Monitoring Stormwater at a Permeable-Paver Parking Lot: A Student Laboratory at Elmhurst College

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Project Overview

- Permeable-Paver parking lot
- Adjacent to college residence hall (West Hall)
- Stormwater Monitoring and Collection
- Water Analysis
- Curricular Development
- A student laboratory

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Why Are We Interested in This Project?

- Elmhurst College's Strategic Plan 2009-2014 includes our commitment to environmental sustainability.
  - "respect the environment and foster sustainability" (Stewardship)
  - "how does the College address environmental sustainability" (Issue Four)
- Elmhurst College actively addresses sustainability in our curricular offerings and in student/faculty research.
- This project fits well with our new LEED-certified (gold) residence hall (West Hall).
- This project provides a natural laboratory for study of relevant, real world environmental problems.
- This project can engage students and faculty at many levels.

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Sustainability: A New Paradigm

(lessons learned from Sustainable Design)

- Sustainability: The Brundtland Report
  - development that meets the needs of the present without compromising the ability of future generations to meet their own needs
- Triple Bottom Line: Economy, Environment, Societies
- Genuine, high student interest
- Beyond environmental awareness
- Beyond regulation
- Beyond green

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A New Paradigm

(lessons learned from Green Chemistry)

- Addresses hazards rather than controls (exposure)
- Is economically driven rather than economically draining
- Is non-regulatory
- Prevents problems before they occur
- Considers the full life cycle impacts at the design stage

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Sustainability in the Curriculum

- First Year Seminar Courses
  - *Local Choices, Global Effects*
  - *Water*
  - *Energy*
- Environmental Issues Courses (CHM and BIO)
- *Sustainability and Green Chemistry* (nonmajors)
- *Green Chemistry* (majors)
- *Environmental Ethics*

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Development of the Project

- West Hall planning (Wight & Company)
  - ENL as interim Dean
  - Permeable-paver parking lot
  - Bioswales and prairie plantings
- West Hall as a model of sustainability
  - LEED certification (eventually gold level)
  - Signage
  - Water collection & analysis: a student laboratory

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West Hall Area as Student Laboratory

- All types and levels of students
  - Science majors (chemistry, biology)
    - First year students
    - Advanced students
  - Non-science majors
  - Secondary school students and teachers
  - Elementary students

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Opportunities for Study

- Sustainability and green design (LEED)
- The system itself
- Rainfall measurement
- Water collection thresholds
- Water analysis
- Plant / soil studies and research

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Water Analysis at Many Levels

- Test Strips
- Testing Kits
- Analytical Chemistry techniques
  - Wet Chemistry (*e.g.* titrations, standard curves)
- Instrumental Analysis
  - Spectrophotometry
  - Ion Selective electrochemistry
  - Atomic Absorption
  - Ion Conductivity

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The Water Monitoring System (ISCO)

- Flow Module 2150 w/ Battery Module 2191
- Interface Module 2105
- Sampler, 24-bottle 6712
- pH/Temperature Probe 701
- Rain Gauge 674
- Flow Logger 4120
- Flow Link 5.1 Software
- Storm Box

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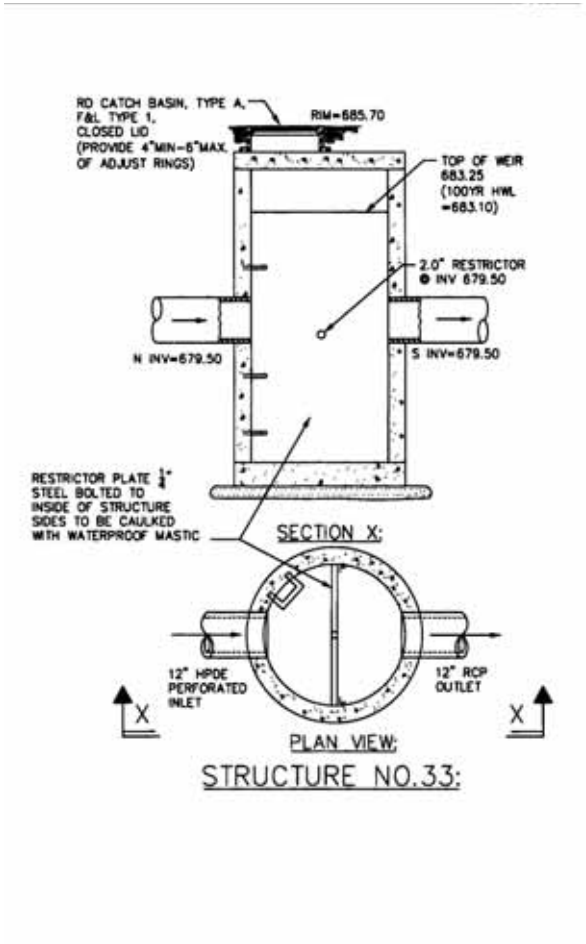
Collection Basin



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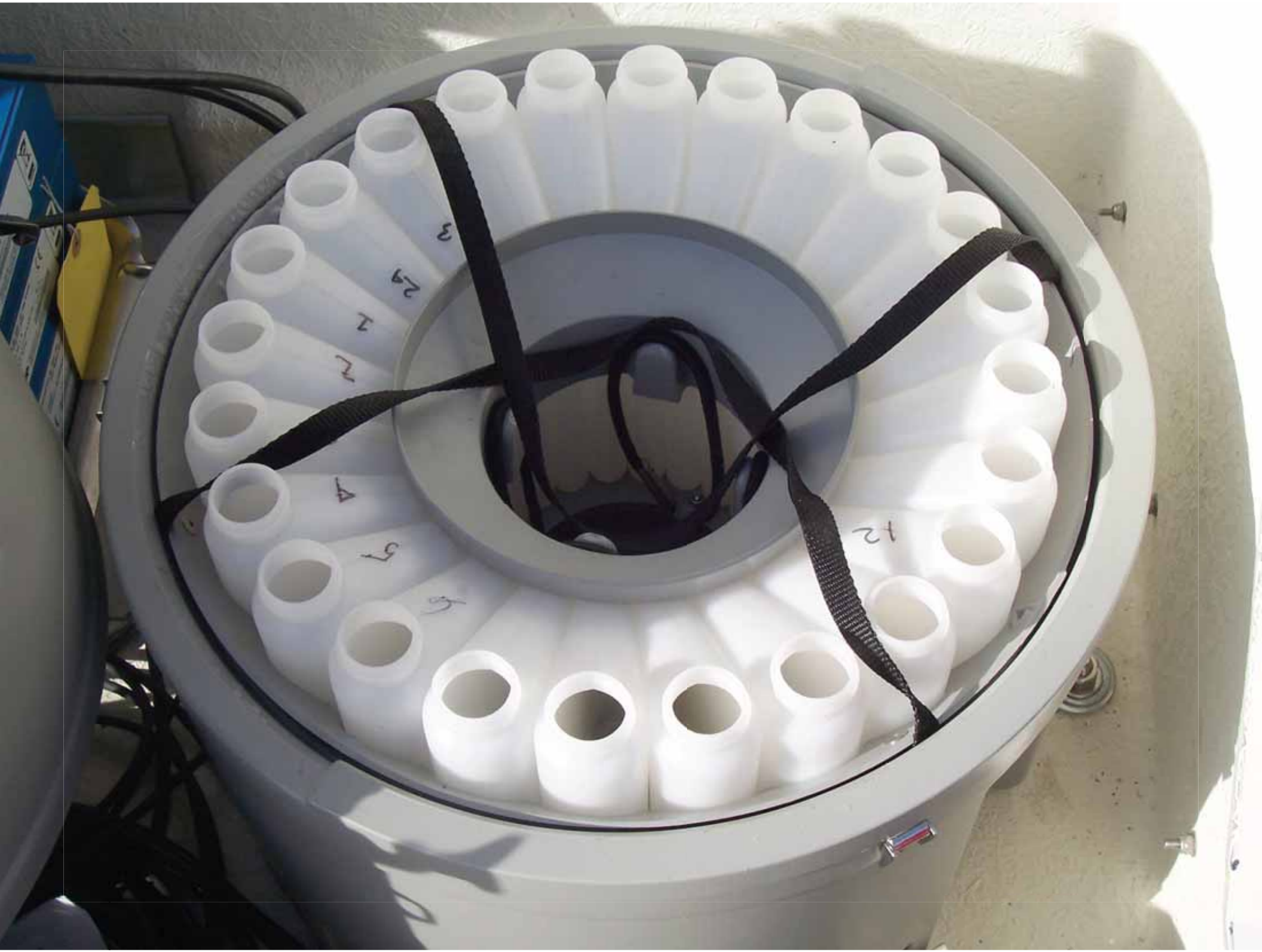
9712
ISCO



