2013 St. Croix National Scenic Riverway
Zebra Mussel Monitoring and
Support of Federally Listed Endangered Mussel Species
Activities Report

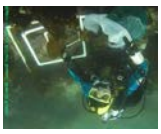
National Park Service (NPS) supported by
the U.S. Army Corps of Engineers (USACE)

Introduction:

The St. Croix National Scenic Riverway was the first unit of the National Park System, included in the Wild and Scenic Rivers Act of 1968. Considered a nationally significant resource, the Riverway is recognized for its outstanding recreational and biological assets. It is also well documented for the richness and abundance of freshwater mussels (approximately 40 species, the greatest in the Upper Mississippi River watershed), though many threats to mussel quantity and diversity have been identified. As an example, severe impacts could occur to this faunal group by a zebra mussel infestation, black carp or other aquatic invasive species. Freshwater mollusks are a keystone faunal group of freshwater systems, and their potential loss is unacceptable.

Zebra Mussels were first discovered reproducing in the St. Croix River in 2000. To understand the invasion of zebra mussels into the river, measurements of densities within the known infestation zone (the lower 21 miles of river) have been collected since 2004. Anecdotal evidence from the Upper Mississippi River suggested zebra mussel colonization predominates on native mussel beds, especially when substrates are less favorable for recruitment (i.e., sand, silt, etc.). Therefore, choosing sample locations was based on native mussel bed survey work previously conducted in 2001, by the Minnesota Department of Natural Resources (MN DNR). The eight locations identified were from Stillwater, Minnesota, to Prescott, Wisconsin, reflecting the range of habitats and hydrology found in the infestation zone. Now tracked for a decade, density data for zebra mussels provides trends at these locations, which include three Essential Habitat Areas. The NPS continues to monitor these sites with the support of the ACOE.

In 2013, a newly added component to the density monitoring included installation of caged and uncaged cinder blocks and plate samplers with glass slides at each location. The intent was to detect the earliest veliger settlement by providing high quality artificial substrate. This addition was fortunate, as several factors altered and reduced the usual data collection efforts this summer. Most important of these, in July, the National Park Service Washington D.C. Office issued a servicewide stand-down for our dive program. The effect of this action was to prevent St. Croix NSR dive team members from performing agreed-to scuba related tasks from mid-July through the rest of the year. To compensate for the loss of diver-collected substrate, a Ponar type sampler took the place of staff fingers to lift material from the river bottom. This strategy had mixed success. The grab was too heavy to operate smoothly without a sounding reel or winch, which was not available. Additionally, the equipment was prone to gape or detach. It was, however, able to sample approximately the 1/8 meter of substrate used throughout the study and pulled similar quantities of substrate when encountering sand. Do to the altered protocol; sampling of all eight locations could not be performed during the assigned week. We scheduled additional attempts at substrate sampling in October, in collaboration with the MN DNR. Unfortunately, the partial federal government shutdown at the beginning of the new fiscal year cancelled those plans.



The following narrative includes the limited findings related to zebra mussel densities, as well as the three other tasks agreed to in the scope of work with the ACOE (qualitative and quantitative veliger sampling and support of the Pool 3 mussel survey) and other zebra mussel activities conducted by the NPS within the St. Croix Basin.

Density

The purpose for quantitative sampling within the known infestation zone of the Lower Str. Croix River is to determine density, size demography, and evidence of recent recruitment of *D. polymorpha*. To this end, the NPS with the support of the ACOE continues to collect substrate at eight locations as a long term monitoring effort.

The eight long-term zebra mussel density study locations:

1) **Prescott Higgins' Eye Essential Habitat Area (RM R0.2),
2) *St. Croix Bluffs (RM R5)
3) *Kinnickinnic Narrows (RM L6)
4) *Black Bass Bar (RM L10)
5) †*Lake St. Croix Beach (RM R14)
6) †**Hudson Higgins' Eye Essential Habitat Area (RM R17)
7) †*South Highline Beach (RM L21)
8) †*Stillwater Mussel Relocation Site (RM L23).

*These six sites were sampled 2004 to 2012 by NPS.
**These two sites were included in the NPS assessment since 2005.
†Site not sampled in 2013

In previous years, because adult densities could be high and variable, zebra mussels were sampled using a 1/8-m^2 steel quadrate. The quadrate was haphazardly tossed from the boat to settle onto the river bottom, and substrate within the quadrate then excavated by a diver's hands and placed into a bucket. After the bucket is brought to the surface and the contents of each sample are rinsed through a 3-mm mesh sieve, the retained material (zebra mussels as well as rocks and shells with attached mussels) is placed into a 4-L plastic Ziploc bag and preserved by freezing at the Park's laboratory. These samples are later thawed, zebra mussels, clams and snails separated from inorganics and enumerated (Table 1). This process has provided over ten years of comparable data, documenting the stochasticity of the river's zebra mussel population. Unfortunately, factors this summer reduced the amount and locations sampled during the season.

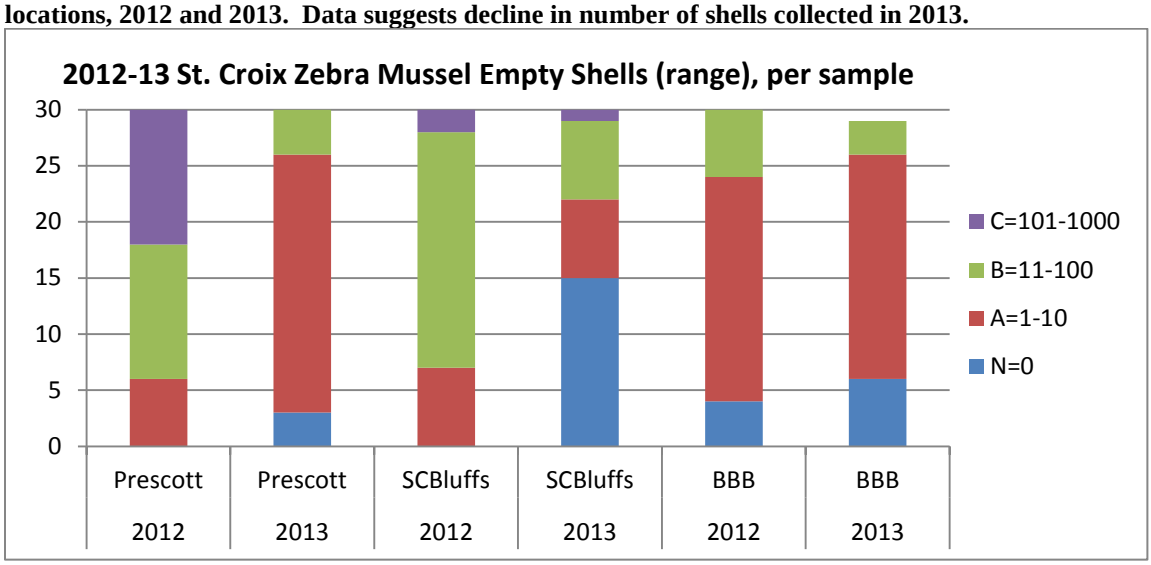
Table 1. Mollusks collected in samples at four long-term monitoring locations, 2013.

