Long Term Surface Water Discharge Study Report For Calendar Year 2009

Lee & Collier Counties, Florida

Prepared for

March 2010

Prepared by

JOHNSON ENGINEERING

Bonita Bay Group®

Long Term Surface Water Discharge Study

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Lee & Collier Counties, Florida

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1. INTRODUCTION

1. INTRODUCTION

PROJECT OBJECTIVE: The objective of the project is to collect rainfall, stage and water quality data from six selected Bonita Bay project sites (Verandah, Sandoval, Shadow Wood Preserve, The Brooks, Mediterra and Twin Eagles). These data will provide information for evaluation of the behavior of these water management systems over extended time periods as it relates to total inflows, outflows and water quality.

OUTLINE OF INFORMATION IN THIS REPORT

The geographical relationship of the six Southwest Florida projects is shown on the aerial following on page 1-3. Five of the six projects incorporate golf courses; only Sandoval has no golf course. For ease of reference to previous reports an effort was made to keep the sections and appendices in the same sequence and format. For example, details of how "runoff through structures was calculated" for this 2009 report can be found in the 2007 Report, Section 4 on Runoff.

The report summarizes data collected in Calendar Year (C.Y.) 2009. It provides rainfall data and associated graphs showing the impact of rainfall on lake stages. Upstream and downstream continuous recording stage gages at outflow weir structures acquire data that are converted to outflow rates and volumes. The volume of rain falling on the site can then be related to runoff from the site on a percentage basis. Detailed explanations of how the data were gathered and used are described in the Calendar Year (C.Y.) 2008 Report in Sections 2. Rainfall, 3. Stage Recorders and 4. Runoff. Section 7. Future Considerations, describes several of the elements in this study that can be further evaluated. Section 8. Conclusions and Comments state significant results from this year's data.

The appendix of this report shows detailed aerials of each of the six project sites together with locations of rain gages, stage recorders, and water quality stations.

RAINFALL:

Rainfall for C.Y. 2007 was very low, for C.Y. 2008 was normal and for C.Y. 2009 was slightly lower than average.

Calendar Year	Average Rainfall for All 6 Projects
2007	37.22”
2008	62.35”
2009	50.46”

Section 2. Rainfall of this report provides more detailed comparison between projects. Average historical rainfall for Lee County is approximately 61 inches, for comparison, for the reporting years 1992-2009, being the mean of 18 county maintained rain gage stations. See map in Appendix A

STAGE RECORDERS AND RUNOFF:

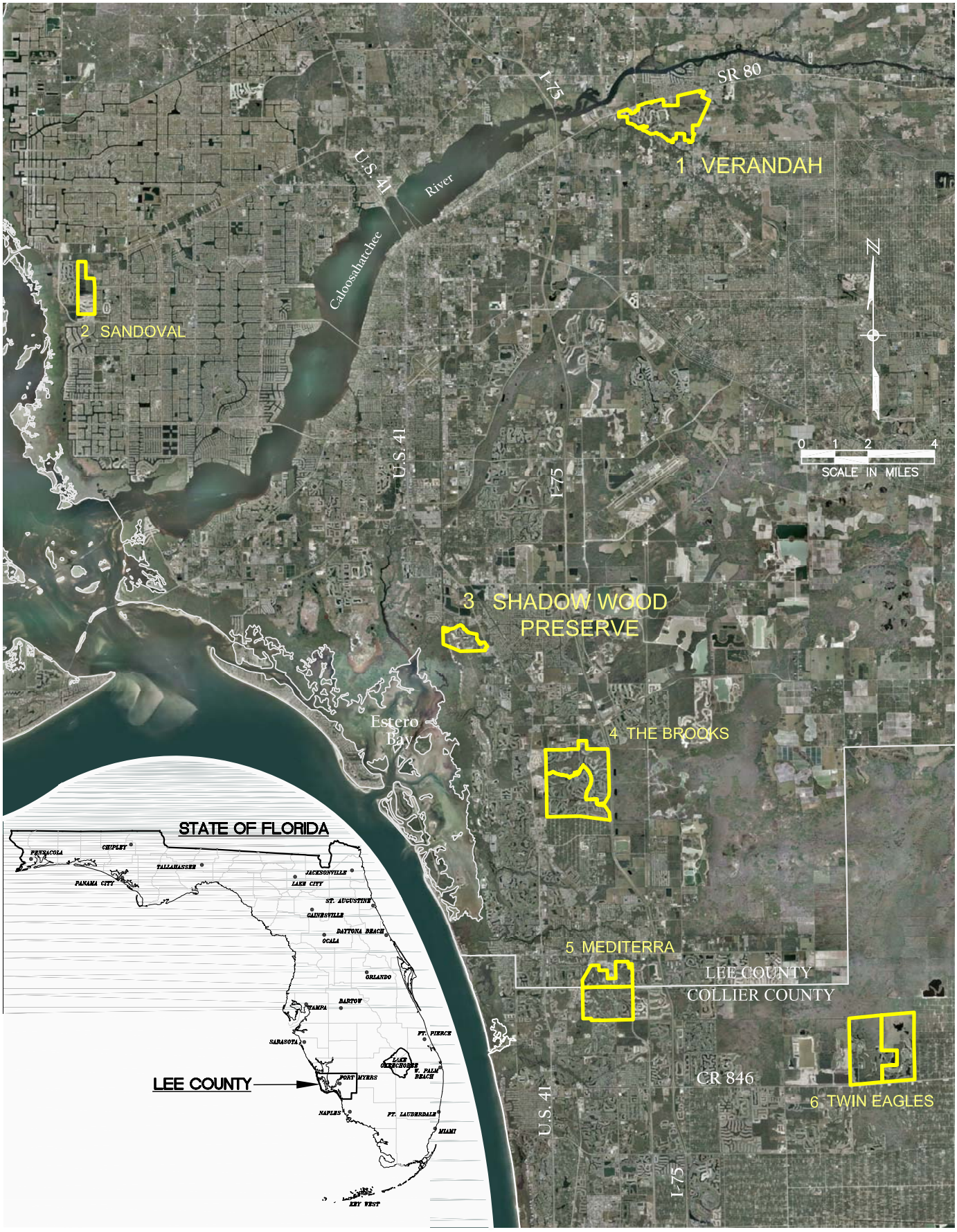
Stage recorders located both upstream and downstream at each outfall structure record lake levels, from which outflow volume is calculated. Two of the six projects (1. Verandah and 2. Sandoval) had discharges downstream in C.Y. 2007; all six projects had outflow in C.Y. 2008; five of the six projects had outflow in C.Y. 2009 (6. Twin Eagles had no outflow in 2009).

WATER QUALITY:

Water quality at the six projects is measured by sampling either at the outfall location during times of discharge, or at an upstream location for Mediterra and Twin Eagles, both of which rarely discharge. In addition to the water quality samples collected at those two sites, physical field parameters are also recorded and some limited data sonde data are available for Twin Eagles. Expanded sampling is expected for 2010.

APPENDIX

The Appendix is organized in Sections “A” through “F”. The Appendix data include: “A” Daily Rainfall for each Project; “B” 2008 Aerial Photographs for the Six Projects; “C” Stage Data for each Outfall Structure; “D” Comparison of Sandoval development between 2006 and 2009; “E” Photographs – 2007-2009; and “F” Water Quality Data for 2009.



\\Ftms01\proj-fmw\20066052\Drawing\2009 Report Drawings\8x11 Project Locations.dwg (8x11) mll2 Jul 12, 2010 - 9:54am

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BONITA BAY PROJECT LOCATIONS
WATER QUALITY/DISCHARGE STUDY

DATE	PROJECT NO.	FILE NO.	SCALE	SHEET
Feb 2010	20098229	00-00-00	As Shown	1-3

2. RAINFALL

2. RAINFALL

Lake stage rise and runoff generally occur in response to rainfall. For that reason, Johnson Engineering, Inc. (JEI) installed rain gages at each project location in 2007. Specific location of all JEI rain gages are identified on the aerials in Section B of the Appendix.

Daily rainfall readings are also supplied to JEI from golf courses on five of the projects. Rainfall readings used in this report are the best available data, obtained from JEI or golf course gages, unless otherwise noted. For example, rainfall for Sandoval in 2009 came from the gage at the City of Cape Coral Reverse Osmosis Plant approximately one mile away. Also if gage failure occurs, auxiliary data can be used to replace the missing portion of the data set.

The annual average rainfall for the southwest Florida area is 57.2 inches based on a 30 year reporting period from South Florida Water Management District (SFWMD) records for Southwest Coast stations. The mean rainfall for Lee County based on county records for 1992-2009 is 60.75 inches.

The great variation in rainfall between C.Y. 2007, 2008 and 2009 is easily compared in the table on page 2-2. Total rainfall for each project is listed in order by column.

Daily rainfall is shown on bar charts in Appendix A for each of the six projects, as well as historical rainfall based on agency records.

TOTAL RAINFALL BY PROJECT (Inches) – C.Y. 2008 – C.Y. 2009

	C.Y. 2007	C.Y. 2008	C. Y. 2009
1. Verandah	33.69	66.35	53.89
2. Sandoval	47.64	60.61 [1)]	53.69 [1)]
3. Shadow Wood Preserve	25.33	60.00	41.60
4. The Brooks	32.45	58.71	52.19
5. Mediterra	43.72	61.65	47.46
6. Twin Eagles	40.46	66.80	53.91
AVERAGE	**37.22**	**62.35**	**50.46**

1.) Sandoval rainfall from City of Cape Coral R/O Plant

3. STAGE RECORDERS

3. **STAGE RECORDERS**

Stage recorders are located on the upstream and downstream side of each outflow weir structure. Data from these recorders are used to calculate the rate and volume of outflow over each weir. These calculations are based primarily on the depth of flow over the weir crest. The recorders log data on an hourly basis to insure that intense rainfalls and subsequent rapid rises in stage can be accurately compared.

"Stage-Rainfall Graphs" for the Sandoval WS-3 Outfall Weir Structures for C.Y. 2007, C.Y. 2008 and C.Y. 2009 follow on pages 3-2, 3-3 and 3-4. They show a vertical plot of rainfall and stage on the same horizontal-time axis. This clearly depicts the systematic relationship (peaks and valleys) between rainfall and the lake stage. All elevations are NGVD 1929.

A comparison of pages 3-2, 3-3 and 3-4 shows the dramatic difference in rainfall during C.Y. 2007, 2008 and 2009. A comparison of the graphical area between the "dashed red weir crest" line and the "blue stage" line for all three years gives a rough comparison of the related runoff for the three years.

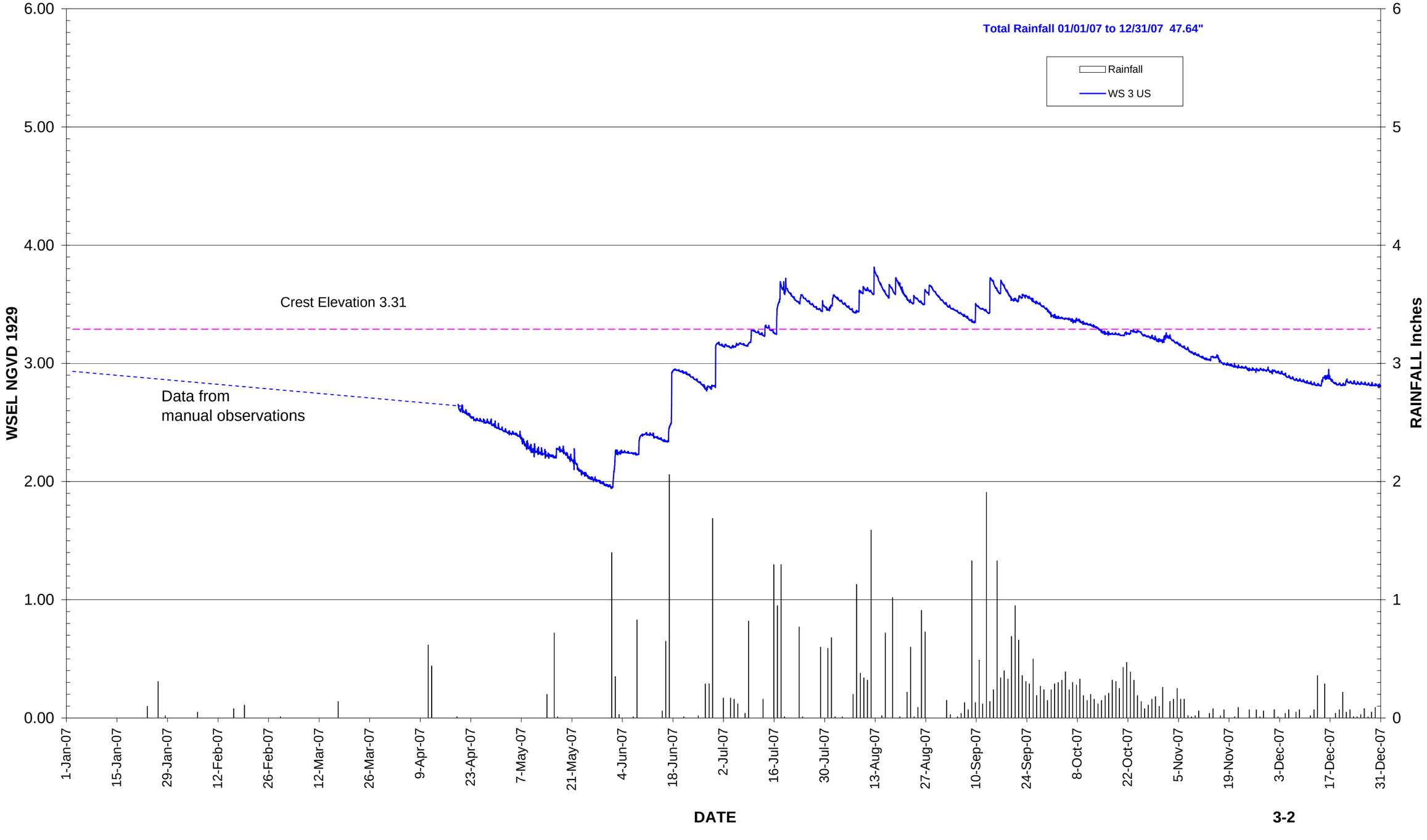
For example, total rainfall for Sandoval WS-3 increased from 47.64 inches in C.Y. 2007 to 60.61 inches in 2008, with corresponding total flow increasing from 5,069,187 cubic feet to 14,484,682 cubic feet. For 2009, the rainfall decreased to 53.69 inches while the discharge remained relatively constant at 14,894,498 cubic feet. This is likely due to a differing rainfall distribution resulting in rainfall spread more evenly throughout the year and an increase in impervious area known to have occurred during 2009. An explanation of contributing factors for the runoff/rainfall relationship in C.Y. 2009 appears in Section 4. Runoff and Section 7. Future Considerations of this Report.

Rainfall/Stage graphs for all outfall structures are found in Appendix Section C.

SANDOVAL 2007 WATER LEVELS
WS 3 US DATA LOGGER

JOHNSON ENGINEERING

TOTAL FLOW 1/1/07 TO 12/31/07 **6,088,426** Cu Ft

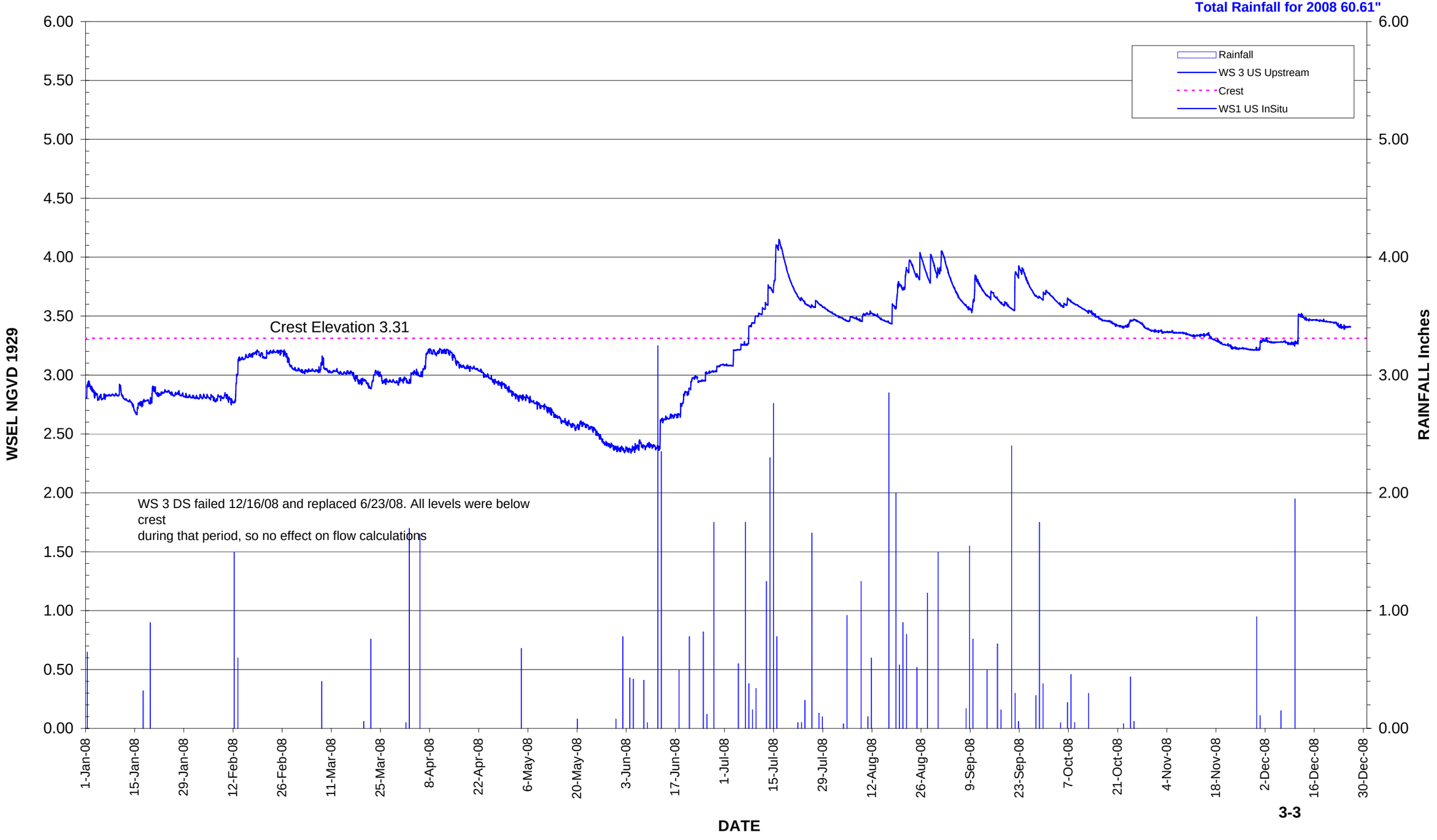


SANDOVAL 2008
WS 3 US DATA LOGGER

JOHNSON ENGINEERING

TOTAL FLOW 01/01/08 TO 12/26/08 **14,484,682** Cu Ft

Total Rainfall for 2008 60.61"

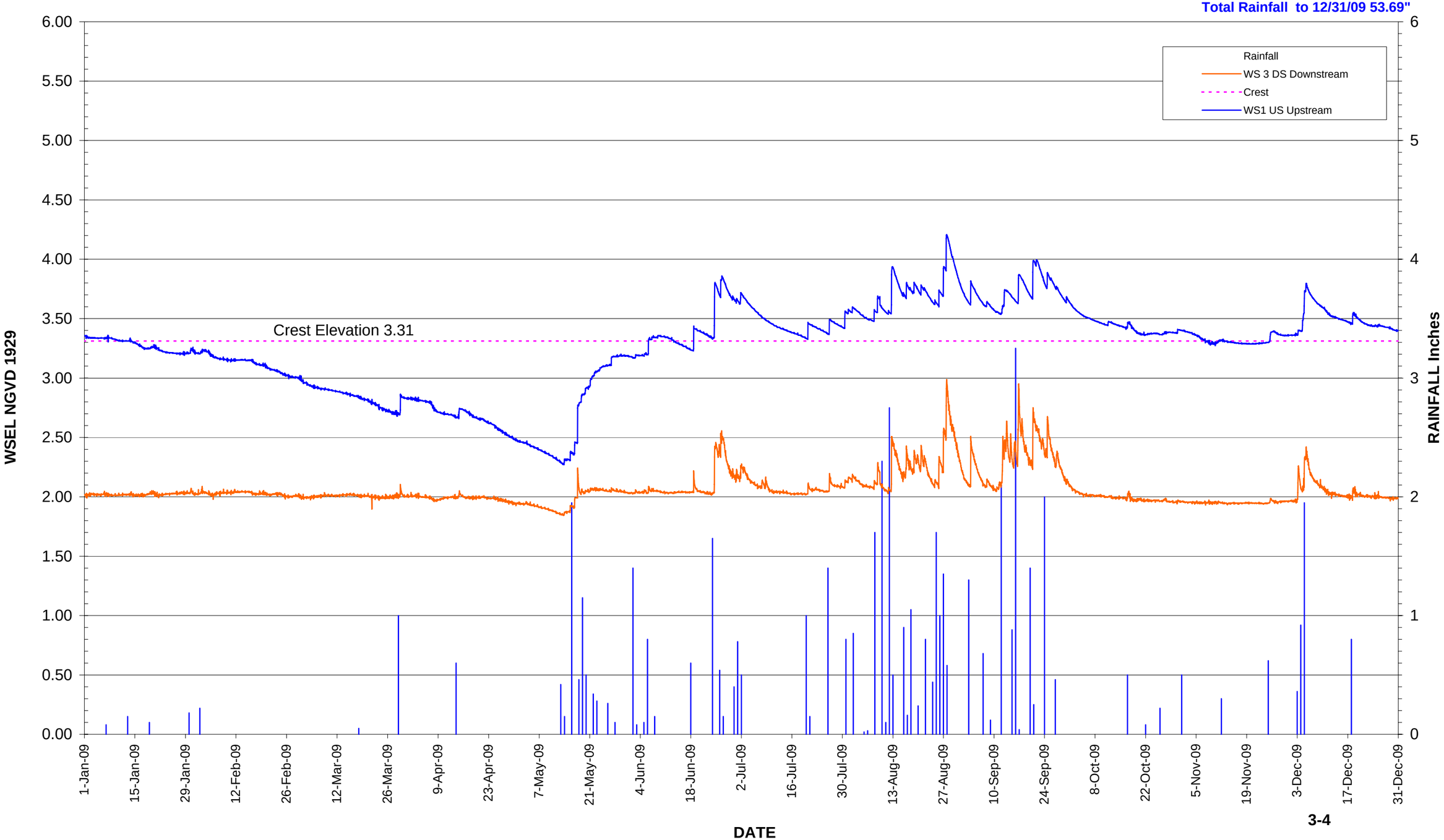


SANDOVAL 2009
WS 3 US and WS 3 DS DATA LOGGERS

JOHNSON ENGINEERING

TOTAL FLOW 01/01/09 TO 12/31/09 **14,894,498** Cu Ft

Total Rainfall to 12/31/09 53.69"



4. RUNOFF

4. RUNOFF DATA

RUNOFF DETERMINATION FROM STAGE RECORDER DATA: Runoff data are determined from continuous (data recorded hourly) stage recorders located at each outfall structure on each project. By recording the stages upstream and downstream of outfall structures, and knowing the geometry configuration of each structure, the cubic feet per second of outflow can be calculated. Since the stage is recorded continuously, the volume of outflow can be determined by a series of hourly computations, which are then summed to determine the total volume of outflow.

The numerous hourly recordings are essential as lake stages during intense rainfalls can rise quickly and have a significant impact on flow and volume calculations. For example: a Sandoval rainfall of 1.71 inches between hours 14:00 and 16:00 on June 17, 2009 created a lake stage rise at Structure WS-1 of 0.28 feet between hours 16:00 and 17:00.

The six projects being studied have four basic overflow weir control structures designed by various professional engineers over a range of years to meet attenuation and water quality criteria established by the South Florida Water Management District. The four basic types seen are:

1. Broad Crested Rectangular Non-Orifice (Brooks and Twin Eagles)
2. Broad Crested Inverted Tee (Sandoval)
3. Broad Crested Inlet Style With and Without Orifice Bleeder (SWP & Verandah)
4. Circular Orifice Style (Mediterra)

Projects 4 and 6, The Brooks and Twin Eagles, both have broad crested rectangular weirs without orifices, both being formed concrete. Project 2, Sandoval, has broad crested, formed concrete inverted tee weir walls built inside large drainage inlets. Projects 1 and 3, Verandah and Shadow Wood Preserve, have broad crested, formed weirs with rectangular slots some with either circular or rectangular orifices and some without orifices, mostly built in standard drainage inlets. Project 5, Mediterra, has a formed concrete weir wall inside a drainage inlet with four large orifice openings to handle normal flow and a rectangular broad crested weir at a higher elevation to handle overflow runoff.

The basic formula for a broad crested rectangular weir flow calculation is:

$Q = CLH^{3/2}$ where:

Q = flow in cubic feet per second (cfs)

C = coefficient, determined experimentally, dimensionless

L = horizontal crest length, in feet

H = head upstream, in feet

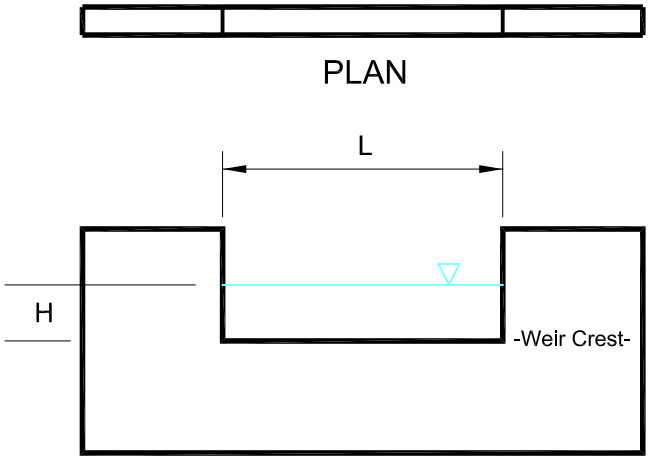
"L" and "H" are determined by field measurements. It is essential to measure "H" accurately on a continual (hourly) basis. "C" is determined experimentally and for structures in this report, is estimated from Brater and King *Handbook of Hydraulics* (Sixth Edition) Table 5-3 on page 5-40. To determine "C", a measured head in feet (H) and a breadth of crest of weir, in feet, is required. To better explain the method of flow calculations, sketches follow:

DIAGRAMS OF TYPICAL BROAD CRESTED WEIRS

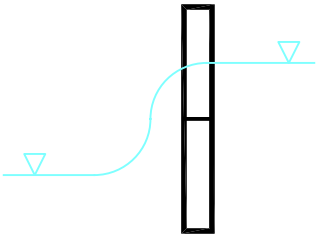
EQUATION ELEMENTS

Q = Flow (cfs)
C = Coefficient
L = Weir Length Ft
H = Height of flow above weir crest Ft

$Q = CLH^{3/2} = (3.30)(10')(2')^{3/2} = \underline{93.3 \text{ cfs}}$

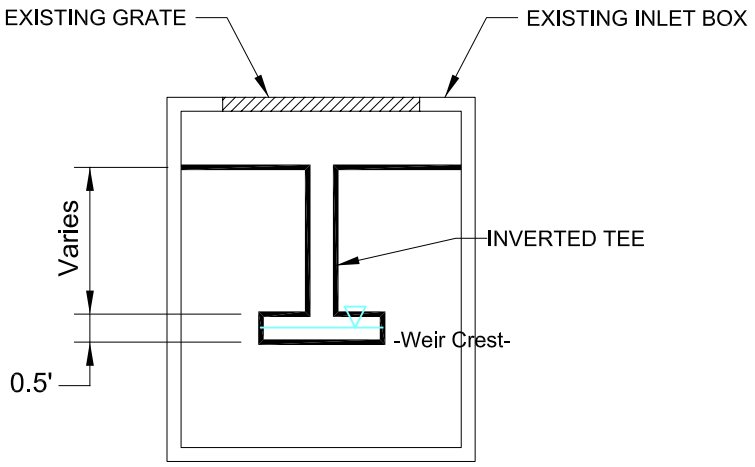


WEIR - CROSS SECTION



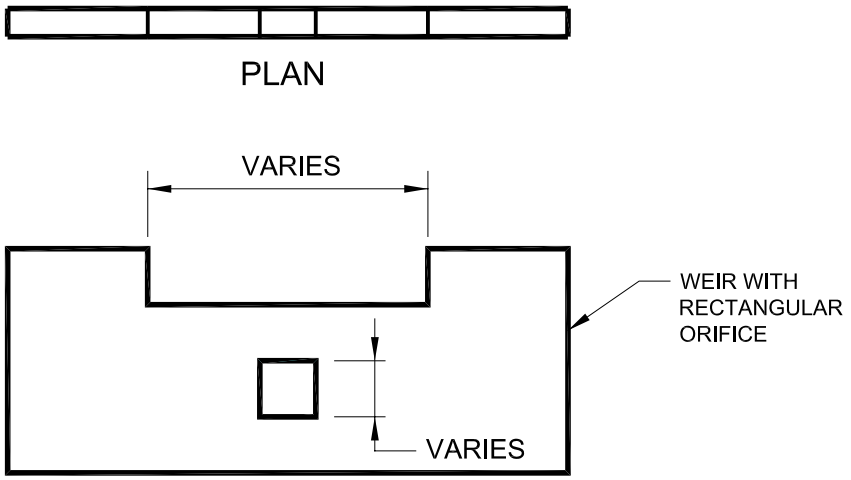
PROFILE

TYPICAL PROJECT 4. THE BROOKS & PROJECT 6. TWIN EAGLES

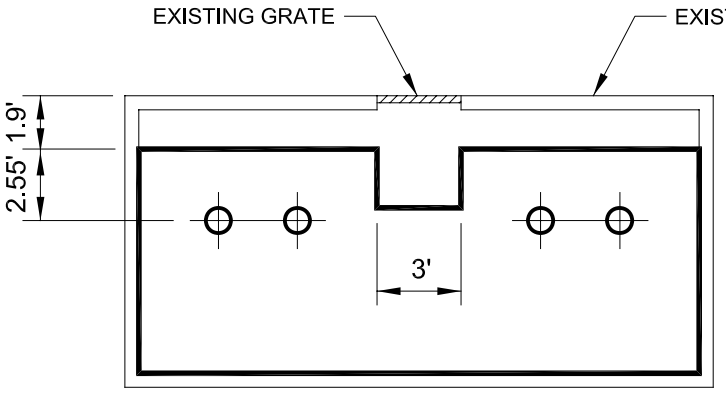


TYPICAL TYPE PROJECT - 2. SANDOVAL

DIAGRAMS OF TYPICAL BROAD CRESTED WEIRS



TYPICAL TYPE PROJECT SWP - 1. VERANDAH



NOTES:

WEIR WALL THICKNESS = 0.5'

ALL ORIFICES ARE 0.9' DIA
WITH INV. EL's OF 11.10'
TOTAL AREA OF (4) HOLES = 2.54 FT ^{2}

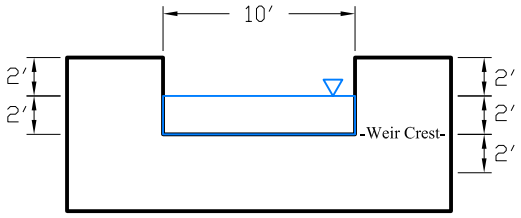
ELEVATIONS WERE ASSUMED FROM PLAN

TYPICAL PROJECT - 5. MEDITERRA

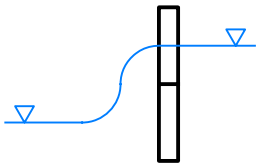
UNSUBMERGED AND SUBMERGED WEIR FLOWS - EXAMPLES

EQUATION ELEMENTS

Q = Flow (cfs)
C = Coefficient
L = Weir length
H = Height of flow above weir crest
a = Coefficient of submergence



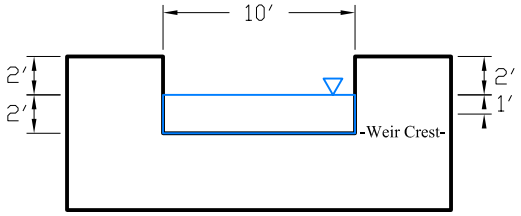
WEIR - CROSS SECTION



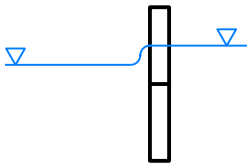
PROFILE

$Q = CLH^{3/2} = (3.30)(10')(2')^{3/2} = \underline{93.3 \text{ cfs}}$

UNSUBMERGED - CONDITION 1



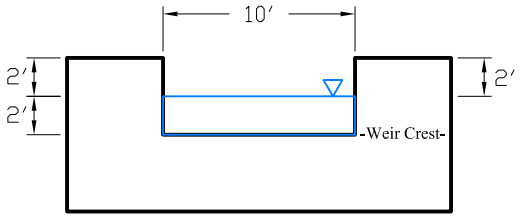
WEIR - CROSS SECTION



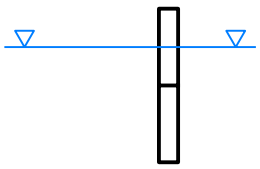
PROFILE

$Q = aCLH^{3/2} = (0.84)(3.30)(10')(2')^{3/2} = \underline{78.4 \text{ cfs}}$

PARTIALLY SUBMERGED - CONDITION 2



WEIR - CROSS SECTION



PROFILE
WATER LEVEL SAME - BOTH SIDES OF WEIR

$Q = aCLH^{3/2} = (0)(3.30)(10')(2')^{3/2} = \underline{0.0 \text{ cfs}}$

FULLY SUBMERGED - CONDITION 3

UPSTREAM WATER LEVELS (AND THEREFORE UPSTREAM STAGE RECORDERS) ARE THE SAME FOR ALL THREE ABOVE CONDITIONS; BUT FLOWS DIFFER GREATLY BECAUSE OF VARYING DEGREES OF SUBMERGENCE FROM DOWNSTREAM WATER LEVELS.

SCALE 1" = 10'

J:\20066052\Unsubmerged and submerged weir flow examples.dwg

An example of determining the coefficient "C" for Project 4, The Brooks is as follows, (see sketch on previous page). First, go to Brater and King Table 5-3 on page 5-40. Entering the table with a head "H" of 2.0 feet and a weir breadth of 1.0 feet the "C" is determined to be 3.30. With "L" and "H" from field measurements and a "C" of 3.30, the flow Q in cfs is calculated.

This flow is at an instantaneous point in time. However, the stages "H" were measured hourly. With the stages measured hourly, each flow (cfs) was multiplied by the one-hour time period and the hourly flow volumes summed to give a total volume for the desired time period.

A similar process was used for Projects 1,2,3 (see sketch on page 4-3). On an inverted "T" weir, for the bottom segment (0.5') depth up to just before flow touches the ceiling the "C" is determined the same as before, using an "H" of 0.5 feet and a weir breadth of 0.5 feet (re Brater and King Table 5-3); and "C" is determined to be 3.00. With "L" and "H" from field measurements and a "C" of 3.00, the flow is calculated as before.

Once the stage elevates above a depth of 0.5 feet and contacts the ceiling, flow becomes "orifice" (center segment remains weir flow) and a different formula is used. The orifice flow formula is $Q = C\ a\ \sqrt{2gh}$ where

Q = flow in cubic feet per second
C = coefficient, determined experimentally, dimensionless
a = area of orifice in square feet
1g = (32.2 ft/sec/sec)
h = head on orifice, in feet

Once the flow rate is determined, volumes are calculated in hourly segments and summed as before.

It is important to note that all flow measuring stations were adapted to existing structures. No weirs were modified to accommodate improved measuring techniques. Calculations are approximations, made using industry standard and accepted hydraulic formulas, based on field measured dimensions and water levels, plan and permit dimensions and elevations.

SUBMERGED WEIR FLOW: The purpose of a downstream stage recorder is to determine if submerged weir flow is occurring. Submerged flow occurs when the downstream water surface rises above the weir crest. If occurring, the equation for the flow rate "Q" (and therefore volume) of outflow changes. Examples of un-submerged and submerged weir flow are shown in the sketches on page 4-5. The first condition on the sketches shows normal, unobstructed flow over the weir outfall structure, in which case the basic equation is used. In this case only the upstream stage elevation (i.e., depth "H") is needed together with the coefficient "C" and the length of "L". Condition 2 shows the downstream stage above the weir crest. This elevated downstream stage inhibits flow over the weir and a different, submerged equation must be used. The third and most dramatic condition shows water levels on both sides of the weir the same, so obviously flow would be zero. However, with no downstream gage in place, the flow might erroneously be calculated on an unobstructed (not submerged) basis. A major flow would be calculated when the actual flow was "0". This underscores the importance of recording downstream water levels.

TYPICAL WEIR TYPES

Broad crested rectangular weir at The Brooks. View northeast across weir and downstream stage recorder. Photo taken March 23, 2008.

Broad crested inverted tee – Sandoval Water Control Structure WS-1.
Photo taken September 13, 2008. View inside inlet at flow over control weir.

SUBMERGED WEIR FLOW

View west at Verandah structure WV-L4 inlet box. Weir crest and flat (fully submerged) water level is indicated at arrows. Without a downstream gage (located south of the box, no accurate computation of the velocity and volume of flow could be calculated. See diagrammatic sketch on page 4-4.

Runoff – C.Y. 2009 Data

Runoff data are determined from continuous (data recorded hourly) stage recorders located at each outfall structure on each project. By recording the stages upstream and downstream of outfall structures, and knowing the configuration of each structure, the cubic feet per second of outflow can be calculated. Since the stage is recorded continuously, the volume of outflow can be determined by a series of hourly computations, which are then summed to determine the total volume of outflow.

One relationship of interest is the percentage volume of runoff from the site versus the volume of rainfall deposited on the Sandoval site based on the calendar year 2008 records. The volume of rainfall, using the 60.61 inches over the 390 acre site, was 85,966,187 cubic feet. The C.Y. 2008 runoff recorded over the three weir structures was 32,006,147 cubic feet, giving runoff as a proportion of rainfall of 37.2 percent. Runoff as a proportion of rainfall for Sandoval in C.Y.

2007 was 18.4% and in C.Y. 2009 was 58.9%. The dramatic increase from C.Y. 2007 through C.Y. 2009 can be primarily attributed to substantial increases in rainfall (C.Y. 2008) and impervious area (reference pages 2-2 and D-1, D-2 and D-3).

Runoff as a proportion to rainfall for Sandoval in C.Y. 2009 was 37.2%. Since rainfall for Sandoval in 2009 (41.79 inches) was less than in 2008 (60.61 inches), this may seem surprising. However a significant change was the four laning of Surfside Blvd. (80% impervious) and the draining of the entire roadway back into the Sandoval detention system. The increase of project acreage of 14.2 acres, most of which was impervious, increased the percent of runoff for the project. Also development in Sandoval increased the percentage of impervious cover (not including lakes) from 28% in 2008 to 36% in 2009.

A detail estimation of Sandoval "increase in impervious surface" (see Appendix Section D-1) was made because it was the most rapidly developing of the six projects, especially in C.Y. 2009. The increase in impervious surface for the other five project watersheds in 2009 was considered minimal.

PROJECT	LAKE AREAS (% of total project area)	% IMPERVIOUS SURFACE [1] 2006	FEB 2010
1. Verandah	18%	16%	[2]
2. Sandoval	17%	13%	36%
3. Shadow Wood Preserve	15%	22%	[2]
4. The Brooks	22%	23%	[2]
5. Mediterra	15%	14%	[2]
6. Twin Eagles	12%	4%	[2]

[1] Percentage figure is impervious (developed) surface, divided by the total project area. Impervious surface percentages above do not include lake areas. Total project area does include lake areas.

[2] Changes since 2006 were minimal.

A cursory review of the above table shows how consistent project water management design has been on Bonita Bay developments. Although designed by numerous different engineering companies, percentages of lakes and impervious cover, with the possible exception of the sparsely populated Twin Eagles, are quite similar. This also is confirmation that water management design rules are being equitably applied.

Graphs showing rainfall/stage-time at outfall structures are included in Appendix Section C. A Summary Table showing rainfall, runoff, percentage runoff/rainfall follows on page 4-12.

The study of runoff on a project basis demonstrates that there are numerous separate influencing factors other than simple rainfall and subsequent outflow through a structure. Among these are: degree of imperviousness, attenuation by interconnecting lakes, recharge to or from groundwater, ongoing maintenance and construction activities, etc.

Long Term Discharge Study Summary Table

	A	B	C	C1	D	E	E1	F	G	G1	H	I	I1	J	K	K1
	Total Area Ac	2007 Rainfall Inches	2008 Rainfall Inches	2009 Rainfall Inches	2007 Discharge Cu Ft	2008 Discharge Cu Ft	2009 Discharge Cu Ft	2007 Equiv Depth Ac Ft D/(A*43560)	2008 Equiv Depth Ac Ft E/(A*43560)	2009 Equiv Depth Ac Ft E1/(A*43560)	2007 Rainfall Cu Ft B/12*(A*43560)	2008 Rainfall Cu Ft C/12*(A*43560)	2009 Rainfall Cu Ft C1/12*(A*43560)	2007 % Runoff D/H	2008 % Runoff E/I	2009 % Runoff E1/I1
1. Verandah	443.76	33.89	66.35	53.89	6,437,919	40,286,253	49,178,447	0.33	2.08	2.54	54,591,666	106,879,818	86,808,642	11.79%	37.69%	56.65%
2. Sandoval	399.64	47.64	60.61	53.69	12,463,164	32,006,187	34,642,893	0.72	1.84	1.99	67,570,189	85,966,187	77,887,718	18.44%	37.23%	44.48%
3. Shadow Wood Preserve	241.72	25.33	60	41.6	0	7,013,145	7,160,435	0.00	0.67	0.68	22,225,646	52,646,616	36,501,654	0.00%	13.32%	19.62%
4. The Brooks	1174.85	32.45	58.71	52.19	0	98,135,769	88,064,412	0.00	1.92	1.72	138,389,693	250,380,860	222,574,980	0.00%	39.19%	39.57%
5. Mediterra	768.39	43.72	61.65	47.46	0	11,075,767	285,971	0.00	0.33	0.01	121,946,259	171,957,614	132,378,076	0.00%	6.44%	0.22%
6. Twin Eagles	460.7	40.46	66.8	53.91	0	3,193,741	0	0.00	0.16	0.00	67,662,917	111,712,379	90,155,903	0.00%	2.86%	0.00%
Averages	581.51	37.25	62.35	50.46	3,150,181	31,951,810	29,888,693	0.17	1.17	1.16	78,731,062	129,923,912	107,717,829	5.04%	22.79%	26.75%

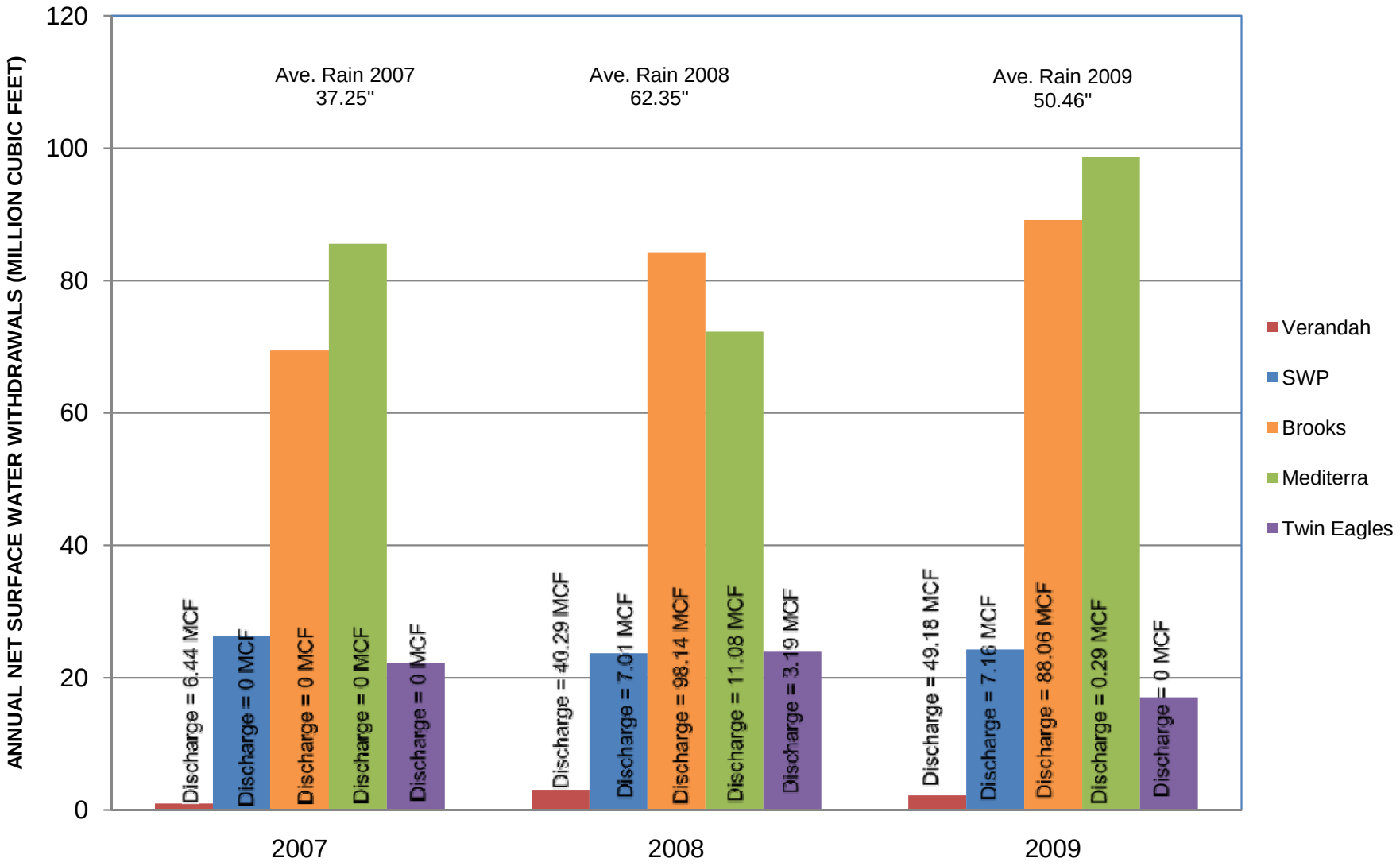
NOTES:
1. No discharge during 2007 for Shadow Wood Preserve, The Brooks, Mediterra or Twin Eagles.
2. Bold text in columns F through K represent formulas used to calculate values in those columns.
3. No discharge during 2009 for Twin Eagles.
4. Sandoval project area increased from 390.73 Ac in 2008 to 399.64Ac in 2009 due to inclusion of new adjacent roadway into project
5. Verandah project area increased from 436.1 Ac in 2008 to 443.76 Ac in 2009 due to additional clearing and berming for future development.

Average Discharge per Acre (Yearly Basis)

	2007			2008			2009		
	Area Ac	CF/Ac	Rainfall	Area Ac	CF/Ac	Rainfall	Area Ac	CF/Ac	Rainfall
1. Verandah	436.1	**14,762**	33.89	436.1	**92,378**	66.35	443.76	**110,822**	53.89
2. Sandoval	390.73	**31,897**	47.64	390.73	**81,914**	60.61	399.64	**86,685**	53.69
3. Shadow Wood Preserve	241.72	**0**	25.33	241.72	**29,014**	60	241.72	**29,623**	41.6
4. The Brooks	1174.85	**0**	32.45	1174.85	**83,530**	58.71	1174.85	**74,958**	52.19
5. Mediterra	768.39	**0**	43.72	768.39	**14,414**	61.65	768.39	**372**	47.46
6. Twin Eagles	460.7	**0**	40.46	460.7	**6,932**	66.8	460.7	**0**	53.91
Averages	578.75	7,777	37.25	578.75	51,364	62.35	581.51	50,410	50.46

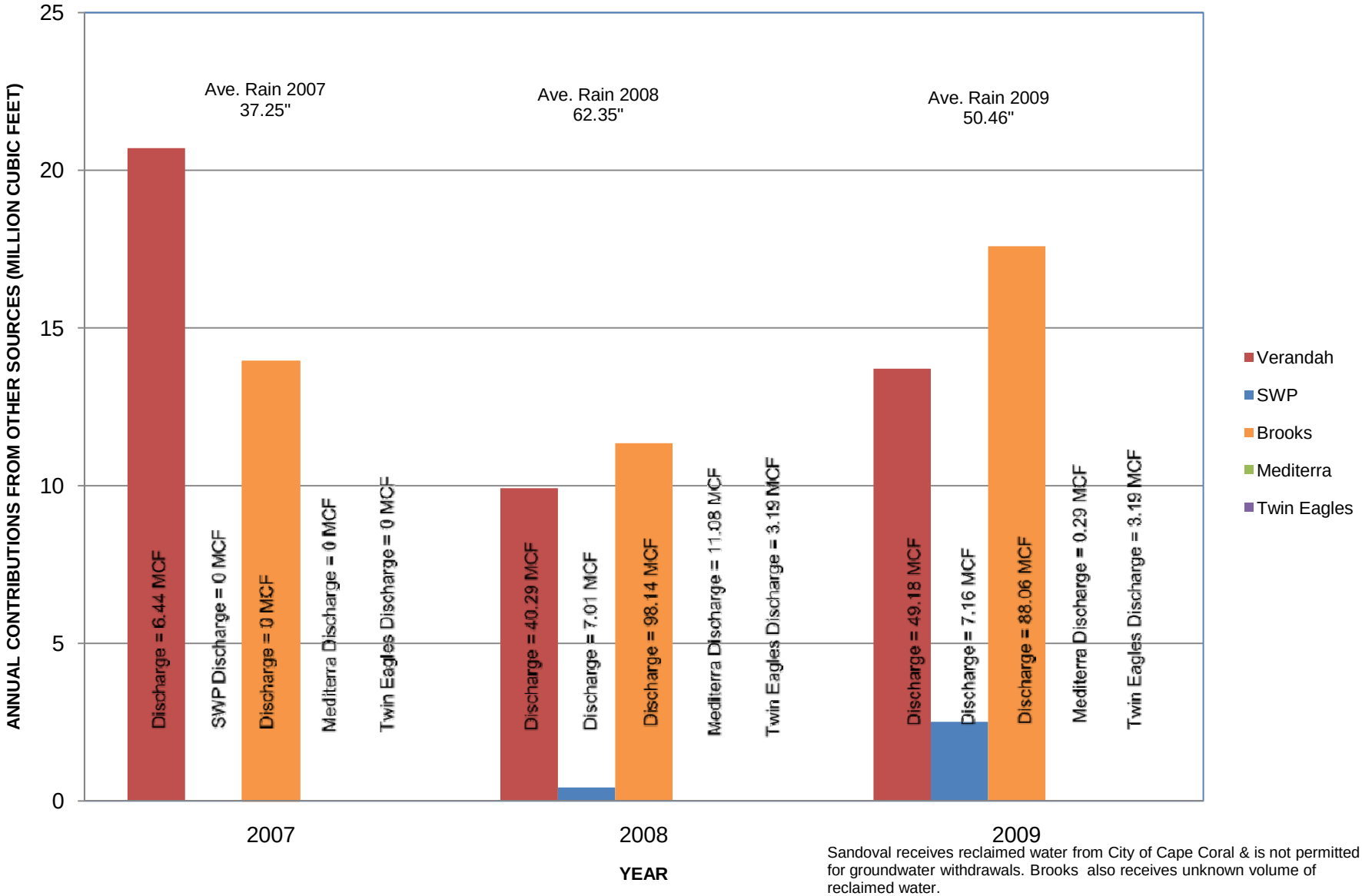
NOTES:
1. Acreage changed for Verandah and Sandoval between 2008 and 2009 due to construction activities
2. CF/Ac is total cubic feet discharge during calendar year at study site divided by total basin area in acres

ANNUAL NET SURFACE WATER WITHDRAWALS FROM STUDY BASIN

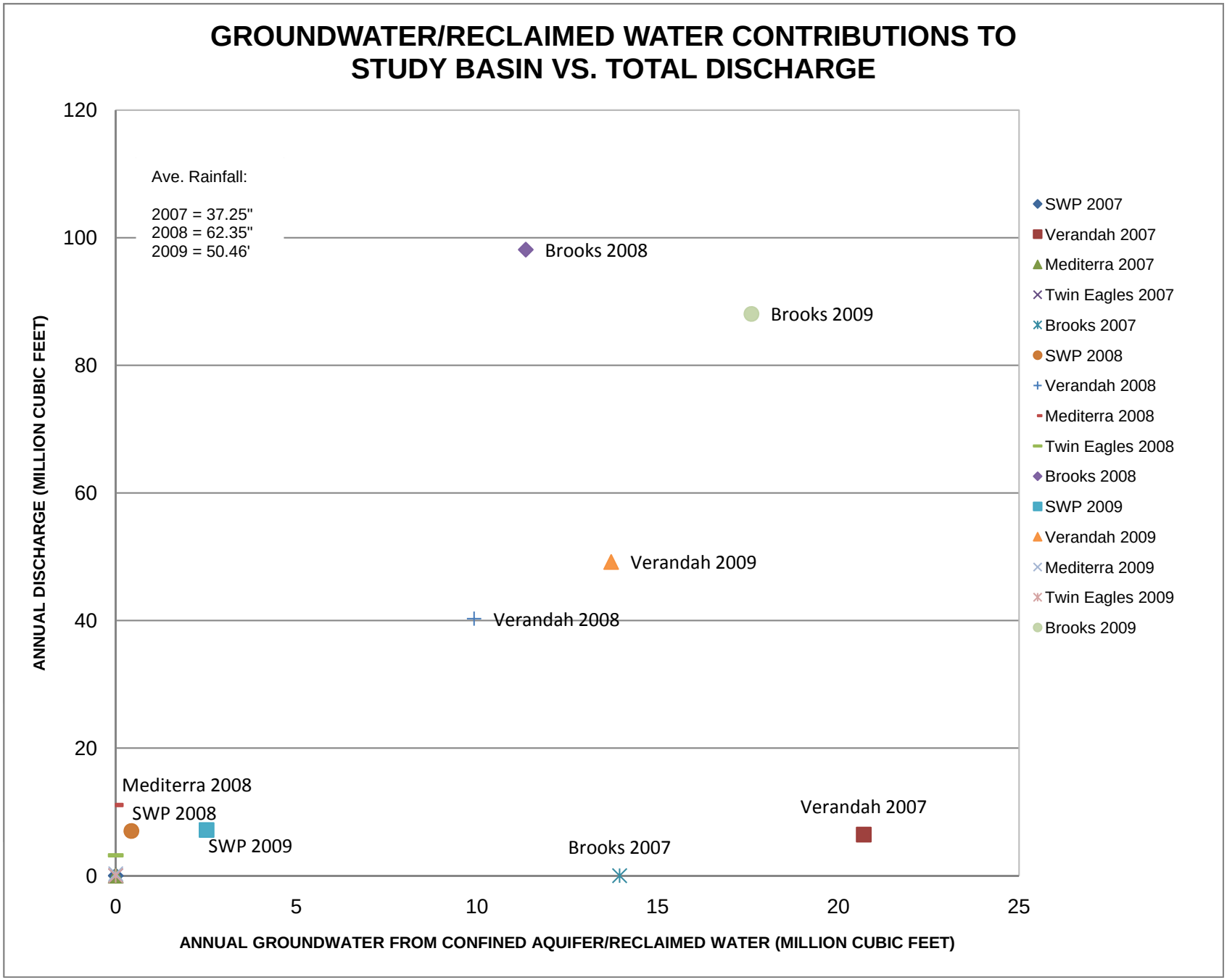


Sandoval receives reclaimed water from City of Cape Coral & is not permitted for surface water withdrawals

ANNUAL CONTRIBUTIONS FROM GROUNDWATER OR RECLAIMED WATER TO STUDY BASIN



Sandoval receives reclaimed water from City of Cape Coral & is not permitted for groundwater withdrawals. Brooks also receives unknown volume of reclaimed water.


GROUNDWATER/RECLAIMED WATER CONTRIBUTIONS TO STUDY BASIN VS. TOTAL DISCHARGE
ANNUAL DISCHARGE (MILLION CUBIC FEET)
ANNUAL GROUNDWATER FROM CONFINED AQUIFER/RECLAIMED WATER (MILLION CUBIC FEET)
Ave. Rainfall:
2007 = 37.25"
2008 = 62.35"
2009 = 50.46'
120
100
80
60
40
20
0
0
5
10
15
20
25
Brooks 2008
Brooks 2009
Verandah 2009
Verandah 2008
Mediterra 2008
SWP 2008
SWP 2009
Brooks 2007
Verandah 2007
SWP 2007
Verandah 2007
Mediterra 2007
Twin Eagles 2007
Brooks 2007
SWP 2008
Verandah 2008
Mediterra 2008
Twin Eagles 2008
Brooks 2008
SWP 2009
Verandah 2009
Mediterra 2009
Twin Eagles 2009
Brooks 2009

5. WATER QUALITY

5. WATER QUALITY

In 2008, a water quality component was implemented as part of the Long Term Discharge Study. Reference is made to the Water Quality Monitoring Plan Long Term Discharge Study, published in July of 2008, by Johnson Engineering staff with the input and assistance of staff at Florida Gulf Coast University, to guide the water quality monitoring.

The objective of the program as described in the above referenced report is to "collect water quality sampling data from the project sites to better understand the system behaviors during dynamic flow periods and static to dropping water level periods in the water management systems." Some text from the 2008 plan is restated here for convenience.

General project site selection occurred during development of The Long Term Discharge Study Operational Plan, prepared in March 2007 by Johnson Engineering.

That site selection process resulted in six study sites with well defined drainage basin boundaries and ownership entities willing to participate in the study. The landform communities for the six projects range from typical Florida coastal environments to inland prairie systems. All are well maintained residential communities with standard wet detention water managements systems with defined, controlled outfall structures providing stormwater runoff attenuation. Five are residential-golf course communities and one is residential community only without a golf course. Multi-family areas are limited then to one group of 12 buildings at the Verandah site, amounting to approximately 5% of the basin area at this site. The density of single family lots ranges from higher at Sandoval, with approximately 440 developed homesites on 391 acres, to mid-range at Mediterra, with approximately 215 homesites on 768 acres, to lower density at Twin Eagles, with approximately 40 developed homesites on 461 acres. Inspection of the attached aerial exhibits for each project reveals fairly mature projects with several continuing to add dwelling units as they approach build out. Sandoval in particular had significant increases in the number of building units during 2009 as well as construction of a new four-lane roadway resulting in both higher impervious areas as well as increased basin area. These were reflected in higher runoff rates.

Because of the varying density gradient seen from site to site, opportunities for comparative data analysis will exist, including percent impervious area or total storage volumes, among others. Follow-up data analysis by Florida Gulf Coast University staff may consider these types of enhanced data comparisons. The sites selected in the previous process outlined in the 2007 Operational Plan are:

1. Verandah

2. Sandoval

3. Shadow Wood Preserve

4. The Brooks

5. Mediterra

6. Twin Eagles

These project sites have segregated themselves into 2 distinct categories based on careful water level and discharge measurements taken during the 2007 calendar year, which was very dry. Two projects were clearly discharging stormwater runoff during portions of the 2007 calendar year, and four projects did not discharge at all during 2007.

Site selection for water quality monitoring locations inside the six project sites is based partially on this discharge-no discharge criteria. Discharge behaviors for 2008 and 2009 were similar to 2007 and proportional to the amount of rainfall received at the various project sites compared to the amounts received during the 2007 calendar year. Keep in mind that rainfall amounts received during 2007 were significantly below average for the region. Higher rainfall levels did result in discharge at additional sites in 2008 and differences in discharge behaviors compared to 2007. 2009 rainfall decreased from 2008 and total discharge decreased in three projects and slightly increased in three projects, indicating the complex nature of discharge behaviors. More discussion of other factors influencing discharge is found in Section 8, page 8-2 comment #3.

Because of the unknown rainfall amount consideration, the water quality monitoring program must include flexibility to vary and adapt sampling protocols used at the six project locations to

accommodate either more or less rainfall. It is unknown from year to year how many project sites will discharge during the year.

Water quality samples are collected from monitoring stations at each project site depending on site-specific conditions. The samples are collected by Johnson Engineering staff in accordance with FDEP Standard Operating Procedures (SOP). Each sample is laboratory analyzed for nutrients, chlorophyll-a, metals, total suspended solids and turbidity.

Since all of the selected project sites are communities that have tightly managed maintenance activities, there exist opportunities to develop sampling protocols that would target certain management activities and plan coincidental sampling to generate data related to water management system behavior and water quality. This would need to be done in close consultation with on-site operational staff to preserve the existing positive cooperative relationship that all of the project sites have developed with the program managers.

2008 Results

Twenty nine sample sets were collected during the 2008 calendar year, including samples from all six project sites, as shown in the attached event summary table on page 6-5. Grab samples were taken during the very early portions of the initial discharges from the project control structures. Subsequent samples were taken utilizing on-site automated samplers set to do 24 hour compositing. Because of limited amounts of discharge, additional static grab sampling was done during periods of extended no-flow conditions.

See the Long Term Surface Water Discharge Study Water Quality Monitoring Plan for additional details and methodologies. FDEP Standard Operating Procedures (SOP) were employed in all cases, by Johnson Engineering staff trained in FDEP SOPs and protocols.

Detailed sampling results can be found in the Water Quality Appendix F. Below is a brief summary of the sampling activities.

1. Verandah - six sample sets composed of two sets of initial grab samples and four sets of 24 hour composite data

2. Sandoval - six sample sets composed of two sets of initial grab samples and four sets of 24 hour composite data

3. Shadow Wood Preserve - five sample sets composed of one set of initial grab samples and four sets of 24 hour composite data

4. The Brooks - five sample sets composed of one set of initial grab samples and four sets of 24 hour composite data

5. Mediterra - four sample sets composed of one initial grab sample, one 24-hour set of composite data and two static lake sample sets

6. Twin Eagles - three sample sets composed of one initial grab sample and two static lake sample sets.

2009 Results

A total of 18 water quality samples were collected during the 2009 calendar year, including samples from all six project sites, as shown in the attached event summary table on pages F-1 and F-2. A total of sixteen time composite discharge samples were collected from Verandah, Sandoval, Brooks and Shadow Wood Preserve. Those samples were collected by automated samplers over a 12–24 hour period following rain events that produced discharge. Two grab samples were collected from Mediterra and Twin Eagles (one each). No composite discharge samples were able to be collected from those two sites because they did not discharge during the 2009 monitoring period.

See the Water Quality Monitoring Plan Long Term Discharge Study for additional details and methodologies. FDEP Standard Operating Procedures (SOP) were employed in all cases, by Johnson Engineering staff trained in FDEP SOP and protocols.

Detailed sampling results can be found in the Water Quality Appendix F, including typical results charts for the various parameters. Below is a brief summary of the sampling activities.

1. Verandah - five time composite discharge sample sets

2. Sandoval - five time composite discharge sample sets

3. Shadow Wood Preserve - three time discharge composite sample sets

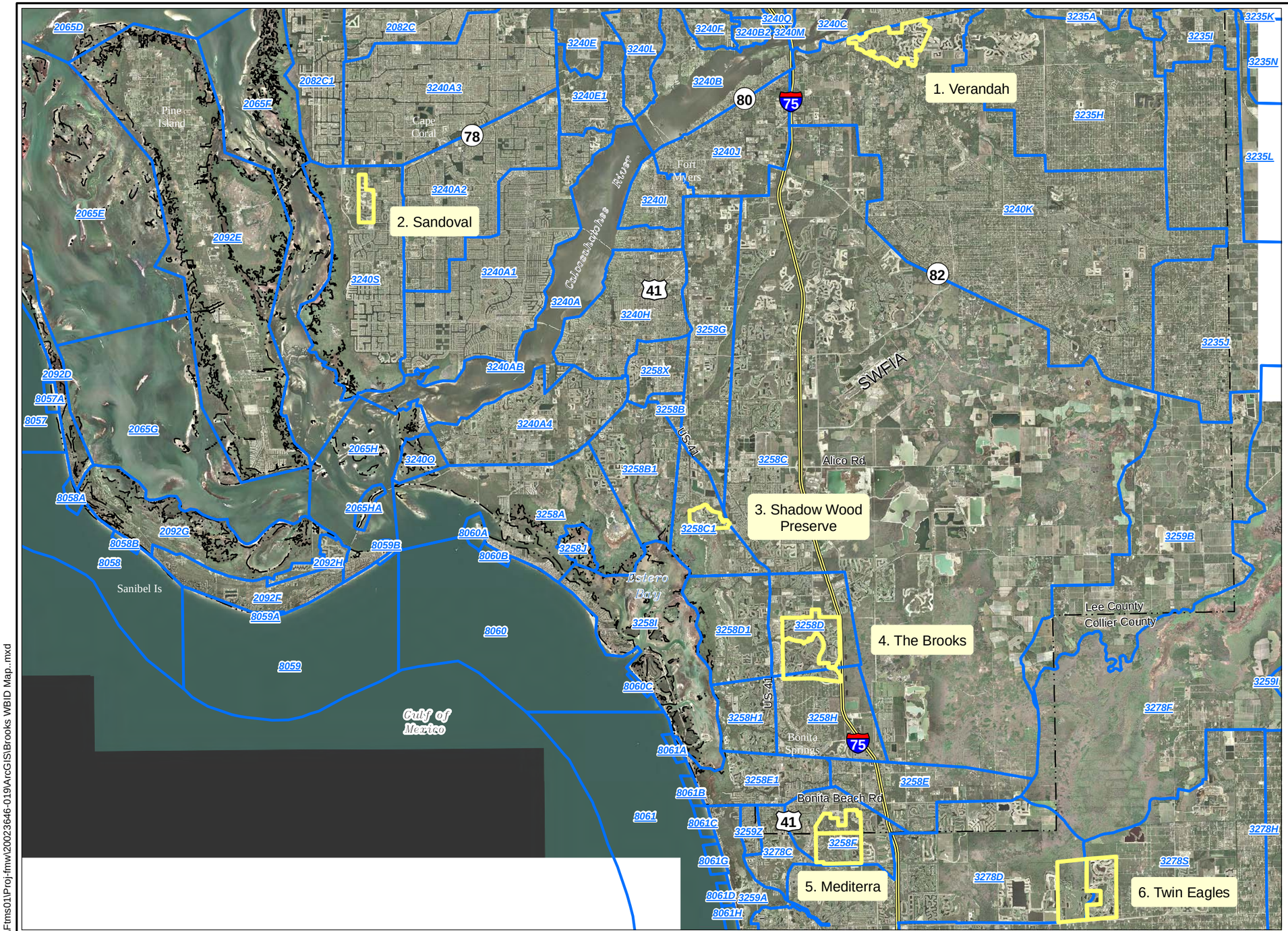
4. The Brooks - three time composite discharge sample sets

5. Mediterra – one static grab sample set

6. Twin Eagles - one static grab sample set

Included in the Water Quality Appendix F are two charts depicting the results of the In-Situ Aqua Troll Pressure/Conductivity/Temperature probe data collection. One of these devices was installed to evaluate performance related to detecting small changes in salinity in water management systems. While the data retrieved to date is limited, the probe sensitivity and reliability indicate that it will be of value in systems where salinity is a consideration due to salt water intrusion potential. The device is installed at the Verandah project situated on the Orange River, a tributary to the environmentally sensitive Caloosahatchee River in Lee County, Florida. Long term effects of salinity changes on water management systems in this area is unknown, but significant changes in salinity are known to occur in the Caloosahatchee River during drought periods and due to heavy discharge from Lake Okeechobee through the upstream Franklin Locks.

In early 2010, the Environmental Protection Agency (EPA) proposed a set of numeric nutrient criteria for Florida based on a complex set of criteria reviewed in other literature. If those proposed guidelines for Class III colored lakes were applied to discharge samples taken from four of the six projects in 2009, we see that some projects would probably meet the criteria today while others would likely not. See the water quality charts in Appendix F. Chlorophyll-a concentrations, for example, appear to be generally lower than the proposed limit at Verandah, Sandoval, The Brooks and Shadow Wood Preserve (SWP), based on 2009 results. Total Nitrogen concentrations generally appear to be lower than the proposed limit at Verandah, The Brooks and Shadow Wood Preserve, but not at Sandoval. Total Phosphorus concentrations appear to generally exceed the proposed limit at Verandah and Sandoval, while The Brooks and Shadow Wood Preserve generally would meet the proposed limit based on the 2009 results.



\\Fms01\Proj-fmw\20023646-019\ArcGIS\Brooks WBID Map..mxd

Long Term Discharge Study
Lee and Collier County, Florida

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PHONE (941) 334-0046
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E.B. #642 & L.B. #642

WBID Planning Units Showing Project Locations

DATE	PROJECT NO.	FILE NO.	SCALE	SHEET
03/21/10	20098229	00-00-00	As Shown	Map 5-6

6. HYDROGEOLOGY

6. HYDROGEOLOGY

Verandah

Poorly graded (well sorted) fine sands compose the upper-most 2-15 feet of the Surficial aquifer at the project site. The amount of fines present generally increases below this depth until the top of the clay confining layer separating the Surficial and Sandstone aquifers, described as a sandy clay to a lean clay, is encountered at approximately 12-25 feet below land surface (bls). Minor amounts of shell and limestone gravel may be present in the surficial sands as well. A geotechnical investigation performed at the site by Ardaman and Associates in 2000 identified hard-bedded to weathered and fractured limestone in four of the borings taken on-site. This limestone layer mainly occurs in the eastern part of the Verandah property, outside of the study basin covered in this report. However, a boring taken near Lake B did show approximately 2 feet of hard-bedded limestone from 3-5 feet bls, although that was the only reported occurrence within the study basin.

Sandstone aquifer test wells constructed on the eastern part of the property as part of a testing program performed by CDM in 2005 show a sandy limestone representing the top of the Sandstone aquifer occurring at approximately 80 feet bls. Fifty to 70 feet of clay confining material separates the Sandstone and Surficial aquifers in the vicinity of the test site, based on lithologic logs from the test wells. Results from aquifer performance testing conducted by CDM report hydraulic parameters for the Sandstone aquifer as follows: transmissivity values from 28,000 to 57,800 gpd/ft; storage coefficients from $1.4x10^{-7}$ to $4.2x10^{-4}$; and leakance values from $1.2x10^{-5}$ to $5.8x10^{-4}$ gpd/ft^3.

Water levels in the Surficial aquifer generally exceed those in the Sandstone aquifer by 5 feet or more, according to water level data from USGS monitor wells in the area, which means groundwater will typically flow from the Surficial to the Sandstone aquifer at the Verandah project site. However, given the thickness and composition of the confining material, the amount of recharge to the Sandstone aquifer is likely on the order of an inch or two per year, so the site does not constitute a significant recharge area for the Sandstone aquifer.

The Orange and Caloosahatchee Rivers, along with the staging of the surface water management system, exert the dominant control on water levels and flow gradients within the Surficial aquifer. Surficial aquifer groundwater generally flows from northeast to southwest across the study basin, following the site topography which reaches a high near SR-80 and declines sharply immediately adjacent to the Orange River. Although gradients within the Surficial aquifer may be relatively high for southwest Florida, the Surficial aquifer will not transmit large volumes of water through the study basin due to composition of the aquifer material, which is primarily fine sand with appreciable amounts of clay and silt in places. The exception may be where the more transmissive shallow limestone layer occurs. One occurrence of this layer was noted within the study basin, but if the unit is discontinuous and located only near Lake B or to the south of Lake B, it will likely not play a major role in the overall groundwater budget for the study basin.

Sandoval

Fine sands with varying amounts of silt, and rock and shell fragments compose the upper-most 20 feet or more of the Surficial aquifer at the project site. The sands may be very loose to dense with alternating intervals of relative density, based on a geotechnical investigation performed by Universal Engineering in 2003. In two of 11 borings taken at the project site, hard rock interbedded with fine sand and silt occurred at approximately 12-14 feet bls. The rock layer appears limited to the southwestern part of the project site and is approximately 5-7 feet thick. Data from the Lower West Coast Potentiometric Mapping project performed for the SFWMD indicate that the Surficial aquifer may be approximately 30-40 feet thick in this area.

Data from the LWC Potentiometric Mapping Project show interpolated top of aquifer elevations and thicknesses for the Sandstone aquifer of approximately -100 feet NGVD and 50 feet, respectively at the project site. The top of the Mid-Hawthorn aquifer may occur at approximately -150 feet NGVD. In the absence of porous rock, the transmissivity of the Surficial aquifer is likely quite low given the nature of the sediments.

Water levels in the Surficial aquifer generally exceed or equal those in the Sandstone or Mid-Hawthorn aquifer, according to water level data from USGS monitor wells in the area, which means groundwater will typically flow from the Surficial to the deeper aquifers at the Sandoval project site. However, given the thickness and composition of the confining material, the amount

of recharge to the deeper aquifer is likely on the order of an inch or less per year, so the site does not constitute a significant recharge area to deeper aquifers.

Staging of the on-site lake system, tidally influenced lands to the west of the project site, and managed canals near the southern and eastern sides of the project site exert the dominant control on water levels and flow gradients within the Surficial aquifer. Surficial aquifer groundwater generally flows from northeast to southwest across the study basin or radially outwards from the center of the project site, generally following the topography and flowing towards canals and lands near sea level.

Shadow Wood Preserve

Poorly graded (well sorted) fine sands compose the upper-most 2-15 feet of the Surficial aquifer at the project site. Silty sand or weathered or fractured to hard-bedded limestone may underlie the uppermost surficial sands. In six borings taken at the project site by Ardaman and Associates in 1997, all but one reported the presence of limestone within the Surficial aquifer. The top of the limestome layer may occur as shallowly as 2 feet bls near the eastern part of the site or as deeply as 18 feet bls towards the southwest. The thickness of the limestone layer ranges from 1-8 feet, and in some locations a layer of silty sand with gravel may occur between two limestone layers. Only one boring in the north-central part of the property did not report the presence of limestone, but notes indicate a loss of circulation at 10.5 feet bls. Missimer International prepared a report describing the construction and testing of Sandstone, Mid-Hawthorn and Lower Hawthorn aquifer test wells at the site in 2000. The test wells were clustered slightly north of the center of the property, and lithologic logs indicated the presence of a limestone layer in the Surficial aquifer over 30 feet thick, beginning at approximately 10 feet bls and separated from the uppermost sand layer by a thin, 1-foot layer of clay.

The lithologic logs show the top of the Sandstone aquifer occurring at approximately 110 feet bls, marked by a clayey sandstone 45 feet thick that is underlain by approximately 5-8 feet of limestone at the base. Over 60 feet of clay confining material separate the Surficial and Sandstone aquifers at the site. Results from aquifer performance testing conducted by Missimer International report transmissivity values for the Surficial aquifer 177,800 to 209,800 gpd/ft.

Water levels in the Surficial aquifer generally exceed or equal those in the Sandstone aquifer, according to water level data from USGS monitor wells in the area, which means groundwater will typically flow from the Surficial to the Sandstone aquifer at the Shadow Wood Preserve project site. However, given the thickness and composition of the confining material, the amount of recharge to the Sandstone aquifer is likely on the order of an inch or less per year, so the site does not constitute a significant recharge area for the Sandstone aquifer.

Mullock Creek, tidally influences lands to the west of the project site and staging of the surface water management lakes, exert the dominant control on water levels and flow gradients within the Surficial aquifer at the project site. Surficial aquifer groundwater generally flows from east to west across the study basin, from a topographic high near US-41 and lands to the east to near sea level to the west of project site and in Mullock Creek. Groundwater may also flow radially outwards from the center of the project site, again following the site topography which has had fill added and dictated by the staging of the lake system. The stormwater lakes are excavated sufficiently deep to intersect the limestone layer where present. Due to the occurrence of the highly transmissive limestone layer and the relatively steep hydraulic gradient, the Surficial aquifer can transmit large volumes of water through the study basin and may both contribute baseflow to the stormwater lakes or drain water from the lakes, depending on the relative differences in head.

Brooks

Fine to medium sands with varying amounts of clay compose the upper-most 10-20 feet of the Surficial aquifer at the project site, based on lithologic logs from test wells compiled by Missimer International in 1996. Hard fossiliferous limestone may occur beneath the sand and extends to approximately 40 feet bls. At some locations, a shell layer may be present between the sands and limestone. The limestone layer may also have a greater percentage of sand at the top, decreasing with depth. This limestone displays high macroporosity and permeability appears high. A soft, green calcareous clay occurs beneath the limestone and forms the confining layer between the Surficial and Lower Tamiami aquifers. The top of the Lower Tamiami aquifer begins at around 75-80 feet bls, and the formation has a thickness of 40-50 feet. A few feet of Sandstone or sand may be present at the base of the aquifer.

On-site aquifer performance testing performed at three on-site locations for the Surficial aquifer by Missimer International reported transmissivity values of 82,000 to 390,000 gpd/ft. These transmissivity values are high, though not as great as values encountered farther south. On-site aquifer performance testing on the Lower Tamiami aquifer report transmissivity values of 59,000 to 89,000 gpd/ft, storage coefficients of $8.1x10^{-5}$ to $1.7x10^{-5}$, and leakance values of $1.2x10^{-3}$ to $2x10^{-3}$ gpd/ft^3.

Water levels in the Surficial aquifer generally exceed or equal those in the Lower Tamiami aquifer, according to water level data from USGS monitor wells in the area and data collected on-site, which means groundwater will typically flow from the Surficial to the Lower Tamiami aquifers at the project site. Recharge to the Lower Tamiami aquifer could be on the order of 5 to 8 inches per year at the project site, depending on the head difference between the two aquifers.

Staging of the on-site lake system and pumping of Surficial aquifer irrigation wells exert the dominant control on water levels and flow gradients within the Surficial aquifer. Surficial aquifer groundwater generally flows from east to west across the study basin towards the coast, following the general topography. Given the high transmissivity of the Surficial aquifer, the potential exists for large volumes of water to be transmitted both into and out of the project site, depending on the hydraulic gradients.

Mediterra

Fine to medium sands with varying amounts of silt compose the upper-most 1-6 feet of the Surficial aquifer at the project site, based on lithologic logs from test wells compiled by Missimer International in 1999. Hard to soft fossiliferous limestone may occur as shallowly as 1 foot bls and extends to approximately 30-40 feet bls. This limestone displays high macroporosity and loss of circulation was indicated during drilling. Sand, silt and shell layers may also be present within this limestone unit between 4-19 feet bls. Most of these clastic layers are only a few feet thick, although one well reported a thickness up to 10 feet. A soft, green to light grey clay occurs beneath the limestone and forms the confining layer between the Surficial and Lower Tamiami aquifers. The top of the Lower Tamiami aquifer begins at around 60 feet bls, and the formation has a thickness of 30 feet or greater.