Data and Results

- Rainfall, Flow and Water Collection
- Water Analysis

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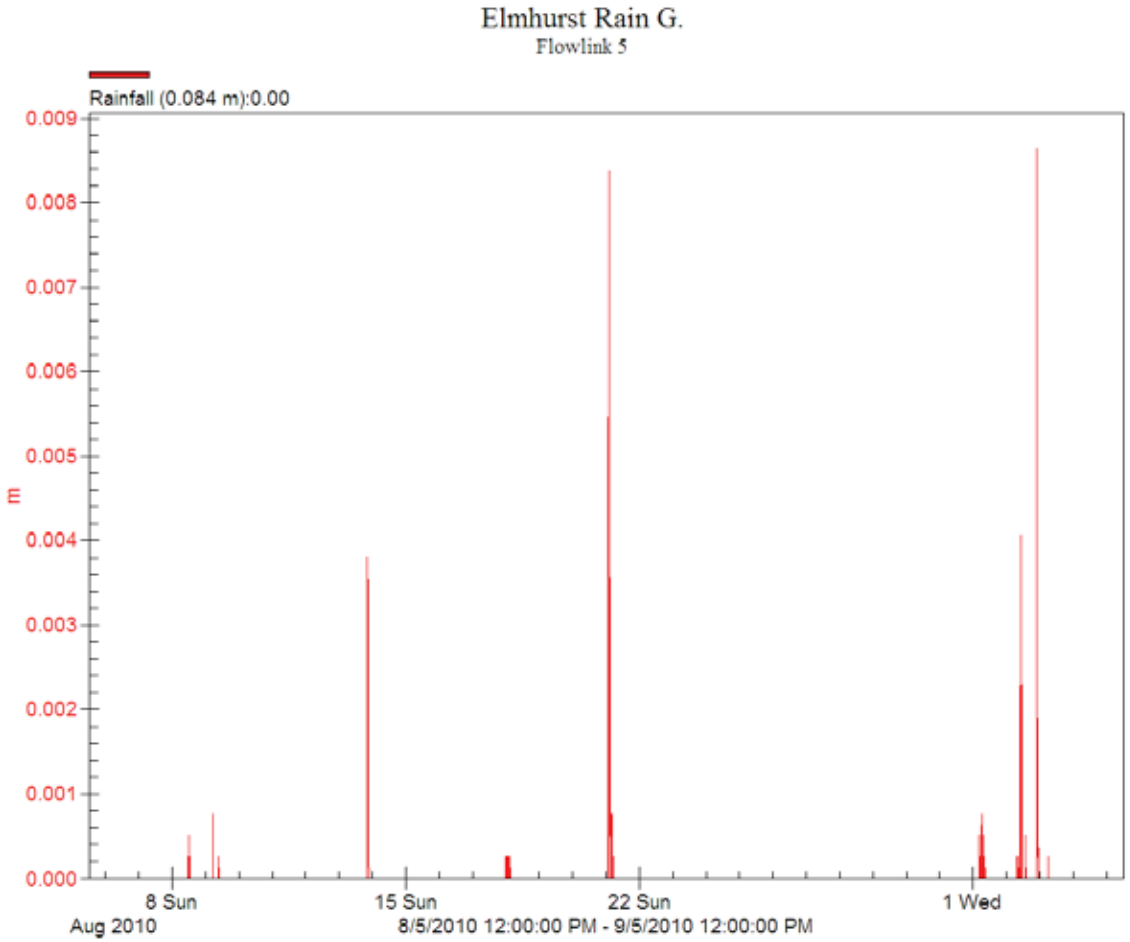
Rainfall – One Month