2013 Specimens Collected by Location						
Location	Sample #	Live Zebra Mussels	Live on Native Mussels	#Native Mussels	#Corbicula	#Snails
Prescott	30	1	1	5	13	26
St. Croix Bluffs	30	9	1	1	13	11
Kinnickinnic Narrows	30	0	0	4	1	22
Black Bass Bar	29	0	0	3	11	22

Substrate samples were taken in the St. Croix at just four locations in August. Long-term monitoring sites at Prescott, St. Croix Buffs Regional Park, just above the confluence with the Kinnickinnic River, and at Black Bass Bar were sampled using a standard stainless-steel Ponar type grab sampler. This 45lb unit was 9"x 9" with an approximant sample volume of 8200ml. Our typical sampling using a diver and a $1/8^{th}$ meter quadrate—digging to 13cm—resulted in an average sample of 8125cm^3 worth of substrate. Though generally adequate, one issue faced in the field was an occasional large rock(s) on the bottom that hampered the grab's ability to close.

In all cases, the ability to move the sampler within the site perimeter was hampered by weight and inability to easily pivot the sampling platform (and loss of the Ponar—recovered by retired FWS biologist Nick Rowse). Finally, sampling occurred at only the most downstream four sites. Therefore, obstacles of bias, sample size and substrate material render the data incomparable to previous years. However, the shell mass range first assessed in 2012 (Fig. 1), if compared to this year's information, might suggest continued very low numbers of zebra mussels collected since 2010.

Figure 1. Comparison of shell mass as part of substrate (30 samples each) at 3 locations, 2012 and 2013. Data suggests decline in number of shells collected in 2013.



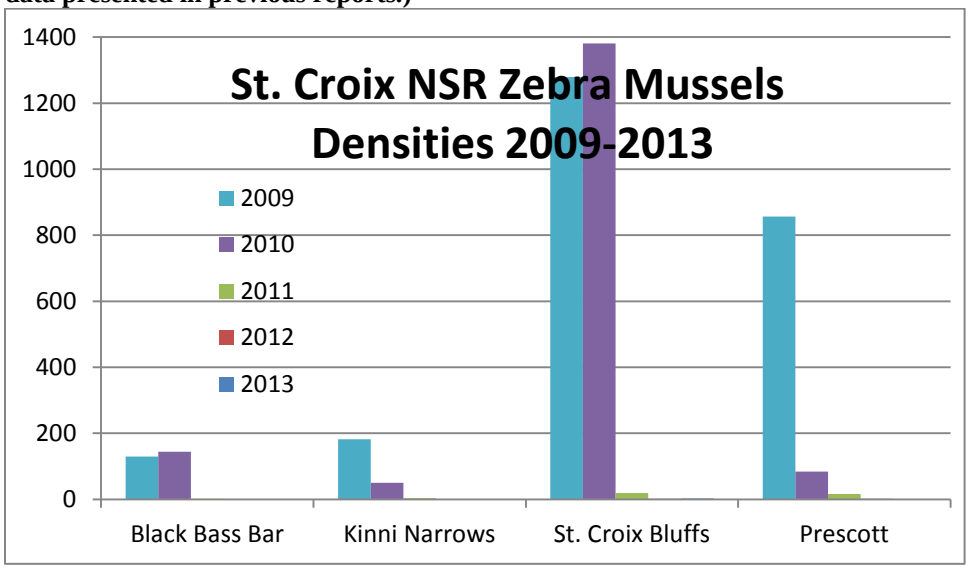
Additional data was collected using cinder blocks placed in May at all eight long term monitoring sites. Blocks both caged in 5 by 8cm wire mesh and uncaged, were paired and affixed with HOBO® Temperature Data Loggers, PVC plate samplers and glass microscope slides. These were then checked at mid-summer, and pulled for the season at the end of September. All slides removed for examination were negative for post-veliger settlement, but 2 blocks were found with very small attached zebra mussels (Table 2.)

Table 2. Live zebra mussels collected by agency and collection type

2013 Live Zebra Mussels Collected at 8 LTM Sites					
				#	Density (if applicable)
ACOE					
	Prescott Quadrate			2	0.004/m^2
	Prescott Timed Search		On native mussels	4	na
NPS					
	St. Croix Bluffs Quadrate			9	2.4/m^2
	Prescott Quadrate			1	0.27/m^2
	Prescott Block (Each Block is 0.35$m^{2)}$				
		uncaged zm	caged zm		
		2 ~ 1mm	4 ~ 1mm	6	8.6/m^2
	Remainder of 16 blocks, 12 samplers, 119 quadrates			0	
Total ZM				22	

Though the data collection in 2013 was less than optimal or expected and is not readily comparable to previous years, the evidence suggest zebra mussel numbers overall in Lake St. Croix are lower than the peak years of the mid-2000s. It is possible, given the circumstantial evidence, that populations remain as low as in recent years (Fig. 2). If this is the case, a brief discussion into the possible causes is warranted.

Figure 2. Live Zebra Mussel Collected at Four Locations on Lake St. Croix 2009-13. (See Appendix C for data presented in previous reports.)



Predation has been discussed as a contributing cause for declines of zebra mussels, especially in the Prescott Pool. Unpublished data collected by the author and others from 2006-8, became the pilot study for a larger, more comprehensive project in 2010 and 2011 (USGS, results expected in 2014). Preliminary analysis suggests common carp, and to a lesser extent other benthic grazers, as significant predators of especially size-specific zebra mussels. Gut contents of carp collected during the pilot study in 2007-08, were packed with shells, apparently to the exclusion of other food. These years represent the peak of zebra mussel populations in the Lower St. Croix. By 2010-11 when zebra mussel numbers were in decline or crashing, carp gut contents reflected the change, though mussels were still represented in some samples. Additional inferences will be made upon release of the study, but clearly, these fish fed heavily on what was available, and seemed to prefer a size class, thus maintaining a stunted population. It therefore may be that predation was a contributing factor in the crash. The USGS study will provide additional insight.

