One Stanton Street
Marinette, WI 54143-2542

Tele: 715-735-7411

November 17, 2017

Mr. Conor Neal
Geologist and Project Manager
Remediation and Reuse Branch
Land & Chemicals Division
US Environmental Protection Agency, Region 5
77 West Jackson Blvd
Chicago, IL 60604-3590

RE: September 2017 Pilot Dye Test Results Technical Memorandum and Meeting Request -Tyco Fire Products LP Facility, EPA RCRA Administrative Order Docket No. RCRA-05-2009-0007 Tyco Stanton Street Facility; EPA ID No. WID 006 125 215

Dear Mr. Neal:

Tyco Fire Products LP (Tyco) has prepared the attached technical memorandum documenting implementation and results of the Pilot Dye Test conducted at the site between September 18 and 22, 2017 for your review and comment. The pilot dye test was conducted in response to a U.S. Environmental Protection Agency (USEPA) and Wisconsin Department of Natural Resources (WDNR) request to implement a pilot-scale test prior to implementation of a full-scale test. The performance of a full-scale dye test was agreed to in the April 23, 2014 Agreement on Resolution of 2013 Five-Year Review Technical Issues (AOR).

Tyco and its consultant have reviewed the report and due to the highly technical nature of the resulting data and the subsequent interpretation, it is difficult to fully appreciate the results by just reading the attached text. Tyco requests and is willing to meet with the agencies at the earliest convenience to present the information captured during implementation of the pilot dye test, the resulting data analysis, and conclusions, in concert with our consultant, to answer the agencies' questions in real time in order to keep this project moving forward. Due to holidays and vacation schedules, we suggest a meeting to occur during the weeks of December 4th or December 11th; perhaps meeting in Milwaukee as a halfway point for all. The meeting also may be used to provide the agency with updates on other tasks underway.

Tyco looks forward to meeting with you regarding this document. In the meantime, should you have any questions or require additional information, please do not hesitate to call.

Respectfully,

Jeffrey H. Danko
Environmental Geologist

cc: Kristin DuFresne – WDNR
Brian Austin – WDNR
Jim Killian – WDNR
Trevor Moen - WDNR
Joseph Janeczek – Johnson Controls
Rich Mator – Johnson Controls
Ryan Suennen – Tyco Fire Protection Products
Jeff Danko – Tyco Fire Protection Products
Heather Ziegelbauer – CH2M
Mariel Carter – Stephenson Public Library

September 2017 Pilot Dye Test Results

PREPARED FOR:	Tyco Fire Products LP (Tyco)
COPY TO:	EPA WDNR
PREPARED BY:	CH2M HILL Engineers, Inc. (CH2M)
DATE:	November 17, 2017
DOCUMENT CONTROL NO.:	690992.257

1.0 Introduction

This technical memorandum summarizes the results of the September 18 to 22, 2017 pilot dye test. The test took place in the Menominee River, adjacent to the Tyco facility located at One Stanton Street, Marinette, Wisconsin (site), in accordance with the August 14, 2017 *Pilot Dye Test Work Plan* (Work Plan) (CH2M, 2017).

1.1 Project Basis

The pilot test was conducted before the planned full-scale barrier wall dye testing proposed in the September 2015 *Revised Barrier Wall Groundwater Monitoring Plan Update* (BWGMP) (CH2M, 2015) and scheduled for implementation in 2018. The objective of the BWGMP was to provide an approach to monitor the barrier's effectiveness at containing onsite groundwater over the long term. The BWGMP was required by the *Administrative Order on Consent* (AOC) between Tyco and the U.S. Environmental Protection Agency (EPA), dated February 26, 2009, and the April 23, 2014 *Agreement on Resolution of 2013 Five-Year Review Technical Issues* (AOR). Before starting work on the full-scale test, Wisconsin Department of Natural Resources (WDNR) requested potential Rhodamine WT (RWT) dye concentrations in the Menominee River be refined under a worst-case barrier wall seepage situation, and recommended a pilot dye test. Tyco responded to that request in an email on May 16, 2017 (Danko, 2017, pers. comm.) and ultimately agreed to conduct a pilot dye test during a May 23, 2017 conference call with EPA and WDNR. A chronology of the submittals associated with the pilot dye test include:

- Tyco submitted the Work Plan to agencies on August 14, 2017.
- EPA and WDNR provided comments on the Work Plan on August 22, 2017.
- Tyco responded to EPA and WDNR comments on September 1, 2017; no revisions to the work plan were warranted.
- Agencies approved the Work Plan via email on September 9, 2017.

1.2 Project Background

The approved Work Plan (CH2M, 2017) provided details about the project background.

1.3 Project Objectives

Tyco identified the following objectives were identified for the pilot dye test:

- Quantitatively and qualitatively assess dispersion and dilution of RWT dye released in the Menominee River adjacent to the barrier wall under late-summer conditions:

   - Collect field measurements of Menominee River characteristics and dilutions that will be used to calibrate the dilution model
   - Collect direct measurements of plume mixing at various locations in river that are proximate and distant from barrier walls
- Assess suitability of previously proposed fluorometers for measuring dye concentrations in surface water samples, as well as proposed surface water sampling methods
- Assess river background fluorescence and potential effects from turbid river water
- Assess river flow dynamics along barrier wall at proposed full-scale injection locations and downstream, including in the Main Channel (locations T2 and T3), the Turning Basin (location T1), and the South Channel
- Model RWT dye dispersion in surface water to demonstrate likely downstream extents of dye at concentrations of potential concern in "worst-case" scenario
- Use data collected and model results to refine full-scale dye test design, if appropriate, including refining groundwater dye addition concentrations to balance detectability of a low-rate wall seepage rate against surface water impacts from a "worst-case" high-seepage rate scenario
- Develop technical report that summarizes the data collected and modeling and define, if applicable, proposed changes to the full-scale barrier wall dye test design

1.4 Pilot Test Approach

The Work Plan (CH2M, 2017) detailed the pilot test approach, summarized herein. Tracer dye (RWT) was added to the river at a known concentration and rate and with submersible fluorometers deployed downstream to measure RWT concentrations through time. Additional surface water grab samples were collected, as were river velocity measurements. Tests were conducted at three locations (see attached Figure 1).

The river velocity data and RWT concentration curves were used to develop dispersion coefficients that were used in a mixing model. These calibrated dispersion coefficients were used to model theoretical RWT dye concentrations at different points in the river under several hypothetical release scenarios.

2.0 Pilot Test Methodology

The Work Plan (CH2M, 2017) detailed the pilot test methodology, summarized herein.

The study methodology developed in the Work Plan (CH2M, 2017) stated that dye testing activities and river dynamics are fluid by nature and would require that river conditions be carefully observed before and during the initial tests. For this reason, a degree of flexibility was purposely built into the Work Plan so measurement and sample locations and initial dye concentrations could be evaluated and adjusted. This proved to be necessary for this pilot dye test, and adjustments were made so the highest-quality data would be collected based on the observed site-specific conditions.

The following summary provides adjustments (and rationale for adjustment) from the Work Plan.

2.1 Injection and Transect Locations

Figure 1 depicts the three dye test locations and submersible fluorometer deployment locations. The following adjustments were made to the Work Plan (CH2M, 2017):

- The initial dye tests, including shallow and deep injections, were conducted at location T3 rather than planned location T1 due to less complex (that is, more predictable) river flow dynamics.

- Self-contained underwater fluorescence apparatus (SCUFA) fluorometers were deployed both to the east and west of the dye injection site at location T1 in the Turning Basin because of the complex nature and variable flow dynamics and circulation patterns that were observed.
- SCUFA fluorometer transects were moved closer to the dye injection locations to increase the likelihood of capturing useful RWT concentration curves during the dye tests. The transect distances proposed in the Work Plan were 100 and 300 feet downstream. Transect distances at the main channel area (T2 and T3) were located at distances of 10, 25, and 50 feet downcurrent (Figure 2). In the Turning Basin (T1), the instrument transects were located on both sides of the dye injection (due to reversing current directions) at distances of 10 and 20 feet.

Figure 2. Deployment of SCUFA Moorings at T3 with Two Moorings 25 feet Downstream of Injection and Two More 50 feet Downstream

- SCUFA fluorometers along each transect were moved closer to the barrier wall, to increase the likelihood of capturing useful RWT concentration curves during the dye tests. The distances from the barrier wall proposed in the Work Plan (CH2M, 2017) were 5 and 20 feet. Actual instrument deployment distances from the wall were from 2 to 10 feet at location T1, 2 to 5 feet at location T2, and 1.5 to 5.5 feet at location T3.
- The SCUFA fluorometer deployed in the South Channel was re-positioned for use at the dye testing locations following the results of initial testing (since RWT was not detected in the transects located closest to the dye injection).

2.2 Dye Injections

RWT dye was diluted with tap water to a known concentration, and then injected into the river using a peristaltic pump. Tap water was used so a sufficient volume of dye solution could be prepared for each test. Pump flow rates were measured and verified by repeatedly pumping and discharging tap water into a graduated cylinder for a fixed period of time at various flow rate scale settings. Pump flow rates were verified and recorded before and following the dye injection at each test location. Tap water was pumped into a 2-liter graduated cylinder for 2 minutes to determine an average flow rate. Injection flow rates for the four dye tests varied from 870 to 940 milliliters per minute (mL/min).

- Table 1 summarizes the dye injection concentrations, injection durations, and pumping rates for each dye test.
- Concentration of the dye injection solution was increased from the proposed 1,000 parts per billion (ppb) to between 38,100 to 56,800 ppb, because RWT became diluted very rapidly in the river in initial tests (T3-A and T3-B in Table 1) and could not be detected by the fluorometers. Dye injection concentrations were kept less than the greatest allowable concentration of 64,900 ppb permitted by WDNR.
- Dye injection (pumping) rate was increased to the capacity of the pumps because RWT diluted very rapidly in the river during initial testing and could not be detected by the fluorometers.
- One dye test (location T3) was conducted at an injection depth of 12 feet below the water surface, as described in the Work Plan (CH2M, 2017). The remaining dye tests were conducted near-surface (between 2 and 2.5 feet) for the following three reasons: (1) ease of collecting grab samples, (2) ability to visually observe portions of the plume, and (3) no observed effects from ultraviolet (UV) degradation of dye.
- Measurements were not extended for a period of three times the duration of the dye injection, as proposed in the Work Plan (CH2M, 2017). Sufficient data were collected following each dye injection due to the relatively rapid dye dispersal following each injection period.

2.3 Field Tracer Measurements

The concentrations of RWT were measured by a variety of techniques during the pilot test, as described in the Work Plan (CH2M, 2017). Additional details on the field tracer measurements include:

- Continuous measurements of RWT concentrations were collected using five SCUFA submersible fluorometers on bottom-anchored moorings. Each of these instruments was deployed at a depth (below surface) that was comparable to that of the dye injection.
- Near-surface river water (grab) samples were collected using either a dip sampler or Alpha sampler, and were analyzed immediately using a calibrated AquaFluor (handheld) fluorometer. The number of samples proposed in the Work Plan (10) was exceeded for all dye tests.
- Initial test results using the dye injection flow rates and concentrations proposed in the Work Plan did not yield measurable dye concentration in the river with any of the instruments. As a result, and to increase the likelihood of capturing dye concentrations during subsequent tests, the pumping rate and injection concentration were increased and the measurement locations were modified (as previously described).
- At one test location, proposed screening techniques for the full-scale dye test were tested using a YSI 6920-v2 sonde equipped with RWT and turbidity sensors. Following repeated attempts at calibration (using the same dye standards as those used to calibrate the SCUFAs), the readings obtained from this instrument did not agree with those from either of the other fluorometers used in the pilot test. The use of the YSI sonde was discontinued.

2.4 Field Instruments and Calibration

Calibration of fluorometers, turbidimeters, and dye pumps was conducted in general accordance with the work plan. Details about the calibration included:

- Calibration standards at concentrations of 5, 10, 25, 100, and 500 ppb were prepared before the field deployment. These dye standards were prepared with river water and were used to conduct pre-test calibration and post-test verification checks on each of the instruments used. The background receiving water collected before the pilot test was used as a blank (that is, zero fluorescence) during the calibration process. The fluorometers used in the study were calibrated to the 25 ppb dye standard.
- Turbidity standards of 1 and 10 Nephelometric Turbidity Units (NTUs) were used to calibrate the turbidity channel of the SCUFA fluorometers. Following calibration for turbidity, the SCUFAs were calibrated for fluorescence (that is, dye concentration) and then reassessed for the effects of turbidity on apparent dye concentration in the absence of dye. The turbidity calibrations showed little drift between pre- and post-test calibration checks. Therefore, the effect of turbidity on dye concentration, with no dye present and at turbidities measured in the receiving water (< 1.5 NTU), is assumed to be negligible.
- Calibration curves were developed to post-process RWT concentrations recorded by the SCUFAs. The secondary fluorometers used during the pilot test (AquaFluor, YSI sonde) were not adjusted following the initial (pre-test) calibrations. Attachment A provides additional information on the calibration curves.
- The fluorometers were also tested using dye standards prepared with distilled water as a quality control (QC) check both before and after the pilot test. These QC standards were prepared to the same concentrations as the receiving water standards (listed above). The QC check results, provided in Attachment A, show the instruments display a strong linear response and indicate there was only very minor instrument drift for each primary instrument used in the dye tests.

2.5 River Velocity Measurements

River velocity measurements were collected in accordance with the Work Plan (CH2M, 2017) using both Hach FH950 flow meters and a Teledyne RDI RiverRay Acoustic Doppler Current Profiler (ADCP).

- River velocity (spot) measurements using a Hach FH950 handheld flow meter were collected before and during each dye test. Most of these current measurements were collected by field personnel located on shore (with the support vessel used when measurements locations were more than a couple of feet from the wall).
- After fluorometer deployment locations were adjusted closer to the barrier wall (following initial testing results), current velocity was measured frequently. This approach was necessary due to the limitation of the RiverRay ADCP in working near structures such as the barrier wall (which can affect beam angles and the resolution of the instrument measurements).
- The RiverRay ADCP was deployed on September 22 to collect more detailed velocity profile information. A total of 11 transects were conducted in both the Main Channel (8 transects) and Turning Basin (3 transects).
- River velocity was not measured at all nine full-scale dye injection locations, as proposed in the Work Plan (CH2M, 2017). The spot velocity measurements at the three dye test locations provide sufficient information to define the representative currents at the test sites and will be sufficient for the dilution modeling.
- The RiverRay ADCP was used to obtain transects of velocity both in the Main Channel and in the Turning Basin. Four transects across the width of the Main Channel were obtained adjacent to sites

T2 and T3. Additionally, three transects were taken in the Turning Basin, two along an east-west alignment and a third directly north from T1 towards the Main Channel. Since the spot measurements of velocity during the dye tests provided sufficient data for the spreadsheet model, the ADCP data were not processed at this time. The data will be kept and used in the future if more complex hydrodynamic and constituent transport modeling is needed.

Preliminary river discharge data indicate that flows ranged from 3,110 cubic feet per second (cfs) to 3,540 cfs during the week of pilot testing at USGS gage 04067500 (McAllister, Wisconsin) upstream of the site, higher than the mean daily discharges for those dates (1944-2017) of 2,340 to 2,380 cfs.

2.6 Quality Assurance/Quality Control

The quality assurance/quality control (QA/QC) measures CH2M applied followed engineering standards of performance for data collection, calibration, and verification methods to confirm the pilot dye test provided high-quality and verifiable data. The QA/QC objective for the pilot test was to collect measurements of river dilution and river conditions that are of known and acceptable quality. The following requirements were followed to achieve these objectives:

- Provide verifiable dye addition rates and initial dye concentrations, as discussed in Sections 2.2 and 2.4.
- Provide verifiable equipment calibration with pre- and post-test calibrations of the fluorometer instruments, as discussed in Section 2.4.
- Maintain accurate positioning for measurements. A handheld global positioning system unit was used to gather coordinates on various pilot test locations. For the other distance and water depth measurements, an engineering tape or laser range-finder, or both, were used.
- Provide equipment redundancy (backup equipment).

The Work Plan (CH2M, 2017), which was submitted to the EPA and the WDNR for review and approval, was a basic element of QA/QC activities.

3.0 Field Tracer and Dilution Measurement Results

Table 1 summarizes the dye tests. This includes information on the dye test locations, details on each dye injection (depth, initial concentration, duration, and injection rate), and details on downstream locations of the fluorometer transects and number of water grab samples collected and analyzed (by the handheld instruments) during each test. Attachment B provides surface water grab results.

3.1 River Characterization

To assess river flow dynamics along the barrier wall at the dye test site (and at locations directly downstream), site-specific field measurements of current velocity were collected. River velocities were measured near the wall along the Main Channel, in the Turning Basin, and in the South Channel before and during the dye injection to determine dye dispersion characteristics and paths. The river velocity measurements were also performed before the pilot dye tests to assist in refining and adjusting the actual location of dye fluorometer transects.

The river velocity and depth results are summarized as follows:

- River velocities measured in the Main Channel (test locations T2 and T3) ranged from 0.06 to 0.65 feet per second (ft/sec), depending on location and depth. The current direction measurements were in an easterly (downstream) direction. Velocities were generally lower at depth than at the surface and generally increased with distance from the wall. Measurements at T2 show higher velocities than at T3, primarily because the width of the river constricts significantly between T3 and T2. Currents at T2 could also be influenced by vessels present at the shipyard immediately upstream of the Tyco property. Average velocities collected at T3 were approximately 0.3 ft/sec near the surface and 0.2 ft/sec at depth. Average velocities at T2 were 0.5 ft/sec near the surface.

- Velocities measured in the Turning Basin (test location T1) ranged from 0.01 to 0.06 ft/sec, with surface current directions primarily to the east (except for one reading), but varied in response to local winds. Currents in the Turning Basin were observed to be weak and variable, and were heavily influenced by prevailing winds. This was evidenced by accumulation of floating debris (that is, vegetation, wood, and trash) up against the barrier wall with light northeast winds. It is likely that surface currents and bottom currents are moving in different directions at times when surface currents are under the influence of wind.
- Because of the corrugated shape of the barrier wall (that is, alternating concave/convex design), turbulent eddies were observed to form in the flow field close to the wall. This phenomenon added a level of complexity to the velocity measurements close to the wall and likely influenced the movement of dye downstream. Some variability seen in the recorded dye concentrations are likely attributable to dye clouds remaining in the relatively quiescent zones in these small, regularly spaced alcoves in the wall.
- Water depths adjacent to the barrier wall (5 and 20 feet laterally from the wall) ranged from 17 to 27 feet in the Main Channel and from about 10 to 18 feet in the Turning Basin.

Table 2 summarizes river velocities and depths at each of the test locations.

3.2 Background Dye Fluorescence

Site-specific conditions affecting fluorescence measurements include background fluorescence and turbidity. Receiving water may have background fluorescence that must be accounted for; to calculate actual dilutions, this needs to be subtracted from the field measurements. Therefore, background river water (with no dye concentration) was tested with the fluorometers before and after the dye tests. The pre-test and post-test instrument calibrations were used to define the detection limit of dye for the instruments and determine whether background fluorescence and turbidity could potentially read as dye concentration. Background results are summarized as follows:

- Background river water was collected upstream of the project site just before the pilot test and was used in the calibration (and verification readings) of the fluorometers that were used.
- Background river samples were collected and analyzed at two upstream locations and did not have detectable fluorescence. Table 3 summarizes the fluorescence readings of the background river water measured by the SCUFAs (pre- and post-study).
- Some scatter in fluorometer readings was noted during the background testing and during the full-scale test, including small negative and small positive values that appear to reflect some variability in fluorescence readings given the calibration of the fluorometers.
- Only one sample of effluent from the groundwater treatment system (rather than the planned three samples) was collected; analysis of the sample using a calibrated fluorometer indicated the effluent has no fluorescence and a turbidity close to zero.

3.3 First Dye Test Location T3

Four dye tests were conducted at location T3 (Main Channel, upstream of location T2), summarized in Tables 1 and 4. This location was chosen for initial testing because river currents were determined to be more predictable than those at the proposed Work Plan location T1 in the Turning Basin. Both the shallow and deep dye injections were conducted at this testing location.

Initial test results using the dye injection flow rates and the initial concentrations proposed in the Work Plan (denoted with Test identifications 'A' and 'B' in Table 1) indicated the proposed pilot test approach (in terms of dye injection rate and concentration) did not yield measurable dye concentrations in the river at any of the fluorometers, either static or handheld instruments. It was determined that this was because dilutions near the barrier wall (that is, less than 5 feet) were much greater than what was considered in the Work Plan formulation. Through a process of trial and error, it was determined that the combination of increasing the dye injection (pumping) rate and the initial dye concentration, combined with decreasing the measurement distances, allowed for measurement of dye within the range of concentrations that the instruments were calibrated for while limiting the initial dye concentration to levels that were permitted by WDNR.

The following points summarize the dye testing at location T3 for test T3-C (shallow):

- Similar to location T2, significantly stronger currents in the Main Channel allowed the plume to be visible from the surface within only less than 10 feet of the injection site. A high level of dispersion of dye was also observed at this location during both the shallow and the deep injection tests.
- For the shallow test T3-C, 43,000 ppb concentration dye solution was injected at a rate of 880 mL/min for 36 minutes (31.7 liters of dye solution); the SCUFA fluorometer measurements continued for approximately 20 minutes after the injection of dye was complete.
- Based on the fluorometer readings from the surface water samples (47) (Attachment B), the vast majority (greater than 75%) of readings from the shallow test (T3-C) were under 25 ppb, with many of those (approximately 60%) under 10 ppb. The four greatest dye concentrations measured near the surface (76, 116, 117, and 397 ppb) were located within 5 feet of the injection site.
- Table 4 provides the maximum instantaneous dye concentrations measured by the SCUFAs at the transect locations for the shallow test. These measurements indicate that for the shallow test (T3-C in Table 4), the maximum dye concentrations ranged from 172 ppb at 10 feet downcurrent (minimum dilution factor over 250) to about 13 ppb at 50 feet downcurrent (minimum dilution factor near 3,300). Gradually decreasing dye concentrations from the source are well-defined by this dataset.
- Figure 3 (on page 10) presents measured dye concentrations from the five SCUFAs deployed during test T3-C (shallow). Results indicate significant scatter in measured dye concentrations at all locations throughout the test, indicative of a narrow, low concentration dye plume that moves laterally with background turbulence in the river such that the plume sometimes bypasses the instrumentation without detection. Under more laminar flow conditions, the SCUFA records would be expected to show an elevated dye concentration for a duration similar to the injection duration of the dye test.
- The measured dye concentrations during Test T3-C are more easily viewed on Figure 4 (page 10), which uses a log scale on the vertical axis. Results are presented as a frequency distribution for each of the five instruments. The greatest concentrations are measured at the instrument closest to the injection location, as expected. However, dye exceeding 2 ppb is measured more frequently at both the 25 feet downstream (at the instrument further offshore) and 50 feet downstream (at the instrument nearest the wall) locations than at the instrument located 10-feet downstream. This indicates the narrow plume is oscillating laterally and frequently bypasses the instrument at 10 feet.
- Differences in measurements at adjacent instruments (both at 25 feet downstream) are interesting with the offshore instrument recording more dye on average by almost an order of magnitude. These instruments were approximately 3 feet apart. The adjacent instruments 50 feet downstream show more dye at the station nearest the wall but also less difference between the stations, indicating more plume spread.

The following points summarize the dye testing at location T3 for test T3-D (deep):

- Dye was never visible from the surface during the deep test T3-D. The combination of the injection depth (12 feet), relatively swift currents (and rapid dispersion of dye), and the color of the ambient river water did not allow for visual observation of the dye plume.
- For the deep test T3-D, a 38,100 ppb dye solution concentration was injected at a rate of 940 mL/min for 50 minutes; the SCUFA fluorometer measurements continued for approximately 20 minutes after the injection of dye was complete.
- Based on the fluorometer readings from the surface water samples (25), nearly all of the dye concentration readings from the deep test (T3-D) were under 10 ppb, with many of those under 5 ppb. The greatest dye concentration measured at a depth of 12 feet below the surface (1,143 ppb) was located at the dye injection site. The next greatest measured dye concentration was about 13 ppb, and was located 10 feet downstream of the injection site. The other readings during the deep injection test T3-D were under 10 ppb.
- Maximum instantaneous dye concentrations measured by the SCUFAs at the transect locations for the deep test (T3-D in Table 4), ranged from 55.8 ppb at 10 feet downcurrent (minimum dilution factors about 700) to 82.6 ppb at 50 feet (minimum dilution factors above 450). These results suggest the RWT plume, when discharged at depth, achieved much higher dilution than that near the surface (172 ppb max during T3-C surface test) because boundary effects (the surface) are not as much of a factor and there is more 'clean' ambient water available for dilution.
- Figure 5 (page 11) presents measured dye concentrations from the five SCUFAs deployed during test T3-D (deep). Results indicate significant scatter in measured dye concentrations, indicative of a narrow, low-concentration dye plume that moves laterally with background turbulence in the river such that the plume bypasses the instrumentation without detection. Peak concentrations of 56 ppb were measured at the SCUFA 10 feet downstream of the injection. Three greater results (37.9 to 82.6 ppb) were measured 50 feet downstream over a 1-minute period starting at 3:32, 17 minutes after the conclusion of dye injection. With an ambient current speed of 0.15 ft/sec, the dye plume should have cleared the downstream SCUFA in 5.5 minutes. These spikes followed a 12-minute period without a measurement exceeding 1 ppb. Furthermore, the three samples within the 1-minute period were interspersed with three other samples measuring under 9 ppb, which matches well with the 10.1 ppb peak dye concentration measured during the prior portion of the deployment. With these factors, it is the professional judgement of project staff that the spikes are anomalous and not indicative of the dye plume concentrations and were not used going forward in the analysis. With the removal of these spikes, the dilution factor for the downstream instrument increases to over 3,700.
- The measured dye concentrations during Test T3-D are more easily viewed on Figure 6 (page 11), which uses a log scale on the vertical axis. Results are presented as a frequency distribution for each of the five instruments. The greatest concentrations are measured at the instrument closest to the injection location, as expected. However, the steep slope of the frequency curve for the instrument at 10 feet downcurrent is more evidence of a plume meandering laterally and frequently bypassing the instrument.
- As seen in Test T3-C, there is significantly more dye measured at the offshore instrument 25 feet downstream than the nearshore instrument, although they are less than 3 feet apart. In general, less dye was measured for the deeper release than the shallow release. Unknown bottom conditions could be affecting the plume trajectory.