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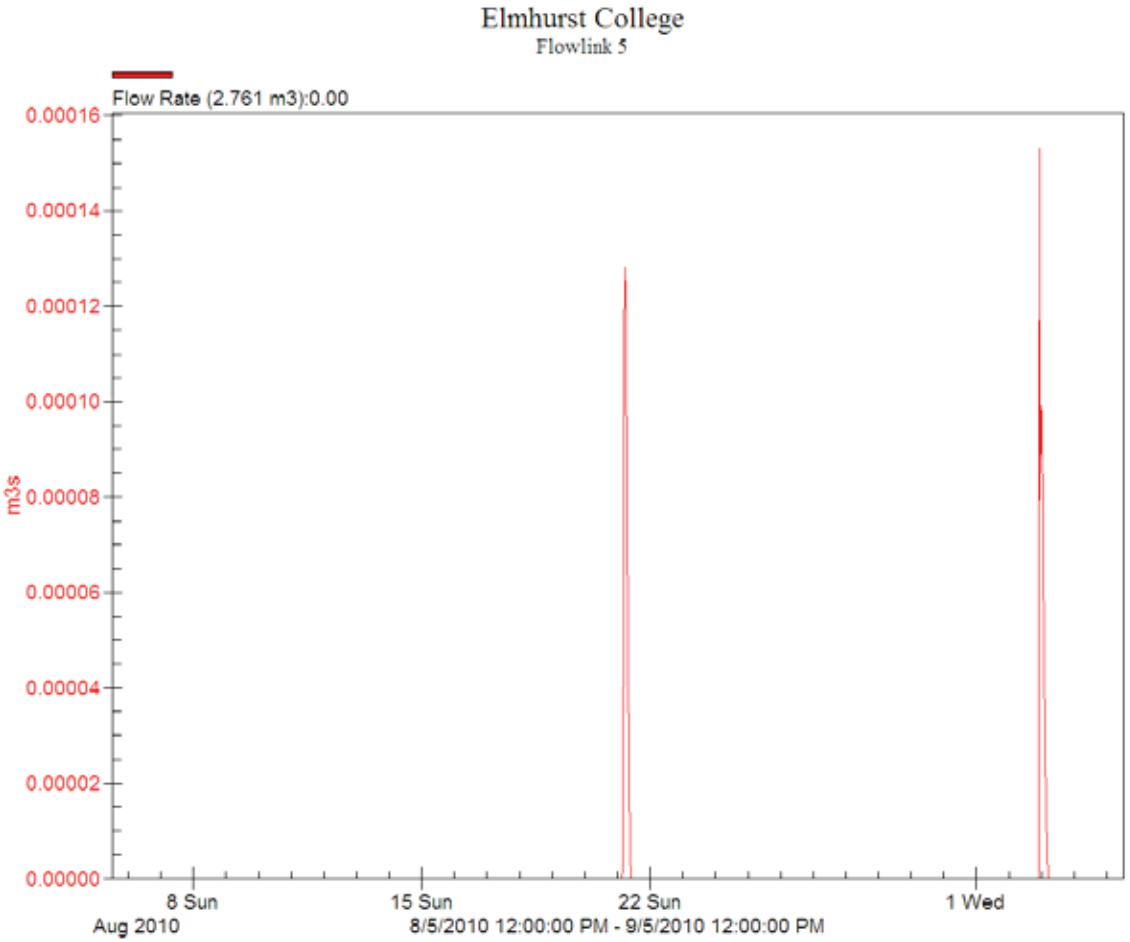
Flow – One Month



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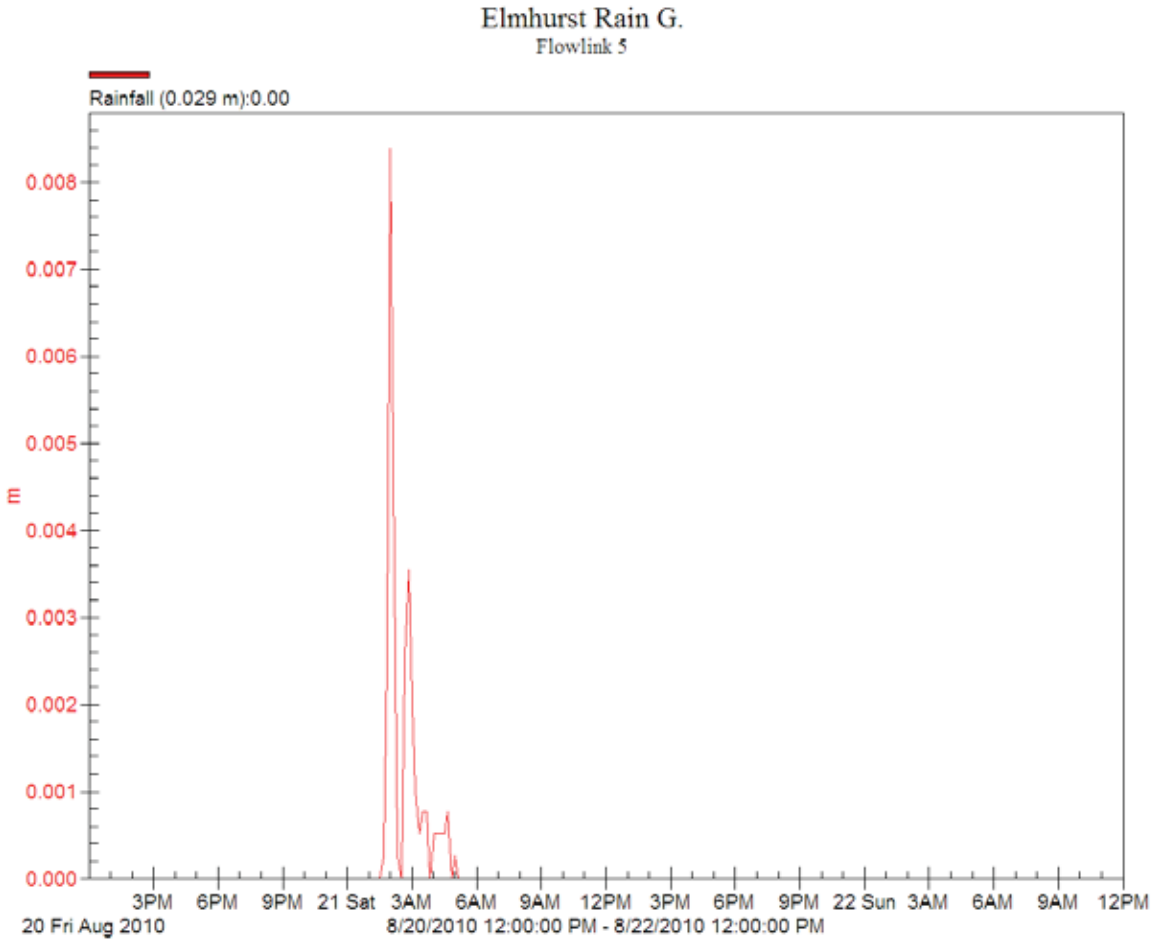
Rain – 2 Day



