th St-SC4)	5 1	4	2 9	51	49	51	31	3	13	13	13	13	1 3	1 1
	908036 - Talynn`s North Sample Site (Snapshot Site SC5)	1 4		1	14	12	14								
	908035 - No Name Creek - North of 120th and Y (Snapshot Site SC6)	1 3		1	13	10	13			8	8	8	8	8	8
	908026 - Beard/Mackie (Squaw Creek - Snapshot Site SC7)	2 2	1	6	22	22	22			17	17	17	17	1 7	1 5
	908034 - Squaw Creek at 150th St. (Snapshot Site SC10)	1 6		3	16	15	16		1		1	1			
	908019 - Montgomery Creek 1 (Snapshot Site SC8)	8 6	2 8	6 9	86	82	85	64	1	15	15	15	15	1 5	1 3
	908020 - Montgomery Creek 2 (Snapshot Site SC11)	8 6	2 7	7 1	86	85	86	65	1	15	15	15	15	1 5	1 3
	908021 - Prairie Creek 1 (Snapshot Site SC12)	8 5	2 7	7 1	85	85	85	64	1			1			
	908022 - Prairie Creek 2 (Snapshot Site SC13)	8 5	2 6	6 9	85	81	85	63	1			1			
	908029 - Bluestem Creek (Squaw Creek Trib; 150th St E of X Ave-SC9)	5 2	8	3 4	52	48	49	32	3	12	12	12	12	1 2	1 0
	908016 - Squaw Creek @ 170th St. Bridge (Snapshot Site SC14)	3 2	2	1 3	32	32	32		1			1			
	985116 - Cyclone Contracting	1	1	1	1	1	1		1	1	1	1	1	1	1
	985033 - Gilbert Creek	4		3	4	3	2		2	3	3	3	3	3	
	985119 - Gilbert Creek	2	2	2	2	2	2		1	1	1	1	1	1	1
	985041 - Gilbert Creek above Squaw Creek (Snapshot Site SC15)	1 6		4	16	14	16			15	15	15	15	1 5	1 2
	985034 - Squaw Creek above Gilbert Creek (Snapshot Site SC16)	1 6		3	16	13	15		2		1	2			
	985035 - Squaw Creek below Gilbert Creek	5		5	5	5	5		1			1			
		1												1	1

Water Quality Focus: Phosphorus

- Generates attached algae, organic matter and bacteria
- Boom/bust daily oxygen
- Shifts biology to pollution tolerant spp.
- Impacts recreation suitability

Phosphorus

	Mean Orthophosphate (µg/L)
EPA Ecoregion Reference (total P)	**76.25 µg/L**
Subregion 25th Percentile	**118.13**
Squaw Creek (Downstream of Glacial to mouth)	290
Upper Squaw Creek (source to Onion)	260
Lower Squaw Creek (Onion to Mouth)	300
Worle Creek	210
Squaw Creek (Glacial Creek to Headwaters)	260
Glacial Creek	200
North Onion Creek	200
South Onion Creek	200
Onion Creek	410
College Creek	260
Clear Creek	330
Onion Creek (all grouped)	360

