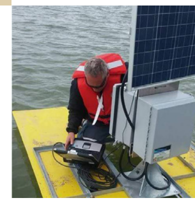
Coordinated Aquatic Monitoring Program



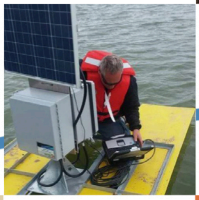
Six Year Summary Report

Appendix 1:
Sedimentation Monitoring Pilot Program

2008-2013

Submitted to:
Manitoba/Manitoba Hydro MOU Working Group

2017



Report Citation:

Coordinated Aquatic Monitoring Program (CAMP). 2017. Six Year Summary Report (2008-2013). Report prepared for Manitoba/Manitoba Hydro MOU Working Group by North/South Consultants Inc., Winnipeg, MB.

SEDIMENTATION MONITORING PILOT PROGRAM

PLAYGREEN LAKE 2013-2014

December 2016

STUDY TEAM

The study was conducted by Water Resourced Engineering Department at Manitoba Hydro. Field sampling was conducted by Hydraulic Operations Department at Manitoba Hydro. The report and and analysis was reviewed and approved by the Coordinated Aquatic Monitoring Program (CAMP) working group.

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1.0 Introduction

This report documents the findings of the first year of sedimentation monitoring under the Coordinated Aquatic Monitoring Program (CAMP). The working group determined that sedimentation monitoring should be incorporated into the CAMP in an effort to better understand the physical environment influences on other key parameters (fisheries, benthos, water quality, etc.) already included in the program.

This work was initiated to integrate the collection of physical environment monitoring into the CAMP. The monitoring was carried out on Playgreen Lake during the summer and fall (open water season) of 2013 and winter 2014 (ice covered season). This report outlines the background, methodology and data collected, as well as preliminary analysis and observations. Findings from this study will also be used to adapt the CAMP sedimentation monitoring as the program moves towards longer term and wider area system monitoring.

1.1 Background

In the long term, the CAMP intends to monitor sedimentation on a system-wide scale, however it was decided that it would be of value to first initiate a program to examine the sedimentation processes of representative water bodies in detail to guide the development of a system-wide program. The scope of this study is therefore more detailed than what will likely be adopted for the general CAMP. The scope of the pilot program was developed at a March 2013 CAMP workshop.

Sedimentation and sediment transport are complex natural processes occurring in Playgreen Lake and have been influenced to some extent by Lake Winnipeg Regulation (LWR). A previous study of erosion and sedimentation on Playgreen Lake (MacLaren, 1985) concluded that the erosion and sedimentation regime of the lake is not dramatically different during the pre- and post-LWR periods. This study also concluded that the rate of shoreline recession in Playgreen Lake, even at shorelines highly susceptible to erosion was virtually identical pre- and post-regulation. However, despite these previous findings, interest exists in the sedimentation processes of Playgreen Lake and the relationship to LWR.

1.2 Study Objectives

The objectives of the Playgreen Lake Sedimentation Monitoring pilot program were to:

- Monitor sediment under low, medium and high flow conditions with the goal of determining whether sedimentation processes respond to varying flow conditions.
- Document the current state of sediment transport and sedimentation.
- Use the Playgreen Lake study to test and review monitoring methods that may facilitate a more efficient system-wide approach to sedimentation monitoring.

The long-term objectives of the CAMP physical environment monitoring program are as follows:

- Monitor the long term changes of processes.
- Provide long term information on the physical parameters that will enable assessment of environmental conditions over time with recognized environmental quality indices and guidelines.
- Provide information that can be used to aid in licensing of future hydroelectric facilities and relicensing existing facilities, and to assess potential impact of the existing hydraulic system.

1.3 Monitoring Scope

This pilot program included the collection of sediment transport and deposition data in Playgreen Lake during the open water and winter (ice covered) seasons. This was the first year of data collection on Playgreen Lake and was done during an above average year (or high flows), based on the general flow conditions during the monitoring period. It was originally planned to monitor under high, medium and low flow as conditions. However, since the sedimentation program was initiated there has been a change to focus on broad system monitoring, using the information collected in Playgreen Lake and other monitoring programs to shape the program.

Methods and scope of future monitoring may change based on the findings of this work, other studies, and stakeholder input. The focus of the monitoring was predominantly on the south basin of Playgreen Lake, with one sampling location at the outlet of the lake in the North Basin (Figure 1). The monitoring program included the collection of:

- Total suspended sediment (TSS) concentration and discrete turbidity at 50 sampling sites at three times during the open water season,

- TSS concentration and discrete turbidity at 27 sampling sites at two times during the winter season,
- Continuous turbidity data at 7 sites during the open water season,
- Continuous turbidity data at 7 sites during the winter season,
- Bedload and bed material at 21 sites,
- Sediment depositional information at 15 sites,

Table 1 outlines which parameters were collected at each monitoring site; this information is also shown in Figure 1.

2.0 Sedimentation Data and Analysis

2.1 Suspended Sediment

2.1.1 Total Suspended Solids (TSS)

Water samples were collected from 50 discrete monitoring sites between the inlet and outlet of Playgreen Lake. At each site, duplicate samples were collected at 0.3 and 0.6 m depths following standard protocols. All 50 sites were sampled between July and September 2013, while 27 sites were sampled in January and February 2014. The samples were analyzed in a laboratory to determine the TSS concentration and sediment particle size.

Figures 2 to 8 display the TSS levels for each of the 50 monitoring sites sampled in the open water season and Figures 9 and 10 show the values for the 27 sites sampled in winter. Table 2 presents the average TSS concentration during each site visit. Figure 11 shows the variation of TSS along the length of Playgreen Lake from upstream to downstream. Figures 12 to 14 show depth averaged discrete TSS levels overlaid with the daily average wind speed and direction (wind speed data from Norway House Airport).

The TSS levels at most of the monitoring sites were between 2 and 54 mg/L, from July 2013 to February 2014. At most sampling locations TSS levels were similar for the deep and shallow measurements. The majority of TSS concentrations, almost 90%, are less than 25 mg/L and almost 80% were lower than 20 mg/L. However, TSS levels at sites PL-S-06a, PL-S-07a and PL-S-07b were elevated in September, exceeding 85 mg/L to as high as 156 mg/L. This is likely due to their location near the outlet of Two Mile Channel and the erodible south bank of Playgreen Lake. The TSS variation along Playgreen Lake (Figure 11) suggests that sediment concentrations are generally higher for sites nearest to the exit of 2-mile channel and decrease in the downstream direction. Based on the limited amount of data available at this time it is uncertain if elevated sediment concentrations near 2-mile channel are a result of sediment originating in Lake Winnipeg, within 2-mile channel, or local erosion within Playgreen Lake. Overlaying wind data with the discrete TSS measurements (Figures 12 to 14) did not identify any observable cause for elevated TSS levels. Winds during the late September collection were lighter than during the July collection; however TSS levels in this area were higher.

TSS concentrations during the ice covered season were typically low, with an average concentration less than during the open water season (Table 2). The reduced TSS concentrations are likely related to the presence of the ice cover preventing waves and protecting the shoreline from wind driven erosion.

Future sedimentation studies may benefit from additional monitoring locations near the inlet and outlet of Two Mile Channel to determine where suspended sediment is originating.

2.1.2 Suspended Sediment Particle Size

Water samples taken at the 50 discrete monitoring sites were analyzed to produce the particle size distribution charts shown in Figures 15. The analysis indicated that the suspended sediments consisted of mostly coarse and medium silts.

2.2 Turbidity

Continuous and discrete turbidity data were collected along the length of Playgreen Lake. Continuous data was collected at 7 sites in the study area, while discrete readings were collected at the 50 discrete monitoring sites when water samples were taken. The YSI EXO2 sondes used to collect the continuous and discrete turbidity data report turbidity in Nephelometric Turbidity Units (NTU).

At each site duplicate readings were recorded at 0.3 and 0.6 m relative depths following standard protocols. Discrete turbidity recordings were made during each of the 3 open water site visits (OW1 to 3) and during the January ice covered site visit (IC1). Figure 16 shows the magnitude and variation of turbidity along the length of Playgreen Lake from upstream to downstream. The turbidity readings at discrete sites ranged between 1 and 66 NTU. The discrete turbidity data shows a similar trend to the TSS data with elevated values in the south central region of the lake. As with the TSS data, the cause of higher levels is uncertain with this limited amount of data but could be related to the proximity of these sites to the erodible south bank of the lake and Two Mile Channel.

As was the case with the TSS data, turbidity levels during the ice covered site visit were lower than open water levels with an average of 4.5 NTU. Average turbidity data is presented in Table 2.

The continuous turbidity loggers were deployed at 2 m below the water surface. The continuous turbidity data was reviewed and suspect data removed before converting data into 15 minute averages to facilitate the production of the plots. Figures 17 and 18 show the continuous turbidity data for the open water and ice covered season, respectively.

During the open water season turbidity readings ranged between 15 and 179 NTU. The turbidity levels from four of the continuous monitoring sites (PL-S-03a, 11b, 18a, and 21a) were relatively low with maximum levels between 15 and 45 NTU. Sites PL-S-09b, 14b experienced greater variability. PL-S-06a located near the outlet of Two-Mile Channel recorded turbidity readings that were much higher than the other sites with a maximum level of 179 NTU. However, due to equipment issues, this site only provided recordings in late September.

In an attempt to investigate what might be causing periods of elevated turbidity, the continuous data for site PL-S-09b (the most variable complete record) was plotted along with flow and wind data. The flow rate through Playgreen Lake was approximated using a dataset calculated by adding the discharge of the Jenpeg Generating Station and the East Channel of the upper Nelson River. Wind data used in the analysis was calculated using the max gust velocity at the Norway House Airport to develop a three day running average wind condition; this data is presented in Figure 19. The plotted data indicates that there is not a significant correlation between turbidity levels and flow. There is a significant drop in flow rate over a short period in August however turbidity levels fluctuate similarly in the early summer at high flows as they do in the fall under lower flows. There appears to be a stronger correlation between wind and turbidity, with elevated turbidity levels often corresponding to periods of sustained high winds.

2.3 Bed Material and Bed Load

Bed material samples were collected at 20 of the discrete monitoring sites during the summer 2013. These sites extended along the study area including the outlet of two-mile channel and the inlet of eight-mile channel.

Figures 20 to 32 show the grain size distribution of bed material collected in summer 2013. The samples range from silt to coarse gravel with sites nearer the center of the lake being coarser than the sites near the shoreline.

Bedload sampling resulted in no bedload being trapped in the device (i.e. a bedload rate below measurable rates). Therefore, bedload sampling was dropped from the monitoring scope after the first year.

2.4 Sediment Traps

Fifteen sediment traps were deployed throughout the study area. Each sediment trap consisted of three vertical cylinders placed near the lake bed for a period of 72 – 82 days. No results are available from the sediment traps due to problems in recovery of the sediment traps.

3.0 Summary of Key Observations

This pilot program included the collection of sediment transport and sedimentation data in Playgreen Lake during the open water and winter (ice covered) seasons. This was the first year of data collection under CAMP on Playgreen Lake and was done under relatively high flow condtions. Subsequent monitoring may be modified based on the findings of this work, other studies, and stakeholder input. The key observations of this year's data analysis are:

- The majority of discrete TSS measurements were below 25 mg/L, and turbidity readings had similar trends as TSS.
- The highest TSS and turbidity levels were observed in the central region of the south basin near 2-mile channel. It is uncertain at this time if they are a result of sediment originating in Lake Winnipeg, within 2-mile channel, or from local erosion within Playgreen Lake. Subsequent studies may benefit from additional monitoring locations near the inlet and outlet of Two Mile Channel to determine where suspended sediment is originating.
- TSS and turbidity levels during the ice covered season were low, showing less variability and lower average levels than during the open water season. The reduced turbidity is likely related to the presence of the ice cover preventing waves and protecting the shoreline from wind driven erosion.
- Continuous turbidity monitoring indicated that there is likely a correlation between wind and turbidity. As with the discrete data, these preliminary observations will be examined further as successive years of data are collected.
- Bedload rates were nil at the monitoring sites.

TABLES

Table 1: Playgreen Lake 2013/14 Sedimentation Monitoring Sites

Name	Easting	Northing	TSS & Tu Open Water	TSS & Tu Winter	Continuous Turbidity	Bedload & Bed Material	Sediment Traps
PL-S-01a	575163	5949862	x	x		x	
PL-S-01b	576163	5949851	x				x
PL-S-01c	577186	5949829	x			x	
PL-S-02a	575124	5953060	x	x			
PL-S-03a	574468	5954754	x		x		x
PL-S-03b	575536	5955433	x				
PL-S-04a	571788	5956022	x	x		x	
PL-S-04b	572834	5956945	x	x		x	
PL-S-05a	566000	5958336	x	x			
PL-S-05b	567310	5959351	x	x			
PL-S-06a	563704	5958770	x	x	x	x	x
PL-S-07a	562670	5959853	x				x
PL-S-07b	563921	5960622	x	x		x	x
PL-S-07c	565645	5961804	x	x		x	x
PL-S-08a	562472	5963300	x				
PL-S-08b	563729	5964176	x				
PL-S-09a	559836	5966051	x				x
PL-S-09b	561500	5967136	x	x	x	x	x
PL-S-09c	563463	5968537	x	x		x	x
PL-S-10a	555694	5967808	x				
PL-S-10b	557334	5968853	x				
PL-S-10c	559359	5970110	x	x		x	
PL-S-10d	561277	5971313	x	x		x	

Name	Easting	Northing	TSS & Tu Open Water	TSS & Tu Winter	Continuous Turbidity	Bedload & Bed Material	Sediment Traps
PL-S-11a	551963	5971777	x				
PL-S-11b	553273	5972583	x				x
PL-S-11c	554715	5973324	x	x	x	x	x
PL-S-11d	556369	5974237	x	x		x	
PL-S-11e	557599	5974952	x				
PL-S-12a	548511	5975748	x				
PL-S-12b	549953	5976489	x				
PL-S-12c	551633	5977282	x	x			
PL-S-12d	552942	5977997	x	x			
PL-S-12e	554093	5978526	x				
PL-S-13a	547426	5981212	x				
PL-S-13b	548405	5981780	x	x		x	
PL-S-13c	549344	5982402	x	x		x	
PL-S-14a	546335	5985018	x				x
PL-S-14b	547839	5985055	x	x	x	x	x
PL-S-14c	549230	5985106	x				
PL-S-15a	546407	5986265	x	x		x	x
PL-S-16a	547677	5987337	x				
PL-S-16b	548444	5986808	x	x			
PL-S-16c	549053	5986424	x				
PL-S-17a	548593	5989790	x				
PL-S-17b	549913	5988686	x	x		x	
PL-S-17c	551037	5987853	x				
PL-S-18a	551924	5991173	x	x	x	x	x

Name	Easting	Northing	TSS & Tu Open Water	TSS & Tu Winter	Continuous Turbidity	Bedload & Bed Material	Sediment Traps
PL-S-19a	552559	5992999	x	x			
PL-S-20a	553405	5994295	x	x		x	
PL-S-21a	564763	6027724	x	x	x	x	

Table 2: Discrete Data Collection Summary

Site Visit	Date Range	Average TSS (mg/L)	Average Turbidity (NTU)
OW1	July 9-15, 2013	15.14	18.34
OW2	Aug. 25-Sept. 5, 2013	11.12	10.39
OW3	Sept. 21-28, 2013	22.95	17.70
IC1	Jan. 24-29, 2014	6.87	4.94
IC2	Feb. 25-27, 2014	4.07	no data