On-site aquifer performance testing performed at three on-site locations for the Surficial aquifer by Missimer International reported transmissivity values of 4,900,00 to 1,100,000,000 gpd/ft. These transmissivity values are extremely high and may have been enhanced by blasting during the construction of on-site lakes and canals in the area. Nearby specific capacity testing on the Lower Tamiami aquifer report estimated transmissivity values of 85,000 to 195,000 gpd/ft.

Water levels in the Surficial aquifer generally exceed or equal those in the Lower Tamiami aquifer, according to water level data from USGS monitor wells in the area and data collected on-site, which means groundwater will typically flow from the Surficial to the Lower Tamiami aquifers at the project site. Recharge to the Lower Tamiami aquifer could be appreciable at the project site if the leakance value between the two aquifers is high, but this data is not readily available in the immediate proximity of the project site. The amount of recharge will be driven by relative head differences between the aquifers and the hydraulic properties of the confining layer.

Staging of the on-site lake system and canals to the west and south of the project site exert the dominant control on water levels and flow gradients within the Surficial aquifer. Surficial aquifer groundwater generally flows from east to west across the study basin or southeast to northwest towards the Imperial River. Given the extremely high transmissivity of the Surficial aquifer, the potential exists for large volumes of water to be transmitted both into and out of the project site, depending on the hydraulic gradients.

Twin Eagles

Fine sands with varying amounts of silt, and rock and shell fragments compose the upper-most 12-20 feet of the Surficial aquifer at the project site. The sands may be very loose to dense with alternating intervals of relative density, based on a geotechnical investigation performed by Law Engineering in 1997. Lithologic logs prepared by CDM in 2006 for wells constructed on-site also may show a shell layer approximately 4-feet thick in places beneath the sands. Moderately hard to soft sandy limestone occurs at a depth of approximately 8-12 feet bls and extends to approximately 35 feet bls. This limestone displays high vuggy and intergranular macroporosity. A soft, silty clay occurs beneath the limestone and forms the confining layer between the Surficial and Lower Tamiami aquifers, with a thickness of approximately 10-15 feet. The top of

the Lower Tamiami aquifer begins at around 50 feet bls, and the formation extends to 85 feet bls or greater.

On-site specific capacity testing performed on Surficial aquifer wells by CDM reported values of 525 to 4,740 gpm/ft, which equate to approximately transmissivity values of 787,500 to 7,100,000 gpd/ft, respectively. These transmissivity values are extremely high and may have been enhanced by blasting during the construction of on-site lakes and the Cocohatchee Canal that forms the southern border of the project site. On-site testing also indicates a high transmissivity for the Lower Tamiami aquifer on the order of 350,000 gpd/ft.

Water levels in the Surficial aquifer generally exceed or equal those in the Lower Tamiami aquifer by approximately 5 feet or greater, according to water level data from USGS monitor wells in the area and data collected on-site, which means groundwater will typically flow from the Surficial to the Lower Tamiami aquifers at the project site. Results from APTs conducted in the area and the general lack of thickness and consistency of the confining layer suggest the amount of recharge to the Lower Tamiami aquifer could be significant at the project site. The amount of recharge will be driven by relative head differences between the aquifers and the hydraulic properties of the confining layer.

Staging of the on-site lake system and managed canals near the southern and eastern sides of the project site exert the dominant control on water levels and flow gradients within the Surficial aquifer. Surficial aquifer groundwater generally flows from north to south across the study basin towards the Cocohatchee Canal, which generally has a managed water level several feet lower than Twin Eagles control elevation. This steep hydraulic gradient combined with the high transmissivity and thickness of the limestone layer of the Surficial aquifer create a condition where large volumes of groundwater could exit the site and contribute baseflow to the Cocohatchee Canal.

7. FUTURE CONSIDERATIONS AND CHANGES TO PROJECT SITES IN 2009

7. FUTURE CONSIDERATIONS AND CHANGES TO PROJECT SITES IN 2009

RAINFALL AND RUNOFF

Calendar Years 2007 – 2008 were an extremely dry year in 2007, followed by a more normal wet year in 2008. Volume of runoff/rainfall varied significantly. Data from C.Y. 2009 creates information for a more somewhat below normal rainfall year providing a balance between extreme C.Y. 2007-2008 conditions.

WATER QUALITY

Water Quality data can be related to quantity of rainfall-runoff, degree of dilution, percentage of impervious cover and other factors such as changes in intensity of use and groundwater interactions. Additional water quality data in collected in 2009 should help evaluate these complex relationships. Water quality testing could better match runoff pollution results (phosphates, nitrates, etc.) with treatment on golf courses, residential subdivisions, shopping centers, etc.

Because of the limited number of total samples and the variety of sampling performed, long term relevance of the data collected is not as great as it could be with larger numbers of sample sets collected over longer periods of time. Efforts should be made to continue sampling these locations over time, as the value added by being able to tie the water quality results to the discharge characteristics is great. Increasing the total number of datasets for both the static samples and the discharge samples is of high value.

SURFACE RUNOFF - GROUNDWATER INTERRELATION

The C.Y. 2007 dry year created a situation where all but two of the six projects (1. Verandah, 2. Sandoval) had no runoff (i.e. full retention of rainfall). Therefore, rainfall primarily left through either evapotranspiration or groundwater flow during C.Y. 2007. In subsequent years this discharge through evapotranspiration and groundwater continued, in addition to direct discharge through control structures. The relationship between these is not well documented. Prior to residential development, farm ditches discharged rainwater from the sites or it infiltrated into the water table through pervious soils.

The surface runoff-groundwater flow relationship is of particular interest for project 6. Twin Eagles. The only year where runoff occurred was C.Y. 2008 (66.8 inches of rainfall). It is suspected that a major groundwater flow is occurring through underground limerock strata intersecting the lake basins.

Investigation of the benefits of increased groundwater recharge and flow versus direct discharge (through water control structures) downstream would be of interest in guiding water management design for future developments. Development of a groundwater component to the monitoring program to be initiated during 2010 is currently under development.

CHANGES IN PROJECT DEVELOPMENT

Management of Bonita Bay golf courses are in transition from "corporate owned" to "membership owned" facilities. JEI has been in contact with the new managers and anticipate similar good cooperation as in the past.

The three Sandoval weir outfall structures were modified in February 2010 as a result of the added runoff area from the Surfside Blvd. four laning. No flows were altered during the 2009 calendar year because of this, but flow formulas will be adjusted to compensate for these changes in following reports. Sandoval continued to have new residential housing units constructed during 2009, more so than the other five projects. This results in increased impervious areas which have been approximated. Minor increases in impervious areas at the other project sites occurred during 2009.

The Twin Eagles Golf Course was closed for several months in mid-C.Y. 2009. This short period of closure had no apparent effect on runoff. The course has reopened and no future impact is anticipated.

8. CONCLUSIONS AND COMMENTS

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CONCLUSIONS

1. Calendar Year 2009 had, on average, rainfall of 50.46 inches over the six project sites; C.Y. 2008 had a high average rainfall of 62.35 inches, C.Y. 2007 - had a low average rainfall of 37.22 inches. The annual average rainfall for the Southwest Florida area is 57.2 inches based on a 30 year reporting period from SFWMD records for Southwest Florida stations. The mean rainfall for Lee County based on county records for 1992-2009 is 60.75 inches.

2. The period of time during which the summer rainfall occurred, mid-June through mid-September, was consistent for both drier (2007 and 2009) and wetter year (2008). While rainfall was higher overall in 2008 than 2009, there was a significant difference in the timing distribution of when the rainfall occurred between the two years. Very little rainfall occurred during the first quarter of 2009 compared to 2008. While the total for 2009 was below average and less than 2008 rainfall, the rain that did fall in 2009 was more concentrated on the summer/fall wet season and likely helped lead to an increased percentage of runoff for the projects that did discharge during 2009.

3. In dry C.Y. 2007, only two (1. Verandah, and 2. Sandoval) project sites had runoff; in C.Y. 2008 all six project sites had runoff; and in C.Y. 2009 all but one project site (6. Twin Eagles) had runoff.

4. The percentage of runoff (outflow volume/rainfall volume) increased for each of the six project sites between 2007 and 2008. The primary contributor to this rise was increased rainfall and impervious area. Construction activity had decreased significantly during this period and impervious increases were generally smaller than previous years. Runoff percentages for 2009 increased over 2008 for three of the four sites with significant runoff during the year. This is likely due to the change in rainfall distribution as noted in note 2 above along with additional impervious area particularly at 2. Sandoval.

5. In C.Y. 2008 and 2009 Sandoval had very high outflows, 37.23% and 44.48%, respectively, of the total rainfall volume, and is notably the only area that has no golf course; Twin Eagles the lowest outflow in 2008 at 2.9%; in 2009 only Twin Eagles had no outflow (see possible explanations on page 7-1 last paragraph).

6. Interconnecting of lake systems (i.e. Sandoval an excellent example) further attenuates single drainage area surge discharges.

7. Several related factors, other than simple rainfall and direct runoff through weir outfall structures influence total runoff, among these factors being percentage of imperviousness, groundwater recharge through infiltration from elevated lakes and attenuation of runoff by interconnecting lake systems.

8. The C.Y. 2007 Report stated that full retention and interconnection significantly attenuates surge discharges, probably to a greater (and more beneficial) extent than initial "pre equal post development" design regulations anticipated; 2008 and 2009 data further reinforce that concept.

9. A review of the table on page 4-10 shows how consistent project water management design has been on Bonita Bay developments. Although designed by numerous different engineering companies, percentages of lakes and impervious covers are quite similar, for similar densities, confirming that water management rules are being equitably applied.

10. Some projects, Twin Eagles and Mediterra in this study, consistently discharge less than normally expected, even in average rainfall years.

COMMENTS

1. The relationship between the percentage of direct downstream discharge (through water control structures) and groundwater flow should be investigated and monitored, this being especially true for the 6. Twin Eagles project.

2. Efficiency of nutrient removal from typical wet detention versus groundwater exfiltration may be of interest.

3. Water budgets for watersheds in this part of the State have about 75 percent of the rainfall lost as evapotranspiration (ET), twenty percent as runoff and five percent as recharge. These numbers will vary from watershed to watershed and from year to year. The percentage of runoff shown in the table on page 4.12 has a high range of variability and in some cases is much higher than an overall watershed value as outlined above. There are several possible reasons for the variability. These include underground rock formations with high transmissivity, groundwater flows intercepted by an interconnected storm water system, changes to impervious coverage due to continued construction, changes to rainfall distribution from one year to the next year, evaporation, ET, irrigation inputs and differences in rainfall distribution based on geographical location. The data generated to date verify the high degree of variability in local site conditions and even conditions changing over time at the same site location.

4. The hydrogeologic characteristics (see Section 6) at the six project sites may have a significant influence on the discharge behaviors seen at the sites. The groundwater program being undertaken should provide additional data to evaluate this component.

5. All project sites, except Sandoval, have irrigation systems withdrawing from either surfical or groundwater aquifers. Sandoval is irrigated completely by offsite reuse water, and the Brooks irrigation system has a partial contribution from offsite reuse water. These systems have the potential to influence discharge behaviors, especially when surrounding soils are saturated and water levels in the lake are at discharge elevations. Additional inflows from non-surficial sources at these times can lead to higher than normal runoff rates. Irrigation activity from surficial aquifers has the potential to decrease discharge when lake levels are at discharge elevations due to additional evapotranspiration that the Surficial irrigation water is exposed to. Taken together, these functions complicate the understanding of discharge behaviors. See withdrawal charts in Section 4.

APPENDICES

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RAINFALL/STAGE-TIME GRAPHS – ALL PROJECTS C-1

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PHOTOGRAPHS – PROJECT SITES……..E-1

WATER QUALITY DATA F-1

APPENDIX A-1

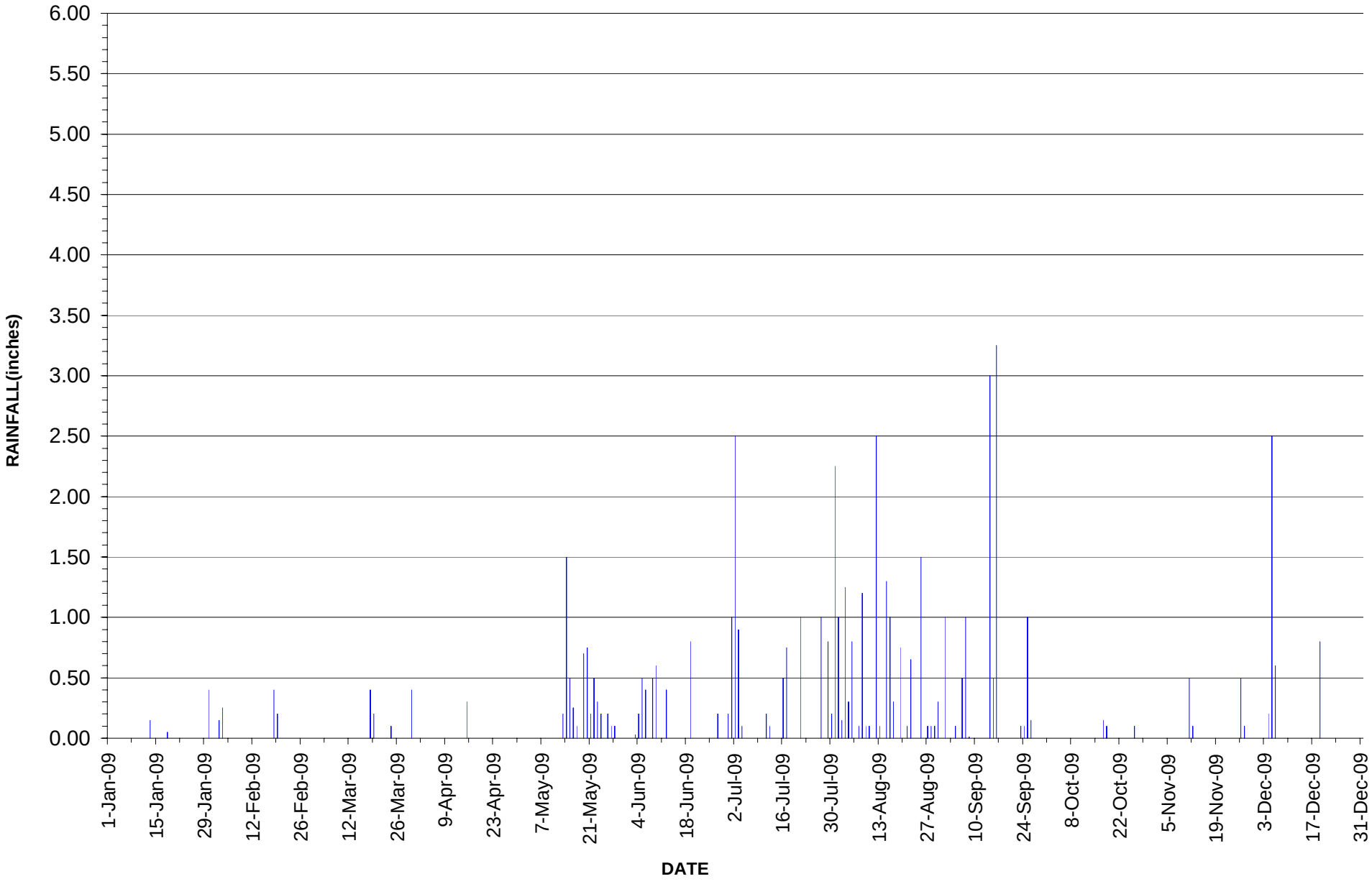
RAINFALL GRAPHS – ALL PROJECTS

VERANDAH RAIN DATA 2009
RV-1

JOHNSON ENGINEERING

Rainfall taken from Golf Course gages

Total Rainfall 1/1/09 to 12/31/09 53.89"

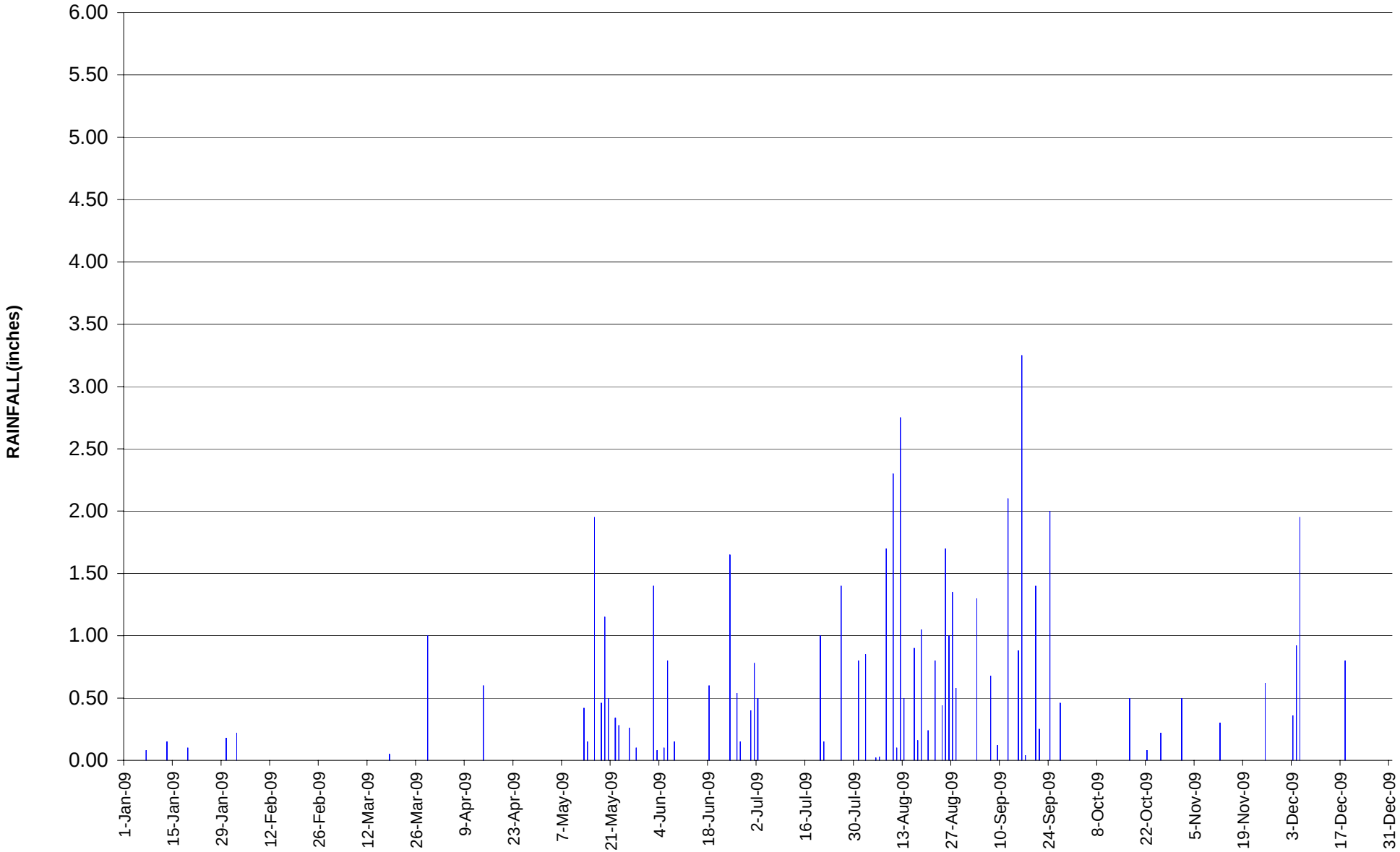


SANDOVAL RAIN DATA 2009
RO Plant

JOHNSON ENGINEERING

Rainfall taken from Cape Coral RO Plant

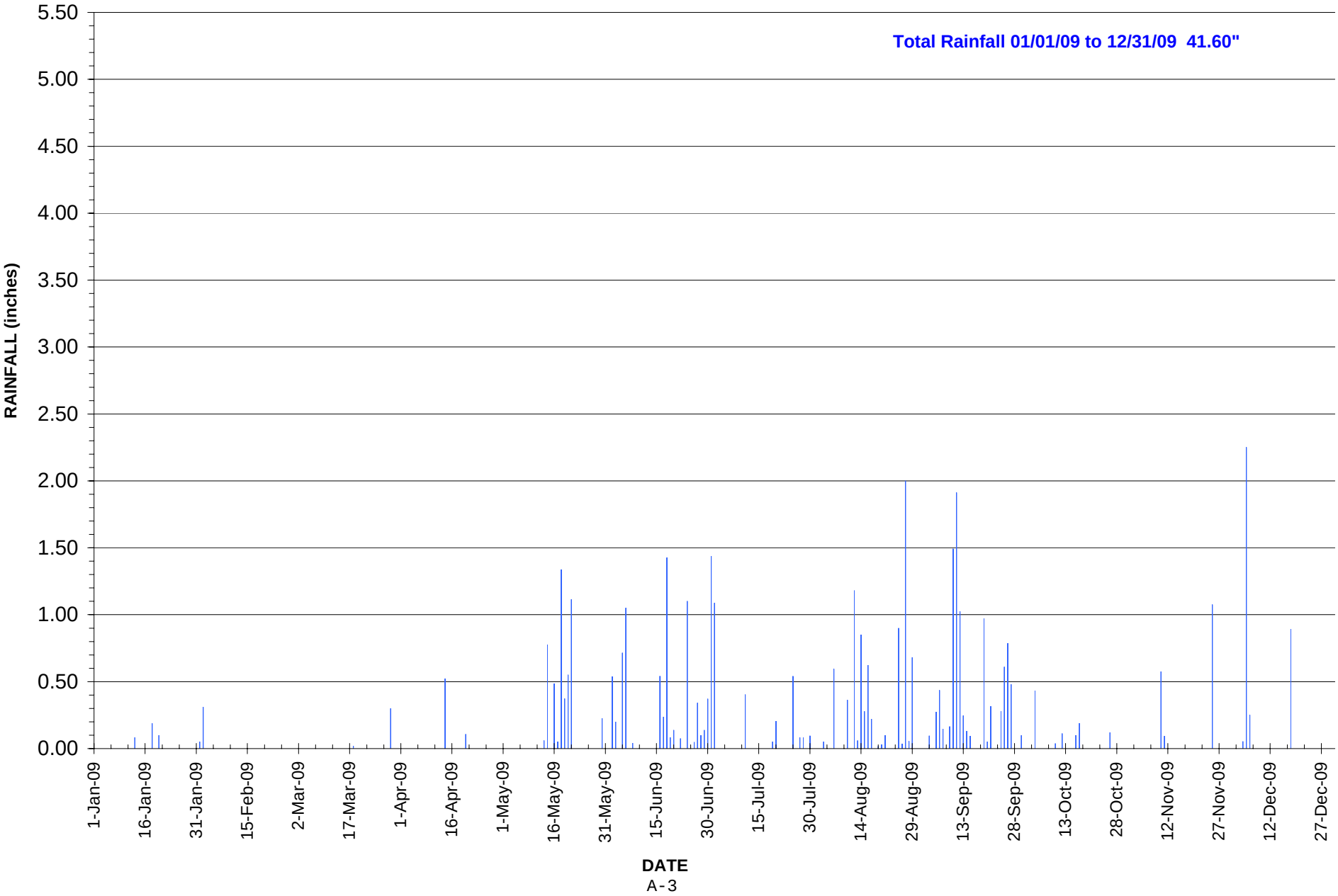
Total Rainfall for 01/01/09 to 12/31/09 53.69"



SHADOW WOOD PRESERVE RAIN DATA 2009
RS-1

JOHNSON ENGINEERING

Rainfall taken from Golf Course gages

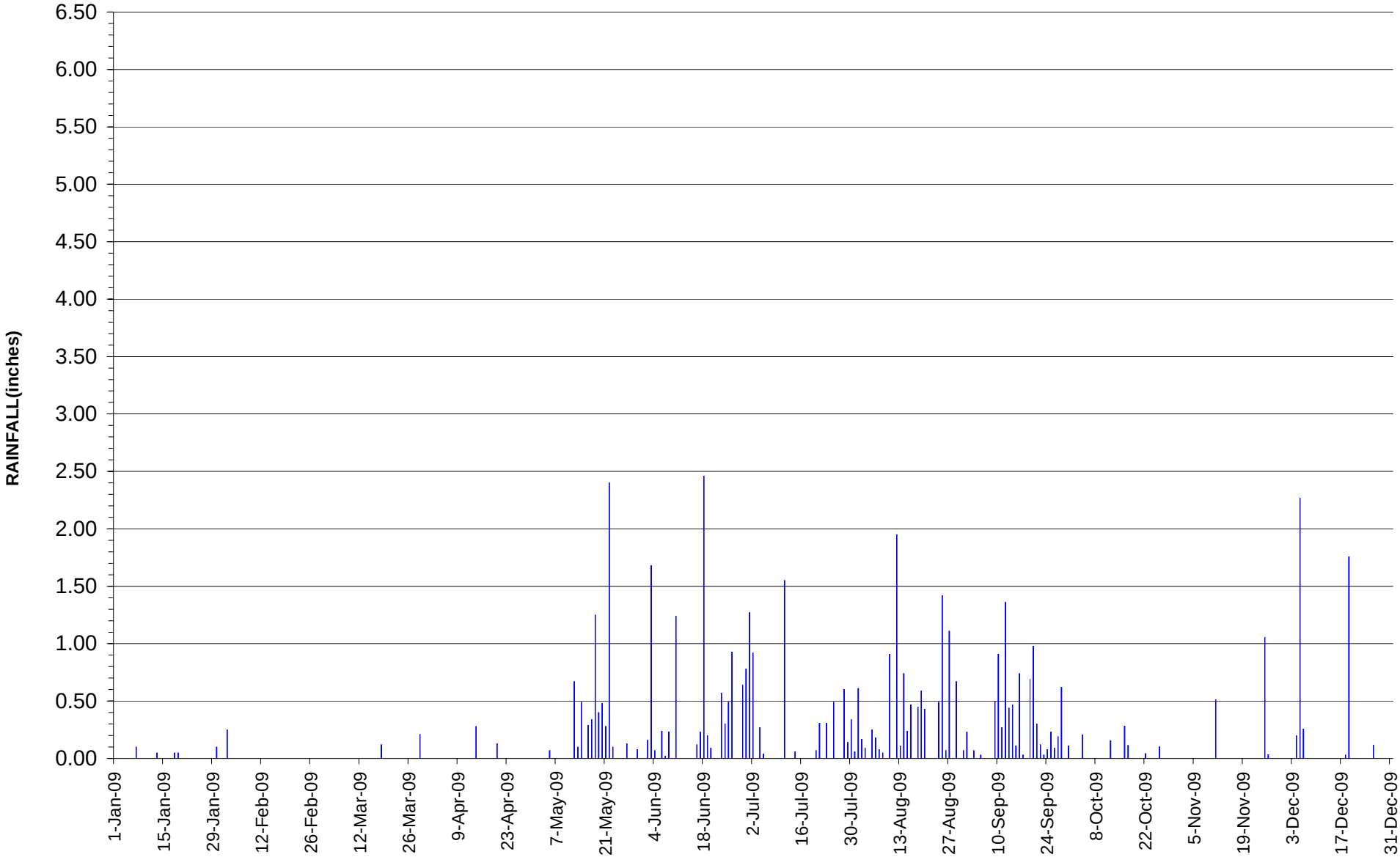


THE BROOKS RAIN DATA 2009
RB-1

JOHNSON ENGINEERING

Rainfall taken from Golf Course gages

Total Rainfall 01/01/09 to 12/31/09 52.19"

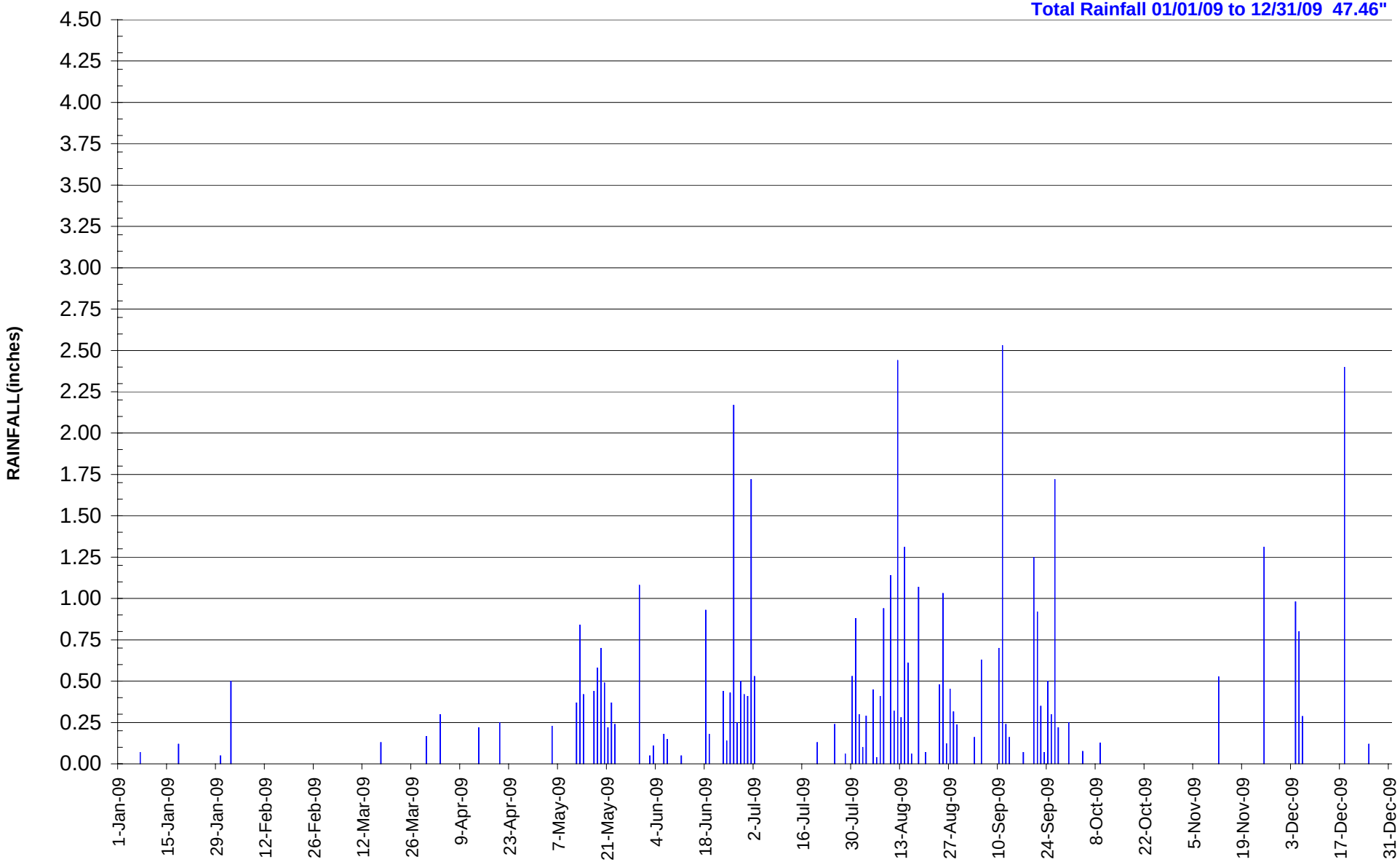


MEDITERRA RAIN DATA 2009
RM-1 at Maintenance Area

JOHNSON ENGINEERING

Rainfall from GC gages

Total Rainfall 01/01/09 to 12/31/09 47.46"

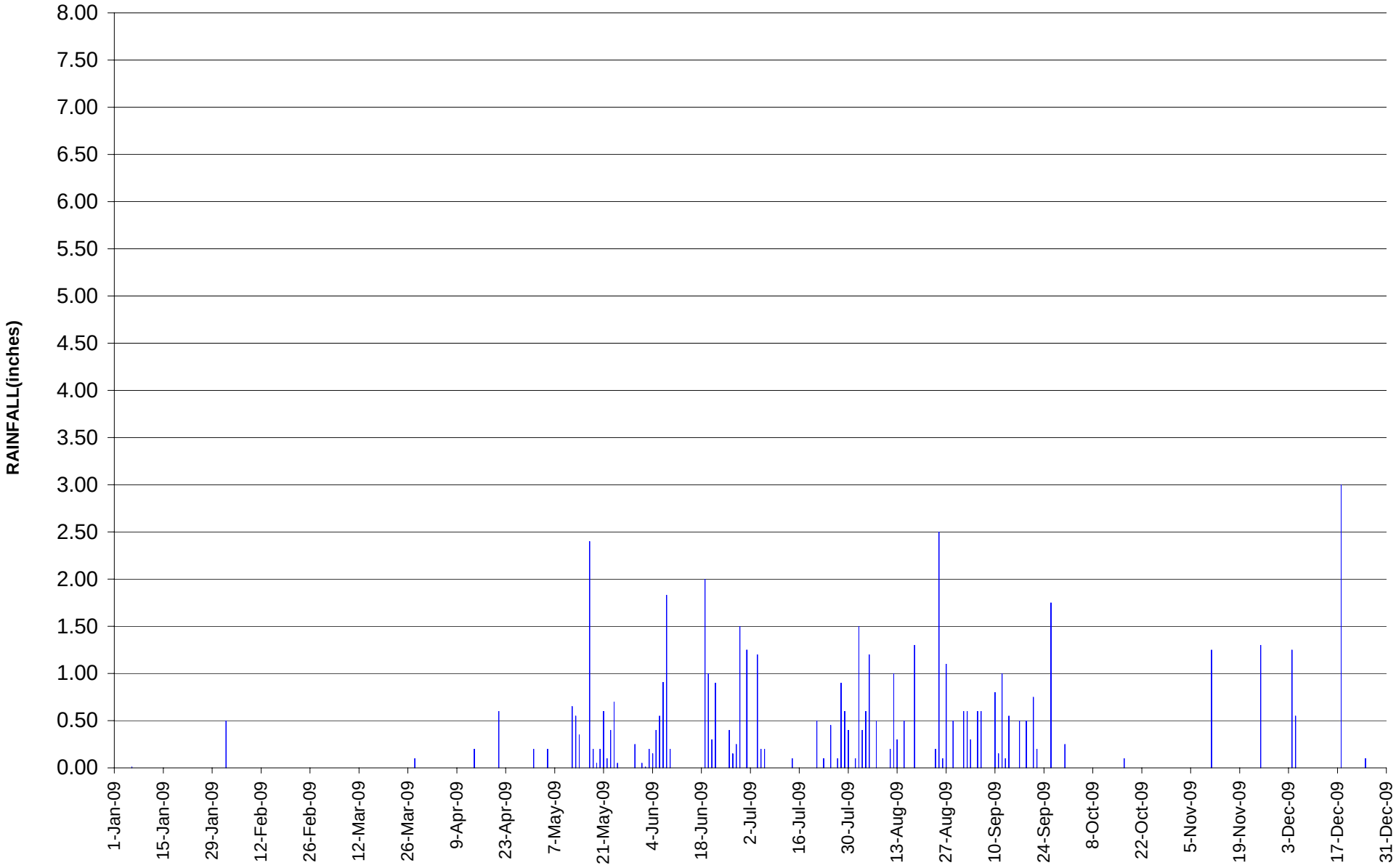


TWIN EAGLES DATA 2009
RT-1 at Outfall

JOHNSON ENGINEERING

Rainfall taken from Golf Course gages

Total Rainfall 1/1/09 to 12/31/09 53.91"



Lee County - Daily Rainfall December, 2007																		
	Lake Fair(2)	N Reserv(1)	Page-LT(2)	Lakes Pk(2)	Lehigh(2)	Cork(2)	Bonita(2)	Olga(2)	WTEP(2)	Alva(1)	Hendry(1)	Yellow Fever(3)	Cecil Webb(2)	Gateway(2)	FMB(2)	10 Mile(3)	Lover's Key (3)	BurntStore(3)
1	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.00	0.12	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
3	0.12	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
4	0.00	0.03	0.00	0.01	0.08	0.00	0.07	0.00	0.04	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.18	0.01
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.17	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.05	0.01	0.00	0.06	0.05	0.00	0.02	0.04	0.13	0.31	0.00	0.00	0.10	0.02	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
14	0.69	0.58	2.02	1.42	0.65	1.18	1.00	0.35	0.14	0.68	0.09	2.07	0.66	0.55	0.29	1.12	0.13	1.92
15	0.00	0.01	0.00	0.01	0.15	0.00	0.01	0.01	0.00	0.10	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01
16	0.05	0.17	0.05	0.02	0.05	0.21	0.10	0.04	0.06	0.13	0.13	0.14	0.17	0.04	0.01	0.04	0.16	0.20
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.05	0.03	0.08	0.15	0.01	0.11	0.27	0.00	0.09	0.02	0.01	0.05	0.06	0.03	0.12	0.11	0.38	0.13
22	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01
23	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00
24	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
27	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00	0.00	0.00	0.00	0.13	0.05	0.00	0.07	0.00	0.01	0.08	0.00	0.00	0.00	0.00	0.00	0.01	0.01
30	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Total	0.91	0.95	2.16	1.63	1.46	1.61	1.46	0.50	0.40	1.32	0.67	2.39	0.93	0.86	0.44	1.30	0.90	2.33

* = Equipment malfunction; value in question

ND = No Data

\+ = Partial reading; value not used to calculate mean

(1)Stevens Tilting Bucket Raingauge; Stevens AxSys System

(2)Texas Electronics Tilting Bucket Raingauge:Campbell Scientific CR500 datalogger

(3)Campbell Scientific CR10X

2007 Totals	**34.02**	**45.06**	**50.59**	**36.91**	**37.87**	**33.42**	**29.21**	**35.66**	**40.64**	**35.98**	**41.53**	**43.34**	**40.73**	**32.66**	**20.89**	**33.98**	**25.06**	**31.86**

Taken from Lee County maintained hydrological monitoring website.

http://www.lee-county.com/gov/dept/NaturalResources/HydrologicalMonitoring/

Lee County - Daily Rainfall December, 2008																		
	Lake Fair(2)	N Reserv(1)	Page-LT(2)	Lakes Pk(2)	Lehigh(2)	Cork(2)	Bonita(2)	Olga(2)	WTEP(2)	Alva(1)	Hendry(1)	Yellow Fever(3)	Cecil Webb(2)	Gateway(2)	FMB(2)	10 Mile(3)	Lover's Key (3)	BurntStore(3)
1	0.24	0.17	0.13	0.19	0.06	0.11	0.15	0.08	0.14	0.12	0.00	0.11	0.12	0.09	0.19	0.22	0.17	0.27
2	0.12	0.13	0.08	0.09	0.02	0.04	0.03	0.07	0.07	0.04	0.00	0.01	0.12	0.06	0.03	0.11	0.05	0.17
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
7	0.01	0.07	0.04	0.11	0.06	0.16	0.13	0.01	0.05	0.02	0.03	0.04	0.00	0.07	0.19	0.27	0.09	0.01
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	1.80	1.71	2.02	1.70	0.96	0.92	0.58	1.02	1.37	0.89	1.17	1.64	1.08	0.99	1.24	1.87	0.93	1.34
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.09	0.00	0.01	0.16	0.00	0.00	0.00	ND	0.00	0.00	0.00	0.09	0.01	0.06	0.00
16	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.01	ND	0.00	0.00	0.00	0.00	0.00	0.01	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.05	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
27	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
29	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
30	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.01
31	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00
Total	2.20	2.11	2.27	2.21	1.21	1.25	1.06	1.28	1.65	1.16	1.20	1.81	1.35	1.21	1.74	2.62	1.34	1.84
* = Equipment malfunction; value in question																		
ND = No Data																		
+ = Partial reading; value not used to calculate mean																		
(1)Stevens Tilting Bucket Raingauge; Stevens AxSys System																		
(2)Texas Electronics Tilting Bucket Raingauge:Campbell Scientific CR500 datalogger																		
(3)Campbell Scientific CR10X																		
2008 Totals	**59.57**	**67.88**	**66.91**	**53.52**	**55.06**	**61.64**	**47.10**	**49.03**	**62.27**	**59.18**	**53.13**	**59.24**	**53.55**	**56.32**	**44.03**	**58.61**	**48.71**	**57.64**

Taken from Lee County maintained hydrological monitoring website.

http://www.lee-county.com/gov/dept/NaturalResources/HydrologicalMonitoring/

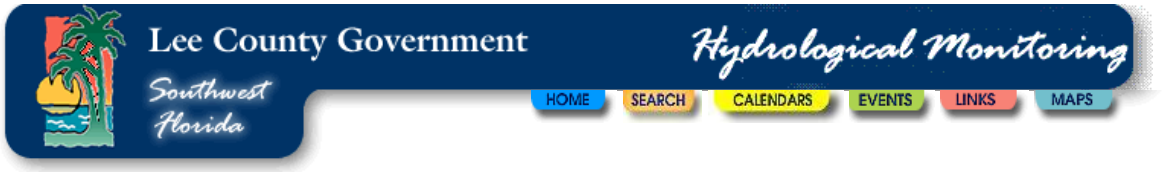
Lee County - Daily Rainfall December, 2009																		
	Lake Fair(2)	N Reserv(2)	Page-LT(2)	Lakes Pk(2)	Lehigh(2)	Cork(2)	Bonita(2)	Olga(2)	WTEP(2)	Alva(2)	Hendry(2)	Yellow Fever(3)	Cecil Webb(2)	Gateway(2)	FMB(2)	10 Mile(3)	Lover's Key (3)	BurntStore(3)
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
3	0.18	0.41	0.12	0.12	0.06	0.07	0.00	0.09	0.15	0.29	0.02	0.00	0.34	0.15	0.06	0.09	0.06	0.41
4	1.84	2.25	2.12	2.07	0.95	1.11	0.58	1.66	2.12	1.32	0.56	ND	2.03	1.63	2.04	2.27	1.67	2.52
5	0.78	0.94	0.79	0.77	1.06	1.19	0.65	0.91	1.19	1.15	1.72	ND	1.11	0.93	0.66	0.84	0.98	0.55
6	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.00	ND	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.00	0.01	0.00	0.00
9	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.35	0.68	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.01	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
18	0.73	0.72	0.67	0.65	0.87	1.37	1.26	0.54	0.91	0.81	1.08	0.51	0.64	0.85	0.68	0.71	1.01	0.58
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.13	0.00	0.00	0.00	0.00	0.10	0.11	0.00	0.00	0.00	0.09	0.00	0.03	0.03	0.00	0.00	0.11	0.01
26	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01
28	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	3.68	4.33	3.70	3.62	3.34	4.52	2.67	3.20	4.38	3.64	3.54	0.53	4.17	3.61	3.44	3.93	3.87	4.10

* = Equipment malfunction; value in question
ND = No Data
\+ = Partial reading; value not used to calculate mean
(1)Stevens Tilting Bucket Raingauge; Stevens AxSys System
(2)Texas Electronics Tilting Bucket Raingauge:Campbell Scientific CR500 datalogger
(3)Campbell Scientific CR10X

2009 Totals	46.43	41.84	39.12	47.54	40.92	47.55	37.46	43.65	39.21	46.51	37.62	36.92	34.78	42.41	37.84	53.43	35.52	36.61

Taken from Lee County maintained hydrological monitoring website.

http://www.lee-county.com/gov/dept/NaturalResources/HydrologicalMonitoring/



Whats New

New Items

- Mission Statement

Quick Links

Hydrological Monitoring Data

- Drainage Atlas Map
- Flow Measurement Data
- Hydrological Annual Reports
- Rainfall Data
- Stage Recorders Data
- Monitor Wells Data

Hydrological Monitoring Links

- Home
- Rain Gauges
- Stage Recorders
- Monitor Wells
- Watersheds
- Master Plan
- MWSWT Map
- Equipment
- NEXRAD
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- Mission Statement
- Disclaimer

Back to HydroMonitor Homepage

Mean Monthly Rainfall

Mean Monthly Rainfall (1991-2009) (inches)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1991	ND	ND	ND	ND	ND	ND	ND	ND	5.79	3.61	0.60	0.18	10.18+
1992	1.43	4.02	3.76	2.59	0.84	12.41	7.36	7.44	3.92	1.22	0.85	0.46	46.30
1993	4.50	2.63	3.56	2.18	2.56	6.46	6.38	9.08	7.33	7.30	0.85	1.16	53.99
1994	2.99	1.97	1.60	6.77	1.59	5.93	8.43	10.37	8.65	2.86	2.61	4.10	57.87
1995	3.61	1.34	1.13	4.79	3.21	14.40	16.49	16.56	8.26	15.01	1.13	1.33	87.26
1996	2.72	0.80	4.29	2.04	6.48	14.16	6.66	9.58	9.61	5.73	0.36	0.87	63.30
1997	1.81	1.73	2.04	7.55	5.03	9.36	10.61	8.75	11.78	0.52	5.20	8.09	72.47
1998	4.10	10.53	7.39	1.08	4.22	4.37	11.56	11.40	12.89	2.68	9.87	1.81	81.90
1999	3.46	0.23	0.82	1.38	4.94	18.46	8.88	15.06	10.82	3.28	1.86	1.41	70.60
2000	1.28	0.26	3.02	1.31	1.82	7.81	9.14	10.39	14.66	2.86	0.44	1.01	54.00
2001	0.38	0.05	6.98	0.53	2.32	8.90	18.24	9.96	16.77	2.37	0.45	1.60	68.55
2002	2.12	1.57	1.62	1.85	4.03	12.35	6.68	9.97	8.64	3.16	5.28	3.66	60.93
2003	1.46	0.92	4.58	3.29	4.88	13.56	6.50	13.02	13.53	0.60	2.34	3.18	67.86
2004	2.95	3.77	0.22	2.78	0.91	9.37	9.57	15.35	7.14	0.82	0.75	1.49	55.12
2005	0.56	2.68	7.15	3.40	2.89	16.95	11.07	6.65	5.42	8.55	3.90	0.21	69.43
2006	0.35	2.66	0.74	0.06	2.28	9.45	11.88	10.04	8.67	0.98	0.71	1.40	49.19
2007	0.48	0.99	0.24	1.69	2.45	5.96	8.18	5.93	6.92	1.94	0.34	1.23	36.35
2008	1.24	2.19	2.34	3.58	0.85	9.34	11.90	11.73	8.99	2.40	0.39	1.67	56.62
2009	0.35	0.26	0.78	0.43	5.37	7.72	5.47	8.51	6.91	0.98	1.25	3.75	41.78
2010													
Mean	1.99	2.14	2.90	2.63	3.15	10.39	9.72	10.54	9.30	3.52	2.06	2.03	60.37^
	1.99	4.13	7.03	9.66	12.81	23.20	32.92	43.46	52.76	56.28	58.34	60.37	

036266

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County Government Information: (239) 332-2737
www.lee-county.com

SFWMD AVERAGE RAINFALL (30 YEAR: 1976-2005)

NORMAL	Upper Kiss	Lower Kiss	Lake O	East EAA	West EAA	Conserv _1_2	Conserv Area_3	Martin/ St. Lucie	Palm Beach	Broward	Dade	East Caloos	BCP	SW Coast	District
JAN	2.38	1.86	2.12	2.19	2.17	2.20	1.91	2.48	3.29	2.34	1.97	2.20	2.21	2.43	2.23
FEB	2.44	2.18	2.06	1.92	1.97	2.34	1.98	2.51	2.82	2.47	2.04	2.04	2.04	2.28	2.19
MAR	3.35	2.98	2.93	2.80	2.85	2.68	2.56	3.80	3.79	2.78	2.66	2.97	2.68	2.86	3.01
APR	2.33	2.18	2.22	2.35	2.42	2.56	2.58	2.84	3.24	3.32	3.18	2.39	2.39	2.40	2.50
MAY	3.55	3.78	3.66	4.30	4.35	4.60	4.42	4.23	5.12	5.35	5.30	3.88	4.21	4.04	4.19
JUN	7.41	7.07	6.77	7.21	8.44	7.28	8.22	6.69	8.10	8.91	8.94	8.85	9.49	9.72	8.03
JUL	6.88	6.35	5.96	6.38	7.34	6.08	6.48	6.50	6.38	6.04	6.13	7.58	8.09	8.76	6.83
AUG	7.21	6.48	6.66	7.09	8.10	6.60	7.12	7.58	7.74	7.41	8.29	8.30	8.35	8.90	7.54
SEP	6.15	6.01	6.29	6.73	7.02	6.37	6.13	7.80	9.07	7.70	8.34	7.31	7.54	8.23	7.05
OCT	2.86	2.73	2.90	3.38	3.73	4.18	3.87	5.17	5.66	5.57	5.50	3.44	3.76	3.57	3.76
NOV	2.48	2.18	2.28	2.61	2.37	3.16	2.59	3.59	4.61	3.55	3.14	2.37	2.18	2.17	2.66
DEC	2.65	1.83	1.82	1.86	1.73	1.92	1.65	2.32	2.96	2.21	1.96	1.81	1.81	1.84	2.01
YEAR	49.69	45.63	45.67	48.82	52.49	49.97	49.51	55.51	62.78	57.65	57.45	53.14	54.75	57.20	52.00

C:/mydocuments/rain_tbl.nrm1976-2005.doc

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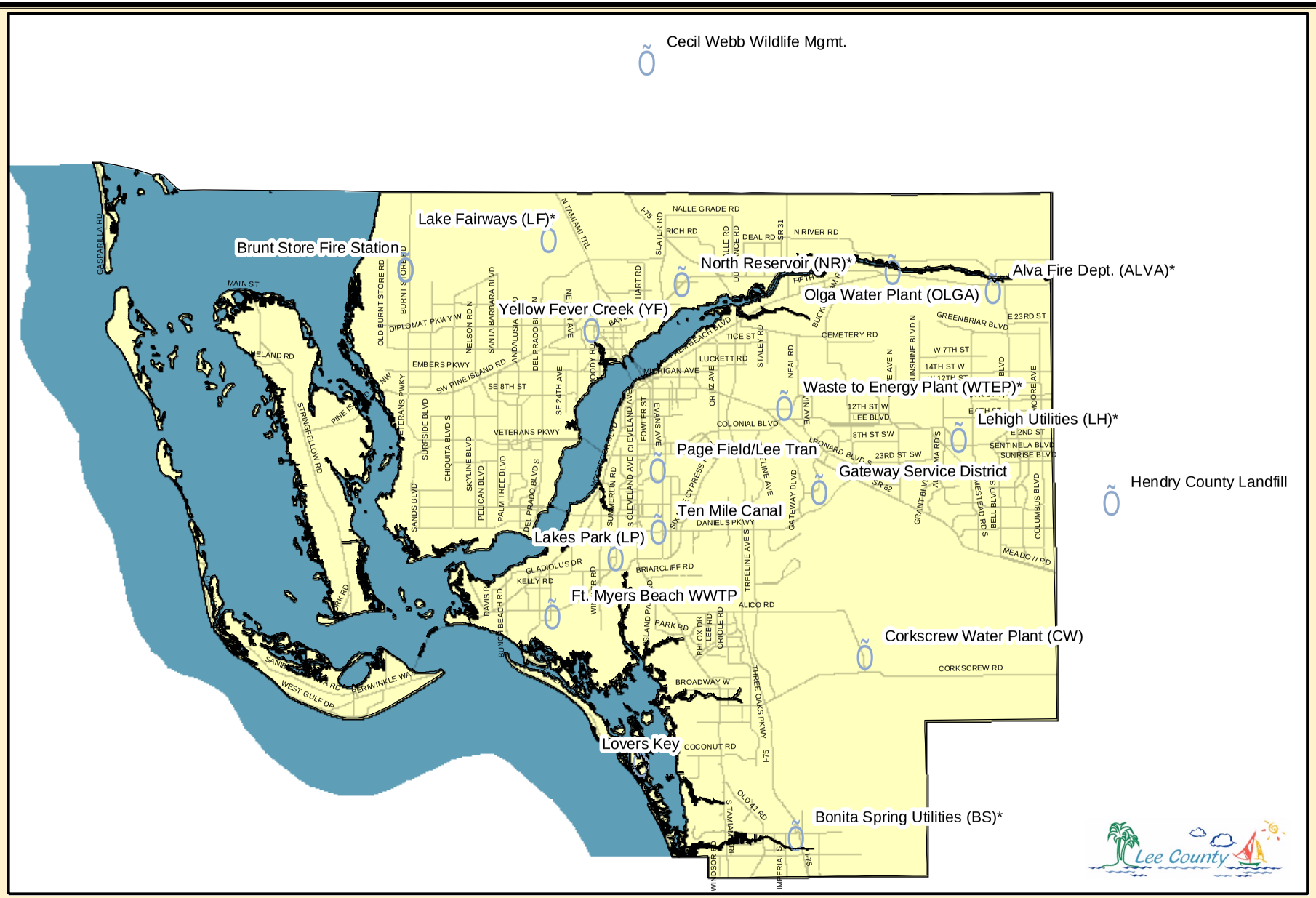
SFWMD Headquarters: 3301 Gun Club Road, West Palm Beach, Florida 33406
561-686-8800 | 1-800-432-2045 (Florida Only)



Legend

- Rain Gauges
- Major Roads
- land
- gulf of Mexico

Lee County Rain Gauges

ArcGIS 8.1
July 2004
Scott Summerall

Source: ESRI Data & Maps CD
Created in ArcGIS 8 using ArcMap
By: Scott Summerall

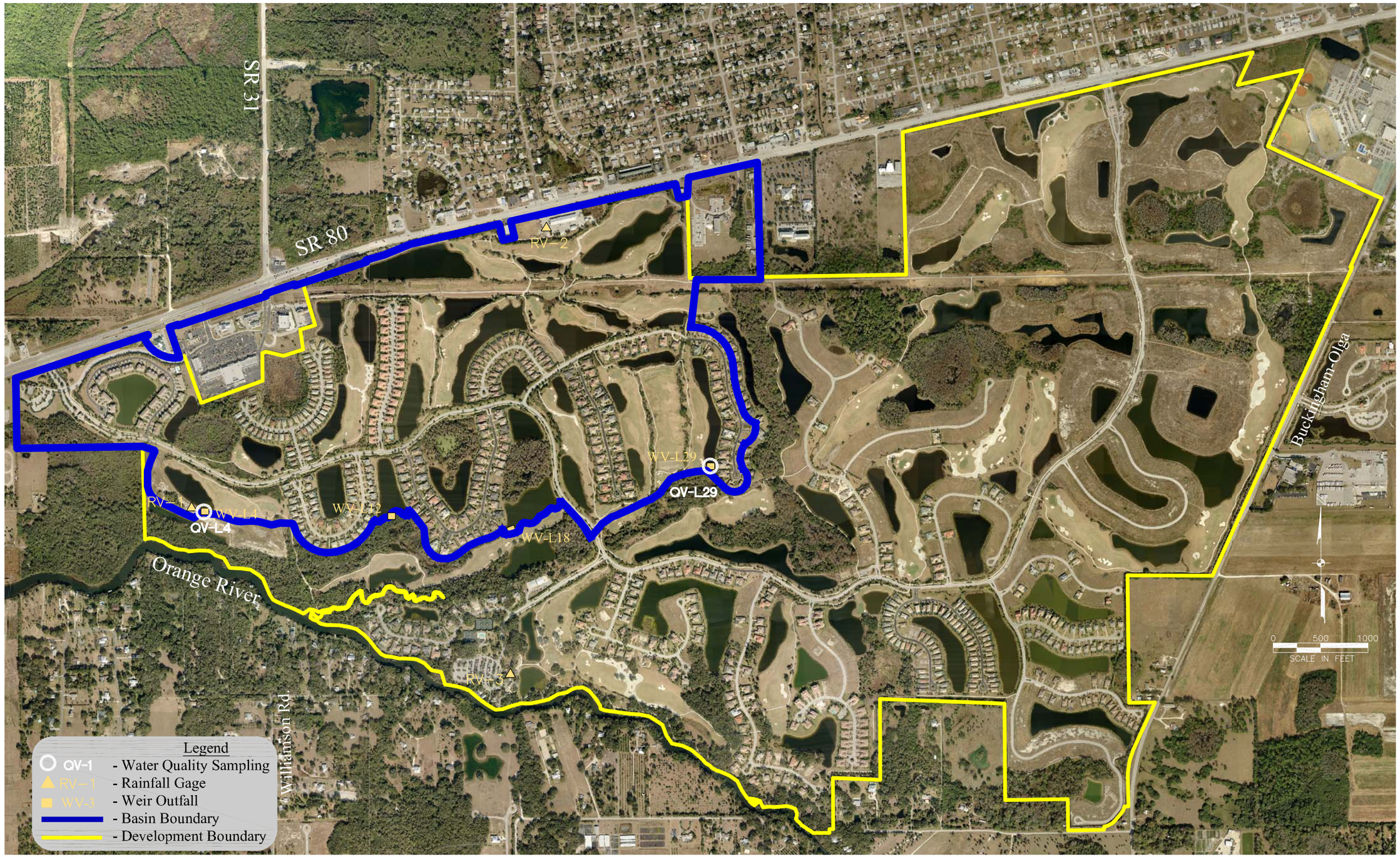
4 2 0 4 Miles

ESRI

Lee County

APPENDIX B-1

AERIAL PHOTOGRAPHS – ALL PROJECTS



J:\20066052\Drawing\2009 Report Drawings\11x17 Aerials Verandah.dwg (11x17 Verandah) mil2 Jul 12, 2010 - 6:36pm

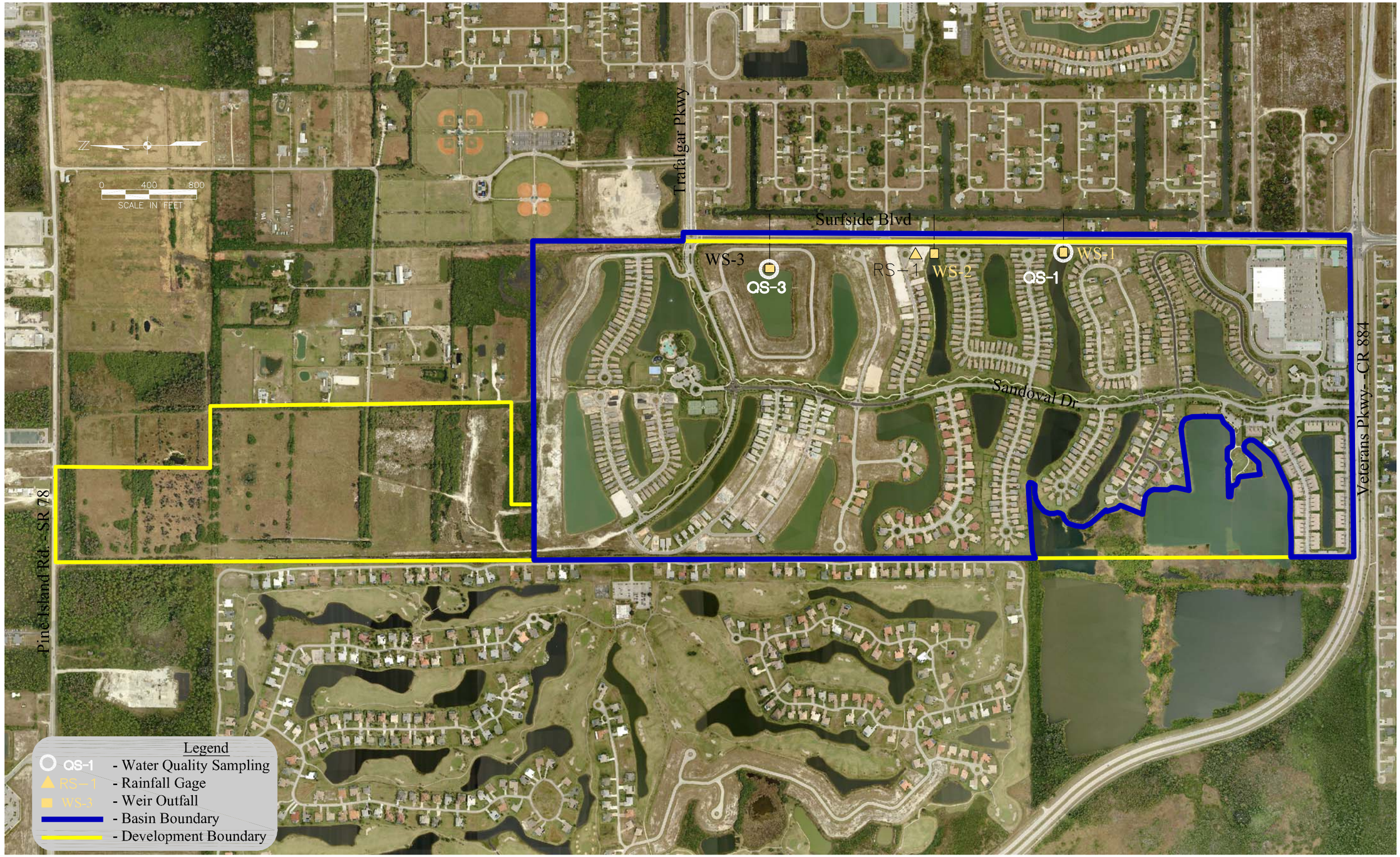
NOTE: Aerial shown is dated January 2010.

Bonita Bay Group
Lee County, Florida

JOHNSON ENGINEERING
2122 JOHNSON STREET
P.O. BOX 1550
FORT MYERS, FLORIDA 33902-1550
PHONE (239) 334-0046
FAX (239) 334-3661
E.B. #642 & L.B. #642

1. VERANDAH - Aerial January 2010
Water Quality / Discharge Study

DATE	PROJECT NO.	FILE NO.	SCALE	SHEET
Feb. 2010	20098229		As Shown	8-1



J:\2006052\Drawing\2009 Report Drawings\11x17 Aerials Sandoval.dwg (11x17 Sandoval) mil2 Jul 12, 2010 - 2:55pm

NOTES:
Aerial shown is dated January 2010.

Basin boundary revised to show Surfside right of way addition 3/1/10.

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E.B. #642 & L.B. #642

2. SANDOVAL - Aerial January 2010
Water Quality / Discharge Study

DATE	PROJECT NO.	FILE NO.	SCALE	SHEET
3/1/10	20098229		As Shown	8-2

J:\20066052\Drawing\2009 Report Drawings\11x17 Aerials SWP.dwg (11x17 Shadow Wood Preserve) mil2 Jul 12, 2010 - 3:11pm

NOTE: Aerial shown is dated January 2010.

Bonita Bay Group
Lee County, Florida

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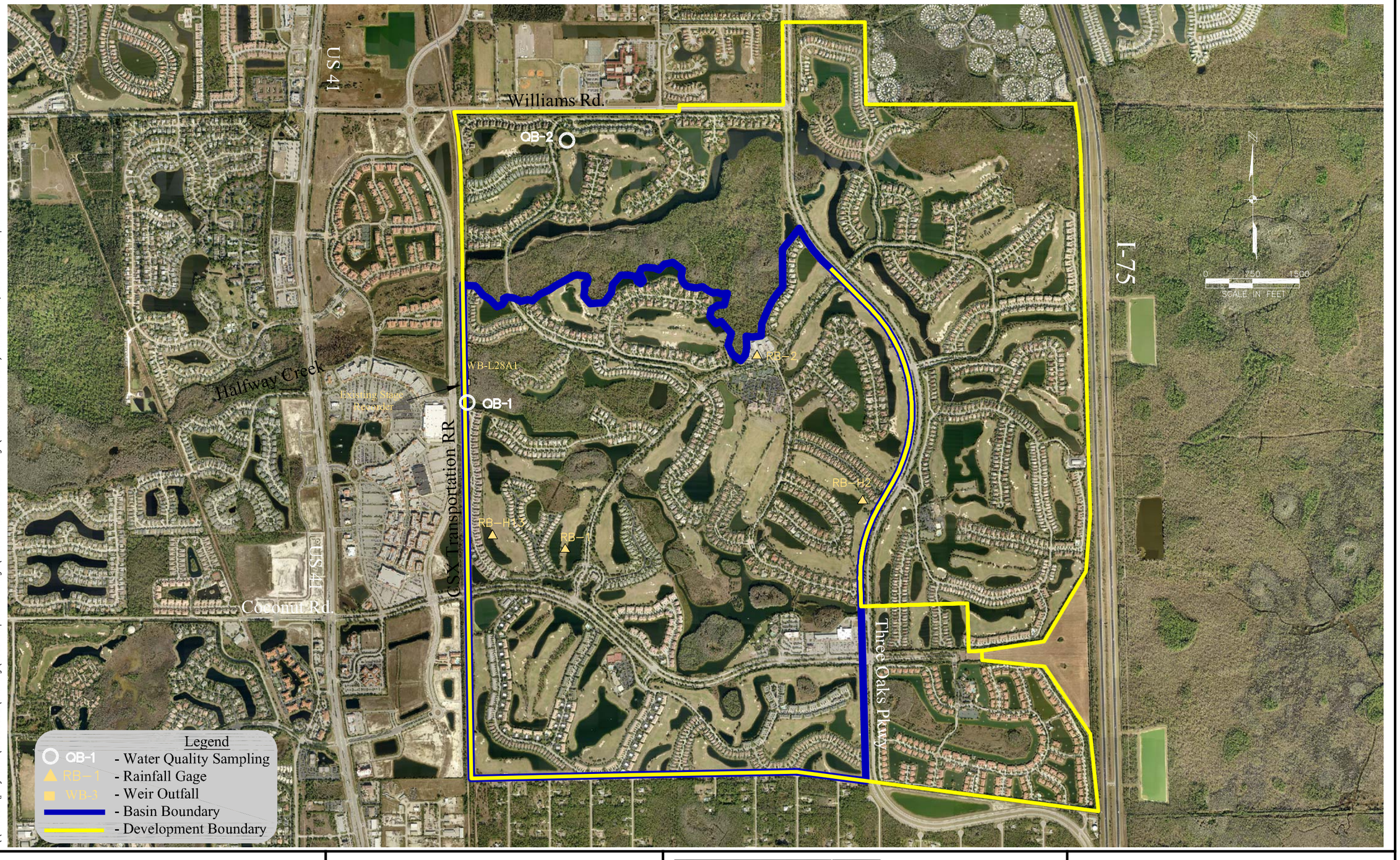
3. SHADOW WOOD PRESERVE-Aerial Jan 2010
Water Quality / Discharge Study

DATE	PROJECT NO.	FILE NO.	SCALE	SHEET
Feb. 2010	20098229		As Shown	8-3



\\Ftms01\proj-fmw\20066052\Drawing\2009 Report Drawings\11x17 Aerials Brooks.dwg (11x17 The Brooks) mil2 Jul 12, 2010 - 1:25pm

NOTE: Aerial shown is dated January 2010.

Bonita Bay Group
Lee County, Florida

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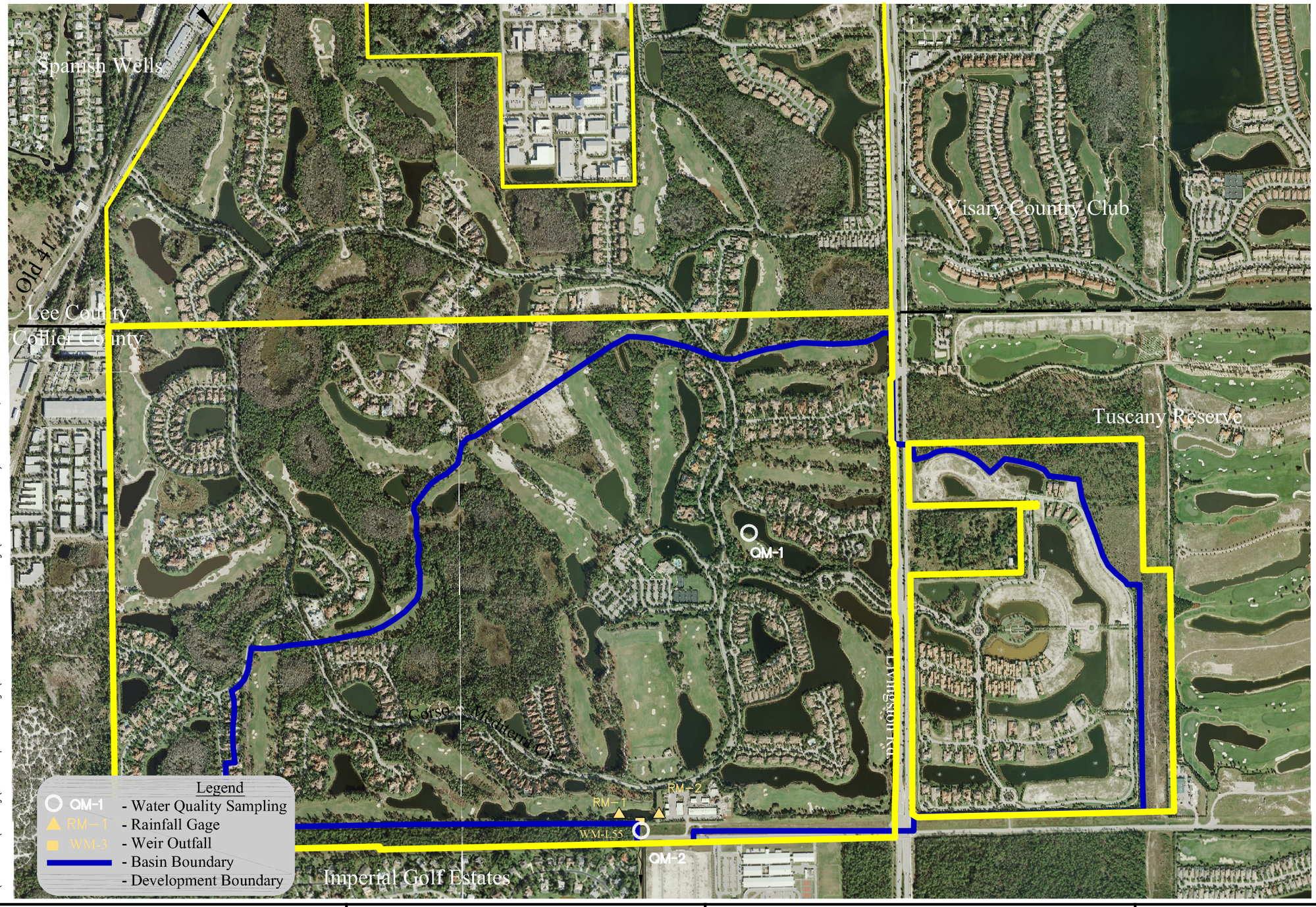
E.B. #642 & L.B. #642

4. THE BROOKS - Aerial January 2010
Water Quality / Discharge Study

DATE	PROJECT NO.	FILE NO.	SCALE	SHEET
Feb. 2010	20098229		As Shown	8-4



J:\20066052\Drawing\2009 Report Drawings\11x17 Aerials Mediterra.dwg (11x17 Mediterra) mll2 Jul 14, 2010 - 10:21am

NOTE: Aerial shown is dated January 2010.

Bonita Bay Group
Lee County, Florida

JOHNSON ENGINEERING
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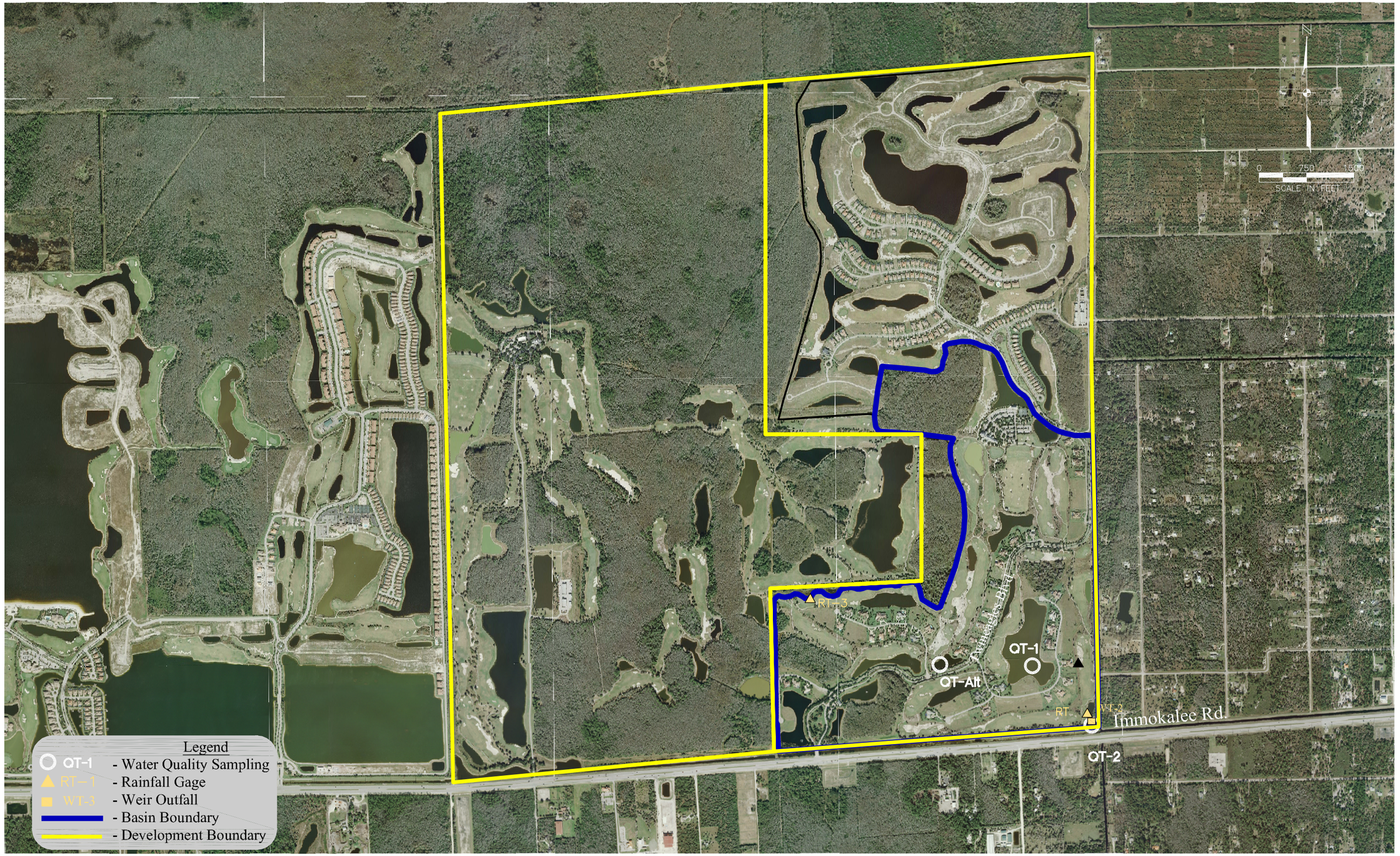
FORT MYERS, FLORIDA 33902-1550
PHONE (239) 334-0046
FAX (239) 334-3661
E.B. #642 & L.B. #642

5. MEDITERRA - Aerial January 2010
Water Quality / Discharge Study

DATE	PROJECT NO.	FILE NO.	SCALE	SHEET
Feb. 2010	20098229		As Shown	8-5



J:\20066052\Drawing\2009 Report Drawings\11x17 Aerials Twin Eagles.dwg (11x17 Twin Eagles) mil2 Jul 13, 2010 - 7:02am

NOTE: Aerial shown is dated January 2010.