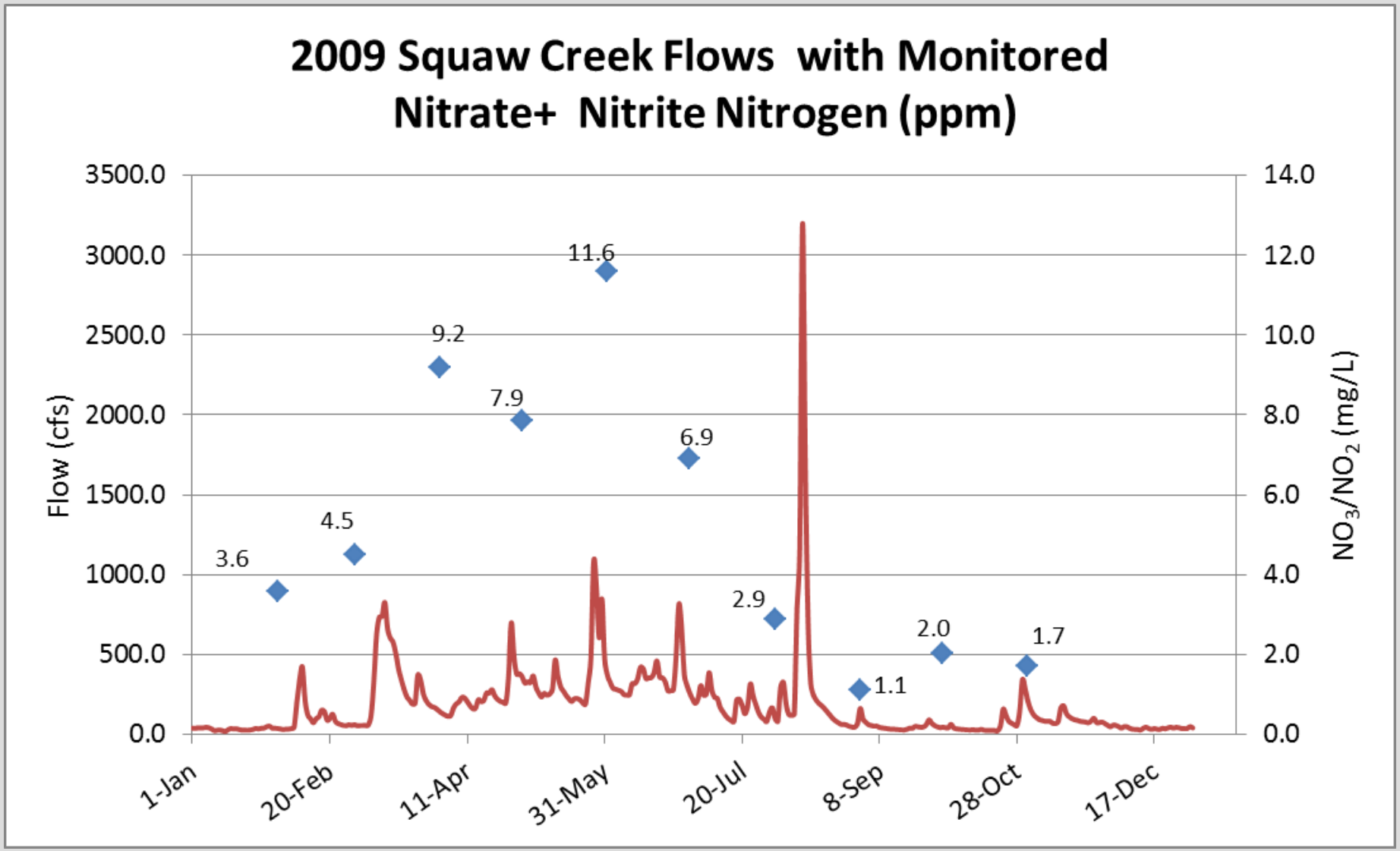
E. coli – All Sites

Stream Reach	Year	Number of Samples	Geometric Mean (org/100mL)	Number of Samples > 235 (org/100mL)
		Standard	126 org/100mL	None
Lower Squaw, Below Worrell Creek	2009	8	703	6
	2010	9	891	8
	2011	9	118	5
	2012	5	921	4
	2013	5	19	3
Lower Squaw, Above Worrell Creek	2009	8	577	6
	2010	10	353	5
	2011	9	846	7
	2012	4	443	2
	2013	4	6	1
Lower Squaw, Above College Creek	2009	2	2200	2
	2011	2	428	2
Ames High Tributary	2009	2	566	1
	2010	3	<1	0
Clear Creek	2009	5	176	2
	2010	8	5	1
	2011	5	1	3
	2012	6	117	2
	2013	2	33	0
Prairie Creek	2011	2	5686	2
Montgomery Creek	2011	2	2155	2