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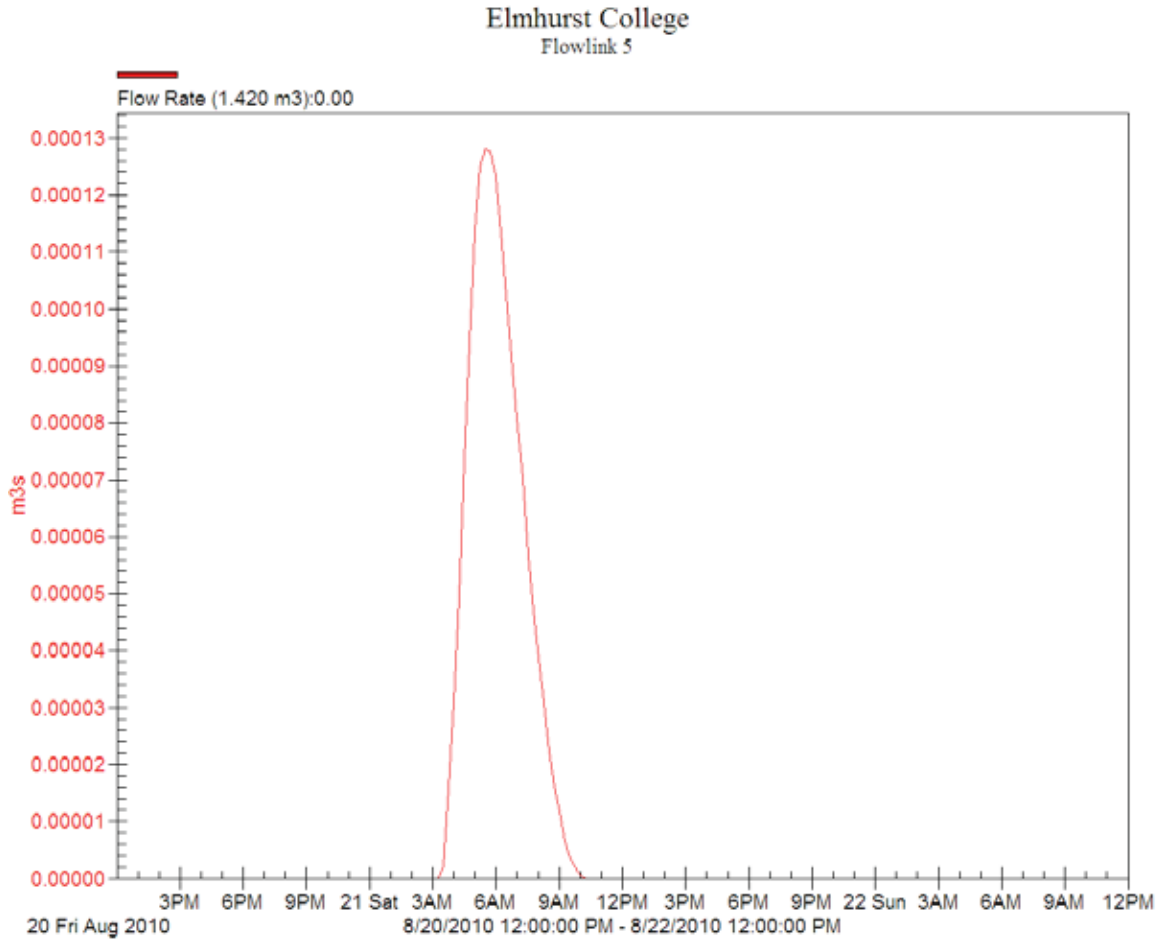
Flow – Two Days



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Rainfall, Flow and Water Collection

Date (2010)	Total Rainfall (m, in)	Flow/Sample Collection
7/6 - 7/7	0.019, 0.750	No
7/8 - 7/11	0.002, 0.078	No
7/11 - 7/13	0.011, 0.433	No
7/22 – 7/26	0.165, 6.50	Yes
8/2 – 8/3	0.045, 1.78	Yes
8/4 – 8/5	0.018, 0.820	Yes
8/13 – 8/14	0.009, 0.354	No
8/20 – 8/22	0.029, 1.150	Yes
9/1 – 9/2	0.014, 0.551*	No*
9/2 – 9/3	0.021, 0.827* (0.035. 1.378)**	Yes*
9/10 – 9/11	0.004, 0.157	No

* Two starred (*) entries should be combined.
**Combined data.

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Rainfall, Flow and Water Collection

Date (2010)	Total Rainfall (m, in)	Flow/Sample Collection
9/16 – 9/17	0.003, 0.118	No
9/18 – 9/19	0.004, 0.157	No
9/20 – 9/21	0.001, 0.039	No
9/24 – 9/25	0.006, 0.236	No
10/1 – 10/2	0.004, 0.157	No
10/2 – 10/3	0.003, 0.118	No
10/13 – 10/14	0.010, 0/394	No
10/23 – 10/24	0.003, 0.118	No
10/24 – 10/25	0.005, 0/197	No
10/26 – 10/27	0.008, 0.315	No
11/4 – 11/5	0.001, 0.039	No

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Rainfall / Water Collection Results

- *Highest rainfall with no water collection:
  - 0.019 m, 0.75 in

- *Lowest rainfall with water collection:

  0.035 m, 1.38 in

- **Estimate of 'holding' capacity of the system:*
  0.02 m – 0.03 m (0.8 in – 1.2 in)

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Data and Results

- Rainfall, Flow and Water Collection
- Water Analysis

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pH Data

- Rain: pH 5.6 – 6.0
- Water samples:
  - pH range 7.8 – 8.0 (after collection)
  - pH range at monitoring station **8.0 – 8.3**
- Rainwater: pH **7.5**

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Nitrate Analysis Methods

- Test Strips (Hach)
- Hach Method 8192 (Powder Pillows)
  - Cadmium Reduction
  - NitraVer6 / NitraVer 3
  - SM 4500 E
- Hach Method 8039
  - Cadmium Reduction
  - NitraVer 5
  - SM 4500 E

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Nitrate Analysis Methods, contd

- Ultraviolet Screening Method (SM 4500 B)
- Nitrate Electrode Method (SM 4500 D)

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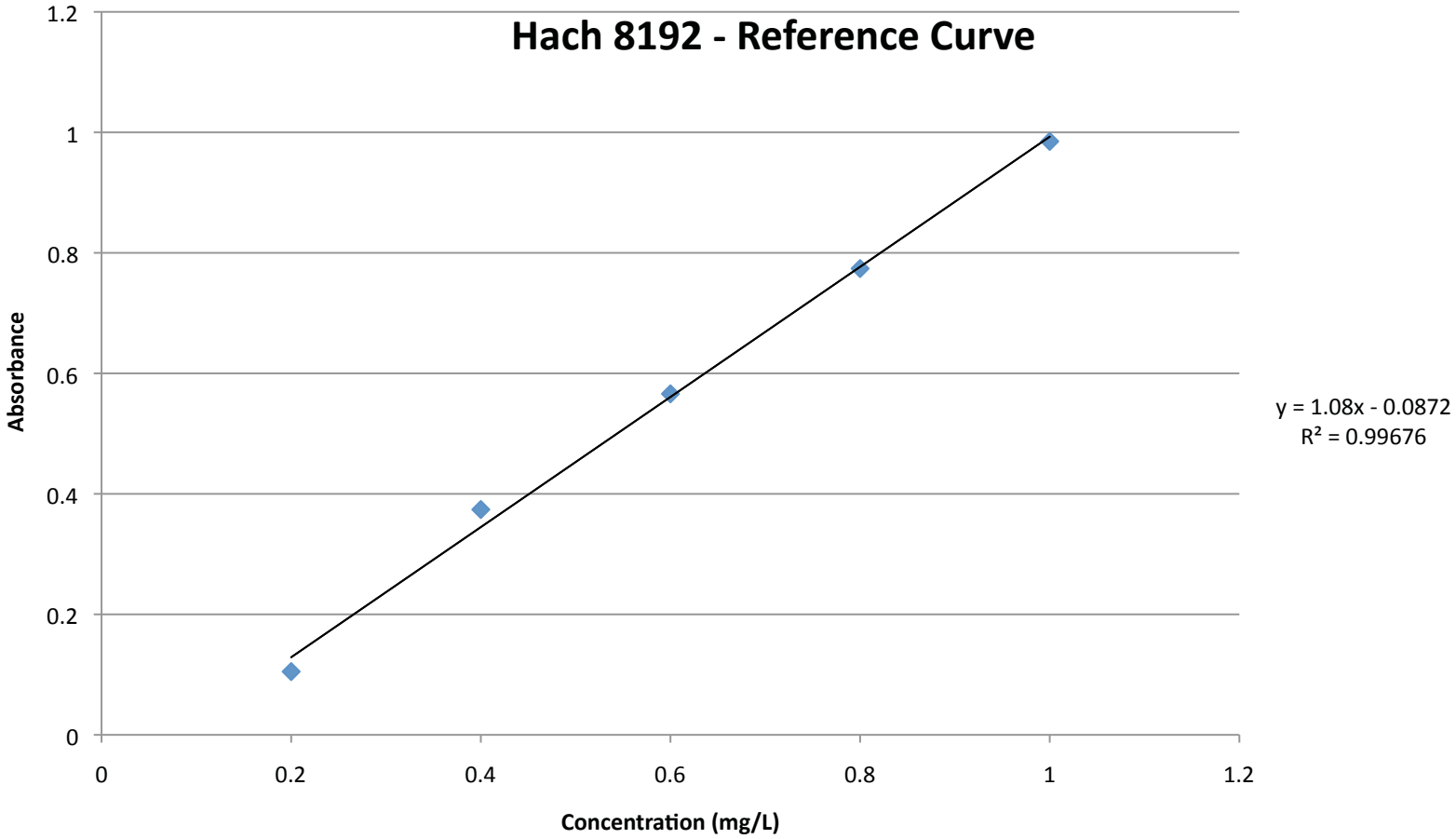
Hach 8192 – Nitrate Reference Curve