Hydrology during the past several years has been atypical. As Appendix B (Fig 1) points out, the usual water flows of a spring runoff/flood/high water, followed by lower summer flows with a slight rise in the fall – has not occurred since 2009 (see examples 1, 2, 6). The case more recently has been persistent high water lasting well into the summer (July), often followed by a complete lack of rainfall for weeks—even lasting into the fall (Fig. 3).

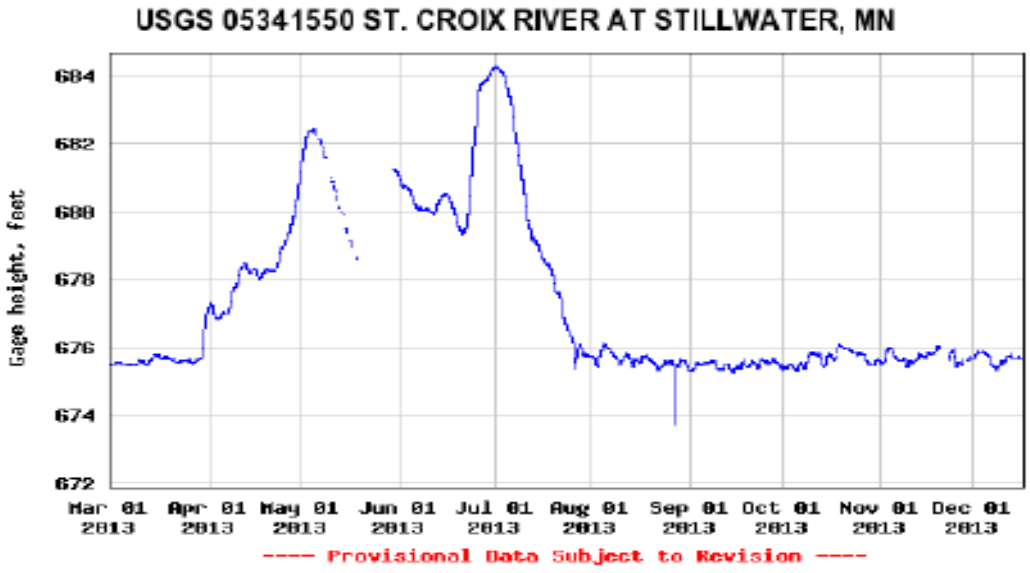
Robertson and Lenz (2002) showed water-residence time in 1999, 1988 and 1996 for St. Croix and associated river pools (Table 3). The hydroelectric dam reservoir in St. Croix Falls, the four naturally occurring riverine impoundments from Stillwater to Prescott, and the final human

impoundment on the Willow River, were measured for water-residence in a dry ('88), wet ('96) and the study year of 1999. These data were in support of their nutrient loading study of the river, but provide useful clues to settlement after zebra mussel reproduction. If typical veliger development occurs within the pools and settlement at two weeks is assumed (reference), wet years would allow for settlement within the river only if reproduction occurs upstream of the Troy Beach Pool. Our data since 2004, show a very small population in residence within the Bayport Pool (Appendix C., Tables 1 & 2). If near flood conditions continue into July, decreasing even "wet" year residence times, early and mid-summer reproduction by zebra mussels would affect the Mississippi. This is a topic due continued study.

Table 3. Water-Residence Time in St. Croix Pools from Mile 63 (after Robertson and Lenz 2002)

Water-residence time in the St. Croix pools			
Pool	Average water-residence time (days)		
	1999	Dry Year	Wet Year
St. Croix Falls Reservoir	0.4	0.9	0.4
Lake Mallalieu	5.0	6.7	4.1
Bayport Pool	4.9	11.0	5.0
Troy Beach Pool (Lake St. Croix Beach)	8.2	19.4	8.1
Black Bass Pool (Afton)	4.5	11.0	4.3
Kinnickinnic Pool (Prescott)	3.4	8.1	3.3
Lake St. Croix (four pools combined)	20.6	50.1	20.0

Figure 3. Gage Height at Stillwater from March to December, 2013.



Is temperature a contributing factor in the sudden decline of zebra mussels in the St. Croix River? It is an important limiting factor related to reproduction and increases in mean summer air temperatures in the future could raise river water temperatures to a point intolerable for this

species. However, a search through the literature and a comparison of daily high temperatures (Appendix B, Fig. 3) near the river's surface in Stillwater, do not provide evidence that this variable has contributed to the decline.

There appears to be consensus on the upper temperatures zebra mussels can tolerate over short and extended periods. In their work, Claudi and Mackie (1995) report temperature thresholds of 28-29°C for animals slowly acclimated to 25°C. Spidle et al. (1995) suggested zebra mussels could tolerate 30°C for their study trails (=14 d)with no mortality and <39°C for hours if acclimated. They also referenced McMahon's (1994) assertion that this species could persist at 30°C indefinitely. Iwanyzki and McCauley (1993) also suggested 30°C as the approximate "ultimate upper incipient lethal temperature," and noted a close correlation between upper lethal temperatures and acclimation temperatures (in the lab mussels could live at 30° but not 31°).

McMahon (1996) showed differences in the thermal tolerance adaptability between North American and European populations, even suggesting a 17-18°C as the optimal spawning temperature in the invaded continent (unlike 12°C in Europe). Moreover, his previous work (McMahon et al. 1994) supported Iwanyzki and McCauley in their 30°C threshold findings. His presentation of the available literature at the time showed an ambient elevated thermal tolerance in North American zebra mussels, though acclimation was again key to high temperature survival.

Thorp et al. (1998) have shown zebra mussels are more tolerant than quagga mussels (esp. riverine populations) to elevated temperatures; however, both species are affected by even small increases in ambient temperature as they near their thermal maximums (Spidle et al. 1995; Thorp et al., 1998).