Nitrogen

	Mean NO_3/NO_2 (mg/L)
EPA Ecoregion Reference	**2.18 mg/L**
Subregion 25th Percentile	**3.26 mg/L**
Squaw Creek (Downstream of Glacial to mouth)	6.5
Upper Squaw Creek (source to Onion)	6.7
Lower Squaw Creek (Onion to Mouth)	5.9
Worle Creek	9.2
Squaw Creek (Glacial Creek to Headwaters)	3.9
Glacial Creek	1.8
North Onion Creek	1.15
South Onion Creek	0.15
Onion Creek	6.7
College Creek	2.5
Clear Creek	6.8
Onion Creek (all grouped)	5.3

Nitrate + Nitrite Nitrogen



WQ Summary

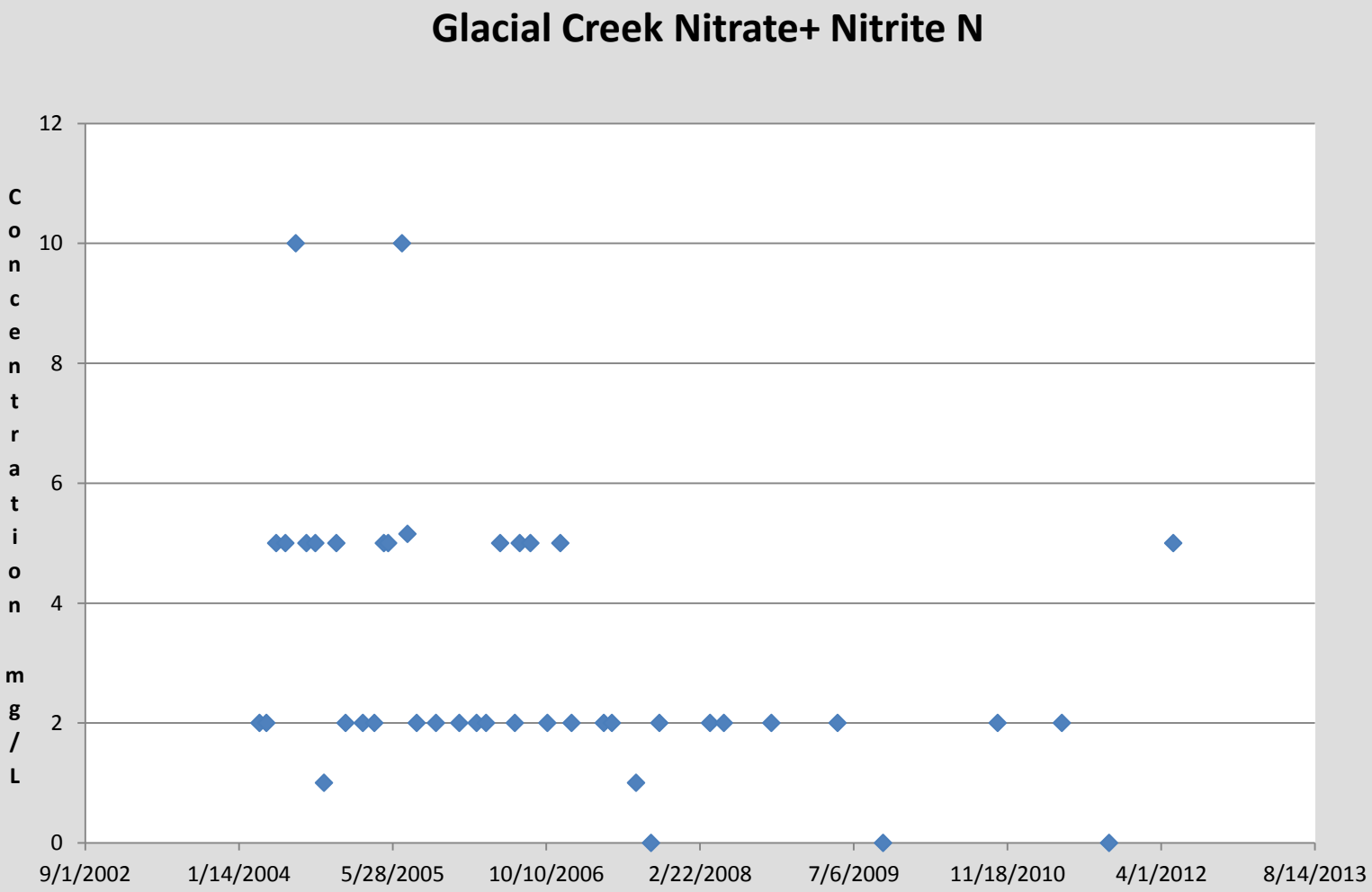
	Mean NO_3/NO_2 (mg/L)	Mean SRP (µg/L)	E. coli (org/100mL)		Mean DO (mg/L)	Mean Chloride (mg/L)
			Geometric Mean	% of Samples > 235		
Squaw Creek (Downstream of Glacial to mouth)	6.5	290	330	74.7%	9.2	40.3
Upper Squaw Creek (source to Onion	6.7	260	-	-	9.7	28.8
Lower Squaw Creek (Onion to Mouth)	5.9	300	330	74.7%	9.0	45.3
Worle Creek	9.2	210	-	-	9.9	48.1
Squaw Creek (Glacial Creek to Headwaters)	3.9	260	-	-	9.6	31.2
Glacial Creek	1.8	200	-	-	9.4	25
North Onion Creek	1.15	200	-	-	10.0	25
South Onion Creek	0.15	200	-	-	8.0	25
Onion Creek	6.7	410	-	-	8.7	45.7
College Creek	2.5	260	-	-	8.6	59.8
Clear Creek	6.8	330	18	30.7%	9.3	38.2
Onion Creek (all grouped)	5.3	360	-	-	8.9	40.5