OW: Open Water site
IC: Ice Covered site

FIGURES

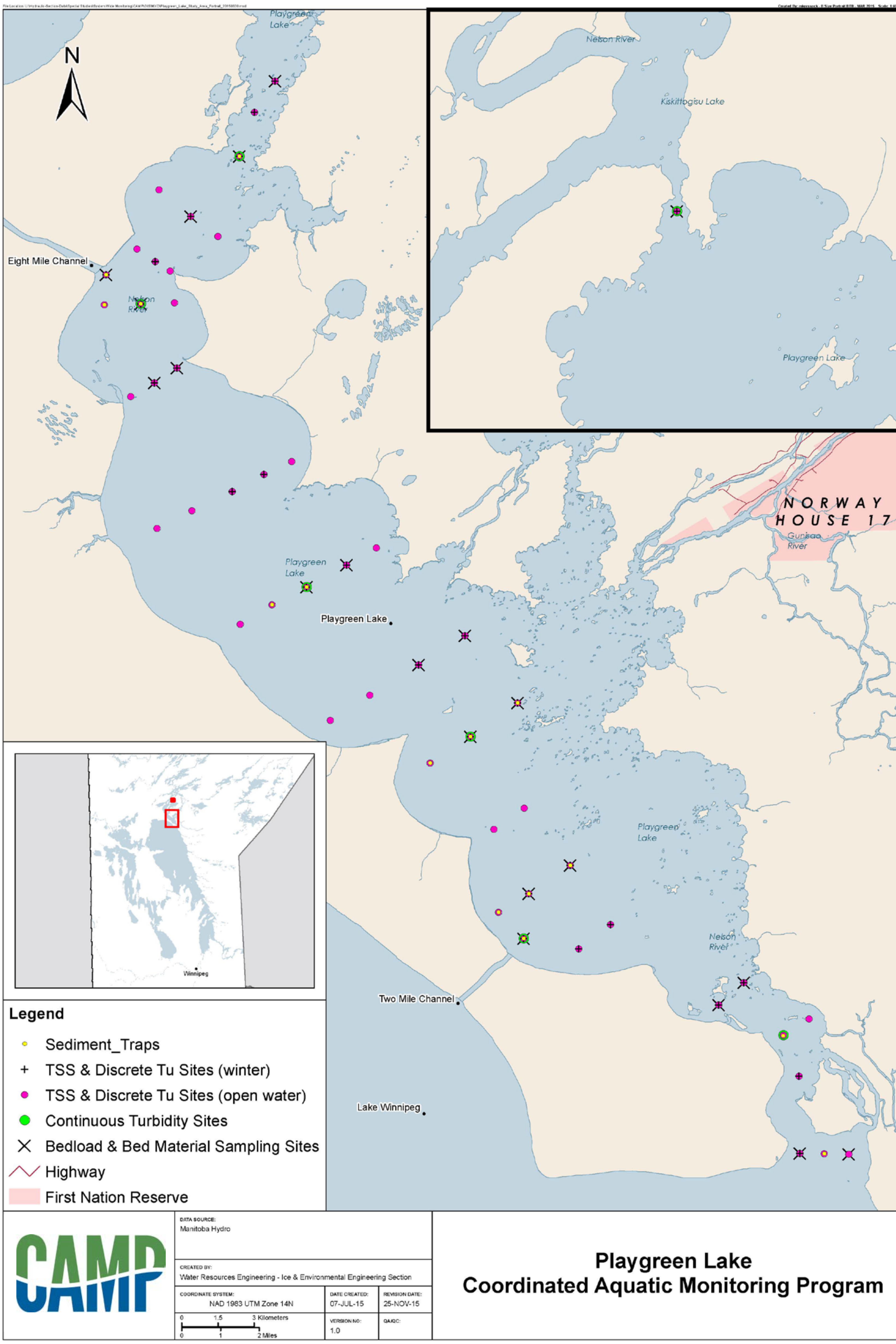


Figure 1: Playgreen Lake Study Area

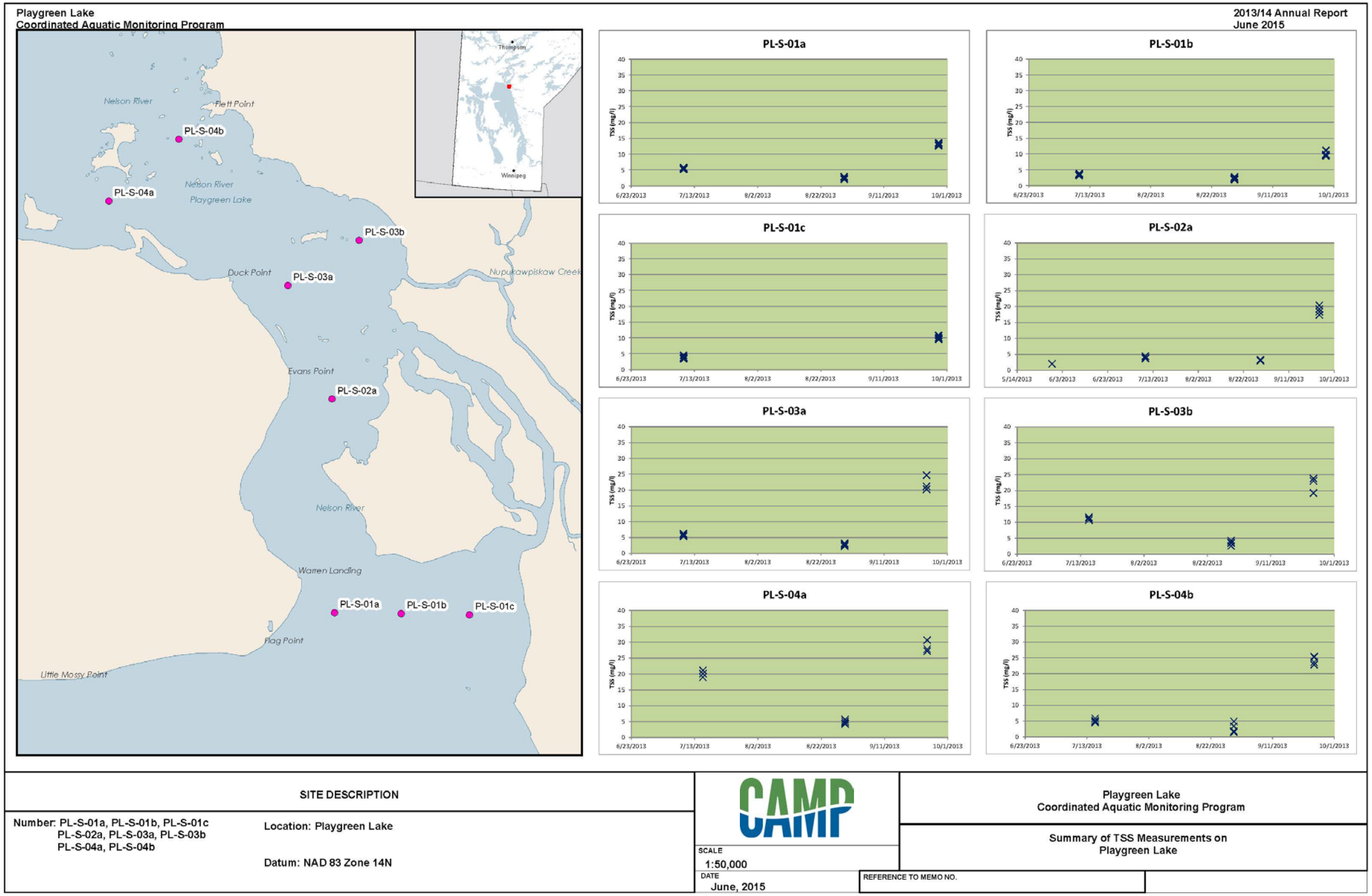


Figure 2: Open Water Discrete TSS data Sites PL-S-01a to 04b

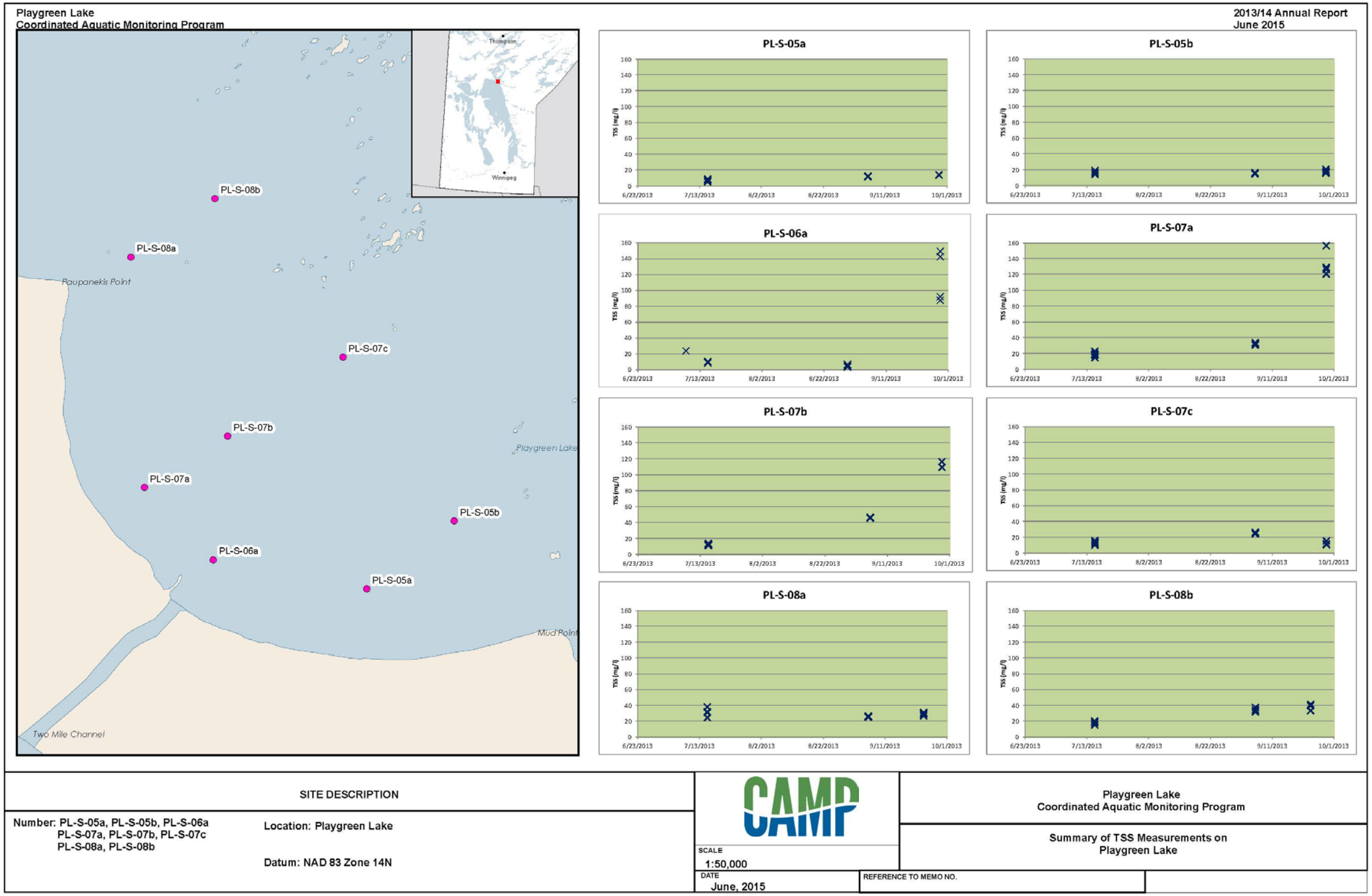


Figure 3: Open Water Discrete TSS data Sites PL-S-05a to 08b

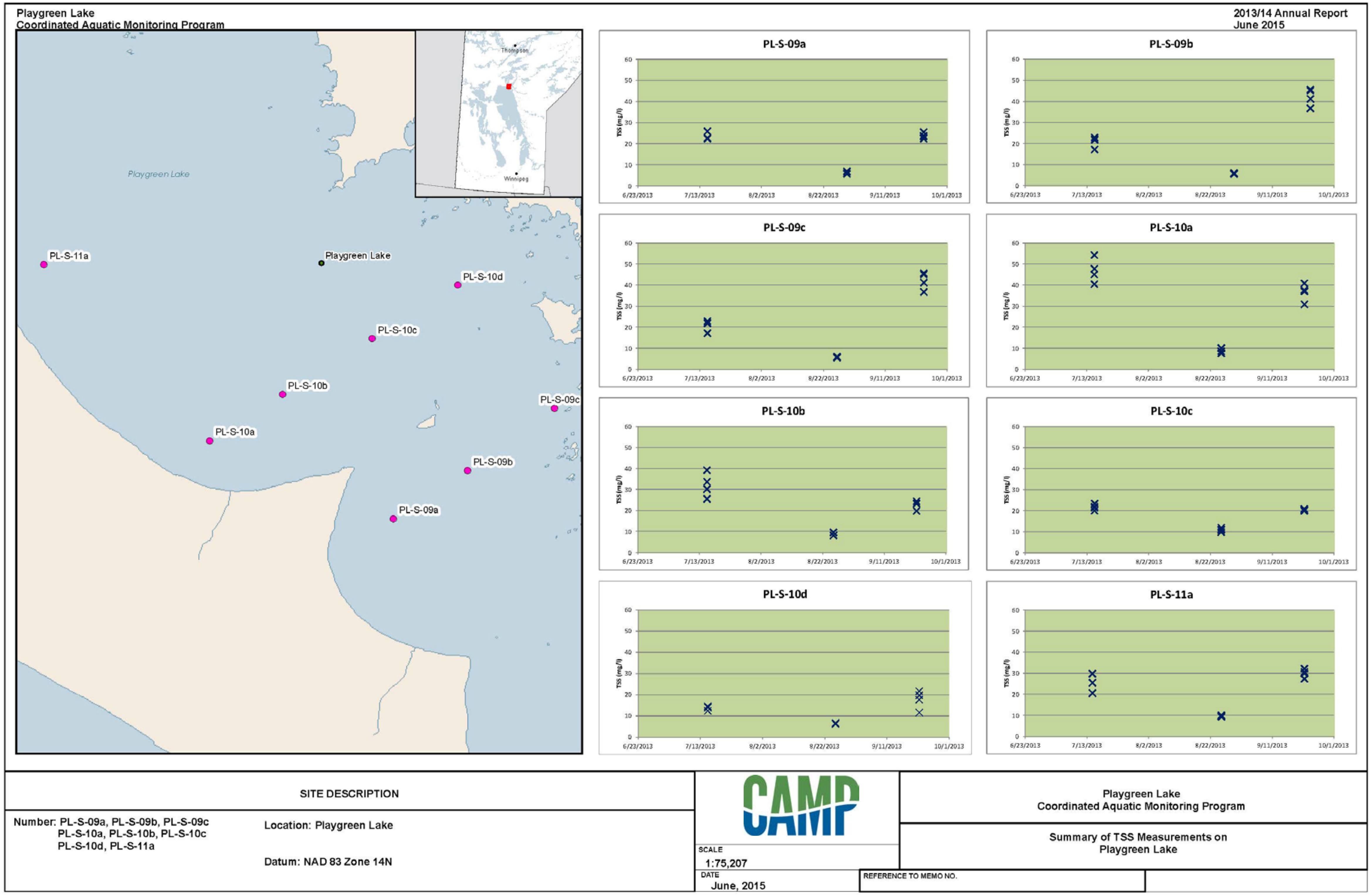


Figure 4: Open Water Discrete TSS data Sites PL-S-09a to 11a

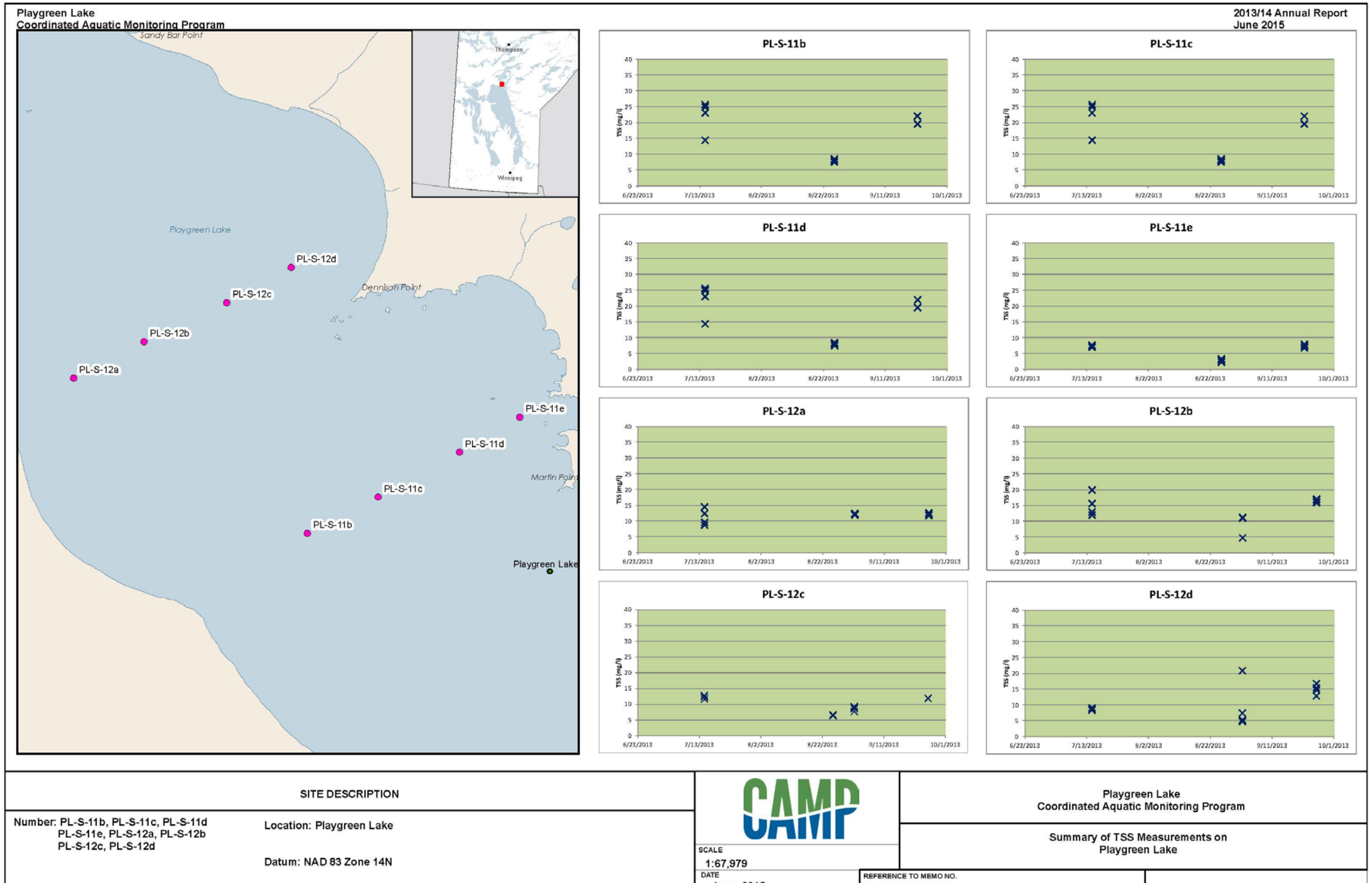


Figure 5: Open Water Discrete TSS data Sites PL-S-11b to 12d