Apart from trying to determine population crashes with in the river, thermal tolerances have management implication. As would be expected, aquatic invasive species in North America tolerate both heat and desiccation differently, making broadly based treatments options tricky. While applying hot water (50°C) to a boat hull may induce near instantaneous death (<1 min) in adult zebra mussels living in summer water temperatures of 27°C (McMahon et al. 1995), however resting eggs of *Bythotrephes longimanus* (spiny waterflea) can withstand these temperatures longer than typical real-world treatments options allow (~5 min) (Branstrator et al. 2013). Conversely, Boelman et al. (1997) suggested that at 95% humidity, zebra mussel could survive for 5 days at 25°C. *B. longimanus* resting eggs may only last 4 hours at 17°C and 53% (ϕ)(Branstrator et al. 2013). Therefore, temperature and drying are important control tools for aquatic invasive species.

Even during low flows typical in late summer, or periodic draught conditions experienced recently, the pool level at the lower end of Lake St. Croix remains fairly constant. It is unlikely that near-shore desiccation would occur here and water temperatures even at the river's edge probably are not limiting.

Exploring the river conditions that have contributed to the sudden decline in zebra mussels is important and will continue. We believe that a combination of a population stressed by an opportunistic predator and unusual water flows, have led to a decline in St. Croix River zebra

mussels. If high water decreases the water-residence within and among the pools making up Lake St. Croix to the point veligers are unable to develop to settlement; and fish (esp. common carp) are removing reproductive-age mussel just as flows become favorable (July); then a population crash would not be unexpected. As more data are analyzed and released this year for interpretation, more insight will occur. We anticipate further study in the next few years to support these assumptions. As water conditions return to more typical flows and if carp do not return to feed until populations increase, it will be critical to track any possible rebound.

Veliger Collection – Qualitative

Veliger collection with a plankton tow net was done at four lakes in Minnesota and eight lakes in Wisconsin within the St. Croix River watershed (see below for details). Plankton tow samples were collected at three locations within each lake (center, littoral and launch). The composite was then preserved with 70-percent ethyl alcohol and kept in a sealed container. Samples were sent to CLEAN LAKES, Inc., buffered for analysis, and run under a Flow-CAM® continuous imaging flow cytometer for whole sample veliger detection. All samples were determined to have abundant or adequate organisms enough for proper analyses. No samples contained zebra mussel veligers. (Appendix D)

MN

- North Center Lake - Chisago County
- Rush Creek - Chisago County
- Pokegama Lake - Pine County
- Cross Lake - Pine County

WI

- Minerva Lake -Burnett County
- Yellow Lake - Burnett County
- Clam River Flowage - Burnett County
- Big Trade Lake - Polk County
- Bone - Polk County
- Balsam - Polk County
- Deer - Polk County
- Bass Lake – Polk County

Veliger Collection – Quantitative

Quantitative veliger sampling involves a manual diaphragm pump of a single composite (90 liters) water sample taken at five designated sampling sites. In 2013, sampled material was poured through a 53-mm mesh nylon filter. Filtered material was then washed into a sample container and preserved using 70% ethanol. After the second and final sampling event, containers were mailed to the Army Corps Research and Development Center in Vicksburg, MS.

NPS veliger sampling sites include established sites at Stillwater, St. Croix Falls and above the Snake River confluence on the St. Croix River and on the Snake River below the Cross Dam and Sunrise River below the Kost Dam. During the event, teams from various agencies, including ACOE, sample throughout the upper Mississippi Basin, including the lower St. Croix River (Hudson and Prescott). Information and results related to all sites sampled in 2013 are pending, and will be contained in a separate report.

- Tail of Cross Lake (Snake)
- Tail of Kost Dam (Sunrise)
- Upstream of Co Rd 118 (MN) / Ferry Rd. (WI) (St. Croix)
- Interstate Parks at the Dalles (St. Croix)
- Stillwater @ mile 25.4 (St. Croix)

Zebra Mussel Sampling

The NPS installed four PVC plate samplers at the impoundments on the Namekagon and St. Croix Rivers (Hayward, Gordon, Trego and St. Croix Falls). Samplers were installed in June, checked in July and removed in October. Glass slides, used as an additional tool to detect post-veliger settlement, were removed for analysis in July and October. All slides and associated samplers proved negative for zebra mussels in 2013.

NPS staff conducted a survey of 500 dry-docked boats at five marinas on the lower St. Croix River, during two days in November. At each location, the first 100 boats were examined for zebra mussel attachment. Marinas were located from Stillwater at river mile 24.5 to Afton at river mile 11.4. As the data below suggests (Table 3), a very small percentage of boats at these marinas were infested with zebra mussels. Staff at Wolf Marine said the positive boat stored at their facility was moored on the Mississippi most of the summer. The St. Croix Marina in Hudson appears to have infestations similar to the early 2000's, and information gleaned from samplers installed by the USFWS, suggests zebra mussels remain present and reproducing at least within the Hudson Narrows.

Table 4. Dry-docked boats visited at five marinas in 2013.

2013 Dry Docked Boats at 5 St. Croix Marina

100 boats ck'd per marina		w/o SCM
Wolf Marine	1	
Sunnyside	3	
Windmill	5	
Bayport	1	
St. Croix (Hudson)	18	
Avg. per marina	5.6%	2.5%

The Fish and Wildlife Service provided staff to monitor and provide outreach at 15Wisconsin Lakes located in the middle of the Basin and either draining directly into the St. Croix or providing easy opportunities for inter water-body spread, due to the proximity of public access. Additionally, seven locations on the lower St. Croix River (six marinas and one public launch)

were assessed throughout the late spring and fall (11 visits). Monitoring was done using PVC plate samplers and glass slides at multiple sites at each location. Samplers were checked approximately every couple of weeks. Outreach was primarily conversations with marina staff, though clients and members of the boating public were contacted throughout the season at the various lakes and launches. Zebra mussels were detected on samplers in Afton, Hudson and Bayport. One lake in St. Croix County, Wisconsin, Bass Lake, also remained positive with newly transformed animals attaching to the plate samplers by September. (Appendix A)

Mississippi River Pool 3 (Redwing to Hastings) Native Mussel Assessment

The U.S. Army Corps of Engineers has been studying the effects of small-scale drawdowns of river pools on the Upper Mississippi River for over a decade. Successful habitat improvements within small acreage in these pools after limited drawdowns (judged by new growth of plant species used by fish and wildlife), has driven plans for possible further management actions. Pool wide drawdowns on Pool 3 through 10 have been attempted, or are being considered.

To assess the impacts of a drawdown on native mussels within Pool 3, the National Park Service aided the ACOE in July and August to perform a Pool wide random survey of mussel fauna. For 2 weeks, NPS staff and equipment aided staff from the Corps, MN/WI DNRs and USFWS. The goal of the effort was to estimate the mussel population size in Pool 3, again, to further understand impacts of a proposed water level management drawdown for ecosystem restoration.