Macroinvertebrates

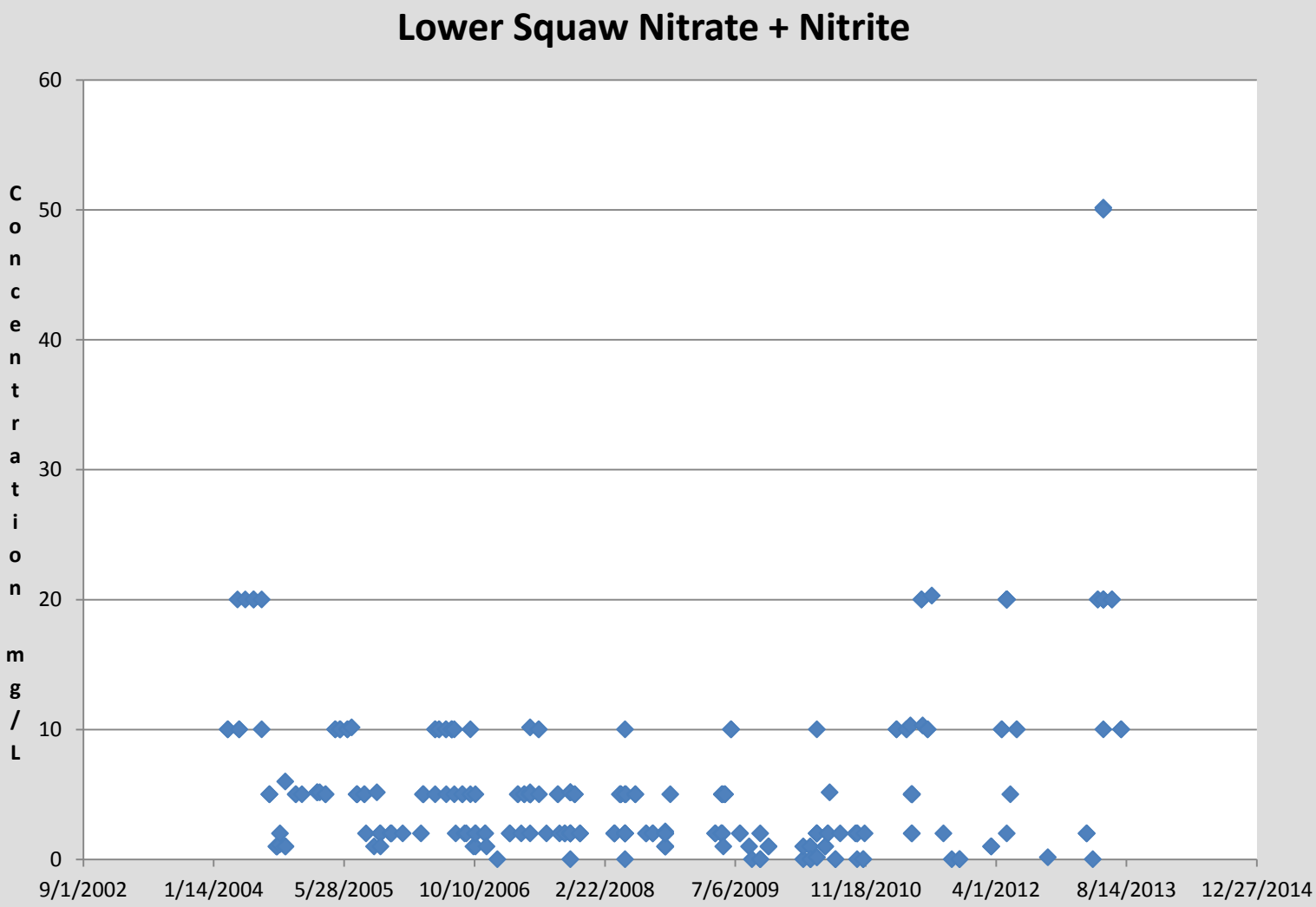
Creek	Number of Samples	% of Samples with Tricoptera (Caddisflies)	% of Samples with Ephemoptera-(Mayflies)	% of Samples with Plecoptera (Stoneflies)	# of Samples with Tricoptera (Caddisflies)	# of Samples with Ephemoptera-(Mayflies)	# of Samples with Plecoptera (Stoneflies)
Clear Creek Total	10	10%	20%	0%	1	2	0
College Creek Total	33	15%	33%	9%	5	11	3
Lower Squaw Creek T	51	45%	57%	67%	23	29	34
Onion Creek Total	11	36%	55%	27%	4	6	3
Upper Squaw Creek T	24	33%	54%	50%	8	13	12
Worrel Creek Total	8	13%	50%	50%	1	4	4
Grand Total	137	31%	47%	41%	42	65	56

- **Lower Squaw Creek healthiest macroinvertbrate population**
- **Clear Creek and College Creek have least healthy macroinvertebrate**
- **Key factors: water quality, flow and habitat**
- **Iowa IBI standards : 47b (Des Moines Lobe Ecoregion)**