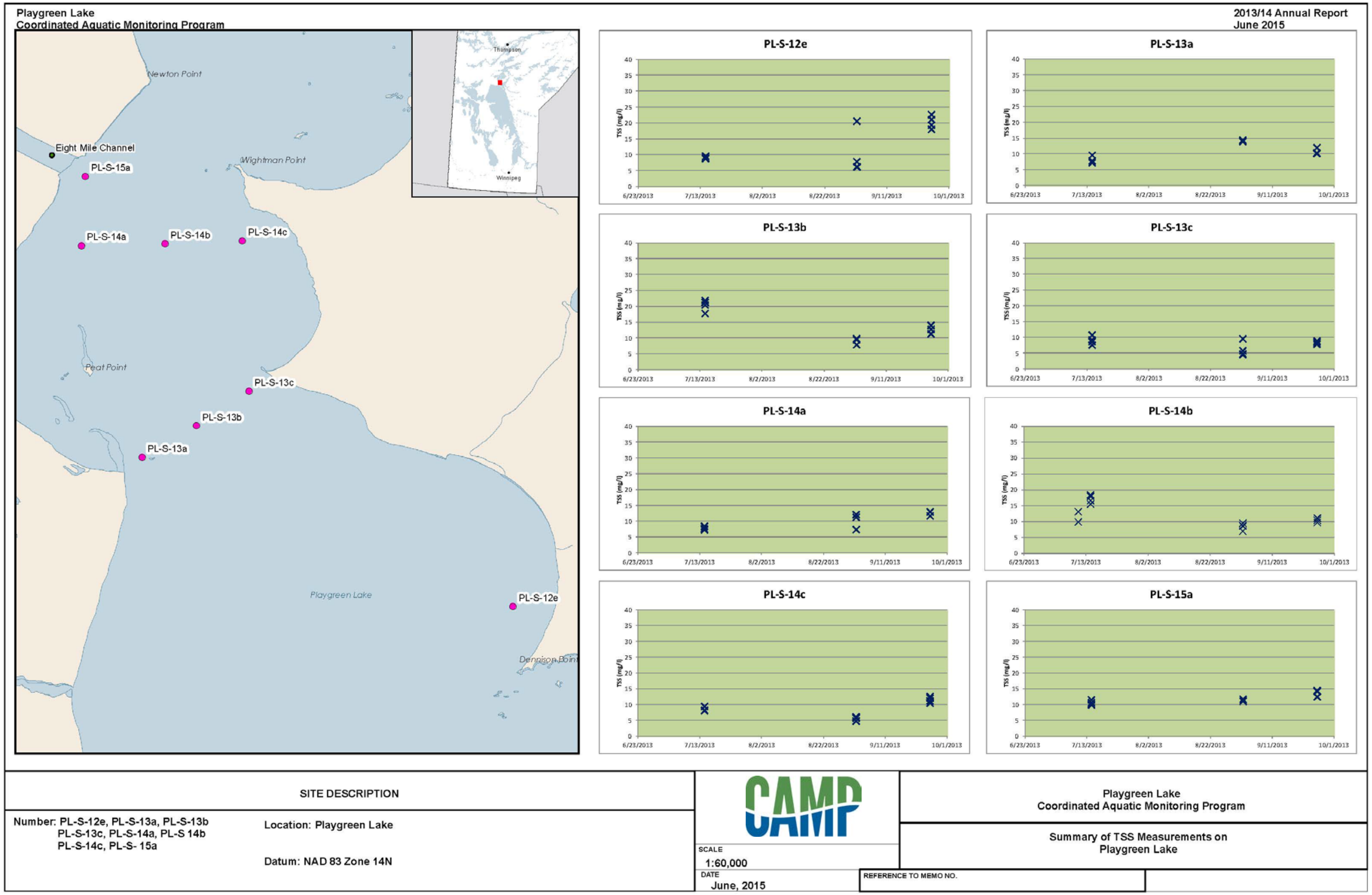


Figure 6: Open Water Discrete TSS data Sites PL-S-12e to 15a

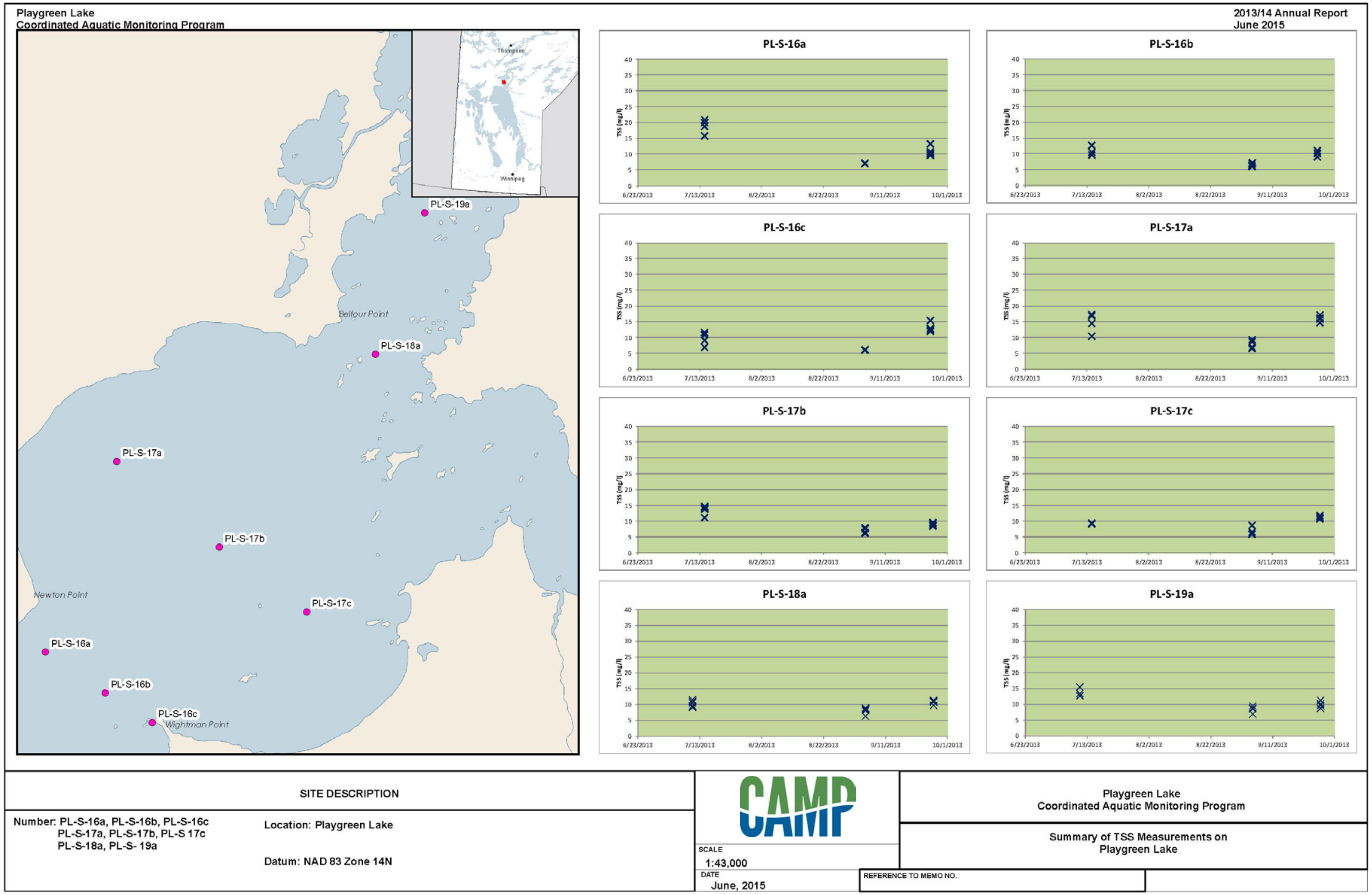


Figure 7: Open Water Discrete TSS data Sites PL-S-16a to 19a

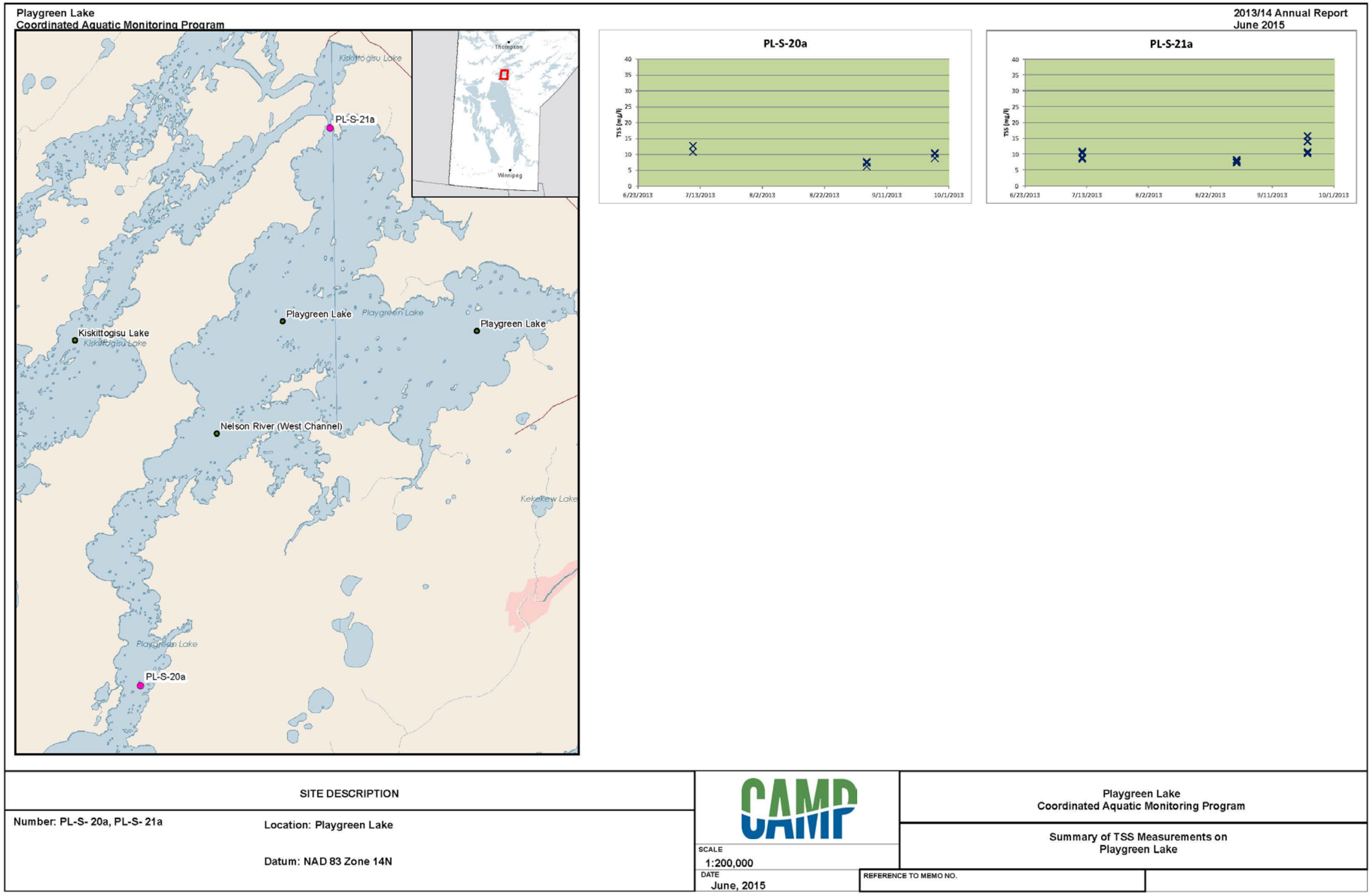


Figure 8: Open Water Discrete TSS data Sites PL-S-20a to 21a

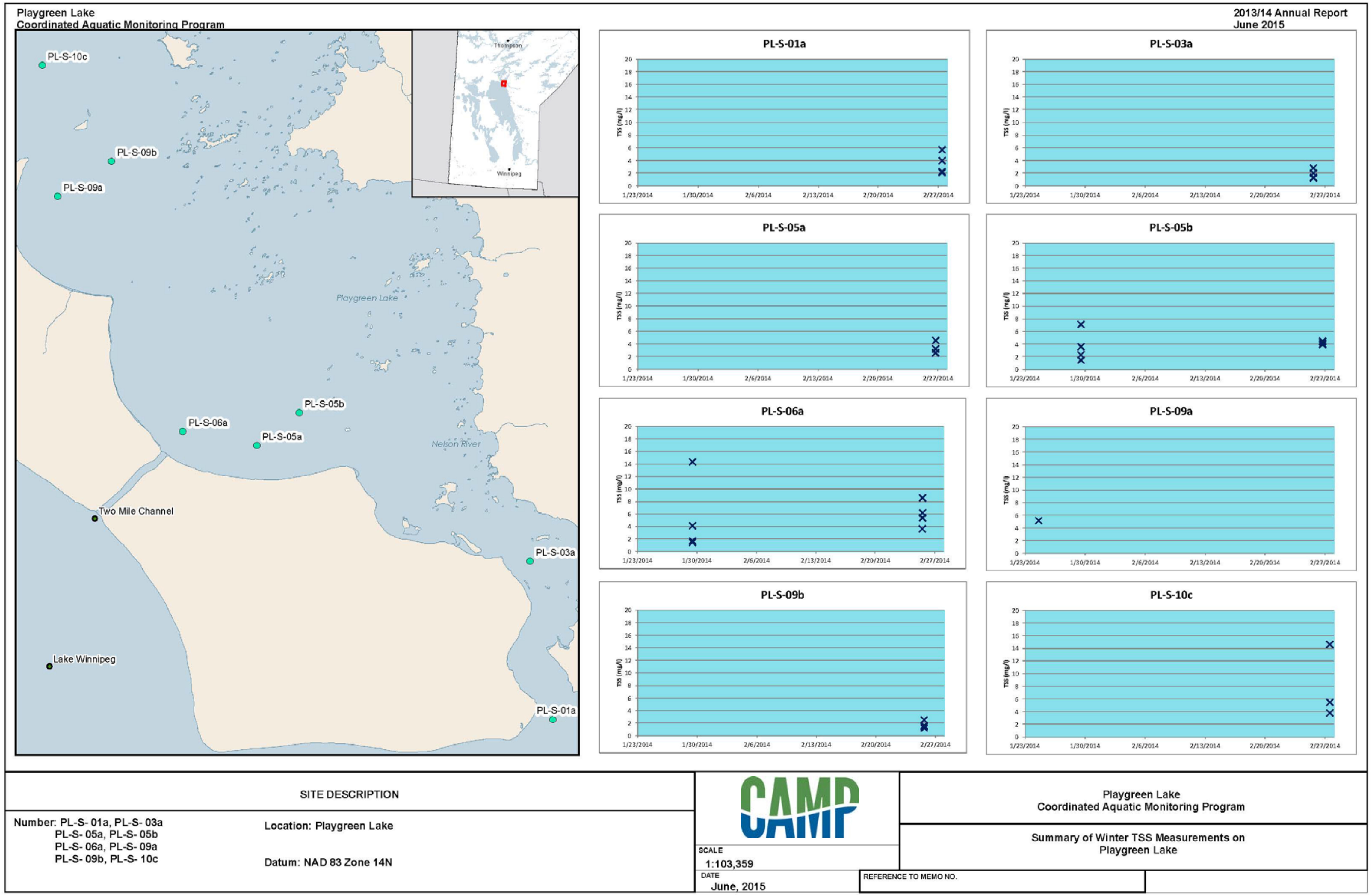


Figure 9: Ice Covered Discrete TSS data Sites PL-S-01a to 10c

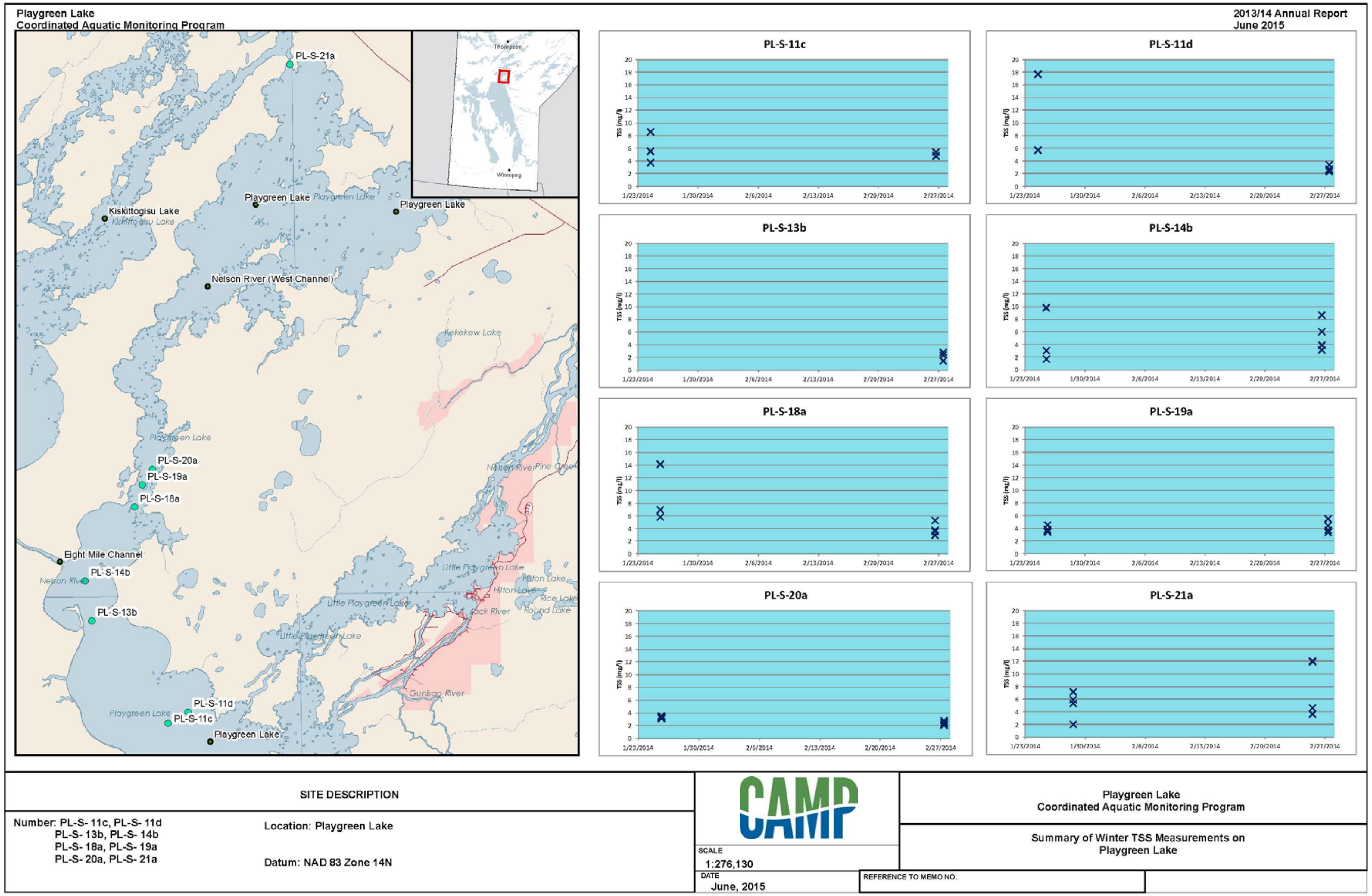
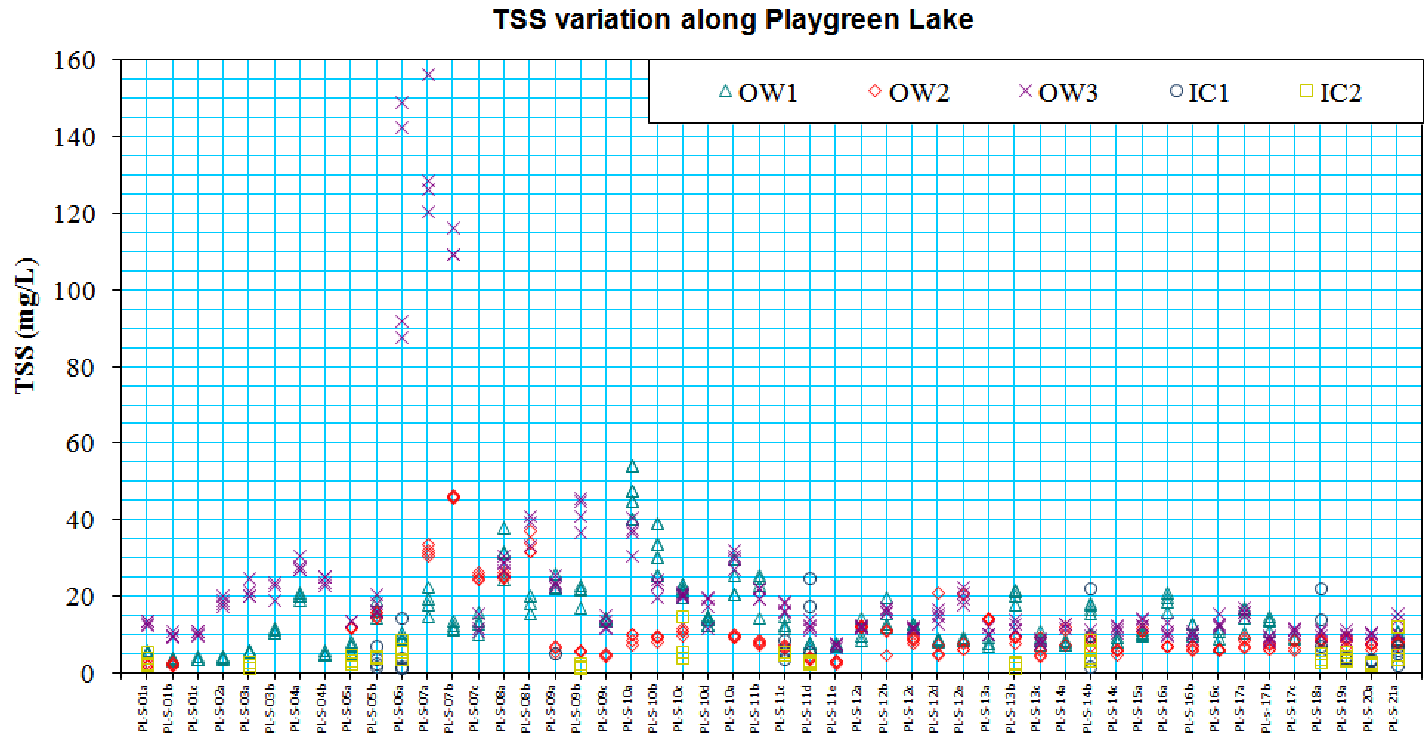


Figure 10: Ice Covered Discrete TSS data Sites PL-S-11c to 21a