Native Mussel Support

Again, in 2013 winged mapleleaf mussel propagation conducted by the U.S. Fish and Wildlife Service, ACOE, MN DNR and others was supported by the NPS. High water for much of the spring into early summer prevented aggregation again in 2013. A period of animal non-disturbance has been deemed essential to reach management goals. Lower water has come too late in the season for mussel collection and stockpiling to occur for several years. However, by the September 13th, just two weeks into monitoring our historic caches (aggregations) enough gravid females had been collected for their glochidia to infest all the host fish available at the Genoa NFH propagation facility. Additional information related to these activities are contained in a separate ACOE/FWS report, pending.

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APPENDIX A

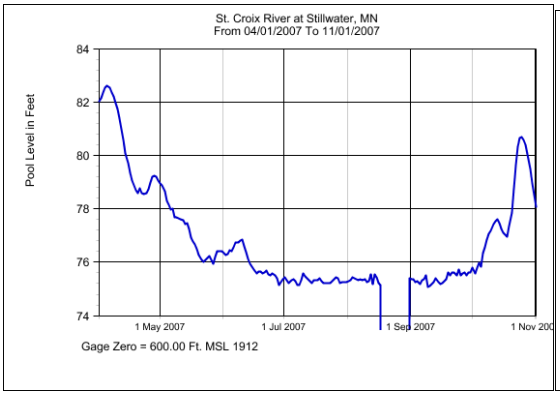
Table 1. USFWS St. Croix River Basin Zebra Mussel Monitoring and Outreach, 2013.

2013 Zebra Mussel Plate Sampler Monitoring/ANS Outreach USFWS; Wedan				
Location	# Samplers	Zm Present	Public Contacts	Comments
Afton Marina	2	yes	7	Few found late spring, again fall
St. Croix Marina - Hudson	3	yes	3	not on all samplers
Bayport Marina	3	yes	0	not on all samplers
Stillwater Marina	3	no	4	
Old Sawmill Marina	2	no	3	
Wolf Marine	3	no	6	
Boomsite Landing (MnDNR)	1	no	22	
7	17	3 sites	45	Totals
Mallalieu-St Croix	2	no	9	
Bass-St Croix	2	yes	12	Present from fall ck 9/19-20/2013
Cedar-St Croix/Polk	2	no	4	
Big Lake-	2	no	3	
Wapagassett-Polk	2	no	23	
Deer-Polk	2	no	9	
Long-Polk	2	no	8	
Balsam-Polk	6	no	22	
Half Moon-Polk	2	no	11	
Bone-Polk	2	no	19	
Big Round-Polk	2	no	4	
Big Butternut-Polk	2	no	9	
Big Sand-Burnett	2	no	25	
Clam Lake-Burnett	2	no	16	
Yellow Lk-Burnett	2	no	27	
15	34	1 sites	201	Totals
22	**42**	**4 sites**	**246**	**Grand Totals**

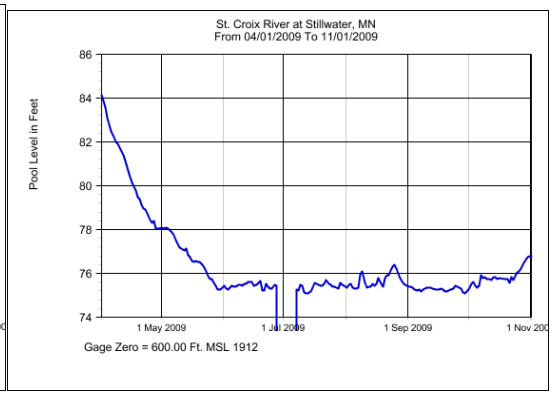
APPENDIX B

Figure 1. USGS Hydrographs 2000-2012 St. Croix River at Stillwater.