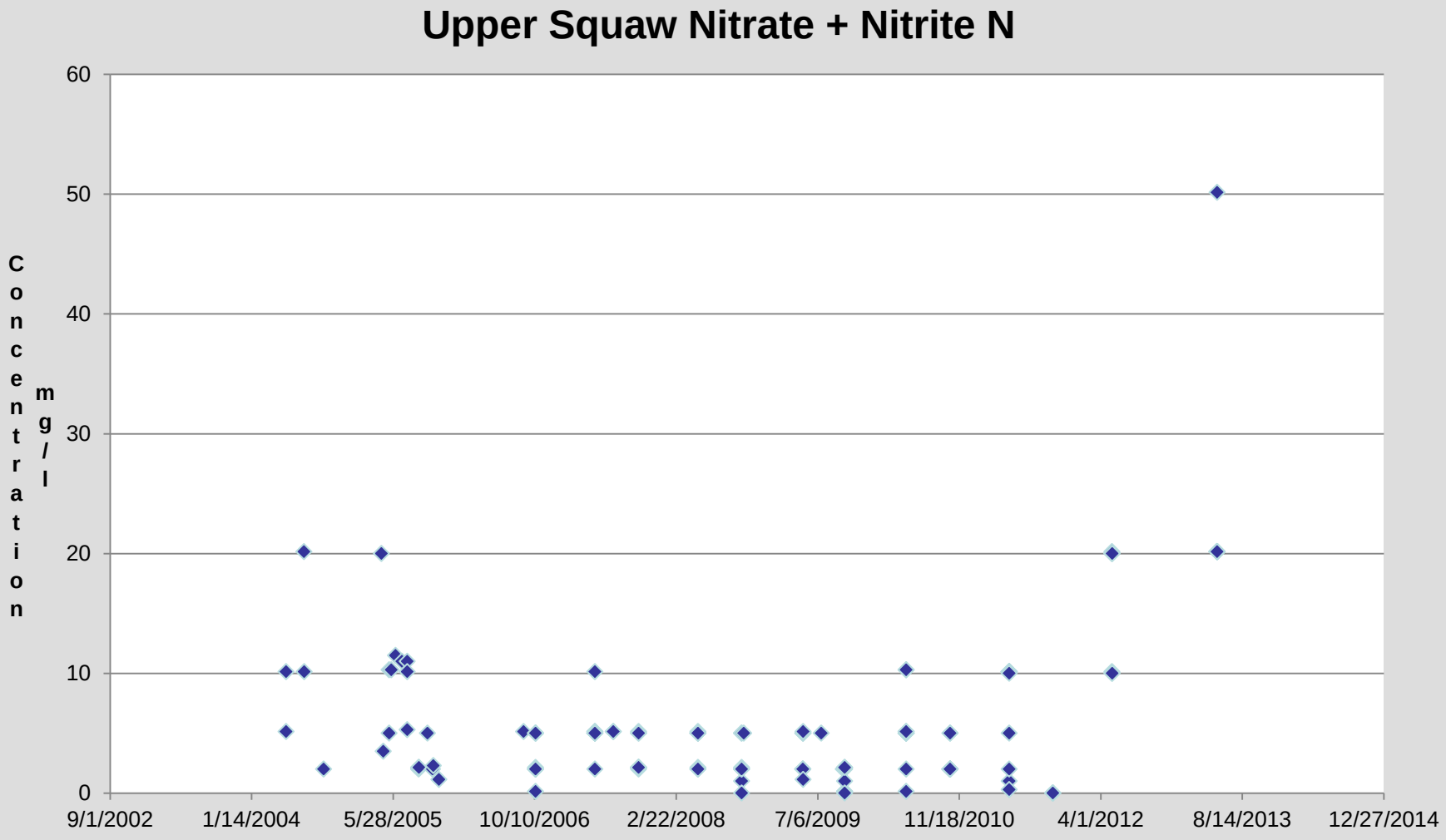
Trends


Glacial Creek Nitrate+ Nitrite N
Concentration mg/L
12
10
8
6
4
2
0
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013

Trends: Lower Squaw (Sample number and distribution)