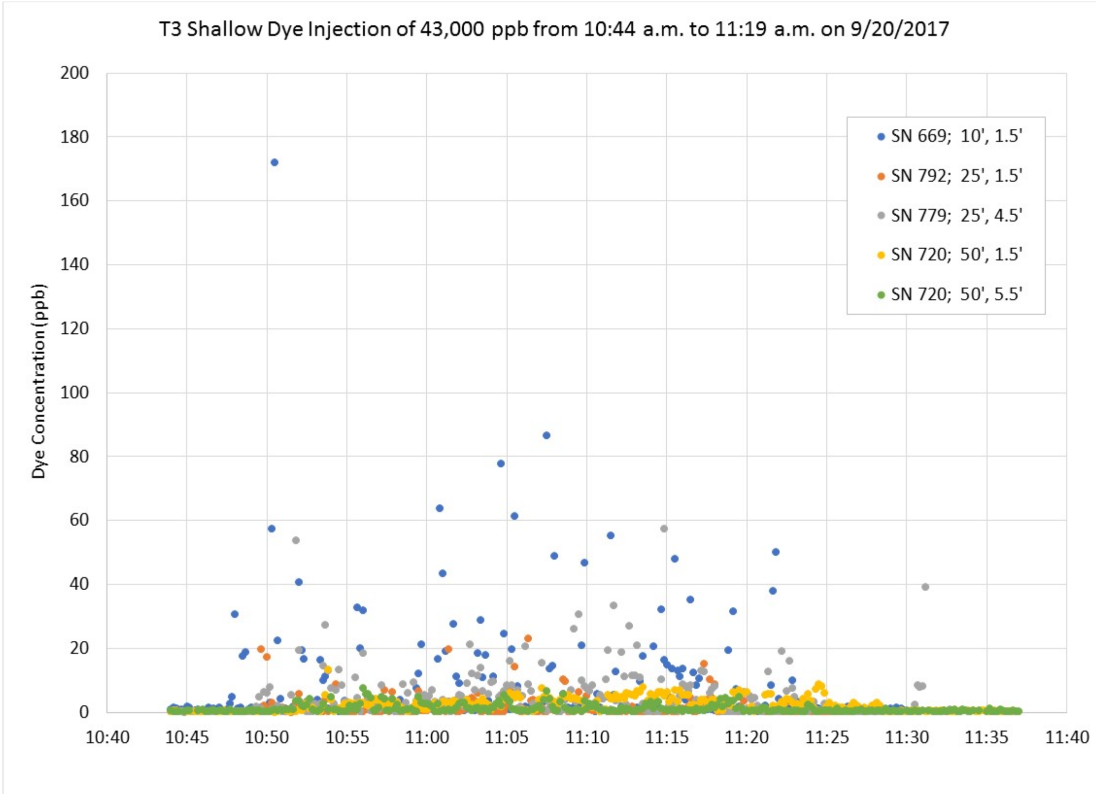

Figure 3. Time Series of Measured Dye Concentrations from SCUFAs Deployed during Test T3-C (Shallow) on 9/20/2017

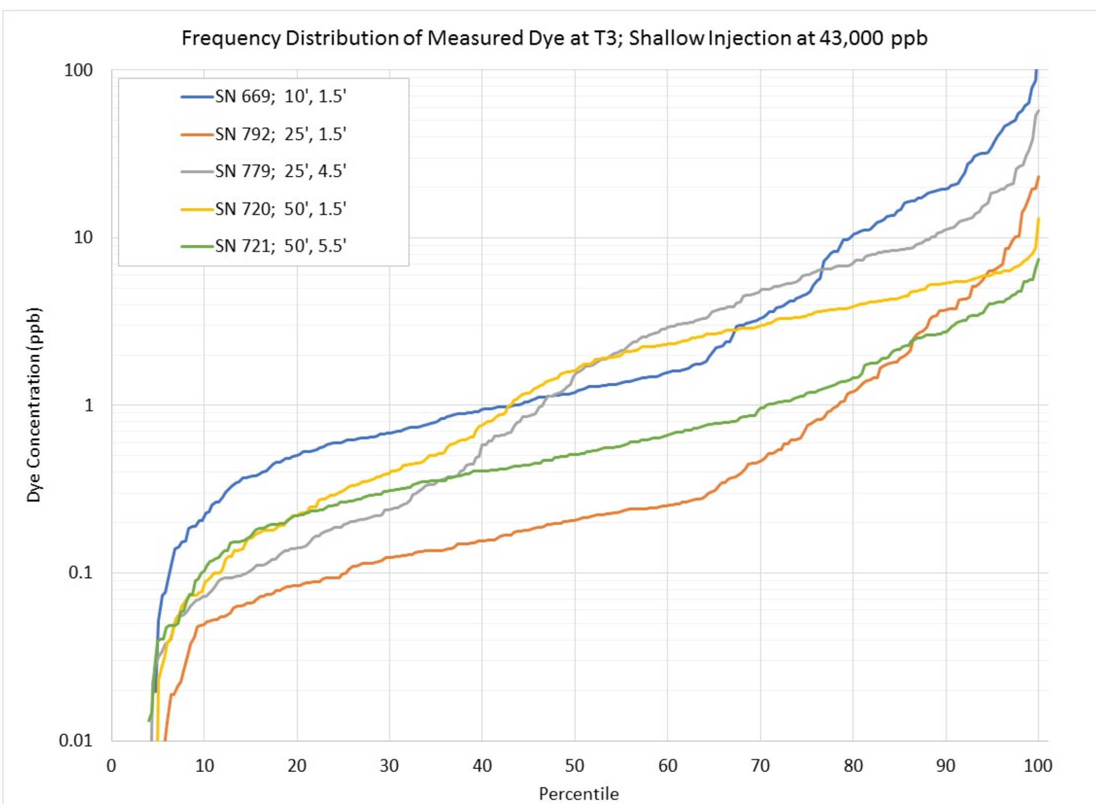

Figure 4. Frequency Distribution of Measured Dye Concentrations from SCUFAs Deployed during Test T3-C (Shallow) on 9/20/2017

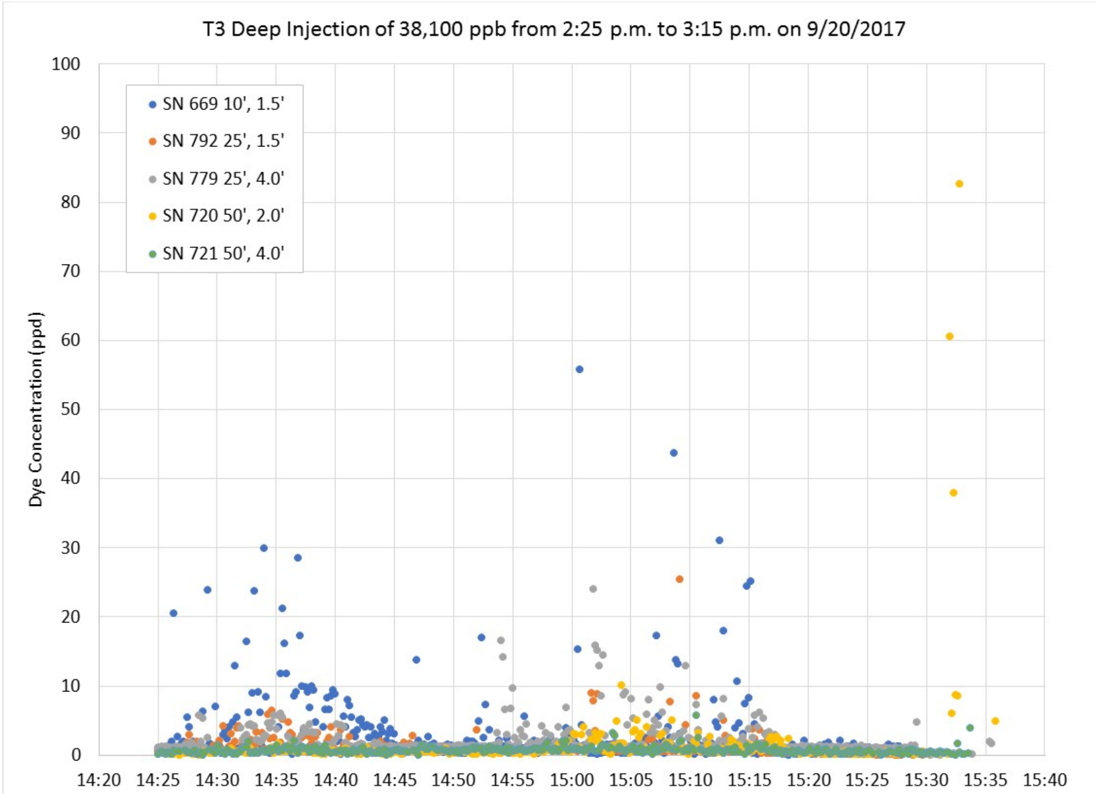

Figure 5. Time Series of Measured Dye Concentrations from SCUFAs Deployed during Test T3-D (Deep) on 9/20/2017

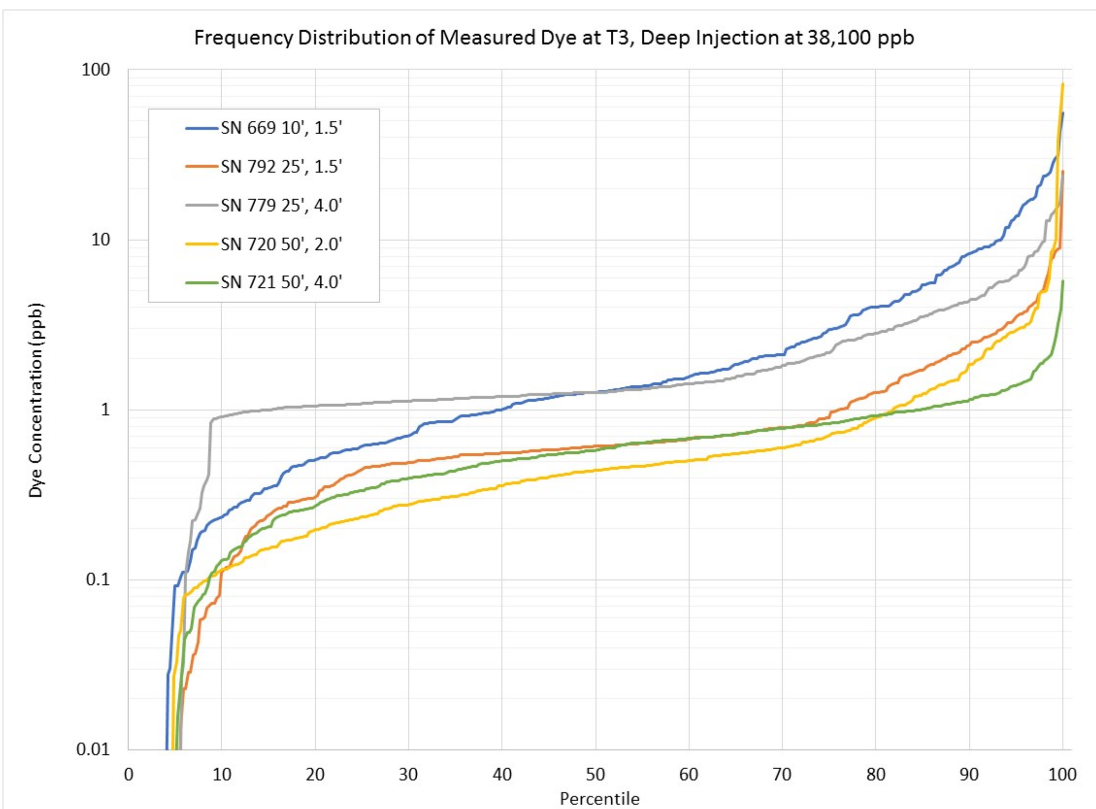

Figure 6. Frequency Distribution of Measured Dye Concentrations from SCUFAs Deployed during Test T3-D (Deep) on 9/20/2017

3.4 Second Dye Test Location T2

Tables 1 and 4 summarize dye tests at location T2 (in the Main Channel, near the east corner of barrier wall).

- A 56,800 ppb dye solution was injected at 870 mL/min for 60 minutes; the SCUFA fluorometer measurements continued for approximately 10 minutes after the injection of dye was complete.
- Because of the significantly stronger currents in the Main Channel, the RWT plume was only visible from the surface relatively close (that is, several feet) to the injection site. Further, turbulent eddies created by the corrugated shape of the barrier wall (coupled with currents over 0.5 ft/sec) produced a high level of dispersion of dye injected at this location.
- Based on the fluorometer readings from the surface water samples (40), less than one-half yielded measurable dye concentration (Attachment B). Of those with measurable concentrations, the majority of readings were 50 ppb or less, with most well-under 10 ppb. The greatest dye concentration measured near the surface (797 ppb) was located less than 1 foot from the injection apparatus. The next greatest concentration (51 ppb) was measured 5 feet from the injection.
- Table 4 provides maximum instantaneous dye concentrations measured by the SCUFAs at the transect locations. These measurements indicate the maximum dye concentrations ranged from 139 ppb at 10 feet downcurrent (minimum dilution factors of 400), to around 19 ppb at 50 feet (minimum dilution factors of 3,000). As Table 4 shows, the trend of decreasing dye concentration away from the source is evident with this dataset.
- Figure 7 (page 13) presents measured dye concentrations from the five SCUFAs deployed during test T2 (shallow). Results indicate more consistent dye measurements than either of the two previous tests. Concentrations with distance downstream were greatest at the near-wall locations, indicating the plume in this reach hugs the shoreline. This is likely related to the constriction of the channel width adjacent to T2, as no upstream interference as is possible at T3.
- Figure 8 (page 13) presents the frequency distributions of measured dye during Test T2**.** The greatest concentrations are measured at the instrument closest to the injection location, as expected. Significantly greater dye concentrations were recorded at the downstream instruments during this test than at the tests at location T3. Median dye concentrations exceeded 1 ppb for all SCUFAs except the offshore meter at 25 feet downstream of the injection. Dye concentrations measured at 50 feet downstream adjacent to the wall were greater than those measured 25 feet downstream, 4 feet from the wall. This indicates a narrow dye plume being carried quickly by the ambient current. In general, the relative flatness of the frequency curves indicates more consistent measurements.

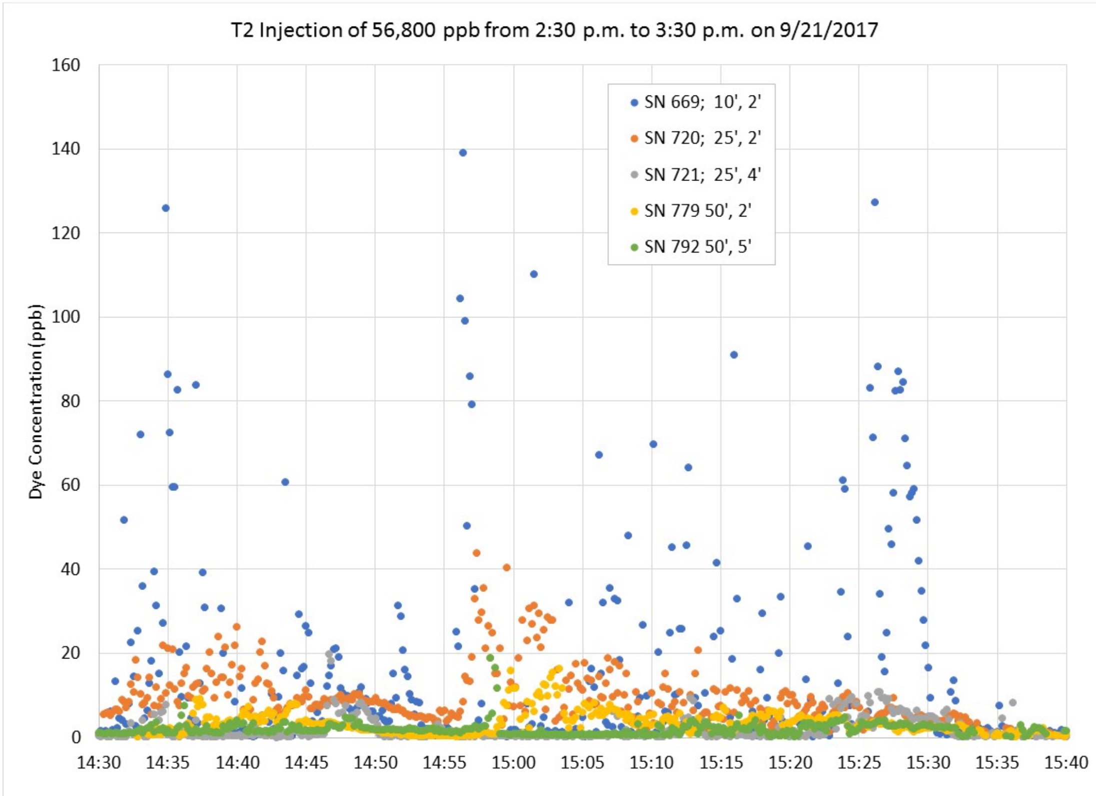

Figure 7. Time Series of Measured Dye Concentrations from SCUFAs Deployed during Test T2 (Shallow) on 9/21/2017

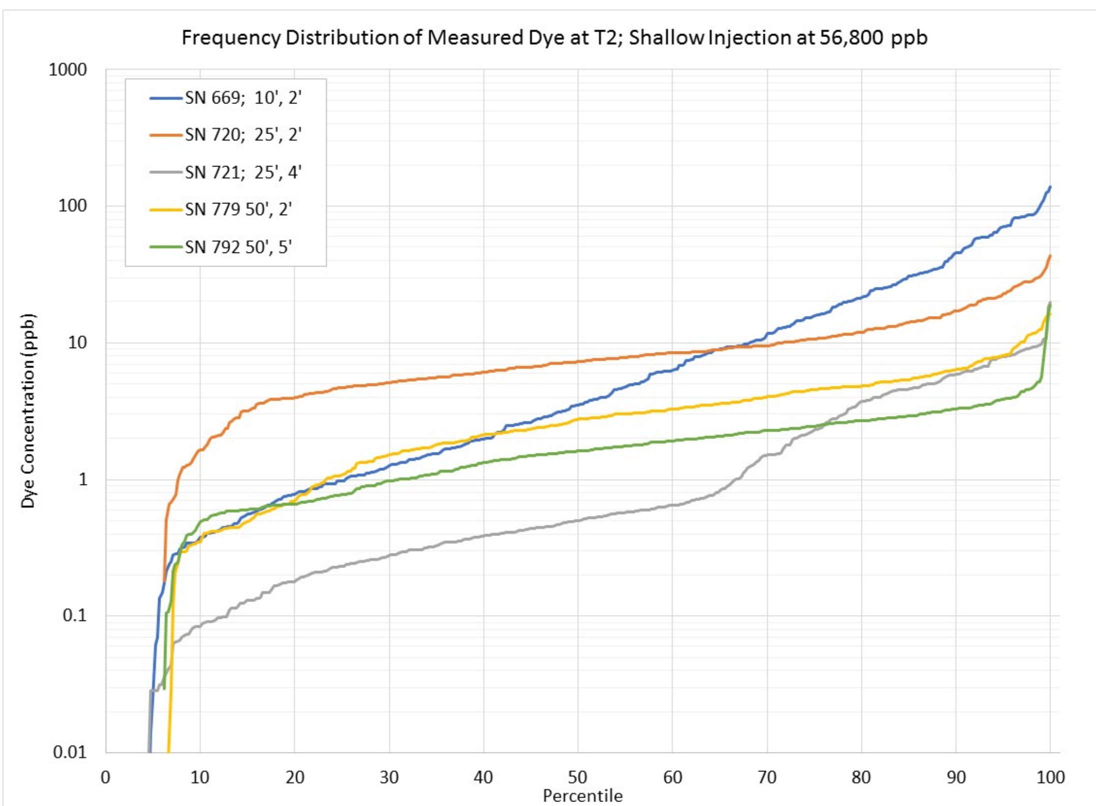

Figure 8. Frequency Distribution of Measured Dye Concentrations from SCUFAs Deployed during Test T2 (Shallow) on 9/21/2017

3.5 Third Dye Test Location T1

Tables 1 and 4 summarize dye tests conducted at location T1 (Turning Basin).

- A 56,800 ppb dye solution was injected at a rate of 940 mL/min at this test location for 56 minutes; the SCUFA fluorometer measurements continued for approximately 65 minutes after the injection of dye was complete.
- Because this test was conducted in the near-surface water (with an injection depth of only 2 feet below the surface), the RWT plume was readily visible for the entire injection period. The lack of significant current resulted in the dye 'pooling' in the area directly around the injection site, where the greatest measured dye concentrations were observed (Figure 9, on page 15).
- Based on the AquaFluor handheld fluorometer readings from the surface water samples, maximum dye concentrations within 5 feet of the injection site averaged about 500 ppb, with a maximum concentration of about 1,500 ppb (Attachment B).
- As expected, measured dye concentrations at increasing distances from the injection site (that is, at transects 10 and 20 feet on either side) showed consistently lower dye concentrations, averaging about 60 ppb (with a maximum concentration of 295 ppb). At these downcurrent distances, many samples measured had dye concentrations under 10 ppb, indicating a very high rate of dispersion (that is, dilution factors well-over 5,000).
- Table 4 provides maximum instantaneous dye concentrations measured by the SCUFAs at the transect locations. These measurements indicate the maximum dye concentrations ranged from about 100 ppb to over 400 ppb, with the greatest value occurring 10 feet east of the injection site.
- Figure 10 (page 16) presents measured dye concentrations from the five SCUFAs deployed during test T1 (shallow). The low current velocities provide much more consistent dye measurements than any of the tests conducted in the main river channel. Figure 10 clearly shows Gaussian-shaped curves of dye concentration passing several of the instruments. Currents were generally to the east and thus instruments east of the injection point show the classic dye curve patterns (yellow and green in Figure 10). Currents did move towards the west for a portion of the study, allowing meters west of the injection point (orange and blue in Figure 10) to also record classic dye concentration profiles.
- Figure 11 (page 16) presents the frequency distributions of measured dye during Test T1. The greatest peak concentrations were recorded east of the plume, with peak values indicating a dilution factor of only 130 10 feet from the injection point. The station 10 feet west of the plume recorded the greatest average concentration.
- The meter stationed 10 feet directly offshore from the injection location measured a peak concentration of 141 ppb 15 minutes after the conclusion of the dye injection, as a plume was carried back over the injection location by shifting local currents.

Figure 9. Dye Plume at Location T1 in Turning Basin with Visible Plume Moving East under Weak and Variable Currents. Tape Marks 5 Feet East of Injection Location, 2 Feet Below the Water Surface.