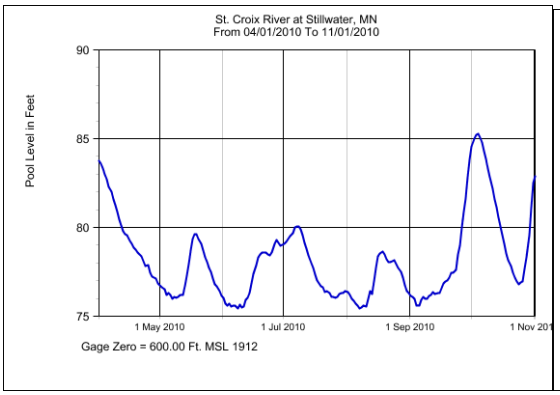
1. 2007



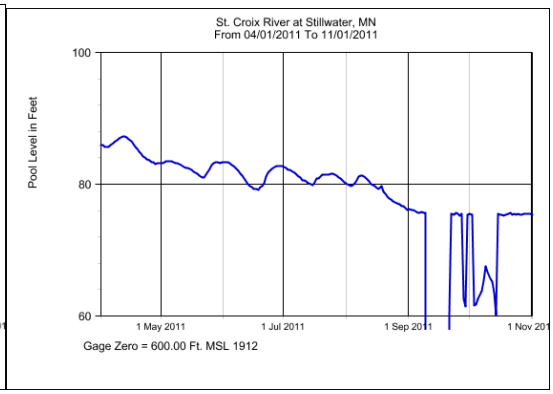
2. 2009



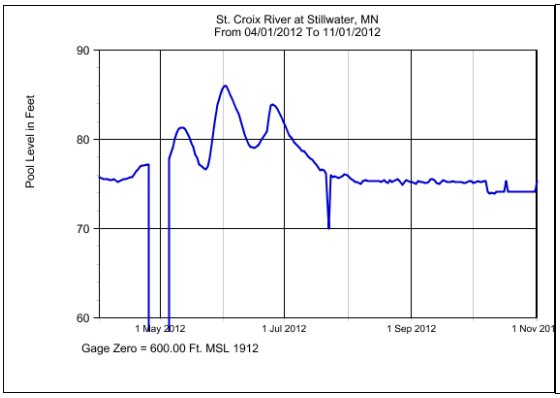
3. 2010



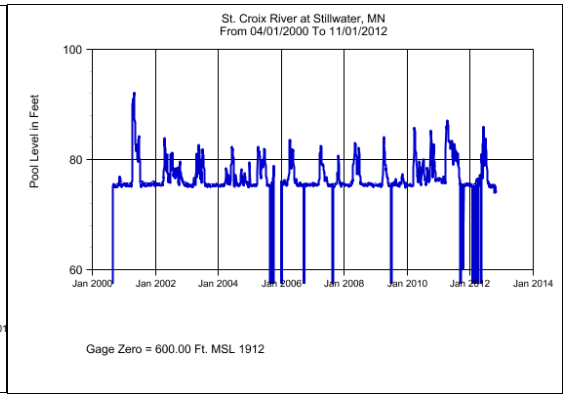
4. 2011



5. 2012



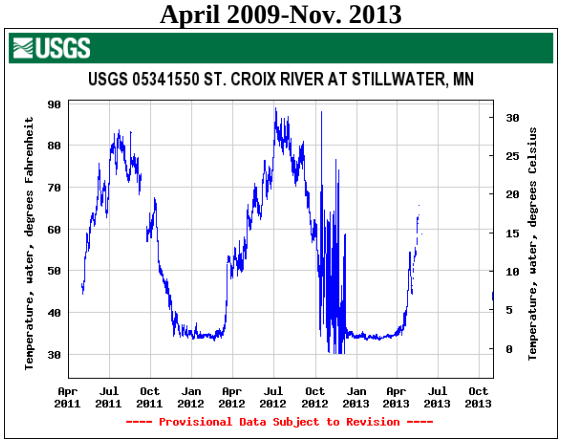
6. 2000-2012



Graphs 1 and 2 represent typical summer water levels on the river as presented in the twelve years shown in Graph 6. Graphs 3-5 reflect the past three years of abnormal high water during the assumed typical zebra mussel reproduction period.

Figure 2. USGS Temperature Reading 2010-13 for the St. Croix River at Stillwater.

April 2009-Nov. 2013



April to Nov. 2013

Readings for the last week in August 2013

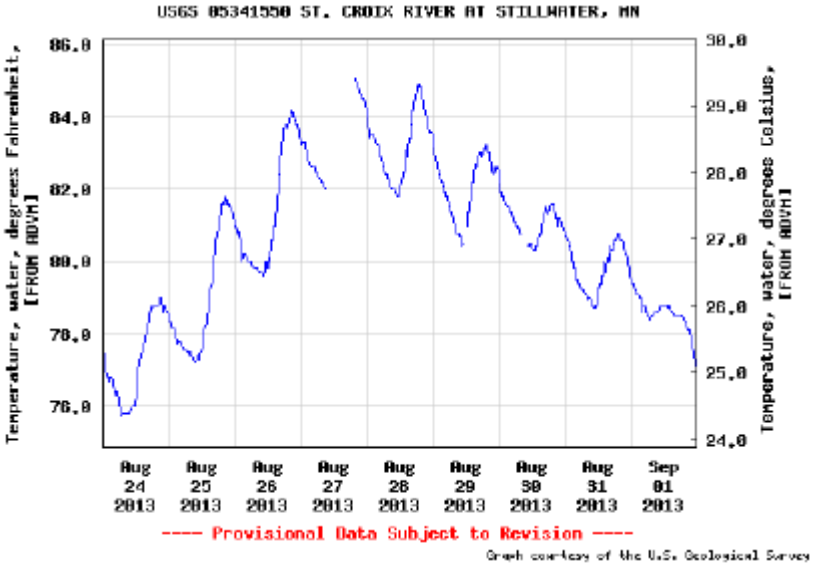


Figure 3. ACOE and cli-Mate Temperature Readings for July 2004 for the St. Croix River at Stillwater. (Table 1 shows July water temperatures; Table 2. Air temperature, late June and July; Table 3. Water temperature days at 26+ and 30 degrees Celsius for 2004).

Table 1.

Historic Data For St. Croix River at Stillwater,
Gage Zero: 600.00 Ft. MSL 1912
Longitude: -92.80388889
Latitude: 45.05611111
River Mile: 23.4
Location of Gage:
St. Croix River at Stillwater, MN

08:00 Central

Date / Time	Water Temperature (F)
7/1/2004 8:00	76
7/2/2004 8:00	80
7/3/2004 8:00	99
7/4/2004 8:00	94
7/5/2004 8:00	96
7/6/2004 8:00	96
7/7/2004 8:00	93
7/8/2004 8:00	70
7/9/2004 8:00	73
7/10/2004 8:00	71
7/11/2004 8:00	72
7/12/2004 8:00	74
7/13/2004 8:00	76
7/14/2004 8:00	76
7/15/2004 8:00	77
7/16/2004 8:00	77
7/17/2004 8:00	77
7/18/2004 8:00	76
7/19/2004 8:00	77
7/20/2004 8:00	78
7/21/2004 8:00	80
7/22/2004 8:00	81
7/23/2004 8:00	78
7/24/2004 8:00	76
7/25/2004 8:00	76
7/26/2004 8:00	76
7/27/2004 8:00	75
7/28/2004 8:00	74
7/29/2004 8:00	73
7/30/2004 8:00	74
7/31/2004 8:00	71

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Table 2.

Daily Data Between Two Dates
STILLWATER 1 SE (MN)
USC00218037

Date	TMAX	TMIN	MEAN
6/29/2004	87	56	71.5
6/30/2004	89	60	74.5
7/1/2004	89	63	76
7/2/2004	89	64	76.5
7/3/2004	89	67	78
7/4/2004	82	66	74
7/5/2004	85	63	74
7/6/2004	76	59	67.5
7/7/2004	71	55	63
7/8/2004	79	53	66
7/9/2004	80	66	73
7/10/2004	83	63	73
7/11/2004	85	69	77
7/12/2004	89	71	80
7/13/2004	88	67	77.5
7/14/2004	86	64	75
7/15/2004	86	64	75
7/16/2004	85	69	77
7/17/2004	83	62	72.5
7/18/2004	81	59	70
7/19/2004	86	66	76
7/20/2004	92	72	82
7/21/2004	94	71	82.5
7/22/2004	97	67	82
7/23/2004	83	58	70.5
7/24/2004	76	57	66.5
7/25/2004	80	54	67
7/26/2004	83	56	69.5
7/27/2004	84	58	71
7/28/2004	84	64	74
7/29/2004	80	63	71.5
7/30/2004	82	56	69
7/31/2004	79	55	67
Count:	31	31	31
Average:	84.1	62.6	73.3
Median:	84	63	74
Low Value:	71	53	63
High Value:	97	72	82
M = Missing			
T = Trace			

Midwestern Regional Climate Center
cli-MATE: MRCC Application Tools Environment
Generated at: 1/13/2014 12:57:45 PM CST

Table 3.