Upper Squaw Creek Nitrate + Nitrite N



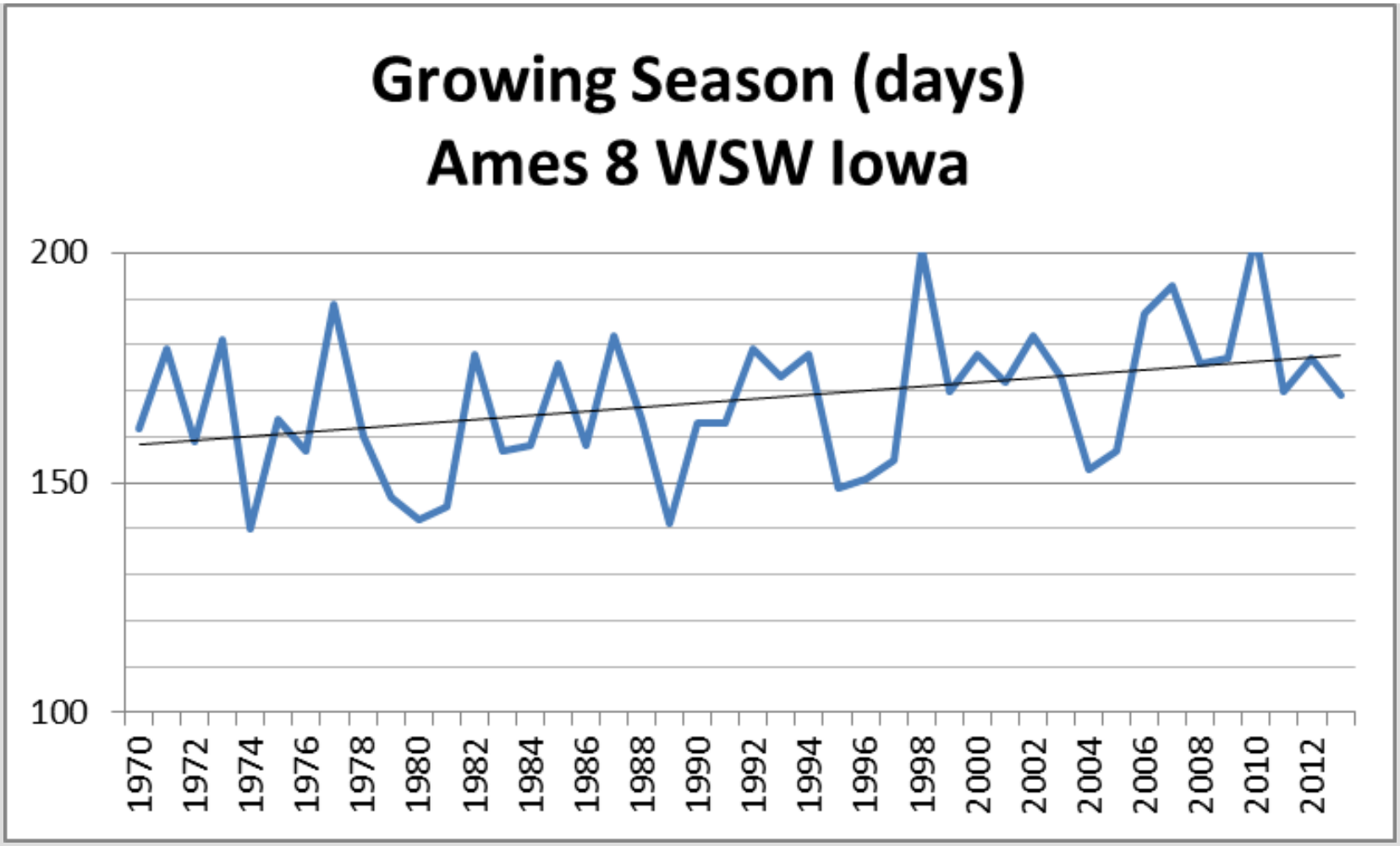
Diagnostic Measures

- **Phosphorus – particulate and dissolved forms**
  - **Dissolved P : OrthoP vs. OrthoPO4**
  - **Total P: standards**
- **Chlorophyll – measure of algae (floating or attached)**
- **Biochemical Oxygen Demand 5 day – amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present**
- **DO Flux: daily oxygen concentration fluctuations (day/night) and pH values to negatively impact aquatic life.**
- **Nitrogen (organic and dissolved forms)**