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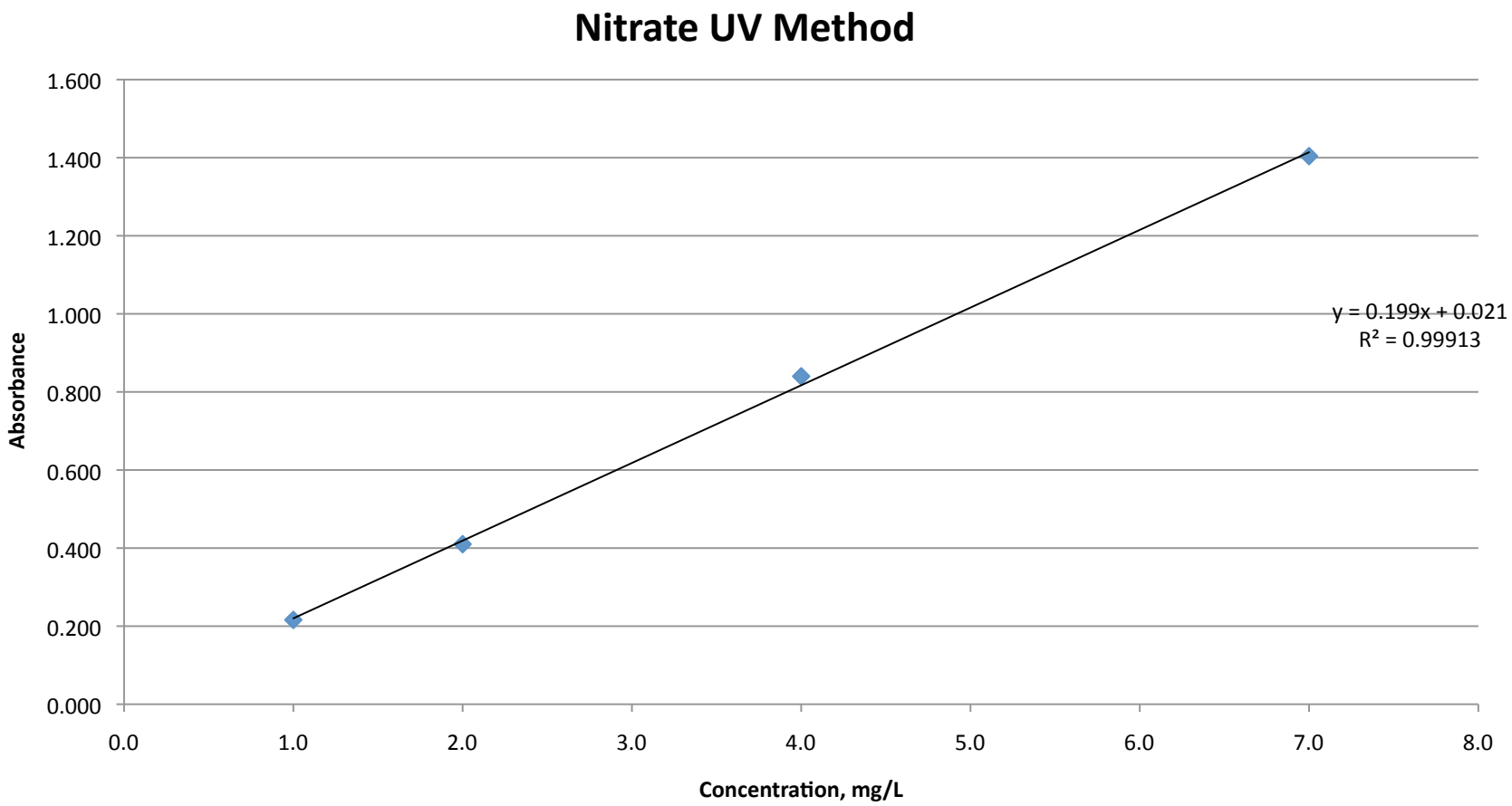
UV Method – Nitrate Reference Curve