Bonita Bay Group
Lee County, Florida

JOHNSON ENGINEERING
2122 JOHNSON STREET
P.O. BOX 1550
FORT MYERS, FLORIDA 33902-1550
PHONE (239) 334-0046
FAX (239) 334-3661
E.B. #642 & L.B. #642

6. TWIN EAGLES - Aerial January 2010
Water Quality / Discharge Study

DATE	PROJECT NO.	FILE NO.	SCALE	SHEET
Feb. 2010	20098229		As Shown	8-6

APPENDIX C-1

RAINFALL/STAGE-TIME GRAPHS – ALL PROJECTS

VERANDAH 2009
WV-L4US and WV-L4DS DATA LOGGERS

JOHNSON ENGINEERING

TOTAL FLOW 1/01/09 TO 12/31/09 **32,921,660** Cu Ft

Total Rainfall 2009 **53.89"**

Rainfall from Golf Course Gages

Some reverse flows reported.
Submerged flows reported

Crest Elev 4.74 NGVD

Bleeder Elev 3.95 NGVD

DS Gage is dry

Rainfall
WV-L4DS
CREST ELEV
BLEEDER ELEV
WV-L4US InSitu

WSEL NGVD 1929

RAINFALL - Inches

8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00

6
5
4
3
2
1
0

1-Jan-09
15-Jan-09
29-Jan-09
12-Feb-09
26-Feb-09
12-Mar-09
26-Mar-09
9-Apr-09
23-Apr-09
7-May-09
21-May-09
4-Jun-09
18-Jun-09
2-Jul-09
16-Jul-09
30-Jul-09
13-Aug-09
27-Aug-09
10-Sep-09
24-Sep-09
8-Oct-09
22-Oct-09
5-Nov-09
19-Nov-09
3-Dec-09
17-Dec-09
31-Dec-09

DATE

C-1

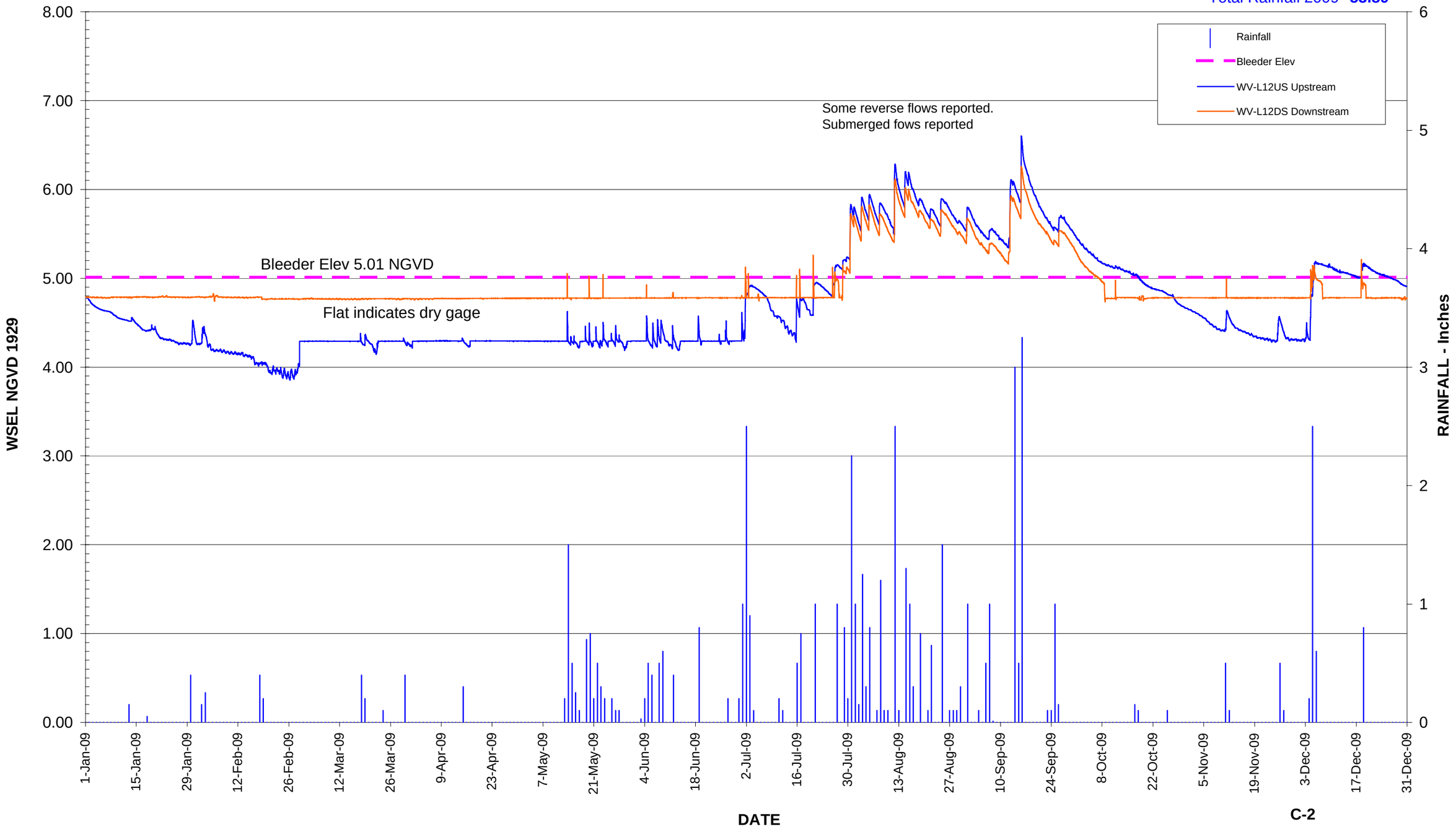
VERANDAH 2009
WV-L12US and WV-L12DS DATA LOGGERS

JOHNSON ENGINEERING

Rainfall from Golf Course gages

TOTAL FLOW 1/01/09 TO 12/31/09 **8,627,149** Cu Ft

Total Rainfall 2009 **53.89"**



C-2

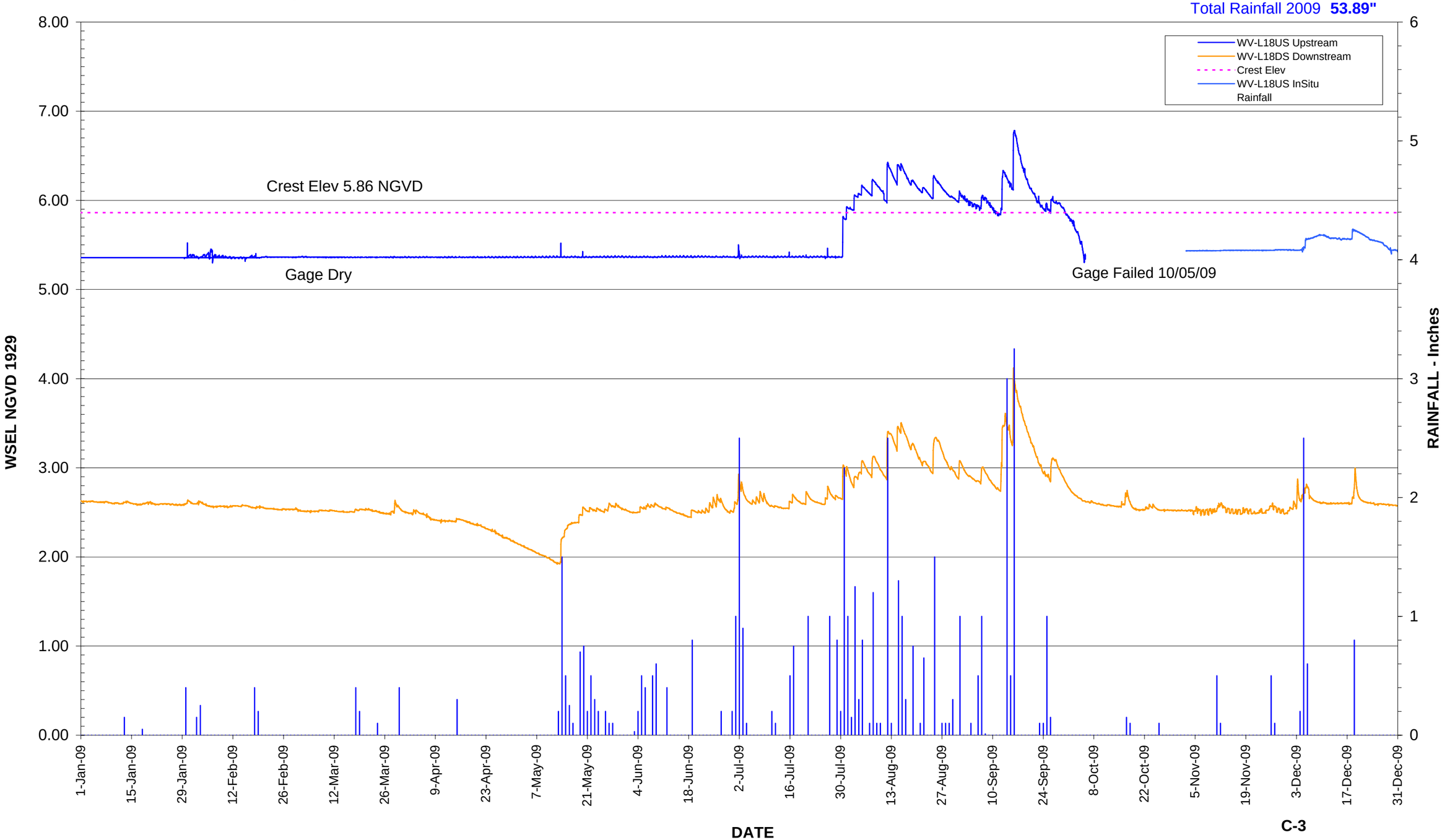
VERANDAH 2009
WV-L18US and WV-L18DS DATA LOGGERS

JOHNSON ENGINEERING

Rainfall from Golf Course Gages

TOTAL FLOW 1/01/09 TO 12/31/09 **2,779,744**Cu Ft

Total Rainfall 2009 **53.89"**



C-3

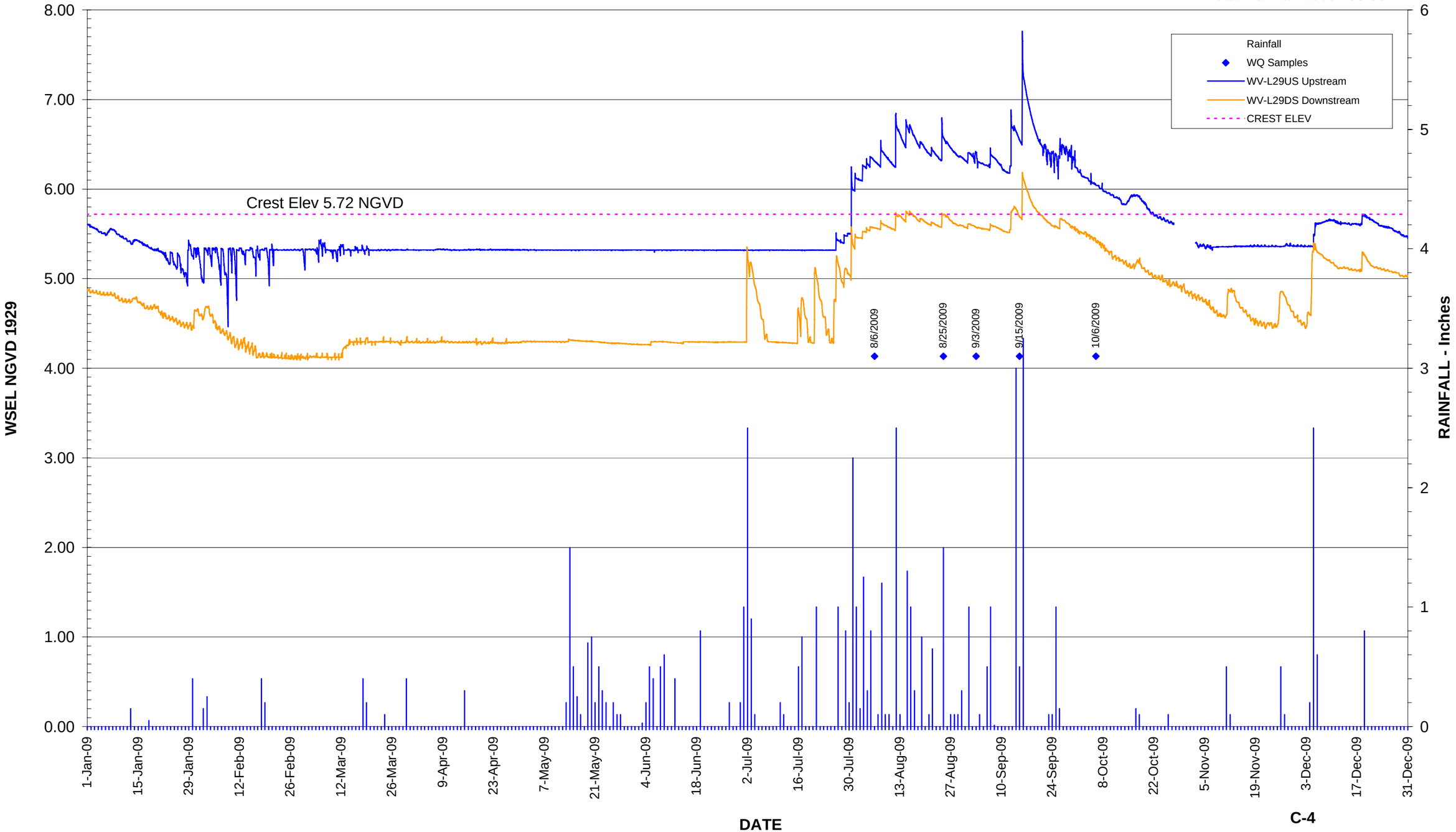
VERANDAH 2009
WV-L29US and WV-L29DS DATA LOGGERS

JOHNSON ENGINEERING

Rainfall from Golf Course Gages

TOTAL FLOW 1/01/09 TO 12/31/09 **4,849,984** Cu Ft

Total Rainfall 2009 **53.89"**



C-4

SANDOVAL 2009 WATER LEVELS
WS1US and WS1DS DATA LOGGERS

JOHNSON ENGINEERING

TOTAL FLOW 1/01/09 TO 12/31/09 **13,818,717** Cu Ft

Total Rainfall 2009 **53.69"**

Notes:
1. Rainfall from R.O. Plant gages.
2. WQ sample symbols indicate date of sample only.

6/2/2009
6/30/2009
8/14/2009
9/15/2009
10/2/2009

Rainfall
WQ Samples
Crest
WS1-US Upstream
WS1-DS Downstream

Crest Elev 3.37

WS1DS gage failed

WSEL NAVD 1988

6.00
5.00
4.00
3.00
2.00
1.00
0.00

RAINFALL - Inches

6
5
4
3
2
1
0

1-Jan-09
15-Jan-09
29-Jan-09
12-Feb-09
26-Feb-09
12-Mar-09
26-Mar-09
9-Apr-09
23-Apr-09
7-May-09
21-May-09
4-Jun-09
18-Jun-09
2-Jul-09
16-Jul-09
30-Jul-09
13-Aug-09
27-Aug-09
10-Sep-09
24-Sep-09
8-Oct-09
22-Oct-09
5-Nov-09
19-Nov-09
3-Dec-09
17-Dec-09
31-Dec-09

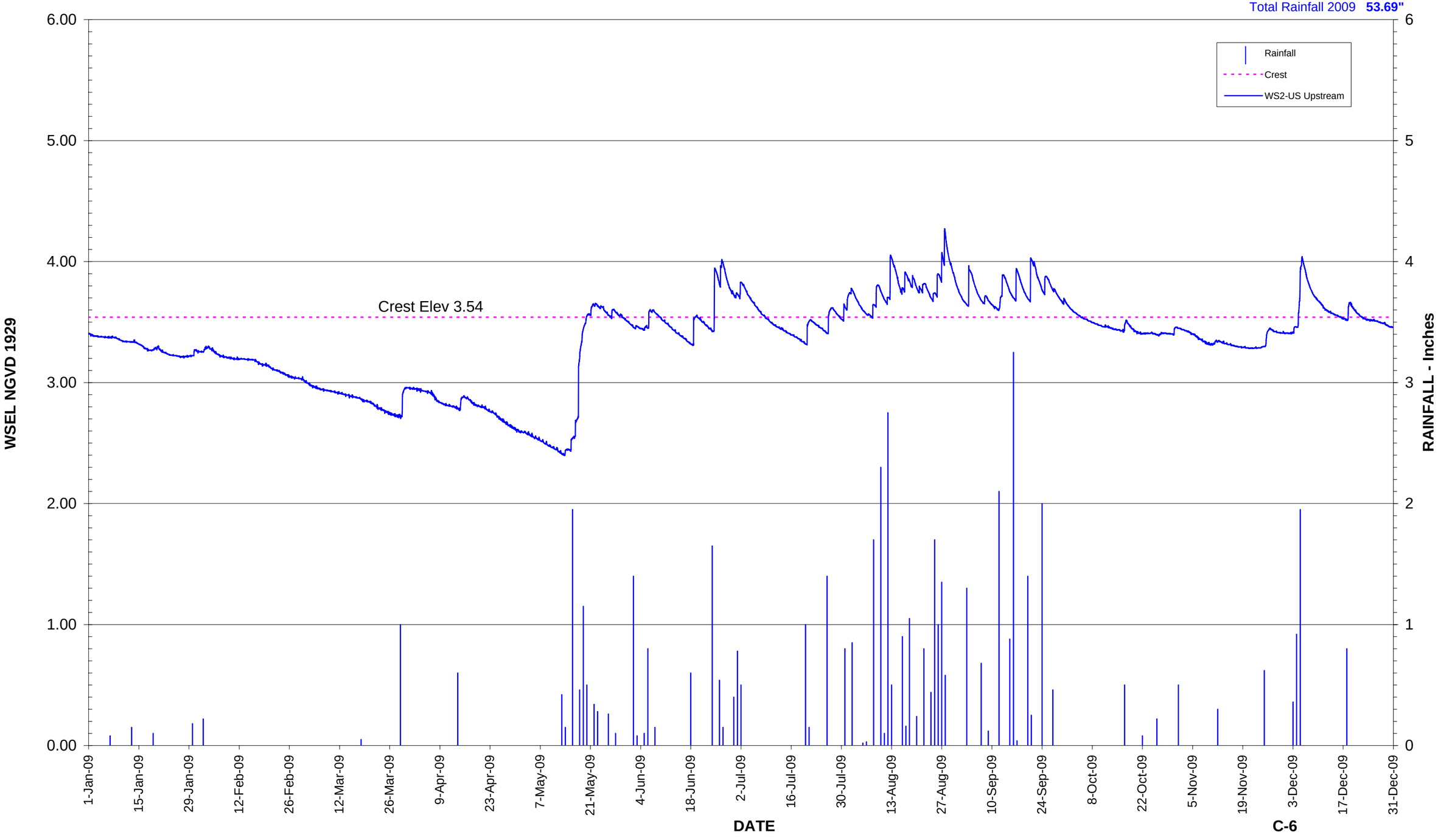
DATE

SANDOVAL 2009 WATER LEVELS
WS2US DATA LOGGER

JOHNSON ENGINEERING

TOTAL FLOW 01/01/09 TO 12/31/09 **5,929,678**

Total Rainfall 2009 **53.69"**



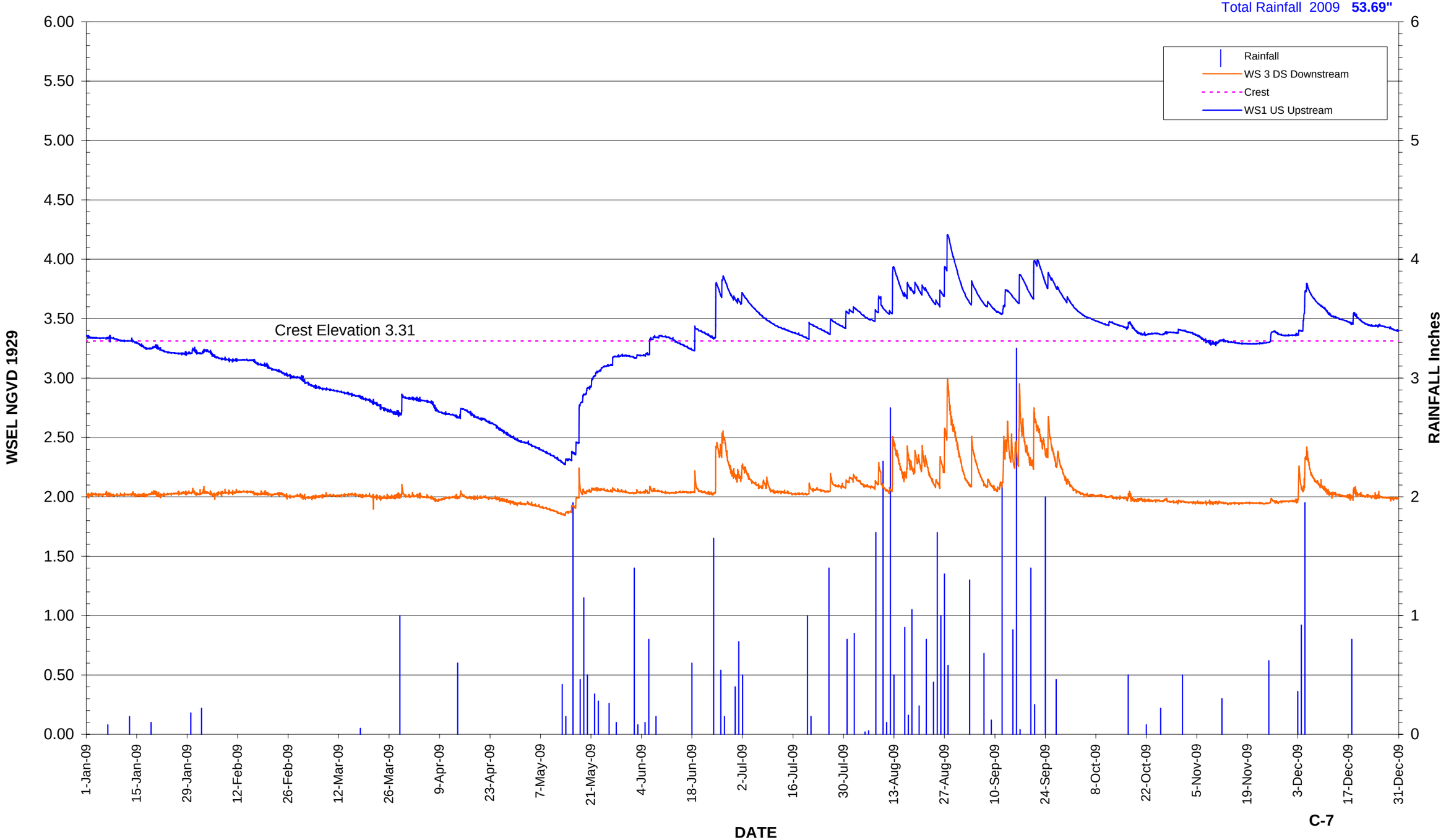
C-6

SANDOVAL 2009
WS 3 US and WS 3 DS DATA LOGGERS

JOHNSON ENGINEERING

TOTAL FLOW 01/01/09 TO 12/31/09 **14,894,498** Cu Ft

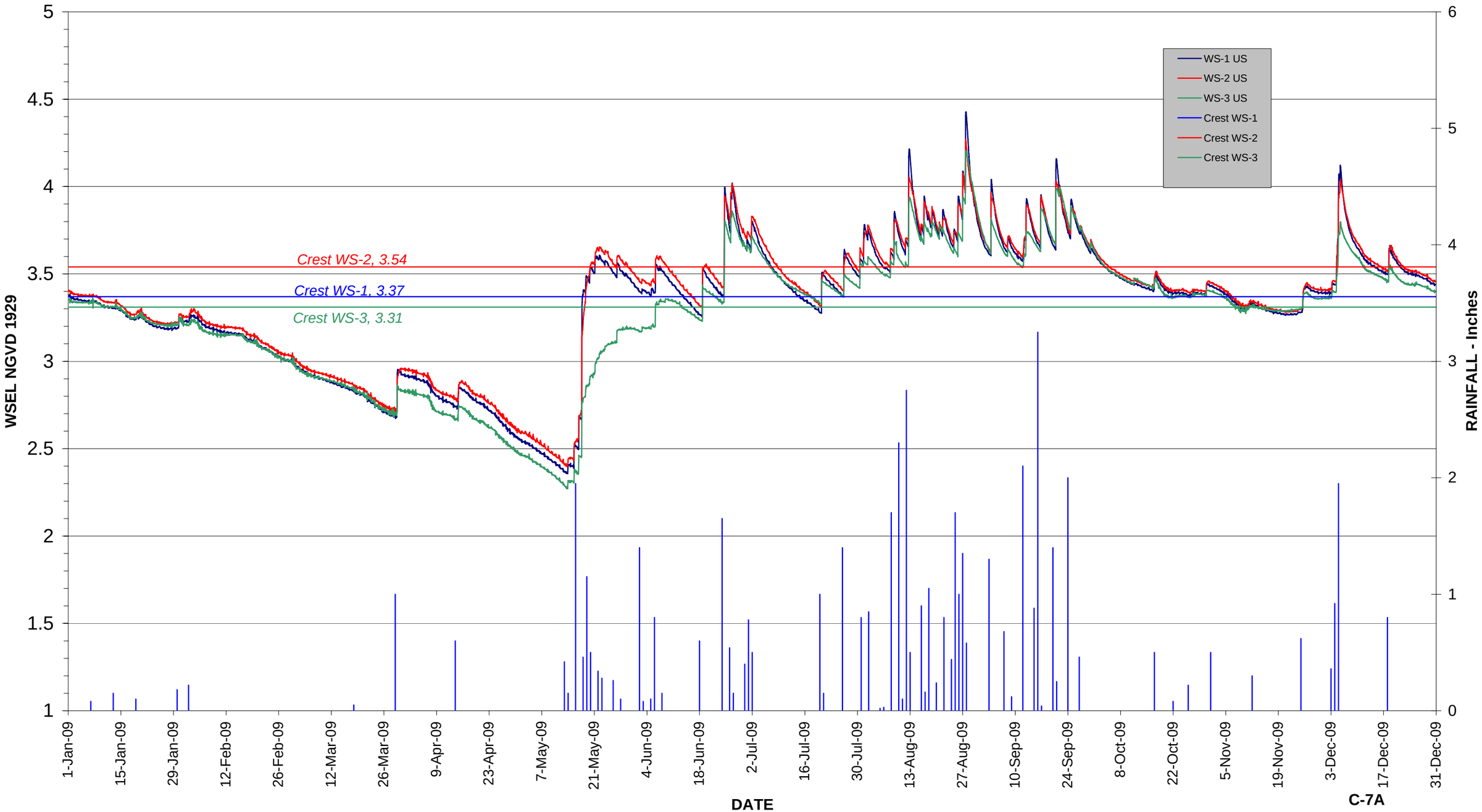
Total Rainfall 2009 **53.69"**



C-7

SANDOVAL 2009
WS-1, WS-2, and WS-3

JOHNSON ENGINEERING



SHADOW WOOD PRESERVE 2009
SW LA1 US and SW LA1 DS DATA LOGGERS

JOHNSON ENGINEERING

TOTAL FLOW 1/01/09 TO 12/31/09 1,829,878 Cu Ft

Total Rainfall 2009 **41.6"**

Notes:
1. Rainfall from Golf Course gages.
2. WQ sample symbols indicate date of sample only.

SW LA1 US Upstream
SW LA1 DS Downstream
Crest Elevation
WQ Samples
Rainfall

9/1/2009
9/16/2009
10/5/2009

Crest Elevation = +3.5 FT NGVD

Level below gage

Level below gage

WSEL NGVD 1929

RAINFALL - Inches

6.00
5.00
4.00
3.00
2.00
1.00
0.00

6
5
4
3
2
1
0

1-Jan-09
15-Jan-09
29-Jan-09
12-Feb-09
26-Feb-09
12-Mar-09
26-Mar-09
9-Apr-09
23-Apr-09
7-May-09
21-May-09
4-Jun-09
18-Jun-09
2-Jul-09
16-Jul-09
30-Jul-09
13-Aug-09
27-Aug-09
10-Sep-09
24-Sep-09
8-Oct-09
22-Oct-09
5-Nov-09
19-Nov-09
3-Dec-09
17-Dec-09
31-Dec-09

DATE

C-8

SHADOW WOOD PRESERVE 2009
SW LA7 US and SW LA7 DS DATA LOGGERS

JOHNSON ENGINEERING

TOTAL FLOW 1/01/09 TO 12/31/09 **65,163** Cu Ft

Total Rainfall 2009 **41.60"**

Notes:
1. Rainfall taken from Golf Course gages.

Crest Elevation = +4.85 FT NGVD

Gage failed. No data.

Rainfall
SW LA7 US
SW LA7 DS
Crest Elevation
SW LA7 DS InSitu

WSEL NGVD 1929

RAINFALL - Inches

6.00
5.00
4.00
3.00
2.00
1.00
0.00

6
5
4
3
2
1
0

1-Jan-09
11-Jan-09
21-Jan-09
31-Jan-09
10-Feb-09
20-Feb-09
2-Mar-09
12-Mar-09
22-Mar-09
1-Apr-09
11-Apr-09
21-Apr-09
1-May-09
11-May-09
21-May-09
31-May-09
10-Jun-09
20-Jun-09
30-Jun-09
10-Jul-09
20-Jul-09
30-Jul-09
9-Aug-09
19-Aug-09
29-Aug-09
8-Sep-09
18-Sep-09
28-Sep-09
8-Oct-09
18-Oct-09
28-Oct-09
7-Nov-09
17-Nov-09
27-Nov-09
7-Dec-09
17-Dec-09
27-Dec-09

DATE

C-9

SHADOW WOOD PRESERVE 2009
SW LA8 US and SW LA8 DS DATA LOGGERS

JOHNSON ENGINEERING

TOTAL FLOW 1/01/09 TO 12/31/09 **55,561** Cu Ft

Total Rainfall 2009 **41.60** "

Notes:
1. SW LA8 DS gage failed and no data after 8/30/09
2. Assumed no submergence based on 2008 behavior
3. Rainfall from Golf Course gages.

Rainfall
SW LA8 DS
Crest Elevation
SW LA8 US
SW LA8 US InSitu

Crest Elevation = +4.74 FT NGVD

Gage failed and no data after 8/30/09

WSEL NGVD 1929

RAINFALL Inches

6.00
5.00
4.00
3.00
2.00
1.00
0.00

6
5
4
3
2
1
0

1-Jan-09
11-Jan-09
21-Jan-09
31-Jan-09
10-Feb-09
20-Feb-09
2-Mar-09
12-Mar-09
22-Mar-09
1-Apr-09
11-Apr-09
21-Apr-09
1-May-09
11-May-09
21-May-09
31-May-09
10-Jun-09
20-Jun-09
30-Jun-09
10-Jul-09
20-Jul-09
30-Jul-09
9-Aug-09
19-Aug-09
29-Aug-09
8-Sep-09
18-Sep-09
28-Sep-09
8-Oct-09
18-Oct-09
28-Oct-09
7-Nov-09
17-Nov-09
27-Nov-09
7-Dec-09
17-Dec-09
27-Dec-09

DATE

C-10

SHADOW WOOD PRESERVE 2009
SW LA12 US and SW LA12 DS DATA LOGGERS

JOHNSON ENGINEERING

TOTAL FLOW 1/01/09 TO 12/31/09 **5,210,433** Cu Ft

Total Rainfall 2009 **41.60"**

Notes:
1. LA12 DS gage failed between 7/22/09 and 8/31/09
2. DS water elevations estimated for this period
3. Rainfall from Golf Course gages

SW LA12 US
SW LA12 DS
Crest Elevation
SW LA12 DS InSitu
Rainfall

Crest Elevation = +3.34 FT NGVD

DS data estimated from 7/22/09 to 8/31/09

WSEL NGVD 1929

RAINFALL - Inches

6.00
5.00
4.00
3.00
2.00
1.00
0.00

6
5
4
3
2
1
0

1-Jan-09
11-Jan-09
21-Jan-09
31-Jan-09
10-Feb-09
20-Feb-09
2-Mar-09
12-Mar-09
22-Mar-09
1-Apr-09
11-Apr-09
21-Apr-09
1-May-09
11-May-09
21-May-09
31-May-09
10-Jun-09
20-Jun-09
30-Jun-09
10-Jul-09
20-Jul-09
30-Jul-09
9-Aug-09
19-Aug-09
29-Aug-09
8-Sep-09
18-Sep-09
28-Sep-09
8-Oct-09
18-Oct-09
28-Oct-09
7-Nov-09
17-Nov-09
27-Nov-09
7-Dec-09
17-Dec-09
27-Dec-09

DATE

THE BROOKS 2009
WB-L28A US and WB-L28A DS DATA LOGGERS

JOHNSON ENGINEERING

TOTAL FLOW 1/01/09 TO 10/6/09 **88,064,412** Cu Ft

Total Rainfall 2009 **52.19** "

Notes:
1. Rainfall from Golf Course gages.
2. WQ sample symbols indicate date of sample only.

Rainfall
WQ Samples
WB-L28A Upstream
WB-L28A Downstream
WB-L28A DS InSitu
Crest

8/10/2009
9/17/2009
10/5/2009

Crest 13.47

US gage estimated

Gage failed DS InSitu installed 5/25/09

WSEL NGVD 1929

16.00
15.00
14.00
13.00
12.00
11.00
10.00
9.00
8.00

RAINFALL - Inches

6
5
4
3
2
1
0

1-Jan-09
15-Jan-09
29-Jan-09
12-Feb-09
26-Feb-09
12-Mar-09
26-Mar-09
9-Apr-09
23-Apr-09
7-May-09
21-May-09
4-Jun-09
18-Jun-09
2-Jul-09
16-Jul-09
30-Jul-09
13-Aug-09
27-Aug-09
10-Sep-09
24-Sep-09
8-Oct-09
22-Oct-09
5-Nov-09
19-Nov-09
3-Dec-09
17-Dec-09
31-Dec-09

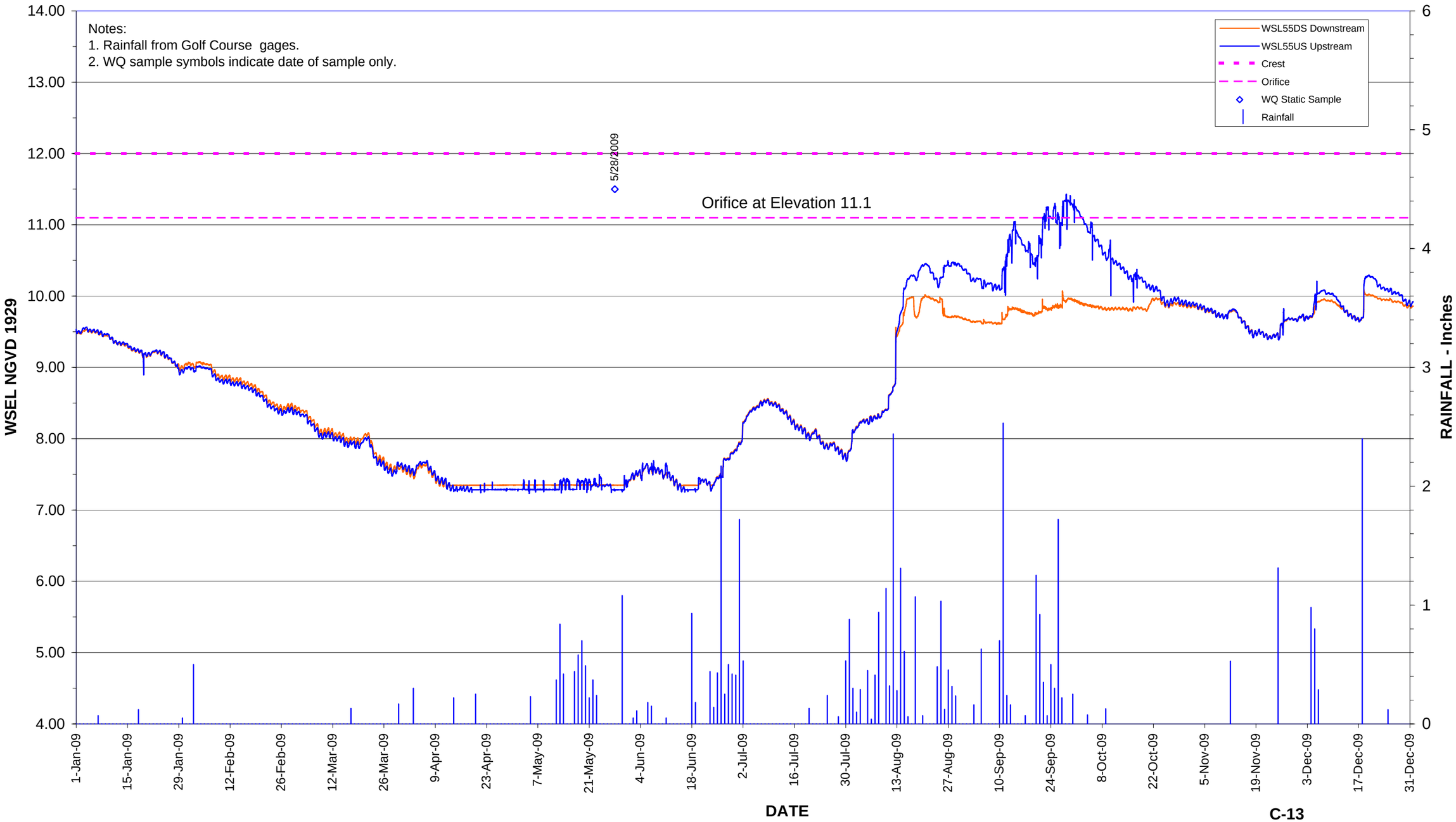
DATE

MEDITERRA OUTFALL 2009
WML55DS and WML55US DATA LOGGERS

JOHNSON ENGINEERING

TOTAL FLOW 2009 - **285,971** Cubic Feet

Total Rainfall 2009 **47.46"**



C-13

Twin Eagles Outfall 2009
WT2DS and WT2US DATA LOGGERS

JOHNSON ENGINEERING

TOTAL FLOW 1/01/09 TO 12/31/09 **0** Cu Ft

Total Rainfall 2009 **53.91"**

Notes:
1. Rainfall from Golf Course gages.
2. WQ sample symbols indicate date of sample only.
3. No flow during 2009

Rainfall
WQ Samples
WT2DS Downstream
WT2US Upstream
Crest

Crest Elevation 14.0

5/28/2009

Gages are dry

WSEL NGVD 1929

RAINFALL- Inches

16.00
15.00
14.00
13.00
12.00
11.00
10.00
9.00
8.00

6
5
4
3
2
1
0

1-Jan-09
15-Jan-09
29-Jan-09
12-Feb-09
26-Feb-09
12-Mar-09
26-Mar-09
9-Apr-09
23-Apr-09
7-May-09
21-May-09
4-Jun-09
18-Jun-09
2-Jul-09
16-Jul-09
30-Jul-09
13-Aug-09
27-Aug-09
10-Sep-09
24-Sep-09
8-Oct-09
22-Oct-09
5-Nov-09
19-Nov-09
3-Dec-09
17-Dec-09
31-Dec-09

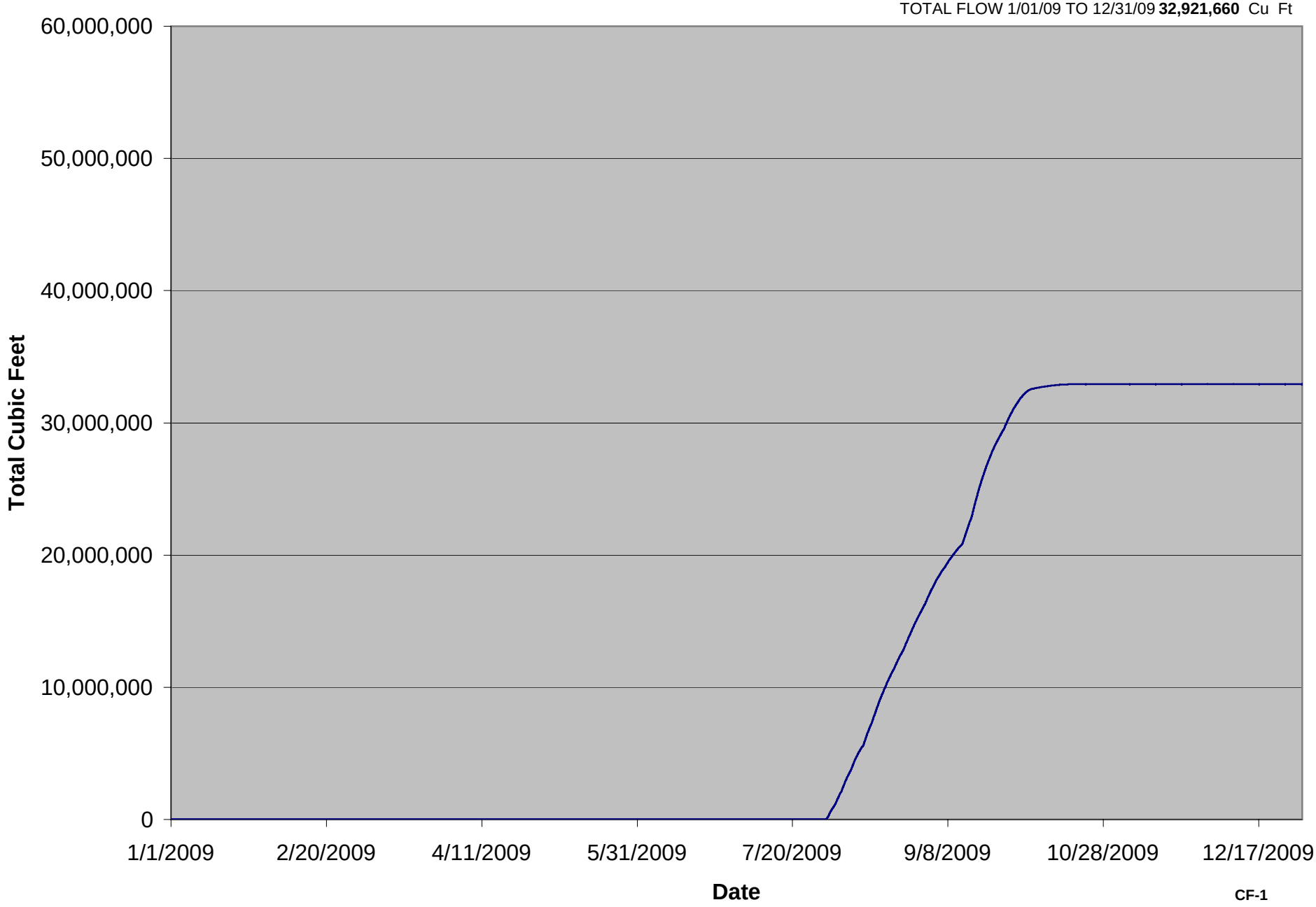
DATE

C-14

Cumulative Flow Chart 2009
Verandah Structure L4

JOHNSON ENGINEERING

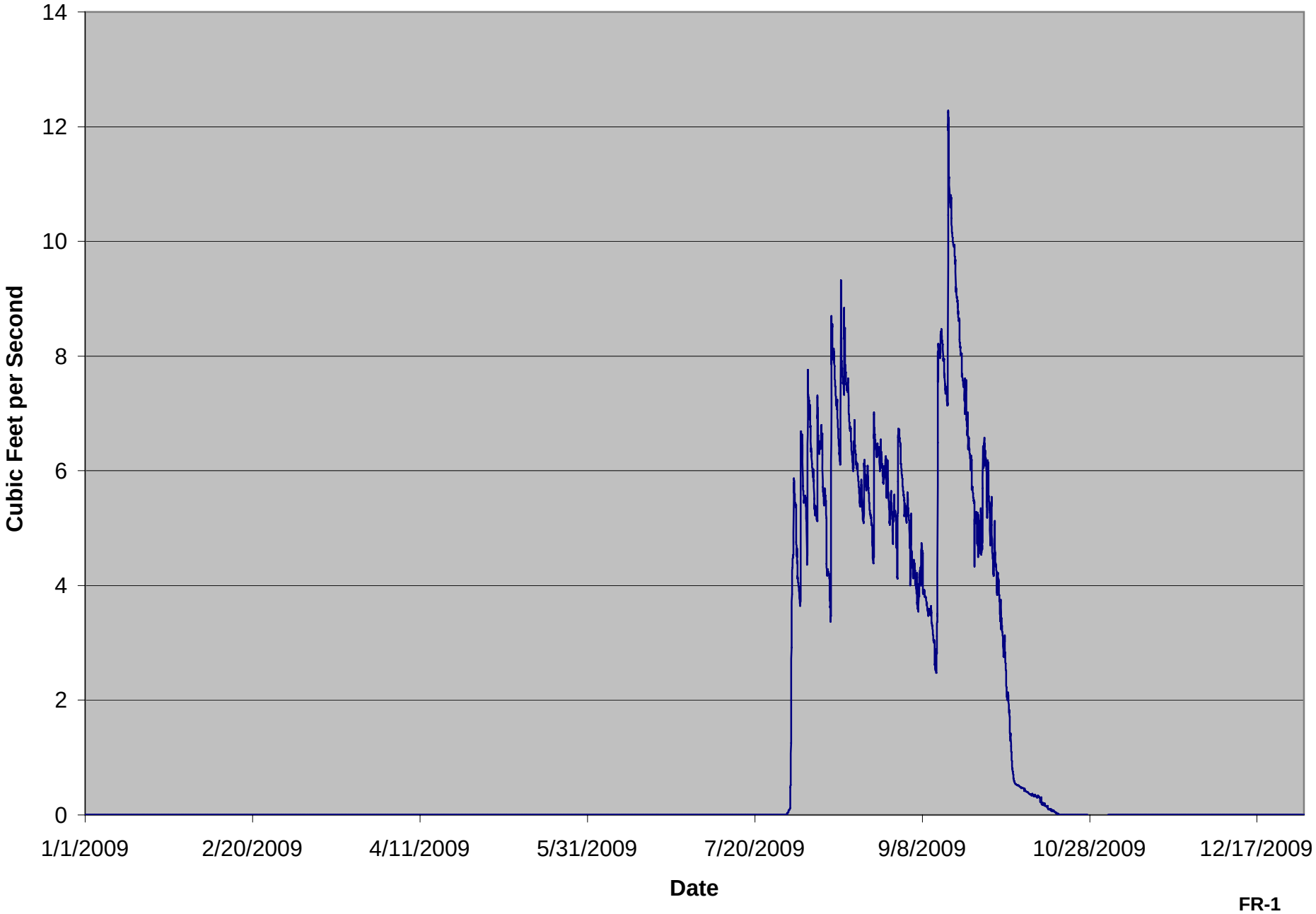
TOTAL FLOW 1/01/09 TO 12/31/09 **32,921,660** Cu Ft



CF-1

Flow Rate Chart 2009
Verandah Structure L4

JOHNSON ENGINEERING

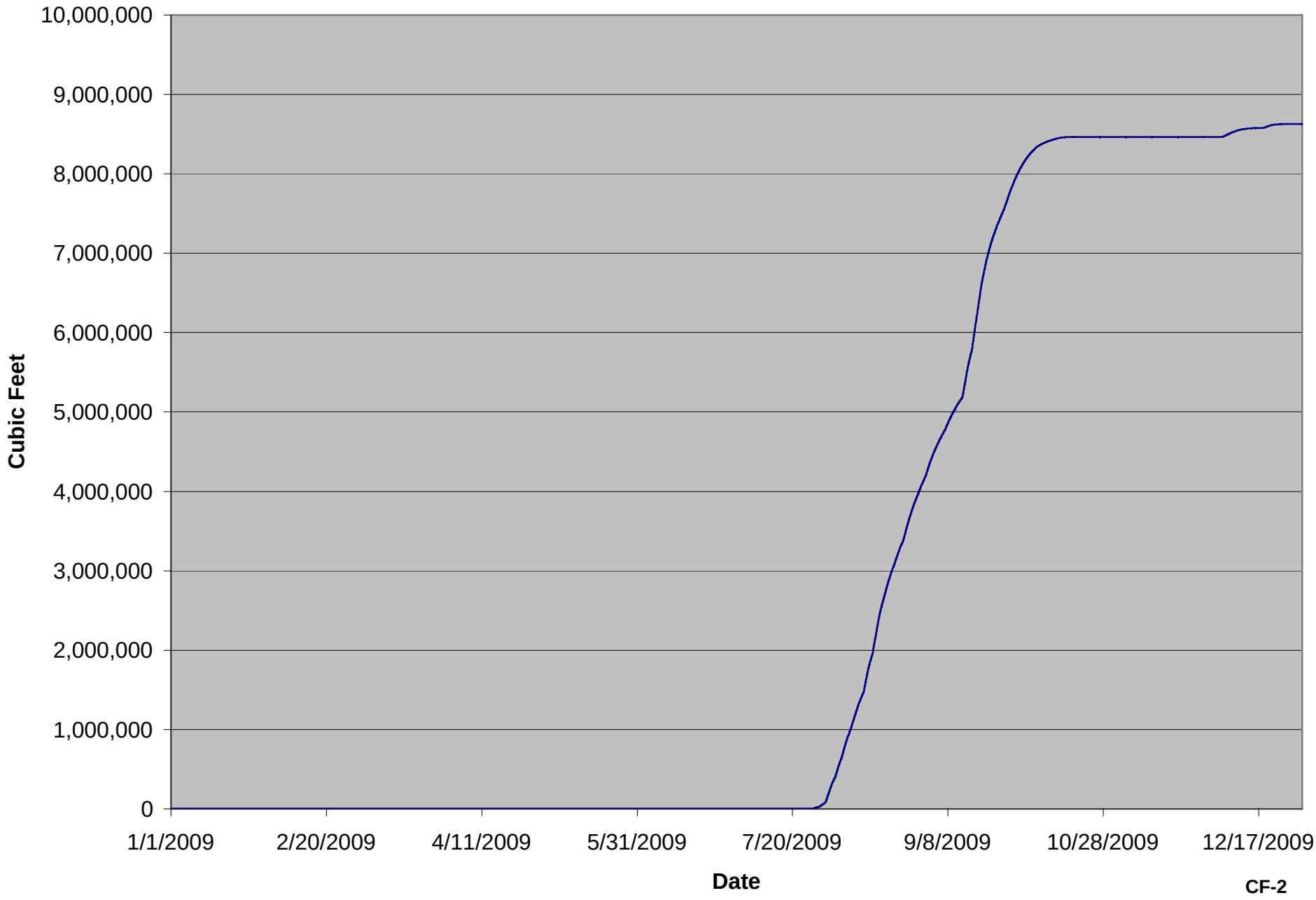


FR-1

Cumulative Flow Chart 2009
Verandah Structure L12

JOHNSON ENGINEERING

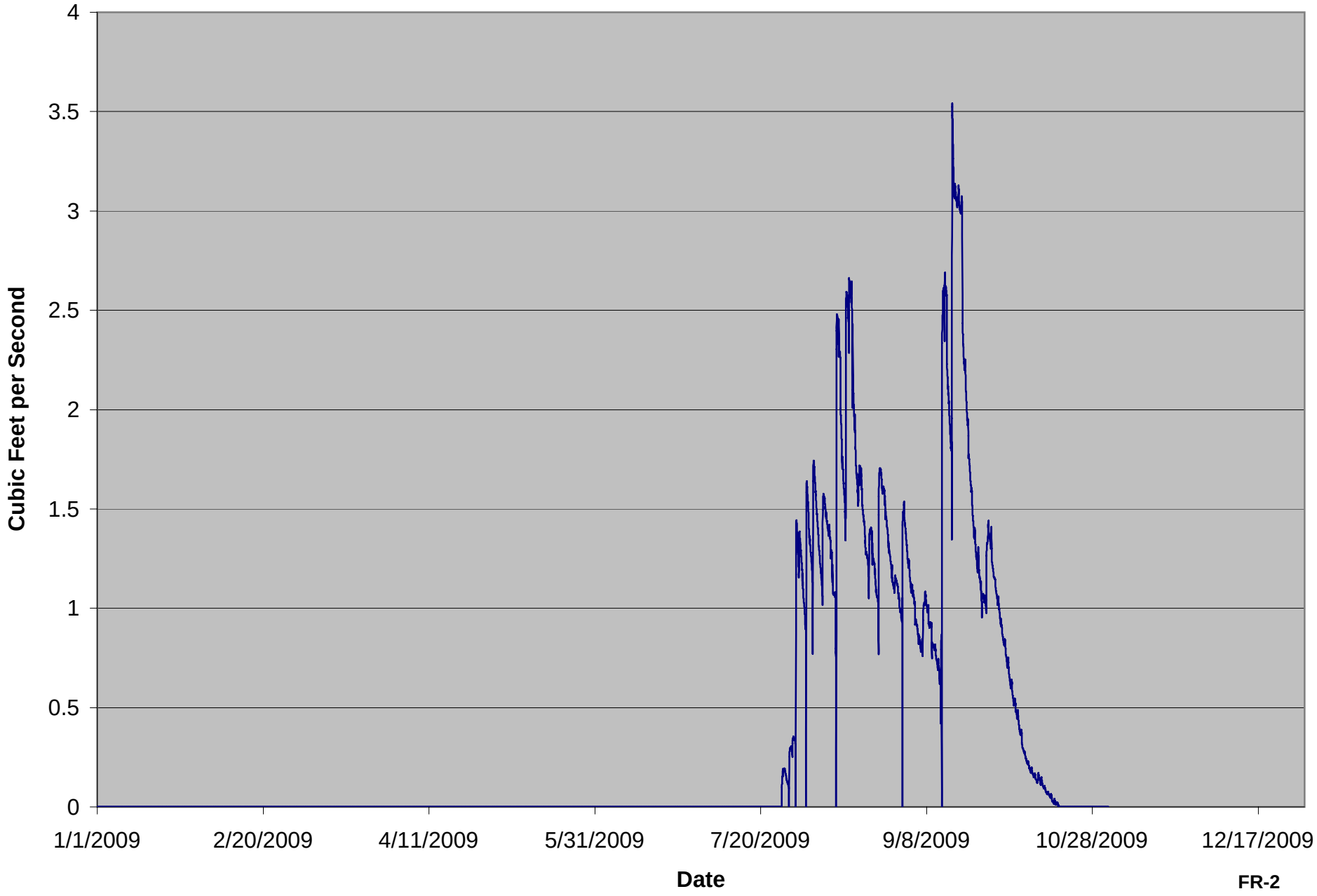
TOTAL FLOW 1/01/09 TO 12/31/09 **8,627,149** Cu Ft



CF-2

Flow Rate Chart 2009
Verandah Structure L12

JOHNSON ENGINEERING

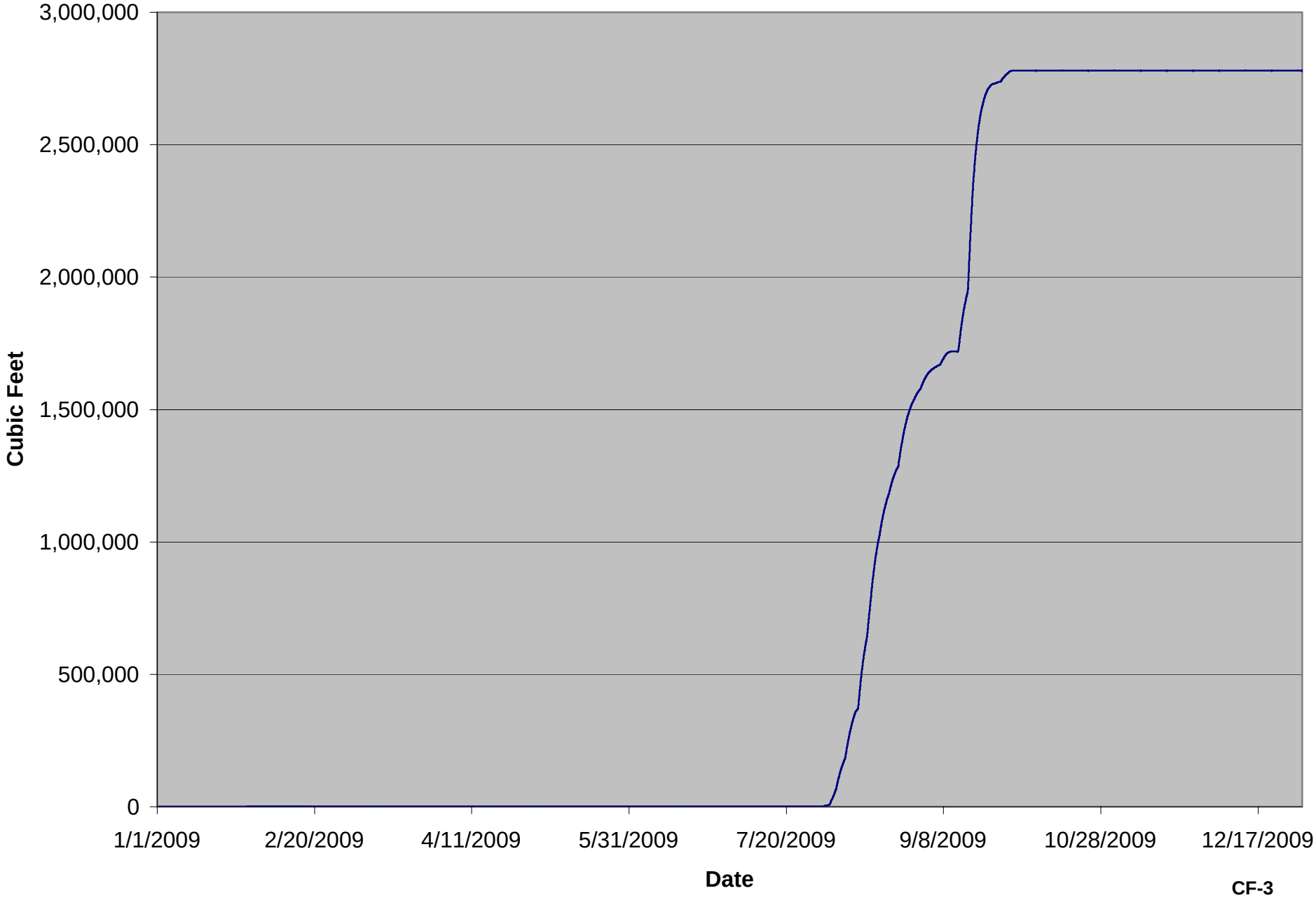


FR-2

Cumulative Flow Chart 2009
Verandah Structure L18

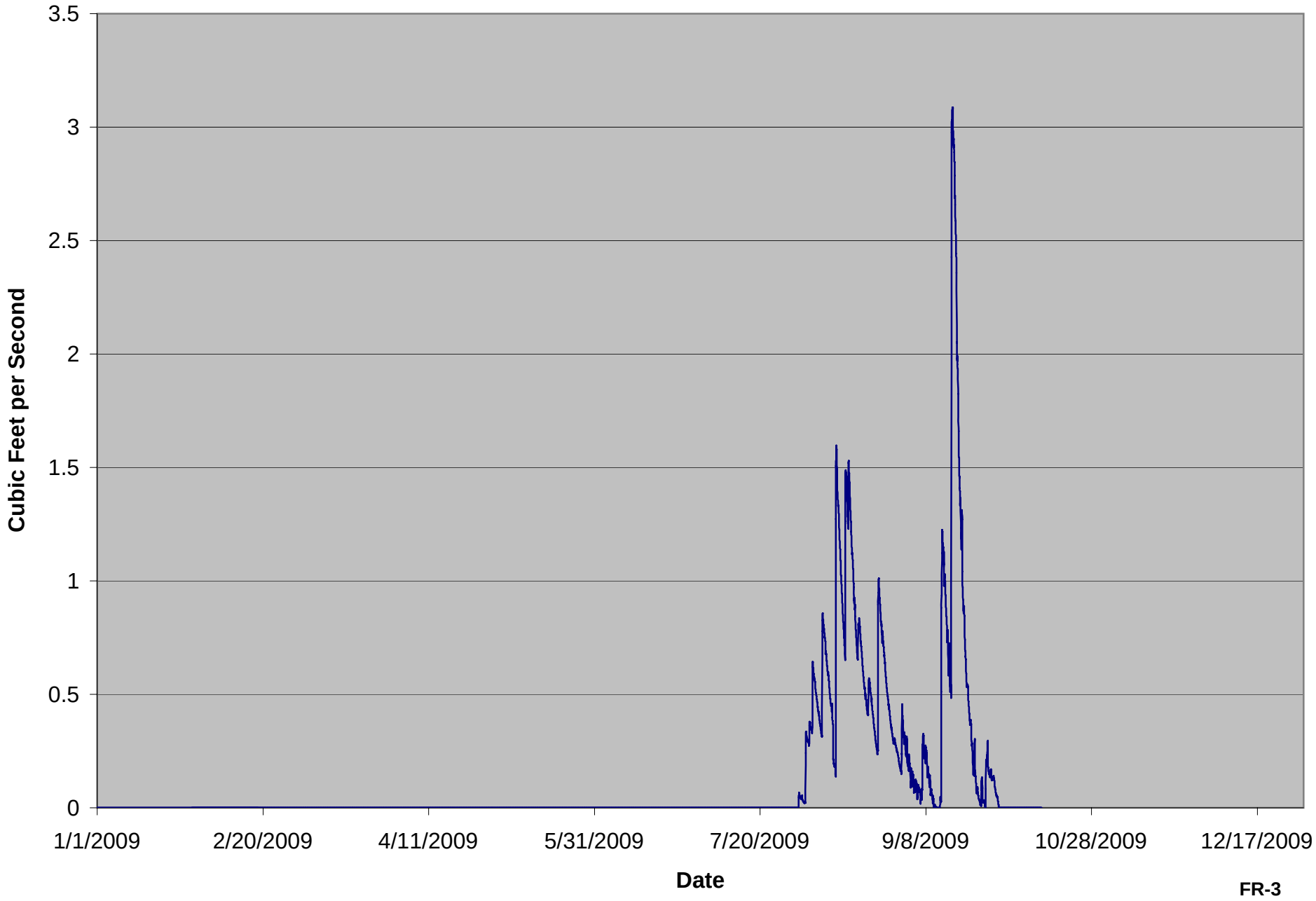
JOHNSON ENGINEERING

TOTAL FLOW 1/01/09 TO 12/31/09 **2,779,744**Cu Ft



Flow Rate Chart 2009
Verandah Structure L18

JOHNSON ENGINEERING

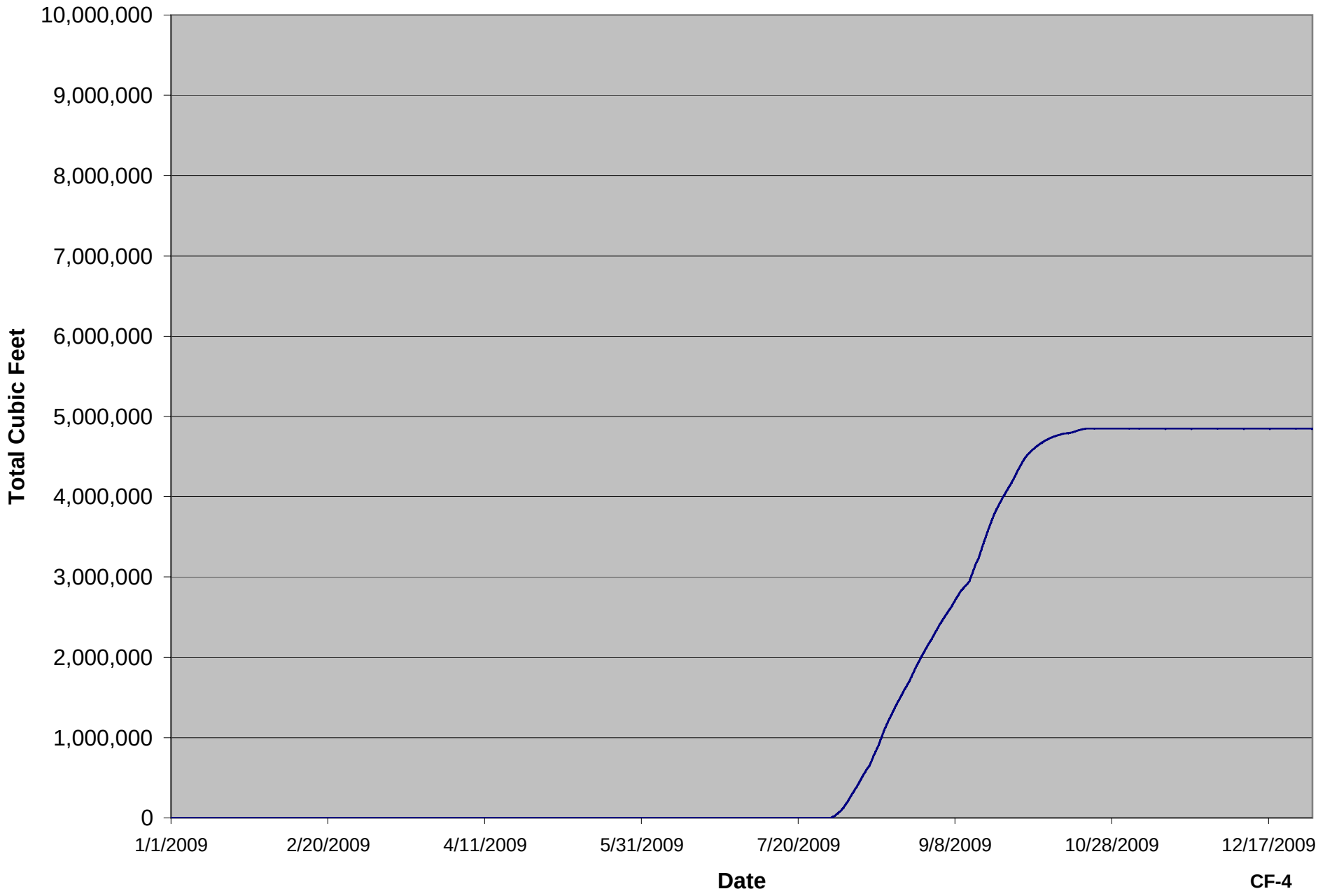


FR-3

Cumulative Flow Chart 2009
Verandah Structure L29

JOHNSON ENGINEERING

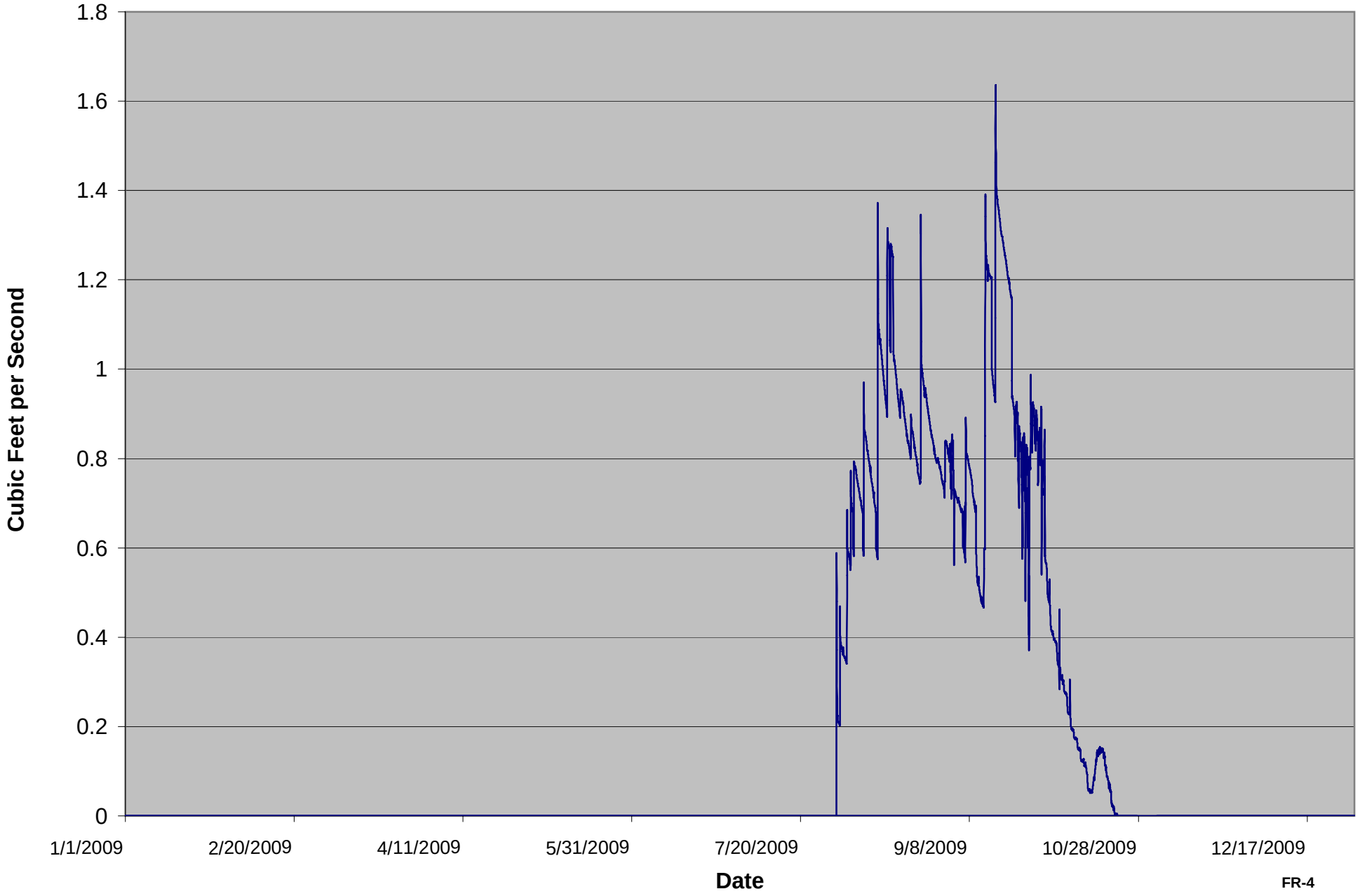
TOTAL FLOW 1/01/09 TO 12/31/09 **4,849,984** Cu Ft



CF-4

Flow Rate Chart 2009
Verandah Structure L29

JOHNSON ENGINEERING

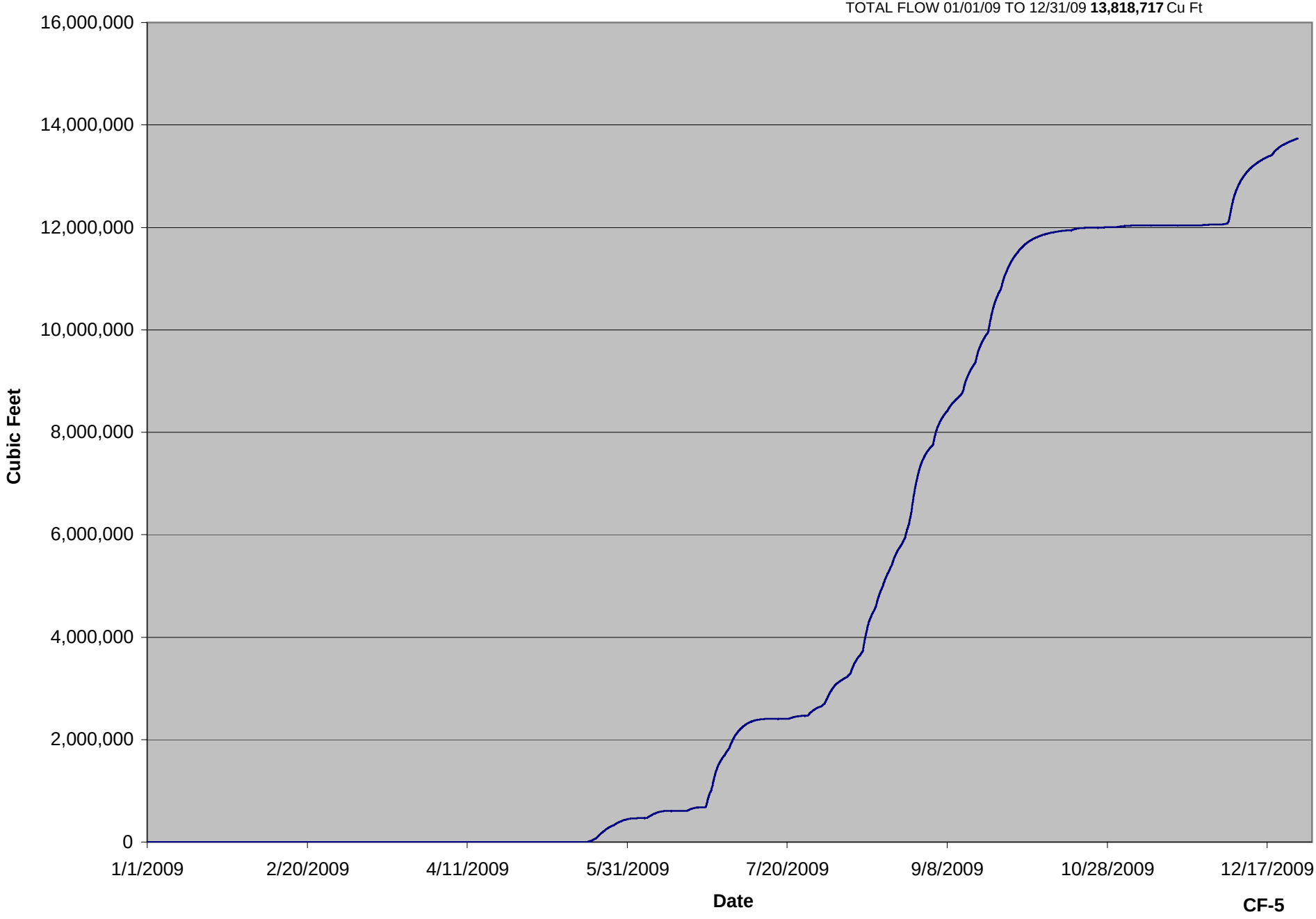


FR-4

Cumulative Flow Chart 2009
Sandoval Structure S1

JOHNSON ENGINEERING

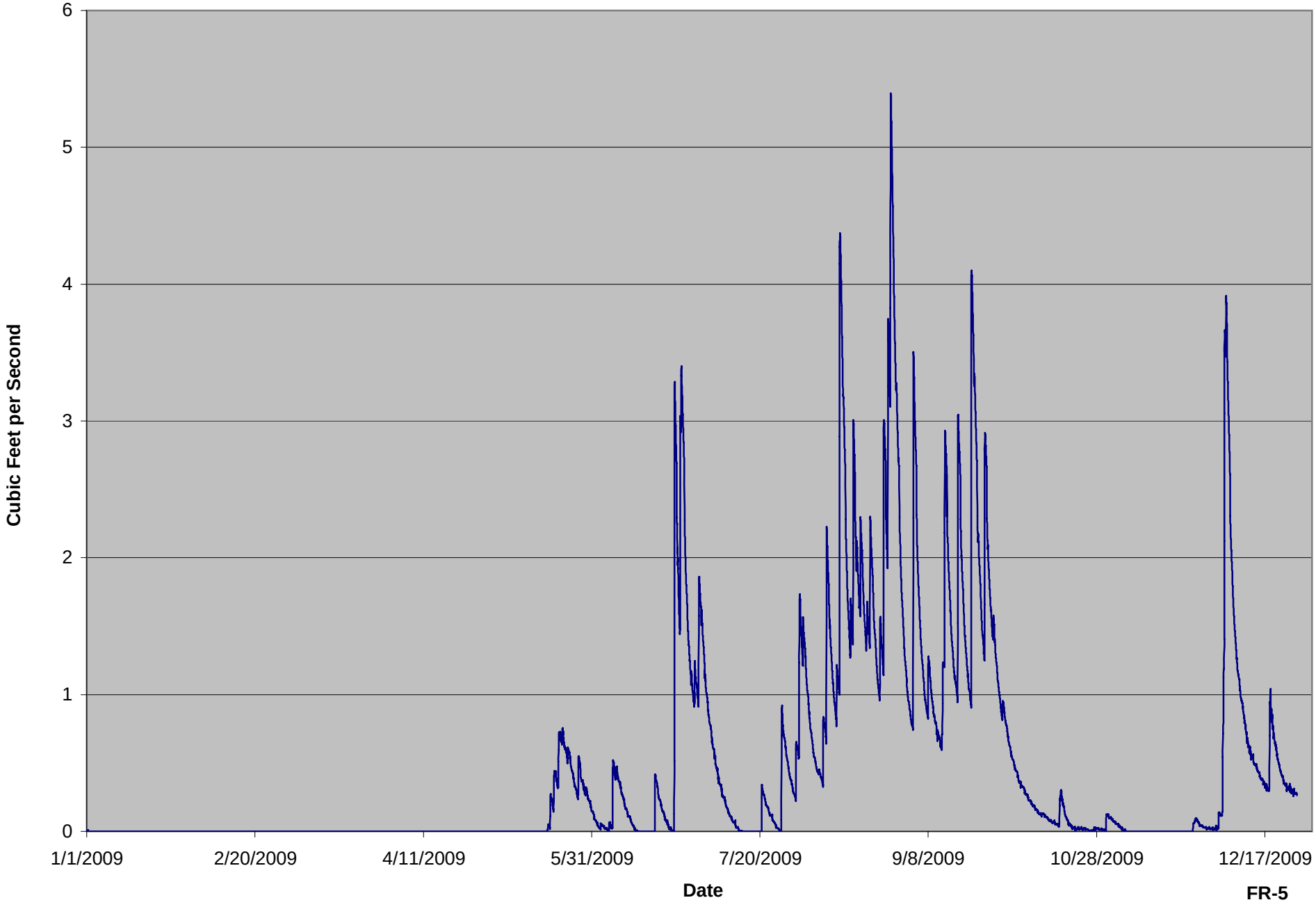
TOTAL FLOW 01/01/09 TO 12/31/09 **13,818,717** Cu Ft