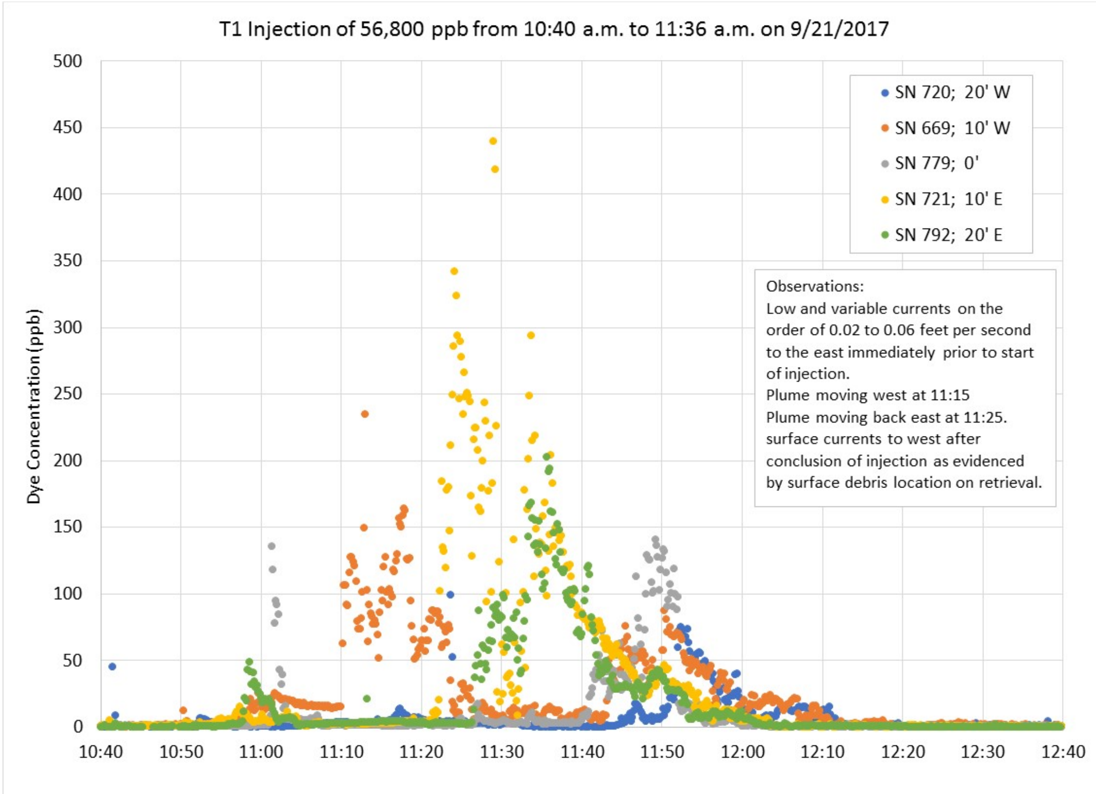

Figure 10. Time Series of Measured Dye Concentrations from SCUFAs Deployed during Test T1 (Shallow) on 9/21/2017

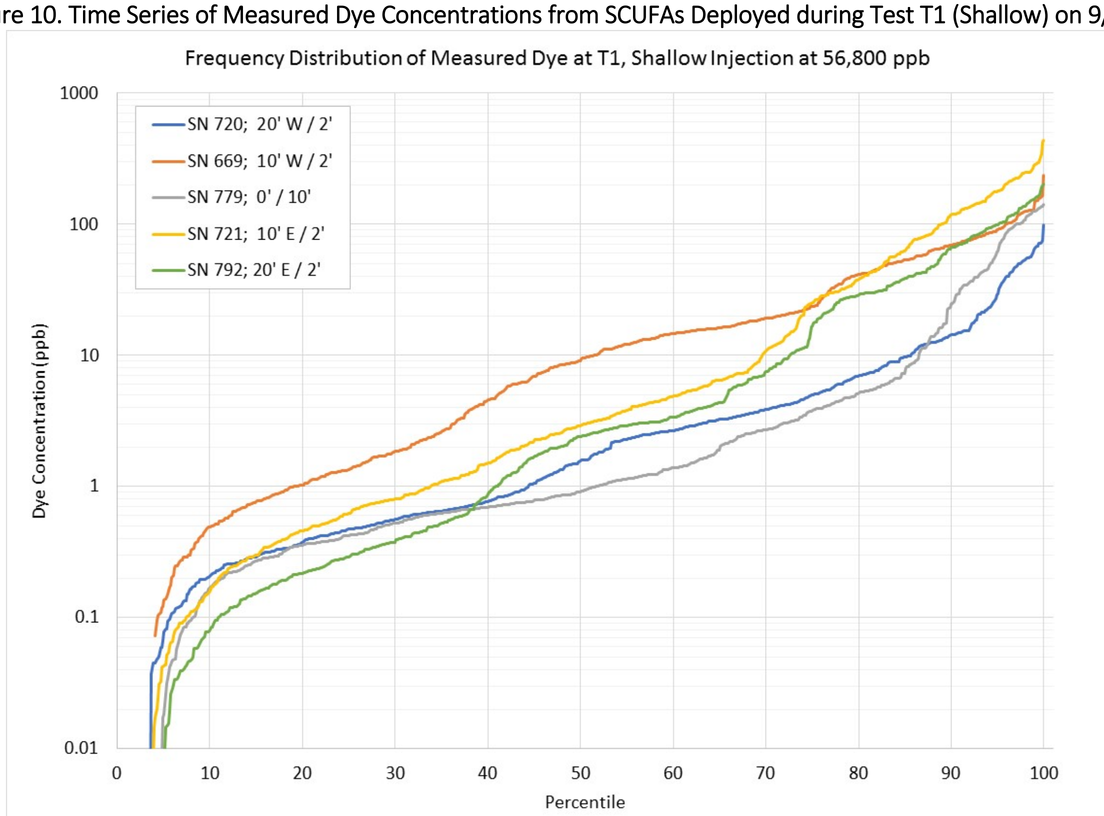

Figure 11. Frequency Distribution of Measured Dye Concentrations from SCUFAs Deployed during Test T1 (Shallow) on 9/21/2017

4.0 Dilution Modeling

4.1 Modeling Objectives and Approach

The objective of the modeling effort is to develop plausible predictions of RWT concentrations in the river adjacent to a seepage point in the barrier wall, and the downstream extent of RWT concentrations exceeding key criteria.

4.2 Model Selection

Initial modeling was conducted using a Microsoft Excel-based model based on standard river dispersion equations from Fischer et al. (1979). The analytical solution to the advection dispersion equation for a shoreline discharge in a river is as follows:

$$C\,(y,t) = Co\frac{e^{-y^2/4\kappa t}}{2\sqrt{\pi\kappa t}}$$

where *t* is time of travel (input as downstream distance x over river velocity), *y* is the distance laterally out from the river bank, and kappa (*κ*) is a lateral dispersion coefficient based on depth (*d)* and shear velocity (*u)*:

$$\kappa = 0.6 * d * u$$

A comparison of the baseline model presented herein, termed Model 1, with field results indicated the observed concentrations deviated from the model with increasing distance (x) from the injection point, with the model overestimating concentrations and thus underestimating dilution. To improve the model, a correction factor was developed with the form:

$$\frac{a}{x^b}$$

The two parameters a and b were adjusted iteratively until visual checks of the model performance were deemed adequate. The final values for coefficients a and b were 10 and 0.9, respectively. The need for the second correction factor is related in part to the vertical dispersion from the point source, whereas the classic solution presented above is for a vertical line source with no changes in depth. This approach is termed Model 2 in the model results discussion.

4.3 Model Assumptions

The calculation of concentration as a function of distance downstream from the source was based on the classic advection-diffusion equation. The simple equation assumes a constant river depth, river width, and river velocity. The lateral dispersion kappa has a leading coefficient of 0.6. Results are sensitive to this assumption with predicted concentrations different by a factor of two for a range of coefficients from 0.2 to 1.0, with greater concentrations for lesser values of the coefficient.

4.4 Model Runs

The spreadsheet model was coded in Excel using site-specific input parameters for river width and depth. Velocity inputs were input specifically for each test, with average velocities of 0.3 ft/sec for T3 Shallow, 0.2 ft/sec for T3 Deep, and 0.5 ft/sec for T2.

Calculations were performed with two models, one without and a second with the additional scaling factor. An instantaneous dilution factor of 100 was also added to the calculations to account for the rapid mixing observed in approximately the first foot from the injection point, and before an advection-diffusion solution becomes valid. One way to visualize this instantaneous dilution is to imagine a cube 6 inches on a side oriented perpendicular to the ambient river flow. At the upstream face of this cube, dye is added at the given injection rate. Ambient currents quickly mix the dye evenly throughout the cube. Once it is well-mixed, the cube-shaped cloud of dye is translated downstream by the ambient currents and disperses outward. With an ambient current of 0.2 ft/sec, the dilution to mix the dye over this hypothetical cube would be 90, assuming the greatest flow rate of 940 mL/minute used in the dye test. For lesser flow rates or greater ambient currents, this instantaneous dilution will be considerably larger. Assuming an ambient current of 0.5 ft/sec (as recorded at T2) yields an instantaneous dilution of 244 using the T2 injection rate of 870 mL/min. A conservative instantaneous dilution of 100 was applied uniformly for each test based on these calculations.

4.5 Model Results

Figure 12 (page 20) presents results of the spreadsheet model compared to both spot sample dye measurements with the Aquafluor instruments and the greatest single measurements from each of the SCUFA installations. Results here are for three tests in the Main Channel, T3-shallow, T3-deep, and T2-shallow. Concentrations are presented as a fraction of the injection concentration to allow direct comparison of all three dye tests in the Main Channel. The SCUFA results shown in larger hollow symbols are greater than any of the spot measurements tested with the handheld Aquafluor instruments. This is because the SCUFA results represent the greatest individual concentration reading obtained during the deployment, and the continuous readings have a better chance of measuring peak dye concentrations than grab samples.

The curves presented on Figure 12 (page 20) use the original model without the additional correction factor. The curves provide a reasonably good upper boundary of the measurements within 20 feet of the injection point, but overestimate peak measured concentrations farther away from the injection point. The curves presented in Figure 13 (page 20) include the second correction factor (Model 2), and provide a better representation of the upper boundary of measured values throughout the 100-foot-long zone where measurements were collected.

The curves provide a reasonable estimate of the expected upper bounds of dye concentration, matching maximum recorded dye concentrations. Model and field data indicate an average dilution factor of approximately 100 immediately adjacent to the injection point for injections in the Main Channel. At 20 feet downstream, minimum dilutions were an order of magnitude higher at 1,000. At the downstream extent of the monitoring (100 feet), minimum dilutions factors were 10,000. The model provides estimates of maximum dye concentrations; based on continuous observations, most measured dye concentrations were considerably lower than the maximum concentrations used in the model. Based on pilot test observations, the modeled maximum concentrations would exist only in a narrow, shifting plume.

Figure 14 (page 21) shows results of Model 2 for the dye test at T1 in the turning basin. The initial dilution for the model was set at 15 to give the best fit to the SCUFA data, reflecting lower velocities in the turning basin. The model indicates minimum dilutions of approximately 100 within 10 feet of the injection location, and minimum dilution of 1,000 within 50 feet of the injection location. These results are consistent with the lower velocities observed in the Turning Basin compared to the Main Channel.

Estimates of the downstream extent of dye concentrations in the river exceeding 10 ppb (maximum recommended concentration entering a drinking water plant and lower visibility limit) and 0.1 ppb (recommended drinking water concentration) are summarized in Table 5 and depicted on Figure 15 (attached). These scenarios include potential dye concentrations injected into groundwater (conservatively assuming no attenuation before seeping into the river), assumed potential seepage rates ranging from 0.2 to 10 gallons per minute (gpm), and river velocity ranges for the Main Channel observed during the pilot dye test (which represent relatively low flow conditions). The estimates are based on concentrations measured within 100 feet of the release, assume constant river width, depth, and velocity, and do not account for dilution within Green Bay. Although dilution calculations are provided for the originally proposed 150,000 ppb injection concentration, given that RWT concentrations in the river cannot exceed 64,900 ppb and uncertainties regarding groundwater attenuation, it is recommended that injections not be conducted at this concentration. The distance downstream that concentrations may exceed 10 ppb at 64,900 ppb range from 45 feet to 950 feet, depending on the seepage rate and river velocity. While 10 ppb is a listed minimum visibility value, field experience during the pilot test indicates dye was only visible less than 10 feet downstream of injection locations, therefore it is unlikely that dye would be visible up to 950 feet downstream of a wall seepage location.

Estimates of the downstream extent of dye concentrations exceeding 0.1 ppb at 64,900 ppb range from 1,500 feet (low seepage rate) to 25,000 feet (high seepage rate scenario, reaches Green Bay). However, at extremely low flows (1,200 cfs), there would not be sufficient river water to dilute the dye, even assuming complete mixing, flowing through a 10 gpm seep to attain a concentration of 0.1 ppb before reaching Green Bay. It should be noted, however, that the assumed maximum dye solution volume of 11,400 gallons, a 10 gpm leak would be expected to discharge most of the injected dye solution within 24 hours of reaching the wall. Furthermore, the 10 gpm seepage rate worst-case scenario represents the potential initial flow rate from a catastrophic type failure (vessel hitting wall, failure of wall at a seam). Flow rates would decrease as the hydraulic head difference between the main plant and river quickly decreased. There is no evidence that such an event has occurred, and the existing wall inspection and hydraulic head monitoring program would be expected to detect such an event.

Estimates are also presented in Table 5 for the theoretical injection concentration at which a 0.2 gpm seep would be theoretically detectable in the river. Assuming an injection concentration of 64,900 ppb, attenuation factor of 5 within groundwater between the injection point and the wall, dye may be present in portions of the river above 0.1 ppb for up to 500 feet downstream of the seep. However, based on results from the pilot test, there are a number of concerns regarding the detectability of dye seeping into the river:

- Samples would have to be collected from exactly the middle of the plume (both laterally and vertically). Based on observations during the pilot test, the plumes in the Main Channel migrate laterally significantly through time and are very narrow, so actually sampling from the middle of the plume would be exceedingly difficult. Additionally, there appears to be limited vertical mixing, therefore samples would also have to be fortuitously collected from the same vertical level as the wall seepage.
- The instruments used in the pilot test were calibrated to a standard of 25 ppb and exhibited considerable variation near zero values (negative values and small positive values). While calibration of instruments to a lower standard (1 ppb or 0.1 ppb) may improve resolution at near-zero values, there is concern that the instrument readings may still be too variable to reliably identify dye concentrations at the 0.1 ppb level.

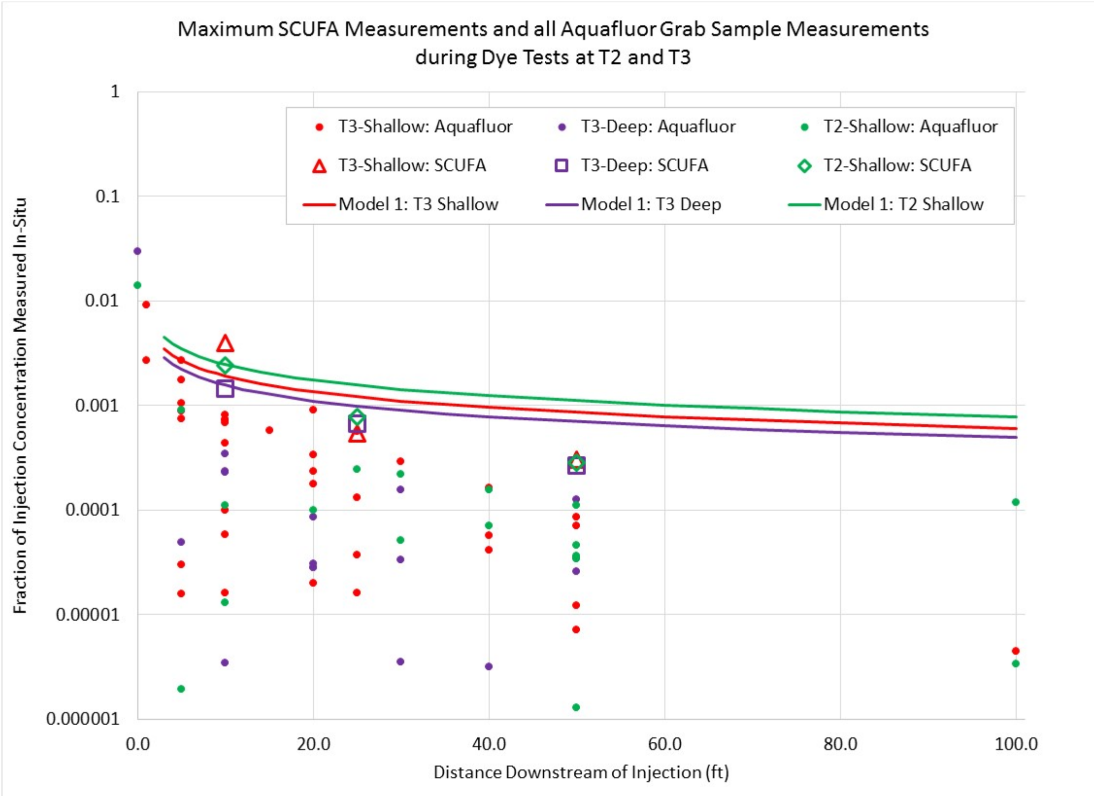

Figure 12. Modeled Dye Concentration (Model 1) as a Function of Distance from Injection Points in Main Channel, with Observed Data for Comparison

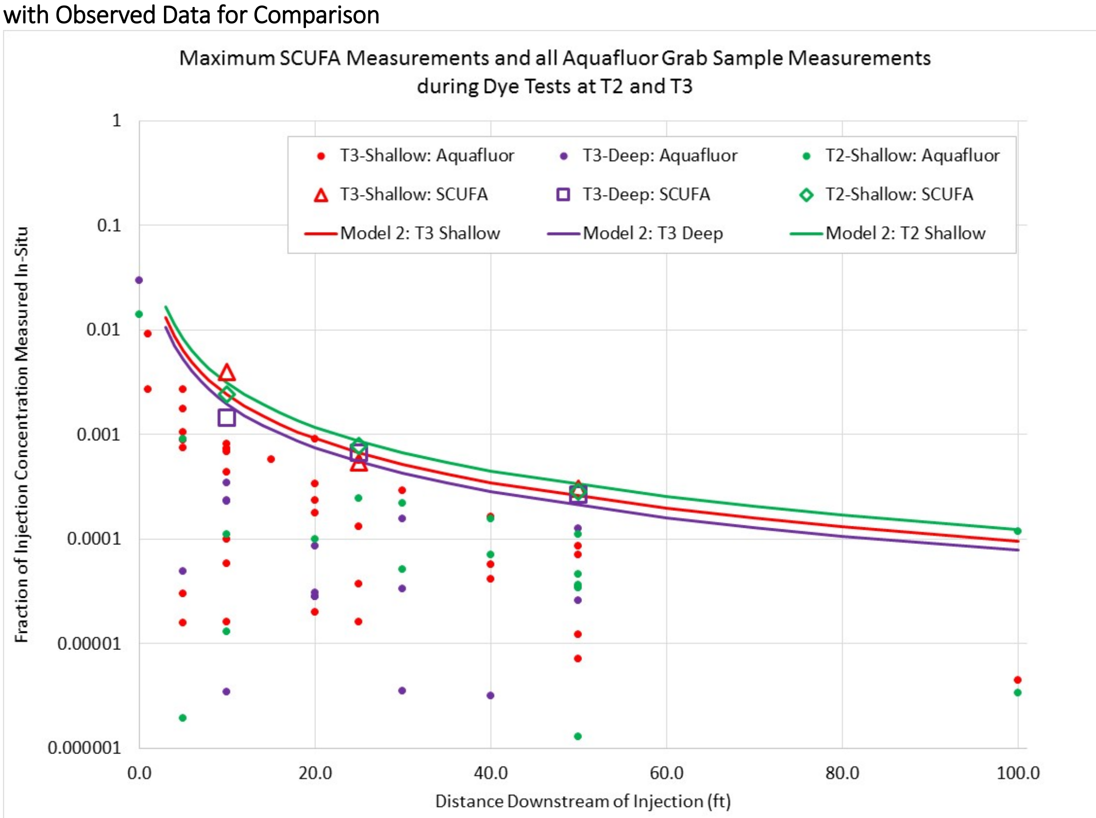

Figure 13. Modeled Dye Concentration (Model 2) as a Function of Distance from Injection Points in Main Channel, with Observed Data for Comparison

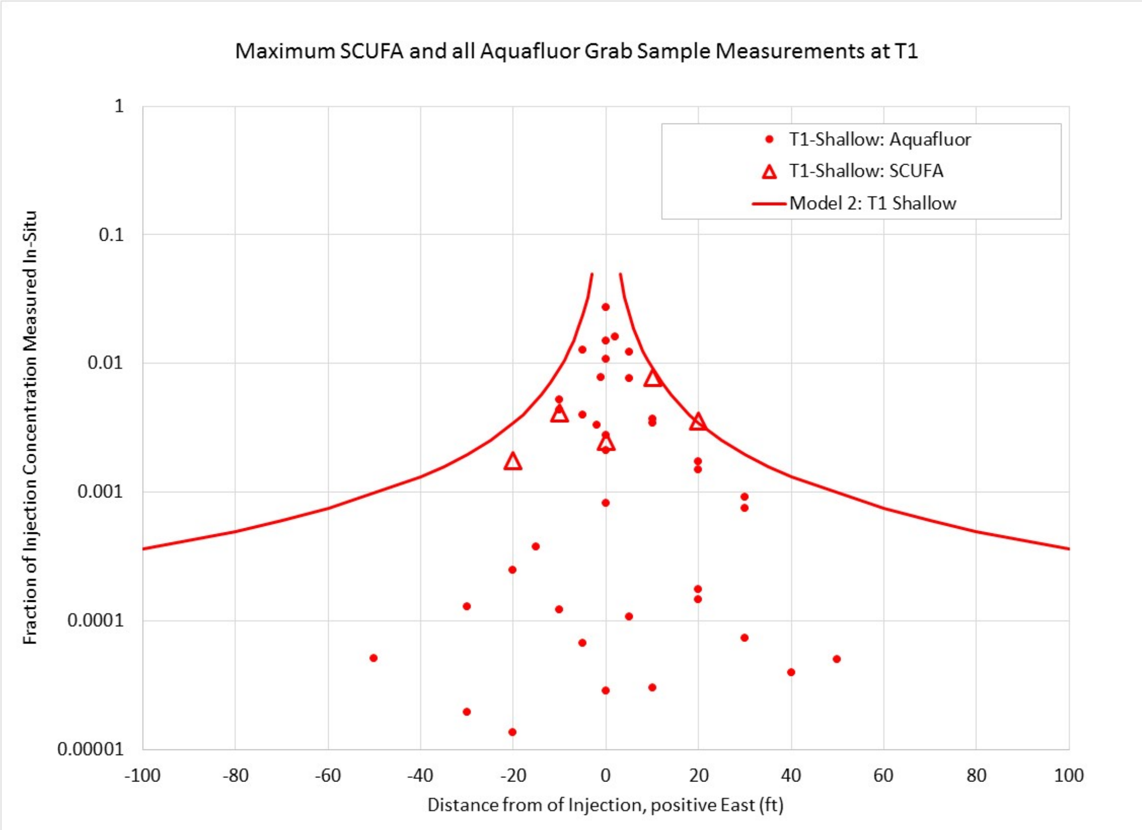

Figure 14. Modeled Dye Concentration (Model 2) as a Function of Distance from Injection Point in Turning Basin, with Observed Data for Comparison

5.0 Evaluation of Pilot Dye Test and Implications for Full-Scale Dye Test

5.1 Full-scale Dye Test Background

The proposed full-scale barrier wall dye testing includes injecting RWT dye into groundwater at nine locations near the barrier wall in the Main Plant Area, accompanied by surface water sampling of the Menominee River adjacent to the barrier wall to detect whether dye has seeped through. The dye testing results will be qualitative in nature: if dye is detected in the river exceeding background concentrations during the full-scale dye test, it will indicate groundwater communication between the contained area and the river, but will not indicate the size or exact location of the communication. Because of the length of the barrier wall, access difficulties to potential dye testing locations, and volume of dye required, the dye test was designed only to measure the effectiveness of representative portions of the barrier wall. However, the information obtained during the dye test will be regarded as being representative of the entire wall containment integrity.

Design of the full-scale test required multiple assumptions, including:

- Injectability of dye into groundwater
- Dye behavior in groundwater (attenuation rate and behavior)
- Wall seepage rate
- River characteristics, including dilution factor and background.

CH2M (2015) indicated up to 11,400 gallons of dye solution would be injected at either 40,000 ppb or 150,000 ppb RWT concentration, depending on the fluorometer to be used. The recommended dye injection concentrations were calculated in an attempt to balance the bounding goals of minimizing risk of unacceptable concentrations of dye in the river if there is a higher wall seepage rate and the risk, with injecting dye at too low of a concentration that could result in undetectable concentrations in the river even if there is seepage through the wall.

Periodic surface water sampling was proposed in the BWGMP to test for the presence of dye in the river. Vertical sample transects adjacent to the injection location, as well as approximately 50 feet upstream and downstream of the injection location were proposed, with initial screening by a YSI 6820 (or equivalent) sonde equipped with a Rhodamine WT sensor to select sample depths. Up to three samples would be collected at each transect for analysis using the fluorometer. Sample transects would be sampled 1 day after dye addition is completed at each location, and then at 1, 2, 4, 8, and 16 weeks following the final dye injection. If dye is detected, subsequent sampling events would not occur.

5.2 Lessons from Pilot Dye Test

A number of lessons were learned during the pilot dye test. Lessons learned include:

- The YSI sonde did not perform as expected and should not be used during the full-scale test. It is recommended that either a SCUFA (or similar submersible fluorometer) attached to a Seabird be used in lieu of the YSI sonde, or foregoing pre-screening and collect samples and analyze at the surface using either an Aquafluor or 10AU Field Fluorometer.
- Grab river water sampling using an Alpha bottle was a feasible method to collect river grab samples.
- Spot samples collected using an Alpha bottle and measured using an Aquafluor fluorometer in general had lower dye concentrations than measured by the (continuously measuring) SCUFAs. This is because the spot measurements represent dye concentrations at a single point in time and location within a shifting, narrow plume. This indicates that use of a method that continuously measures dye concentrations during the full-scale test would be more likely to detect dye seeping through the wall. Long-term deployment of SCUFAs or similar fluorometers at all 9 injection locations and multiple locations and depths near the wall would not be feasible. A practicable approach would be to deploy a SCUFA on a seabird mount to continuously monitor dye concentrations at various depths and distances from the wall at each dye addition location at the intervals recommended in the full-scale BWGMP (1 day after dye addition is completed at each location, and then at 1, 2, 4, 8, and 16 weeks following the final dye injection). However, there are still concerns regarding the quality of the data that would be obtained and the ability to definitively determine whether there is a seep or not.
- River water had minimal turbidity, which is not expected to affect fluorescence measurements.
- The Aquafluor handheld fluorometer and SCUFA submersible fluorometers both calibrated reasonably and appeared to provide acceptable results at the dye concentrations utilized during the pilot test.
- Calibration of the instruments for the pilot-scale test were done using a 25 ppb dye standard, and thus had decreased precision at low concentrations (readings between 0.0 and 0.5 ppb were measured and considered to indicate zero fluorescence; numerous negative readings were also recorded). Because the full-scale dye test will rely on potential detections in the 0.1 ppb range, calibration and equipment setup should be biased towards reading more precisely at lower ends of the scale. Nonetheless, based on the results of the pilot test, CH2M and Tyco are concerned that the fluorometers will not provide reliable readings at the low levels that are critical for the full-scale test and will make it difficult to definitively determine whether dye is present (or not) in the river. It is recommended that testing of equipment calibrated to measure near 0.1 ppb be conducted before full-scale testing.