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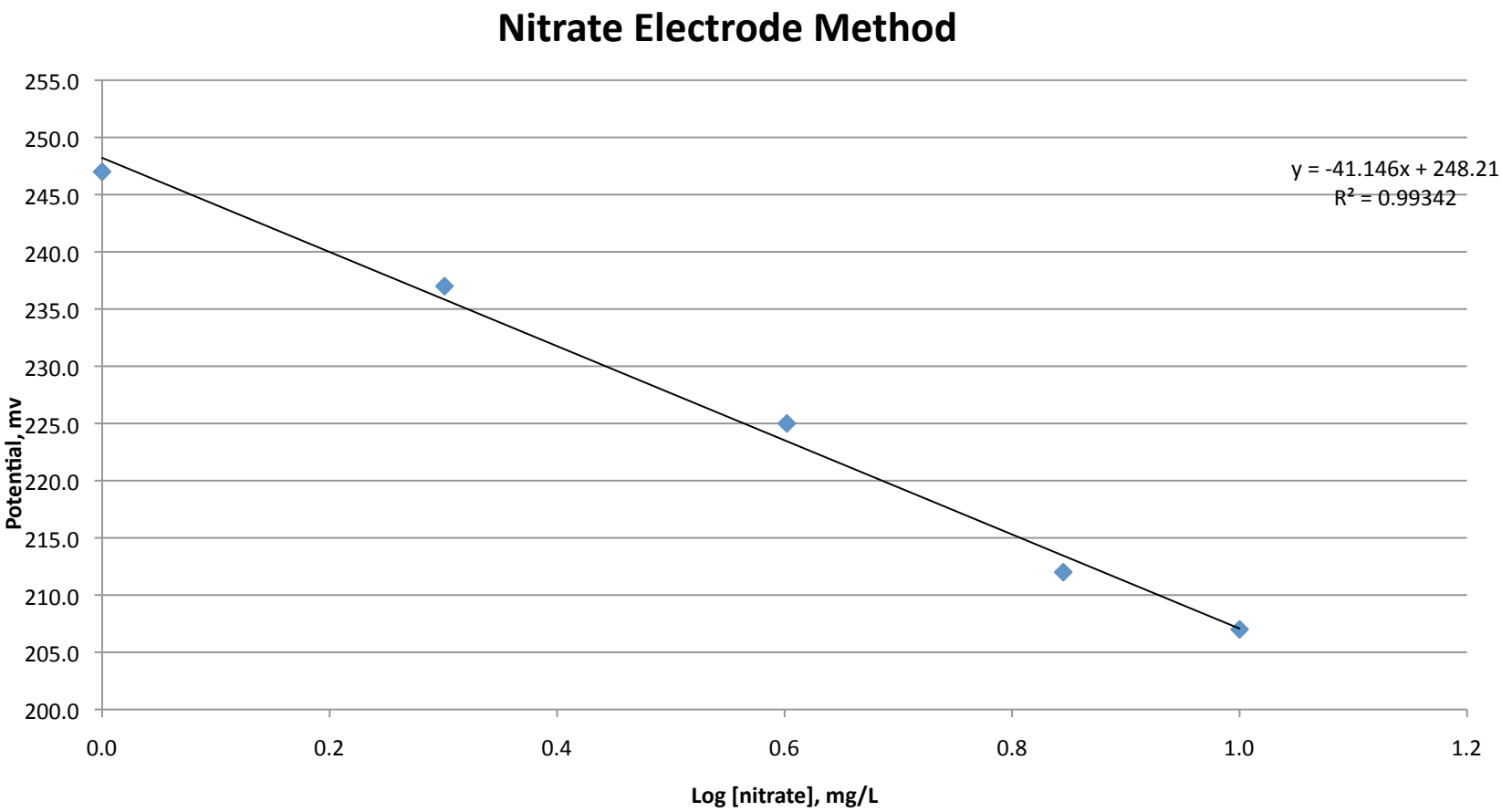
Electrode Method – NO_3^- Reference Curve



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Phosphate Analysis Methods

- Test Strips
- Hach Method 8048

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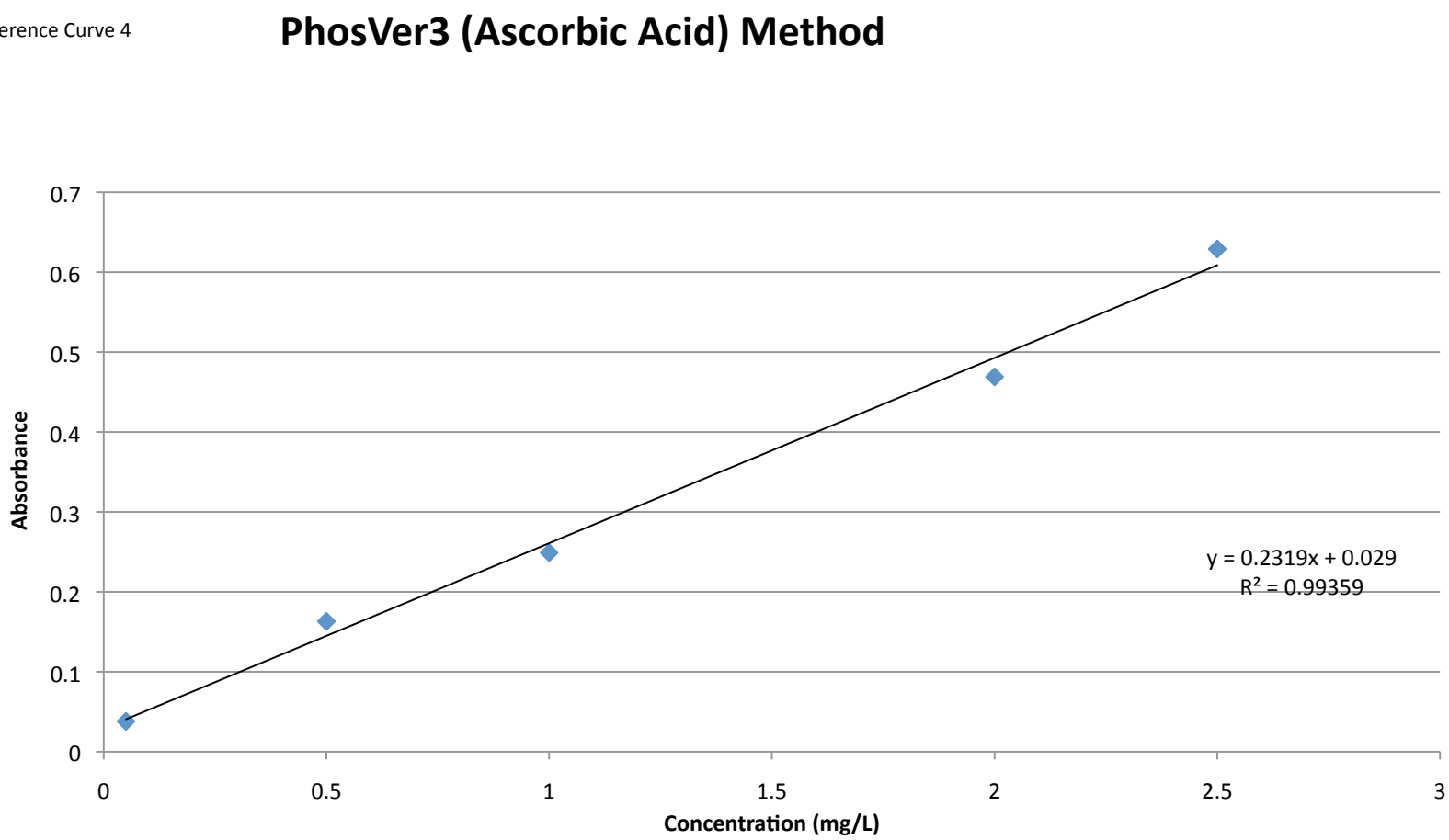
Phosphate Reference Curve