Datum: NAD 83 Z14 N

Established: 2013

CAMP

Playgreen Lake
Coordinated Aquatic Monitoring Program

TSS Variation Along
Playgreen Lake (2013 / 2014)

SCALE
NTS

DATE
Nov. 2015

Figure 11: Discrete TSS variation along Playgreen Lake

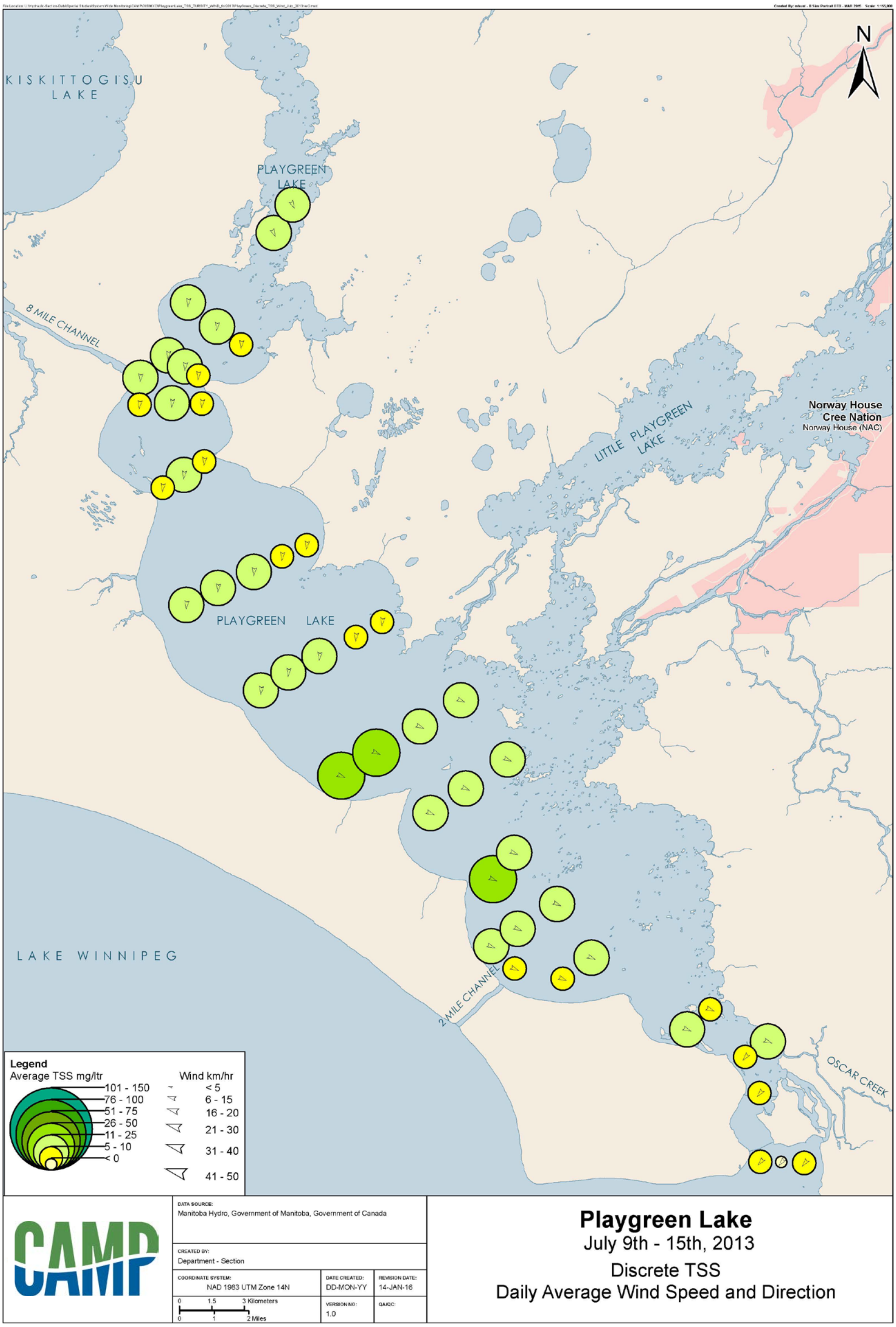


Figure 12: Playgreen Lake OW1 site visit depth averaged discrete TSS measurements with daily average wind speed and direction

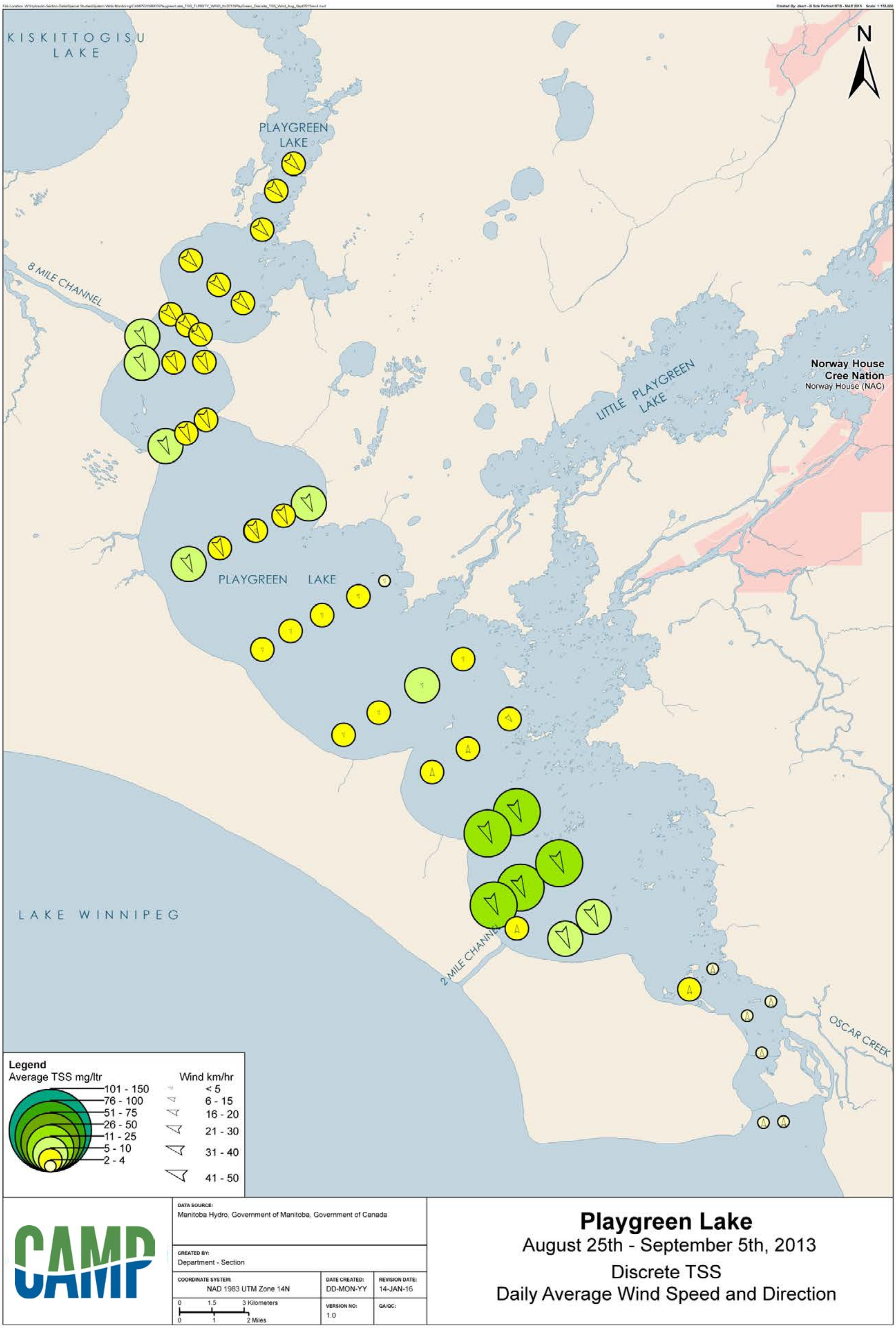


Figure 13: Playgreen Lake OW2 site visit depth averaged discrete TSS measurements with daily average wind speed and direction