- No fluorescence was measured in background river samples or the samples collected from the onsite groundwater treatment plant effluent, although the calibration to 25 ppb prevented precise measurement resolution at the 0.1 ppb scale.
- High rates of dilution were observed in the river at relatively low river flow rates. Dye injected at 720 ppb at a known rate and location was not detectable by the SCUFA or Aquafluor instruments just 10 feet downgradient of the injection location. This high rate of dilution indicates that sampling during the full-scale test would need to fortuitously occur as close as possible to the unknown seep location to improve chances of detection. Furthermore, additional dilution would be expected during higher river flow rates and velocities, making detection of dye even more problematic under these conditions.
- In the Main Channel, dye injected at concentrations near the maximum allowable concentration near the surface was generally not visible more than 10 feet downgradient of the injection location. Given the possibility (likelihood) that any seepage through the wall may be significantly below the river surface, it is unlikely that a dye-affected seep would be visibly identifiable.
- Even at greater injection concentrations and rates and known injection locations, the ability to detect the dye downstream of the injection location was limited due to high rates of dilution and changes in plume location resulting from turbulent flow (which may be enhanced by the corrugated nature of the barrier wall). This represents an unacceptably high risk that dye seeping through the wall would not be detected through the collection of spot samples at select locations.
- While the use of continuous sampling using SCUFA instruments or similar should result in a better chance of recording near-peak plume concentrations than grab samples, the SCUFAs would need to be deployed in the appropriate position both laterally and vertically in the water column. Even with knowledge of the dye injection location, SCUFA instruments just 10 feet downstream did not reliably record any continuous representation of the plume, as evidenced by the scatter presented on Figures 3, 5, and 7.
- Under a worst-case, conservative scenario (64,900 ppb seep into river at 10 gpm), downstream dye concentrations greater than 10 ppb may extend 950 feet downstream. Dye concentrations greater than 0.1 ppb under a worst-case scenario may extend into Green Bay, and under low flow conditions, may not reach 0.1 ppb concentration before reaching Green Bay even if there is complete mixing across the river.
- Assuming a 64,900 ppb injection rate and a groundwater attenuation factor of 5 and a wall seepage rate of 0.2 gpm, dye concentrations greater than 0.1 ppb may extend up to 500 feet downstream. While this result suggests that a relatively low dye seepage rate through the wall would be detectable in the river, several observations made during the pilot scale test indicate that detection may be difficult, including:
  - The dye plume in the Main Channel would likely be narrow and move laterally through time, making collection of river samples that reflect the highest concentration in the dye plume exceedingly difficult.
  - Little vertical dispersion is expected, so river sampling would also have to fortuitously be collected from near the same level as the seep.
  - The variability in fluorometer readings at low or no concentration levels during the pilot test indicate that it may be difficult or impossible at low concentrations (in the 0.1 ppb range) to discern between actual presence of dye in the river and instrument variability.

Given the observed variability in dye plume dynamics during the pilot-scale dye test and difficulty consistently measuring dye presence even when injection locations and concentrations were known, identifying seeps during full-scale dye testing, when the location of potential seeps is unknown, may be impracticable. Specifically, without knowledge of the location, size, and concentration of dye (attenuation/dilution of dye in groundwater) associated with a potential seep, successful detection of the seep by detecting dye in the surface water would be by chance. Furthermore, given the low vertical dispersivity expected, the fluorometers would also have to be deployed at nearly the same elevation as the (unknown) seep. The likelihood that a feasible submersible fluorometer network could “miss” an actual seep through the wall (because the dye concentration associated with the seep is too low, the fluorometers are not in the correct location, and/or dye plume dynamics in the river are too variable) appears to be unacceptably high. Use of a SCUFA mounted on Seabird mount to scan the surface water near each dye addition location could reduce some of these uncertainties; however, there would still be uncertainty as to whether a seep would be detected even if present.

Furthermore, as calibrated during the Pilot Test, fluorometer readings were too variable at low values to be useful for the full-scale pilot test. While calibration to a lower dye concentration may improve the accuracy of fluorometer readings at low levels, the pilot scale field experience suggests that there will likely be too much variability for the needs of the full-scale dye test. Since the full-scale dye test as conceived would consider any dye concentration detected in the river as evidence of a seep, the potential for variability in dye readings would make the confirmation that detected fluorescence represents actual dye in the river subject to interpretation and uncertainty. Additionally, given the variability in dye readings, pinpointing the location and magnitude of a leak could be exceedingly difficult, thus, interpreting the significance of a potentially detected-seep would be difficult.

There are additional uncertainties involving dye behavior in groundwater, including the ability to inject the necessary volume of dye at a reasonable rate without daylighting at the surface, the mass of dye required (approximately 1000 times per dye addition location than used in the pilot-scale test), and the attenuation and dilution of the dye in the groundwater system (and therefore the concentration of dye present at the wall).

5.3 Proposed Elimination of Full-scale Dye Test

Based on the experience and observations made during the pilot-scale dye test, it is the opinion of CH2M and Tyco that a full-scale dye test is not practicable and will not provide the necessary certainty to assess barrier wall performance. The level of scatter and inconsistency in recording continuous dye results from instruments positioned 10 feet from a known, controlled source provide little confidence that instruments deployed in a similar fashion would provide any measurements from an unknown source. Therefore, it is recommended that the full-scale dye test not be implemented. As discussed in the Tyco January 31, 2017 response document*,* potential alternative approaches (such as arsenic water sampling, temperature differential survey, geophysical methods, pore water sampling, natural groundwater tracer analysis, or isotope study) should be considered. Given the high degree of river dilution, however, these alternative methods likely will have similar implementability challenges that lead to the same conclusions as the pilot-scale dye test. Sediment sampling in the river is scheduled to be completed in 2018, before the preparation of the 5-year technical review; additionally, monitoring and assessment of water levels and groundwater arsenic concentrations and barrier wall inspections continue and provide additional lines of evidence regarding the performance of the containment system.

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Tables

Table 1. Pilot Dye Test Injection Summary

Tyco Fire Products LP, Marinette, Wisconsin

Date	Injection Start Time	Injection Stop Time	Injection GPS Location	Test Injection Location	Test ID	Dye Injection Depth (ft)	Dye Injection Concentration (ppb)	Dye Injection Duration (min.)	Injection Rate (mL/min)	SCUFA Transect Locations (ft downstream)	No. of Grab Samples Collected	Comments
9/21/2017	10:40:00 AM	11:36:00 AM	N 45°05.855' W 87°36.746'	T1	A	2	56,800	56	940	-10, -20, 0, 10, 20	37	Turning Basin; negative distances are west of injection site, positive are east
9/21/2017	2:30:00 PM	3:30:00 PM	N 45°05.928' W 87°36.753'	T2	A	2.5	56,800	60	870	10, 25, 50	40	Main Channel; east end of barrier wall
9/19/2017	11:24:00 AM	12:25:00 PM	N 45°05.970' W 87°36.893'	T3	A	4	1,000	~60	250	100, 300	13	Main Channel; shallow injection
9/19/2017	5:57:00 PM	6:45:00 PM	N 45°05.970' W 87°36.893'	T3	B	4	720	48	900	10, 50	44	Main Channel; shallow injection
9/20/2017	10:44:00 AM	11:20:00 AM	N 45°05.970' W 87°36.893'	T3	C	2	43,000	36	880	10, 25, 50	47	Main Channel; shallow injection
9/20/2017	2:25:00 PM	3:15:00 PM	N 45°05.970' W 87°36.893'	T3	D	12	38,100	50	940	10, 25, 50	25	Main Channel; deep injection

Notes:

ft = feet

GPS = global positioning system

ID = identification

min = minimum

mL/min = milliliter per minute

No. = number

ppb = part per billion

SCUFA = self-contained underwater fluorescence apparatus

Table 2. River Velocity Field Data

Tyco Fire Products LP, Marinette, Wisconsin

Date	Time	Test Injection Location	Station / Sample ID	Sample Distance from Wall (ft)	Sample Depth (ft)	Sample Distance Downstream, Or East of Injection Site (ft)	Velocity (ft/sec)	Comments
9/18/2017	3:10:00 PM	T3	T3-SL-1A	1	4	0	0.1	
9/18/2017	3:10:00 PM	T3	T3-SL-2A	1	4	300	0.28	
9/18/2017	3:10:00 PM	T3	T3-SL-3A	1	8	300	0.20	
9/18/2017	3:10:00 PM	T2	T2-SL-1A	1	4	0	0.20	
9/18/2017	3:10:00 PM	T2	T2-SL-2A	1	8	0	0.15	
9/18/2017	3:45:00 PM	T3	T3-SL-4A	1	0	10	0.571	
9/18/2017	3:45:00 PM	T3	T3-SL-5A	1	20	10	0.24	
9/18/2017	3:45:00 PM	T3	T3-SL-6A	1	0	10	0.35	
9/18/2017	3:45:00 PM	T3	T3-SL-7A	1	4	20	0.50	
9/19/2017	12:45:00 PM	T3	T3-SB-1A	20	4	200	0.45	
9/19/2017	12:45:00 PM	T3	T3-SB-2A	20	4	200	0.65	
9/19/2017	11:45:00 AM	T3	T3-SL-1A	1	4	50	0.14	
9/19/2017	11:45:00 AM	T3	T3-SL-2A	1	14	50	0.06	
9/19/2017	12:07:00 PM	T3	T3-SL-3A	1	4	50	0.187	
9/19/2017	12:50:00 PM	T3	T3-SL-4A	1	4	300	0.307	
9/19/2017	6:00:00 PM	T3	T3-SL-1B	2	4	30	0.27	
9/19/2017	6:02:00 PM	T3	T3-SL-1B	1	4	0	0.25	
9/19/2017	6:48:00 PM	T3	T3-SL-2B	2	4	50	0.40	
9/19/2017	6:49:00 PM	T3	T3-SL-2B	1	4	10	0.255	
9/19/2017	6:50:00 PM	T3	T3-SL-3B	1	4	10	0.365	
9/19/2017	6:50:00 PM	T3	T3-SL-4B	1	4	20	0.288	
9/19/2017	6:50:00 PM	T3	T3-SL-5B	1	4	20	0.303	
9/19/2017	6:50:00 PM	T3	T3-SL-3B	2	4	40	0.29	
9/19/2017	6:51:00 PM	T3	T3-SL-6B	1	4	30	0.366	
9/19/2017	6:51:00 PM	T3	T3-SL-7B	1	4	30	0.375	
9/19/2017	6:51:00 PM	T3	T3-SL-4B	2	2	40	0.26	
9/19/2017	6:52:00 PM	T3	T3-SL-8B	1	8	10	0.168	
9/19/2017	6:52:00 PM	T3	T3-SL-9B	1	8	10	0.185	
9/19/2017	6:53:00 PM	T3	T3-SL-5B	2	6	40	0.15	
9/19/2017	6:54:00 PM	T3	T3-SL-10B	1	9	20	0.192	
9/19/2017	6:54:00 PM	T3	T3-SL-11B	1	9	20	0.217	
9/19/2017	6:55:00 PM	T3	T3-SL-12B	1	8	30	0.204	
9/19/2017	6:55:00 PM	T3	T3-SL-13B	1	8	30	0.222	
9/20/2017	10:59:00 AM	T3	T3-SL-1C	1	2	10	0.173	
9/20/2017	10:59:00 AM	T3	T3-SL-2C	1	4	10	0.115	
9/21/2017	10:35:00 AM	T1	T1-SL-1A	2	2	-20	0.06	East
9/21/2017	10:35:00 AM	T1	T1-SL-2A	2	2	-20	0.02	East
9/21/2017	10:35:00 AM	T1	T1-SL-3A	2	2	-10	0.047	East
9/21/2017	10:35:00 AM	T1	T1-SL-4A	2	2	-10	0.038	East
9/21/2017	10:35:00 AM	T1	T1-SL-5A	2	2	0	0.027	East
9/21/2017	10:35:00 AM	T1	T1-SL-6A	2	2	0	0.037	East
9/21/2017	10:35:00 AM	T1	T1-SL-7A	2	2	10	0.044	East
9/21/2017	10:35:00 AM	T1	T1-SL-7A	2	2	10	0.010	East
9/21/2017	10:35:00 AM	T1	T1-SL-8A	2	2	20	0.027	East
9/21/2017	10:35:00 AM	T1	T1-SL-9A	2	2	20	0.007	West
9/21/2017	2:25:00 PM	T2	T2-SL-1A	2	4	10	0.452	
9/21/2017	2:25:00 PM	T2	T2-SL-2A	2	4	10	0.508	
9/21/2017	2:25:00 PM	T2	T2-SL-3A	2	4	10	0.481	
9/21/2017	2:25:00 PM	T2	T2-SL-4A	3	4	25	0.485	

Table 2. River Velocity Field Data

Tyco Fire Products LP, Marinette, Wisconsin

Date	Time	Test Injection Location	Station / Sample ID	Sample Distance from Wall (ft)	Sample Depth (ft)	Sample Distance Downstream, Or East of Injection Site (ft)	Velocity (ft/sec)	Comments
9/21/2017	2:25:00 PM	T2	T2-SL-5A	3	4	25	0.529	
9/21/2017	2:25:00 PM	T2	T2-SL-6A	3	4	25	0.518	
9/21/2017	2:25:00 PM	T2	T2-SL-7A	3	4	50	0.404	
9/21/2017	2:25:00 PM	T2	T2-SL-8A	3	4	50	0.455	
9/21/2017	2:25:00 PM	T2	T2-SL-9A	3	4	50	0.421	

Notes:

ft = feet

ft/sec = feet per second

Table 3. Summary of Background Fluorescence Measurements for the SCUFA Instruments Used in the Pilot Dye Test

Tyco Fire Products LP, Marinette, Wisconsin

SCUFA Instrument Serial Number	Pre-study Measurements[a]		Post-study Measurements[a]	
	Fluorescence (ppb)[b]	Turbidity (NTU)	Fluorescence (ppb)[b]	Turbidity (NTU)
669	-10.9	0.4	-1.27	0.8
720	-3.24	0.86	-4.99	1.09
721	-4	0.69	-9.03	1.3
779	-1.33	1	-1.15	1.1
792	-3.16	1	-5.651	1.07

Notes:

[a] Values shown represent the average of three instrument readings.

[b] Negative fluorescence values are an artifact of the SCUFA sensor and internal SCUFA software and should be interpreted as zero (0).

ppb = part per billion

SCUFA = self-contained underwater fluorescence apparatus

NTU = Nephelometric Turbidity Units

Table 4. Summary of Maximum Dye Concentrations Measured During Pilot Dye Test

Tyco Fire Products LP, Marinette, Wisconsin

Date	Test Injection Location	SCUFA Transect Locations (feet up/downstream)	Feet from Wall	Dye Injection Depth (ft)	Dye Injection Concentration (ppb)	***Maximum*** (Instantaneous) Dye Concentration Measured (ppb)[a]	Minimum Dilution Factor
9/21/2017	T1	-20 (west)	2	2	56,800	99.1	573
		-10 (west)	2			234.6	242
		0 (injection site)	10			141.0	403
		+10 (east)	2			439.6	129
		+20 (east)	2			202.8	280
9/21/2017	T2	10	2	3	56,800	139.1	408
		25	2 and 5			43.8	1297
		50	2 and 5			18.9	3005
9/20/2017	T3-C	10	1.5	2	43,000	171.8	250
		25	1.5 and 4			57.4	749
		50	1.5 and 5.5			13.1	3282
9/20/2017	T3-D	10	1.5	12	38,100	55.8	683
		25	1.5 and 4			25.4	1500
		50	1.5 and 5.5			82.6 / 10.1 [b]	461/3765

Notes:

[a] Data shown indicated measurements recorded by SCUFAs (i.e., do not include any data from handheld fluorometers).

[b] First value represents peak measurement spike, second value is next highest maximum after spike removed. Two dilutions provided for two dye values. See text for discussion.

ft = feet

ppb = part per billion

SCUFA = self-contained underwater fluorescence apparatus

Table 5. Estimated Downstream Extent of Dye Concentrations in River

Tyco Fire Products LP, Marinette, Wisconsin

Dye Concentration (ppb)	Seepage Rate (gallons per minute)	River Velocity (ft/sec)	Distance to 10 ppb[a] (ft)	Distance to 0.1 ppb[b] (ft)
150,000	0.2	0.2	105	2,700
150,000	0.2	0.5	75	2,000
150,000	10	0.2	1,700	44,000 (Green Bay)[c]
150,000	10	0.5	1,300	33,000 (Green Bay)[c]
64,900	0.2	0.2	60	1,500
64,900	0.2	0.5	45	1,600
64,900	10	0.2	950	25,000 (Green Bay)[c]
64,900	10	0.5	700	18,000 (Green Bay)[c]
40,000	0.2	0.2	40	1,100
40,000	0.2	0.5	30	800
40,000	10	0.2	650	18,000 (Green Bay)[c]
40,000	10	0.5	500	13,000 (Green Bay)[c]
12,980[d]	0.2	0.2	20	500
12,980[d]	0.2	0.5	15	350
12,980[d]	0.2	1	10	270

Notes:

[a] 10 ppb is maximum recommended Rhodamine WT concentration entering drinking water plant and visibility limit

[b] 0.1 ppb is maximum recommended Rhodamine WT concentration in drinking water

[c] At lower river flows (such as 1200 cubic feet per second low river flows) there is not sufficient diluting river water to reach 0.1 ppb until dye reaches Green Bay.

[d] 12,980 ppb scenario assumes groundwater injection at 64,900 ppb and 5x attenuation in groundwater before reaching barrier wall

ft = feet

ft/sec = feet per second

ppb = part per billion

Figures

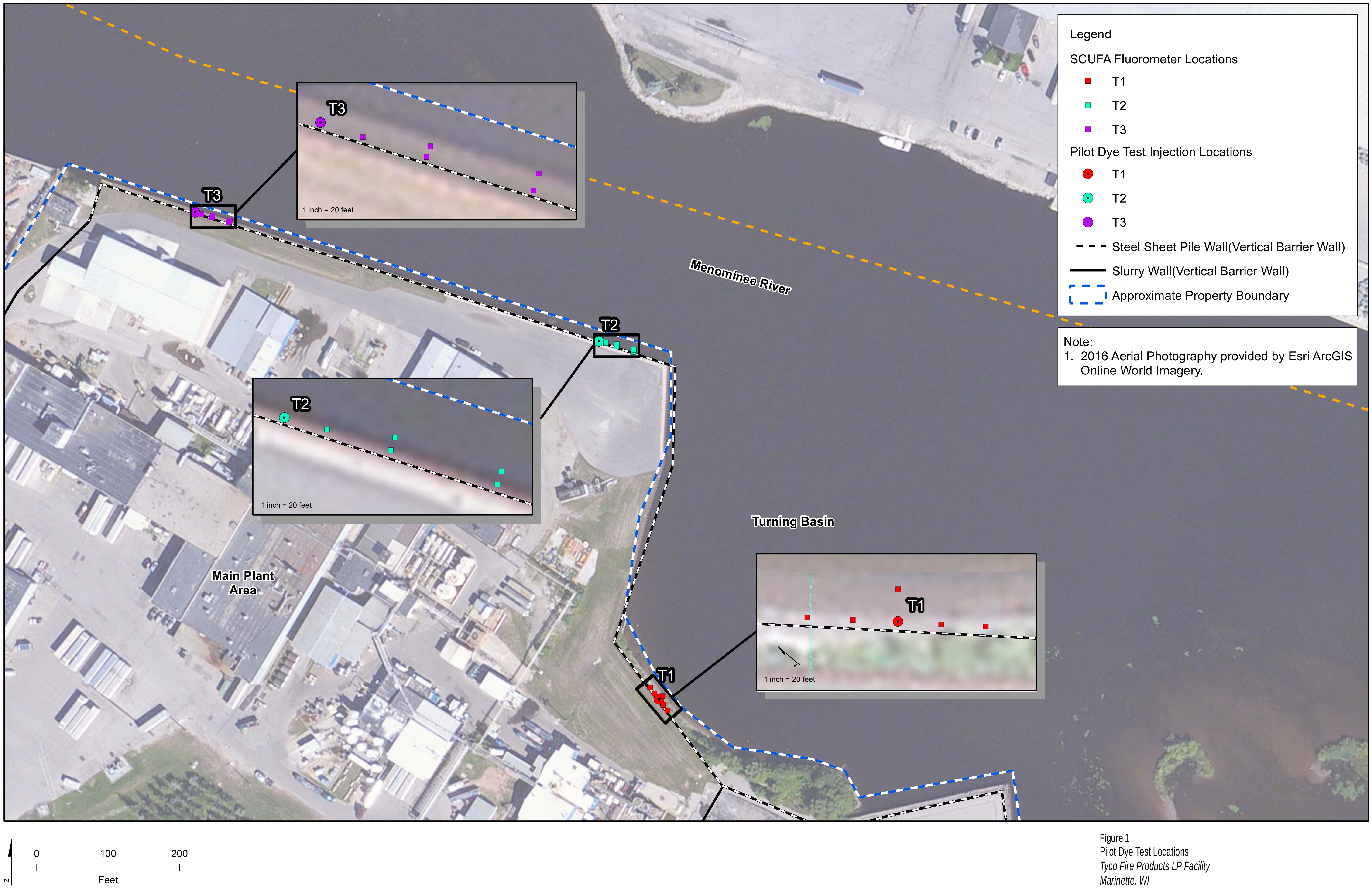
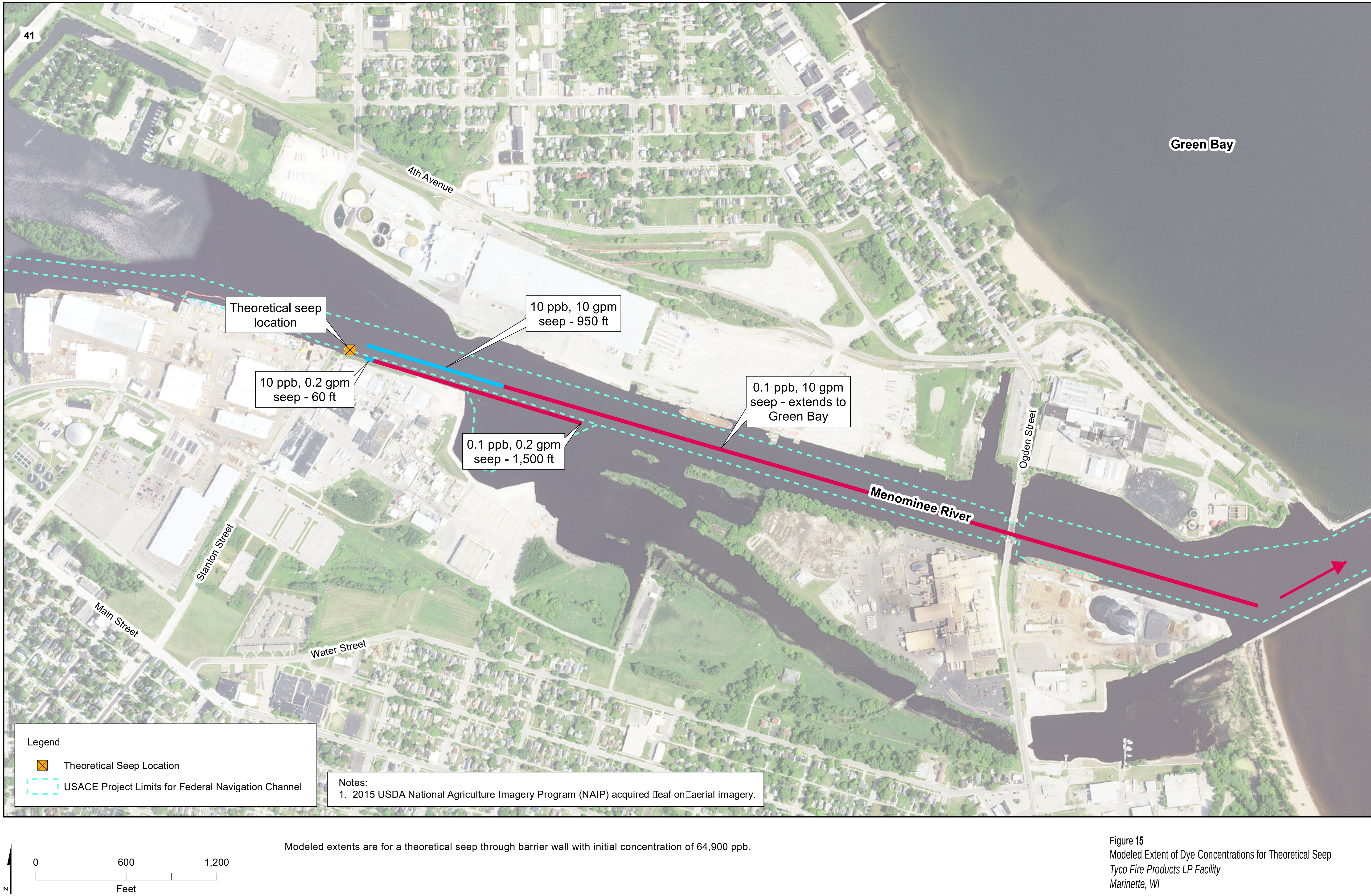


Figure 1
Pilot Dye Test Locations
Tyco Fire Products LP Facility
Marinette, WI

\\LAKEFRONT\PROJ\TYCO\MAPFILES\2017\FIGURE 1 - PILOT DYE TEST LOCATIONS_ZOOMEDINSETS104.MXD JHANSEN1 11/1/2017 12:45:23 PM

CH2MHILL



Modeled extents are for a theoretical seep through barrier wall with initial concentration of 64,900 ppb.