Water Temperatures ACOE Gage Stillwater, MN
2004 to 2012 days above 26.67C (80F) & 30C (86C)

Year	Above 30C	Days 80+	Highest ©	Highest (F)
2004	assumed error	3-Jul	37.39	99.3
	assumed error	4-Jul	34.61	94.3
	assumed error	5-Jul	35.78	96.4
	assumed error	6-Jul	35.61	96.1
	assumed error	7-Jul	33.72	92.7
		22-Jul	27.28	81.1
2004	5(0)	6(1)	37.39(27.28)	99.3 (81.1)
2005	0	11	28.89	84
2006	0	7	28.4	83.12
2007	0	2	26.8	80.24
2008	0	0	na	na
2009	0	0	na	na
2010	0	3	27	80.6
2011	0	6	28.4	83.12
2012	0	27	29.72	85.5
2013	data missing			

80F= 26.67C
86F= 30C

APPENDIX C

Note: Previous year informations related to native mussels collected, native mussel valves collected, densities, trends, etc. could not be performed this season due to the shutdown of the dive program within the park and general partial shutdown in October. Some of the following data have been presented in previous years, but is resubmitted as reference. m^2

Figure 1. Native Mussels Collected by Location in 2012 and Totals Collected at All Sites Combined 2004 - 2012

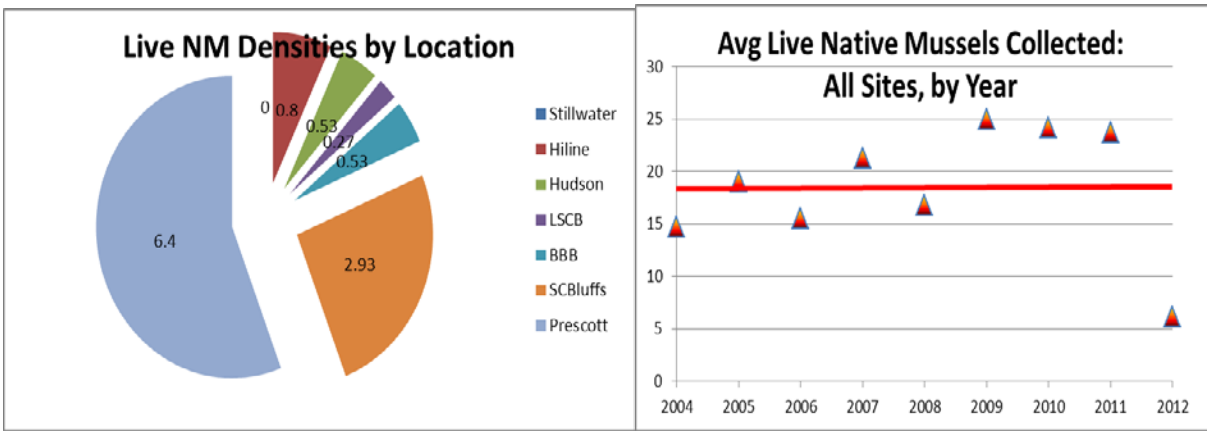

Figure 2. St. Croix River Zebra Mussel Densities 2009 to 2012 (crash years 2011-13).

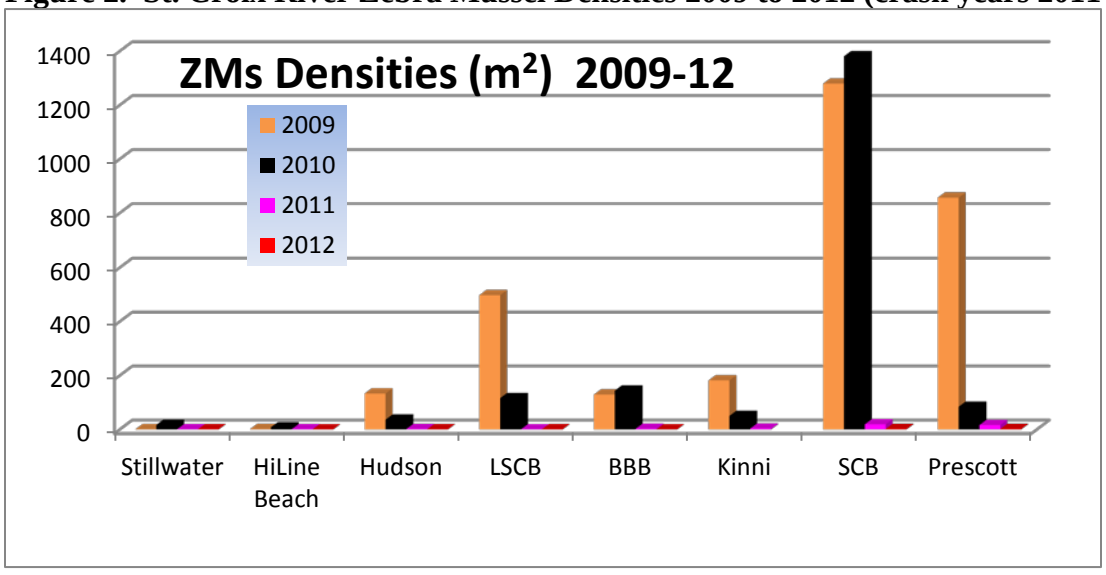

Table 1. St. Croix River Zebra Mussel Densities

Black Bass Bar	Kinni Narrows	St. Croix Bluffs	Prescott	
0	0	2.4	0.27	2013
0	NA	1.87	1.87	2012
2.13	3.2	18.93	16.27	2011
144	50	1381	84	2010
129.33	181.87	1279.47	856.8	2009
53.6	12.54	2295	612	2008
16.5	24.4	12288	574	2007
44	358.67	742	111	2006
1.06	8.5	89.33	71.73	2005
0.8	12.27	107.73	NA	2004

Figure 3. St. Croix River Zebra Mussel Densities, All Methods 2004-2013 (note ponar only samples lower four sites, 2013; 2007/08 data (12288/2295m^2 at St. Croix Bluffs removed to aid graphics)