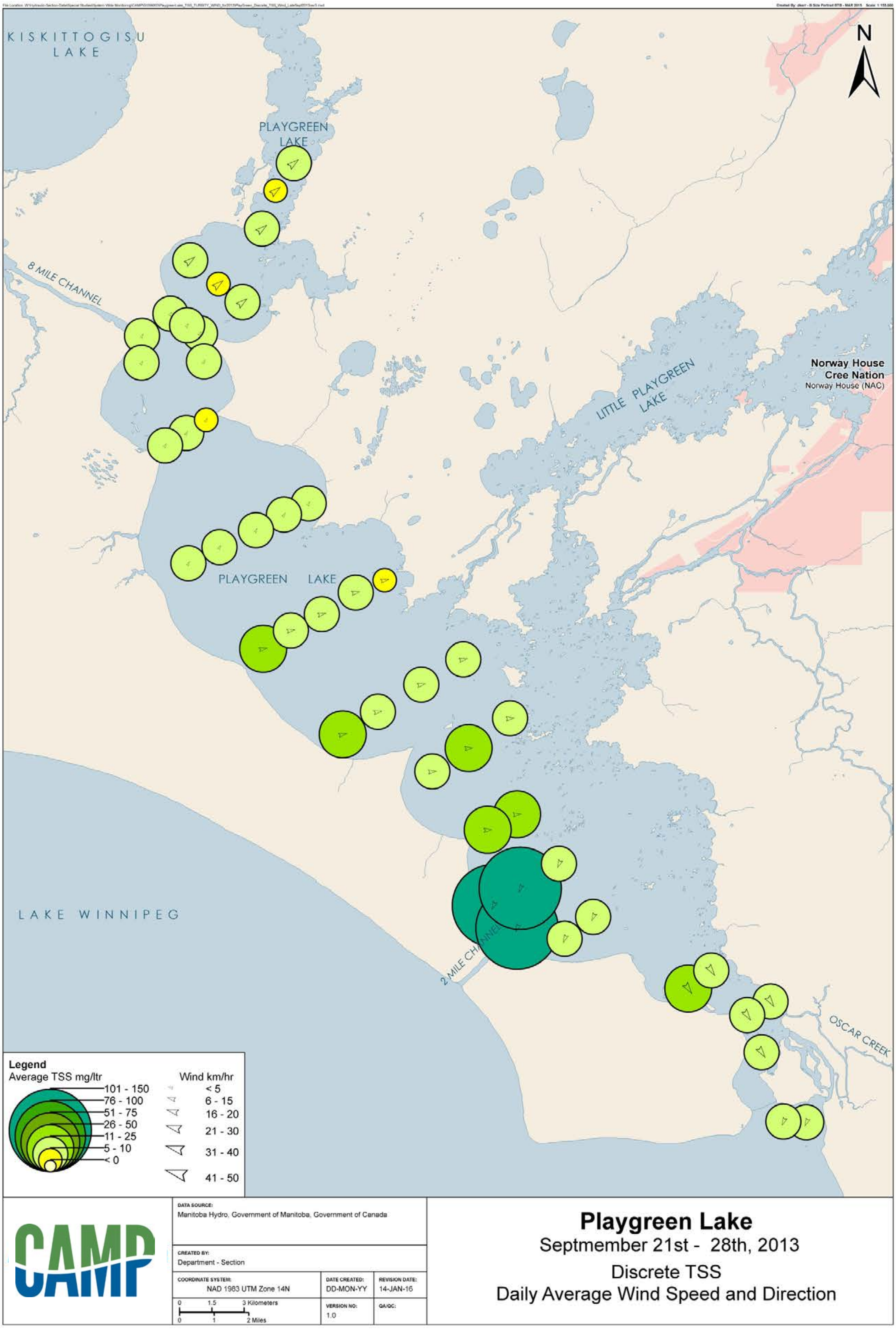
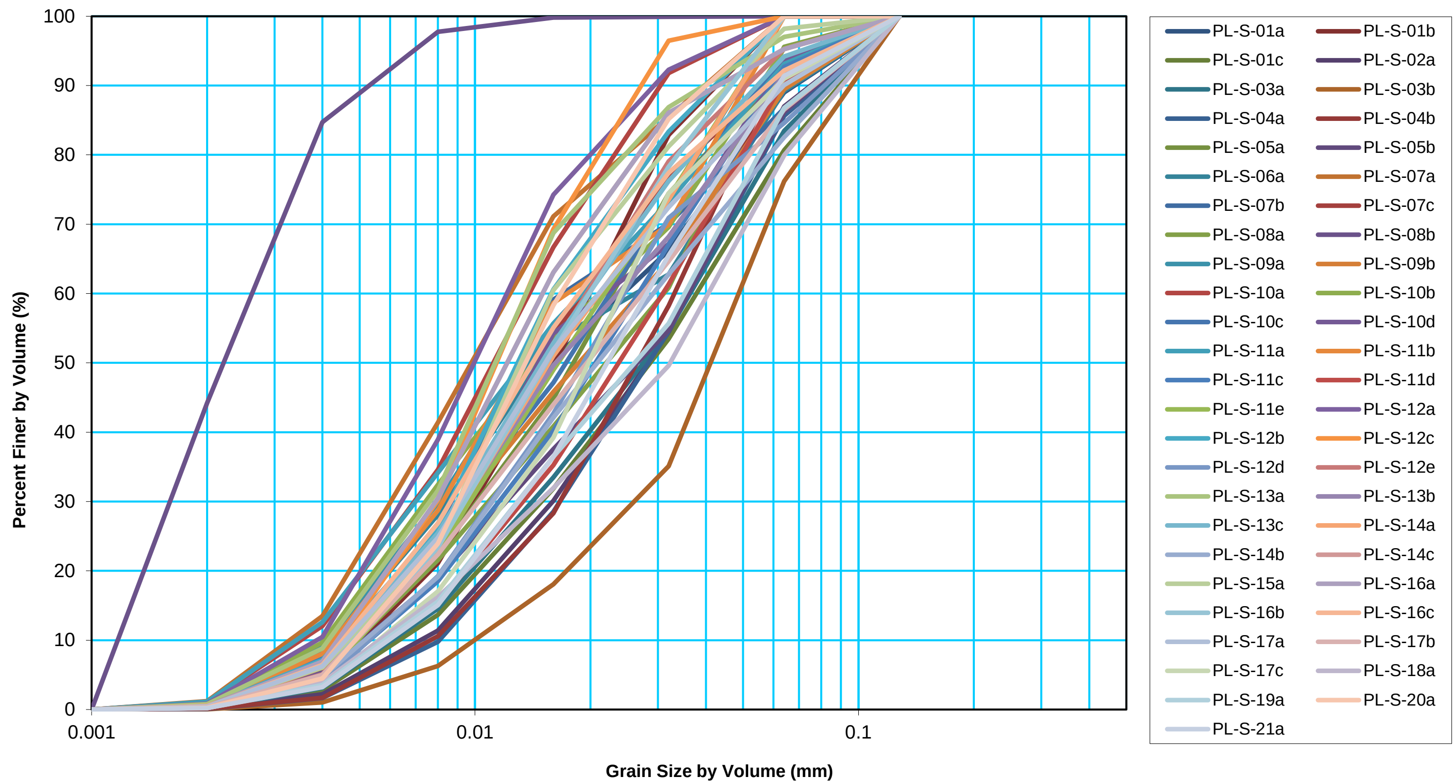
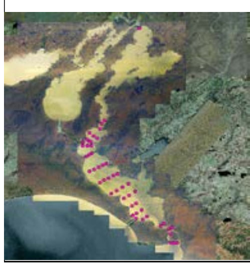


Figure 14: Playgreen Lake OW3 site visit depth averaged discrete TSS measurements with daily average wind speed and direction





SITE DESCRIPTION

Number: PL-S-01a,b,c, PL-S-02a, PL-S-03a,b, PL-S-04a,b, PL-S-05a,b, PL-S-6a, PL-S-07a,b,c, PL-S-08a,b, PL-S-09a,b, PL-S-10,a,b,c,d, PL-S-11a,b,c,d,e, PL-S-12a,b,c,d,e, PL-S-13a,b,c, PL-S-14a,b,c, PL-S-15a, PL-S-16a,b,c, PL-S-17a,b,c PL-S-18a, PL-S-19a, PL-S-20a, PL-S-21a

Datum: NAD 83 Z14 N

CAMP

Coordinated Aquatic Monitoring Program

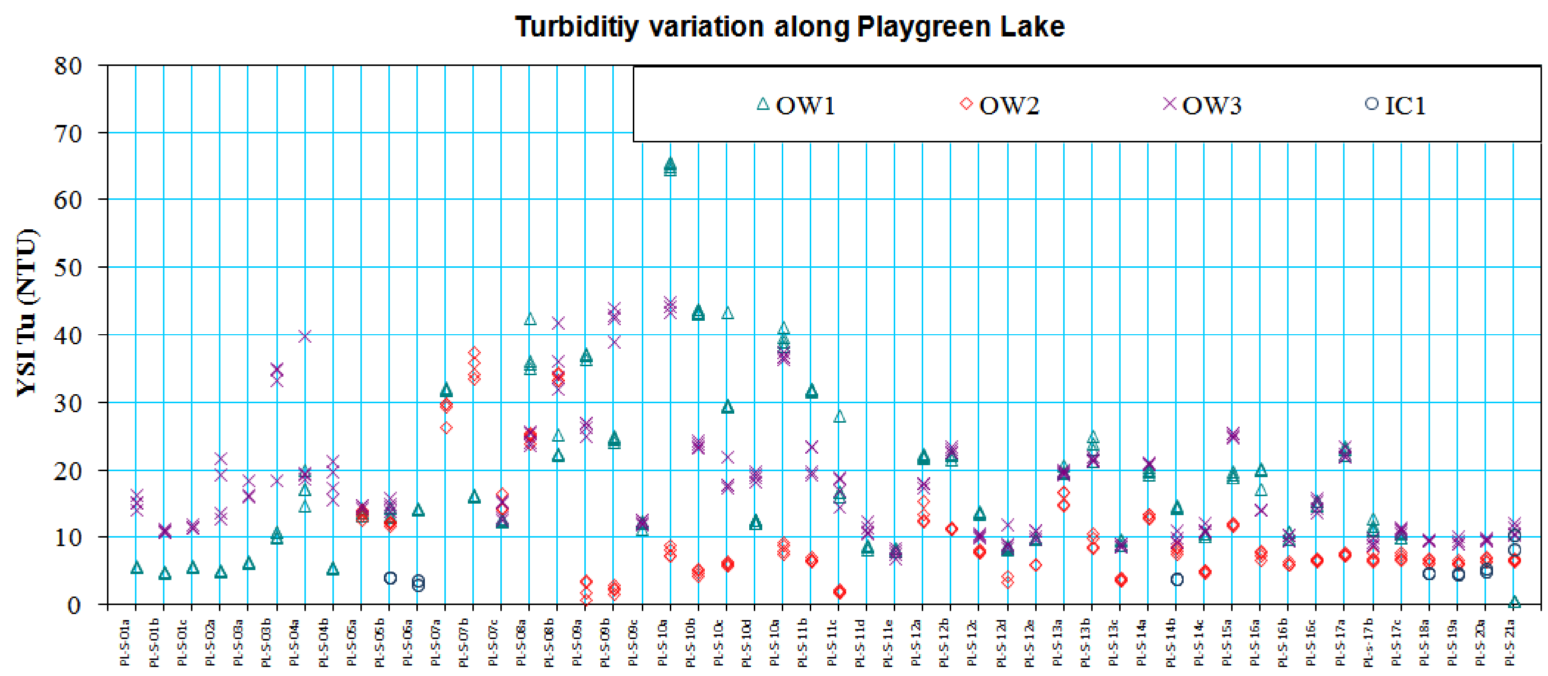
Particle Size Distribution at
All Monitoring Sites
(Summer 2013)

SCALE
NTS

DATE
March 2015

REFERENCE TO MEMO NO.

Figure 15: Playgreen Lake TSS particle size distribution



Datum: NAD 83 Z14 N

Established: 2013

CAMP

SCALE
NTS

DATE
Nov 2015

Playgreen Lake
Coordinated Aquatic Monitoring Program

Turbidity Variation Along
Playgreen Lake (2013 / 2014)