Figure 15
Modeled Extent of Dye Concentrations for Theoretical Seep
Tyco Fire Products LP Facility
Marinette, WI

ch2m.

Attachment A
SCUFA Calibration

Tyco Fire Protection Products
Pilot Dye Test

SCUFA Calibration Notebook

September 2017

SCUFA No. I

(I) SCUFA TURBIDITY CALIBRATION SHEET: PRE-STUDY

FACILITY:	TYCO
DATE:	9/18/17
Serial Number:	0669
Planned Deployment Site:	100-ft TRANSECT, 5 ft. OFF WALL
Conducted By:	B. PAULSON

Turbidity Standards Used			
Manufacturer	NTU	Lot #	Expiration
HACH STABLCAL	1.0	A7198	JULY 2019
" "	10.0	A7215	JULY 2019

Turbidity Calibration: Pre-Study ☑

Calibrate SCUFA using manufactures software	Calibrate to: 1.0 NTU
	AFTER CALIBRATION, METER READS 1.30 NTU
	-25.48 ppb.

Calibration Check:

Standard (NTU)	SCUFA Turbidity Reads (NTU)			SCUFA Fluorescence Reads (ppb)		
	1	2	3	1	2	3
DI	0.079	0.041	0.113	-26.003	-26.091	-25.921
1.0 NTU	1.043	1.172	1.172	-25.816	-25.725	-25.801
10.0 NTU	14.406	14.731	14.539	+19.207	+19.686	+19.614

(I) SCUFA FLUORESCENCE CALIBRATION SHEET: PRE-STUDY

FACILITY:	TYCO
DATE:	9/18/17
Serial Number:	0669
Planned Deployment Site:	100-ft TRANSECT, 5-ft OFF WALL
Planned Deployment Date:	9/19/17 – 9/21/17
Conducted By:	B. PAULSON

Temperature Compensation is on: ☑

Based on High Range Standards (for Effluent): ☐

Based on Low Range Standards (for RW): ☑

Analog Output, 5-Hz sampling rate (profiling mode) ☐

Zero Point& Full Scale Voltage Set (0.0/20 ppb/NTU) ☐

Calibrate SCUFA using manufactures software	Calibrate to: 0.025 ppm (25 ppb)
	SCUFA READINGS AFTER CALIBRATION:
	~~16.406 ppb~~ RW 23.826 ppb
	~~1.750 NTU~~ RW .979 NTU
	9/19/17 – SCUFA SET UP TO READ @ 10 SEC. SAMPLE INTERVAL (6 SAMPLES/MIN.); LOGGING DAYS AVAILABLE = 1.3 DAYS MEMORY REQ'D = 75.1%

* MEMORY ERASED PRIOR TO IDL SET UP.

Calibration Check:

Standard (ppb)	SCUFA Fluorescence Reads (ppb)			SCUFA Turbidity Reads (NTU)		
	1	2	3	1	2	3
DI Water	~~-3.706~~ -12.717	~~-3.460~~ -13.190	~~-4.071~~ -11.973	~~.337~~ 0.208	~~.820~~ 0.144	~~.499~~ 0.015
~~Effluent~~	~~-0.380~~	~~-0.820~~	~~-0.700~~	~~0.722~~	~~0.786~~	~~0.594~~
~~Seawater~~ River WATER	-10.791	-10.984	-10.919	0.337	0.337	0.465
5 ppb STD	5.204 -3.054	3.966 -3.926	4.280 -3.029	.465 0.658	.465 0.144	.594 0.401
10 " "	10.118	9.912	9.963	1.557	1.365	1.493
25 " "	25.118	25.480	24.780	1.686	1.750	2.007
100 " "	94.242	95.016	94.719	1.172	0.851	1.300
500 " "	459.098	459.270	459.705	.594	0.208	0.594

BP.

Using Standard set #2

(I) SCUFA TURBIDITY CALIBRATION CHECK SHEET: POST-STUDY

FACILITY:	TYCO FP
DATE:	9/22/17
Serial Number:	0669
Deployment Site:	T1, T2 & T3
Conducted By:	B. PAULSON

Turbidity Standards Used			
Manufacturer	NTU	Lot #	Expiration
HACH STABLCAL	1.0	A7198	JULY 2019
" "	10.0	A7215	" "

Post-Event Calibration Check:

Standard (NTU)	SCUFA Turbidity Reads (NTU)			SCUFA Fluorescence Reads (ppb)		
	-0.370	-0.820	-0.306	1	2	3
DI	~~-6.828~~	~~-6.442~~	~~-6.209~~	-6.828	-6.442	-6.209
1.0 NTU	0.979	0.915	0.979	-4.650	-4.725	-4.753
10.0	13.510	13.575	13.382	12.991	13.115	11.903

Notes:

(I) SCUFA FLUORESCENCE CALIBRATION CHECK SHEET: POST-STUDY

FACILITY:	
DATE:	
Serial Number:	
Deployment Site:	
Conducted By:	

Based on High Range (Effluent Pre-event Standards): ☐

Based on High Range (Effluent Post-event Standards): ☐

Based on Low Range (RW Pre-event Standards): ☐

Based on Low Range (RW Post-event Standards): ☐

Post-Event Results

Date:			Time:			
Dye Standard (ppb)	SCUFA Fluorescence Reads (ppb)			SCUFA Turbidity Reads (NTU)		
	1	2	3	1	2	3

Notes:

BJ
9/12/17

(I) SCUFA FLUORESCENCE CALIBRATION CHECK SHEET: POST-STUDY

FACILITY:	TYCO FP
DATE:	9/22/17
Serial Number:	0669
Deployment Site:	T1, T2 & T3
Conducted By:	B. PAULSON

Based on High Range (Effluent Pre-event Standards): ☐

Based on High Range (Effluent Post-event Standards): ☐

Based on Low Range (RW Pre-event Standards): ☒

Based on Low Range (RW Post-event Standards): ☐

Post-Event Results						
Date: 9/22/17			Time: 0940			
Dye Standard (ppb)	SCUFA Fluorescence Reads (ppb)			SCUFA Turbidity Reads (NTU)		
	1	2	3	1	2	3
DI ~~RIVER WATER~~	-6.221	-6.416	-6.940	-0.370	-0.756	-0.435
5 ppb	5.436	5.256	4.661	1.493	1.365	1.300
10 "	8.376	8.659	8.613	0.915	0.915	0.979
25 "	22.719	23.932	24.543	2.393	1.815	1.557
100 "	89.400	88.556	89.177	1.043	0.594	0.851
500 "	433.218	434.592	434.375	0.272	0.594	0.599
RIVER WATER (BLANK)	-1.308	-1.208	-1.296	0.851	0.722	0.658

Notes:

(I) SCUFA TEST AND SET-UP SHEET – Stand Alone

FACILITY:	
DATE:	
Serial Number:	
Planned Deployment Site:	
Planned Deployment Date	
Conducted By:	

Logging Test	
Sample Rate	
Test Solution(s) and Soak Time(s)	
Battery Test	
Memory Check	
File Name	
Notes	

Set-up	
Sample Rate	
Start Time	
Battery Charged?	
Notes	

BKB
9/22/17

Download	
File Name	
Notes	

(I) SCUFA QC SHEET

FACILITY:	Tyco
DATE:	9/18/2017
Serial Number:	0669
Planned Deployment Site:	100-ft TRANSECT, 5-ft OFF WALL
Planned Deployment Date:	9/19/17 – 9/21/17
Conducted By:	B.Paulson

Based on High Range DI Standards (for Effluent): ☐

Based on Low Range DI Standards (for RW): ☑

Precision Check Based on DI Dye Standards:

Pre-Event Results

Date: 9/18/2017 Time: 6:00 PM

Dye Standard (ppb)	SCUFA Fluorescence Reads (ppb)			SCUFA Turbidity Reads (NTU)		
	1	2	3	1	2	3
DI Water	-1.550	-1.680	-1.590	-0.080	-0.110	-0.180
5 ppb STD	4.230	4.370	4.070	0.594	0.722	0.465
10 " "	10.425	9.688	9.733	0.529	0.594	0.465
25 " "	24.020	24.380	24.930	0.851	0.786	0.722
100 " "	96.260	96.450	95.970	0.272	0.465	0.401
500 " "	463.298	~~460~~ 461.09	460.275	0.529	0.465	0.401

Post-Event Results

Date: 9/22/17 Time: ~~1020~~ 1000 – 1020 HRS.

Dye Standard (ppb)	SCUFA Fluorescence Reads (ppb)			SCUFA Turbidity Reads (NTU)		
	1	2	3	1	2	3
DI Water	-4.933	-4.610	-5.082	-0.627	-0.563	-0.370
5 ppb STD	1.288	1.024	1.596	0.658	0.144	0.272
10 " "	6.802	6.834	5.623	0.272	0.337	0.208
25 " "	21.731	21.584	21.556	0.272	0.015	0.015
100 " "	91.093	91.328	91.446	0.272	0.594	0.272
500 " "	454.433	454.923	455.170	-0.627	-0.884	-0.563

(1) SCUFA FLUORESCENCE ~~CALIBRATION SHEET: PRE-STUDY~~ VERIFICATION

FACILITY:	TYCO FP
DATE:	9/20/17 (0735 – 0805 hrs.)
Serial Number:	0669
Planned Deployment Site:	LOCATION 3
Planned Deployment Date:	9/20/17
Conducted By:	B. PAULSON

Temperature Compensation is on: ☑

Based on High Range Standards (for Effluent): ☐

Based on Low Range Standards (for RW): ☑

Analog Output, 5-Hz sampling rate (profiling mode) ☐

Zero Point& Full Scale Voltage Set (0.0/20 ppb/NTU) ☐

Calibrate SCUFA using manufactures software	Calibrate to: ______ ppm (_______ppb)
	NOTE:
	* INSTRUMENT WAS CALIBRATED PREVIOUSLY ON 9/18/17 – THESE MEASUREMENTS ARE JUST BEING USED TO VERIFY THAT INSTRUMENT CALIBRATIONS ARE STILL VALID.

Calibration Check:

9/18 CALIB. OF VALUES AVG.	Standard (ppb)	SCUFA Fluorescence Reads (ppb)			SCUFA Turbidity Reads (NTU)		
		1	2	3	1	2	3
	DI Water	-4.110	-4.999	-4.428	-0.370	-0.306	-0.563
	~~Effluent~~						
	RIVER ~~Seawater~~	-2.669	-2.921	-2.187	0.851	0.722	0.722
4.45	5 ppb STD	4.686	4.948	4.976	1.622	1.429	1.300
9.99	10 " "	9.263	9.842	9.807	1.172	1.236	1.108
25.13	25 " "	23.211	23.083	23.461	1.943	2.200	1.815
94.66	100 " "	92.429	92.301	92.440	0.851	1.152	1.108
459.4	500 " "	446.949	447.921	446.222	0.529	0.658	0.594

*

SCUFA No. II

(II) SCUFA TURBIDITY CALIBRATION SHEET: PRE-STUDY

FACILITY:	
DATE:	
Serial Number:	
Planned Deployment Site:	
Conducted By:	

Turbidity Standards Used			
Manufacturer	NTU	Lot #	Expiration

Turbidity Calibration: **Pre-Study** ☐

Calibrate SCUFA using manufactures software	Calibrate to: _____ NTU
	RKB 9/22/17

Calibration Check:

Standard (NTU)	SCUFA Turbidity Reads (NTU)			SCUFA Fluorescence Reads (ppb)		
	1	2	3	1	2	3

(II) SCUFA TURBIDITY CALIBRATION SHEET: PRE-STUDY

FACILITY:	TYCO
DATE:	9/18/17
Serial Number:	0720
Planned Deployment Site:	100-ft TRANSECT, 20-ft OFF WALL
Conducted By:	K. Winslow / B. Paulson

Turbidity Standards Used			
Manufacturer	NTU	Lot #	Expiration
HACH STABLCAL	1.0	A 7198	July 2019
"	10.0	A 7215	July 2019

Turbidity Calibration: **Pre-Study** ☑

Calibrate SCUFA using manufactures software	Calibrate to: 1.0 NTU
	AFTER Calibration, meter reads 0.96 NTU
	-5.84 ppb

Calibration Check:

Standard (NTU)	SCUFA Turbidity Reads (NTU)			SCUFA Fluorescence Reads (ppb)		
	1	2	3	1	2	3
DI	-.114	-.036	-.207	-6.558	-6.585	-6.493
1.0 NTU	0.94	1.10	0.93	-5.73	-5.92	-5.88
10.0 NTU	11.539	11.680	11.664	4.745	4.716	4.571

(II) SCUFA FLUORESCENCE CALIBRATION SHEET: PRE-STUDY

FACILITY:	TYCO
DATE:	9/18/17
Serial Number:	0720
Planned Deployment Site:	100-ft TRANSECT, 20-ft OFF WALL
Planned Deployment Date:	9/19/17 – 9/21/17
Conducted By:	R. WNUK / B. PAULSON

Temperature Compensation is on: ☑

Based on High Range Standards (for Effluent): ☐

Based on Low Range Standards (for RW): ☑

Analog Output, 5-Hz sampling rate (profiling mode) ☐

Zero Point& Full Scale Voltage Set (0.0/20 ppb/NTU) ☐

Calibrate SCUFA using manufactures software	Calibrate to: 0.025 ppm (25 ppb)
	SCUFA READINGS AFTER CALIBRATION:
	20.045 ppb 22.759 ppb
	1.070 NTU 1.631 NTU
	9/19/17 – SCUFA 0720 SET UP TO READ @ 10 SEC.
	SAMPLE INTERVAL (6 SAMPLES/MIN.);
	LOGGING DAYS AVAILABLE = 1.3 DAYS
	MEMORY REQ'D = 75.1%

* MEMORY ERASED PRIOR TO IDL SET UP.

Calibration Check:

Standard (ppb)	SCUFA Fluorescence Reads (ppb)			SCUFA Turbidity Reads (NTU)		
	1	2	3	1	2	3
DI Water	-7.85 -3.362	-7.49 -2.730	-7.60 -2.860	0.042 0.058	0.089 0.104	0.058 -0.005
~~Effluent~~	-3.111	-3.260	-3.359	0.899	0.821	0.868
~~Seawater~~ RIVER WATER	61.111	60.894	61.026	5.541	5.541	5.510
5 ppb STD	5.231 0.071	5.373 0.085	5.080 -0.075	1.616 0.104	1.382 0.136	1.328 0.089
10 " "	9.237	8.974	9.422	1.288	1.195	1.257
25 " "	23.151	23.305	22.781	1.522	1.507	1.647
100 " "	96.958	96.134	96.121	1.226	1.008	1.070
500 " "	493.845	493.773	493.561	0.883	0.915	0.805

Using Standard Set #2

(II) SCUFA TURBIDITY CALIBRATION CHECK SHEET: POST-STUDY

FACILITY:	TYCO FP
DATE:	9/22/17
Serial Number:	0720
Deployment Site:	T1, T2 & T3
Conducted By:	B. PAULSON

Turbidity Standards Used			
Manufacturer	NTU	Lot #	Expiration
HACH STABLCAL	1.0	A7198	July 2019
" "	10.0	A7215	" "

Post-Event Calibration Check:

Standard (NTU)	SCUFA Turbidity Reads (NTU)			SCUFA Fluorescence Reads (ppb)		
	1	2	3	1	2	3
DI	2.099	2.052	2.036	21.251	21.408	21.357
1.0	1.024	0.946	1.039	-6.214	-6.610	-6.728
10.0	11.306	10.994	10.978	15.707	15.395	15.588

Notes:

(II) SCUFA FLUORESCENCE CALIBRATION CHECK SHEET: POST-STUDY

FACILITY:	
DATE:	
Serial Number:	
Deployment Site:	
Conducted By:	

Based on High Range (Effluent Pre-event Standards): ☐

Based on High Range (Effluent Post-event Standards): ☐

Based on Low Range (RW Pre-event Standards): ☐

Based on Low Range (RW Post-event Standards): ☐

Post-Event Results						
Date:			Time:			
Dye Standard (ppb)	SCUFA Fluorescence Reads (ppb)			SCUFA Turbidity Reads (NTU)		
	1	2	3	1	2	3

BHP

9/22/17

Notes:

(II) SCUFA FLUORESCENCE CALIBRATION CHECK SHEET: POST-STUDY

FACILITY:	TYCO FP
DATE:	9/22/17
Serial Number:	0720
Deployment Site:	T1, T2 & T3
Conducted By:	B. Pairson

Based on High Range (Effluent Pre-event Standards): ☐

Based on High Range (Effluent Post-event Standards): ☐

Based on Low Range (RW Pre-event Standards): ☒

Based on Low Range (RW Post-event Standards): ☐

Post-Event Results						
Date: 9/22/17				Time: 1025 — 1045		
Dye Standard (ppb)	SCUFA Fluorescence Reads (ppb)			SCUFA Turbidity Reads (NTU)		
	1	2	3	1	2	3
DI WATER	-3.432	-3.921	-3.401	0.073	0.182	0.291
RIVER WATER	-4.423	-5.155	-5.384	1.008	1.133	1.148
5 ppb STD	3.520	3.105	3.532	1.413	1.646	1.538
10 " "	8.255	7.596	7.674	1.226	1.195	1.164
25 " "	23.018	23.469	23.490	1.553	1.600	1.460
100 " "	92.148	92.283	92.949	1.164	1.179	1.086
500 " "	483.151	483.426	484.003	0.696	0.837	0.463

Notes:

(II) SCUFA TEST AND SET-UP SHEET – Stand Alone

FACILITY:	
DATE:	
Serial Number:	
Planned Deployment Site:	
Planned Deployment Date	
Conducted By:	

Logging Test	
Sample Rate	
Test Solution(s) and Soak Time(s)	
Battery Test	
Memory Check	
File Name	
Notes	

Set-up	
Sample Rate	
Start Time	
Battery Charged?	
Notes	BKD 9/22/17

Download	
File Name	
Notes	

(II) SCUFA QC SHEET

FACILITY:	Tyco
DATE:	9/18/2017
Serial Number:	0720
Planned Deployment Site:	100-ft TRANSECT, 20-ft OFF WALL
Planned Deployment Date:	9/19/17 - 9/21/17
Conducted By:	B. Paulson

Based on High Range DI Standards (for Effluent): ☐

Based on Low Range DI Standards (for RW): ☑

Precision Check Based on DI Dye Standards:

Pre-Event Results

Date: 9/18/2017 Time: 5:50 PM

Dye Standard (ppb)	SCUFA Fluorescence Reads (ppb)			SCUFA Turbidity Reads (NTU)		
	1	2	3	1	2	3
DI Water	-6.560	-5.513	-5.947	0.027	0.051	-0.019
5 ppb STD	3.335	3.424	4.225	0.478	0.447	0.432
10 " "	9.710	9.480	9.610	0.478	0.447	0.400
25 " "	21.280	21.180	21.710	0.463	0.432	0.338
100 " "	98.440	97.950	98.210	0.260	0.214	0.229
500 " "	496.190	499.114	498.860	0.416	0.151	0.167

Post-Event Results

Date: 9/22/17 Time: 1045-1105

Dye Standard (ppb)	SCUFA Fluorescence Reads (ppb)			SCUFA Turbidity Reads (NTU)		
	1	2	3	1	2	3
DI Water	-5.237	-4.955	-5.233	0.042	0.104	0.058
5 ppb DI STD	4.228	4.255	5.009	0.385	0.369	0.463
10 " " "	8.343	8.131	8.417	0.400	0.432	0.463
25 " " "	20.410	21.152	21.160	0.400	0.385	0.400
100 " " "	93.410	93.828	93.009	0.369	0.104	0.245
500 " " "	492.897	492.210	492.609	0.136	0.167	0.104

SCUFA No. III

(III) SCUFA TURBIDITY CALIBRATION SHEET: PRE-STUDY

FACILITY:	Tyco
DATE:	9/18/2017
Serial Number:	0721
Planned Deployment Site:	300-ft TRANSECT, 5-ft OFF WALL
Conducted By:	B. Paulson

Turbidity Standards Used			
Manufacturer	NTU	Lot #	Expiration
HACH STABLCAL	1.0	A7198	July 2019
" "	10.0	A7215	July 2019

Turbidity Calibration: Pre-Study ☑

Calibrate SCUFA using manufactures software	Calibrate to: 1.0 NTU
	After calibration, meter reads .950 NTU
	-18.76 ppb

Calibration Check:

Standard (NTU)	SCUFA Turbidity Reads (NTU)			SCUFA Fluorescence Reads (ppb)		
	1	2	3	1	2	3
DI	-.218	-.201	-.207	-20.446	-20.288	-20.265
1.0 NTU	.921	.983	1.029	-19.841	-19.918	-19.897
10.0 NTU	12.652	12.691	12.674	-1.150	-1.172	-1.190

(III) SCUFA FLUORESCENCE CALIBRATION SHEET: PRE-STUDY

FACILITY:	Tyco
DATE:	9/18/2017
Serial Number:	0721
Planned Deployment Site:	300-ft TRANSECT, 5-ft OFF WALL
Planned Deployment Date:	9/19/17 - 9/21/17
Conducted By:	B. Paulson

Temperature Compensation is on: ☑

Based on High Range Standards (for Effluent): ☐

Based on Low Range Standards (for RW): ☑

Analog Output, 5-Hz sampling rate (profiling mode) ☐

Zero Point& Full Scale Voltage Set (0.0/20 ppb/NTU) ☐

Calibrate SCUFA using manufactures software	Calibrate to: .025 ppm (25 ppb)
	SCUFA readings after calibration:
	22.821 ppb
	1.632 NTU
	9/19/17 - SCUFA 0721 SET UP TO READ AT 10 SECOND
	SAMPLING INTERVAL (6 SAMPLES/MIN.);
	LOGGING DAYS AVAILABLE = 1.3 DAYS
	MEMORY REQ'D = 75.1%

Calibration Check:

* MEMORY ERASED PRIOR TO IDL SET UP.

Standard (ppb)	SCUFA Fluorescence Reads (ppb)			SCUFA Turbidity Reads (NTU)		
	1	2	3	1	2	3
DI Water	~~-8.907~~ -9.020 RW	-9.943	-9.009	-.364	-0.218	-0.348
~~Effluent~~						
~~Seawater~~ RIVER WATER	-3.536	-4.126	-4.346	+.809	0.622	0.645
5 ppb STD	4.832	4.334	4.496	1.367	1.344	1.361
10 ppb STD	10.008	8.910	9.230	1.107	1.096	1.062
25 ppb STD	24.764	24.459	24.724	1.632	1.581	1.649
100 ppb STD	75.750	75.496	75.532	1.079	1.057	1.124
500 ppb STD	372.71	373.827	372.928	0.521	0.436	0.498

RW

III

~~(IV)~~ SCUFA TURBIDITY CALIBRATION CHECK SHEET: POST-STUDY

FACILITY:	TYCO FP
DATE:	9/22/17
Serial Number:	0721
Deployment Site:	T1, T2, T3
Conducted By:	B. Paulson

Turbidity Standards Used			
Manufacturer	NTU	Lot #	Expiration
HACH	1.0	A7198	July 2019
"	10.0	A7215	"

Post-Event Calibration Check:

Standard (NTU)	SCUFA Turbidity Reads (NTU)			SCUFA Fluorescence Reads (ppb)		
	1	2	3	1	2	3
SW B.T DI	-0.384	-0.449	-0.443	-15.222	-15.322	-15.304
1.0	1.023	1.085	0.993	-9.743	-9.630	-10.335
10.0	11.862	11.930	11.817	32.818	32.878	32.408

Notes:

III ~~(IV)~~ **SCUFA FLUORESCENCE CALIBRATION CHECK SHEET: POST-STUDY**

FACILITY:	TYCO FP
DATE:	9/22/17
Serial Number:	0721
Deployment Site:	T1, T2, T3
Conducted By:	B. Paulson

Based on High Range (Effluent Pre-event Standards): ☐

Based on High Range (Effluent Post-event Standards): ☐

Based on Low Range (RW Pre-event Standards): ☒

Based on Low Range (RW Post-event Standards): ☐

Post-Event Results						
Date: 9/22/17			Time: 1055			
Dye Standard (ppb)	SCUFA Fluorescence Reads (ppb)			SCUFA Turbidity Reads (NTU)		
	1	2	3	1	2	3
RW Blank	9.604	8.804	8.690	1.248	1.361	1.282
RW 5	-2.302	-2.424	-2.521	1.192	1.107	1.074
RW 10	-2.499	-2.703	-2.405	0.910	0.820	0.933
RW 25	11.271	11.018	11.778	1.220	1.220	1.215
RW 100	66.240	65.932	65.811	0.962	1.198	0.911
RW 500	356.87	356.600	356.782	0.504	0.324	0.493

Notes:

(III) SCUFA QC SHEET

FACILITY:	Tyco
DATE:	9/18/2017
Serial Number:	0721
Planned Deployment Site:	~~300-ft TRANSECT, 5-ft OFF WALL~~ T1, T2, T3
Planned Deployment Date:	9/19/17 – 9/21/17
Conducted By:	B. Paulson

Based on High Range DI Standards (for Effluent): ☐

Based on Low Range DI Standards (for RW): ☑

Precision Check Based on DI Dye Standards:

Pre-Event Results

Date: 9/18/2017 Time: 5:40 PM

Dye Standard (ppb)	SCUFA Fluorescence Reads (ppb)			SCUFA Turbidity Reads (NTU)		
	1	2	3	1	2	3
DI Water	-10.069	-9.972	-9.371	-.432	-0.404	-0.455
5 ppb STD	3.847	2.882	2.946	0.030	0.149	0.098
10 " "	9.986	9.462	9.578	0.228	0.098	0.030
25 " "	17.145	17.405	17.901	0.245	0.194	0.188
100 " "	68.143	67.141	67.190	-0.170	-0.190	-0.145
500 " "	379.790	378.220	378.920	0.092	0.070	0.087

Post-Event Results

Date: 9/22/17 Time: ~~10~~ 1115

Dye Standard (ppb)	SCUFA Fluorescence Reads (ppb)			SCUFA Turbidity Reads (NTU)		
	1	2	3	1	2	3
DI Water	-11.222	-11.120	-11.060	~~200~~ -0.332	-0.398	-0.364
5	-4.639	-4.919	-4.490	0.357	0.121	0.047
10	3.675	3.960	3.977	0.329	0.188	0.265
25	7.561	7.792	7.091	-0.099	-0.062	-0.252
100	63.628	63.502	63.073	-0.097	-0.112	-0.094
500	368.677	367.649	366.558	-0.190	-0.122	-0.082

SCUFA No. IV

(IV) SCUFA TURBIDITY CALIBRATION SHEET: PRE-STUDY

FACILITY:	Tyco
DATE:	9/18/2017
Serial Number:	0779 20
Planned Deployment Site:	300-ft TRANSECT, 8-ft OFF WALL
Conducted By:	K. Winslow / B. Paulson (BP)

Turbidity Standards Used			
Manufacturer	NTU	Lot #	Expiration
HACHSTABLCAL	1.0	A7198	July 2019
" "	10.0	A7215	July 2019

Turbidity Calibration: **Pre-Study** ☑

Calibrate SCUFA using manufactures software	Calibrate to: 1.0 NTU
	After calibration, meter reads 1.018 NTU
	-1.314 ppb

Calibration Check:

Standard (NTU)	SCUFA Turbidity Reads (NTU)			SCUFA Fluorescence Reads (ppb)		
	1	2	3	1	2	3
DI	.122	.088	.080	-2.460	-2.475	-2.467
1.0 NTU	1.275	1.280	1.262	-0.392	-0.403	-0.435
10.0 NTU	10.097	10.023	10.078	2.989	3.028	3.035

(IV) SCUFA FLUORESCENCE CALIBRATION SHEET: PRE-STUDY

FACILITY:	Tyco
DATE:	9/18/2017
Serial Number:	0779
Planned Deployment Site:	300-ft TRANSECT, ~~8~~ 20-ft OFF WALL
Planned Deployment Date:	9/19/17 – 9/21/17
Conducted By:	B. Paulson

Temperature Compensation is on: ☑

Based on High Range Standards (for Effluent): ☐

Based on Low Range Standards (for RW): ☑

Analog Output, 5-Hz sampling rate (profiling mode) ☐

Zero Point& Full Scale Voltage Set (0.0/20 ppb/NTU) ☐

Calibrate SCUFA using manufactures software	Calibrate to: .025 ppm (25 ppb)
	SCUFA readings after calibration:
	24.415 ppb
	1.336 NTU
	9/19/17 – SCUFA 0779 SET UP TO READ @ 10 SECOND
	SAMPLING INTERVAL (6 SAMPLES/MIN.);
	LOGGING DAYS AVAILABLE = 1.3 DAYS.
	MEMORY REQ'D = 75.1%

* MEMORY ERASED PRIOR TO IDL SET UP.