CF-5

Flow Rate Chart 2009
Sandoval Structure S1

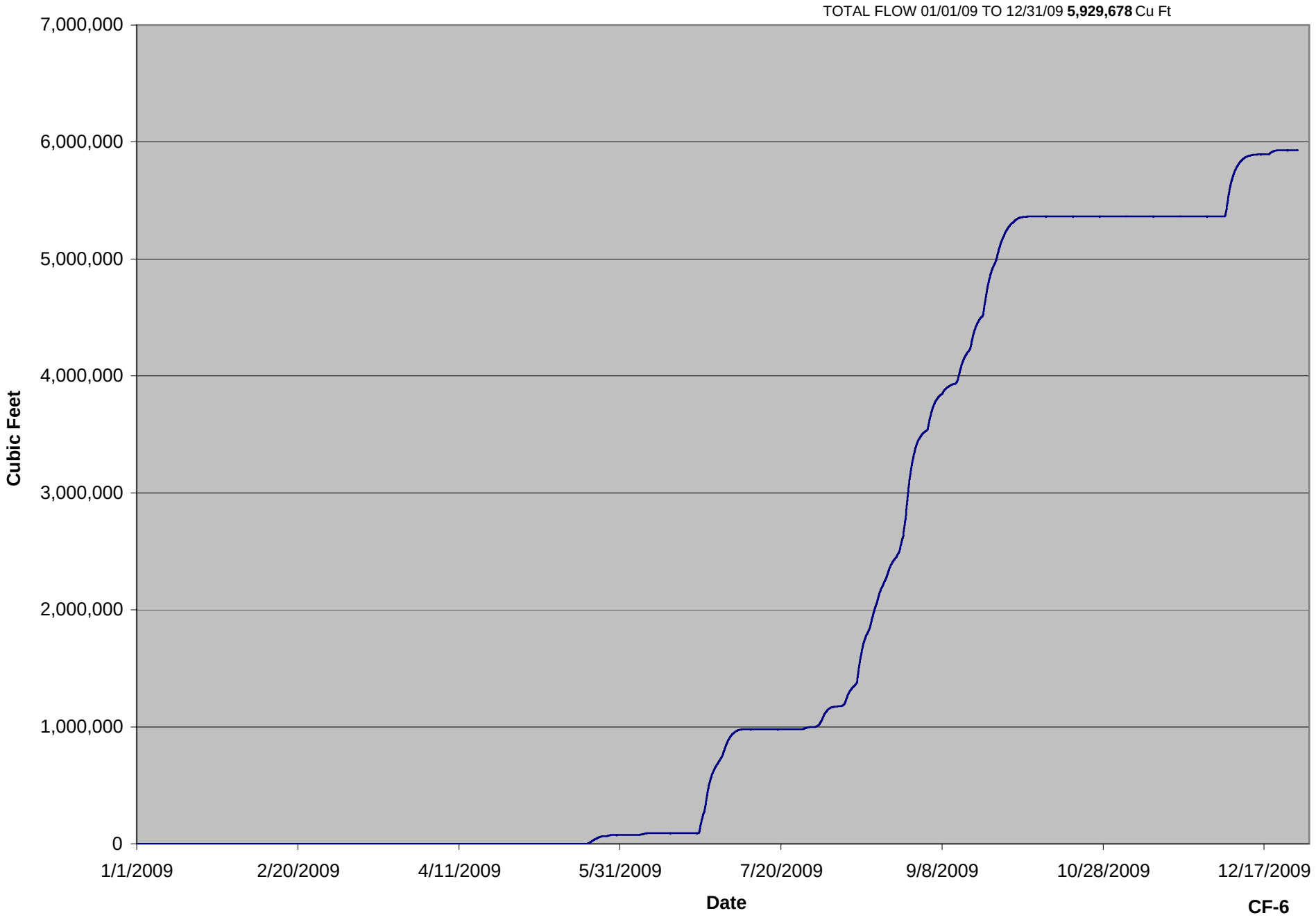
JOHNSON ENGINEERING



FR-5

Cumulative Flow Chart 2009
Sandoval Structure S2

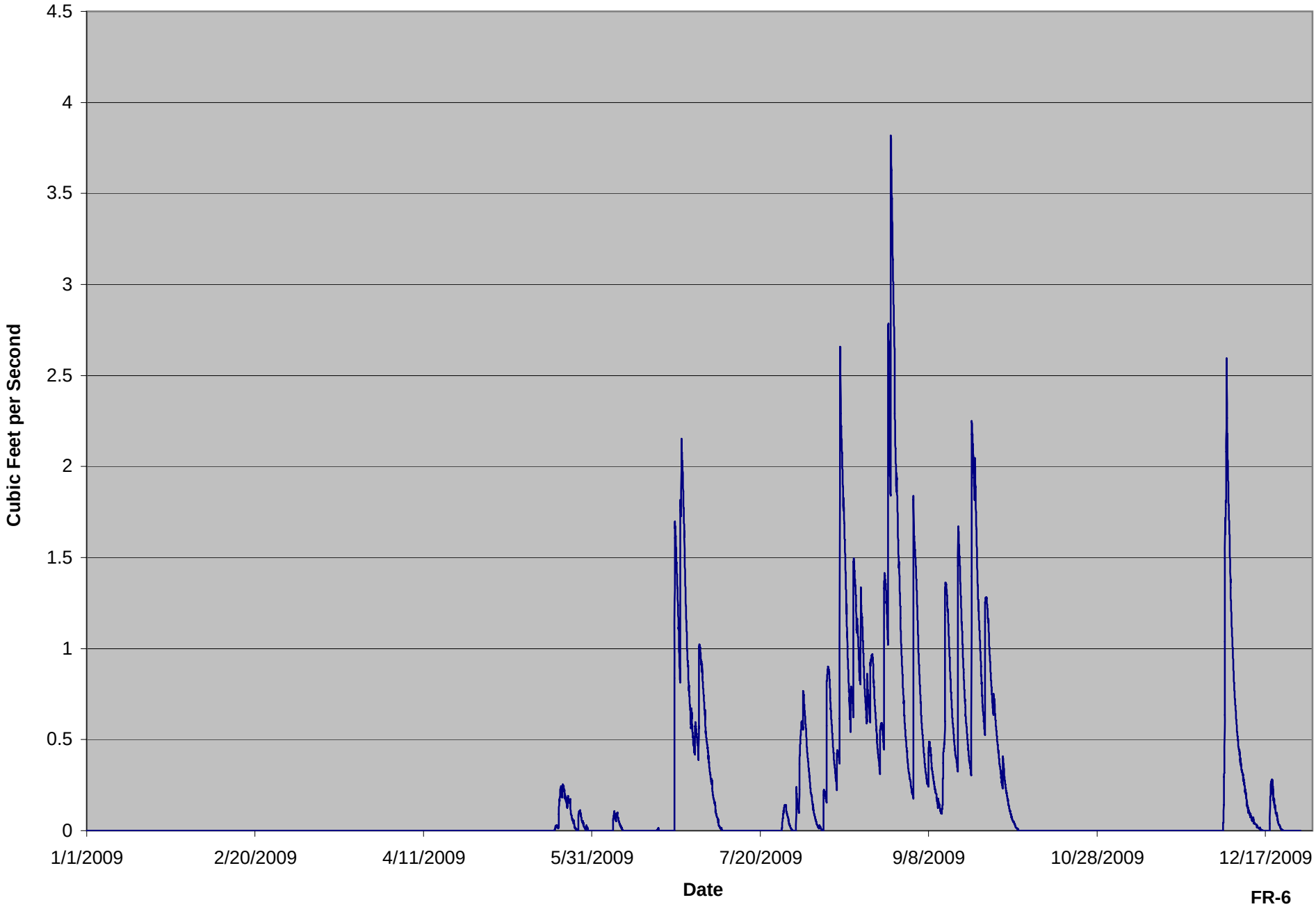
JOHNSON ENGINEERING



CF-6

Flow Rate Chart 2009
Sandoval Structure S2

JOHNSON ENGINEERING

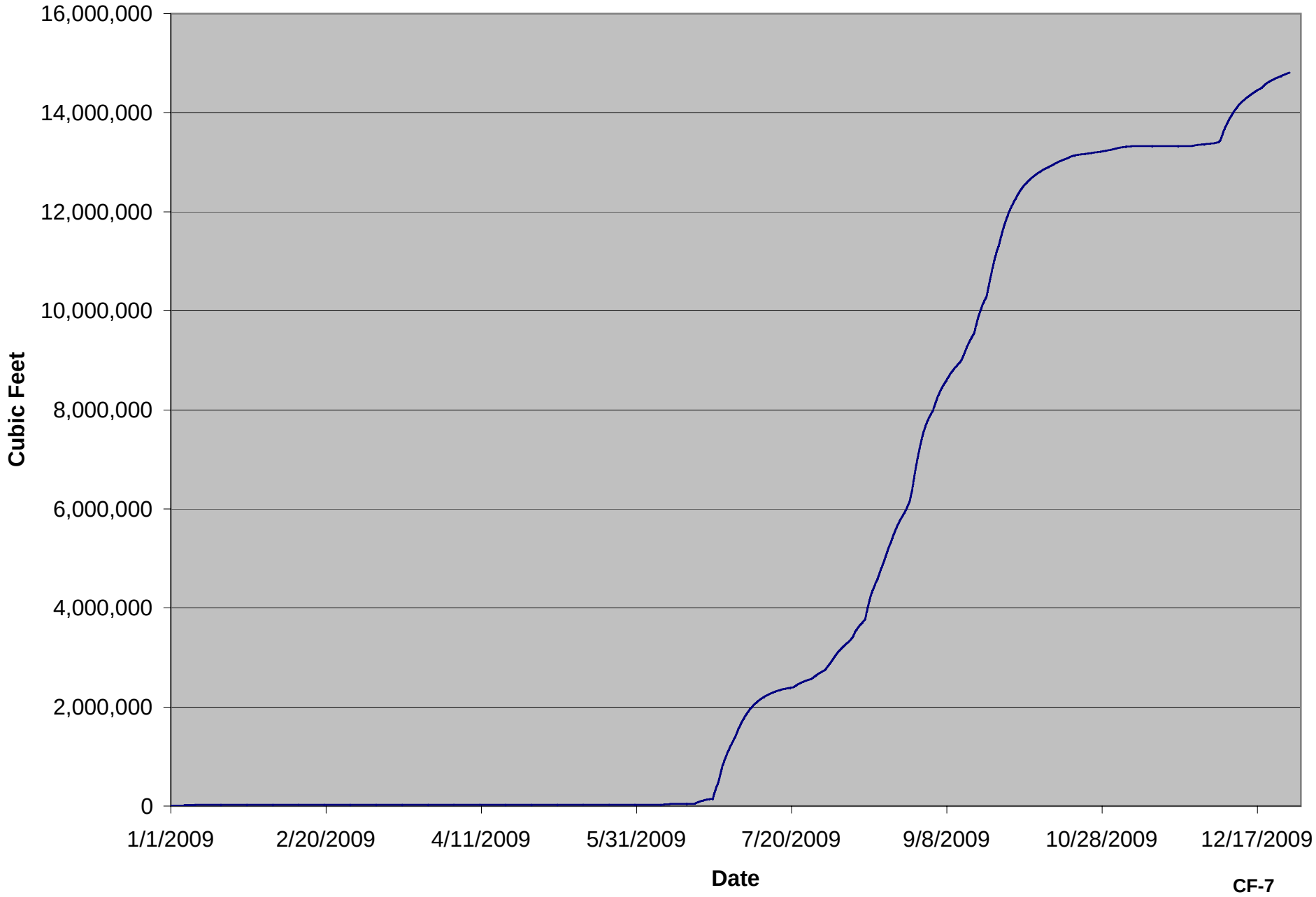


FR-6

Cumulative Flow Chart 2009
Sandoval Structure S3

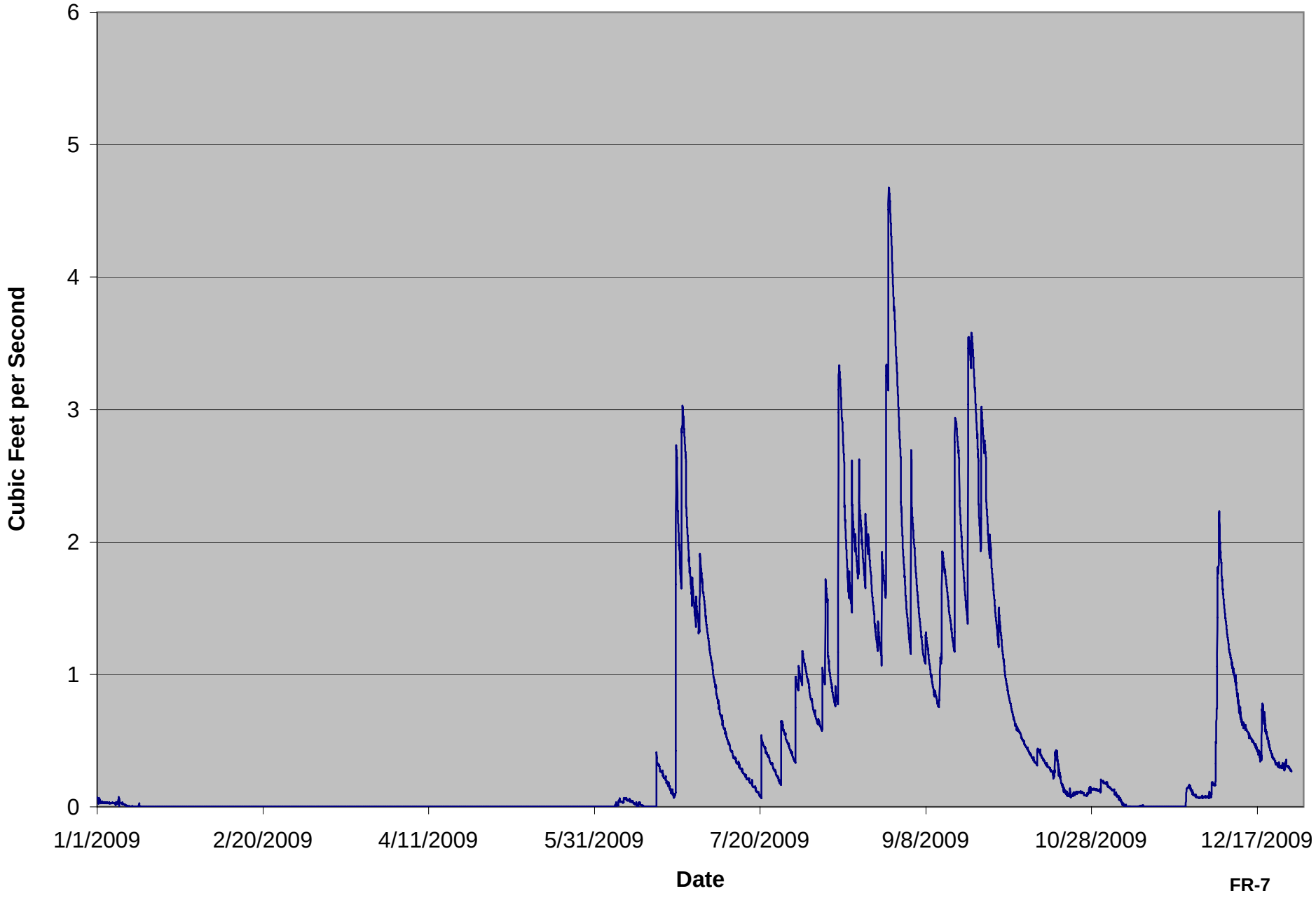
JOHNSON ENGINEERING

TOTAL FLOW 01/01/09 TO 12/31/09 **14,894,498** Cu Ft



Flow Rate Chart 2009
Sandoval Structure S3

JOHNSON ENGINEERING

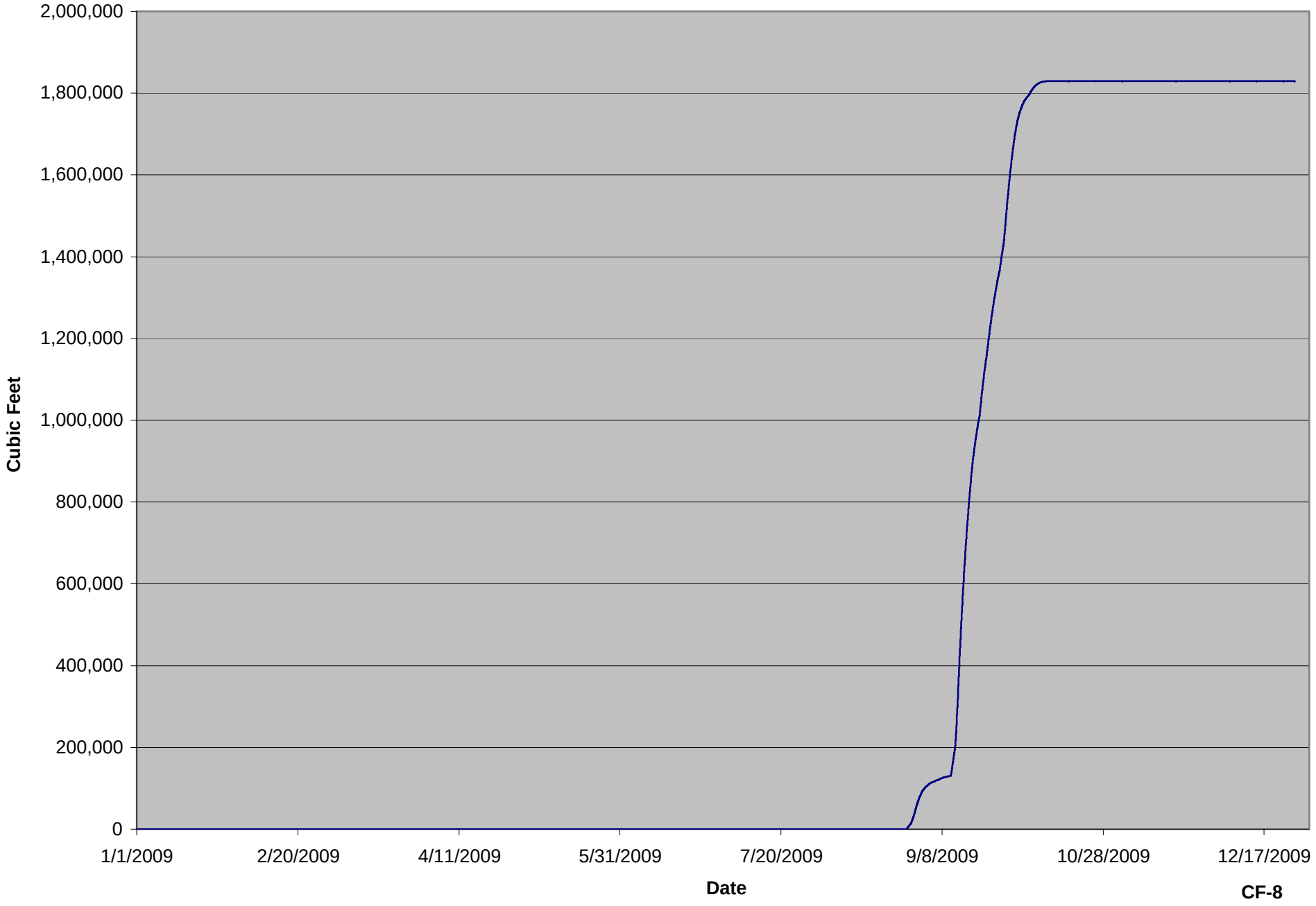


FR-7

Cumulative Flow Chart 2009
Shadow Wood Preserve Structure LA1

JOHNSON ENGINEERING

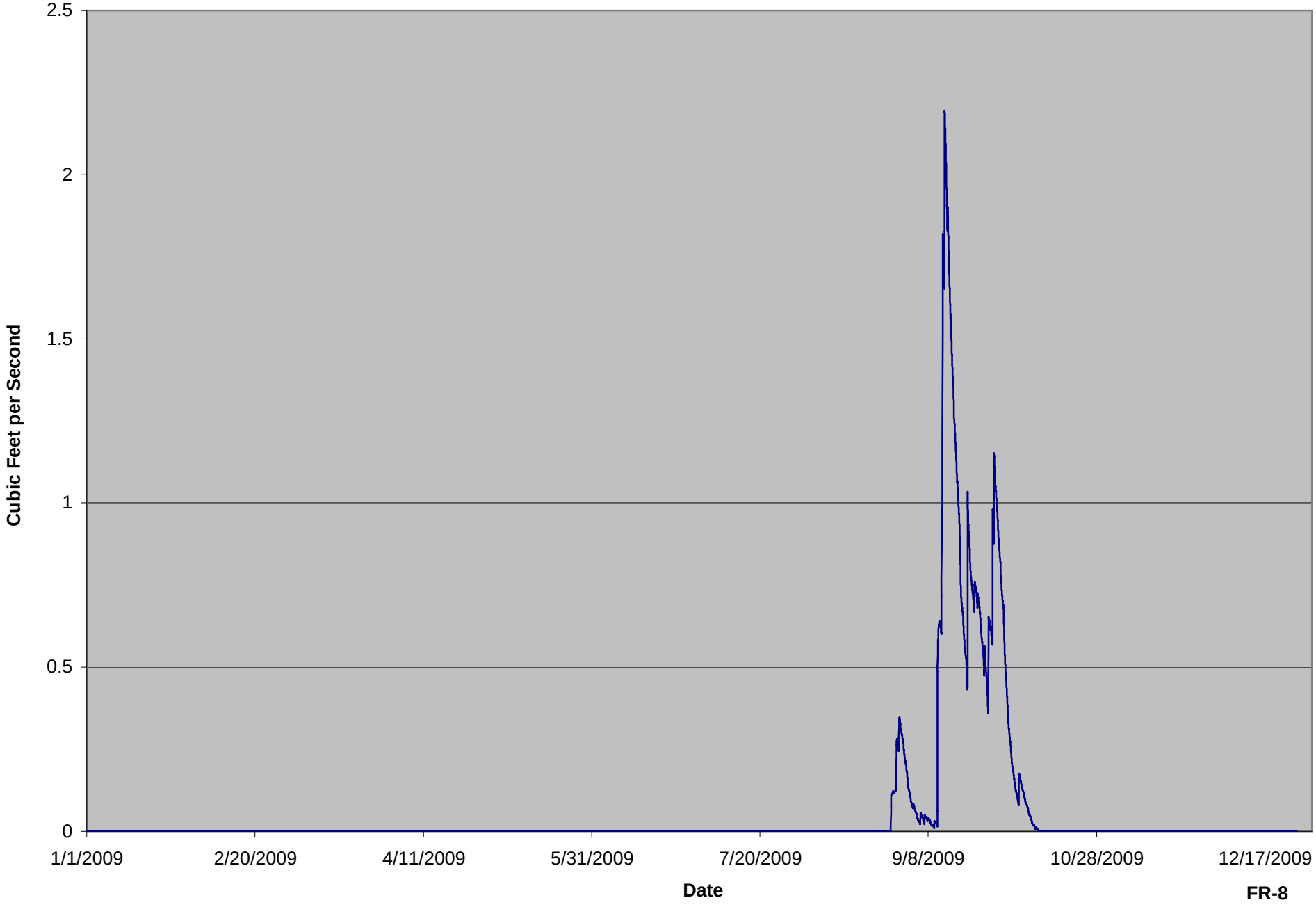
TOTAL FLOW 01/01/09 TO 12/31/09 **1,829,278** Cu Ft



CF-8

Flow Rate Chart 2009
Shadow Wood Preserve Structure LA1

JOHNSON ENGINEERING

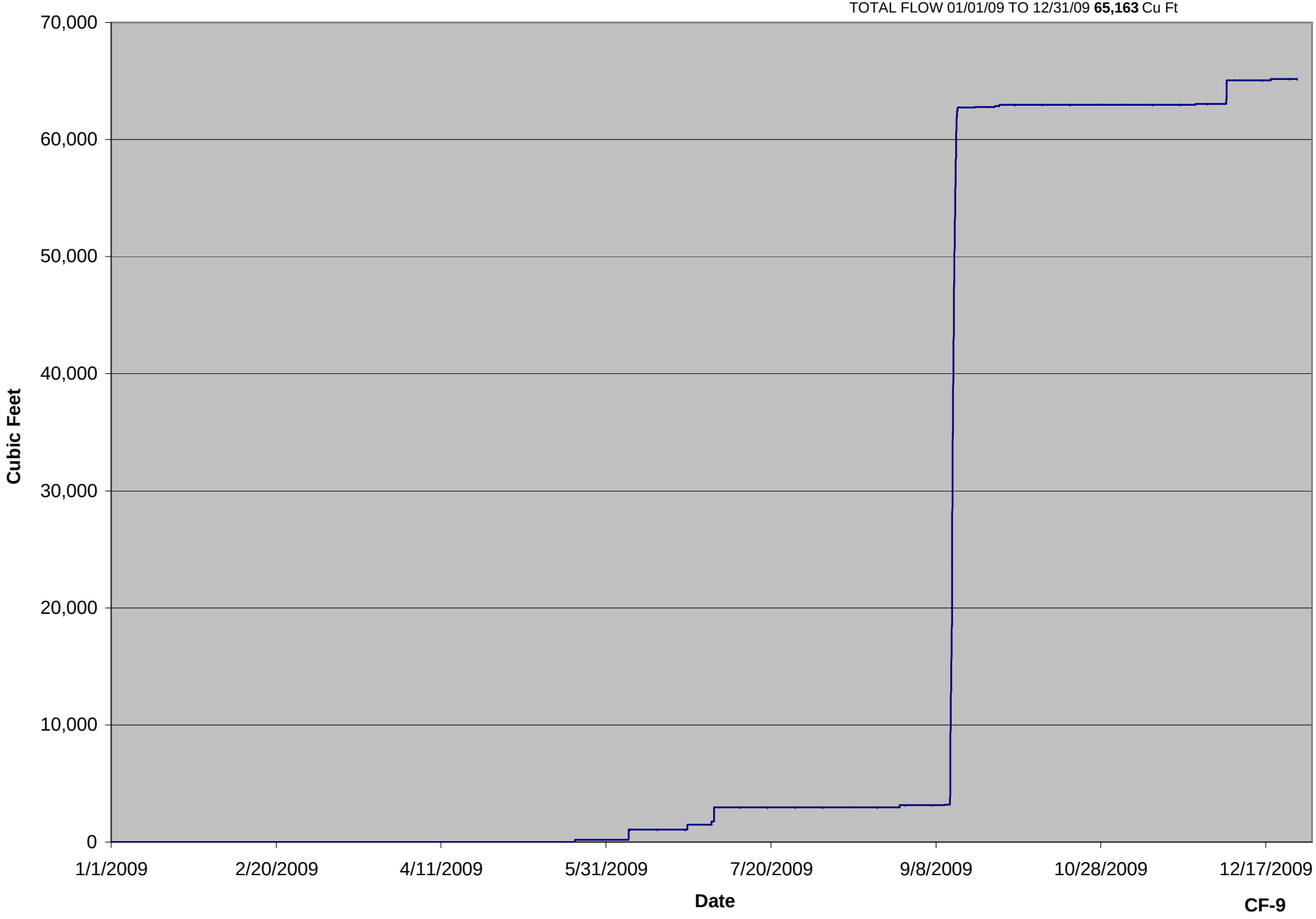


FR-8

Cumulative Flow Chart 2009
Shadow Wood Preserve Structure LA7

JOHNSON ENGINEERING

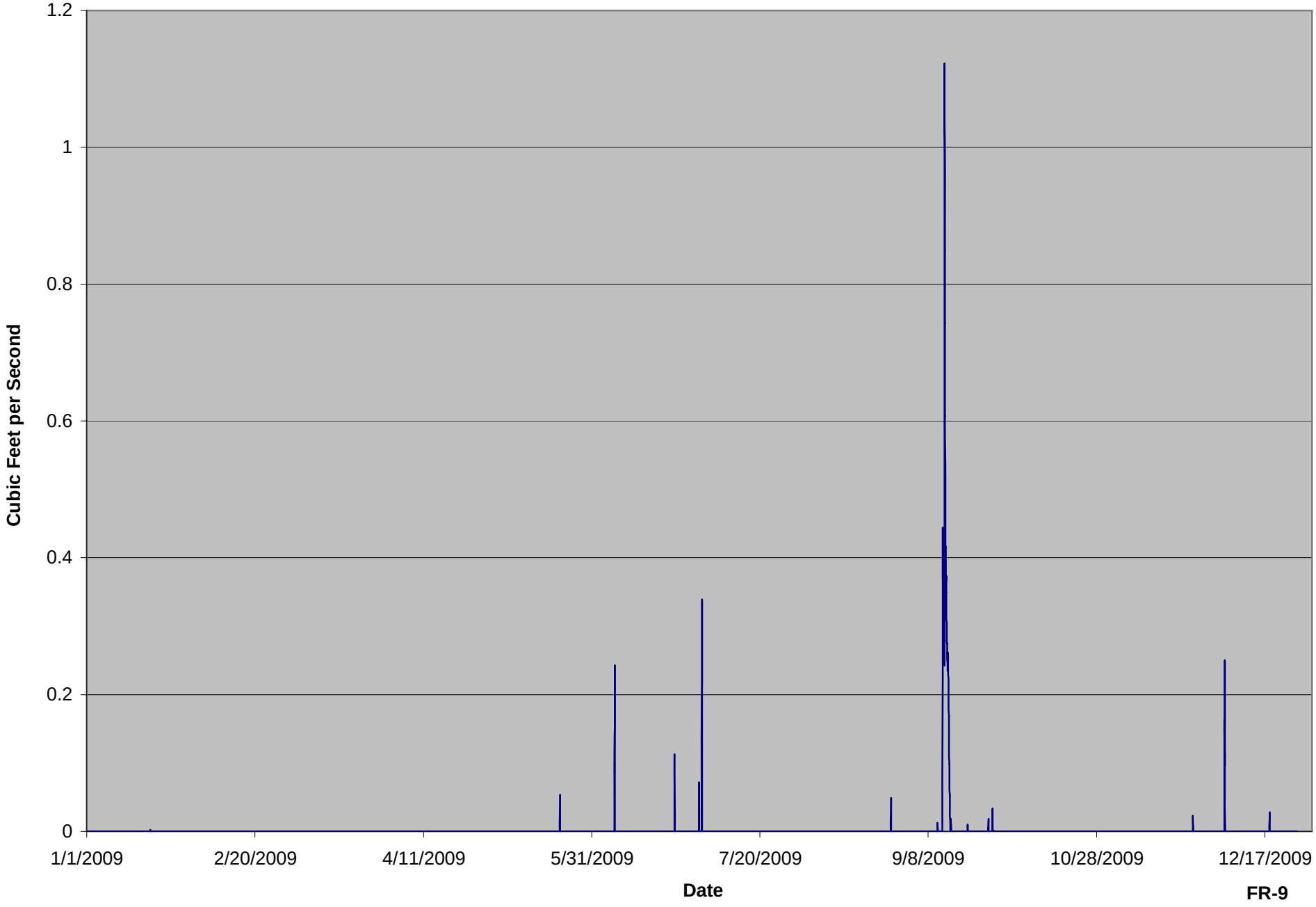
TOTAL FLOW 01/01/09 TO 12/31/09 **65,163** Cu Ft



CF-9

Flow Rate Chart 2009
Shadow Wood Preserve Structure LA7

JOHNSON ENGINEERING

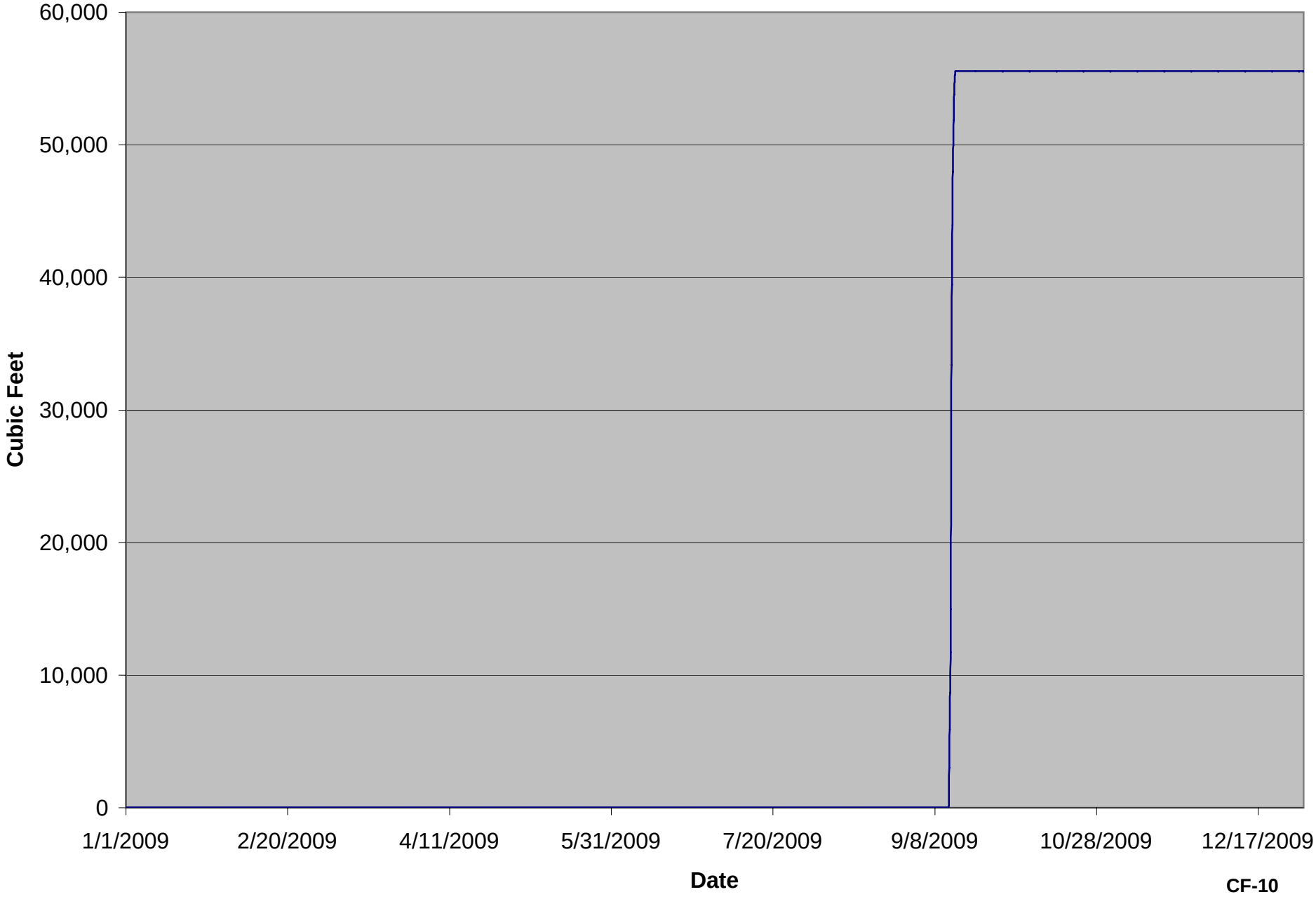


FR-9

Cumulative Flow Chart 2009
SWP Structure LA8

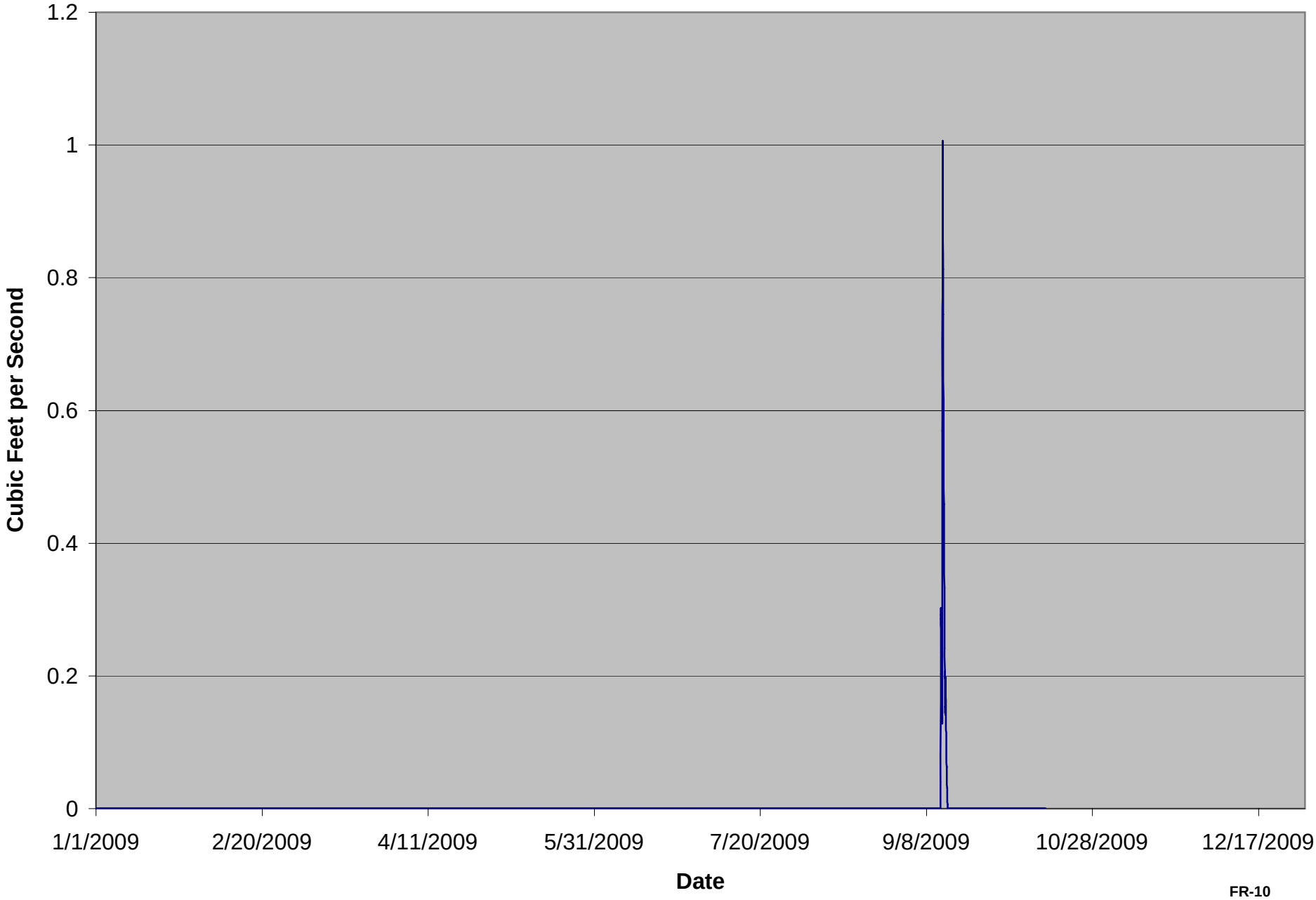
JOHNSON ENGINEERING

TOTAL FLOW 01/01/09 TO 12/31/09 **55,561** Cu Ft



Flow Rate Chart 2009
SWP Structure LA8

JOHNSON ENGINEERING

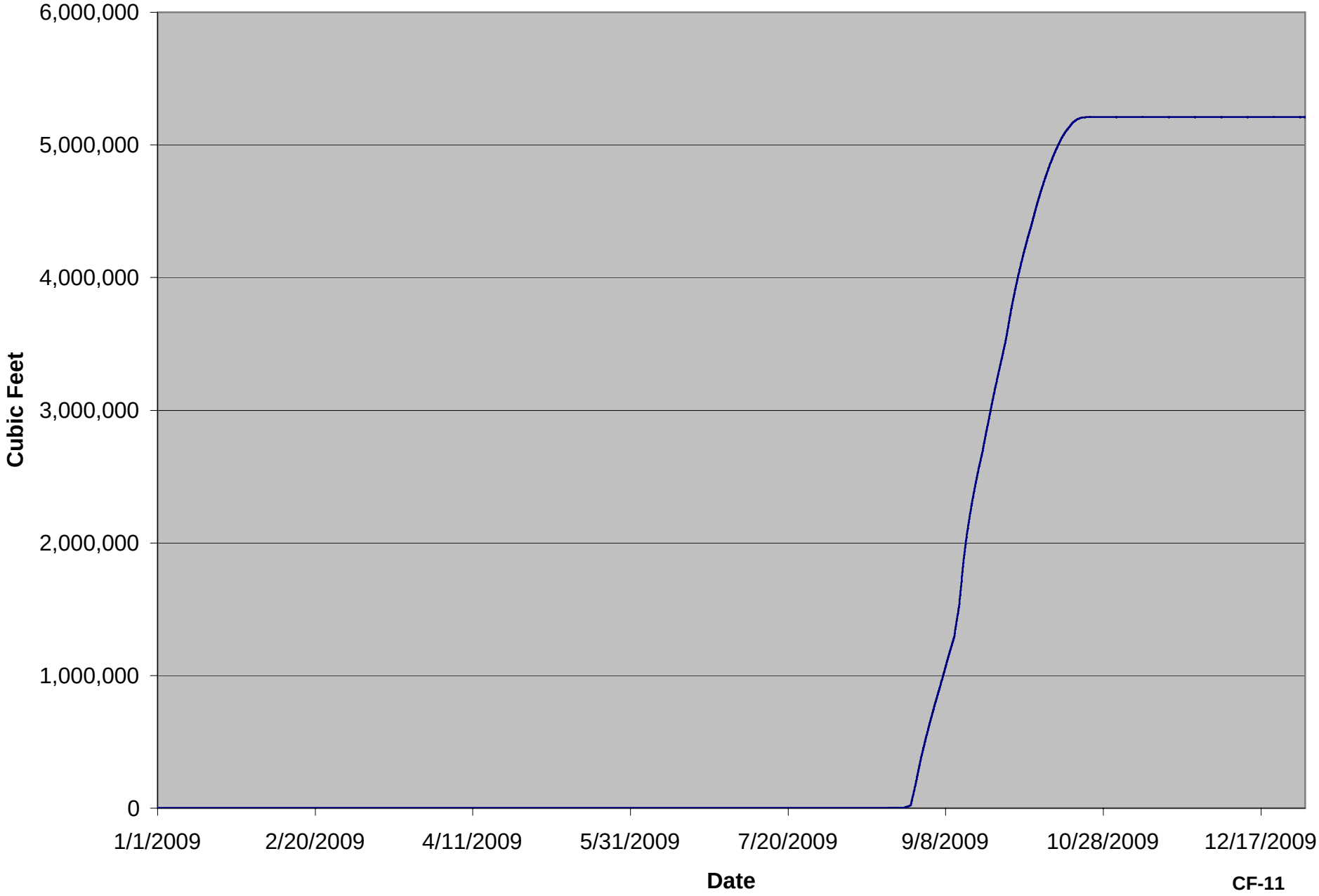


FR-10

Cumulative Flow Chart 2009
SWP Structure LA12

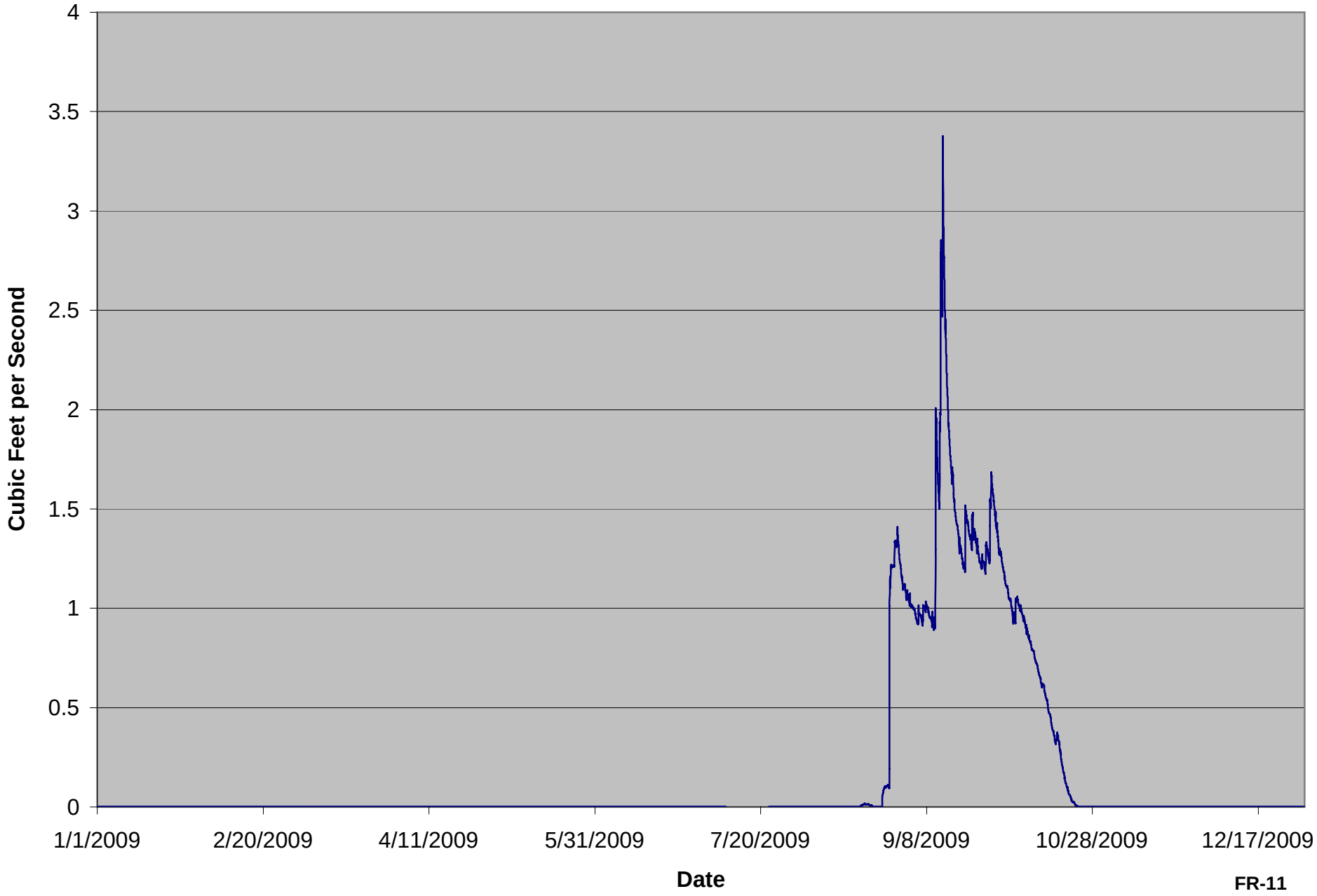
JOHNSON ENGINEERING

TOTAL FLOW 01/01/09 TO 12/31/09 **5,210,433** Cu Ft



Flow Rate Chart 2009
SWP Structure LA12

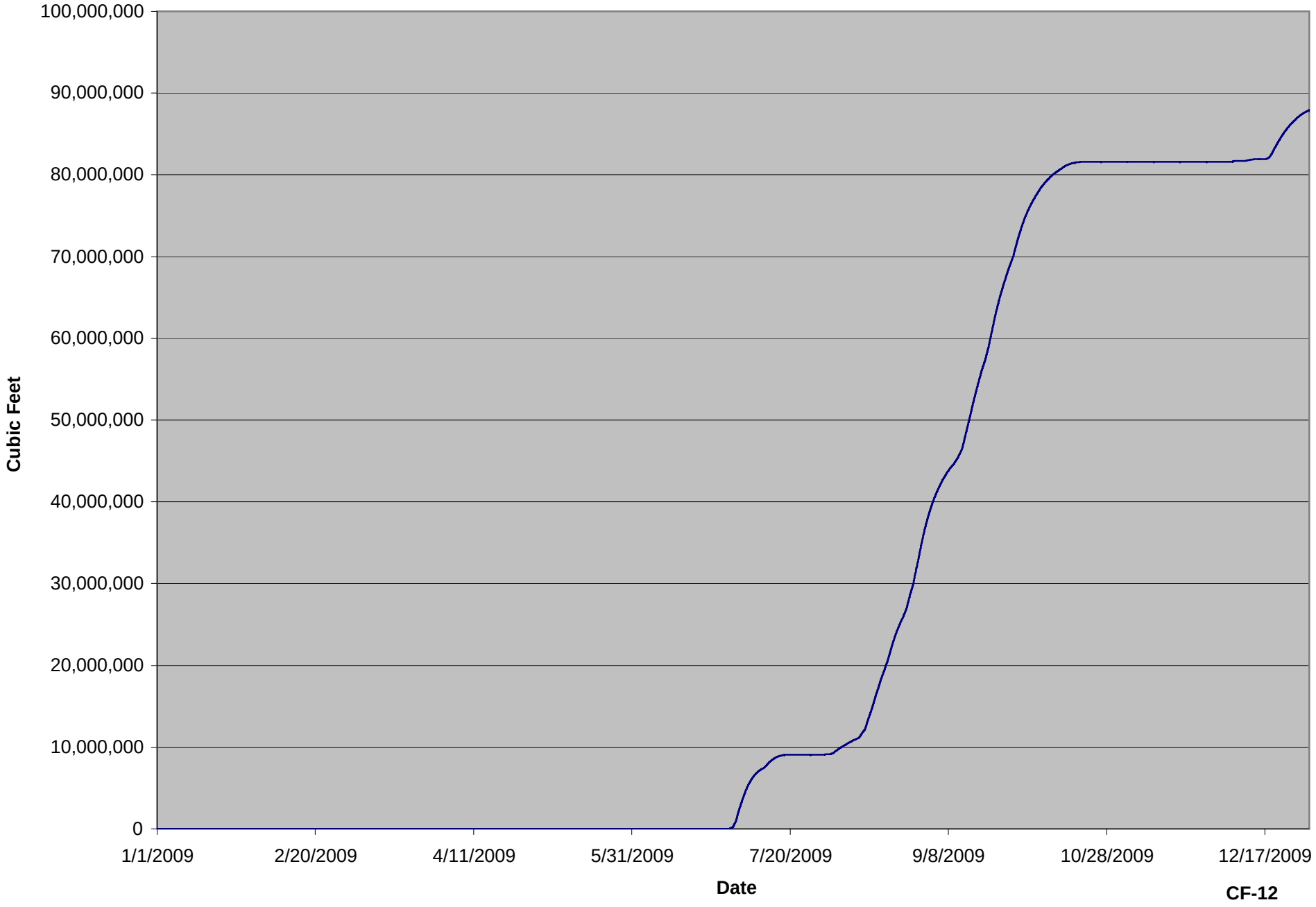
JOHNSON ENGINEERING



FR-11

Cumulative Flow Chart 2009
Brooks South Outfall Structure WB-L28

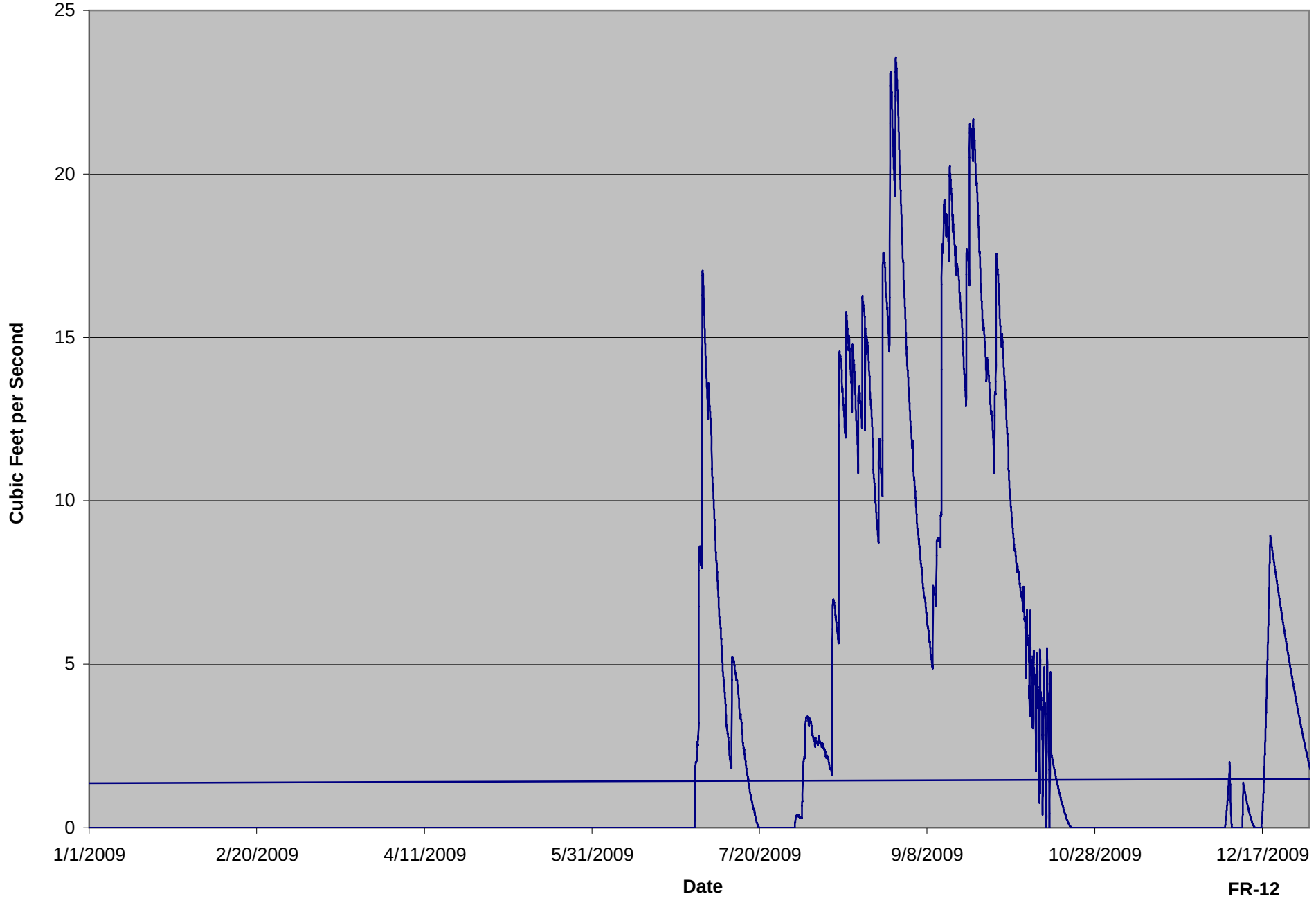
JOHNSON ENGINEERING



CF-12

Flow Rate Chart 2009
Brooks South Outfall Structure WB-L28

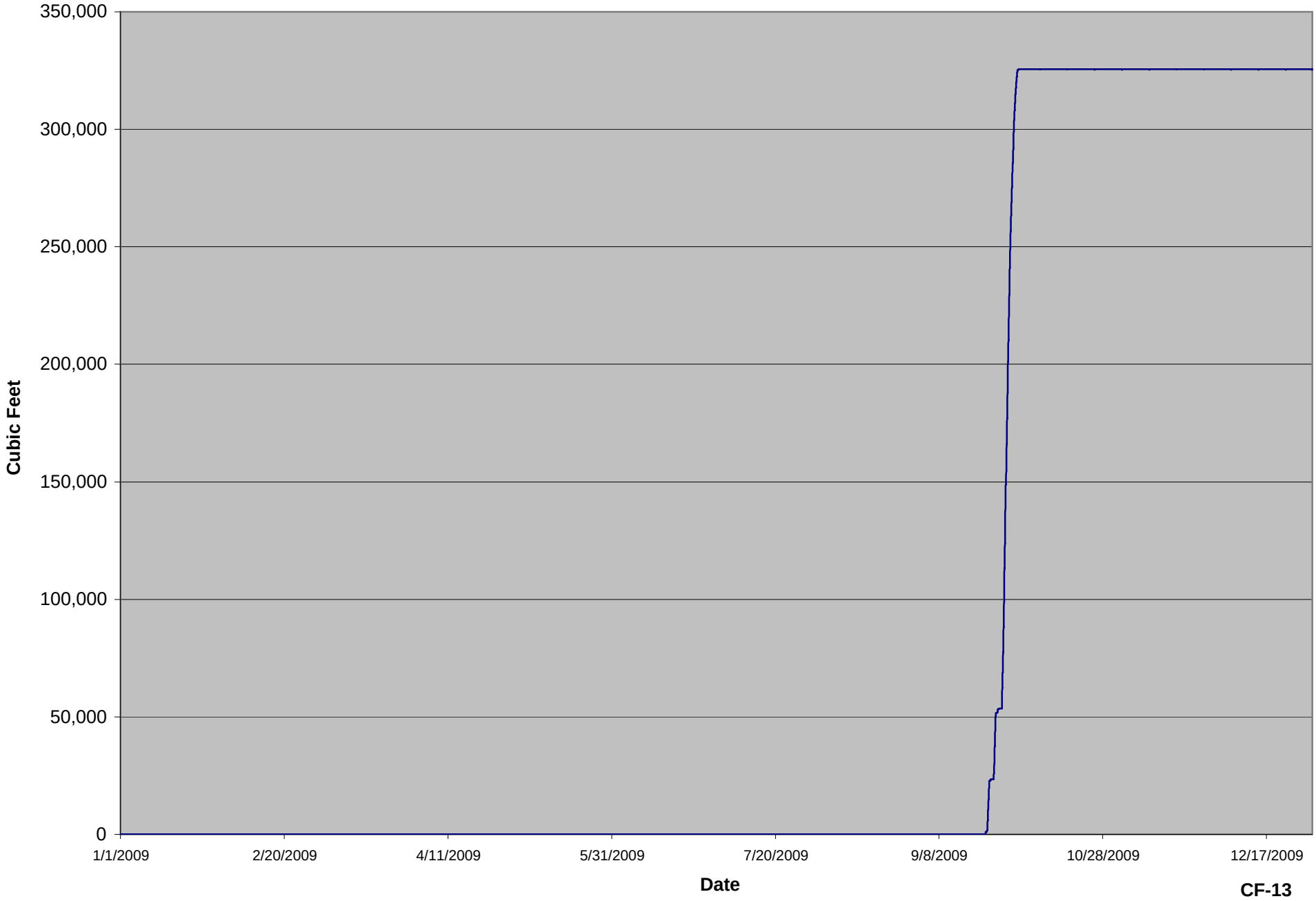
JOHNSON ENGINEERING



FR-12

Cumulative Flow Chart 2009
Mediterra Structure L55

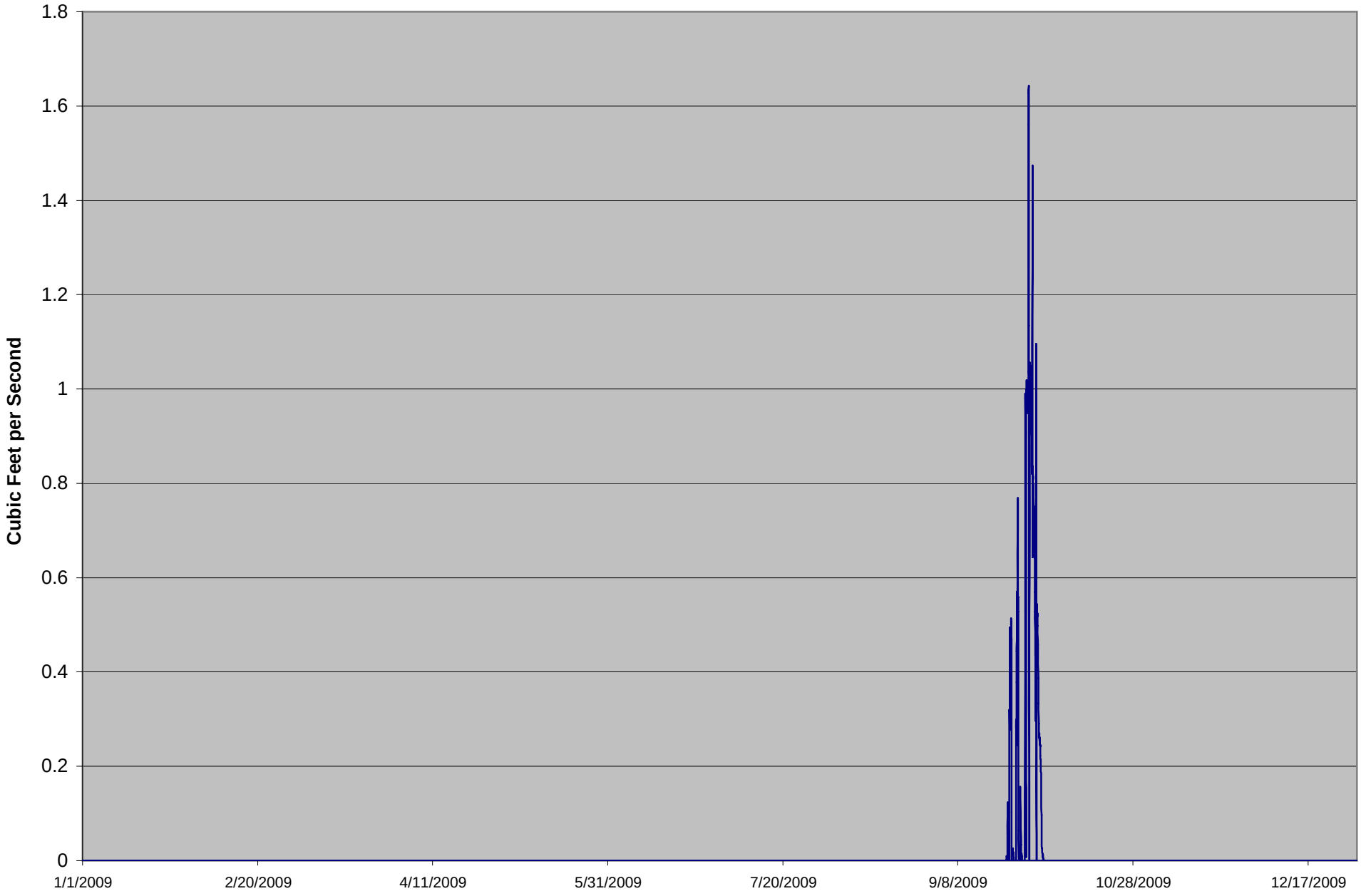
JOHNSON ENGINEERING



CF-13

Flow Rate Chart 2009
Mediterra Structure L55

JOHNSON ENGINEERING

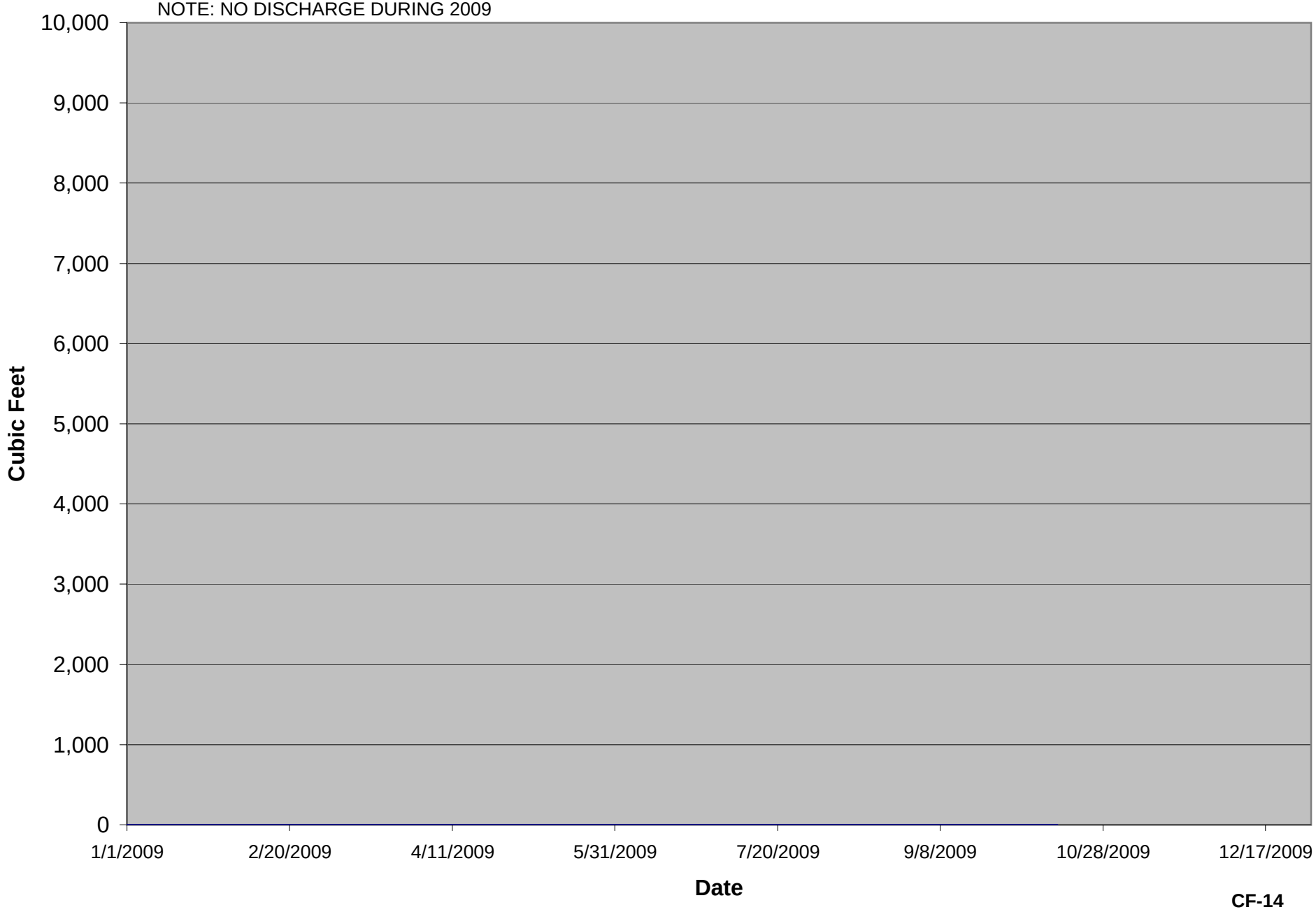


FR-13

Cumulative Flow Chart 2009
Twin Eagles Structure WT-2

JOHNSON ENGINEERING

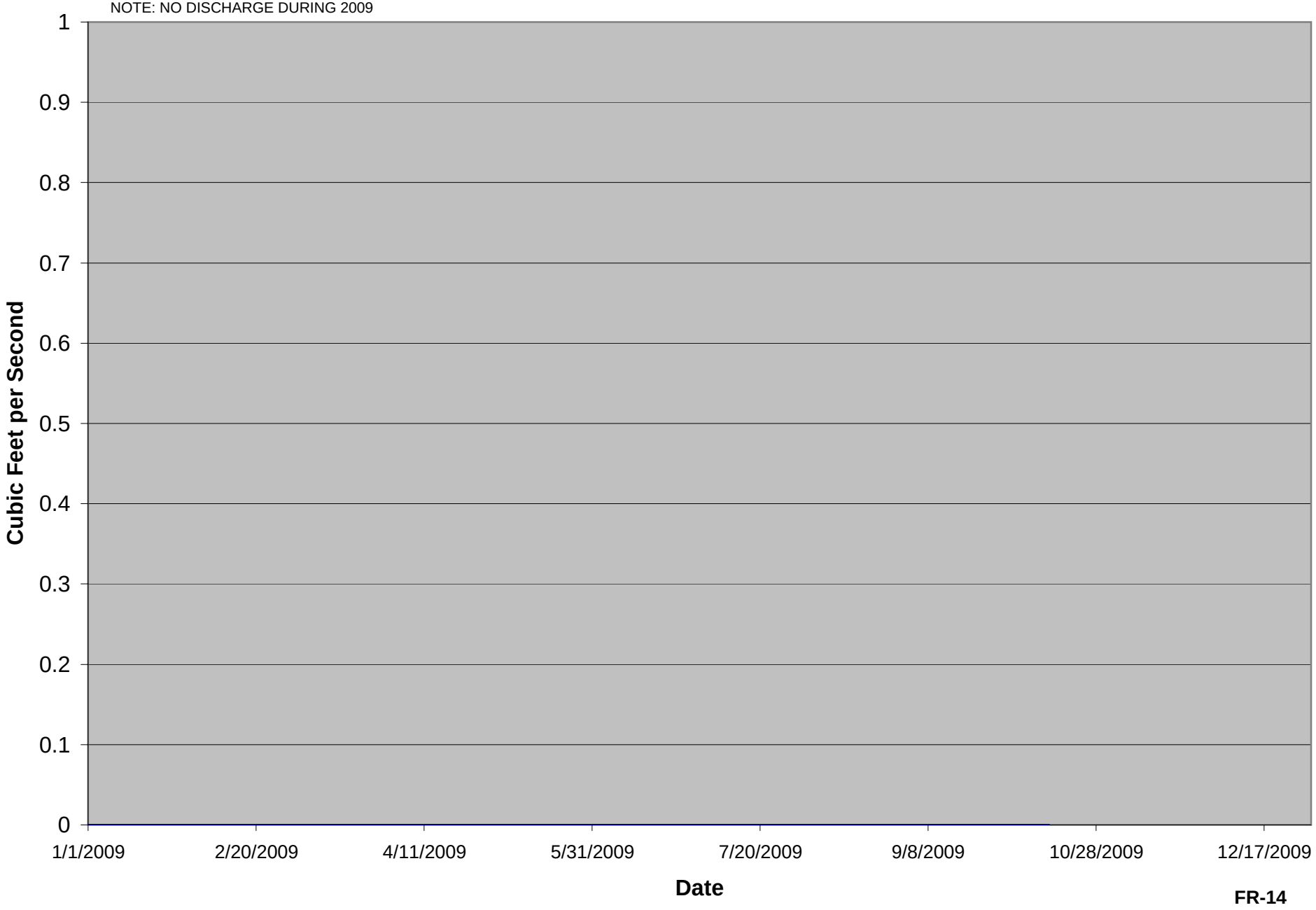
NOTE: NO DISCHARGE DURING 2009



Flow Rate Chart 2009
Twin Eagles Structure WT-2

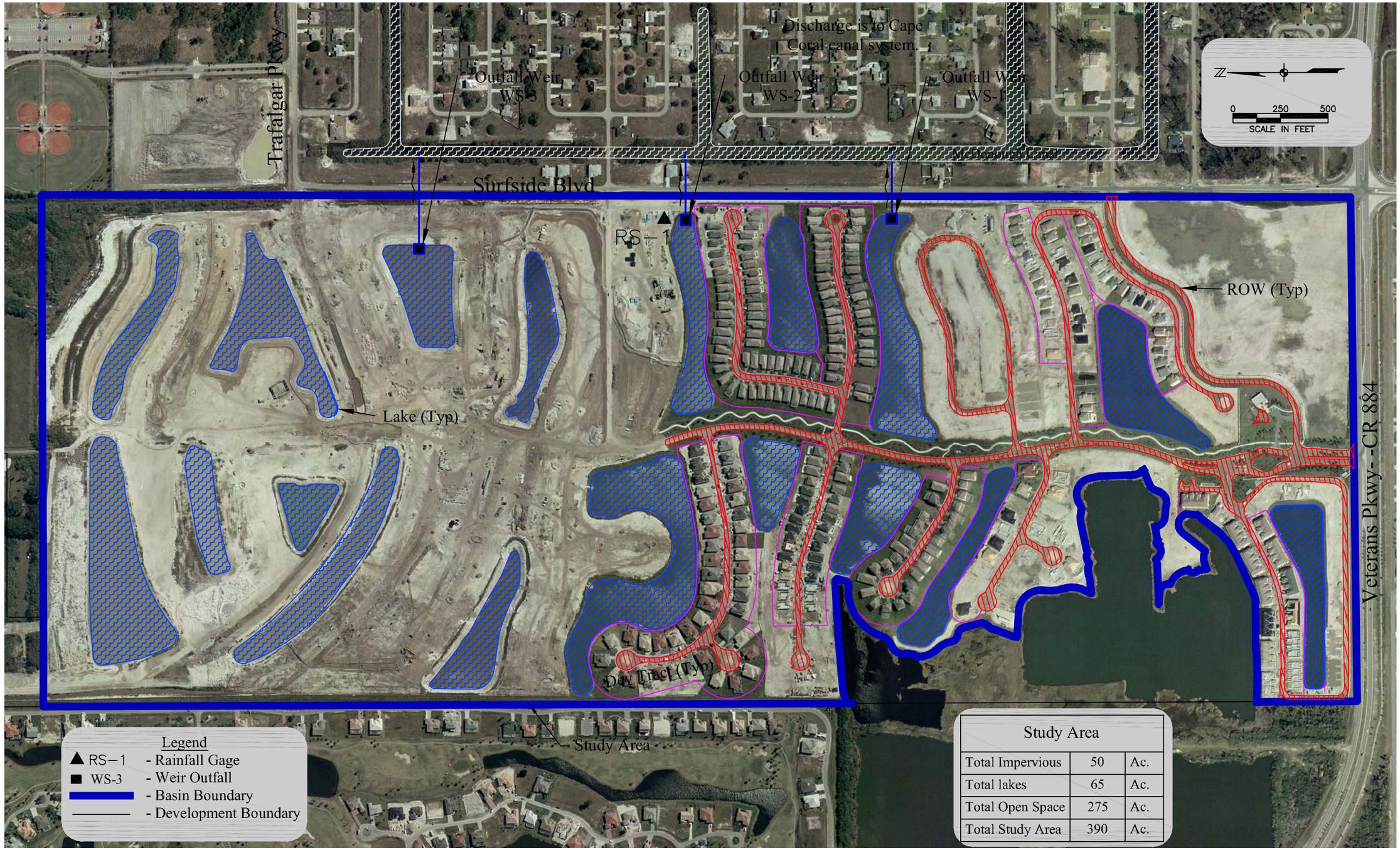
JOHNSON ENGINEERING

NOTE: NO DISCHARGE DURING 2009



APPENDIX D-1

SANDOVAL AERIALS – DEVELOPED AREAS



J:\20066052\Drawing\2008 Report Drawings\Watershed Sudy.dwg (11x17 2006 Aerial) mll2 Apr 19, 2009 - 9:49am

Data shown from Digiair Aerial dated Feb., 2006

Bonita Bay Group
Lee County, Florida

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2122 JOHNSON STREET
P.O. BOX 1550
FORT MYERS, FLORIDA 33902-1550
PHONE (239) 334-0046
FAX (239) 334-3661
E.B. #642 & L.B. #642

2. SANDOVAL - Feb. 2006
Watershed Study Area

DATE	PROJECT NO.	FILE NO.	SCALE	SHEET
12/06/06	20066052	00-00-00	As Shown	D-1

Trafalgar PKwy

Outfall Weir WS-3

Outfall Weir WS-2

Outfall Weir WS-1

Discharge is to Cape Coral canal system.

McDonough Canal

Surfside Blvd

RS-1

ROW (Typ)

Lake (Typ)

Dev Tract (Typ)

Study Area

Veterans Pkwy - CR 884

0 250 500
SCALE IN FEET

Legend

- RS-1 - Rainfall Gage
- WS-3 - Weir Outfall
- Basin Boundary
- Development Boundary

Study Area	Feb. 2006		Feb. 2008	
Total Impervious	50	Ac.	110	Ac.
Total lakes	65	Ac.	65	Ac.
Total Open Space	275	Ac.	215	Ac.
Total Study Area	390	Ac.	390	Ac.

J:\20066052\Drawing\2008 Report Drawings\Watershed Sudy.dwg (11x17 2008 Aerial) mll2 Apr 19, 2009 - 9:47am

Data shown from Mr. SID Aerial dated Jan., 2008

New construction areas created between Feb. 2007 and Feb. 2008

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E.B. #642 & L.B. #642

2. SANDOVAL - Feb. 2008
Watershed Study Area

DATE	PROJECT NO.	FILE NO.	SCALE	SHEET
12/06/06	20066052	00-00-00	As Shown	D-2

Trafalgar Pkwy

Outfall Weir WS-3

Outfall Weir WS-2

Outfall Weir WS-1

Discharge is to Cape Coral canal system.

McDonough Canal

Surfside Blvd

RS–1

ROW (Typ)

Dev Tract (Typ)

Lake (Typ)

Study Area

Veterans Pkwy- -CR 884

0 250 500
SCALE IN FEET

Legend
- RS–1 - Rainfall Gage
- WS-3 - Weir Outfall
- Basin Boundary
- Development Boundary

Study Area	Feb. 2006		Feb. 2008		Feb. 2010	
Total Impervious	50	Ac.	110	Ac.	142	Ac.
Total lakes	65	Ac.	65	Ac.	72	Ac.
Total Open Space	275	Ac.	215	Ac.	186	Ac.
Total Study Area	390	Ac.	390	Ac.	400	Ac.

Data shown from Mr. SID Aerial dated Jan., 2008
New construction areas created between Feb. 2007 and Feb. 2008.
New construction areas created between Feb. 2008 and Feb. 2010.

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2. SANDOVAL - Feb. 2010
Watershed Study Area

DATE	PROJECT NO.	FILE NO.	SCALE	SHEET
3/1/10	20066052	00–00–00	As Shown	D–3

J:\20066052\2009 Report\Drawings\Watershed Study.dwg (11x17 2010 Report) jwm Mar 09, 2010 – 1:49pm

APPENDIX E-1

PHOTOGRAPHS – PROJECT SITES

1. VERANDAH

Water Control Structure WV-L4 – View east.

Water Control Structure WV-L29. Photos taken April 12, 2007.

1. VERANDAH

Water Control Structure WV-L4 – View northwest. Photo taken July 11, 2008
Slow velocity, under submerged condition was measured by movement of dye.

Discharge from L-12 structure. Photo taken July 17, 2008.

1. VERANDAH

Water Control Structure L-12 view northerly. Flow discharges through the rectangular orifice near the bottom of the structure. Photo taken April 12, 2007.

Ditch improvement Summer 2009 downstream of Structure L-4. Photo taken June 15, 2009.

2. SANDOVAL

Water Control Structure WS-2.
View south with inlet on left and upstream recorder at right in lake. Photos taken April 19, 2007.

View south at structure WS-3 and recorders.

2. SANDOVAL

Water Control Structure WS-1. Photo taken September 13, 2008.
View inside inlet at flow over control weir.

View north at WS-1 – September 13, 2008.
Water quality monitoring. Solar panel at right.

2. SANDOVAL

Water Control Structure WS-3. View down into structure showing the inverted tee configuration. Photo taken September 13, 2009.

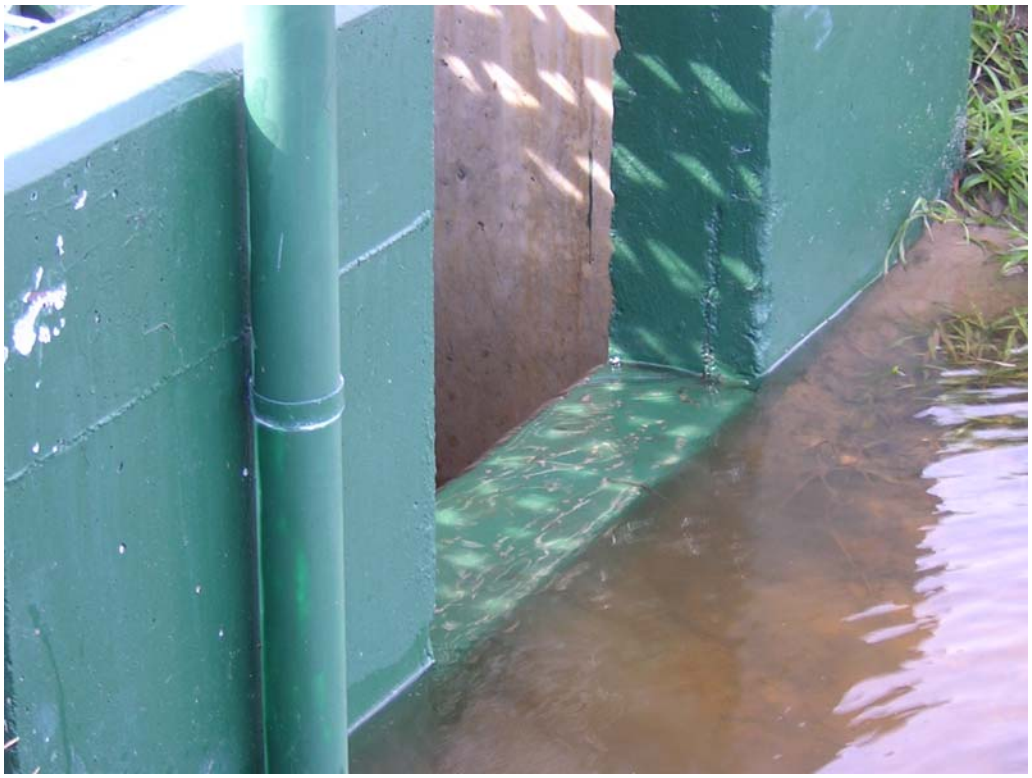
Showing velocity probe used to cross-check calculations. Photo taken September 13, 2009.

3. SHADOW WOOD PRESERVE

View Water Control Structure SW-LA12.
Structure is located at arrow in wooden retaining wall.

View Water Control Structure SW-LA8. Upstream stage recorder is at left of inlet face.
Photos taken May 1, 2007.

3. SHADOW WOOD PRESERVE



Water Control Structure SW-LA8 – unsubmerged flow. Photo taken July 17, 2008

View vertically down at flow over Water Control Structure SW-LA12. Photo taken July 17, 2008. See previous page E-3A (top) for horizontal photo of structure.

4. THE BROOKS

View northeast across weir showing upstream stage recorder and WQ sampling station.
Photo taken June 13, 2009

View south at weir with stage recorder (white pipe).
Photo taken March 23, 2008

4. THE BROOKS

View northeast across L-28 weir. Photo taken July 17, 2008. Refer to graph page C-12 to see stage of approximate elevation 14.8' that corresponds to this photo.

View north across L-28 weir and downstream recorder gage. Photo taken July 17, 2008.

4. THE BROOKS

Project staff meeting at Bonita Bay office at The Brooks. L to R: Eric Livingston, FDEP; Kim Fikoski, Bonita Bay Group; David Ceilley, Florida Gulf Coast University; Mike Lohr, Johnson Engineering; Edwin Everham, Florida Gulf Coast University; and Archie Grant, Johnson Engineering. Photo taken June 20, 2007.

Onsite project staff meeting near The Brooks outfall, showing Florida Gulf Coast University staff, Johnson Engineering staff, and Bonita Bay Group staff. Photo taken June 20, 2007.