Reference Curve 4



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Metals Analysis Method

- Atomic Absorbance for:
  - Zinc Zn
  - Copper Cu
  - Lead Pb

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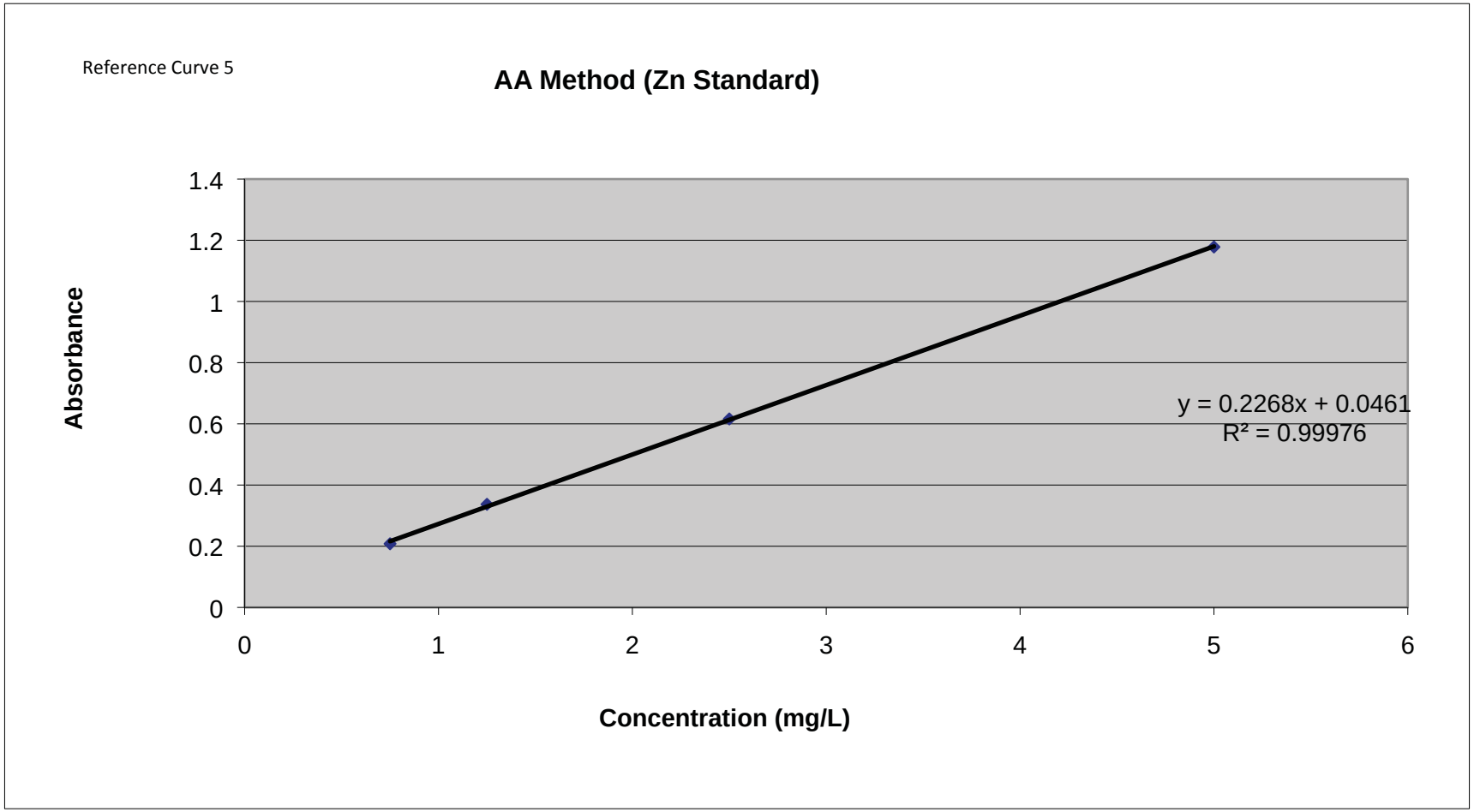
Zinc (AA) – Reference Curve



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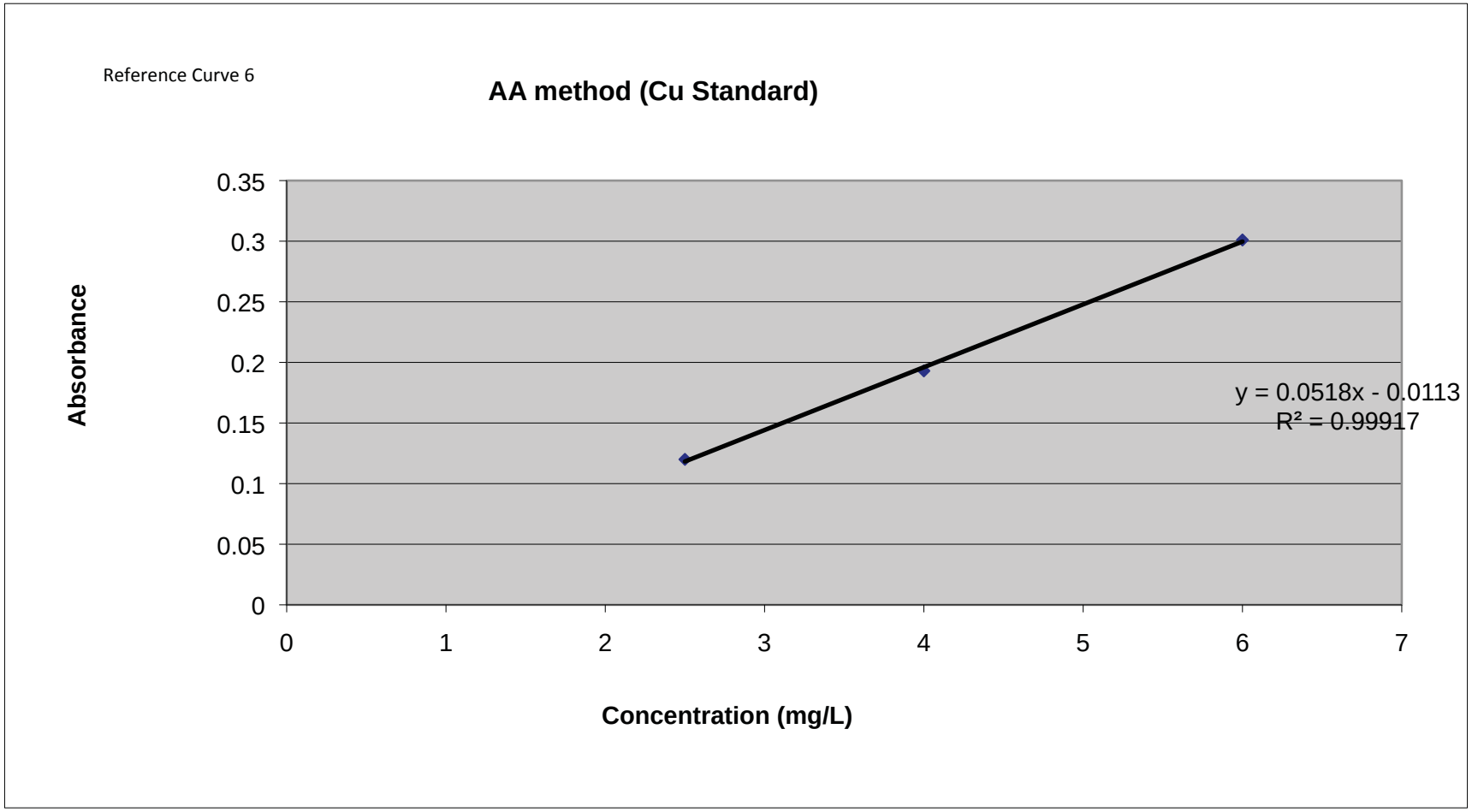
Copper (AA) – Reference Curve