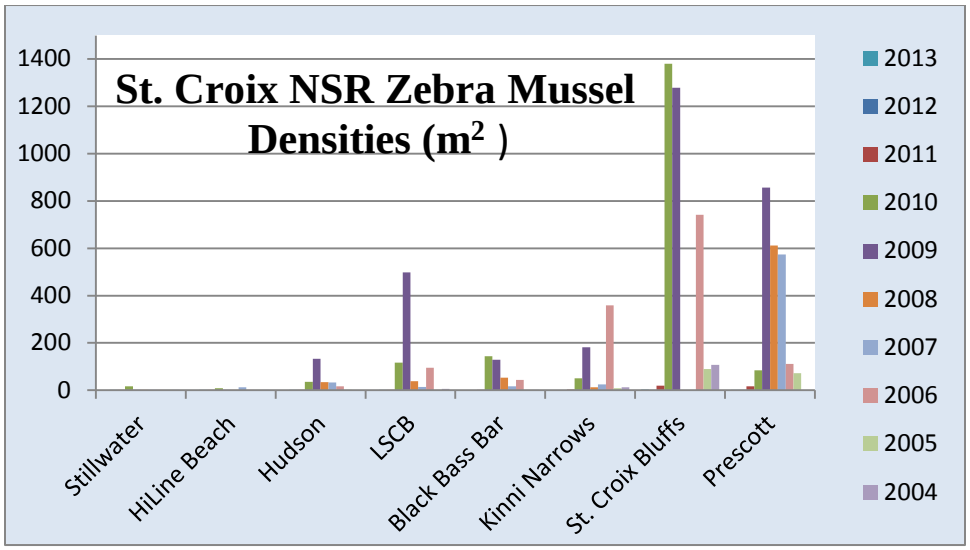

Figure 4. Number of Empty Zebra Mussel Shells as Part of Substrate Samples, 2013

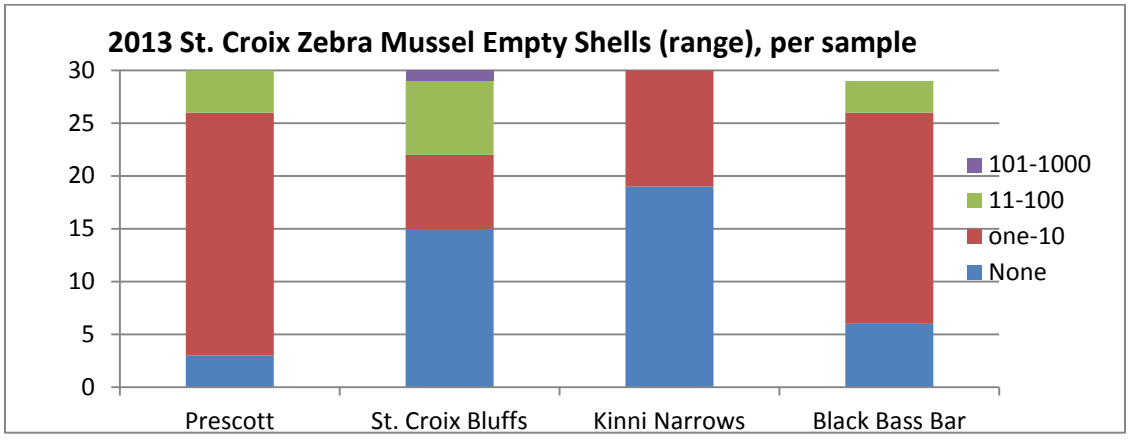

Figure 5. Approximate Quadrate Site Sampling (Red polygon is ACOE and Green is NPS: scale approx. 1km), Clockwise: Prescott, St. Croix Bluffs, Kinnickinnic Narrows, Black Bass Bar.

APPENDIX D

Table X. 2013 Results from St. Croix Basin Lakes – Minnesota and Wisoonsin, showing no veligers detected in analyzed samples.

CLIVR 0908

CLEAN LAKES INC. **Veliger Detection Report**

Company Name:	St. Croix National Scenic Riverway	Contact Person:	Byron Karns
Mailing Address:	401 Hamilton St	Billing Address:	
City/State/Zip:	St. Croix, WI, 54024	City/State/Zip:	
Telephone:	715-483-3284 Fax: 715-483-3288	Project Reference Name:	St. Croix NSR
Email Address:	byron_karns@nps.gov	Project Reference Number:	SC13002, 13004-13006, 13008-13015

Client Sample Site ID	Date Sample Collected	Date Sample Received	Detailed Sample Location	Clean Lakes Sample #	Date Sample Analyzed	Amount Tested (mL)	Results	Lab Notes
North Center Lake	8/28/2013	11/1/2013	South Launch	SC13002	11/30/2013	50	ND	Abundant organisms
Rush Creek	8/26/2013	11/1/2013	Impoundment Outflow at Field Stre	SC13004	11/30/2013	50	ND	Adequate organisms
Snake River	8/26/2013	11/1/2013	Cross Lake Boat Launch	SC13005	11/30/2013	50	ND	Abundant organisms
Snake River	8/26/2013	11/1/2013	Pokagama Outflow Boat Launch	SC13006	12/1/2013	50	ND	Adequate organisms
Big Trade Lake	8/29/2013	11/1/2013	N. End Boat Launch	SC13008	12/1/2013	50	ND	Adequate organisms
Bone Lake	8/29/2013	11/1/2013	Lion's Launch	SC13009	12/1/2013	50	ND	Adequate organisms
Minerva Lake Cha	8/27/2013	11/1/2013	Houman's Resort	SC13010	12/2/2013	50	ND	Adequate organisms
Yellow Lake	8/27/2013	11/1/2013	Yellow Lake Lodge, NW corner	SC13011	12/2/2013	50	ND	Abundant organisms
Clam Lake Floway	8/29/2013	11/1/2013	Lower Lake Launch	SC13012	12/2/2013	50	ND	Abundant organisms
Balsam Lake	8/28/2013	11/1/2013	Southwest Launch	SC13013	12/3/2013	50	ND	Adequate organisms
Deer Lake	8/28/2013	11/1/2013	Launch	SC13014	12/3/2013	50	ND	Adequate organisms
Bass Lake	8/15/2013	11/1/2013	Launch	SC13015	12/3/2013	50	ND	Adequate organisms

Report Submitted by:

12/4/2013

Leif Elgethun, Laboratory Director Date

Legend

ND:	No Veligers Detected	HC:	High Concentration
D:	Veligers Detected	LC:	Low Concentration
I:	Results Inconclusive	A:	Attachments

Contact: Leif Elgethun, Veliger Detection Manager, 1770 W. State St. #125., Boise, ID 83703, (208) 301-2293, Fax: (888) 330-8602, Email: leifelgethun@cleanlake.com