5. MEDITERRA

View west at headwall on outfall culvert located at south end of project and just upstream of outfall weir (see below).

Outfall weir (beneath grate). Downloading data from stage recorders inside inlet. Flow into and out of inlet as shown by arrows. Underground piping connects upstream lake to inlet and to downstream outfall. Weir wall is inside inlet 4 feet below grate.

5. MEDITERRA

Mediterra outfall to south. Note flow ripples in swale downstream of submerged notched structure. Photo taken July 21, 2008.

Water quality sampling lake at Mediterra site QM-1. Photo taken October 31, 2008.

6. TWIN EAGLES

View east at lake, weir at arrow and rain gage located near southeast corner of Twin Eagles. Photo taken March 23, 2008.

View southeast at outfall weir structure. Photo taken March 23, 2008.

6. TWIN EAGLES

Photo shows first documented flow since January 2007 at WT-2 outfall following heavy rainfall from Tropical Storm Fay. Photo taken August 20, 2008.

High water mark on weir wall. Photo taken August 20, 2008.

6. TWIN EAGLES

View looking northerly at water quality sampling lake site QT-1. Photo taken March 23, 2008.

View looking east along Big Cypress Basin Drainage Canal north of CR-846 Immokalee Rd. Twin Eagles outfall is east of structure TE-1, entering the canal from the north (left) near white arrow. Photo taken March 23, 2008.

APPENDIX F-1

WATER QUALITY DATA

FDEP Long Term Discharge Study -20066052, 20098229
Water Quality Sample Events

Note: rainfall amounts shown are for the most recent daily totals

Samples during discharge periods

Samples during non discharge periods

Verandah

Event #	Date	Sample ID	Sample Type	Rainfall Inches
1	7/9/2007	WV-L4US	Grab	0.24
2	7/11/2008	WDL4	Grab	0.2
3	7/24/2008	QVL-29	24 Hr Composite	0.5
4	8/26/2008	QVL-29	24 Hr Composite	1
5	9/11/2008	QVL-29	24 Hr Composite	1.45
6	10/6/2008	QVL-29	6 Hr Composite/Rain	0.8
7	8/6/2009	QVL-29	24 Hr Composite	1.14
8	8/25/2009	QVL-29	20 Hr Composite	0.8
9	9/3/2009	QVL-29	20 Hr Composite	1.07
10	9/15/2009	QVL-29	20 Hr Composite	1.74
11	10/6/2009	QVL-29	18 Hr Composite	0.09

Sandoval

Event #	Date		Sample Type	Rainfall Inches
1	7/19/2007	WS-3	Grab	1.3
2	7/2/2008	QS-1	Grab	0.11
3	7/18/2008	WS-1	24 Hr Composite	0.19
4	8/21/2008	QS-1	24 Hr Composite	0.85
5	9/11/2008	QS-1	24 Hr Composite	0.97
6	10/6/2008	QS-1	6 Hr Composite/Rain	0.39
7	6/2/2009	QS-1	22 Hr Composite	1.4
8	6/30/2009	QS-1	12 Hr Composite	0.4
9	8/14/2009	QS-1	12 Hr Composite	0.5
10	9/15/2009	QS-1	12 Hr Composite	0.88
11	10/2/2009	QS-1	12 Hr Composite	0.08

Shadow Wood Preserve

Event #	Date		Sample Type	Rainfall Inches
1	7/14/2008	QSWP-1	Grab	0.4
2	7/23/2008	QSWP-LA1	24 Hr Composite	0.25
3	8/28/2008	WSWP-LA1	24 Hr Composite	0.15
4	9/11/2008	WV-L29	24 Hr Composite	0.4
5	10/9/2008	QSWP-1	24 Hr Composite	0.1
6	9/1/2009	QSWP-1	20 Hr Composite	0
7	9/16/2009	QSWP-1	20 Hr Composite	0.09
8	10/5/2009	QSWP-1	12 Hr Composite	0.43

The Brooks

Event #	Date		Sample Type	Rainfall Inches
1	7/9/2008	QB-1	Grab	0.75
2	7/22/2008	QB-1	24 Hr Composite	0.12
3	8/21/2008	QB-1	24 Hr Composite	1.44
4	9/11/2008	QB-1	24 Hr Composite	1.77
5	10/7/2008	QB-1	6 Hr Composite/Rain	0.39
6	8/10/2009	QB-1	24 Hr Composite	1.39
7	9/17/2009	QB-1	18 Hr Composite	0.44
8	10/5/2009	QB-1	24 Hr Composite	0.09

Mediterra

Event #	Date		Sample Type	Rainfall Inches
1	9/22/2008	MW-L55	Grab	4.46
2	10/8/2008	WM-1	24 Hr Composite	2.46
3	10/30/2008	QM-1T, QM-1B	Static Lake	NA
4	11/24/2008	QM-1T, QM-1B	Static Lake	NA
5	5/28/2009	QM-1T, QM-1B	Static Lake	NA

Twin Eagles

Event #	Date		Sample Type	Rainfall Inches
1	8/20/2008	QT-2	Grab	7.65
2	9/11/2008	QT-1T, QT-1B	Static Lake	NA
3	11/24/2008	QT-1T, QT-1B	Static Lake	NA
4	5/28/2009	QT-1T, QT-1B	Static Lake	NA

Surface Water Sampling Physical Parameters - Mediterra QM-1

Date	Time	Depth (ft)	Temp C	SpC (mS/cm)	ORP (mV)	pH	DO (mg/L)	Turb (NTU)	Total Depth (ft)	Comments
10/30/2008	1342	1.0	23.63	0.586	-26.9	7.26	8.46	-0.12	15.4	
10/30/2008	1344	2.0	22.94	0.579	-34.5	7.23	6.83	-0.15	15.4	
10/30/2008	1346	3.0	22.86	0.595	-33.0	7.21	6.89	-0.18	15.4	
10/30/2008	1348	4.0	22.85	0.611	-32.8	7.18	6.97	-0.19	15.4	
10/30/2008	1350	5.0	22.81	0.616	-33.9	7.17	6.50	-0.20	15.4	
10/30/2008	1352	6.0	22.71	0.617	-36.9	7.16	5.77	-0.20	15.4	
10/30/2008	1354	7.0	22.71	0.619	-38.0	7.15	5.63	-0.23	15.4	
10/30/2008	1356	8.0	22.69	0.617	-39.1	7.15	5.50	-0.30	15.4	
10/30/2008	1358	9.0	22.67	0.618	-40.1	7.15	5.34	-0.37	15.4	
10/30/2008	1400	10.0	22.66	0.615	-41.4	7.15	5.21	-0.40	15.4	
10/30/2008	1403	11.0	22.66	0.616	-41.9	7.15	5.28	-0.50	15.4	
10/30/2008	1408	12.0	22.65	0.615	-43.1	7.15	5.26	-0.60	15.4	
10/30/2008	1410	13.0	22.66	0.617	-42.4	7.15	5.44	-0.70	15.4	
10/30/2008	1415	14.0	23.25	0.763	-210.0	7.02	0.76	15.50	15.4	
11/24/2008	1251	1.0	21.29	0.564	198.7	6.99	14.61		14.1	
11/24/2008	1300	2.0	20.06	0.556	197.0	7.25	13.18		14.1	
11/24/2008	1301	3.0	19.88	0.555	199.2	7.26	12.42		14.1	
11/24/2008	1306	4.0	19.78	0.555	202.4	7.26	10.88		14.1	
11/24/2008	1310	5.0	19.72	0.554	200.5	7.27	9.83		14.1	
11/24/2008	1313	6.0	19.72	0.554	200.7	7.28	8.34		14.1	
11/24/2008	1315	7.0	19.70	0.534	199.1	7.28	8.84		14.1	
11/24/2008	1318	8.0	19.69	0.555	199.3	7.28	8.31		14.1	
11/24/2008	1321	9.0	19.69	0.555	198.0	7.29	8.10		14.1	
11/24/2008	1324	10.0	19.59	0.555	197.1	7.27	7.81		14.1	
11/24/2008	1327	11.0	19.86	0.580	-74.2	7.21	6.10		14.1	
5/28/2009	1213	1.0	30.95	0.473	214.5	7.85	5.73	10.5	9.5	YSI6600AA
5/28/2009		2.0	30.90	0.473	234.8	7.89	5.91	10.7	9.5	YSI6600AA
5/28/2009		3.0	30.64	0.473	240.2	7.90	5.98	11	9.5	YSI6600AA
5/28/2009		4.0	30.33	0.469	248.1	7.86	5.88	11	9.5	YSI6600AA
5/28/2009		5.0	30.16	0.477	257.9	7.80	5.80	11	9.5	YSI6600AA
5/28/2009		6.0	29.84	0.482	269.9	7.64	5.23	11.3	9.5	YSI6600AA
5/28/2009		7.0	29.56	0.485	278.9	7.38	3.84	12	9.5	YSI6600AA
5/28/2009	1229	8.0	29.19	0.487	281.3	7.28	2.22	12.3	9.5	YSI6600AA
5/28/2009	1233	9.0	29.07	0.488	244.9	7.24	1.45	378	9.5	Bottom possibly disturbed by probe

Notes:

1. Depth profile taken from boat at approximately mid lake where WQ samples are taken.

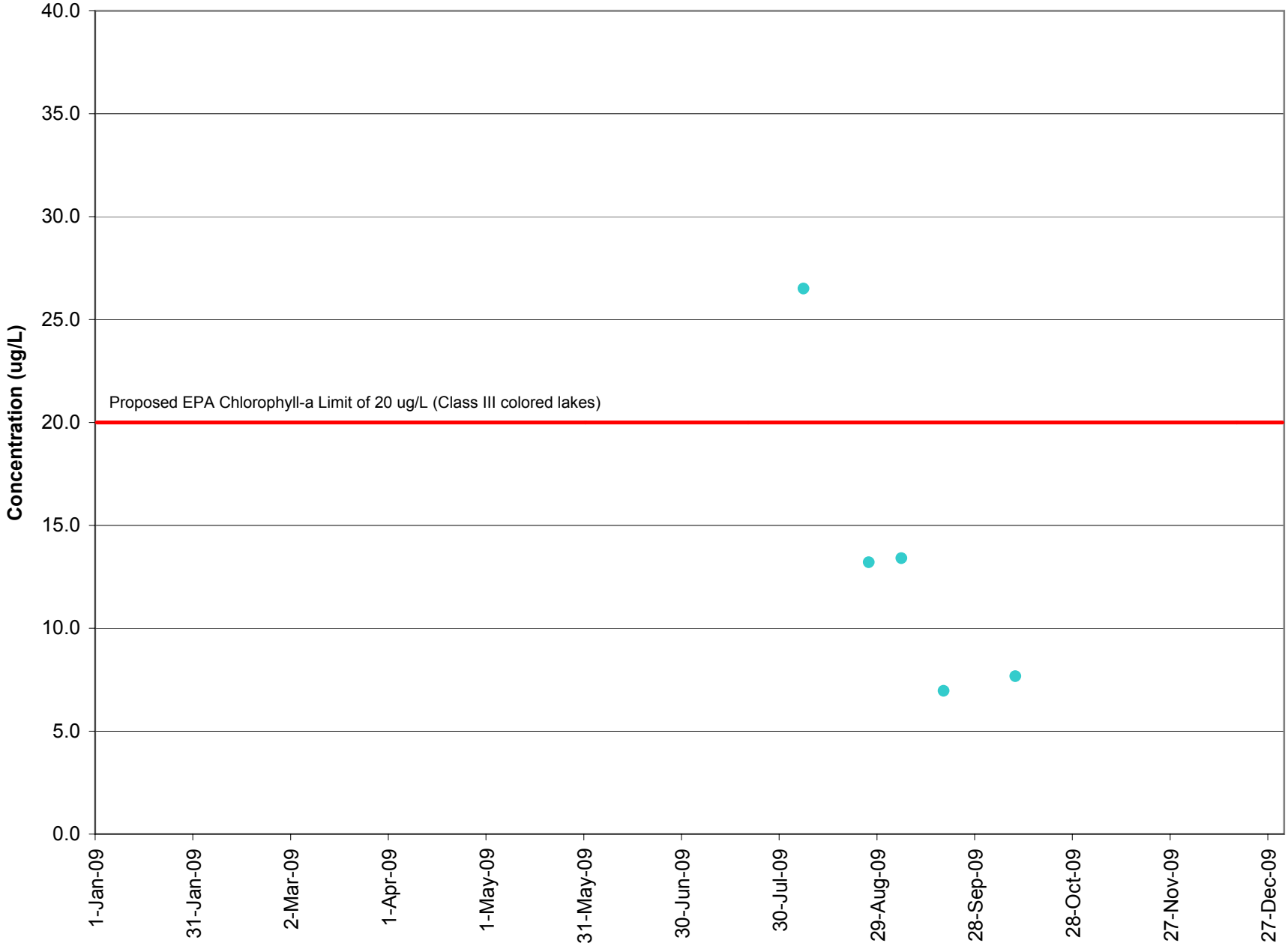
Surface Water Sampling Physical Parameters - Twin Eagles QT-1

Date	Time	Depth (ft)	Temp C	SpC (mS/cm)	ORP (mV)	pH	DO (mg/L)	Turb (NTU)	Total Depth (ft)	Comments
9/11/2008	1612	1.0	28.97	0.286	143.0	8.35	8.89	4.47	17.5	
9/11/2008	1613	2.0	29.01	0.286	146.4	8.32	8.63	4.47	17.5	
9/11/2008	1614	3.0	28.93	0.286	149.9	8.28	8.26	4.47	17.5	
9/11/2008	1615	4.0	28.84	0.287	155.1	8.10	7.88	4.47	17.5	
9/11/2008	1616	5.0	28.81	0.288	156.7	8.10	7.41	4.47	17.5	
9/11/2008	1617	6.0	28.60	0.289	160.4	7.88	6.59	4.47	17.5	
9/11/2008	1618	7.0	28.60	0.289	160.7	7.86	6.56	4.47	17.5	
9/11/2008	1619	8.0	28.44	0.290	160.4	7.85	6.35	4.47	17.5	
9/11/2008	1620	9.0	28.49	0.290	160.2	7.82	6.21	4.47	17.5	
9/11/2008	1621	10.0	28.37	0.291	159.7	7.78	5.90	4.47	17.5	
9/11/2008	1622	11.0	28.30	0.290	158.7	7.75	5.80	4.47	17.5	
9/11/2008	1623	12.0	28.22	0.290	158.0	7.75	5.27	4.47	17.5	
9/11/2008	1624	13.0	28.19	0.291	157.2	7.68	5.21	4.47	17.5	
9/11/2008	1625	14.0	28.15	0.290	157.7	7.62	5.35	4.47	17.5	
9/11/2008	1626	15.0	28.14	0.292	156.7	7.61	5.29	4.47	17.5	
9/11/2008	1627	16.0	28.14	0.292	156.3	7.60	5.14	6.44	17.5	
11/24/2008	1524	1.0	20.07	0.476	30.6	8.90	13.20	1.20	14.2	
11/24/2008	1529	2.0	19.99	0.478	36.6	8.87	12.40	1.20	14.2	
11/24/2008	1532	3.0	19.85	0.478	39.9	8.79	8.62	1.20	14.2	
11/24/2008	1535	4.0	19.90	0.477	43.0	8.76	8.59	1.20	14.2	
11/24/2008	1538	5.0	19.71	0.471	45.1	8.73	8.50	1.20	14.2	
11/24/2008	1541	6.0	18.93	0.473	48.5	8.57	8.28	1.20	14.2	
11/24/2008	1544	7.0	18.72	0.480	50.9	8.52	7.99	1.20	14.2	
11/24/2008	1547	8.0	18.65	0.478	52.3	8.52	7.98	1.20	14.2	
11/24/2008	1550	9.0	18.66	0.475	53.3	8.55	6.97	1.20	14.2	
11/24/2008	1553	10.0	18.63	0.478	52.8	8.56	6.52	1.20	14.2	
11/24/2008	1556	11.0	18.60	0.479	53.7	8.58	4.97	1.20	14.2	
11/24/2008	1558	12.0	18.60	0.479	53.9	8.59	4.88	1.20	14.2	
11/24/2008	1601	13.0	18.60	0.478	54.2	8.57	4.88	1.20	14.2	
5/28/2009	1442	1.5	29.84	0.618	208.7	8.38	9.08	4.2	8.9	
5/28/2009	1448	2.5	29.80	0.617	205.3	8.35	8.50	9.2	8.9	
5/28/2009	1450	3.5	29.46	0.617	205.5	8.38	8.55	4.8	8.9	
5/28/2009	1452	4.5	29.45	0.617	205.1	8.38	8.54	4.7	8.9	
5/28/2009	1455	5.5	28.45	0.630	210.6	8.16	6.00	9.4	8.9	
5/28/2009	1457	6.5	27.98	0.631	210.6	8.10	4.88	7.1	8.9	
5/28/2009	1500	7.5	27.37	0.640	200.1	7.90	1.92	8.4	8.9	
5/28/2009	1502	8.5	27.13	0.643	-164.9	7.75	0.37	55.1	8.9	

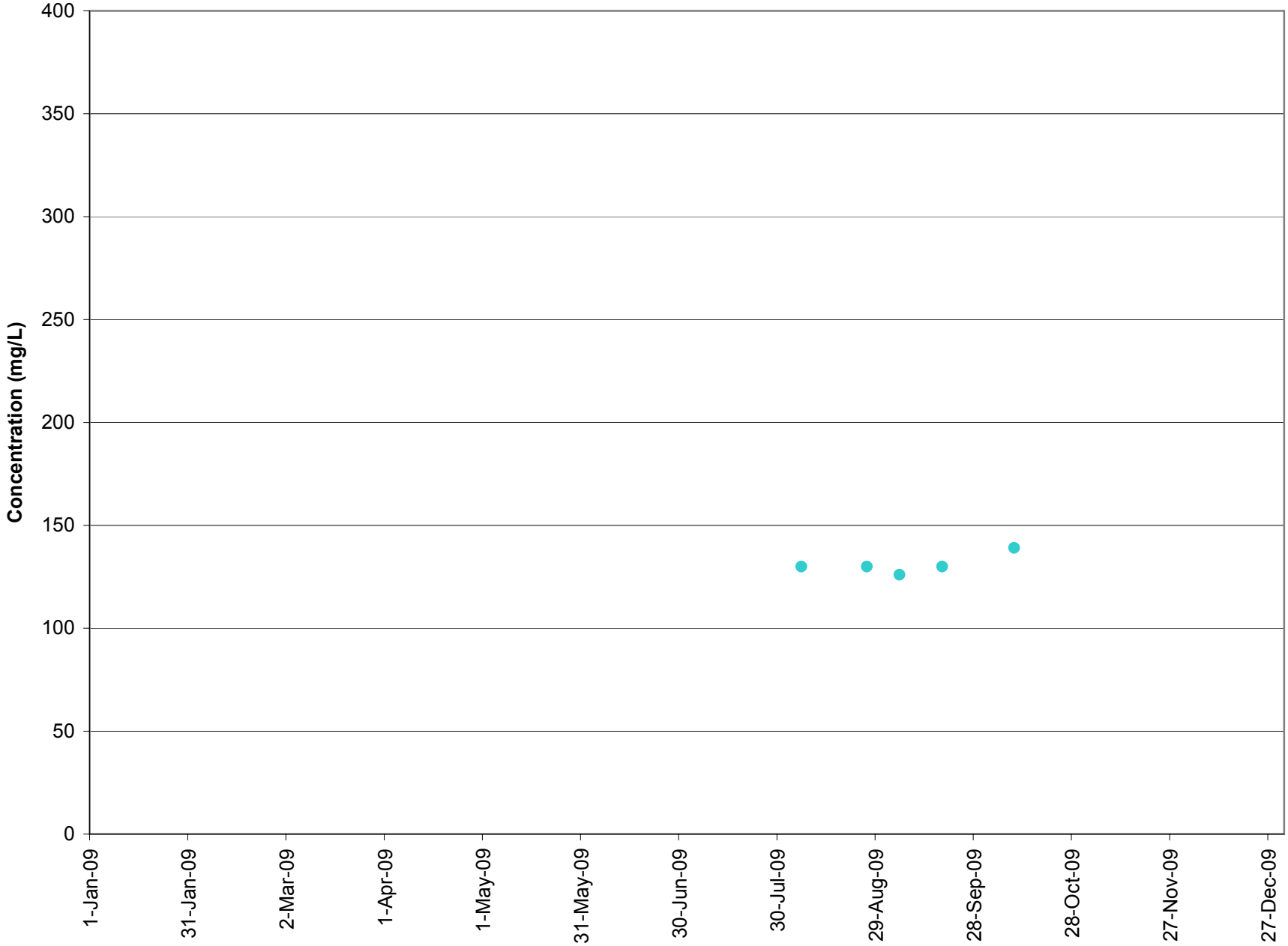
Notes:

1. Depth profile taken from boat at approximately mid lake where WQ samples are taken.

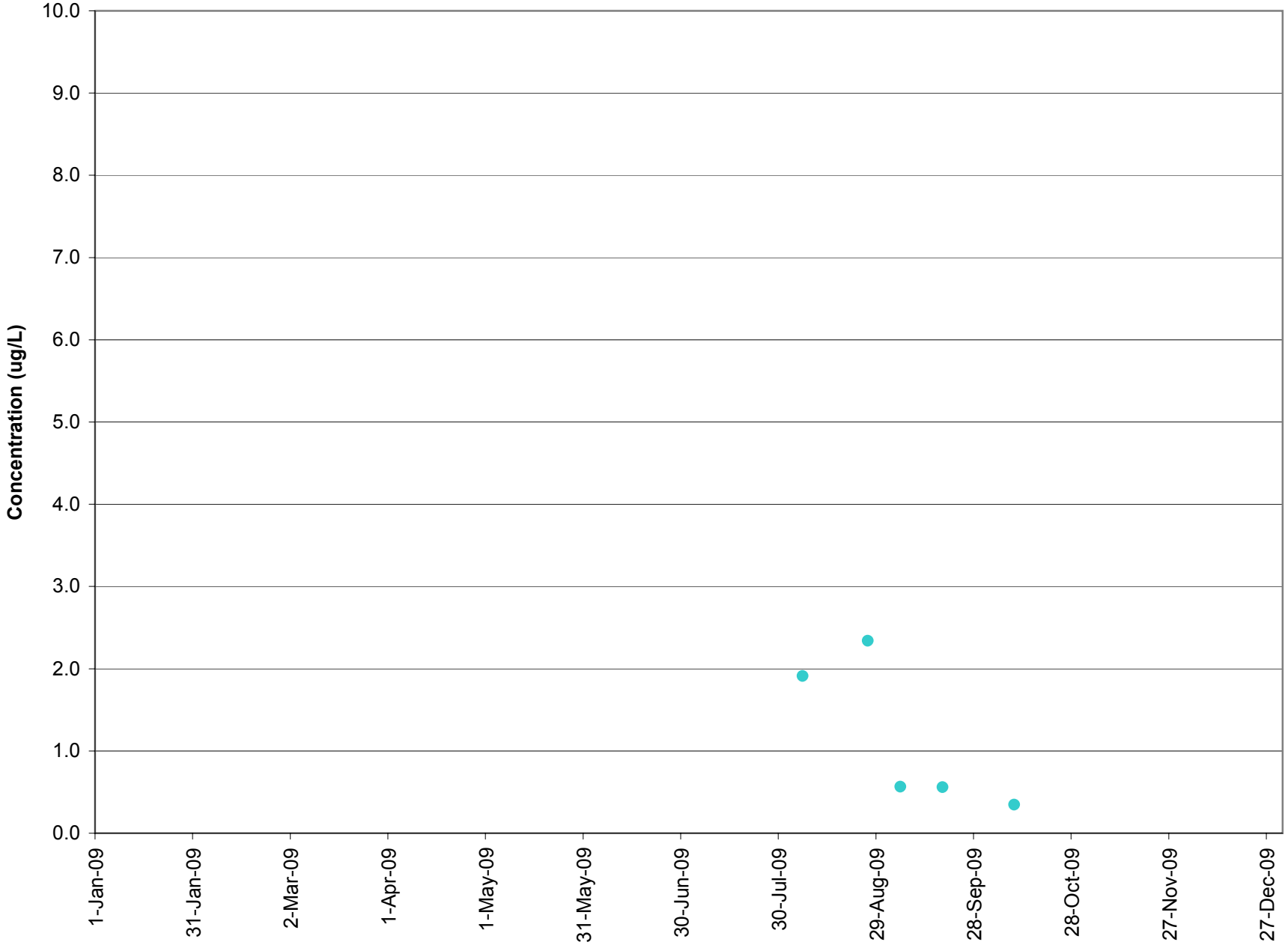
Long Term Discharge Study 2009
Verandah QV-L29
Chlorophyll-a



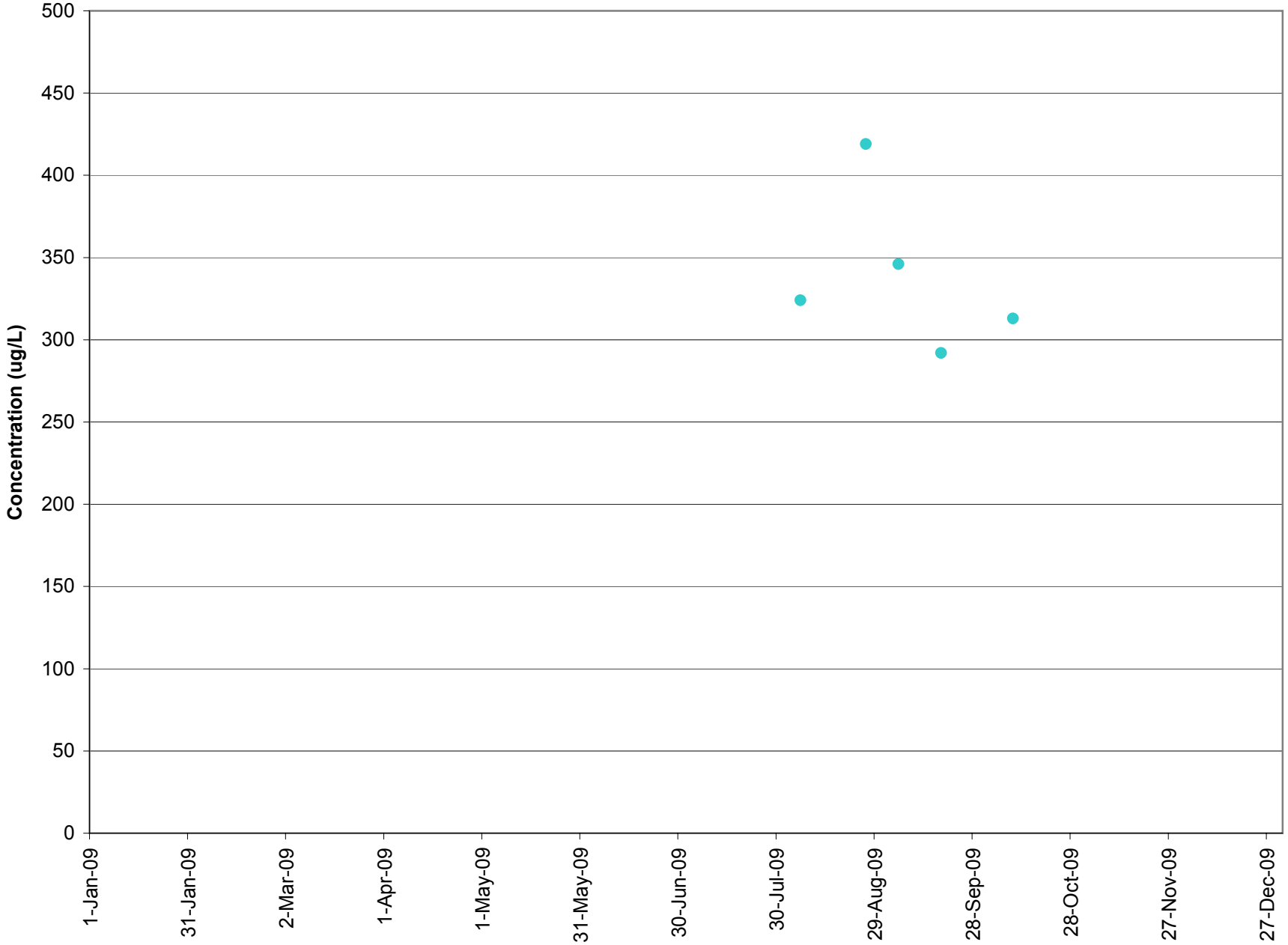
Long Term Discharge Study 2009
Verandah QV-L29
Chloride



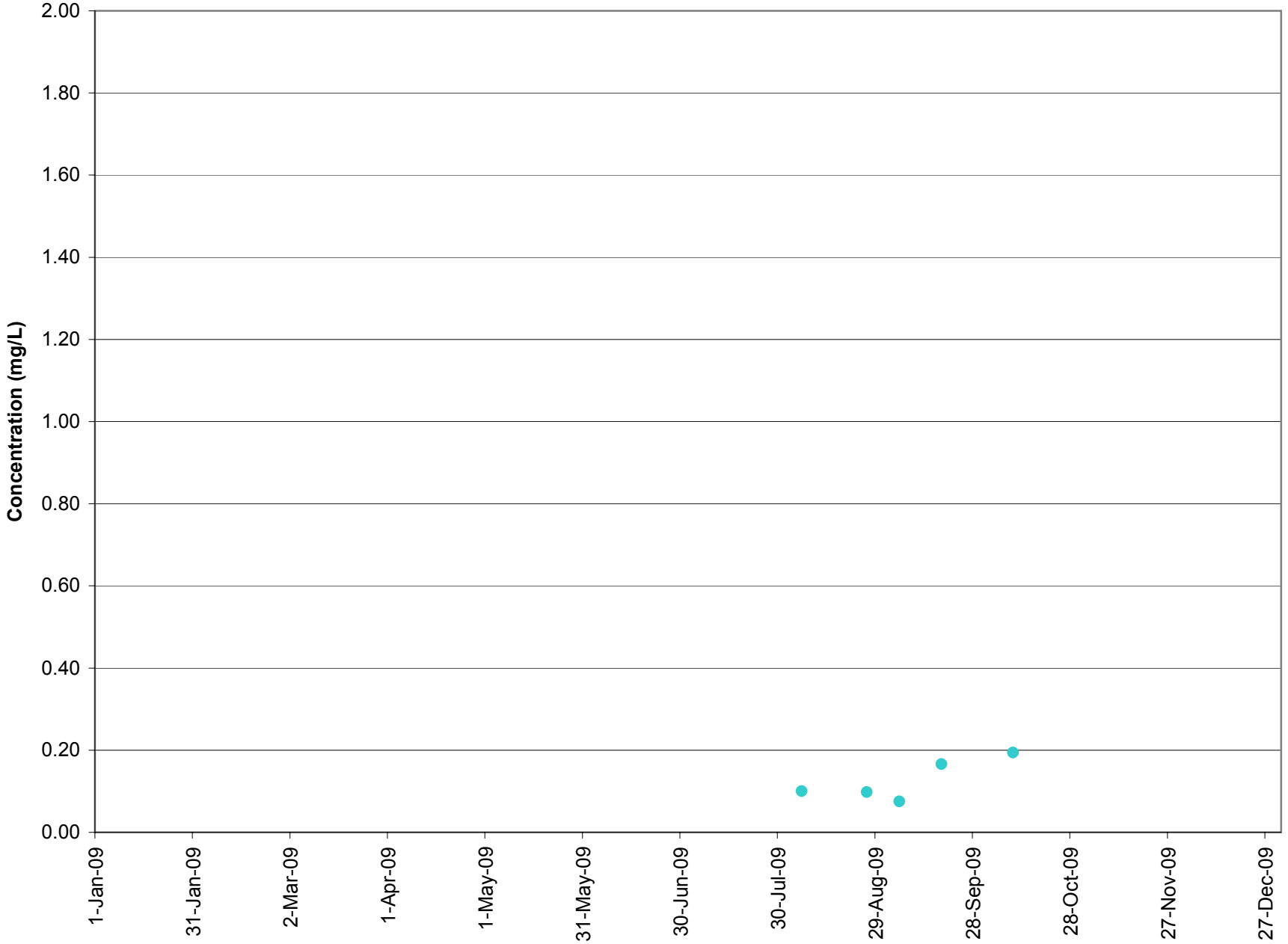
Long Term Discharge Study 2009
Verandah QV-L29
Copper



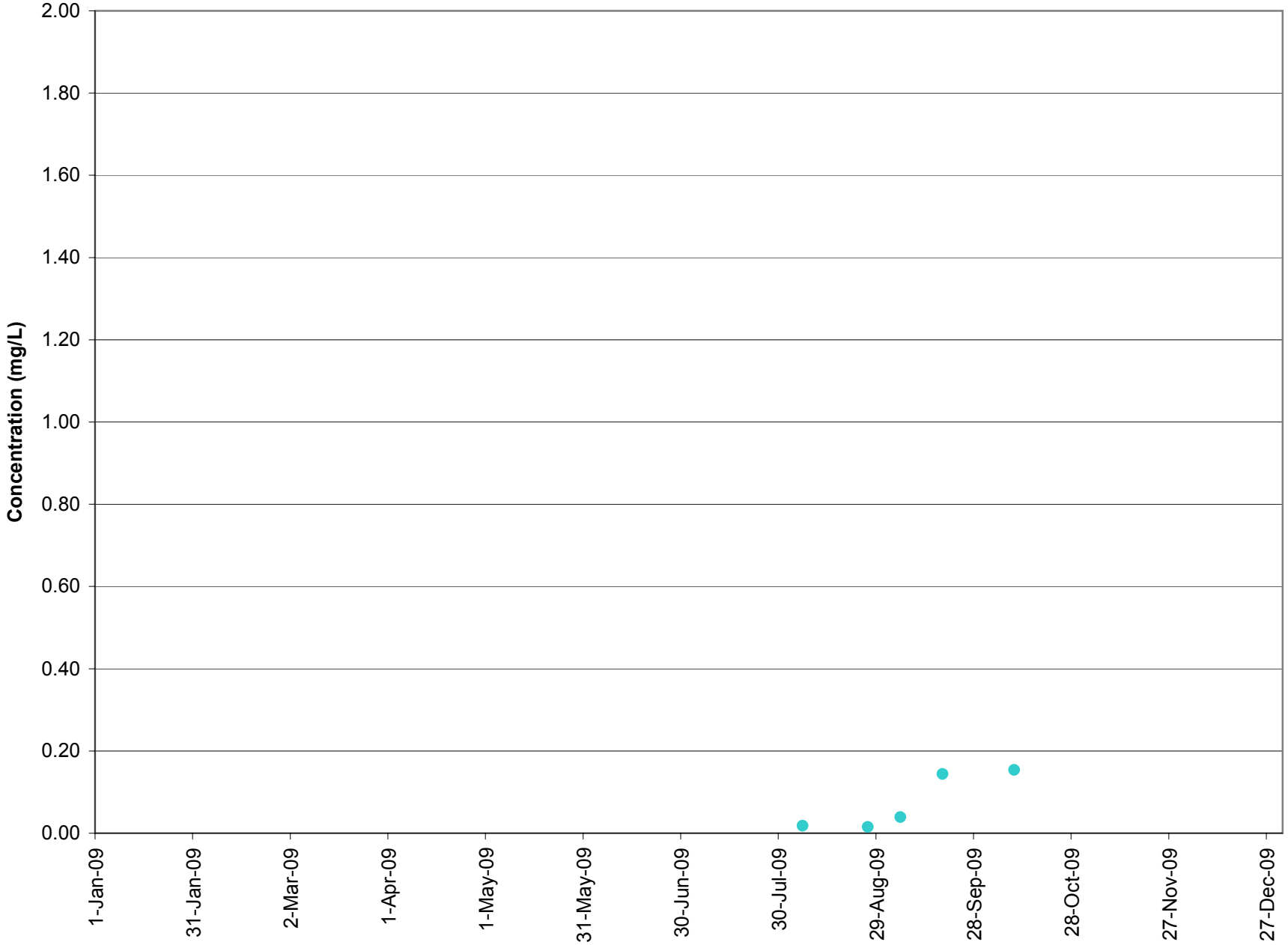
Long Term Discharge Study 2009
Verandah QV-L29
Iron



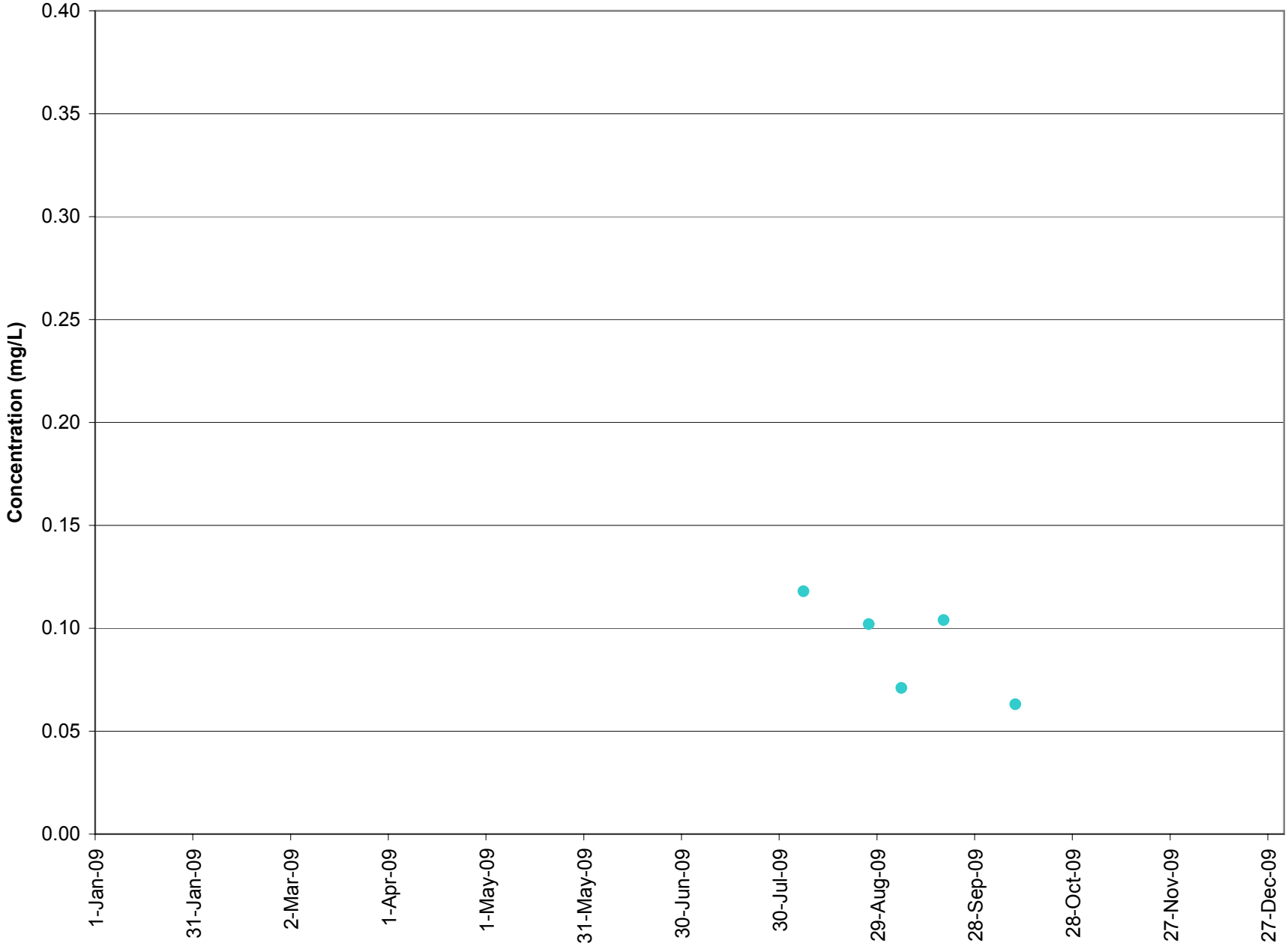
Long Term Discharge Study 2009
Verandah QV-L29
Ammonia Nitrogen



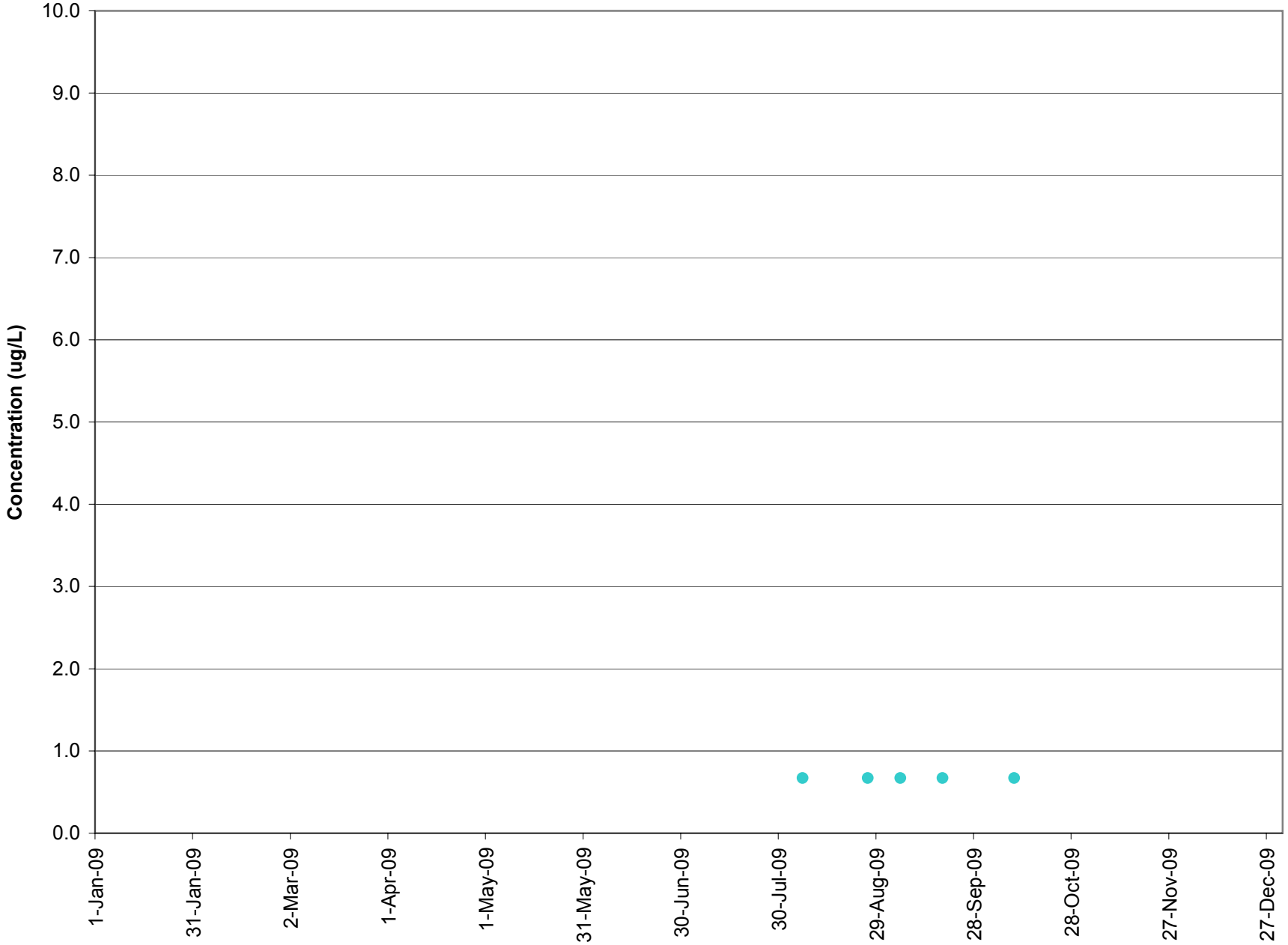
Long Term Discharge Study 2009
Verandah QV-L29
Nitrate + Nitrite



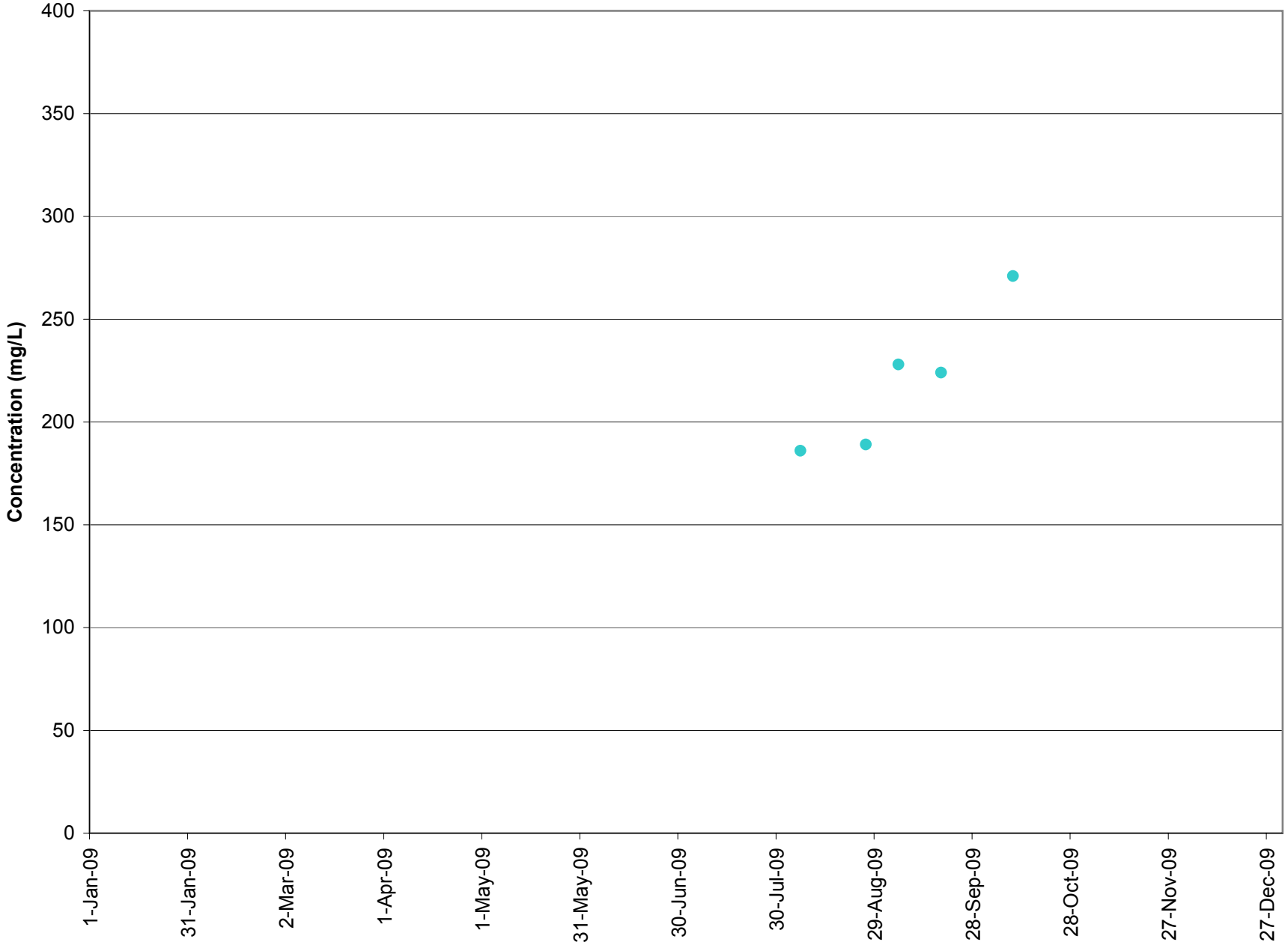
Long Term Discharge Study 2009
Verandah QV-L29
Ortho Phosphorus



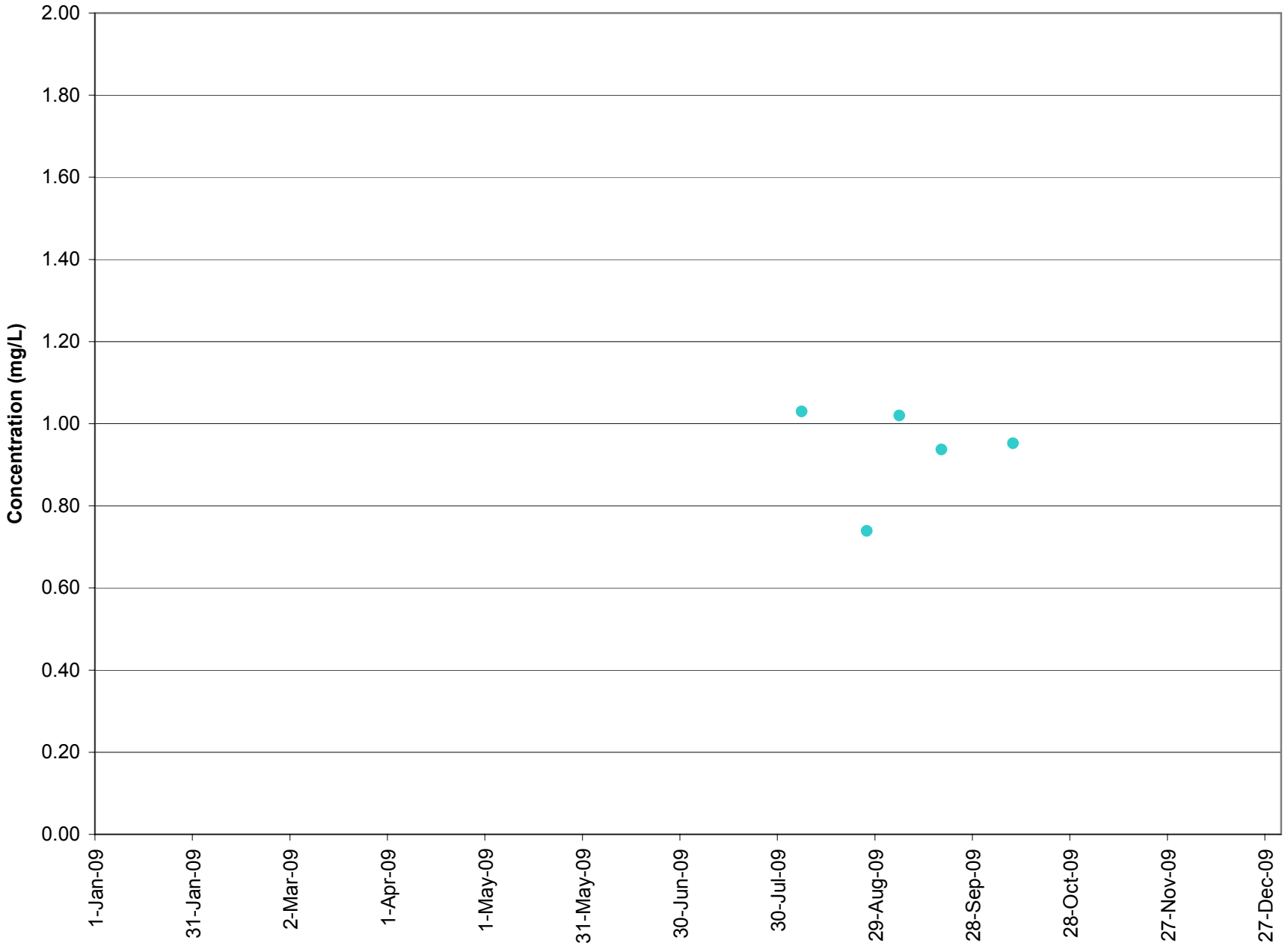
Long Term Discharge Study 2009
Verandah QV-L29
Lead



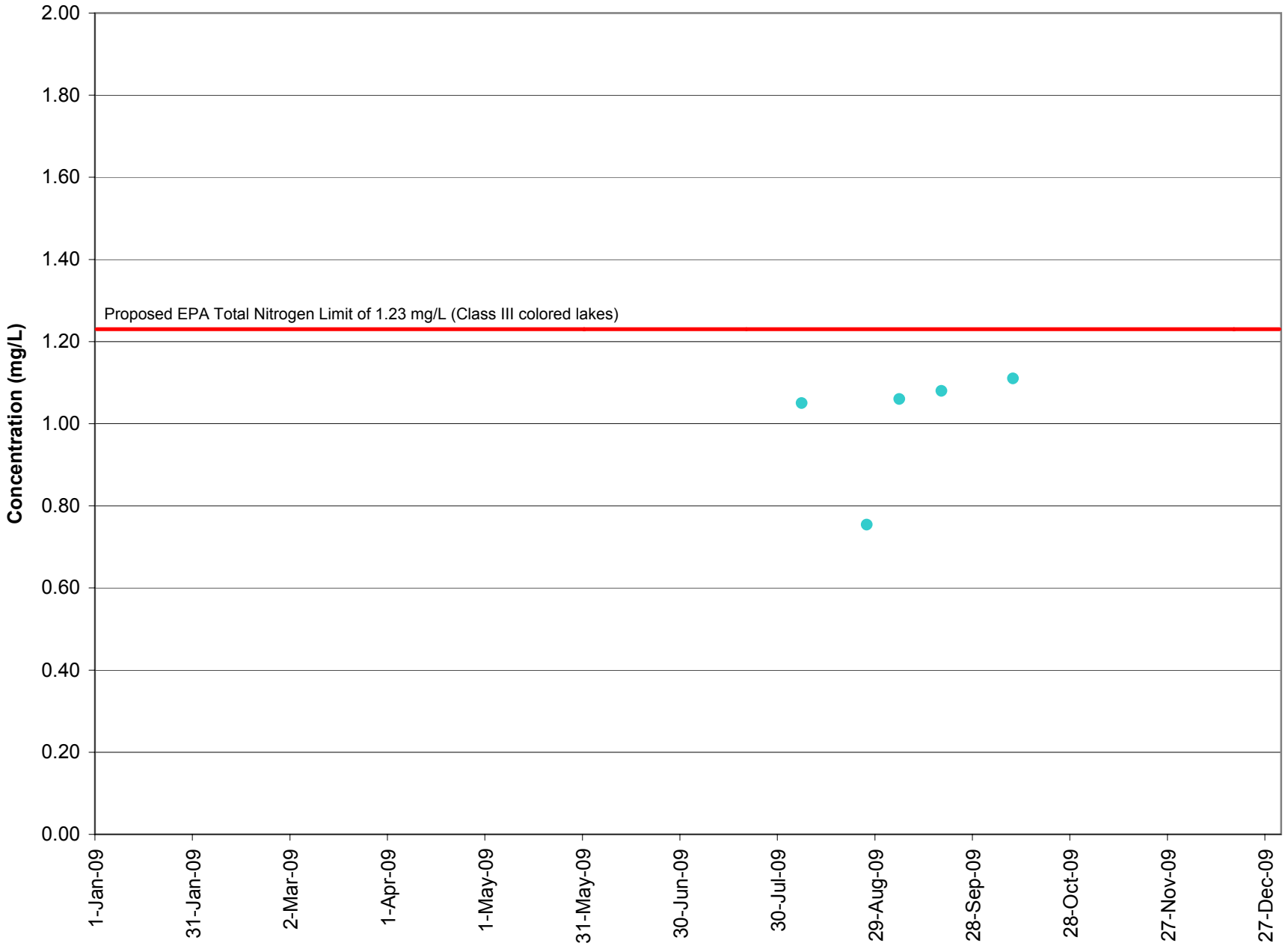
Long Term Discharge Study 2009
Verandah QV-L29
Total Hardness



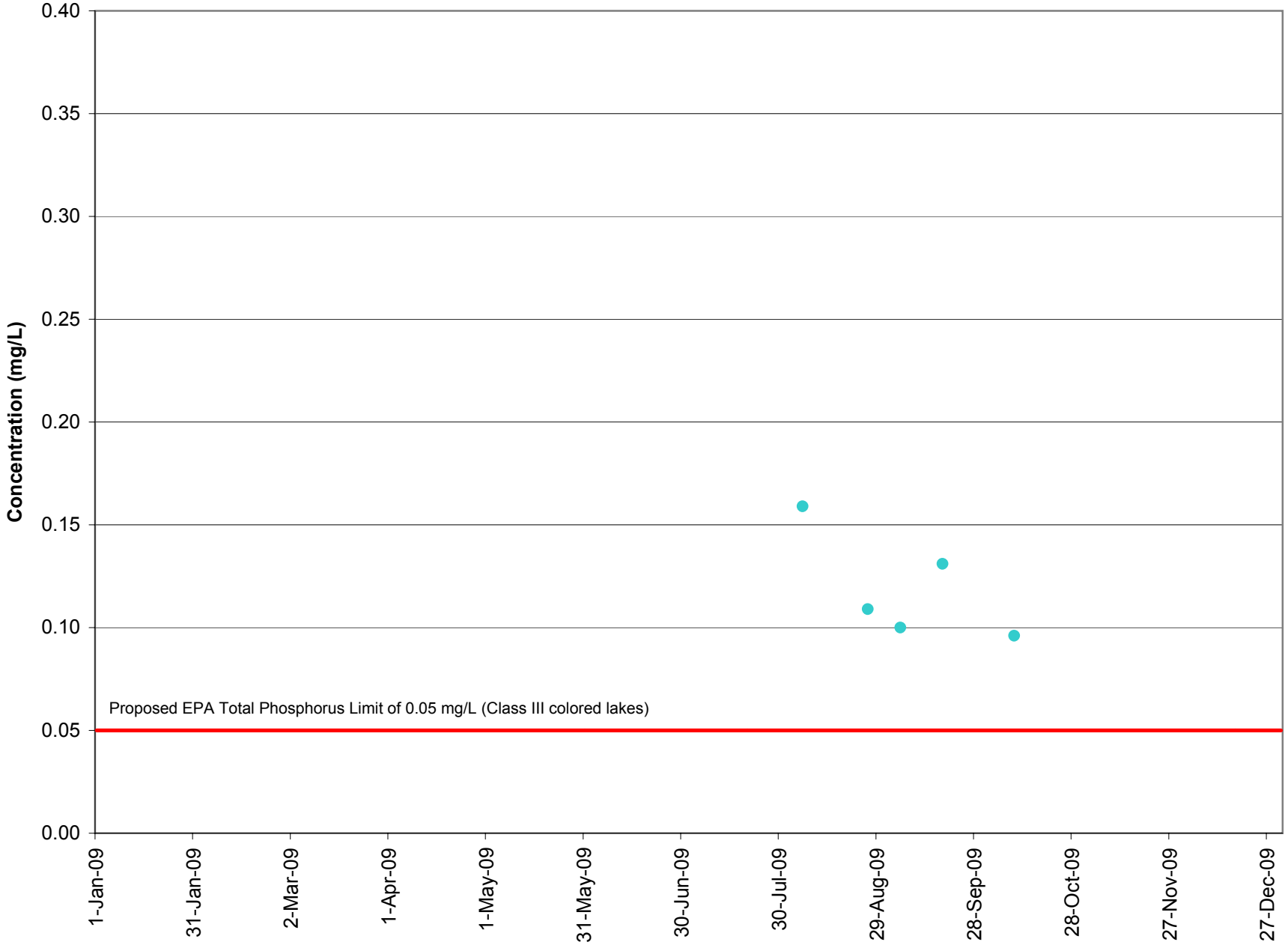
Long Term Discharge Study 2009
Verandah QV-L29
Total Kjeldahl Nitrogen



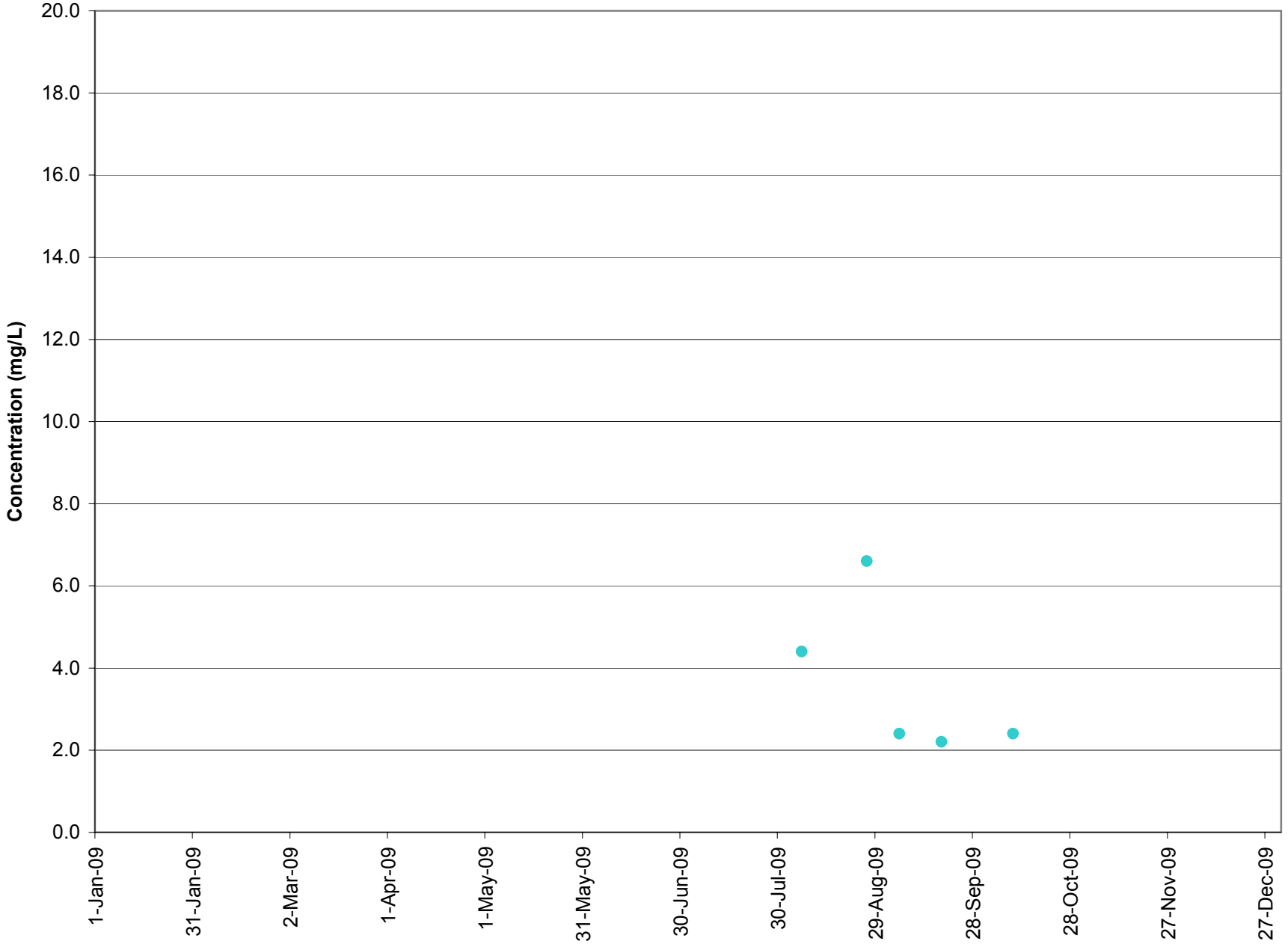
Long Term Discharge Study 2009
Verandah QV-L29
Total Nitrogen



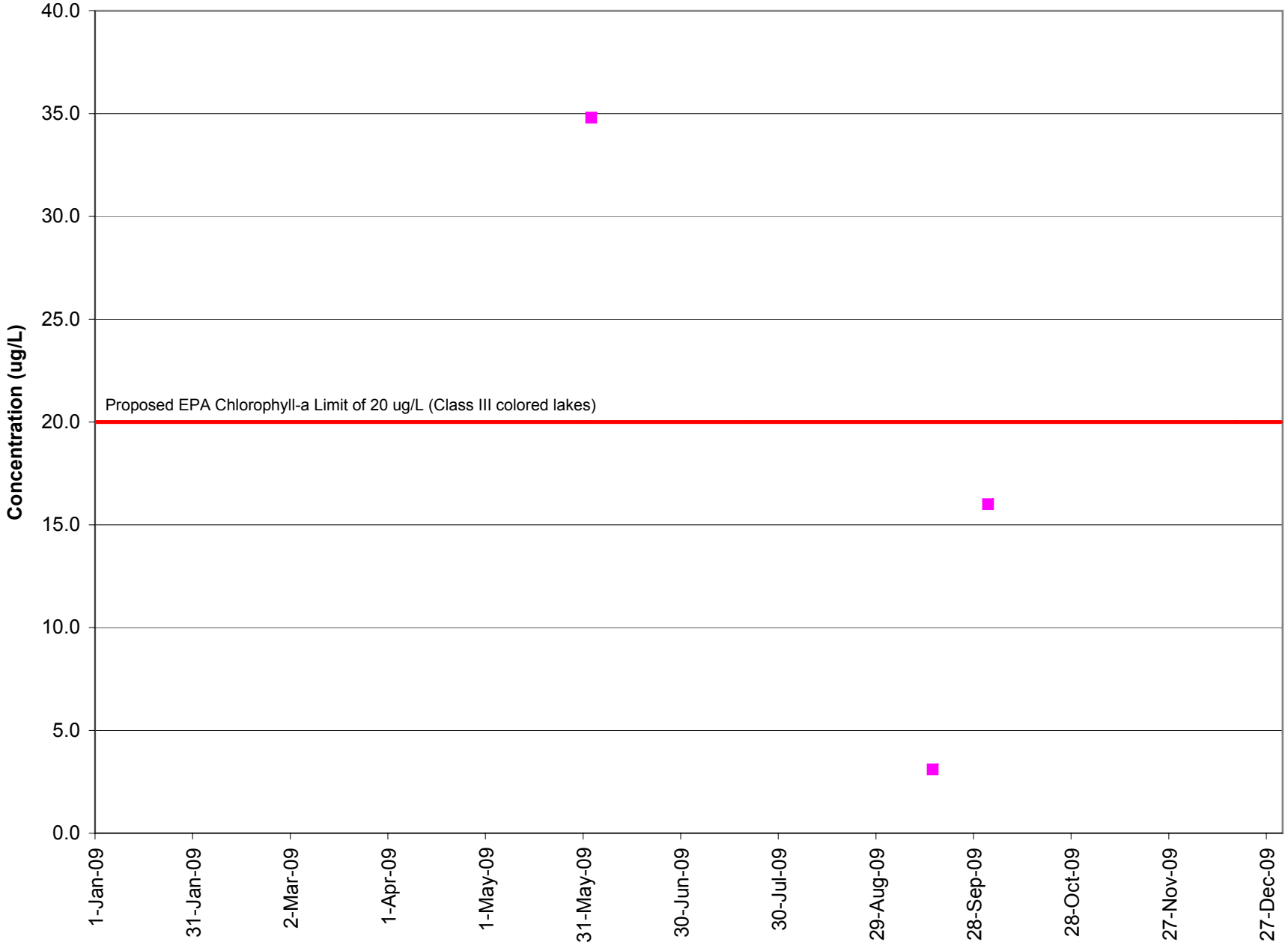
Long Term Discharge Study 2009
Verandah QV-L29
Total Phosphorus



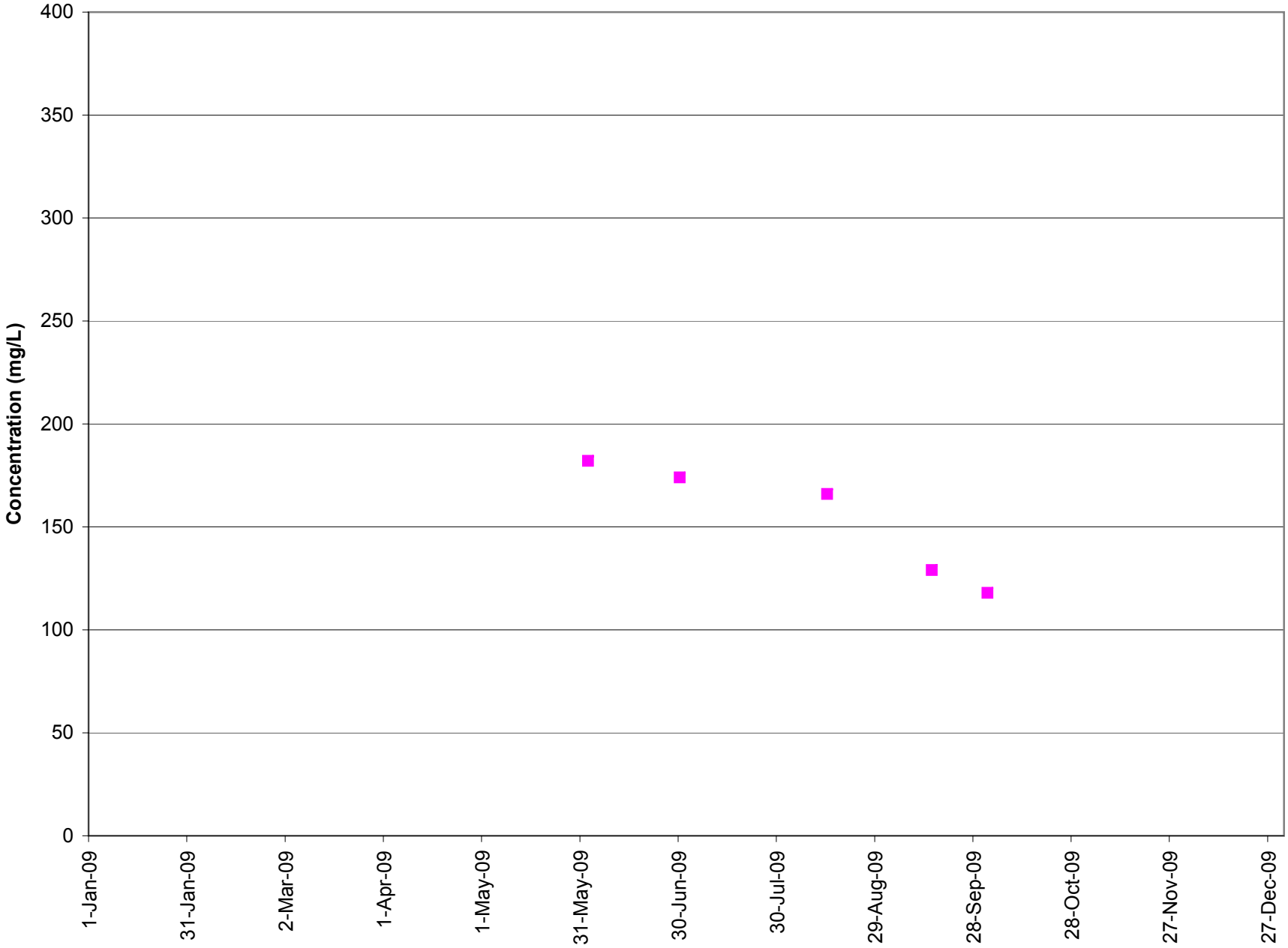
Long Term Discharge Study 2009
Verandah QV-L29
Total Suspended Solids



Long Term Discharge Study 2009
Sandoval QS-1
Chlorophyll-a



Long Term Discharge Study 2009
Sandoval QS-1
Chloride



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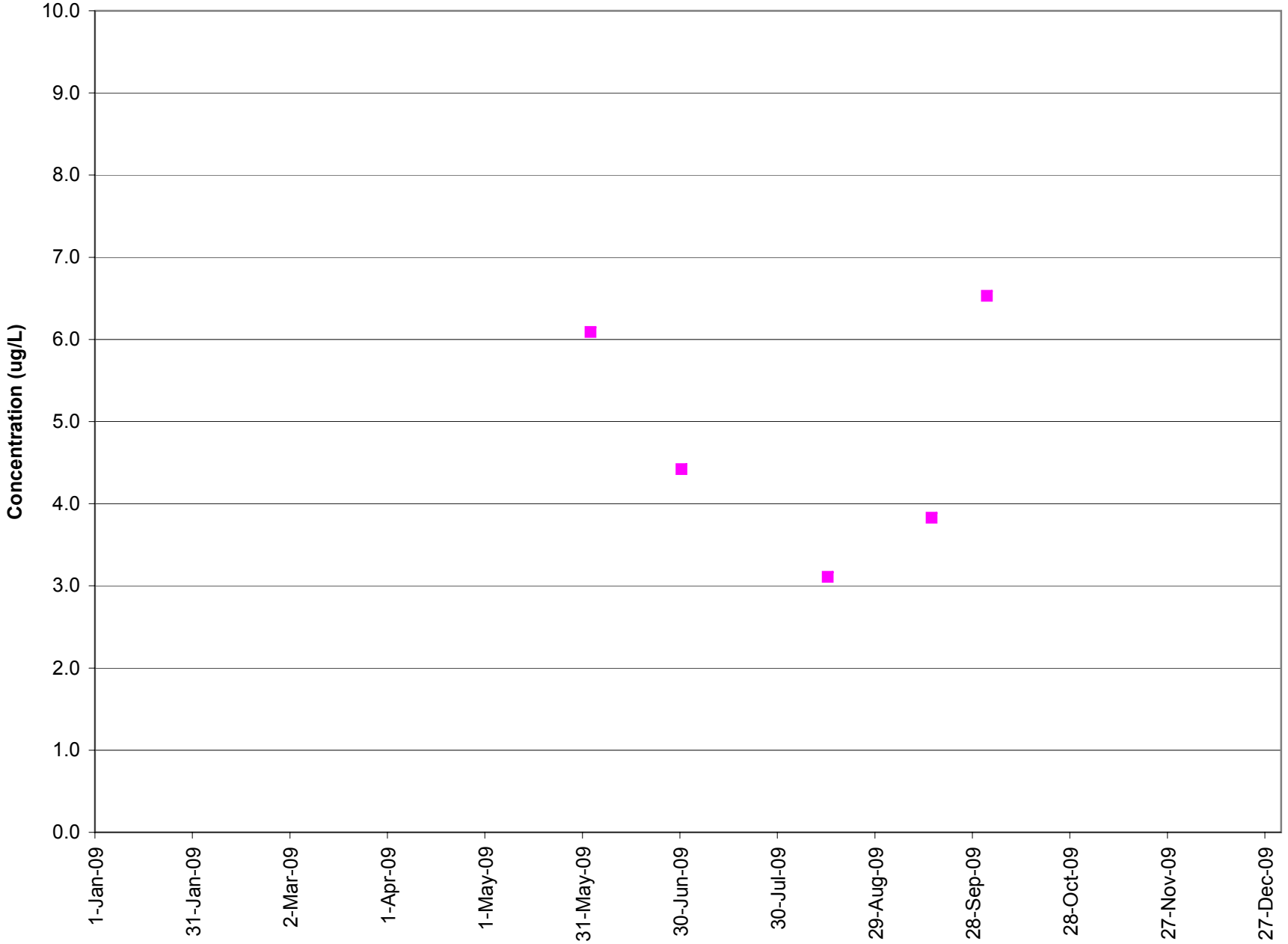
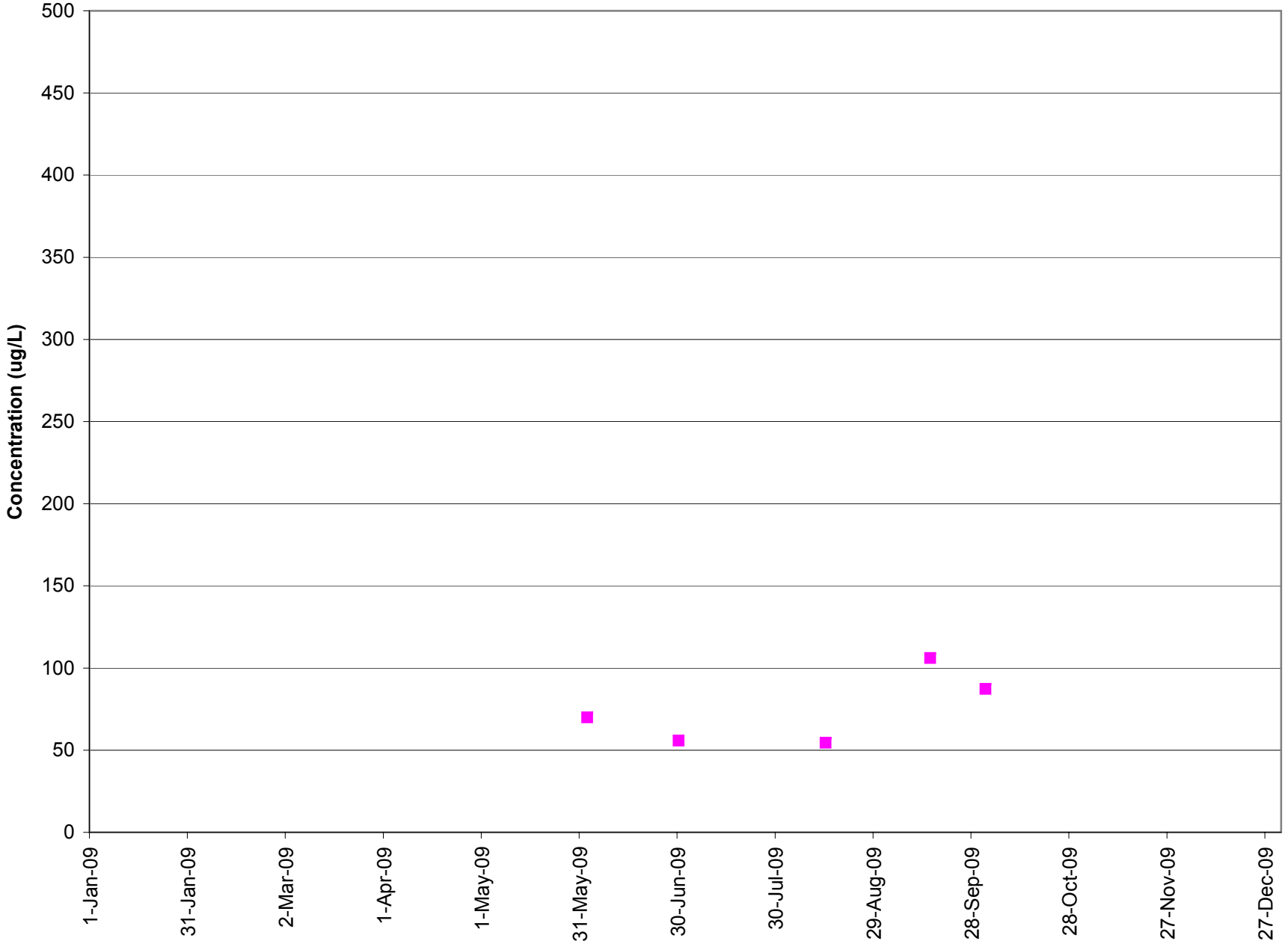
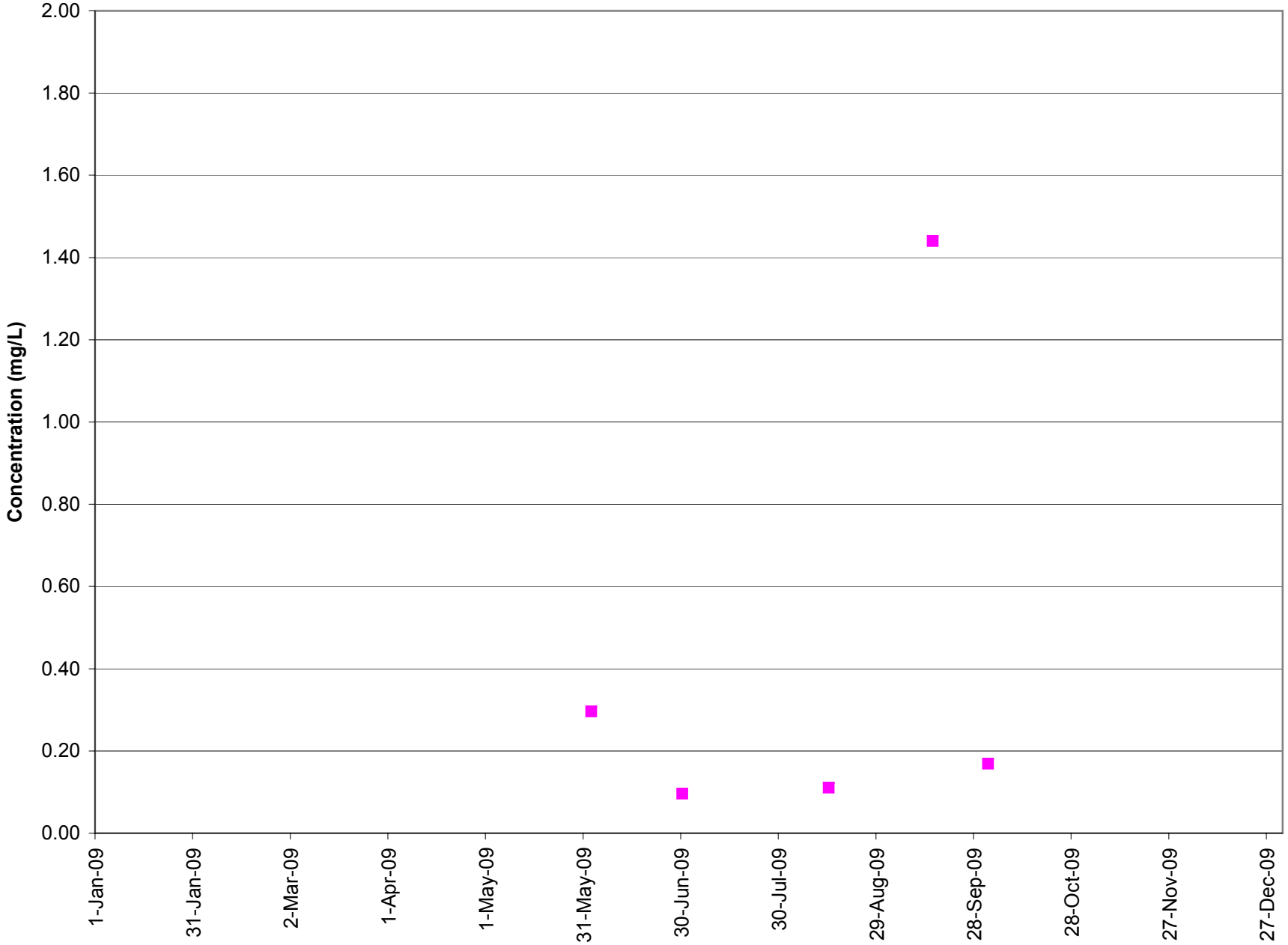
Long Term Discharge Study 2009
Sandoval QS-1
Copper