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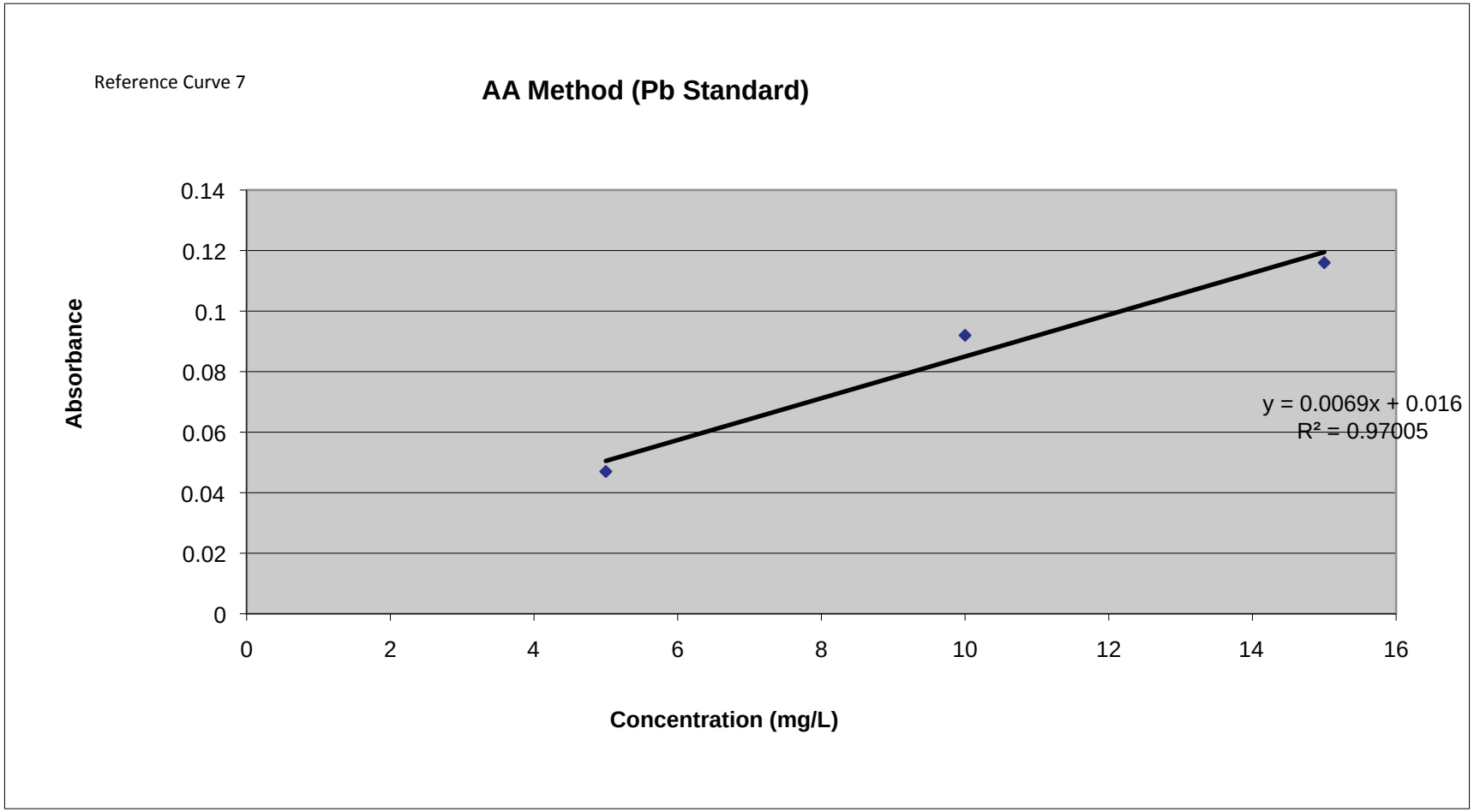
Lead (AA) – Reference Curve



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Results

- Nitrate
- Phosphate
- Metals

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Results – Nitrate Standard Solutions

	1 mg/mL Soln (Measured mg/L)	10 mg/mL Soln (Measured mg/L)
Hach Method 8192	1.32	9.4
Hach Method 8093	1.45	9.6
UV Spectrophotometric	0.96	--
Nitrate Electrode	1.00	--

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Results - Nitrate Test Strips

- Test strips measure: 1 – 2 mg/L on all collected samples

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Results – Water Samples
Hach Method 8192

Bottle (6/8)	[Nitrate], mg/L
# 13	0.217
# 15	0.383
# 18	0.310

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Results – Water Samples
Hach Method 8093

Bottle (6/16)	[Nitrate], mg/L
# 13	1.5
# 15	1.0
# 18	1.7

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Results – Water Samples
UV Spectrophotometric Method

Bottle (9/3)	[Nitrate], mg/L
# 1	0.930
# 2	1.085
# 3	1.025
# 4	0.950
# 5	1.221
# 6	1.126
Rainwater	NR - excessive organic matter

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Results – Water Samples
Nitrate Electrode Method

Bottle	[Nitrate], mg/L
# 1, 2 (7/24)	3.12
# 3, 4, 5, 6 (7/24)	2.94
#1, 3, 5 (10/27)	3.27
# 2, 4, 6 (10/27)	3.10
Rainwater (10/27)	4.10

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Results - Phosphate Test Strips

- Test strips measure: 0 - 5 mg/L on all collected samples

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Results – Phosphate Method (Hach 8048)

Bottle (9/3)	$[PO_4^{3-}]$, mg/L
# 1	0.30
# 2	0.97
# 3	xxx
# 4	0.21
# 5	xxx
# 6	xxx
1.0 mg/L standard	0.99

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AA Analysis for Zn

Bottle (9/3)	[Zn], mg/L
# 1	0.189
# 2	0.134
# 3	0.103
# 4	0.106
# 5	0.182
# 6	0.174
Rainwater	0.374

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AA Analysis for Cu and Pb

- No measurable concentration by AA

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Future Research

- Write curricular materials
- Introduce water collection/analysis in classes
- Refine sample collection / storage
- Refine water analyses
- Analysis of Ions by Ion Chromatography (SM 4110)
- Examine other test kits
- Extend to biological testing (e.g. BOD)
- Conduct plant studies at West Hall

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