Figure 16: Discrete Turbidity Data along Playgreen Lake

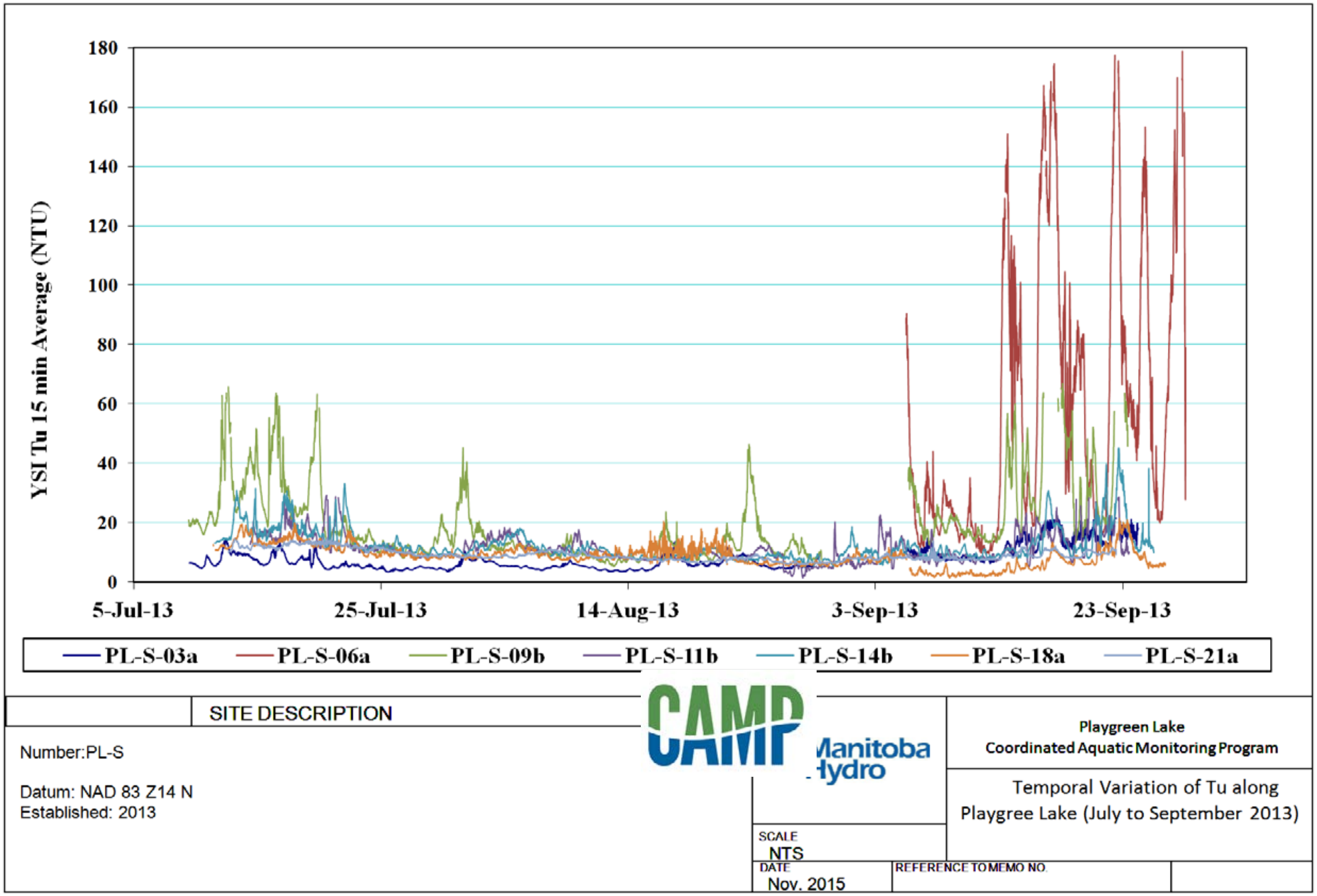
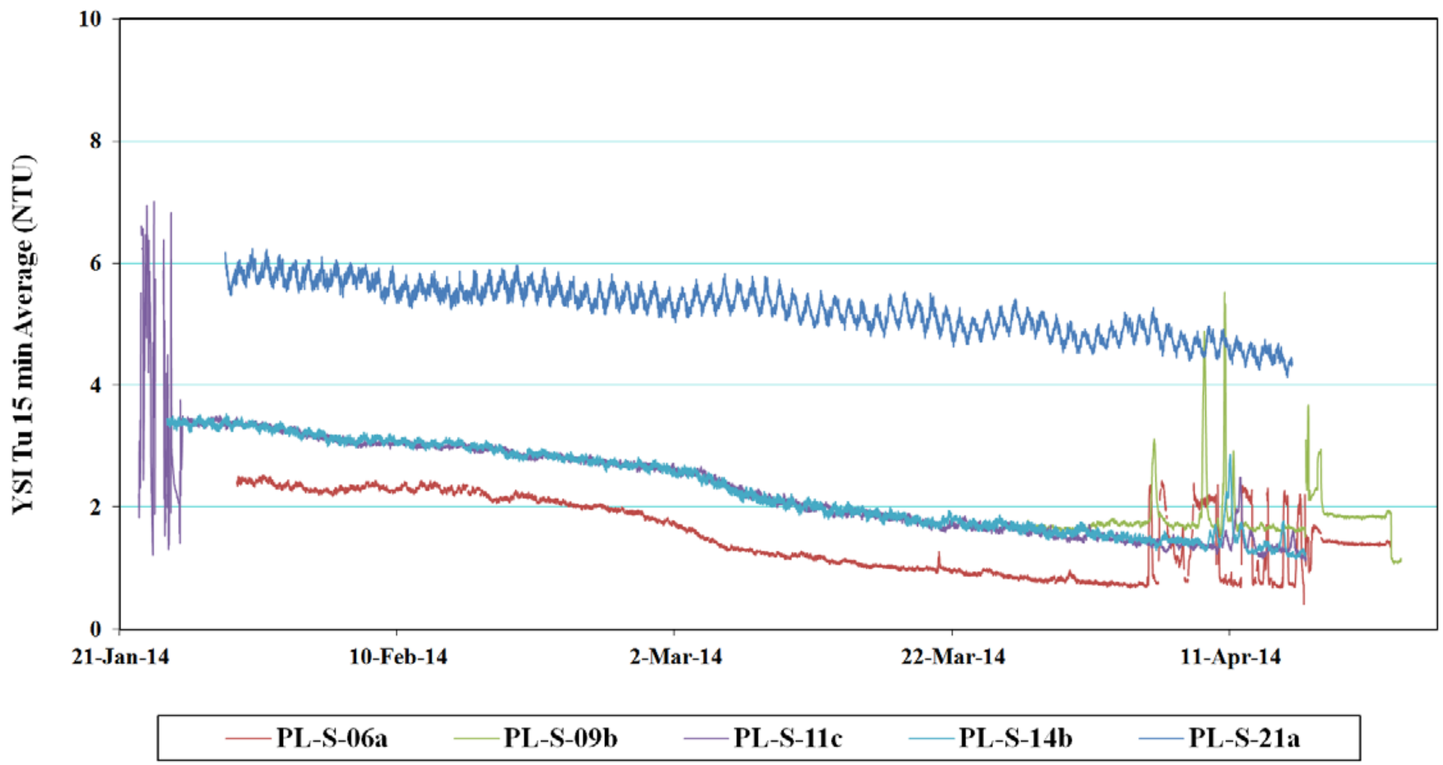
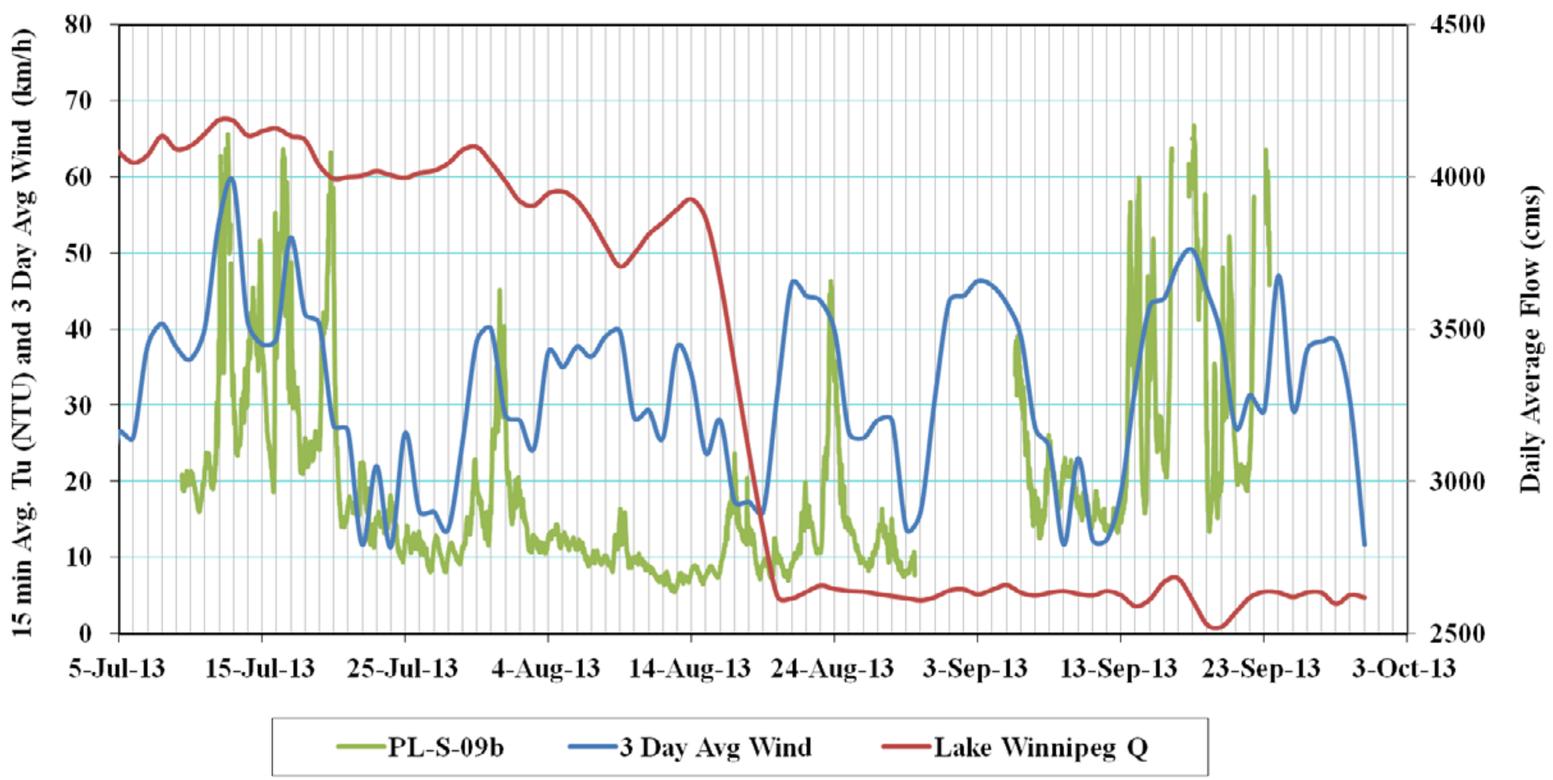


Figure 17: Open water continuous turbidity data



	SITE DESCRIPTION	CAMP	Playgreen Lake Coordinated Aquatic Monitoring Program
Number: PL-S Datum: NAD 83 Z14 N Established: 2013		SCALE NTS	Temporal Variation of Tu along Playgreen Lake (January to April 2014)
		DATE Nov. 2015	REFERENCE TO MEMO NO.

Figure 18: Ice covered continuous turbidity data



SITE DESCRIPTION

Number:PL-S

Datum: NAD 83 Z14 N
Established: 2013

Playgreen Lake
Coordinated Aquatic Monitoring Program

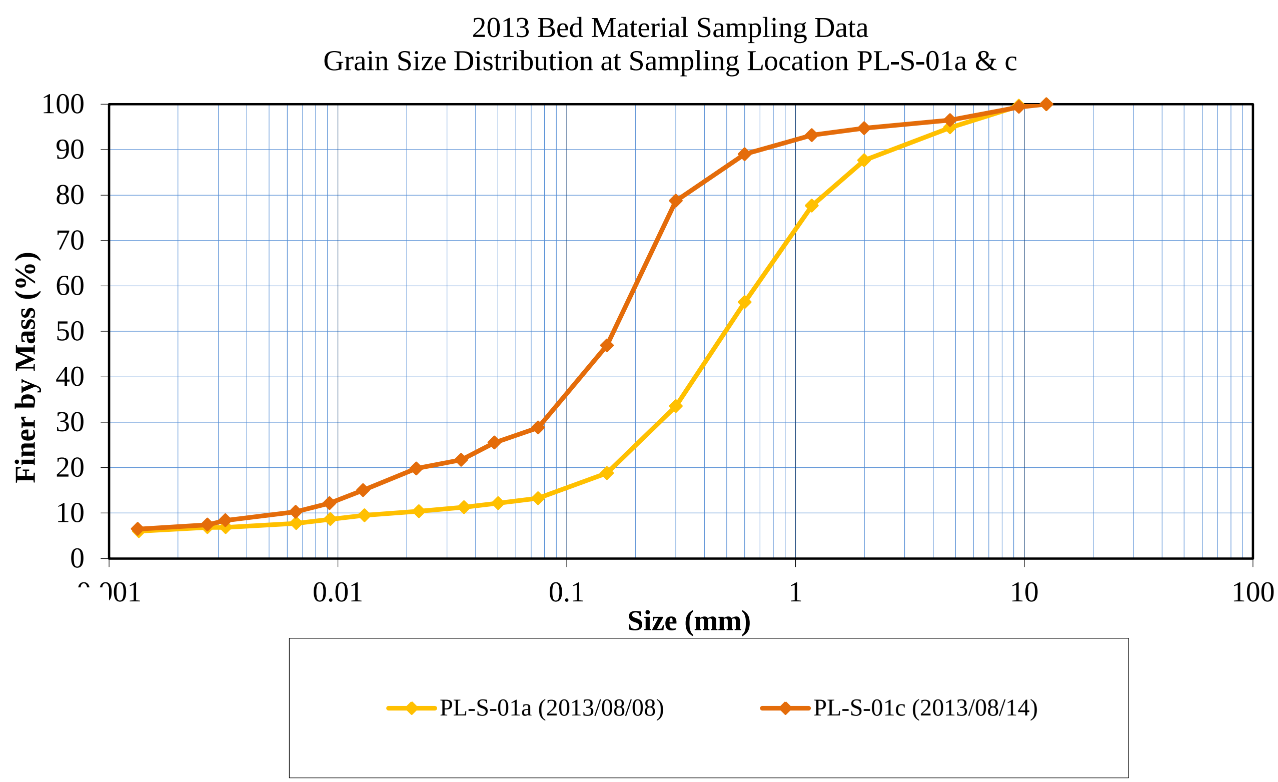
Tu, Wind and Flow Analysis
(July to September 2013)

SCALE
NTS

DATE
Nov. 2015

REFERENCE TO MEMO NO.

Figure 19: PL-S-09b open water continuous turbidity, wind and flow analysis



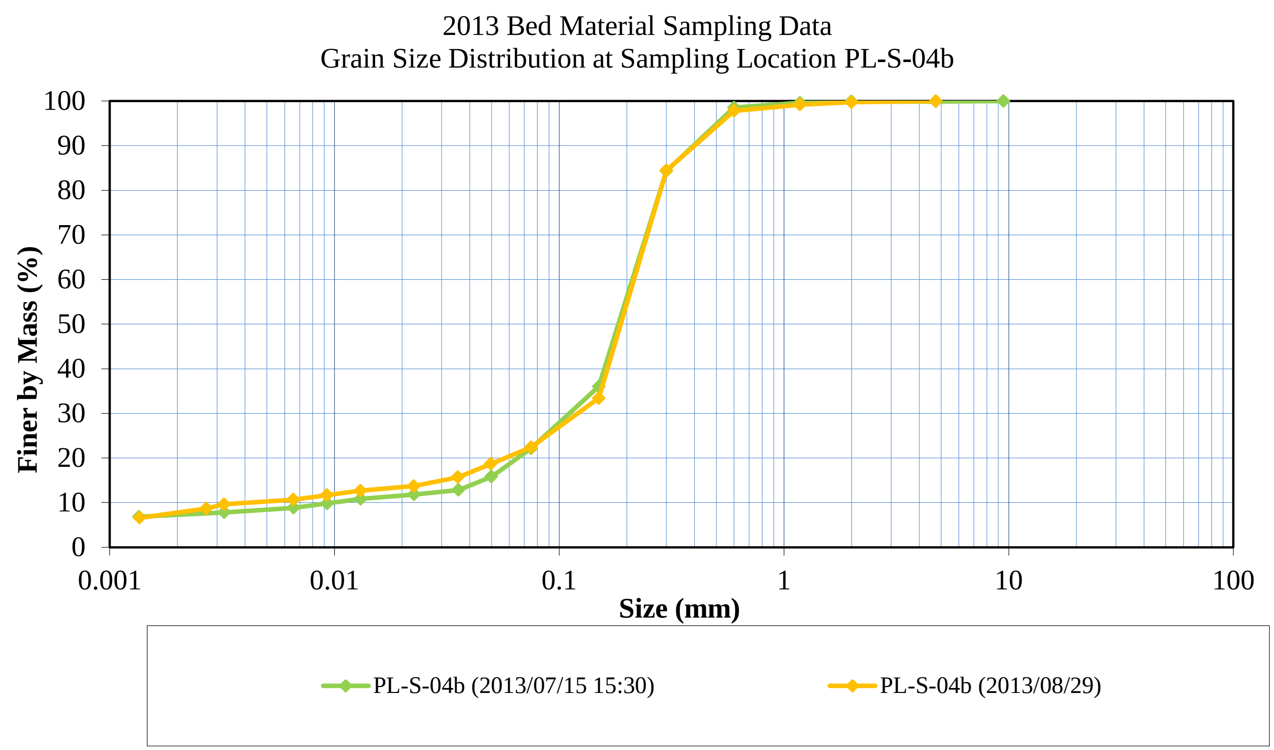
SITE DESCRIPTION

Playgreen Lake
Coordinated Aquatic Monitoring Program

Bed Material Sampling Data
Grain Size Distribution at Sampling Location PL-S-01a & c (2013)

SCALE	DATE	REFERENCE TO MEMO NO.
NTS	March 2015	

Figure 20: Bed material grain size distribution sites PL-S-01a & 01c



SITE DESCRIPTION

Playgreen Lake
Coordinated Aquatic Monitoring Program

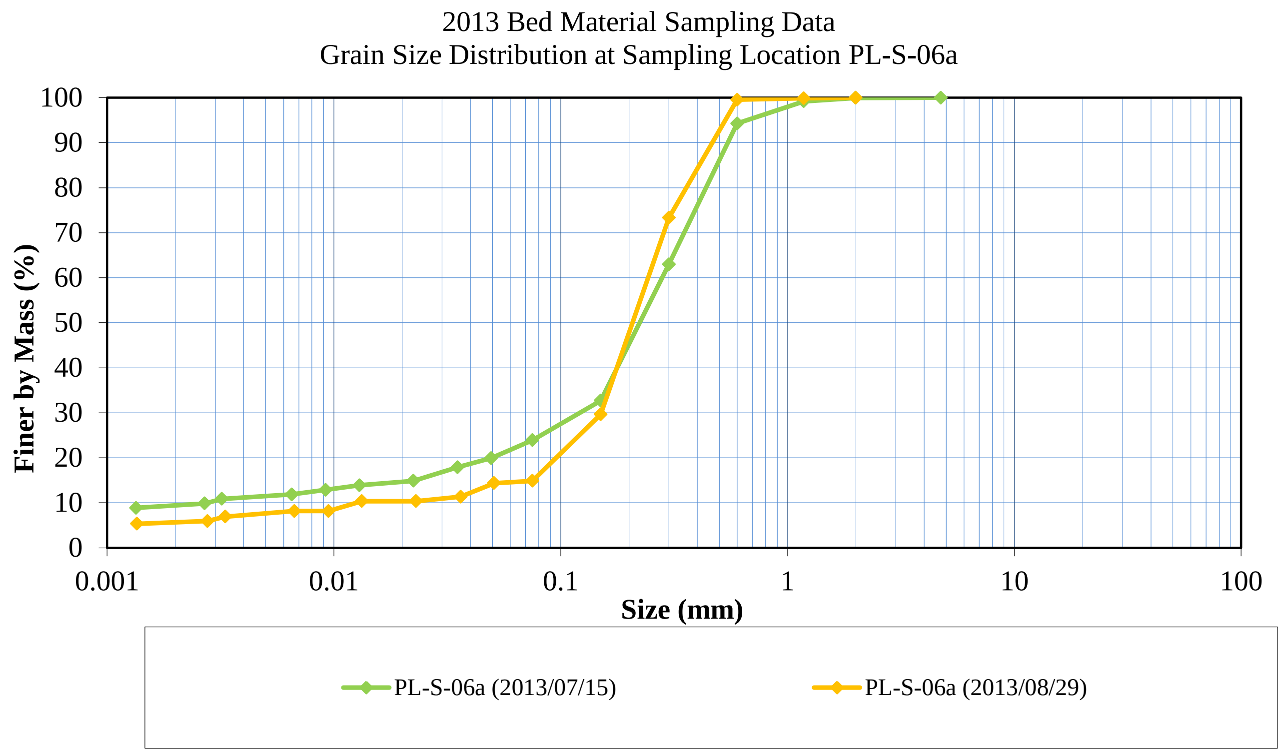
Bed Material Sampling Data
Grain Size Distribution at Sampling Location PL-S-04b (2013)

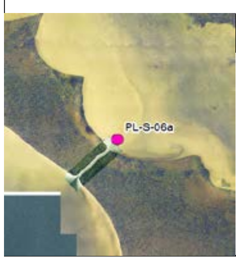
SCALE
NTS

DATE
Dec 2014

REFERENCE TO MEMO NO.