Long Term Discharge Study 2009
Sandoval QS-1
Iron



Long Term Discharge Study 2009
Sandoval QS-1
Ammonia Nitrogen



Long Term Discharge Study 2009
Sandoval QS-1
Nitrate + Nitrite

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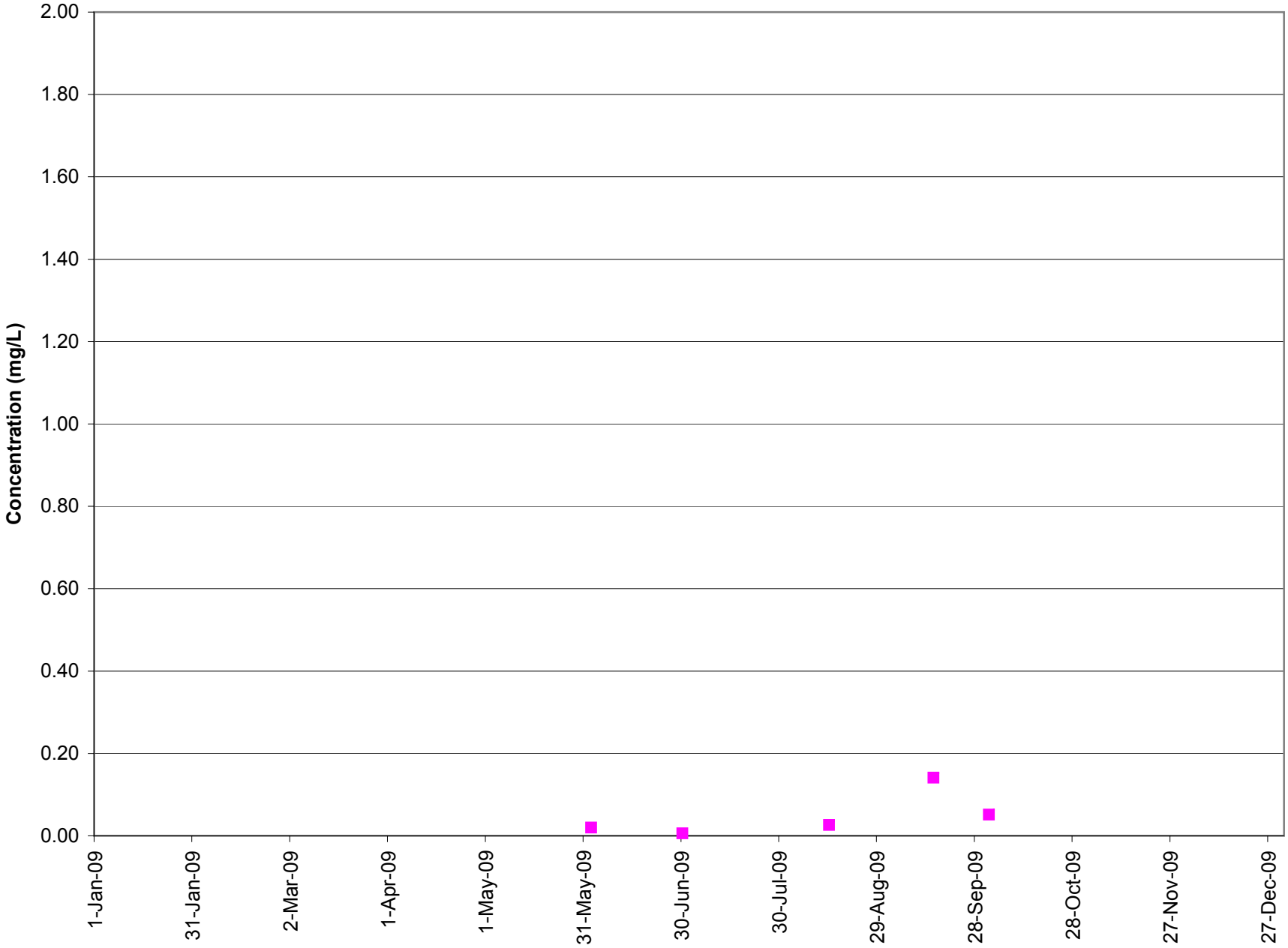
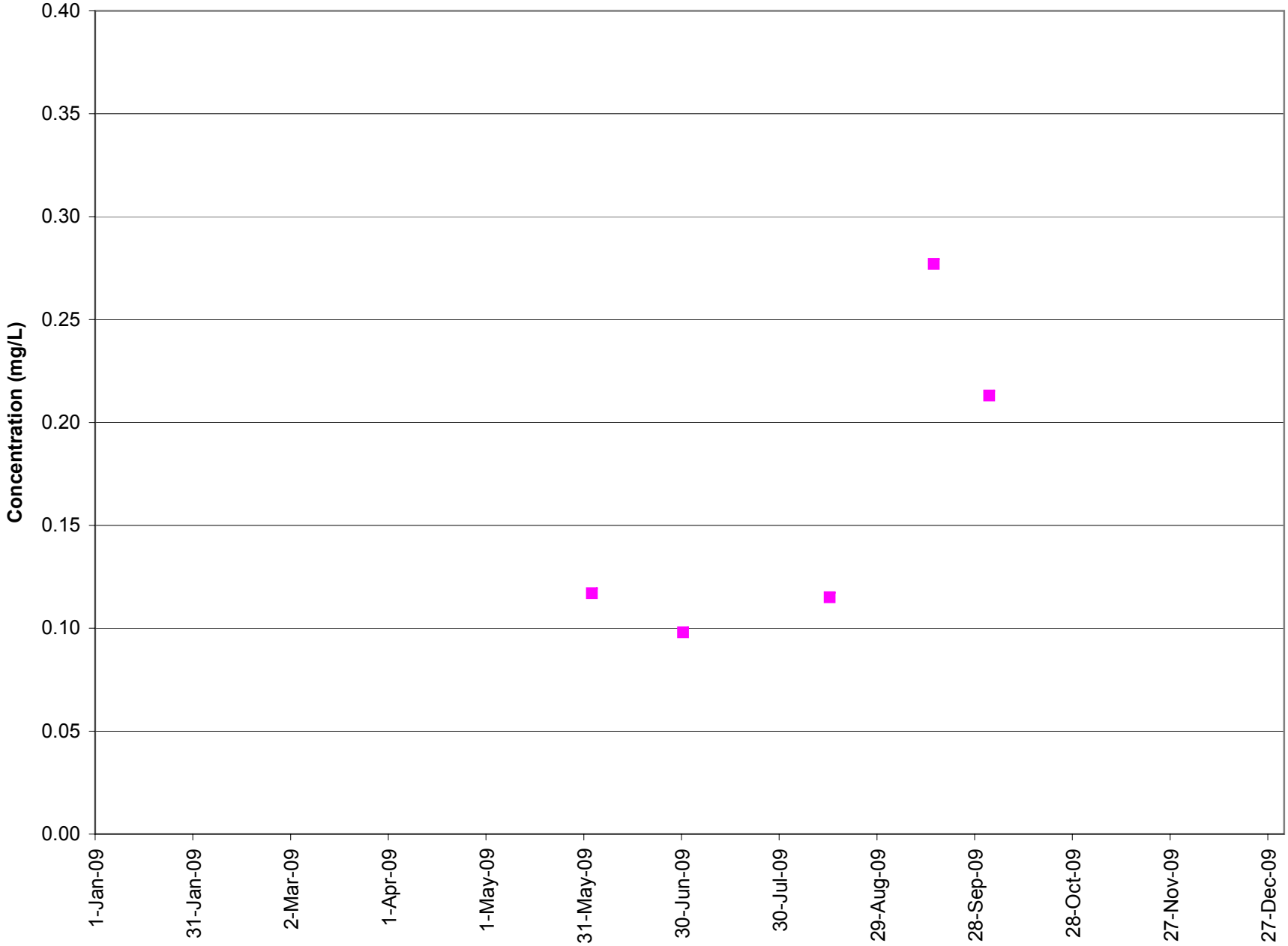
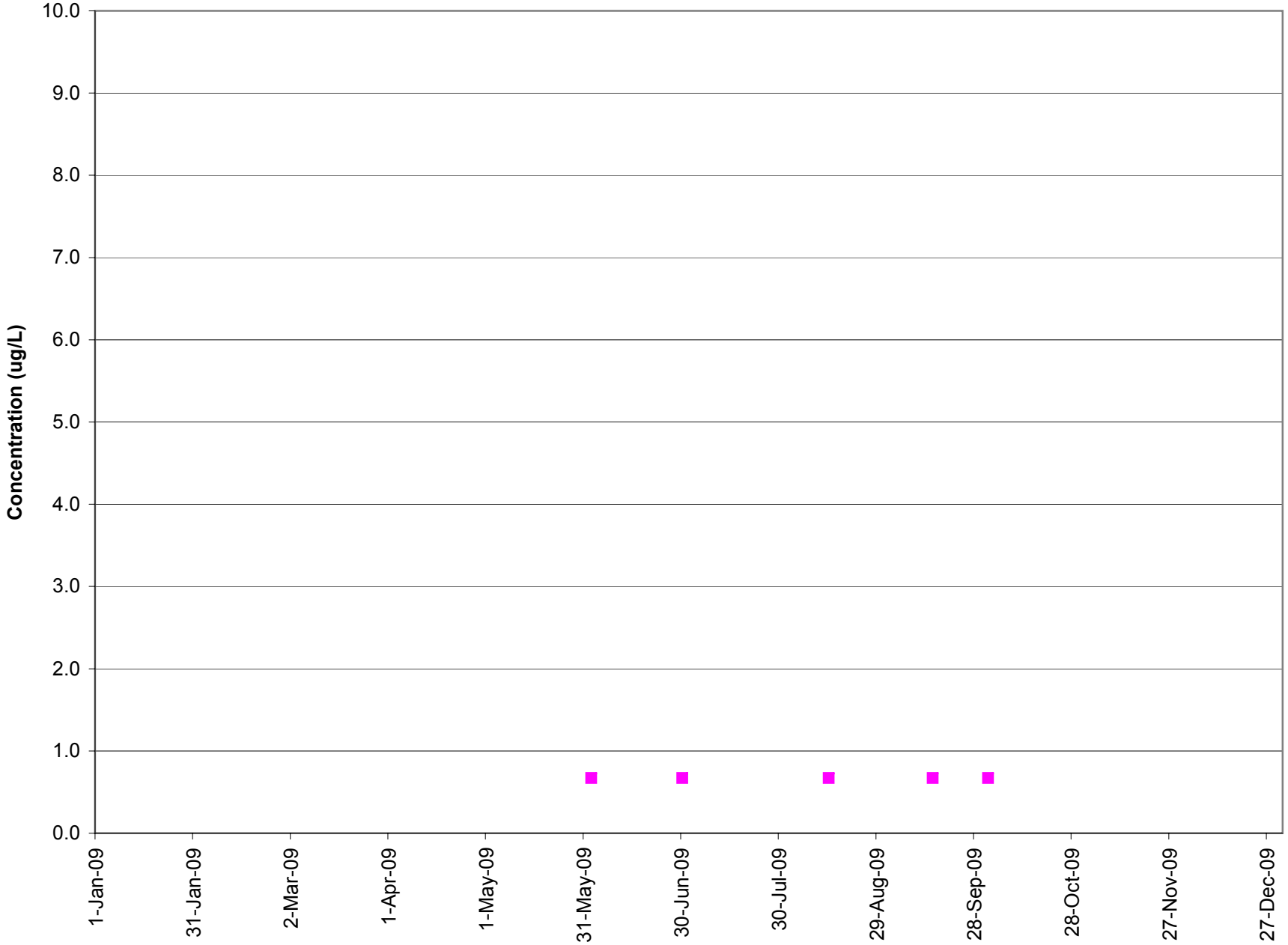


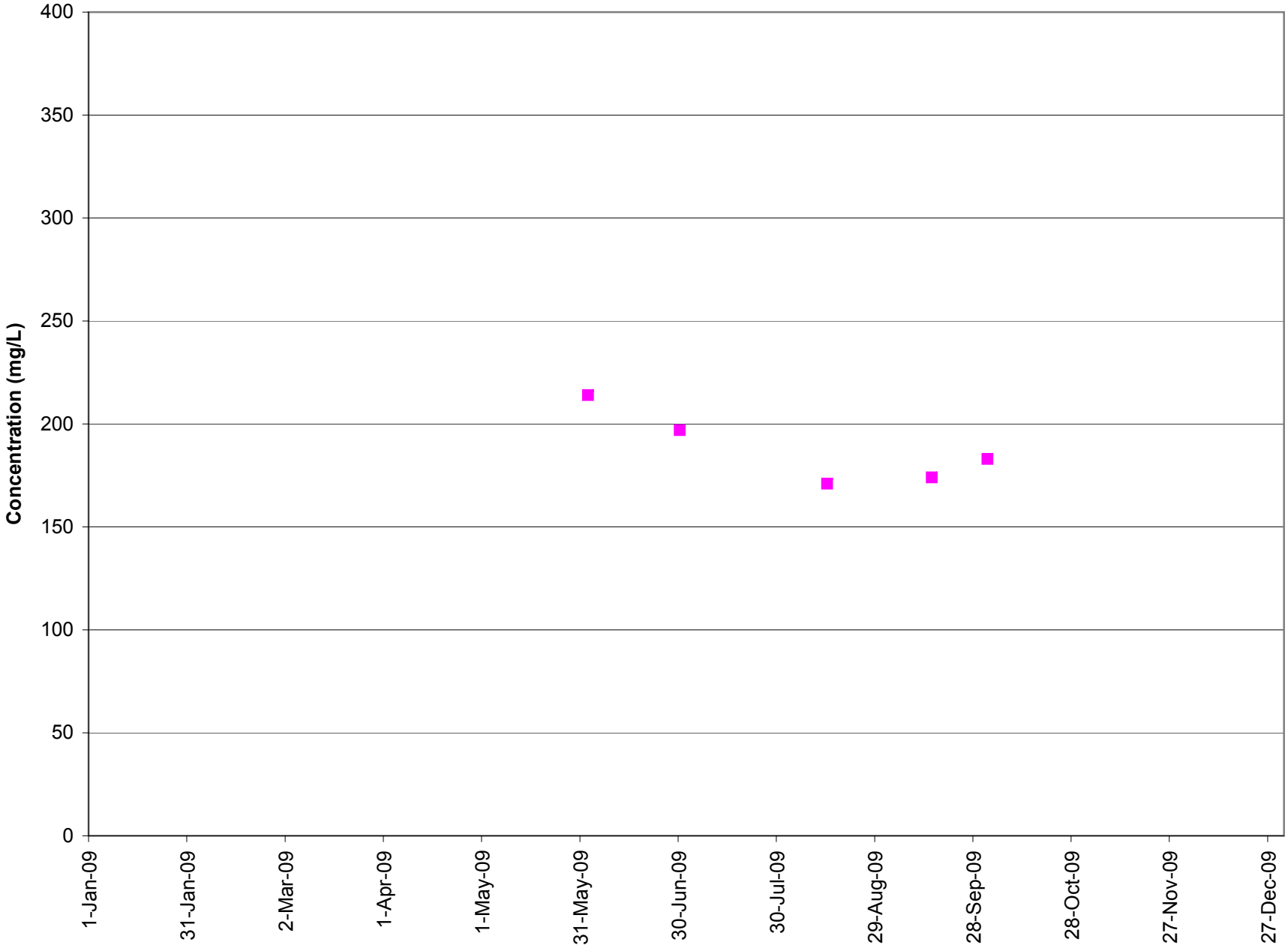
Long Term Discharge Study 2009
Sandoval QS-1
Ortho Phosphorus



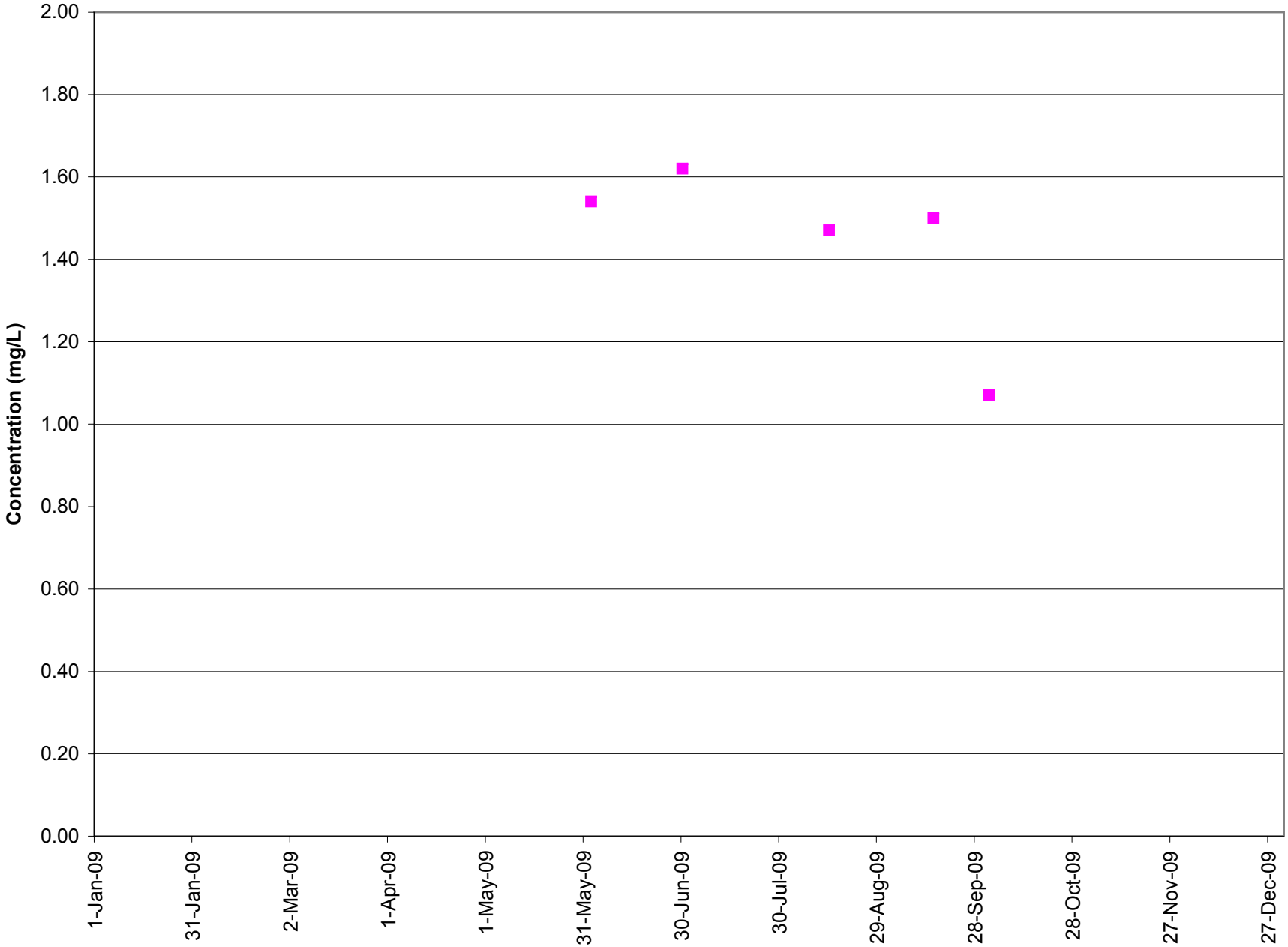
Long Term Discharge Study 2009
Sandoval QS-1
Lead



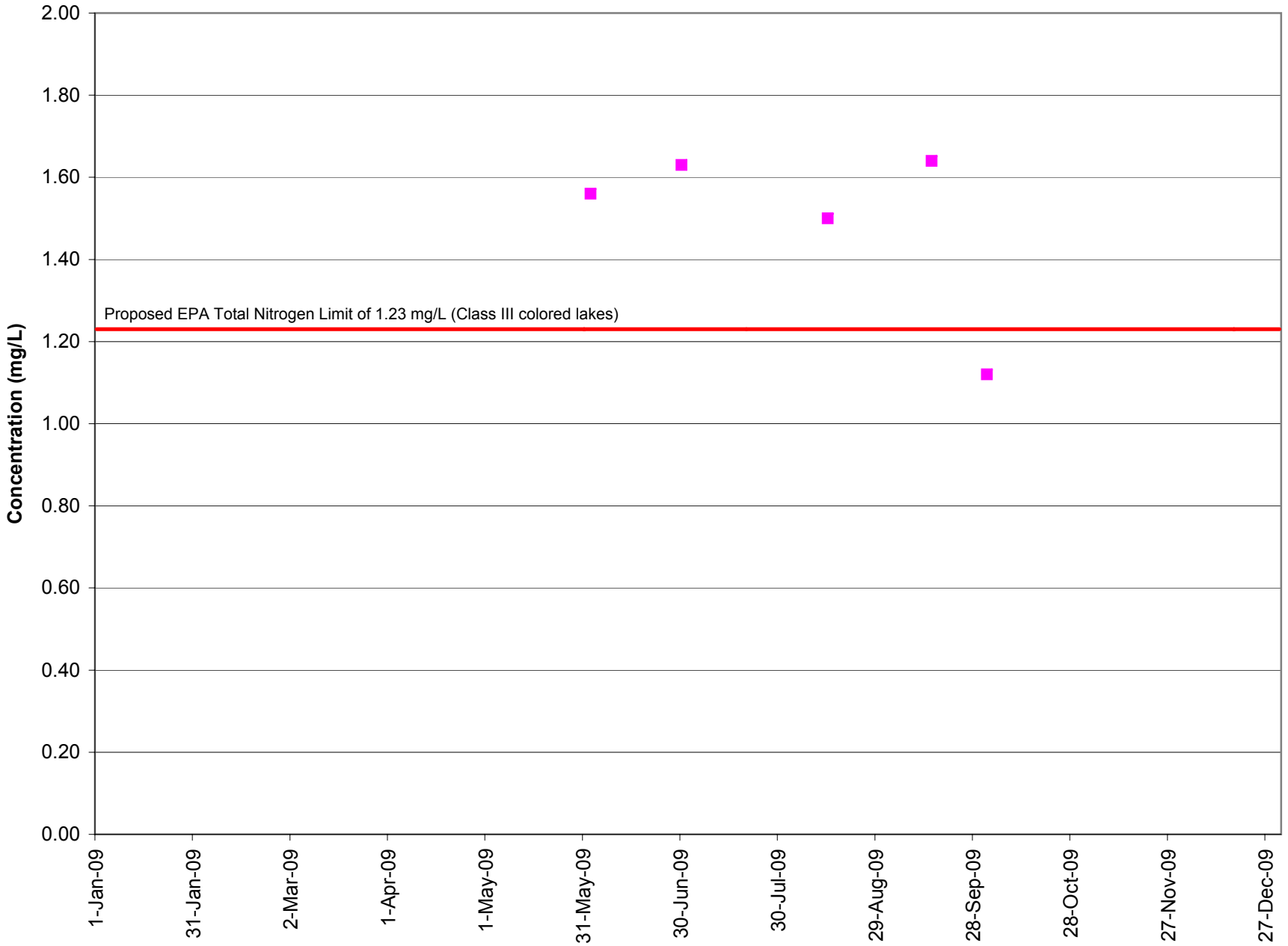
Long Term Discharge Study 2009
Sandoval QS-1
Total Hardness



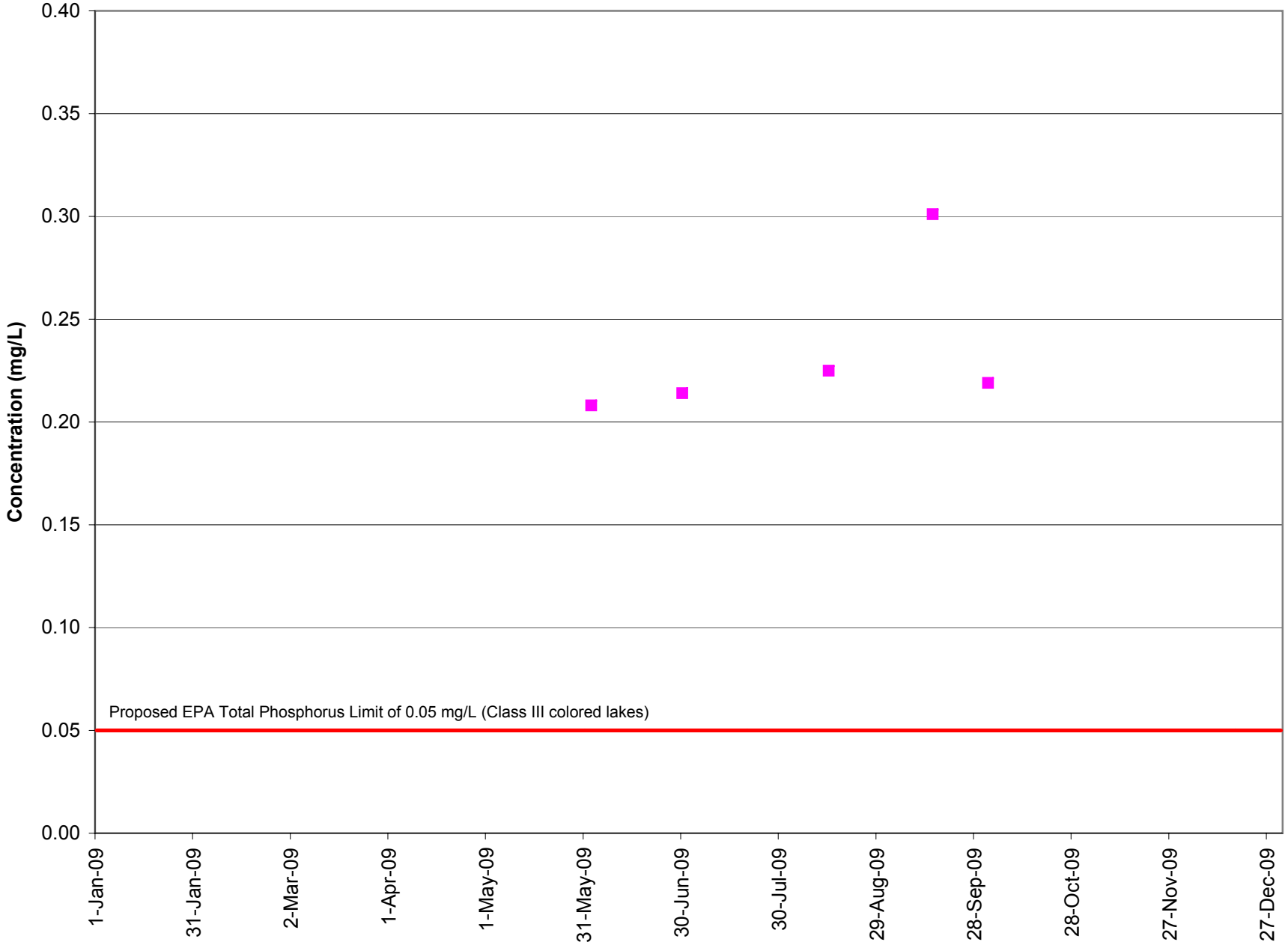
Long Term Discharge Study 2009
Sandoval QS-1
Total Kjeldahl Nitrogen



Long Term Discharge Study 2009
Sandoval QS-1
Total Nitrogen



Long Term Discharge Study 2009
Sandoval QS-1
Total Phosphorus



Long Term Discharge Study 2009
Sandoval QS-1
Total Suspended Solids

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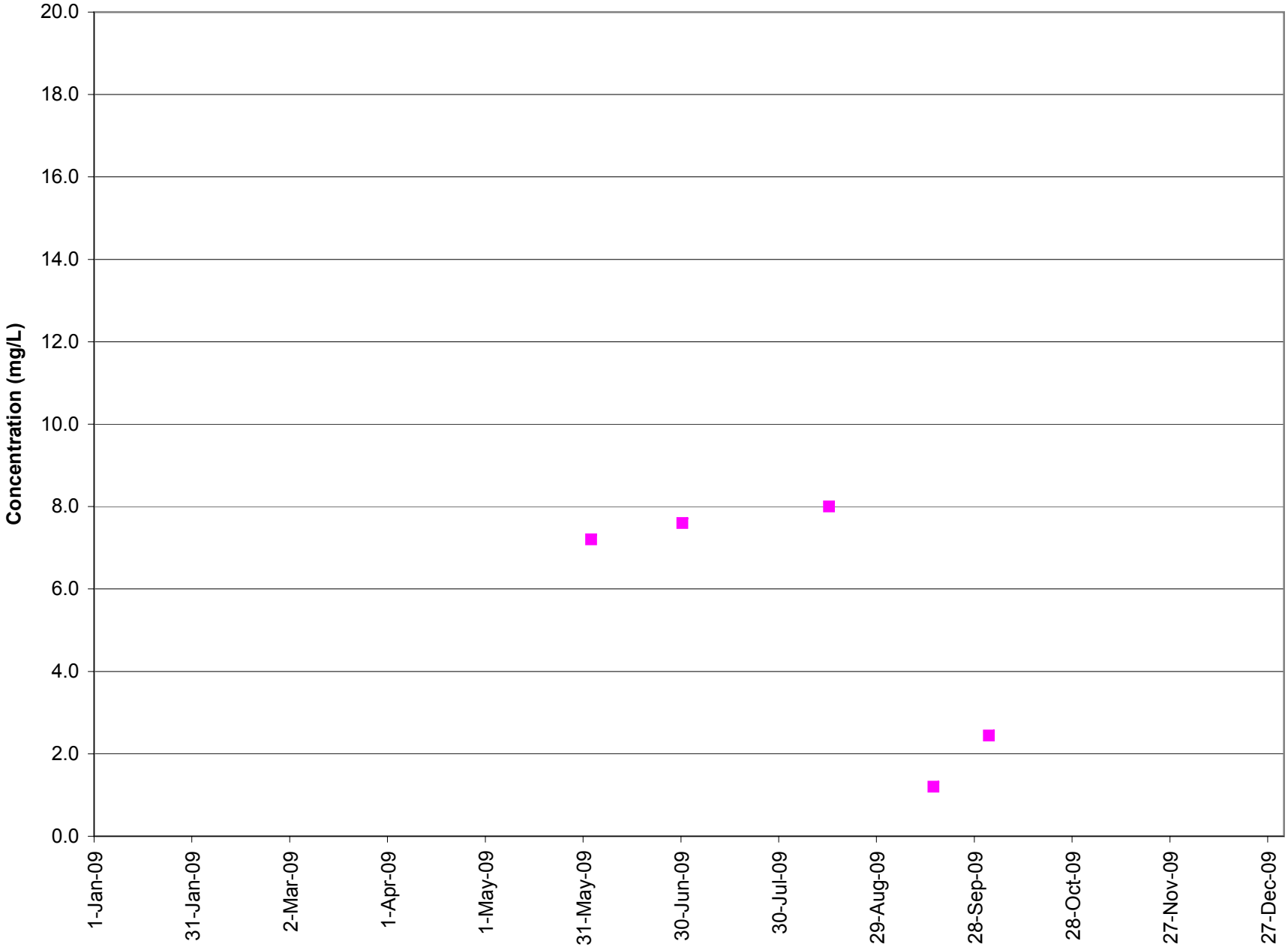
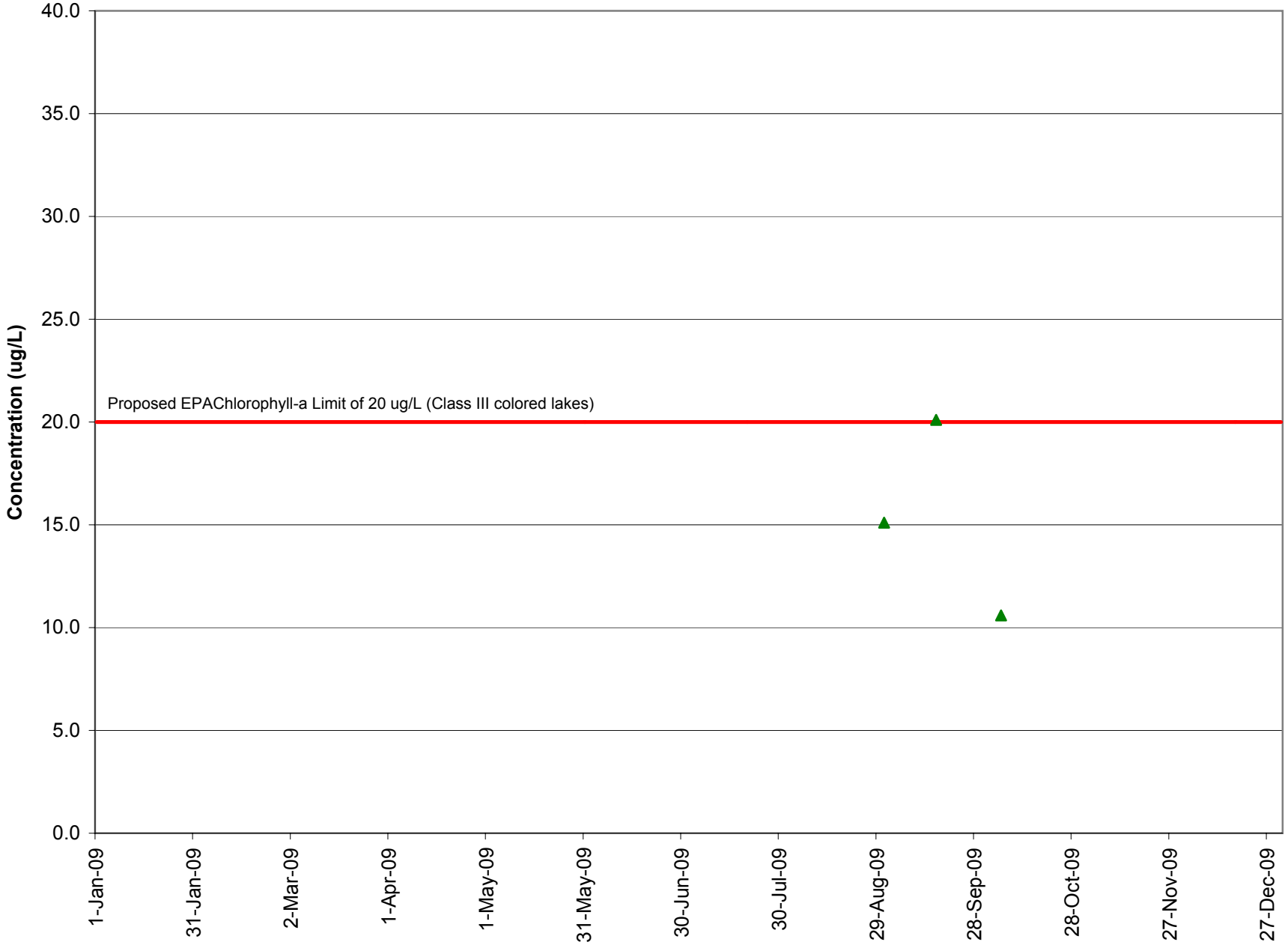


Long Term Discharge Study 2009
Shadow Wood Preserve QSWP-1
Chlorophyll-a



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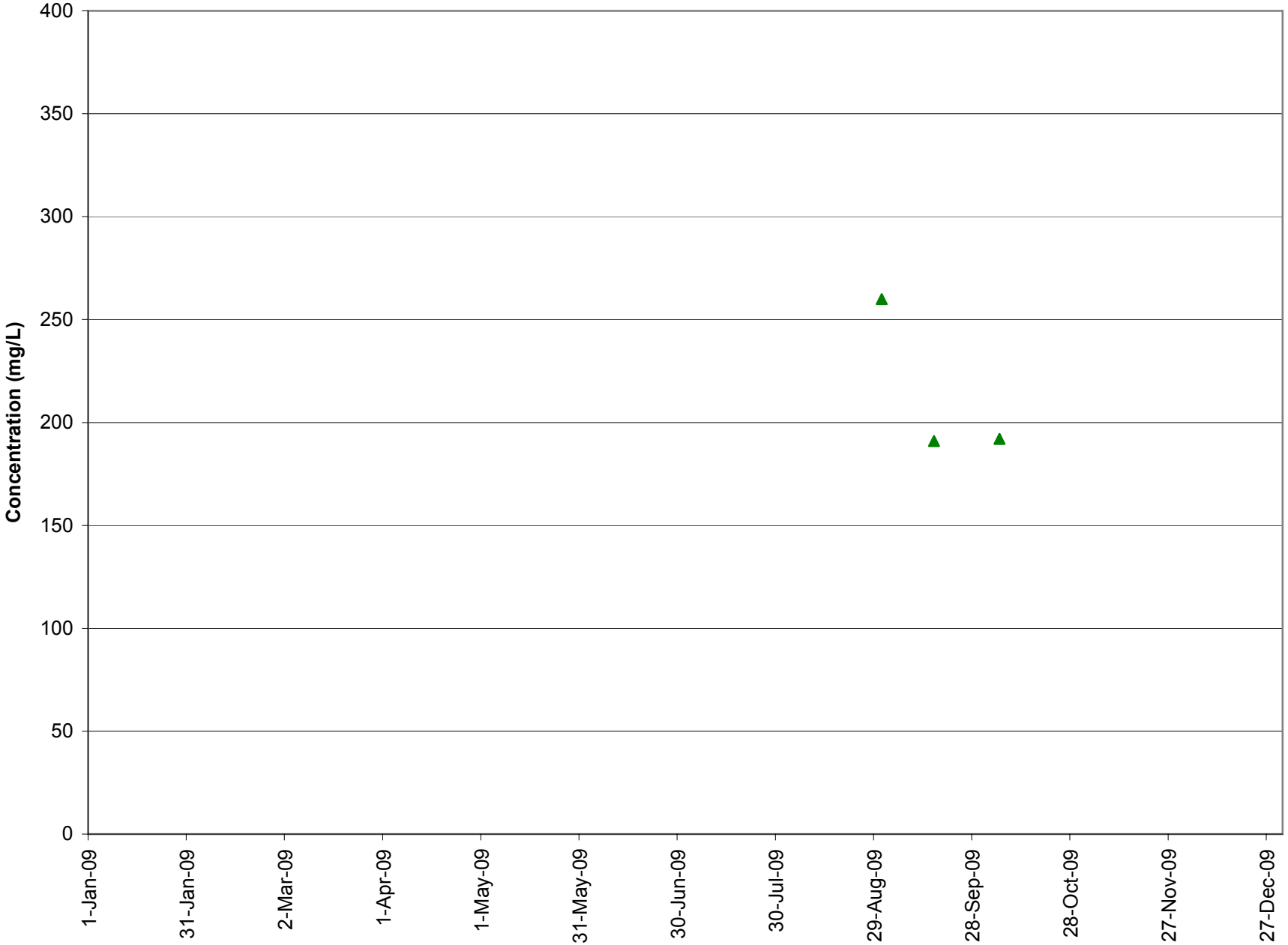
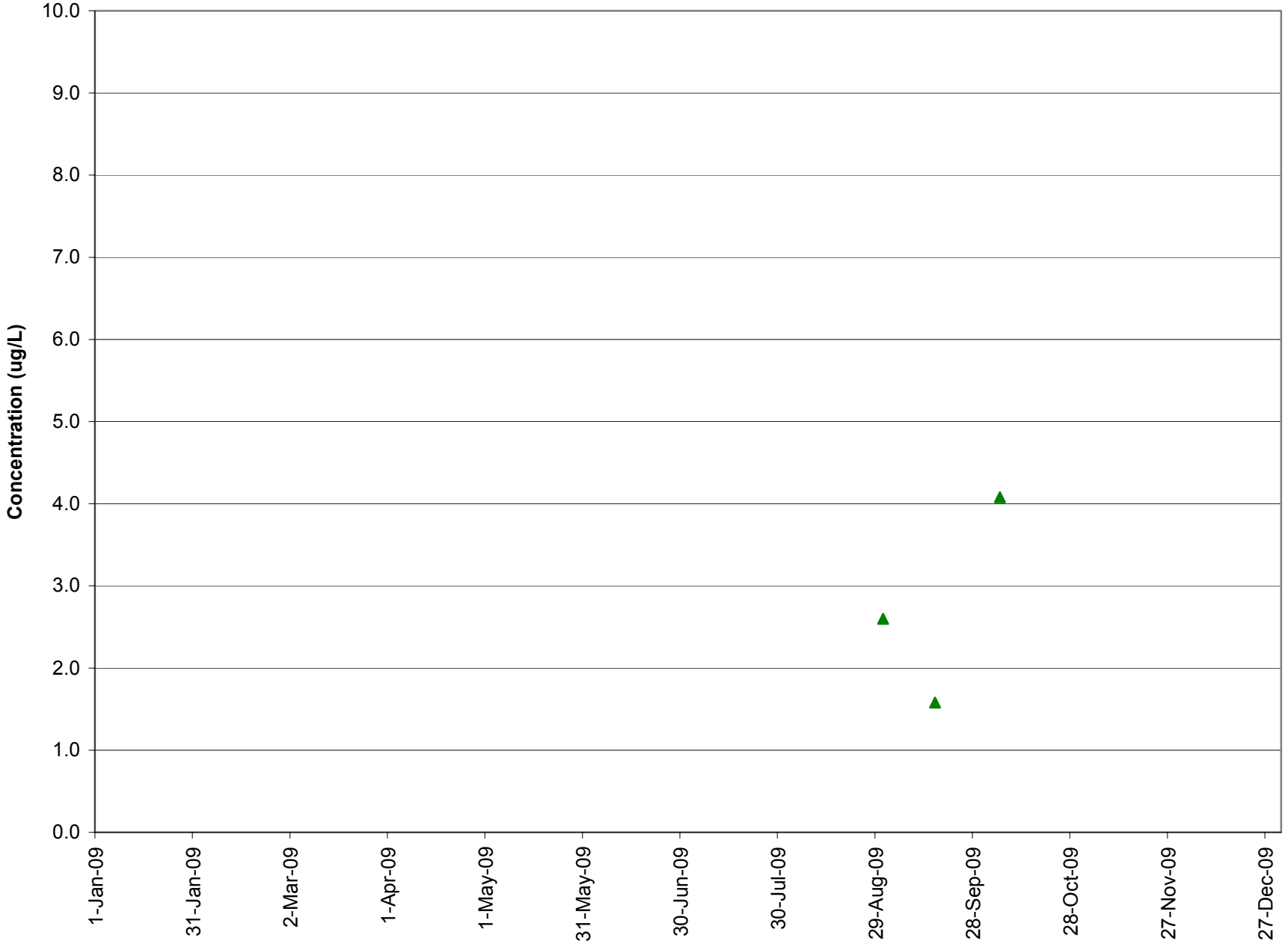
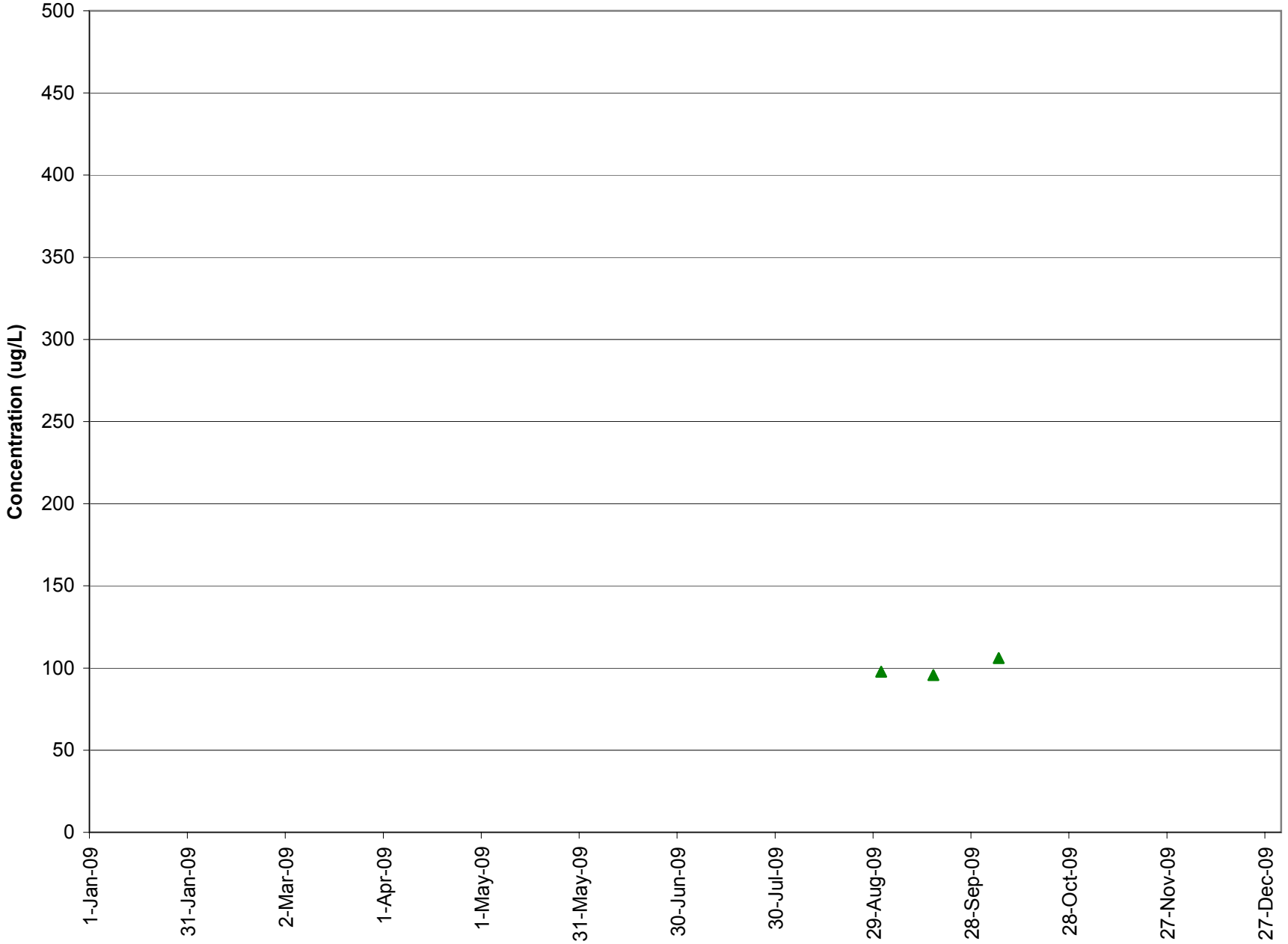
Long Term Discharge Study 2009
Shadow Wood Preserve QSWP-1
Chloride



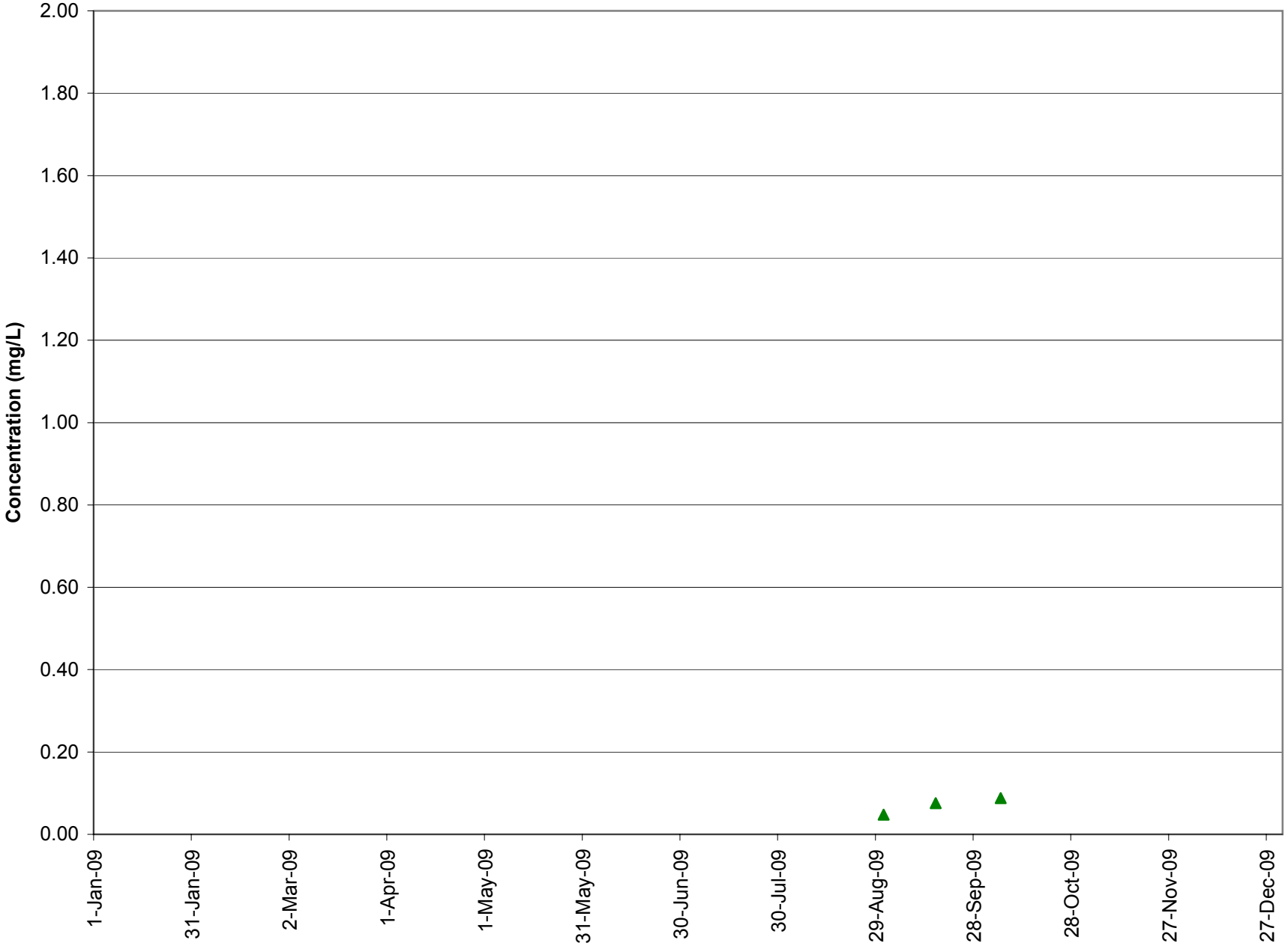
Long Term Discharge Study 2009
Shadow Wood Preserve QSWP-1
Copper



Long Term Discharge Study 2009
Shadow Wood Preserve QSWP-1
Iron



Long Term Discharge Study 2009
Shadow Wood Preserve QSWP-1
Ammonia Nitrogen



Long Term Discharge Study 2009
Shadow Wood Preserve QSWP-1
Nitrate + Nitrite

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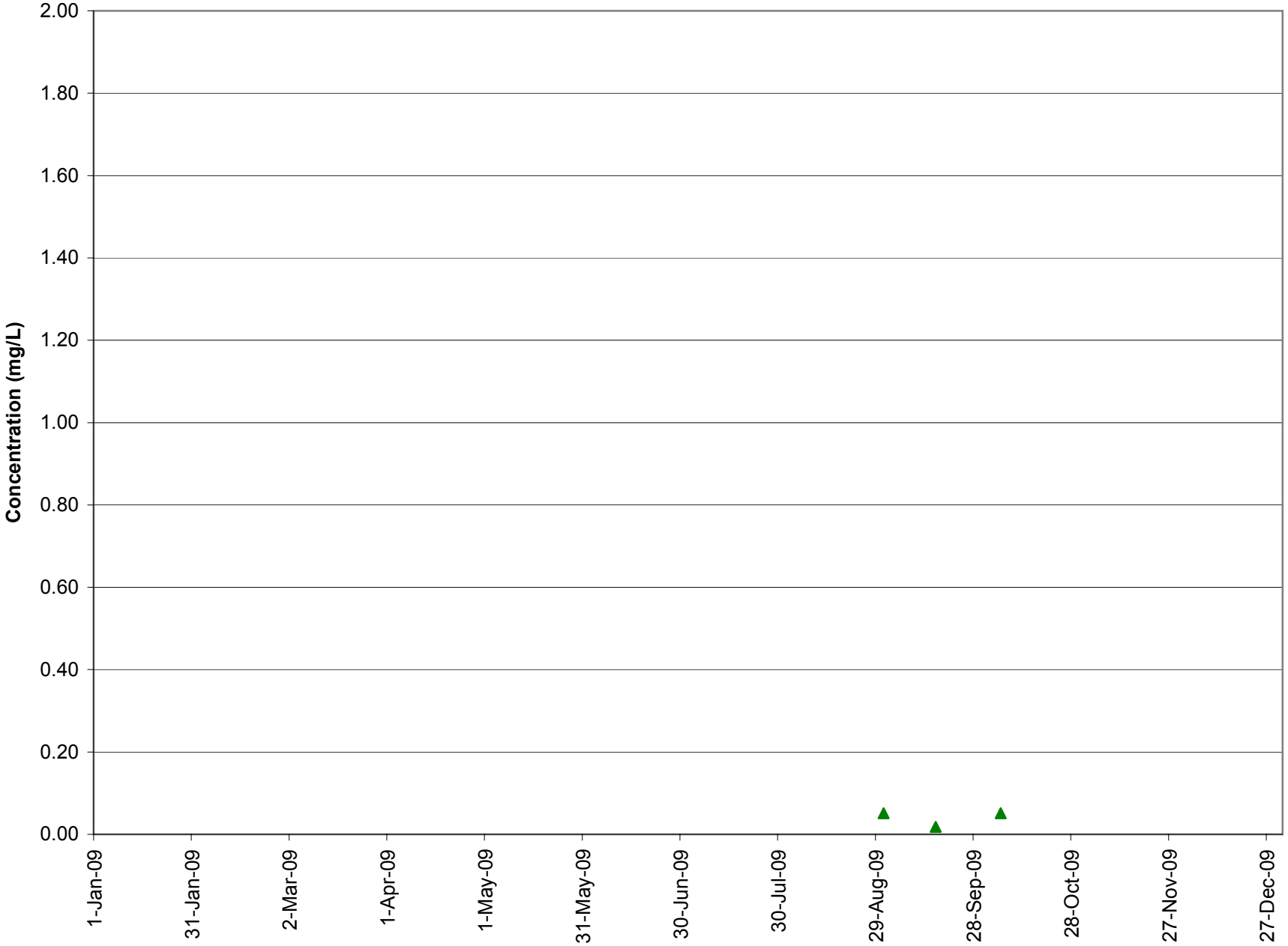

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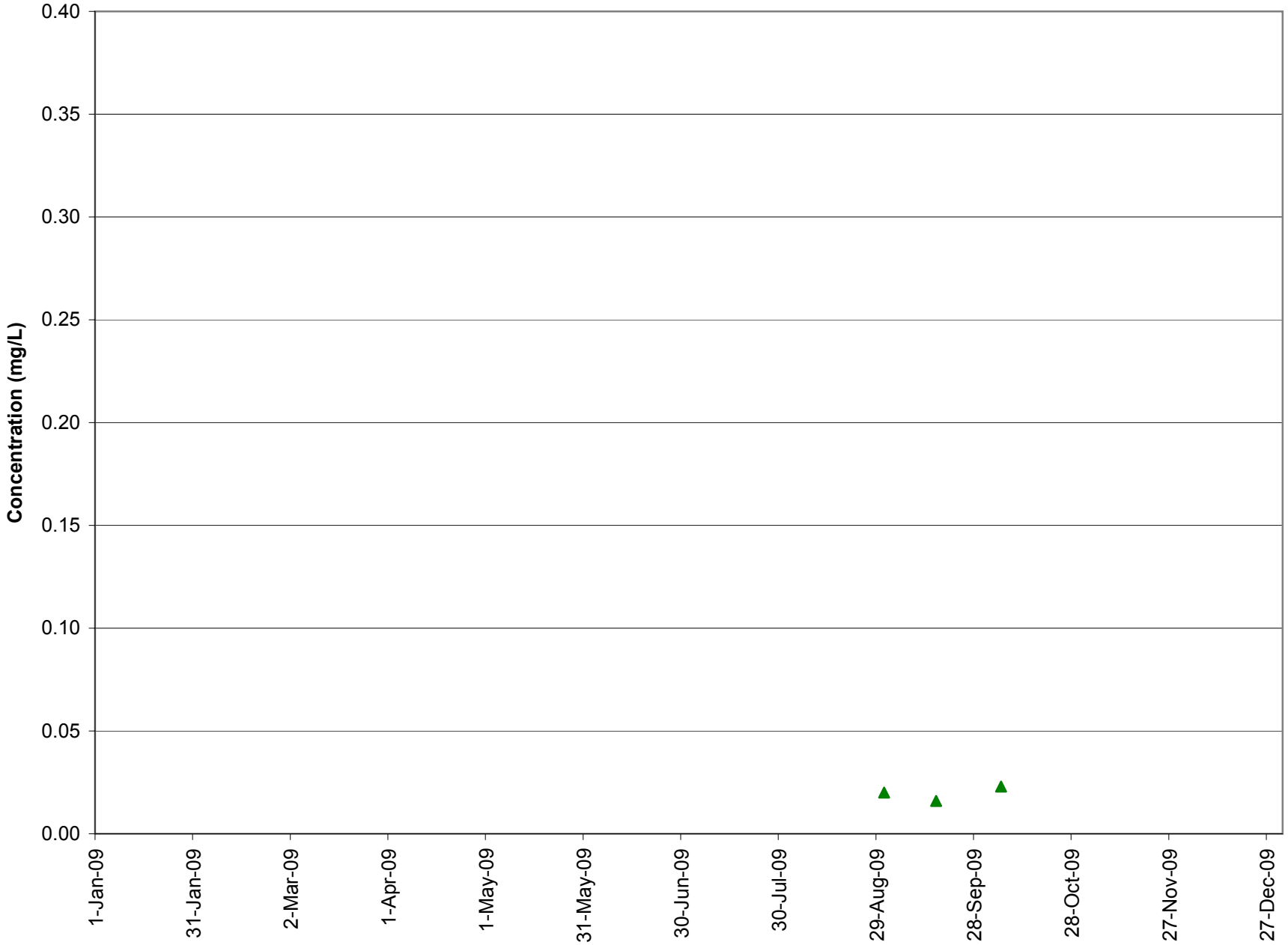
Long Term Discharge Study 2009
Shadow Wood Preserve QSWP-1
Ortho Phosphorus



Long Term Discharge Study 2009
Shadow Wood Preserve QSWP-1
Lead

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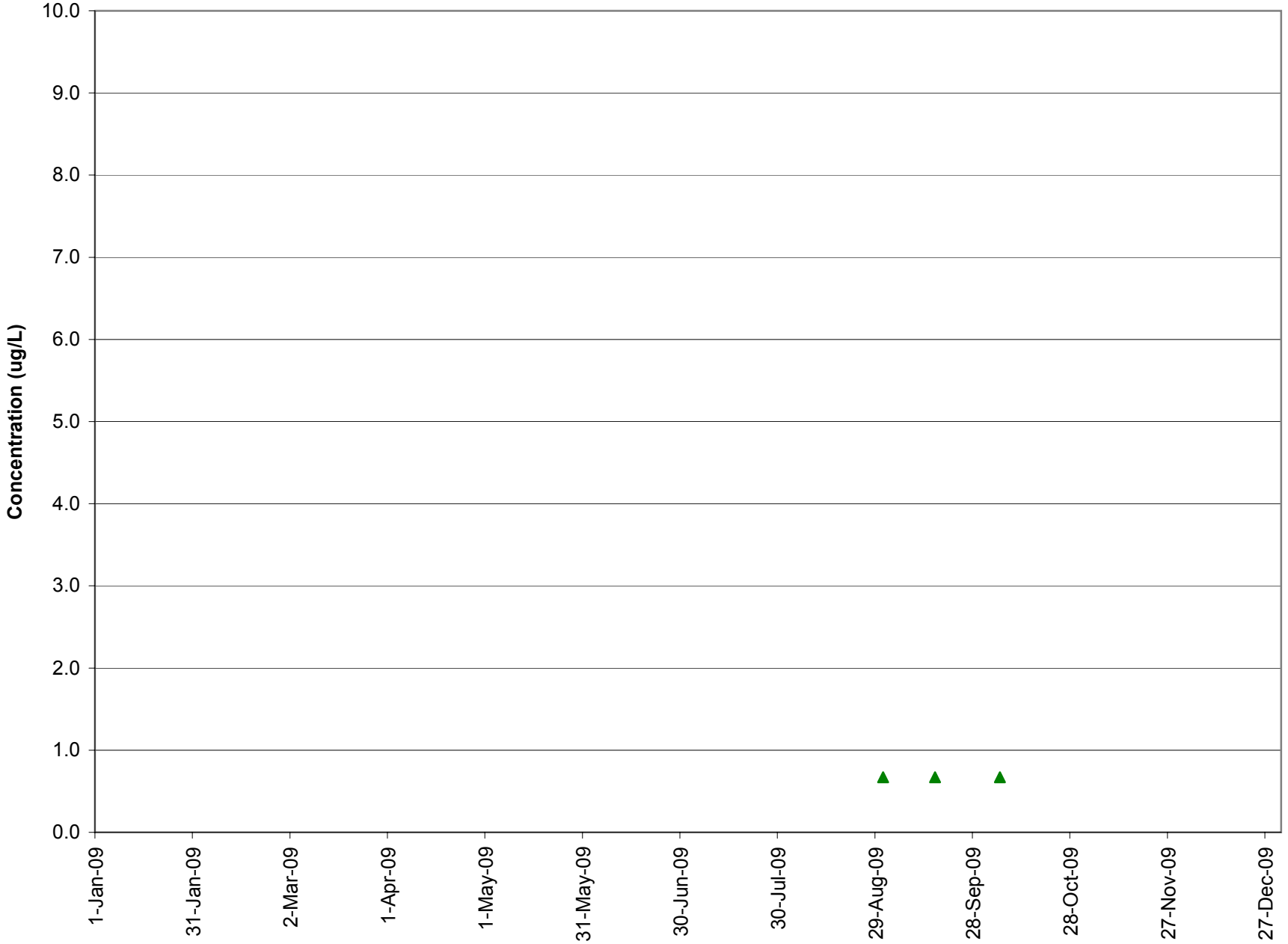

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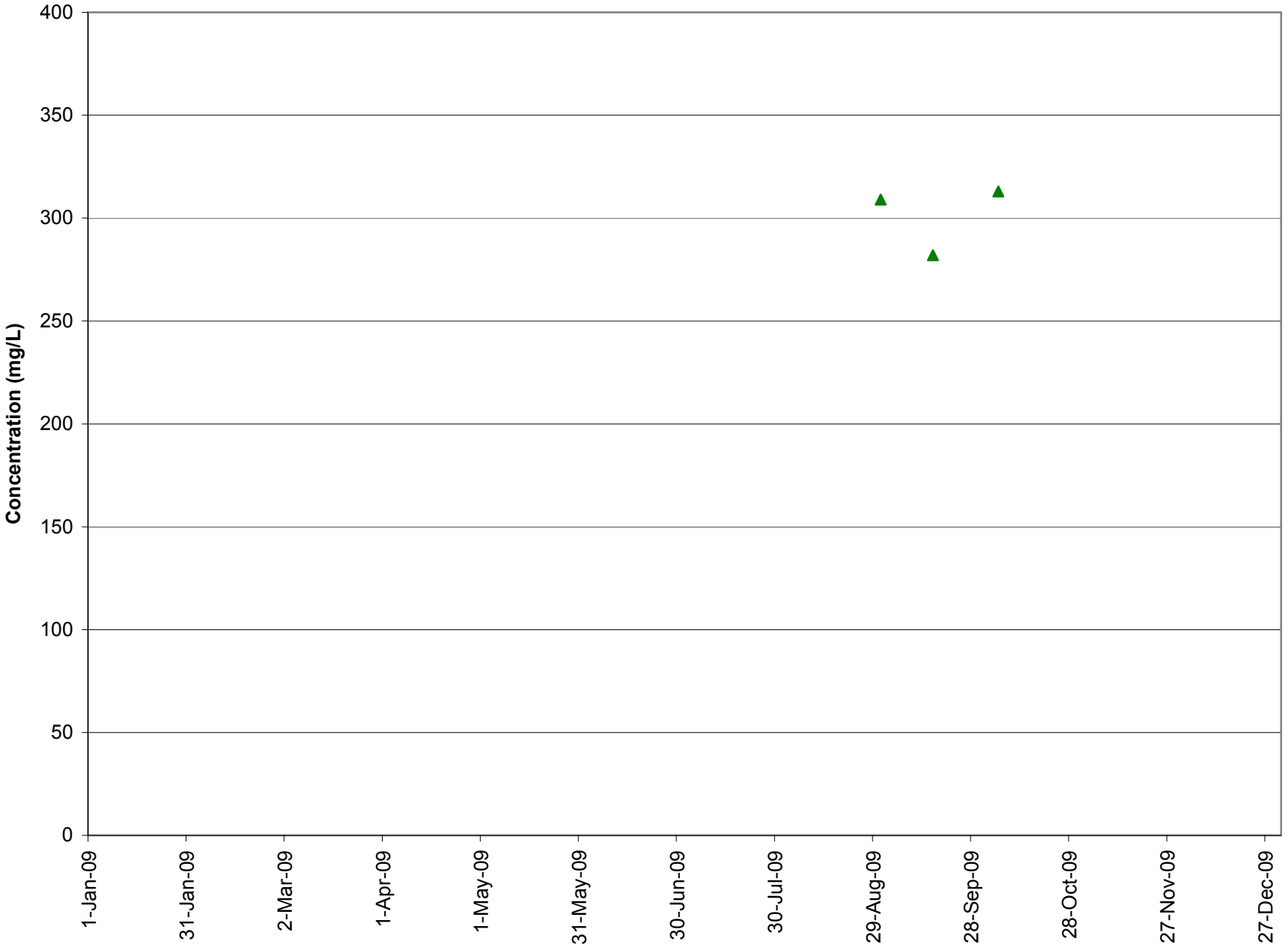
Long Term Discharge Study 2009
Shadow Wood Preserve QSWP-1
Total Hardness



Long Term Discharge Study 2009
Shadow Wood Preserve QSWP-1
Total Kjeldahl Nitrogen

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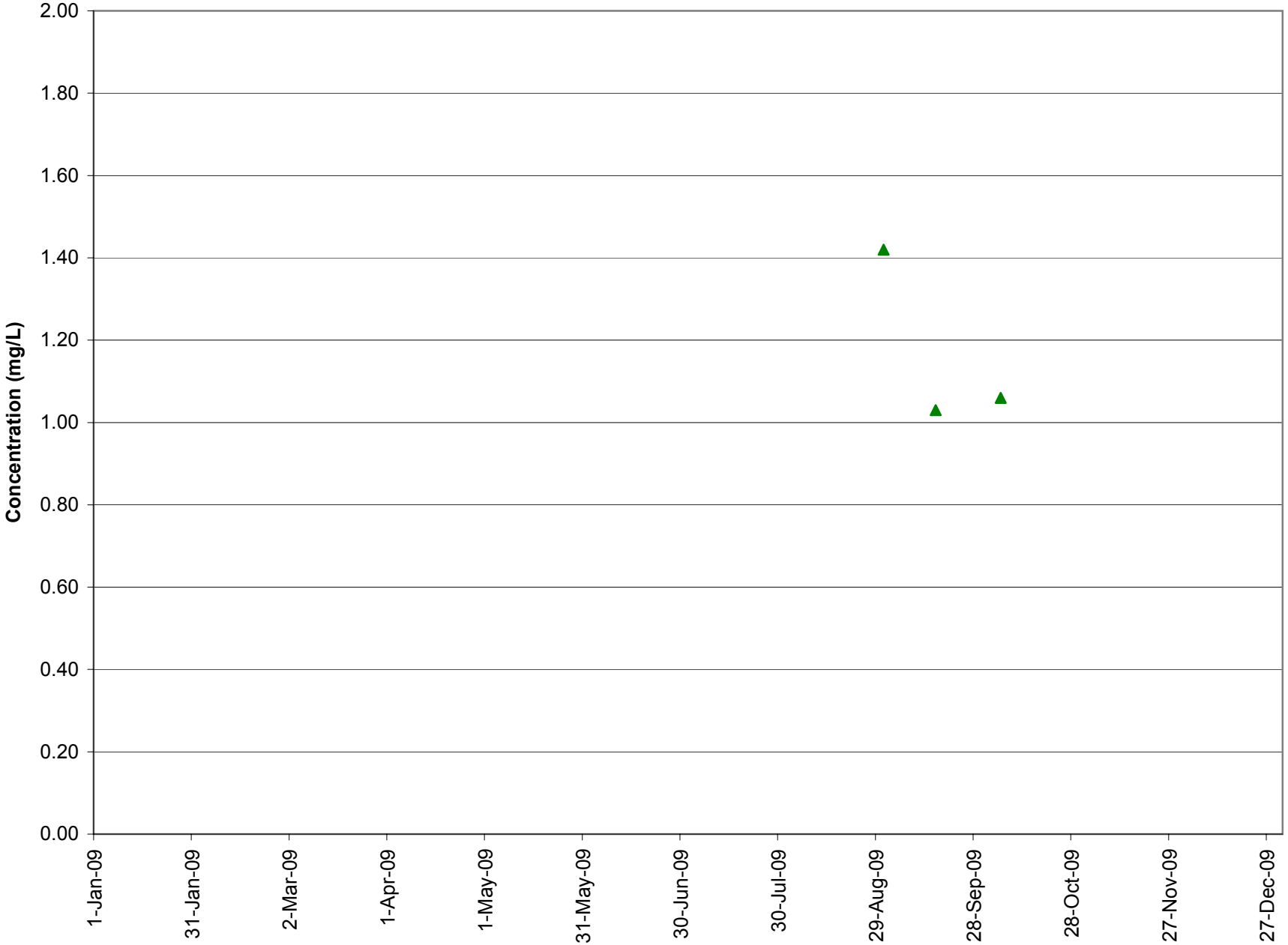
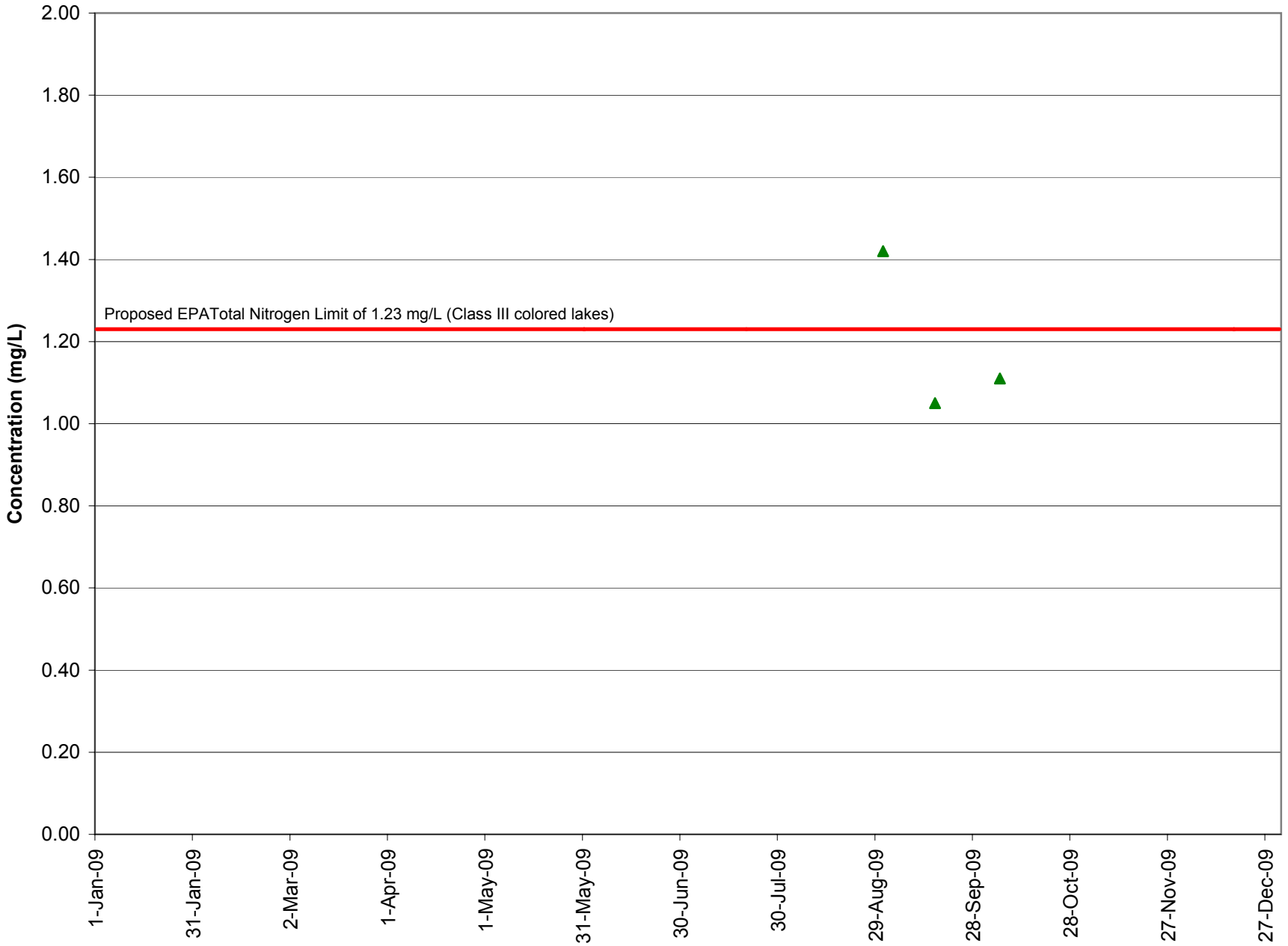
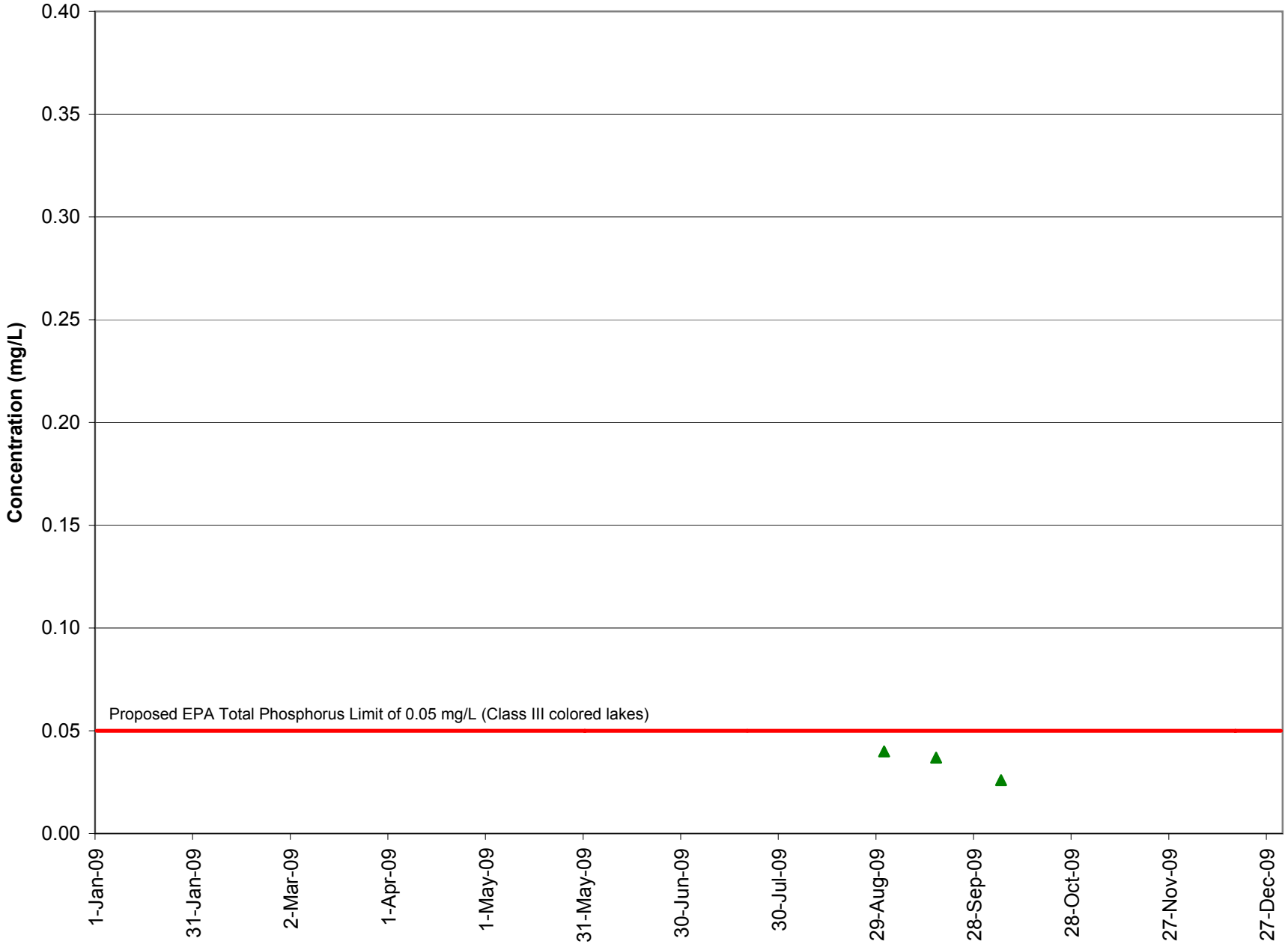