Calibration Check:

Standard (ppb)	SCUFA Fluorescence Reads (ppb)			SCUFA Turbidity Reads (NTU)		
	1	2	3	1	2	3
DI Water	-9.647	-9.699	-9.493	-0.003	-0.058	0.066
~~Effluent~~						
~~Seawater~~ RIVER WATER	-1.313	-1.565	-1.101	0.986	0.994	1.031
5 ppb STD	4.148	5.305	4.744	1.262	1.318	1.363
10 ppb STD	9.432	9.528	9.532 ~~9.532~~	1.113	1.095	1.071
25ppb STD	30.101	30.230	30.210	2.060	~~1.7~~ 1.718	1.728
100ppb STD	113.156	112.912	~~113~~ 112.959	1.031	1.079	0.920
500ppb STD	548.835	548.243	547.472	0.517	0.461	0.509

IV

~~(III)~~ SCUFA TURBIDITY CALIBRATION CHECK SHEET: POST-STUDY

FACILITY:	TYCO FP
DATE:	9/22/17
Serial Number:	0779
Deployment Site:	T1, T2, T3
Conducted By:	B. Paulson.

Turbidity Standards Used			
Manufacturer	NTU	Lot #	Expiration
HACH	1.0	A7198	July 2019
"	10.0	A7215	"

Post-Event Calibration Check:

Standard (NTU)	SCUFA Turbidity Reads (NTU)			SCUFA Fluorescence Reads (ppb)		
	1	2	3	1	2	3
DI	0.271	0.263	0.188	-9.804	-9.822	-9.663
1.0	0.946	0.941	0.912	-5.999	-6.000	-6.221
10.0	9.538	9.643	9.673	17.225	16.907	17.218

Notes:

~~IIII~~ IV SCUFA FLUORESCENCE CALIBRATION CHECK SHEET: POST-STUDY

FACILITY:	TYCO FP
DATE:	9/22/17
Serial Number:	0779
Deployment Site:	T1, T2, T3
Conducted By:	B. Paulson

Based on High Range (Effluent Pre-event Standards): ☐

Based on High Range (Effluent Post-event Standards): ☐

Based on Low Range (RW Pre-event Standards): ☒

Based on Low Range (RW Post-event Standards): ☐

Post-Event Results						
Date: 9/22/17			Time: 0810			
Dye Standard (ppb)	SCUFA Fluorescence Reads (ppb)			SCUFA Turbidity Reads (NTU)		
	1	2	3	1	2	3
RW Blank	1.292	1.162	0.997	1.251	1.045	0.989
RW 5	1.368	1.358	1.454	0.973	0.822	0.997
RW 10	5.129	4.705	4.701	0.777	0.801	0.798
RW 25	21.672	21.720	21.605	0.925	0.926	0.893
RW 100	110.009	110.134	109.180	0.856	0.864	0.904
RW 500	584.493	584.546	584.450	0.239	0.281	0.255

Notes:

(IV) SCUFA QC SHEET

FACILITY:	Tyco
DATE:	9/18/2017
Serial Number:	0779
Planned Deployment Site:	300-ft Transect, 20 8-ft off wall
Planned Deployment Date:	9/19/17 - 9/21/17
Conducted By:	B. Paulson

Based on High Range DI Standards (for Effluent): ☐

Based on Low Range DI Standards (for RW): ☑

Precision Check Based on DI Dye Standards:

Pre-Event Results

Date: 9/18/2017 Time: 5:30 PM

Dye Standard (ppb)	SCUFA Fluorescence Reads (ppb)			SCUFA Turbidity Reads (NTU)		
	1	2	3	1	2	3
DI Water	-6.455	-6.446	-7.181	0.008	-0.005	0.016
5ppb STD	2.271	2.172	2.179	0.406	0.456	0.549
10 " "	6.151	6.140	6.334	0.422	0.374	0.395
25 " "	21.150	21.230	23.910	0.390	0.387	0.464
100 " "	113.350	113.930	113.904	0.199	0.202	0.191
500 " "	556.210	556.240	555.730	0.369	0.321	0.263

Post-Event Results

Date: Time:

Dye Standard (ppb)	SCUFA Fluorescence Reads (ppb)			SCUFA Turbidity Reads (NTU)		
	1	2	3	1	2	3
DI Water	-5.530	-5.417	-5.562	0.085	0.072	0.045
5	-4.208	-4.160	-4.185	0.135	0.196	0.141
10	3.651	3.799	3.289	0.154	0.172	0.183
25	16.581	16.583	16.621	-0.008	-0.005	-0.026
100	113.597	113.671	113.758	0.008	0.053	0.024
500	578.335	578.185	578.937	-0.005	-0.003	-0.016

SCUFA No. V

(V) SCUFA TURBIDITY CALIBRATION SHEET: PRE-STUDY

FACILITY:	Tyco
DATE:	9/18/2017
Serial Number:	0792
Planned Deployment Site:	LOCATION 1 (TURNING BASIN)
Conducted By:	B. Paulson

Turbidity Standards Used			
Manufacturer	NTU	Lot #	Expiration
HACH STABLCAL	1.0	A7198	July 2019
HACH STABLCAL	10.0	A7215	July 2019

Turbidity Calibration: **Pre-Study** ☑

Calibrate SCUFA using manufactures software	Calibrate to: 1.0 NTU
	After calibratron, meter reads 1.077 NTU
	-5.535 ppb

Calibration Check:

Standard (NTU)	SCUFA Turbidity Reads (NTU)			SCUFA Fluorescence Reads (ppb)		
	1	2	3	1	2	3
DI	-.048	-.020	-.040	-6.720	-6.764	-6.757
1.0 NTU	1.023	1.077	1.026	-6.110	-5.511	-6.382
10.0 NTU	10.368	10.443	10.460	-2.075	-2.038	-2.073

(V) SCUFA FLUORESCENCE CALIBRATION SHEET: PRE-STUDY

FACILITY:	Tyco
DATE:	9/18/2017
Serial Number:	0792
Planned Deployment Site:	LOCATION 1 (TURNING BASIN)
Planned Deployment Date:	9/19/17
Conducted By:	B. Paulson

Temperature Compensation is on: ☑

Based on High Range Standards (for Effluent): ☐

Based on Low Range Standards (for RW): ☑

Analog Output, 5-Hz sampling rate (profiling mode) ☐

Zero Point& Full Scale Voltage Set (0.0/20 ppb/NTU) ☐

Calibrate SCUFA using manufactures software	Calibrate to: .005 ppm (5.0 ppb)
	SCUFA readings after calibration:
	3.748 ppb
	1.089 NTU
	9/19/17 – SCUFA SET UP TO READ AT ONE SAMPLE PER MINUTE (LOGGING DAYS AVAILABLE = 8.0 DAYS; MEMORY REQ'D = 12.5%).

Calibration Check:

Standard (ppb)	SCUFA Fluorescence Reads (ppb)			SCUFA Turbidity Reads (NTU)		
	1	2	3	1	2	3
DI Water	-10.290	-10.413	-10.387	-0.045	-0.045	-0.042
~~Effluent~~						
~~Seawater~~ RIVER WATER	-2.693	-3.839	-3.439	1.035	1.003	0.955
5 ppb STD	4.745	4.718	4.935	1.183	1.149	1.240
10 " "	10.888	10.796	10.685	1.100	1.097	1.095
25 " "	40.331	39.172	39.966	1.892	1.666	1.735
100 " "	162.849	164.000	164.261	1.017	1.009	1.012
500 " "	791.040	791.138	791.248	0.875	0.903	0.575

(V) SCUFA TURBIDITY CALIBRATION CHECK SHEET: POST-STUDY

FACILITY:	TYCO FP
DATE:	9/22/17
Serial Number:	0792
Deployment Site:	T1, T2 + T3
Conducted By:	B. Paulson

Turbidity Standards Used			
Manufacturer	NTU	Lot #	Expiration
HACH	1.0	A7198	July 4 2019
"	10.0	A7215	" "

Post-Event Calibration Check:

Standard (NTU)	SCUFA Turbidity Reads (NTU)			SCUFA Fluorescence Reads (ppb)		
	1	2	3	1	2	3
DI	0.343	0.360	0.335	-11.274	-11.251	-11.133
1.0	1.872	1.855	1.752	44.131	43.586	42.888
10.0	12.865	12.660	12.634	115.692	115.662	115.772

Notes:

(V) SCUFA FLUORESCENCE CALIBRATION CHECK SHEET: POST-STUDY

FACILITY:	TY(D) FP
DATE:	9/22/17
Serial Number:	0792
Deployment Site:	T1, T2, T3
Conducted By:	B. Paulson

Based on High Range (Effluent Pre-event Standards): ☐

Based on High Range (Effluent Post-event Standards): ☐

Based on Low Range (RW Pre-event Standards): ☒

Based on Low Range (RW Post-event Standards): ☐

Post-Event Results GN						
Date: 9/22/17			Time: ~~0830~~ 1030			
Dye Standard (ppb)	SCUFA Fluorescence Reads (ppb)			SCUFA Turbidity Reads (NTU)		
	1	2	3	1	2	3
RW Blank	-5.507	-5.842	-5.605	1.077	1.026	1.092
RW 5	1.408	1.034	1.029	1.360	1.246	1.209
RW 10	9.830	9.273	9.319	0.966	0.886	0.917
RW 25	30.600	30.198	30.052	0.955	0.955	0.960
RW 100	171.010	170.713	171.069	1.023	1.032	1.083
RW 500	769.208	770.748	770.626	0.306	0.312	0.309

Notes:

(V) SCUFA QC SHEET

FACILITY:	Tyco
DATE:	9/18/2017
Serial Number:	0792
Planned Deployment Site:	~~LOCATION 1 (TURNING BASIN)~~ BN T1, T2, T3
Planned Deployment Date:	9/19/17
Conducted By:	B. Paulson

Based on High Range DI Standards (for Effluent): ☐

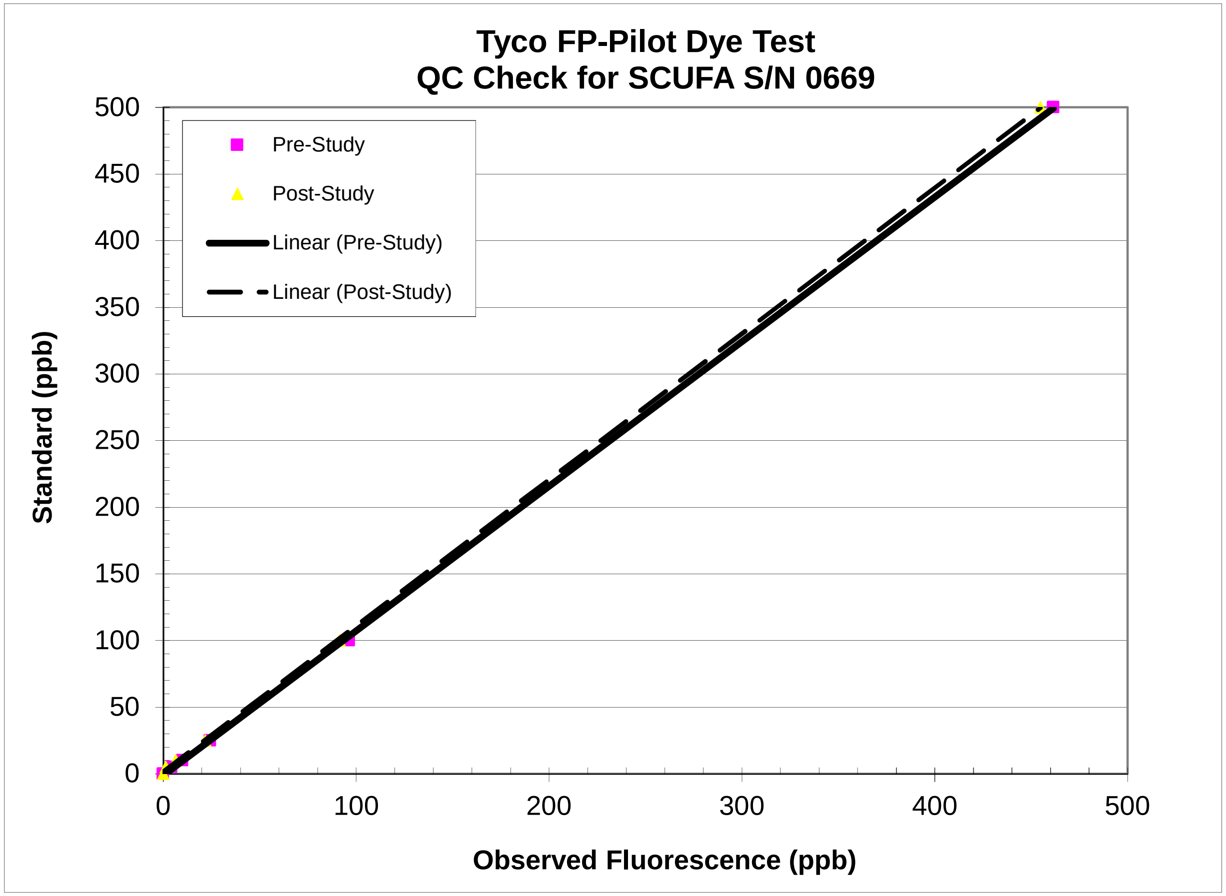
Based on Low Range DI Standards (for RW): ☑

Precision Check Based on DI Dye Standards:

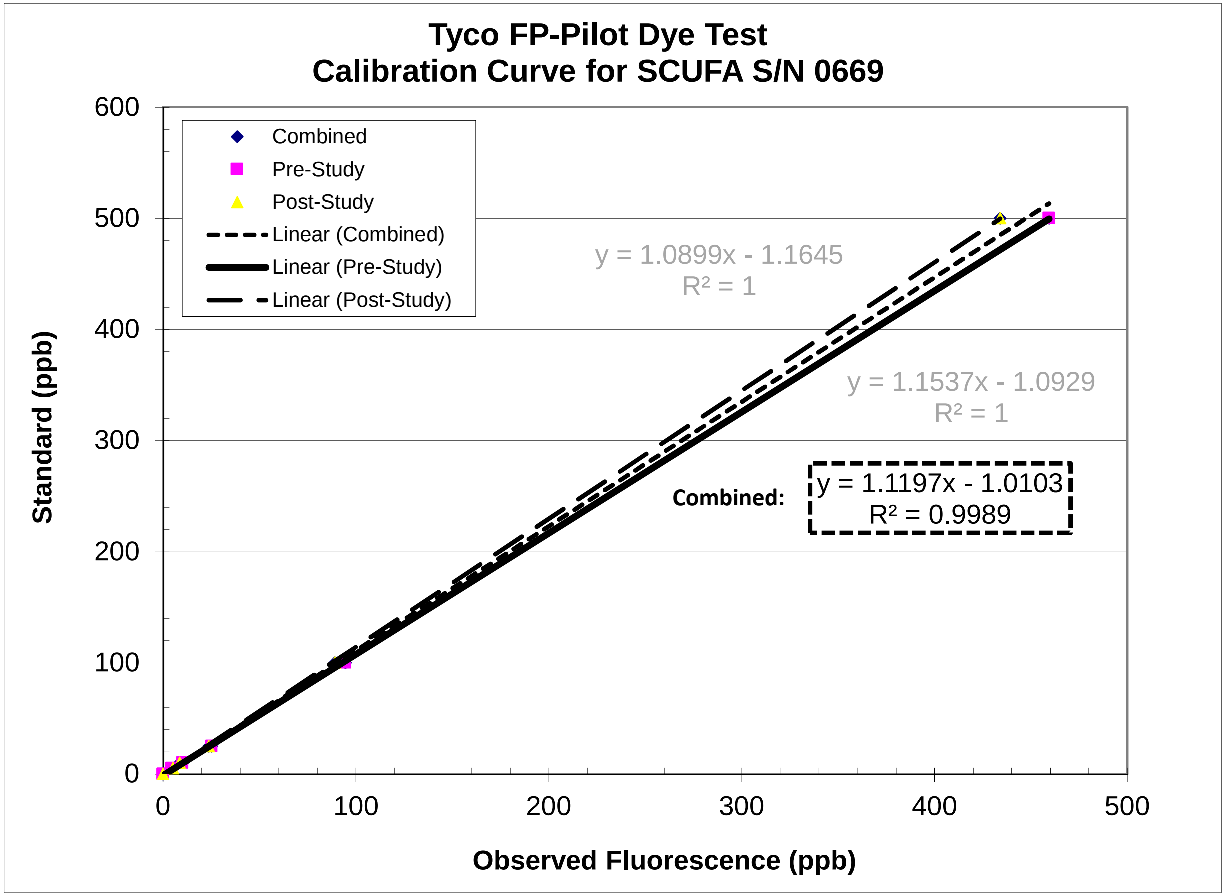
Pre-Event Results						
Date: 9/18/2017			Time: 5:20 PM			
Dye Standard (ppb)	SCUFA Fluorescence Reads (ppb)			SCUFA Turbidity Reads (NTU)		
	1	2	3	1	2	3
DI Water	-10.390	-10.510	-10.060	-0.130	-0.110	-0.114
5 ppb STD	2.290	2.240	2.330	0.289	0.235	0.343
10 ppb STD	8.554	8.795	8.462	0.097	0.140	0.157
25 ppb STD	31.702	31.380	30.790	0.006	0.000	0.012
100 ppb STD	161.930	161.840	162.080	0.026	0.020	0.0150
500 ppb STD	814.640	815.020	816.150	-0.185	-0.171	-0.205

Post-Event Results						
Date: 9/22/17			Time: ~~0845~~ GN 1045			
Dye Standard (ppb)	SCUFA Fluorescence Reads (ppb)			SCUFA Turbidity Reads (NTU)		
	1	2	3	1	2	3
DI Water	-5.153	-5551	-5.728	0.008	0.034	0.040
5	-4.281	-4.373	-4.498	0.112	0.189	0.155
10	8.569	8.304	8.021	0.152	0.157	0.095
25	27.441	27.697	27.469	0.152	0.100	0.032
100	145.043	145.630	145.016	0.309	0.292	0.252
500	703.979	703.971	703.898	0.829	0.840	0.815

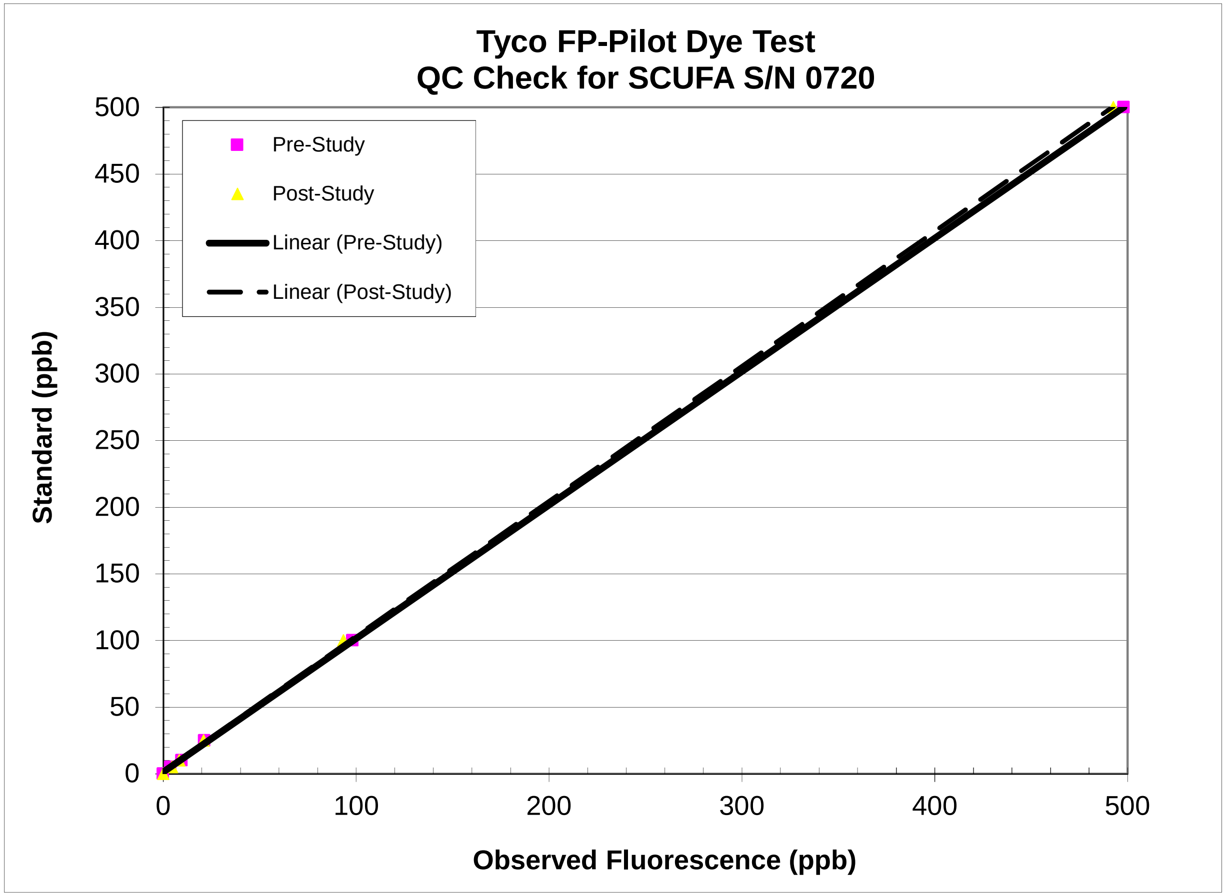
SN 0669 DI QC Check: Pre-Study		
Standard (ppb)	Fluorescence Measured (ppb)	Turbidity Measured (NTU)
0	0.0	
5	4.2	
10	9.9	
25	24.4	
100	96.3	
500	461.5	
SN 0669 DI QC Check: Post-Study		
0	0.0	
5	1.3	
10	6.4	
25	21.6	
100	91.3	
500	454.8	