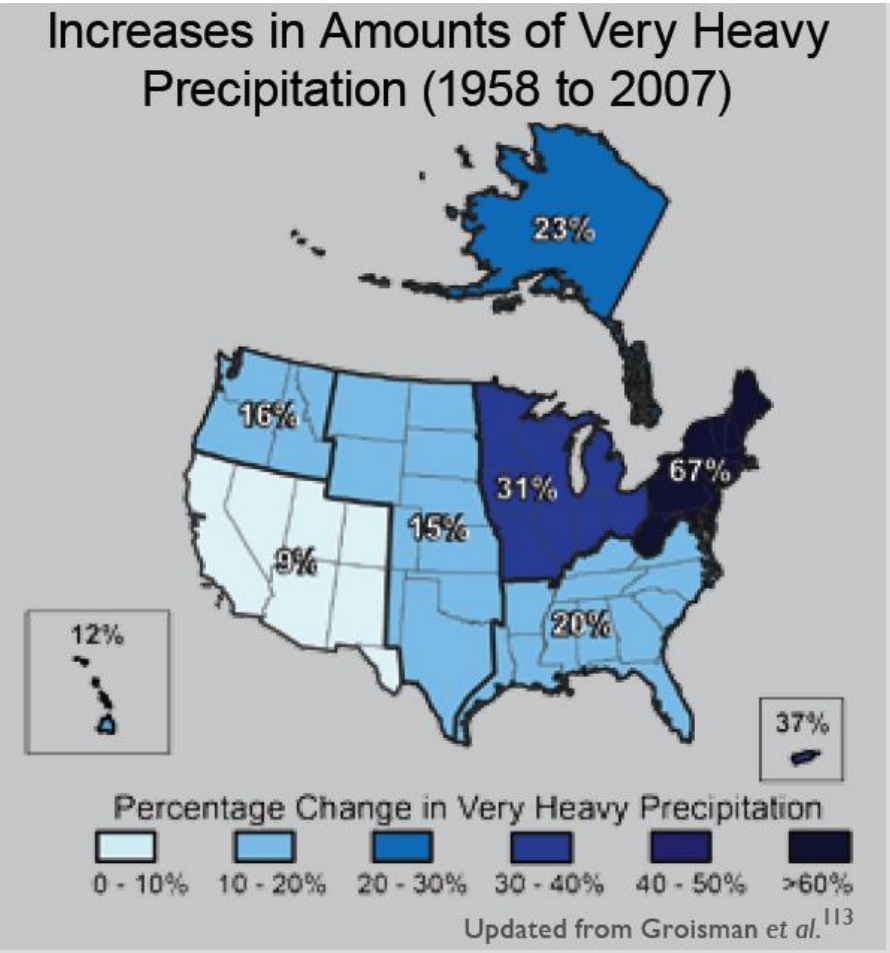
Stream Monitoring

- **Volunteer monitoring**
- **General diagnostic: 6-8 times per summer**
  - **Total phosphorus, chlorophyll-a, BOD5, TN, (continuous dissolved oxygen over several days for DO Flux)**
- **Full diagnostic:**
  - **Above general diagnostics**
  - **USGS site: continuous daily flows**
  - **Add second primary site midway (~Gilbert Creek)**
  - **25-35 samples focusing on higher flows**
    - Total Phosphorus, Ortho-PN (organic + dissolved), Total Suspended Solids
    - Most loads occur in high flows & therefore focus of sampling.
    - Certified laboratory for analyses
  - **Secondary sites – sampling with interpolated flows**

Thank you


Growing Season (days)
Ames 8 WSW Iowa
200
150
100
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012

Climate Variability



- Growing season length
- Increases in frequency of large storms
- Wet/dry periods
- Temperatures
- Catastrophic losses
- Spring vs. summer rainfall patterns