Long Term Discharge Study 2009
Shadow Wood Preserve QSWP-1
Total Nitrogen



Long Term Discharge Study 2009
Shadow Wood Preserve QSWP-1
Total Phosphorus



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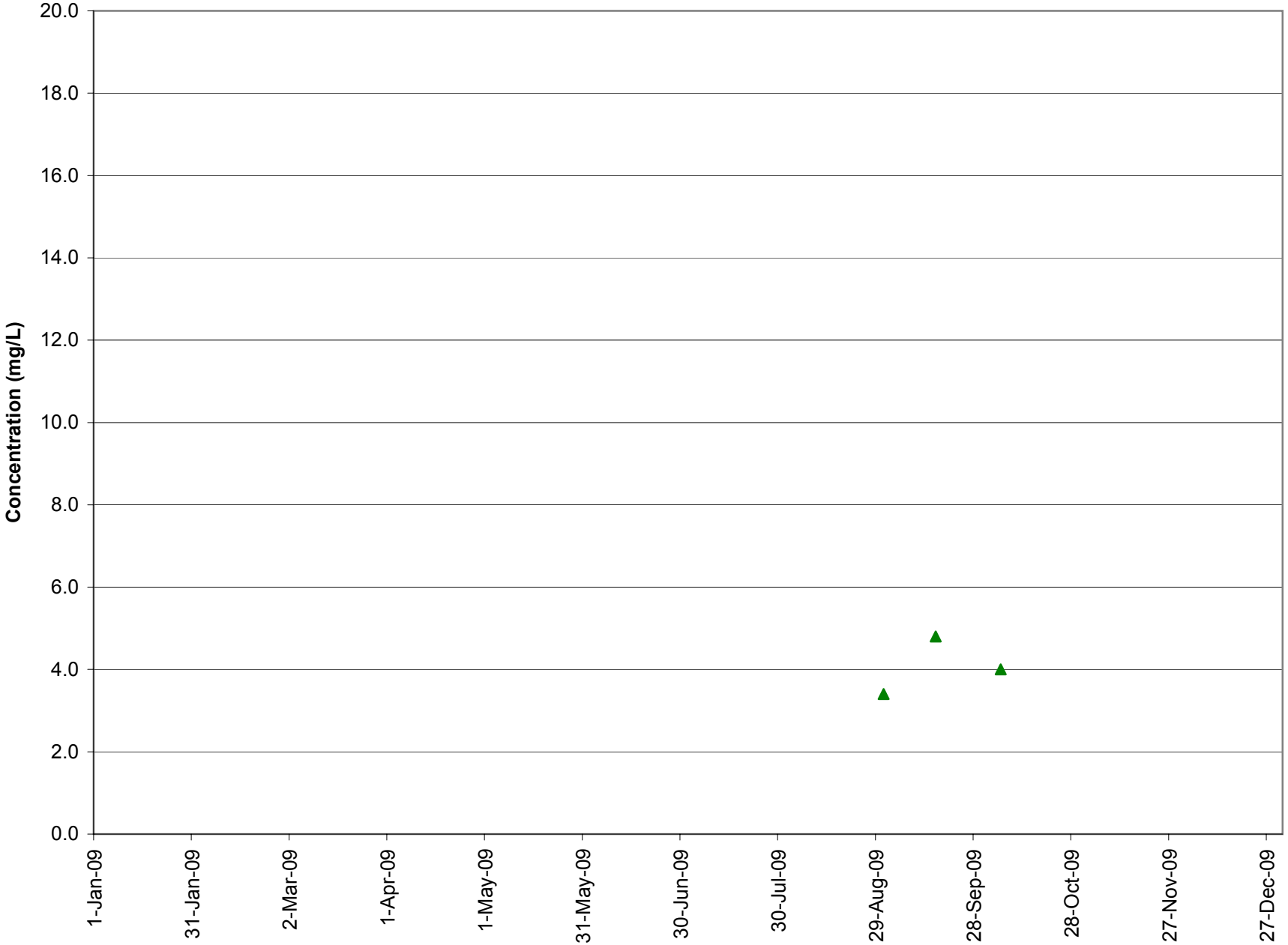
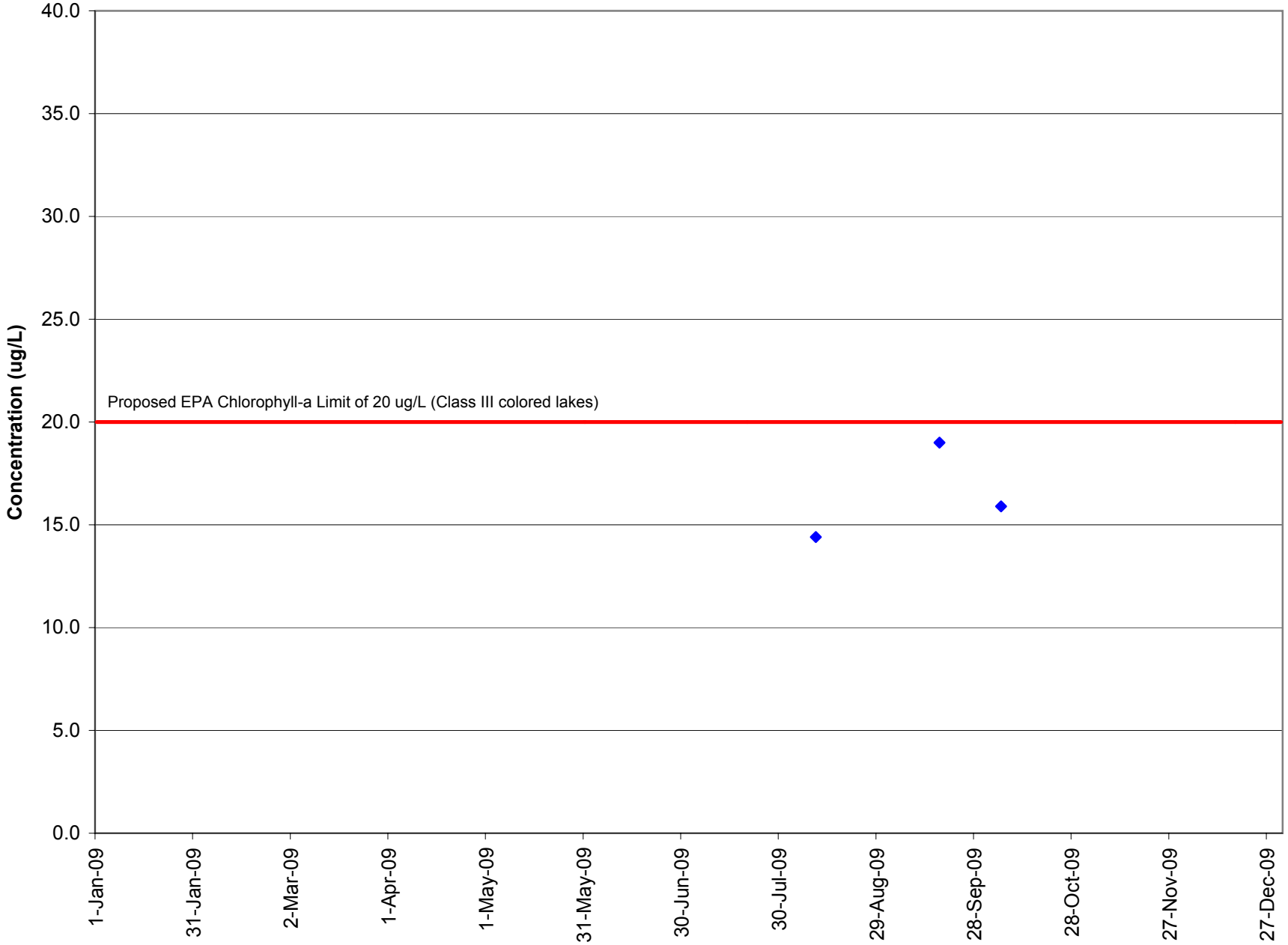
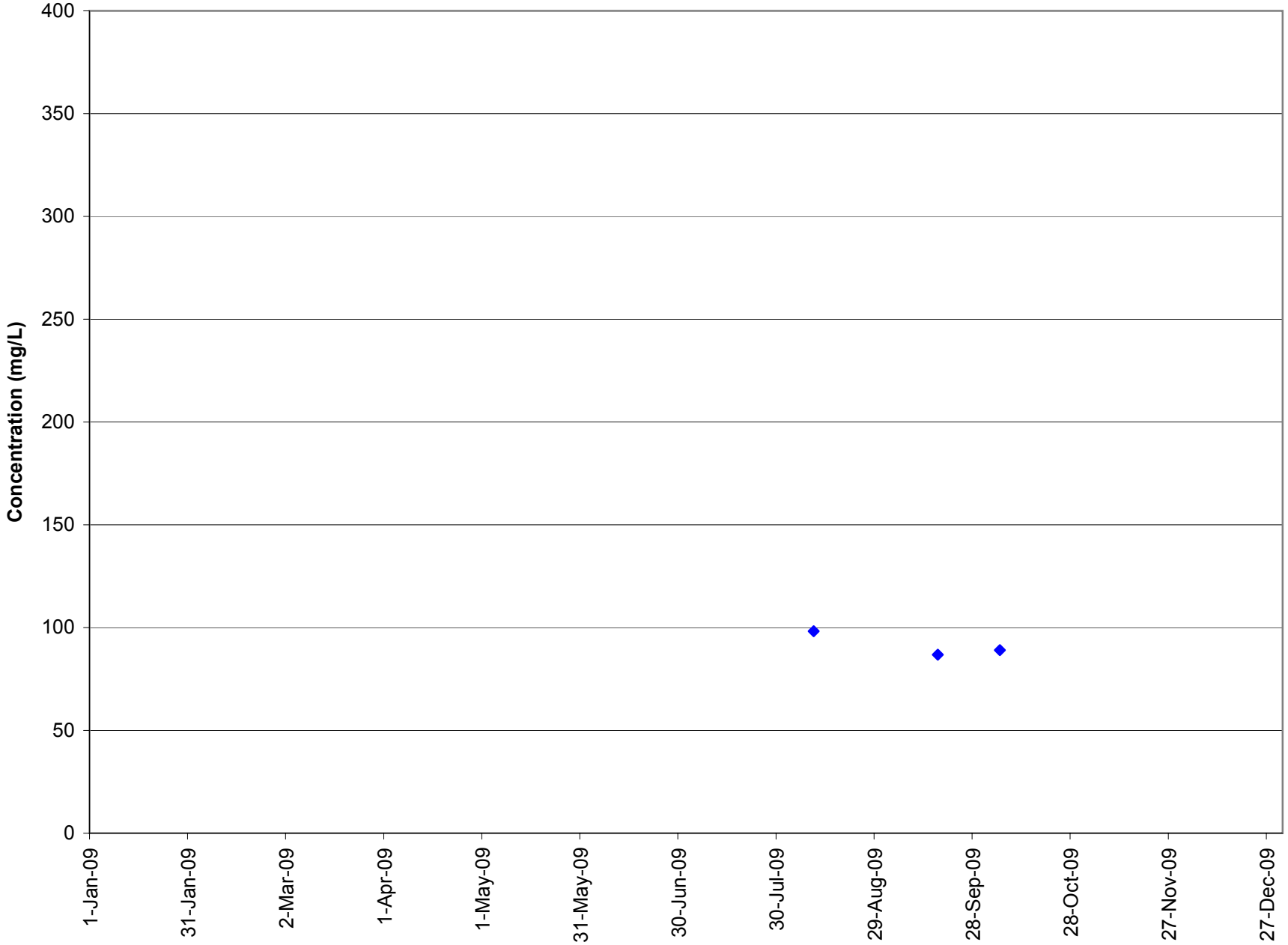
Long Term Discharge Study 2009
Shadow Wood Preserve QSWP-1
Total Suspended Solids



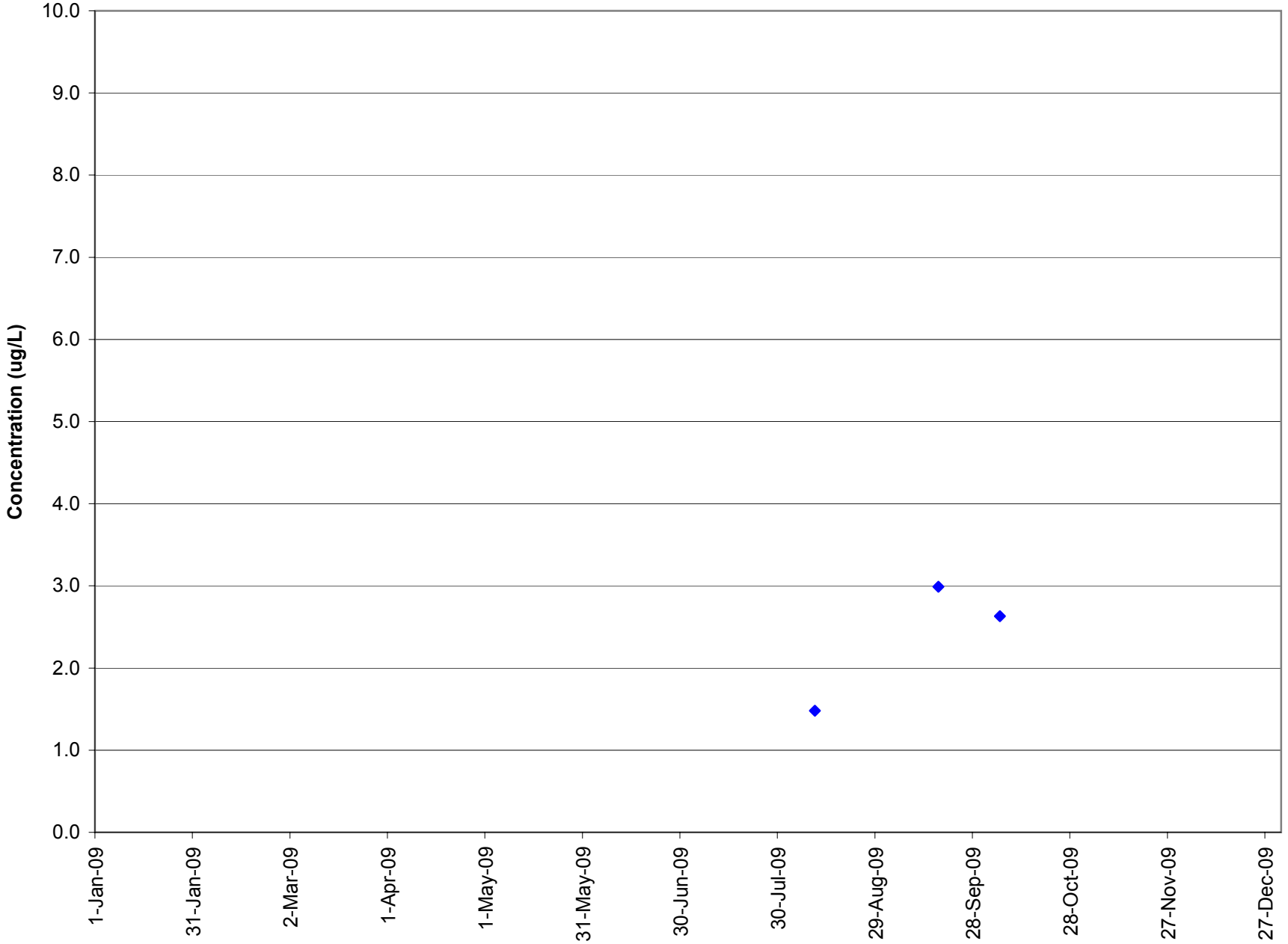
Long Term Discharge Study 2009
The Brooks QB-1
Chlorophyll-a



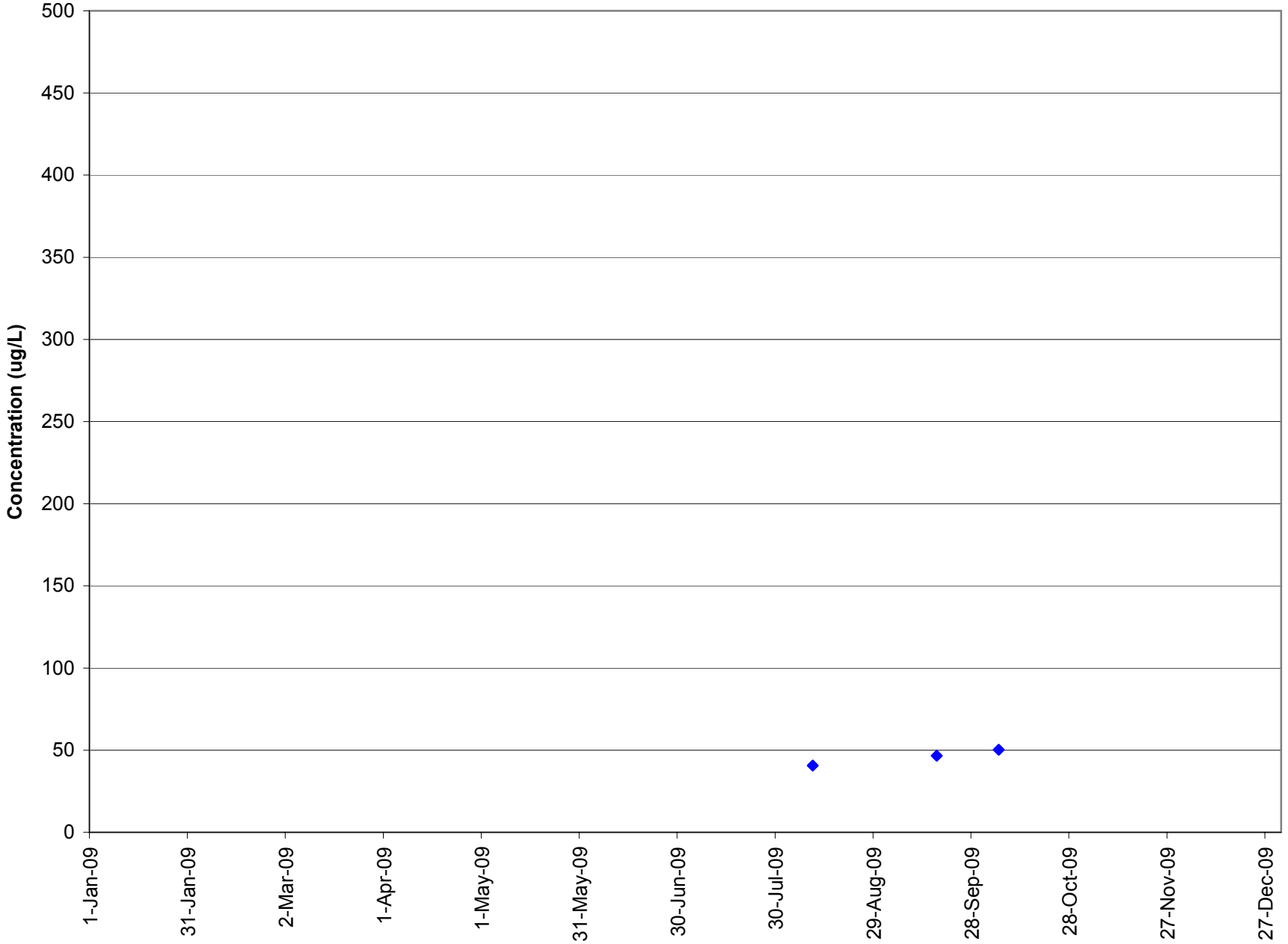
Long Term Discharge Study 2009
The Brooks QB-1
Chloride



Long Term Discharge Study 2009
The Brooks QB-1
Copper



Long Term Discharge Study 2009
The Brooks QB-1
Iron



Long Term Discharge Study 2009
The Brooks QB-1
Ammonia Nitrogen

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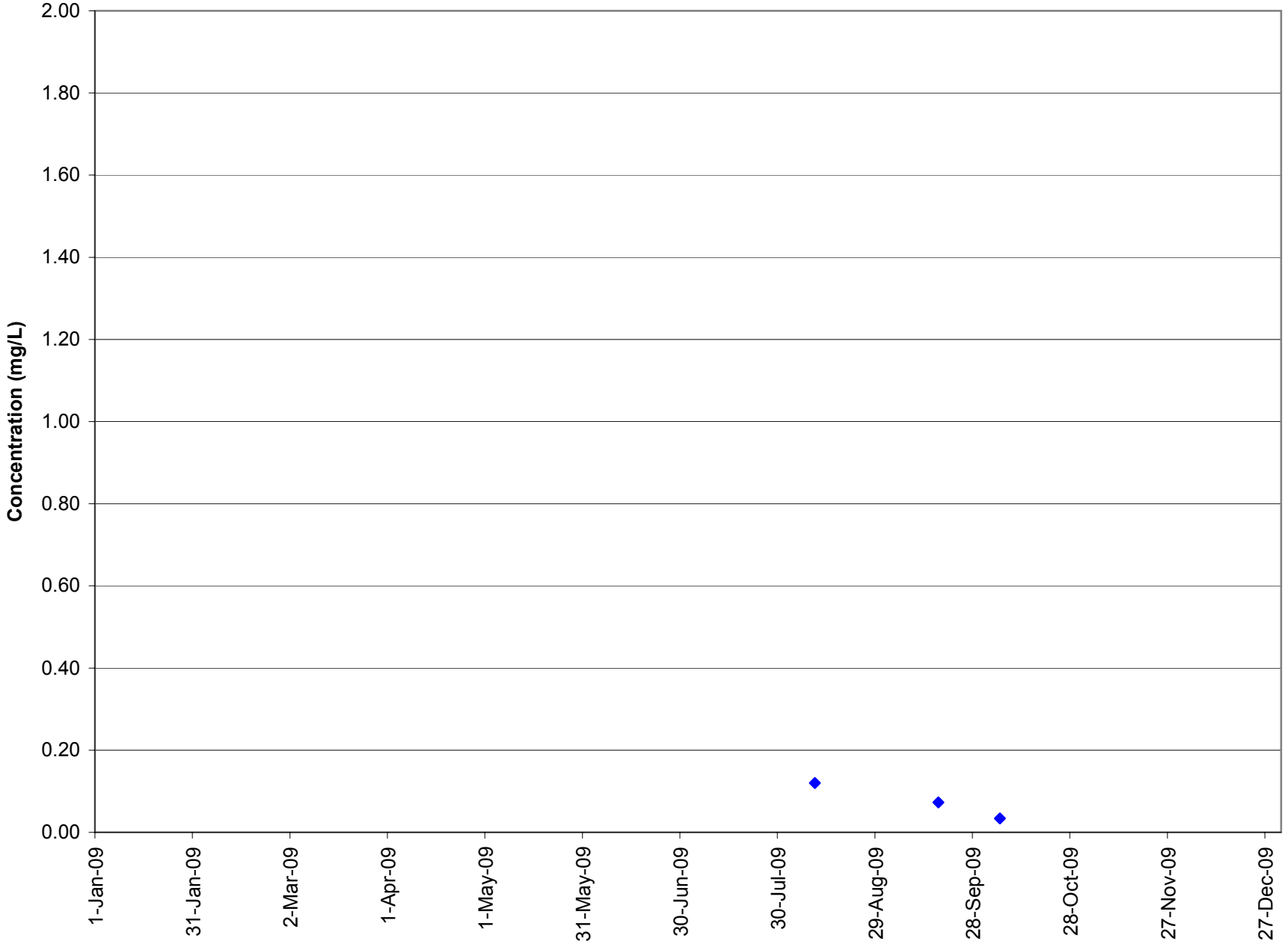

Long Term Discharge Study 2009
The Brooks QB-1
Nitrate + Nitrite

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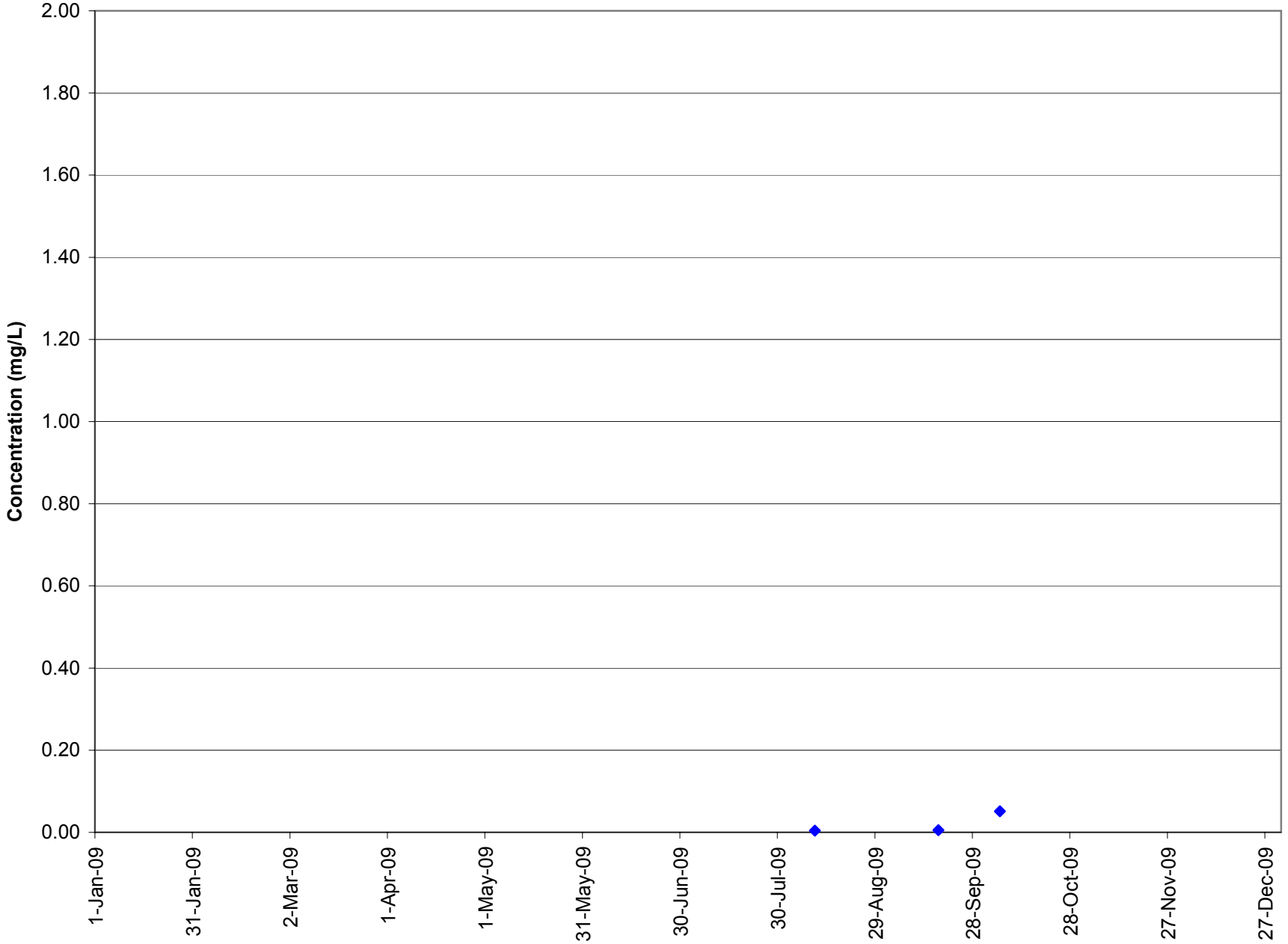

Long Term Discharge Study 2009
The Brooks QB-1
Ortho Phosphorus

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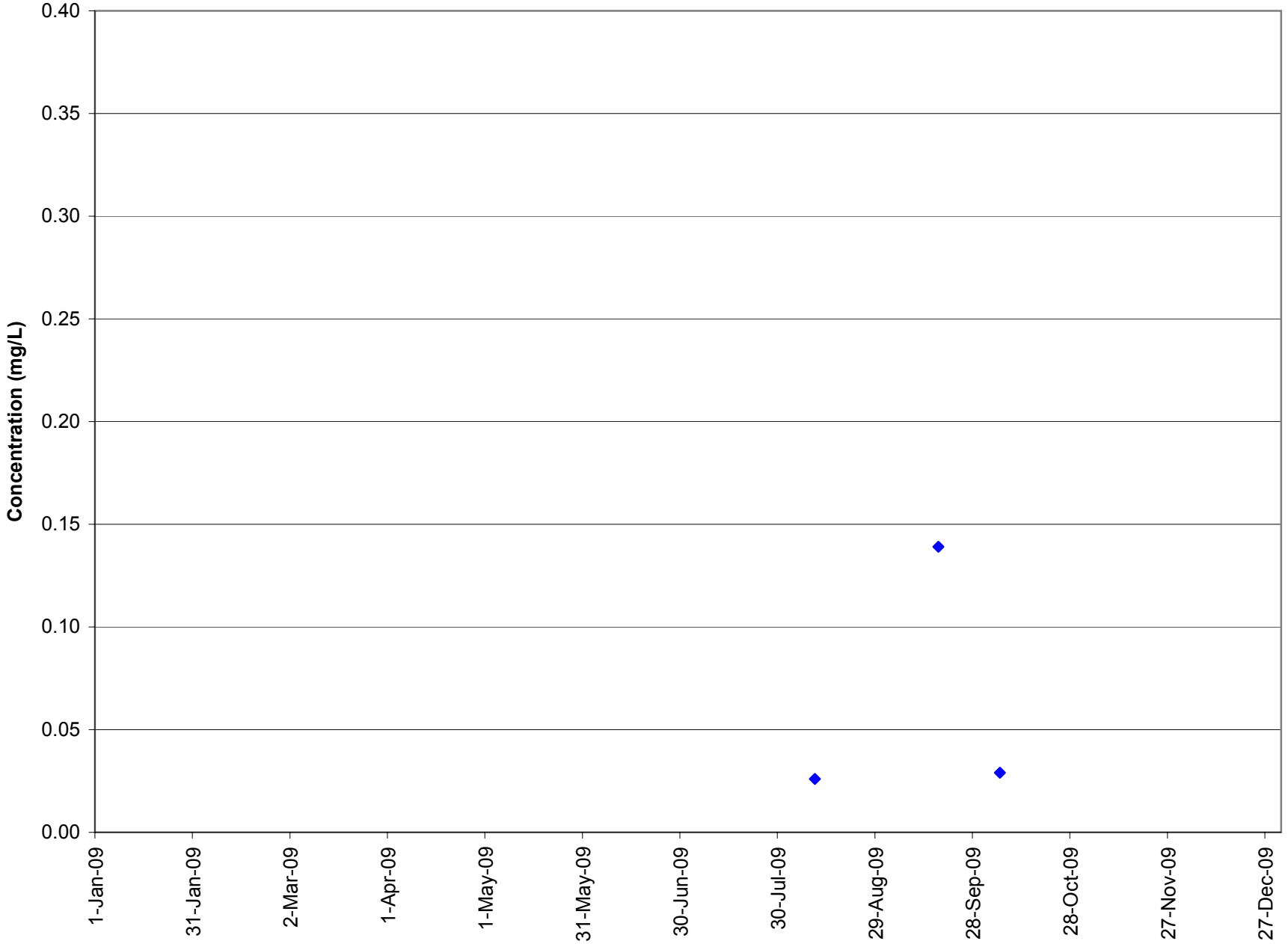

Long Term Discharge Study 2009
The Brooks QB-1
Lead

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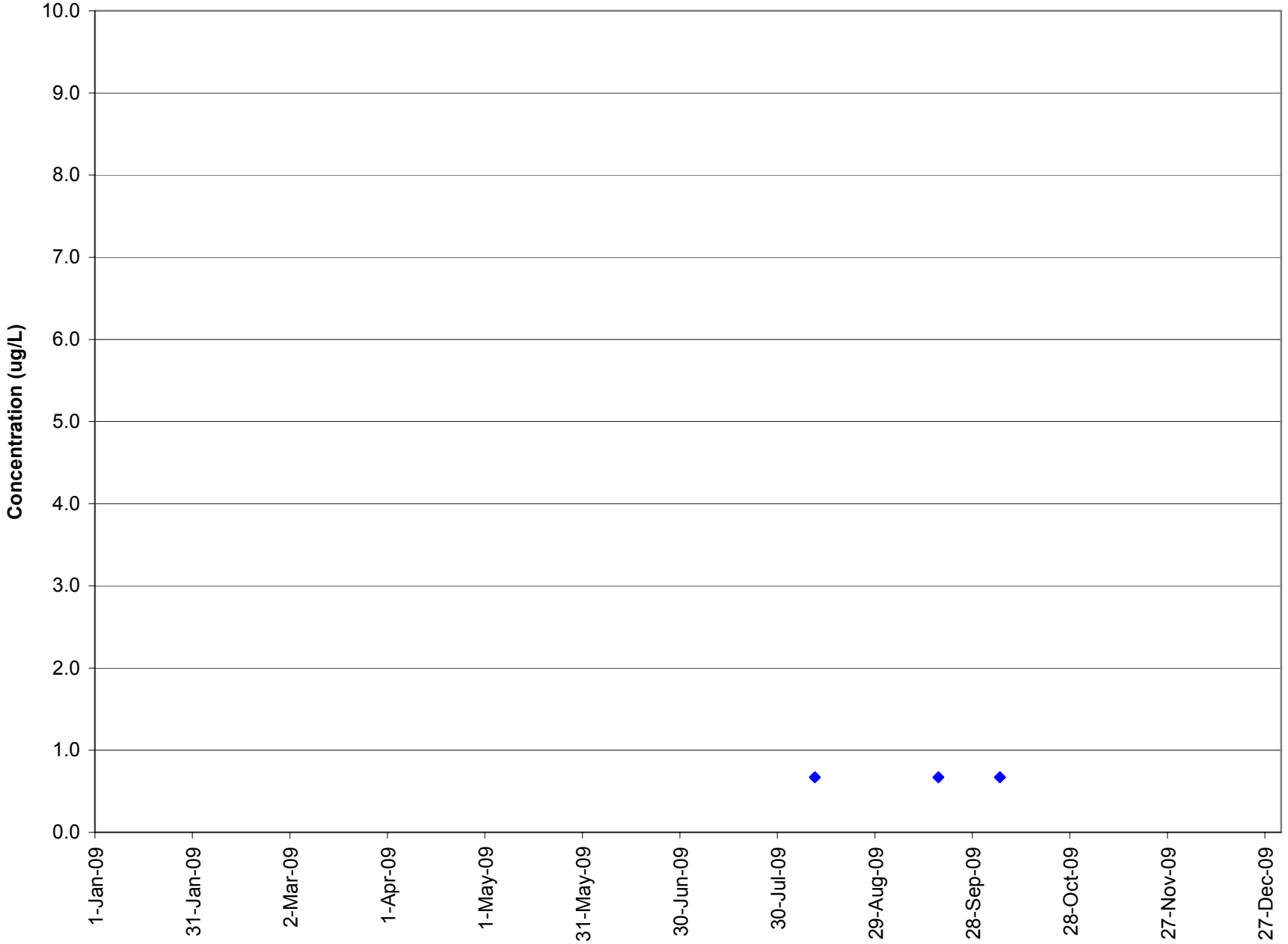

Long Term Discharge Study 2009
The Brooks QB-1
Total Hardness

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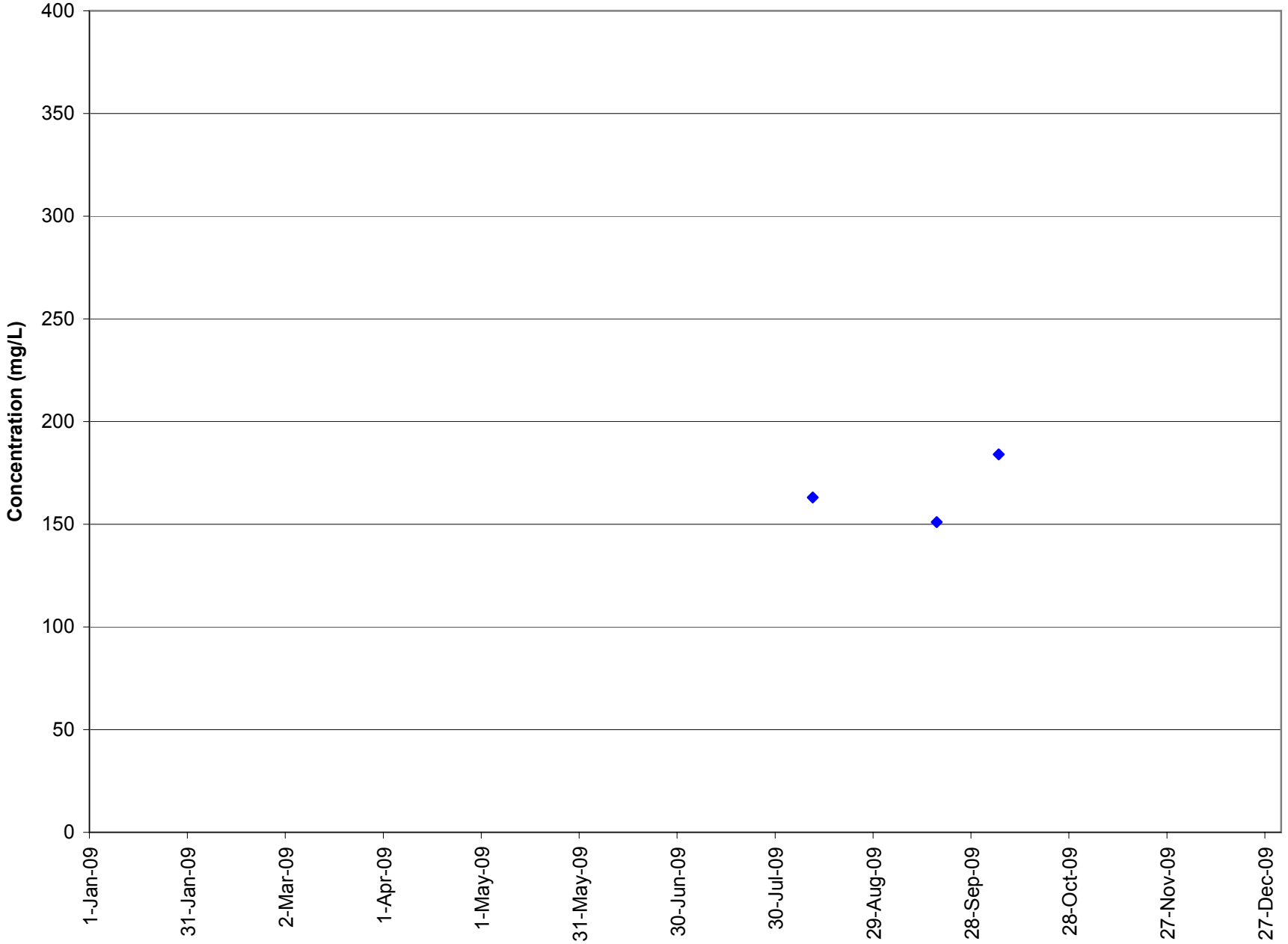
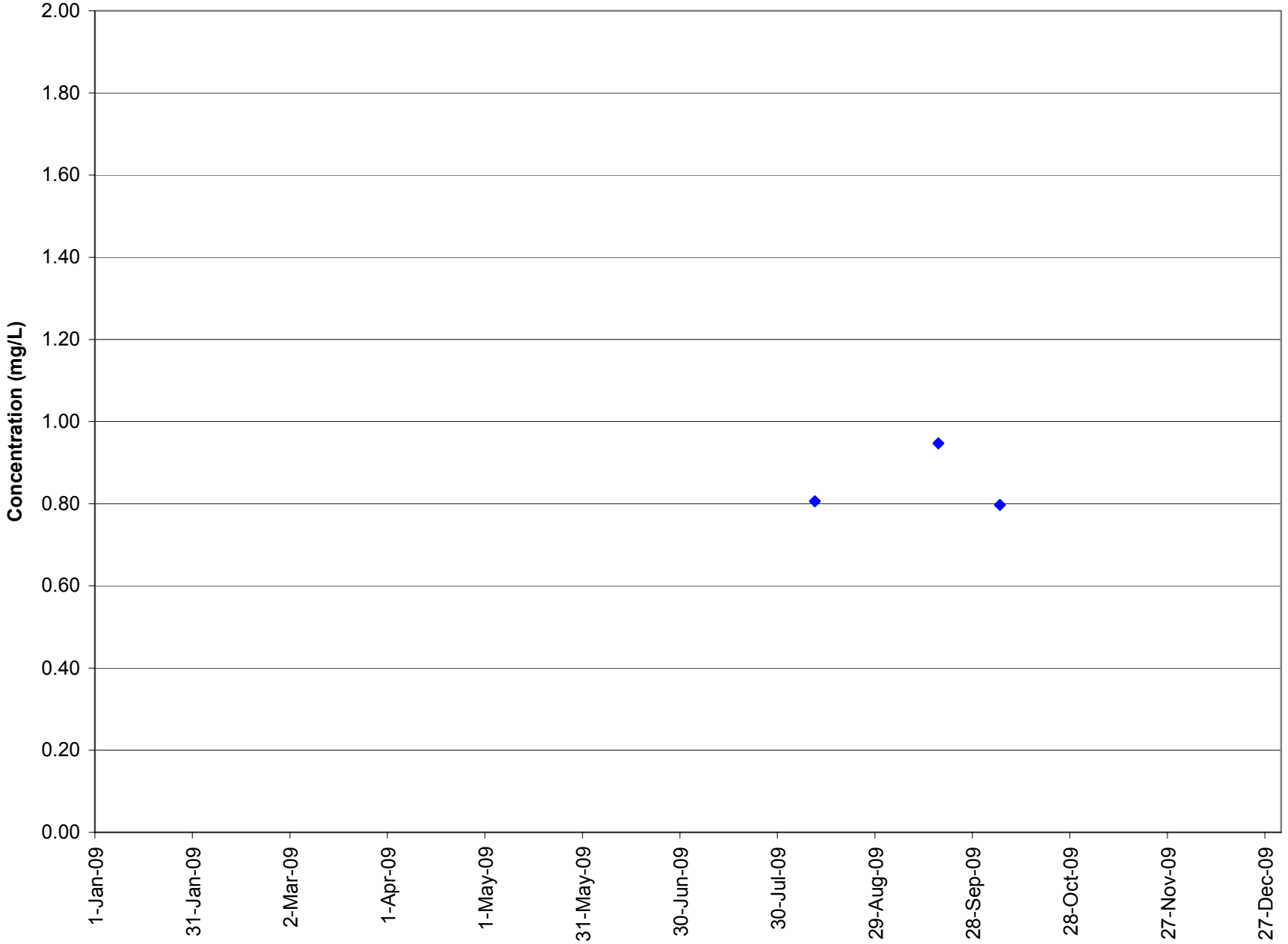
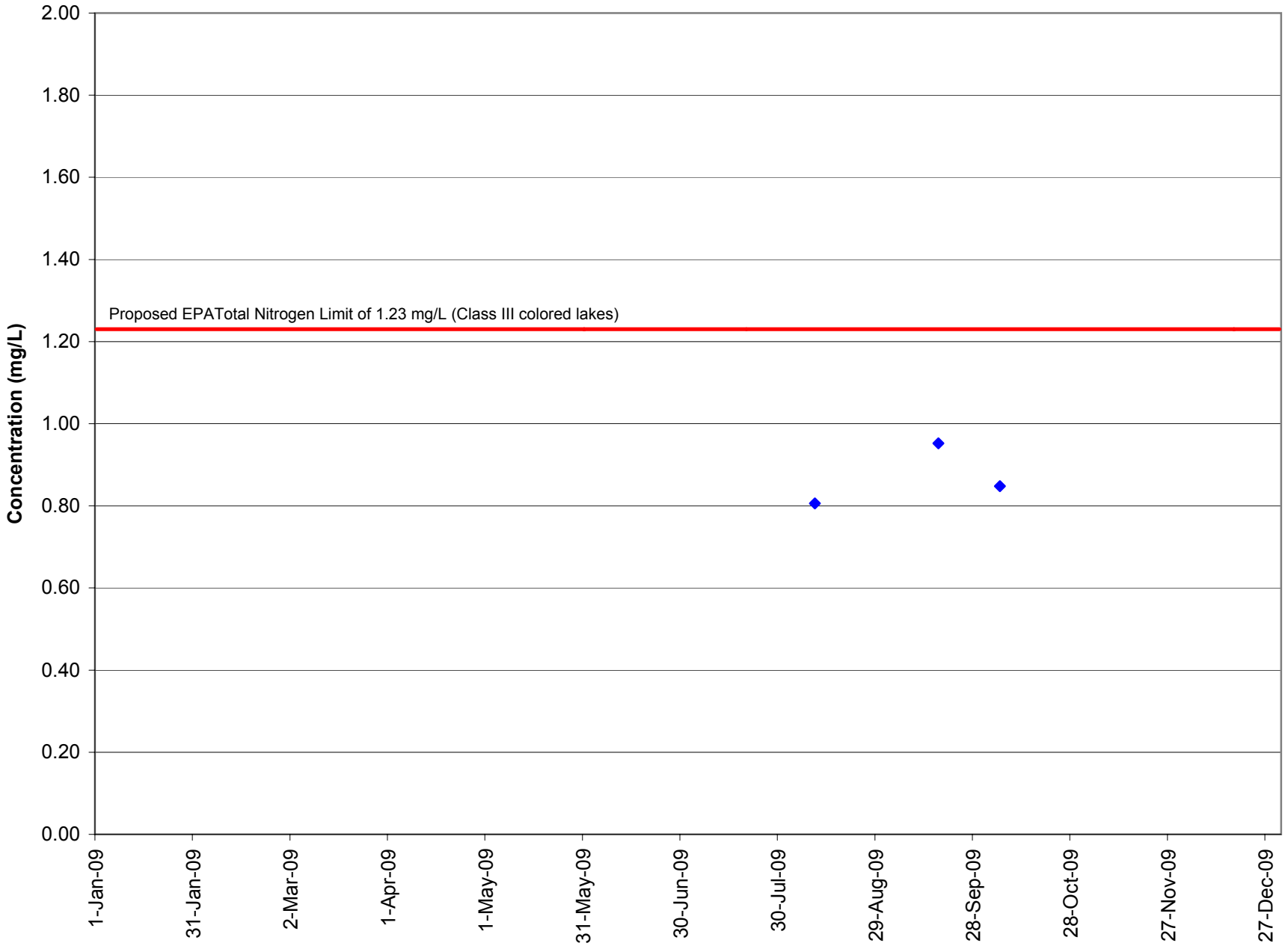


Long Term Discharge Study 2009
The Brooks QB-1
Total Kjeldahl Nitrogen



Long Term Discharge Study 2009
The Brooks QB-1
Total Nitrogen



Long Term Discharge Study 2009
The Brooks QB-1
Total Phosphorus

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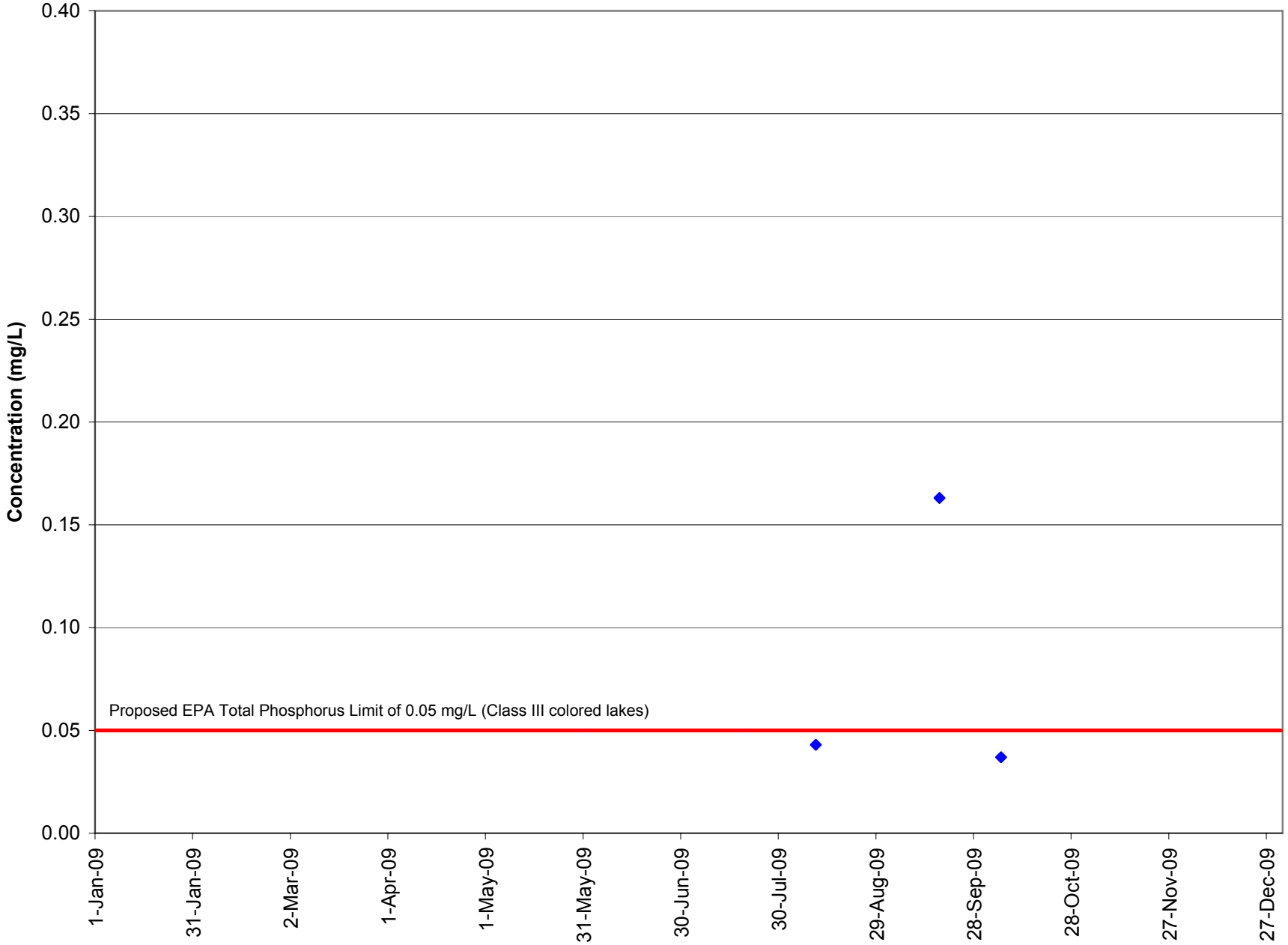

Long Term Discharge Study 2009
The Brooks QB-1
Total Suspended Solids

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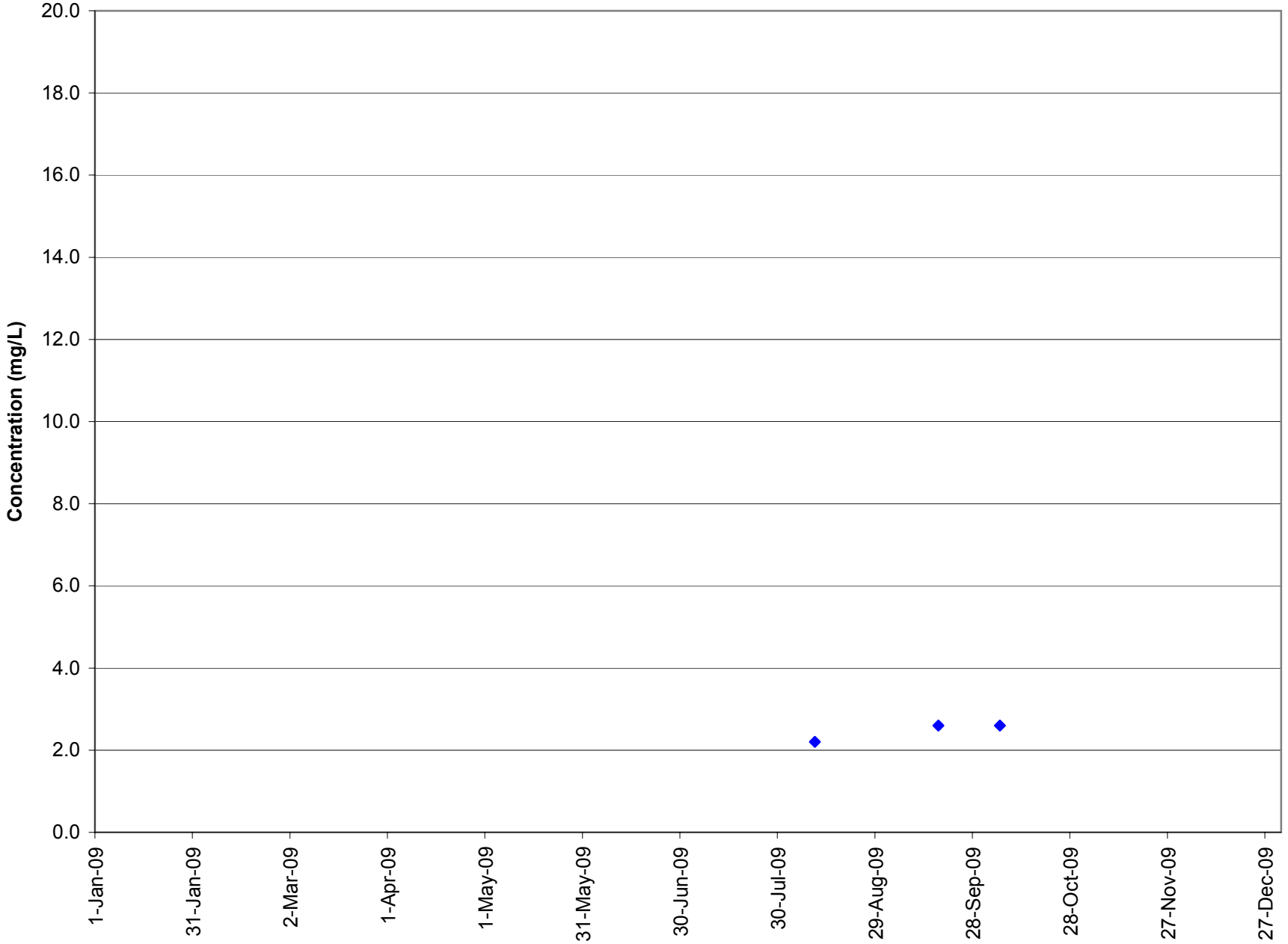
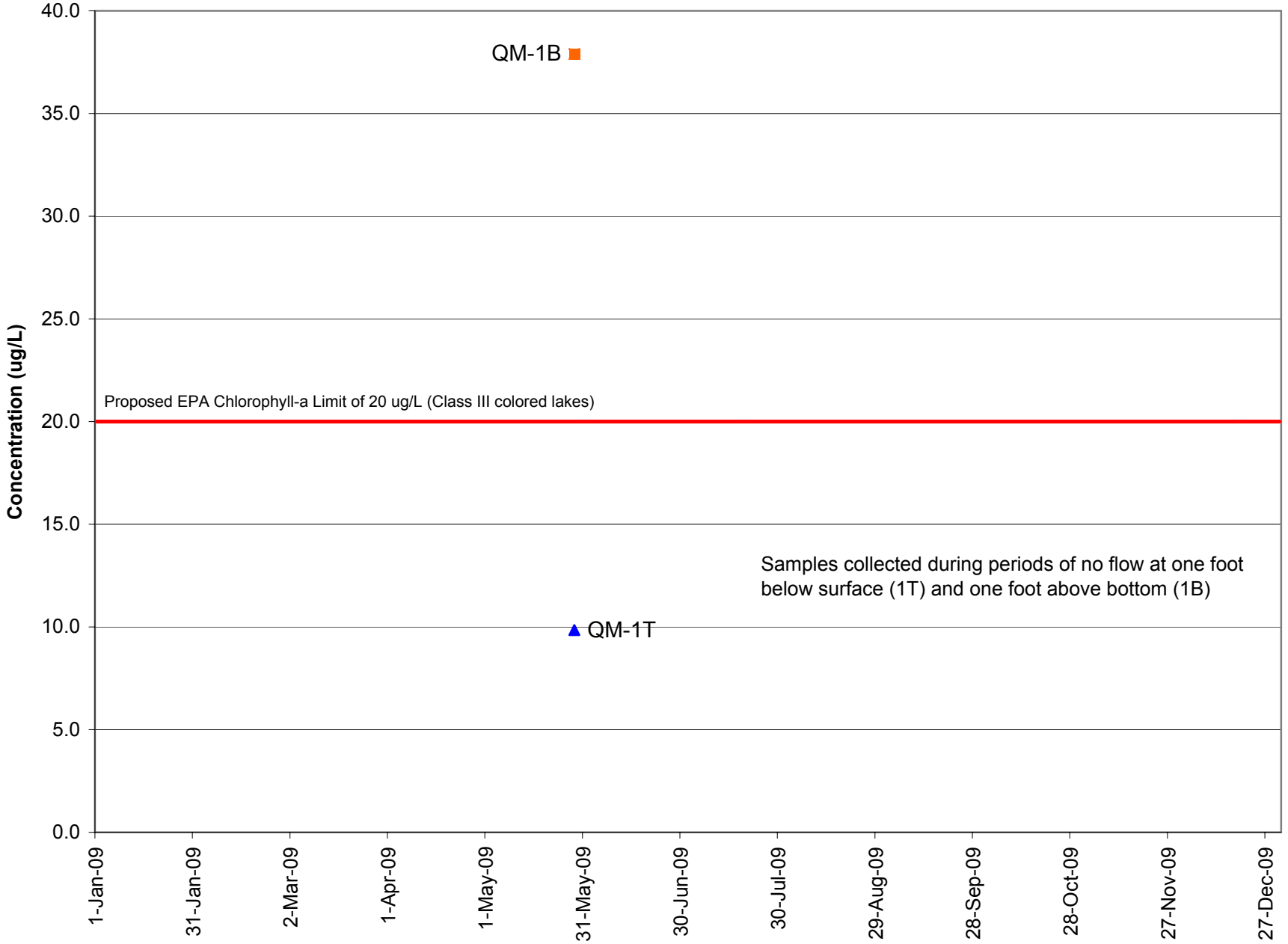
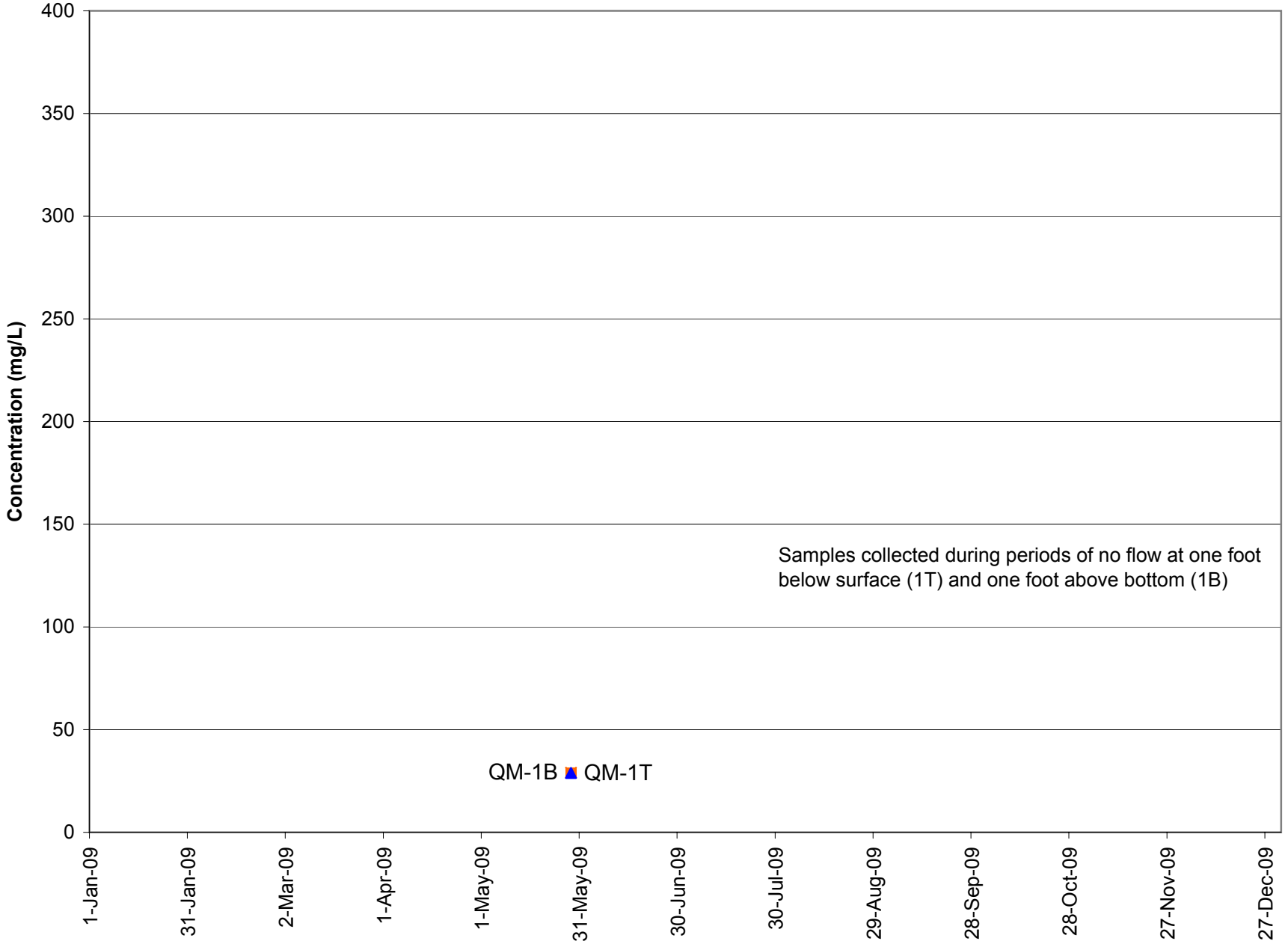


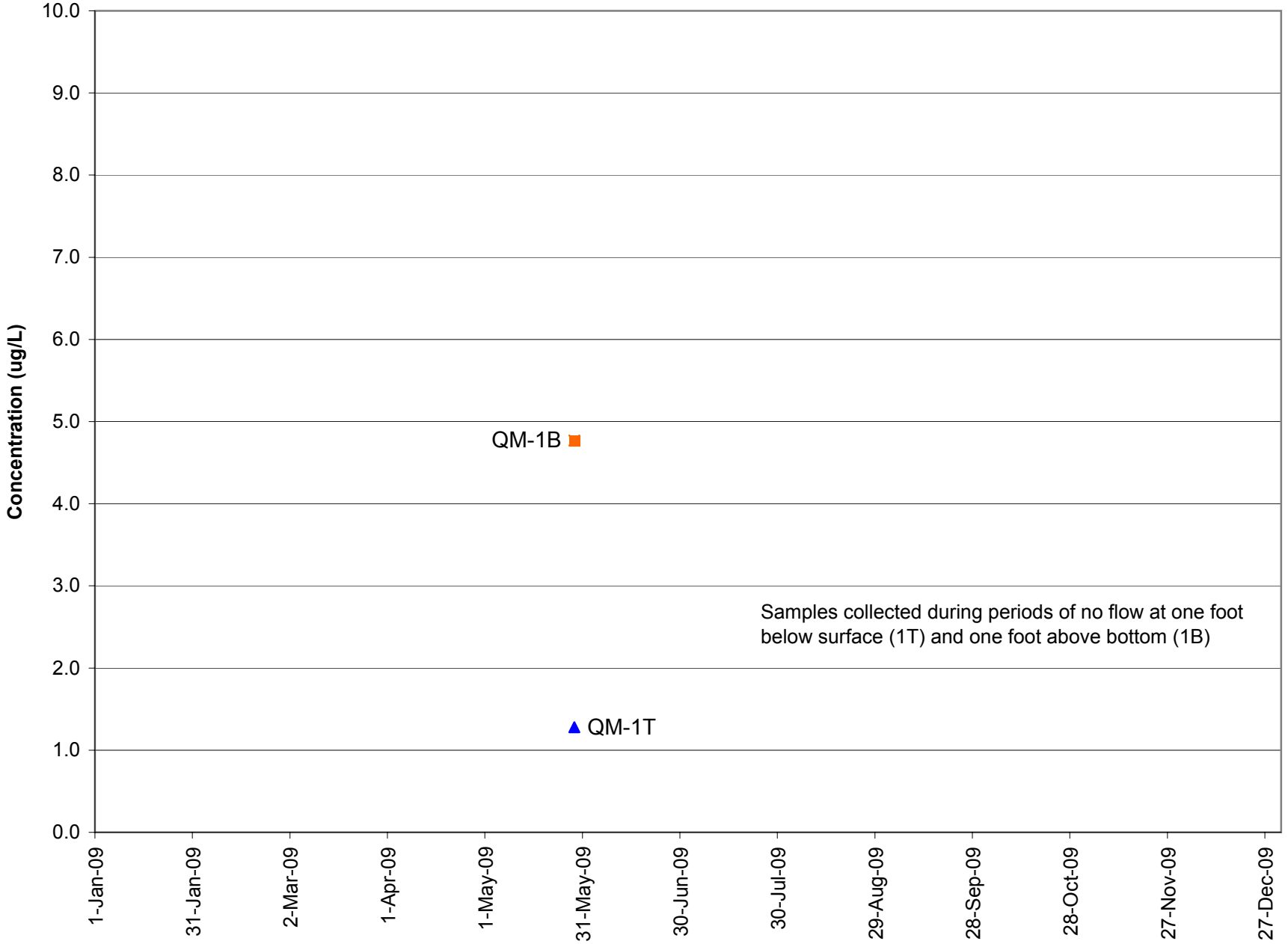
Long Term Discharge Study 2009
Mediterra QM-1
Chlorophyll-a



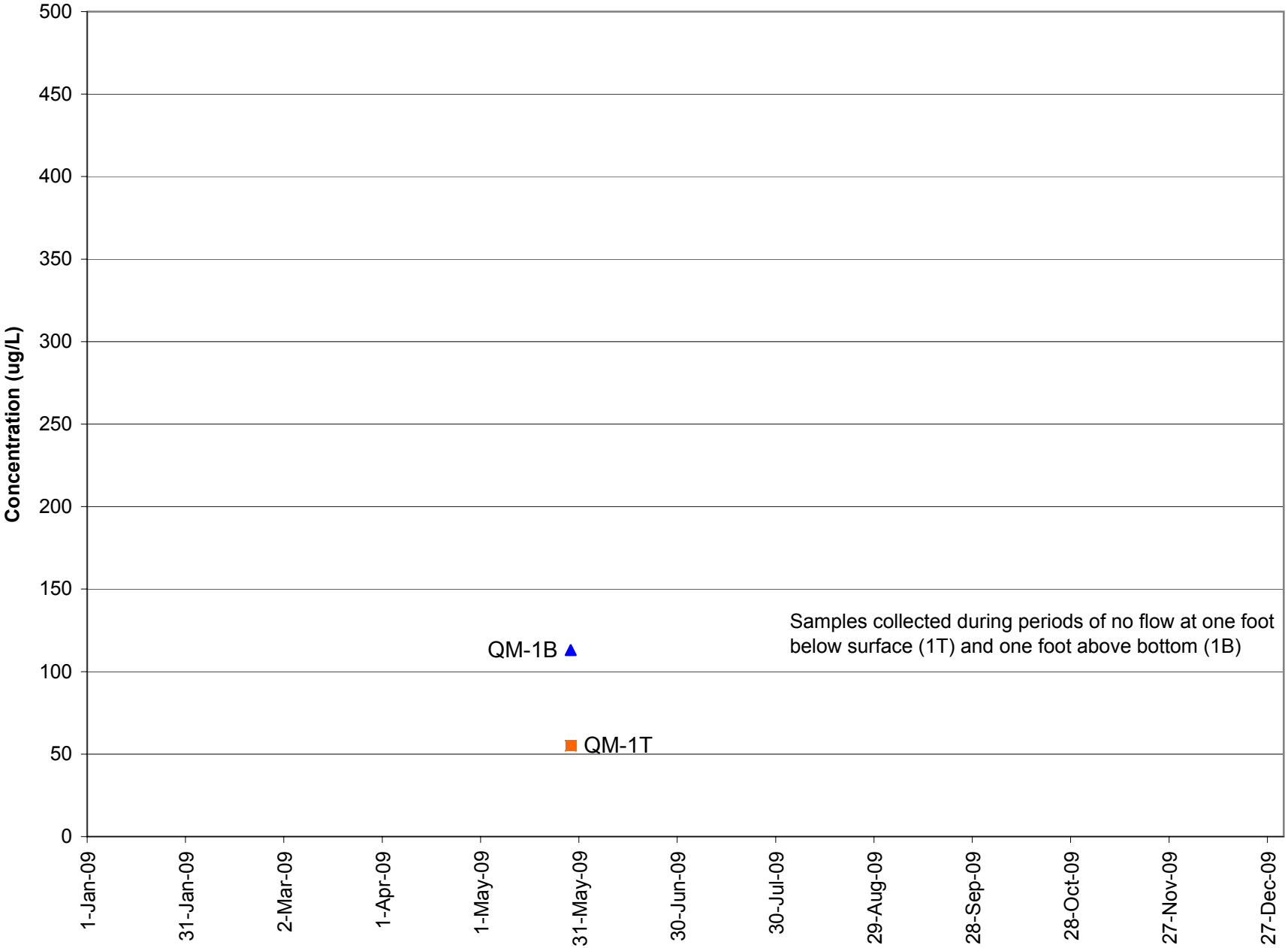
Long Term Discharge Study 2009
Mediterra QM-1
Chloride



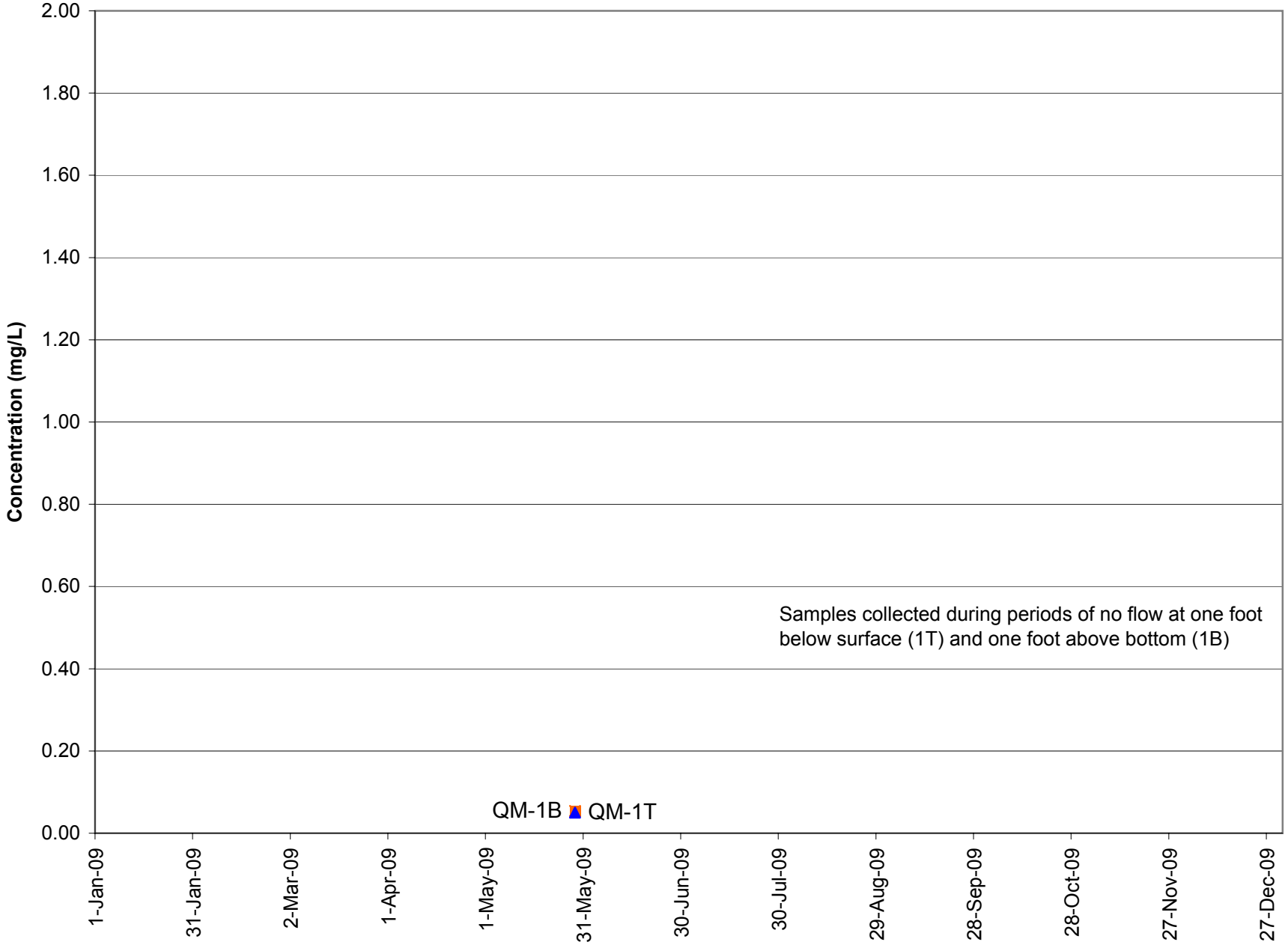
Long Term Discharge Study 2009
Mediterra QM-1
Copper



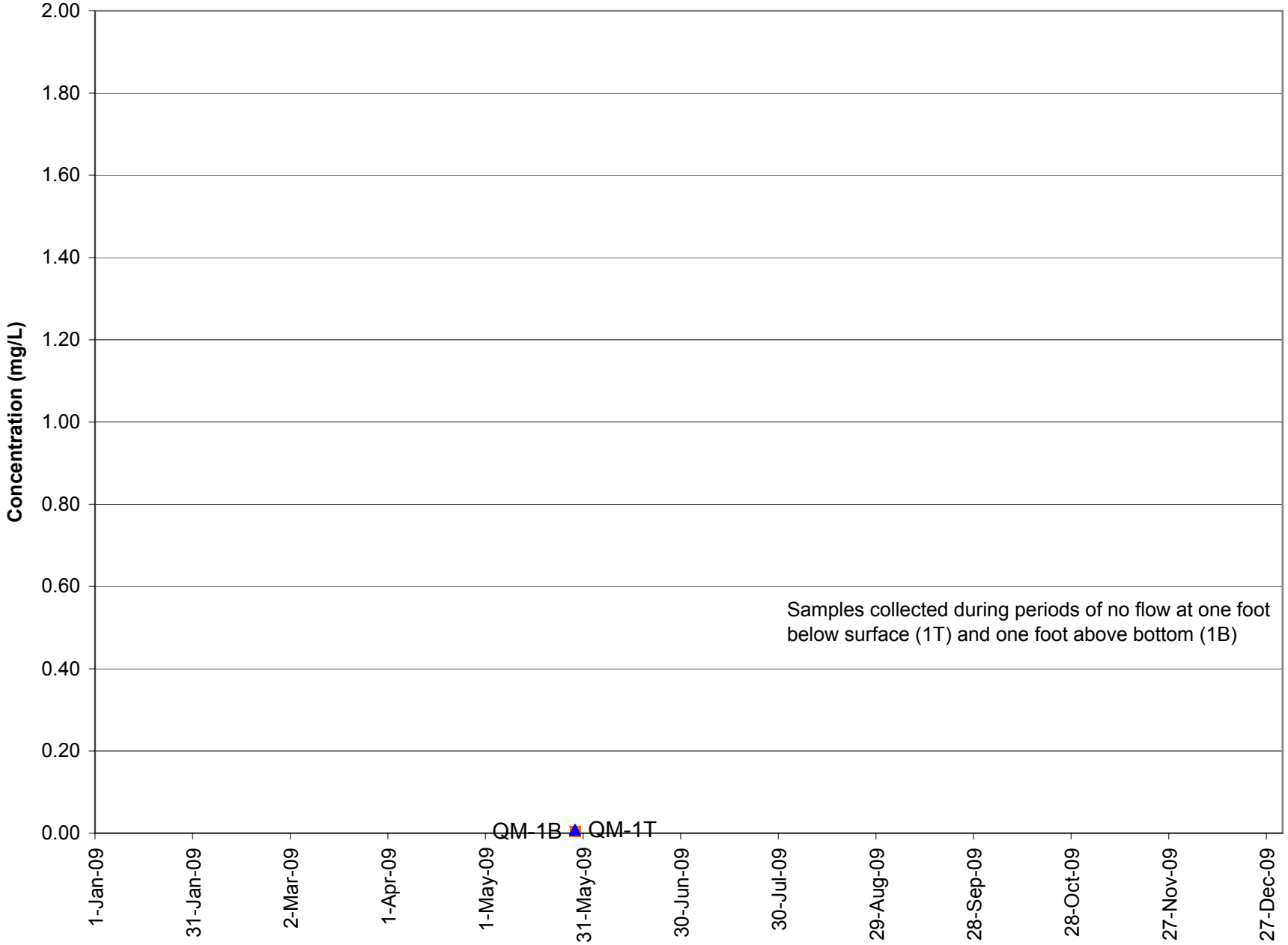
Long Term Discharge Study 2009
Mediterra QM-1
Iron