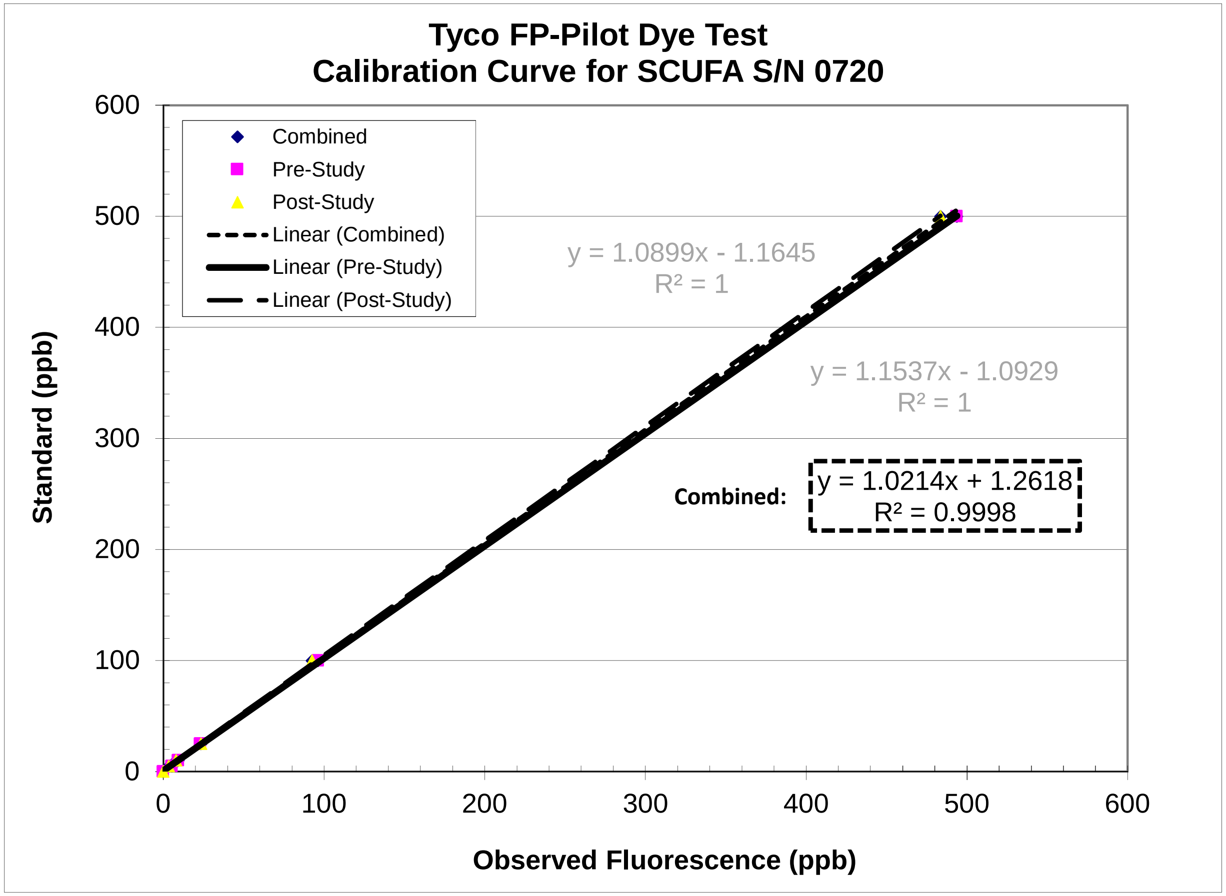
SN 0669 Pre-Study Calibration		
Standard (ppb)	Fluorescence Measured (ppb)	Turbidity Measured (NTU)
0	0.0	0.1
5	4.5	0.5
10	10.0	1.5
25	25.1	1.8
100	94.6	1.1
500	459.4	0.5
SN 0669 Post-Study Calibration		
0	0.0	0.0
5	5.1	1.4
10	8.6	0.9
25	23.7	1.9
100	89.0	0.8
500	434.0	0.5



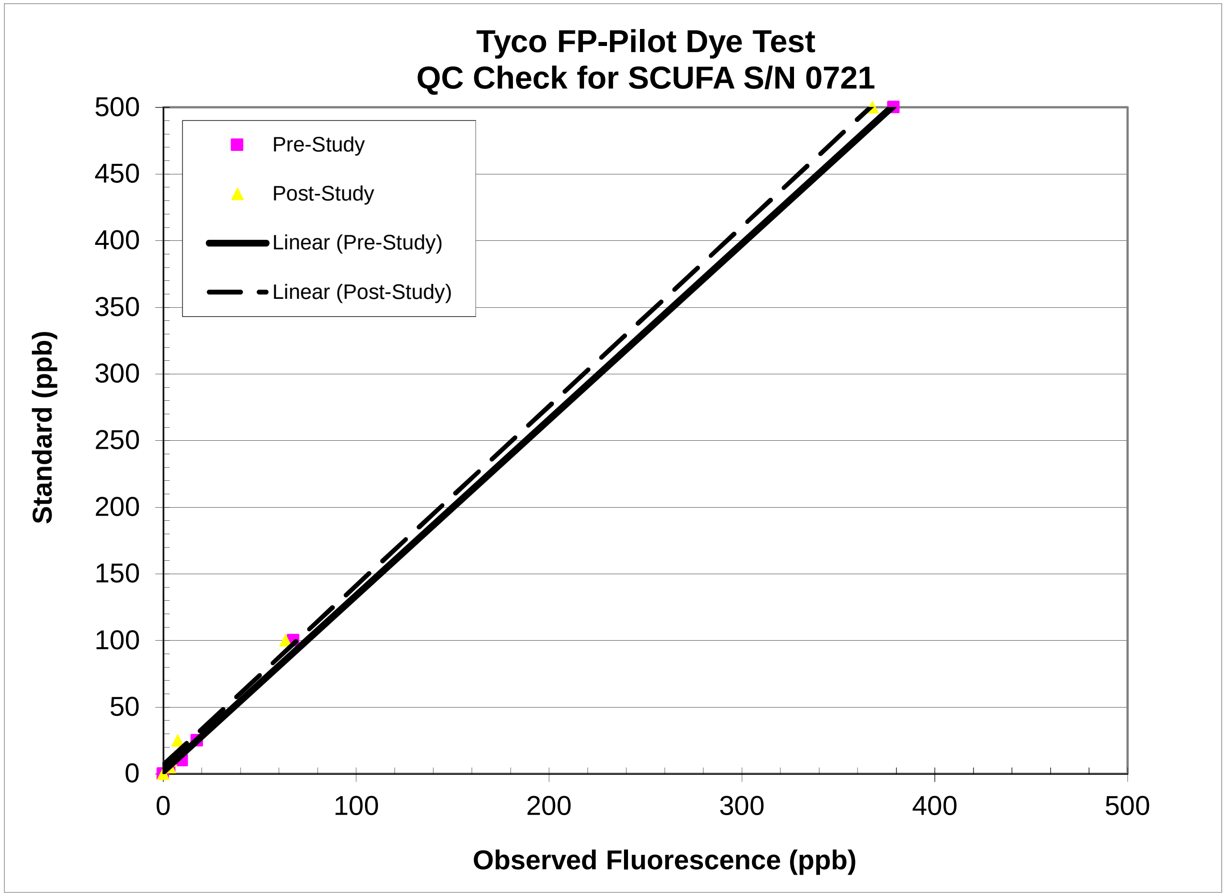
Standard (ppb)	Fluorescence Measured (ppb)	Turbidity Measured (NTU)
SN 0720 DI QC Check: Pre-Study		
0	0.0	
5	3.7	
10	9.6	
25	21.4	
100	98.2	
500	498.1	
SN 0720 DI QC Check: Post-Study		
0	0.0	
5	4.5	
10	8.3	
25	20.9	
100	93.4	
500	492.6	



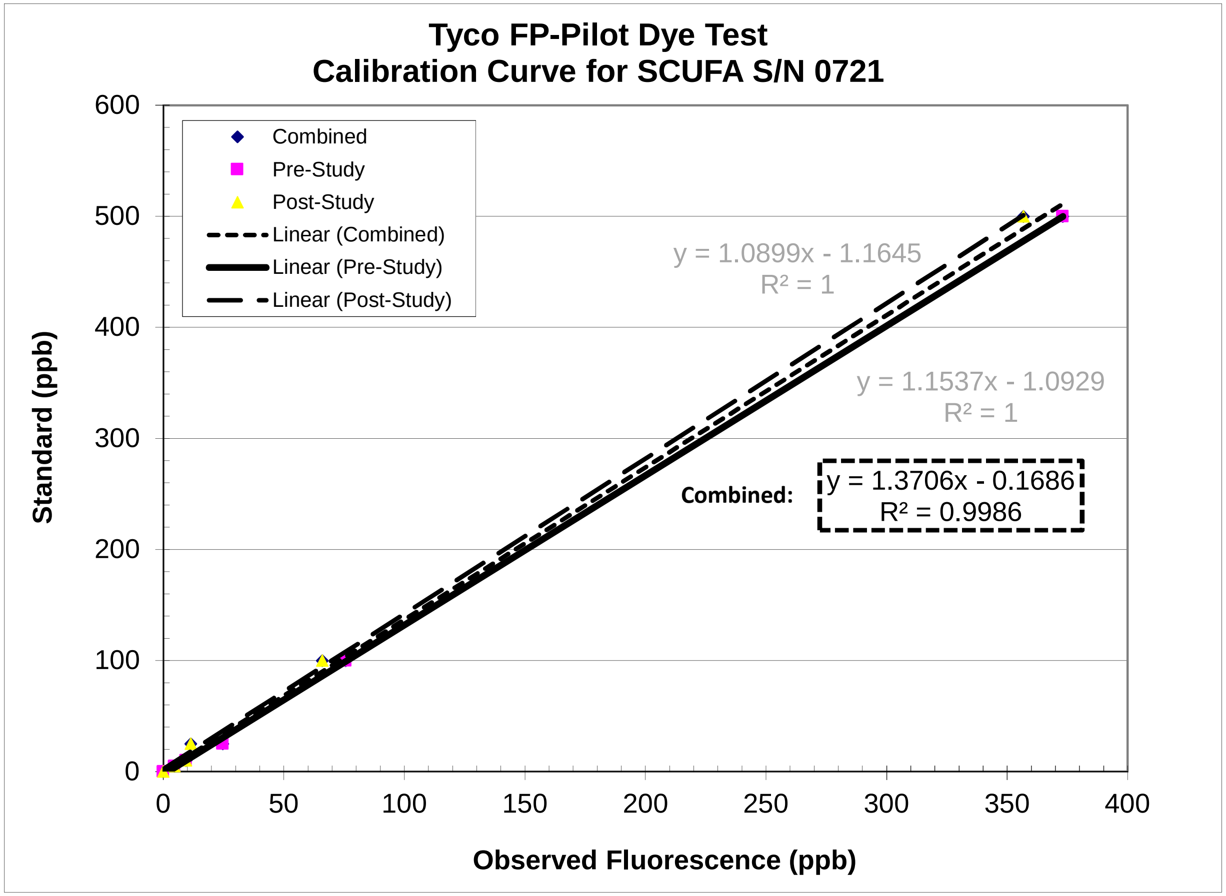
SN 0720 Pre-Study Calibration		
Standard (ppb)	Fluorescence Measured (ppb)	Turbidity Measured (NTU)
0	0.0	0.1
5	5.3	1.4
10	9.2	1.3
25	23.1	1.6
100	96.4	1.1
500	493.7	0.9
SN 0720 Post-Study Calibration		
0	0.0	0.2
5	3.4	1.5
10	7.8	1.2
25	23.3	1.5
100	92.5	1.1
500	483.5	0.7



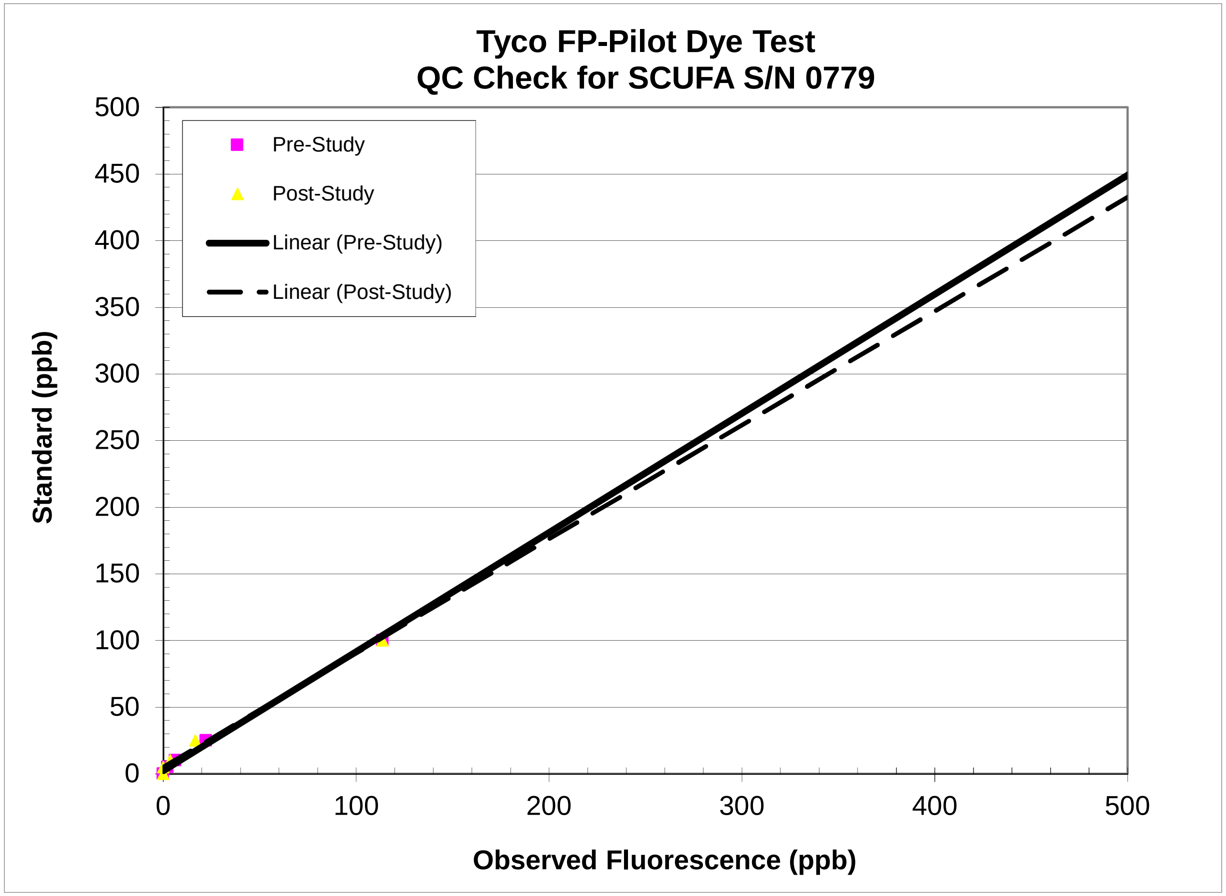
SN 0721 DI QC Check: Pre-Study		
Standard (ppb)	Fluorescence Measured (ppb)	Turbidity Measured (NTU)
0	0.0	
5	3.2	
10	9.7	
25	17.5	
100	67.5	
500	378.7	
SN 0721 DI QC Check: Post-Study		
0	0.0	
5	3.2	
10	3.9	
25	7.5	
100	63.4	
500	367.6	



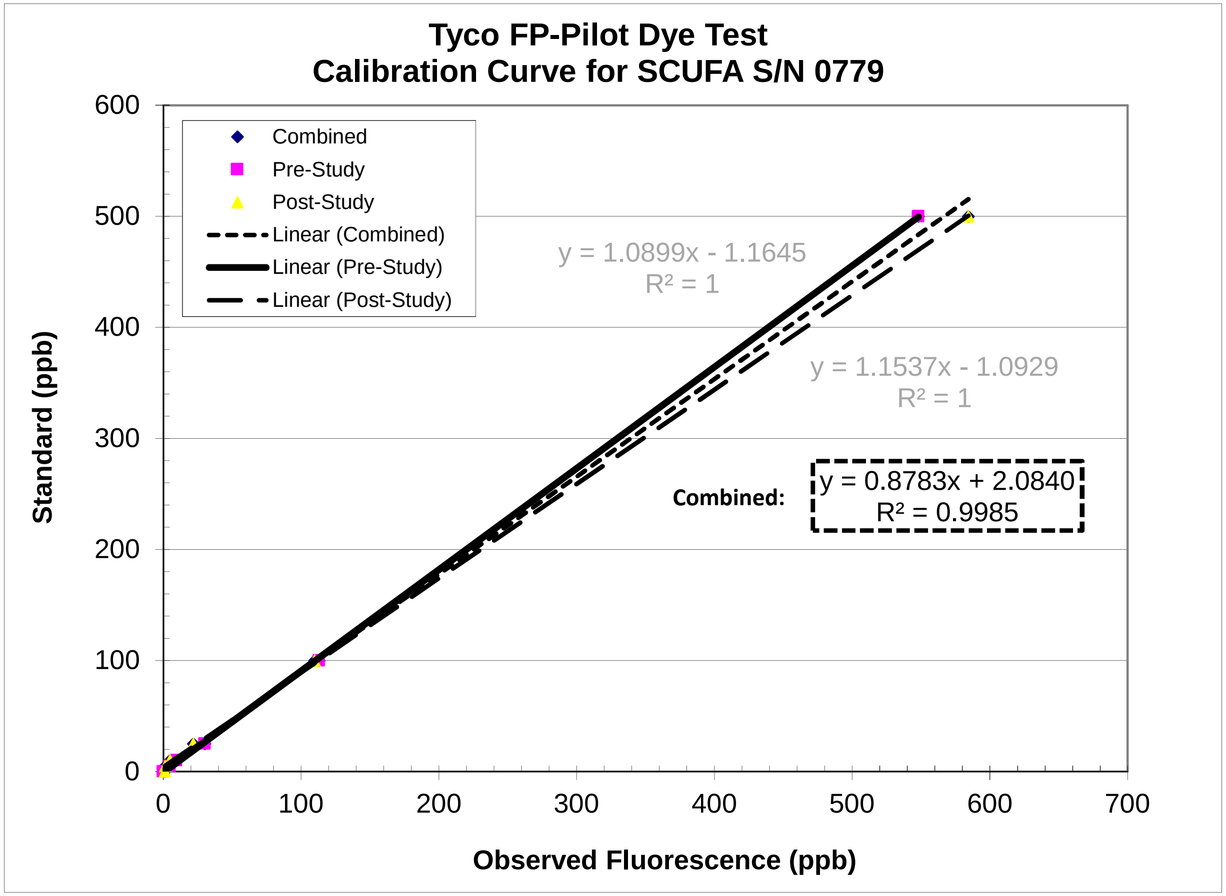
SN 0721 Pre-Study Calibration		
Standard (ppb)	Fluorescence Measured (ppb)	Turbidity Measured (NTU)
0	0.0	0.0
5	4.6	1.4
10	9.4	1.1
25	24.7	1.6
100	75.6	1.1
500	373.2	0.5
SN 0721 Post-Study Calibration		
0	0.0	1.3
5	4.6	1.1
10	9.4	0.9
25	11.4	1.2
100	66.0	1.0
500	356.8	0.4



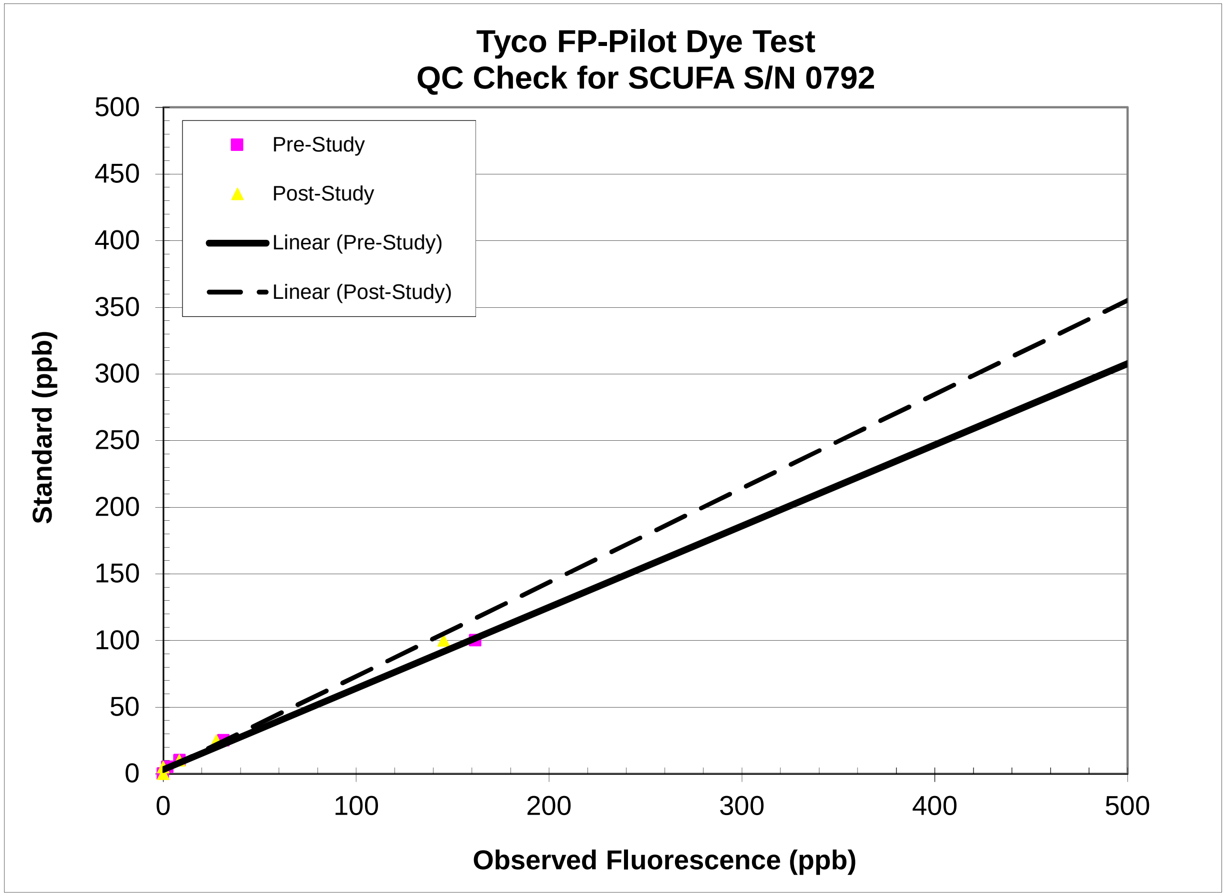
Standard (ppb)	Fluorescence Measured (ppb)	Turbidity Measured (NTU)
SN 0779 DI QC Check: Pre-Study		
0	0.0	
5	2.2	
10	6.2	
25	22.1	
100	113.7	
500	556.1	
SN 0779 DI QC Check: Post-Study		
0	0.0	
5	0.0	
10	3.6	
25	16.6	
100	113.7	
500	578.5	



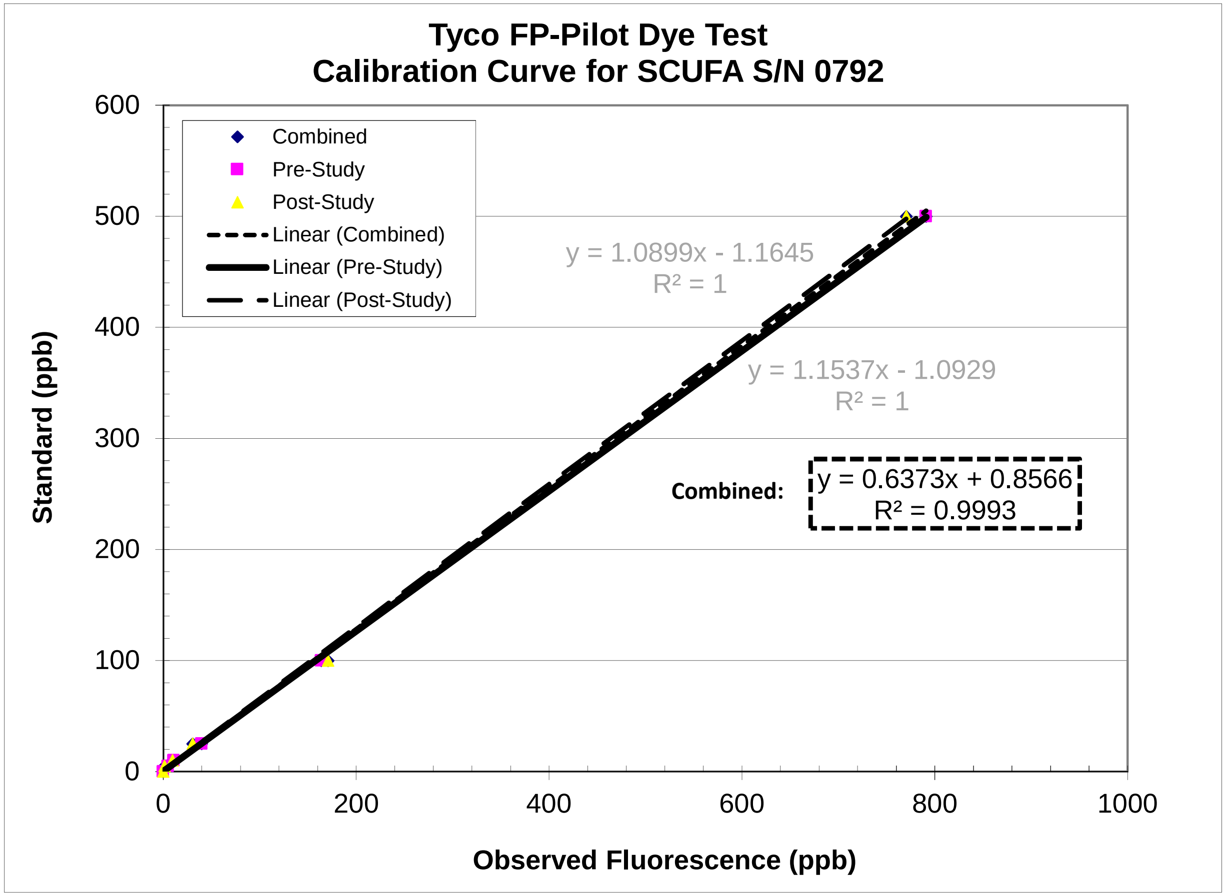
SN 0779 Pre-Study Calibration		
Standard (ppb)	Fluorescence Measured (ppb)	Turbidity Measured (NTU)
0	0.0	0.0
5	4.7	1.3
10	9.5	1.1
25	30.2	1.8
100	113.0	1.0
500	548.2	0.5
SN 0779 Post-Study Calibration		
0	1.2	1.1
5	1.4	0.9
10	4.9	0.8
25	21.7	0.9
100	109.8	0.9
500	584.5	0.3