Figure 21: Bed material grain size distribution site PL-S-04b





SITE DESCRIPTION

Coordinated Aquatic Monitoring Program

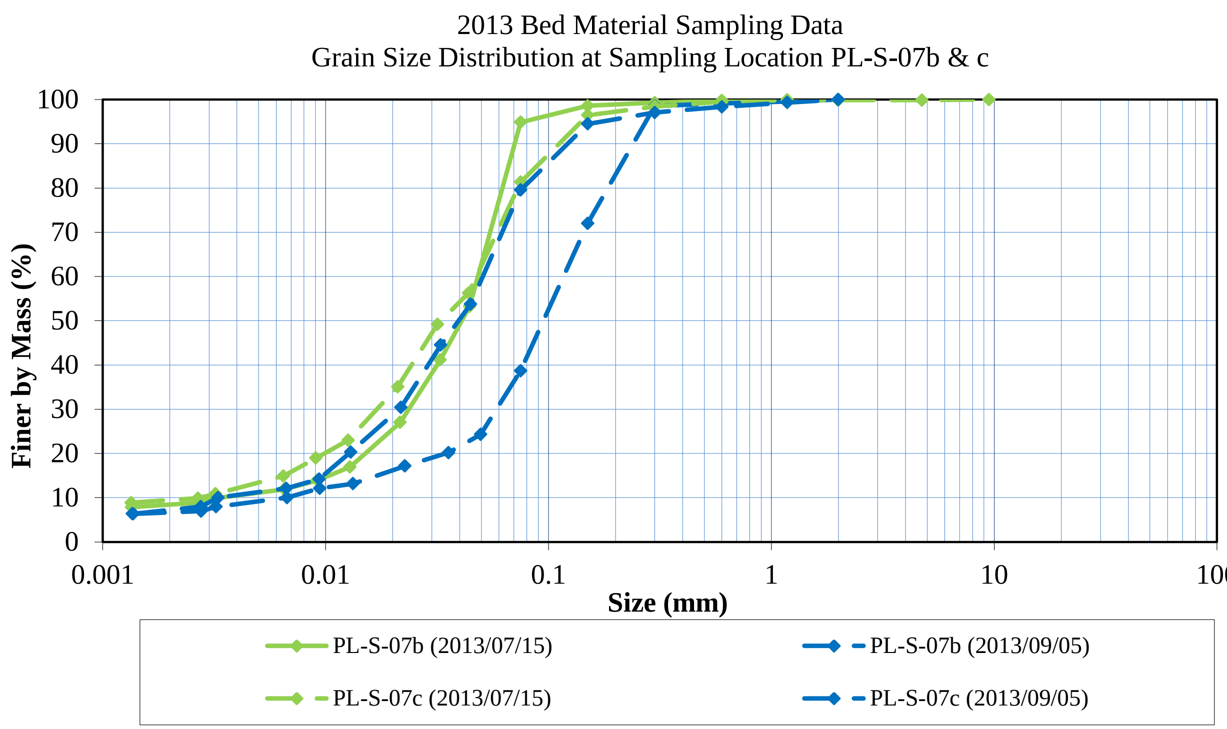
Bed Material Sampling Data
Grain Size Distribution at Sampling
Location PL-S-06a (2013)

SCALE
NTS

DATE
Dec 2014

REFERENCE TO MEMO NO.

Figure 22: Bed material grain size distribution site PL-S-06a



SITE DESCRIPTION

CAMP

Coordinated Aquatic Monitoring Program

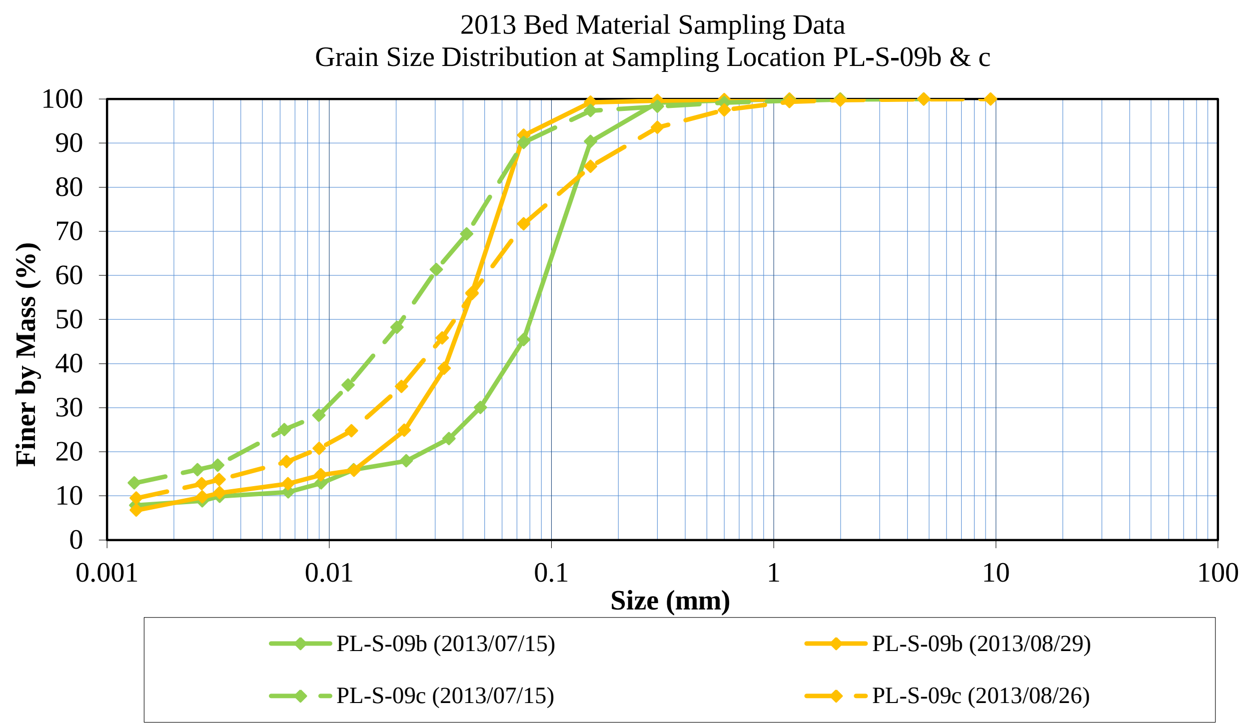
Bed Material Sampling Data
Grain Size Distribution at Sampling Location PL-S-07b & c (2013)

SCALE
NTS

DATE
Dec 2014

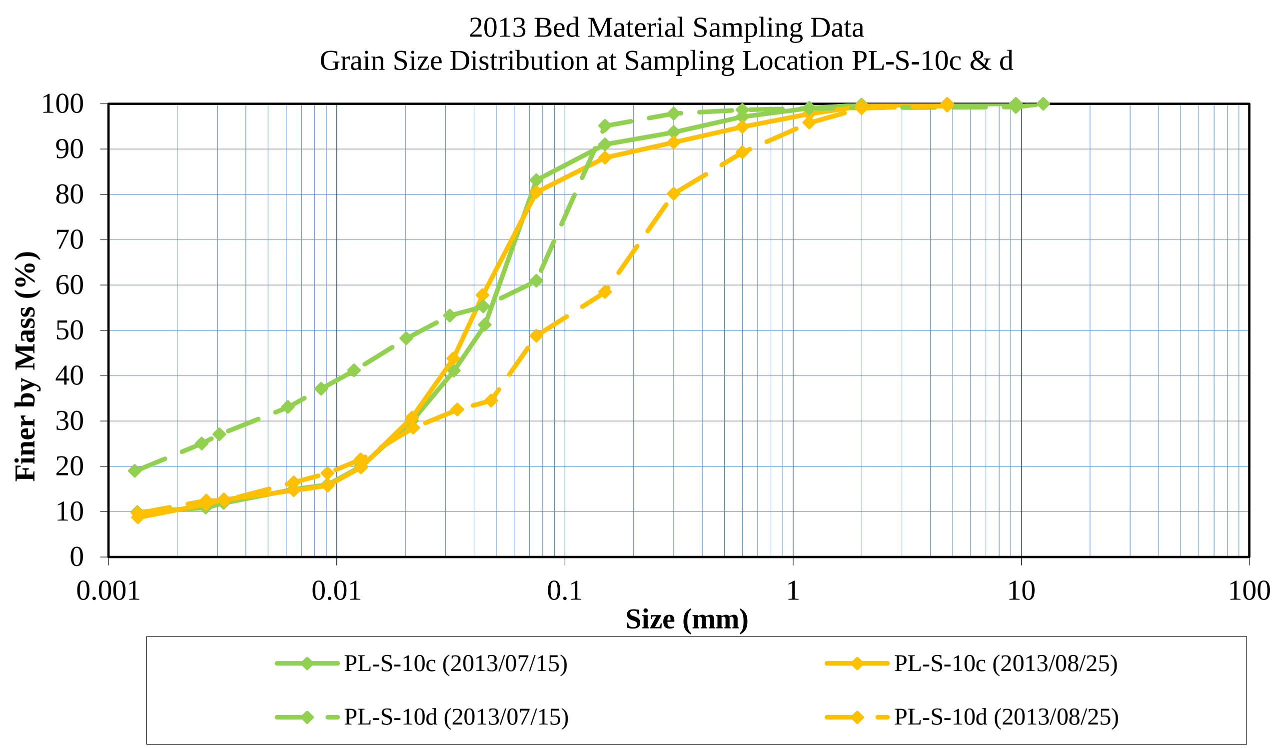
REFERENCE TO MEMO NO.

Figure 23: Bed material grain size distribution sites PL-S-07b & 07c



SITE DESCRIPTION	CAMP	Coordinated Aquatic Monitoring Program
		Bed Material Sampling Data Grain Size Distribution at Sampling Location PL-S-09b & c (2013)
	SCALE NTS	
	DATE Dec 2014	REFERENCE TO MEMO NO.

Figure 24: Bed material grain size distribution sites PL-S-09b & 09c



SITE DESCRIPTION

CAMP

Playgreen Lake
Coordinated Aquatic Monitoring Program

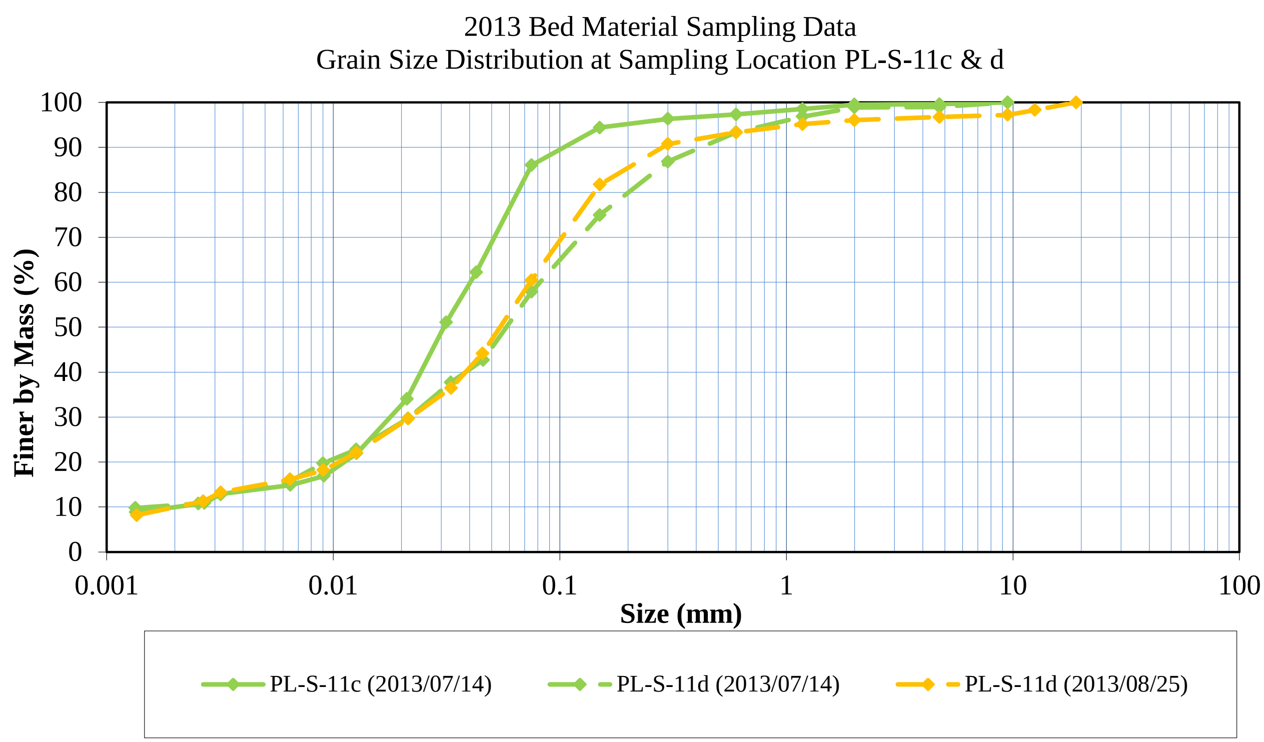
Bed Material Sampling Data
Grain Size Distribution at Sampling Location PL-S-10c & d (2013)

SCALE
NTS

DATE
Dec 2014

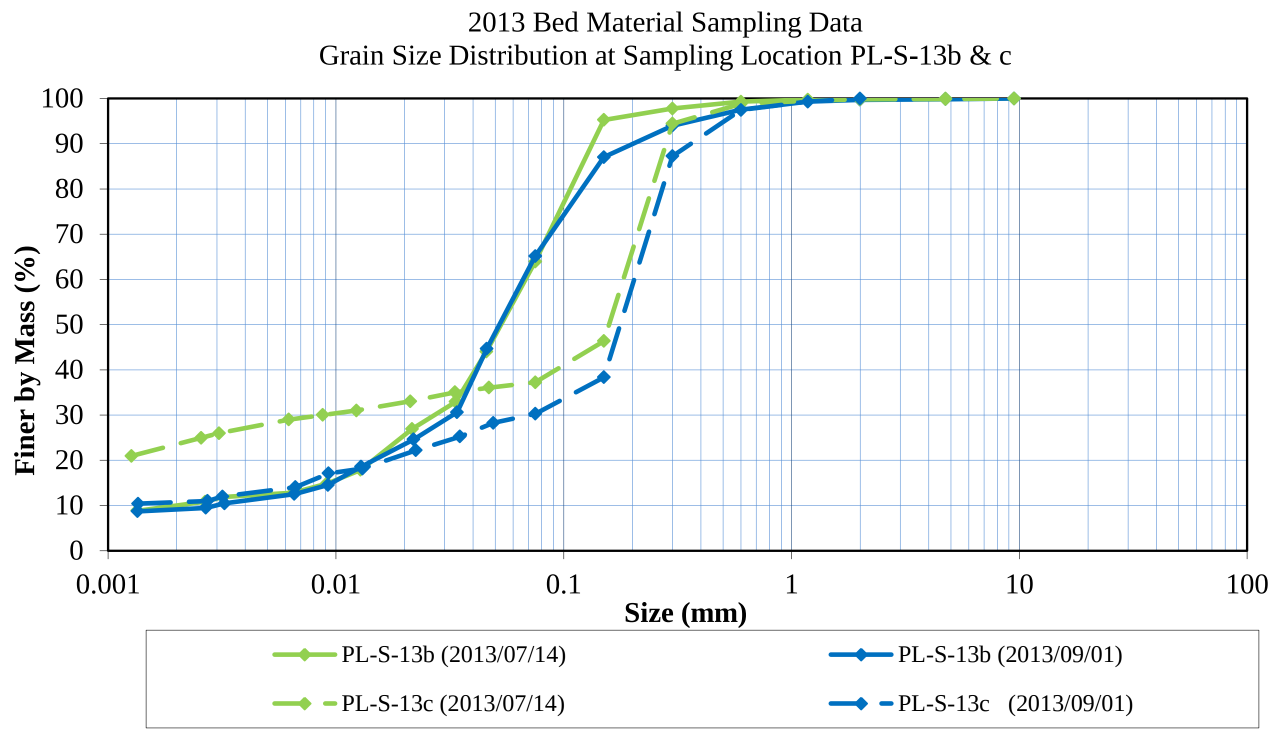
REFERENCE TO MEMO NO.