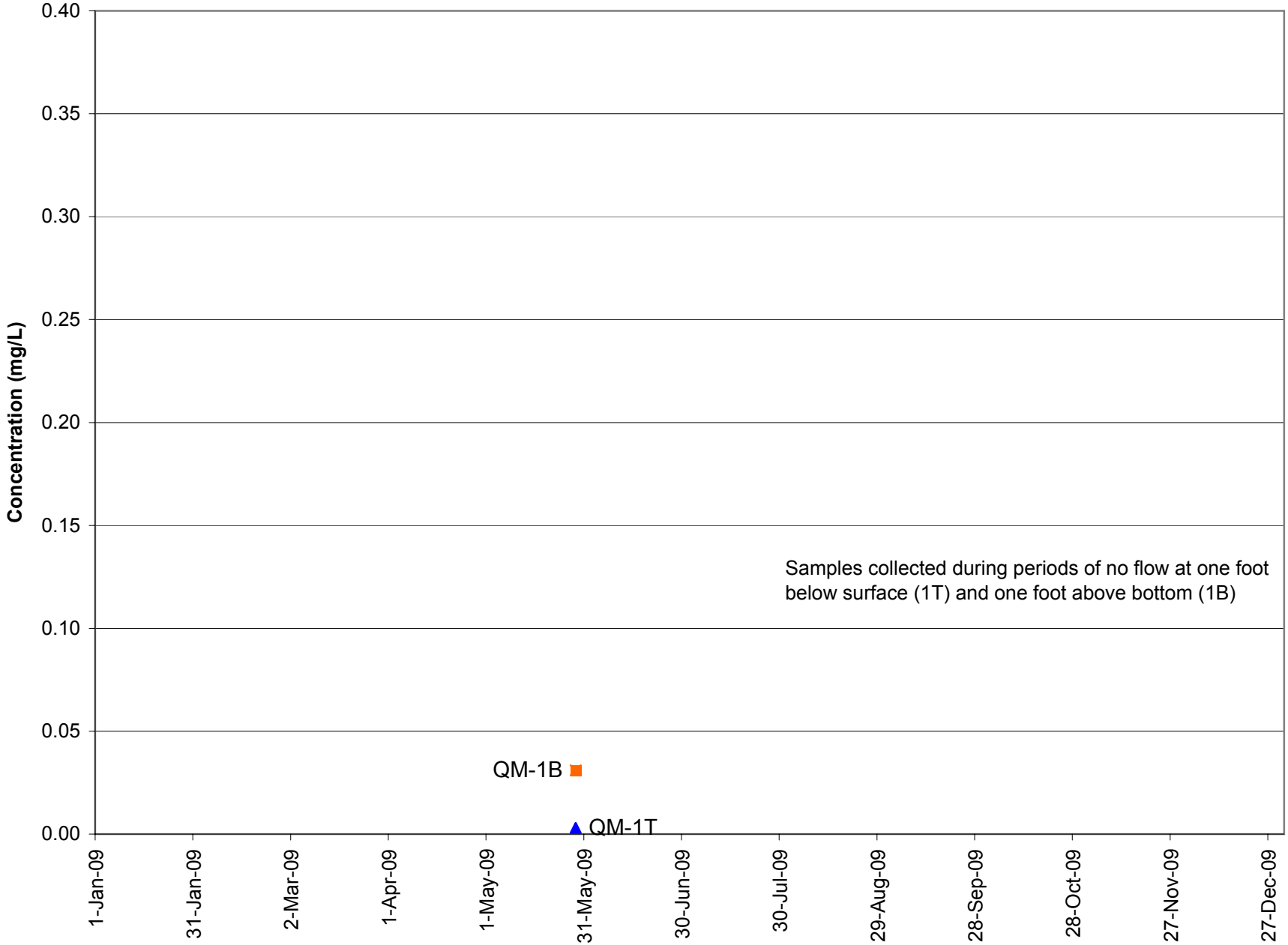
Long Term Discharge Study 2009
Mediterra QM-1
Ammonia Nitrogen



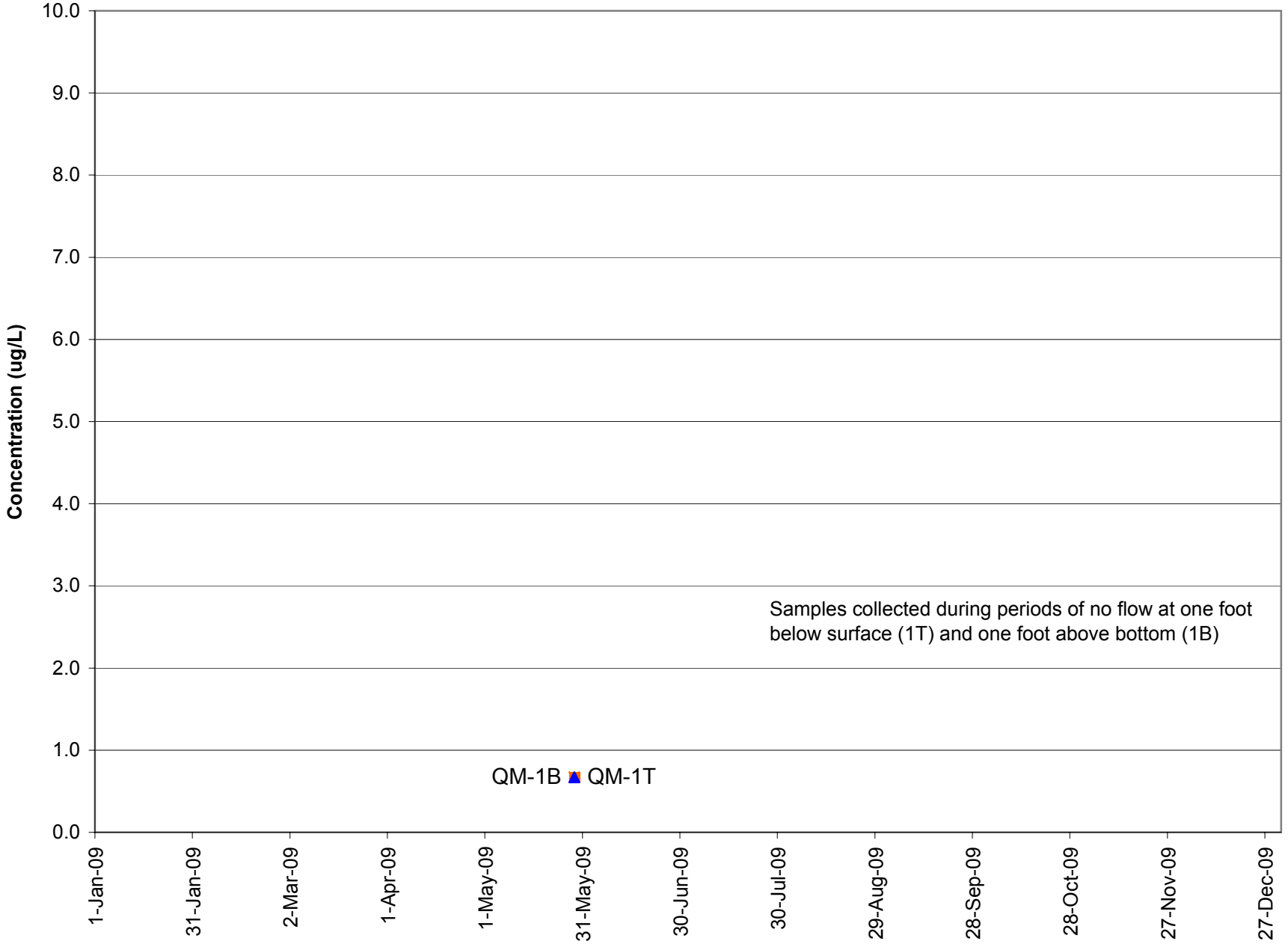
Long Term Discharge Study 2009
Mediterra QM-1
Nitrate + Nitrite



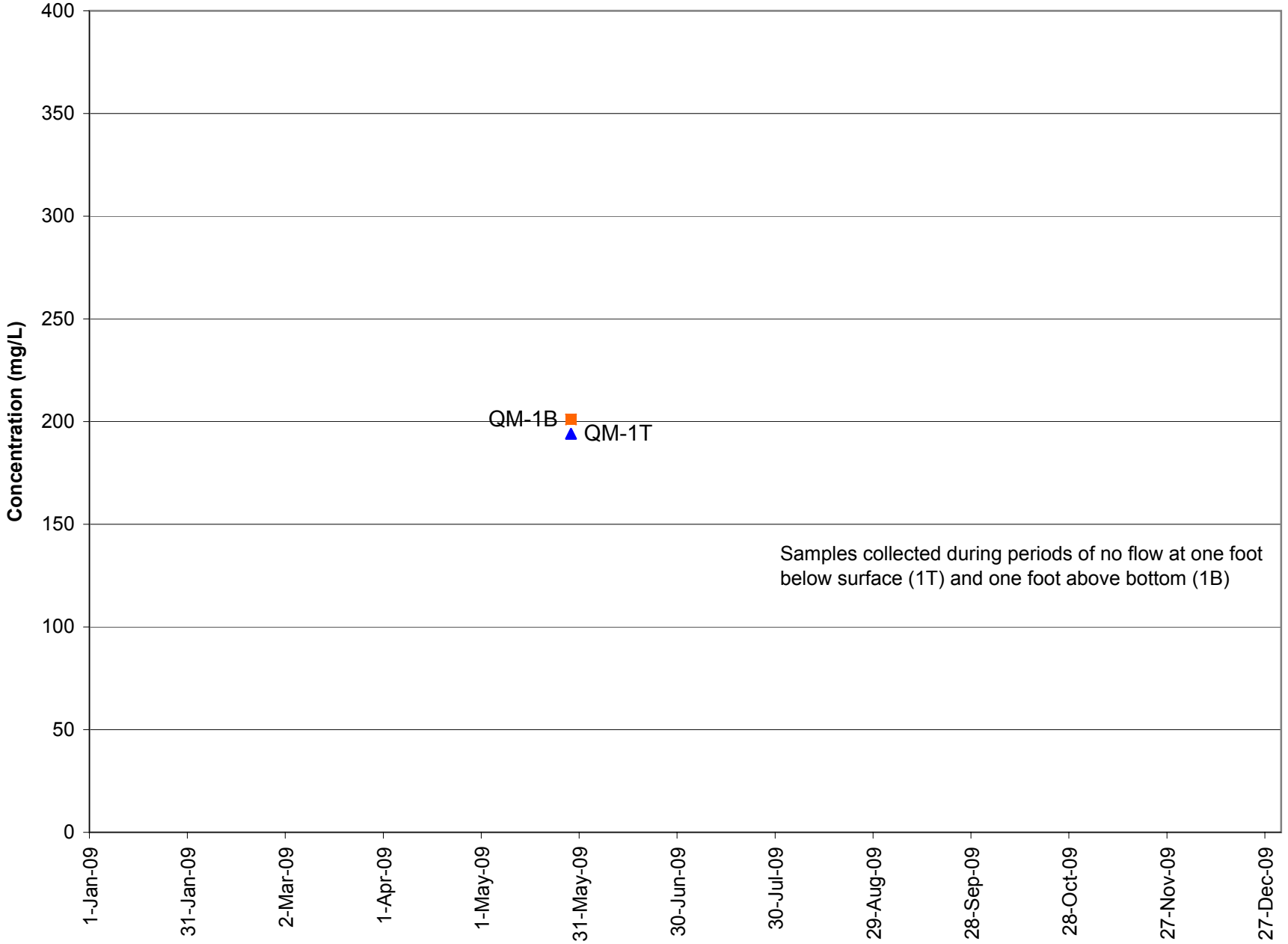
Long Term Discharge Study 2009
Mediterra QM-1
Ortho Phosphorus



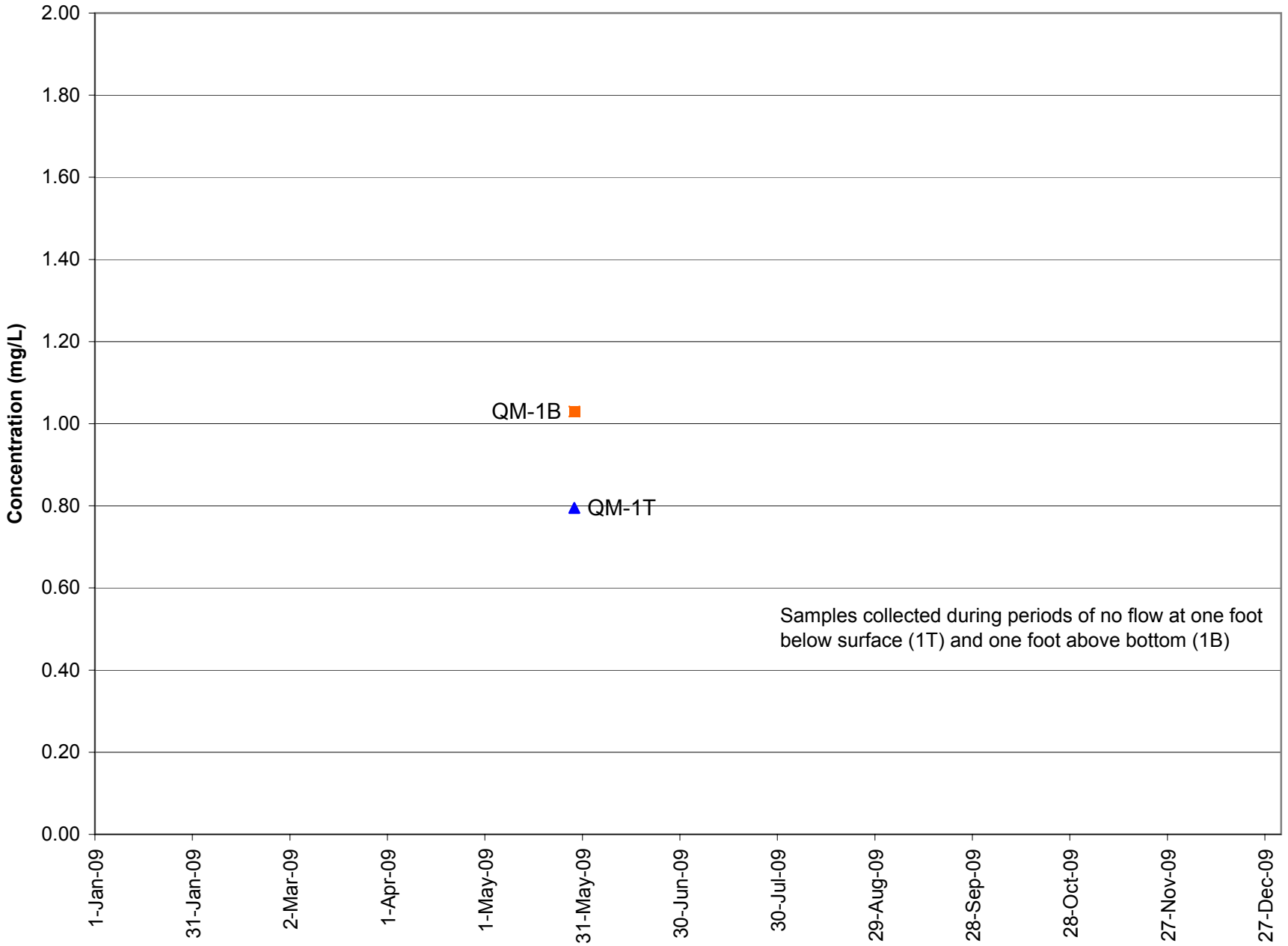
Long Term Discharge Study 2009
Mediterra QM-1
Lead



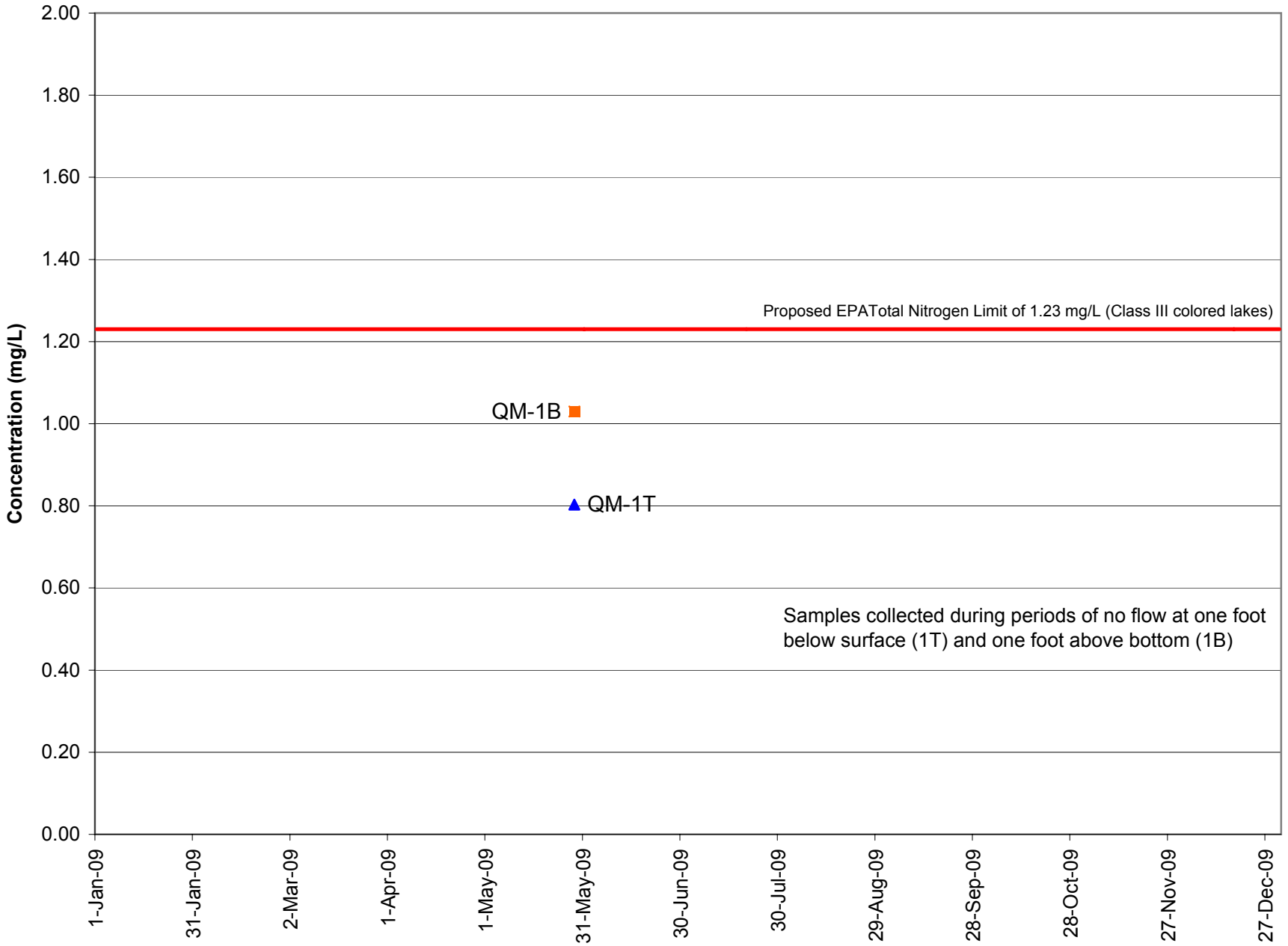
Long Term Discharge Study 2009
Mediterra QM-1
Total Hardness



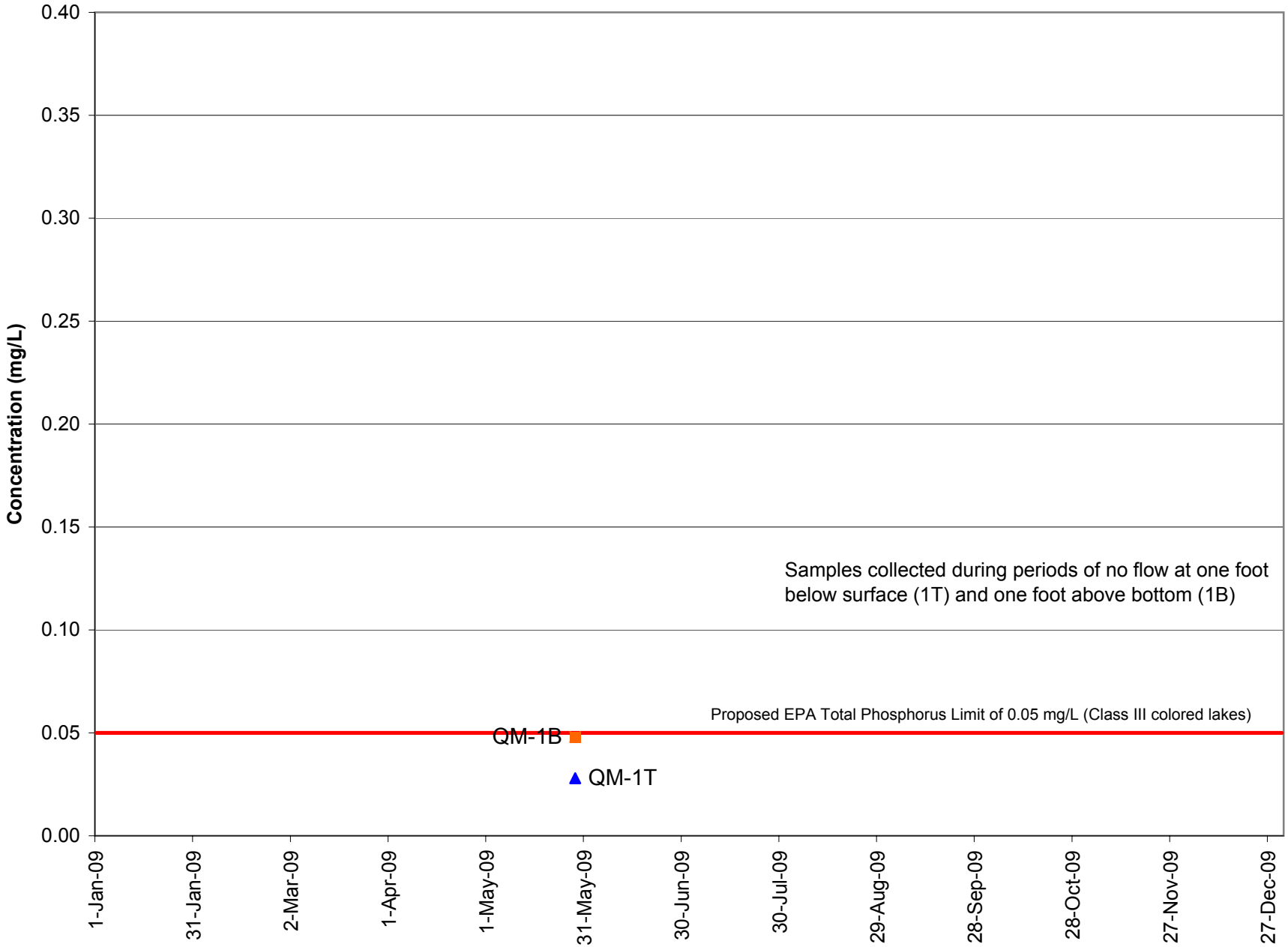
Long Term Discharge Study 2009
Mediterra QM-1
Total Kjeldahl Nitrogen



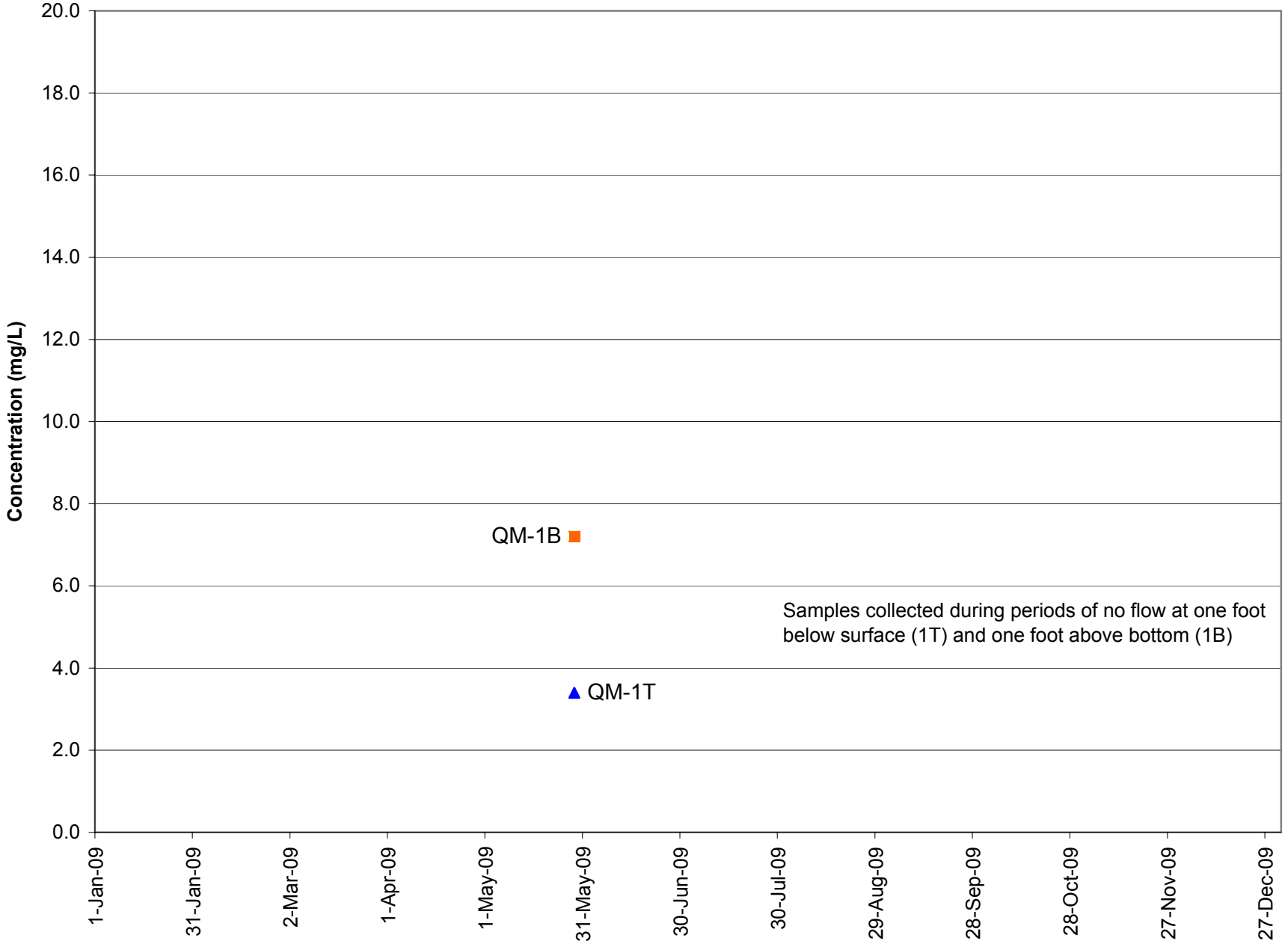
Long Term Discharge Study 2009
Mediterra QM-1
Total Nitrogen



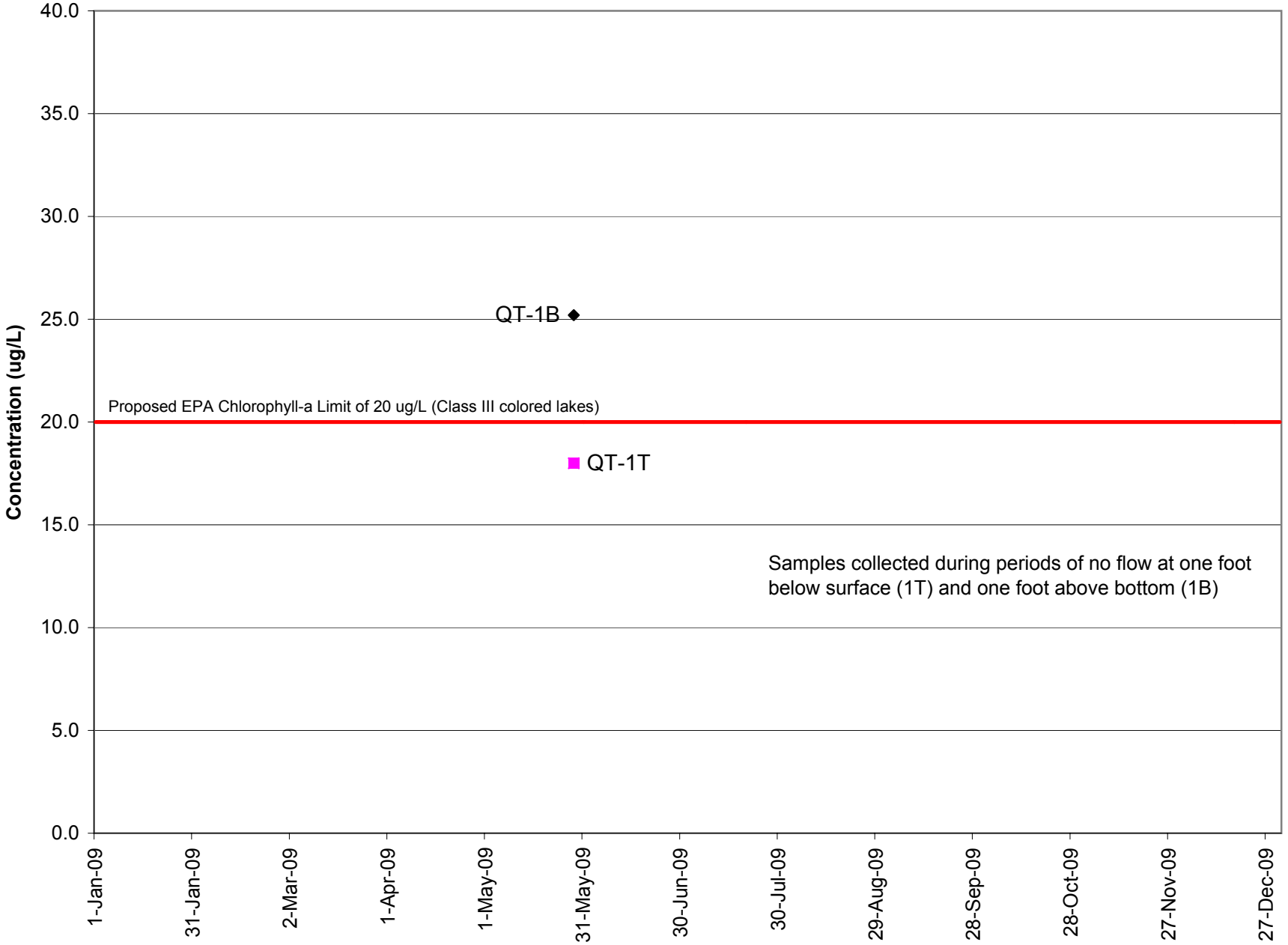
Long Term Discharge Study 2009
Mediterra QM-1
Total Phosphorus



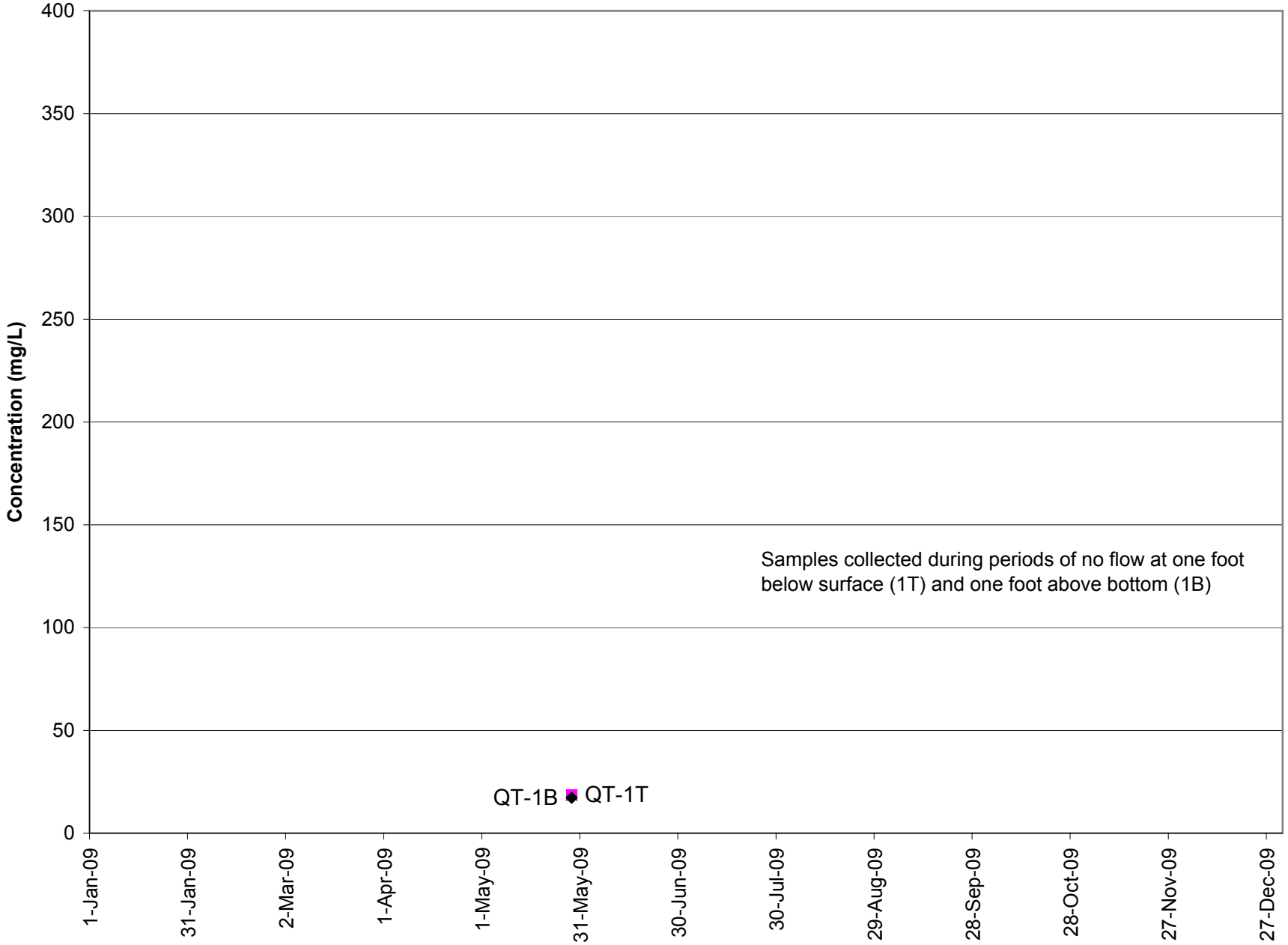
Long Term Discharge Study 2009
Mediterra QM-1
Total Suspended Solids



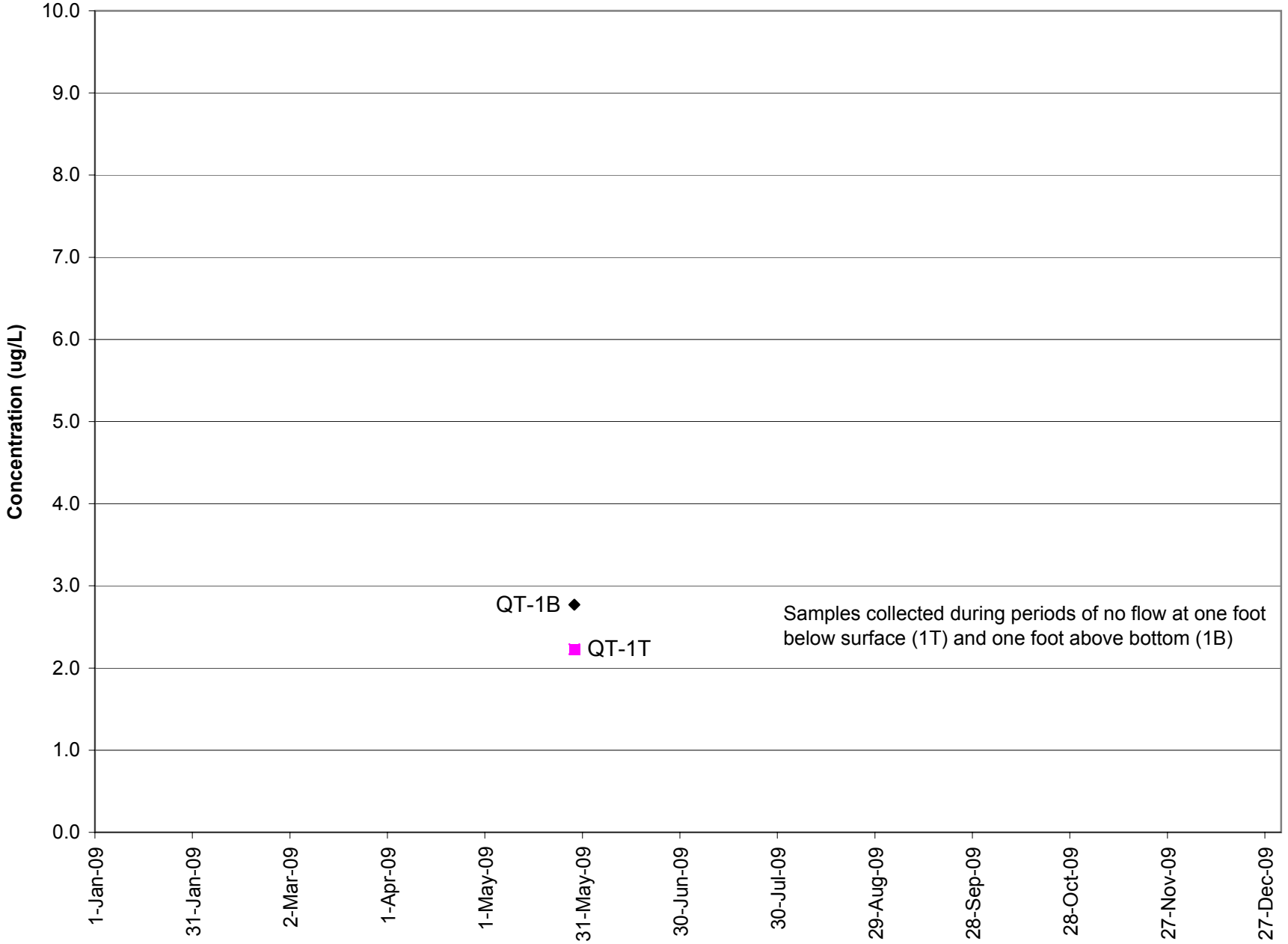
Long Term Discharge Study 2009
Twin Eagles QT-1
Chlorophyll-a



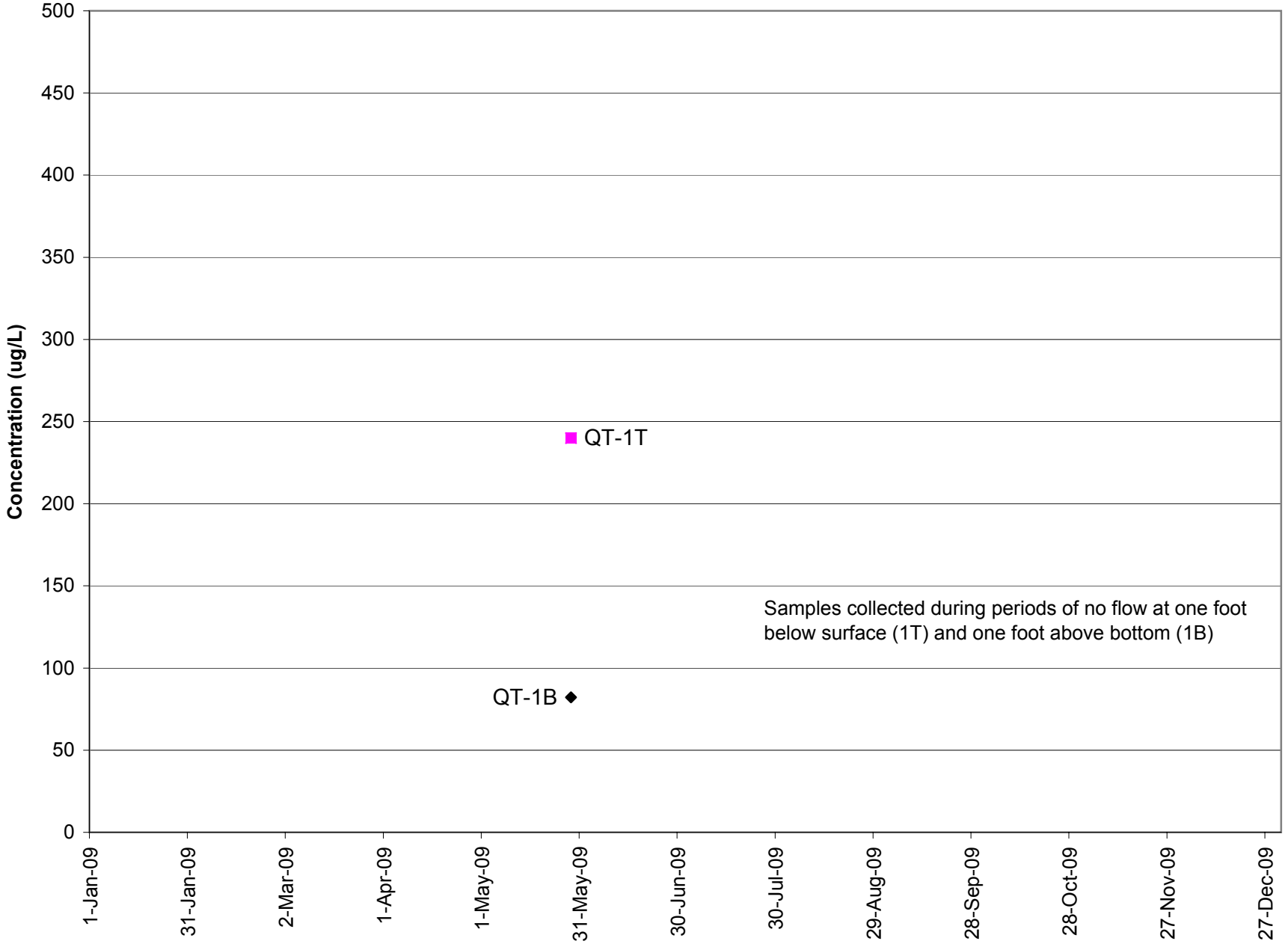
Long Term Discharge Study 2009
Twin Eagles QT-1
Chloride



Long Term Discharge Study 2009
Twin Eagles QT-1
Copper



Long Term Discharge Study 2009
Twin Eagles QT-1
Iron



Long Term Discharge Study 2009
Twin Eagles QT-1
Ammonia Nitrogen

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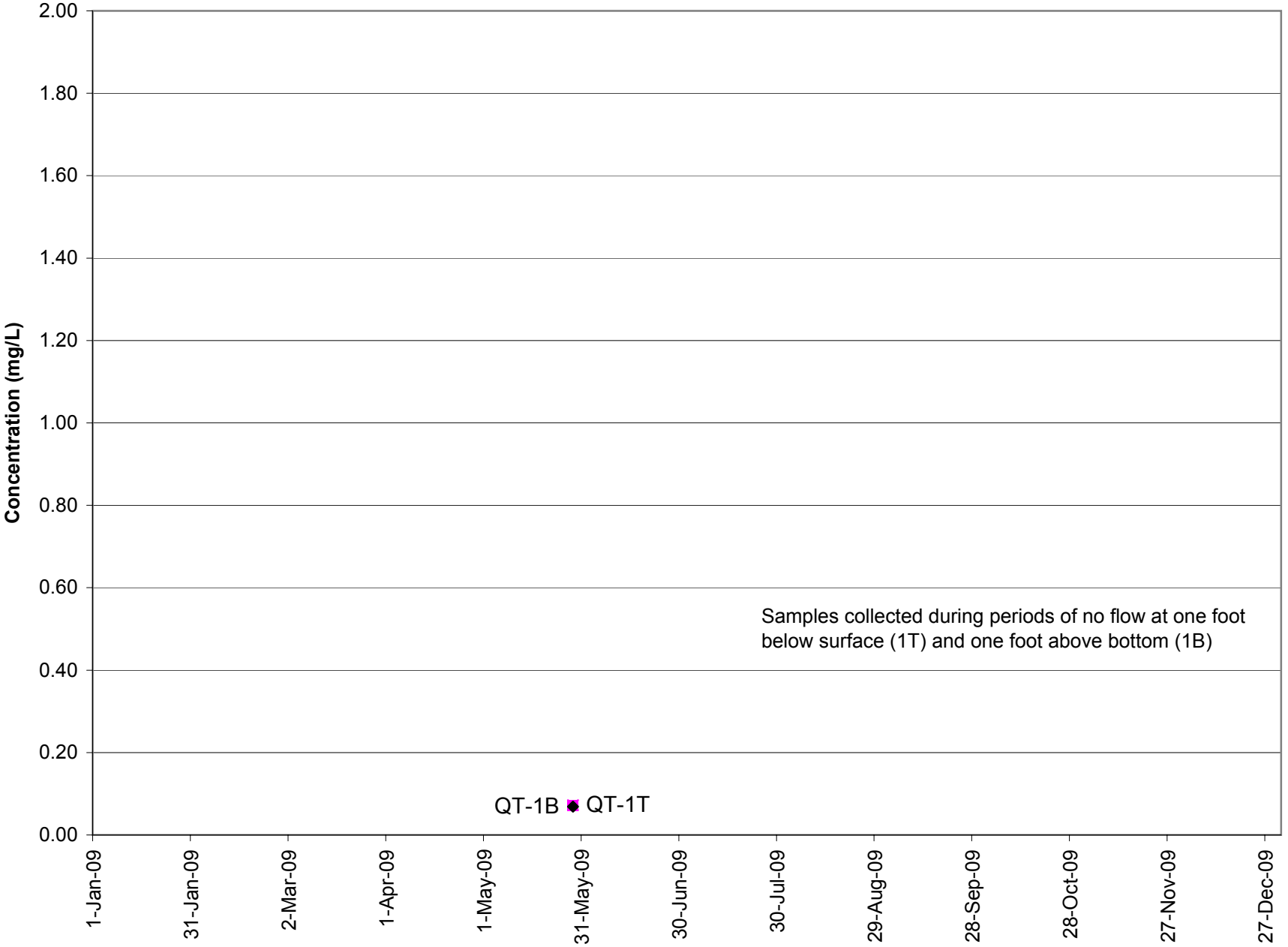
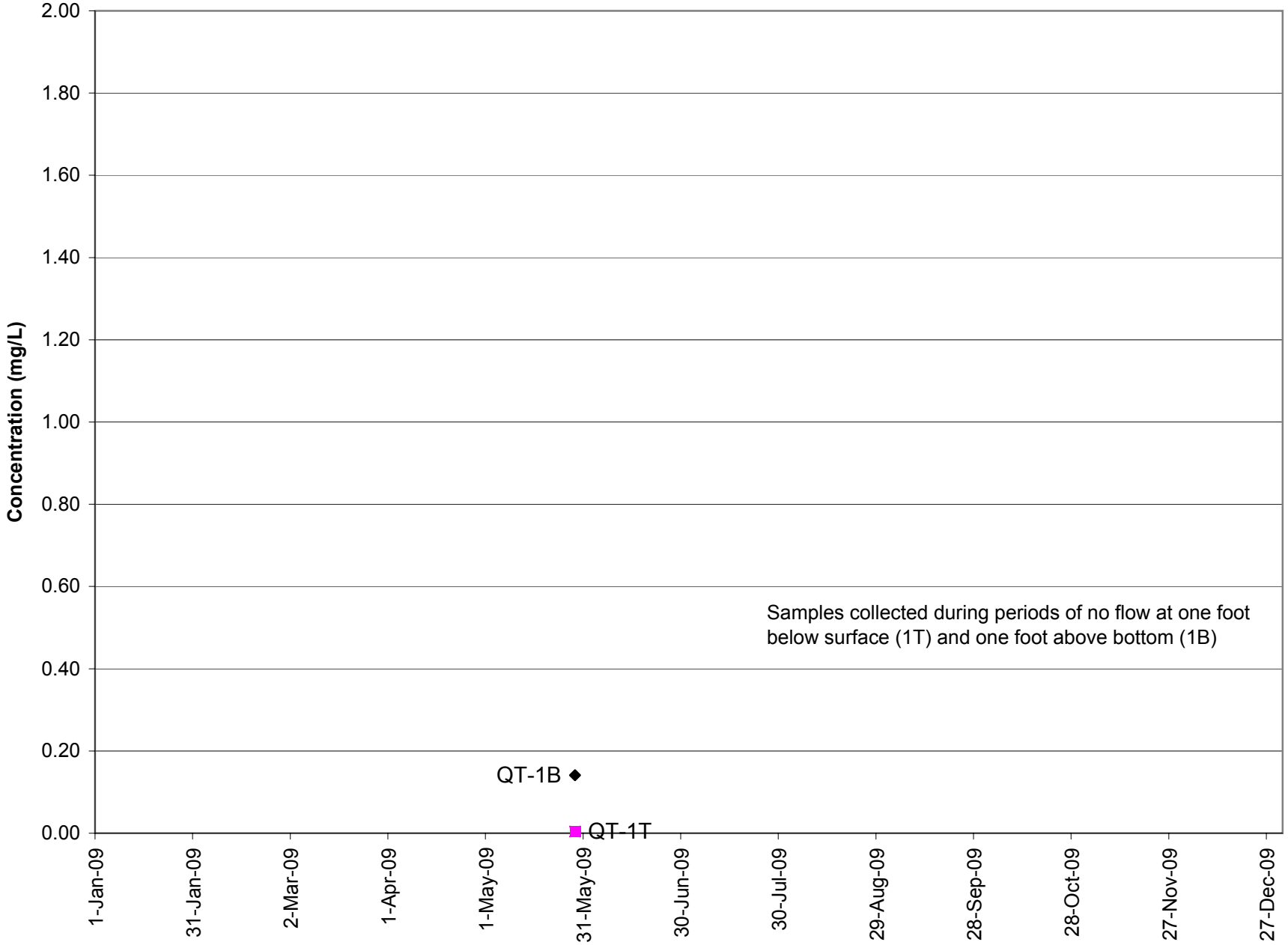
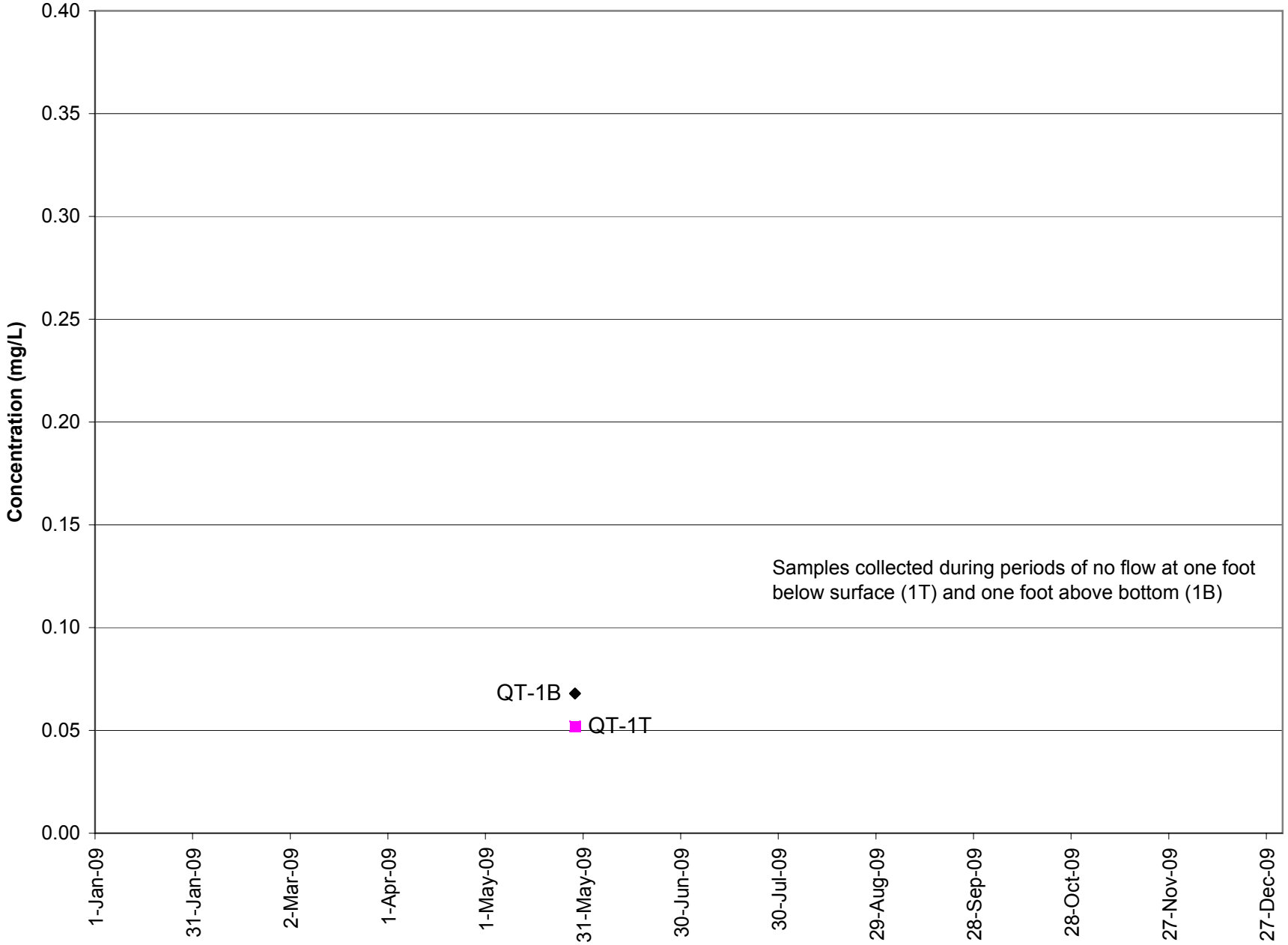


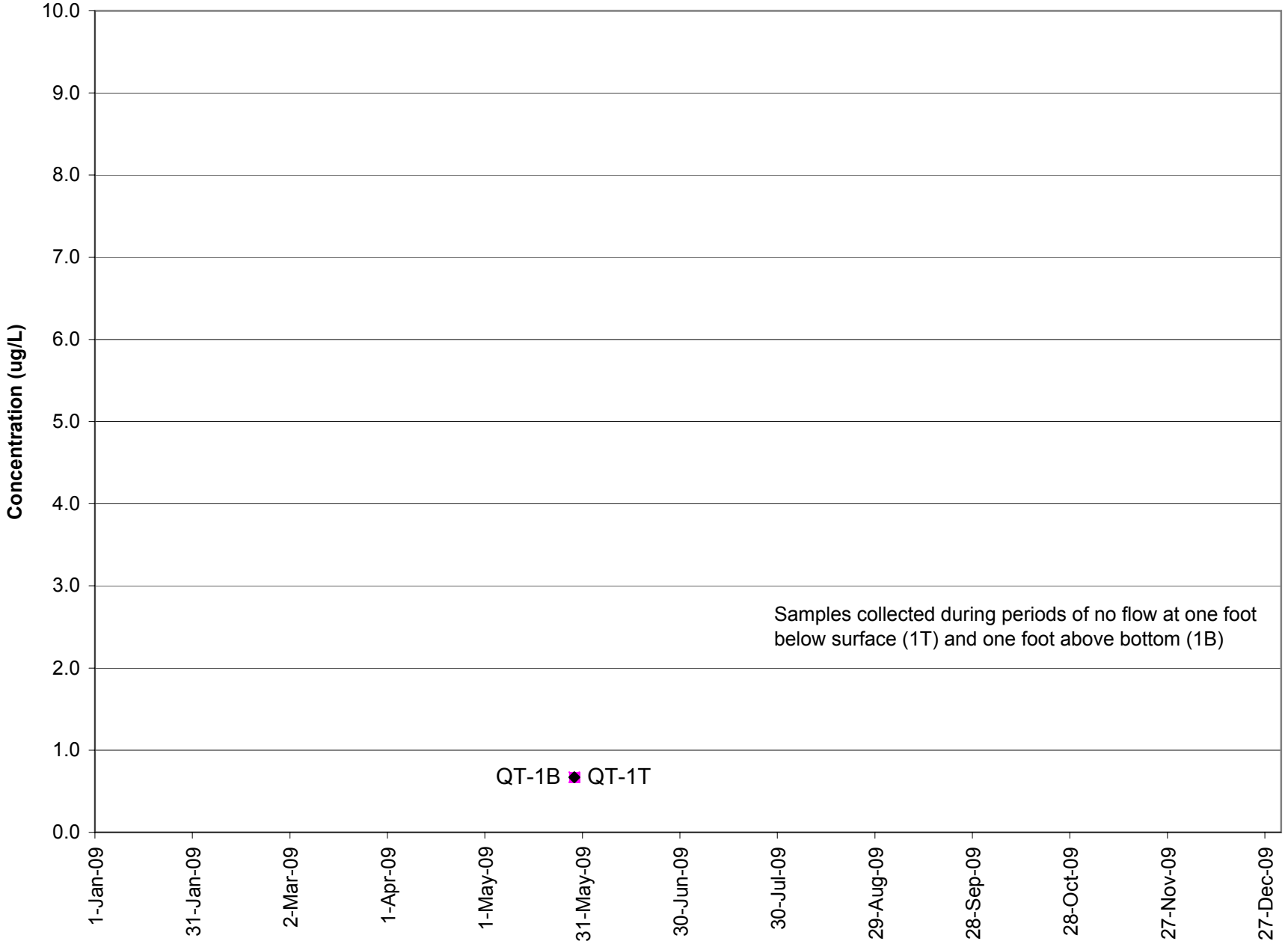
Long Term Discharge Study 2009
Twin Eagles QT-1
Nitrate + Nitrite



Long Term Discharge Study 2009
Twin Eagles QT-1
Ortho Phosphorus



Long Term Discharge Study 2009
Twin Eagles QT-1
Lead



Long Term Discharge Study 2009
Twin Eagles QT-1
Total Hardness

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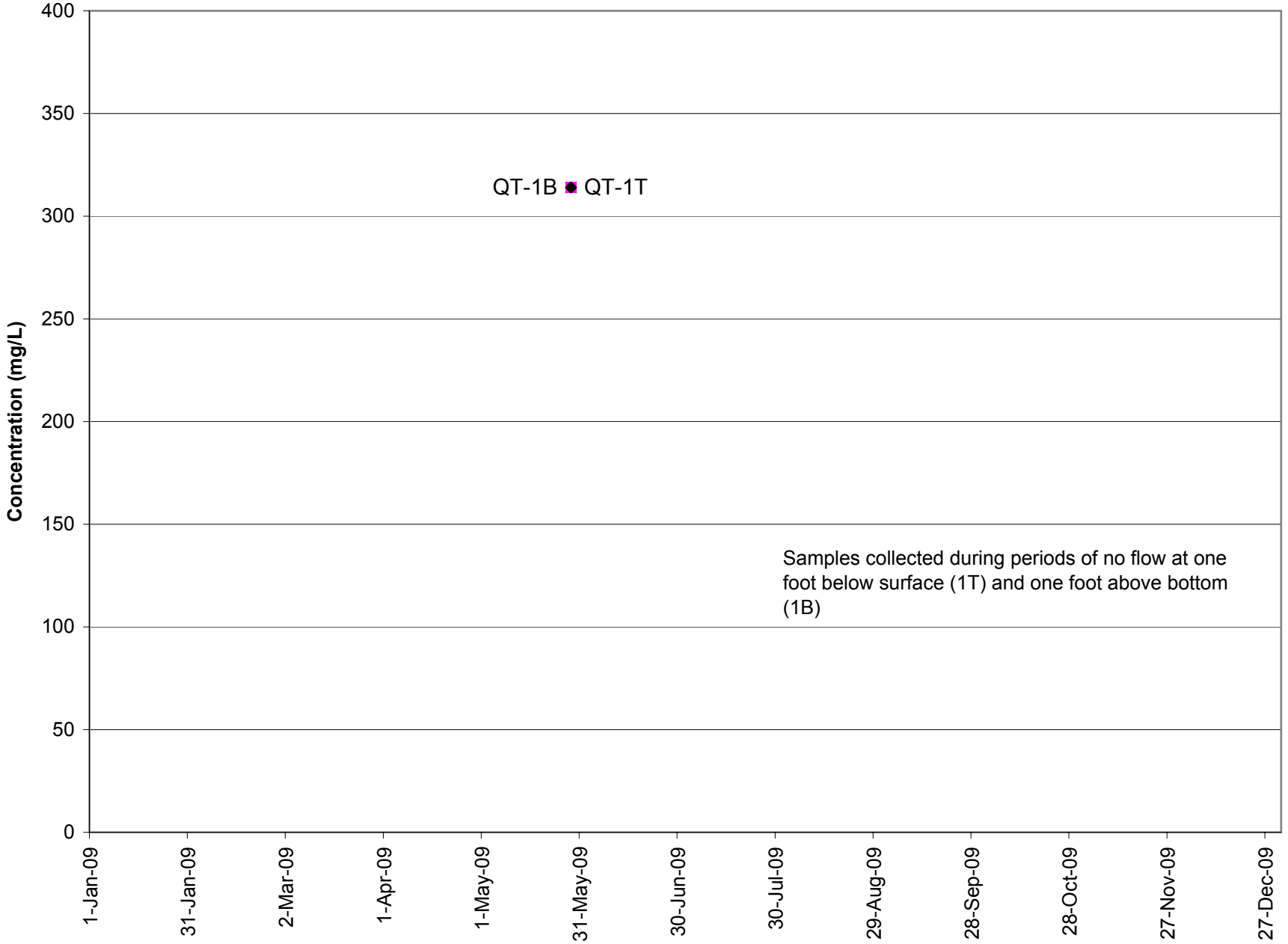
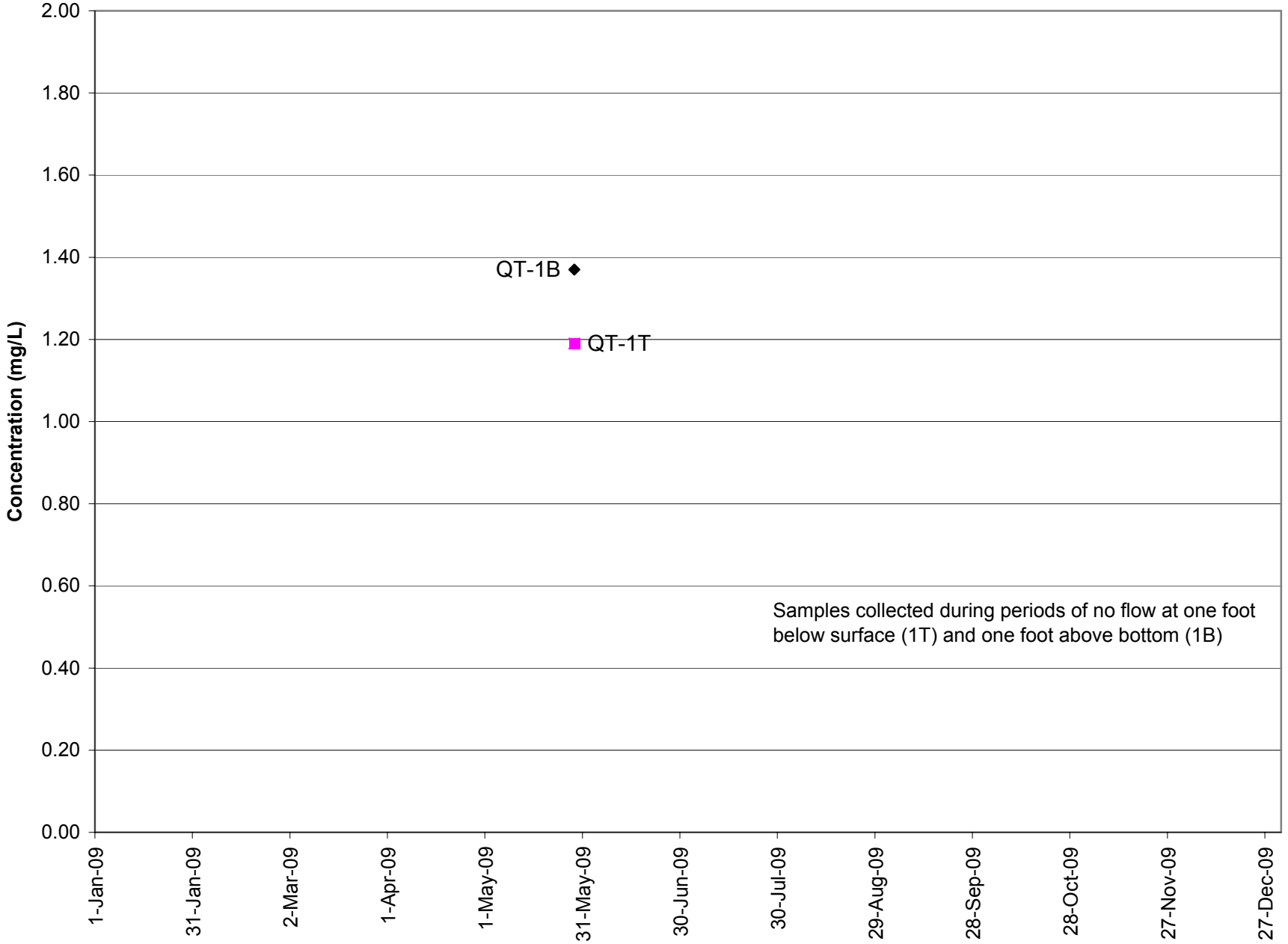
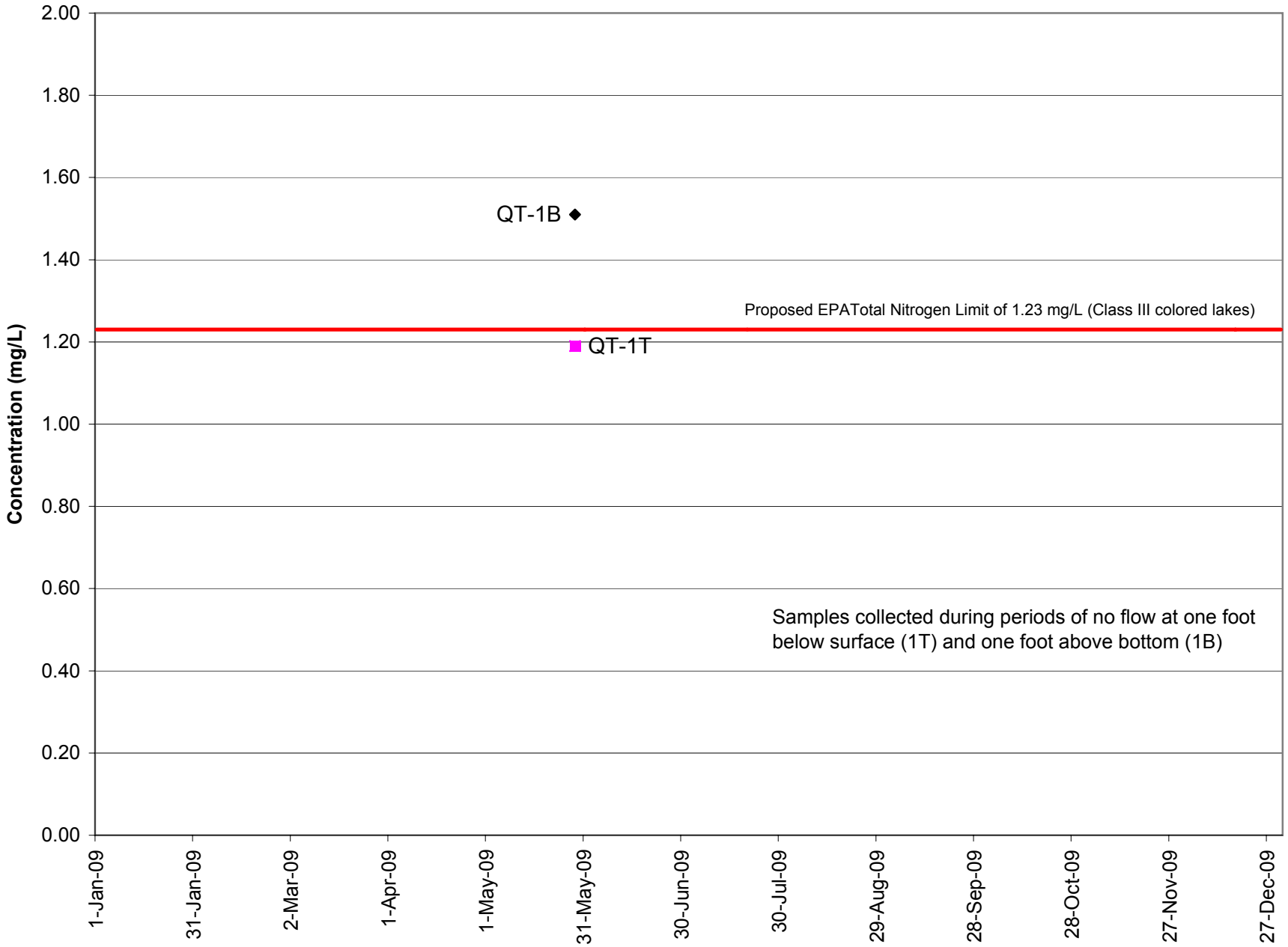


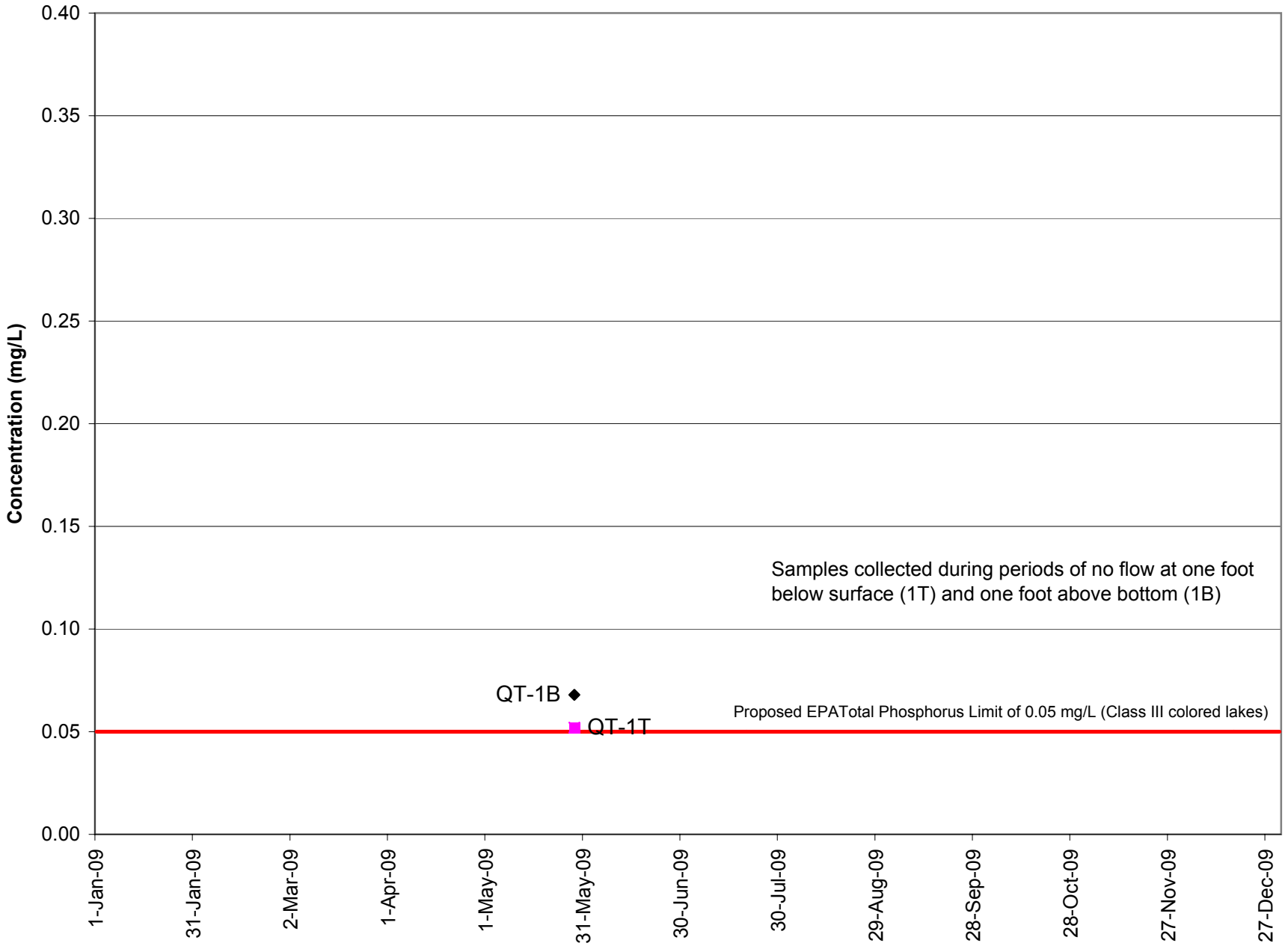
Long Term Discharge Study 2009
Twin Eagles QT-1
Total Kjeldahl Nitrogen



Long Term Discharge Study 2009
Twin Eagles QT-1
Total Nitrogen



Long Term Discharge Study 2009
Twin Eagles QT-1
Total Phosphorus



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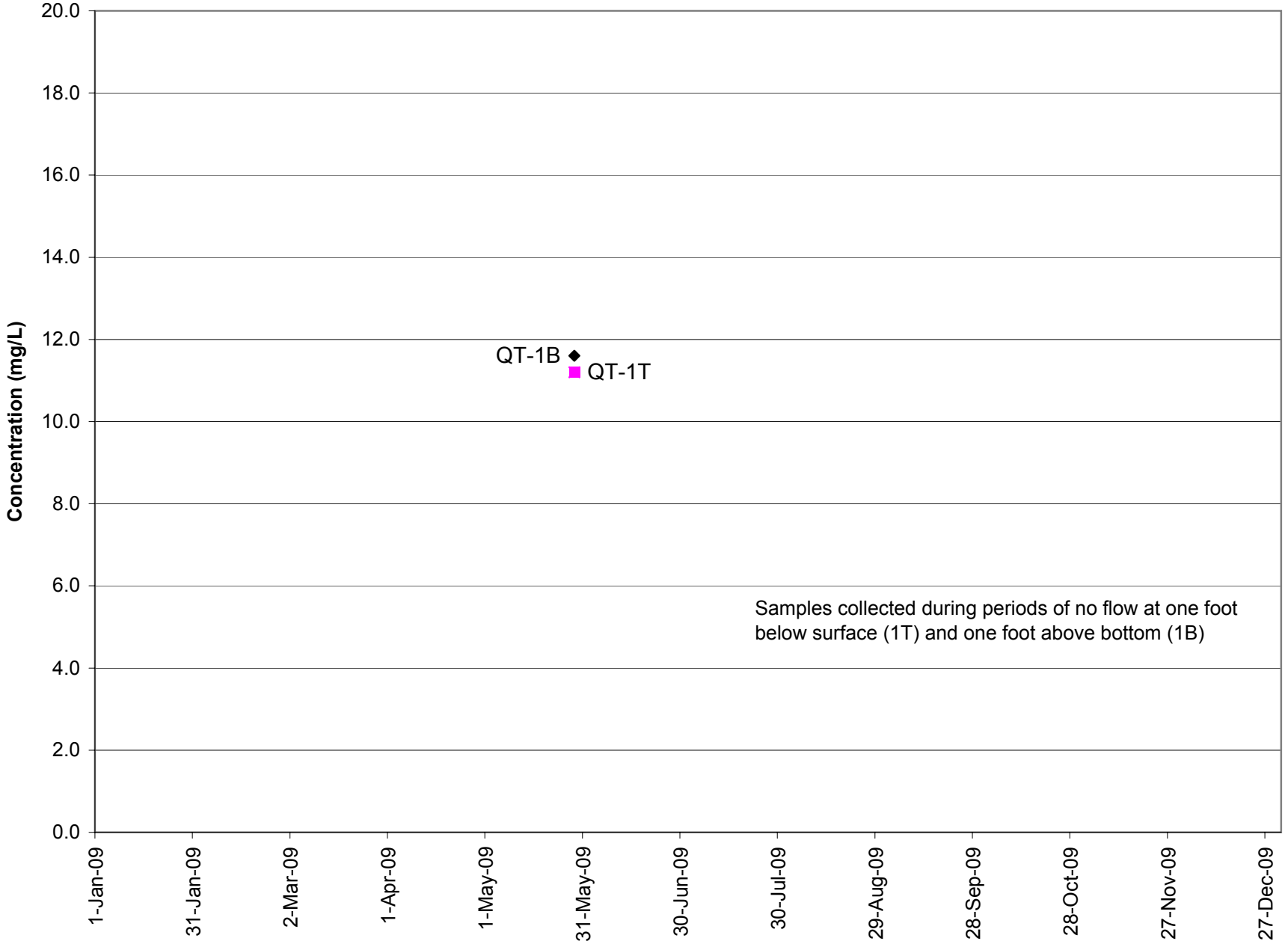
Long Term Discharge Study 2009
Twin Eagles QT-1
Total Suspended Solids



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Front cover: Sandoval community in Cape Coral, Florida at outfall structure WS-2 with rain and water level gages in left foreground. Photo taken September 13, 2008

Back cover: Discharge from Sandoval outfall WS-1. Photo taken September 13, 2009.

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