SN 0792 DI QC Check: Pre-Study		
Standard (ppb)	Fluorescence Measured (ppb)	Turbidity Measured (NTU)
0	0.0	
5	2.3	
10	8.6	
25	31.3	
100	162.0	
500	815.3	
SN 0792 DI QC Check: Post-Study		
0	0.0	
5	0.0	
10	8.3	
25	27.5	
100	145.2	
500	703.9	



SN 0792 Pre-Study Calibration		
Standard (ppb)	Fluorescence Measured (ppb)	Turbidity Measured (NTU)
0	0.0	0.0
5	4.8	1.2
10	10.8	1.1
25	39.8	1.8
100	163.7	1.0
500	791.1	0.8
SN 0792 Post-Study Calibration		
0	0.0	1.1
5	1.2	1.3
10	9.5	0.9
25	30.3	1.0
100	170.9	1.0
500	770.4	0.3



Attachment B
Aquafluor Field Data

Attachment B. Aquafluor Field Data

Tyco Fire Products LP, Marinette, Wisconsin

Date	Time	Test Injection Location	Station / Sample ID	Sample Distance from Wall (ft)	Sample Depth (ft)	Sample Distance Downstream, Or East of Injection Site (ft)	Rhodamine WT Concentration (ppb)
9/19/2017	12:10:00 PM	T3	T3-SL-1A	5.0	4.0	50.0	-0.842
9/19/2017	12:30:00 PM	T3	T3-SB-1A	25.0	3.0	100.0	10.04
9/19/2017	12:32:00 PM	T3	T3-SB-2A	25.0	3.0	100.0	-0.082
9/19/2017	12:34:00 PM	T3	T3-SB-3A	25.0	0.5	100.0	-0.202
9/19/2017	12:35:00 PM	T3	T3-SL-2A	5.0	0.0	100.0	-1.841
9/19/2017	12:40:00 PM	T3	T3-SB-4A	20.0	5.0	200.0	-0.219
9/19/2017	12:41:00 PM	T3	T3-SB-5A	20.0	1.0	200.0	-0.294
9/19/2017	12:43:00 PM	T3	T3-SB-6A	20.0	10.0	200.0	-0.475
9/19/2017	12:45:00 PM	T3	T3-SL-3A	5.0	4.0	300.0	-1.424
9/19/2017	12:47:00 PM	T3	T3-SL-4A	5.0	10.0	300.0	-1.317
9/19/2017	12:49:00 PM	T3	T3-SB-7A	20.0	0.5	300.0	-0.286
9/19/2017	12:51:00 PM	T3	T3-SB-8A	20.0	10.0	300.0	-0.350
9/19/2017	12:58:00 PM	T3	T3-SB-9A	20.0	0.5	-75.0	-0.054
9/19/2017	6:03:00 PM	T3	T3-SL-1B	2.0	4.0	30.0	0.14
9/19/2017	6:04:00 PM	T3	T3-SL-2B	6.0	4.0	30.0	-0.22
9/19/2017	6:04:00 PM	T3	T3-SL-1B	2.0	0.0	10.0	-0.575
9/19/2017	6:05:00 PM	T3	T3-SL-2B	2.0	4.0	10.0	-0.728
9/19/2017	6:06:00 PM	T3	T3-SL-4B	2.0	4.0	30.0	-0.075
9/19/2017	6:06:00 PM	T3	T3-SL-3B	2.0	10.0	10.0	-0.699
9/19/2017	6:08:00 PM	T3	T3-SL-4B	5.0	0.0	10.0	-0.903
9/19/2017	6:09:00 PM	T3	T3-SL-5B	5.0	4.0	10.0	-1.051
9/19/2017	6:09:00 PM	T3	T3-SL-6B	2.0	0.0	5.0	-1.235
9/19/2017	6:10:00 PM	T3	T3-SL-7B	2.0	4.0	5.0	-0.967
9/19/2017	6:12:00 PM	T3	T3-SL-8B	2.0	4.0	0.0	2.242
9/19/2017	6:15:00 PM	T3	T3-SL-9B	2.0	0.0	15.0	2.554
9/19/2017	6:16:00 PM	T3	T3-SL-10B	2.0	4.0	15.0	2.500
9/19/2017	6:17:00 PM	T3	T3-SL-11B	2.0	10.0	15.0	2.254
9/19/2017	6:18:00 PM	T3	T3-SL-12B	5.0	0.0	15.0	2.278
9/19/2017	6:20:00 PM	T3	T3-SL-13B	5.0	4.0	15.0	2.325
9/19/2017	6:20:00 PM	T3	T3-SL-14B	5.0	8.0	15.0	2.692
9/19/2017	6:25:00 PM	T3	T3-SL-3B	2.0	0.0	30.0	-0.15
9/19/2017	6:25:00 PM	T3	T3-SL-5B	3.0	4.0	50.0	-2.661
9/19/2017	6:25:00 PM	T3	T3-SL-15B	2.0	0.0	20.0	2.553
9/19/2017	6:25:00 PM	T3	T3-SL-16B	2.0	4.0	20.0	3.045
9/19/2017	6:26:00 PM	T3	T3-SL-6B	6.0	4.0	50.0	-2.878
9/19/2017	6:26:00 PM	T3	T3-SL-17B	2.0	8.0	20.0	3.096
9/19/2017	6:27:00 PM	T3	T3-SL-18B	5.0	0.0	20.0	2.875
9/19/2017	6:27:00 PM	T3	T3-SL-19B	5.0	4.0	20.0	2.520
9/19/2017	6:28:00 PM	T3	T3-SL-7B	6.0	5.0	50.0	-3.366
9/19/2017	6:29:00 PM	T3	T3-SL-8B	3.0	10.0	50.0	-3.079
9/19/2017	6:29:00 PM	T3	T3-SL-20B	5.0	8.0	20.0	2.334
9/19/2017	6:30:00 PM	T3	T3-SL-21B	2.0	0.0	30.0	2.504

Attachment B. Aquafluor Field Data

Tyco Fire Products LP, Marinette, Wisconsin

Date	Time	Test Injection Location	Station / Sample ID	Sample Distance from Wall (ft)	Sample Depth (ft)	Sample Distance Downstream, Or East of Injection Site (ft)	Rhodamine WT Concentration (ppb)
9/19/2017	6:31:00 PM	T3	T3-SL-9B	6.0	8.0	50.0	-3.089
9/19/2017	6:31:00 PM	T3	T3-SL-22B	2.0	4.0	30.0	2.543
9/19/2017	6:32:00 PM	T3	T3-SL-23B	2.0	10.0	30.0	2.654
9/19/2017	6:33:00 PM	T3	T3-SL-10B	0.0	4.0	0.0	-2.920
9/19/2017	6:34:00 PM	T3	T3-SL-24B	5.0	0.0	30.0	2.574
9/19/2017	6:35:00 PM	T3	T3-SL-25B	5.0	4.0	30.0	2.390
9/19/2017	6:36:00 PM	T3	T3-SL-26B	5.0	8.0	30.0	2.475
9/19/2017	6:38:00 PM	T3	T3-SL-27B	2.0	0.0	35.0	2.604
9/19/2017	6:39:00 PM	T3	T3-SL-12B	5.0	2.0	10.0	17.4
9/19/2017	6:39:00 PM	T3	T3-SL-28B	2.0	4.0	35.0	2.613
9/19/2017	6:40:00 PM	T3	T3-SL-29B	2.0	10.0	35.0	2.598
9/19/2017	6:41:00 PM	T3	T3-SL-30B	5.0	0.0	35.0	2.548
9/19/2017	6:42:00 PM	T3	T3-SL-31B	5.0	4.0	35.0	2.896
9/19/2017	6:44:00 PM	T3	T3-SL-32B	2.0	2.0	10.0	3.748
9/20/2017	10:55:00 AM	T3	T3-SL-9C	4.0	2.0	25.0	-2.5
9/20/2017	11:04:00 AM	T3	T3-SL-14C	4.0	0.5	25.0	-2.26
9/20/2017	11:03:00 AM	T3	T3-SL-13C	2.0	0.5	25.0	-2.03
9/20/2017	10:54:00 AM	T3	T3-SL-8C	1.0	2.0	25.0	-1.97
9/20/2017	10:06:00 AM	T3	T3-SL-6C	1.0	1.0	100.0	-1.639
9/20/2017	11:19:00 AM	T3	T3-SL-21C	5.0	2.0	50.0	-1.25
9/20/2017	11:00:00 AM	T3	T3-SL-12C	2.0	0.0	50.0	-1.14
9/20/2017	10:59:00 AM	T3	T3-SL-11C	5.0	2.0	50.0	-0.76
9/20/2017	10:03:00 AM	T3	T3-SL-4C	4.0	1.0	40.0	-0.698
9/20/2017	9:55:00 AM	T3	T3-SL-1C	1.0	2.0	20.0	-0.105
9/20/2017	11:11:00 AM	T3	T3-SL-18C	2.0	2.0	100.0	0.19
9/20/2017	10:57:00 AM	T3	T3-SL-10C	2.0	2.0	50.0	0.31
9/20/2017	10:05:00 AM	T3	T3-SL-5C	1.0	1.0	50.0	0.523
9/20/2017	11:20:00 AM	T3	T3-SL-22C	1.0	2.0	5.0	0.68
9/20/2017	10:56:00 AM	T3	T3-SL-11C	2.0	2.0	10.0	0.696
9/20/2017	11:21:00 AM	T3	T3-SL-26C	4.0	2.0	25.0	0.698
9/20/2017	9:59:00 AM	T3	T3-SL-2C	2.0	0.5	20.0	0.865
9/20/2017	11:17:00 AM	T3	T3-SL-24C	1.0	2.0	5.0	1.296
9/20/2017	11:08:00 AM	T3	T3-SL-16C	2.0	2.0	50.0	1.51
9/20/2017	10:52:00 AM	T3	T3-SL-7C	2.0	2.0	25.0	1.61
9/20/2017	11:13:00 AM	T3	T3-SL-21C	4.0	2.0	40.0	1.774
9/20/2017	11:09:00 AM	T3	T3-SL-17C	2.0	2.0	40.0	2.43
9/20/2017	11:04:00 AM	T3	T3-SL-16C	2.0	2.0	10.0	2.484
9/20/2017	10:08:00 AM	T3	T3-SL-9C	1.0	0.0	50.0	3.03
9/20/2017	10:06:00 AM	T3	T3-SL-8C	4.0	1.0	50.0	3.706
9/20/2017	10:57:00 AM	T3	T3-SL-12C	1.0	2.0	10.0	4.303
9/20/2017	11:14:00 AM	T3	T3-SL-22C	2.0	1.0	25.0	5.679
9/20/2017	11:16:00 AM	T3	T3-SL-20C	4.0	2.0	40.0	7.05

Attachment B. Aquafluor Field Data
Tyco Fire Products LP, Marinette, Wisconsin

Date	Time	Test Injection Location	Station / Sample ID	Sample Distance from Wall (ft)	Sample Depth (ft)	Sample Distance Downstream, Or East of Injection Site (ft)	Rhodamine WT Concentration (ppb)
9/20/2017	11:16:00 AM	T3	T3-SL-23C	4.0	2.0	20.0	7.686
9/20/2017	11:05:00 AM	T3	T3-SL-17C	2.0	2.0	20.0	10.04
9/20/2017	10:04:00 AM	T3	T3-SL-6C	2.0	0.5	30.0	12.51
9/20/2017	9:58:00 AM	T3	T3-SL-1C	2.0	1.0	20.0	14.54
9/20/2017	11:10:00 AM	T3	T3-SL-19C	2.0	2.0	10.0	18.92
9/20/2017	11:07:00 AM	T3	T3-SL-15C	1.0	2.0	25.0	24.35
9/20/2017	11:00:00 AM	T3	T3-SL-15C	2.0	2.0	15.0	24.76
9/20/2017	10:00:00 AM	T3	T3-SL-3C	2.0	0.5	10.0	29.15
9/20/2017	11:07:00 AM	T3	T3-SL-18C	1.0	1.0	10.0	31.3
9/20/2017	9:59:00 AM	T3	T3-SL-2C	1.0	1.0	10.0	31.35
9/20/2017	11:19:00 AM	T3	T3-SL-25C	1.0	2.0	5.0	32.29
9/20/2017	10:00:00 AM	T3	T3-SL-3C	1.0	0.5	10.0	34.69
9/20/2017	10:55:00 AM	T3	T3-SL-10C	1.0	2.0	5.0	38.45
9/20/2017	11:11:00 AM	T3	T3-SL-20C	2.0	2.0	20.0	39.31
9/20/2017	11:13:00 AM	T3	T3-SL-19C	2.0	1.0	5.0	45.36
9/20/2017	10:03:00 AM	T3	T3-SL-5C	2.0	1.0	5.0	75.67
9/20/2017	10:02:00 AM	T3	T3-SL-4C	2.0	1.0	5.0	115.7
9/20/2017	11:21:00 AM	T3	T3-SL-27C	1.0	2.0	1.0	116.7
9/20/2017	10:05:00 AM	T3	T3-SL-7C	2.0	1.0	1.0	397.2
9/20/2017	2:31:00 PM	T3	T3-SL-1D	1.0	12.0	10.0	8.805
9/20/2017	2:33:00 PM	T3	T3-SL-1D	2.0	12.0	20.0	1.07
9/20/2017	2:35:00 PM	T3	T3-SL-2D	1.0	12.0	30.0	1.280
9/20/2017	2:36:00 PM	T3	T3-SL-2D	2.0	12.0	40.0	-1.81
9/20/2017	2:40:00 PM	T3	T3-SL-3D	2.0	12.0	10.0	-1.41
9/20/2017	2:40:00 PM	T3	T3-SL-3D	1.0	12.0	50.0	0.987
9/20/2017	2:43:00 PM	T3	T3-SL-4D	1.0	12.0	20.0	1.157
9/20/2017	2:44:00 PM	T3	T3-SL-4D	2.0	12.0	0.0	1143
9/20/2017	2:48:00 PM	T3	T3-SL-5D	2.0	12.0	20.0	1.07
9/20/2017	2:50:00 PM	T3	T3-SL-5D	1.0	12.0	10.0	0.131
9/20/2017	2:51:00 PM	T3	T3-SL-6D	2.0	12.0	40.0	-2.00
9/20/2017	2:52:00 PM	T3	T3-SL-6D	1.0	12.0	30.0	0.135
9/20/2017	2:55:00 PM	T3	T3-SL-7D	2.0	10.0	10.0	-2.38
9/20/2017	2:56:00 PM	T3	T3-SL-7D	1.0	12.0	50.0	-0.499
9/20/2017	2:57:00 PM	T3	T3-SL-8D	2.0	14.0	10.0	13.08
9/20/2017	3:00:00 PM	T3	T3-SL-9D	2.0	14.0	20.0	3.29
9/20/2017	3:00:00 PM	T3	T3-SL-8D	1.0	10.0	20.0	-0.373
9/20/2017	3:03:00 PM	T3	T3-SL-10D	2.0	14.0	40.0	0.12
9/20/2017	3:05:00 PM	T3	T3-SL-9D	1.0	14.0	30.0	5.919
9/20/2017	3:07:00 PM	T3	T3-SL-11D	2.0	12.0	5.0	1.89
9/20/2017	3:08:00 PM	T3	T3-SL-10D	1.0	14.0	50.0	4.805
9/20/2017	3:11:00 PM	T3	T3-SL-11D	1.0	12.0	10.0	8.848
9/20/2017	3:16:00 PM	T3	T3-SL-12D	1.0	12.0	20.0	-0.508

Attachment B. Aquafluor Field Data

Tyco Fire Products LP, Marinette, Wisconsin

Date	Time	Test Injection Location	Station / Sample ID	Sample Distance from Wall (ft)	Sample Depth (ft)	Sample Distance Downstream, Or East of Injection Site (ft)	Rhodamine WT Concentration (ppb)
9/20/2017	3:19:00 PM	T3	T3-SL-13D	1.0	12.0	30.0	-0.155
9/20/2017	3:25:00 PM	T3	T3-SL-14D	1.0	12.0	100.0	-0.233
9/21/2017	10:47:00 AM	T1	T1-SL-1A	2.0	2.0	10.0	1.714
9/21/2017	10:51:00 AM	T1	T1-SL-1A	2.0	2.0	5.0	6.09
9/21/2017	10:53:00 AM	T1	T1-SL-2A	2.0	2.0	-1.0	439.6
9/21/2017	10:53:00 AM	T1	T1-SL-2A	2.0	2.0	-5.0	3.799
9/21/2017	10:55:00 AM	T1	T1-SL-3A	2.0	2.0	-2.0	189.0
9/21/2017	10:55:00 AM	T1	T1-SL-3A	8.0	2.0	0.0	1.630
9/21/2017	10:58:00 AM	T1	T1-SL-4A	4.0	0.5	0.0	609.5
9/21/2017	10:58:00 AM	T1	T1-SL-4A	2.0	2.0	-10.0	6.938
9/21/2017	11:00:00 AM	T1	T1-SL-5A	10.0	2.0	0.0	157.8
9/21/2017	11:00:00 AM	T1	T1-SL-5A	2.0	2.0	-20.0	0.775
9/21/2017	11:01:00 AM	T1	T1-SL-6A	8.0	2.0	0.0	120.7
9/21/2017	11:03:00 AM	T1	T1-SL-6A	2.0	2.0	20.0	10.01
9/21/2017	11:06:00 AM	T1	T1-SL-7A	8.0	2.0	-15.0	21.22
9/21/2017	11:07:00 AM	T1	T1-SL-7A	2.0	2.0	-5.0	228.0
9/21/2017	11:09:00 AM	T1	T1-SL-8A	2.0	2.0	-30.0	1.105
9/21/2017	11:09:00 AM	T1	T1-SL-8A	2.0	2.0	30.0	4.173
9/21/2017	11:11:00 AM	T1	T1-SL-9A	2.0	2.0	-5.0	722.7
9/21/2017	11:13:00 AM	T1	T1-SL-10A	2.0	2.0	-10.0	247.2
9/21/2017	11:14:00 AM	T1	T1-SL-9A	1.0	2.0	-10.0	294.5
9/21/2017	11:14:00 AM	T1	T1-SL-11A	2.0	2.0	-20.0	14.06
9/21/2017	11:15:00 AM	T1	T1-SL-10A	5.0	2.0	-30.0	7.37
9/21/2017	11:16:00 AM	T1	T1-SL-12A	5.0	2.0	-50.0	2.916
9/21/2017	11:18:00 AM	T1	T1-SL-13A	2.0	2.0	0.0	46.89
9/21/2017	11:20:00 AM	T1	T1-SL-11A	0.0	2.0	0.0	847.9
9/21/2017	11:20:00 AM	T1	T1-SL-14A	2.0	2.0	5.0	436.4
9/21/2017	11:22:00 AM	T1	T1-SL-12A	0.0	2.0	0.0	1558
9/21/2017	11:23:00 AM	T1	T1-SL-15A	2.0	2.0	20.0	8.351
9/21/2017	11:24:00 AM	T1	T1-SL-13A	2.0	2.0	10.0	210.7
9/21/2017	11:27:00 AM	T1	T1-SL-16A	2.0	2.0	5.0	694.2
9/21/2017	11:28:00 AM	T1	T1-SL-14A	4.0	2.0	10.0	194.40
9/21/2017	11:28:00 AM	T1	T1-SL-17A	4.0	2.0	20.0	84.85
9/21/2017	11:30:00 AM	T1	T1-SL-15A	2.0	2.0	20.0	97.34
9/21/2017	11:32:00 AM	T1	T1-SL-16A	4.0	2.0	30.0	51.69
9/21/2017	11:32:00 AM	T1	T1-SL-18A	4.0	2.0	50.0	2.831
9/21/2017	11:34:00 AM	T1	T1-SL-17A	2.0	2.0	30.0	42.65
9/21/2017	11:34:00 AM	T1	T1-SL-19A	4.0	2.0	40.0	2.268
9/21/2017	11:35:00 AM	T1	T1-SL-20A	2.0	2.0	2.0	906.2
9/21/2017	2:38:00 PM	T2	T2-SL-1A	2.0	2.0	10.0	6.256
9/21/2017	2:39:00 PM	T2	T2-SL-1A	4.0	2.0	10.0	-4.44
9/21/2017	2:41:00 PM	T2	T2-SL-2A	4.0	2.0	25.0	-4.29

Attachment B. Aquafluor Field Data

Tyco Fire Products LP, Marinette, Wisconsin

Date	Time	Test Injection Location	Station / Sample ID	Sample Distance from Wall (ft)	Sample Depth (ft)	Sample Distance Downstream, Or East of Injection Site (ft)	Rhodamine WT Concentration (ppb)
9/21/2017	2:41:00 PM	T2	T2-SL-2A	2.0	2.0	25.0	13.82
9/21/2017	2:42:00 PM	T2	T2-SL-3A	4.0	2.0	50.0	-4.15
9/21/2017	2:43:00 PM	T2	T2-SL-3A	2.0	2.0	50.0	6.270
9/21/2017	2:44:00 PM	T2	T2-SL-4A	4.0	2.0	10.0	-4.17
9/21/2017	2:45:00 PM	T2	T2-SL-5A	4.0	2.0	20.0	-3.79
9/21/2017	2:45:00 PM	T2	T2-SL-4A	2.0	2.0	10.0	0.740
9/21/2017	2:46:00 PM	T2	T2-SL-6A	4.0	2.0	30.0	-2.06
9/21/2017	2:46:00 PM	T2	T2-SL-5A	2.0	2.0	20.0	5.639
9/21/2017	2:47:00 PM	T2	T2-SL-7A	4.0	2.0	40.0	0.726
9/21/2017	2:47:00 PM	T2	T2-SL-6A	2.0	2.0	30.0	2.934
9/21/2017	2:48:00 PM	T2	T2-SL-7A	2.0	2.0	40.0	4.059
9/21/2017	2:49:00 PM	T2	T2-SL-8A	4.0	2.0	50.0	-1.717
9/21/2017	2:50:00 PM	T2	T2-SL-8A	2.0	2.0	50.0	1.950
9/21/2017	2:51:00 PM	T2	T2-SL-9A	2.0	2.0	0.0	796.5
9/21/2017	2:51:00 PM	T2	T2-SL-9A	2.0	2.0	5.0	0.110
9/21/2017	2:53:00 PM	T2	T2-SL-10A	2.0	2.0	-5.0	0.699
9/21/2017	2:54:00 PM	T2	T2-SL-10A	2.0	2.0	100.0	6.66
9/21/2017	2:55:00 PM	T2	T2-SL-11A	2.0	2.0	75.0	-0.456
9/21/2017	2:56:00 PM	T2	T2-SL-11A	4.0	2.0	25.0	2.23
9/21/2017	2:57:00 PM	T2	T2-SL-12A	2.0	2.0	-10.0	-0.939
9/21/2017	2:59:00 PM	T2	T2-SL-12A	4.0	2.0	10.0	-1.499
9/21/2017	2:59:00 PM	T2	T2-SL-13A	2.0	2.0	5.0	51.37
9/21/2017	3:00:00 PM	T2	T2-SL-13A	4.0	2.0	20.0	-1.60
9/21/2017	3:01:00 PM	T2	T2-SL-14A	2.0	2.0	10.0	-0.028
9/21/2017	3:02:00 PM	T2	T2-SL-14A	4.0	2.0	30.0	-2.13
9/21/2017	3:02:00 PM	T2	T2-SL-15A	2.0	2.0	20.0	-0.021
9/21/2017	3:03:00 PM	T2	T2-SL-15A	4.0	2.0	40.0	-2.04
9/21/2017	3:03:00 PM	T2	T2-SL-16A	2.0	2.0	30.0	12.44
9/21/2017	3:04:00 PM	T2	T2-SL-17A	2.0	2.0	40.0	8.877
9/21/2017	3:05:00 PM	T2	T2-SL-16A	4.0	2.0	50.0	-2.46
9/21/2017	3:05:00 PM	T2	T2-SL-18A	2.0	2.0	50.0	2.081
9/21/2017	3:06:00 PM	T2	T2-SL-17A	4.0	2.0	100.0	-2.02
9/21/2017	3:07:00 PM	T2	T2-SL-18A	4.0	2.0	50.0	-1.87
9/21/2017	3:07:00 PM	T2	T2-SL-19A	2.0	2.0	100.0	0.192
9/21/2017	3:08:00 PM	T2	T2-SL-20A	2.0	0.0	50.0	2.610
9/21/2017	3:12:00 PM	T2	T2-SL-19A	4.0	4.0	50.0	-2.111
9/21/2017	3:12:00 PM	T2	T2-SL-21A	2.0	4.0	50.0	0.073

Notes:

ft = feet

ppb = part per billion