Figure 25: Bed material grain size distribution sites PL-S-10c & 10d



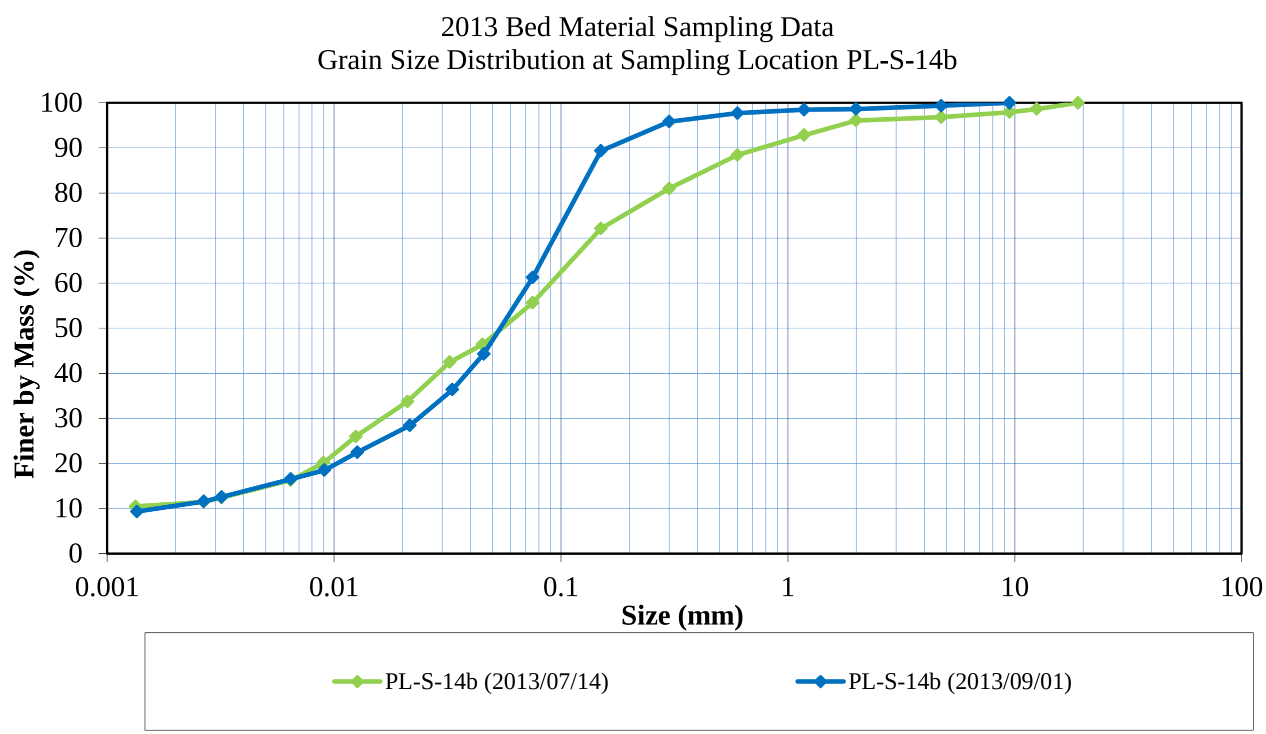
SITE DESCRIPTION	CAMP	Coordinated Aquatic Monitoring Program
	SCALE NTS	Bed Material Sampling Data Grain Size Distribution at Sampling Location PL-S-11c & d (2013)
	DATE Dec 2014	REFERENCE TO MEMO NO.

Figure 26: Bed material grain size distribution sites PL-S-11c & 11d



SITE DESCRIPTION	CAMP	Coordinated Aquatic Monitoring Program
	SCALE NTS	Bed Material Sampling Data Grain Size Distribution at Sampling Location PL-S-13b & c (2013)
	DATE Dec 2014	REFERENCE TO MEMO NO.

Figure 27: Bed material grain size distribution sites PL-S-13b & 13c



SITE DESCRIPTION

CAMP

Coordinated Aquatic Monitoring Program

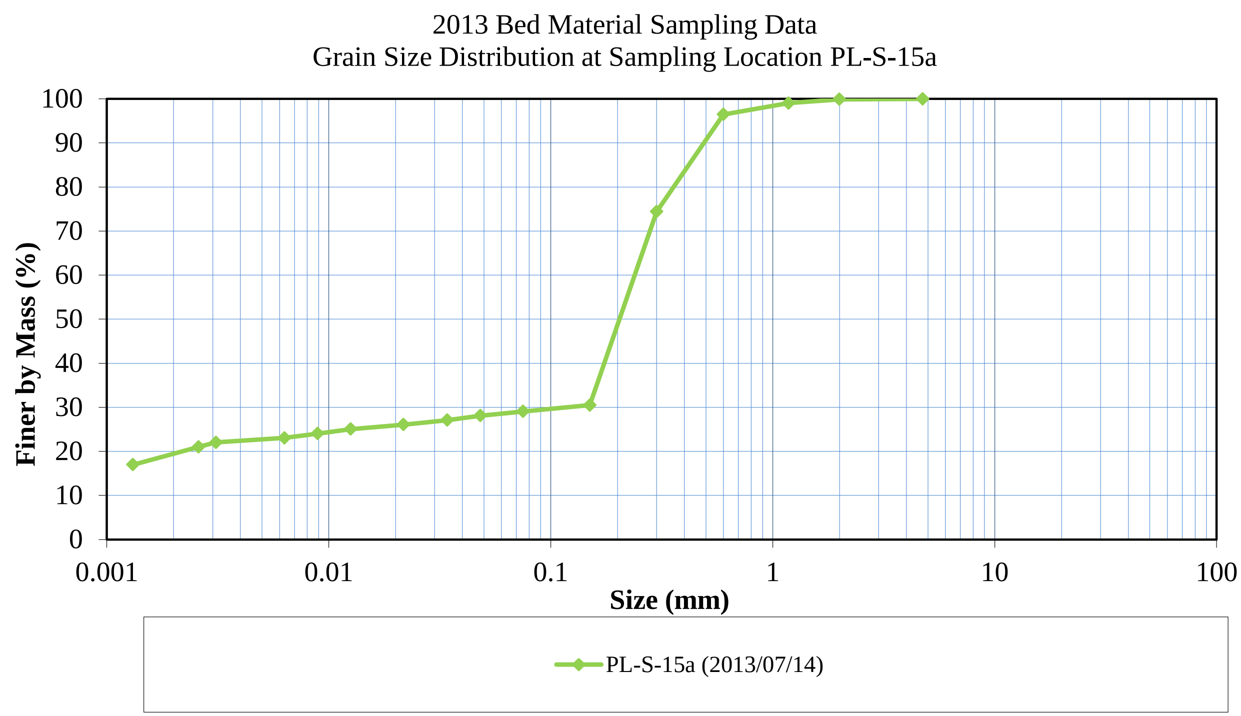
Bed Material Sampling Data
Grain Size Distribution at Sampling Location PL-S-14b (2013)

SCALE
NTS

DATE
Dec 2014

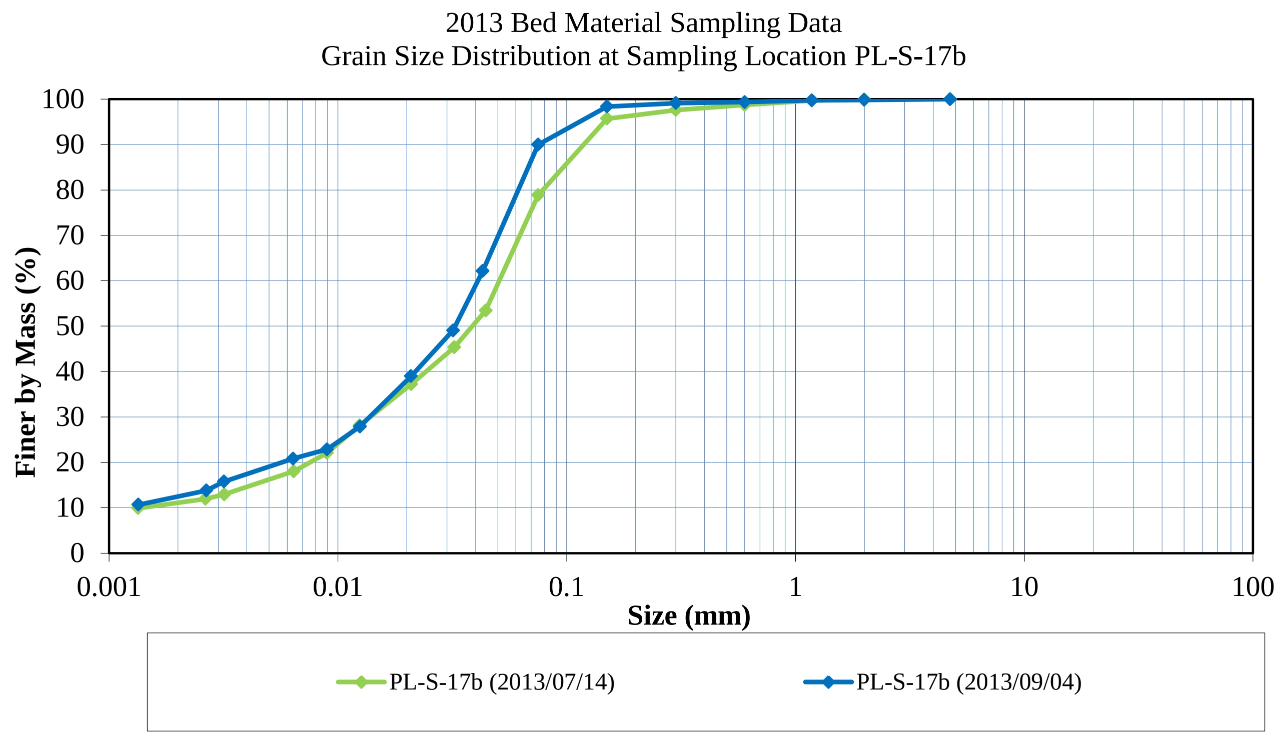
REFERENCE TO MEMO NO.

Figure 28: Bed material grain size distribution site PL-S-14b



SITE DESCRIPTION	CAMP	Coordinated Aquatic Monitoring Program
	SCALE NTS	Bed Material Sampling Data Grain Size Distribution at Sampling Location PL-S-15a (2013)
	DATE Dec 2014	REFERENCE TO MEMO NO.

Figure 29: Bed material grain size distribution site PL-S-15a



SITE DESCRIPTION

Coordinated Aquatic Monitoring Program

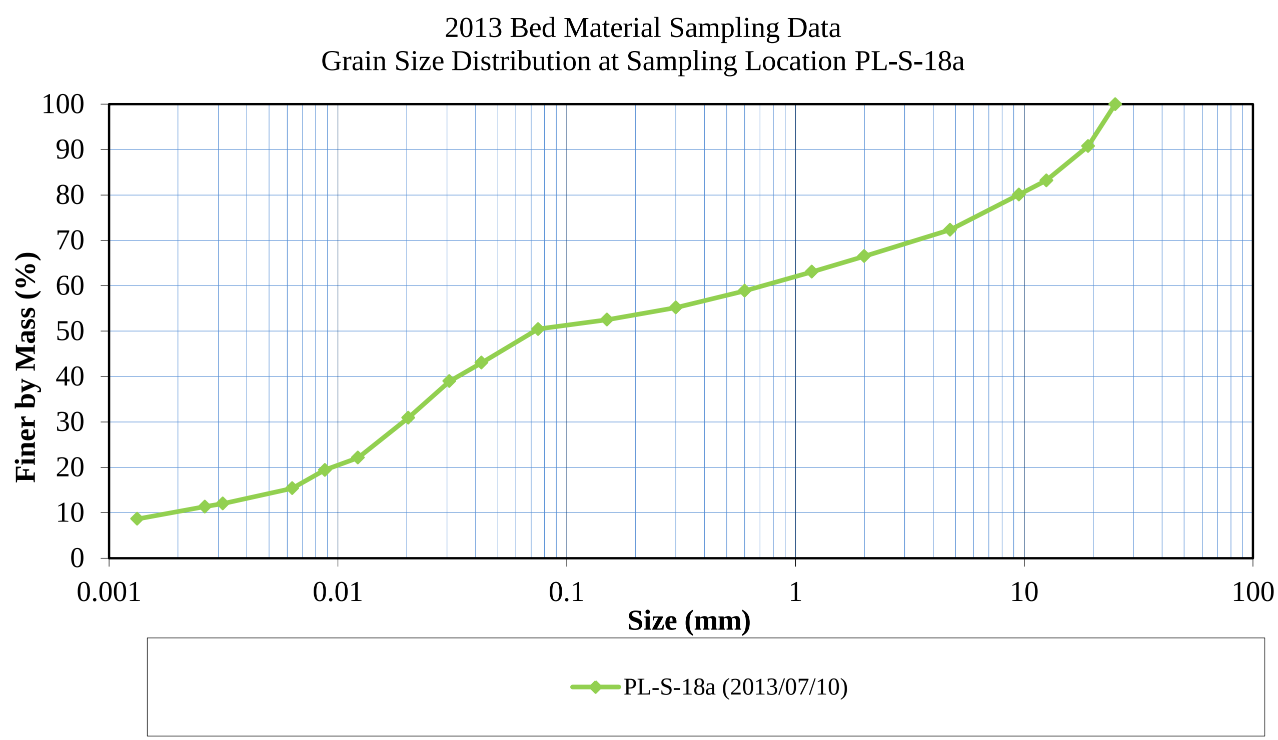
Bed Material Sampling Data
Grain Size Distribution at Sampling Location PL-S-17b (2013)

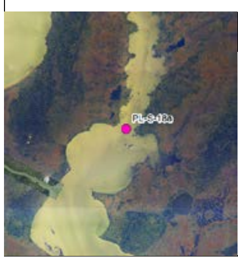
SCALE
NTS

DATE
Dec 2014

REFERENCE TO MEMO NO.

Figure 30: Bed material grain size distribution site PL-S-17b





SITE DESCRIPTION

Coordinated Aquatic Monitoring Program

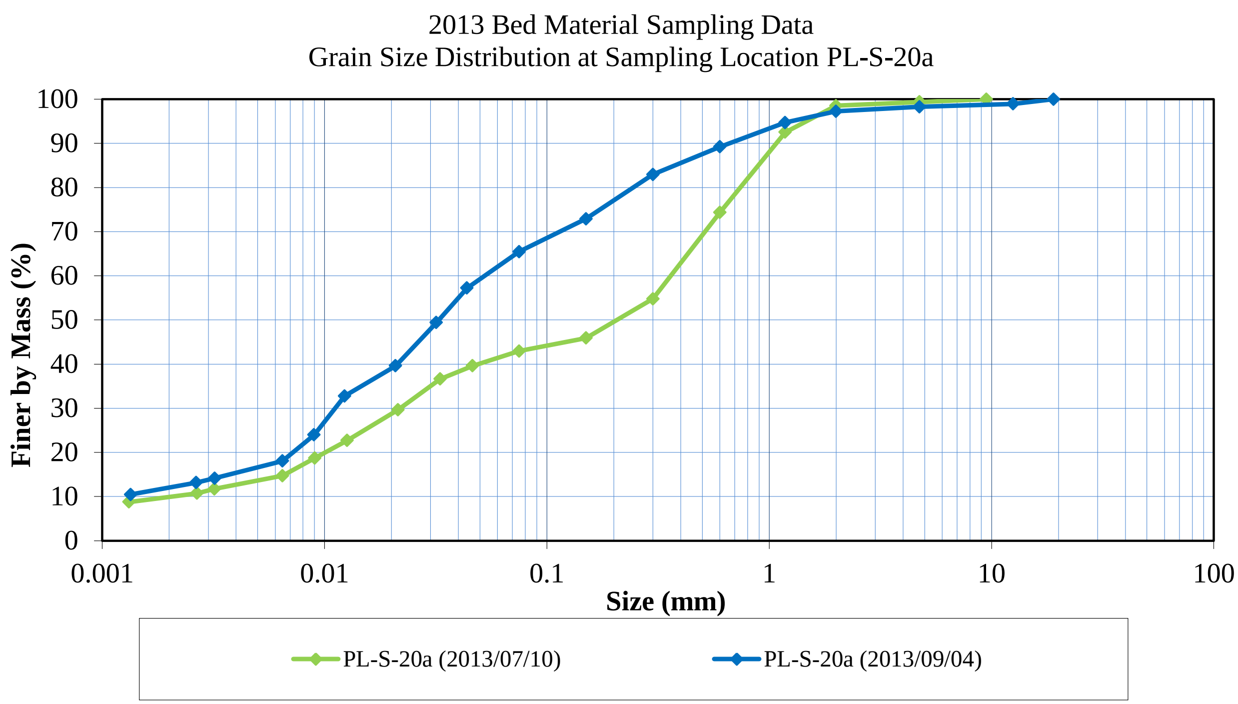
Bed Material Sampling Data
Grain Size Distribution at Sampling Location PL-S-18a (2013)

SCALE
NTS

DATE
Dec 2014

REFERENCE TO MEMO NO.

Figure 31: Bed material grain size distribution site PL-S-18a



SITE DESCRIPTION

Coordinated Aquatic Monitoring Program

Bed Material Sampling Data
Grain Size Distribution at Sampling Location PL-S-20a (2013)

SCALE	DATE	REFERENCE TO MEMO NO.
NTS	Dec 2014	

Figure 32: Bed material grain size distribution site PL-S-20a

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